ooRexx
Documentation 5.1.0

Open Object Rexx

Reference

ooRexx Documentation 5.1.0 Open Object Rexx Reference
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Preface

This book describes the Open Object Rexx Interpreter, called the *interpreter* or *language processor* in the following, and the object-oriented Rexx language.

This book is intended for people who plan to develop applications using Rexx. Its users range from the novice, who might have experience in some programming language but no Rexx experience, to the experienced application developer, who might have had some experience with Open Object Rexx.

This book is a reference rather than a tutorial. It assumes you are already familiar with object-oriented programming concepts.

Descriptions include the use and syntax of the language and explain how the language processor "interprets" the language as a program is running.

1. Document Conventions

This manual uses several conventions to highlight certain words and phrases and draw attention to specific pieces of information.

1.1. Typographic Conventions

Typographic conventions are used to call attention to specific words and phrases. These conventions, and the circumstances they apply to, are as follows.

`Mono-spaced Bold` is used to highlight literal strings, class names, or inline code examples. For example:

> The **`Class`** class comparison methods return **`.true`** or **`.false`**, the result of performing the comparison operation.
>
> This method is exactly equivalent to **`subWord(`***n***`, 1)`**.

`Mono-spaced Normal` denotes method names or source code in program listings set off as separate examples.

> This method has no effect on the action of any `hasEntry`, `hasIndex`, `items`, `remove`, or `supplier` message sent to the collection.

```
-- reverse an array
a = .Array~of("one", "two", "three", "four", "five")

-- five, four, three, two, one
aReverse = .CircularQueue~new(a~size)~appendAll(a)~makeArray("lifo")
```

Proportional Italic is used for method and function variables and arguments.

> A supplier loop specifies one or two control variables, *index*, and *item*, which receive a different value on each repetition of the loop.
>
> Returns a string of length *length* with *string* centered in it and with *pad* characters added as necessary to make up length.

1.2. Notes and Warnings

Finally, we use three visual styles to draw attention to information that might otherwise be overlooked.

Note

Notes are tips, shortcuts or alternative approaches to the task at hand. Ignoring a note should have no negative consequences, but you might miss out on a trick that makes your life easier.

Important

Important boxes detail things that are easily missed, like mandatory initialization. Ignoring a box labeled 'Important' will not cause data loss but may cause irritation and frustration.

Warning

Warnings should not be ignored. Ignoring warnings will most likely cause data loss.

2. How to Read the Syntax Diagrams

Throughout this book, syntax is described using the structure defined below.

- Read the syntax diagrams from left to right, from top to bottom, following the path of the line.

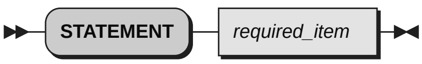
  The ▶▶— symbol indicates the beginning of a statement.

  The —··· symbol indicates that the statement syntax is continued on the next line.

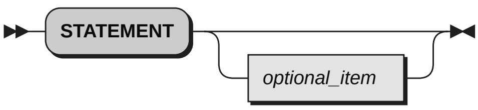
  The ···— symbol indicates that a statement is continued from the previous line.

  The —▶◀ symbol indicates the end of a statement.

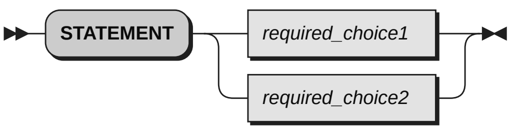
- Required items appear on the horizontal line (the main path).



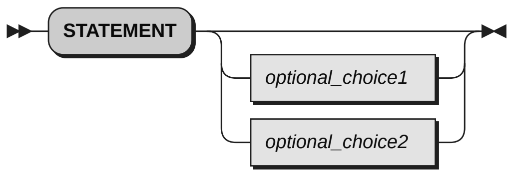
- Optional items appear below the main path.



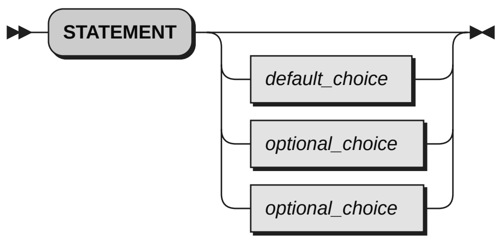
- If you can choose from two or more items, they appear vertically, in a stack. If you must choose one of the items, one item of the stack appears on the main path.



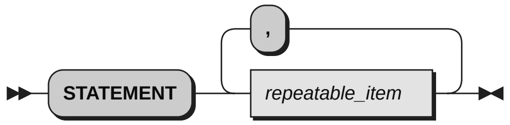
- If choosing one of the items is optional, the entire stack appears below the main path.



- If one of the items is the default, it is usually the topmost item of the stack of items below the main path.

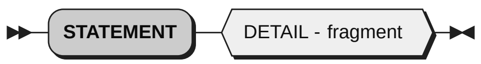


- A path returning to the left above the main line indicates an item that can be repeated.



  A repeat path above a stack indicates that you can repeat the items in the stack.

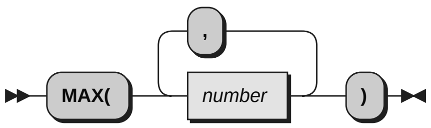
- A pointed rectangle around an item indicates that the item is a fragment, a part of the syntax diagram that appears in greater detail below the main diagram.



- Keywords appear in uppercase (for example, **`SIGNAL`**). They must be spelled exactly as shown but you can type them in upper, lower, or mixed case. Variables appear in all lowercase letters (for example, *index*). They represent user-supplied names or values.

- If punctuation marks, parentheses, arithmetic operators, or such symbols are shown, you must enter them as part of the syntax.

The following example shows how the syntax is described:



3. Getting Help and Submitting Feedback

The Open Object Rexx Project has a number of methods to obtain help and submit feedback for ooRexx and the extension packages that are part of ooRexx. These methods, in no particular order of preference, are listed below.

3.1. The Open Object Rexx SourceForge Site

Open Object Rexx utilizes SourceForge to house its source repositories, mailing lists and other project features at *https://sourceforge.net/projects/oorexx*. ooRexx uses the Developer and User mailing lists at *https://sourceforge.net/p/oorexx/mailman* for discussions concerning ooRexx. The ooRexx user is most likely to get timely replies from one of these mailing lists.

Here is a list of some of the most useful facilities provided by SourceForge.

The Developer Mailing List
: Subscribe to the oorexx-devel mailing list at *https://lists.sourceforge.net/lists/listinfo/oorexx-devel* to discuss ooRexx project development activities and future interpreter enhancements. You can find its archive of past messages at *http://sourceforge.net/mailarchive/forum.php?forum_name=oorexx-devel*.

The Users Mailing List
: Subscribe to the oorexx-users mailing list at *https://lists.sourceforge.net/lists/listinfo/oorexx-users* to discuss how to use ooRexx. It also supports a historical archive of past messages.

The Announcements Mailing List
: Subscribe to the oorexx-announce mailing list at *https://lists.sourceforge.net/lists/listinfo/oorexx-announce* to receive announcments of significant ooRexx project events.

The Bug Mailing List
: Subscribe to the oorexx-bugs mailing list at *https://lists.sourceforge.net/lists/listinfo/oorexx-bugs* to monitor changes in the ooRexx bug tracking system.

Bug Reports
: You can view ooRexx bug reports at *https://sourceforge.net/p/oorexx/bugs*. To be able to create new bug reports, you will need to first register for a SourceForge userid at *https://sourceforge.net/user/registration*. When reporting a bug, please try to provide as much information as possible to help developers determine the cause of the issue. Sample program code that can reproduce your problem will make it easier to debug reported problems.

Documentation Feedback
: You can submit feedback for, or report errors in, the documentation at *https://sourceforge.net/p/oorexx/documentation*. Please try to provide as much information in a documentation report as possible. In addition to listing the document and section the report concerns, direct quotes of the text will help the developers locate the text in the source code for the document. (Section numbers are generated when the document is produced and are not available in the source code itself.) Suggestions as to how to reword or fix the existing text should also be included.

Request For Enhancement
: You can new suggest ooRexx features or enhancements at *https://sourceforge.net/p/oorexx/feature-requests*.

Patch Reports
: If you create an enhancement patch for ooRexx please post the patch at *https://sourceforge.net/p/oorexx/patches*. Please provide as much information in the patch report as possible so that the developers can evaluate the enhancement as quickly as possible.

: Please do not post bug fix patches here, instead you should open a bug report at *https://sourceforge.net/p/oorexx/bugs* and attach the patch to it.

The ooRexx Forums
: The ooRexx project maintains a set of forums that anyone may contribute to or monitor. They are located at *https://sourceforge.net/p/oorexx/discussion*. There are currently three forums available: Help, Developers and Open Discussion. In addition, you can monitor the forums via email.

3.2. The Rexx Language Association Mailing List

The Rexx Language Association maintains a forum at *http://www.rexxla.org/forum.html*.

3.3. comp.lang.rexx Newsgroup

The comp.lang.rexx newsgroup at *https://groups.google.com/forum/#!forum/comp.lang.rexx* is a good place to obtain help from many individuals within the Rexx community. You can obtain help on Open Object Rexx and other Rexx interpreters and tools.

4. Related Information

See also *Open Object Rexx: Programmer Guide* and *Open Object Rexx: Application Programming Interfaces*.

Open Object Rexx General Concepts

The Rexx language is particularly suitable for:

- Application scripting
- Command procedures
- Application front ends
- User-defined macros (such as editor subcommands)
- Prototyping
- Personal computing

As an object-oriented language, Rexx provides data encapsulation, polymorphism, an object class hierarchy, class-based inheritance of methods, and concurrency. It includes a number of useful base classes and allows you create new object classes of your own.

Open Object Rexx is compatible with earlier Rexx versions, both non-object based Rexx and IBM's Object Rexx. It has the usual structured-programming instructions, for example IF, SELECT, DO WHILE, and LEAVE, and a number of useful built-in functions.

The language imposes few restrictions on the program format. There can be more than one clause on a line, or a single clause can occupy more than one line. Any indentation scheme is allowed. You can, therefore, code programs in a format that emphasizes their structure, making them easier to read.

There is no limit to the size of variable values, as long as all values fit into the storage available. There are no restrictions on the types of data that variables can contain.

A language processor (interpreter) runs Rexx programs. That is, the program runs line by line and word by word, without first being translated (compiled) to machine language. One of the advantages of this is that you can fix the error and rerun the program faster than when using a compiler.

Note: Open Object Rexx also supplies the *rexxc* program that can be used to translate Rexx programs into a sourceless executable file. Translating a program is not the same as compiling a program to machine language. A translated Rexx program will still be interpreted line by line, though it will typically start faster as the initial parsing has already been done.

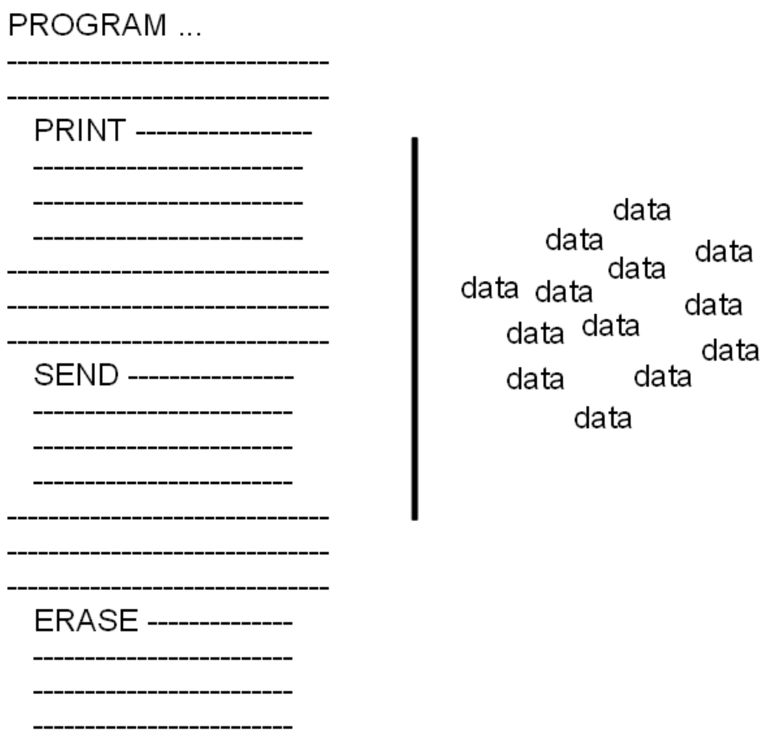
1.1. What Is Object-Oriented Programming?

Object-oriented programming is a way to write computer programs by focusing not on the instructions and operations a program uses to manipulate data, but on the data itself. First, the program simulates, or models, objects in the physical world as closely as possible. Then the objects interact with each other to produce the desired result.

Real-world objects, such as a company's employees, money in a bank account, or a report, are stored as data so the computer can act upon it. For example, when you print a report, print is the action and report is the object acted upon. Essentially, the objects are the "nouns", while the actions are the "verbs".

1.2. Modularizing Data

In conventional, structured programming, actions like print are often isolated from the data by placing them in subroutines or modules. A module typically contains an operation for implementing one simple action. You might have a PRINT module, a SEND module, an ERASE module. The data these modules operate on must be constructed by the programmer and passed to the modules to perform an action.



But with object-oriented programming, it is the data that is modularized. And each data module includes its own operations for performing actions directly related to its data. The programmer that uses the objects need only be aware of the operations an object performs and not how the data is organized internally.

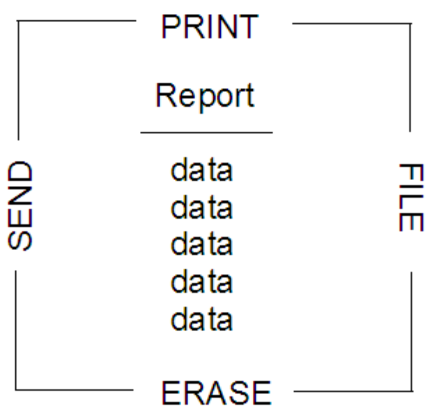


Figure 1.1. Modular Data—a Report Object

In the case of report, the report object would contain its own built-in PRINT, SEND, ERASE, and FILE operations.

Object-oriented programming lets you model real-world objects—even very complex ones—precisely and elegantly. As a result, object manipulation becomes easier and computer instructions become simpler and can be modified later with minimal effort.

Object-oriented programming *hides* any information that is not important for acting on an object, thereby concealing the object's complexities. Complex tasks can then be initiated simply, at a very high level.

1.3. Modeling Objects

In object-oriented programming, objects are modeled to real-world objects. A real-world object has actions related to it and characteristics of its own.

Take a ball, for example. A ball can be acted on—rolled, tossed, thrown, bounced, caught. But it also has its own physical characteristics—size, shape, composition, weight, color, speed, position. An accurate data model of a real ball would define not only the physical characteristics but *all* related actions and characteristics in one package:

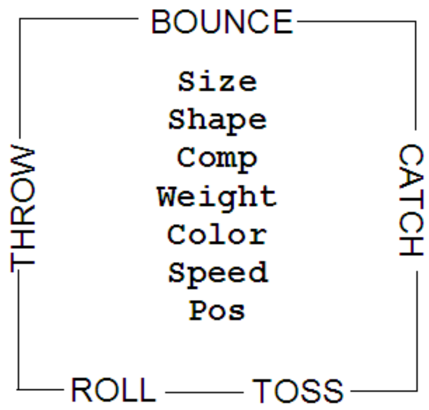


Figure 1.2. A Ball Object

In object-oriented programming, objects are the basic building blocks—the fundamental units of data.

There are many kinds of objects; for example, character strings, collections, and input and output streams. An object—such as a character string—always consists of two parts: the possible actions or operations related to it, and its characteristics or variables. A variable has a *name*, and an associated data value that can change over time. The variables represent the internal state of the object, and can be directly accessed only by the code that implements the object's actions.

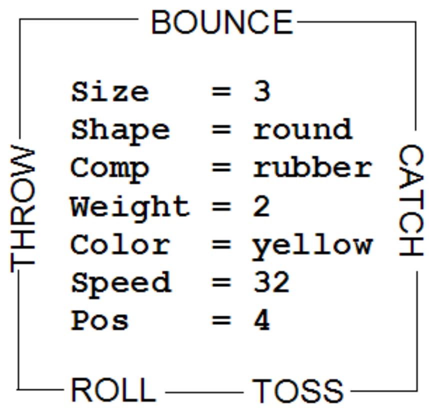


Figure 1.3. Ball Object with Variable Names and Values

To access an object's data, you must always specify an action. For example, suppose the object is the number **5**. Its actions might include addition, subtraction, multiplication, and division. Each of these actions is an interface to the object's data. The data is said to be *encapsulated* because the only way to access it is through one of these surrounding actions. The encapsulated internal characteristics of an object are its *variables*. The variables are associated with an object and exist for the lifetime of that object:

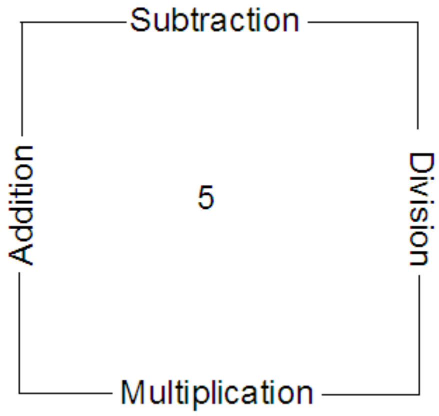


Figure 1.4. Encapsulated 5 Object

1.4. How Objects Interact

The actions defined by an object are its only interface to other objects. Actions form a kind of "wall" that encapsulates the object, and shields its internal information from outside objects. This shielding is called *information hiding.* Information hiding protects an object's data from corruption by outside objects, and also protects outside objects from relying on another object's private data, which can change without warning.

One object can act upon another (or cause it to act) only by calling that object's actions, namely by sending *messages*. Objects respond to these messages by performing an action, returning data, or both. A message to an object must specify:

- A receiving object
- The "message send" symbol, ~, which is called the *twiddle*
- The action and, optionally in parentheses, any parameters required by the action

So the message format looks like this:

```
object~action(parameters)
```

Assume that the object is the string **`!iH.`** Sending it a message to use its REVERSE action:

```
"!iH"~reverse
```

returns the string object **`Hi!.`**

1.5. Methods

Sending a message to an object results in performing some action; that is, it executes some underlying code. The action-generating code is called a *method*. When you send a message to an object, the message is the name of the target method. Method names are character strings like

`reverse`. In the preceding example, sending the **`reverse`** message to the **`!iH`** object causes it to run the `reverse` method. Most objects are capable of more than one action, and so have a number of available methods.

The classes Rexx provides include their own predefined methods. The Message class, for example, has `completed`, `init`, `notify`, `result`, `send`, and `start` methods. When you create your own classes, you can write new methods for them in Rexx code. Much of the object programming in Rexx is writing the code for the methods you create.

Rexx lets you send the same message to objects that are different:

Example 1.1. Methods

```
"!iH"~reverse   -- Reverses the characters "!iH" to form "Hi!"
pen~reverse     -- Reverses the direction of a plotter pen
ball~reverse    -- Reverses the direction of a moving ball
```

As long as each object has its own `reverse` method, `reverse` runs even if the programming implementation is different for each object. Each object knows only its own version of `reverse`. And even though the objects are different, each reverses itself as dictated by its own code.

Although the **`!iH`** object's `reverse` code is different from the plotter pen's, the method name can be the same because Rexx keeps track of the methods each object owns. You do not need to have several message names like **`reverse_string`**, **`reverse_pen`**, **`reverse_ball`**. This keeps method-naming schemes simple and makes complex programs easy to follow and modify.

1.6. Data Abstraction

The ability to create new, high-level data types and organize them into a meaningful class structure is called *data abstraction*. Data abstraction is at the core of object-oriented programming. Once you model objects with real-world properties from the basic data types, you can continue creating, assembling, and combining them into increasingly complex objects. Then you can use these objects as if they were part of the original programming language.

1.7. Classes and Instances

In Rexx, objects are organized into *classes*. Classes are like templates; they define the methods and variables that a group of similar objects have in common and store them in one place.

If you write a program to manipulate some screen icons, for example, you might create an Icon class. In that Icon class you can include all the icon objects with similar actions and characteristics:

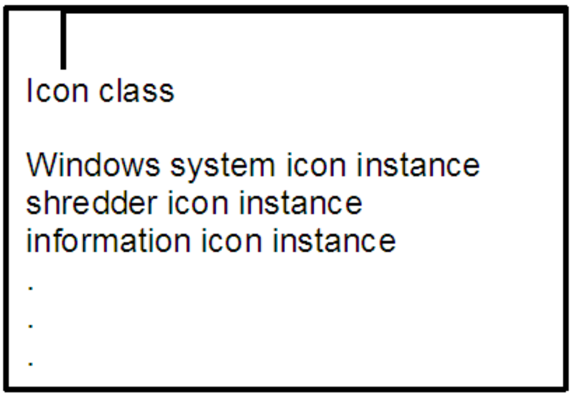


Figure 1.5. A Simple Class

All the icon objects might use common methods like DRAW or ERASE. They might contain common variables like position, color, or size. What makes each icon object different from one another is the data assigned to its variables. For the Windows system icon, it might be position="20,20", while for the shredder it is "20,30" and for information it is "20,40":

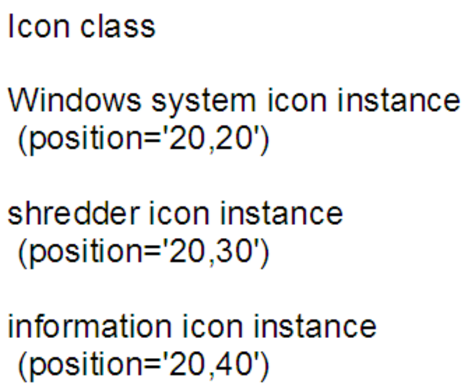


Figure 1.6. Icon Class

Objects that belong to a class are called *instances* of that class. As instances of the Icon class, the Windows system icon, shredder icon, and information icon *acquire* the methods and variables of that class. Instances behave as if they each had their own methods and variables of the same name. All instances, however, have their own unique properties—the *data* associated with the variables. Everything else can be stored at the class level.

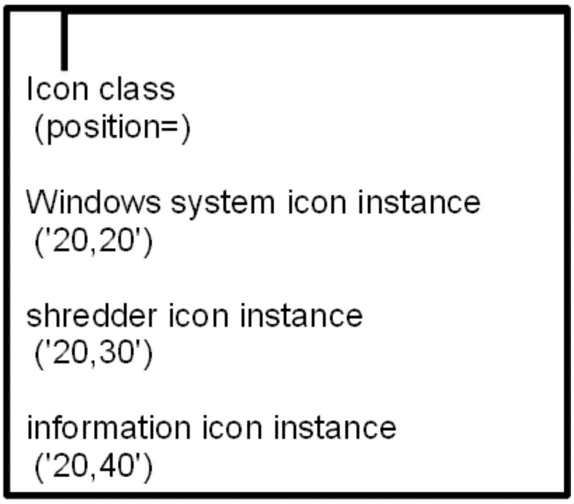


Figure 1.7. Instances of the Icon Class

If you must update or change a particular method, you only have to change it at one place, at the class level. This single update is then acquired by every new instance that uses the method.

A class that can create instances of an object is called an *object class*. The Icon class is an object class you can use to create other objects with similar properties, such as an application icon or a drives icon.

An object class is like a factory for producing instances of the objects.

1.8. Polymorphism

Polymorphism gives you a single interface to objects of different types. This example shows instances of classes inheriting from the Collection class, all sharing a common method named `put`, but with a different implementation each.

Example 1.2. Polymorphism

```
stem~put("value", "tail")          -- sets a Stem tail to "value"
stringTable~put("value", "index") -- sets a StringTable "index" to "value"
array~put("value", 1)              -- sets Array index 1 to "value"
set~put("value")                   -- makes "value" a member of the Set
```

The ability to hide the various implementations of a method while leaving the interface the same illustrates polymorphism. On a higher level, polymorphism permits extensive code reuse.

1.9. Subclasses, Superclasses, and Inheritance

When you write your first object-oriented program, you do not have to begin your real-world modeling from scratch. Rexx provides predefined classes and methods. From there you can create additional classes and methods of your own, according to your needs.

Rexx classes are hierarchical. Any subclass (a class below another class in the hierarchy) *inherits* the methods and variables of one or more *superclasses* (classes above a class in the hierarchy):

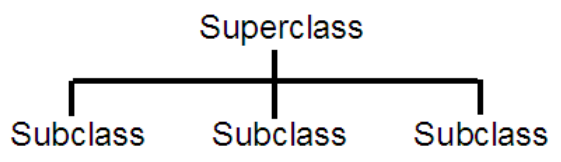


Figure 1.8. Superclass and Subclasses

You can add a class to an existing superclass. For example, you might add the Icon class to the Screen-Object superclass:

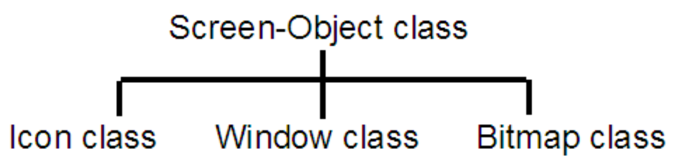


Figure 1.9. The Screen-Object Superclass

In this way, the subclass inherits additional methods from the superclass. A class can have more than one superclass, for example, subclass Bitmap might have the superclasses Screen-Object and Art-Object. Acquiring methods and variables from more than one superclass is known as *multiple inheritance*:

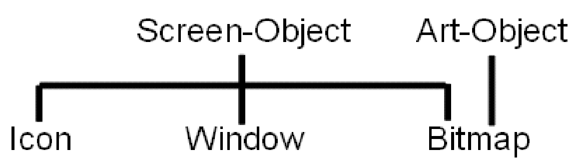


Figure 1.10. Multiple Inheritance

1.10. Structure and General Syntax

A Rexx program is built from a series of *clauses* that are composed of:

- Zero or more whitespace characters (blank or horizontal tabs) (which are ignored)
- A sequence of tokens (see *Section 1.10.4, "Tokens"*)
- Zero or more whitespace characters (again ignored)
- A semicolon (;) delimiter that the line end, certain keywords, or the colon (:) implies.

Conceptually, each clause is scanned from left to right before processing, and the tokens composing it are identified. Instruction keywords are recognized at this stage, comments are removed, and sequences of whitespace characters (except within literal strings) are converted to single blanks. Whitespace characters adjacent to operator characters and special characters are also removed.

1.10.1. Characters

A *character* is a member of a defined set of elements that is used for the control or representation of data. You can usually enter a character with a single keystroke. The coded representation of a character is its representation in digital form. A character, the letter A, for example, differs from its *coded representation* or encoding. Various coded character sets (such as ASCII and EBCDIC) use different encodings for the letter A (decimal values 65 and 193, respectively). This book uses characters to convey meanings and not to imply a specific character code, except where otherwise stated. The exceptions are certain built-in functions that convert between characters and their representations. The functions C2D, C2X, D2C, X2C, and XRANGE depend on the character set used.

A code page specifies the encodings for each character in a set. Be aware that:

- Some code pages do not contain all characters that Rexx defines as valid (for example, the logical NOT character).
- Some characters that Rexx defines as valid have different encodings in different code pages, for example the exclamation mark (!).

1.10.2. Whitespace

A whitespace character is one that the interpreter recognizes as a "blank" or "space" character. There are two characters used by Rexx as whitespace that can be used interchangeably:

(blank)
A "blank" or "space" character. This is represented by '20'X in ASCII implementations.

(horizontal tab)
A "tab". This is represented by '09'X in ASCII implementations.

Horizontal tabs encountered in Rexx program source are converted into blanks, allowing tab characters and blanks to be use interchangeably in source. Additionally, Rexx operations such as the PARSE instruction or the SUBWORD() built-in function will also accept either blank or tab characters as word delimiters.

1.10.3. Comments

A comment is a sequence of characters delimited by specific characters. It is ignored by the program but acts as a separator. For example, a token containing one comment is treated as two tokens.

The interpreter recognizes the following types of comments:

- A line comment, where the comment is limited to one line
- The standard Rexx comment, where the comment can cover several lines

A *line comment* is started by two subsequent minus signs (--) and ends at the end of a line. Example:

```
"Fred"
"Don't Panic!"
'You shouldn''t'        -- Same as "You shouldn't"
""
```

In this example, the language processor processes the statements from **'Fred'** to **'You shouldn''t'**, ignores the words following the line comment, and continues to process the statement **""**.

A *standard comment* is a sequence of characters (on one or more lines) delimited by /* and */. Within these delimiters any characters are allowed. Standard comments can contain other standard comments, as long as each begins and ends with the necessary delimiters. They are called *nested comments*. Standard comments can be anywhere and of any length.

```
/* This is an example of a valid Rexx comment */
```

Take special care when commenting out lines of code containing **/*** or ***/** as part of a literal string. Consider the following program segment:

Example 1.3. Comments

```
01    parse pull input
02    if substr(input,1,5) = "/*123"
03      then call process
04    dept = substr(input,32,5)
```

To comment out lines 2 and 3, the following change would be incorrect:

```
01    parse pull input
02 /* if substr(input,1,5) = "/*123"
03      then call process
04 */ dept = substr(input,32,5)
```

This is incorrect because the language processor would interpret the `/*` that is part of the literal string `/*123` as the start of a nested standard comment. It would not process the rest of the program because it would be looking for a matching standard comment end (`*/`).

You can avoid this type of problem by using concatenation for literal strings containing `/*` or `*/`; line 2 would be:

```
if substr(input,1,5) = "/" || "*123"
```

You could comment out lines 2 and 3 correctly as follows:

Example 1.4. Comments

```
01    parse pull input
02 /* if substr(input,1,5) = "/" || "*123"
03      then call process
04 */ dept = substr(input,32,5)
```

Both types of comments can be mixed and nested. However, when you nest the two types, the type of comment that comes first takes precedence over the one nested. Here is an example:

Example 1.5. Comments

```
"Fred"
"Don't Panic!"
'You shouldn''t'        /* Same as "You shouldn't"
""                      -- The null string         */
```

In this example, the language processor ignores everything after `'You shouldn''t'` up to the end of the last line. In this case, the standard comment has precedence over the line comment.

When nesting the two comment types, make sure that the start delimiter of the standard comment **/*** is not in the line commented out with the line comment signs.

Example 1.6. Comments

```
"Fred"
"Don't Panic!"
'You shouldn''t'        -- Same as /* "You shouldn't"
""                      The null string         */
```

This example produces an error because the language processor ignores the start delimiter of the standard comment, which is commented out using the line comment.

1.10.4. Tokens

A *token* is the unit of low-level syntax from which clauses are built. Programs written in Rexx are composed of tokens. Tokens can be of any length, up to an implementation-restricted maximum. They are separated by whitespace or comments, or by the nature of the tokens themselves. The classes of tokens are:

- Literal strings
- Hexadecimal strings
- Binary strings
- Symbols
- Numbers
- Operator characters
- Special characters

1.10.4.1. Literal Strings

A literal string is a sequence including *any* characters except *line-end* and *end-of-file* characters, and delimited by a single quotation mark (**'**) or a double quotation mark (**"**). You use two consecutive double quotation marks (**""**) to represent one double quotation mark (**"**) within a literal string delimited by double quotation marks. Similarly, you use two consecutive single quotation marks (**''**) to represent one single quotation mark (**'**) within a string delimited by single quotation marks. A literal string is a constant and its contents are never modified when it is processed. Literal strings must be complete on a single line. This means that unmatched quotation marks can be detected on the line where they occur.

A literal string with no characters (that is, a string of length **0**) is called a *null string*.

These are valid strings:

Example 1.7. Valid strings

```
"Fred"
"Don't Panic!"
```

```
'You shouldn''t'        /* Same as "You shouldn't" */
""                      /* The null string         */
```

A literal string has no upper bound on the number of characters, limited only by available memory.

Note that a string immediately followed by a left parenthesis is considered to be the name of a function. If immediately followed by the symbol X or x, it is considered to be a hexadecimal string. If followed immediately by the symbol B or b, it is considered to be a binary string.

1.10.4.2. Hexadecimal Strings

A hexadecimal string is a literal string, expressed using a hexadecimal notation of its encoding. It is any sequence of zero or more hexadecimal digits (**0-9**, **a-f**, **A-F**), grouped in pairs. A single leading **0** is assumed, if necessary, at the beginning of the string to make an even number of hexadecimal digits. The groups of digits are optionally separated by one or more whitespace characters, and the whole sequence is delimited by single or double quotation marks and immediately followed by the symbol **x** or **X**. Neither **x** nor **X** can be part of a longer symbol. The whitespace characters, which can only be on byte boundaries (and not at the beginning or end of the string), are to improve readability. The language processor ignores them.

A hexadecimal string is a literal string formed by packing the hexadecimal digits given. Packing the hexadecimal digits removes whitespace and converts each pair of hexadecimal digits into its equivalent character, for example, **'41'x** to **A**.

Hexadecimal strings let you include characters in a program even if you cannot directly enter the characters themselves. These are valid hexadecimal strings:

Example 1.8. Valid hexadecimal strings

```
"ABCD"x
"1d ec f8"X
'1 d8'x
```

Note

A hexadecimal string is *not* a representation of a number. It is an escape mechanism that lets a user describe a character in terms of its encoding (and, therefore, is machine-dependent). In ASCII, **'20'x** is the encoding for a blank. In every case, a string of the form **'.....'x** is an alternative to a straightforward string. In ASCII **'41'x** and **"A"** are identical, as are **'20'x** and a blank, and must be treated identically.

The packed length of a hexadecimal string (the string with whitespace removed) is unlimited.

1.10.4.3. Binary Strings

A binary string is a literal string, expressed using a binary representation of its encoding. It is any sequence of zero or more binary digits (**0** or **1**) in groups of 8 (bytes) or 4 (nibbles). The first group can have less than four digits; in this case, up to three 0 digits are assumed to the left of the first digit, making a total of four digits. The groups of digits are optionally separated by one or more whitespace characters, and the whole sequence is delimited by matching single or double quotation marks and immediately followed by the symbol **b** or **B**. Neither **b** nor **B** can be part of a longer symbol. The whitespace characters, which can only be byte or nibble boundaries (and not at the beginning or end of the string), are to improve readability. The language processor ignores them.

A binary string is a literal string formed by packing the binary digits given. If the number of binary digits is not a multiple of 8, leading zeros are added on the left to make a multiple of 8 before packing. Binary strings allow you to specify characters explicitly, bit by bit. These are valid binary strings:

Example 1.9. Valid binary strings

```
"11110000"b        /* == "f0"x                  */
"101 1101"b        /* == "5d"x                  */
'1'b               /* == '00000001'b or '01'x  */
"10000 10101010"b  /* == "0001 0000 1010 1010"b */
""b                /* == ""                     */
```

The packed length of a binary-literal string is unlimited.

1.10.4.4. Symbols

Symbols are groups of characters, selected from the:

- English alphabetic characters (**A-Z** and **a-z**).
- Numeric characters (**0-9**)
- Characters **. ! ?** and underscore (_).

Any lowercase alphabetic character in a symbol is translated to uppercase (that is, lowercase **a-z** to uppercase **A-Z**) before use.

These are valid symbols:

Example 1.10. Valid symbols

```
Fred
Albert.Hall
WHERE?
```

If a symbol does not begin with a digit or a period, you can use it as a variable and can assign it a value. If you have not assigned a value to it, its value is the characters of the symbol itself, translated to uppercase (that is, lowercase **a-z** to uppercase **A-Z**). Symbols that begin with a number or a period are *constant symbols* and cannot directly be assigned a value.

One other form of symbol is allowed to support the representation of numbers in exponential format. The symbol starts with a digit (**0-9**) or a period, and it can end with the sequence **E** or **e**, followed immediately by an optional sign (**-** or **+**), followed immediately by one or more digits (which cannot be followed by any other symbol characters). The character sequence to the left of the "E" or "e" must be a valid simple number, consisting only of digits or '.'. There must be at least one digit and at most one '.'. The sign in this context is part of the symbol and is not an operator.

These are valid numbers in exponential notation:

Example 1.11. Valid exponential numbers

```
17.3E-12
.03e+9
```

These are not valid numbers in exponential notation, but rather multiple tokens with an operator between:

Example 1.12. Invalid exponential numbers

```
.E-12     -- no digits
3ae+6     -- non-digit character
3..0e+9   -- more than one '.'
```

1.10.4.5. Numbers

Numbers are character strings consisting of one or more decimal digits, with an optional prefix of a plus (+) or minus (-) sign, and optionally including a single period (`.`) that represents a decimal point. A number can also have a power of 10 suffixed in conventional exponential notation: an **E** (uppercase or lowercase), followed optionally by a plus or minus sign, then followed by one or more decimal digits defining the power of 10. Whenever a character string is used as a number, rounding can occur to a precision specified by the NUMERIC DIGITS instruction (the default is nine digits). See *Chapter 10, Numbers and Arithmetic* for a full definition of numbers.

Numbers can have leading whitespace (before and after the sign) and trailing whitespace. Whitespace characters cannot be embedded among the digits of a number or in the exponential part. Note that a symbol or a literal string can be a number. A number cannot be the name of a variable.

These are valid numbers:

Example 1.13. Valid numbers

```
12
"-17.9"
127.0650
73e+128
" + 7.9E5 "
```

You can specify numbers with or without quotation marks around them. Note that the sequence **`-17.9`** (without quotation marks) in an expression is not simply a number. It is a minus operator (which can be prefix minus if no term is to the left of it) followed by a positive number. The result of the operation is a number, which might be rounded or reformatted into exponential form depending on the size of the number and the current NUMERIC DIGITS setting.

A *whole number* is a number that has a no decimal part and that the language processor would not usually express in exponential notation. That is, it has no more digits before the decimal point than the current setting of NUMERIC DIGITS.

Implementation maximum: The exponent of a number expressed in exponential notation can have up to nine digits.

1.10.4.6. Operator Characters

The characters **+ - \ / % * | & = ¬ > <** and the sequences **>= <= \> \< \= >< <> == \== // && || ** ¬> ¬< ¬= ¬== >> << >>= \<< ¬<< \>> ¬>> <<=** indicate operations (see *Section 1.11.2, "Operators"*). A few of these are also used in parsing templates, and the equal sign and the sequences **+= -= *= /= %= //= ||= &= |= &&= **=** are also used to indicate assignment. Whitespace characters and standard Rexx comments adjacent to operator characters and within operator character sequences are ignored. Therefore, the following are identical in meaning:

Example 1.14. White space and numbers

```
345>=123
345 >=123
345 >= 123
345 > = 123
345 >/*not smaller*/ = 123
```

Some of these characters (and some special characters—see the next section) might not be available in all character sets. In this case, appropriate translations can be used. In particular, the vertical bar (|) is often shown as a split vertical bar (¦).

Note

The Rexx interpreter uses ASCII character 124 in the concatenation operator and as the logical OR operator. Depending on the code page or keyboard for your particular country, ASCII 124 can be shown as a solid vertical bar (**|**) or a split vertical bar (**¦**). The character on the screen might not match the character engraved on the key. If you receive error 13, **`Invalid character in program`**, on an instruction including a vertical bar character, make sure this character is ASCII 124.

Throughout the language, the NOT (¬) character is synonymous with the backslash (\). You can use the two characters interchangeably according to availability and personal preference.

The Rexx interpreter recognizes both ASCII character 170 (**`'AA'x`**) and ASCII character 172 (**`'AC'x`**) for the logical NOT operator. Depending on your country, the **¬** might not appear on your keyboard. If the character is not available, you can use the backslash (\) in place of **¬**.

1.10.4.7. Special Characters

The following characters, together with the operator characters, have special significance when found outside of literal strings:

```
,   ;   :   (   )   [   ]   ~
```

These characters constitute the set of special characters. They all act as token delimiters, and whitespace characters (blank or horizontal tab) adjacent to any of these are removed. There is an exception: a whitespace character adjacent to the outside of a parenthesis or bracket is deleted only if it is also adjacent to another special character (unless the character is a parenthesis or bracket and the whitespace character is outside it, too). For example, the language processor does not remove the blank in **`A (Z)`**. This is a concatenation that is not equivalent to **`A(Z)`**, a function call. The language processor removes the blanks in **`(A) + (Z)`** because this is equivalent to **`(A)+(Z)`**.

1.10.4.8. Example

The following example shows how a clause is composed of tokens:

Example 1.15. Special characters

```
"REPEAT"   A + 3;
```

This example is composed of six tokens—a literal string (**`"REPEAT"`**), a blank operator, a symbol (**`A`**, which can have an assigned value), an operator (**`+`**), a second symbol (**`3`**, which is a number and a symbol), and the clause delimiter (**`;`**). The blanks between the **`A`** and the **`+`** and between the **`+`** and the **`3`** are removed. However, one of the blanks between the **`"REPEAT"`** and the **`A`** remains as an operator. Thus, this clause is treated as though written:

```
"REPEAT" A+3;
```

1.10.5. Implied Semicolons

The last element in a clause is the semicolon (;) delimiter. The language processor implies the semicolon at a line end, after certain keywords, and after a colon if it follows a single symbol. This means that you need to include semicolons only when there is more than one clause on a line or to end an instruction whose last character is a comma.

A line end usually marks the end of a clause and, thus, Rexx implies a semicolon at most end of lines. However, there are the following exceptions:

- The line ends in the middle of a multi-line (**`/*`** ... **`*/`**) comment. The clause continues on to the next line.
- The last token was the continuation character (a comma or a minus sign) and the line does not end in the middle of a comment. (Note that a comment is not a token.)

Rexx automatically implies semicolons after colons (when following a single symbol or literal string, a label) and after certain keywords when they are in the correct context. The keywords that have this effect are ELSE, OTHERWISE, and THEN. These special cases reduce typographical errors significantly.

Note

The two characters forming the comment delimiters, **`/*`** and **`*/`**, must not be split by a line end (that is, **`/`** and **`*`** should not appear on different lines) because they could not then be recognized correctly; an implied semicolon would be added.

1.10.6. Continuations

One way to continue a clause on the next line is to use the comma or the minus sign (-), which is referred to as the *continuation character*. The continuation character is functionally replaced by a blank, and, thus, no semicolon is implied. One or more comments can follow the continuation character before the end of the line.

The following example shows how to use the continuation character to continue a clause:

Example 1.16. Continuations

```
say "You can use a comma",       -- this line is continued
"to continue this clause."
```

or

```
say "You can use a minus"-       -- this line is continued
"to continue this clause."
```

1.11. Terms, Expressions, and Operators

Expressions in Rexx are a general mechanism for combining one or more pieces of data in various ways to produce a result, usually different from the original data. All expressions evaluate to objects.

Everything in Rexx is an object. Rexx provides some objects, which are described in later sections. You can also define and create objects that are useful in particular applications—for example, a menu object for user interaction. See *Section 1.3, "Modeling Objects"* for more information.

1.11.1. Terms and Expressions

Terms are literal strings, symbols, message terms and sequences, Array terms, Variable Reference terms, function calls, or subexpressions interspersed with zero or more operators that denote operations to be carried out on terms.

Literal strings, which are delimited by quotation marks, are constants.

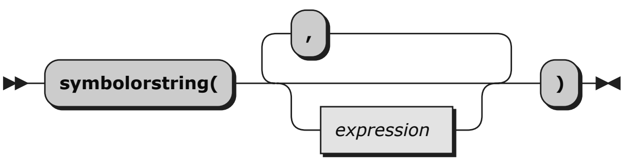
Symbols (no quotation marks) are translated to uppercase. A symbol that does not begin with a digit or a period can be the name of a variable; in this case the value of that variable is used. A symbol that begins with a period can identify an object that the current environment provides; in this case, that object is used. Otherwise a symbol is treated as a constant string. A symbol can also be *compound*.

Message terms are described in *Section 1.11.4, "Message Terms"*, *Message sequences* are described in *Section 1.11.5, "Message Sequences"*.

Array terms are described in *Section 1.11.6, "Array Term"*.

Variable Reference terms are described in *Section 1.11.7, "Variable Reference Term"*.

Function calls (see *Chapter 7, Functions*), which are of the following form:



The *symbolorstring* is a symbol or literal string.

An *expression* consists of one or more terms. A *subexpression* is a term in an expression surrounded with a left and a right parenthesis.

Evaluation of an expression is left to right, modified by parentheses and operator precedence in the usual algebraic manner (see *Section 1.11.3, “Parentheses and Operator Precedence”*). Expressions are wholly evaluated, unless an error occurs during evaluation.

As each term is used in an expression, it is evaluated as appropriate. The result is an object. Consequently, the result of evaluating any expression is itself an object (such as a character string).

1.11.2. Operators

An *operator* is a representation of an operation, such as an addition, to be carried out on one or two terms. Each operator, except for the prefix operators, acts on two terms, which can be symbols, strings, function calls, message terms, intermediate results, or subexpressions. Each prefix operator acts on the term or subexpression that follows it. Whitespace characters (and comments) adjacent to operator characters have no effect on the operator; thus, operators constructed from more than one character can have embedded whitespace and comments. In addition, one or more whitespace characters, if they occur in expressions but are not adjacent to another operator, also act as an operator. The language processor functionally translates operators into message terms. For dyadic operators, which operate on two terms, the language processor sends the operator as a message to the term on the left, passing the term on the right as an argument. For example, the sequence

```
say 1+2
```

is functionally equivalent to:

```
say 1~"+"(2)
```

The blank concatenation operator sends the message " " (a single blank), and the abuttal concatenation operator sends the "" message (a null string). When the ¬ character is used in an operator, it is changed to a ****. That is, the operators ¬= and \= both send the message \= to the target object.

For an operator that works on a single term (for example, the prefix - and prefix + operators), Rexx sends a message to the term, with no arguments. This means `-z` has the same effect as `z~"-"`.

See *Section 5.1.4.2, “Comparison Methods”* for comparison operator methods of the Object class and *Section 5.1.7.18, “Arithmetic Methods”* for arithmetic operator methods of the String class.

There are four types of operators:

- Concatenation
- Arithmetic
- Comparison
- Logical

1.11.2.1. String Concatenation

The concatenation operators combine two strings to form one string by appending the second string to the right-hand end of the first string. The concatenation may occur with or without an intervening blank. The concatenation operators are:

(blank)	Concatenate terms with one blank in between
||	Concatenate without an intervening blank
(abuttal)	Concatenate without an intervening blank

You can force concatenation without a blank by using the **||** operator.

The abuttal operator is assumed between two terms that are not separated by another operator. This can occur when two terms are syntactically distinct, such as a literal string and a symbol, or when they are only separated by a comment.

Examples:

An example of syntactically distinct terms is: if **Fred** has the value **37.4**, then **Fred"%"** evaluates to **37.4%**.

If the variable `PETER` has the value **1**, then `(Fred)(Peter)` evaluates to **37.41**.

The two adjoining strings, one hexadecimal and one literal, **"4a 4b"x"LMN"** evaluate to **JKLMN**.

In the case of

```
Fred/* The NOT operator precedes Peter. */¬Peter
```

there is no abuttal operator implied, and the expression is not valid. However,

```
(Fred)/* The NOT operator precedes Peter. */(¬Peter)
```

results in an abuttal, and evaluates to **37.40**.

1.11.2.2. Arithmetic

You can combine character strings that are valid numbers (see *Section 1.10.4.5, “Numbers”*) using the following arithmetic operators:

+	Add
-	Subtract
*	Multiply
/	Divide
%	Integer divide (divide and return the integer part of the result)
//	Remainder (divide and return the remainder—not *modulo*, because the result can be negative)
**	Power (raise a number to a whole-number power)
Prefix -	Same as the subtraction: **0 - number**
Prefix +	Same as the addition: **0 + number**

See *Chapter 10, Numbers and Arithmetic* for details about precision, the format of valid numbers, and the operation rules for arithmetic. Note that if an arithmetic result is shown in exponential notation, it is likely that rounding has occurred.

1.11.2.3. Comparison

The comparison operators compare two terms and return the value **`1`** if the result of the comparison is true, or **`0`** otherwise.

The strict comparison operators all have one of the characters defining the operator doubled. The **`==`**, **`\==`**, and **`¬==`** operators test for an exact match between two strings. The two strings must be identical (character by character) and of the same length to be considered strictly equal. Similarly, the strict comparison operators such as **`>>`** or **`<<`** carry out a simple character-by-character comparison, with no padding of either of the strings being compared. The comparison of the two strings is from left to right. If one string is shorter than the other and is a leading substring of another, then it is smaller than (less than) the other. The strict comparison operators also do not attempt to perform a numeric comparison on the two operands.

For all other comparison operators, if both terms involved are numeric, a numeric comparison (see *Section 10.4, "Numeric Comparisons"*) is effected. Otherwise, both terms are treated as character strings, leading and trailing whitespace characters are ignored, and the shorter string is padded with blanks on the right.

Character comparison and strict comparison operations are both case-sensitive, and the exact collating order might depend on the character set used for the implementation. In an ASCII environment, such as Windows and Unix-like systems, the ASCII character value of digits is lower than that of the alphabetic characters, and that of lowercase alphabetic characters is higher than that of uppercase alphabetic characters.

The comparison operators and operations are:

=	True if the terms are equal (numerically or when padded)
\=, ¬=	True if the terms are not equal (inverse of =)
>	Greater than
<	Less than
><	Greater than or less than (same as not equal)
<>	Greater than or less than (same as not equal)
>=	Greater than or equal to
\<, ¬<	Not less than
<=	Less than or equal to
\>, ¬>	Not greater than
==	True if terms are strictly equal (identical)
\==, ¬==	True if the terms are not strictly equal (inverse of ==)
>>	Strictly greater than
<<	Strictly less than
>>=	Strictly greater than or equal to
\<<, ¬<<	Strictly not less than
<<=	Strictly less than or equal to
\>>, ¬>>	Strictly not greater than

> **Note**
>
> Throughout the language, the NOT (¬) character is synonymous with the backslash(****). You can use the two characters interchangeably, according to availability and personal preference. The backslash can appear in the following operators: **** (prefix not),**\=**, **\==**, **\<**, **\>**, **\<<**, and **\>>**.

1.11.2.4. Logical (Boolean)

A character string has the value false if it is **0**, and true if it is **1**. The logical operators take one or two such values and return **0** or **1** as appropriate. Values other than **0** or **1** are not permitted.

&	AND — returns **1** if both terms are true.
|	Inclusive OR — returns **1** if either term or both terms are true.
&&	Exclusive OR — returns **1** if either term, but not both terms, is true.
Prefix \, ¬	Logical NOT— negates; **1** becomes **0**, and **0** becomes **1**.

1.11.3. Parentheses and Operator Precedence

Expression evaluation is from left to right; parentheses and operator precedence modify this:

- When parentheses are encountered—other than those that identify the arguments on messages (see *Section 1.11.4, "Message Terms"*) and function calls—the entire subexpression between the parentheses is evaluated immediately when the term is required.

- When the sequence

  ```
  term1 operator1 term2 operator2 term3
  ```

  is encountered, and **operator2** has precedence over **operator1**, the subexpression (**term2 operator2 term3**) is evaluated first.

  Note, however, that individual terms are evaluated from left to right in the expression (that is, as soon as they are encountered). The precedence rules affect only the order of **operations**.

For example, ***** (multiply) has a higher priority than **+** (add), so **3+2*5** evaluates to **13** (rather than the **25** that would result if a strict left-to-right evaluation occurred). To force the addition to occur before the multiplication, you could rewrite the expression as **(3+2)*5**. Adding the parentheses makes the first three tokens a subexpression. Similarly, the expression **-3**2** evaluates to **9** (instead of **-9**) because the prefix minus operator has a higher priority than the power operator.

The order of precedence of the operators is (highest at the top):

~ ~~	(message send)
+ - ¬ \	(prefix operators)
**	(power)
* / % //	(multiply and divide)
+ -	(add and subtract)

(blank) || (abuttal)   (concatenation with or without blank)

= > <   (comparison operators, all with equal precedence)

== >> <<

\= ¬=

>< <>

\> ¬>

\< ¬<

\== ¬==

\>> ¬>>

\<< ¬<<

>= >>=

<= <<=

&   (and)

| &&   (or, exclusive or)

Suppose the symbol **A** is a variable whose value is **3**, **DAY** is a variable whose value is **Monday**, and other variables are uninitialized. Then:

Example 1.17. Arithmetic

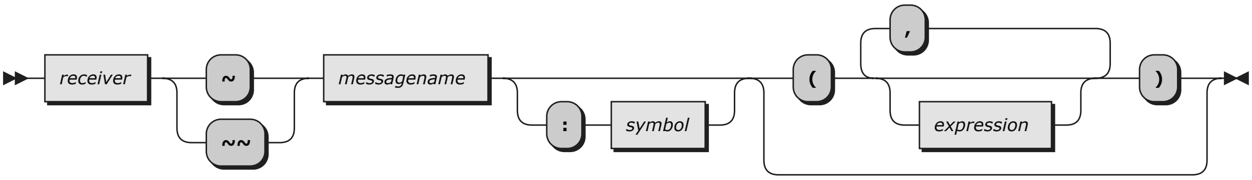
```
A+5                     ->    "8"
A-4*2                   ->    "-5"
A/2                     ->    "1.5"
0.5**2                  ->    "0.25"
(A+1)>7                 ->    "0"         /* that is, .false */
" "=""                  ->    "1"         /* that is, .true  */
" "==""                 ->    "0"         /* that is, .false */
" "\==""                ->    "1"
/* that is, .true  */
(A+1)*3=12              ->    "1"         /* that is, .true  */
"077">"11"              ->    "1"         /* that is, .true  */
"077" >> "11"           ->    "0"         /* that is, .false */
"abc" >> "ab"           ->    "1"         /* that is, .true  */
"abc" << "abd"          ->    "1"         /* that is, .true  */
"ab " << "abd"          ->    "1"         /* that is, .true  */
Today is Day            ->    "TODAY IS Monday"
"If it is" day          ->    "If it is Monday"
Substr(Day,2,3)         ->    "ond"    /* Substr is a function */
"!"xxx"!"               ->    "!XXX!"
```

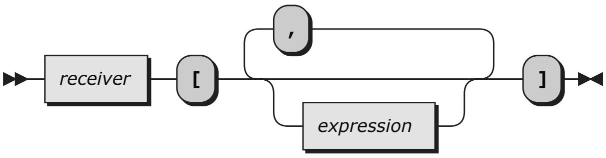
> **Note**
>
> The Rexx order of precedence usually causes no difficulty because it is the same as in conventional algebra and other computer languages. There are two differences from common notations:
>
> - The prefix minus operator always has a higher priority than the power operator.
> - Power operators (like other operators) are evaluated from left to right.
>
> For example:
>
> ```
> -3**2      ==  9  /* not -9  */
> -(2+1)**2 ==  9  /* not -9  */
> 2**2**3    == 64  /* not 256 */
> ```

1.11.4. Message Terms

You can include *messages* to objects in an expression wherever a term, such as a literal string, is valid. A message can be sent to an object to perform an action, obtain a result, or both.

A *message term* can have one of the following forms:





The *receiver* is a term (see *Section 1.11.1, “Terms and Expressions”* for a definition of term). It receives the message. The ~ or ~~ indicates sending a message. The *messagename* is a literal string or a symbol that is taken as a constant. The *expression*s (separated by commas) between the parentheses or brackets are the arguments for the message. The *receiver* and the argument *expressions* can themselves include message terms. If the message has no arguments, you can omit the parentheses.

The left parenthesis, if present, must immediately follow a token (*messagename* or *symbol*) with no blank in between them. Otherwise, only the first part of the construct is recognized as a message term. (A blank operator would be assumed at that point.) Only a comment (which has no effect) can appear between a token and the left parenthesis.

You can use any number of *expressions*, separated by commas. The *expressions* are evaluated from left to right and form the arguments during the execution of the called method. Any ARG, PARSE ARG, or USE ARG instruction or ARG() built-in function in the called method accesses these objects while the called method is running. You can omit *expressions*, if appropriate, by including extra commas.

The *receiver* object is evaluated, followed by one or more *expression* arguments. The message name (in uppercase) and the resulting argument objects are then sent to the receiver object. The receiver object selects a method to be run based on the message name, and runs the selected method with the specified argument objects. The receiver eventually returns, allowing processing to continue.

If the message term uses ~, the receiver method must return a result object. This object is included in the original expression as if the entire message term had been replaced by the name of a variable whose value is the returned object.

For example, the message POS is valid for strings, and you could code:

```
c="escape"
a="Position of 'e' is:" c~pos("e",3)
/* would set A to "Position of 'e' is: 6" */
```

If the message term uses ~~, the receiver method need not return a result object. Any result object is discarded, and the receiver object is included in the original expression in place of the message term.

For example, the messages INHERIT and SUBCLASS are valid for classes (see *Section 5.1.1, “Class Class (Metaclass)”*) and, assuming the existence of the Persistent class, you could code:

```
account = .object~subclass("Account")~~inherit(.persistent)
/* would set ACCOUNT to the object returned by SUBCLASS, */
/* after sending that object the message INHERIT */
```

If the message term uses brackets, the message `[]` is sent to the receiver object. (The *expressions* within the brackets are available to the receiver object as arguments.) The effect is the same as for the corresponding ~ form of the message term. Thus, **`a[b]`** is the same as **`a~"[]"(b)`**.

For example, the message `[]` is valid for arrays (see *Section 5.3.6, “Array Class”*) and you could code:

Example 1.18. Arrays

```
a = .array~of(10,20)
say "Second item is" a[2]   /* Same as: a~at(2)              */
/* or a~"[]"(2)                  */
/* Produces: "Second item is 20" */
```

A message can have a variable number of arguments. You need to specify only those required. For example, **`"ESCAPE"~POS("E")`** returns **`1`**.

A colon (:) and symbol can follow the message name. In this case, the symbol must be the name of a variable (usually the special variable *SUPER*) or an *environment symbol*. The resulting value changes the usual method selection. For more information, see *Section 4.2.7, “Changing the Search Order for Methods”*.

1.11.5. Message Sequences

The ~ and ~~ forms of message terms differ only in their treatment of the result object. Using **~** returns the result of the method. Using **~~** returns the object that received the message. Here is an example:

Example 1.19. Messages

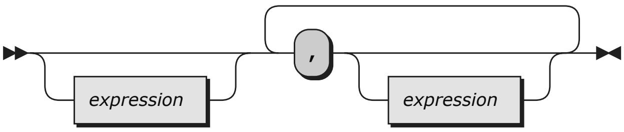
```
/* Two ways to use the INSERT method to add items to a list */
```

```
/* Using only ~ */
team = .list~of("Bob","Mary")
team~insert("Jane")
team~insert("Joe")
team~insert("Steve")
say "First on the team is:" team~firstitem     /* Bob   */
say "Last on the team is:" team~lastitem       /* Steve */
/* Do the same thing using ~~ */
team=.list~of("Bob","Mary")
/* Because ~~ returns the receiver of the message       */
/* each INSERT message following returns the list       */
/* object (after inserting the argument value).         */
team~~insert("Jane")~~insert("Joe")~~insert("Steve")
say "First on the team is:" team~firstitem     /* Bob   */
say "Last on the team is:" team~lastitem       /* Steve */
```

Thus, you would use **~** when you want the returned result to be the receiver of the next message in the sequence.

1.11.6. Array Term

As a convenience, Rexx allows a shortened syntax for creating arrays, called *Array term*, of the following form:



Except for trailing commas, an Array term returns a newly created array, as if it had been created with the message term **`rexx:Array~of(…)`**. (An Array term will always return an instance of the Rexx-defined **`Array`** class, even if a user-defined class named **`Array`** exists.)

Here are some examples:

```
week = "mon", "tue", "wed", "thu", "fri", "sat", "sun"
say week~items "days"                            -- 7 days

say ("here", "we", "go")~makeString(, " ")       -- here we go

iso639 = .Directory~of(("de", "Deutsch"), ("en", "English"), ("fr", "français"))

do list over .environment, .local
  say list~items                                 -- 65
end                                              -- 10

say 0~sendWith("MAX", (2, 3, 5, 7, 11, 13))      -- 13

sparse = ,,,0
say "size" sparse~size"," sparse~items "items"   -- size 4, 1 items
```

If the array term has trailing commas, the returned array has a bigger size than what **`.Array~of(…)`** would have returned:

```
say (1, , 3, ,)~size .Array~of(1, , 3, ,)~size  -- 5 3
say (,)~size .Array~of(,)~size                   -- 2 0
```

In a context, where commas already have a different meaning, it may be necessary to put an Array term between brackets. For example:

```
call func "uno", 2, "tre"      -- no Array term: three parms
call func ("uno", 2, "tre")    -- Array term: one Array as parm
```

An Array term cannot return an array of size zero or one, although it can return an array with zero or one items (but still of at least size two).

```
say (,)~items      -- 0
say (,)~size       -- 2
```

1.11.7. Variable Reference Term

A variable reference term represents a reference to a variable. Variable reference terms can be used as arguments to subroutines, functions, methods, or routines, thus allowing the original variable to be modified or created by the called Rexx code.

While subroutines, functions, methods, or routines can modify argument objects when accessed with the USE ARG instruction without using a variable reference, changing the value of arguments to new objects—like setting them to a new string, a new Array, or to **`.nil`**—can only be done using a variable reference term.

Variable reference terms start with either of the two reference operators, **>** or **<**, followed by a simple variable name or a stem variable name. Variable references to compound variables are not allowed.

Here is an example:

```
call dir >files, ".txt"
say files~items "files with extension .txt"

::routine dir
  use strict arg >array, extension = ""
  array = .Array~new
  do file over .File~new(".")~list
    if file~caselessEndsWith(extension) then
      array~append(file)
  end
```

Variable reference arguments and *USE ARG* names must match. They must either be both simple variable references, or both stem references. USE ARG variable references can never be optional, a default value is not allowed.

1.12. Clauses and Instructions

Clauses can be subdivided into the following types:

- *Null Clauses*,
- *Directives*,
- *Labels*,
- *Instructions*,
- *Assignments*,
- *Message Instructions*,
- *Keyword Instructions*, and
- *Commands*.

1.12.1. Null Clauses

A clause consisting only of whitespace characters, comments, or both is a *null clause*. It is completely ignored.

Note

A null clause is not an instruction; for example, putting an extra semicolon after the THEN or ELSE in an IF instruction is not equivalent to using a dummy instruction (as it would be in the C language). The NOP instruction is provided for this purpose.

1.12.2. Directives

A clause that begins with two colons is a *directive*. Directives are nonexecutable code and can start in any column. They divide a program into separate executable units (methods and routines) and supply information about the program or its executable units. Directives perform various functions, such as creating new Rexx classes (::CLASS directive) or defining a method (::METHOD directive). See *Chapter 3, Directives* for more information about directives.

1.12.3. Labels

A clause that consists of a single symbol or string followed by a colon is a *label*. The colon in this context implies a semicolon (clause separator), so no semicolon is required.

The label's name is taken from the string or symbol part of the label. If the label uses a symbol for the name, the label's name is in uppercase. If a label uses a string, the name can contain mixed-case characters.

Labels identify the targets of CALL instructions, SIGNAL instructions, and internal function calls. Label searches for CALL, SIGNAL, and internal function calls are case-sensitive. Label-search targets specified as symbols cannot match labels with lowercase characters. Literal-string or computed-label searches can locate labels with lowercase characters.

Labels can be any number of successive clauses. Several labels can precede other clauses. Labels are treated as null clauses and can be traced selectively to aid debugging.

Duplicate labels are permitted, but control is only passed to the first of any duplicates in the main program (prolog), a method, or a routine. The duplicate labels occurring later can be traced but cannot be used as a target of a CALL, SIGNAL, or function invocation.

1.12.4. Instructions

An *instruction* consists of one or more clauses describing some course of action for the language processor to take. Instructions can be assignments, message instructions, keyword instructions, or commands.

1.12.5. Assignments

A single clause of the form *symbol=expression* is an instruction known as an *assignment*. An assignment gives a (new) value to a variable. See *Section 1.13, "Assignments and Symbols"*.

1.12.5.1. Extended Assignments

The character sequences **+=, -=, *=, /=, %=, //=, ||=, &=, |=, &&=,** and ****=** can be used to create extended assignments. These sequences combine an operation with the assignment. See *Section 1.13.1, “Extended Assignments”* for more details.

1.12.6. Message Instructions

A *message instruction* is a single clause in the form of a message term (see *Section 1.11.4, “Message Terms”*) or in the form *messageterm=expression*. A message is sent to an object, which responds by performing some action. See *Section 1.15, “Message Instructions”*.

1.12.7. Keyword Instructions

A *keyword instruction* is one or more clauses, the first of which starts with a keyword that identifies the instruction. Keyword instructions control, for example, the external interfaces and the flow of control. Some keyword instructions can include nested instructions. In the following example, the DO construct (DO, the group of instructions that follow it, and its associated END keyword) is considered a single keyword instruction.

```
DO
  instruction
  instruction
  instruction
END
```

A *subkeyword* is a keyword that is reserved within the context of a particular instruction, for example, the symbols TO and WHILE in the DO instruction.

1.12.8. Commands

A *command* is a clause consisting of an expression only. The expression is evaluated and the result is passed as a command string to an external environment.

1.13. Assignments and Symbols

A *variable* is an object whose value can change during the running of a Rexx program. The process of changing the value of a variable is called *assigning* a new value to it. The value of a variable is a single object. Note that an object can be composed of other objects, such as an array or directory object.

You can assign a new value to a variable with the ARG, PARSE, PULL, or USE instructions, or the VALUE built-in function, but the most common way of changing the value of a variable is the assignment instruction itself. Any clause in the form

symbol= *expression*;

is taken to be an assignment. The result of *expression* becomes the new value of the variable named by the symbol to the left of the equal sign.

Example:

```
/* Next line gives FRED the value "Frederic" */
Fred="Frederic"
```

The symbol naming the variable cannot begin with a digit (**0-9**) or a period.

You can use a symbol in an expression even if you have not assigned a value to it, because a symbol has a defined value at all times. A variable to which you have not assigned a value is *uninitialized*. Its value is the characters of the symbol itself, translated to uppercase (that is, lowercase **a-z** to uppercase **A-Z**). However, if it is a compound symbol (described in *Section 1.13.5, "Compound Symbols"*), its value is the derived name of the symbol.

Example 1.20. Derived symbol names

```
/* If Freda has not yet been assigned a value,    */
/* then next line gives FRED the value "FREDA"    */
Fred=Freda
```

The meaning of a symbol in Rexx varies according to its context. As a term in an expression, a symbol belongs to one of the following groups: constant symbols, simple symbols, compound symbols, environment symbols, and stems. Constant symbols cannot be assigned new values. You can use simple symbols for variables where the name corresponds to a single value. You can use compound symbols and stems for more complex collections of variables although the collection classes might be preferable in many cases. See *Section 5.3.2, "Collection Class"*.

Notes:

1. When the ARG, PARSE, PULL, or USE instruction, the VALUE built-in function, or the variable pool interface changes a variable, the effect is identical to an assignment.

2. Any clause that starts with a symbol and whose second token is (or starts with) an equal sign (**=**) is an assignment, rather than an expression (or a keyword instruction). This is not a restriction, because you can ensure that the clause is processed as a command, such as by putting a null string before the first name, or by enclosing the expression in parentheses.

   If you unintentionally use a Rexx keyword as the variable name in an assignment, this should not cause confusion. For example, the following clause is an assignment, not an ADDRESS instruction:

   ```
   Address="10 Downing Street";
   ```

3. You can use the *VAR* function to test whether a symbol has been assigned a value. In addition, you can set *NOVALUE* to trap the use of any uninitialized variables (except when they are tails in compound variables or stem variables, which are always initialized with a Stem object when first used.)

1.13.1. Extended Assignments

The character sequences **+=, -=, *=, /=, %=, //=, ||=, &=, |=, &&=,** and ****=** can be used to create extended assignment instructions. An extended assignment combines a non-prefix operator with an assignment where the term on the left side of the assignment is also used as the left term of the operator. For example,

```
a += 1
```

is exactly equivalent to the instruction

```
a = a + 1
```

Extended assignments are processed identically to the longer form of the instruction.

1.13.2. Constant Symbols

A *constant symbol* starts with a digit (**0-9**) or a period.

You cannot change the value of a constant symbol. It is simply the string consisting of the characters of the symbol (that is, with any lowercase alphabetic characters translated to uppercase).

These are constant symbols:

Example 1.21. Constants

```
77
827.53
.12345
12e5       /* Same as 12E5 */
3D
17E-3
```

Constant symbols, where the first character is a period, which have at least one other character, and which are not a valid Rexx number, are *environment symbols* and may have a value other than the symbol name.

1.13.3. Simple Symbols

A *simple symbol* does not contain any periods and does not start with a digit (**0-9**).

By default, its value is the characters of the symbol (that is, translated to uppercase). If the symbol has been assigned a value, it names a variable and its value is the value of that variable.

These are simple symbols:

Example 1.22. Simple symbols

```
FRED
Whatagoodidea?    /* Same as WHATAGOODIDEA? */
?12
```

1.13.4. Stems

A *stem* is a symbol that contains a single period as the last character of the name. It cannot start with a digit.

These are stems:

Example 1.23. Stems

```
FRED.
A.
```

The value of a stem is always a Stem object (see *Section 5.3.16, “Stem Class”* for details). The stem variable's Stem object is automatically created the first time you use the stem variable or a *compound variable* containing the stem variable name. The Stem object's assigned name is the name of the stem variable (with the characters translated to uppercase). If the stem variable has been assigned a value, or the Stem object has been given a default value, the assigned name overrides the default stem name. A reference to a stem variable will return the associated Stem object.

When a stem is the target of an assignment, the action taken depends on the value being assigned. If the new value is a Stem object, the new Stem object will replace the Stem object that is currently associated with the stem variable. This can result in multiple stem variables referring to the same Stem object, effectively creating a variable alias.

Example 1.24. Stems

```
hole.   = "empty"
hole.19 = "full"
say  hole.1  hole.mouse  hole.19
/* Says "empty empty full" */

hole2. = hole.       /* copies reference to hole. stem to hole2. */

say  hole2.1  hole2.mouse  hole2.19

/* Also says "empty empty full" */
```

If the new value is not a Stem object, a new Stem object is created and assigned to the stem variable, replacing the Stem object currently associated with the stem variable.

The new value assigned to the stem variable is given to the new Stem object as a default value. Following the assignment, a reference to any compound symbol with that stem variable returns the new value until another value is assigned to the stem, the Stem object, or the individual compound variable.

Example 1.25. Stems

```
hole.  = "empty"
hole.19 = "full"
say  hole.1  hole.mouse  hole.19
/* says "empty empty full" */
```

Thus, you can initialize an entire collection of compound variables to the same value.

You can pass stem collections as function, subroutine, or method arguments.

Example 1.26. Stems

```
/* CALL RANDOMIZE count, stem. calls routine */
```

```
Randomize: Use Arg count, stem.
do i = 1 to count
  stem.i = random(1,100)
end
return
```

The USE ARG instruction functions as an assignment instruction. The variable STEM. in the example above is functionally equivalent to:

```
stem. = arg(2)
```

Note

USE ARG must be used to access the stem variable as a collection. PARSE and PARSE ARG will force the stem to be a string value.

Stems can also be returned as function, subroutine, or method results. The resulting return value is the Stem object associated with the stem variable.

Example 1.27. Stems

```
/* RANDOMIZE(count) calls routine */
Randomize: Use Arg count
do i = 1 to count
  stem.i = random(1,100)
end
return stem.
```

When a stem. variable is used in an expression context, the stem variable reference returns the associated Stem object. The Stem object will forward many object messages to its default value. For example, the STRING method will return the Stem object's default value's string representation:

Example 1.28. Stems

```
total. = 0
say total.                         /* says "0" */
```

The `[]` method with no arguments will return the currently associated default value. variables can always be obtained by using the stem. However, this is not the same as using a compound variable whose derived name is the null string.

Example 1.29. Stems

```
total. = 0
null = ""
total.null = total.null + 5
say total.[] total.null              /* says "0 5" */
```

You can use the *DROP*, *EXPOSE*, and *PROCEDURE* instructions to manipulate collections of variables, referred to by their stems. **`DROP FRED.`** assigns a new Stem object to the specified stem. **`EXPOSE FRED.`** and **`PROCEDURE EXPOSE FRED.`** expose all possible variables with that stem.

The *DO* instruction can also iterate over all of the values assigned to a stem variable.

1.13.5. Compound Symbols

A *compound symbol* contains at least one period and two other characters. It cannot start with a digit or a period, and if there is only one period it cannot be the last character.

The name begins with a stem (that part of the symbol up to and including the first period) and is followed by a tail consisting of one or more name parts (delimited by periods) that are constant symbols, simple symbols, or null. Note that you cannot use constant symbols with embedded signs (for example, 12.3E+5) after a stem; in this case the whole symbol would not be valid.

These are compound symbols:

Example 1.30. Compound symbols

```
FRED.3
Array.I.J
AMESSY..One.2.
```

Before the symbol is used, that is, at the time of reference, the language processor substitutes in the compound symbol the character string values of any simple symbols in the tail (**`I`**, **`J`**, and **`One`** in the examples), thus generating a new, derived tail. The value of a compound symbol is, by default, it's the name of the Stem object associated with the stem variable concatenated to the derived tail or, if it has been used as the target of an assignment, the value of Stem element named by the derived tail.

The substitution in the symbol permits arbitrary indexing (subscripting) of collections of variables that have a common stem. Note that the values substituted can contain *any* characters (including periods and blanks). Substitution is done only once.

More formally, the derived name of a compound variable that is referenced by the symbol

```
s0.s1.s2. --- .sn
```

is given by

```
d0.v1.v2. --- .vn
```

where **`d0`** is the name of the Stem object associated with the stem variable **`s0`** and **`v1`** to **`vn`** are the values of the constant or simple symbols **`s1`** through **`sn`**. Any of the symbols **`s1`** to **`sn`** can be null. The values **`v1`** to **`vn`** can also be null and can contain *any* characters (including periods). Lowercase characters are not translated to uppercase, blanks are not removed, and periods have no special significance. There is no limit on the length of the evaluated name.

Some examples of simple and compound symbols follow in the form of a small extract from a Rexx program:

Example 1.31. Compound symbols

```
a=3       /* assigns "3" to the variable A    */
```

```
z=4                 /*   "4"     to Z        */
c="Fred"            /*   "Fred"  to C        */
a.z="Fred"          /*   "Fred"  to A.4      */
a.fred=5            /*   "5"     to A.FRED   */
a.c="Bill"          /*   "Bill"  to A.Fred   */
c.c=a.fred          /*   "5"     to C.Fred   */
y.a.z="Annie"       /*   "Annie" to Y.3.4    */
say  a  z  c  a.a  a.z  a.c  c.a  a.fred y.a.4
/* displays the string:                    */
/*    "3 4 Fred A.3 Fred Bill C.3 5 Annie"  */
```

You can use compound symbols to set up arrays and lists of variables in which the subscript is not necessarily numeric, thus offering a great scope for the creative programmer. A useful application is to set up an array in which the subscripts are taken from the value of one or more variables, producing a form of associative memory (content-addressable).

1.13.5.1. Evaluated Compound Variables

The value of a stem variable is always a Stem object (see *Section 5.3.16, “Stem Class”* for details). A Stem object is a type of collection that supports the `[]` and `[]=` methods used by other collection classes. The `[]` method provides an alternate means of accessing compound variables that also allows embedded subexpressions.

Tails for compound variables are normally specified by symbols separated by periods. An alternative is to specify the tail as a bracketed list of expressions separated by commas. The expressions are evaluated to character strings. These are concatenated with intervening periods and the resulting string is used as tail. This notation can be used in assignments to compound variables as well as when referencing them. Examples:

Example 1.32. Evaluated compound variables

```
a.[1+2,3+4]=17      -- assigns A.3.7
Say a.3.7           -- => 17
v1='1+2'
v2='3+4'
a.v1.v2=18          -- tail used: '1+2.3+4'
Say a.['1+2','3+4'] -- => 18
Parse Value '1 2 3' With . a.[1,1+1] .
Say a.1.2           -- => 2
```

1.13.6. Environment Symbols

An environment symbol starts with a period and has at least one other character. The symbol may not be a valid Rexx number. By default the value of an environment symbol is the string consisting of the characters of the symbol (translated to uppercase). If the symbol identifies an object in the current environment, its value is the mapped object.

These are environment symbols:

Example 1.33. Environment symbols

```
.method    // A reference to the Rexx Method class

.true      // The Rexx "true" object.  Has the value "1"

.xyz       // Normally the value .XYZ
```

```
.3DGlasses // Normally the value .3DGLASSES
```

When you use an environment symbol, the language processor performs a series of searches to see if the environment symbol has an assigned value. The search locations and their ordering are:

1. Constants **`.true`**, **`.false`** and **`.nil`**.
2. The list of classes declared on *::CLASS directives* within the current program package or added to the current package using the *addClass* method.
3. The list of public classes declared on ::CLASS directives of other files included with a *::REQUIRES directive* or added to the current Package instance using the *addPackage* method.
4. The list of public Rexx supplied classes in the REXX package, like *Object*, *String*, or *Array*.
5. The package local environment directory specific to the current package. You can access the package local environment directory through the **`Package`** *local* method.
6. The local environment directory specific to the current interpreter instance. The local environment includes instance-specific objects such as the .INPUT and .OUTPUT objects. You can directly access the local environment directory by using the *.LOCAL environment symbol*.
7. The global environment directory. The global environment includes Rexx supplied objects like *.endofline* or the *.RexxInfo object*. You can directly access the global environment by using the *.ENVIRONMENT environment symbol*. Entries in the global environment directory can also be accessed via the *VALUE built-in function* by using a null string for the *selector* argument.
8. Rexx defined symbols. Other simple environment symbols are reserved for use by Rexx *built-in environment objects*. The currently defined built-in objects are *.RS*, *.LINE*, *.METHODS*, *.ROUTINES*, *.RESOURCES*, and *.CONTEXT*.

If an entry is not found for an environment symbol, then the default character string value is used.

Note

You can place entries in both the **`.LOCAL`** and the **`.ENVIRONMENT`** directories for programs to use. To avoid conflicts with future Rexx defined entries, it is recommended that the entries that you place in either directory include at least one period in the entry name, for example:

```
/* establish settings directory */
.local~setentry("MyProgram.settings", .directory~new)
```

1.14. Namespaces

Namespaces can be used to differentiate between classes or routines of the same name, having been loaded through *::REQUIRES directives*.

Using ::REQUIRES with the NAMESPACE option allows to tag a loaded file with a namespace name, which in turn can be used to qualify references to classes or routines within that namespace to explicitly identify a specific class or routine. A special reserved namespace "REXX" will allow to always access the Rexx-provided classes.

Examples:

Example 1.34. Namespaces

```
-- disambiguate between two classes with same name
say .number~id                          -- The Real Number class
say natural:number~id                   -- The Natural Number class

-- use reserved namespace "REXX" to get Rexx-defined .Array
-- not :class array as defined below
say rexx:array~of(2, 3, 5, 7)~items     -- 4

-- call ::routine verify, not built-in function
call natural:verify(17)

-- use natural:number as a message target
say natural:number~subclass("Integer")  -- The Integer class


-- subclass natural:number, not ::class number as defined below
::class rationalNumber subclass natural:number

-- class "number"; same name as a class in 'number.cls'
::class number
::method id class
return "The Real Number class"

-- class "Array"; same name as Rexx-defined
::class array

::requires 'number.cls' namespace natural
```

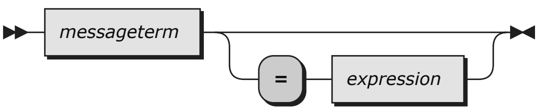
Example 1.35. number.cls

```
::class number public
::method id class
return "The Natural Number class"

::routine verify public
return arg(1) >= 0 & arg(1)~dataType("W")
```

1.15. Message Instructions

You can send a message to an object to perform an action, obtain a result, or both. You use a message instruction if the main purpose of the message is to perform an action. You use a *message term* if the main purpose of the message is to obtain a result.

A *message instruction* is a clause of the form:



If there is only a *messageterm*, the message is sent in exactly the same way as for a *message term*. If the message yields a result object, it is assigned to the sender's special variable RESULT. If you use the ~~ form of message term, the receiver object is used as the result. If there is no result object, the variable RESULT is dropped (becomes uninitialized). A message term using ~~ is sometimes referred to as a *cascading message*.

Example 1.36. Message instructions

```
mytable~add("John",123)
```

This sends the message ADD to the object MYTABLE. The ADD method need not return a result. If ADD returns a result, the result is assigned to the variable RESULT.

The equal sign (=) sets a value. If **=expression** follows the message term, a message is sent to the receiver object with an **=** concatenated to the end of the message name. The result of evaluating the expression is passed as the first argument of the message.

Example 1.37. Message instructions

```
person~age = 39                  /* Same as person~"AGE="(39) */
table[i] = 5                     /* Same as table~"[]="(5,i)  */
```

The expressions are evaluated in the order in which the arguments are passed to the method. That is, the language processor evaluates the **=expression** first. Then it evaluates the argument expressions within any [] pairs from left to right.

The extended assignment form may also be used with message terms.

Example 1.38. Message instructions

```
   table[i] += 1        -- Same as table[i] = table[i] + 1
```

See *Section 1.13.1, “Extended Assignments”* for more details

1.16. Commands to External Environments

Issuing commands to the surrounding environment is an integral part of Rexx.

1.16.1. Environment

The base system for the language processor is assumed to include at least one environment for processing commands. An environment is selected by default on entry to a Rexx program. You can change the environment by using the *ADDRESS* instruction. You can find out the name of the current environment by using the *ADDRESS* built-in function. The underlying operating system defines environments external to the Rexx program. The environments selected depend on the caller. The default environment is **CMD** on Windows and **sh** on Unix-like systems . There are three aliases for the default environment, **""** (null string), **COMMAND** and **SYSTEM**. These environments execute commands through the standard command interpreter or system shell, which is **cmd.exe** on Windows and **sh** on Unix-like systems . On Unix-like systems alternate environments **bsh**, **bash**, **csh**, **ksh**, **tcsh**, and **zsh** are available, which allow execution of commands through a shell named like the environment, if such a shell is installed on the system.

An additional environment **PATH**—available on both Windows and Unix-like systems—provides an alternative to command interpreter- / shell-based environments. It executes commands directly, without the need for a command interpreter or shell by searching the environment variable **PATH** to locate the command. Note that this environment does not provide shell or command interpreter features such as internal commands, redirection, piping, environment variable substitution or wildcard expansion.

If called from an editor that accepts subcommands from the language processor, the default environment can be that editor.

A Rexx program can issue commands—called *subcommands*—to other application programs. For example, a Rexx program written for a text editor can inspect a file being edited, issue subcommands to make changes, test return codes to check that the subcommands have been processed as expected, and display messages to the user when appropriate.

An application that uses Rexx as a macro language must register its environment with the Rexx language processor. See the *Open Object Rexx: Application Programming Interfaces* for a discussion of this mechanism.

1.16.2. Commands

To send a command to the currently addressed environment, use a clause of the form:

```
expression;
```

The expression (which must not be an expression that forms a valid *message instruction*) is evaluated, resulting in a character string value (which can be the null string), which is then prepared as appropriate and submitted to the environment specified by the current ADDRESS setting.

The environment then processes the command and returns control to the language processor after setting a return code. A *return code* is a string, typically a number, that returns some information about the command processed. A return code usually indicates if a command was successful but can also represent other information. The language processor places this return code in the Rexx *special variable RC*.

In addition to setting a return code, the underlying system can also indicate to the language processor if an error or failure occurred. An *error* is a condition raised by a command to which a program that uses that command can respond. For example, a locate command to an editing system might report **requested string not found** as an error. A *failure* is a condition raised by a command to which a program that uses that command cannot respond, for example, a command that is not executable or cannot be found.

Errors and failures in commands can affect Rexx processing if a condition trap for ERROR or FAILURE is ON (see *Chapter 11, Conditions and Condition Traps*). They can also cause the command to be traced if **TRACE E** or **TRACE F** is set. **TRACE Normal** is the same as **TRACE F** and is the default—see *Section 2.29, “TRACE”*.

The .RS environment symbol can also be used to detect command failures and errors. When the command environment indicates that a command failure has occurred, the Rexx environment symbol .RS has the value **-1**. When a command error occurs, .RS has a value of **1**. If the command did not have a FAILURE or ERROR condition, .RS is **0**.

Here is an example of submitting a command. Where the default environment is Windows, the sequence:

Example 1.39. Commands

```
fname = "CHESHIRE"
```

```
exten = "CAT"
"TYPE" fname"."exten
```

would result in passing the string **TYPE CHESHIRE.CAT** to the command processor, CMD.EXE. The simpler expression:

Example 1.40. Commands

```
"TYPE CHESHIRE.CAT"
```

has the same effect.

On return, the return code placed in RC will have the value 0 if the file CHESHIRE.CAT were typed, or a nonzero value if the file could not be found in the current directory.

Note

Remember that the expression is evaluated before it is passed to the environment. Constant portions of the command should be specified as literal strings.

Example 1.41. Commands — Windows

```
delete "*".lst            /* not "multiplied by" */
var.003 = anyvalue
type "var.003"            /* not a compound symbol */

w = any
dir"/w"                   /* not "divided by ANY" */
```

Example 1.42. Commands — Linux

```
rm "*".lst                /* not "multiplied by" */
var.003 = anyvalue
cat "var.003"             /* not a compound symbol */

w = any
ls "/w"                   /* not "divided by ANY" */
```

Enclosing an entire message instruction in parentheses causes the message result to be used as a command. Any clause that is a message instruction is not treated as a command. Thus, for example, the clause

```
myfile~linein
```

causes the returned line to be assigned to the variable RESULT, not to be used as a command to an external environment, while

```
(myfile~linein)
```

would submit the return value from the linein method as a command to the external environment.

1.17. Using Rexx on Windows and Unix-like systems

1.17.1. Calling other Rexx scripts

Rexx programs can call other Rexx programs as external functions or subroutines with the *CALL* instruction.

If a program is called with the CALL instruction, the program runs in the same process as the calling program. If you call another program by a Rexx command, the program is executed in a new process and therefore does not share .environment, .local, or the Windows or Unix-like systems shell environment.

Example 1.43. Calling other Rexx scripts

```
call "other.REX"           /* runs in the same process */
"rexx other.REX"           /* runs in a new child process */
"start rexx other.REX"     /* runs in a new detached process */
```

When Rexx programs call other Rexx programs as commands, the return code of the command is the exit value of the called program provided that this value is a whole number in the range -32768 to 32767. Otherwise, the exit value is ignored and the called program is given a return code of 0.

1.17.2. Shebang support

Rexx supports *shebang*s, also called *hashbang*s, as the first line of a Rexx program on both Unix-like and Windows systems.

Typically, shebangs are found on Unix-like systems to identify the script language with which to run a script. On these systems, to run a script as a Rexx program, depending on where the interpreter is installed, the shebang would be something like **`#!/usr/bin/rexx`**.

With several Unix-like systems changing the standard installation location away from **`/usr/bin`** (including macOS), a new convention is used for the sample programs, which works if the Rexx interpreter is anywhere on the path. This convention uses the **`env`** command in the shebang, like this: **`#!/usr/bin/env rexx`**. This has the advantage that it is portable, and will use the first occurrence of **`rexx`** that is found on **`$PATH`**.

On a Windows system, Rexx will simply ignore the first line of a Rexx program, if it starts with the character sequence "**`#!`**".

1.17.3. Line-end characters

Windows and Unix-like systems use different characters to indicate a line-break (ending one line and starting a new one) in a text file. While Windows uses the two-character sequence **`'0d 0a'x`** (carriage-return, line-feed), Unix-like systems use the character **`'0a'x`** (line-feed) as a line-end indicator.

Rexx supports both line-end indicators on each platform, both for the Rexx program itself, and for data manipulated with e. g. built-in functions *LINES*, *LINEIN*, **`Stream`** methods *lines*, *lineIn*, *arrayIn*,

String method *makeArray*, or **MutableBuffer** method *makeArray*. This means, when moving from one platform to another, typically there should be no line-end conversions necessary for Rexx programs or data read by these programs.

Note that you cannot include line-end characters **'0d'x** or **'0a'x** in a *literal string*.

1.17.4. End-of-file character

Traditionally Windows used a special character **'1a'x** (end-of-file) to signify the end of a text file. Although today use of this special end-of-file character has become less common, some editors may still append it to the end of a text file. Unix-like systems do not use a special end-of-file character in text files.

Rexx will honor the end-of-file character **'1a'x** within a Rexx program source file on both Windows and Unix-like platforms. It will not scan the source file beyond any end-of-file character it finds. This means, that a character **'1a'x** cannot be directly used within a Rexx program source file, for example within a *literal string* or a comment.

Keyword Instructions

A *keyword instruction* is one or more clauses, the first of which starts with a keyword that identifies the instruction. Some keyword instructions affect the flow of control, while others provide services to the programmer. Some keyword instructions, like DO, can include nested instructions.

In the syntax diagrams on the following pages, symbols (words) in capitals denote keywords or subkeywords. Other words, such as *expression*, denote a collection of tokens as defined previously. Note, however, that the keywords and subkeywords are not case-dependent. The symbols **`if`**, **`If`**, and **`iF`** all have the same effect. A clause requires a semicolon (**`;`**) as a terminating delimiter unless the end of a line implies it.

A keyword instruction is recognized *only* if its keyword is the first token in a clause and if the second token does not start with an equal (=) character (implying an assignment) or a colon (implying a label). The keywords ELSE, END, OTHERWISE, THEN, and WHEN are treated in the same way. Note that any clause that starts with a keyword defined by Rexx cannot be a command. Therefore,

```
arg(fred) rest
```

is an ARG keyword instruction, not a command that starts with a call to the ARG built-in function. A syntax error results if the keywords are not in their correct positions in a DO, IF, or SELECT instruction. The keyword THEN is also recognized in the body of an IF or WHEN clause. In other contexts, keywords are not reserved and can be used as labels or as the names of variables (though this is generally not recommended).

Subkeywords are reserved within the clauses of individual instructions. For example, the symbols VALUE and WITH are subkeywords in the ADDRESS and PARSE instructions, respectively. For details, see the description of each instruction.

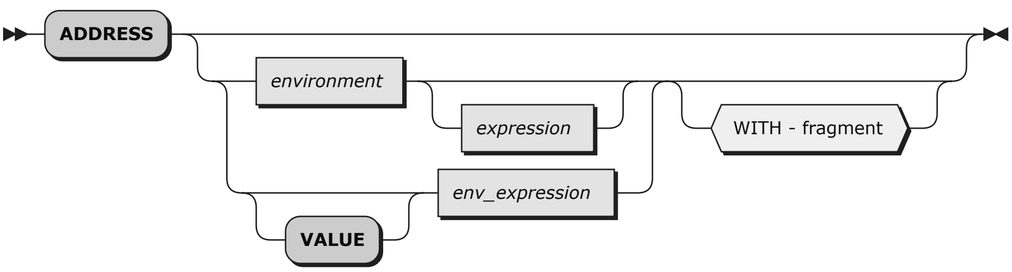
Whitespace characters (blanks or horizontal tabs) adjacent to keywords separate the keyword from the subsequent token. One or more whitespace characters following VALUE are required to separate the *expression* from the subkeyword in the example following:

```
 ADDRESS VALUE expression
```

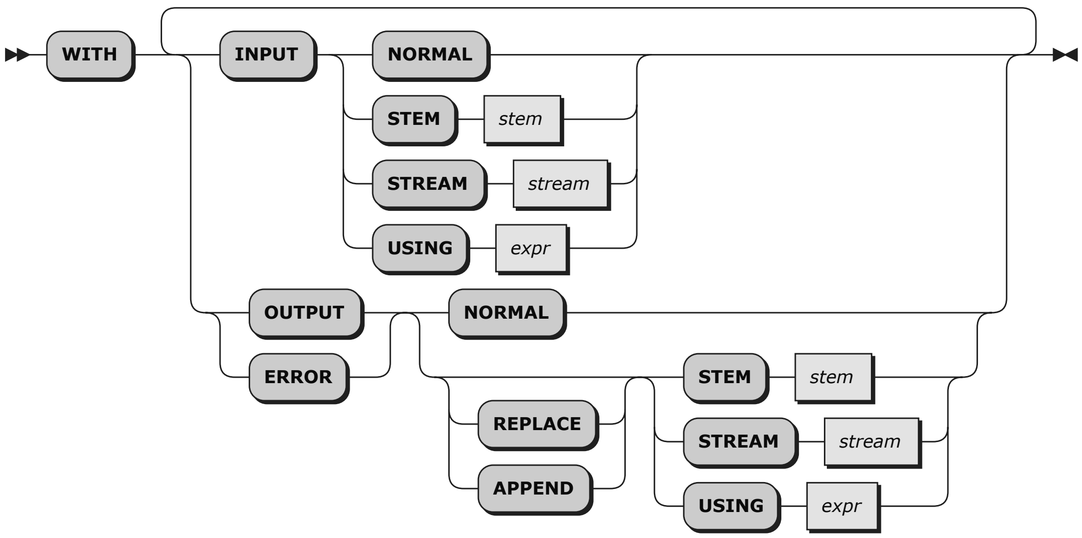
However, no whitespace character is required after the VALUE subkeyword in the following example, although it would improve readability:

```
ADDRESS VALUE"ENVIR"||number
```

2.1. ADDRESS



WITH:



ADDRESS permanently changes the destination or I/O redirection of commands, or temporarily changes the destination and sends a command with optional I/O redirection of standard input, standard output, and standard error from or to Rexx objects.

Commands are strings sent to an external environment. You can send commands by specifying clauses consisting of only an expression or by using the ADDRESS instruction. (See *Section 1.16, "Commands to External Environments"*.)

To send a single command to a specified environment, code an *environment*, a literal string or a single symbol, which is taken to be a constant, followed by an *expression*. The environment name is the name of an external procedure or process that can process commands. The *expression* is evaluated to produce a character string value, and this string is routed to the *environment* to be processed as a command. After execution of the command, *environment* is set back to its original state, thus temporarily changing the destination for a single command. The special variable RC and the environment symbol .RS are set and errors and failures in commands processed in this way are trapped or traced.

The following evironments are available in ooRexx:

`sh` (Unix-like systems only)
: This is the default environment on Unix-like systems. It uses **`sh`** as a shell program to execute the command. All shell features such as redirection or piping can be used.

`bsh`, **`bash`**, **`csh`**, **`ksh`**, **`tcsh`**, **`zsh`** (Unix-like systems only)
: These environments use alternate Unix-like system shells **`bsh`**, **`bash`**, **`csh`**, **`ksh`**, **`tcsh`**, or **`zsh`** to execute the command. If the appropriate shell is not installed on the system, executing a command in any of these enviroments will raise a failure.

`cmd` (Windows only)
: This is the default environment on Windows systems. It uses **`cmd.exe`** as a command interpreter to execute the command. Command interpreter features such as internal commands, redirection or piping can be used.

`command`, **`system`**, **`""`**
: These environment names are synonyms for the default environments **`sh`** on Unix-like systems and **`cmd`** on Windows.

`path`
: This environment executes commands directly, without using an intermediate command interpreter or shell program. It searches the environment variable PATH to locate the command to execute.

No shell features such as internal commands, redirection, piping or environment variable substitution are available.

The **`WITH`** subkeyword sets a command's I/O redirection. STDIN input can be redirected from a Rexx object to the command, and STDOUT and STDERR output from the command can be redirected to a Rexx object.

I/O redirection is permanent when specified on an ADDRESS instruction without a command, and temporary if a command is specified. Any permanent I/O redirection is associated with the environment name and will be saved and restored across function and subroutine calls. For permanent I/O redirections, any redirection objects or expressions are not evaluated at the time the ADDRESS instruction is processed. Each time a command is sent to this environment, these objects and expressions will be evaluated in the then current variable context.

`WITH INPUT`

redirects data from a stem, a stream, or other Rexx object to the command's input.

If option **`NORMAL`** is specified, the command's standard input will be used.

If option **`STEM`** is specified, *stem* must be a stem variable, where *stem*`.0` specifies the number of input lines, and each *stem.i* (with *i* from `1` through *stem*`.0`) specifies an input line.

If option **`STREAM`** is specified, *stream* must be a literal string, a constant symbol, or an expression enclosed in parentheses that evaluates to a string which is used as the stream name. Input lines for the command are read from *stream* using the `lineIn` method.

If option **`USING`** is specified, *expr* must be a literal string, a constant symbol, or an expression enclosed in parentheses that evaluates to a String, a Stem object, an InputStream, a Monitor or a File object, or an Array object or any other object that supports a `makeArray` method (e. g. a RexxQueue object). If the resulting object is a String, the command will receive a single input line, if it is a Stem, an InputStream, a Monitor, or a File object, input is redirected as described for options **`STEM`** and **`STREAM`**. If the resulting object is an Array object, all Array items are converted to strings and are sent to the command as input lines. Empty array items are ignored.

`WITH OUTPUT` and **`WITH ERROR`**

redirect a command's standard output or error output to a stem, a stream, or other Rexx objects.

If option **`NORMAL`** is specified, the command's default output destination, or default error destination is used.

If option **`STEM`** is specified, *stem* must be a stem variable. If **`REPLACE`** is specified together with **`STEM`**, the number of output lines is stored in *stem*`.0` and individual lines are stored as *stem.i*, with *i* running from `1` through *stem*`.0`. **`REPLACE`** is the default. If **`APPEND`** is specified with **`STEM`**, individual lines are stored as *stem.i*, with *i* starting at the value of the existing *stem*`.0` plus `1`. The initial *stem*`.0` value is then incremented by the total number of output lines for the command.

If option **`STREAM`** is specified, *stream* must be a literal string, a constant symbol, or an expression enclosed in parentheses that evaluates to a string which is used as the stream name. Output or error lines from the command are written to the stream with the `lineOut` method. If **`REPLACE`** is specified with **`STREAM`**, *stream* is truncated to zero length before any output lines are written. **`REPLACE`** is the default. If **`APPEND`** is specified with **`STREAM`**, output lines are appended to *stream*.

If option **`USING`** is specified, *expr* must be a constant symbol, or an expression enclosed in parentheses that evaluates to a Stem object, an OutputStream, a Monitor, a RexxQueue, a File object, or an OrderedCollection object. If the resulting object is a Stem or a File object, output lines are written as described for options **`STEM`** and **`STREAM`**. If it is an OutputStream or a Monitor object, output lines are always appended to the stream; neither **`REPLACE`** nor **`APPEND`** can be specified in this case. If the object is a RexxQueue, method `queue` is used for each output line. Neither **`REPLACE`** nor **`APPEND`** can be specified for a RexxQueue. If the resulting object is an OrderedCollection object and **`REPLACE`** is specified, the collection is emptied using method `emtpy` before any output lines are added to the collection using method `append`. **`REPLACE`** is the default. If **`APPEND`** is specified, output lines are appended to the existing collection using method `append`.

Notes:

1. Specifying one of the **`INPUT`**, **`OUTPUT`**, or **`ERROR`** subkeywords more than once is an error.

2. If an input source object and an output or error target object is the same, Rexx uses appropriate read and write buffering to make sure results are correct.

3. If the standard output target and the standard error target object is the same object, Rexx will send interleaved output and error lines to the target.

Example 2.1. Instructions — ADDRESS

```
ADDRESS "CMD" 'dir "\Program Files"'             -- Windows
ADDRESS "sh" "ls /usr/bin"                       -- Unix-like system

address "" "cat" with input using "single line" -- Unix-like system: "single line"
address "" "ver" with output stem v.; say v.2   -- "Microsoft Windows ..."

address "" with input using (a) output using (a)
a = 4, 2, 3, 1
"sort"
say a~toString(, " ")                            -- 1 2 3 4
```

If you specify only *environment*, a lasting change of destination occurs: all commands (see *Section 1.16.2, “Commands”*) that follow are routed to the specified command environment, until the next ADDRESS instruction is processed. The previously selected environment is saved.

Assume that the environment for a Windows text editor is registered by the name **`EDIT`**:

Example 2.2. Instructions — ADDRESS environments

```
address CMD
"DIR C:\AUTOEXEC.BAT"
if rc=0 then "COPY C:\AUTOEXEC.BAT C:\*.TMP"
address EDIT
```

Subsequent commands are passed to the editor until the next ADDRESS instruction.

Similarly, you can use the VALUE form to make a lasting change to the environment. Here *env_expression*, which can be a variable name, is evaluated, and the resulting character string value forms the name of the environment. You can omit the subkeyword VALUE if *env_expression* does not begin with a literal string or symbol, that is, if it starts with a special character such as an operator character or parenthesis.

Example 2.3. Instructions — ADDRESS environments

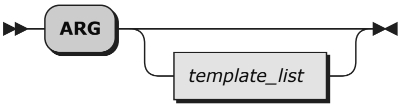
```
ADDRESS ("ENVIR"||number)  /* Same as ADDRESS VALUE "ENVIR"||number */
```

With no arguments, commands are routed back to the environment that was selected before the previous change of the environment, and the current environment name is saved. After changing the environment, repeated execution of ADDRESS alone, therefore, switches the command destination between two environments. Using a null string for the environment name ("") is the same as using the default environment.

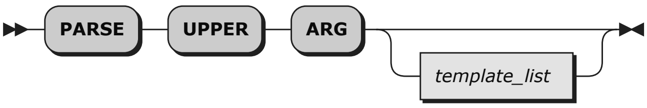
The two environment names are automatically saved across internal and external subroutine and function calls. See the *CALL* instruction for more details.

The address setting is the currently selected environment name. You can retrieve the current address setting by using the *ADDRESS* built-in function. The *Open Object Rexx: Application Programming Interfaces* describes the creation of alternative subcommand environments.

2.2. ARG



ARG retrieves the argument strings provided to a program, internal routine, or method and assigns them to variables. It is a short form of the instruction:



The *template_list* can be a single template or list of templates separated by commas. Each template consists of one or more symbols separated by whitespace characters, patterns, or both.

The objects passed to the program, routine, or method are converted to string values and parsed into variables according to the rules described in *Chapter 9, Parsing*.

The language processor converts the objects to strings and translates the strings to uppercase (that is, lowercase **a-z** to uppercase **A-Z**) before processing them. Use the PARSE ARG instruction if you do not want uppercase translation.

You can use the ARG and PARSE ARG instructions repeatedly on the same source objects (typically with different templates). The source objects do not change.

Example 2.4. Instructions — ARG

```
/* String passed is "Easy Rider"  */
Arg adjective noun .

/* Now:  ADJECTIVE  contains "EASY"          */
/*       NOUN       contains "RIDER"         */
```

If you expect more than one object to be available to the program or routine, you can use a comma in the parsing *template_list* so each template is selected in turn.

Example 2.5. Instructions — ARG

```
/* Function is called by  FRED("data X",1,5)    */
```

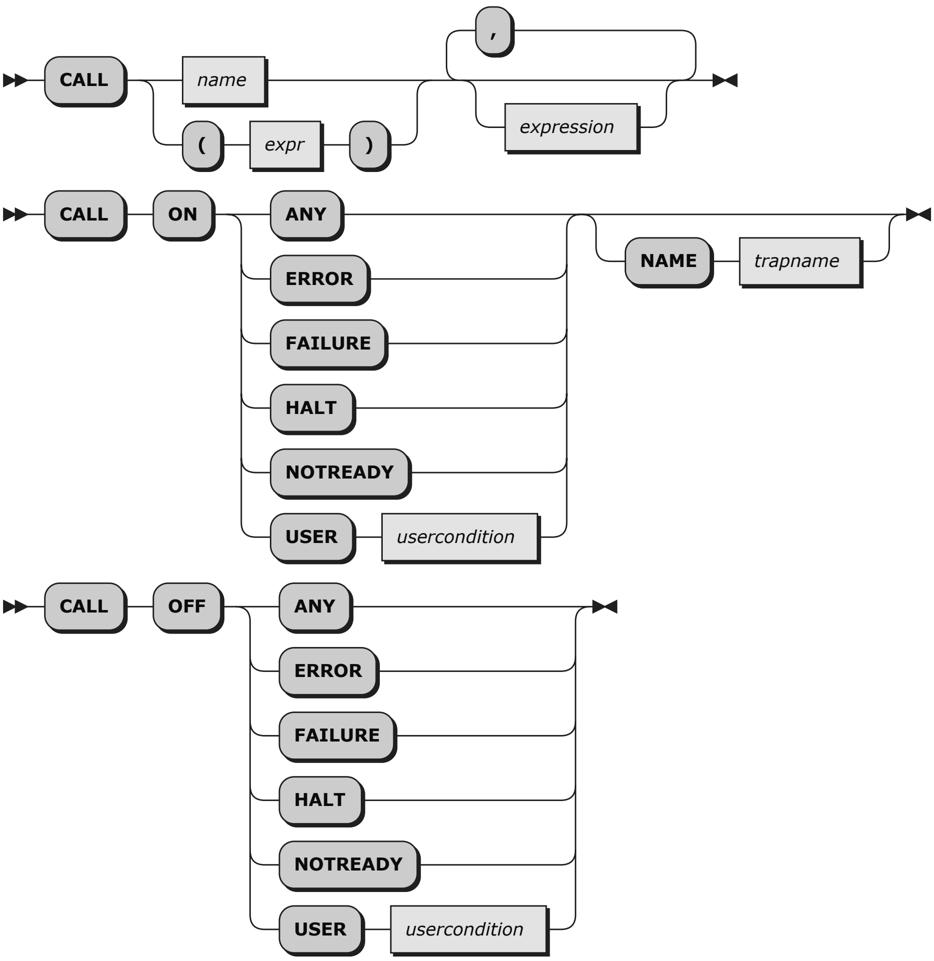
```
Fred:  Arg string, num1, num2

/* Now:   STRING  contains "DATA X"            */
/*        NUM1    contains "1"                 */
/*        NUM2    contains "5"                 */
```

Notes:

1. The *ARG* built-in function can also retrieve or check the arguments.

2. The *USE ARG* instruction is an alternative way of retrieving arguments. USE ARG performs a direct, one-to-one assignment of argument objects to Rexx variables. You should use this when your program needs a direct reference to the argument object, without string conversion or parsing. ARG and PARSE ARG produce string values from the argument objects, and the language processor then parses the string values.

2.3. CALL



CALL calls a routine (if you specify *name*) or controls the trapping of certain conditions (if you specify ON or OFF).

To control trapping, you specify OFF or ON and the condition you want to trap. OFF turns off the specified condition trap. ON turns on the specified condition trap. The *usercondition* is a single symbol that is taken as a constant. The *trapname* is a symbol or string taken as a constant. All information on condition traps is contained in *Chapter 11, Conditions and Condition Traps*.

To call a routine, specify *name*, which must be a literal string or symbol that is taken as a constant. The routine called can be:

An internal routine
: A subroutine that is in the same program as the CALL instruction or function call that calls it. Internal routines are located using label instructions.

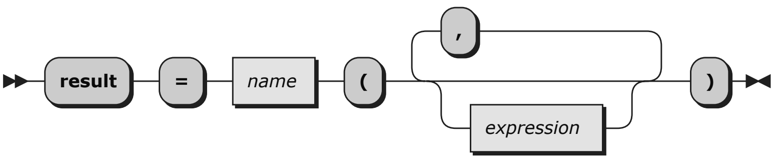
A built-in routine
: A function that is defined as part of the Rexx language.

An external routine
: A subroutine that is neither built-in nor a label within the same same program as the CALL instruction call that invokes it. See *Section 7.2.1, "Search Order"* for details on the different types of external routines.

If *name* is a literal string (that is, specified in quotation marks), the search for internal routines is bypassed, and only a built-in function or an external routine is called. Note that built-in function names are in uppercase. Therefore, a literal string call to a built-in function must also use uppercase characters.

You can also specify (*expr*), any valid expression enclosed in parentheses. The expression is evaluated before any of the argument expressions, and the value is the target of the CALL instruction. The language processor does not translate the expression value into uppercase, so the evaluated name must exactly match any label name or built-in function name. See *Section 1.12.3, "Labels"* for a description of label names.

The called routine can optionally return a result. In this case, the CALL instruction is functionally identical with the clause:



You can use any number of *expressions*, separated by commas. The expressions are evaluated from left to right and form the arguments during execution of the routine. Any ARG, PARSE ARG, or USE ARG instruction or ARG built-in function in the called routine accesses these objects while the called routine is running. You can omit expressions, if appropriate, by including extra commas.

The CALL then branches to the routine called *name*, using exactly the same mechanism as function calls. See *Chapter 7, Functions*. The search order is as follows:

Internal routines
: These are sequences of instructions inside the same program, starting at the label that matches *name* in the CALL instruction. If you specify the routine name in quotation marks, then an internal routine is not considered for that search order. The RETURN instruction completes the execution of an internal routine.

Built-in routines
: These are routines built into the language processor for providing various functions. They always return an object that is the result of the routine. See *Section 7.4, "Built-in Functions"*.

Note

You can call any built-in function as a subroutine. Any result is stored in RESULT. Simply specify **`CALL`**, the function name (with *no parenthesis*) and any arguments, for example:

```
call length "string"   /* Same as length("string") */
say result             /* Produces: 6              */
```

External routines

Users can write or use routines that are external to the language processor and the calling program. You can code an external routine in Rexx or in any language that supports the system-dependent interfaces. If the CALL instruction calls an external routine written in Rexx as a subroutine, you can retrieve any argument strings with the ARG, PARSE ARG, or USE ARG instructions or the ARG built-in function.

For more information on the search order, see *Section 7.2.1, “Search Order”*.

During execution of an internal routine, all variables previously known are generally accessible. However, the PROCEDURE instruction can set up a local variables environment to protect the subroutine and caller from each other. The EXPOSE option on the PROCEDURE instruction can expose selected variables to a routine.

Calling an external program or routine defined with a ::ROUTINE directive is similar to calling an internal routine. The external routine, however, is an implicit PROCEDURE in that all the caller's variables are always hidden. The status of internal values, for example NUMERIC settings, start with their defaults (rather than inheriting those of the caller). In addition, you can use EXIT to return from the routine.

When control reaches an internal routine, the line number of the CALL instruction is available in the variable SIGL (in the caller's variable environment). This can be used as a debug aid because it is possible to find out how control reached a routine. Note that if the internal routine uses the PROCEDURE instruction, it needs to EXPOSE SIGL to get access to the line number of the CALL.

After the subroutine processed the RETURN instruction, control returns to the clause following the original CALL. If the RETURN instruction specified an expression, the variable RESULT is set to the value of that expression. Otherwise, the variable RESULT is dropped (becomes uninitialized).

An internal routine can include calls to other internal routines, as well as recursive calls to itself.

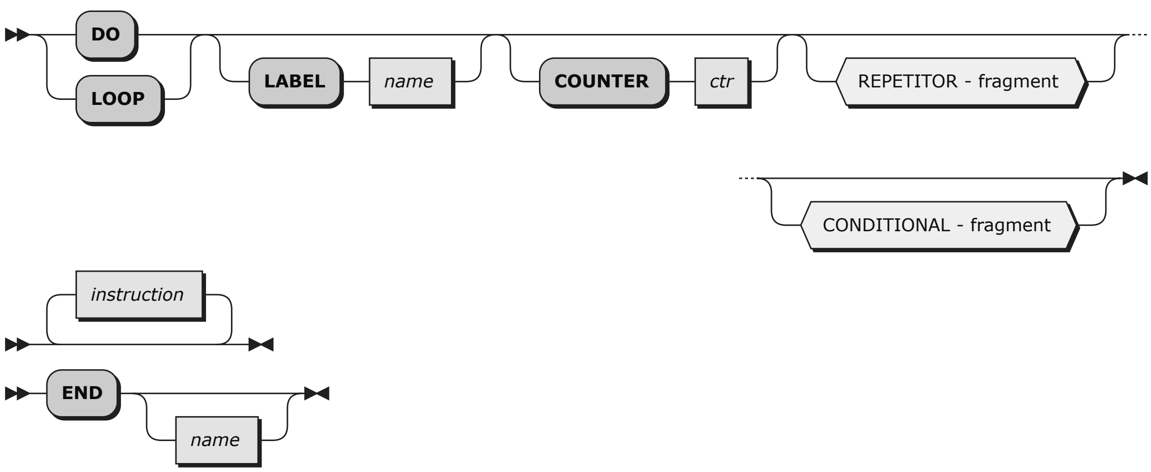
Example 2.6. Instructions — CALL

```
/* Recursive subroutine execution... */
arg z
call factorial z
say z"! =" result
exit
factorial: procedure     /* Calculate factorial by  */
  arg n                  /*  recursive invocation.  */
  if n=0 then return 1
  call factorial n-1
  return  result * n
```

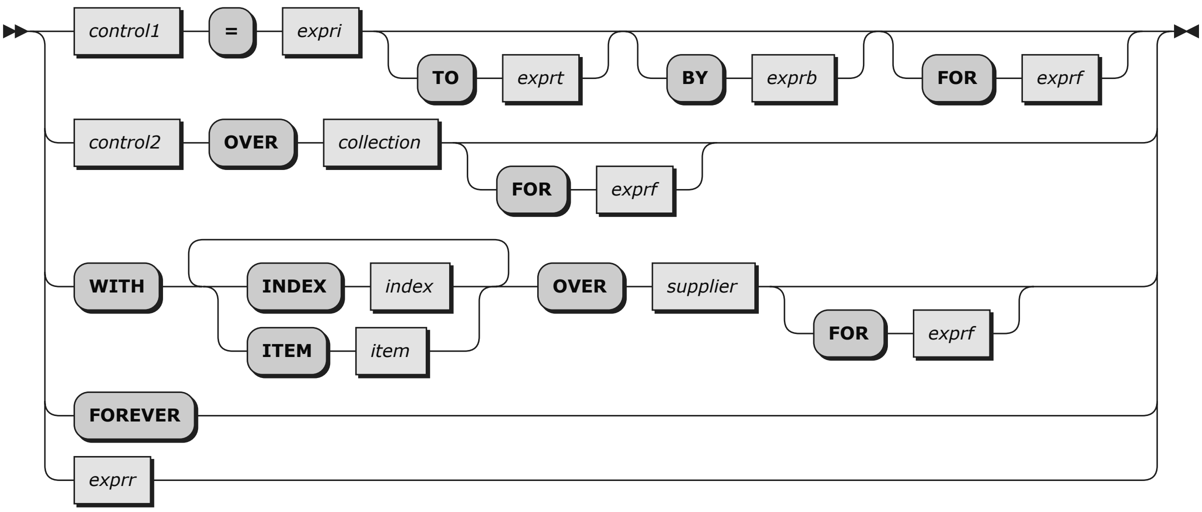
During internal subroutine (and function) execution, all important pieces of information are automatically saved and then restored upon return from the routine. These are:

- **The status of loops and other structures:** Executing a SIGNAL within a subroutine is safe because loops and other structures that were active when the subroutine was called are not ended. However, those currently active within the subroutine are ended.
- **Trace action:** After a subroutine is debugged, you can insert a TRACE Off at the beginning of it without affecting the tracing of the caller. If you want to debug a subroutine, you can insert a TRACE Results at the start and tracing is automatically restored to the conditions at entry (for example, Off) upon return. Similarly, **?** (interactive debug) is saved across routines.
- ***NUMERIC* settings:** The DIGITS, FUZZ, and FORM of arithmetic operations are saved and then restored on return. A subroutine can, therefore, set the precision, for example, that it needs to use without affecting the caller.
- ***ADDRESS* settings:** The current and previous destinations for commands, including any associated I/O redirection configurations, are saved and then restored on return.
- **Condition traps:** CALL ON and SIGNAL ON are saved and then restored on return. This means that CALL ON, CALL OFF, SIGNAL ON, and SIGNAL OFF can be used in a subroutine without affecting the conditions the caller set up.
- **Condition information:** This information describes the state and origin of the current trapped condition. The *CONDITION* built-in function returns this information.
- **.RS value:** The value of the *.RS environment symbol*.
- **Elapsed-time clocks:** A subroutine inherits the elapsed-time clock (see *Section 7.4.65, “TIME”*) from its caller, but because the time clock is saved across routine calls, a subroutine or internal function can independently restart and use the clock without affecting its caller. For the same reason, a clock started within an internal routine is not available to the caller.

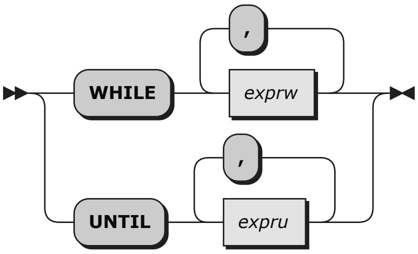
2.4. DO



REPETITOR:



CONDITIONAL:



DO groups instructions and optionally processes them repetitively. During repetitive execution, control variables (*control1*, *control2*, *index*, or *item*) can be stepped through some range of values.

LOOP groups instructions and processes them repetitively. LOOP behaves identically to DO, except for the simple LOOP ... END case, which is equivalent to DO FOREVER ... END.

Notes:

1. The LABEL and COUNTER phrases can be in any order, if used. They must precede any repetitor or conditional fragment.

2. The COUNTER phrase is only valid with a repetitive or conditional DO, it cannot be used on a simple DO group.

3. *control1*, *control2*, *index*, *item*, and *ctr* must be symbols that are valid variable names.

4. The *exprr*, *expri*, *exprb*, *exprt*, and *exprf* options, if present, are any expressions that evaluate to a number. The *exprr* and *exprf* options are further restricted to result in a positive whole number or zero. If necessary, the numbers are rounded according to the setting of NUMERIC DIGITS.

5. The *exprw* or *expru* options, if present, can be any expression that evaluates to `1` or `0`. This includes the list form of a conditional expression, which is a list of expressions separated by ",". The list of expressions is evaluated left-to-right. Each subexpression must evaluate to either `0` or `1`. Evaluation will stop with the first `0` result and `0` will be returned as the condition result. If all of the subexpressions evaluate to `1`, then the condition result is also `1`.

6. The TO, BY, and FOR phrases can be in any order, if used, and are evaluated in the order in which they are written.

7. The INDEX and ITEM phrases can be in any order, if used. They cannot be used more than once.

8. The *instruction* can be any instruction, including assignments, commands, message instructions, and keyword instructions (including any of the more complex constructs such as IF, SELECT, and the DO or LOOP instruction itself).

9. The subkeywords WHILE, UNTIL, OVER, WITH, INDEX, and ITEM are reserved within a DO or LOOP instruction in that they act as expression terminators for other keywords. Thus they cannot be used as symbols in any of the expressions. Similarly, TO, BY, and FOR cannot be used in *expri*, *exprt*, *exprb*, or *exprf*. FOREVER is also reserved, but only if it immediately follows the keyword DO or LOOP and is not followed by an equal sign. However, parentheses around or within an expression can prevent these keywords from terminating an expression. For example,

   Example 2.7. Instructions — DO variable without parenthesis

   ```
   do i = 1 while i < until
      say i
   end
   ```

   is considered a syntax error because of the variable named UNTIL. Using parentheses around the expression allows the variable UNTIL to be used:

   Example 2.8. Instructions — DO variable with parenthesis

   ```
   do i = 1 while (i < until)
      say i
   end
   ```

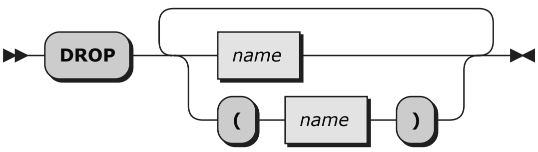
10. The *exprb* option defaults to **1**, if relevant.

11. The *collection* can be any expression that evaluates to an object that supports a `makeArray` method. Array and List items return an array with the items in the appropriate order, as do Streams. Tables, Stems, Directories, etc. are not ordered so the items get placed in the array in no particular order.

12. The *supplier* can be any expression that evaluates to an object that supports a `supplier` method.

For more information, refer to *Appendix A, Using DO and LOOP*.

2.5. DROP



DROP "unassigns" variables, that is, restores them to their original uninitialized state. If *name* is not enclosed in parentheses, it identifies a variable you want to drop and must be a symbol that is a valid variable name, separated from any other *name* by one or more whitespace characters or comments.

If parentheses enclose a single *name*, then its value is used as a subsidiary list of variables to drop. Whitespace characters are not necessary inside or outside the parentheses, but you can add them if desired. This subsidiary list must follow the same rules as the original list, that is, be valid character strings separated by whitespace, except that no parentheses are allowed. The list need not contain any names—that is, it can be empty.

Variables are dropped from left to right. It is not an error to specify a name more than once or to drop a variable that is not known. If an exposed variable is named (see *Section 2.7, "EXPOSE"* and *Section 2.19, "PROCEDURE"*), then the original variable is dropped.

Example 2.9. Instructions — DROP

```
j=4
Drop  a z.3 z.j
/* Drops the variables: A, Z.3, and Z.4              */
/* so that reference to them returns their names.    */
```

Here, a variable name in parentheses is used as a subsidiary list.

Example 2.10. Instructions — DROP

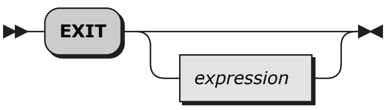
```
mylist="c d e"
drop (mylist) f
/* Drops the variables C, D, E, and F           */
/* Does not drop MYLIST                         */
```

Specifying a stem (that is, a symbol that contains only one period as the last character) assigns the stem variable to a new, empty stem object.

Example:

```
Drop  z.
/* Assigns stem variable z. to a new empty stem object */
```

2.6. EXIT



EXIT leaves a program unconditionally. Optionally, EXIT returns a result object to the caller. The program is stopped immediately, even if an internal routine is being run. If no internal routine is active, *RETURN* and EXIT are identical in their effect on the program running.

If you specify *expression*, it is evaluated and the object resulting from the evaluation is passed back to the caller when the program stops.

Example 2.11. Instructions — EXIT

```
j=3
Exit j*4
/* Would exit with the string "12" */
```

If you do not specify *expression*, no data is passed back to the caller. If the program was called as a function, this is detected as an error.

You can also use EXIT within a method. The method is stopped immediately, and the result object, if specified, is returned to the sender. If the method has previously issued a *REPLY* instruction, the EXIT instruction must not include a result expression.

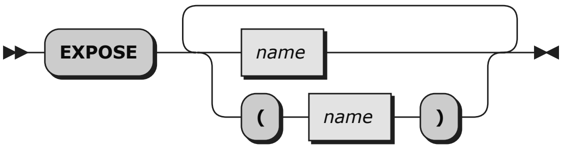
Notes:

1. If the program was called through a command interface, an attempt is made to convert the returned value to a return code acceptable by the underlying operating system. The returned string must be a whole number in the range -32768 to 32767. If the conversion fails, no error is raised, and a return code of 0 is returned.

2. If you do not specify EXIT, EXIT is implied at the end of the program, but no result value is returned.

3. On Unix-like systems the returned value is limited to a numerical value between 0 and 255.

2.7. EXPOSE



EXPOSE causes the object variables identified in *name* to be exposed to a method. References to exposed variables, including assigning and dropping, access variables in the current object's variable pool. (An object variable pool is a collection of variables that is associated with an object rather than with any individual method.) Therefore, the values of existing variables are accessible, and any changes are persistent even after RETURN or EXIT from the method.

Any changes a method makes to an object variable pool are immediately visible to any other methods that share the same object variable scope. All other variables that a method uses are local to the method and are dropped on RETURN or EXIT. If an EXPOSE instruction is included, it must be the first instruction of the method.

If parentheses enclose a single *name*, then, after the variable *name* is exposed, the character string value of *name* is immediately used as a subsidiary list of variables. Whitespace characters are not necessary inside or outside the parentheses, but you can add them if desired. This subsidiary list must follow the same rules as the original list, that is, valid variable names separated by whitespace characters, except that no parentheses are allowed.

Variables are exposed in sequence from left to right. It is not an error to specify a name more than once, or to specify a name that has not been used as a variable.

Example 2.12. Instructions — EXPOSE

```
/* Example of exposing object variables */
myobj = .myclass~new
myobj~c
myobj~d          /* Would display "Z is: 120"                */

::class myclass /* The ::CLASS directive                     */
::method c       /* The ::METHOD directive                    */
```

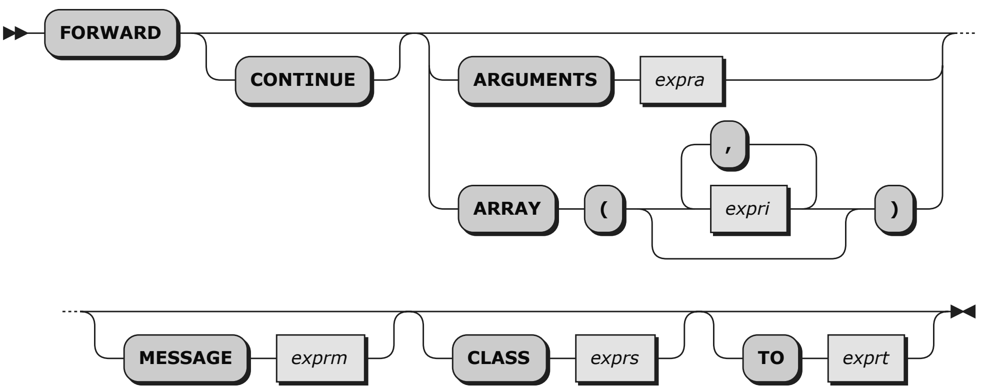
```
  expose z
  z = 100       /* Would assign 100 to the object variable z */
  return

::method d
  expose z
  z=z+20        /* Would add 20 to the same object variable z */
  say "Z is:" z
  return
```

You can expose an entire collection of *compound variables* by specifying their stem in the variable list or a subsidiary list. The variables are exposed for all operations.

Example 2.13. Instructions — EXPOSE

```
expose j k  c. d.
/*  This exposes "J", "K", and all variables whose            */
/*  name starts with "C." or "D."                             */
c.1="7."        /*  This sets "C.1" in the object             */
                /*  variable pool, even if it did not         */
                /*  previously exist.                         */
```

2.8. FORWARD



Note

You can specify the options in any order.

FORWARD forwards the message that caused the currently active method to begin running. The FORWARD instruction can change parts of the forwarded message, such as the target object, the message name, the arguments, and the superclass override.

If you specify the **TO** option, the language processor evaluates *exprt* to produce a new target object for the forwarded message. The *exprt* is a literal string, a constant symbol, or an expression enclosed in parentheses. If you do not specify the **TO** option, the initial value of the Rexx special variable SELF is used.

If you specify the **ARGUMENTS** option, the language processor evaluates *expra* to produce an array object that supplies the set of arguments for the forwarded message. The *expra* can be a literal string, a constant symbol, or an expression enclosed in parentheses. The **ARGUMENTS** value must evaluate to a Rexx array object.

If you specify the **ARRAY** option, each *expri* is an expression (use commas to separate the expressions). The language processor evaluates the expression list to produce a set of arguments for the forwarded message. It is an error to use both the **ARRAY** and the **ARGUMENTS** options on the same FORWARD instruction.

If you specify neither **ARGUMENTS** nor **ARRAY,** the language processor uses the same arguments specified on the original method call.

If you specify the **MESSAGE** option, the *exprm* is a literal string, a constant symbol, or an expression enclosed in parentheses. If you specify an expression enclosed in parentheses, the language processor evaluates the expression to obtain its value. The uppercase character string value of the **MESSAGE** option is the name of the message that the FORWARD instruction issues.

If you do not specify **MESSAGE**, FORWARD uses the message name used to call the currently active method.

If you specify the **CLASS** option, the *exprs* is a literal string, a constant symbol, or an expression enclosed in parentheses. This is the class object used as a superclass specifier on the forwarded message.

If you do not specify CLASS, the message is forwarded without a superclass override.

If you do not specify the **CONTINUE** option, the language processor immediately exits the current method before forwarding the message. Results returned from the forwarded message are the return value from the original message that called the active method (the caller of the method that issued the FORWARD instruction). Any conditions the forwarded message raises are raised in the calling program (without raising a condition in the method issuing the FORWARD instruction).

If you specify the **CONTINUE** option, the current method does not exit and continues with the next instruction when the forwarded message completes. If the forwarded message returns a result, the language processor assigns it to the special variable RESULT. If the message does not return a result, the language processor drops (uninitializes) the variable RESULT.

The FORWARD instruction passes all or part of an existing message invocation to another method. For example, the FORWARD instruction can forward a message to a different target object, using the same message name and arguments.

Example 2.14. Instructions — FORWARD

```
::method substr
  forward to (self~string)       /* Forward to the string value */
```

You can use FORWARD in an UNKNOWN method to reissue to another object the message that the UNKNOWN method traps.

Example 2.15. Instructions — FORWARD

```
::method unknown
  use arg msg, args
  /* Forward to the string value */
  /* passing along the arguments */
  forward to (self~string) message (msg) arguments (args)
```

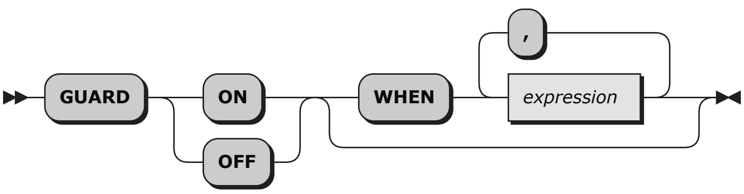
You can use FORWARD in a method to forward a message to a superclass's methods, passing the same arguments. This is very common usage in object INIT methods.

Example 2.16. Instructions — FORWARD

```
::class  savings subclass account
::method init
  expose type penalty
  forward class (super) continue       /* Send to the superclass      */
  type = "Savings"                     /* Now complete initialization */
  penalty = "1% for balance under 500"
```

In the preceding example, the **CONTINUE** option causes the FORWARD message to continue with the next instruction, rather than exiting the Savings class INIT method.

2.9. GUARD



GUARD controls a method's exclusive access to an object.

GUARD ON acquires for an active method exclusive use of its object variable pool. This prevents other methods that also require exclusive use of the same variable pool from running on the same object. If another method has already acquired exclusive access, the GUARD instruction causes the issuing method to wait until the variable pool is available.

GUARD OFF releases exclusive use of the object variable pool. Other methods that require exclusive use of the same variable pool can begin running.

If you specify WHEN, the method delays running until the *expression* evaluates to **.true**. If the *expression* evaluates to **.false**, GUARD waits until another method assigns or drops an object variable (that is, a variable named on an EXPOSE instruction) used in the WHEN *expression*. When an object variable changes, GUARD reevaluates the WHEN *expression*. If the *expression* evaluates to **.true**, the method resumes running. If the *expression* evaluates to **.false**, GUARD resumes waiting.

The condition *expression* after a WHEN can also be a list of *expression*s which is evaluated left-to-right. Each *expression* must evaluate to either **.false** or **.true**. Evaluation will stop with the first **.false** result and **.false** will be returned as the condition result. If all of the *expression*s evaluate to **.true**, then the condition result is also **.true**.

Example 2.17. Instructions — GUARD

```
::method c
  expose y
  if y>0 then
    return 1
  else
    return 0
::method d
```

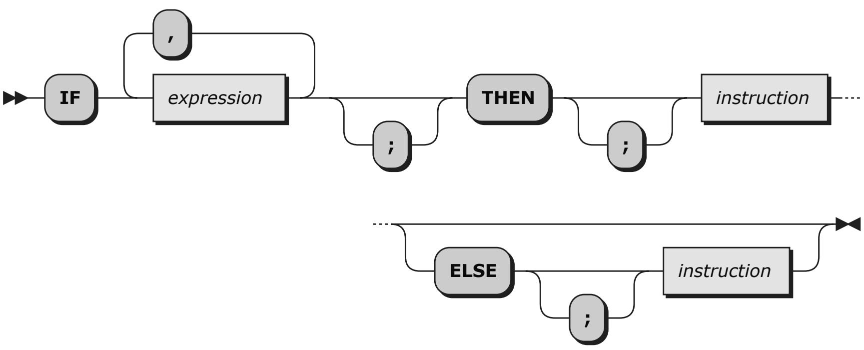
```
   expose z
   guard on when z>0
   self~c    /* Reevaluated when Z changes  */
   say "Method D"
```

If you specify WHEN and the method has exclusive access to the object's variable pool, then the exclusive access is released while GUARD is waiting for an object variable to change. Exclusive access is reacquired before the WHEN *expression* is evaluated. Once the WHEN *expression* evaluates to **`.true`**, exclusive access is either retained (for GUARD ON WHEN) or released (for GUARD OFF WHEN), and the method resumes running.

Note

If the condition expression cannot be met, GUARD ON WHEN puts the program in a continuous wait condition. This can occur in particular when several activities run concurrently. See *Section 12.4.3, "Guarded Methods"* for more information.

2.10. IF



IF conditionally processes an instruction or group of instructions depending on the evaluation of the *expression*. The *expression* is evaluated and must result in **`0`** or **`1`**.

The instruction after the THEN is processed only if the result is **`.true`**. If you specify an ELSE, the instruction after ELSE is processed only if the result of the evaluation is **`.false`**.

Example:

```
if answer="YES" then say "OK!"
else say "Why not?"
```

Remember that if the ELSE clause is on the same line as the last clause of the THEN part, you need a semicolon before ELSE.

Example:

```
if answer="YES" then say "OK!";  else say "Why not?"
```

ELSE binds to the nearest IF at the same level. You can use the NOP instruction to eliminate errors and possible confusion when IF constructs are nested, as in the following example.

Example 2.18. Instructions — IF

```
If answer = "YES" Then
  If name = "FRED" Then
    say "OK, Fred."
  Else
    nop
Else
  say "Why not?"
```

The *expression* may also be a list of expressions separated by ",". The list of expressions is evaluated left-to-right. Each subexpression must evaluate to either **`0`** or **`1`**. Evaluation will stop with the first **`0`** result and **`0`** will be returned as the condition result. If all of the subexpressions evaluate to **`1`**, then the condition result is also **`1`**.

Example 2.19. Instructions — IF

```
If answer~datatype('w'), answer//2 = 0 Then
  say answer "is even"
Else
  say answer "is odd"
```

The example above is not the same as using the following

Example 2.20. Instructions — IF

```
If answer~datatype('w') & answer//2 = 0 Then
  say answer "is even"
Else
  say answer "is odd"
```

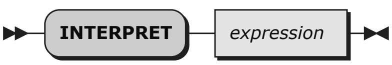
The logical & operator will evaluate both terms of the operation, so the term "answer//2" will result in a syntax error if answer is a non-numeric value. With the list conditional form, evaluation will stop with the first **`.false`** result, so the "answer//2" term will not be evaluated if the datatype test returns **`0`**.

Notes:

1. The *instruction* can be any assignment, message instruction, command, or keyword instruction, including any of the more complex constructs such as DO, LOOP, SELECT, or the IF instruction itself. A null clause is not an instruction, so putting an extra semicolon (or label) after THEN or ELSE is not equivalent to putting a dummy instruction (as it would be in C). The NOP instruction is provided for this purpose.

2. Except when within a bracketed subexpression, the symbol THEN cannot be used within *expression*, because the keyword THEN is treated differently in that it need not start a clause. This allows the expression on the IF clause to be ended by THEN, without a semicolon (;) being required.

2.11. INTERPRET



INTERPRET processes instructions that have been built dynamically by evaluating *expression*.

The *expression* is evaluated to produce a character string, and is then processed (interpreted) just as though the resulting string were a line inserted into the program and bracketed by a DO; and an END;.

Any instructions (including INTERPRET instructions) are allowed, but note that constructions such as DO...END and SELECT...END must be complete. For example, a string of instructions being interpreted cannot contain a LEAVE or ITERATE instruction (valid only within a repetitive loop) unless it also contains the whole repetitive DO...END or LOOP...END construct.

A semicolon is implied at the end of the expression during execution, if one was not supplied.

Example 2.21. Instructions — INTERPRET

```
/* INTERPRET example */
data="FRED"
interpret data "= 4"
/* Builds the string  "FRED = 4" and        */
/* Processes:  FRED = 4;                    */
/* Thus the variable FRED is set to "4"     */
```

```
/* Another INTERPRET example */
data="do 3; say "Hello there!"; end"
interpret data        /* Displays:          */
                      /*  Hello there!      */
                      /*  Hello there!      */
                      /*  Hello there!      */
```

Notes:

1. Labels within the interpreted string are not permanent and are, therefore, an error.

2. Executing the INTERPRET instruction with **`TRACE R`** or **`TRACE I`** can be helpful in interpreting the results you get.

   ### Example 2.22. Instructions — INTERPRET

   ```
   /* Here is a small Rexx program. */
   Trace Int
   name="Kitty"
   indirect="name"
   interpret 'say "Hello"' indirect'"!"'
   ```

   When this is run, you get the following trace:

   ```
        3 *-* name="Kitty"
          >L>   "Kitty"
          >>>   "Kitty"
        4 *-* indirect="name"
          >L>   "name"
          >>>   "name"
        5 *-* interpret 'say "Hello"' indirect'"!"'
          >L>   "say "Hello""
          >V>   INDIRECT => "name"
          >O>   " " => "say "Hello" name"
          >L>   """!"""
          >O>   "" => "say "Hello" name"!""
          >>>   "say "Hello" name"!""
   ```

```
     5 *-* say "Hello" name"!"
       >L>   "Hello"
       >V>   NAME => "Kitty"
       >O>   " " => "Hello Kitty"
       >L>   "!"
       >O>   "" => "Hello Kitty!"
       >>>   "Hello Kitty!"
Hello Kitty!
```

Lines 3 and 4 set the variables used in line 5. Execution of line 5 then proceeds in two stages. First the string to be interpreted is built up, using a literal string, a variable (**`INDIRECT`**), and another literal string. The resulting pure character string is then interpreted, just as though it were actually part of the original program. Because it is a new clause, it is traced as such (the second **`*-*`** trace flag under line 5) and is then processed. Again a literal string is concatenated to the value of a variable (**`NAME`**) and another literal, and the final result (**`Hello Kitty!`**) is then displayed.

3. For many purposes, you can use the *VALUE* function instead of the INTERPRET instruction. The following line could, therefore, have replaced line 5 in the previous example:

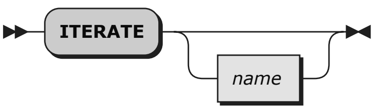
   Example 2.23. Instructions — INTERPRET

   ```
   say "Hello" value(indirect)"!"
   ```

   INTERPRET is usually required only in special cases, such as when two or more statements are to be interpreted together, or when an expression is to be evaluated dynamically.

4. You cannot use a *directive* within an INTERPRET instruction.

2.12. ITERATE



ITERATE alters the flow within a repetitive loop (that is, any DO construct other than that with a simple DO or a LOOP instruction).

Execution of the group of instructions stops, and control is passed to the DO or LOOP instruction just as though the END clause had been encountered. The control variable, if any, is incremented and tested, as usual, and the group of instructions is processed again, unless the DO or LOOP instruction ends the loop.

The *name* is a symbol, taken as a constant. If *name* is not specified, ITERATE continues with the current repetitive loop. If *name* is specified, it must be the name of the control variable or the LABEL name of a currently active loop, which can be the innermost, and this is the loop that is stepped. Any active loops inside the one selected for iteration are ended (as though by a LEAVE instruction).

Example 2.24. Instructions — ITERATE

```
loop label MyLabelName i=1 to 4 /* label set to 'MYLABELNAME' */
  if i=2 then iterate
  say i
```

```
end myLabelName
/* Displays the numbers:
  1
  3
  4
*/
```

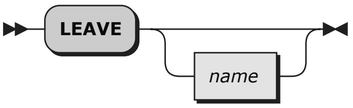
Notes:

1. If specified, *name* must match the symbol naming the control variable or LABEL name in the DO or LOOP clause in all respects except the case. No substitution for compound variables is carried out when the comparison is made.

2. A loop is active if it is currently being processed. If a subroutine is called, or an INTERPRET instruction is processed, during the execution of a loop, the loop becomes inactive until the subroutine has returned or the INTERPRET instruction has completed. ITERATE cannot be used to continue with an inactive loop.

3. If more than one active loop uses the same name, ITERATE selects the innermost loop.

2.13. LEAVE



LEAVE causes an immediate exit from one or more repetitive loops or block instruction (simple DO or SELECT).

Processing of the group of instructions is ended, and control is passed to the instruction following the END clause, just as though the END clause had been encountered and the termination condition had been met. However, on exit, the control variable, if any, contains the value it had when the LEAVE instruction was processed.

The *name* is a symbol, taken as a constant. If *name* is not specified, LEAVE ends the innermost active repetitive loop. If *name* is specified, it must be the name of the control variable or LABEL name of a currently active LOOP, DO, or SELECT, which can be the innermost, and that block, and any active block inside it, are then ended. Control then passes to the clause following the END that matches the instruction of the selected block.

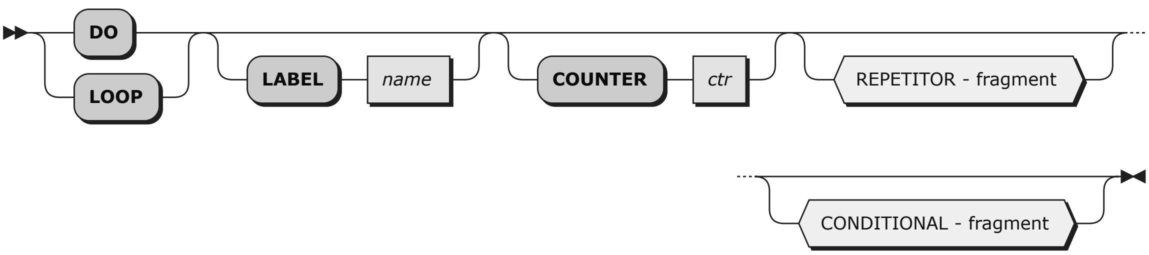
Example 2.25. Instructions — LEAVE

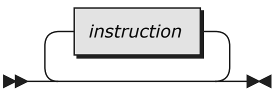
```
max=5
do label myDoBlock /* define a label 'MYDOBLOCK' */
  loop i=1 to max /* label defaults to control variable 'I' */
    if i = 2 then iterate i
    if i = 4 then leave myDoBlock
    say i
  end i
end myDoBlock
say 'after looping' i 'times'
/* Displays the following
  1
  3
  after looping 4 times
*/
```

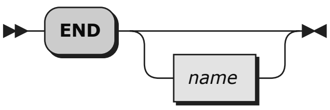
Notes:

1. If specified, *name* must match the symbol naming the control variable or LABEL name in the DO, LOOP, or SELECT clause in all respects except the case. No substitution for compound variables is carried out when the comparison is made.
2. A loop is active if it is currently being processed. If a subroutine is called, or an INTERPRET instruction is processed, during execution of a loop, the loop becomes inactive until the subroutine has returned or the INTERPRET instruction has completed. LEAVE cannot be used to end an inactive block.
3. If more than one active block uses the same control variable, LEAVE selects the innermost block.

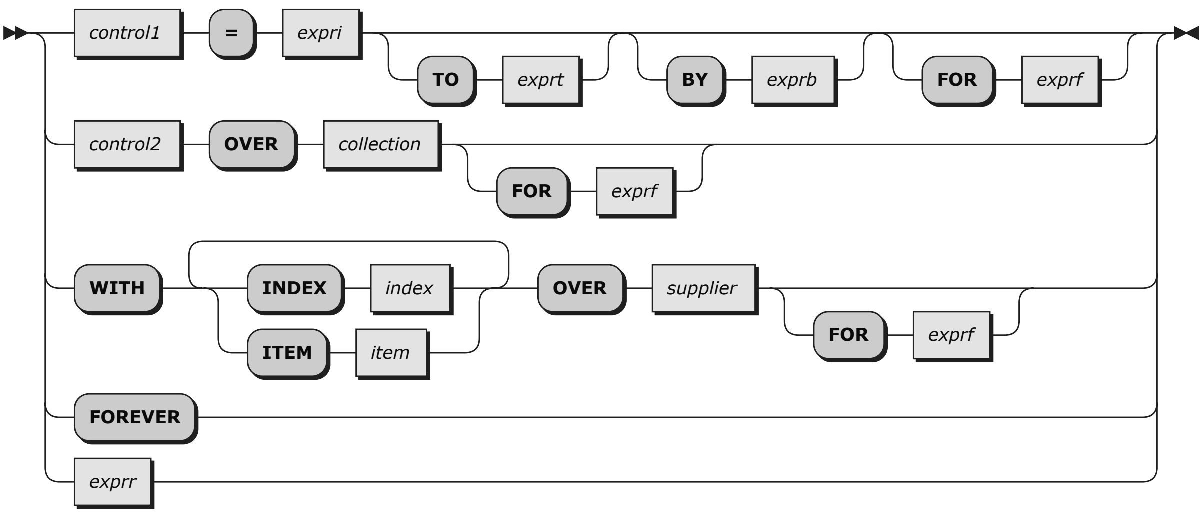
2.14. LOOP



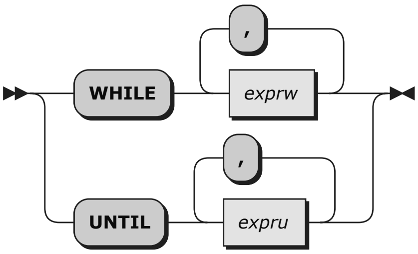




REPETITOR:



CONDITIONAL:



LOOP groups instructions and processes them repetitively.

LOOP behaves identically to DO, except for the simple LOOP ... END case, which is equivalent to DO FOREVER ... END.

For details refer to *Section 2.4, “DO”*.

2.15. NOP

NOP is a dummy instruction that has no effect. It can be useful as the target of a THEN or ELSE clause.

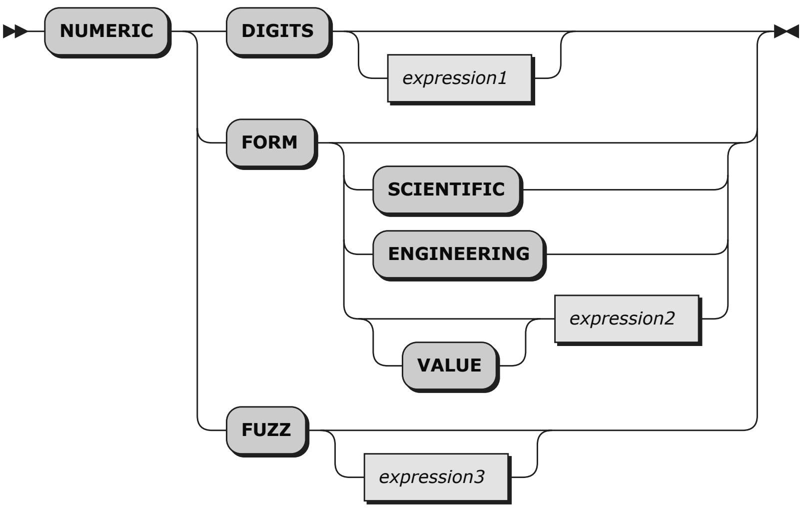
Example 2.26. Instructions — NOP

```
Select
  when a=c then nop           /* Do nothing */
  when a>c then say "A > C"
  otherwise     say "A < C"
end
```

Note

Putting an extra semicolon instead of the NOP would merely insert a null clause, which would be ignored. The second WHEN clause would be seen as the first instruction expected after the THEN, and would, therefore, be treated as a syntax error. NOP is a true instruction, however, and is, therefore, a valid target for the THEN clause.

2.16. NUMERIC



NUMERIC changes the way in which a program carries out arithmetic operations. The options of this instruction are described in detail in *Chapter 10, Numbers and Arithmetic*.

NUMERIC DIGITS

controls the precision to which arithmetic operations and built-in functions are evaluated. If you omit *expression1*, the precision defaults to 9 digits, but can be overridden on a source-file basis using the *::OPTIONS* directive. Otherwise, the character string value result of *expression1* must evaluate to a positive whole number and must be larger than the current NUMERIC FUZZ setting.

There is no limit to the value for DIGITS (except the amount of storage available), but high precisions are likely to require a great amount of processing time. It is recommended that you use the default value whenever possible.

You can retrieve the current NUMERIC DIGITS setting with the *DIGITS* built-in function.

NUMERIC FORM

controls the form of exponential notation for the result of arithmetic operations and built-in functions. This can be either SCIENTIFIC (in which case only one, nonzero digit appears before the decimal point) or ENGINEERING (in which case the power of 10 is always a multiple of 3). The default is SCIENTIFIC, but can be overridden on a source-file basis using the *::OPTIONS* directive. The subkeywords SCIENTIFIC or ENGINEERING set the FORM directly, or it is taken from the character string result of evaluating the expression (*expression2*) that follows VALUE. The result in this case must be either **`SCIENTIFIC`** or **`ENGINEERING`**. You can omit the subkeyword VALUE if *expression2* does not begin with a symbol or a literal string, that is, if it starts with a special character, such as an operator character or parenthesis.

You can retrieve the current NUMERIC FORM setting with the *FORM* built-in function.

NUMERIC FUZZ

controls how many digits, at full precision, are ignored during a *numeric comparison* operation. If you omit *expression3*, the default is 0 digits, but can be overridden on a source-file basis using the *::OPTIONS* directive. Otherwise, the character string value result of *expression3* must evaluate to 0 or a positive whole number rounded, if necessary, according to the current NUMERIC DIGITS setting, and must be smaller than the current NUMERIC DIGITS setting.

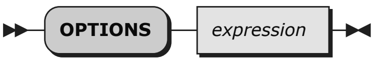
NUMERIC FUZZ temporarily reduces the value of NUMERIC DIGITS by the NUMERIC FUZZ value during every numeric comparison. The numbers are subtracted under a precision of DIGITS minus FUZZ digits during the comparison and are then compared with 0.

You can retrieve the current NUMERIC FUZZ setting with the *FUZZ* built-in function.

Note

The three numeric settings are automatically saved across internal subroutine and function calls. See the *CALL* instruction for more details.

2.17. OPTIONS

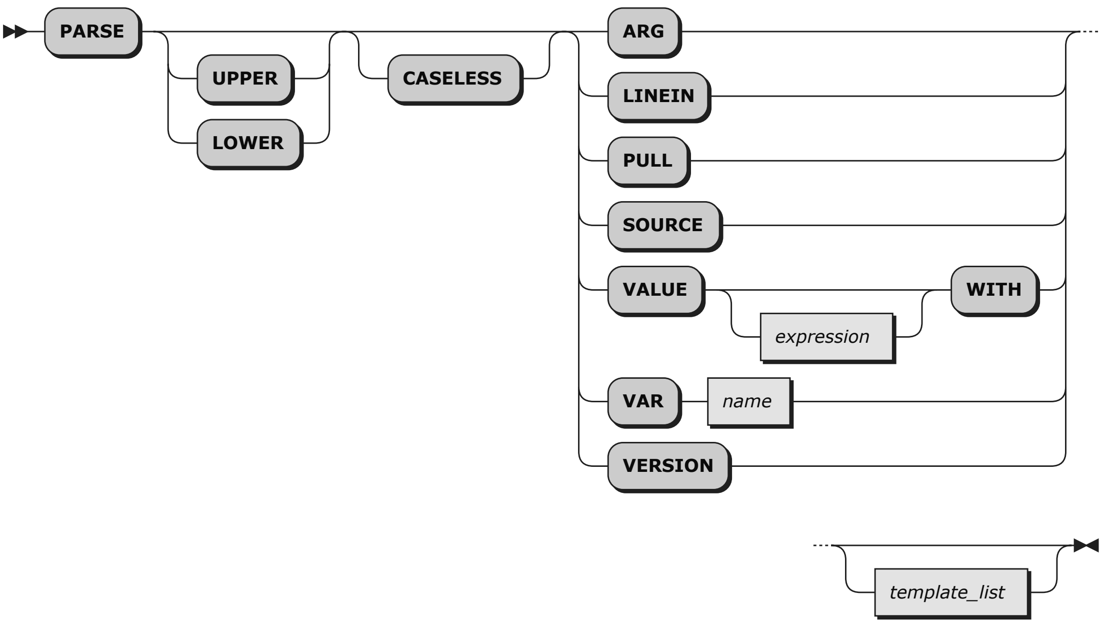


The OPTIONS instruction is used to pass special requests to the language processor.

The *expression* is evaluated, and individual words in the result that are meaningful to the language processor will be obeyed. Options might control how the interpreter optimizes code, enforces standards, enables implementation-dependent features, etc. Unrecognized words in the result are ignored, since they are assumed to be instructions for a different language processor.

Open Object Rexx does not recognize any option keywords.

2.18. PARSE



Note

You can specify UPPER and CASELESS or LOWER and CASELESS in either order.

PARSE assigns data from various sources to one or more variables according to the rules of parsing. (See *Chapter 9, Parsing*.)

If you specify UPPER, the strings to be parsed are translated to uppercase before parsing. If you specify LOWER, the strings are translated to lowercase. Otherwise no translation takes place.

If you specify CASELESS, character string matches during parsing are made independent of the case. This means a letter in uppercase is equal to the same letter in lowercase.

The *template_list* can be a single template or list of templates separated by commas. Each template consists of one or more symbols separated by whitespace, patterns, or both.

Each template is applied to a single source string. Specifying several templates is not a syntax error, but only the PARSE ARG variant can supply more than one non-null source string. See *Section 9.8.1, "Parsing Several Strings"* for information on parsing several source strings.

If you do not specify a template, no variables are set but the data is prepared for parsing, if necessary. Thus for PARSE PULL, a data string is removed from the current data queue, for PARSE LINEIN (and PARSE PULL if the queue is empty), a line is taken from the default input stream, and for PARSE VALUE, *expression* is evaluated. For PARSE VAR, the specified variable is accessed. If it does not have a value, the NOVALUE condition is raised, if it is enabled.

The following list describes the data for each variant of the PARSE instruction.

PARSE ARG

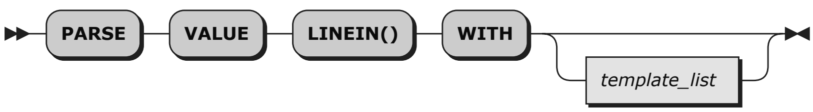
parses the strings passed to a program, routine, or method as input arguments. See the *ARG instruction* for details and examples.

Note

Parsing uses the string values of the argument objects. The USE ARG instruction provides direct access to argument objects. You can also retrieve or check the argument objects to a Rexx program, routine, or method with the *ARG* built-in function.

PARSE LINEIN

parses the next line of the default input stream. (See *Chapter 14, Input and Output Streams* for a discussion of Rexx input and output.) PARSE LINEIN is a shorter form of the following instruction:



If no line is available, program execution usually pauses until a line is complete. Use PARSE LINEIN only when direct access to the character input stream is necessary. Use the PULL or PARSE PULL instructions for the usual line-by-line dialog with the user to maintain generality. PARSE LINEIN will not pull lines from the external data queue.

To check if any lines are available in the default input stream, use the *LINES* built-in function.

PARSE PULL

parses the next string of the external data queue. If the external data queue is empty, PARSE PULL reads a line of the default input stream (the user's terminal), and the program pauses, if necessary, until a line is complete. You can add data to the head or tail of the queue by using the *PUSH* and *QUEUE* instructions, respectively. You can find the number of lines currently in the queue with the *QUEUED* built-in function. The queue remains active as long as the language processor is active. Other programs in the system can alter the queue and use it to communicate with programs written in Rexx. See also the *PULL* instruction.

Note

PULL and PARSE PULL read the current data queue. If the queue is empty, they read the default input stream, .INPUT (typically, the keyboard).

PARSE SOURCE

parses data describing the source of the program, routine or method running.

The first two tokens of source string are the operating system name, followed by either **`COMMAND`**, **`FUNCTION`**, **`SUBROUTINE`**, **`METHOD`**, or **`REQUIRES`**, depending on whether the program was called as a host command, or from a function call in an expression, or using the CALL instruction, or as a method of an object, or from a ::REQUIRES directive to run the prolog code. These two tokens are followed by the path specification of the program, or the name given to a Package, Routine or Method instance, or the string **`INSTORE`** when run via **`rexx -e`**.

The string might look like one of the following:

```
WindowsNT COMMAND C:\Program Files\ooRexx\rexxtry.rex
LINUX COMMAND /usr/local/bin/rexxtry.rex
```

PARSE VALUE

parses the data, a character string, that is the result of evaluating *expression*. If you specify no *expression*, the null string is used. Note that WITH is a subkeyword in this context and cannot be used as a symbol within *expression*.

Thus, for example:

```
PARSE VALUE time() WITH  hours ":" mins ":" secs
```

gets the current time and splits it into its constituent parts.

PARSE VAR *name*

parses the character string value of the variable *name*. The *name* must be a symbol that is valid as a variable name, which means it cannot start with a period or a digit. Note that the variable *name* is not changed unless it appears in the template, so that, for example:

```
PARSE VAR string word1 string
```

removes the first word from *string*, puts it in the variable *word1*, and assigns the remainder back to *string*.

```
PARSE UPPER VAR string word1 string
```

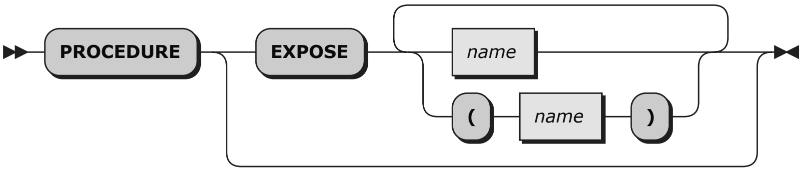
also translates the data from *string* to uppercase before it is parsed.

PARSE VERSION

parses information describing the language level and the date of the language processor. This information consists of five blank-delimited words:

- The string **`REXX-ooRexx_5.0.0(MT)_64-bit`**, if using the ooRexx interpreter at version 5, release 0, modification 0, and compiled for 64-bit addressing mode.
- The language level description, for example **`6.05`** for ooRexx 5.0, or **`6.04`** for ooRexx 4.2.
- Three tokens that describe the language processor release date in the same format as the default for the *DATE* built-in function, for example, **`"1 Sep 2016"`**.

2.19. PROCEDURE



PROCEDURE, within an internal routine (subroutine or function), protects the caller's variables by making them unknown to the instructions that follow it. After a RETURN instruction is processed, the original variable environment is restored and any variables used in the routine (that were not exposed) are dropped. (An exposed variable is one belonging the caller of a routine that the PROCEDURE instruction has exposed. When the routine refers to, or alters, the variable, the original (caller's) copy of the variable is used.) An internal routine need not include a PROCEDURE instruction. In this case the variables it is manipulating are those the caller owns. If the PROCEDURE instruction is used, it must be the first instruction processed after the CALL or function invocation; that is, it must be the first instruction following the label.

If you use the EXPOSE option, any variable specified by the *name* is exposed. Any reference to it (including setting and dropping) is made to the variables environment the caller owns. Hence, the values of existing variables are accessible, and any changes are persistent even on RETURN from the routine. If the *name* is not enclosed in parentheses, it identifies a variable you want to expose and must be a symbol that is a valid variable name, separated from any other *name* with one or more whitespace characters.

If parentheses enclose a single *name*, then, after the variable *name* is exposed, the character string value of *name* is immediately used as a subsidiary list of variables. Whitespace characters are not necessary inside or outside the parentheses, but you can add them if desired. This subsidiary list must follow the same rules as the original list, that is, valid variable names separated by whitespace characters, except that no parentheses are allowed.

Variables are exposed from left to right. It is not an error to specify a name more than once, or to specify a name that the caller has not used as a variable.

Any variables in the main program that are not exposed are still protected. Therefore, some of the caller's variables can be made accessible and can be changed, or new variables can be created. All these changes are visible to the caller upon RETURN from the routine.

Example 2.27. Instructions — PROCEDURE

```
/* This is the main Rexx program */
j=1; z.1="a"
call toft
```

```
say j k m       /* Displays "1 7 M"          */
exit

/* This is a subroutine     */
toft: procedure expose j k z.j
  say j k z.j   /* Displays "1 K a"          */
  k=7; m=3      /* Note: M is not exposed    */
  return
```

Note that if **Z.J** in the EXPOSE list is placed before **J**, the caller's value of **J** is not visible, so **Z.1** is not exposed.

The variables in a subsidiary list are also exposed from left to right.

Example 2.28. Instructions — PROCEDURE

```
/* This is the main Rexx program */
j=1;k=6;m=9
a ="j k m"
call test
exit

/* This is a subroutine     */
test: procedure expose (a)   /* Exposes A, J, K, and M     */
  say a j k m                /* Displays "j k m 1 6 9"     */
  return
```

You can use subsidiary lists to more easily expose a number of variables at a time or, with the VALUE built-in function, to manipulate dynamically named variables.

Example 2.29. Instructions — PROCEDURE

```
/* This is the main Rexx program */
c=11; d=12; e=13
Showlist="c d"     /* but not E              */
call Playvars
say c d e f        /* Displays "11 New 13 9" */
exit

/* This is a subroutine     */
Playvars: procedure expose (showlist) f
  say word(showlist,2)              /* Displays "d"                    */
  say value(word(showlist,2),"New") /* Displays "12" and sets new value */
  say value(word(showlist,2))       /* Displays "New"                  */
  e=8                               /* E is not exposed                */
  f=9                               /* F was explicitly exposed        */
  return
```

Specifying a stem as *name* exposes this stem and all possible compound variables whose names begin with that stem.

Example 2.30. Instructions — PROCEDURE

```
/* This is the main Rexx program */
a.=11; i=13; j=15
i = i + 1
C.5 = "FRED"
call lucky7
```

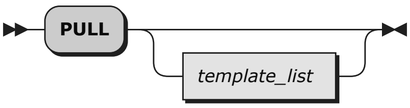
```
say a. a.1 i j c. c.5
say "You should see 11 7 14 15 C. FRED"
exit

lucky7:Procedure Expose i j a. c.
  /* This exposes I, J, and all variables whose     */
  /* names start with A. or C.                      */
  A.1="7"  /* This sets A.1 in the caller-'s         */
           /* environment, even if it did not       */
           /* previously exist.                     */
  return
```

Note

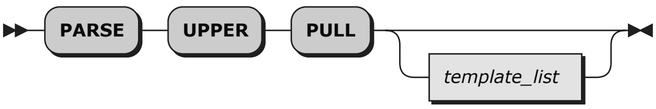
Variables can be exposed through several generations of routines if they are included in all intermediate PROCEDURE instructions.

See the *CALL* instruction and *Chapter 7, Functions* for details and examples of how routines are called.

2.20. PULL



PULL reads a string from the head of the external data queue or, if the external data queue is empty, from the standard input stream (typically the keyboard). (See *Chapter 14, Input and Output Streams* for a discussion of Rexx input and output.) It is a short form of the following instruction:



The current head of the queue is read as one string. Without a *template_list* specified, no further action is taken and the string is thus effectively discarded. The *template_list* can be a single template or list of templates separated by commas, but PULL parses only one source string. Each template consists of one or more symbols separated by whitespace, patterns, or both.

If you specify several comma-separated templates, variables in templates other than the first one are assigned the null string. The string is translated to uppercase (that is, lowercase **a**-**z** to uppercase **A**-**Z**) and then parsed into variables according to the rules described in *Chapter 9, Parsing*. Use the PARSE PULL instruction if you do not desire uppercase translation.

Note

If the current data queue is empty, PULL reads from the standard input (typically, the keyboard). If there is a PULL from the standard input, the program waits for keyboard input with no prompt.

Example:

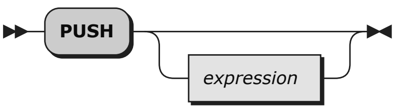
```
Say "Do you want to erase the file?  Answer Yes or No:"
Pull answer .
if answer="NO" then say "The file will not be erased."
```

Here the dummy placeholder, a period (`.`), is used in the template to isolate the first word the user enters.

If the external data queue is empty, a line is read from the default input stream and the program pauses, if necessary, until a line is complete. (This is as though PARSE UPPER LINEIN had been processed. For details see *PARSE LINEIN*

The *QUEUED* built-in function returns the number of lines currently in the external data queue.

2.21. PUSH



PUSH stacks the string resulting from the evaluation of *expression* LIFO (Last In, First Out) into the external data queue. (See *Chapter 14, Input and Output Streams* for a discussion of Rexx input and output.)

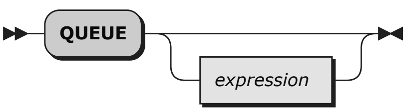
If you do not specify *expression*, a null string is stacked.

Example 2.31. Instructions — PUSH

```
a="Fred"
push       /* Puts a null line onto the queue */
push a 2   /* Puts "Fred 2"    onto the queue */
```

The *QUEUED* built-in function returns the number of lines currently in the external data queue.

2.22. QUEUE



QUEUE appends the string resulting from *expression* to the tail of the external data queue. That is, it is added FIFO (First In, First Out). (See *Chapter 14, Input and Output Streams* for a discussion of Rexx input and output.)

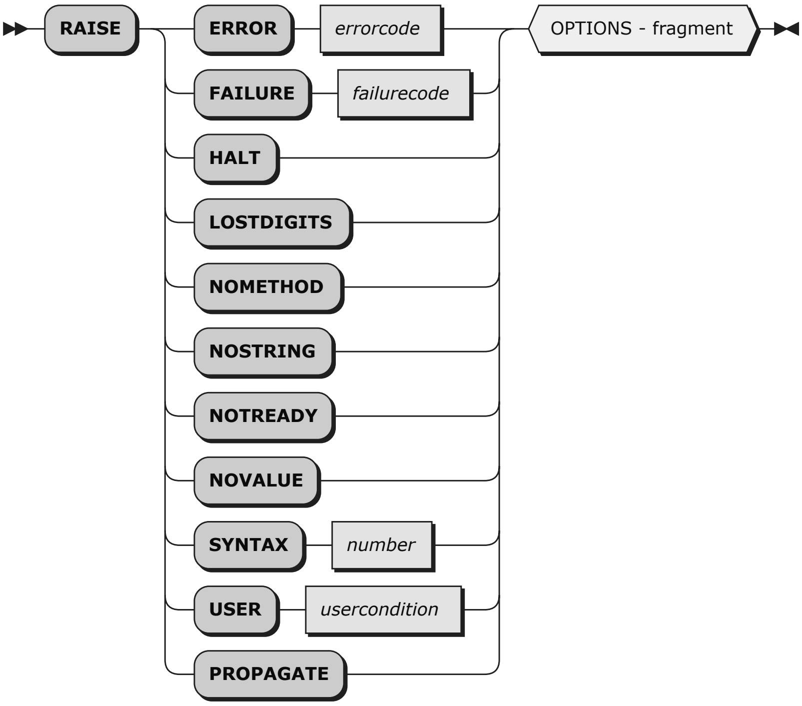
If you do not specify *expression*, a null string is queued.

Example 2.32. Instructions — QUEUE

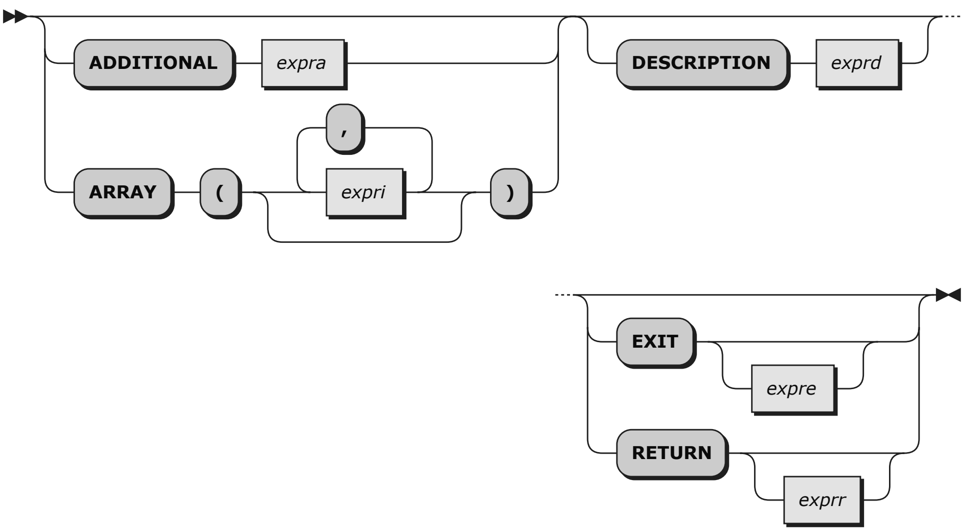
```
a="Toft"
queue a 2  /* Enqueues "Toft 2" */
queue      /* Enqueues a null line behind the last */
```

The *QUEUED* built-in function returns the number of lines currently in the external data queue.

2.23. RAISE



OPTIONS:



Note

You can specify the options **`ADDITIONAL`**, **`ARRAY`**, **`DESCRIPTION`**, **`RETURN`**, and **`EXIT`** in any order. However, if you specify **`EXIT`** without *expre* or **`RETURN`** without *exprr*, it must appear last.

RAISE returns or exits from the currently running routine or method and raises a condition in the caller (for a routine) or sender (for a method). See *Chapter 11, Conditions and Condition Traps* for details of the actions taken when conditions are raised. The RAISE instruction can raise all conditions that can be trapped.

If the ERROR or FAILURE condition is raised, you must supply the associated return code as *errorcode* or *failurecode*, respectively. These can be literal strings, constant symbols, or expressions enclosed in parentheses. If you specify an expression enclosed in parentheses, a subexpression, the language processor evaluates the expression to obtain its character string value.

If the SYNTAX condition is raised, you must supply the associated Rexx error number as *number*. This error *number* can be either a Rexx major error code or a Rexx detailed error code in the form *nn.nnn*. The *number* can be a literal string, a constant symbol, or an expression enclosed in parentheses. If you specify an expression enclosed in parentheses, the language processor evaluates the expression to obtain its character string value.

If a USER condition is raised, you must supply the associated user condition name as *usercondition*, which must be a symbol that is taken as a constant.

If you specify the **ADDITIONAL** option, the language processor evaluates *expra* to produce an object that supplies additional object information associated with the condition. The *expra* can be a literal string, a constant symbol, or an expression enclosed in parentheses. The ADDITIONAL entry of the condition object and the **"A"** option of the CONDITION built-in function return this additional object information. For SYNTAX conditions, the ADDITIONAL value must evaluate to a single-dimensional Array.

If you specify the **ARRAY** option, each *expri* is an expression (use commas to separate the expressions). The language processor evaluates the expression list to produce an array object that supplies additional object information associated with the condition. The ADDITIONAL entry of the condition object and the **"A"** option of the CONDITION built-in function return this additional object information as an array of values. It is an error to use both the **ARRAY** option and the **ADDITIONAL** option on the same RAISE instruction.

The content of *expra* or *expri* is used as the contents of the secondary error message produced for a *condition*.

If you specify neither ADDITIONAL nor ARRAY, there is no additional object information associated with the condition.

If you specify the **DESCRIPTION** option, the *exprd* can be a literal string, a constant symbol, or an expression enclosed in parentheses. If you specify an expression enclosed in parentheses, the language processor evaluates the expression to obtain its character string value. This is the description associated with the condition. The **"D"** option of the CONDITION built-in function and the DESCRIPTION entry of the condition object return this string.

If you do not specify DESCRIPTION, the language processor uses a null string as the descriptive string.

If you specify the **RETURN** or **EXIT** option, the language processor evaluates the expression *exprr* or *expre*, respectively, to produce a result object that is passed back to the caller or sender as if it were a RETURN or EXIT result. The *expre* or *exprr* is a literal string, a constant symbol, or an expression enclosed in parentheses. If you specify an expression enclosed in parentheses, the language processor evaluates the expression to obtain its character string value. If you do not specify *exprr* or *expre*, no result is passed back to the caller or sender. In either case, the effect is the same as that of the *RETURN* or *EXIT* instruction. The **EXIT** option is the default. Following the return or exit, the appropriate action is taken in the caller or sender (see *Section 11.1, “Action Taken when a Condition Is Not Trapped”*). If specified, the result value can be obtained from the RESULT entry of the condition object.

Example 2.33. Instructions — RAISE

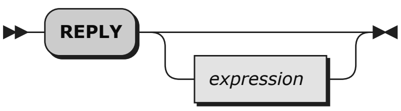
```
raise syntax 40                      /* Raises syntax error 40                */
raise syntax 40.12 array (1, number) /* Raises syntax error 40, subcode 12    */
                                     /* Passing two substitution values       */
raise syntax (errnum)                /* Uses the value of the variable ERRNUM */
                                     /* as the syntax error number            */
raise user badvalue                  /* Raises user condition BADVALUE        */
```

If you specify PROPAGATE, and there is a currently trapped condition, this condition is raised again in the caller (for a routine) or sender (for a method). Any ADDITIONAL, DESCRIPTION, ARRAY, RETURN, or EXIT information specified on the RAISE instruction replaces the corresponding values for the currently trapped condition. A SYNTAX error occurs if no condition is currently trapped.

Example 2.34. Instructions — RAISE

```
signal on syntax
a = "xyz"
c = a+2                /* Raises the SYNTAX condition             */
.
.
.
exit
syntax:
  raise propagate      /* Propagates SYNTAX information to caller */
```

2.24. REPLY



REPLY sends an early reply from a method to its caller. The method issuing REPLY returns control, and possibly a result, to its caller to the point from which the message was sent; meanwhile, the method issuing REPLY continues running on a newly created thread.

If you specify *expression*, it is evaluated and the object resulting from the evaluation is passed back. If you omit *expression*, no object is passed back.

Unlike RETURN or EXIT, the method issuing REPLY continues to run after the REPLY until it issues an EXIT or RETURN instruction. The EXIT or RETURN must not specify a result expression.

Example 2.35. Instructions — REPLY

```
reply 42           /* Returns control and a result    */
call tidyup        /* Can run in parallel with sender */
return
```

Notes:

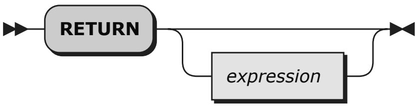
1. You can use REPLY only in a method.

2. A method can execute only one REPLY instruction.

3. When the method issuing the REPLY instruction is the only active method on the current thread with exclusive access to the object's variable pool, the method retains exclusive access on the new thread. When other methods on the thread also have access, the method issuing the REPLY releases its access and reacquires the access on the new thread. This might force the method to wait until the original activity has released its access.

See *Chapter 12, Concurrency* for a complete description of concurrency.

2.25. RETURN



RETURN returns control, and possibly a result, from a Rexx program, method, or routine to the point of its invocation.

If no internal routine (subroutine or function) is active, RETURN and *EXIT* are identical in their effect on the program that is run.

If called as a routine, *expression* (if any) is evaluated, control is passed back to the caller, and the Rexx special variable RESULT is set to the value of *expression*. If you omit *expression*, the special variable RESULT is dropped (becomes uninitialized). The various settings saved at the time of the *CALL* (for example, tracing and addresses) are also restored.

If a function call is active, the action taken is identical, except that *expression* must be specified on the RETURN instruction. The result of *expression* is then used in the original expression at the point where the function was called. See *Chapter 7, Functions* for more details.

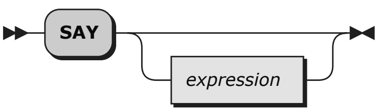
If a method is processed, the language processor evaluates *expression* (if any) and returns control to the point from which the method's activating message was sent. If called as a term of an expression, *expression* is required. If called as a message instruction, *expression* is optional and is assigned to the Rexx special variable RESULT if a return *expression* is specified. If the method has previously issued a REPLY instruction, the RETURN instruction must not include a result *expression*.

If a PROCEDURE instruction was processed within an internal subroutine or internal function, all variables of the current generation are dropped (and those of the previous generation are exposed) after *expression* is evaluated and before the result is used or assigned to RESULT.

Note

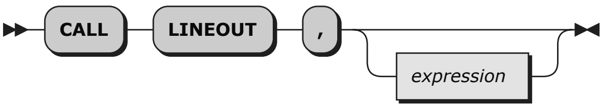
If the RETURN statement causes the program to return to the operating system on a Unix-like systems the value returned is limited to a numerical value between 0 and 255 (an unsigned byte). If no *expression* is supplied then the default value returned to the operating system is zero.

2.26. SAY



SAY writes a line to the default output stream, which displays it to the user. However, the output destination can depend on the implementation. See *Chapter 14, Input and Output Streams* for a discussion of Rexx input and output. The string value of the *expression* result is written to the default character output stream. The resulting string can be of any length. If you omit *expression*, the null string is written.

The SAY instruction is a shorter form of the following instruction:



except that:

- SAY does not affect the special variable RESULT.
- If you use SAY and omit *expression*, a null string is used.
- CALL *LINEOUT* can raise NOTREADY; SAY will not.

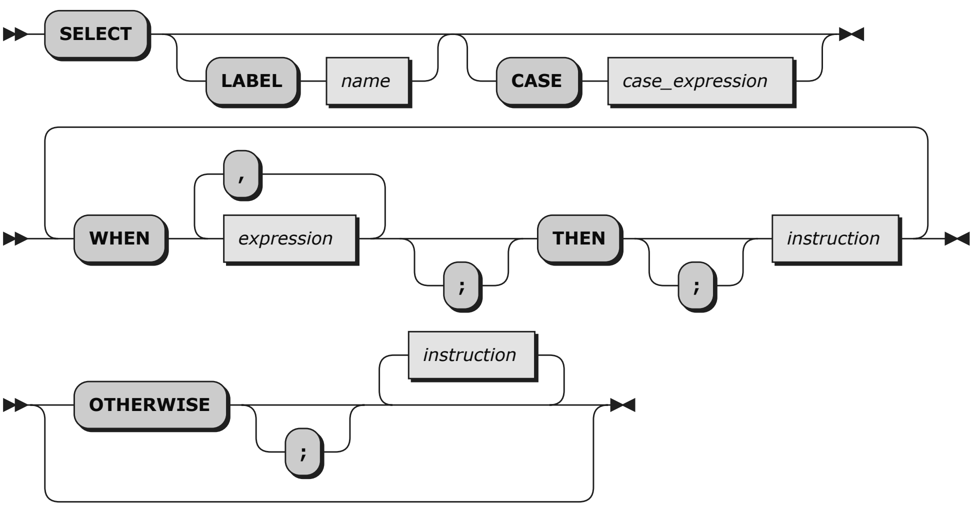
Example 2.36. Instructions — SAY

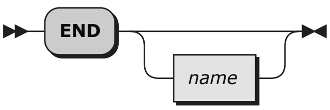
```
data=100
Say data "divided by 4 =>" data/4
/* Displays: "100 divided by 4 => 25"  */
```

Notes:

1. Data from the SAY instruction is sent to the default output stream (.OUTPUT). However, the standard rules for redirecting output apply to the SAY output.
2. The SAY instruction does not format data; the operating system and the hardware handle line wrapping. However, formatting is accomplished, the output data remains a single logical line.

2.27. SELECT





SELECT conditionally calls one of several alternative instructions.

Evaluation of the *expression* list after a WHEN is as follows:

SELECT without CASE

The list of *expressions* after a WHEN is evaluated left-to-right. Each *expression* must evaluate to either **`.false`** or **`.true`**. Evaluation will stop with the first **`.false`** result and **`.false`** will be returned as the condition result.

If all of the *expressions* evaluate to **`.true`**, then the condition result is also **`.true`**.

SELECT CASE

The *case_expression* is evaluated only once, before the first WHEN instruction is processed. The list of *expressions* after a WHEN is evaluated left-to-right. Each *expression* is compared to the result of *case_expression* using "==". Evaluation will stop with the first **`.true`** result and **`.true`** will be returned as the condition result.

If all comparisons evaluate to **`.false`**, then the condition result is also **`.false`**.

If the result from above is **`.true`**, the instruction following the associated THEN (which can be a complex instruction such as IF, DO, LOOP, or SELECT) is processed and control is then passed to the END. If the result is **`.false`**, control is passed to the next WHEN clause.

If none of the WHEN results are **`.true`**, control is passed to the instructions, if any, after OTHERWISE. In this situation, the absence of an OTHERWISE produces an error, however, you can omit the instruction list that follows OTHERWISE.

Example 2.37. Instructions — SELECT

```
balance=100
check=50
balance = balance - check
Select
  when balance > 0 then
    say "Congratulations! You still have" balance "dollars left."
  when balance = 0 then do
    say "Warning, Balance is now zero!  STOP all spending."
    say "You cut it close this month! Hope you do not have any"
    say "checks left outstanding."
    end
  Otherwise do
    say "You have just overdrawn your account."
    say "Your balance now shows" balance "dollars."
    say "Oops!  Hope the bank does not close your account."
    end
end  /* Select */
```

Example 2.38. Instructions — SELECT

```
select
  when answer~datatype('w'), answer//2 = 0 Then
     say answer "is even"
  when answer~datatype('w'), answer//2 = 1 Then
     say answer "is odd"
```

```
  otherwise
     say answer "is not a number"
end
```

The example above is not the same as using the following

```
select
  when answer~datatype('w') & answer//2 = 0 Then
     say answer "is even"
  when answer~datatype('w') & answer//2 = 1 Then
     say answer "is odd"
  otherwise
     say answer "is not a number"
end
```

The logical "&" operator will evaluate both terms of the operation, so the term "answer//2" will result in a syntax error if answer is a non-numeric value. With the list conditional form, evaluation will stop with the first **`.false`** result, so the "answer//2" term will not be evaluated if the datatype test returns **`.false`**.

Example 2.39. Instructions — SELECT CASE

```
select case random(6)
  when 1 then say "bad luck!"
  when 5, 6 then say "great!"
  otherwise say "try again"
end
```

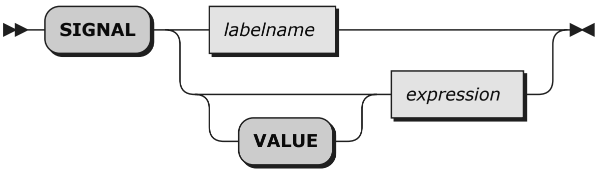
Notes:

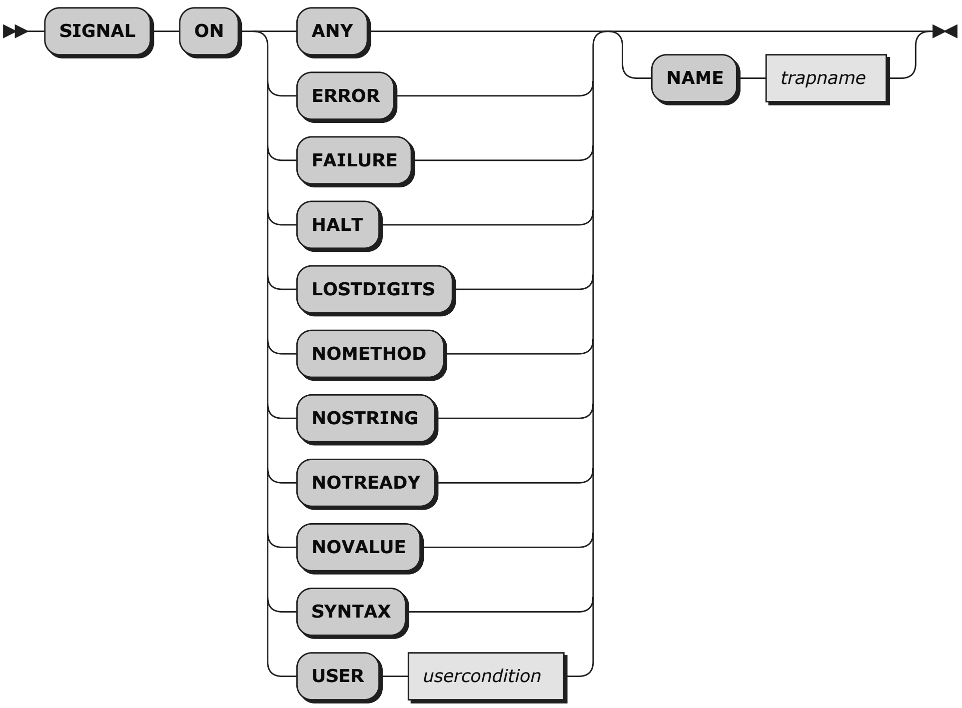
1. The *instruction* can be any assignment, command, message instruction, or keyword instruction, including any of the more complex constructs, such as DO, LOOP, IF, or the SELECT instruction itself.

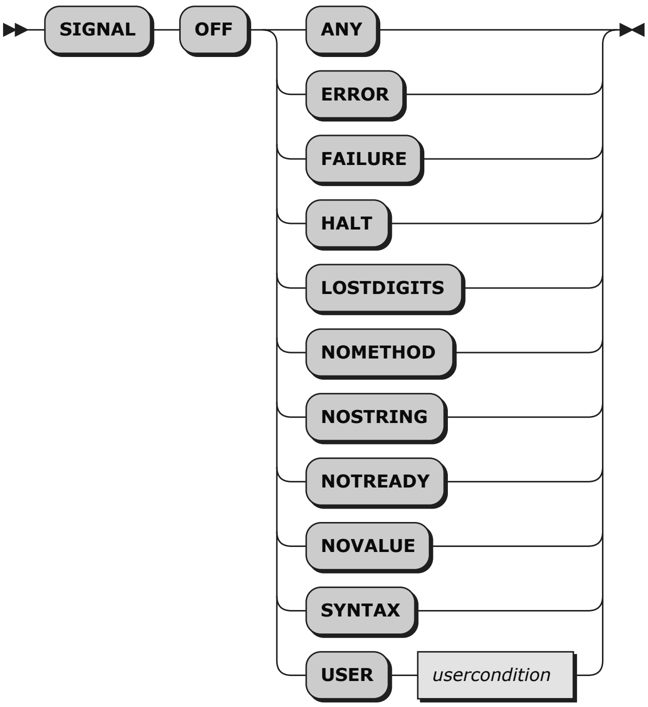
2. A null clause is not an instruction, so putting an extra semicolon (or label) after a THEN clause is not equivalent to putting a dummy instruction. The NOP instruction is provided for this purpose.

3. Except when within a bracketed subexpression, the symbol THEN cannot be used within *expression*, because the keyword THEN is treated differently in that it need not start a clause. This allows the expression on the WHEN clause to be ended by the THEN without a semicolon (;).

2.28. SIGNAL







SIGNAL causes an unusual change in the flow of control (if you specify *labelname* or VALUE *expression*), or controls the trapping of certain conditions (if you specify ON or OFF).

To control trapping, you specify OFF or ON and the condition you want to trap. OFF turns off the specified condition trap. ON turns on the specified condition trap. All information on condition traps is contained in *Chapter 11, Conditions and Condition Traps*.

To change the flow of control, a label name is derived from *labelname* or taken from the character string result of evaluating the *expression* after VALUE. The *labelname* you specify must be a literal string or symbol that is taken as a constant. If you specify a symbol for *labelname*, the search looks for a label with uppercase characters. If you specify a literal string, the search uses the literal string directly. You can locate label names with lowercase letters only if you specify the label as a literal string with the same case. Similarly, for SIGNAL VALUE, the lettercase of *labelname* must match exactly. You can omit the subkeyword VALUE if *expression* does not begin with a symbol or literal string, that is, if it starts with a special character, such as an operator character or parenthesis. All active pending DO, IF, SELECT, and INTERPRET instructions in the current routine are then ended and cannot be resumed. Control is then passed to the first label in the program that matches the given name, as though the search had started at the beginning of the program.

The *labelname* and *usercondition* are single symbols, which are taken as constants. The *trapname* is a string or symbol taken as a constant.

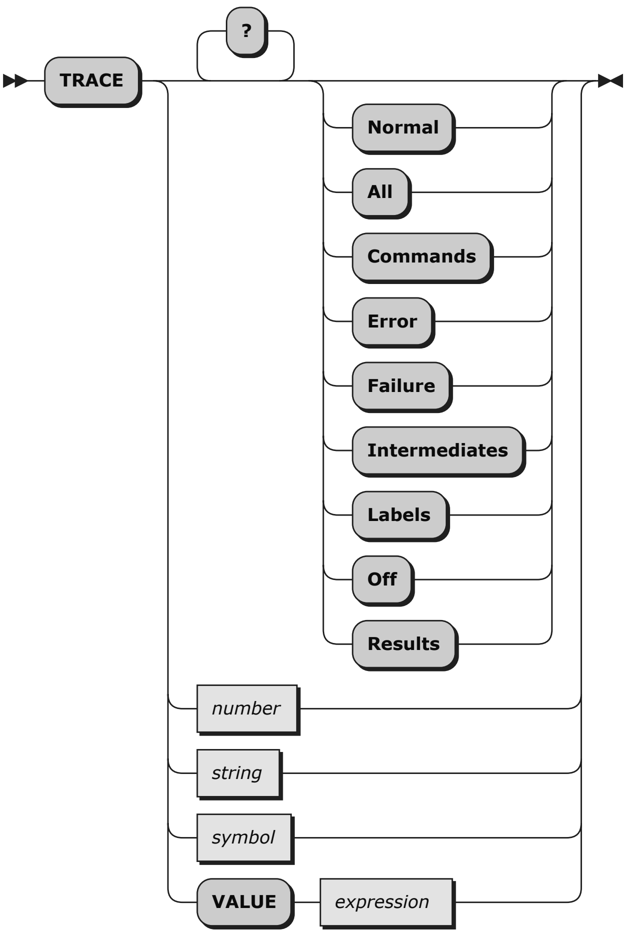
Example 2.40. Instructions — SIGNAL

```
Signal fred;  /* Transfer control to label FRED below */
....
....
Fred: say "Hi!"
```

If there are duplicates, control is always passed to the first occurrence of the label in the program.

When control reaches the specified label, the line number of the SIGNAL instruction is assigned to the special variable SIGL. This can aid debugging because you can use SIGL to determine the source of a transfer of control to a label.

2.29. TRACE



TRACE controls the tracing action (that is, how much is displayed to the user) during the processing of a Rexx program. Tracing describes some or all of the clauses in a program, producing descriptions of clauses as they are processed. TRACE is mainly used for debugging. Its syntax is more concise than that of other Rexx instructions because TRACE is usually entered manually during interactive debugging. (This is a form of tracing in which the user can interact with the language processor while the program is running.)

Note

TRACE cannot be used in the Rexx macrospace.

If specified, the *number* must be a whole number.

The *string* or *expression* evaluates to:

- A numeric option
- One of the valid *prefix* or *alphabetic character (word)* options
- Null

The *symbol* is taken as a constant and is therefore:

- A numeric option
- One of the valid *prefix* or *alphabetic character (word)* options

The option that follows TRACE or the character string that is the result of evaluating *expression* determines the tracing action. You can omit the subkeyword VALUE if *expression* does not begin with a symbol or a literal string, that is, if it starts with a special character, such as an operator or parenthesis.

2.29.1. Trace Alphabetic Character (Word) Options

Although you can enter the word in full, only the first capitalized letter is needed; all following characters are ignored. That is why these are referred to as alphabetic character options.

TRACE actions correspond to the alphabetic character options as follows:

`All`
: Traces (that is, displays) all clauses before execution.

`Commands`
: Traces all *commands* before execution. If the command results in an error or failure, tracing also displays the return code from the command.

`Error`
: Traces any *command* resulting in an error or failure after execution, together with the return code from the command.

`Failure`
: Traces any *command* resulting in a failure after execution, together with the return code from the command. This is the same as the **`Normal`** option.

`Intermediates`
Traces all clauses before execution. Also traces intermediate results during the evaluation of expressions and substituted names.

`Labels`
Traces method and routine invocations, internal subroutine calls, transfers of control because of the SIGNAL instruction, and labels passed during program execution. This is especially useful with debug mode, when the language processor pauses after each invocation or call.

`Normal`
Traces any failing command after execution, together with the return code from the command. This is the default setting, if not overridden using the *::OPTIONS* directive.

For the default Windows command processor, an attempt to enter an unknown command raises a FAILURE condition. The CMD return code for an unknown command is 1. An attempt to enter a command in an unknown command environment also raises a FAILURE condition; in such a case, the variable RC is set to 30.

`Off`
Traces nothing and resets the special prefix option (described later) to OFF.

`Results`
Traces all clauses before execution. Displays the final results (in contrast with **`Intermediates`** option) of the expression evaluation. Also displays values assigned during PULL, ARG, PARSE, and USE instructions. This setting is recommended for general debugging.

2.29.2. Prefix Option

The prefix **?** is valid alone or with one of the alphabetic character options. You can specify the prefix more than once, if desired. Each occurrence of a prefix on an instruction reverses the action of the previous prefix. The prefix must immediately precede the option (no intervening whitespace).

The prefix **?** controls interactive debugging. During normal execution, a TRACE option with a prefix of **?** causes interactive debugging to be switched on. (See *Chapter 15, Debugging Aids* for full details of this facility.) When interactive debugging is on, interpretation pauses after most clauses that are traced. For example, the instruction **`TRACE ?E`** makes the language processor pause for input after executing any command that returns an error, that is, a nonzero return code or explicit setting of the error condition by the command handler.

Any TRACE instructions in the program being traced are ignored to ensure that you are not taken out of interactive debugging unexpectedly.

You can switch off interactive debugging in several ways:

- Entering **`TRACE O`** turns off all tracing.
- Entering **`TRACE`** with no options restores the defaults—it turns off interactive debugging but continues tracing with TRACE Normal (which traces any failing command after execution).
- Entering **`TRACE ?`** turns off interactive debugging and continues tracing with the current option.
- Entering a TRACE instruction with a **?** prefix before the option turns off interactive debugging and continues tracing with the new option.

Using the **?** prefix, therefore, switches you in or out of interactive debugging. Because the language processor ignores any further TRACE statements in your program after you are in interactive debug mode, use **CALL TRACE "?"** to turn off interactive debugging.

2.29.3. Numeric Options

If interactive debugging is active and the option specified is a positive whole number (or an expression that evaluates to a positive whole number), that number indicates the number of debug pauses to be skipped. (See *Chapter 15, Debugging Aids* for further information.) However, if the option is a negative whole number (or an expression that evaluates to a negative whole number), all tracing, including debug pauses, is temporarily inhibited for the specified number of clauses. For example, **TRACE -100** means that the next 100 clauses that would usually be traced are not displayed. After that, tracing resumes as before.

2.29.4. Tracing Tips

- When a loop is traced, the DO clause itself is traced on every iteration of the loop.
- You can retrieve the trace actions currently in effect by using the *TRACE* built-in function.
- The trace output of commands traced before execution always contains the final value of the command, that is, the string passed to the environment, and the clause generating it.
- Trace actions are automatically saved across subroutine, function, and method calls. See *Section 2.3, "CALL"* for more details.

One of the most common traces you will use is:

Example 2.41. Instructions — TRACE

```
TRACE ?R
/* Interactive debugging is switched on if it was off, */
/* and tracing results of expressions begins.         */
```

2.29.5. The Format of Trace Output

Every clause traced appears with automatic formatting (indentation) according to its logical depth of nesting, for example. Results, if requested, are indented by two extra spaces and are enclosed in double quotation marks so that leading and trailing whitespace characters are apparent. Any control codes in the data encoding (ASCII values less than "20"x) are replaced by a question mark (?) to avoid screen interference. Results other than strings appear in the string representation obtained by sending them a **STRING** message. The resulting string is enclosed in parentheses. The line number in the program precedes the first clause traced on any line. All lines displayed during tracing have a three-character prefix to identify the type of data being traced. These can be:

-

Identifies the source of a single clause, that is, the data actually in the program.

+++

Identifies a trace message. This can be the nonzero return code from a command, the prompt message when interactive debugging is entered, an indication of a syntax error when in interactive debugging.

>I>

Identifies an entry to a routine or method. This trace entry will only appear if tracing is enabled using the ::OPTIONS directive using TRACE A, TRACE R, TRACE I or TRACE L.

>K>

Identifies the result of a subkeyword value in a keyword instruction, like the TO subkeyword of a DO or LOOP instruction, or the DIGITS subkeyword in a NUMERIC instruction.

>>>

Identifies the result of an expression (for **TRACE R**) or the value returned from a subroutine call, or a value evaluated by execution of a DO loop.

>=>

Identifies a variable assignment or a message assignment result. The trace message includes both the name of the assignment target and the assigned value. Assignment trace lines are displayed by assignment instructions, variable assigned via PARSE, ARG, PULL, or USE ARG, as well as control variable updates for DO and LOOP instructions.

>.>

Identifies the value assigned to a placeholder during parsing (see *Section 9.1.2, “The Period as a Placeholder”*).

The following prefixes are used only if **TRACE Intermediates** is in effect:

>A>

Identifies a value used as a function, subroutine, or message argument.

>C>

The data traced is the original name of the compound variable and the name of a compound variable, after the name has been replaced by the value of the variable but before the variable is used. If no value was assigned to the variable, the trace shows the variable in uppercase characters.

>E>

The data traced is the name and value of an environment symbol.

>F>

The data traced is the name and result of a function call.

>L>

The data traced is a literal (string, uninitialized variable, or constant symbol).

>M>

The data traced is the name and result of an object message.

>N>

The data traced is the name and result of a namespace-prefixed symbol.

>O>

The data traced is the name and result of an operation on two terms.

>P>
: The data traced is the name and result of a prefix operation.

>R>
: The data traced is the name of an argument variable and the name of the referenced variable.

>V>
: The data traced is the name and contents of a variable.

Note

The characters **=>** indicate the value of a variable or the result of an operation.

The characters **<=** indicate a value assignment. The name to the left of the marker is the assignment topic. The data to the right of the marker is the assigned value.

The character **?** could indicate a non-printable character in the output.

If no option is specified on a TRACE instruction, or if the result of evaluating the expression is null, the default tracing actions are restored. The defaults are TRACE N and interactive debugging (**?**) off.

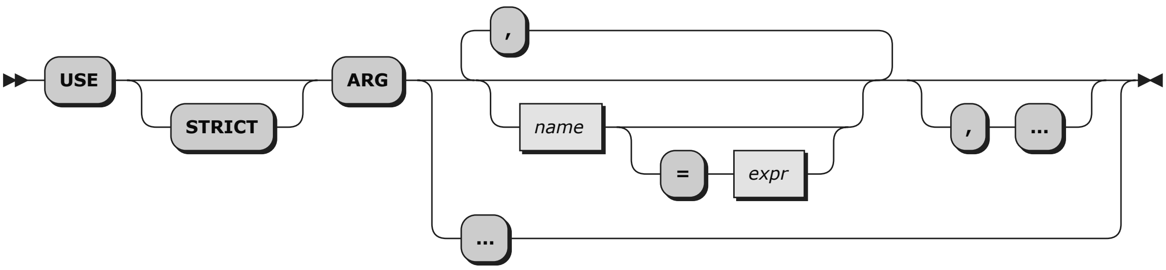
Following a syntax error that SIGNAL ON SYNTAX does not trap, the clause in error is always traced.

2.30. USE

The USE instruction can be used to

- retrieve the argument objects by using *USE ARG or USE STRICT ARG*, or to
- define local variables in a method by using *USE LOCAL*.

2.30.1. USE ARG, USE STRICT ARG



USE ARG retrieves the argument objects provided in a program, routine, function, or method and assigns them to variables, *variable references*, or *message term assignments*.

Each *name* must be a valid variable name, a variable reference term, or an assignment message term. The *name*s are assigned from left to right. For each *name* you specify, the language processor assigns it a corresponding argument from the program, routine, function, or method call. If there is no corresponding argument, *name* is assigned the value of *expr*. If **=** *expr* is not specified for the given argument, the variable *name* is dropped. If the assignment target is a variable reference term, the corresponding argument must never be omitted. If the assignment target is a message term, no action is taken for omitted arguments.

A USE ARG instruction can be processed repeatedly and it always accesses the same current argument data.

If **=** *expr* is specified for an argument, the expression is evaluated to provide a default value for an argument when the corresponding argument does not exist. The default *expr* must be a literal string, a constant symbol, or an expression enclosed in parentheses. No default value is allowed for variable reference terms.

The **STRICT** option imposes additional constraints on argument processing. The number of arguments must match the number of *names*, otherwise an error is raised. An argument is considered optional if *expr* has been specified for the argument.

An ellipsis (`...`) can be specified after the last variable in a USE STRICT ARG statement to indicate that more arguments may follow. This allows defining a minimum number of arguments that must be supplied or for which there are default values defined, which may optionally be followed by any additional arguments.

Example 2.42. Instructions — USE

```
/* USE Example                       */
/* FRED("Ogof X",1,5) calls function */
Fred: use arg string, num1, num2

/* Now: STRING contains "Ogof X"     */
/*      NUM1 contains "1"            */
/*      NUM2 contains "5"            */
```

```
/* Another example, shows how to pass non-string arguments with USE ARG */
/* Pass a stem and an array to a routine to modify one element of each  */
stem.1 = "Value"
array = .array~of("Item")
say "Before subroutine:" stem.1 array[1]  /* Shows "Value Item"         */
Call Change_First stem. , array
say "After subroutine:" stem.1 array[1]   /* Shows "NewValue NewItem"   */
Exit

Change_First: Procedure
  Use Arg substem., subarray
  substem.1 = "NewValue"
  subarray[1] = "NewItem"
  Return
```

```
/* USE STRICT Example                */
/* FRED("Ogof X",1) calls function  */
Fred: use strict arg string, num1, num2=4

/* Now: STRING contains "Ogof X"     */
/*      NUM1 contains "1"            */
/*      NUM2 contains "4"            */
```

In the above example, a call to the function FRED may have either 2 or 3 arguments. The STRICT keyword on the USE instruction will raise a syntax error for any other combination of arguments.

Example 2.43. Instructions — USE

```
call test "one"
call test "one", "two"
call test "one", "two", "three"
```

```
call test "one", , "three", "four", "five"
exit

test: procedure /* a minimum of one argument must be supplied */
  use strict arg v1, v2="zwei", ...
  say "There are ["arg()"] argument(s); v1,v2=["v1","v2"]"
  do i=3 to arg()
    say " arg #" i"=["arg(i)"]"
  end
  say "--"
  return
```

Output:

```
There are [1] argument(s); v1,v2=[one,zwei]
--
There are [2] argument(s); v1,v2=[one,two]
--
There are [3] argument(s); v1,v2=[one,two]
 arg # 3=[three]
--
There are [5] argument(s); v1,v2=[one,zwei]
 arg # 3=[three]
 arg # 4=[four]
 arg # 5=[five]
--
```

The assignment targets may be any term that can be on the left side of an assignment statement.

Example 2.44. Instructions — USE

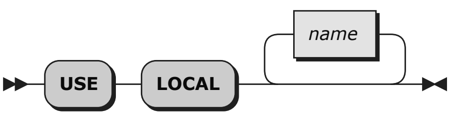
```
expose myArray myDirectory
use arg myArray[1], myDirectory~name
```

would be equivalent to

```
myArray[1] = arg(1)
myDirectory~name = arg(2)
```

You can retrieve or check the arguments by using the *ARG* built-in function. The ARG and PARSE ARG instructions are alternative ways of retrieving arguments. ARG and PARSE ARG access the string values of arguments. USE ARG performs a direct, one-to-one assignment of arguments. This is preferable when you need direct access to an argument, without translation or parsing. USE ARG also allows access to both string and non-string argument objects; ARG and PARSE ARG convert the arguments to string values before parsing.

2.30.2. USE LOCAL



USE LOCAL defines local variables in a method.

Generally object variables must be specified in a method using EXPOSE, while all other variables used in the method will become local variables. In contrast to this, USE LOCAL allows to explicitly declare local variables, while all other variables not listed on the USE LOCAL instruction will automatically become object variables.

Each *name* must be a valid variable name. if no *name* is specified, all variables will become object variables.

If a USE LOCAL instruction is present, it must be the first instruction of the method.

Note that USE LOCAL will always keep Rexx special variables RC, RESULT, SIGL, SELF, and SUPER as local variables.

Example 2.45. Instructions — USE LOCAL

```
::method init
USE LOCAL x y z   -- only x, y, and z are local
                  -- all other become object variables

::method init
use local         -- any variable is an object variable
```

Directives

A Rexx program contains one or more executable code units. *Directive instructions* separate these executable units. A directive begins with a double colon (::) and is a nonexecutable instruction. For example, it cannot appear in a string for the INTERPRET instruction to be interpreted. The first directive instruction in a program marks the end of the main executable section of the program.

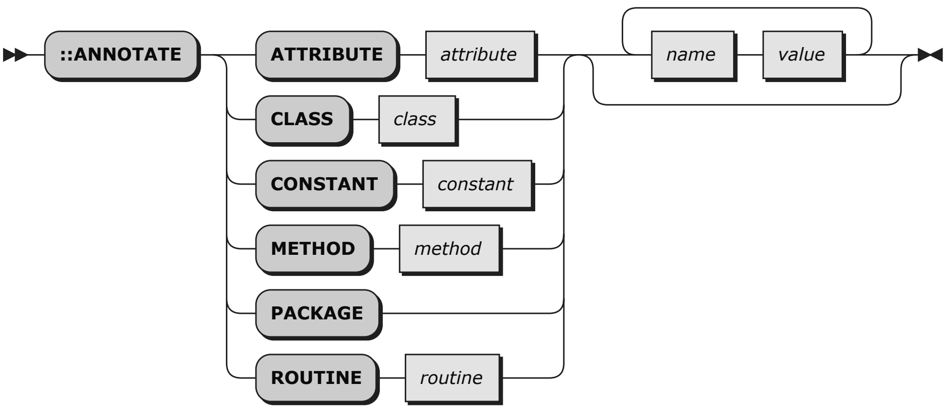
For a program containing directives, all directives are processed first to set up the program's classes, methods, and routines. Then any program code in the main code unit (preceding the first directive) is processed. This code can use any classes, methods, and routines that the directives established.

Supported directives are *::ANNOTATE*, *::ATTRIBUTE*, *::CLASS*, *::CONSTANT*, *::METHOD*, *::OPTIONS*, *::REQUIRES*, *::RESOURCE*, and *::ROUTINE*.

A directive requires a semicolon (`;`) as a terminating delimiter unless the end of a line implies it.

3.1. ::ANNOTATE

The ::ANNOTATE directive creates annotations to the package, its classes, methods, attributes, constants, or routines.



The ::ANNOTATE directive can add metadata information (called "annotations") in the form of *name/value* pairs to the current package, or any of its classes, methods, attributes, constants, and routines.

An annotation *attribute*, *class*, *constant*, *method*, and *routine* must be a valid class name, constant name, method name, or routine name defined with its respective directive in the same source program.

The annotation *name* must be a symbol that is taken as a constant; a literal string is not allowed. The annotation *value* must be a single literal string, a symbol, or a valid number, optionally preceded by a plus or minus sign, that is taken as a constant.

Example 3.1. ANNOTATE directive

```
::annotate package author "B. Fox"                  -- annotate current package

::class command

::attribute address
::attribute command

::method init
```

```
use strict arg command, address = ""
self~command = command
self~address = address

::annotate class command languagelevel "6.05"       -- annotate class COMMAND
::annotate attribute command os "unix windows mac" -- annotate attribute COMMAND
::annotate method init version "100" maxParms 2    -- annotate method INIT
```

Notes:

1. Each ::ANNOTATE directive, except for ::ANNOTATE PACKAGE, must be placed **after** its respective ::ATTRIBUTE, ::CLASS, ::CONSTANT, ::METHOD, or ::ROUTINE directive in the sourcefile.

2. When annotating non-floating attributes, constants, or methods, the ::ANNOTATE directive must precede any following ::CLASS directive.

3. An annotation for an attribute, a method, or a routine should be placed **after** any attribute/method/routine code body, as ::ANNOTATE, like any other directive, will end the code body.

4. A subclass of an annotated class will not inherit any annotations of its superclass or mixinclass.

5. A copy of an annotated method, package, or routine object will keep any existing annotations.

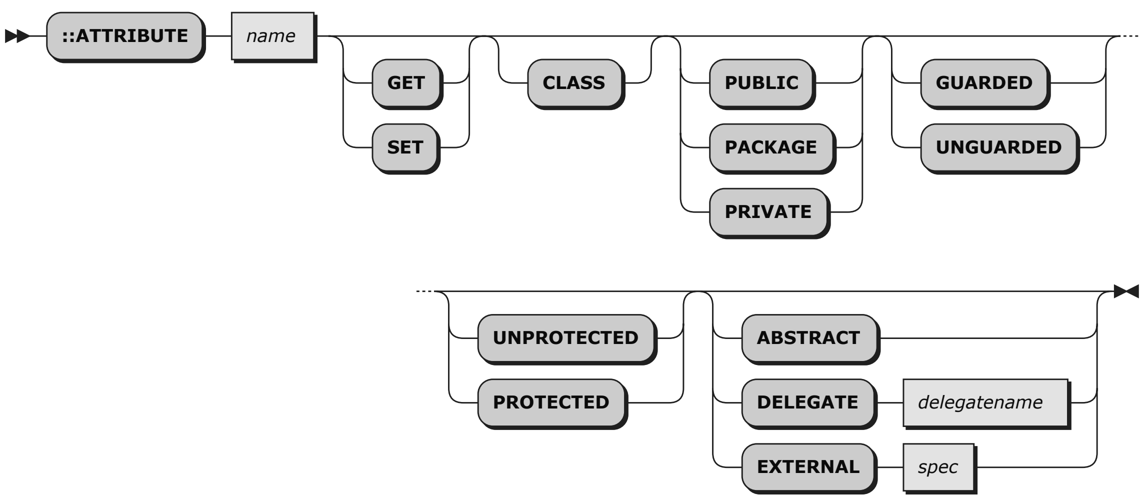
6. The ::ANNOTATE directive cannot be used to annotate packages, classes, methods, attributes, constants, and routines which are provided by Rexx or have been made available through a ::REQUIRES directive.

7. Currently Rexx does not use or predefine any specific annotation *names*.

8. To query an annotation *name/value* pair, to get a list of all attached annotation *name/value* pairs, or to add new or change existing annotations, use
   - the Package methods *annotation* and *annotations*,
   - the Class methods *annotation* and *annotations*,
   - the Method methods *annotation* and *annotations*, or
   - the Routine methods *annotation* and *annotations*.

3.2. ::ATTRIBUTE

The ::ATTRIBUTE directive creates attribute methods and defines the method properties.



The ::ATTRIBUTE directive creates accessor methods for object instance variables. An accessor method allows an object instance variable to be retrieved or assigned a value. ::ATTRIBUTE can create an attribute getter method, a setter method, or the getter/setter pair.

The *name* is a literal string or a symbol that is taken as a constant. The *name* must also be a valid Rexx variable name. The ::ATTRIBUTE directive creates methods in the class specified in the most recent ::CLASS directive. If no ::CLASS directive precedes an ::ATTRIBUTE directive, the attribute methods are not associated with a class but are accessible to the main (executable) part of a program through the *.METHODS built-in object*. Only one ::ATTRIBUTE directive can appear for any method name not associated with a class.

If you do not specify either **GET** or **SET**, ::ATTRIBUTE will create two attribute methods with the names *name* and *name*=. These are the methods for getting and setting an attribute. These generated methods are equivalent to the following code sequences:

Example 3.2. ATTRIBUTE directive equivalent code

```
::method name          -- attribute get method
  expose name          -- establish direct access to object variable (attribute)
  use strict arg       -- enforce zero parameters
  return name          -- return object variable's current value

::method "NAME="       -- attribute set method
  expose name          -- establish direct access to object variable (attribute)
  use strict arg name -- retrieve argument and assign it to the object variable
```

Both methods will be created with the same method properties (for example, PRIVATE, GUARDED, etc.). If **GET** or **SET** are not specified, the pair of methods will be automatically generated. In that case, there is no method code body following the directive, so another directive (or the end of the program) must follow the ::ATTRIBUTE directive.

If **GET** or **SET** is specified, only the single get or set attribute method is generated. Specifying separate **GET** or **SET** ::ATTRIBUTE directives allows the methods to be created with different properties. For example, the sequence:

```
::attribute name get
::attribute name set private
```

will create a `NAME` method with PUBLIC access and a `NAME=` method with PRIVATE access.

The **GET** and **SET** options may also be used to override the default method body generated for the attribute. This is frequently used so the SET attribute method can perform new value validation.

Example 3.3. ATTRIBUTE directive — get and set methods

```
::attribute size get
::attribute size set
  expose size     /* establish direct access to object variable (attribute) */
  use arg value   /* retrieve argument                                      */
  if datatype(value, "Whole") = .false | value < 0  then
    raise syntax 93.906 array ("size", value)
  size=value
```

If you specify the **CLASS** option, the created methods are class methods. See *Chapter 4, Objects and Classes*. The attribute methods are associated with the class specified on the most recent ::CLASS directive. The ::ATTRIBUTE must be preceded by a ::CLASS directive if **CLASS** is specified.

If **ABSTRACT** is specified, then all created methods will be marked as ABSTRACT and will raise an error if directly invoked. For ABSTRACT methods there is no method code body following the directive, so another directive (or the end of the program) must follow the ::ATTRIBUTE directive.

If **DELEGATE** is specified, execution of get method *name* and set method *name=* (depending on whether **GET** or **SET** or none of these two is specified on the ::ATTRIBUTE directive) is delegated to object *delegatename*. It is a common design pattern to delegate method execution to an embedded object. The directive for such a delegation

```
::attribute name delegate delegateName
```

is equivalent to the following code sequence:

Example 3.4. DELEGATE subkeyword equivalent code

```
::method name
expose delegateName
forward to(delegateName)

::method "NAME="
expose delegateName
forward to(delegateName)
```

If the **EXTERNAL** option is specified, then *spec* identifies a method in an external native library that will be invoked as the named method. The *spec* is a literal string containing a series of whitespace-delimited tokens defining the external method. The first token must be **LIBRARY**, which indicates the method resides in a native library of the type allowed on a ::REQUIRES directive. The second token must identify the name of the external library. The external library is located using platform-specific mechanisms for loading libraries. For Unix-like systems, the library name is case-sensitive. The third token is optional and specifies the name of the method within the library package. If not specified, the ::METHOD name is used. The target package method name is case insensitive.

If the **GET** or **SET** option is not specified with the **EXTERNAL** option, then two method objects need to be created. The target method name is appended to the string "GET" to derive the name of the getter attribute method. To generate the setter attribute method, the name is appended to the string "SET". If **GET** or **SET** is specified and the method name is not specified within *spec*, then the target library method name is generated by concatenating *name* with "GET" or "SET" as appropriate. If the method name is specified in *spec* and **GET** or **SET** is specified, the spec name will be used unchanged.

Example 3.5. ATTRIBUTE directive — naming the get and set methods

```
-- maps "NAME" method to "GETNAME and
-- "NAME=" to "SETNAME"
::ATTRIBUTE name EXTERNAL "LIBRARY mylib"
-- maps "ADDRESS" method to "GETADDRESS"
::ATTRIBUTE address GET EXTERNAL "LIBRARY mylib"
-- maps "ADDRESS=" method to "setHomeAddress"
::ATTRIBUTE address SET EXTERNAL "LIBRARY mylib setHomeAddress"
```

Notes:

1. You can specify all options in any order.

2. If you specify the **PACKAGE** option, the methods are created with a package-scope, if you specify the **PRIVATE** option, the created methods are private methods. Package-scope and private methods have restricted access rules on how they can be invoked. See *Section 4.2.8, "Public, Package-Scope, and Private Methods"* for details of how these methods can be used. If you omit the **PACKAGE** or **PRIVATE** option, or specify **PUBLIC**, the method is a public method that any sender can activate.

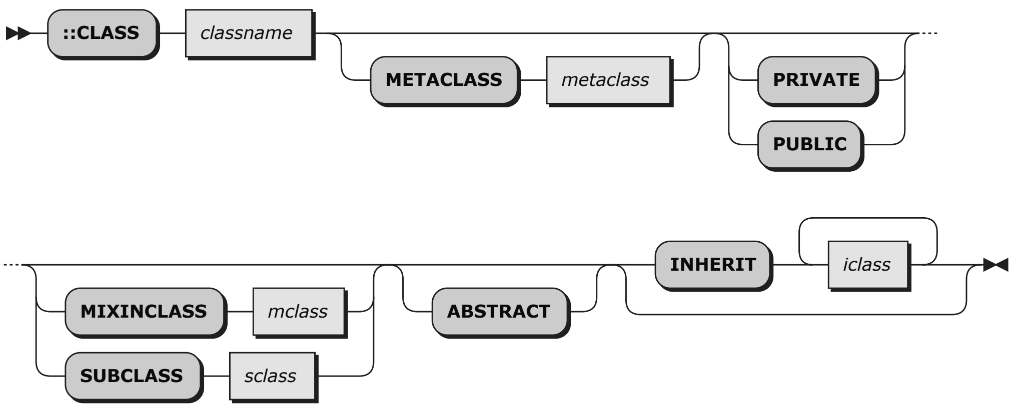
3. If you specify the **UNGUARDED** option, the methods can be called while other methods are active on the same object. If you do not specify **UNGUARDED**, the method requires exclusive use of the object variable pool; it can run only if no other method that requires exclusive use of the object variable pool is active on the same object.

4. If you specify the **PROTECTED** option, the methods are protected methods. (See *Chapter 13, The Security Manager* for more information.) If you omit the **PROTECTED** option or specify **UNPROTECTED**, the methods are not protected.

5. It is an error to specify ::ATTRIBUTE more than once within a class definition that creates a duplicate get or set method.

3.3. ::CLASS

The ::CLASS directive causes the interpreter to create a Rexx class.



The ::CLASS directive creates a Rexx class named *classname*. The *classname* is a literal string or symbol that is taken as a constant. The created class is available to programs through the Rexx environment symbol .*classname*. The *classname* acquires all methods defined by subsequent ::METHOD directives until the end of the program or another ::CLASS directive is found. Only null clauses (comments or blank lines) can appear between a ::CLASS directive and any following directive instruction or the end of the program. Only one ::CLASS directive can appear for *classname* in a program.

If you specify the **METACLASS** option, the instance methods of the *metaclass* class become class methods of the *classname* class. (See *Chapter 4, Objects and Classes*.) The *metaclass* and *classname* are literal strings or symbols that are taken as constants. In the search order for methods, the metaclass methods precede inherited class methods and follow any class methods defined by ::METHOD directives with the **CLASS** option.

If you specify the **PUBLIC** option, the class is visible beyond its containing Rexx program to any other program that references this program with a *::REQUIRES directive*. If you do not specify the **PUBLIC** option, the class is visible only within its containing Rexx program. All public classes defined within a program are used before PUBLIC classes created with the same name.

If you specify the **SUBCLASS** option, the class becomes a subclass of the class *sclass* for inheritance of instance and class methods. The *sclass* is a literal string or symbol that is taken as a constant.

If you specify the **MIXINCLASS** option, the class becomes a subclass of the class *mclass* for inheritance of instance and class methods. You can add the new class instance and class methods to existing classes by using the **INHERIT** option on a ::CLASS directive or by sending an `INHERIT` message to an existing class. If you specify neither the **SUBCLASS** nor the **MIXINCLASS** option, the class becomes a non-mixin subclass of the Object class.

If you specify the **ABSTRACT** option, the class will be marked as an abstract class. Trying to create an instance of an abstract class will raise an error. Only subclasses of abstract classes will allow to create instances from.

If you specify the **INHERIT** option, the class inherits instance methods and class methods from the classes *iclasses* in their order of appearance (leftmost first). This is equivalent to sending a series of *inherit* messages to the class object, with each `inherit` message (except the first) specifying the preceding class in *iclasses* as the *classpos* argument. As with the `inherit` message, each of the classes in *iclasses* must be a mixin class. The *iclasses* is a whitespace-separated list of literal strings or symbols that are taken as constants. If you omit the **INHERIT** option, the class inherits only from *sclass*.

Example 3.6. CLASS directive

```
::class rectangle
::method area    /* defined for the RECTANGLE class */
  expose width height
  return width*height

::class triangle
::method area    /* defined for the TRIANGLE class */
  expose width height
  return width*height/2
```

The ::CLASS directives in a program are processed in the order in which they appear. If a ::CLASS directive has a dependency on ::CLASS directives that appear later in the program, processing of the directive is deferred until all of the class's dependencies have been processed.

Example 3.7. CLASS directive deferred processing

```
::class savings subclass account  /* requires the ACCOUNT class */
::method type
  return "a Savings Account"

::class account
::method type
  return "an Account"
```

The Savings class in the preceding example is not created until the Account class that appears later in the program has been created.

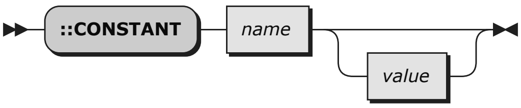
Notes:

1. You can specify the options **METACLASS**, **MIXINCLASS**, **SUBCLASS**, and PUBLIC in any order.

2. If you specify **INHERIT**, it must be the last option.

3.4. ::CONSTANT

The ::CONSTANT directive creates methods that return constant values for a class and its instances.



A ::CONSTANT directive defines a method that returns a constant value. This is useful for creating named constants associated with a class.

The *name* is a literal string or a symbol that is taken as a constant. A method of the given name is created as both an instance method and a class method of the most recent ::CLASS directive. A ::CLASS directive is not required before a ::CONSTANT directive. If no ::CLASS directive precedes ::CONSTANT, a single "floating" constant method is created that is not associated with a class but is accessible through the *.METHODS built-in object*. Only one ::CONSTANT directive can appear for any method name not associated with a class.

The methods created by a ::CONSTANT directive are UNGUARDED and will have a return result that is specified by *value*. If specified, the constant *value* must be a single literal string, a symbol that is taken as a constant, or an expression enclosed in parentheses. Also permitted is the single character "**-**" or "**+**" followed by a symbol that is a valid number. If *value* is omitted, the constant *name* will return its value in uppercase.

Here are some examples of valid constants:

Example 3.8. CONSTANT examples

```
::class MathConstants public
::constant pi 3.14159265
::constant author "Isaac Asimov"
::constant absolute_zero -273.15
::constant e ( rxcalcexp(1) )
::constant eSquare (self~e ** 2)
::constant primes (2, 3, 5, 7, 11, 13)

::class Search
::constant caseless

::requires rxmath library
```

A ::CONSTANT directive is a shorthand syntax for creating constants associated with a class. The created name constant can be accessed using either the class object or an instance of the class itself.

Example 3.9. CONSTANT access examples

```
say "Pi is" .MathConstants~pi    -- displays "Pi is 3.14159265"
instance = .MathConstants~new
say "Pi is" instance~pi          -- also displays "Pi is 3.14159265"

say .Search~caseless             -- "CASELESS"

::class MathConstants public
::constant pi 3.14159265

::class Search
::constant caseless
```

Notes:

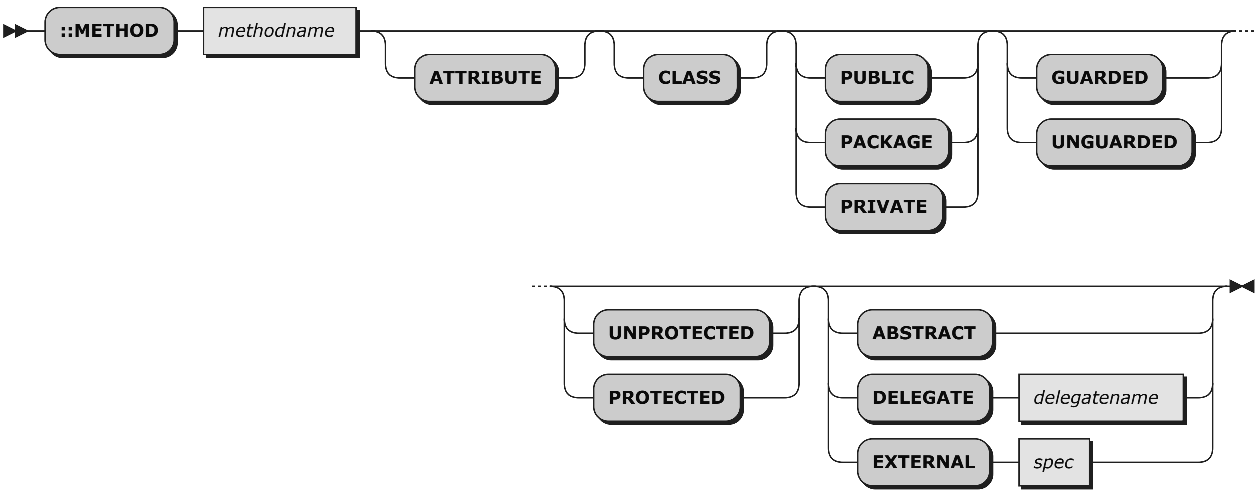
1. Calculated ::CONSTANT directives (where *value* is an expression enclosed in parenthesis) can reference any other constant ::CONSTANT directives (where *value* is omitted, a single literal string, a symbol that is taken as a constant, or a valid number optionally preceded by "**-**" or "**+**"). For a calculated ::CONSTANT directive to reference another calculated ::CONSTANT directive, the referenced directive must be defined earlier in order of appearance. Forward references to calculated ::CONSTANT directives are not allowed.

2. For a floating ::CONSTANT directive the constant *value* must be a single literal string, or a symbol that is taken as a constant. An expression enclosed in parentheses is not allowed.

3. A ::CONSTANT directive cannot have a method body.

3.5. ::METHOD

The ::METHOD directive creates a method object and defines the method attributes.



A ::METHOD directive creates method objects that may be associated with a class instance. The created method may be from Rexx code, mapped to method in an external native library, or automatically generated. The type of method is determined by the combination of options specified.

The *methodname* is a literal string or a symbol that is taken as a constant. The method is defined as *methodname* in the class specified in the most recent ::CLASS directive. Only one ::METHOD directive can appear for any *methodname* in a class.

A ::CLASS directive is not required before a ::METHOD directive. If no ::CLASS directive precedes ::METHOD, the method is not associated with a class but is accessible to the main (executable) part of a program through the *.METHODS built-in object*. Only one ::METHOD directive can appear for any method name not associated with a class.

If you specify the **CLASS** option, the method is a class method. See *Chapter 4, Objects and Classes*. The method is associated with the class specified on the most recent ::CLASS directive. The ::METHOD directive must follow a ::CLASS directive when the **CLASS** option is used.

If **ABSTRACT** is specified, then the created method will be marked as an abstract method and will raise an error if directly invoked. For abstract methods there is no method code body following the directive, so another directive (or the end of the program) must follow the ::METHOD directive.

If **ABSTRACT**, **ATTRIBUTE**, or **EXTERNAL** is not specified, the ::METHOD directive starts a section of method code which is ended by another directive or the end of the program. The ::METHOD is not included in the source of the created METHOD object.

Example 3.10. METHOD examples

```
r = .rectangle~new(20,10)
say "Area is" r~area       /* Produces "Area is 200" */

::class rectangle

::method area              /* defined for the RECTANGLE class */
  expose width height
  return width*height

::method init
  expose width height
  use arg width, height

::method perimeter
  expose width height
  return (width+height)*2
```

If you specify the **ATTRIBUTE** option, method variable accessor methods are created. In addition to generating a method named *methodname*, another method named *methodname*= is created. The first method returns the value of object instance variable that matches the method name. The second method assigns a new value to the object instance variable.

For example, the directive

```
::method name attribute
```

creates two methods, NAME and NAME=, equivalent to the following code sequences:

```
::method name          -- attribute get method
  expose name          -- establish direct access to object variable (attribute)
  use strict arg       -- enforce zero parameters
  return name          -- return object variable's current value

::method "NAME="       -- attribute set method
  expose name          -- establish direct access to object variable (attribute)
  use strict arg name -- retrieve argument and assign it to the object variable
```

Using the **ATTRIBUTE** option is equivalent to using the *::ATTRIBUTE* directive.

If you specify the **ABSTRACT** option, the method creates an ABSTRACT method placeholder. ABSTRACT methods define a method that an implementing subclass is expected to provide a concrete implementation for. Any attempt to invoke an ABSTRACT method directly will raise a SYNTAX condition.

If **DELEGATE** is specified, execution of method *name* is delegated to object *delegatename*. It is a common design pattern to delegate method execution to an embedded object. The directive for such a delegation

```
::method name delegate delegateName
```

is equivalent to the following code sequence:

Example 3.11. DELEGATE subkeyword equivalent code

```
::method name
expose delegateName
forward to(delegateName)
```

If the **EXTERNAL** option is specified, then *spec* identifies a method in an external native library that will be invoked as the named method. The *spec* is a literal string containing a series of whitespace delimited tokens defining the external method. The first token must be **LIBRARY**, which indicates the method resides in a native library of the type allowed on a ::REQUIRES directive. The second token must identify the name of the external library. The external library is located using platform-specific mechanisms for loading libraries. For Unix-like systems, the library name is case-sensitive. The third token is optional and specifies the name of the method within the library package. If not specified, the ::METHOD name is used. The target package method name is case insensitive.

Example 3.12. METHOD EXTERNAL examples

```
-- creates method INIT from method RegExp_Init in library rxregexp
::METHOD INIT EXTERNAL "LIBRARY rxregexp RegExp_Init"

-- creates method RegExp_Parse from library rxregexp
::METHOD RegExp_Parse EXTERNAL "LIBRARY rxregexp"
```

If the **ATTRIBUTE** option is specified with the **EXTERNAL** option, then two method objects need to be created. The target method name is appended to the string "GET" to derive the name of the getter attribute method. To generate the setter attribute method, the name is appended to the string "SET".

Example 3.13. METHOD EXTERNAL examples

```
-- maps "NAME" method to "GETNAME and
-- "NAME=" to "SETNAME"
::METHOD name ATTRIBUTE EXTERNAL "LIBRARY mylib"

-- maps "ADDRESS" method to "GETMyAddress and
-- "ADDRESS=" to "SETMyAddress"
::METHOD address ATTRIBUTE EXTERNAL "LIBRARY mylib MyAddress"
```

Notes:

1. You can specify all options in any order.

2. If you specify the **PACKAGE** option, the method is created with a package-scope, if you specify the **PRIVATE** option, the created method is a private method. Package-scope and private methods have restricted access rules on how they can be invoked. See *Section 4.2.8, “Public, Package-Scope, and Private Methods”* for details of how these methods can be used. If you omit the **PACKAGE** or **PRIVATE** option, or specify **PUBLIC**, the method is a public method that any sender can activate.

3. If you specify the **UNGUARDED** option, the method can be called while other methods are active on the same object. If you do not specify **UNGUARDED**, the method requires exclusive use of the

object variable pool; it can run only if no other method that requires exclusive use of the object variable pool is active on the same object.

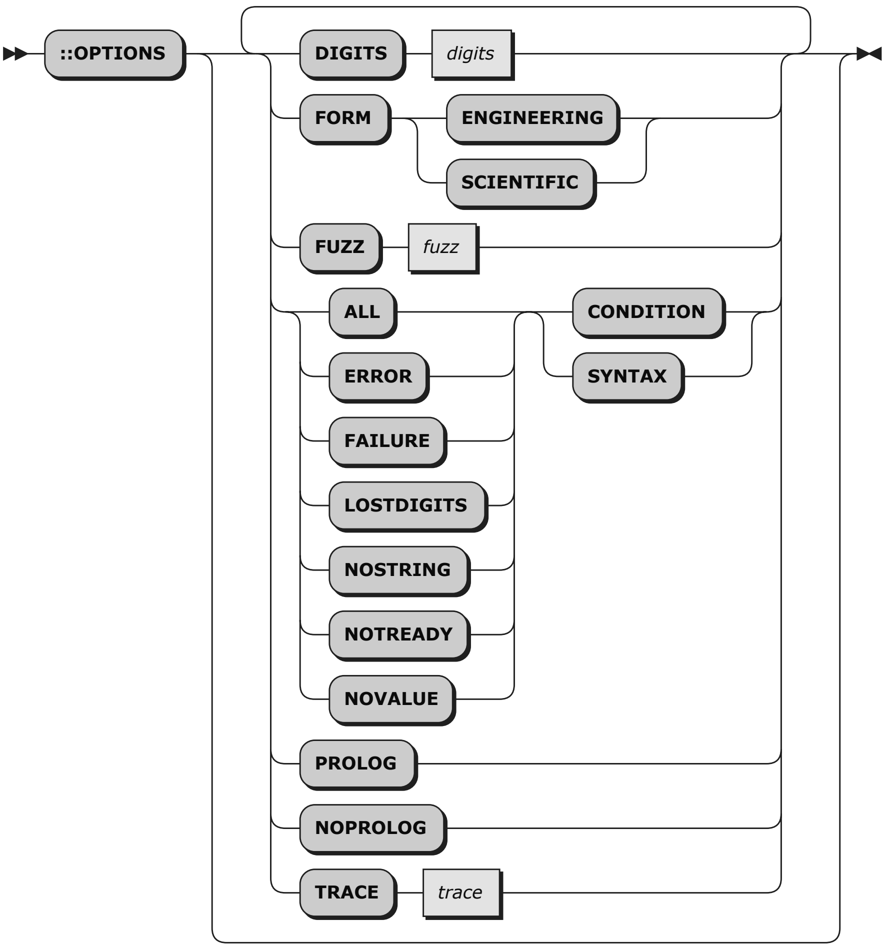
4. If you specify the **PROTECTED** option, the method is a protected method. (See *Chapter 13, The Security Manager* for more information.) If you omit the **PROTECTED** option or specify **UNPROTECTED**, the method is not protected.

5. If you specify **ATTRIBUTE**, **ABSTRACT**, or **EXTERNAL**, another directive (or the end of the program) must follow the ::METHOD directive.

6. It is an error to specify ::METHOD more than once within the same class and use the same *methodname*.

3.6. ::OPTIONS

The ::OPTIONS directive defines default values for numeric, trace, and other runtime settings for all Rexx code contained within a package.



Any of the options may be specified on a single ::OPTIONS directive in any order. If an option is specified more than once, the last specified value will the be one used. If more than one ::OPTIONS directive appears in a source file, the options are processed in the order they appear and the effect is accumulative. If a given option type is specified on more than one directive, the last specified will be the value used.

The specified options will override the normal default settings for all Rexx code contained in the source file. For example,

```
::OPTIONS DIGITS 20
```

would direct that all method and routine code defined in this source package execute with an initial *NUMERIC* DIGITS setting of 20 digits. The ::OPTIONS directive controls only the initial setting. A method or routine may change the current setting with the NUMERIC DIGITS instruction as normal. The values specified with ::OPTIONS only apply to code that appears in the same source file. It does not apply to code in other source files that may reference or use this code. For example, a subclass of a class defined in this source package will not inherit the ::OPTIONS settings if the subclass code is located in a different source package.

The following options may be specified on an ::OPTIONS directive:

DIGITS
: controls the precision to which arithmetic operations and built-in functions are evaluated. The value *digits* must be a symbol or string that is a valid positive whole number value and must be larger than the current FUZZ ::OPTIONS setting. The package value can be retrieved using the Package class *digits* method.

  There is no limit to the value for DIGITS (except the amount of storage available), but high precisions are likely to require a great amount of processing time. It is recommended that you use the default value whenever possible.

FORM
: controls the form of exponential notation for the result of arithmetic operations and built-in functions. This can be either **SCIENTIFIC** (in which case only one, nonzero digit appears before the decimal point) or **ENGINEERING** (in which case the power of 10 is always a multiple of 3). The default is **SCIENTIFIC**. The subkeywords **SCIENTIFIC** or **ENGINEERING** must be specified as symbols. The package value can be retrieved using the Package class *form* method.

FUZZ
: controls how many digits, at full precision, are ignored during a *numeric comparison* operation. The value *fuzz* must be a symbol or string that is a valid positive whole number value and must be smaller than the current DIGIT ::OPTIONS setting. The package value can be retrieved using the Package class *fuzz* method.

  NUMERIC FUZZ temporarily reduces the value of NUMERIC DIGITS by the NUMERIC FUZZ value during every numeric comparison. The numbers are subtracted under a precision of DIGITS minus FUZZ digits during the comparison and are then compared with 0.

ALL
: is a shortcut for all six ::OPTIONS *condition* directives **ERROR**, **FAILURE**, **LOSTDIGITS**, **NOSTRING**, **NOTREADY**, and **NOVALUE**.

  ::OPTIONS ALL SYNTAX sets all six *conditions* to raise SYNTAX, while ::OPTIONS ALL CONDITION sets all of them to their default state.

ERROR
FAILURE
LOSTDIGITS
NOSTRING
NOTREADY
NOVALUE
: controls whether an ERROR, FAILURE, LOSTDIGITS, NOSTRING, NOTREADY, or NOVALUE condition event raises its associated condition, or raises a SYNTAX condition.

  If ::OPTIONS *condition* CONDITION is in effect, which is the default, the *condition* event raises its associated condition as usual. If ::OPTIONS *condition* SYNTAX is in effect, a SYNTAX condition is raised instead.

  To override an ::OPTIONS *condition* SYNTAX package default, you can use *SIGNAL* ON *condition*, SIGNAL OFF *condition*, SIGNAL ON ANY, or SIGNAL OFF ANY, to raise the associated condition, or raise no condition at all. For *conditions* **ERROR**, **FAILURE**, and **NOTREADY** you can also use *CALL* ON *condition*, CALL OFF *condition*, CALL ON ANY, or CALL OFF ANY, to raise the associated condition, or raise no condition at all.

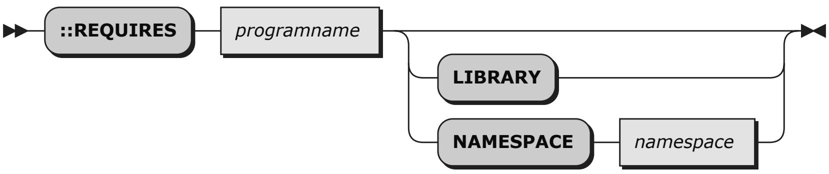
PROLOG
NOPROLOG
: controls whether prolog code (any code in the source program that comes before the first directive) is run when another program requires it through a *::REQUIRES* directive.

If ::OPTIONS PROLOG is in effect, any prolog code is run as usual when the source program is being required using a :REQUIRES directive. If ::OPTIONS NOPROLOG is in effect, any prolog code is not run. The default is ::OPTIONS PROLOG.

TRACE
: controls the tracing action (that is, how much is displayed to the user) during the processing of all Rexx code contained in the package. Tracing describes some or all of the clauses in a program, producing descriptions of clauses as they are processed. TRACE is mainly used for debugging. The value *trace* must be one of the *prefix* or *alphabetic character (word)* options valid for the *TRACE* instruction. The package value can be retrieved using the Package class *trace* method.

3.7. ::REQUIRES

The ::REQUIRES directive specifies that the program requires access to the classes and objects of the Rexx program *programname*.



If the **LIBRARY** option is not specified, all public classes and routines defined in the named program are made available to the executing program. The *programname* is a literal string or a symbol that is taken as a constant. The string or symbol *programname* can be any string or symbol that is valid as the target of a CALL instruction. The program *programname* is called as an external routine with no arguments. The program is searched for using the *external program search order*.

If any Rexx code precedes the first directive in *programname* then that code is executed at the time the ::REQUIRES is processed by the interpreter. This will be executed prior to executing the main Rexx program in the file that specifies the ::REQUIRES statement.

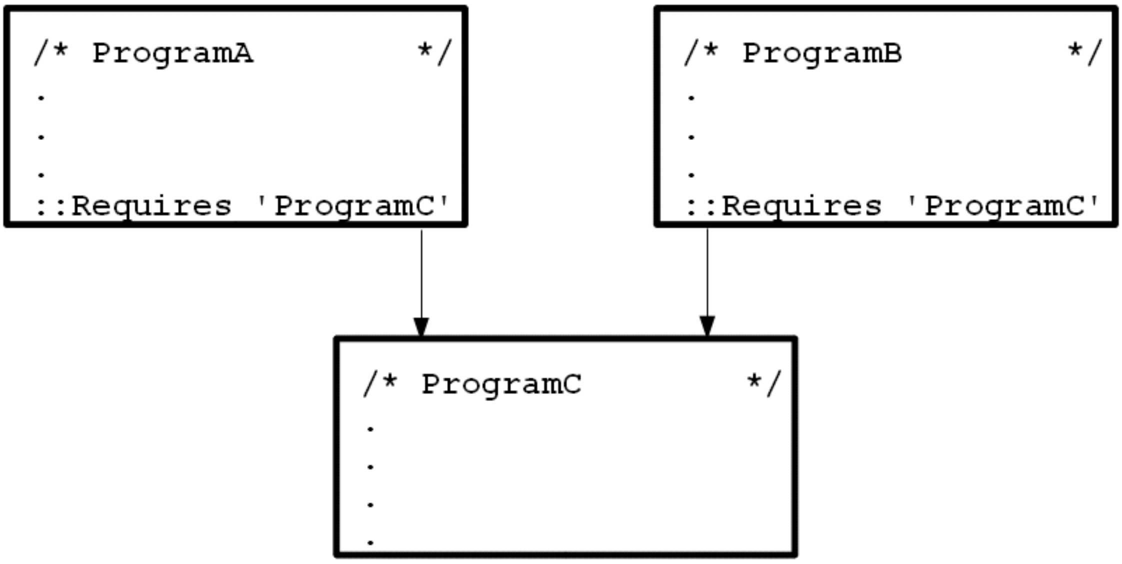
If the **LIBRARY** option is specified, *programname* is the name of an external native library that is required by this program. The library will be loaded using platform-specific mechanisms, which generally means the library name is case sensitive. Any routines defined in the library will be made available to all programs running in the process. If the native library cannot be loaded, the program will not be permitted to run. All LIBRARY ::REQUIRES directives will be processed before ::REQUIRES for Rexx programs, which will ensure that the native libraries are available to the initialization code of the Rexx packages.

If the **NAMESPACE** option is specified, *namespace* must be a symbol that is taken as a constant; a literal string is not allowed.

The **NAMESPACE** option attaches the qualifier *namespace* to the package loaded by the ::REQUIRES directive. To distinguish public classes or public routines of the same name in different ::REQUIRES files, use a namespace-qualified symbol of the form *namespace*`:`*class* or *namespace*`:`*routine*. For details see *Section 1.14, “Namespaces”*.

::REQUIRES directives can be placed anywhere after the main section of code in the package. The order of ::REQUIRES directives determines the search order for classes and routines defined in the named programs and also the load order of the referenced files. Once a program is loaded by a ::REQUIRES statement in a program, other references to that same program by ::REQUIRES statements in other programs will resolve to the previously loaded program. The initialization code for the ::REQUIRES file will only be executed on the first reference.

The following example illustrates that two programs, ProgramA and ProgramB, can both access classes and routines that another program, ProgramC, contains. (The code at the beginning of ProgramC runs prior to the start of the main Rexx program.)

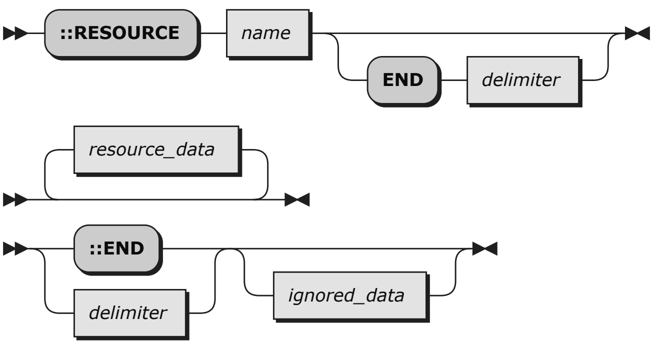


The language processor uses local routine definitions within a program in preference to routines of the same name accessed through ::REQUIRES directives. Local class definitions within a program override classes of the same name in other programs accessed through ::REQUIRES directives.

Another directive, or the end of the program, must follow a ::REQUIRES directive. Only null clauses can appear between them.

3.8. ::RESOURCE

The ::RESOURCE directive allows to include associated data directly in the program code.



The ::RESOURCE directive allows to include lines of *resource_data* of almost arbitrary form directly within the source program.

The resource *name* must be a symbol or a literal string that is taken as a constant. The optional resource end *delimiter* must be a symbol or a literal string that is taken as a constant. If *delimiter* is not specified, it defaults to the string "::END".

Example 3.14. RESOURCE directive

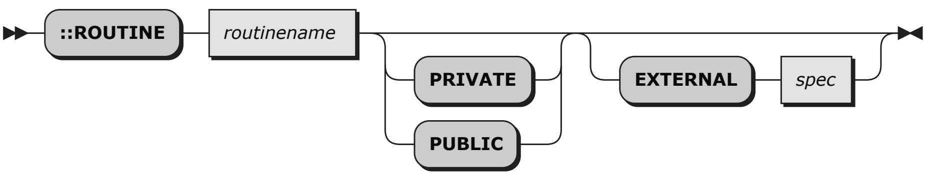
```
::resource greyCat end "-"
La nuit, tous les chats sont gris
---------------------------------

::resource "brown fox"
The quick brown fox jumps over the lazy dog
::END

::resource nollop end ANONYMOUS
     The wicked peon quivered,
then gazed balefully at the judges
         who examined him.
ANONYMOUS TYPESETTER
```

Notes:

1. Specifying more than one ::RESOURCE directive with the same resource *name* is an error.
2. The terminating resource end *delimiter* must start in the first column and is case-sensitive. Any text following on the same line as the terminating *delimiter* is ignored.
3. Although *resource_data* may include almost arbitrary data (including any Rexx code), it is not well-suited for inclusion of binary data. Including special characters like *line-end* or *end-of-file* may cause unwanted results.
4. Resource data is accessible through the *.RESOURCES built-in object*, and the Package class methods *resource* and *resources*.

3.9. ::ROUTINE

The ::ROUTINE directive creates named routines within a program.



The *routinename* is a literal string or a symbol that is taken as a constant. Only one ::ROUTINE directive can appear for any *routinename* in a program.

If the **`EXTERNAL`** option is not specified, the ::ROUTINE directive starts a routine, which is ended by another directive or the end of the program.

If you specify the **`PUBLIC`** option, the routine is visible beyond its containing Rexx program to any other program that references this program with a ::REQUIRES directive. If you do not specify the **`PUBLIC`** option, or specify the **`PRIVATE`** option, the routine is visible only within its containing Rexx program.

Routines you define with the ::ROUTINE directive behave like external routines. In the search order for routines, they follow internal routines and built-in functions but precede all other external routines.

Example 3.15. ROUTINE examples

```
::class c
::method a
call r "A"  /* displays "In method A" */

::method b
call r "B"  /* displays "In method B" */

::routine r
use arg name
say "In method" name
```

If the **EXTERNAL** option is specified, then *spec* identifies a routine in an external native library that will be defined as the named routine for this program. The *spec* is a literal string containing a series of whitespace delimited tokens defining the external function. The first token identifies the type of native routine to locate:

LIBRARY
: Identifies a routine in an external native library of the type supported by the ::REQUIRES directive. The second token must identify the name of the external library. The external library is located using platform-specific mechanisms for loading libraries. For Unix-like systems, the library name is case-sensitive. The third token is optional and specifies the name of the routine within the library package. If not specified, the ::ROUTINE name is used. The routine name is not case sensitive.

REGISTERED
: Identifies a routine in an older-style Rexx function package. The second token must identify the name of the external library. The external library is located using platform-specific mechanisms for loading libraries. For Unix-like systems, the library name is case-sensitive. The third token is optional and specifies the name of the function within the library package. If not specified, the ::ROUTINE name is used. Loading of the function will be attempted using the name as given and as all uppercase. Using **REGISTERED** is the equivalent of loading an external function using the *RXFUNCADD* built-in function.

Example 3.16. ROUTINE EXTERNAL examples

```
-- load a function from rxmath library
::routine RxCalcPi external "LIBRARY rxmath"
-- same function, but a different internal name
::routine Pi external "LIBRARY rxmath RxCalcPi"
-- same as call rxfuncadd "SQLLoadFuncs", "rexxsql", "SQLLoadFuncs"
::routine SQLLoadFuncs EXTERNAL "REGISTERED rexxsql SQLLoadFuncs"
```

Notes:

1. It is an error to specify ::ROUTINE with the same routine name more than once in the same program. It is not an error to have a local ::ROUTINE with the same name as another ::ROUTINE in another program that the ::REQUIRES directive accesses. The language processor uses the local ::ROUTINE definition in this case.

2. Calling an external Rexx program as a function is similar to calling an internal routine. For an external routine, however, the caller's variables are hidden and the internal values (NUMERIC settings, for example) start with their defaults.

Note

If you specify the same ::ROUTINE *routinename* more than once in different programs, the last one is used. Using more than one ::ROUTINE *routinename* in the same program produces an error.

Objects and Classes

This chapter provides an overview of the Rexx class structure.

A Rexx object consists of object methods and object variables ("attributes"). Sending a message to an object causes the object to perform some action; a method whose name matches the message name defines the action that is performed. Only an object's methods can access the object variables belonging to an object. EXPOSE instructions within an object's methods specify which object variables the methods will use. Any variables not exposed are local to the method and are dropped on return from a method.

You can create an object by sending a message to a class object—typically a "new" method. An object created from a class is an *instance* of that class. The methods a class defines for its instances are called the *instance methods* of that class. These are the object methods that are available for every instance of the class. Classes can also define *class methods*, which are a class's own object methods.

Note

When referring to instance methods (for objects other than classes) or class methods (for classes), this book uses the term *methods* when the meaning is clear from the context. When referring to instance methods and class methods of classes, this book uses the qualified terms to avoid possible confusion.

4.1. Types of Classes

There are four kinds of classes:

- Object classes
- Mixin classes
- Abstract classes
- Metaclasses

The following sections explain these.

4.1.1. Object Classes

An *object class* is a factory for producing objects. An object class creates objects (instances) and provides methods that these objects can use. An object acquires the instance methods of the class to which it belongs at the time of its creation. If a class gains additional methods, objects created before the definition of these methods do not acquire the new or changed methods.

The instance variables within an object are created on demand whenever a method EXPOSEs an object variable. The class creates the object instance, defines the methods the object has, and the object instance completes the job of constructing the object.

The *String class* and the *Array class* are examples of object classes.

4.1.2. Mixin Classes

Classes can inherit from more than the single superclass from which they were created. This is called *multiple inheritance*. Classes designed to add a set of instance and class methods to other classes are called *mixin classes*, or simply mixins.

You can add mixin methods to an existing class by sending an INHERIT message or using the INHERIT option on the *::CLASS* directive. In either case, the class to be inherited must be a mixin. During both class creation and multiple inheritance, subclasses inherit both class and instance methods from their superclasses.

Mixins are always associated with a *base class*, which is the mixin's first non-mixin superclass. Any subclass of the mixin's base class can (directly or indirectly) inherit a mixin; other classes cannot. For example, a mixin class created as a subclass of the Array class can only be inherited by other Array subclasses. Mixins that use the Object class as a base class can be inherited by any class.

To create a new mixin class, you send a MIXINCLASS message to an existing class or use the ::CLASS directive with the MIXINCLASS option. A mixin class is also an object class and can create instances of the class.

4.1.3. Abstract Classes

Abstract classes provide definitions for instance methods and class methods but are not intended to create instances. Abstract classes often define the message interfaces that subclasses should implement.

You create an abstract class by specifying the ABSTRACT subkeyword on the ::CLASS directive. Trying to create an instance from an abstract class will result in an error.

It is possible to create abstract methods or attributes on a class. Abstract methods or attributes are placeholders that subclasses are expected to override. Failing to provide a real method or attribute implementation will result in an error when the abstract version is called.

4.1.4. Metaclasses

A *metaclass* is a class you can use to create another class. The Class class is the metaclass of all the classes Rexx provides. This means that instances of .Class are themselves classes. The Class class is like a factory for producing the factories that produce objects.

To change the behavior of an object that is an instance, you generally use subclassing. For example, you can create Statarray, a subclass of the *Array class*. The statArray class can include a method for computing a total of all the numeric elements of an array.

Example 4.1. Creating an array subclass

```
/* Creating an array subclass for statistics */

::class statArray subclass array public

::method init    /*  Initialize running total and forward to superclass */
  expose total
  total = 0
  forward class (super)
```

```
::method put     /*  Modify to increment running total */
  expose total
  use arg value
  total = total + value  /* Should verify that value is numeric!!! */
  forward class (super)

::method "[]="   /*  Modify to increment running total */
  forward message "PUT"

::method remove  /*  Modify to decrement running total */
  expose total
  use arg index
  forward message "AT" continue
  total = total - result
  forward class (super)

::method average /*  Return the average of the array elements */
  expose total
  return total / self~items

::method total   /*  Return the running total of the array elements */
  expose total
  return total
```

You can use this method on the individual array *instances*, so it is an *instance method*.

However, if you want to change the behavior of the factory producing the arrays, you need a new class method. One way to do this is to use the ::METHOD directive with the CLASS option. Another way to add a *class* method is to create a new metaclass that changes the behavior of the Statarray class. A new metaclass is a subclass of .class.

You can use a metaclass by specifying it in a SUBCLASS or MIXINCLASS message or on a ::CLASS directive with the METACLASS option.

If you are adding a highly specialized class method useful only for a particular class, use the ::METHOD directive with the CLASS option. However, if you are adding a class method that would be useful for many classes, such as an instance counter that counts how many instances a class creates, you use a metaclass.

The following examples add a class method that keeps a running total of instances created. The first version uses the ::METHOD directive with the CLASS option. The second version uses a metaclass.

Version 1

Example 4.2. Adding a CLASS method

```
/* Adding a class method using ::METHOD */

a = .point~new(1,1)               /* Create some point instances   */
say "Created point instance" a
b = .point~new(2,2)               /* create another point instance */
say "Created point instance" b
c = .point~new(3,3)               /* create another point instance */
say "Created point instance" c
                                  /* ask the point class how many */
                                  /* instances it has created     */
say "The point class has created" .point~instances "instances."
```

```
::class point public                /* create Point class           */

::method init class
  expose instanceCount
  instanceCount = 0                 /* Initialize instanceCount     */
  forward class (super)             /* Forward INIT to superclass   */

::method new class
  expose instanceCount              /* Creating a new instance      */
  instanceCount = instanceCount + 1 /* Bump the count               */
  forward class (super)             /* Forward NEW to superclass    */

::method instances class
  expose instanceCount              /* Return the instance count    */
  return instanceCount


::method init
  expose xVal yVal                  /* Set object variables         */
  use arg xVal, yVal                /* as passed on NEW             */

::method string
  expose xVal yVal                  /* Use object variables         */
  return "("xVal","yVal")"          /* to return string value       */
```

Version 2

```
/* Adding a class method using a metaclass  */

a = .point~new(1,1)                    /* Create some point instances  */
say "Created point instance" a
b = .point~new(2,2)
say "Created point instance" b
c = .point~new(3,3)
say "Created point instance" c
                                       /* ask the point class how many */
                                       /* instances it has created     */
say "The point class has created" .point~instances "instances."

::class InstanceCounter subclass class /* Create a new metaclass that */
                                       /* will count its instances     */
::method init
  expose instanceCount
  instanceCount = 0                    /* Initialize instanceCount     */
  forward class (super)                /* Forward INIT to superclass   */

::method new
  expose instanceCount                 /* Creating a new instance      */
  instanceCount = instanceCount + 1    /* Bump the count               */
  forward class (super)                /* Forward NEW to superclass    */

::method instances
expose instanceCount                   /* Return the instance count    */
return instanceCount


::class point public metaclass InstanceCounter  /* Create Point class */
                                       /* using InstanceCounter metaclass */
::method init
  expose xVal yVal                     /* Set object variables         */
  use arg xVal, yVal                   /* as passed on NEW             */

::method string
  expose xVal yVal                     /* Use object variables         */
```

```
  return "("xVal","yVal")"             /* to return string value       */
```

4.2. Creating and Using Classes and Methods

You can define a class using either directives or messages.

To define a class using directives, you place a ::CLASS directive after the main part of your source program:

```
::class "Account"
```

This creates an Account class that is a subclass of the Object class. Object is the default superclass if one is not specified. See *Section 5.1.4, "Object Class"* for details. The string "Account" is a string identifier for the new class. The string identifier is both the internal class name and the name of the *environment symbol* used to locate your new class instance.

Now you can use *::METHOD* directive to add methods to your new class. The ::METHOD directives must immediately follow the ::CLASS directive that creates the class.

Example 4.3. Adding a method

```
::method type
  return "an account"

::method "name="
  expose name
  use arg name

::method name
  expose name
  return name
```

This adds the methods TYPE, NAME, and NAME= to the Account class.

You can create a subclass of the Account class and define a method for it:

Example 4.4. Adding a method

```
::class "Savings" subclass account
::method type
return "a savings account"
```

Now you can create an instance of the Savings class with the *new* method and send TYPE, NAME, and NAME= messages to that instance:

Example 4.5. Invoking a method

```
asav = .savings~new
say asav~type
asav~name = "John Smith"
```

The Account class methods NAME and NAME= create a pair of access methods to the account object variable NAME. The following directive sequence creates the NAME and NAME= methods:

Example 4.6. Defining SET and GET methods

```
::method "name="
  expose name
  use arg name

::method name
  expose name
  return name
```

You can replace this with a single *::ATTRIBUTE* directive. For example, the directive

```
::attribute name
```

adds two methods, NAME and NAME= to a class. These methods perform the same function as the NAME and NAME= methods in the original example. The NAME method returns the current value of the object variable NAME; the NAME= method assigns a new value to the object variable NAME.

In addition to defining operational methods and attribute methods, you can add "constant" methods to a class using the *::CONSTANT* directive. The ::CONSTANT directive will create both a class method and an instance method to the class definition. The constant method will always return the same constant value, and can be invoked by sending a message to either the class or an instance method. For example, you might add the following constant to your Account class:

```
::constant checkingMinimum 200
```

This value can be retrieved using either of the following methods

Example 4.7. Retrieving method values

```
  say .Account~checkingMinimum    -- displays "200"
  asave = .savings~new
  say asave~checkingMinimum       -- also displays "200"
```

4.2.1. Using Classes

When you create a new class, it is always a subclass of an existing class. You can create new classes with the ::CLASS directive or by sending the SUBCLASS or MIXINCLASS message to an existing class. If you specify neither the SUBCLASS nor the MIXINCLASS option on the ::CLASS directive, the superclass for the new class is the Object class, and it is not a mixin class.

Example of creating a new class using a message:

```
persistence = .object~mixinclass("Persistence")
myarray=.array~subclass("myarray")~~inherit(persistence)
```

Example of creating a new class using the directive:

```
::class persistence mixinclass object
::class myarray subclass array inherit persistence
```

4.2.2. Scope

A *scope* refers to the methods and object variables defined for a single class (not including the superclasses). Only methods defined in a particular scope can access the object variables within that scope. This means that object variables in a subclass can have the same names as object variables used by a superclass, because the variables are created at different scopes.

4.2.3. Defining Instance Methods with SETMETHOD or ENHANCED

In Rexx, methods are usually associated with instances using classes, but it is also possible to add methods directly to an instance using the *setMethod* or *enhanced* method.

All subclasses of the Object class inherit SETMETHOD. You can use SETMETHOD to create one-off objects, objects that must be absolutely unique so that a class that is capable of creating other instances is not necessary. The Class class also provides an ENHANCED method that lets you create new instances of a class with additional methods. The methods and the object variables defined on an object with SETMETHOD or ENHANCED form a separate scope, like the scopes the class hierarchy defines.

4.2.4. Method Names

A method name can be any string. When an object receives a message, the language processor searches for a method whose name matches the message name in uppercase.

Note

The language processor also translates the specified name of all methods added to objects into uppercase characters.

You must surround a method name with quotation marks when it contains characters that are not allowed in a symbol (for example, the operator characters). The following example creates a new class (the Cost class), defines a new method (%), creates an instance of the Cost class (mycost), and sends a `%` message to **`mycost`**:

Example 4.8. Accessing a method

```
cost=.object~subclass("A cost")
cost~define("%", 'expose p; say "Enter a price."; pull p; say p*1.07;')
mycost=cost~new
mycost~"%"          /* Produces:  Enter a price.             */
                    /* If the user specifies a price of 100, */
                    /* produces: 107.00                      */
```

4.2.5. Default Search Order for Method Selection

The search order for a method name matching the message is for:

1. A method the object itself defines with *setMethod* or *enhanced*.

2. A method the object's class defines. (Note that an object acquires the instance methods of the class to which it belongs at the time of its creation. If a class gains additional methods, objects created before the definition of these methods do not acquire these methods.)

3. A method that a superclass of the object's class defines. This is also limited to methods that were available when the object was created. The order of the *inherit* messages sent to an object's class determines the search order of the superclass method definitions.

This search order places methods of a class before methods of its superclasses so that a class can supplement or override inherited methods.

If the language processor does not find a match for the message name, the language processor checks the object for a method name UNKNOWN. If it exists, the language processor calls the UNKNOWN method and returns as the message result any result the UNKNOWN method returns. The UNKNOWN method arguments are the original message name and a Rexx array containing the original message arguments.

If the object does not have an UNKNOWN method, the language processor raises a NOMETHOD condition. If there are no active traps for the NOMETHOD condition, a syntax error is raised.

4.2.6. Defining an UNKNOWN Method

When an object that receives a message does not have a matching message name, the language processor checks if the object has a method named UNKNOWN. If the object has an UNKNOWN method, the language processor calls UNKNOWN, passing two arguments. The first argument is the name of the method that was not located. The second argument is an array containing the arguments passed with the original message.

For example, the following UNKNOWN method will print out the name of the invoked method and then invoke the same method on another object. This can be used track the messages that are sent to an object:

Example 4.9. Defining an UNKNOWN method

```
::method unknown
expose target      -- will receive all of the messages
use arg name, arguments
say name "invoked with" arguments~toString
-- send along the message with the original args
forward to(target) message(name) arguments(arguments)
```

4.2.7. Changing the Search Order for Methods

You can change the usual search order for methods by specifying a colon and a class symbol after the message name. The class symbol can be a variable name or an environment symbol. It identifies the class object to be used as the starting point for the method search.

The class object must be a superclass of the class defining the active method, or, if you used `setMethod` to define the active method, the object's own class. The class symbol is usually the special variable *SUPER* , but it can be any *environment symbol* or variable name whose value is a valid class.

Suppose you create an Account class that is a subclass of the Object class, define a TYPE method for the Account class, and create the Savings class that is a subclass of Account. You could define a TYPE method for the Savings class as follows:

```
savings~define("TYPE", 'return "a savings account"')
```

You could change the search order by using the following line:

```
savings~define("TYPE", 'return self~type:super "(savings)"')
```

This changes the search order so that the language processor searches for the TYPE method first in the Account superclass (rather than in the Savings subclass). When you create an instance of the Savings class (**`asav`**) and send a TYPE message to **`asav`**:

```
say asav~type
```

`an account (savings)` is displayed. The TYPE method of the Savings class calls the TYPE method of the Account class, and adds the string **`(savings)`** to the results.

4.2.8. Public, Package-Scope, and Private Methods

A method can be public, package-scope, or private.

Any object can send a message that runs a public method.

A package-scope method can only be invoked from methods or routines defined in the same package as the package-scope method.

A private method can only be invoked from specific calling contexts. These contexts are:

1. From within a method owned by the same class as the target. This is frequently the same object, accessed via the special variable SELF. Private methods of an object can also be accessed from other instances of the same class (or subclass instances).

2. From within a method defined at the same class scope as the method. For example:

   Example 4.10. Referencing methods

   ```
   ::class Savings
   ::method newCheckingAccount CLASS
     instance = self~new
     instance~makeChecking
     return instance

   ::method makeChecking private
     expose checking
     checking = .true
   ```

   The newCheckingAccount CLASS method is able to invoke the makeChecking method because the scope of the makeChecking method is .Savings.

3. From within an instance (or subclass instance) of a class to a private class method of its class. For example:

   Example 4.11. Referencing methods

   ```
   ::class Savings
   ::method init class
   ```

```
  expose counter
  counter = 0

::method allocateAccountNumber private class
  expose counter
  counter = counter + 1
  return counter

::method init
  expose accountNumber
  accountNumber = self~class~allocateAccountNumber
```

The instance init method of the Savings class is able to invoke the allocateAccountNumber private method of the .Savings class object because it is owned by an instance of the .Savings class.

Private methods include methods at different scopes within the same object. This allows superclasses to make methods available to their subclasses while hiding those methods from other objects. A private method is like an internal subroutine. It shields the internal information of an object to outsiders, but allowing objects to share information with each other and their defining classes.

4.2.9. Initialization

Any object requiring initialization at creation time must define an INIT method. If this method is defined, the class object runs the INIT method after the object is created. If an object has more than one INIT method (for example, it is defined in several classes), each INIT method must forward the INIT message up the hierarchy to complete the object's initialization.

Example 4.12. Instance initialization

```
asav = .savings~new(1000.00, 6.25)
say asav~type
asav~name = "John Smith"

::class Account

::method INIT
  expose balance
  use arg balance

::method TYPE
  return "an account"

::method name attribute

::class Savings subclass Account

::method INIT
  expose interest_rate
  use arg balance, interest_rate
  self~init:super(balance)

::method type
  return "a savings account"
```

The NEW method of the Savings class object creates a new Savings object and calls the INIT method of the new object. The INIT method arguments are the arguments specified on the NEW method. In the Savings INIT method, the line:

Example 4.13. Instance initialization

```
self~init:super(balance)
```

calls the INIT method of the Account class, using just the balance argument specified on the NEW message.

4.2.10. Object Destruction and Uninitialization

Object destruction is implicit. When an object is no longer in use, Rexx automatically reclaims its storage. If the object has allocated other system resources, you must release them at this time. (Rexx cannot release these resources, because it is unaware that the object has allocated them.)

Similarly, other uninitialization processing may be needed, for example, by a message object holding an unreported error. An object requiring uninitialization should define an UNINIT method. If this method is defined, Rexx runs it before reclaiming the object's storage. If an object has more than one UNINIT method (defined in several classes), each UNINIT method is responsible for sending the UNINIT method up the object hierarchy.

4.2.11. Required String Values

Rexx requires a string value in a number of contexts within instructions and built-in function calls.

- DO statements containing *exprr* or *exprf*
- Substituted values in compound variable names
- Commands to external environments
- Commands and environment names on ADDRESS instructions
- Strings for ARG, PARSE, and PULL instructions to be parsed
- Parenthesized targets on CALL instructions
- Subsidiary variable lists on DROP, EXPOSE, and PROCEDURE instructions
- Instruction strings on INTERPRET instructions
- DIGITS, FORM, and FUZZ values on NUMERIC instructions
- Options strings on OPTIONS instructions
- Data queue strings on PUSH and QUEUE instructions
- Label names on SIGNAL VALUE instructions
- Trace settings on TRACE VALUE instructions
- Arguments to built-in functions
- Variable references in parsing templates
- Data for PUSH and QUEUE instructions to be processed
- Data for the SAY instruction to be displayed

- Rexx dyadic operators when the receiving object (the object to the left of the operator) is a string

If you supply an object other than a string in these contexts, by default the language processor converts it to some string representation and uses this. However, the programmer can cause the language processor to raise the NOSTRING condition when the supplied object does not have an equivalent string value.

To obtain a string value, the language processor sends a **`request("STRING")`** message to the object. Strings and other objects that have string values return the appropriate string value for Rexx to use. (This happens automatically for strings and for subclasses of the String class because they inherit a suitable `makeString` method from the String class.) For this mechanism to work correctly, you must provide a `makeString` method for any other objects with string values.

For other objects without string values (that is, without a `makeString` method), the action taken depends on the setting of the NOSTRING condition trap. If the NOSTRING condition is being trapped (see *Chapter 11, Conditions and Condition Traps*), the language processor raises the NOSTRING condition. If the NOSTRING condition is not being trapped, the language processor sends a *string* message to the object to obtain its readable string representation and uses this string.

Example 4.14. Comparing to the .nil object

```
d = .directory~new
say substr(d,5,7)         /* Produces "rectory" from "a Directory" */
signal on nostring
say substr(d,5,7)         /* Raises the NOSTRING condition */
say substr(d~string,3,6)  /* Displays "Direct" */
```

For arguments to Rexx object methods, different rules apply.

For **`String`** arithmetic, comparison, and concatenation methods:

These methods always require a string argument, so first a **`request("STRING")`** message is sent to the argument object. If `request` returns **`.nil`** because the argument object does not have a `makeString` method, and the NOSTRING condition is not being trapped, a *string* message is sent to the object to obtain its string representation.

For all other methods:

When a method expects a string as an argument, the argument object is sent the **`request("STRING")`** message. If `request` returns **`.nil`**, the method raises an error.

4.2.12. Concurrency

Rexx supports concurrency, multiple methods running simultaneously on a single object. See *Chapter 12, Concurrency* for a full description of concurrency.

4.3. Overview of Classes Provided by Rexx

This section gives a brief overview of the classes and methods Rexx defines.

4.3.1. The Class Hierarchy

Rexx provides the following classes belonging to the *Object class*.

The classes are in a class hierarchy with an inheriting class indented below its superclass or mixin class. Classes inheriting from multiple mixin classes are only listed below one of these mixin classes.

Alarm class

- *AlarmNotification class*
- *Buffer class*
- *Class class*
- *Collection class*
    - *MapCollection class*
        - *Bag class*
        - *Directory class*
            - *Properties class*
        - *IdentityTable class*
        - *Relation class*
        - *Set class*
        - *Stem class*
        - *StringTable class*
        - *Table class*
    - *OrderedCollection class*
        - *Array class*
        - *List class*
        - *Queue class*
            - *CircularQueue class*
    - *SetCollection class*
- *Comparable class*
    - *DateTime class*
    - *File class*
    - *String class*
    - *TimeSpan class*
- *Comparator class*
    - *CaselessColumnComparator class*
    - *CaselessComparator class*
    - *CaselessDescendingComparator class*
    - *ColumnComparator class*
    - *DescendingComparator class*
    - *InvertingComparator class*
    - *NumericComparator class*
- *InputStream class*
    - *InputOutputStream class*
        - *Stream class*
- *MessageNotification class*
    - *Message class*
- *Method class*
- *Monitor class*
- *MutableBuffer class*
- *Object class*
- *Orderable class*
- *OutputStream class*
- *Package class*
- *Pointer class*
- *RexxContext class*
- *RexxInfo class*
- *RexxQueue class*
- *Routine class*
- *StackFrame class*
- *Supplier class*
    - *StreamSupplier class*
- *Ticker class*

Validate class
VariableReference class
WeakReference class

Note that there might also be other classes available, depending on the operating system. Additional classes may be accessed by using an appropriate **`::requires`** directive to load the class definitions.

4.3.2. Class Library Notes

The chapters that follow describe the classes and other objects that Rexx provides and their available methods. Rexx provides the objects listed in these sections and they are generally available through *environment symbols*.

Notes:

1. In the method descriptions in the chapters that follow, methods that return a result begin with the word "returns".

2. For `[]` and `[]=` methods, the syntax diagrams include the index or indexes within the brackets. These diagrams are intended to show how you can use these methods. For example, to set the element **`(2, 3)`** of a multi-dimensional Array named *matrix* to **`0`**, you would typically use the syntax:

   ```
   matrix[2, 3] = 0
   ```

   rather than:

   ```
   matrix~"[]="(0, 2, 3)
   ```

   even though the latter is valid and equivalent. For more information, see *Section 1.11.4, “Message Terms”* and *Section 1.12.6, “Message Instructions”*.

3. When the argument of a method must be a specific kind of object (such as array, class, method, or string) the variable you specify must be of the same class as the required object or be able to produce an object of the required kind in response to a conversion message. In particular, subclasses are acceptable in place of superclasses (unless overridden in a way that changes superclass behavior), because they inherit a suitable conversion method from their Rexx superclass.

   The *isA* method of the Object class can perform this validation.

Builtin Classes

This chapter describes all of the Rexx built-in classes.

Fundamental Classes
These classes are the fundamental building blocks for all other classes.

- *Object* and *Class* class,
- *String Class*,
- *Method*, *Routine*, and *Package* class, and
- *Message* class.

Stream Classes
This set of classes implements Rexx data streams. They consist of *InputStream*, *OutputStream*, *InputOutputStream*, and *Stream* class.

Collection Classes
This set of classes implements object collections. It includes

- Ordered collections *Array*, *List*, *Queue*, and *CircularQueue* class,
- Map collections *Directory*, *StringTable*, *Stem*, *Table*, *IdentityTable*, *Relation*, and *Properties* class, and
- Map/Set collections *Bag* and *Set* class.

Utility Classes
This set of classes consists of

- *MutableBuffer Class*,
- *File Class*,
- Date-, time-, and timing-related classes *DateTime*, *TimeSpan*, *Alarm*, *Ticker*, and the notification classes *AlarmNotification* and *MessageNotification*,
- the synchronization classes *EventSempahore* and *MutexSempahore*,
- *Comparable* class and *Orderable* class,
- eight *Comparator* classes used for sorting *(Caseless)Comparator*, *(Caseless)ColumnComparator*, *(Caseless)DescendingComparator*, *InvertingComparator*, and *NumericComparator*, and
- other miscellaneous classes *Buffer*, *Monitor*, *Pointer*, *RegularExpression*, *RexxContext*, *RexxInfo*, *RexxQueue*, *StackFrame*, *StreamSupplier*, *Supplier*, *Validate*, *VariableReference*, and *WeakReference*.

5.1. Fundamental Classes

This section describes the Rexx fundamental classes.

- *Object* and *Class* class,
- *String Class*,
- *Method*, *Routine*, and *Package* class, and
- *Message* class.

5.1.1. Class Class (Metaclass)

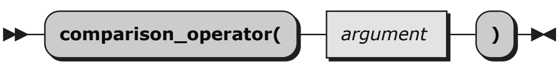
The Class class is like a factory that produces the factories that produce objects. It is a subclass of the *Object class*. The instance methods of the Class class are also the class methods of all classes.

Note that the `copy` method is forbidden for Class and all other class objects, and will result in an error.

Table 5.1. Class Class

Object		
Methods inherited from the *Object class*		
Class		
Comparison Methods = == <> >< \= \==		
activate	*id*	*new*
annotation	*inherit*	*package*
annotations	*isAbstract*	*queryMixinClass*
baseClass	*isMetaclass*	*subclass*
defaultName	*isSubclassOf*	*subclasses*
define	*metaClass*	*superClass*
defineMethods	*method*	*superClasses*
delete	*methods*	*uninherit*
enhanced	*mixinClass*	

5.1.1.1. Comparison Methods



Returns **.true** or **.false**, the result of performing a specified comparison operation.

For the Class class, if *argument* is the same class as the receiver class, the result is **.true**, otherwise **.false** is returned.

The comparison operators you can use in a message are:

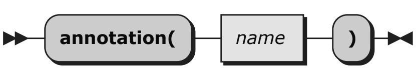
=, ==
: **.true** if the terms are the same class.

\=, ><, <>, \==
: **.true** if the terms are not the same class (inverse of =).

5.1.1.2. activate

Completes initialization of a class object created from a ::CLASS directive. The activate method is called after all classes in a package have been created and made available, but before the main portion of the program starts to execute. Activate is called for each class in the package in their construction order. The class object is fully constructed and capable of creating new instances of the class. All other classes in the same package are also available, although other classes might not have been activated yet. Because the INIT method is called early in the class construction process, only limited class initialization is possible at that time. The activate method is the preferred method for initializing a class object.

5.1.1.3. annotation



Returns the value of the annotation named *name* for this class. If no such annotation exists, `.nil` is returned.

See also

- method *annotations* and
- *::ANNOTATE* directive.

5.1.1.4. annotations

Returns a StringTable of all annotation name/value pairs for this class.

See also

- method *annotation* and
- *::ANNOTATE* directive.

5.1.1.5. baseClass

Returns the base class associated with the class. If the class is a mixin class, the base class is the first superclass that is not also a mixin class. If the class is not a mixin class, the base class is the class receiving the `baseClass` message.

5.1.1.6. defaultName

Returns a short human-readable string representation of the class. The string returned is of the form

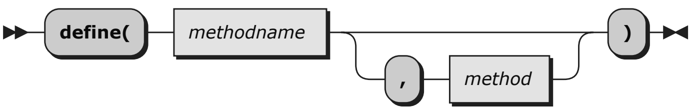
```
The id class
```

where *id* is the identifier assigned to the class when it was created.

Example 5.1. Class class — defaultName method

```
say .array~defaultName     /* Displays "The Array class"   */
say .account~defaultName   /* Displays "The ACCOUNT class" */
say .savings~defaultName   /* Displays "The Savings class" */

::class account            /* Name is all upper case       */
::class "Savings"          /* String name is mixed case    */
```

5.1.1.7. define



Incorporates the method object *method* in the receiver class's collection of instance methods. The method name *methodname* is translated to uppercase. Using the `define` method replaces any existing definition for *methodname* in the receiver class.

If you omit *method*, the method name *methodname* is made unavailable for the receiver class. Sending a message of that name to an instance of the class causes the `unknown` method (if any) to be run.

The *method* argument can be a string containing a method source line instead of a method object. Alternatively, you can pass an array of strings containing individual method lines. Either way, `define` creates an equivalent method object.

Notes:

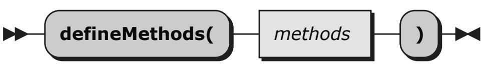
1. The classes Rexx provides do not permit changes or additions to their method definitions.

2. The `define` method is a protected method.

Example 5.2. Class class — define method

```
bank_account=.object~subclass("Account")
bank_account~define("TYPE",'return "a bank account"')
```

5.1.1.8. defineMethods



Incorporates all methods *methods* in the receiver class's collection of instance methods.

The *methods* is a collection whose indexes are the names of methods and whose items are method objects (or strings or arrays of strings containing method code). The method names are translated to uppercase. Any existing methods with the same method name in the receiver class are replaced.

If, for any item in *methods*, the method name is **`.nil`**, then a method of this name in the receiver class is made unavailable.

See also method *define*.

Example 5.3. Class class — defineMethods method

```
before = .c~new
say before~a                              -- a-original

.c~defineMethods(.methods)
after = .c~new
say after~a after~b                       -- a-define b-define

::method a
return "a-define"
::method b
return "b-define"

::class c
::method a
```

```
return "a-original"
```

5.1.1.9. delete

Removes the receiver class's definition for the method name *methodname*. If the receiver class defined *methodname* as unavailable with the `define` method, this definition is nullified. If the receiver class had no definition for *methodname*, no action is taken.

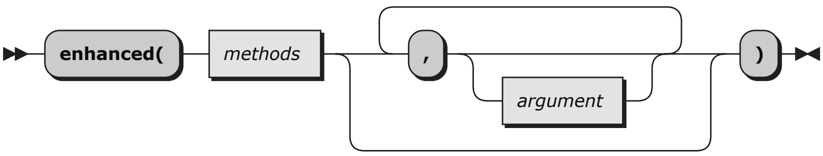
Notes:

1. The classes Rexx provides do not permit changes or additions to their method definitions.
2. `delete` deletes only methods the target class defines. You cannot delete inherited methods the target's superclasses define.
3. The `delete` method is a protected method.

Example 5.4. Class class — delete method

```
myclass=.object~subclass("Myclass")         /* After creating a class  */
myclass~define("TYPE",'return "my class"') /* and defining a method   */
myclass~delete("TYPE")                      /* this deletes the method */
```

5.1.1.10. enhanced



Returns an enhanced new instance of the receiver class, with object methods that are the instance methods of the class, enhanced by the methods in the collection *methods*. The collection indexes are the names of the enhancing methods, and the items are the method objects (or strings or arrays of strings containing method code). You can use any collection that supports a `supplier` method.

`enhanced` sends an `init` message to the created object, passing the *argument*s specified on the `enhanced` method.

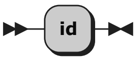
See also method *define*.

Example 5.5. Class class — enhanced method

```
/* Set up rclass with class method or methods you want in your */
/* remote class */
rclassmeths = .directory~new

rclassmeths["DISPATCH"]=d_source     /* d_source must have code for a  */
                                     /* DISPATCH  method.              */
/* The following sends init("Remote Class") to a new instance */
```

```
rclass=.class~enhanced(rclassmeths,"Remote Class")
```

5.1.1.11. id

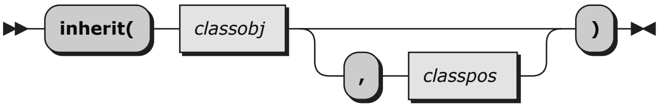


Returns the class identity (instance) string. (This is the string that is an argument on the `subclass` and `mixinClass` methods.) The string representations of the class and its instances contain the class identity.

Example 5.6. Class class — id method

```
myobject=.object~subclass("my object")  /* Creates a subclass    */
say myobject~id                         /* Produces: "my object" */
```

5.1.1.12. inherit



Causes the receiver class to inherit the instance and class methods of the class object *classobj*. The *classpos* is a class object that specifies the position of the new superclass in the list of superclasses. (You can use the `superClasses` method to return the immediate superclasses.)

The new superclass is inserted in the search order after the specified class. If the *classpos* class is not found in the set of superclasses, an error is raised. If you do not specify *classpos*, the new superclass is added to the end of the superclasses list.

Inherited methods can take precedence only over methods defined at or above the base class of the *classobj* in the class hierarchy. Any subsequent change to the instance methods of *classobj* takes immediate effect for all the classes that inherit from it.

The new superclass *classobj* must be created with the **`MIXINCLASS`** option of the **`::CLASS`** directive or the `mixinClass` method and the base class of the *classobj* must be a direct superclass of the receiver object. The receiver must not already descend from *classobj* in the class hierarchy and vice versa.

The method search order of the receiver class after `inherit` is the same as before `inherit`, with the addition of *classobj* and its superclasses (if not already present).

Notes:

1. You cannot change the classes that Rexx provides by sending `inherit` messages.

2. The `inherit` method is a protected method.

Example 5.7. Class class — inherit method

```
room~inherit(.location)
```

5.1.1.13. isAbstract

Returns **.true** if the receiving class is an abstract class, otherwise returns **.false**.

See also ABSTRACT option of the *::CLASS* directive.

Example 5.8. Class class — isAbstract method

```
say .abs~isAbstract                    -- 1

::class abs abstract
```

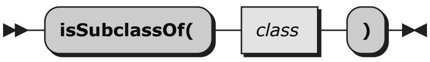
5.1.1.14. isMetaclass

Returns **.true** if the receiving class is a metaclass, otherwise returns **.false**. The **Class** class is the only metaclass that Rexx provides; any subclasses of the Class class are also metaclasses.

Example 5.9. Class class — isMetaclass method

```
do class
 over .RexxInfo~package~classes~allItems~appendAll(.context~package~classes~allItems)
  if class~isMetaclass then
    say class~string": metaclass"      -- The Class class: metaclass
                                       -- The META class: metaclass
end

::class meta subclass class
::class other
```

5.1.1.15. isSubclassOf



Returns **.true** if the object is a subclass of the specified *class*. Returns **.false** if the object is not a subclass of the specified *class*. A class is a subclass of a class if the target class is the same as *class* or if *class* is in the object's direct or mixin class inheritance chain. For example:

Example 5.10. Class class — isSubclassOf method

```
.String~isSubclassOf(.object)          ->  1
.String~isSubclassOf(.mutablebuffer)   ->  0
```

5.1.1.16. metaClass

Returns the receiver class's default metaclass. This is the class used to create subclasses of this class when you send *subclass* or *mixinClass* messages (with no metaclass arguments). The instance methods of the default metaclass are the class methods of the receiver class.

For more information about class methods, see *Section 4.1.1, “Object Classes”*. See also the description of method *subclass*.

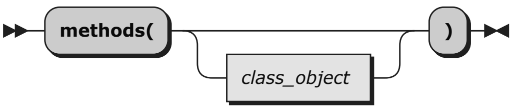
5.1.1.17. method

Returns the method object for the receiver class's definition for the method name *methodname*. If the receiver class defined *methodname* as unavailable, this method returns **`.nil`**. If the receiver class did not define *methodname*, an error is raised.

Example 5.11. Class class — method method

```
/* Create and retrieve the method definition of a class */
myclass=.object~subclass("My class")   /* Create a class         */
mymethod=.method~new(" ","Say arg(1)") /* Create a method object */
myclass~define("ECHO",mymethod)        /* Define it in the class */
method_source = myclass~method("ECHO")~source     /* Extract it  */
say method_source                 /* Says "an Array"              */
say method_source[1]              /* Shows the method source code */
```

5.1.1.18. methods



Returns a *Supplier* object for all the instance methods of the receiving class and its superclasses, if no argument is specified. In this case, the supplier's indexes may contain duplicate entries, if classes override methods in superclasses.

If *class_object* is **`.nil`**, `methods` returns a Supplier object for only the instance methods of the receiving class. If a *class_object* is specified, this method returns a Supplier object containing only the instance methods that *class_object* defines.

The returned supplier's indexes are the method names and the supplier's items are their associated *Method* objects. The Supplier enumerates all the names and methods existing at the time of the supplier's creation.

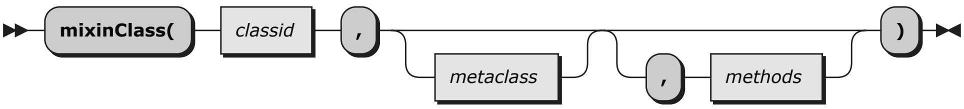
Note

Methods that have been hidden with a `setMethod` or `define` method are included with the other methods that `methods` returns. The hidden methods have **`.nil`** for their associated method.

Example 5.12. Class class — methods method

```
objsupp = .object~methods
do while objsupp~available
  say objsupp~index           -- displays all instance method
  objsupp~next                -- names of the Object class
end
```

5.1.1.19. mixinClass



Returns a new mixin subclass of the receiver class. You can use this method to create a new mixin class that is a subclass of the superclass to which you send the message. The *classid* is a string that identifies the new mixin subclass. You can use the `id` method to retrieve this string.

The *metaclass* is a class object. If you specify *metaclass*, the new subclass is an instance of *metaclass*. (A metaclass is a class that you can use to create a class, that is, a class whose instances are classes. The Class class and its subclasses are metaclasses.)

If you do not specify a *metaclass*, the new mixin subclass is an instance of the default metaclass of the receiver class. For subclasses of the Object class, the default metaclass is the Class class.

The *methods* is a collection whose indexes are the names of methods and whose items are method objects (or strings or arrays of strings containing method code). If you specify *methods*, the new class is enhanced with class methods from this collection. (The metaclass of the new class is not affected.)

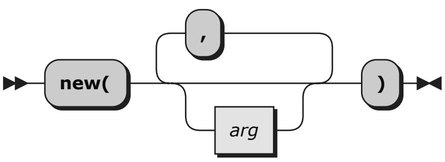
The `metaClass` method returns the metaclass of a class.

The method search order of the new subclass is the same as that of the receiver class, with the addition of the new subclass at the start of the order.

Example 5.13. Class class — mixinClass method

```
buyable=.object~mixinClass("Buyable")  /* New subclass is buyable    */
                                       /* Superclass is Object class */
```

5.1.1.20. new



Returns a new instance of the receiver class, whose object methods are the instance methods of the class. This method initializes a new instance by running its `init` methods (see *Section 4.2.9, “Initialization”*). `new` also sends an `init` message. If you specify args, `new` passes these arguments on the `init` message.

Example 5.14. Class class — new method

```
/* new method example */
a = .account~new             /* -> Object variable balance=0          */
y = .account~new(340.78)     /* -> Object variable balance=340.78     */
                             /*    plus free toaster oven             */
::class account subclass object
::method init                /* Report time each account created      */
                             /* plus free toaster when more than $100  */
Expose balance
Arg opening_balance
Say "Creating" self~objectName "at time" time()
If datatype(opening_balance, "N") then balance = opening_balance
else balance = 0
If balance > 100 then Say "  You win a free toaster oven"
```

5.1.1.21. package

Returns the Package class instance that defined the receiving class. The package instance controls and defines the search order for classes and routines referenced by the receiving class.

See also *Package class*.

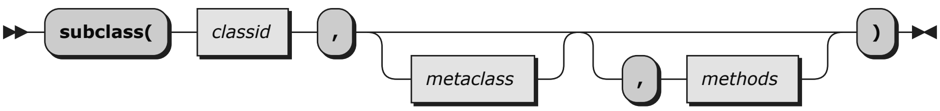
Example 5.15. Class class — package method

```
say .Class~package~name                -- REXX
say .other~package~name                -- C:\ExampleClassPackage.rex

::class other
```

5.1.1.22. queryMixinClass

Returns **`.true`** if the class is a mixin class, or **`.false`**.

5.1.1.23. subclass



Returns a new subclass of the receiver class. You can use this method to create a new class that is a subclass of the superclass to which you send the message. The *classid* is a string that identifies the subclass. (You can use the `id` method to retrieve this string.)

The *metaclass* is a class object. If you specify *metaclass*, the new subclass is an instance of *metaclass*. (A metaclass is a class that you can use to create a class, that is, a class whose instances are classes. The Class class and its subclasses are metaclasses.)

If you do not specify a *metaclass*, the new subclass is an instance of the default metaclass of the receiver class. For subclasses of the Object class, the default metaclass is the Class class.

The *methods* is a collection whose indexes are the names of methods and whose items are method objects (or strings or arrays of strings containing method code). If you specify *methods*, the new class is enhanced with class methods from this collection. (The metaclass of the new class is not affected.)

The `metaclass` method returns the metaclass of a class.

The method search order of the new subclass is the same as that of the receiver class, with the addition of the new subclass at the start of the order.

Example 5.16. Class class — subclass method

```
room=.object~subclass("Room")   /* Superclass is .object     */
                                /* Subclass is room          */
                                /* Subclass identity is Room */
```

5.1.1.24. subclasses

subclasses

Returns the immediate subclasses of the receiver class in the form of a single-dimensional Array of the required size, in an unspecified order. (The program should not rely on any order.)

5.1.1.25. superClass

superClass

Returns the immediate superclass of the receiver class. The immediate superclass is the original class used on a `subclass` or a `mixinClass` method. For the Object Class, `superClass` returns **`.nil`**.

Example 5.17. Class class — superClass method

```
say .object~superclass    -- displays "The NIL object"
say .class~superclass     -- displays "The Object class"
say .set~superclass       -- displays "The Table class"
```

5.1.1.26. superClasses

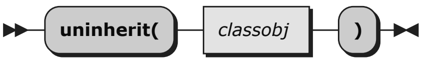
superClasses

Returns the immediate superclasses of the receiver class in the form of a single-dimensional Array of the required size. The immediate superclasses are the original class used on a `subclass` or a `mixinClass` method, plus any additional superclasses defined with the `inherit` method. The array is in the order in which the class has inherited the classes. The original class used on a `subclass` or `mixinClass` method is the first item of the array.

Example 5.18. Class class — superClasses method

```
z=.class~superClasses
/* To obtain the information this returns, you could use:     */
do i over z
  say i
end
```

5.1.1.27. uninherit



Nullifies the effect of any previous `inherit` message sent to the receiver for the class *classobj*.

Note

You cannot change the classes that Rexx provides by sending `uninherit` messages.

Example 5.19. Class class — uninherit method

```
location=.object~mixinClass("Location")
room=.object~subclass("Room")~~inherit(location) /* Creates subclass */
/* and specifies inheritance */
room~uninherit(location)
```

5.1.2. Message Class

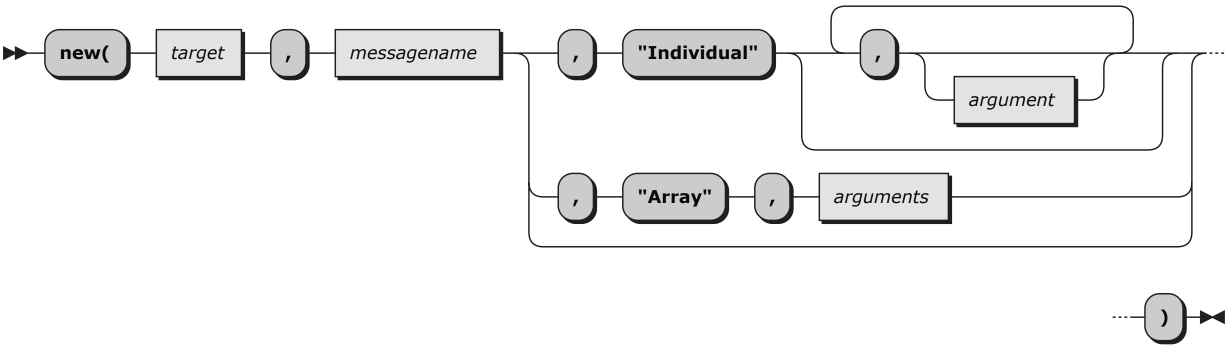
A message object provides for the deferred or asynchronous sending of a message. You can create a message object by using the *new (Class Method)* method of the Message class or the *start* and *startWith* methods of the Object class.

Table 5.2. Message Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ AlarmNotification (Mixin Class)
Methods inherited from the *AlarmNotification class* *cancel* *triggered (Abstract method)*
+ MessageNotification (Mixin Class)
Methods inherited from the *MessageNotification class*

messageComplete (Abstract Method)		
Message		
new (Class Method)		
arguments	*messageName*	*start*
completed	*notify*	*startWith*
errorCondition	*reply*	*target*
halt	*replyWith*	*triggered*
hasError	*result*	*wait*
hasResult	*send*	
messageComplete	*sendWith*	

5.1.2.1. new (Class Method)



Initializes the message object for sending the message name *messagename* to object *target*.

The *messagename* can be a string or an array. If *messagename* is an array object, its first item is the name of the message and its second item is a class object to use as the starting point for the method search.

If you specify neither **`Individual`** nor **`Array`**, the message sent has no arguments.

If you specify the **`Individual`** or **`Array`** option, any remaining arguments are arguments for the message. (You need to specify only the first letter; all characters following the first are ignored.)

`Individual`

: If you specify this option, specifying *argument* is optional. Any *argument*s are passed as message arguments to *target* in the order you specify them.

`Array`

: If you specify this option, you must specify *arguments*, which is an Array object. The member items of the array are passed to *target* as arguments. The first argument is at index 1, the second argument at index 2, and so on. If you omitted any indexes when creating the array, the corresponding message arguments are also omitted.

> **Note**
>
> This method does not send the message *messagename* to object *target*. See methods *start*/*startWith* , *send* /*sendWith* , and *reply* /*replyWith* .

5.1.2.2. arguments

Returns an array of argument objects used to invoke the message.

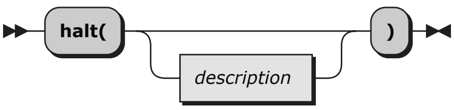
5.1.2.3. completed

Returns **1** if the message object has completed executing its message, or **0**. You can use this method to test for completion as an alternative to calling `result` and waiting for the message to complete.

5.1.2.4. errorCondition

Returns an error condition object from any execution error with the message object's message invocation. If the message completed normally, or is still executing, `errorCondition` returns **.nil**.

5.1.2.5. halt



Returns **.true** if it could raise the halt condition for the message the receiving message object is currently executing. Returns **.false** if there is no message executing.

An optional string *description* can be supplied, which the halted message can retrieve by requesting the "DESCRIPTION" item of the *CONDITION* built-in function or the *Condition Object*.

Example 5.20. Message class — halt method

```
dog = .WatchDog~new(1)                 -- watchdog with 1 sec time-out
say dog~watchTask(.task~new~start("runsLong", 0.5))
say dog~watchTask(.task~new~start("runsLong", 1.5))


::class Task

-- a long-running task that we may want to terminate early
::method runsLong
  use strict arg seconds
  signal on halt
  do s = 0 to seconds by 0.1           -- split SysSleep to enable halting
    call SysSleep 0.1                  -- do "hard work"
  end
  return "task finished"

  halt:
  return condition("DESCRIPTION")      -- return description from halt()


::class Watchdog inherit AlarmNotification
```

```
-- sets a time-out, after which a running task will be halted
::method init
  expose timeOut
  use strict arg timeOut

-- watches over a task, halting it if it runs too long
::method watchTask
  expose timeOut
  use strict arg message
  -- we set an Alarm for 'timeOut' seconds, which, upon triggering
  -- will call method triggered(), passing this Alarm object as an argument
  -- (this is why we inherit from AlarmNotification)
  -- we also attach 'message' to enable triggered() to halt the task
  alarm = .Alarm~new(timeOut, self, message)

  -- now we just wait for 'message' to finish; either normally, or halted
  msgResult = message~result
  alarm~cancel                      -- cancel alarm; may still be active
  return msgResult

::method triggered unguarded
  expose timeOut
  -- our watchTask Alarm has triggered
  -- this means that the task has run too long
  use arg alarm
  message = alarm~attachment        -- message is our attachment
  message~halt("task took longer than" timeOut "sec")
```

will output

```
task finished
task took longer than 1 sec
```

5.1.2.6. hasError

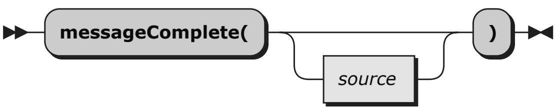
Returns **`1`** if the message object's message was terminated with an error condition. Returns **`0`** if the message has not completed or completed without error.

5.1.2.7. hasResult

Returns **`.true`** if the message object has completed executing its message, and the message has returned a result. Returns **`.false`** if the message object has not yet completed executing its message, or the message hasn't returned a result.

See also method *result*.

5.1.2.8. messageComplete



This method implements the *MessageNotification interface*. It will be called whenever a message completes processing, for which notification was requested by using the *notify* method with a message object as the notification target.

As a result of receiving such a notification, `messageComplete` will send the receiving message to start processing. Any *source* argument will be ignored.

See also class *MessageNotification*.

Example 5.21. Message class — messageComplete method

```
msg = .Message~new(.Array~new(1000)~fill(0)~allIndexes, "sort")
msg~notify(.Message~new(.stdout, "say", "I", "sorting complete"))
msg~notify(.Message~new(.r~new, "items", "I", msg))
msg~start
say "processing continues"

::class r
::method items
use strict arg m
say m~target~items "items sorted"
```

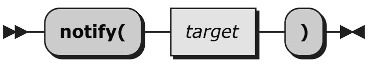
will output

```
processing continues
sorting complete
1000 items sorted
```

5.1.2.9. messageName

Returns the message name of the receiving message object.

5.1.2.10. notify



Requests notification about the completion of processing of the message.

The notification *target* must be an object that implements the *MessageNotification interface*. Upon completion of message processing, *target* will be sent a `messageComplete` message, with the completed Message object as argument *source*.

Any number of notifications can be requested for a message.

To retrieve the result of the completed message, use method *result*.

See also class *MessageNotification*.

Example 5.22. Message class — notify method

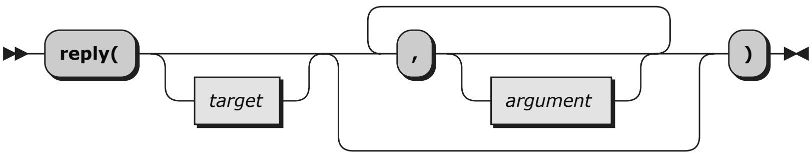
```
msg = .Message~new(.Array~new(1000)~fill(0)~allIndexes, "sort")
```

```
msg~notify(.Sorter~new)
msg~start
say "processing continues"

::class Sorter inherit MessageNotification
::method messageComplete
  use strict arg message

  say message~target~items "items sorted"
```

will output

```
processing continues
1000 items sorted
```

5.1.2.11. reply



Returns and sends a copy of the message to start processing, while the sender also continues processing.

As this method, other than the similar method *start*, starts a copy of the message, it can be called mutiple times with the same receiving message.

If *target* is specified, the message is sent to *target* and both the receiving message and the message copy are changed to use the new *target*. Otherwise the message is sent to the target the message object provides.

If any *arguments* are specified, the message is sent with these *arguments* and both the receiving message and the message copy are changed to use the new *arguments*. Otherwise the message is sent with any arguments the message object provides.

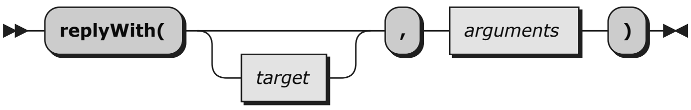
This method returns as soon as possible and does not wait until message processing is complete.

The *notify* method can be used to request notification that message processing is complete. When message processing is complete, the message object retains any result and holds it until requested via the *result* method.

See also

- method *replyWith* ,
- methods *start* and *startWith* , and
- methods *send* and *sendWith* .

5.1.2.12. replyWith



Returns and sends a copy of the message with the specified *arguments* to start processing, while the sender also continues processing.

As this method, other than the similar method *startWith* , starts a copy of the message, it can be called mutiple times with the same receiving message.

If *target* is specified, the message is sent to *target* and both the receiving message and the message copy are changed to use the new *target*. Otherwise the message is sent to the target the message object provides.

The *arguments* array items are used as message arguments and both the receiving message and the message copy are changed to use these new *arguments*.

This method returns as soon as possible and does not wait until message processing is complete.

The *notify* method can be used to request notification that message processing is complete. When message processing is complete, the message object retains any result and holds it until requested via the *result* method.

See also

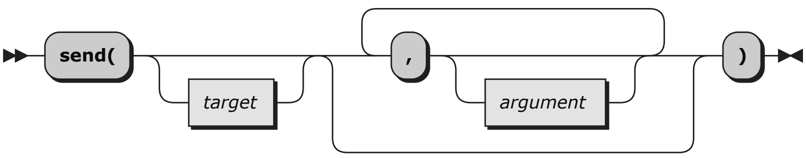
- method *reply* ,
- methods *start* and *startWith* , and
- methods *send* and *sendWith* .

5.1.2.13. result

Returns the result of the message `send` or `start`. If message processing is not yet complete, this method waits until it completes. If the message `send` or `start` raises an error condition, this method also raises an error condition.

For an example see *halt method example*.

5.1.2.14. send



Returns the result (if any) of sending the message.

If *target* is specified, the message is sent to *target* and the receiving message object is changed to use the new *target*. Otherwise the message is sent to the target the message object provides.

If any *arguments* are specified, the message is sent with these *arguments* and the receiving message object is changed to use the new *arguments*. Otherwise the message is sent with any arguments the message object provides.

This method does not return until message processing is complete.

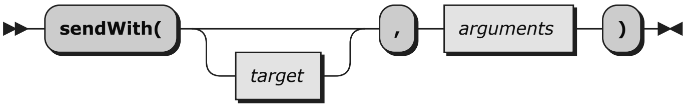
The *notify* method can be used to request notification that message processing is complete. When message processing is complete, the message object retains any result and holds it until requested via the *result* method.

See also

- method *sendWith* ,
- methods *start* and *startWith* , and

- methods *reply* and *replyWith* .

5.1.2.15. sendWith



Returns the result (if any) of sending the message with the specified *arguments*.

If *target* is specified, the message is sent to *target* and the receiving message object is changed to use the new *target*. Otherwise the message is sent to the target the message object provides.

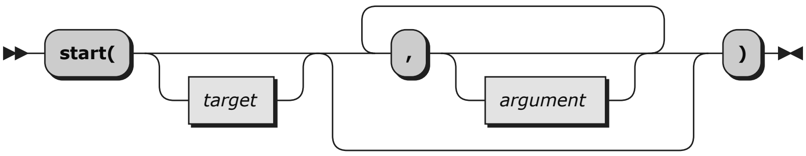
The *arguments* array items are used as message arguments and the receiving message object is changed to use these new *arguments*.

This method does not return until message processing is complete.

The *notify* method can be used to request notification that message processing is complete. When message processing is complete, the message object retains any result and holds it until requested via the *result* method.

See also
- method *send* ,
- methods *start* and *startWith* , and
- methods *reply* and *replyWith* .

5.1.2.16. start



Sends the message to start processing, while the sender also continues processing.

If *target* is specified, the message is sent to *target* and the receiving message object is changed to use the new *target*. Otherwise the message is sent to the target the message object provides.

If any *argument*s are specified, the message is sent with these *argument*s and the receiving message object is changed to use the new *argument*s. Otherwise the message is sent with any arguments the message object provides.

This method returns as soon as possible and does not wait until message processing is complete.

Note that once a message object has been started with either the `start` or the `startWith` method, it can not be run with any of the `send`/`sendWith`, `start`/`startWith`, `reply`/`replyWith` methods again. A message object *can* be run multiple times with methods `send`/`sendWith` and `reply`/`replyWith`.

The *notify* method can be used to request notification that message processing is complete. When message processing is complete, the message object retains any result and holds it until requested via the *result* method.

See also
- method *startWith* ,
- methods *send* and *sendWith* , and

- methods *reply* and *replyWith* .

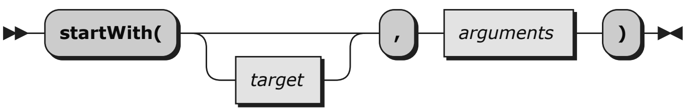
Example 5.23. Message class - start method

```
ez=.testclass~new                  /* Creates a new instance of Testclass     */

/* Creates and starts message mymsg to send SHOWMSG to ez                     */
mymsg=ez~start("SHOWMSG","Hello, Ollie!",5)

/* Continue with main processing while SHOWMSG runs concurrently              */
do 5
  say "Hello, Stan!"
end

/* Get final result of the SHOWMSG method from the mymsg message object       */
say mymsg~result
say "Goodbye, Stan..."
exit

::class testclass public             /* Directive defines Testclass           */

::method showmsg                     /* Directive creates new method SHOWMSG  */
use arg text,reps                    /* class Testclass                       */
do reps
  say text
end
reply "Bye Bye, Ollie..."
return
```

The following output is possible:

```
Hello, Ollie!
Hello, Stan!
Hello, Ollie!
Hello, Stan!
Hello, Ollie!
Hello, Stan!
Hello, Ollie!
Hello, Stan!
Hello, Ollie!
Hello, Stan!
Bye Bye, Ollie...
Goodbye, Stan...
```

5.1.2.17. startWith



Sends the message with the specified *arguments* to start processing, while the sender also continues processing.

If *target* is specified, the message is sent to *target* and the receiving message object is changed to use the new *target*. Otherwise the message is sent to the target the message object provides.

The *arguments* array items are used as message arguments and the receiving message object is changed to use these new *arguments*.

This method returns as soon as possible and does not wait until message processing is complete.

Note that once a message object has been started with either the `start` or the `startWith` method, it can not be run with any of the `send/sendWith`, `start/startWith`, `reply/replyWith` methods again. A message object can be run multiple times with methods `send/sendWith` and `reply/replyWith`.

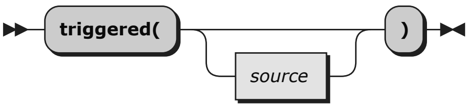
The *notify* method can be used to request notification that message processing is complete. When message processing is complete, the message object retains any result and holds it until requested via the *result* method.

See also
- method *start*,
- methods *send* and *sendWith* , and
- methods *reply* and *replyWith* .

5.1.2.18. target

Returns the object that is the target of the invoked message.

5.1.2.19. triggered



This method implements the *AlarmNotification interface*. It will be called whenever an *Alarm* or a *Ticker* triggers, for which a Message object was set as notification target.

As a result of receiving such a notification, `triggered` will send the receiving message to start processing. Any *source* argument will be ignored.

See also class *AlarmNotification*.

Example 5.24. Message class — triggered method

```
arg = .Array~new(1)
msg = .Message~new(.a~new, "ring", "A", arg)
oneSecond = .Alarm~new(1, msg, arg)
arg~append(oneSecond)
-- oneSecond = .Alarm~new(1, .Message~new(.a~new, "ring", "I", alarm))
say "processing continues"

::class a
::method ring
use strict arg alarm
say "alarm went off at" .DateTime~new
say "was scheduled for" alarm~scheduledTime
```

may output

```
processing continues
alarm went off at 2015-12-18T16:54:15.550000
was scheduled for 2015-12-18T16:54:15.545000
```

5.1.2.20. wait

Waits until the message object has completed executing its message.

See also method *completed*.

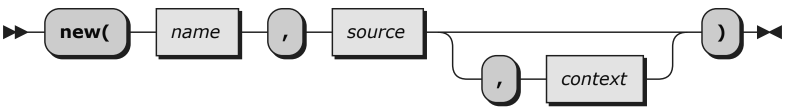
5.1.3. Method Class

The Method class creates method objects from Rexx source code. It is a subclass of the *Object class*.

Table 5.3. Method Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
Method		
new (Class Method)		
loadExternalMethod (Class Method)		
newFile (Class Method)		
annotation	*isPackage*	*setPrivate*
annotations	*isPrivate*	*setProtected*
isAbstract	*isProtected*	*setSecurityManager*
isAttribute	*package*	*setUnguarded*
isConstant	*scope*	*source*
isGuarded	*setGuarded*	

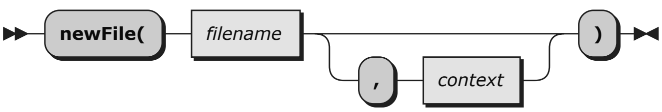
5.1.3.1. new (Class Method)



Returns a new instance of the **`Method`** class, which is an executable representation of the code contained in the *source*. The *name* is a string. The *source* can be a single string or an array of strings containing individual method lines.

The *context* allows the created method to inherit class and routine lookup scope from another source. If specified, *context* can be a Method object, a Routine object, a Package object, or the string "PROGRAMSCOPE". PROGRAMSCOPE is the default, and specifies that the newly created method will inherit the class and routine search scope from the caller of the new method.

5.1.3.2. newFile (Class Method)



Returns a new instance of the **`Method`** class, which is an executable representation of the code contained in the file *filename*. Raises an error if the file *filename* cannot be read. The *filename* is a string.

The *context* allows the created method to inherit class and routine lookup scope from another source. If specified, *context* can be a Method object, a Routine object, a Package object, or the string "PROGRAMSCOPE". PROGRAMSCOPE is the default, and specifies that the newly created method will inherit the class and routine search scope from the caller of the `newFile` method.

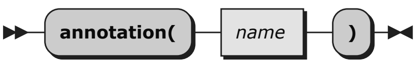
5.1.3.3. loadExternalMethod (Class Method)

Resolves a native method in an external library package and returns a **`Method`** object instance that can be used to call the external method. The *descriptor* is a string containing whitespace-delimited tokens that identify the location of the native method. The first token identifies the type of native function and must be **`LIBRARY`**. The second token must identify the name of the external library. The external library is located using platform-specific mechanisms for loading libraries. For Unix-based systems, the library name is case-sensitive. The third token is optional and specifies the name of the method within the library package. If not specified, *name* is used. The method name is not case sensitive. If the target method cannot be resolved, **`.nil`** is returned.

Example 5.25. Method class — loadExternalMethod method

```
method = .Method~loadExternalMethod("homeAddress=", "LIBRARY mylib setHomeAddress")
```

5.1.3.4. annotation



Returns the value of the annotation named *name* for this method. If no such annotation exists, **`.nil`** is returned.

See also
- method *annotations* and
- *::ANNOTATE* directive.

5.1.3.5. annotations

Returns a StringTable of all annotation name/value pairs for this method.

See also
- method *annotation* and
- *::ANNOTATE* directive.

5.1.3.6. isAbstract

Returns **.true** if the method is an Abstract method, otherwise returns **.false**.

See also
- ABSTRACT option of the *::METHOD* directive and
- ABSTRACT option of the *::ATTRIBUTE* directive.

Example 5.26. Method class — isAbstract method

```
say .InputStream~method("lines")~isAbstract    -- 1
say .Stream~method("lines")~isAbstract         -- 0
```

5.1.3.7. isAttribute

Returns **.true** if the method is an Attribute method, otherwise returns **.false**.

See also *::ATTRIBUTE* directive.

Example 5.27. Method class — isAttribute method

```
say .File~method("lastModified")~isAttribute     -- 1
say .File~method("lastModified=")~isAttribute    -- 1
```

5.1.3.8. isConstant

Returns **.true** if the method is a Constant method, otherwise returns **.false**.

See also *::CONSTANT* directive.

Example 5.28. Method class — isConstant method

```
say .physics~method("c")~isConstant              -- 1

::class physics
::constant c 299792458
```

5.1.3.9. isGuarded

Returns **.true** if the method is a Guarded method. Returns **.false** for Unguarded methods.

5.1.3.10. isPackage

Returns **.true** if the method is a Package-scope method. Returns **.false** for Public methods or Private methods. See *Section 4.2.8, “Public, Package-Scope, and Private Methods”* for details on package-scope method restrictions.

See also method *isPrivate*.

5.1.3.11. isPrivate

Returns **.true** if the method is a Private method. Returns **.false** for Public methods or Package-scope methods. See *Section 4.2.8, “Public, Package-Scope, and Private Methods”* for details on private method restrictions.

See also method *isPackage* .

5.1.3.12. isProtected

Returns **.true** if the method is a Protected method. Returns **.false** for unprotected methods.

5.1.3.13. package

Returns the Package class instance that defined the method instance. The package instance controls and defines the search order for classes and routines referenced by the method code.

5.1.3.14. scope

Returns the defining class scope for a method. Returns **.nil** for any method not defined by a class scope.

Example 5.29. Method class — scope method

```
scopes = .Stem~new
scopes[] = 0
loop with item method over .List~methods
  scopes[method~scope] += 1                  -- possible output:
end                                          -- 27 methods from The List class
loop scope over scopes                       -- 19 methods from The Collection class
  say scopes[scope] "methods from" scope     -- 20 methods from The OrderedCollection class
end                                          -- 31 methods from The Object class

.Method~new("any", "nop")~scope              -- .nil

.methods["FLOAT"]~scope                      -- .nil
::method float
```

5.1.3.15. setGuarded

Specifies that the method is a guarded method that requires exclusive access to its scope variable pool to run. If the receiver is already guarded, a `setGuarded` message has no effect. Guarded is the default state for method objects.

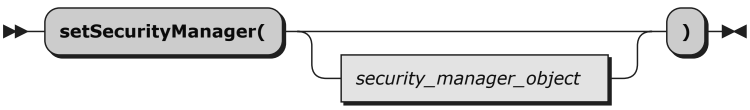
5.1.3.16. setPrivate

Specifies that a method is a private method. By default, method objects are created as public methods. See *Section 4.2.8, “Public, Package-Scope, and Private Methods”* for details on private method restrictions.

5.1.3.17. setProtected

Specifies that a method is a protected method. Method objects are not protected by default. (See *Chapter 13, The Security Manager* for details.)

5.1.3.18. setSecurityManager



Replaces the existing security manager with the specified *security_manager_object*. If *security_manager_object* is omitted, any existing security manager is removed.

5.1.3.19. setUnguarded

Turns off the guard attribute of the method, allowing this method to run on an object even if another method has acquired exclusive access to the scope variable pool. Methods are guarded by default.

A guarded method can be active for an object only when no other method requiring exclusive access to the object's variable pool is active in the same object. This restriction does not apply if an object sends itself a message to run a method and it already has exclusive use of the same object variable pool. In this case, the method runs immediately regardless of its guarded state.

5.1.3.20. source

Returns the method source code as a single-dimensional Array of source lines. If the source code is not available, `source` returns an array of zero items.

5.1.4. Object Class

The Object class is the root of the class hierarchy. The instance methods of the Object class are, therefore, available on all objects.

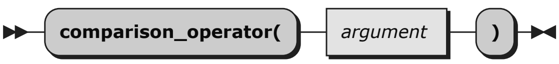
Table 5.4. Object Class

Class (Metaclass)		
Methods inherited from the *Class class*		
Object		
new (Class Method)		
Comparison Methods = == <> >< \= \==		
Concatenation Methods (abuttal) || (blank)		
class	*isA*	*sendWith*
copy	*isInstanceOf*	*setMethod (Private Method)*
defaultName	*isNil*	*start*
hashCode	*objectName*	*startWith*
hasMethod	*objectName=*	*string*
identityHash	*request*	*unsetMethod (Private Method)*
instanceMethod	*run (Private Method)*	
instanceMethods	*send*	

5.1.4.1. new (Class Method)

Returns a new instance of the receiver class.

5.1.4.2. Comparison Methods



Returns `.true` or `.false`, the result of performing a specified comparison operation.

For the Object class, if *argument* is the same object as the receiver object, the result is `.true`, otherwise `.false` is returned. Subclasses may override this method to define equality using different criteria. For example, the String class determines equality based on the value of the string data.

> **Note**
>
> The MapCollection classes such as **`Table`** and **`Relation`** use the == operator combined with the *hashCode* method to determine index and item equivalence. It is generally necessary for a class to override both the hashCode method and the == operator method to maintain the contract specified for the hashCode method.

The comparison operators you can use in a message are:

=, ==
: **.true** if the terms are the same object.

\=, ><, <>, \==
: **.true** if the terms are not the same object (inverse of =).

5.1.4.3. Concatenation Methods

Returns a new string that is the concatenation the of receiver object's string value with *argument*. (See *Section 1.11.2.1, “String Concatenation”*.) The *concatenation_operator* can be:

""
: concatenates without an intervening blank. The abuttal operator "" is the null string. The language processor uses the abuttal operator to concatenate two terms that another operator does not separate.

||
: concatenates without an intervening blank.

" "
: concatenates with one blank between the receiver object and the *argument*. (The operator " " is a blank.)

5.1.4.4. class

Returns the class object that created the object instance.

5.1.4.5. copy

Returns a copy of the receiver object. The copied object has the same methods as the receiver object and an equivalent set of object variables, with the same values.

Example 5.30. Object class — copy method

```
myarray=.array~of("N","S","E","W")
/* Copies array myarray to array directions */
directions=myarray~copy
```

Note

The `copy` method is a “shallow copy”. Only the target object is copied. Additional objects referenced by the target object are not copied. For example, copying an Array object instance only copies the Array, it does not copy any of the objects stored in the Array.

5.1.4.6. defaultName

Returns a short human-readable string representation of the object. The exact form of this representation depends on the object and might not alone be sufficient to reconstruct the object. All objects must be able to produce a short string representation of themselves in this way, even if the object does not have a string value. See *Section 4.2.11, “Required String Values”* for more information. `defaultName` returns a string that identifies the class of the object, for example, **`an Array`** or **`a Directory`**.

See also methods *objectName* and *string*.

See *objectName=* for an example using `defaultName`.

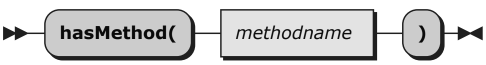
5.1.4.7. hashCode

Returns a string value that is used as a hash value for MapCollections such as Table, Relation, Set, Bag, and Directory. MapCollections use this string value to hash an object for hash table-based searches.

Object implementations are expected to abide by a general contract for hash code usage:

- Whenever hashCode is invoked on the same object more than once, hashCode must return the same hashcode value, provided than none of the internal information the object uses for an "==" comparison has changed.
- If two object instances compare equal using the "==" operator, the hashCode methods for both object instances must return the same value.
- It is not required that two object instances that compare unequal using "==" return different hash code values.
- Returning a wide range of hash values will produce better performance when an object is used as an index for a MapCollection. A return value of 4 string characters is recommended. The characters in the hash value may be any characters from **`'00'x`** to **`'ff'x`**, inclusive.

5.1.4.8. hasMethod



Returns **.true** if the receiver object has a method named *methodname* (translated to uppercase). Otherwise, it returns **.false**.

Note

The `hasMethod` method will return **.true** even if the target method is defined as private. A private method has restricted access rules, so it's possible to receive an unknown method error (error 97) when invoking *methodname* even if `hasMethod` indicates the method exists. See *Section 4.2.8, “Public, Package-Scope, and Private Methods”* for private method restrictions.

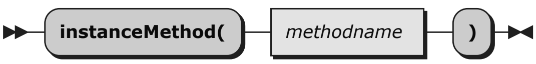
5.1.4.9. identityHash

Returns a unique identity number for the object. This number is guaranteed to be unique for the receiver object until the object is garbage collected.

5.1.4.10. init

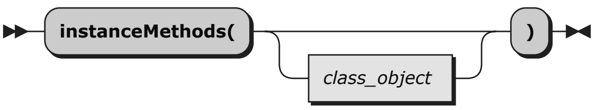
Performs any required object initialization. Subclasses of the Object class can override this method to provide more specific initialization.

5.1.4.11. instanceMethod



Returns the corresponding Method class instance if the *methodname* is a valid method of the class. Otherwise it returns **.nil**.

5.1.4.12. instanceMethods



Returns a *Supplier* object for all the object methods of the receiving object and its superclasses, if no argument is specified. In this case, the supplier's indexes may contain duplicate entries, if classes override methods in superclasses.

If a *class_object* is specified, `instanceMethods` returns a Supplier object for only the object methods of the receiving object. If the receiving object object is not an instance of *class_object*, an empty Supplier is returned.

The returned supplier's indexes are the method names and the supplier's items are their associated *Method* objects. The Supplier enumerates all the names and methods existing at the time of the supplier's creation.

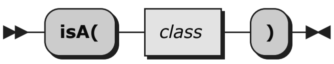
Note

Methods that have been hidden with a `setMethod` or `define` method are included with the other methods that `instanceMethods` returns. The hidden methods have **`.nil`** for their associated method.

Example 5.31. Object class — instanceMethods method

```
-- list all class methods of .String only
say .String~instanceMethods(.String)~allIndexes   --> CR,NEW,NL,NULL,TAB

-- count all class methods of .String and its superclasses
-- 4 .String class methods, 32 .Object class methods, 34 .Class class methods
say .String~instanceMethods~allIndexes~items      --> 70


-- count all instance methods of .String only
say ''~instanceMethods(.String)~allIndexes~items  --> 116

-- count all instance methods of .String and its superclasses
say ''~instanceMethods~allIndexes~items           --> 148
```

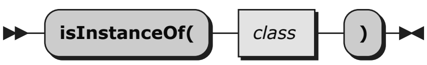
5.1.4.13. isA



Note

This method is an alias of the *isInstanceOf* method.

5.1.4.14. isInstanceOf



Returns **`.true`** if the object is an instance of the specified *class*, otherwise it returns **`.false`**, An object is an instance of a class if the object is directly an instance of the specified *class* or if *class* is in the object's direct or mixin class inheritance chain. For example:

Example 5.32. Object class — isInstanceOf method

```
"abc"~isInstanceOf(.string)           ->  1
"abc"~isInstanceOf(.object)           ->  1
"abc"~isInstanceOf(.mutablebuffer)    ->  0
```

5.1.4.15. isNil

Returns **.true** if the receiving object is the **.nil** object. Returns **.false** otherwise.

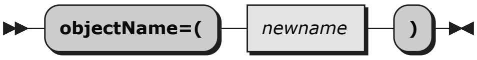
Example 5.33. Object class — isNil method

```
say .Object~isNil    -- 0
say .nil~isNil       -- 1
```

5.1.4.16. objectName

Returns any name set on the receiver object using the **objectName=** method. If the receiver object does not have a name, this method returns the result of the `defaultName` method. See *Section 4.2.11, “Required String Values”* for more information. See the **objectName=** method for an example using `objectName`.

5.1.4.17. objectName=

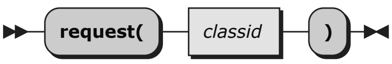


Sets the receiver object's name to the string *newname*.

Example 5.34. Object class — objectName= method

```
points=.array~of("N","S","E","W")
say points~objectName         /* (no change yet) Says: "an Array"    */
points~objectName=("compass") /* Changes obj name POINTS to "compass"*/
say points~objectName         /* Shows new obj name. Says: "compass" */
say points~defaultName        /* Default is still available.         */
                              /* Says "an Array"                     */
say points                    /* Says string representation of       */
                              /* points "compass"                    */
say points[3]                 /* Says: "E"  Points is still an array */
                              /* of 4 items                          */
```

5.1.4.18. request

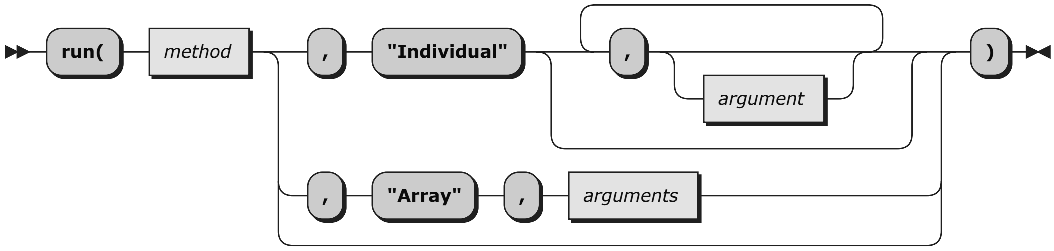


Returns an object of the *classid* class, or **.nil** if the request cannot be satisfied.

This method first compares the identity of the object's class (see the *id* method of the Class class) to *classid*. If they are the same, the receiver object is returned as the result. Otherwise, `request` tries to obtain and return an object satisfying *classid* by sending the receiver object the conversion message **make** with the string *classid* appended (converted to uppercase). For example, a **`request("string")`** message causes a `makeString` message to be sent. If the object does not have the required conversion method, `request` returns **`.nil`**.

The conversion methods cause objects to produce different representations of themselves. The presence or absence of a conversion method defines an object's capability to produce the corresponding representations. For example, lists can represent themselves as arrays, because they have a `makeArray` method, but they cannot represent themselves as directories, because they do not have a `makeDirectory` method. Any conversion method must return an object of the requested class. For example, `makeArray` must return an array. The language processor uses the `makeString` method to obtain string values in certain contexts; see *Section 4.2.11, "Required String Values"*.

5.1.4.19. run (Private Method)



Runs *method*, which can be either

- a *method* object, or
- a string containing a method source line, or an Array of strings containing individual method source lines (for these cases an equivalent method object is created).

The *method* has access to the object variables of the receiver object, as if the receiver object had defined the method by using `setMethod`.

If you specify neither **`Individual`** nor **`Array`**, the method runs without arguments.

If you specify the **`Individual`** or **`Array`** option, any remaining *argument*s are arguments for the method. (You need to specify only the first letter; all characters following the first character are ignored.)

`Individual`
: Passes any remaining *arguments* to the method as arguments in the order you specify them.

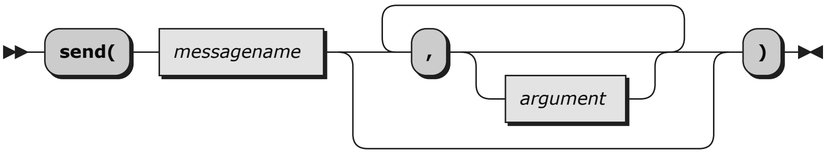
`Array`
: Requires *arguments*, which is an Array object. The member items of the array are passed to the method as arguments. The first argument is at index 1, the second argument at index 2, and so on. If you omitted any indexes when creating the array, the corresponding arguments are omitted when passing the arguments.

Notes:

1. The `run` method is a private method (see *Section 4.2.8, "Public, Package-Scope, and Private Methods"*) with the additional restriction that it can only be called
   - from an instance method of the receiving object itself, or
   - from a class method in the receiving object's inheritance chain.

2. The `run` method is a protected method.

5.1.4.20. send



Returns the result of invoking a method on the target object using the specified message name and arguments. The `send` method allows methods to be invoked using dynamically constructed method names.

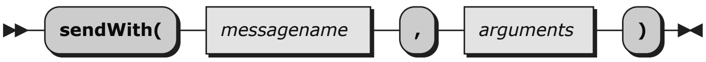
The *messagename* can be a string or an array. If *messagename* is an array object, its first item is the name of the message and its second item is a class object to use as the starting point for the method search.

Any *argument*s are passed to the receiver as arguments for *messagename* in the order you specify them.

Example 5.35. Object class — send method

```
world = .WorldObject~new
-- these calls are equivalent and produce "Hello World, I'm Fred!"
say world~hello("World", "Fred")
say world~send("HELLO", "World", "Fred")

::class WorldObject
::method hello
  use strict arg place, name
  return "Hello" place", I'm"  name"!"
```

5.1.4.21. sendWith



Returns the result of invoking a method on the target object using the specified message name and arguments. The `sendWith` method allows methods to be invoked using dynamically constructed method names and arguments.

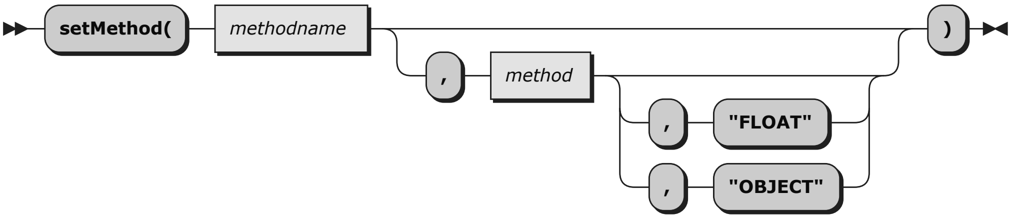
The *messagename* can be a string or an array. If *messagename* is an array object, its first item is the name of the message and its second item is a class object to use as the starting point for the method search.

The *arguments* argument must be a single-dimensional Array instance. The values contained in *arguments* are passed to the receiver as arguments for *messagename* in the order you specify them.

Example 5.36. Object class — sendWith method

```
world = .WorldObject~new
-- these calls are equivalent and produce "Hello World, I'm Fred!"
say world~hello("World", "Fred")
say world~sendWith("HELLO", .Array~of("World", "Fred"))

::class WorldObject
::method hello
  use strict arg place, name
  return "Hello" place", I'm"  name"!"
```

5.1.4.22. setMethod (Private Method)



Adds *method* to the receiver object's collection of object methods.

The *methodname* is the name of the new method. This name is translated to uppercase. If you previously defined a method with the same name using `setMethod`, the new method replaces the earlier one. If you omit *method*, `setMethod` makes the method name *methodname* unavailable for the receiver object. In this case, sending a message of that name to the receiver object runs the `unknown` method (if any).

The *method* can be either

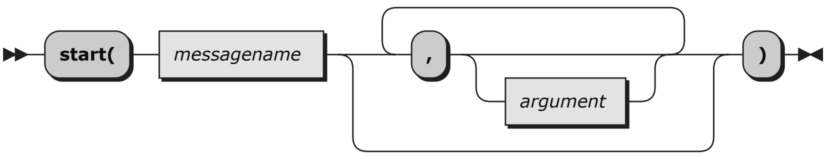
- a *method* object, or
- a string containing a method source line, or an Array of strings containing individual method source lines (for these cases an equivalent method object is created).

The third parameter is optional, and describes if the method that is attached to an object should have **`OBJECT`** or **`FLOAT`** scope. **`FLOAT`** scope, which is the default, means that it shares the same scope with methods that were defined outside of a class. **`OBJECT`** scope means it shares the scope with other, potentially statically defined, methods of the object it is attached to.

Notes:

1. The `setMethod` method is a private method (see *Section 4.2.8, "Public, Package-Scope, and Private Methods"*) with the additional restriction that it can only be called
   - from an instance method of the receiving object itself, or
   - from a class method in the receiving object's inheritance chain.
2. The `setMethod` method is a protected method.

5.1.4.23. start



Returns a *message* object and sends it a `start` message to start concurrent processing. The object receiving the message *messagename* processes this message concurrently with the sender's continued processing.

The *messagename* can be a string or an array. If *messagename* is an array object, its first item is the name of the message and its second item is a class object to use as the starting point for the method search.

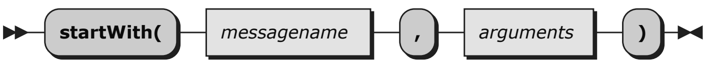
Any *arguments* are passed to the receiver as arguments for *messagename* in the order you specify them.

When the receiver object has finished processing the message, the message object retains its result and holds it until the sender requests it by sending a `result` message. For further details, see **`Message`** class method *start*.

Example 5.37. Object class — start method

```
world = .WorldObject~new
-- these calls are equivalent and produce "Hello World, I'm Fred!"
msg1 = world~start("HELLO", "World", "Fred")
msg2 = .message~new(world, "HELLO", "i", "World", "Fred")~~start
say msg1~result
say msg2~result

::class WorldObject
::method hello
  use strict arg place, name
  return "Hello" place", I'm"  name"!"
```

5.1.4.24. startWith



Returns a *message* object and sends it a `start` message to start concurrent processing. The object receiving the message *messagename* processes this message concurrently with the sender's continued processing.

The *messagename* can be a string or an array. If *messagename* is an array object, its first item is the name of the message and its second item is a class object to use as the starting point for the method search.

The *arguments* argument must be a single-dimensional Array instance. Any values contained in *arguments* are passed to the receiver as arguments for *messagename* in the order you specify them.

When the receiver object has finished processing the message, the message object retains its result and holds it until the sender requests it by sending a `result` message. For further details, see **`Message`** class method *start*.

Example 5.38. Object class — startWith method

```
world = .WorldObject~new
-- these calls are equivalent and produce "Hello World, I'm Fred!"
msg1 = world~startWith("HELLO", .Array~of("World", "Fred"))
msg2 = .message~new(world,"HELLO", "a", .Array~of("World", "Fred"))~~start
say msg1~result
say msg2~result

::class WorldObject
::method hello
  use strict arg place, name
  return "Hello" place", I'm"  name"!"
```

5.1.4.25. string

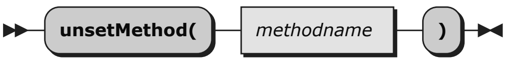
Returns a human-readable string representation of the object. The exact form of this representation depends on the object and might not alone be sufficient to reconstruct the object. All objects must be able to produce a string representation of themselves in this way.

The object's string representation is obtained from the *objectName* method (which can in turn use the *defaultName* method).

The distinction between this method, the *makeString* method (which obtains string values) and the *request* method is important. All objects have a `string` method, which returns a string representation (human-readable form) of the object. This form is useful in tracing and debugging. Only those objects that have information with a meaningful string form have a `makeString` method to return this value. For example, Directory objects have a readable string representation (**`"a Directory"`**), but no string value, and, therefore, no `makeString` method.

Of the classes that Rexx provides, the *Array Class*, the *CircularQueue Class*, the *DateTime Class*, the *File Class*, the *MutableBuffer Class*, the *StackFrame Class*, the *String Class*, and the *TimeSpan Class* have a `makeString` method. Any subclasses of these classes inherit this method by default, so these subclasses also have string values. Any other class can also provide a string value by defining a `makeString` method.

5.1.4.26. unsetMethod (Private Method)



Cancels the effect of all previous `setMethods` for method *methodname*. It also removes any method *methodname* introduced with *enhanced* when the object was created. If the object has received no `setMethod` method, no action is taken.

Notes:

1. The `unsetMethod` method is a private method (see *Section 4.2.8, “Public, Package-Scope, and Private Methods”*) with the additional restriction that it can only be called
   - from an instance method of the receiving object itself, or
   - from a class method in the receiving object's inheritance chain.
2. The `unsetMethod` method is a protected method.

5.1.5. Package Class

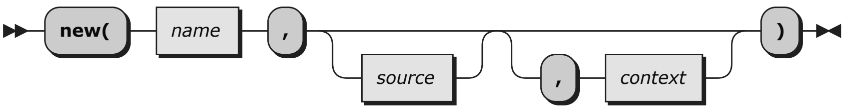
The Package class contains the source code for a package of Rexx code. A package instance holds all of the routines, classes, and methods created from a source code unit and also manages external dependencies referenced by ::REQUIRES directives. The files loaded by ::REQUIRES are also contained in Package class instances. It is a subclass of the *Object class*.

Table 5.5. Package Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
Package
new (Class Method)

addClass	*findPublicClass*	*prolog*
addPackage	*findPublicRoutine*	*publicClasses*
addPublicClass	*findRoutine*	*publicRoutines*
addPublicRoutine	*form*	*resource*
addRoutine	*fuzz*	*resources*
annotation	*importedClasses*	*routines*
annotations	*importedPackages*	*setSecurityManager*
classes	*importedRoutines*	*source*
definedMethods	*loadLibrary*	*sourceLine*
digits	*loadPackage*	*sourceSize*
findClass	*local*	*trace*
findNamespace	*name*	
findProgram	*namespaces*	

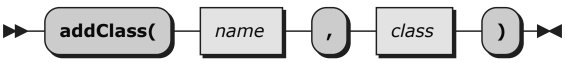
5.1.5.1. new (Class Method)



Returns a new instance of the package class, which is a representation of the code contained in the *source*. The *name* is a string. The *source* can be a single string or an array of strings containing individual method lines. If *source* isn't specified, *name* identifies a file that will be used as the package source. The file is searched for using the *external program search order*.

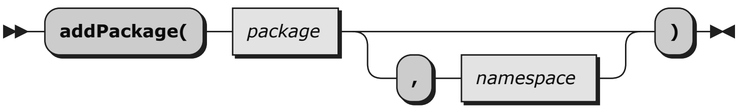
The *context* allows the created package to inherit class and routine lookup scope from another source. If specified, *context* can be a Method object, a Routine object, or a Package object. If not specified, the newly created package will inherit the class and routine search scope from the caller of new method.

5.1.5.2. addClass



Adds the class object *class* to the available classes under the name *name*. This is added to the package as a non-public class.

5.1.5.3. addPackage



Adds the package object *package* to the dependent packages. An optional string *namespace* may be specified, which will allow to qualify references to classes or routines within *package*.

The added package is processed as if it had been added using a ::REQUIRES directive in the original package source.

Example 5.39. Package class — addPackage method

```
.context~package~addPackage(.Package~new('winsystm.cls'), 'windows')
say windows:virtualkeycodes~new~keyName(36)   -- HOME
```

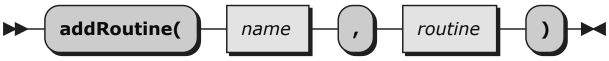
5.1.5.4. addPublicClass

Adds the class object *class* to the available public classes under the name *name*. This is added to the package as a public class.

5.1.5.5. addPublicRoutine

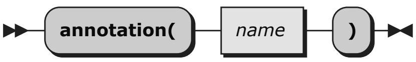
Adds the routine object *routine* to the available routines under the name *name*. This is added to the package as a public routine.

5.1.5.6. addRoutine



Adds the routine object *routine* to the available routines under the name *name*. This is added to the package as a non-public routine.

5.1.5.7. annotation



Returns the value of the annotation named *name* for this package. If no such annotation exists, `.nil` is returned.

See also
- method *annotations* and
- *::ANNOTATE* directive.

5.1.5.8. annotations

Returns a StringTable of all annotation name/value pairs for this package.

See also
- method *annotation* and
- *::ANNOTATE* directive.

5.1.5.9. classes

Returns a StringTable containing all classes defined by this package.

See also methods *publicClasses* and *importedClasses*.

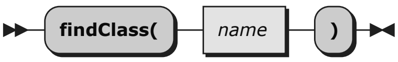
5.1.5.10. definedMethods

Returns a StringTable containing all unattached methods defined by this package. This is the same StringTable available to code within the package via the .METHODS environment symbol.

5.1.5.11. digits

Returns the initial *NUMERIC* DIGITS setting used for all Rexx code contained within the package. The default value is 9. The *::OPTIONS* directive can override the default value.

5.1.5.12. findClass



Performs the standard environment symbol searches given *name*. The search is performed using the same search mechanism used for environment symbols or class names specified on ::CLASS directives. If the name is not found, **`.nil`** will be returned.

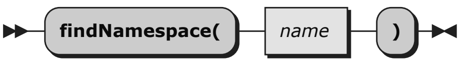
Note that the standard environment symbol search will return an object instance (and not a class) when searching e. g. for "nil", "true", "false", "endofline", "RexxInfo", or objects in the .LOCAL directory.

See also method *findPublicClass*.

Example 5.40. Package class — findClass method

```
say .RexxInfo~package~findClass("Dummy")  -- The NIL object
say .context~package~findClass("Dummy")   -- The DUMMY class

::class Dummy
```

5.1.5.13. findNamespace



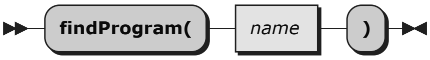
Returns the Package object that has been tagged with namespace *name*. Returns **`.nil`** if namespace *name* does not exist.

See also method *addPackage*.

Example 5.41. Package class — findNamespace method

```
say .context~package~findNamespace("rexx")      -- The REXX Package
say .context~package~findNamespace("windows")   -- a Package

::requires "winsystm.cls" namespace windows
```

5.1.5.14. findProgram



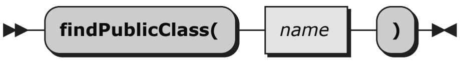
Locates program *name* using the target package context and returns the fully resolved filename. *name* must be a string that specifies the filename or path to an external program. The program is searched for using the *external program search order*.

Returns **`.nil`** if *name* cannot be located.

Example 5.42. Package class — findProgram method

```
say .context~package~findProgram("mime.cls")  -- e. g. C:\Program Files\ooRexx\mime.cls
```

5.1.5.15. findPublicClass



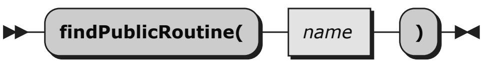
Returns the public class named *name*. Returns **`.nil`** if no public class of the specified name exists within the scope of the receiving package.

See also method *findClass*.

Example 5.43. Package class — findPublicClass method

```
say .context~package~findPublicClass("String")   -- The String class
say .context~package~findPublicClass("Dummy")    -- The NIL object
say .context~package~findPublicClass("RexxInfo") -- The NIL object

::class Dummy   -- private class
```

5.1.5.16. findPublicRoutine



Returns the public routine named *name*. Returns **`.nil`** if no public routine of the specified name exists within the scope of the receiving package.

See also methods *publicRoutines* and *findRoutine*.

Example 5.44. Package class — findPublicRoutine method

```
say .context~package~findPublicRoutine("Dummy")~source    -- "nop"

::routine Dummy public
nop
```

5.1.5.17. findRoutine

```
>>--findRoutine(--name--)--><
```

Searches for a routine within the package search order. This includes ::ROUTINE directives within the package, public routines imported from other packages, or routines added using the addRoutine method. The argument *name* must be a string object. If the name is not found, **`.nil`** will be returned.

5.1.5.18. form

```
>>--form--><
```

Returns the initial *NUMERIC* FORM setting used for all Rexx code contained within the package. The default value is SCIENTIFIC. The *::OPTIONS* directive can override the default value.

5.1.5.19. fuzz

```
>>--fuzz--><
```

Returns the initial *NUMERIC* FUZZ setting used for all Rexx code contained within the package. The default value is 0. The *::OPTIONS* directive can override the default value.

5.1.5.20. importedClasses

```
>>--importedClasses--><
```

Returns a StringTable containing all public classes imported from other packages.

See also methods *classes* and *publicClasses*.

5.1.5.21. importedPackages

```
>>--importedPackages--><
```

Returns an Array containing all packages imported by the target package.

5.1.5.22. importedRoutines

```
>>--importedRoutines--><
```

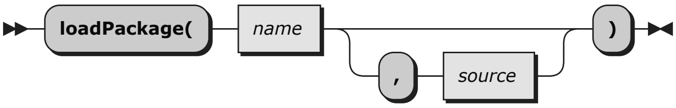
Returns a StringTable containing all public routines imported from other packages.

5.1.5.23. loadLibrary

```
>>--loadLibrary(--name--)--><
```

Loads a native library package and adds it to the list of libraries loaded by the interpreter. The *name* identifies a native external library file that will be located and loaded as if it had been named on a ::REQUIRES LIBRARY directive. If the library is successfully loaded, `loadLibrary` will return **`.true`**, otherwise it returns **`.false`**.

5.1.5.24. loadPackage



Loads a package and adds it to the list of packages loaded by the package manager. If only *name* is specified, *name* identifies a file that will be located and loaded as if it had been named on a *::REQUIRES* directive. The file is searched for using the *external program search order*.

If *source* is given, it must be an array of strings that is the source for the loaded package.

If a package *name* has already been loaded by the package manager, the previously loaded version will be used.

The resolved package object will be added to the receiving package object's dependent packages.

5.1.5.25. local

Returns a *Directory* of objects local to the receiving package.

See also *.LOCAL* for a Directory of objects local to the interpreter instance.

5.1.5.26. name

Returns the string name of the package.

The package name may be

- the absolute path of the executing program,
- any name that was specified when creating an instance of a Package or Routine class,
- "REXX" for classes defined by Rexx, or
- "INSTORE" for code executed through the **`rexx -e`** command.

Example 5.45. Package class — name method

```
say .context~package~name              -- e. g. C:\ExamplePackageName.rex
say .Class~package~name                -- REXX
say .Routine~new("rtn", "return .context~package~name")[]  -- rtn
say .Package~new("pkg", "")~name       -- pkg
```

5.1.5.27. namespaces

Returns a StringTable of all namespaces defined in the target package.

See also method *findNamespace*.

Example 5.46. Package class — namespaces method

```
say .context~package~namespaces~allIndexes      -- WINDOWS

::requires "winsystm.cls" namespace windows
```

5.1.5.28. prolog

Returns a routine object that represents the code of the target package that precedes any directives.

Example 5.47. Package class — prolog method

```
say .context~package~prolog~source  -- "say .context~package~prolog~source"

::options noprolog
```

5.1.5.29. publicClasses

Returns a StringTable containing all public classes defined in this package.

See also methods *findPublicClass* and *classes*.

Example 5.48. Package class — publicClasses method

```
say .package~new("csvstream.cls")~publicClasses~allIndexes -- CSVSTREAM
say .context~package~publicClasses~allIndexes              -- DUMMY
say .rexxinfo~package~publicClasses~items                  -- 56

::class dummy public
```

5.1.5.30. publicRoutines

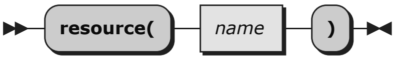
Returns a StringTable containing all public routines defined in this package. The StringTable indexes are the routine names, the StringTable values are individual routine objects.

See also method *findPublicRoutine*.

Example 5.49. Package class — publicRoutines method

```
say .package~new("csvstream.cls")~publicRoutines~items  -- 0
say .context~package~publicRoutines~allIndexes          -- DUMMY
say .rexxinfo~package~publicRoutines~items              -- 0

::routine dummy public
```

5.1.5.31. resource



Returns an Array of resources data lines a ::RESOURCE *name* directive in the target package defines. Returns **`.nil`**, if no resource *name* exists.

See also

- method *resources* and
- *::RESOURCE* directive.

Example 5.50. Package class — resource method

```
say .context~package~resource("GREYCAT")~makeString  -- La nuit, tous les chats sont gris

::resource greyCat
La nuit, tous les chats sont gris
::END
```

5.1.5.32. resources

Returns a StringTable of all data resources that ::RESOURCE directives in the target package define. The StringTable indexes are the resource names, the StringTable values are arrays of individual resource data lines.

See also

- method *resource* and
- *::RESOURCE* directive.

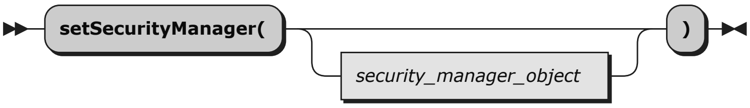
Example 5.51. Package class — resources method

```
say .context~package~resources~allIndexes  -- "BROWN FOX"
                                           -- "GREYCAT"
::resource greyCat
La nuit, tous les chats sont gris
::END

::resource "brown fox"
The quick brown fox jumps over the lazy dog
::END
```

5.1.5.33. routines

Returns a StringTable containing all routines defined in this package. The StringTable indexes are the routine names, the StringTable values are individual routine objects.

5.1.5.34. setSecurityManager

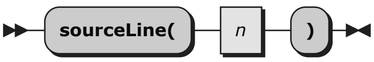


Replaces the existing security manager with the specified *security_manager_object*. If *security_manager_object* is omitted, any existing security manager is removed.

5.1.5.35. source

Returns the package source code as a single-dimensional Array of source lines. If the source code is not available, `source` returns an array of zero items.

5.1.5.36. sourceLine



Returns the *n*th source line from the package source. If the source code is not available or the indicated line does not exist, a null string is returned.

5.1.5.37. sourceSize

Returns the size of the source code for the package object. If the source code is not available, 0 is returned.

5.1.5.38. trace

Returns the initial *TRACE* setting used for all Rexx code contained within the package. The default value is Normal. The *::OPTIONS* directive can override the default value.

5.1.6. Routine Class

The Routine class creates routine objects from Rexx source code. It is a subclass of the *Object class*.

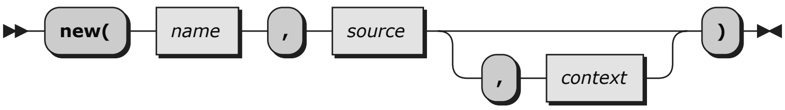
Table 5.6. Routine Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
Routine

new (Class Method)
loadExternalRoutine (Class method)
newFile (Class Method)

[]	*call*	*setSecurityManager*
annotation	*callWith*	*source*
annotations	*package*	

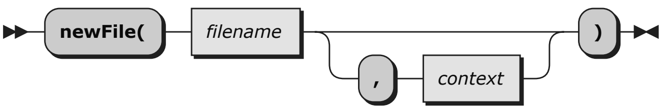
5.1.6.1. new (Class Method)



Returns a new instance of the **`Routine`** class, which is an executable representation of the code contained in the *source*. The *name* is a string. The *source* can be a single string or an array of strings containing individual method lines.

The *context* allows the created routine to inherit class and routine lookup scope from another source. If specified, *context* can be a Method object, a Routine object, a Package object, or the string "PROGRAMSCOPE". PROGRAMSCOPE is the default, and specifies that the newly created routine will inherit the class and routine search scope from the caller of the `new` method.

5.1.6.2. newFile (Class Method)



Returns a new instance of the **`Routine`** class, which is an executable representation of the code contained in the file *filename*. The *filename* is a string.

The *context* allows the created routine to inherit class and routine lookup scope from another source. If specified, *context* can be a Method object, a Routine object, a Package object, or the string "PROGRAMSCOPE". PROGRAMSCOPE is the default, and specifies that the newly created routine will inherit the class and routine search scope from the caller of the `newFile` method.

5.1.6.3. loadExternalRoutine (Class method)

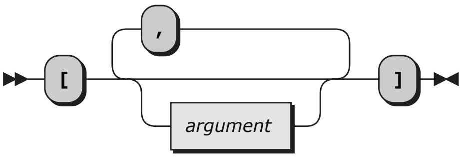
Resolves a native routine in an external library package and returns a Routine object instance that can be used to call the external routine. The *descriptor* is a string containing whitespace-delimited tokens that identify the location of the native routine. The first token identifies the type of native routine and must be **`LIBRARY`**. The second token must identify the name of the external library. The external library is located using platform-specific mechanisms for loading libraries. For Unix-based systems, the library name is case-sensitive. The third token is optional and specifies the name of the routine within the library package. If not specified, *name* is used. The routine name is not case sensitive. If the target routine cannot be resolved, **`.nil`** is returned.

Example 5.52. Routine class — loadExternalRoutine method

```
pi = .Routine~loadExternalRoutine("pi", "library rxmath rxcalcpi")
```

```
say pi~call(16) -- 3.141592653589793
```

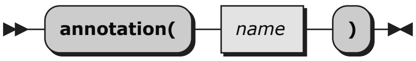
5.1.6.4. []



Calls the routine object using the provided *argument*s. The code in the routine object is called as if it was an external routine call. The return value will be any value returned by the executed routine.

See also method *call* for which this method is a synonym.

5.1.6.5. annotation



Returns the value of the annotation named *name* for this routine. If no such annotation exists, **`.nil`** is returned.

See also

- method *annotations* and
- *::ANNOTATE* directive.

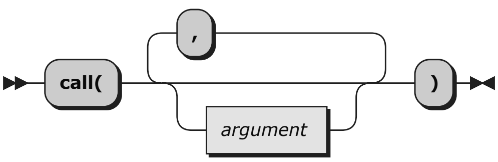
5.1.6.6. annotations

Returns a StringTable of all annotation name/value pairs for this routine.

See also

- method *annotation* and
- *::ANNOTATE* directive.

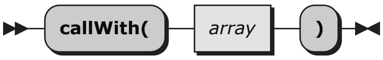
5.1.6.7. call



Calls the routine object using the provided *argument*s. The code in the routine object is called as if it was an external routine call. The return value will be any value returned by the executed routine.

See also method *[]* for which this method is a synonym.

5.1.6.8. callWith

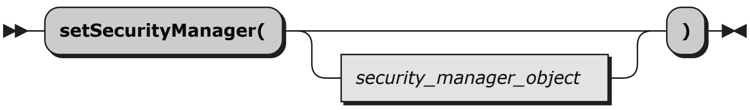


Calls the routine object using the arguments provided in *array*. Each element of *array* will be mapped to its corresponding call argument. The code in the routine object is called as if it was an external routine call. The return value will be any value returned by the executed routine.

5.1.6.9. package

Returns the Package class instance that defined the routine instance. The package instance controls and defines the search order for classes and routines referenced by the routine code.

5.1.6.10. setSecurityManager



Replaces the existing security manager with the specified *security_manager_object*. If *security_manager_object* is omitted, any existing security manager is removed.

5.1.6.11. source

Returns the routine source code as a single-dimensional Array of source lines. If the source code is not available, `source` returns an array of zero items.

5.1.7. String Class

String objects represent character-string data values. A character string value can have any length and contain any characters.

Table 5.7. String Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Comparable (Mixin Class)		
Methods inherited from the *Comparable class* *compareTo*		
String		
new (Class Method)	*digit (Class Method)*	*punct (Class Method)*
alnum (Class Method)	*graph (Class Method)*	*space (Class Method)*
alpha (Class Method)	*lower (Class Method)*	*tab (Class Method)*
blank (Class Method)	*nl (Class Method)*	*upper (Class Method)*
cntrl (Class Method)	*null (Class Method)*	*xdigit (Class Method)*

cr (Class Method)
print (Class Method)

Arithmetic Methods + - * ** / // %
Comparison Methods = == < <= << <<= <> > >= >< >> >>= \= \== \< \<< \> \>>
Concatenation Methods (abuttal) || (blank)
Logical Methods \ & && |

[]
? (inline if)
abbrev
abs
append
b2x
bitAnd
bitOr
bitXor
c2d
c2x
caselessAbbrev
caselessChangeStr
caselessCompare
caselessCompareTo
caselessContains
caselessContainsWord
caselessCountStr
caselessEndsWith
caselessEquals
caselessLastPos
caselessMatch
caselessMatchChar
caselessPos
caselessStartsWith
caselessWordPos
ceiling
center/centre
changeStr
compare
compareTo
contains
containsWord
copies
countStr
d2c
d2x
dataType
decodeBase64
delStr
delWord
encodeBase64
endsWith
equals
floor
format
hashCode
insert
lastPos
left
length
lower
makeArray
makeString
match
matchChar
max
min
modulo
overlay
pos
replaceAt
reverse
right
round
sign
space
startsWith
strip
subChar
substr
subWord
subWords
translate
trunc
upper
verify
word
wordIndex
wordLength
wordPos
words
x2b
x2c
x2d

5.1.7.1. new (Class Method)

Returns a new string object initialized with the characters in *stringvalue*.

5.1.7.2. alnum (Class Method)

Returns the string **`0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz`**, a character sequence representing the POSIX character class name **`ALNUM`** (alphanumeric characters).

See also class methods *alpha* and *digit*.

5.1.7.3. alpha (Class Method)

Returns the string **ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz**, a character sequence representing the POSIX character class name **ALPHA** (alphabetic characters).

See also class methods *lower* and *upper*.

5.1.7.4. blank (Class Method)

Returns the string **'09 20'x**, a character sequence representing the POSIX character class name **BLANK** (tab and space character).

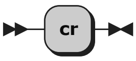
See also class method *space*.

5.1.7.5. cntrl (Class Method)

Returns the string **'00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F 7F'x**, a character sequence representing the POSIX character class name **CNTRL** (control characters).

See also class method *print (Class Method)*.

5.1.7.6. cr (Class Method)



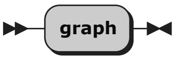
Returns the single character string for the carriage-return character, which has the value **'0d'x**.

5.1.7.7. digit (Class Method)

Returns the string **0123456789**, a character sequence representing the POSIX character class name **DIGIT** (digits).

See also class method *xdigit*.

5.1.7.8. graph (Class Method)



Returns the string **!"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_` abcdefghijklmnopqrstuvwxyz{|}~**, a character sequence representing the POSIX character class name **GRAPH** (visible characters).

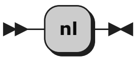
See also class method *print*.

5.1.7.9. lower (Class Method)

Returns the string **abcdefghijklmnopqrstuvwxyz**, a character sequence representing the POSIX character class name **LOWER** (lowercase letters).

See also class methods *upper* and *alpha*.

5.1.7.10. nl (Class Method)



Returns the single character string for the line-feed character, which has the value **'0a'x**.

5.1.7.11. null (Class Method)

Returns the single character string for the null character, which has the value **'00'x**.

5.1.7.12. print (Class Method)

Returns the string ** !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_` abcdefghijklmnopqrstuvwxyz{|}~** (with a leading space), a character sequence representing the POSIX character class name **PRINT** (visible characters and space character).

See also class method *graph*.

5.1.7.13. punct (Class Method)

Returns the string **!"#$%&'()*+,-./:;<=>?@[\]^_`{|}~**, a character sequence representing the POSIX character class name **PUNCT** (punctuation characters).

5.1.7.14. space (Class Method)

Returns the string **'09 0A 0B 0C 0D 20'x**, a character sequence representing the POSIX character class name **SPACE** (whitespace characters horizontal tab, line feed, vertical tab, form feed, carriage return, and space).

See also class method *blank*.

5.1.7.15. tab (Class Method)

Returns the single character string for the tab character, which has the value **'09'x**.

5.1.7.16. upper (Class Method)

Returns the string **ABCDEFGHIJKLMNOPQRSTUVWXYZ**, a character sequence representing the POSIX character class name **UPPER** (uppercase letters).

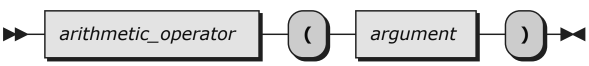
See also class method *lower*.

5.1.7.17. xdigit (Class Method)

Returns the string **0123456789ABCDEFabcdef**, a character sequence representing the POSIX character class name **XDIGIT** (hexadecimal digits).

See also class method *digit*.

5.1.7.18. Arithmetic Methods



Note

The syntax diagram above is for the non-prefix operators. For the prefix operators, omit the parentheses and *argument*.

Returns the result of performing the specified arithmetic operation on the receiver object. The receiver object and the *argument* must be valid *numbers*. The *arithmetic_operator* can be:

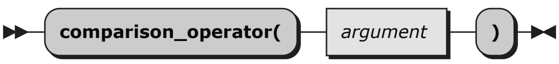
+	Addition
-	Subtraction
*	Multiplication
/	Division
%	Integer division (divide and return the integer part of the result)
//	Remainder (divide and return the remainder—not *modulo*, because the result can be negative)
**	Exponentiation (raise a number to a whole-number power)
Prefix -	Same as the subtraction: **`0 - number`**
Prefix +	Same as the addition: **`0 + number`**

See *Chapter 10, Numbers and Arithmetic* for details about precision, the format of valid numbers, and the operation rules for arithmetic. Note that if an arithmetic result is shown in exponential notation, it might have been rounded.

Example 5.53. String class — arithmetic methods

```
5+5     ->    10
8-5     ->     3
5*2     ->    10
6/2     ->     3
9//4    ->     1
9%4     ->     2
2**3    ->     8
+5      ->     5             /* Prefix +  */
-5      ->    -5             /* Prefix -  */
```

5.1.7.19. Comparison Methods



Returns **`.true`** or **`.false`**, the result of performing the specified comparison operation. The receiver object and the *argument* are the terms compared. Both must be string objects. If *argument* is not a string object, it is converted to its string representation for the comparison. The one exception is when *argument* is **`.nil`** for the ==, \==, =, \=, ><, and <> operators. A string object will never compare equal to **`.nil`**, even when the string matches the string value of **`.nil`** ("The NIL object"). As a result, == will always return **`.false`** when compared to **`.nil`** and \== will always return **`.true`**. All of the relational comparisons (for example, <, >, <=, etc.) will always return **`.false`** when compared to **`.nil`**.

The comparison operators you can use in a message are:

=	**`.true`** if the terms are equal (for example, numerically or when padded). **`.false`** if *argument* is **`.nil`**.
\=, ><, <>	**`.true`** if the terms are not equal (inverse of =). **`.true`** if *argument* is **`.nil`**.
>	Greater than. **`.false`** if *argument* is **`.nil`**.

<	Less than. **`.false`** if *argument* is **`.nil`**.
>=	Greater than or equal to. **`.false`** if *argument* is **`.nil`**.
\<	Not less than. **`.false`** if *argument* is **`.nil`**.
<=	Less than or equal to. **`.false`** if *argument* is **`.nil`**.
\>	Not greater than. **`.false`** if *argument* is **`.nil`**.

Example 5.54. String class — comparison methods

```
5=5         ->     1          /* equal           */

42\=41      ->     1          /* All of these are */
42><41      ->     1          /* "not equal"      */
42<>41      ->     1

13>12       ->     1          /* Variations of    */
12<13       ->     1          /* less than and    */
13>=12      ->     1          /* greater than     */
12\<13      ->     0
12<=13      ->     1
12\>13      ->     1
```

All strict comparison operations have one of the characters doubled that define the operator. The **==** and **\==** operators check whether two strings match exactly. The two strings must be identical (character by character) and of the same length to be considered strictly equal.

The strict comparison operators such as **>>** or **<<** carry out a simple character-by-character comparison. There is no padding of either of the strings being compared. The comparison of the two strings is from left to right. If one string is shorter than and a leading substring of another, then it is smaller than (less than) the other. The strict comparison operators do not attempt to perform a numeric comparison on the two operands.

For all the other comparison operators, if both terms are numeric, the String class does a numeric comparison (ignoring, for example, leading zeros—see *Section 10.4, “Numeric Comparisons”*). Otherwise, it treats both terms as character strings, ignoring leading and trailing whitespace characters and padding the shorter string on the right with blanks.

Character comparison and strict comparison operations are both case-sensitive, and for both the exact collating order can depend on the character set. In an ASCII environment, the digits are lower than the alphabetic characters, and lowercase alphabetic characters are higher than uppercase alphabetic characters.

The strict comparison operators you can use in a message are:

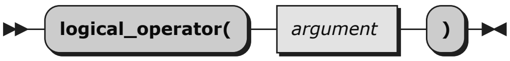
==	**`.true`** if terms are strictly equal (identical)
\==	**`.true`** if the terms are NOT strictly equal (inverse of ==)
>>	Strictly greater than
<<	Strictly less than
>>=	Strictly greater than or equal to
\<<	Strictly NOT less than
<<=	Strictly less than or equal to

\>> Strictly NOT greater than

Example 5.55. String class — comparison methods

```
"space"=="space"     ->     1          /* Strictly equal     */

"space"\==" space"   ->     1          /* Strictly not equal */

"space">>" space"    ->     1          /* Variations of      */
" space"<<"space"    ->     1          /* strictly greater   */
"space">>=" space"   ->     1          /* than and less than */
"space"\<<" space"   ->     1
" space"<<="space"   ->     1
" space"\>>"space"   ->     1
```

5.1.7.20. Logical Methods



Note

For NOT (prefix \), omit the parentheses and *argument*.

Returns **.true** or **.false**, the result of performing the specified logical operation. The receiver object and the *argument* are character strings that evaluate to **1** or **0**.

The *logical_operator* can be:

& AND (Returns **1** if both terms are **.true**.)

| Inclusive OR (Returns **1** if either term or both terms are true.)

&& Exclusive OR (Returns **1** if either term, but not both terms, is **.true**.)

Prefix \ Logical NOT (Negates; **1** becomes **0**, and **0** becomes **1**.)

Example 5.56. String class — logical methods

```
1&0     ->     0
1|0     ->     1
1&&0    ->     1
\1      ->     0
```

5.1.7.21. Concatenation Methods

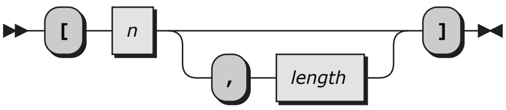
Concatenates the receiver object with *argument*. (See Section 1.11.2.1, “String Concatenation”.) The *concatenation_operator* can be:

""	concatenates without an intervening blank. The abuttal operator "" is the null string. The language processor uses the abuttal to concatenate two terms that another operator does not separate.
||	concatenates without an intervening blank.
" "	concatenates with one blank between the receiver object and the *argument*. (The operator " " is a blank.)

Example 5.57. String class — concatenation methods

```
f = "abc"
f"def"       ->   "abcdef"
f || "def"   ->   "abcdef"
f "def"      ->   "abc def"
```

5.1.7.22. []



If *length* is omitted, returns the character at position *n* of the receiving string. If *n* is larger than the length of the receiving string, a null string is returned.

If *length* is specified, returns the substring of the receiving string starting at position *n* and of length *length*. No padding occurs for any portion of the returned string not within the boundaries of the receiving string.

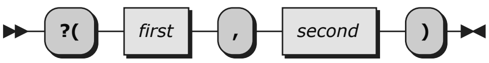
The *n* must be a positive whole number, and, if specified, *length* must be a a non-negative whole number.

See also methods *subChar* and *substr*.

Example 5.58. String class — [] method

```
"abc"[2]        -- "b"
"abc"[2,4]      -- "bc"
```

5.1.7.23. ? (inline if)

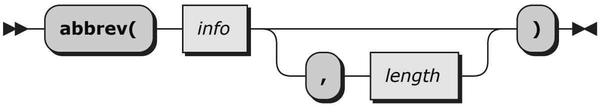


Returns *first* if the receiving string is **`.true`**, returns *second* if it is **`.false`**.

Example 5.59. String class — ? method

```
do apples = 0 to 2                                 -- 0 apples
  say apples (apples = 1)~?("apple", "apples")    -- 1 apple
end                                                -- 2 apples
```

5.1.7.24. abbrev



Returns **1** if *info* is equal to the leading characters of the receiving string and the length of *info* is not less than *length*. Returns **0** if either of these conditions is not met.

If you specify *length*, it must be a positive whole number or zero. The default for *length* is the number of characters in *info*.

Example 5.60. String class — abbrev method

```
"Print"~abbrev("Pri")       ->    1
"PRINT"~abbrev("Pri")       ->    0
"PRINT"~abbrev("PRI",4)     ->    0
"PRINT"~abbrev("PRY")       ->    0
"PRINT"~abbrev("")          ->    1
"PRINT"~abbrev("",1)        ->    0
```

Note

A null string always matches if a length of **0**, or the default, is used. This allows a default keyword to be selected automatically if desired.

Example 5.61. String class — abbrev method

```
say "Enter option:";   pull option .
select  /* keyword1 is to be the default */
  when "keyword1"~abbrev(option) then ...
  when "keyword2"~abbrev(option) then ...
  ...
  otherwise nop;
end;
```

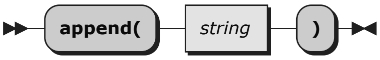
5.1.7.25. abs

Returns the absolute value of the receiving string. The result has no sign and is formatted according to the current NUMERIC settings.

Example 5.62. String class — abs method

```
12.3~abs       ->      12.3
"-0.307"~abs   ->      0.307
```

5.1.7.26. append



Returns a string consisting of *string* appended to the receiving string.

5.1.7.27. b2x

Returns a string, in character format, that represents the receiving binary string converted to hexadecimal.

The receiving string is a string of binary (**0** or **1**) digits. It can be of any length. It can optionally include whitespace characters (at 4-digit boundaries only, not leading or trailing). These are to improve readability and are ignored.

The returned string uses uppercase alphabetic characters for the values **A**-**F** and does not include whitespace.

If the receiving binary string is a null string, `b2x` returns a null string. If the number of binary digits in the receiving string is not a multiple of four, up to three **0** digits are added on the left before the conversion to make a total that is a multiple of four.

Example 5.63. String class — b2x method

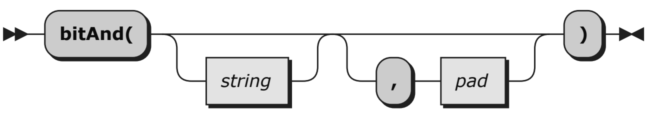
```
"11000011"~b2x     ->   "C3"
"10111"~b2x        ->   "17"
"101"~b2x          ->   "5"
"1 1111 0000"~b2x  ->   "1F0"
```

You can combine `b2x` with the methods `x2d` and `x2c` to convert a binary number into other forms.

Example 5.64. String class — b2x method with x2d

```
"10111"~b2x~x2d  ->   "23"   /* decimal 23 */
```

5.1.7.28. bitAnd

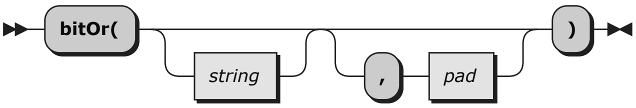


Returns a string composed of the receiver string and the argument *string* logically ANDed together, bit by bit. (The encodings of the strings are used in the logical operation.) The length of the result is the length of the longer of the two strings. If you omit the *pad* character, the AND operation stops when the shorter of the two strings is exhausted, and the unprocessed portion of the longer string is appended to the partial result. If you provide *pad*, it extends the shorter of the two strings on the right before the logical operation. The default for *string* is the zero-length (null) string.

Example 5.65. String class — bitand method

```
"12"x~bitAnd                  ->    "12"x
"73"x~bitAnd("27"x)           ->    "23"x
"13"x~bitAnd("5555"x)         ->    "1155"x
"13"x~bitAnd("5555"x,"74"x)   ->    "1154"x
"pQrS"~bitAnd(,"DF"x)         ->    "PQRS"      /* ASCII   */
```

5.1.7.29. bitOr

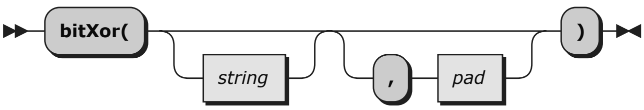


Returns a string composed of the receiver string and the argument *string* logically inclusive-ORed, bit by bit. The encodings of the strings are used in the logical operation. The length of the result is the length of the longer of the two strings. If you omit the *pad* character, the OR operation stops when the shorter of the two strings is exhausted, and the unprocessed portion of the longer string is appended to the partial result. If you provide *pad*, it extends the shorter of the two strings on the right before the logical operation. The default for *string* is the zero-length (null) string.

Example 5.66. String class — bitor method

```
"12"x~bitOr                  ->    "12"x
"15"x~bitOr("24"x)           ->    "35"x
"15"x~bitOr("2456"x)         ->    "3556"x
"15"x~bitOr("2456"x,"F0"x)   ->    "35F6"x
"1111"x~bitOr(,"4D"x)        ->    "5D5D"x
"pQrS"~bitOr(,"20"x)         ->    "pqrs" /* ASCII   */
```

5.1.7.30. bitXor



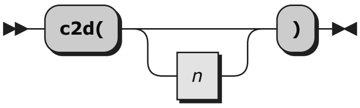
Returns a string composed of the receiver string and the argument *string* logically eXclusive-ORed, bit by bit. The encodings of the strings are used in the logical operation. The length of the result is the length of the longer of the two strings. If you omit the *pad* character, the XOR operation stops when the shorter of the two strings is exhausted, and the unprocessed portion of the longer string is appended to the partial result. If you provide *pad*, it extends the shorter of the two strings on the right before carrying out the logical operation. The default for *string* is the zero-length (null) string.

Example 5.67. String class — bitxor method

```
"12"x~bitXor                     ->  "12"x
"12"x~bitXor("22"x)              ->  "30"x
"1211"x~bitXor("22"x)            ->  "3011"x
```

```
"1111"x~bitXor("444444"x)         ->  "555544"x
"1111"x~bitXor("444444"x,"40"x)   ->  "555504"x
"1111"x~bitXor(,"4D"x)            ->  "5C5C"x
"C711"x~bitXor("222222"x," ")     ->  "E53302"x  /* ASCII  */
```

5.1.7.31. c2d



Returns the decimal value of the binary representation of the receiving string. If the result cannot be expressed as a whole number, an error results. That is, the result must not have more digits than the current setting of NUMERIC DIGITS. If you specify *n*, it is the length of the returned result. If you do not specify *n*, the receiving string is processed as an unsigned binary number. If the receiving string is null, C2D returns **`0`**.

Example 5.68. String class — c2d method

```
"09"X~c2d       ->       9
"81"X~c2d       ->     129
"FF81"X~c2d     ->   65409
""~c2d          ->       0
"a"~c2d         ->      97     /*  ASCII   */
```

If you specify *n*, the receiving string is taken as a signed number expressed in *n* characters. The number is positive if the leftmost bit is off, and negative if the leftmost bit is on. In both cases, it is converted to a whole number, which can therefore be negative. The receiving string is padded on the left with "00"x characters (not "sign-extended"), or truncated on the left to *n* characters. This padding or truncation is as though **`receiving_string~right(n,'00'x)`** had been processed. If *n* is **`0`**, `c2d` always returns **`0`**.

Example 5.69. String class — c2d method

```
"81"X~c2d(1)      ->     -127
"81"X~c2d(2)      ->      129
"FF81"X~c2d(2)    ->     -127
"FF81"X~c2d(1)    ->     -127
"FF7F"X~c2d(1)    ->      127
"F081"X~c2d(2)    ->    -3967
"F081"X~c2d(1)    ->     -127
"0031"X~c2d(0)    ->        0
```

5.1.7.32. c2x

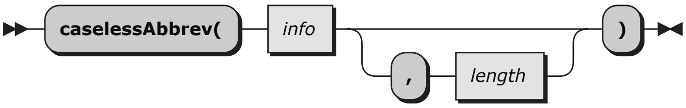
Returns a string, in character format, that represents the receiving string converted to hexadecimal. The returned string contains twice as many bytes as the receiving string. On an ASCII system, sending a `c2x` message to the receiving string **`1`** returns **`31`** because "31"X is the ASCII representation of **`1`**.

The returned string has uppercase alphabetic characters for the values **A-F** and does not include whitespace. The receiving string can be of any length. If the receiving string is null, `c2x` returns a null string.

Example 5.70. String class — c2x method

```
"0123"X~c2x    ->    "0123"   /* "30313233"X     in ASCII */
"ZD8"~c2x      ->    "5A4438" /* "354134343338"X in ASCII */
```

5.1.7.33. caselessAbbrev



Returns **1** if *info* is equal to the leading characters of the receiving string and the length of *info* is not less than *length*. Returns **0** if either of these conditions is not met. The characters are tested using a caseless comparison.

If you specify *length*, it must be a positive whole number or zero. The default for *length* is the number of characters in *info*.

Example 5.71. String class — caselessAbbrev method

```
"Print"~caselessAbbrev("Pri")      ->    1
"PRINT"~caselessAbbrev("Pri")      ->    1
"PRINT"~caselessAbbrev("PRI",4)    ->    0
"PRINT"~caselessAbbrev("PRY")      ->    0
"PRINT"~caselessAbbrev("")         ->    1
"PRINT"~caselessAbbrev("",1)       ->    0
```

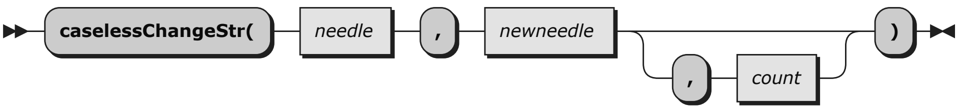
Note

A null string always matches if a length of **0**, or the default, is used. This allows a default keyword to be selected automatically if desired.

Example 5.72. String class — caselessAbbrev method

```
say "Enter option:";   parse pull option .
select  /* keyword1 is to be the default */
  when "keyword1"~caselessAbbrev(option) then ...
  when "keyword2"~caselessAbbrev(option) then ...
  ...
  otherwise nop;
end;
```

5.1.7.34. caselessChangeStr



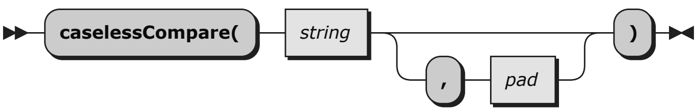
Returns a copy of the receiver object in which *newneedle* replaces occurrences of *needle*. If *count* is not specified, all occurrences of *needle* are replaced. If *count* is specified, it must be a non-negative, whole number that gives the maximum number of occurrences to be replaced. The *needle* searches are performed using caseless comparisons.

Here are some examples:

Example 5.73. String class — caselessChangeStr method

```
"AbaAbb"~caselessChangeStr("A","")      ->    "bbb"
AbaBabAB~changeStr("ab","xy")           ->    "xyxyxyxy"
AbaBabAB~changeStr("ab","xy",1)         ->    "xyaBabAB"
```

5.1.7.35. caselessCompare

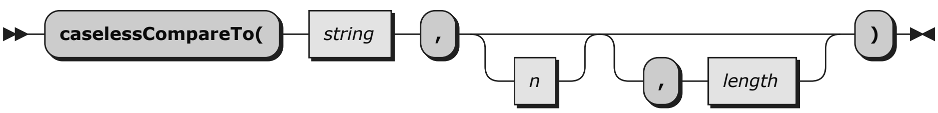


Returns **0** if the argument *string* is identical to the receiving string using a caseless comparison. Otherwise, returns the position of the first character that does not match. The shorter string is padded on the right with *pad* if necessary. The default *pad* character is a blank.

Example 5.74. String class — caselessCompare method

```
"abc"~caselessCompare("ABC")          ->    0
"abc"~caselessCompare("Ak")           ->    2
"ab "~caselessCompare("AB")           ->    0
"AB "~caselessCompare("ab"," ")       ->    0
"ab "~caselessCompare("ab","x")       ->    3
"abXX "~caselessCompare("ab","x")     ->    5
```

5.1.7.36. caselessCompareTo

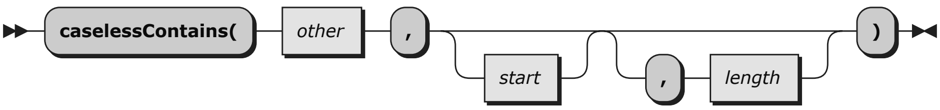


Performs a caseless sort comparison of the target string to the *string* argument. If the two strings are equal, **0** is returned. If the target string is larger, **1** is returned. **-1** if the *string* argument is the larger string. The comparison is performed starting at character *n* for *length* characters in both strings. *n* must be a positive whole number. If *n* is omitted, the comparison starts at the first character. *length* must be a non-negative whole number. If omitted, the comparison will take place to the end of the target string.

Example 5.75. String class — caselessCompareTo method

```
"abc"~caselessCompareTo("abc")          ->    0
"b"~caselessCompareTo("a")              ->    1
"a"~caselessCompareTo("b")              ->   -1
"abc"~caselessCompareTo("aBc")          ->    0
"aBc"~caselessCompareTo("abc")          ->    0
"000abc000"~caselessCompareTo(111abc111", 4, 3)  -> 0
```

5.1.7.37. caselessContains



Returns **`.true`** if the receiving string contains the *other* string. It returns **`.false`** if *other* is the null string or is not found within the receiving string. The search is performed using caseless comparisons.

By default, the search starts at the first character of the receiving string and continues to the end. You can override this by specifying *start*, the point at which the search starts, and *length*, the bounding limit for the search.

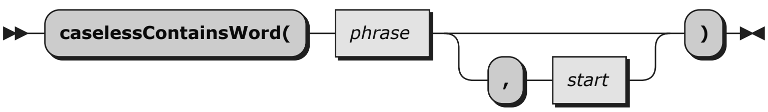
If specified, *start* must be a positive whole number and *length* must be a non-negative whole number.

See also methods *contains*, *caselessStartsWith*, *caselessEndsWith*, and *caselessPos*.

Example 5.76. String class — caselessContains method

```
say "-abcdef-"~caselessContains("EF")          -- 1
say "-abcdef-"~caselessContains("-", 2, 6)     -- 0
```

5.1.7.38. caselessContainsWord



Returns **`.true`** if *phrase* is found in the receiving string. Returns **`.false`** if *phrase* contains no words or if *phrase* is not found. Word matches are made independent of case. Multiple whitespace characters between words in either *phrase* or the receiving string are treated as a single blank for the comparison, but, otherwise, the words must match, except for case.

By default the search starts at the first word in the receiving string. You can override this by specifying *start* (which must be a positive whole number), the word at which the search is to be started.

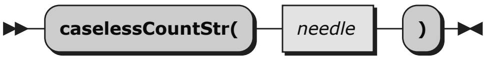
See also methods *containsWord* and *caselessWordPos* (`caselessContainsWord` returns **`.false`** exactly if `caselessWordPos` would have returned **`"0"`**.)

Example 5.77. String class — caselessContainsWord method

```
good = "Now is the time for all good men"
```

```
good~caselessContainsWord("the")          -- .true
good~caselessContainsWord("The")          -- .true
good~caselessContainsWord("is the")       -- .true
good~caselessContainsWord("is   the ")    -- .true
good~caselessContainsWord("is time")      -- .false
good~caselessContainsWord("time")         -- .true
good~caselessContainsWord("time", 5)      -- .false
```

5.1.7.39. caselessCountStr



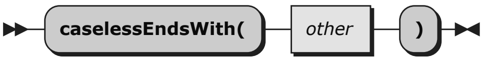
Returns a count of the occurrences of *needle* in the receiving string that do not overlap. All matches are made using caseless comparisons.

Here are some examples:

Example 5.78. String class — caselessCountStr method

```
"a0Aa0A"~caselessCountStr("a")        ->    4
"J0kKk0"~caselessCountStr("KK")       ->    1
```

5.1.7.40. caselessEndsWith

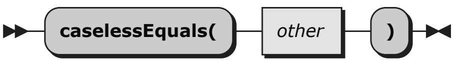


Returns **.true** if the characters of the *other* match the characters at the end of the target string. Returns **.false** if the characters are not a match, or if *other* is the null string. The match is made using caseless comparisons.

The caselessEndsWith method is useful for efficient string parsing as it does not require new string objects be extracted from the target string.

See also methods *caselessStartsWith*, *endsWith*, and *caselessMatch*.

5.1.7.41. caselessEquals

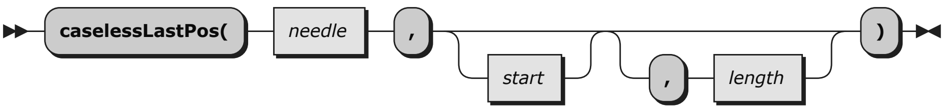


Returns **.true** if the target string is strictly equal to the *other* string, using a caseless comparison. Returns **.false** if the two strings are not strictly equal.

Example 5.79. String class — caselessEquals method

```
"a"~caselessEquals("A")        ->    1
"aa"~caselessEquals("A")       ->    0
"4"~caselessEquals("3")        ->    0
```

5.1.7.42. caselessLastPos



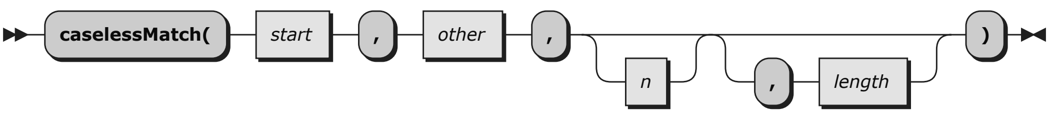
Returns the position of the last occurrence of a string, *needle*, in the receiving string. It returns **`0`** if *needle* is the null string or not found. By default, the search starts at the last character of the receiving string and scans backward to the beginning of the string. You can override this by specifying *start*, the point at which the backward scan starts and *length*, the range of characters to scan. The *start* must be a positive whole number and defaults to **`receiving_string~length`** if larger than that value or omitted. The *length* must be a non-negative whole number and defaults to *start*. The search is performed using caseless comparisons.

See also methods *lastPos*, *caselessPos*, and *pos*.

Example 5.80. String class — caselessLastPos method

```
"abc def ghi"~caselessLastPos(" ")      ->    8
"abcdefghi"~caselessLastPos(" ")        ->    0
"efgxyz"~caselessLastPos("XY")          ->    4
"abc def ghi"~caselessLastPos(" ",7)    ->    4
"abc def ghi"~caselessLastPos(" ",7,3)  ->    0
```

5.1.7.43. caselessMatch



Returns **`.true`** if the characters of the *other* match the characters of the target string beginning at position *start*. Returns **`.false`** if the characters are not a match. The matching is performed using caseless comparisons. *start* must be a positive whole number.

If *n* is specified, the match will be performed starting with character *n* of *other*. The default value for *n* is "1". *n* must be a positive whole number less than or equal to the length of *other*.

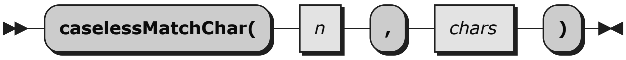
If *length* is specified, it defines a substring of *other* that is used for the match. *length* must be a positive whole number and the combination of *n* and *length* must be a valid substring within the bounds of *other*.

The caselessMatch method is useful for efficient string parsing as it does not require new string objects be extracted from the target string.

Example 5.81. String class — caselessMatch method

```
"Saturday"~caselessMatch(6, "day")           ->    1
"Saturday"~caselessMatch(6, "DAY")           ->    1
"Saturday"~caselessMatch(6, "SUNDAY", 4, 3)  ->    1
"Saturday"~caselessMatch(6, "daytime", 1, 3) ->    1
```

5.1.7.44. caselessMatchChar

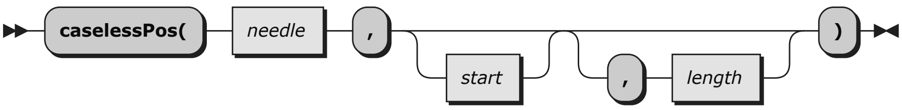


Returns **.true** if the character at position *n* matches any character of the string *chars*. Returns **.false** if the character does not match any of the characters in the reference set. The match is made using caseless comparisons. The argument *n* must be a positive whole number.

Example 5.82. String class — caselessMatchChar method

```
"a+b"~caselessMatchChar(2, "+-*/")          ->    1
"a+b"~caselessMatchChar(1, "+-*/")          ->    0
"Friday"~caselessMatchChar(3, "aeiou")      ->    1
"FRIDAY"~caselessMatchChar(3, "aeiou")      ->    1
```

5.1.7.45. caselessPos



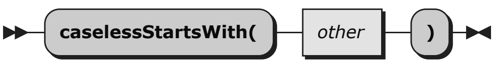
Returns the position in the receiving string of another string, *needle*. It returns **0** if *needle* is the null string or is not found or if *start* is greater than the length of the receiving string. The search is performed using caseless comparisons. By default, the search starts at the first character of the receiving string (that is, the value of *start* is **1**), and continues to the end of the string. You can override this by specifying *start*, the point at which the search starts, and *length*, the bounding limit for the search. If specified, *start* must be a positive whole number and *length* must be a non-negative whole number.

See also methods *pos* and *caselessLastPos*.

Example 5.83. String class — caselessPos method

```
"Saturday"~caselessPos("DAY")       ->    6
"abc def ghi"~caselessPos("x")      ->    0
"abc def ghi"~caselessPos(" ")      ->    4
"abc def ghi"~caselessPos(" ",5)    ->    8
"abc def ghi"~caselessPos(" ",5,3)  ->    0
```

5.1.7.46. caselessStartsWith

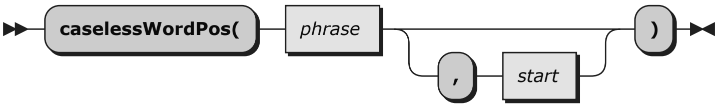


Returns **.true** if the characters of the *other* match the characters at the start of the target string. Returns **.false** if the characters are not a match, or if *other* is the null string. The match is made using caseless comparisons.

The caselessStartsWith method is useful for efficient string parsing as it does not require new string objects be extracted from the target string.

See also methods *startsWith*, *caselessEndsWith*, and *caselessMatch*.

5.1.7.47. caselessWordPos



Returns the word number of the first word of *phrase* found in the receiving string, or **`0`** if *phrase* contains no words or if *phrase* is not found. Word matches are made independent of case. Several whitespace characters between words in either *phrase* or the receiving string are treated as a single blank for the comparison, but, otherwise, the words must match exactly.

By default the search starts at the first word in the receiving string. You can override this by specifying *start* (which must be positive), the word at which the search is to be started.

Example 5.84. String class — caselessWordPos method

```
"now is the time"~caselessWordPos("the")              ->  3
"now is the time"~caselessWordPos("The")              ->  3
"now is the time"~caselessWordPos("IS THE")           ->  2
"now is the time"~caselessWordPos("is   the")         ->  2
"now is   the time"~caselessWordPos("is   time ")     ->  0
"To be or not to be"~caselessWordPos("BE")            ->  2
"To be or not to be"~caselessWordPos("BE",3)          ->  6
```

5.1.7.48. ceiling

Returns the largest integer not less than the receiving string value. The receiving string is first rounded according to standard Rexx rules, as though the operation **`receiving_string+0`** had been carried out. The ceiling is then calculated from that result and returned. The result is never in exponential form. If there are no nonzero digits in the result, any minus sign is removed.

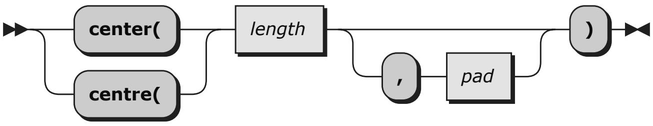
Example 5.85. String class — ceiling method

```
2~ceiling              ->    2
'-2'~ceiling           ->    -2
12.3~ceiling           ->    13
'-12.3'~ceiling        ->    -12
'-0.1'~ceiling         ->    0
```

Note

The *number* is rounded according to the current setting of NUMERIC DIGITS if necessary, before the method processes it.

5.1.7.49. center/centre



Returns a string of length *length* with the receiving string centered in it. The *pad* characters are added as necessary to make up length. The *length* must be a positive whole number or zero. The default *pad* character is blank. If the receiving string is longer than *length*, it is truncated at both ends to fit. If an odd number of characters are truncated or added, the right-hand end loses or gains one more character than the left-hand end.

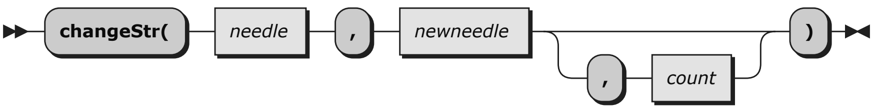
Note

To avoid errors because of the difference between British and American spellings, this method can be called either `center` or `centre`.

Example 5.86. String class — center method

```
abc~center(7)                -> "  ABC  "
abc~CENTER(8,"-")            -> "--ABC---"
"The blue sky"~centre(8)     -> "e blue s"
"The blue sky"~centre(7)     -> "e blue "
```

5.1.7.50. changeStr



Returns a copy of the receiver object in which *newneedle* replaces occurrences of *needle*.

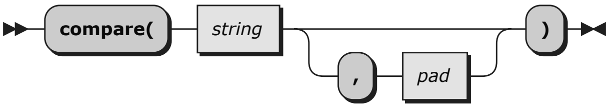
If *count* is not specified, all occurrences of *needle* are replaced. If *count* is specified, it must be a non-negative, whole number that gives the maximum number of occurrences to be replaced.

Here are some examples:

Example 5.87. String class — changeStr method

```
101100~changeStr("1","")      --    "000"
101100~changeStr("1","X")     --    "X0XX00"
101100~changeStr("1","X",1)   --    "X01100"

-- a Quine: will print an exact copy of itself
-- (see https://en.wikipedia.org/wiki/Quine_%28computing%29)
r=";say'r=.'r'.'r~changeStr(.,'22'x,2)";say'r="'r'"'r~changeStr(.,'22'x,2)
```

5.1.7.51. compare

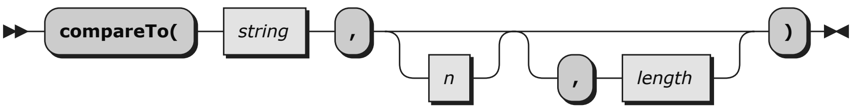


Returns **0** if the argument *string* is identical to the receiving string. Otherwise, returns the position of the first character that does not match. The shorter string is padded on the right with *pad* if necessary. The default *pad* character is a blank.

Example 5.88. String class — compare method

```
"abc"~compare("abc")          ->    0
"abc"~compare("ak")           ->    2
"ab "~compare("ab")           ->    0
"ab "~compare("ab"," ")       ->    0
"ab "~compare("ab","x")       ->    3
"ab-- "~compare("ab","-")     ->    5
```

5.1.7.52. compareTo

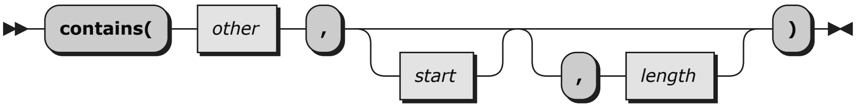


Performs a sort comparison of the target string to the *string* argument. If the two strings are equal, **0** is returned. If the target string is larger, **1** is returned. **-1** if the *string* argument is the larger string. The comparison is performed starting at character *n* for *length* characters in both strings. *n* must be a positive whole number. If *n* is omitted, the comparison starts at the first character. *length* must be a non-negative whole number. If omitted, the comparison will take place to the end of the target string.

Example 5.89. String class — compareTo method

```
"abc"~compareTo("abc")          ->    0
"b"~compareTo("a")              ->    1
"a"~compareTo("b")              ->   -1
"abc"~compareTo("aBc")          ->    1
"aBc"~compareTo("abc")          ->   -1
"000abc000"~compareTo(111abc111", 4, 3)  -> 0
```

5.1.7.53. contains



Returns `.true` if the receiving string contains the *other* string. It returns `.false` if *other* is the null string or is not found within the receiving string.

By default, the search starts at the first character of the receiving string and continues to the end. You can override this by specifying *start*, the point at which the search starts, and *length*, the bounding limit for the search. If specified, *start* must be a positive whole number and *length* must be a non-negative whole number.

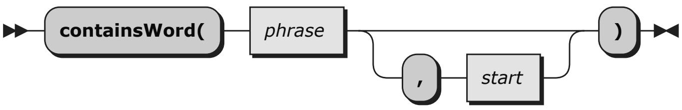
See also

- method *caselessContains*,
- method *startsWith*,
- method *endsWith*, and
- method *pos*.

Example 5.90. String class — caselessContains method

```
say "-abcdef-"~contains("ef")         -- 1
say "-abcdef-"~contains("-", 2, 6)    -- 0
```

5.1.7.54. containsWord



Returns `.true` if *phrase* is found in the receiving string. Returns `.false` if *phrase* contains no words or if *phrase* is not found. Multiple whitespace characters between words in either *phrase* or the receiving string are treated as a single blank for the comparison, but, otherwise, the words must match exactly.

By default the search starts at the first word in the receiving string. You can override this by specifying *start* (which must be positive whole number), the word at which the search is to be started.

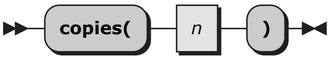
See also

- method *caselessContainsWord* and
- method *wordPos* (containsWord returns `.false` exactly if wordPos would have returned `"0"`.)

Example 5.91. String class — containsWord method

```
good = "Now is the time for all good men"
say good~containsWord("the")          -- .true
say good~containsWord("The")          -- .false
say good~containsWord("is the")       -- .true
say good~containsWord("is   the ")    -- .true
say good~containsWord("is time")      -- .false
say good~containsWord("time")         -- .true
say good~containsWord("time", 5)      -- .false
```

5.1.7.55. copies

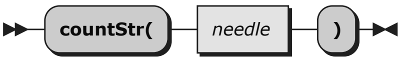


Returns *n* concatenated copies of the receiving string. The *n* must be a positive whole number or zero.

Example 5.92. String class — copies method

```
"abc"~copies(3)    ->    "abcabcabc"
"abc"~copies(0)    ->    ""
```

5.1.7.56. countStr



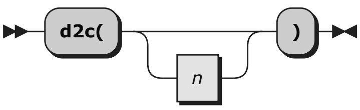
Returns a count of the occurrences of *needle* in the receiving string that do not overlap.

Here are some examples:

Example 5.93. String class — countStr method

```
"101101"~countStr("1")        ->    4
"J0KKK0"~CountStr("KK")       ->    1
```

5.1.7.57. d2c



Returns a string, in character format, that is the ASCII representation of the receiving string, a decimal number. If you specify *n*, it is the length of the final result in characters; leading blanks are added to the returned string. The *n* must be a positive whole number or zero.

The receiving string must not have more digits than the current setting of NUMERIC DIGITS.

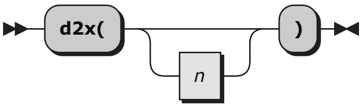
If you omit *n*, the receiving string must be a positive whole number or zero, and the result length is as needed. Therefore, the returned result has no leading "00"x characters.

Example 5.94. String class — d2c method

```
"65"~d2c        ->   "A"      /* "41"x is an ASCII "A"    */
"65"~d2c(1)     ->   "A"
"65"~d2c(2)     ->   " A"
"65"~d2c(5)     ->   "    A"
"109"~d2c       ->   "m"      /* "6D"x  is an ASCII "m"   */
"-109"~d2c(1)   ->   "ô"      /* "93"x  is an ASCII "ô"   */
```

```
"76"~d2c(2)    ->   " L"     /* "4C"x  is an ASCII " L"  */
"-180"~d2c(2)  ->   " L"
```

5.1.7.58. d2x



Returns a string, in character format, that represents the receiving string, a decimal number converted to hexadecimal. The returned string uses uppercase alphabetic characters for the values **A-F** and does not include whitespace.

The receiving string must not have more digits than the current setting of NUMERIC DIGITS.

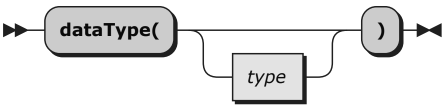
If you specify *n*, it is the length of the final result in characters. After conversion the returned string is sign-extended to the required length. If the number is too big to fit into *n* characters, it is truncated on the left. If you specify *n*, it must be a positive whole number or zero.

If you omit *n*, the receiving string must be a positive whole number or zero, and the returned result has no leading zeros.

Example 5.95. String class — d2x method

```
"9"~d2x         ->    "9"
"129"~d2x       ->    "81"
"129"~d2x(1)    ->    "1"
"129"~d2x(2)    ->    "81"
"129"~d2x(4)    ->    "0081"
"257"~d2x(2)    ->    "01"
"-127"~d2x(2)   ->    "81"
"-127"~d2x(4)   ->    "FF81"
"12"~d2x(0)     ->    ""
```

5.1.7.59. dataType



Returns **NUM** if you specify no argument and the receiving string is a valid Rexx number that can be added to 0 without error. It returns **CHAR** if the receiving string is not a valid number.

If you specify *type*, it returns **.true** if the receiving string matches the type. Otherwise, it returns **.false**. If the receiving string is null, the method returns **.false** (except when the *type* is **X** or **B**, for which `dataType` returns **.true** for a null string). The following are valid *type*s. You need to specify only the capitalized letter, or **9** for the **9Digits** option. The language processor ignores all characters following it.

Alphanumeric
: returns **.true** if the receiving string contains only characters from the ranges **a-z**, **A-Z**, and **0-9**.

Binary
: returns **.true** if the receiving string contains only the characters **0** or **1**, or whitespace. Whitespace characters can appear only between groups of 4 binary characters. It also returns **.true** if string is a null string, which is a valid binary string.

Internal whole number
: returns **.true** if the receiving string is a Rexx whole number that *built-in functions* will accept. Rexx built-in functions internally work with NUMERIC DIGITS 9 for 32-bit systems or NUMERIC DIGITS 18 for 64-bit systems.

Lowercase
: returns **.true** if the receiving string contains only characters from the range **a**-**z**.

Mixed case
: returns **.true** if the receiving string contains only characters from the ranges **a**-**z** and **A**-**Z**.

Number
: returns **.true** if **receiving_string~dataType** returns **NUM**.

lOgical
: returns **.true** if the receiving string is exactly **0** or **1**. Otherwise it returns **.false**.

Symbol
: returns **.true** if the receiving string is a valid symbol, that is, if *SYMBOL*(*receiving_string*) does not return **BAD**. See also *Section 1.10.4.4, "Symbols"*. Note that both uppercase and lowercase alphabetic characters are permitted.

Uppercase
: returns **.true** if the receiving string contains only characters from the range **A**-**Z**.

Variable
: returns **.true** if the receiving string could appear on the left-hand side of an assignment without causing a SYNTAX condition.

Whole number
: returns **.true** if the receiving string is a whole number under the current setting of NUMERIC DIGITS.

heXadecimal
: returns **.true** if the receiving string contains only characters from the ranges **a**-**f**, **A**-**F**, **0**-**9**, and whitespace characters (as long as whitespace characters appear only between pairs of hexadecimal characters). Also returns **.true** if the receiving string is a null string.

9 Digits
: returns **.true** if **receiving_string~dataType("W")** returns **.true** when NUMERIC DIGITS is set to 9.

Example 5.96. String class — datatype method

```
" 12 "~dataType          ->    "NUM"
""~dataType              ->    "CHAR"
"123*"~dataType          ->    "CHAR"
"12.3"~dataType("N")     ->     1
"12.3"~dataType("W")     ->     0
```

```
"Fred"~dataType("M")      ->    1
""~dataType("M")          ->    0
"Fred"~dataType("L")      ->    0
"?20K"~dataType("s")      ->    1
"BCd3"~dataType("X")      ->    1
"BC d3"~dataType("X")     ->    1
"1"~dataType("O")         ->    1
"11"~dataType("O")         ->   0
```

Note

The `dataType` method tests the meaning or type of characters in a string, independent of the encoding of those characters (for example, ASCII or EBCDIC).

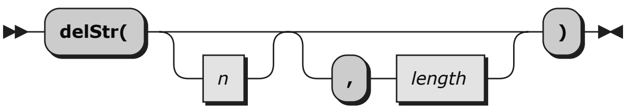
5.1.7.60. decodeBase64

Returns a new string containing the decoded version of the base64 encoded receiving string. If the receiving string is not in base64 format, an error results.

Example 5.97. String class — decodeBase64 method

```
"YWJjZGVm"~decodeBase64       ->    "abcdef"
```

5.1.7.61. delStr

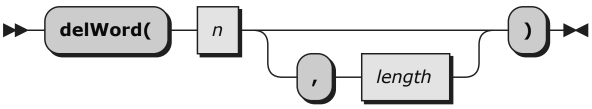


Returns a copy of the receiving string after deleting the substring that begins at the *n*th character and is of *length* characters. If *n* is omitted, it defaults to 1. If you omit *length*, or if *length* is greater than the number of characters from *n* to the end of *string*, the method deletes the rest of *string* (including the *n*th character). The *length* must be a positive whole number or zero. The *n* must be a positive whole number. If *n* is greater than the length of the receiving string, the method returns the receiving string unchanged.

Example 5.98. String class — delStr method

```
"abcd"~delStr(3)       ->    "ab"
"abcde"~delStr(3,2)    ->    "abe"
"abcde"~delStr(6)      ->    "abcde"
```

5.1.7.62. delWord



Returns a copy of the receiving string after deleting the substring that starts at the *n*th word and is of *length* whitespace-delimited words. If you omit *length*, or if *length* is greater than the number of words from *n* to the end of the receiving string, the method deletes the remaining words in the receiving string (including the *n*th word). The *length* must be a positive whole number or zero. The *n* must be a positive whole number. If *n* is greater than the number of words in the receiving string, the method returns the receiving string unchanged. The string deleted includes any whitespace characters following the final word involved but none of the whitespace characters preceding the first word involved.

Example 5.99. String class — delWord method

```
"Now is the  time"~delWord(2,2)  ->  "Now time"
"Now is the time "~delWord(3)    ->  "Now is "
"Now is the  time"~delWord(5)    ->  "Now is the  time"
"Now is   the time"~delWord(3,1) ->  "Now is   time"
```

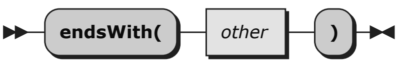
5.1.7.63. encodeBase64

Returns a new string that is the base64 encoded version of the receiving string.

Example 5.100. String class — encodeBase64 method

```
"abcdef"~encodeBase64       ->    "YWJjZGVm"
```

5.1.7.64. endsWith

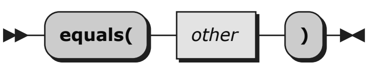


Returns `.true` if the characters of the *other* match the characters at the end of the target string. Returns `.false` if the characters are not a match, or if *other* is the null string.

The endsWith method is useful for efficient string parsing as it does not require new string objects be extracted from the target string.

See also methods *startsWith*, *caselessEndsWith*, and *match*.

5.1.7.65. equals



Returns **.true** if the target string is strictly equal to the *other* string. Returns **.false** if the two strings are not strictly equal. This is the same comparison performed by the "==" comparison method.

Example 5.101. String class — equals method

```
"3"~equals("3")          ->    1
"33"~equals("3")         ->    0
"4"~equals("3")          ->    0
```

5.1.7.66. floor

Returns the largest integer not greater than the receiving string value. The receiving string value is first rounded according to standard Rexx rules, as though the operation **receiving_string+0** had been carried out. The floor is then calculated from that result and returned. The result is never in exponential form. If there are no nonzero digits in the result, any minus sign is removed.

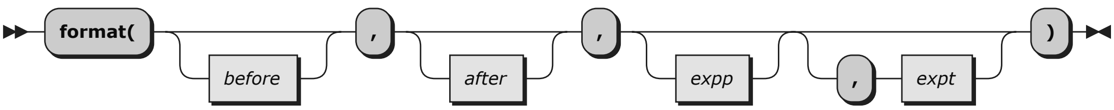
Example 5.102. String class — floor method

```
2~floor                ->    2
'-2'~floor             ->    -2
12.3~floor             ->    12
'-12.3'~floor          ->    -13
```

Note

The *number* is rounded according to the current setting of NUMERIC DIGITS if necessary, before the method processes it.

5.1.7.67. format



Returns a copy of the receiving string, a number, rounded and formatted.

The number is first rounded according to standard Rexx rules, as though the operation **receiving_string+0** had been carried out. If you specify no arguments the result of the method is the same as the result of this operation. If you specify any options, the number is formatted as described in the following.

The *before* and *after* options describe how many characters are to be used for the integer and decimal parts of the result. If you omit either or both of them, the number of characters for that part is as needed.

If *before* is not large enough to contain the integer part of the number (plus the sign for a negative number), an error results. If *before* is larger than needed for that part, the number is padded on the left with blanks. If *after* is not the same size as the decimal part of the number, the number is rounded (or extended with zeros) to fit. Specifying **0** causes the number to be rounded to an integer.

Example 5.103. String class — format method

```
"3"~format(4)              ->    "   3"
"1.73"~format(4,0)         ->    "   2"
"1.73"~format(4,3)         ->    "   1.730"
"-.76"~format(4,1)         ->    "  -0.8"
"3.03"~format(4)           ->    "   3.03"
" - 12.73"~format(,4)      ->    "-12.7300"
" - 12.73"~format          ->    "-12.73"
"0.000"~format             ->    "0"
```

expp and *expt* control the exponent part of the result, which, by default, is formatted according to the current NUMERIC settings of DIGITS and FORM. *expp* sets the number of places for the exponent part; the default is to use as many as needed (which can be zero). *expt* specifies when the exponential expression is used. The default is the current setting of NUMERIC DIGITS.

If *expp* is **0**, the number is not an exponential expression. If *expp* is not large enough to contain the exponent, an error results.

If the number of places needed for the integer or decimal part exceeds *expt* or twice *expt*, respectively, exponential notation is used. If *expt* is **0**, exponential notation is always used unless the exponent would be **0**. (If *expp* is **0**, this overrides a **0** value of *expt*.) If the exponent would be **0** when a nonzero *expp* is specified, then *expp*+2 blanks are supplied for the exponent part of the result. If the exponent would be **0** and *expp* is not specified, the number is not an exponential expression.

Example 5.104. String class — format method

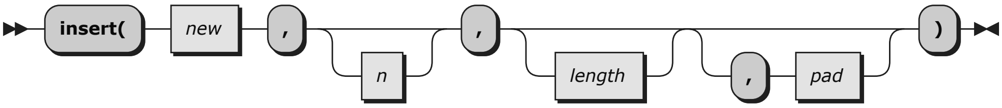
```
"12345.73"~format(, ,2,2)   ->    "1.234573E+04"
"12345.73"~format(,3, ,0)   ->    "1.235E+4"
"1.234573"~format(,3, ,0)   ->    "1.235"
"12345.73"~format(, ,3,6)   ->    "12345.73"
"1234567e5"~format(,3,0)    ->    "123456700000.000"
```

5.1.7.68. hashCode

Returns a string value that is used as a hash value for *MapCollections* such as **Table**, **Relation**, **Set**, **Bag**, or **Directory**. The String `hashCode` method will return the same hash value for all pairs of string instances for which the == operator is **.true**.

See also **Object** method *hashCode* for details.

5.1.7.69. insert

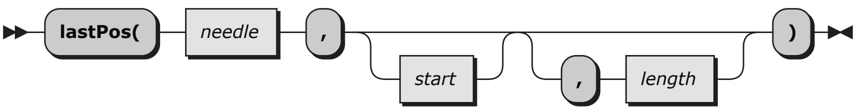


Returns a copy of the receiver string with the string *new*, padded or truncated to length *length*, inserted after the *n*th character. The default value for *n* is **`0`**, which means insertion at the beginning of the string. If specified, *n* and *length* must be positive whole numbers or zero. If *n* is greater than the length of the receiving string, the string *new* is padded at the beginning. The default value for *length* is the length of *new*. If *length* is less than the length of the string *new*, then `insert` truncates *new* to length *length*. The default *pad* character is a blank.

Example 5.105. String class — insert method

```
"abc"~insert("123")            ->    "123abc"
"abcdef"~insert(" ",3)         ->    "abc def"
"abc"~insert("123",5,6)        ->    "abc  123   "
"abc"~insert("123",5,6,"+")    ->    "abc++123+++"
"abc"~insert("123", ,5,"-")    ->    "123--abc"
```

5.1.7.70. lastPos



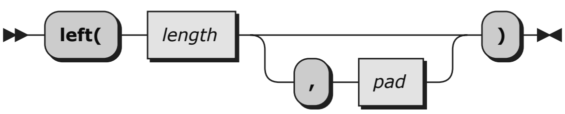
Returns the position of the last occurrence of a string, *needle*, in the receiving string. It returns **`0`** if *needle* is the null string or not found. By default, the search starts at the last character of the receiving string and scans backward to the beginning of the string. You can override this by specifying *start*, the point at which the backward scan starts and *length*, the range of characters to scan. The *start* must be a positive whole number and defaults to **`receiving_string~length`** if larger than that value or omitted. The *length* must be a non-negative whole number and defaults to *start*.

See also methods *pos* and *caselessPos*.

Example 5.106. String class — lastPos method

```
"abc def ghi"~lastPos(" ")      ->    8
"abcdefghi"~lastPos(" ")        ->    0
"efgxyz"~lastPos("xy")          ->    4
"abc def ghi"~lastPos(" ",7)    ->    4
"abc def ghi"~lastPos(" ",7,3)  ->    0
```

5.1.7.71. left



Returns a string of length *length*, containing the leftmost *length* characters of the receiving string. The string returned is padded with *pad* characters (or truncated) on the right as needed. The default *pad* character is a blank. The *length* must be a positive whole number or zero. The `left` method is exactly equivalent to **`substr(1,`** *length*, *pad***`)`**.

Example 5.107. String class — left method

```
"abc d"~left(8)         ->    "abc d   "
"abc d"~left(8,".")     ->    "abc d..."
"abc  def"~left(7)      ->    "abc  de"
```

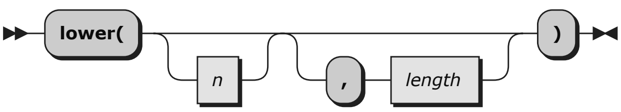
5.1.7.72. length

Returns the length of the receiving string.

Example 5.108. String class — length method

```
"abcdefgh"~length     ->    8
"abc defg"~length     ->    8
""~length             ->    0
```

5.1.7.73. lower

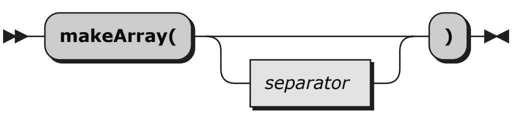


Returns a new string with the characters of the target string beginning with character *n* for *length* characters converted to lowercase. If *n* is specified, it must be a positive whole number. If *n* is not specified, the case conversion will start with the first character. If *length* is specified, it must be a non-negative whole number. If *length* is not specified, the default is to convert the remainder of the string.

Example 5.109. String class — lower method

```
"Albert Einstein"~lower       ->    "albert einstein"
"ABCDEF"~lower(4)             ->    "ABCdef"
"ABCDEF"~lower(3,2)           ->    "ABcdEF"
```

5.1.7.74. makeArray



This method returns an Array of the receiving string's strings substrings that were separated by the *separator* string. *separator* may be any string, including the null string. If the null string is used, an

Array containing each character of the string is returned. If the target string starts with the separator, the first Array item will be a null string. If the string ends with a separator, no extra null string item will be added. If *separator* isn't specified, any *line-end* indicator is honored.

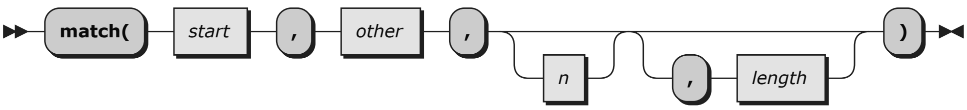
Example 5.110. String class — makeArray method

```
string = "hello".endofline"world".endofline"this is an array."
array = string~makeArray
say "the second line is:" array[2]  /*  world  */

string = "hello*world*this is an array."
array = string~makeArray("*")
say "the third line is:" array[3]  /*  this is an array.  */

string = "hello*world*this is an array.*"
array = string~makeArray("*")     /* contains 3 items */
```

5.1.7.75. makeString

Returns a string with the same string value as the receiver object. If the receiver is an instance of a subclass of the String class, this method returns an equivalent string object. If the receiver is a string object (not an instance of a subclass of the String class), this method returns the receiver object. See *Section 4.2.11, “Required String Values”*.

5.1.7.76. match



Returns **.true** if the characters of the *other* match the characters of the target string beginning at position *start*. Returns **.false** if the characters are not a match. *start* must be a positive whole number.

If *n* is specified, the match will be performed starting with character *n* of *other*. The default value for *n* is "1". *n* must be a positive whole number less than or equal to the length of *other*.

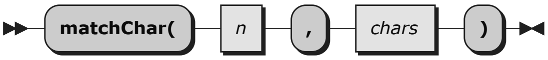
If *length* is specified, it defines a substring of *other* that is used for the match. *length* must be a positive whole number and the combination of *n* and *length* must be a valid substring within the bounds of *other*.

The match method is useful for efficient string parsing as it does not require new string objects be extracted from the target string.

Example 5.111. String class — match method

```
"Saturday"~match(6, "day")           ->    1
"Saturday"~match(6, "DAY")           ->    0
"Saturday"~match(6, "Sunday", 4, 3)  ->    1
"Saturday"~match(6, "daytime", 1, 3) ->    1
```

5.1.7.77. matchChar

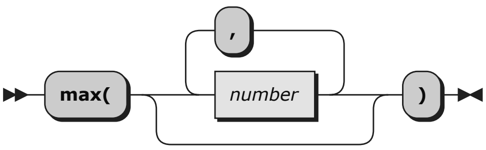


Returns **`.true`** if the character at position *n* matches any character of the string *chars*. Returns **`.false`** if the character does not match any of the characters in the reference set. The argument *n* must be a positive whole number.

Example 5.112. String class — matchChar method

```
"a+b"~matchChar(2, "+-*/")          ->    1
"a+b"~matchChar(1, "+-*/")          ->    0
"Friday"~matchChar(3, "aeiou")      ->    1
"FRIDAY"~matchChar(3, "aeiou")      ->    0
```

5.1.7.78. max

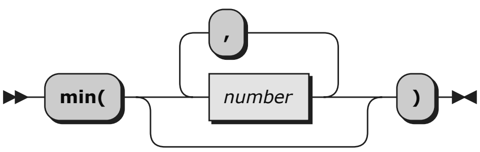


Returns the largest number from among the receiver and any arguments. The number that `max` returns is formatted according to the current NUMERIC settings. You can specify any number of *number*s.

Example 5.113. String class — max method

```
12~max(6,7,9)                                              ->    12
17.3~max(19,17.03)                                         ->    19
"-7"~max("-3","-4.3")                                      ->    -3
1~max(2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21)   ->    21
```

5.1.7.79. min



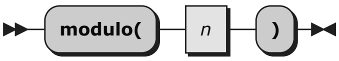
Returns the smallest number from among the receiver and any arguments. The number that `min` returns is formatted according to the current NUMERIC settings. You can specify any number of *number*s.

Example 5.114. String class — min method

```
12~min(6,7,9)                                              ->     6
17.3~min(19,17.03)                                         ->    17.03
```

```
"-7"~MIN("-3","-4.3")                                -> -7
21~min(20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1)   ->  1
```

5.1.7.80. modulo



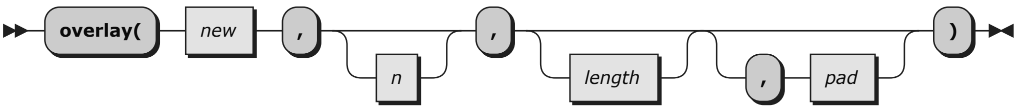
Returns the remainder after dividing the receiving string by *n*. The receiving string must be a whole number and *n* must be a positive whole number. The returned remainder is always in the range 0 through *n* minus one.

If both the receiving string and *n* are non-negative whole numbers, the result is the same as the result of the *remainder* (`//`) operation.

Example 5.115. String class — modulo method

```
say 10~modulo(3)    -- 1
say (-10)~modulo(3) -- 2
```

5.1.7.81. overlay

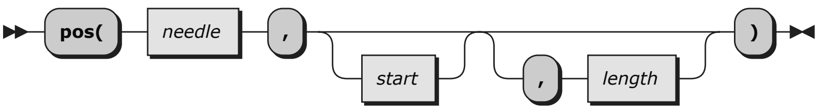


Returns a copy of the receiving string, which, starting at the *n*th character, is overlaid with the string *new*, padded or truncated to length *length*. The overlay can extend beyond the end of the receiving string. If you specify *length*, it must be a positive whole number or zero. The default value for *length* is the length of *new*. If *n* is greater than the length of the receiving string, padding is added before the *new* string. The default *pad* character is a blank, and the default value for *n* is **1**. If you specify *n*, it must be a positive whole number.

Example 5.116. String class — overlay method

```
"abcdef"~overlay(" ",3)         ->    "ab def"
"abcdef"~overlay(".",3,2)       ->    "ab. ef"
"abcd"~overlay("qq")            ->    "qqcd"
"abcd"~overlay("qq",4)          ->    "abcqq"
"abc"~overlay("123",5,6,"+")    ->    "abc+123+++"
```

5.1.7.82. pos



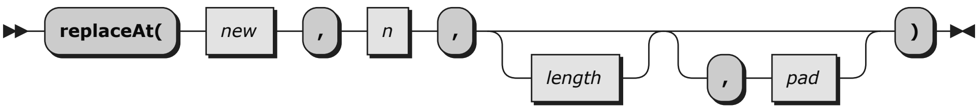
Returns the position in the receiving string of another string, *needle*. It returns **0** if *needle* is the null string or is not found or if *start* is greater than the length of the receiving string. By default, the search starts at the first character of the receiving string (that is, the value of *start* is **1**), and continues to the end of the string. You can override this by specifying *start*, the point at which the search starts, and *length*, the bounding limit for the search. If specified, *start* must be a positive whole number and *length* must be a non-negative whole number.

See also methods *lastPos* and *caselessPos*.

Example 5.117. String class — pos method

```
"Saturday"~pos("day")        ->    6
"abc def ghi"~pos("x")       ->    0
"abc def ghi"~pos(" ")       ->    4
"abc def ghi"~pos(" ",5)     ->    8
"abc def ghi"~pos(" ",5,3)   ->    0
```

5.1.7.83. replaceAt



Returns a copy of the receiving string, with the characters from the *n*th character for *length* characters replaced with *new*. The replacement position and length can extend beyond the end of the receiving string. The starting position, *n*, is required and must be a positive whole number. The *length* argument is optional and must be a positive whole number or zero. If omitted, *length* defaults to the length of *new*.

If *n* is greater than the length of the receiving string, padding is added before the *new* string. The default *pad* character is a blank.

Example 5.118. String class — replaceAt method

```
"abcdef"~replaceAt(" ",3, 1)      ->     "ab def"
"abcdef"~replaceAt(" ",3, 3)      ->     "ab f"
"abc"~replaceAt("123",5,6,"+")    ->     "abc+123"
```

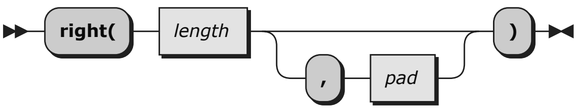
5.1.7.84. reverse

Returns a copy of the receiving string reversed.

Example 5.119. String class — reverse method

```
"ABc."~reverse    ->    ".cBA"
"XYZ "~reverse    ->    " ZYX"
```

5.1.7.85. right



Returns a string of length *length* containing the rightmost *length* characters of the receiving string. The string returned is padded with *pad* characters, or truncated, on the left as needed. The default *pad* character is a blank. The *length* must be a positive whole number or zero.

Example 5.120. String class — right method

```
"abc  d"~right(8)     ->    "  abc  d"
"abc def"~right(5)    ->    "c def"
"12"~right(5,"0")     ->    "00012"
```

5.1.7.86. round

Returns the nearest integer to the receiving string value. Half is always rounded away from zero. The receiving string is first rounded according to standard Rexx rules, as though the operation **`receiving_string+0`** had been carried out. The rounded value is then calculated from that result and returned. The result is never in exponential form. If there are no nonzero digits in the result, any minus sign is removed.

Example 5.121. String class — round method

```
2~round                 ->    2
'-2'~round              ->    -2
2.4~round               ->    2
'-2.4'~round            ->    -2
2.5~round               ->    3
'-2.5'~round            ->    -3
'-0.1'~round            ->    0
```

5.1.7.87. sign

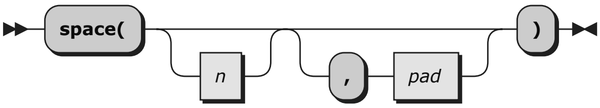
Returns a number that indicates the sign of the receiving string, which is a number. The receiving string is first rounded according to standard Rexx rules, as though the operation **`receiving_string+0`** had been carried out. It returns **`-1`** if the receiving string is less than **`0`**, **`0`** if it is **`0`**, and **`1`** if it is greater than **`0`**.

Example 5.122. String class — sign method

```
"12.3"~sign       ->     1
" -0.307"~sign    ->    -1
```

```
0.0~sign          ->     0
```

5.1.7.88. space

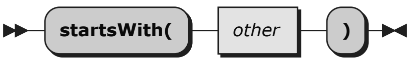


Returns a copy of receiving string, with *n pad* characters between each whitespace-delimited word. If you specify *n*, it must be a positive whole number or zero. If it is **0**, all whitespace characters are removed. Leading and trailing whitespace characters are always removed. The default for *n* is **1**, and the default *pad* character is a blank.

Example 5.123. String class — space method

```
"abc  def  "~space           ->    "abc def"
"  abc def"~space(3)         ->    "abc   def"
"abc  def  "~space(1)        ->    "abc def"
"abc  def  "~space(0)        ->    "abcdef"
"abc  def  "~space(2,"+")    ->    "abc++def"
```

5.1.7.89. startsWith

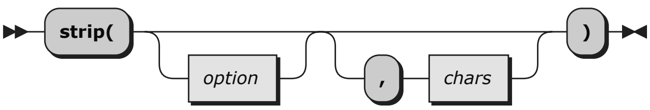


Returns **.true** if the characters of the *other* match the characters at the start of the target string. Returns **.false** if the characters are not a match, or if *other* is the null string.

The startsWith method is useful for efficient string parsing as it does not require new string objects be extracted from the target string.

See also methods *abbrev*, *caselessStartsWith*, *endsWith*, and *match*.

5.1.7.90. strip



Returns a copy of the receiving string with leading characters, trailing characters, or both, removed, based on the *option* you specify. The following are valid *options*. (You need to specify only the first capitalized letter; all characters following it are ignored.)

Both
: Removes both leading and trailing characters. This is the default.

Leading
: Removes leading characters.

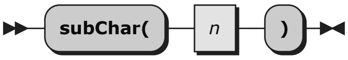
Trailing
: Removes trailing characters.

The *chars* specifies the set of characters to be removed, and the default is to remove all whitespace characters (spaces and horizontal tabs). If *chars* is a null string, then no characters are removed. Otherwise, any occurrences of the characters in *chars* will be removed.

Example 5.124. String class — strip method

```
"  ab c  "~strip          ->    "ab c"
"  ab c  "~strip("L")     ->    "ab c  "
"  ab c  "~strip("t")     ->    "  ab c"
"12.7000"~strip(,0)       ->    "12.7"
"0012.700"~strip(,0)      ->    "12.7"
"0012.000"~strip(,".0")  ->    "12"
```

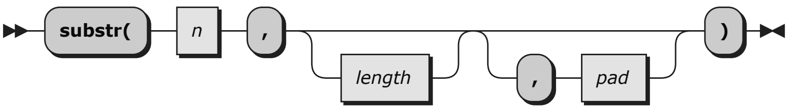
5.1.7.91. subChar



Returns the *n*'th character of the receiving string. *n* must be a positive whole number. If *n* is greater than the length of the receiving string then a zero-length string is returned.

See also methods *[]* and *substr*.

5.1.7.92. substr



Returns the substring of the receiving string that begins at the *n*th character and is of length *length*, padded with *pad* if necessary. The *n* must be a positive whole number. If *n* is greater than **`receiving_string~length`**, only pad characters are returned.

If you omit *length*, the rest of the string is returned. The default *pad* character is a blank.

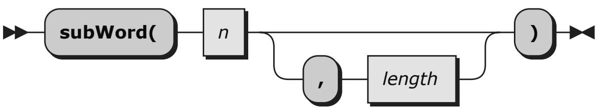
See also methods *[]*, *subChar*, *left*, and *right*.

In some situations the positional (numeric) patterns of *Parsing* templates are more convenient for selecting substrings, in particular if you need to extract more than one substring from a string.

Example 5.125. String class — substr method

```
"abc"~substr(2)          ->    "bc"
"abc"~substr(2,4)        ->    "bc  "
"abc"~substr(2,6,".")    ->    "bc...."
```

5.1.7.93. subWord

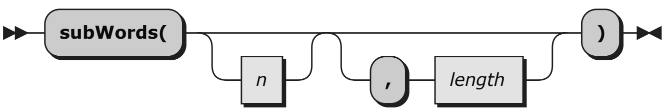


Returns the substring of the receiving string that starts at the *n*th word and is up to *length* whitespace-delimited words. The *n* must be a positive whole number. If you omit *length*, it defaults to the number of remaining words in the receiving string. The returned string never has leading or trailing whitespace, but includes all whitespace characters between the selected words.

Example 5.126. String class — subWord method

```
"Now is the  time"~subWord(2,2)    ->    "is the"
"Now is the  time"~subWord(3)      ->    "the  time"
"Now is the  time"~subWord(5)      ->    ""
```

5.1.7.94. subWords



Returns an array containing all words within the substring of the receiving string that starts at the *n*th word and is up to *length* whitespace-delimited words. The *n* must be a positive whole number. If you omit *n*, it defaults to 1. If you omit *length*, it defaults to the number of remaining words in the receiving string. The strings in the returned array never have leading or trailing whitespace.

Example 5.127. String class — subWords method

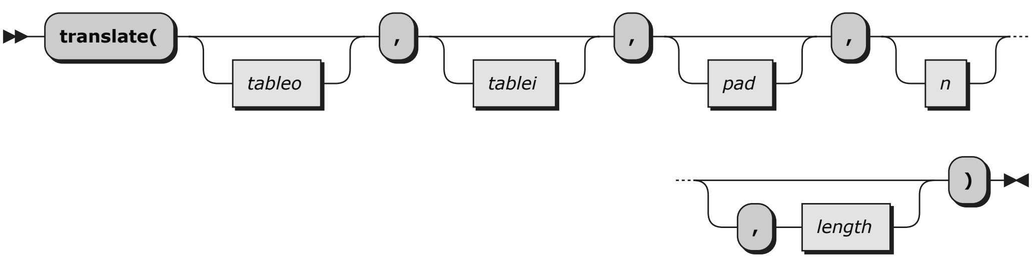
```
"Now is the  time"~subWords          ->    .array~of("Now", "is", "the", "time")
"Now is the  time"~subWords(2,2)     ->    .array~of("is", "the")
"Now is the  time"~subWords(3)       ->    .array~of("the", "time")
"Now is the  time"~subWords(5)       ->    .array~new(0)
```

The subWords method is useful for iterating over the individual words in a string.

Example 5.128. String class — subWords method

```
    do word over source~subWords    -- extract all of the words to loop over
       say word
    end
```

5.1.7.95. translate



Returns a copy of the receiving string with each character translated to another character or unchanged. You can also use this method to reorder the characters in the output table. (See last example)

The output table is *tableo* and the input translation table is *tablei*. `translate` searches *tablei* for each character in the receiving string. If the character is found, the corresponding character in *tableo* is used in the result string. If there are duplicates in *tablei*, the first (leftmost) occurrence is used. If the character is not found, the original character in the receiving string is used. The result string is always of the same length as the receiving string.

The tables can be of any length. If you specify neither translation table and omit *pad*, the receiving string is translated to uppercase (that is, lowercase **a-z** to uppercase **A-Z**), but if you include *pad* the entire string is translated to *pad* characters. *tablei* defaults to **XRANGE("00"x,"FF"x)**, and *tableo* defaults to the null string and is padded with *pad* or truncated as necessary. The default *pad* is a blank.

n is the position of the first character of the translated range. The default starting position is 1. *length* is the range of characters to be translated. If *length* is omitted, the remainder of the string from the starting position to the end is used.

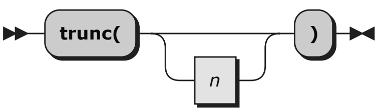
Example 5.129. String class — translate method

```
"abcdef"~translate                          ->    "ABCDEF"
"abcdef"~translate(, , , 3, 2)              ->    "abCDef"
"abcdef"~translate("12", "ec")              ->    "ab2d1f"
"abcdef"~translate("12", "abcd", ".")       ->    "12..ef"
"APQRV"~translate(, "PR")                   ->    "A Q V"
"APQRV"~translate(XRANGE("00"X, "Q"))       ->    "APQ  "
"4123"~translate("abcd", "1234", , 2, 2)    ->    "4ab3"
"4123"~translate("abcd", "1234")            ->    "dabc"
```

Note

The last example shows how to use the `translate` method to reorder the characters in a string. In the example, the last character of any 4-character string specified as the first argument would be moved to the beginning of the string.

5.1.7.96. trunc



Returns the integer part the receiving string, which is a number, and *n* decimal places. The default *n* is **0** and returns an integer with no decimal point. If you specify *n*, it must be a positive whole number or zero. The receiving string is first rounded according to standard Rexx rules, as though the operation **receiving_string+0** had been carried out. This number is then truncated to *n* decimal places or trailing zeros are added if needed to reach the specified length. The result is never in exponential form. If there are no nonzero digits in the result, any minus sign is removed.

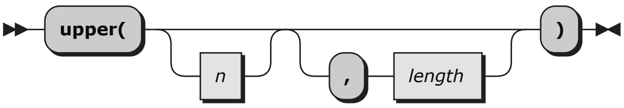
Example 5.130. String class — trunc method

```
12.3~trunc            ->    12
127.09782~trunc(3)    ->    127.097
127.1~trunc(3)        ->    127.100
127~trunc(2)          ->    127.00
```

Note

The *number* is rounded according to the current setting of NUMERIC DIGITS if necessary, before the method processes it.

5.1.7.97. upper

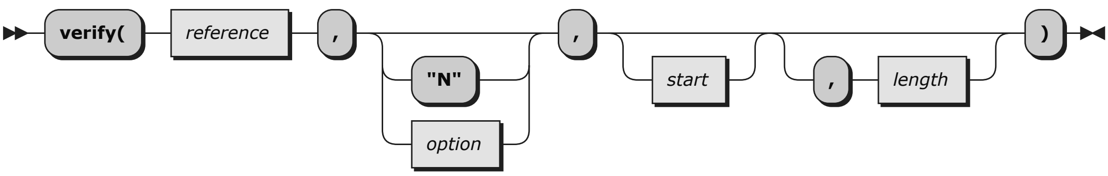


Returns a new string with the characters of the target string beginning with character *n* for *length* characters converted to uppercase. If *n* is specified, it must be a positive whole number. If *n* is not specified, the case conversion will start with the first character. If *length* is specified, it must be a non-negative whole number. If *length* is not specified, the default is to convert the remainder of the string.

Example 5.131. String class — upper method

```
"Albert Einstein"~upper      ->    "ALBERT EINSTEIN"
"abcdef"~upper(4)            ->    "abcDEF"
"abcdef"~upper(3,2)          ->    "abCDef"
```

5.1.7.98. verify



Returns a number that, by default, indicates whether the receiving string is composed only of characters from *reference*. It returns **`0`** if all characters in the receiving string are in *reference* or returns the position of the first character in the receiving string not in *reference*.

The *option* can be either **`Nomatch`** (the default) or **`Match`**. (You need to specify only the first capitalized and highlighted letter; all characters following the first character are ignored)

If you specify **`Match`**, the method returns the position of the first character in the receiving string that is in *reference*, or returns **`0`** if none of the characters are found.

The default for *start* is **`1`**. Thus, the search starts at the first character of the receiving string. You can override this by specifying a different *start* point, which must be a positive whole number.

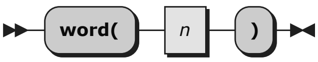
The default for *length* is the length of the string from *start* to the end of the string. Thus, the search proceeds to the end of the receiving string. You can override this by specifying a different *length*, which must be a non-negative whole number.

If the receiving string is null, the method returns **`0`**, regardless of the value of the *option*. Similarly, if *start* is greater than **`receiving_string~length`**, the method returns **`0`**. If *reference* is null, the method returns **`0`** if you specify **`Match`**. Otherwise, the method returns the *start* value.

Example 5.132. String class — verify method

```
"123"~verify("1234567890")              ->    0
"1Z3"~verify("1234567890")              ->    2
"AB4T"~verify("1234567890")             ->    1
"AB4T"~verify("1234567890","M")         ->    3
"AB4T"~verify("1234567890","N")         ->    1
"1P3Q4"~verify("1234567890", ,3)        ->    4
"123"~verify("",N,2)                    ->    2
"ABCDE"~verify("", ,3)                  ->    3
"AB3CD5"~verify("1234567890","M",4)     ->    6
"ABCDEF"~verify("ABC","N",2,3)          ->    4
"ABCDEF"~verify("ADEF","M",2,3)         ->    4
```

5.1.7.99. word

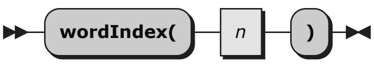


Returns the *n*th whitespace-delimited word in the receiving string or the null string if the receiving string has fewer than *n* words. The *n* must be a positive whole number. This method is exactly equivalent to **`subWord(`*n*`, 1)`**.

Example 5.133. String class — word method

```
"Now is the time"~word(3)    ->    "the"
"Now is the time"~word(5)    ->    ""
```

5.1.7.100. wordIndex



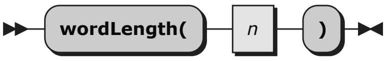
Returns the position of the first character in the *n*th whitespace-delimited word in the receiving string. It returns **`0`** if the receiving string has fewer than *n* words. The *n* must be a positive whole number.

Example 5.134. String class — wordIndex method

```
"Now is the time"~wordIndex(3)    ->    8
```

```
"Now is the time"~wordIndex(6)    ->    0
```

5.1.7.101. wordLength

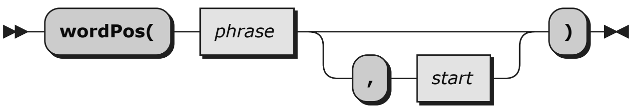


Returns the length of the *n*th whitespace-delimited word in the receiving string or **0** if the receiving string has fewer than *n* words. The *n* must be a positive whole number.

Example 5.135. String class — wordLength method

```
"Now is the time"~wordLength(2)       ->    2
"Now comes the time"~wordLength(2)    ->    5
"Now is the time"~wordLength(6)       ->    0
```

5.1.7.102. wordPos



Returns the word number of the first word of *phrase* found in the receiving string, or **0** if *phrase* contains no words or if *phrase* is not found. Several whitespace characters between words in either *phrase* or the receiving string are treated as a single blank for the comparison, but, otherwise, the words must match exactly.

By default the search starts at the first word in the receiving string. You can override this by specifying *start* (which must be positive), the word at which the search is to be started.

Example 5.136. String class — wordPos method

```
"now is the time"~wordPos("the")              ->  3
"now is the time"~wordPos("The")              ->  0
"now is the time"~wordPos("is the")           ->  2
"now is the time"~wordPos("is   the")         ->  2
"now is   the time"~wordPos("is   time ")     ->  0
"To be or not to be"~wordPos("be")            ->  2
"To be or not to be"~wordPos("be",3)          ->  6
```

5.1.7.103. words

Returns the number of whitespace-delimited words in the receiving string.

Example 5.137. String class — words method

```
"Now is the time"~words      ->    4
" "~words                    ->    0
```

5.1.7.104. x2b

Returns a string, in character format, that represents the receiving string, which is a string of hexadecimal characters converted to binary. The receiving string can be of any length. Each hexadecimal character is converted to a string of 4 binary digits. The receiving string can optionally include whitespace characters (at byte boundaries only, not leading or trailing) to improve readability; they are ignored.

The returned string has a length that is a multiple of four, and does not include any whitespace.

If the receiving string is null, the method returns a null string.

Example 5.138. String class — x2b method

```
"C3"~x2b        ->  "11000011"
"7"~x2b         ->  "0111"
"1 C1"~x2b      ->  "000111000001"
```

You can combine `x2b` with the methods `d2x` and `c2x` to convert numbers or character strings into binary form.

Example 5.139. String class — x2b method with c2x

```
"C3"x~c2x~x2b  ->  "11000011"
"129"~d2x~x2b  ->  "10000001"
"12"~d2x~x2b   ->  "1100"
```

5.1.7.105. x2c

Returns a string, in character format, that represents the receiving string, which is a hexadecimal string converted to character. The returned string is half as many bytes as the receiving string. The receiving string can be any length. If necessary, it is padded with a leading 0 to make an even number of hexadecimal digits.

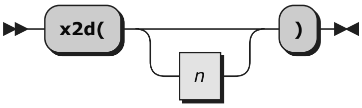
You can optionally include whitespace in the receiving string (at byte boundaries only, not leading or trailing) to improve readability; they are ignored.

If the receiving string is null, the method returns a null string.

Example 5.140. String class — x2c method

```
"4865 6c6c 6f"~x2c ->  "Hello"     /*  ASCII            */
"3732 73"~x2c      ->  "72s"       /*  ASCII            */
```

5.1.7.106. x2d



Returns the decimal representation of the receiving string, which is a string of hexadecimal characters. If the result cannot be expressed as a whole number, an error results. That is, the result must not have more digits than the current setting of NUMERIC DIGITS.

You can optionally include whitespace characters in the receiving string (at byte boundaries only, not leading or trailing) to improve readability; they are ignored.

If the receiving string is null, the method returns **0**.

If you do not specify *n*, the receiving string is processed as an unsigned binary number.

Example 5.141. String class — x2d method

```
"0E"~x2d        ->    14
"81"~x2d        ->    129
"F81"~x2d       ->    3969
"FF81"~x2d      ->    65409
"46 30"X~x2d    ->    240          /*  ASCII   */
"66 30"X~x2d    ->    240          /*  ASCII   */
```

If you specify *n*, the receiving string is taken as a signed number expressed in *n* hexadecimal digits. If the leftmost bit is off, then the number is positive; otherwise, it is a negative number. In both cases it is converted to a whole number, which can be negative. If *n* is **0**, the method returns **0**.

If necessary, the receiving string is padded on the left with **0** characters (note, not "sign-extended"), or truncated on the left to *n* characters.

Example 5.142. String class — x2d method

```
"81"~x2d(2)      ->    -127
"81"~x2d(4)      ->    129
"F081"~x2d(4)    ->    -3967
"F081"~x2d(3)    ->    129
"F081"~x2d(2)    ->    -127
"F081"~x2d(1)    ->    1
"0031"~x2d(0)    ->    0
```

5.2. Stream Classes

This section describes the Rexx classes which implement Rexx data streams: *InputStream*, *OutputStream*, *InputOutputStream*, and *Stream* class.

5.2.1. InputOutputStream Class

This class is defined as an abstract mixin class. It must be implemented by subclassing it or inheriting from it as a mixin. Many of the methods in this class are abstract and must be overridden or they will throw a syntax error when invoked.

Table 5.8. InputOutputStream Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ OutputStream (Mixin Class)		
Methods inherited from the *OutputStream class*		
arrayOut	*close*	*open*
charIn	*lineIn*	*position*
charOut (Abstract Method)	*lineOut (Abstract Method)*	
chars	*lines*	
+ InputStream (Mixin Class)		
Methods inherited from the *InputStream class*		
arrayIn	*close*	*open*
charIn (Abstract Method)	*lineIn (Abstract Method)*	*position*
charOut	*lineOut*	
chars (Abstract Method)	*lines (Abstract Method)*	
InputOutputStream (Mixin Class)		
(no class or instance methods)		

5.2.2. InputStream Class

This class is defined as an abstract mixin class. It must be implemented by subclassing it or inheriting from it as a mixin. Many of the methods in this class are abstract and must be overridden or they will throw a syntax error when invoked.

Table 5.9. InputStream Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
InputStream (Mixin Class)		
arrayIn	*close*	*open*
charIn (Abstract Method)	*lineIn (Abstract Method)*	*position*
charOut	*lineOut*	
chars (Abstract Method)	*lines (Abstract Method)*	

5.2.2.1. arrayIn

This method is a default `arrayIn` implementation using `lineIn` to fill the array.

5.2.2.2. charIn (Abstract Method)

This method is defined as an abstract method. Invoking it will cause syntax error 93.965 to be raised.

5.2.2.3. charOut

This is an unsupported operation for InputStreams. Invoking it will cause syntax error 93.963 to be raised.

5.2.2.4. chars (Abstract Method)

This method is defined as an abstract method. Invoking it will cause syntax error 93.965 to be raised.

5.2.2.5. close

This method is a NOP by default.

5.2.2.6. lineIn (Abstract Method)

This method is defined as an abstract method. Invoking it will cause syntax error 93.965 to be raised.

5.2.2.7. lineOut

This is an unsupported operation for InputStreams. Invoking it will cause syntax error 93.963 to be raised.

5.2.2.8. lines (Abstract Method)

This method is defined as an abstract method. Invoking it will cause syntax error 93.965 to be raised.

5.2.2.9. open

This method is a NOP method.

5.2.2.10. position

This method is an optionally supported operation. By default, it will cause syntax error 93.963 to be raised.

5.2.3. OutputStream Class

This class is defined as an abstract mixin class. It must be implemented by subclassing it or inheriting from it as a mixin. Many of the methods in this class are abstract and must be overridden or they will throw a syntax error when invoked.

Table 5.10. OutputStream Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
OutputStream (Mixin Class)		
arrayOut	*close*	*open*
charIn	*lineIn*	*position*
charOut (Abstract Method)	*lineOut (Abstract Method)*	
chars	*lines*	

5.2.3.1. arrayOut

This method is a default `arrayOut` implementation that writes all lines to the stream using `lineOut`.

5.2.3.2. charIn

This is an unsupported operation for OutputStreams. Invoking it will cause syntax error 93.963 to be raised.

5.2.3.3. charOut (Abstract Method)

This method is defined as an abstract method. Invoking it will cause syntax error 93.965 to be raised.

5.2.3.4. chars

This is an unsupported operation for OutputStreams. Invoking it will cause syntax error 93.963 to be raised.

5.2.3.5. close

This method is a NOP by default.

5.2.3.6. lineIn

This is an unsupported operation for OutputStreams. Invoking it will cause syntax error 93.963 to be raised.

5.2.3.7. lineOut (Abstract Method)

This method is defined as an abstract method. Invoking it will cause syntax error 93.965 to be raised.

5.2.3.8. lines

This is an unsupported operation for OutputStreams. Invoking it will cause syntax error 93.963 to be raised.

5.2.3.9. open

This method is a NOP by default.

5.2.3.10. position

This method is an optionally supported operation. By default, it will cause syntax error 93.963 to be raised.

5.2.4. Stream Class

A stream object allows external communication from Rexx. (See *Chapter 14, Input and Output Streams* for a discussion of Rexx input and output.)

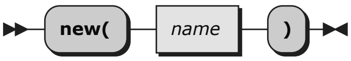
The Stream class is a subclass of the *InputOutputStream class*.

Table 5.11. Stream Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ OutputStream (Mixin Class)		
Methods inherited from the *OutputStream class*		
arrayOut	*close*	*open*
charIn	*lineIn*	*position*
charOut (Abstract Method)	*lineOut (Abstract Method)*	
chars	*lines*	
+ InputStream (Mixin Class)		
Methods inherited from the *InputStream class*		
arrayIn	*close*	*open*
charIn (Abstract Method)	*lineIn (Abstract Method)*	*position*
charOut	*lineOut*	
chars (Abstract Method)	*lines (Abstract Method)*	
+ InputOutputStream (Mixin Class)		
Methods inherited from the *InputOutputStream class*		
(no class or instance methods)		
Stream (Mixin Class)		
new (Inherited Class Method)		
arrayIn	*flush*	*qualify*
arrayOut	*init*	*query*
charIn	*lineIn*	*say*
charOut	*lineOut*	*seek*
chars	*lines*	*state*

close	*makeArray*	*string*
command	*open*	*supplier*
description	*position*	*uninit*

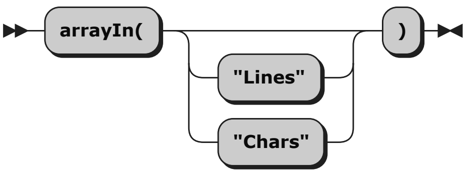
5.2.4.1. new (Inherited Class Method)



Initializes a stream object for stream *name*, but does not open the stream. Returns the new stream object.

name can either be a string or a *File object*.

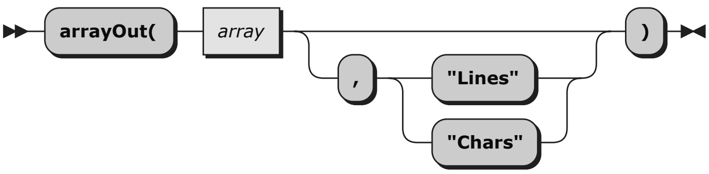
5.2.4.2. arrayIn



Returns an Array that contains the data of the receiving Stream, starting from the current read position. If **LINES** is specified, the Array items returned are the Stream's lines, that were separated with any *line-end* indicator. **LINES** is the default. If **CHARS** is specified, the Array items returned are the Stream's characters.

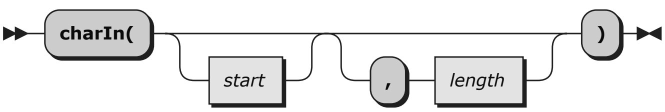
If you have used the *charIn* method, the first line can be a partial line.

5.2.4.3. arrayOut



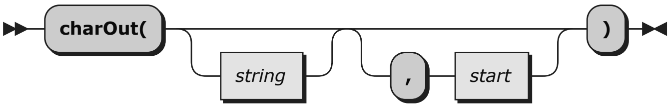
Writes the data in array *array* to the stream. If **LINES** is specified, each element of the array is written using *lineOut*. If **CHARS** is specified, each element is written using *charOut*. The default method is **LINES**.

5.2.4.4. charIn



Returns a string of up to *length* characters from the input stream. The stream advances the read pointer by the number of characters read. If you omit *length*, it defaults to **1**. If you specify *start*, this positions the read pointer before reading. The *start* value must be a positive whole number within the bounds of the stream. If the value is not a positive whole number, a syntax condition is raised. When the value is past the end of the stream, the empty string is returned and the NOTREADY condition is raised. If the stream is not already open, the stream attempts to open for reading and writing. If that fails, the stream opens for input only.

5.2.4.5. charOut



Returns the count of characters remaining after trying to write *string* to the output stream. The stream also advances the write pointer.

The *string* can be the null string. In this case, `charOut` writes no characters to the stream and returns **`0`**. If you omit *string*, `charOut` writes no characters to the stream and returns **`0`**. The stream is also closed.

If you specify *start*, this positions the write pointer before writing. If the stream is not already open, the stream attempts to open for reading and writing. If that fails, the stream opens for for output only.

5.2.4.6. chars

Returns the total number of characters remaining in the input stream. The count includes any line separator characters, if these are defined for the stream. For persistent streams the count is the count of characters from the current read position. (See *Chapter 14, Input and Output Streams* for a discussion of Rexx input and output.) The total number of characters remaining cannot be determined for some streams (for example, STDIN or Windows/Unix-like system devices). For these streams, the `chars` method returns **`1`** to indicate that data is present, or **`0`** if no data is present.

5.2.4.7. close

Closes the stream. `close` returns **`READY:`** if closing the stream is successful, or an appropriate error message. If you have tried to close an unopened file, then the `close` method returns a null string ("").

5.2.4.8. command

Returns a string after performing the specified *stream_command*. The returned string depends on the *stream_command* performed and can be the null string. Commands are available to:

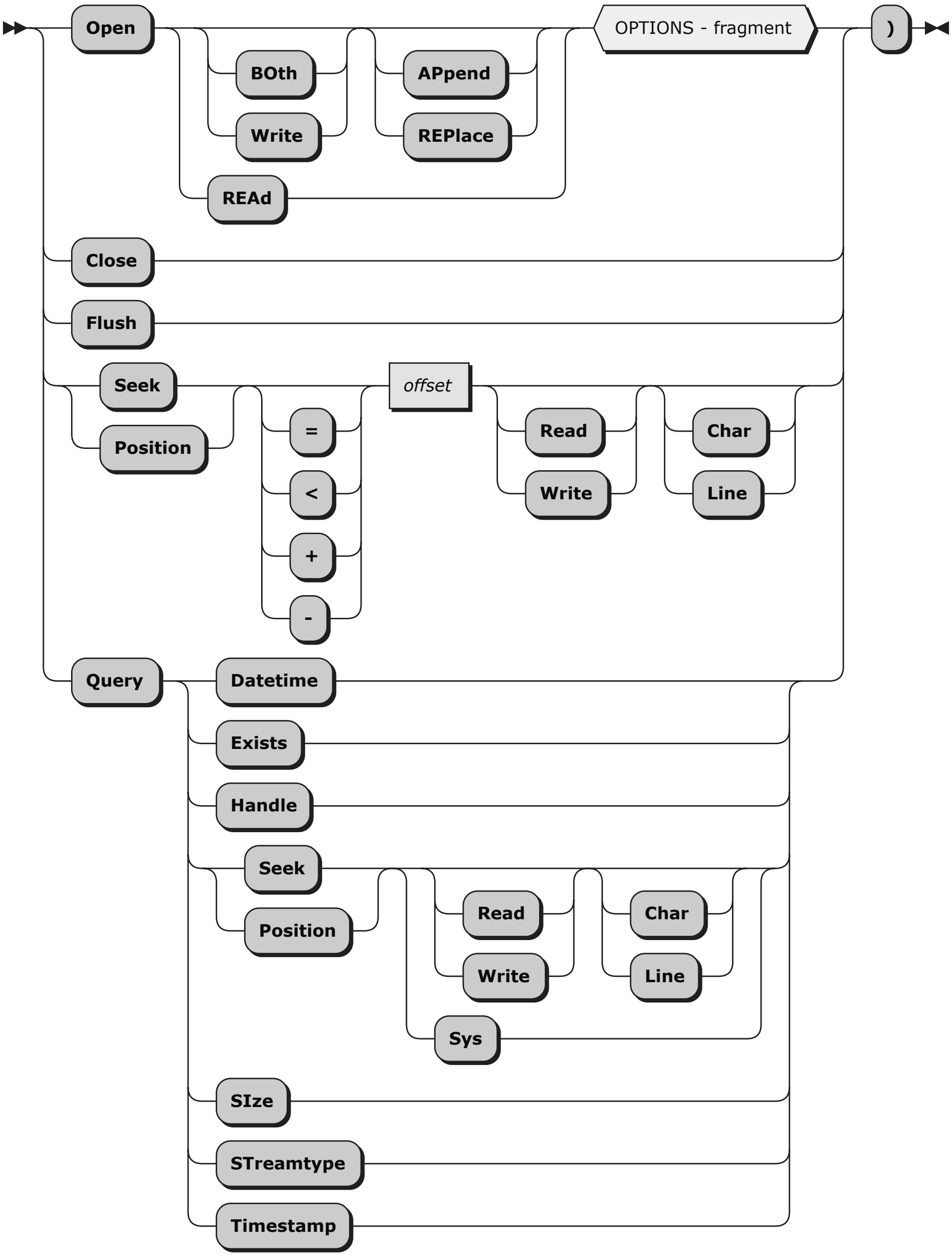
- Open a stream for reading, writing, or both
- Close a stream at the end of an operation
- Move the line read or write position within a persistent stream (for example, a file)
- Get information about a stream

If the method is unsuccessful, it returns an error message string in the same form that the *description* method uses.

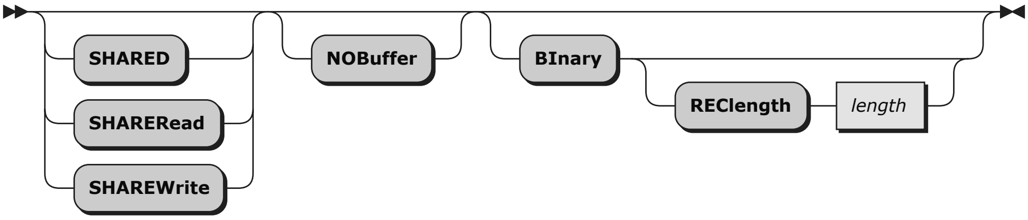
For most error conditions, the additional information is in the form of a numeric return code. This return code is the value of **`ERRNO`** that is set whenever one of the file system primitives returns with a **`-1`**.

5.2.4.8.1. Command Strings

The argument *stream_command* can be any expression that evaluates to one of the following command strings:



OPTIONS:



OPEN

Opens the stream object and returns **READY:**. (If unsuccessful, the previous information about return codes applies.) The default for OPEN is to open the stream for both reading and writing data, for example: **'OPEN BOTH'**. To specify that the stream be only opened for input or output, add READ or WRITE, to the command string.

The following is a description of the options for OPEN:

READ
: Opens the stream only for reading.

WRITE
: Opens the stream only for writing.

BOTH
: Opens the stream for both reading and writing. (This is the default.) The stream maintains separate read and write pointers.

APPEND
: Positions the write pointer at the end of the stream. (This is the default.) The write pointer cannot be moved anywhere within the extent of the file as it existed when the file was opened.

REPLACE
: Sets the write pointer to the beginning of the stream and truncates the file. In other words, this option deletes all data that was in the stream when opened.

SHARED
: Enables another process to work with the stream in a shared mode. This mode must be compatible with the shared mode (SHARED, SHAREREAD, or SHAREWRITE) used by the process that opened the stream.

SHAREREAD
: Enables another process to read the stream in a shared mode.

SHAREWRITE
: Enables another process to write the stream in a shared mode.

NOBUFFER
: Turns off buffering of the stream. All data written to the stream is flushed immediately to the operating system for writing. This option can have a severe impact on output performance. Use it only when data integrity is a concern, or to force interleaved output to a stream to appear in the exact order in which it was written.

BINARY
: Opens the stream in binary mode. This means that *line-end* characters are ignored; they are treated like any other byte of data. This is intended to process binary data using the line operations.

> **Note**
>
> Specifying the BINARY option for a stream that does not exist but is opened for writing also requires the RECLENGTH option to be specified. Omitting the RECLENGTH option in this case raises an error condition.

RECLENGTH *length*

Allows the specification of an exact length for each line in a stream. This allows line operations on binary-mode streams to operate on individual fixed-length records. Without this option, line operations on binary-mode files operate on the entire file (for example, as if you specified the **RECLENGTH** option with a length equal to that of the file). The *length* must be **1** or greater.

Example 5.143. Stream command — OPEN option

```
stream~command("open")
stream~command("open write")
stream~command("open read")
stream~command("open read shared")
```

CLOSE

closes the stream object. The `command` method with the CLOSE option returns **READY:** if the stream is successfully closed or an appropriate error message otherwise. If an attempt to close an unopened file occurs, then the `command` method with the CLOSE option returns a null string ("").

FLUSH

forces any data currently buffered for writing to be written to this stream.

SEEK *offset*

sets the read or write position to a given number (*offset*) within a persistent stream. If the stream is open for both reading and writing and you do not specify READ or WRITE, both the read and write positions are set.

Note

See *Chapter 14, Input and Output Streams* for a discussion of read and write positions in a persistent stream.

To use this command, you must first open the stream (with the OPEN stream command described previously or implicitly with an input or output operation). One of the following characters can precede the *offset* number.

=

explicitly specifies the *offset* from the beginning of the stream. This is the default if you supply no prefix. For example, an *offset* of **1** with the LINE option means the beginning of the stream.

<

specifies *offset* from the end of the stream.

+

specifies *offset* forward from the current read or write position.

-

specifies *offset* backward from the current read or write position.

The `command` method with the SEEK option returns the new position in the stream if the read or write position is successfully located, or an appropriate error message.

The following is a description of the options for SEEK:

READ
: specifies that this command sets the read position.

WRITE
: specifies that this command sets the write position.

CHAR
: specifies the positioning in terms of characters. This is the default.

LINE
: specifies the positioning in terms of lines. For non-binary streams, this is potentially an operation that can take a long time to complete because, in most cases, the file must be scanned from the top to count the line-end characters. However, for binary streams with a specified record length, the new resulting line number is simply multiplied by the record length before character positioning. See *Section 14.1.5, "Line versus Character Positioning"* for a detailed discussion of this issue.

Note

If you do line positioning in a file open only for writing, you receive an error message.

Example 5.144. Stream command — SEEK option

```
stream~command("seek =2 read")
stream~command("seek +15 read")
stream~command("seek -7 write line")
fromend  = 125
stream~command("seek <"fromend "read")
```

POSITION
: is a synonym for SEEK.

QUERY
: Used with these QUERY *stream_command*s, the `command` method returns specific information about a stream. Except for QUERY HANDLE and QUERY SEEK/POSITION, the stream returns the query information even if the stream is not open. The stream returns the null string for nonexistent streams.

QUERY DATETIME
: Returns the date and time stamps of a stream in US format. For example:

Example 5.145. Stream command — QUERY DATETIME option

```
stream~command("query datetime")
```

A sample output might be:

```
11-12-15 03:29:12
```

QUERY EXISTS
Returns the full path specification of the stream object, if it exists, or a null string. For example:

Example 5.146. Stream command — QUERY EXISTS option

```
stream~command("query exists")
```

A sample output might be:

```
c:\data\file.txt
```

QUERY HANDLE
Returns the handle associated with the open stream.

Example 5.147. Stream command — QUERY HANDLE option

```
stream~command("query handle")
```

A sample output might be: **3**

QUERY POSITION
Returns the current read or write position for the stream, as qualified by the following options:

READ
Returns the current read position.

WRITE
Returns the current write position.

Note

If the stream is open for both reading and writing, this returns the read position by default. Otherwise, this returns the appropriate position by default.

CHAR
Returns the position in terms of characters. This is the default.

LINE
Returns the position in terms of lines. For non-binary streams, this operation can take a long time to complete. This is because the language processor starts tracking the current line number if not already doing so, and, thus, might require a scan of the stream from the top to

count the line-end characters. See *Section 14.1.5, “Line versus Character Positioning”* for a detailed discussion of this issue.

Example 5.148. Stream command — QUERY POSITION WRITE option

```
stream~command("query position write")
```

A sample output might be:

```
247
```

SYS
Returns the operating system stream position in terms of characters.

QUERY SEEK
Is a synonym for QUERY POSITION.

QUERY SIZE
Returns the size, in bytes, of a persistent stream.

Example 5.149. Stream command — QUERY SIZE option

```
stream~command("query size")
```

A sample output might be:

```
1305
```

QUERY STREAMTYPE
Returns a string indicating whether the stream is **PERSISTENT**, **TRANSIENT**, or **UNKNOWN**.

QUERY TIMESTAMP
Returns the date and time stamps of a persistent stream in an international format. This is the preferred method of getting date and time because it provides the full 4-digit year

Example 5.150. Stream command — QUERY TIMESTAMP option

```
stream~command("query timestamp")
```

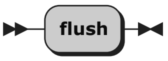
A sample output might be:

```
2015-11-12 03:29:12
```

5.2.4.9. description

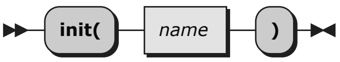
Returns a descriptive string associated with the current state of the stream. The `description` method is identical to the *state* method except that the string that `description` returns is followed by a colon and, if available, additional information about ERROR or NOTREADY states.

5.2.4.10. flush



Returns **`READY:`**. It forces the stream to write any buffered data to the output stream.

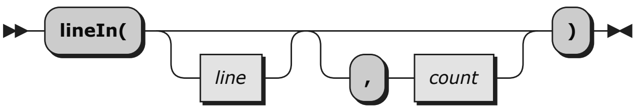
5.2.4.11. init



Initializes a stream object defined by *name*.

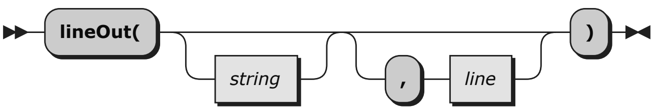
name can either be a string or a *File object*.

5.2.4.12. lineIn



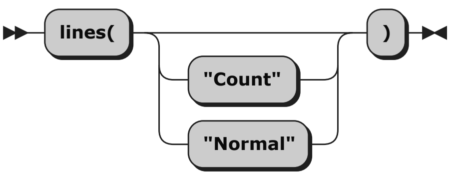
Returns the next *count* lines. The count must be **`0`** or **`1`**. The stream advances the read pointer. If you omit *count*, it defaults to **`1`**. A *line* number may be given to set the read position to the start of a specified line. This line number must be positive and within the bounds of the stream, and must not be specified for a transient stream. A value of 1 for *line* refers to the first line in the stream. If the stream is not already open, then the interpreter tries to open the stream for reading and writing. If that fails, the stream is opened for input only.

5.2.4.13. lineOut



Returns **`0`** if successful in writing *string* to the output stream, or **`1`** if an error occurs while writing the line. The stream advances the write pointer. If you specify *line*, this positions the write pointer before writing. If you omit both *string* and *line*, the stream is closed. If the stream is not already open, the stream attempts to open for reading and writing. If that fails, the stream is opened for output only.

5.2.4.14. lines



Returns the number of lines that are available for input if no option or option **`Count`** is specified. If the stream has already been read with *charIn* this can include an initial partial line. If no data remains, `lines` returns **`0`**. For persistent streams the count starts at the current read position. As such, `lines` reports whether a read action of *charIn* or *lineIn* will succeed. Option **`Count`** is the default.

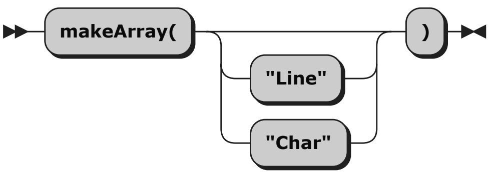
If option **`Normal`** is specified, `lines` returns **`.true`** if at least one line remains in the stream, or **`.false`** if no lines remain.

> **Note**
>
> **`lines("Count")`** determines the actual number of lines by scanning the stream starting at the current position and counting the lines. For large streams, this can be a time-consuming operation. Therefore, avoid the use of **`lines()`** or **`lines("Count")`** in the condition of a loop reading a stream. It is recommended that you use **`lines("Normal")`** or the *chars* method instead.

For an explanation of input and output, see *Chapter 14, Input and Output Streams*.

For a *Queue* instance, the inherited method `lines` returns the actual number of lines in the queue.

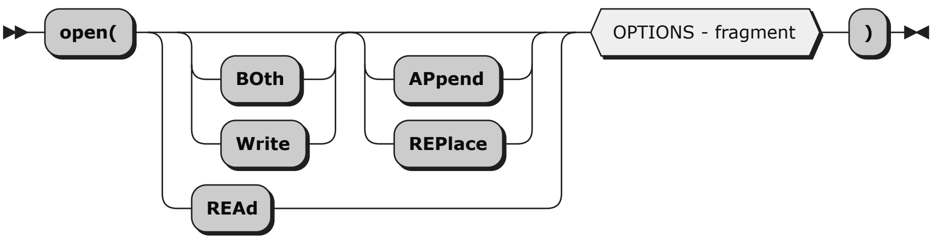
5.2.4.15. makeArray



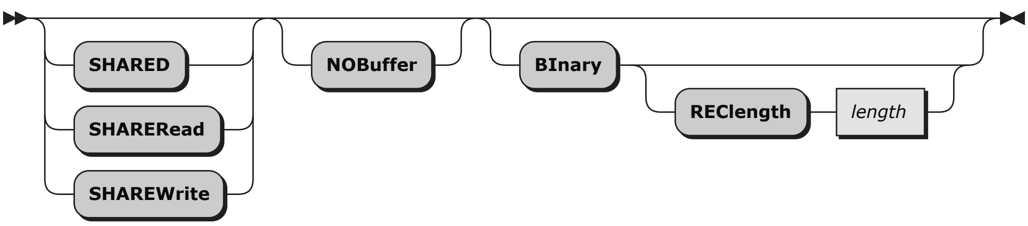
Returns an Array that contains the data of the stream in line or character format, starting from the current read position. The line format is the default.

If you have used the *charIn* method, the first line can be a partial line.

5.2.4.16. open



OPTIONS:



Opens the stream and returns **`READY:`**. If the method is unsuccessful, it returns an error message string in the same form that the *description* method uses.

For most error conditions, the additional information is in the form of a numeric return code. This return code is the value of **`ERRNO`**, which is set whenever one of the file system primitives returns with a **`-1`**.

By default, `open` opens the stream for both reading and writing data, for example: **`'open BOTH'`**. To specify that the stream be only opened for input or output, specify READ or WRITE.

The options for the `open` method are:

READE
:

READ
   Opens the stream for input only.

WRITE
   Opens the stream for output only.

BOTH
   Opens the stream for both input and output. (This is the default.) The stream maintains separate read and write pointers.

APPEND
   Positions the write pointer at the end of the stream. (This is the default.) The write pointer cannot be moved anywhere within the extent of the file as it existed when the file was opened.

REPLACE
   Sets the write pointer to the beginning of the stream and truncates the file. In other words, this option deletes all data that was in the stream when opened.

SHARED
   Enables another process to work with the stream in a shared mode. This mode must be compatible with the shared mode (SHARED, SHAREREAD, or SHAREWRITE) used by the process that opened the stream.

SHAREREAD
   Enables another process to read the stream in a shared mode.

SHAREWRITE
   Enables another process to write the stream in a shared mode.

NOBUFFER
   Turns off buffering of the stream. All data written to the stream is flushed immediately to the operating system for writing. This option can have a severe impact on output performance. Use it only when data integrity is a concern, or to force interleaved output to a stream to appear in the exact order in which it was written.

BINARY
   Opens the stream in binary mode. This means that line-end characters are ignored; they are treated like any other byte of data. This is for processing binary record data using the line operations.

Note

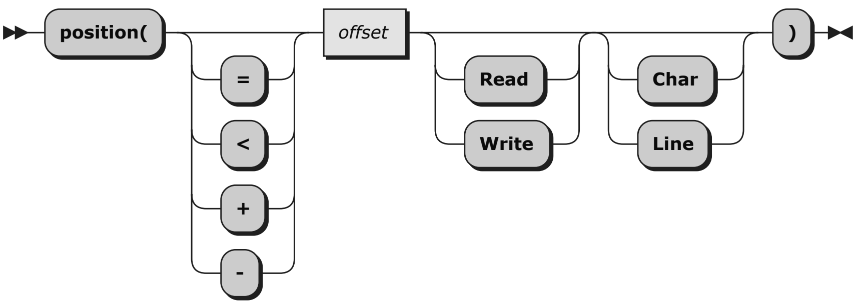
Specifying the BINARY option for a stream that does not exist but is opened for writing also requires the RECLENGTH option to be specified. Omitting the RECLENGTH option in this case raises an error condition.

RECLENGTH *length*
: Allows the specification of an exact length for each line in a stream. This allows line operations on binary-mode streams to operate on individual fixed-length records. Without this option, line operations on binary-mode files operate on the entire file (for example, as if you specified the **`RECLENGTH`** option with a length equal to that of the file). The *length* must be **`1`** or greater.

Example 5.151. Stream object — OPEN method

```
stream~open
stream~open("write")
stream~open("read")
```

5.2.4.17. position

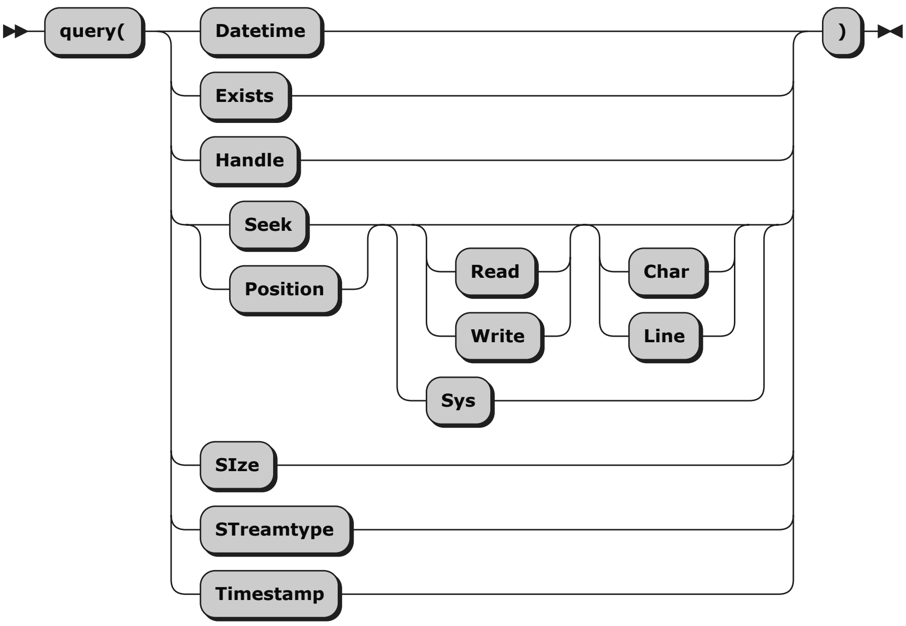


`position` is a synonym for *seek*.

5.2.4.18. qualify

Returns the stream's fully qualified name. The stream need not be open.

5.2.4.19. query



Used with these options, `query` returns specific information about a stream. Except for **HANDLE** and **SEEK**/**POSITION**, the stream returns the query information even if the stream is not open. A null string is returned for nonexistent streams.

DATETIME

returns the date and time stamps of a persistent stream in US format.

Example 5.152. Stream object — QUERY method

```
stream~query("datetime")
```

A sample output might be:

```
11-12-15 03:29:12
```

EXISTS

returns the full path specification of the stream, if it exists, or a null string. For example:

Example 5.153. Stream object — QUERY method

```
stream~query("exists")
```

A sample output might be:

```
c:\data\file.txt
```

HANDLE

returns the handle associated with the open stream.

Example 5.154. Stream object — QUERY method

```
stream~query("handle")
```

A sample output might be:

```
3
```

POSITION
returns the current read or write position for the stream, as qualified by the following options:

READE
returns the current read position.

WRITE
returns the current write position.

Note

If the stream is open for both reading and writing, this returns the read position by default. Otherwise, this returns the specified position.

CHAR
returns the position in terms of characters. This is the default.

LINE
returns the position in terms of lines. For non-binary streams, this operation can take a long time to complete. This is because the language processor starts tracking the current line number if not already doing so, and, thus, might require a scan of the stream from the top to count the line-end characters. See *Section 14.1.5, "Line versus Character Positioning"* for a detailed discussion of this issue.

Example 5.155. Stream object — QUERY method

```
stream~query("position write")
```

A sample output might be:

```
247
```

SYS
returns the operating system stream position in terms of characters.

SIZE
returns the size, in bytes, of a persistent stream.

Example 5.156. Stream object — QUERY method

```
stream~query("size")
```

A sample output might be:

```
1305
```

STREAMTYPE
returns a string indicating whether the stream object is **PERSISTENT**, **TRANSIENT**, or **UNKNOWN**.

TIMESTAMP
returns the date and time stamps of a persistent stream in an international format. This is the preferred method of getting the date and time because it provides the full 4-digit year.

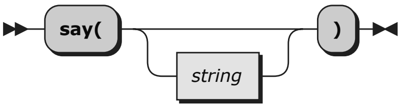
Example 5.157. Stream object — QUERY method

```
stream~query("timestamp")
```

A sample output might be:

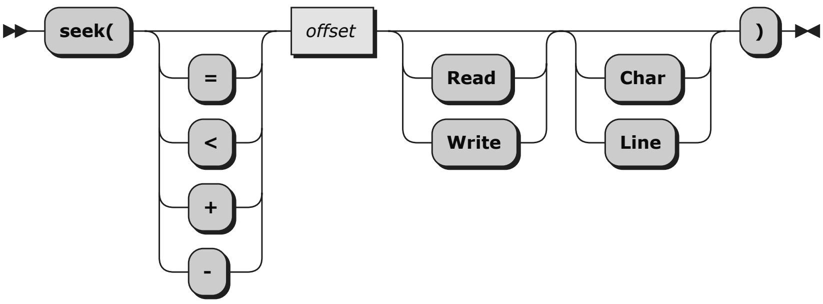
```
2015-11-12 03:29:12
```

5.2.4.20. say



Returns **0** if successful in writing *string* to the output stream or **1** if an error occurs while writing the line.

5.2.4.21. seek



Sets the read or write position to a given number (*offset*) within a persistent stream. If the stream is open for both reading and writing and you do not specify READ or WRITE, both the read and write positions are set.

Note

See *Chapter 14, Input and Output Streams* for a discussion of read and write positions in a persistent stream.

To use this method, you must first open the stream object (with the *open* method or implicitly with an input or output operation). One of the following characters can precede the *offset* number:

=
: Explicitly specifies the *offset* from the beginning of the stream. This is the default if you supply no prefix. For example, an *offset* of **1** means the beginning of the stream.

<
: Specifies *offset* from the end of the stream.

+
: Specifies *offset* forward from the current read or write position.

-
: Specifies *offset* backward from the current read or write position.

The `seek` method returns the new position in the stream if the read or write position is successfully located, or an appropriate error message.

The following is a description of the options for `seek`:

READ
: specifies that the read position be set.

WRITE
: specifies that the write position be set.

CHAR
: specifies that positioning be done in terms of characters. This is the default.

LINE
: specifies that the positioning be done in terms of lines. For non-binary streams, this is potentially an operation that can take a long time to complete because, in most cases, the file must be scanned from the top to count the line-end characters. However, for binary streams with a specified record length, the new resulting line number is simply multiplied by the record length before character positioning. See *Section 14.1.5, "Line versus Character Positioning"* for a detailed discussion of this issue.

Note

If you do line positioning in a file open only for writing, you receive an error message.

Example 5.158. Stream object — SEEK method

```
stream~seek("=2 read")
stream~seek("+15 read")
stream~seek("-7 write line")
fromend  = 125
stream~seek("<"fromend read)
```

5.2.4.22. state

Returns a string indicating the current stream state.

The returned strings are as follows:

ERROR
: The stream has been subject to an erroneous operation (possibly during input, output, or through the various Stream methods). See *Section 14.5, “Errors during Input and Output”*. You might be able to obtain additional information about the error with the *description* method.

NOTREADY
: The stream is known to be in such a state that the usual input or output operations attempted upon would raise the NOTREADY condition. (See *Section 14.5, “Errors during Input and Output”*.) For example, a simple input stream can have a defined length. An attempt to read that stream (with *charIn* or *lineIn*, perhaps) beyond that limit can make the stream unavailable until the stream has been closed (for example, with the *close* method) and then reopened.

READY
: The stream is known to be in such a state that the usual input or output operations might be attempted. This is the usual state for a stream, although it does not guarantee that any particular operation will succeed.

UNKNOWN
: The state of the stream is unknown. This generally means that the stream is closed or has not yet been opened.

5.2.4.23. string

Returns a string that indicates the name of the object the stream represents i.e. the name of the file.

5.2.4.24. supplier

Returns a *StreamSupplier* object for the stream containing the remaining stream lines and linenumber positions for the stream.

5.2.4.25. uninit

This method cleans up the object when it is garbage collected. It should not be invoked directly except via an `uninit` method of a subclass of the Stream class.

If the Stream class is subclassed and the subclass provides an `uninit` method then that method must invoke the superclass `uninit` method.

Example 5.159. Stream object — UNINIT method

```
::class CustomStream subclass Stream

...

::method uninit
/* the subclass instance cleanup code should be placed here */
super~uninit  -- this should be the last action in the method
return
```

5.3. Collection Classes

A **`Collection`** is an object that contains a number of *items*, which can be any objects. Every item stored in a Collection has an associated *index* that you can use to retrieve the item from the collection with the `at` or `[]` methods.

Each Collection defines its own acceptable index types. Rexx provides the following Collection classes:

Array Class
: A sequenced collection of objects ordered by whole-number indexes.

Bag Class
: A collection where the index and the item are the same object. Bag indexes can be any object and each index can appear more than once.

CircularQueue Class
: The CircularQueue class allows for storing objects in a circular queue of a predefined size. Once the end of the queue has been reached, new item objects are inserted from the beginning, replacing earlier entries. The collected objects can be processed in FIFO (first-in, first-out) or in a stack-like LIFO (last-in, first-out) order.

Directory Class
: A collection with character string indexes. Index comparisons are performed using the string == comparison method.

IdentityTable Class
: A collection with indexes that can be any object. The IdentityTable class determines index item matches by using an object identity comparison. With object identity matches, an index will only match the same object instance. An identity table contains no duplicate indexes.

List Class
: A sequenced collection that lets you add new items at any position in the sequence. A list generates and returns an index value for each item placed in the list. The returned index remains valid until the item is removed from the list.

Properties Class
: A collection with character string indexes and values. Properties collections include support for saving and loading from disk files.

Queue Class
: A sequenced collection with the items ordered as a queue. You can remove items from the head of the queue and add items at either its tail or its head. Queues index the items with whole-number indexes, in the order in which the items would be removed. The current head of the queue has index 1, the item after the head item has index 2, up to the number of items in the queue.

Relation Class
: A collection with indexes that can be any object. A relation can contain duplicate indexes.

Set Class
: A collection where the index and the item are the same object. Set indexes can be any object and each index is unique.

Stem Class
: A collection with character string indexes constructed from one or more string segments. Index comparisons are performed using the string == comparison method.

StringTable Class
: A collection with character string indexes. Index comparisons are performed using the string == comparison method.

Table Class
: A collection with indexes that can be any object. A table contains no duplicate indexes.

5.3.1. Organization of the Collection Classes

The following shows the logical organization of the Collection Classes. This does *not* represent the order that methods are inherited but rather the organization of the classes.

Collection Class

- *MapCollection* classes
  Directory Class
  IdentityTable Class
  Properties Class
  Relation Class
  Stem Class
  StringTable Class
  Table Class

- *OrderedCollection* classes
  Array Class
  CircularQueue Class
  List Class
  Queue Class

- *SetCollection* classes
  Bag Class
  Set Class

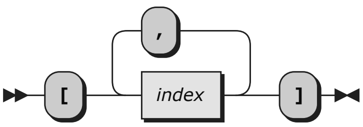
5.3.2. Collection Class

The **`Collection`** class is a MIXIN class that defines the basic set of methods implemented by all Collections. Many of the Collection class methods are abstract and must be implemented by the inheriting subclasses.

Table 5.12. Collection Class

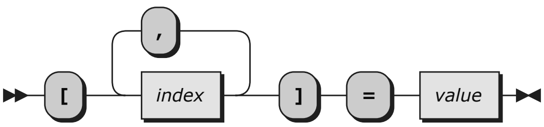
Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
Collection (Mixin Class)		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	

5.3.2.1. [] (Abstract Method)



Returns the item associated with the specified *index* or *index*es. If the collection has no item associated with the specified *index* or *index*es, this method returns **`.nil`**. This is an abstract method that must be implemented by a subclasses.

5.3.2.2. []= (Abstract Method)



Adds an item to the collection at the specified index. This is an abstract method that must be implemented by subclasses.

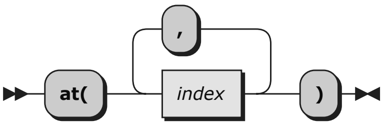
5.3.2.3. allIndexes (Abstract Method)

Returns an array of all indexes used by this collection. This is an abstract method that must be implemented by subclasses.

5.3.2.4. allItems (Abstract Method)

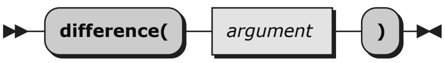
Returns an array containing all items stored in the collection. This is an abstract method that must be implemented by subclasses.

5.3.2.5. at (Abstract Method)



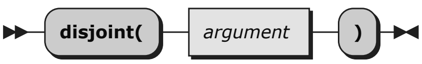
Returns the item associated with the specified *index* or *index*es. If the collection has no item associated with the specified *index* or *index*es, this method returns **`.nil`**. This is an abstract method that must be implemented by subclasses.

5.3.2.6. difference



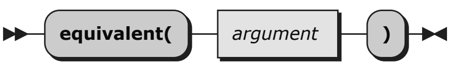
Returns a new collection (of the same class as the receiver) containing only those items from the receiver whose indexes the *argument* collection does not contain. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.2.7. disjoint



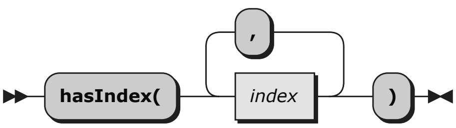
Returns **`.true`** if the receiver collection and *argument* collection do not have any items in common. **`.false`** otherwise. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.2.8. equivalent



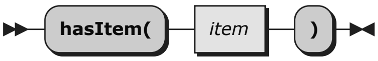
Returns **`.true`** if all indexes in the receiver collection are also contained in the *argument* collection and both collections contain the same number of items; returns **`.false`** otherwise. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.2.9. hasIndex



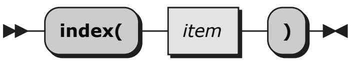
Returns **.true** if the receiver collection contains an item associated with the specified index or indexes. Returns **.false** otherwise.

5.3.2.10. hasItem



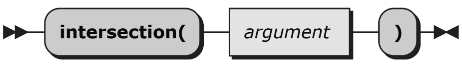
Returns **.true** if the collection contains the specified item at any index location. Returns **.false** otherwise.

5.3.2.11. index (Abstract Method)



Returns the index associated with *item*. If item occurs more than once in the collection, the returned index value is undetermined. This is an abstract method which must be implemented by a subclass of this class.

5.3.2.12. intersection



Returns a new collection (of the same class as the receiver) containing only those items from the receiver whose indexes are in both the receiver collection and the *argument* collection. The *argument* can be a **Collection** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

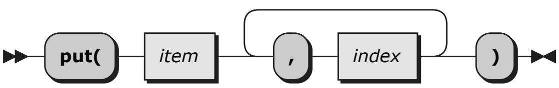
5.3.2.13. items

Returns the number of items in the collection.

5.3.2.14. makeArray

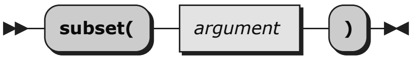
Returns a single-dimensional Array with the same number of items as the receiver object. Any index with no associated item is omitted from the new array. Items in the new array will have the same order as the source array.

5.3.2.15. put (Abstract Method)



Adds an item to the collection at the specified index. This is an abstract method that must be implemented by a subclass of this class.

5.3.2.16. subset

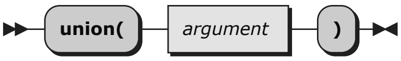


Returns `.true` if all indexes in the receiver collection are also contained in the *argument* collection; returns `.false` otherwise. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.2.17. supplier

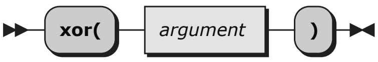
Returns a *Supplier* object for the collection. The supplier allows you to enumerate through the index/item pairs for the collection. The supplier is created from a snapshot of the collection and is unaffected by subsequent changes to the collection's contents.

5.3.2.18. union



Returns a new collection of the same class as the receiver that contains all the items from the receiver collection and selected items from the *argument* collection. This method includes an item from *argument* in the new collection only if there is no item with the same associated index in the receiver collection and the method has not already included an item with the same index. The order in which this method selects items in *argument* is unspecified (the program should not rely on any order). The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.2.19. xor



Returns a new collection of the same class as the receiver that contains all items from the receiver collection and the *argument* collection; all indexes that appear in both collections are removed. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.3. MapCollection Class

The **`MapCollection`** class is a MIXIN class that defines the basic set of methods implemented by all collections that create a mapping from an index object to a value.

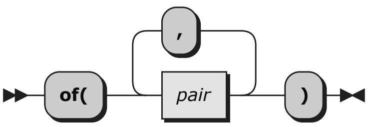
This class is defined as a MIXIN class. The following classes inherit from **`MapCollection`**: *Directory*, *IdentityTable*, *Properties*, *Relation*, *Stem*, *StringTable*, *Table*, and **`SetCollection`** classes *Bag* and *Set*.

Table 5.13. MapCollection Class

Object

Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
MapCollection (Mixin Class)		
of (Class Method)		
makeArray		
putAll		

5.3.3.1. of (Class Method)



Returns a newly created **MapCollection** object containing the specified index/item *pair*s. Each *pair* must be a single-dimensional Array with exactly two items: the index as the first Array item, and the value as the second item. The *pair*s are processed left-to-right and added to the MapCollection object.

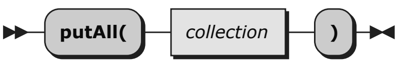
Example 5.160. MapCollection class — of method

```
iso639 = .Directory~of(.Array~of("de", "Deutsch"), .Array~of("en",
 "English"), .Array~of("fr", "fran&ccedil;ais"))
say iso639~allIndexes~makeString(, ", ")          -- de, en, fr
say iso639~allItems~makeString(, ", ")            -- Deutsch, English, fran&ccedil;ais

-- using array notation
iso639 = .Directory~of(("de", "Deutsch"), ("en", "English"), ("fr", "fran&ccedil;ais"))
```

5.3.3.2. makeArray

Returns a single-dimensional Array of the index values used by the receiver object. The index objects will not be ordered in any predictable order.

5.3.3.3. putAll



Returns the receiving collection with all items in *collection* added to it. The *collection* argument can be any object that supports a `supplier` method. Items from *collection* are added using the index values returned by the supplier. The item indexes from the source *collection* must be strings. The items are added in the order provided by the supplier object. If duplicate indexes exist in *collection*, the last item provided by the supplier will overwrite previous items with the same index.

5.3.4. OrderedCollection Class

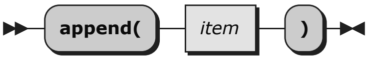
The **`OrderedCollection`** class is a MIXIN class that defines the basic set of methods implemented by all collections that have an inherent index ordering.

This class is defined as a MIXIN class. The following classes inherit from OrderedCollection: *Array*, *CircularQueue*, *List*, and *Queue*.

Table 5.14. OrderedCollection Class

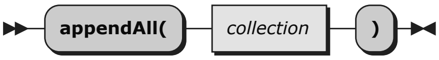
Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
OrderedCollection (Mixin Class)		
append (Abstract Method)	*intersection*	*sortWith*
appendAll	*last (Abstract Method)*	*stableSort*
delete (Abstract Method)	*lastItem (Abstract Method)*	*stableSortWith*
difference	*next (Abstract Method)*	*subset*
first (Abstract Method)	*previous (Abstract Method)*	*union*
firstItem (Abstract Method)	*section (Abstract Method)*	*xor*
insert (Abstract Method)	*sort*	

5.3.4.1. append (Abstract Method)



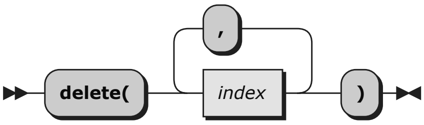
Append an item to the end of the collection ordering. This is an abstract method that must be implemented by a subclass of this class.

5.3.4.2. appendAll



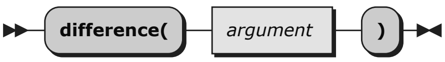
Returns the receiving collection with all items in *collection* appended to the end of it. The *collection* may be any object that implements an `allItems` method.

5.3.4.3. delete (Abstract Method)



Returns and deletes the member item with the specified *index* from the collection. If there is no item with the specified *index*, **`.nil`** is returned and no item is deleted. All elements following the deleted item will be moved up in the collection ordering and the size of the collection will be reduced by one element. Depending on the nature of the collection, the indexes of the moved items may be modified by the deletion.

5.3.4.4. difference



Returns a new collection (of the same class as the receiver) containing only those items from the receiver that are not also contained in the *argument* collection. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

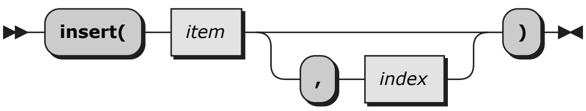
5.3.4.5. first (Abstract Method)

Returns the index of the first item in the collection order. Returns **`.nil`** if the collection is empty.

5.3.4.6. firstItem (Abstract Method)

Returns the first item in the collection order. Returns **`.nil`** if the collection is empty.

5.3.4.7. insert (Abstract Method)

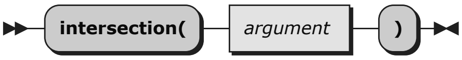


Returns a collection-supplied index for item *item*, which is added to the collection. The inserted item follows an existing item with index *index* in the collection ordering. If *index* is **`.nil`**, *item* becomes the first item in the ordered collection. If you omit *index*, the *item* becomes the last item in the collection.

Inserting an item in the collection at position *index* will cause the items in the collection after position *index* to have their relative positions shifted by the collection object. Depending on the nature of the collection, the index values for any items already in the collection may be modified by the insertion.

This is an abstract method that must be implemented by a subclass of this class.

5.3.4.8. intersection



Returns a new collection (of the same class as the receiver) containing only those items from the receiver that are in both the receiver collection and the *argument* collection. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.4.9. last (Abstract Method)

Returns the index of the last item in the collection order. Returns **`.nil`** if the collection is empty.

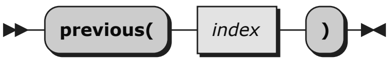
5.3.4.10. lastItem (Abstract Method)

Returns the first item in the collection order. Returns **`.nil`** if the collection is empty.

5.3.4.11. next (Abstract Method)

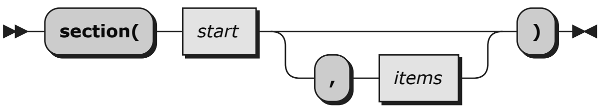
Returns the index of the item that follows the collection item having index *index* or returns **`.nil`** if the item having that index is last in the collection.

5.3.4.12. previous (Abstract Method)



Returns the index of the item that precedes the collection item having index *index* or returns **`.nil`** if the item having that index is first in the collection.

5.3.4.13. section (Abstract Method)

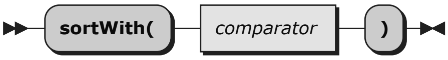


Returns a new collection (of the same class as the receiver) containing selected items from the receiver. The first item in the new collection is the item corresponding to index *start* in the receiver. Subsequent items in the new collection correspond to those in the receiver, in the same sequence. If you specify the whole number *items*, the new collection contains only this number of items (or the number of subsequent items in the receiver, if this is less than *items*). If you do not specify *items*, the new collection contains all subsequent items of the receiver. The receiver remains unchanged.

5.3.4.14. sort

Sorts the collection of Comparable items into ascending order using an algorithm that is not guaranteed to be stable, and returns the sorted collection. See *Section 5.3.19, “Sorting Ordered Collections”* for details.

5.3.4.15. sortWith

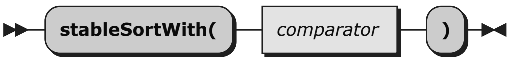


Sorts the collection of items into ascending order using an algorithm that is not guaranteed to be stable, and returns the sorted collection. Ordering of elements is determined using the *comparator* argument. See *Section 5.3.19, “Sorting Ordered Collections”* for details.

5.3.4.16. stableSort

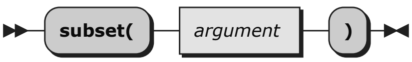
Sorts the collection of Comparable items into ascending order using a stable Mergesort algorithm, and returns the sorted collection. See *Section 5.3.19, “Sorting Ordered Collections”* for details.

5.3.4.17. stableSortWith



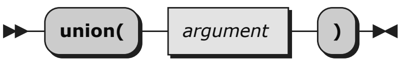
Sorts the collection of items into ascending order using a stable Mergesort algorithm, and returns the sorted collection. Ordering of elements is determined using the *comparator* argument. See *Section 5.3.19, “Sorting Ordered Collections”* for details.

5.3.4.18. subset



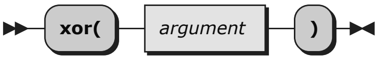
Returns **`.true`** if all items in the receiver collection are also contained in the *argument* collection; returns **`.false`** otherwise. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.4.19. union



Returns a new collection of the same class as the receiver that contains all the items from the receiver collection and selected items from the *argument* collection. This method includes an item from *argument* in the new collection only if there is no equivalent item in the receiver collection and the method has not already included. The order in which this method selects items in *argument* is unspecified (the program should not rely on any order). The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.4.20. xor



Returns a new collection of the same class as the receiver that contains all items from the receiver collection and the *argument* collection; all items that appear in both collections are removed. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.5. SetCollection Class

This is a tagging MIXIN class only and does not define any methods of its own. Collections that implement **`SetCollection`** are *MapCollections* that constrain the index and item to be be the same object.

This class is defined as a MIXIN class. The following classes inherit from SetCollection: *Bag* and *Set*.

Table 5.15. SetCollection Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
SetCollection (Mixin Class)		
(no class or instance methods)		

5.3.6. Array Class

An **`Array`** is a possibly sparse collection with indexes that are positive whole numbers. You can reference Array items by using one or more indexes. The number of indexes is the same as the number of dimensions of the Array. This number is called the dimensionality of the Array.

Array items can be any valid Rexx object.

Table 5.16. Array Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ Collection (Mixin Class)

Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ OrderedCollection (Mixin Class)		
Methods inherited from the *OrderedCollection class*		
append (Abstract Method)	*intersection*	*sortWith*
appendAll	*last (Abstract Method)*	*stableSort*
delete (Abstract Method)	*lastItem (Abstract Method)*	*stableSortWith*
difference	*next (Abstract Method)*	*subset*
first (Abstract Method)	*previous (Abstract Method)*	*union*
firstItem (Abstract Method)	*section (Abstract Method)*	*xor*
insert (Abstract Method)	*sort*	
Array		
new (Class Method)		
of (Class Method)		
[]	*firstItem*	*previous*
[]=	*hasIndex*	*put*
allIndexes	*hasItem*	*remove*
allItems	*index*	*removeItem*
append	*insert*	*section*
at	*isEmpty*	*size*
delete	*items*	*sort*
dimension	*last*	*sortWith*
dimensions	*lastItem*	*stableSort*
empty	*makeArray*	*stableSortWith*
fill	*makeString*	*supplier*
first	*next*	*toString*

Array objects are variable-sized. The dimensionality of an array is fixed, but the size of each dimension is variable. When you create an array, you can specify a hint about how many elements you expect to put into the array or the array's dimensionality. However, you do not need to specify a size or dimensionality of an array when you are creating it. You can use any whole-number indexes to reference items in an array.

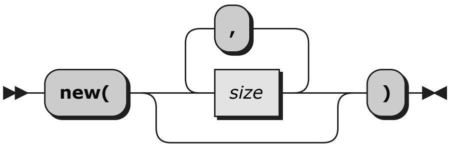
For any array method that takes an index, the index may be specified as either individual arguments or as an array of indexes. For example, the following are equivalent:

Example 5.161. Array class — [] method

```
x = myarray[1,2,3]   -- retrieves an item from a multi-dimensional Array
index = .array~of(1,2,3)  -- create an index list
x = myarray[index]   -- also retrieves from "1,2,3"
```

Methods such as *index* that return index items will return a single numeric value for single-dimensional Arrays and an array of indexes for multi-dimensional Arrays.

5.3.6.1. new (Class Method)



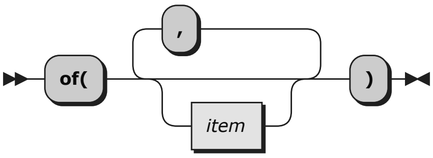
Returns a new empty array. If you specify any *size* arguments, the size is taken as a hint about how big each dimension should be. The Array class uses this only to allocate the initial array object. For multi-dimensional Arrays, you can also specify how much space is to be allocated initially for each dimension of the array.

Each *size* argument must a non-negative whole number. If it is **`0`**, the corresponding dimension is initially empty. The dimensions may also be specified with one single-dimensional Array of sizes.

Example 5.162. Array class — of method

```
   a = .array~new()         -- create a new, empty array
   a = .array~new(3,3)      -- create a new 3x3 array
   sizes = .array~of(4,4,4)
   a = .array~new(sizes)    -- create new 4x4x4 array
```

5.3.6.2. of (Class Method)



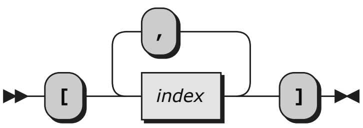
Returns a newly created single-dimensional Array containing the specified *item* objects. The first *item* has index 1, the second has index 2, and so on.

If you use the `of` method and omit any argument items, the returned array does not include the indexes corresponding to the omitted arguments.

Example 5.163. Array class — of method

```
a = .array~of("Fred", "Mike", "David")

do name over a
   say name  -- displays "Fred", "Mike", and "David"
end
```

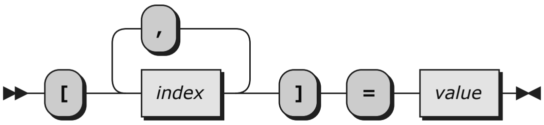
5.3.6.3. []



Returns the same value as the *at* method.

Note that the *index* argument may also be specified as an array of indexes.

5.3.6.4. []=



This method is the same as the *put* method.

Note that the *index* argument may also be specified as an array of indexes.

5.3.6.5. allIndexes

Returns an array of all index positions in the array containing items. For multi-dimensional Arrays, each returned index will be an array of index values.

Example 5.164. Array class — allIndexes method

```
a = .array~of("Fred", "Mike", "David")

do name over a~allIndexes
   say name  -- displays "1", "2", and "3"
end

a~remove(2)  -- remove second item

do name over a~allIndexes
   say name  -- displays "1" and "3"
end
```

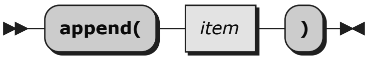
5.3.6.6. allItems

Returns an array of all items contained in the array.

Example 5.165. Array class — allItems method

```
a = .array~of("Fred", "Mike", "David")

do name over a~allItems
   say name  -- displays "Fred", "Mike", and "David"
end

a~remove(2)  -- remove second item

do name over a~allItems
   say name  -- displays "Fred" and "David"
end
```

5.3.6.7. append

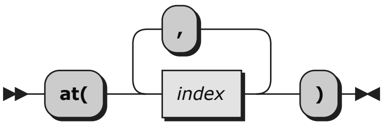


Appends an item to the array after the last item (the item with the highest index). The return value is the index of the newly added item. The `append` method is only valid with single-dimensional Arrays.

Example 5.166. Array class — append method

```
a = .array~of("Mike", "Rick")
a~append("Fred")  -- a = .array~of("Mike", "Rick", "Fred")
```

5.3.6.8. at



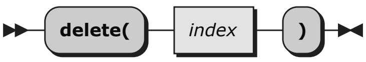
Returns the item associated with the specified *index* or *index*es. If the array has no item associated with the specified *index* or *index*es, this method returns **`.nil`**.

Note that the *index* argument may also be specified as an array of indexes.

Example 5.167. Array class — at method

```
a = .array~of("Mike", "Rick")
say a~at(2)  -- says: "Rick"
```

5.3.6.9. delete



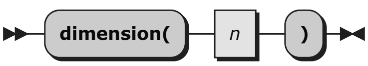
Returns and deletes the member item with the specified *index* from the array. If there is no item with the specified *index*, **`.nil`** is returned and no item is deleted. All elements following the deleted item will be moved up in the array ordering and the item indexes will be adjusted for the deletion. The size of the array will be reduced by one element.

The `delete` method is only valid with single-dimensional Arrays. The *index* argument may also be specified as an array of a single index.

Example 5.168. Array class — delete method

```
a = .array~of("Fred", "Mike", "Rick", "David")
a~delete(2)  -- removes "Mike", resulting in the array
             -- ("Fred", "Rick", "David")
```

5.3.6.10. dimension

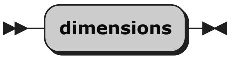


Returns the current size (upper bound) of dimension *n* (a positive whole number). If you omit *n*, this method returns the dimensionality (number of dimensions) of the array. If the number of dimensions has not been determined, **`0`** is returned.

Example 5.169. Array class — dimension method

```
a = .array~of(,"Mike", "Rick")
say a~dimension     -- says: 1 (number of dimensions in the array)
say a~dimension(1)  -- says: 3 (upper bound of dimension one)

a = .array~new~~put("Mike",1,1)~~put("Rick",1,2)
say a~dimension     -- says: 2 (number of dimensions in the array)
say a~dimension(1)  -- says: 1 (upper bound of dimension one)
say a~dimension(2)  -- says: 2 (upper bound of dimension two)
```

5.3.6.11. dimensions



Returns an array containing each of the array dimension sizes. A single-dimensional Array will return an array with a single size element.

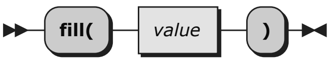
5.3.6.12. empty

Returns the receiving Array with all items removed.

Example 5.170. Array class — empty method

```
a = .array~of("Mike", "Rick", "Fred", "Rick")
a~empty    -- a~items now returns "0"
```

5.3.6.13. fill



Returns the receiving Array with all index locations set to *value*.

Example 5.171. Array class — fill method

```
a = .array~new(3,3)
a~fill(0)    -- initialize the matrix to all zeroes.
```

5.3.6.14. first

Returns the index of the first item in the array or **`.nil`** if the array is empty. For multi-dimensional Arrays, the index is returned as an array of index values.

Example 5.172. Array class — first method

```
a = .array~of("Mike", "Rick", "Fred", "Rick")
say a~first  -- says: 1
a = .array~of(,"Mike", "Rick")
say a~first  -- says: 2
```

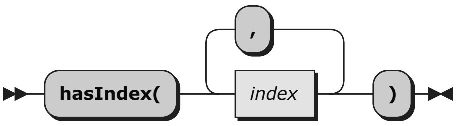
5.3.6.15. firstItem

Returns the first item in the array or **.nil** if the array is empty.

Example 5.173. Array class — firstItem method

```
musketeers=.array~of("Porthos","Athos","Aramis"") /* Creates array MUSKETEERS      */
item=musketeers~firstItem                         /* Gives first item in array     */
                                                  /* (Assigns "Porthos" to item)   */
```

5.3.6.16. hasIndex



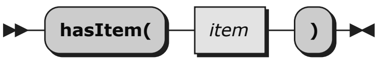
Returns **.true** if the array contains an item associated with the specified index or indexes. Returns **.false** otherwise.

Note that the *index* argument may also be specified as an array of indexes.

Example 5.174. Array class — hasIndex method

```
a = .array~of("Mike", "Rick", "Fred", "Rick")
say a~hasIndex(2)  -- says: 1
say a~hasIndex(5)  -- says: 0
```

5.3.6.17. hasItem

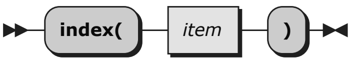


Returns **.true** if the array contains the specified item at any index location. Returns **.false** otherwise. Item equality is determined by using the == method of *item*.

Example 5.175. Array class — hasItem method

```
a = .array~of("Mike", "Rick", "Fred", "Rick")
say a~hasItem("Rick")  -- says: 1
say a~hasItem("Mark")  -- says: 0
```

5.3.6.18. index

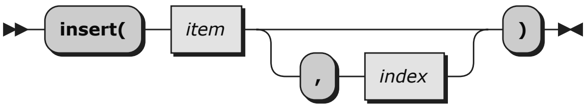


Returns the index of the specified item within the array. If the target item appears at more than one index, the first located index will be returned. For multi-dimensional Arrays, the index is returned as an array of index values. If the array does not contain the specified item, **.nil** is returned. Item equality is determined by using the == method of *item*.

Example 5.176. Array class — index method

```
a = .array~of("Mike", "Rick", "Fred", "Rick")
say a~index("Rick")  -- says: 2
```

5.3.6.19. insert



Returns an Array-supplied index for item *item*, which is added to the Array. The inserted item follows an existing item with index *index* in the Array ordering. If *index* is **.nil**, *item* becomes the first item in the Array. If you omit *index*, the *item* becomes the last item in the Array.

Inserting an item in the Array at position *index* will cause the items in the Array after position *index* to have their indexes shifted by the Array object. The index values for any items in the Array are incremented by the insertion.

Example 5.177. Array class — insert method

```
musketeers=.Array~of("Porthos","Athos","Aramis") /* Creates Array MUSKETEERS        */
                                                 /* consisting of: Porthos         */
                                                 /*                Athos           */
                                                 /*                Aramis          */
musketeers~insert("D'Artagnan",1)    /* Adds D'Artagnan after Porthos  */
                                          /* Array is now: Porthos           */
                                          /*             D'Artagnan   */
                                          /*             Athos             */
                                          /*             Aramis            */
/* Alternately, you could use */
musketeers~insert("D'Artagnan",.nil) /* Adds D'Artagnan before Porthos */
                                          /* Array is now:  D'Artagnan  */
                                          /*              Porthos          */
                                          /*              Athos            */
                                          /*              Aramis           */
/* Alternately, you could use */
musketeers~insert("D'Artagnan")      /* Adds D'Artagnan after Aramis   */
                                          /* Array is now:  Porthos          */
                                          /*              Athos            */
                                          /*              Aramis           */
                                          /*              D'Artagnan  */
```

5.3.6.20. isEmpty

▸▸— **isEmpty** —▸◂

Returns **`.true`** if the array is empty. Returns **`.false`** otherwise.

Example 5.178. Array class — isEmpty method

```
a = .array~new
say a~isEmpty  -- says: 1
a[1] = "1"
say a~isEmpty  -- says: 0
```

5.3.6.21. items

▸▸— **items** —▸◂

Returns the number of items in the array.

Example 5.179. Array class — items method

```
a = .array~of("Fred", , "Mike", , "David")
say a~items  -- says: 3
```

5.3.6.22. last

▸▸— **last** —▸◂

Returns the index of the last item in the array or **`.nil`** if the array is empty. For multi-dimensional Arrays, index is returned as an array of index items.

Example 5.180. Array class — last method

```
a = .array~of("Fred", , "Mike", , "David")
say a~last  -- says: 5
```

5.3.6.23. lastItem

▸▸— **lastItem** —▸◂

Returns the last item in the array or **`.nil`** if the array is empty.

Example 5.181. Array class — lastItem method

```
musketeers=.array~of("Porthos","Athos","Aramis"") /* Creates array MUSKETEERS      */
item=musketeers~lastItem                          /* Gives last item in array      */
                                                  /* (Assigns "Aramis" to item)    */
```

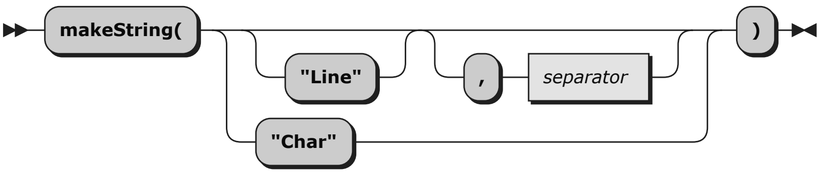
5.3.6.24. makeArray

Returns a single-dimensional Array with the same number of items as the receiver object. Any index with no associated item is omitted from the new array. Items in the new array will have the same order as the source array. A multi-dimensional Array will be converted into a non-sparse single-dimensional Array.

Example 5.182. Array class — makeArray method

```
a = .array~of("Fred", , "Mike", , "David")
b = a~makeArray  -- b = .array~of("Fred", "Mike", "David")
```

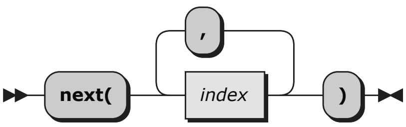
5.3.6.25. makeString



Returns a string that contains the data of an array (one to n dimensional). The elements of the array are treated either in line or character format, starting at the first element in the array. The line format is the default. If the line format is used, a *separator* string can be specified. The separator will be used between concatenated elements instead of the default line end separator.

See method *toString* (which is a synonym for this method) for examples.

5.3.6.26. next



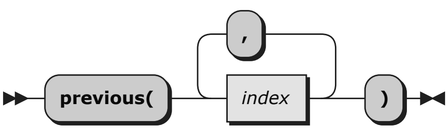
Returns the index of the item that follows the array item having index *index* or returns **.nil** if the item having that index is last in the array. For multi-dimensional Arrays, the same ordering as used by the *allItems* method is used to determine the next position and the index is returned as an array of index values.

Note that the *index* argument may also be specified as an array of indexes.

Example 5.183. Array class — next method

```
a = .array~of("Fred", , "Mike", , "David")
say a~next(3)  -- says: 5
```

5.3.6.27. previous



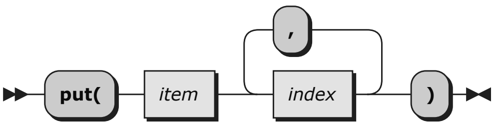
Returns the index of the item that precedes the array item having index *index* or **`.nil`** if the item having that index is first in the array. For multi-dimensional Arrays, the same ordering used by the *allItems* method is used to determine the previous position and the index is returned as an array of index values.

Note that the *index* argument may also be specified as an array of indexes.

Example 5.184. Array class — previous method

```
a = .array~of("Fred", , "Mike", , "David")
say a~previous(3)  -- says: 1
```

5.3.6.28. put



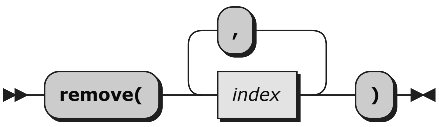
Makes the object *item* a member item of the array and associates it with the specified *index* or *index*es. This replaces any existing item associated with the specified *index* or *index*es with the new item. If the *index* for a particular dimension is greater than the current size of that dimension, the array is expanded to the new dimension size.

Note that the *index* argument may also be specified as an array of indexes.

Example 5.185. Array class — put method

```
a = .array~new
a~put("Fred", 1) -- a = .array~of("Fred")
a~put("Mike", 2) -- a = .array~of("Fred", "Mike")
a~put("Mike", 1) -- a = .array~of("Mike", "Mike")

do name over a
  say name
end

/* Output would be: */

Mike
Mike
```

5.3.6.29. remove



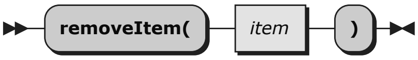
Returns and removes the member item with the specified *index* or *index*es from the array. If there is no item with the specified *index* or *index*es, **`.nil`** is returned and no item is removed. The index of the removed item becomes unused and the `hasIndex` method for the given index will now return **`.false`**. The size of the array is unchanged and no other indexes of the array are modified with the removal.

Note that the *index* argument may also be specified as an array of indexes.

Example 5.186. Array class — remove method

```
a = .array~of("Fred", "Mike", "Mike", "David")
a~remove(2)  -- removes "Mike"
```

5.3.6.30. removeItem

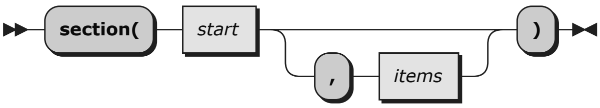


Removes an item from the array. If the target item exists at more than one index, the first located item is removed. Item equality is determined by using the == method of *item*. The return value is the removed item.

Example 5.187. Array class — removeItem method

```
a = .array~of("Fred", "Mike", "Mike", "David")
a~removeItem("Mike")  -- removes the item at index "2"
```

5.3.6.31. section



Returns a new array (of the same class as the receiver) containing selected items from the receiver array. The first item in the new array is the item corresponding to index *start* in the receiver array. Subsequent items in the new array correspond to those in the receiver array (in the same sequence). If you specify the whole number *items*, the new array contains only this number of items (or the number of subsequent items in the receiver array, if this is less than *items*). If you do not specify *items*, the new array contains all subsequent items of the receiver array. The receiver array remains unchanged. The `section` method is valid only for single-dimensional Arrays.

Note that the index argument *start* may also be specified as an array of indexes.

Example 5.188. Array class — section method

```
a = .array~of(1,2,3,4)  -- Loads the array

b = a~section(2)   -- b = .array~of(2,3,4)
c = a~section(2,2) -- c = .array~of(2,3)
d = a~section(2,0) -- d = .array~new
```

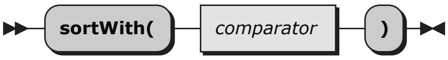
5.3.6.32. size

Returns the number of items that can be placed in the array before it needs to be extended. This value is the same as the product of the sizes of the dimensions in the array.

5.3.6.33. sort

Sorts the Array of Comparable items into ascending order using an algorithm that is not guaranteed to be stable, and returns the sorted Array. See *Section 5.3.19, “Sorting Ordered Collections”* for details.

5.3.6.34. sortWith

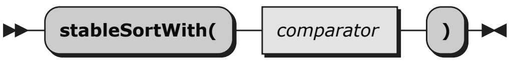


Sorts the Array of items into ascending order using an algorithm that is not guaranteed to be stable, and returns the sorted Array. Ordering of elements is determined using the *comparator* argument. See *Section 5.3.19, “Sorting Ordered Collections”* for details.

5.3.6.35. stableSort

Sorts the Array of Comparable items into ascending order using a stable Mergesort algorithm, and returns the sorted Array. See *Section 5.3.19, “Sorting Ordered Collections”* for details.

5.3.6.36. stableSortWith



Sorts the Array of items into ascending order using a stable Mergesort algorithm, and returns the sorted Array. Ordering of elements is determined using the *comparator* argument. See *Section 5.3.19, “Sorting Ordered Collections”* for details.

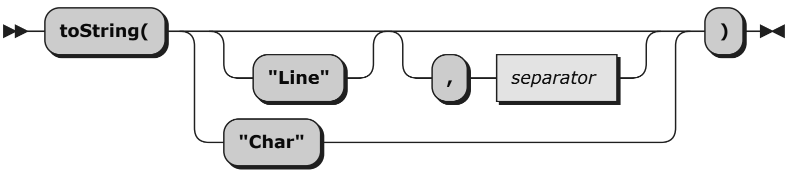
5.3.6.37. supplier

Returns a *Supplier* object for the array. The supplier allows you to iterate over the index/item pairs of the array. The supplier enumerates the array items in their sequenced order. For multi-dimensional Arrays, the supplier `index` method will return the index values as an array of index numbers.

Example 5.189. Array class — supplier method

```
a = .array~of("Fred", "Mike", "David")
sup = a~supplier
a~append("Joe")
do while sup~available
   say sup~item  -- displays "Fred", "Mike", and "David"
   sup~next
end
```

5.3.6.38. toString



Returns a string that contains the data of an array (one to n dimensional). The elements of the array are treated either in line or character format, starting at the first element in the array. The line format is the default. If the line format is used, a *separator* string can be specified. The separator will be used between concatenated elements instead of the default line end separator.

See also method *makeString* for which this method is a synonym.

Example 5.190. Array class — toString method

```
a = .array~of(1,2,3,4)  -- Loads the array

say a~toString  -- Produces: 1
                --           2
                --           3
                --           4

say a~toString("c")  -- Produces: 1234

say a~toString(, ", ")  -- Produces: 1, 2, 3, 4
```

5.3.6.39. Examples

Example 5.191. Array class — examples

```
array1=.array~of(1,2,3,4)  /* Loads the array */

/* Alternative way to create and load an array */
array2=.array~new(4)  /* Creates array2, containing 4 items */
do i=1 to 4                  /* Loads the array */
  array2[i]=i
end
```

You can produce the elements loaded into an array, for example:

Example 5.192. Array class — examples

```
do i=1 to 4
  say array1[i]
end
```

If you omit any argument values before arguments you supply, the corresponding indexes are skipped in the returned array:

Example 5.193. Array class — examples

```
directions=.array~of("North","South", ,"West")
do i=1 to 4                                 /* Produces: North          */
```

```
  say directions[i]                          /*          South          */
                                             /*          The NIL object */
end                                          /*          West           */
```

Here is an example using the ~~:

Example 5.194. Array class — examples

```
z=.array~of(1,2,3)~~put(4,4)
do i = 1 to z~size
  say z[i]              /* Produces:  1 2 3 4 */
end
```

5.3.7. Bag Class

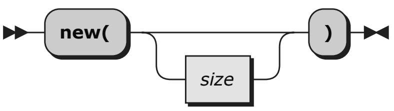
A **Bag** is a non-sparse collection that restricts the elements to having an item that is the same as the index. Any object can be placed in a Bag, and the same object can be placed in a Bag several times.

Table 5.17. Bag Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ SetCollection (Mixin Class)		
Methods inherited from the *SetCollection class* (no class or instance methods)		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ MapCollection (Mixin Class)		
Methods inherited from the *MapCollection class*		
of (Class Method)		
makeArray		
putAll		
Bag		
new (Class Method)		
of (Class Method)		
[]	*hasIndex*	*remove*
[]=	*hasItem*	*removeAll*
allAt	*index*	*removeItem*
allIndex	*intersection*	*subset*

allIndexes	*isEmpty*	*supplier*
allItems	*items*	*union*
at	*makeArray*	*uniqueIndexes*
difference	*put*	*xor*
empty	*putAll*	

5.3.7.1. new (Class Method)

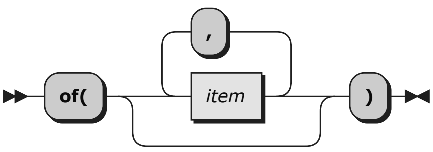


Returns a new empty Bag object.

If you specify *size*, a hint how large the new Bag object is expected to grow, this is used to optimize the initial allocation.

size must be a non-negative whole number.

5.3.7.2. of (Class Method)



Returns a newly created Bag containing the specified *item* objects.

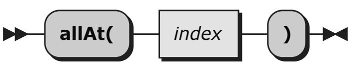
5.3.7.3. []

Returns the item associated with index *index*. Returns **`.nil`** if the Bag has no item associated with *index*.

Index equality is determined by using the == method of *index*.

This method is the same as the *at* method.

5.3.7.4. allAt

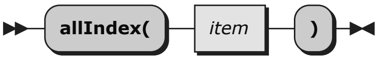


Returns a single-dimensional Array containing all the items associated with index *index*.

Index equality is determined by using the == method of *index*.

This method has the same result as the *allIndex* method.

5.3.7.5. allIndex



Returns a single-dimensional Array containing all indexes for item *item*.

Item equality is determined by using the == method of *item*.

This method has the same result as the *allAt* method.

5.3.7.6. allIndexes

Returns an Array of all indexes contained in the Bag, in an unspecified order. The returned Array will have one index for every item stored in the Bag, including duplicates.

To retrieve the indexes without duplicates, use the *uniqueIndexes* method.

5.3.7.7. allItems

Returns an Array of all items contained in the Bag, in an unspecified order.

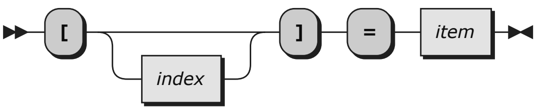
5.3.7.8. at

Returns the item associated with index *index*. Returns **`.nil`** if the Bag does not contain *index*.

Index equality is determined by using the == method of *index*.

This method is the same as the *[]* method.

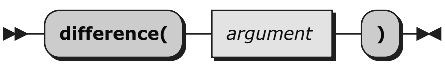
5.3.7.9. []=



Adds an item to the Bag. If specified, *index* must be the same object as *item*.

This method is the same as the *put* method.

5.3.7.10. difference

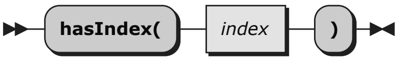


Returns a new Bag containing only those items from the receiver that the *argument* collection does not contain. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.7.11. empty

Returns the receiving Bag with all items removed.

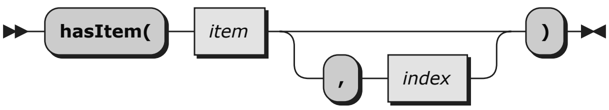
5.3.7.12. hasIndex



Returns **`.true`** if the Bag contains any item associated with index *index*, otherwise returns **`.false`**.

Index equality is determined by using the == method of *index*.

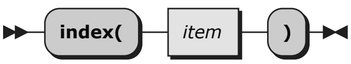
5.3.7.13. hasItem



Returns **`.true`** if the Bag contains the member item *item*, otherwise returns **`.false`**. If *index* is specified, it should be the same object as *index*, otherwise `hasItem` will always return **`.false`**.

Item and index equality is determined by using the == method.

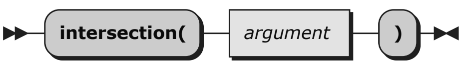
5.3.7.14. index



Returns the index for item *item* if the Bag contains *item*, otherwise returns **`.false`**.

Item equality is determined by using the == method of *item*.

5.3.7.15. intersection

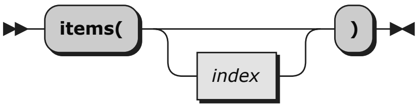


Returns a new Bag containing only those items from the receiver that are also in the *argument* collection. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.7.16. isEmpty

Returns **`.true`** if the Bag is empty. Returns **`.false`** otherwise.

5.3.7.17. items



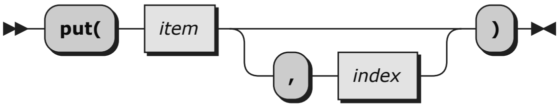
Returns the number of Bag items with index *index*. If you specify no *index*, this method returns the total number of items in the Bag.

Index equality is determined by using the == method of *index*.

5.3.7.18. makeArray

Returns a single-dimensional Array containing all Bag items, in an unspecified order.

5.3.7.19. put



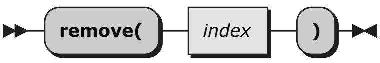
Adds an item to the Bag. If specified, *index* must be the same object as *item*.

This method is the same as the *[]=* method.

5.3.7.20. putAll

Returns the receiving Bag with all items in *collection* added to it. The *collection* argument can be any object that supports a `supplier` method. Items from *collection* are added using the item values returned by the supplier.

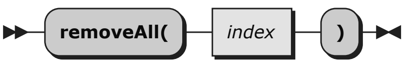
5.3.7.21. remove



Returns and removes from the Bag one member item with index *index*. Returns **`.nil`** if the Bag does not contain *index*.

Index equality is determined by using the == method of *index*.

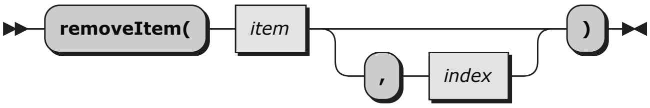
5.3.7.22. removeAll



Returns and removes from the Bag all member items with index *index*. All removed items are returned in an Array containing each of the removed items. If the Bag does not contain *index*, an empty Array is returned.

Index equality is determined by using the == method of *index*.

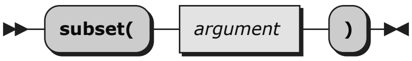
5.3.7.23. removeItem



Returns and removes from a Bag one member item *item*. Returns **`.nil`** if *item* is not a member of the Bag.

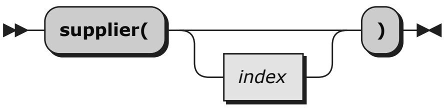
If *index* is specified, it should be the same object as *index*, otherwise `removeItem` will always return **`.nil`**.

5.3.7.24. subset



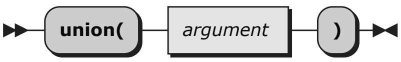
Returns **`.true`** if all indexes in the receiver Bag are also contained in the *argument* collection; returns **`.false`** otherwise. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.7.25. supplier



Returns a *Supplier* object for the Bag. The supplier allows you to iterate over all index/item pairs in the Bag at the time the supplier was created. The supplier enumerates the items in an unspecified order. If you specify *index*, the supplier contains all of the items with the specified index.

5.3.7.26. union



Returns a new Bag that contains all the items from the receiver Bag and selected items from the *argument* collection. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.7.27. uniqueIndexes

Returns an Array of all indexes contained in the Bag, with no duplicates.

5.3.7.28. xor

Returns a new Bag that contains all items from the receiver Bag and the *argument* collection; items that appear in both collections are removed. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.7.29. Examples

Example 5.195. Bag class — examples

```
/* Create a bag of fruit */
fruit = .bag~of("Apple", "Orange", "Apple", "Pear")
say fruit~items          /* How many pieces? (4)      */
say fruit~items("Apple") /* How many apples? (2)      */
fruit~remove("Apple")    /* Remove one of the apples. */
fruit~~put("Banana")~put("Orange") /* Add a couple.   */
say fruit~items          /* How many pieces? (5)      */
```

5.3.8. CircularQueue Class

The **`CircularQueue`** class allows for storing objects in a circular queue of a predefined size. Once the end of the queue has been reached, new item objects are inserted from the beginning, replacing earlier entries. Any object can be placed in the queue and the same object can occupy more than one position in the queue.

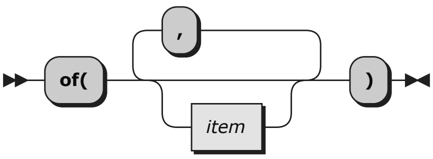
The collected objects can be processed in FIFO (first-in, first-out) or in a stack-like LIFO (last-in, first-out) order.

Table 5.18. CircularQueue Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ OrderedCollection (Mixin Class)		
Methods inherited from the *OrderedCollection class*		
append (Abstract Method)	*intersection*	*sortWith*
appendAll	*last (Abstract Method)*	*stableSort*
delete (Abstract Method)	*lastItem (Abstract Method)*	*stableSortWith*
difference	*next (Abstract Method)*	*subset*
first (Abstract Method)	*previous (Abstract Method)*	*union*
firstItem (Abstract Method)	*section (Abstract Method)*	*xor*
insert (Abstract Method)	*sort*	
Queue		
Methods inherited from the *Queue class*		
new (Class Method)		
of (Class Method)		

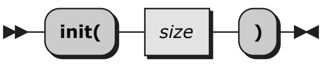
[]	*hasItem*	*pull*
[]=	*index*	*push*
allIndexes	*insert*	*put*
allItems	*isEmpty*	*queue*
append	*items*	*remove*
at	*last*	*removeItem*
delete	*lastItem*	*section*
empty	*makeArray*	*size*
first	*next*	*supplier*
firstItem	*peek*	
hasIndex	*previous*	
	CircularQueue	
of (Class Method)		
append	*makeString*	*size*
init	*push*	*string*
insert	*queue*	*supplier*
intersection	*resize*	*union*
makeArray	*section*	*xor*

5.3.8.1. of (Class Method)



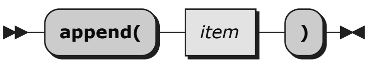
Returns a newly created circular queue containing the specified *item* objects. The first *item* has index 1, the second has index 2, and so on. Any omitted item will be set to the null string. The total number of *item* objects (including omitted ones) determines the size of the circular queue.

5.3.8.2. init



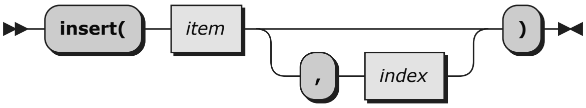
Performs initialization of the circular queue. The required *size* argument, a non-negative whole number, specifies the initial size of the queue.

5.3.8.3. append



Append an item to the end of the collection ordering, returning the index of the added item. If the circular queue is full, then the first item will be deleted, before the insertion takes place.

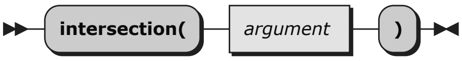
5.3.8.4. insert



Returns a queue-supplied index for *item*, which is added to the queue. The inserted item follows any existing item with index *index* in the queue ordering. If *index* is **`.nil`**, *item* is inserted at the head of the queue. If you omit *index*, *item* becomes the last item in the queue.

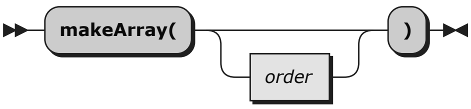
Inserting an item in the queue at position *index* will cause the items in the queue after position *index* to have their indexes modified by the queue object. If inserting an object causes the queue to grow beyond the size, the last item in the queue will be removed.

5.3.8.5. intersection



Returns a new collection (of the same class as the receiver) containing only those items from the receiver that are in both the receiver collection and the *argument* collection. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The resulting CircularQueue instance will be the same size as the receiver.

5.3.8.6. makeArray



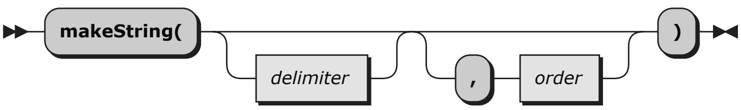
Returns a single-dimensional Array containing the items of the circular queue in the specified *order*.

The following *order* can be used. (Only the capitalized letter is needed; all characters following it are ignored.)

Fifo
: First-in, first-out order. This is the default.

Lifo
: Last-in, first-out order (stack-like).

5.3.8.7. makeString



Returns a string object that concatenates the string values of the collected item objects, using the *delimiter* string to delimit them, in the specified *order*. If the *delimiter* is omitted, the comma character (**`","`**) is used as the default delimiter string.

The following *order* can be used. (Only the capitalized letter is needed; all characters following it are ignored.)

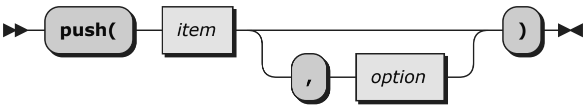
Fifo
: First-in, first-out. This is the default

Lifo
    Last-in, first-out (stack-like)

Example 5.196. CircularQueue class — makeArray method

```
-- reverse an array
a = .Array~of("one", "two", "three", "four", "five")
say .CircularQueue~new(a~size)~appendAll(a)~makeArray("lifo")~makeString(, ", ")
-- five, four, three, two, one
```

5.3.8.8. push

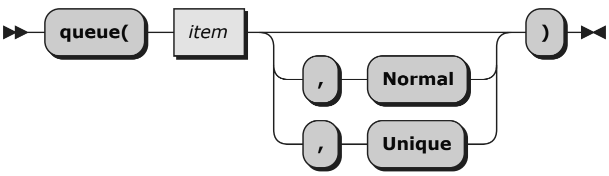


Makes the object *item* a member item of the circular queue, inserting the item object in front of the first item in the queue. The pushed item object will be the new first item in the circular queue.

If the circular queue is full, then the last item stored in the circular queue will be deleted, before the insertion takes place. In this case the *deleted item* will be returned, otherwise **`.nil`** will be returned.

If *option* is specified, it may be "Normal" or "Unique". The default is "Normal". Only the capitalized letter is needed; all characters following it are ignored. If *option* is 'Unique', any matching items already in the queue will be removed before *item* is added to the queue. This allows you to maintain a list like the recent files list of an editor.

5.3.8.9. queue

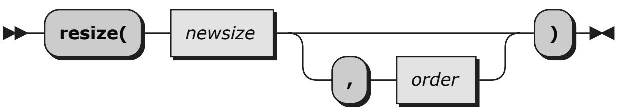


Makes the object *item* a member item of the circular queue, inserting the item at the end of the circular queue.

If the circular queue is full, then the first item will be deleted, before the insertion takes place. In this case the *deleted item* will be returned, otherwise **`.nil`** will be returned.

If *option* is specified, it may be "Normal" or "Unique". The default is "Normal". Only the capitalized letter is needed; all characters following it are ignored. If *option* is 'Unique', any matching items already in the queue will be removed before *item* is added to the queue. This allows you to maintain a list like the recent files list of an editor.

5.3.8.10. resize



Resizes the circular queue object to be able to contain *newSize* items. If more than *newSize* items are in the queue, any extra items are removed in the specified *order*.

The following *order* can be used. (Only the capitalized letter is needed; all characters following it are ignored.)

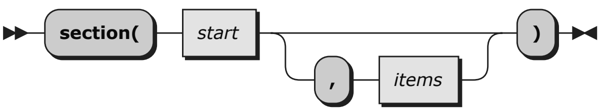
Fifo
: First-in, first-out. This keeps the items at the front of the queue. Item deletions occur at the end of the queue. This is the default action.

Lifo
: Last-in, first-out (stack-like). This removes items from the front of the queue.

Note:

Resizing with a value of **`0`** removes all items from the circular queue.

5.3.8.11. section



Returns a new queue (of the same class as the receiver) containing selected items from the receiver. The first item in the new queue is the item corresponding to index *start* in the receiver. Subsequent items in the new queue correspond to those in the receiver (in the same sequence). If you specify the whole number *items*, the new queue contains only this number of items (or the number of subsequent items in the receiver, if this is less than *items*). If you do not specify *items*, the new queue contains all subsequent items from the receiver. The receiver queue remains unchanged. The new queue item will be sized to the larger of the receiver queue size or *items*. The selection of the items will wrap from the end around to the beginning of the queue. For example,

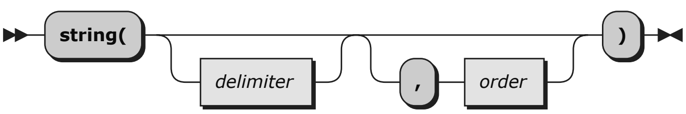
```
q1 = .circularqueue~of("Fred", "Mike", "David")
q2 = q1~section(2)        -- effectively rotates the queue

do name over a
   say name  -- displays "Mike", "David", and "Fred"
end
```

returns a new queue of three items, starting with the second item, effectively rotating the order of the contained items.

5.3.8.12. size

Returns the maximum number of objects that can be stored in the circular queue.

5.3.8.13. string



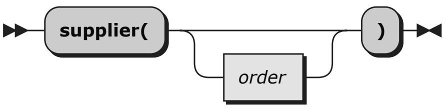
Returns a string object that concatenates the string values of the collected item objects, using the *delimiter* string to delimit them, in the specified *order*. If the *delimiter* is omitted, the comma character (**","**) is used as the default delimiter string.

The following *order* can be used. (Only the capitalized letter is needed; all characters following it are ignored.)

Fifo
: First-in, first-out. This is the default

Lifo
: Last-in, first-out (stack-like)

5.3.8.14. supplier



Returns a *Supplier* object for the collection. The supplier allows you to iterate over the items that were in the queue at the time of the supplier's creation.

The supplier will iterate over the items in the specified *order*. (Only the capitalized letter is needed; all characters following it are ignored.)

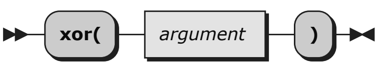
Fifo
: First-in, first-out, default

Lifo
: Last-in, first-out (stack-like)

5.3.8.15. union

Returns a new collection of the same class as the receiver that contains all the items from the receiver collection and selected items from the *argument* collection. The resulting CircularQueue object will have a size that is the larger of the receiver's size or the union size of the two collections. This method includes an item from *argument* in the new collection only if there is no equivalent item in the receiver collection and the method has not already included. The order in which this method selects items in *argument* is unspecified (the program should not rely on any order.). The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.8.16. xor



Returns a new collection of the same class as the receiver that contains all items from the receiver collection and the *argument* collection; all items that appear in both collections are removed. The resulting CircularQueue object will have a size that is the larger of the receiver's size or the xor size of the two collections. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.8.17. Example

Example 5.197. CircularQueue class — examples

```
  -- create a circular buffer with five items
u=.circularQueue~of("a", "b", "c", "d", "e")
say "content: ["u"]," "content (LIFO): ["u~string("->","L")"]"
say

u~resize(4, "FIFO")     -- resize fifo-style (keep newest)
say "after resizing to 4 items in FIFO style (keeping the newest):"
say "content: ["u"]," "content (LIFO): ["u~string("->","L")"]"
say

u~resize(2, "LIFO")     -- resize lifo-style (keep oldest)
say "after resizing to 2 items in LIFO style (keeping the oldest):"
say "content: ["u"]," "content (LIFO): ["u~string("->","L")"]"
say

u~resize(0)             -- resize lifo-style (keep oldest)
say "after resizing to 0 items, thereby deleting all items:"
say "content: ["u"]," "content (LIFO): ["u~string("->","L")"]"
say

u~resize(2)             -- resize lifo-style (keep oldest)
say "after resizing to 2, size="u~size "and items="u~items
u~~queue('x')~~queue('y')~~queue('z')
say "after queuing the three items 'x', 'y', 'z':"
say "content: ["u"]," "content (LIFO): ["u~string("->","L")"]"
say

u~~push('1')~~push('2')~~push('3')
say "after pushing the three items '1', '2', '3':"
say "content: ["u"]," "content (LIFO): ["u~string("->","L")"]"
say
```

Output:

```
content: [a,b,c,d,e], content (LIFO): [e->d->c->b->a]

after resizing to 4 items in FIFO style (keeping the newest):
content: [b,c,d,e], content (LIFO): [e->d->c->b]

after resizing to 2 items in LIFO style (keeping the oldest):
content: [b,c], content (LIFO): [c->b]

after resizing to 0 items, thereby deleting all items:
content: [], content (LIFO): []

after resizing to 2, size=2 and items=0
after queuing the three items 'x', 'y', 'z':
content: [y,z], content (LIFO): [z->y]

after pushing the three items '1', '2', '3':
content: [3,2], content (LIFO): [2->3]
```

5.3.9. Directory Class

A **`Directory`** is a *MapCollection* using unique character string indexes. The items of a Directory can be any valid Rexx object.

See also *StringTable Class*, a **`MapCollection`** similar to **`Directory`**, but without methods `setMethod` and `unsetMethod`.

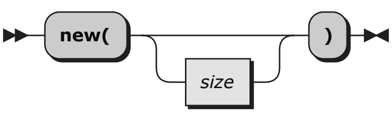
Table 5.19. Directory Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ MapCollection (Mixin Class)		
Methods inherited from the *MapCollection class*		
of (Class Method)		
makeArray		
putAll		
Directory		
new (Class Method)		
[]	*hasIndex*	*removeEntry*
[]=	*hasItem*	*removeItem*
allIndexes	*index*	*setEntry*
allItems	*isEmpty*	*setMethod*
at	*items*	*supplier*
empty	*makeArray*	*unknown*
entry	*put*	*unsetMethod*
hasEntry	*remove*	

In addition to the standard `put`, `[]=`, `at`, and `[]` methods defined for Collections, Directory provides access to items using methods. For example:

```
mydir = .directory~new
mydir~name = "Mike"    -- same as mydir~put("Mike", "NAME")
say mydir~name         -- same as say mydir['NAME']
```

5.3.9.1. new (Class Method)



Returns an empty Directory object.

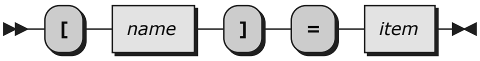
If you specify *size*, a hint how large the new Directory object is expected to grow, this is used to optimize the initial allocation.

size must be a non-negative whole number.

5.3.9.2. []

Returns the item corresponding to *name*. This method is the same as the *at* method.

5.3.9.3. []=



Adds or replaces the entry at index *name*. This method is the same as the *put* method.

5.3.9.4. allIndexes

Returns an array of all the directory indexes, including those of all the *setMethod* methods.

5.3.9.5. allItems

Returns an array of all items contained in the directory, including those returned by all *setMethod* methods.

5.3.9.6. at

Returns the item associated with index *name*. If a method defined using *setMethod* is associated with index *name*, the result of running this method is returned. If the Directory has no item or method associated with index *name*, **.nil** is returned.

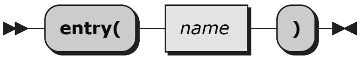
Example 5.198. Directory class — at method

```
say .environment~at("OBJECT")   /* Produces: "The Object class" */
```

5.3.9.7. empty

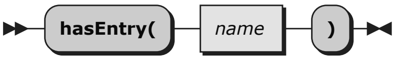
Returns the receiving Directory with all items removed. `empty` also removes all methods added using *setMethod*.

5.3.9.8. entry



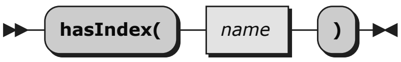
Returns the directory entry with index *name* (translated to uppercase). If there is no such entry, *name* returns the item for any method that *setMethod* supplied. If there is neither an entry nor a method for *name*, **`.nil`** is returned.

5.3.9.9. hasEntry



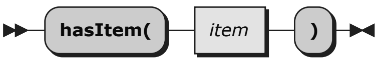
Returns **`.true`** if the directory has an entry or a method for index *name* (translated to uppercase), or **`.false`**.

5.3.9.10. hasIndex



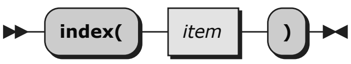
Returns **`.true`** if the Directory contains any item associated with index *name*, or **`.false`**.

5.3.9.11. hasItem



Returns **`.true`** if the Directory contains the *item* at any index position or otherwise returns **`.false`**. Item equality is determined by using the == method of *item*.

5.3.9.12. index



Returns the index of the specified item within the directory. If the target item appears at more than one index, the first located index will be returned. If the directory does not contain the specified item, **`.nil`** is returned. Item equality is determined by using the == method of *item*.

5.3.9.13. isEmpty

Returns **`.true`** if the directory is empty. Returns **`.false`** otherwise.

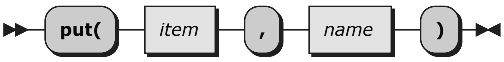
5.3.9.14. items

Returns the number of items in the collection.

5.3.9.15. makeArray

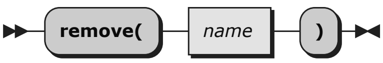
Returns a single-dimensional Array containing the index objects. The array indexes range from **`1`** to the number of items. The collection items appear in the array in an unspecified order. (The program should not rely on any order.)

5.3.9.16. put



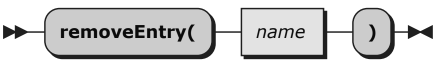
Makes the object *item* a member item of the collection and associates it with index *name*. The new item replaces any existing item or method associated with index *name*.

5.3.9.17. remove



Removes and returns the member item with index *name* from the directory. If a method is associated with *setMethod* for index *name*, the method is removed and the result of running the method is returned. If there is no item or method with index *name*, **`.nil`** is returned.

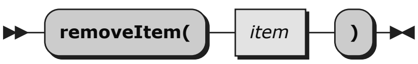
5.3.9.18. removeEntry



Removes and returns the member item with index *name* (translated to uppercase) from the directory. If a method is associated with *setMethod* for index *name*, the method is removed and the result of running the method is returned. If there is no item or method with index *name*, **`.nil`** is returned.

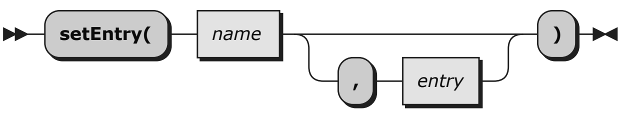
See also *setEntry*, *setMethod*, *hasEntry*, and *entry*.

5.3.9.19. removeItem



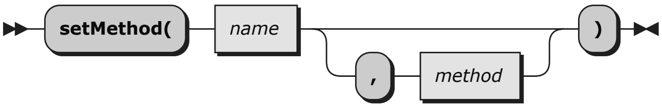
Removes an item from the directory. If the target item exists at more than one index, the first located item is removed. The return value is the removed item. Item equality is determined by using the == method of *item*.

5.3.9.20. setEntry



Sets the directory entry with index *name* (translated to uppercase) to the object *entry*, replacing any existing entry or method for *name*. If you omit *entry*, this method removes any entry or method with this *name*.

5.3.9.21. setMethod



Associates index *name* (translated to uppercase) with method *method*. Thus, the object returns the result of running *method* when you access this entry. This occurs when you specify *name* on the `[]`, `at`, `entry`, or `remove` method. This method replaces any existing item or method for *name*.

You can specify **`"UNKNOWN"`** as *name*. Doing so supplies a method that is run whenever an `at` or `entry` message specifies a name for which no item or method exists in the collection. This method's first argument is the specified directory index. This method has no effect on the action of any `hasEntry`, `hasIndex`, `items`, `remove`, or `supplier` message sent to the collection.

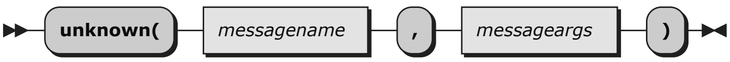
The *method* can be a string containing a method source line instead of a method object. Alternatively, an array of strings containing individual method lines can be passed. In either case, an equivalent method object is created.

If you omit *method*, `setMethod` removes the entry with the specified *name*.

5.3.9.22. supplier

Returns a *Supplier* object for the collection. The supplier allows you to iterate over the index/item pairs in the directory at the time the supplier was created. The supplier iterates the items in an unspecified order.

5.3.9.23. unknown

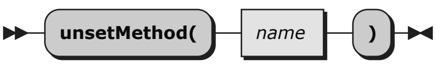


Runs either the *entry* or *setEntry* method, depending on whether *messagename* ends with an equal sign.

If *messagename* does not end with an equal sign, this method runs the `entry` method, passing *messagename* as its argument. The *messageargs* argument is ignored. The `entry` method is the return result.

If *messagename* does end with an equal sign, this method runs the `setEntry` method, passing the first part of *messagename* (up to, but not including, the final equal sign) as its first argument, and the first item in the array *messageargs* as its second argument. In this case, `unknown` returns no result.

5.3.9.24. unsetMethod



Removes the association between index *name* (translated to uppercase) and a method.

5.3.9.25. Examples

Example 5.199. Directory class — examples

```
/******************************************************************************/
/*  A Phone Book Directory program                                            */
/*  This program demonstrates use of the directory class.                     */
/******************************************************************************/

/* Define an UNKNOWN method that adds an abbreviation lookup feature.         */
/* Directories do not have to have an UNKNOWN method.                         */
book = .directory~new~~setMethod("UNKNOWN", .methods["UNKNOWN"])

book["ANN" ] = "Ann B. ....... 555-6220"
book["ann" ] = "Little annie . 555-1234"
book["JEFF"] = "Jeff G. ...... 555-5115"
book["MARK"] = "Mark C. ...... 555-5017"
book["MIKE"] = "Mike H. ...... 555-6123"
book~Rick    = "Rick M. ...... 555-5110"  /* Same as book["RICK"] = ...       */

Do i over book                 /* Iterate over the collection                 */
  Say book[i]
end i

Say ""                         /* Index lookup is case sensitive...           */
Say book~entry("Mike")         /* ENTRY method uppercases before lookup       */
Say book["ANN"]                /* Exact match                                 */
Say book~ann                   /* Message sends uppercase before lookup       */
Say book["ann"]                /* Exact match with lowercase index            */

Say ""
Say book["M"]                  /* Uses UNKNOWN method for lookup              */
Say book["Z"]
Exit

/* Define an unknown method to handle indexes not found.                      */
/* Check for abbreviations or indicate listing not found                      */
::Method unknown
  Parse arg at_index
  value = ""
  Do i over self
    If abbrev(i, at_index) then do
      If value <> "" then value = value", "
      value = value || self~at(i)
    end
  end i
  If value = "" then value = "No listing found for" at_index
  Return value
```

5.3.10. IdentityTable Class

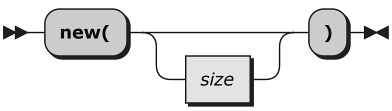
An **`IdentityTable`** is a collection with indexes that can be any object. In an IdentityTable, each item is associated with a single index, and there can be only one item for each index. Index and item matches are made using an object identity comparison. That is, an index will only match if the same instance is used in the collection.

Table 5.20. IdentityTable Class

Object
Methods inherited from the *Object class*

Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ MapCollection (Mixin Class)		
Methods inherited from the *MapCollection class*		
of (Class Method)		
makeArray		
putAll		
IdentityTable		
new (Class Method)		
[]	*hasIndex*	*put*
[]=	*hasItem*	*remove*
allIndexes	*index*	*removeItem*
allItems	*isEmpty*	*supplier*
at	*items*	
empty	*makeArray*	

5.3.10.1. new (Class Method)



Returns an empty IdentityTable object.

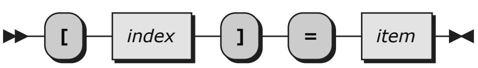
If you specify *size*, a hint how large the new IdentityTable object is expected to grow, this is used to optimize the initial allocation.

size must be a non-negative whole number.

5.3.10.2. []

Returns the item associated with *index*. This method is the same as the *at* method.

5.3.10.3. []=



Adds *item* to the table at index *index*. This method is the same as the *put* method.

5.3.10.4. allIndexes

Returns an array of all indices contained in the table.

5.3.10.5. allItems

Returns an array of all items contained in the table.

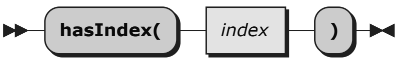
5.3.10.6. at

Returns the item associated with index *index*. Returns **`.nil`** if the IdentityTable has no item associated with *index*.

5.3.10.7. empty

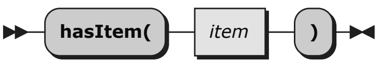
Returns the receiving IdentityTable with all items removed.

5.3.10.8. hasIndex



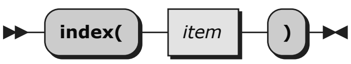
Returns **`.true`** if the IdentityTable contains any item associated with index *index*, or **`.false`**.

5.3.10.9. hasItem



Returns **`.true`** if the IdentityTable contains the *item* at any index position or otherwise returns **`.false`**.

5.3.10.10. index



Returns the index of the specified item within the table. If the target item appears at more than one index, the first located index will be returned. Returns **`.nil`** if the table does not contain the specified item.

5.3.10.11. isEmpty

Returns **.true** if the table is empty. Returns **.false** otherwise.

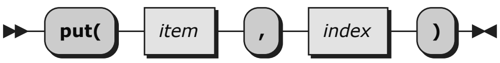
5.3.10.12. items

Returns the number of items in the collection.

5.3.10.13. makeArray

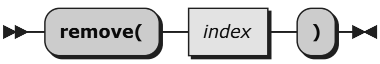
Returns a single-dimensional Array containing the index objects. The array indexes range from **1** to the number of items. The collection items appear in the array in an unspecified order.

5.3.10.14. put



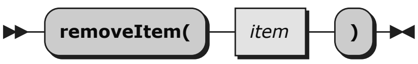
Makes the object *item* a member item of the collection and associates it with index *index*. The new item replaces any existing item associated with index *index*.

5.3.10.15. remove



Returns and removes from a collection the member item with index *index*. Returns **.nil** if no item has index *index*.

5.3.10.16. removeItem



Removes an item from the table. If the target item exists at more than one index, the first located item is removed. The return value is the removed item.

5.3.10.17. supplier

Returns a *Supplier* object for the collection. The supplier allows you iterate over the index/item pairs contained in the table at the time the supplier was created. The supplier iterates over the items in an unspecified order.

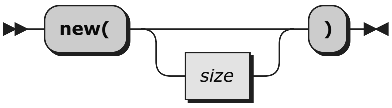
5.3.11. List Class

A **`List`** is a non-sparse sequenced collection similar to the *Array class* to which you can add new items at any position in the sequence. The List creates a new index value whenever an item is added to the List and the associated index value remains valid for that item regardless of other additions or removals. Only indexes the List object generates are valid, i.e. the List is never a sparse list and the List object will not modify indexes for items in the list.

Table 5.21. List Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ OrderedCollection (Mixin Class)		
Methods inherited from the *OrderedCollection class*		
append (Abstract Method)	*intersection*	*sortWith*
appendAll	*last (Abstract Method)*	*stableSort*
delete (Abstract Method)	*lastItem (Abstract Method)*	*stableSortWith*
difference	*next (Abstract Method)*	*subset*
first (Abstract Method)	*previous (Abstract Method)*	*union*
firstItem (Abstract Method)	*section (Abstract Method)*	*xor*
insert (Abstract Method)	*sort*	
List		
new (Class Method)		
of (Class Method)		
[]	*firstItem*	*makeArray*
[]=	*hasIndex*	*next*
allIndexes	*hasItem*	*previous*
allItems	*index*	*put*
append	*insert*	*remove*
at	*isEmpty*	*removeItem*
delete	*items*	*section*
empty	*last*	*supplier*
first	*lastItem*	

5.3.11.1. new (Class Method)

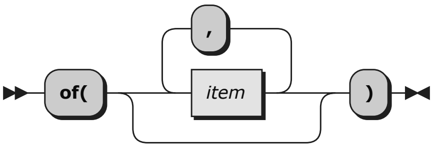


Returns a new empty List object.

If you specify *size*, a hint how large the new List object is expected to grow, this is used to optimize the initial allocation.

size must be a non-negative whole number.

5.3.11.2. of (Class Method)

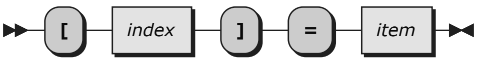


Returns a newly created list containing the specified *item* objects in the order specified.

5.3.11.3. []

Returns the item located at *index*. This method is the same as the *at* method.

5.3.11.4. []=



Replaces the item at *index* with *item*. This method is the same as the *put* method.

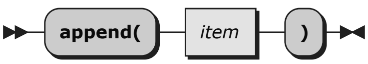
5.3.11.5. allIndexes

Returns an array of all indexes contained in the list in the same order they are used in the list.

5.3.11.6. allItems

Returns an array of all items contained in the list in list iteration order.

5.3.11.7. append

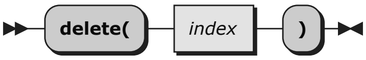


Appends *item* to the end of the list, returning the index associated with *item*.

5.3.11.8. at

Returns the item associated with index *index*. Returns **`.nil`** if the list has no item associated with *index*.

5.3.11.9. delete



Returns and deletes the member item with the specified *index* from the list. If there is no item with the specified *index*, **`.nil`** is returned and no item is deleted. All elements following the deleted item will be moved up in the list ordering, but the indexes associated with the moved items will not change. The size of the list will be reduced by one element. The `delete` method and the `remove` method produce the same result for the list class.

5.3.11.10. empty

Returns the receiving List with all items removed.

5.3.11.11. first

Returns the index of the first item in the list or **`.nil`** if the list is empty.

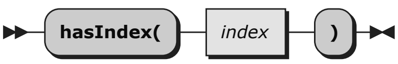
5.3.11.12. firstItem

Returns the first item in the list or **`.nil`** if the list is empty.

Example 5.200. List class — firstItem method

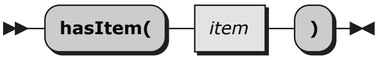
```
musketeers=.list~of("Porthos","Athos","Aramis") /* Creates list MUSKETEERS      */
item=musketeers~firstItem                       /* Gives first item in list     */
                                                /* (Assigns "Porthos" to item)  */
```

5.3.11.13. hasIndex



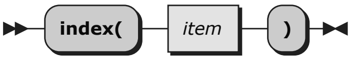
Returns **`.true`** if the list contains any item associated with index *index*, or **`.false`**.

5.3.11.14. hasItem



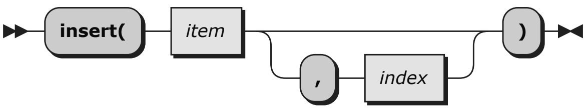
Returns **.true** if the list contains the *item* at any index position or otherwise returns **.false**. Item equality is determined by using the == method of *item*.

5.3.11.15. index



Returns the index of the specified item within the list. If the target item appears at more than one index, the first located index will be returned. Returns **.nil** if the list does not contain the specified item. Item equality is determined by using the == method of *item*.

5.3.11.16. insert



Returns a list-supplied index for item *item*, which is added to the list. The inserted item follows an existing item with index *index* in the list ordering. If *index* is **.nil**, *item* becomes the first item in the list. If you omit *index*, the *item* becomes the last item in the list.

Inserting an item in the list at position *index* will cause the items in the list after position *index* to have their relative positions shifted by the list object. The index values for any items in the list are not modified by the insertion.

Example 5.201. List class — insert method

```
musketeers=.list~of("Porthos","Athos","Aramis") /* Creates list MUSKETEERS        */
                                                /* consisting of: Porthos        */
                                                /*                Athos          */
                                                /*                Aramis         */
index=musketeers~first                    /* Gives index of first item      */
musketeers~insert("D'Artagnan",index) /* Adds D'Artagnan after Porthos  */
                                          /* List is now: Porthos           */
                                          /*              D'Artagnan   */
                                          /*              Athos             */
                                          /*              Aramis            */
/* Alternately, you could use */
musketeers~insert("D'Artagnan",.nil) /* Adds D'Artagnan before Porthos */
                                          /* List is now:  D'Artagnan  */
                                          /*               Porthos          */
                                          /*               Athos            */
                                          /*               Aramis           */
/* Alternately, you could use */
musketeers~insert("D'Artagnan")      /* Adds D'Artagnan after Aramis   */
                                          /* List is now:  Porthos          */
                                          /*               Athos            */
                                          /*               Aramis           */
                                          /*               D'Artagnan  */
```

5.3.11.17. isEmpty

Returns **`.true`** if the list is empty. Returns **`.false`** otherwise.

5.3.11.18. items

Returns the number of items in the list.

5.3.11.19. last

Returns the index of the last item in the list or **`.nil`** if the list is empty.

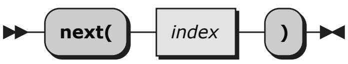
5.3.11.20. lastItem

Returns the last item in the list or **`.nil`** if the list is empty.

5.3.11.21. makeArray

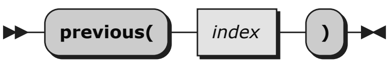
Returns a single-dimensional Array containing the list collection items. The array indexes range from **`1`** to the number of items. The order in which the collection items appear in the array is the same as their sequence in the list collection.

5.3.11.22. next



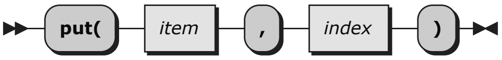
Returns the index of the item that follows the list item having index *index*. Returns **`.nil`** if *index* is the end of the list.

5.3.11.23. previous



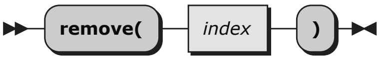
Returns the index of the item that precedes the list item having index *index*. Returns **`.nil`** if *index* is the beginning of the list.

5.3.11.24. put



Replaces any existing item associated with the specified *index* with the *item*. If *index* does not exist in the list, an error is raised.

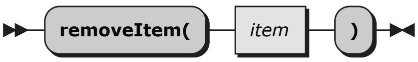
5.3.11.25. remove



Returns and removes from a collection the member item with index *index*. If no item has index *index*, this method returns `.nil` and removes no item.

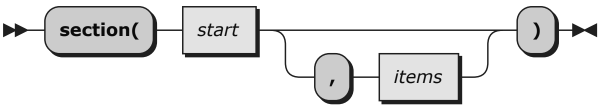
Removing an item from the list at position *index* will shift the relative position of items after position *index*. The index values assigned to those items will not change.

5.3.11.26. removeItem



Removes an item from the list. If the target item exists at more than one index, the first located item is removed. The return value is the removed item. Item equality is determined by using the == method of *item*.

5.3.11.27. section



Returns a new list (of the same class as the receiver) containing selected items from the receiver list. The first item in the new list is the item corresponding to index *start* in the receiver list. Subsequent items in the new list correspond to those in the receiver list (in the same sequence). If you specify the whole number *items*, the new list contains only this number of items (or the number of subsequent items in the receiver list, if this is less than *items*). If you do not specify *items*, the new list contains all subsequent items from the receiver list. The receiver list remains unchanged.

5.3.11.28. supplier

Returns a *Supplier* object for the list. The supplier allows you to iterate over the index/item pairs stored in the list at the time the supplier is created. The iteration is in the same order as the list sequence order.

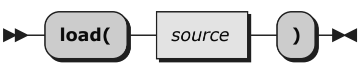
5.3.12. Properties Class

A **`Properties`** object is a collection with unique indexes that are character strings representing names and items that are also restricted to character string values. Properties objects are useful for processing bundles of application option values.

Table 5.22. Properties Class

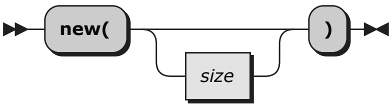
Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ MapCollection (Mixin Class)		
Methods inherited from the *MapCollection class*		
of (Class Method)		
makeArray		
putAll		
Directory		
Methods inherited from the *Directory class*		
new (Class Method)		
[]	*hasIndex*	*removeEntry*
[]=	*hasItem*	*removeItem*
allIndexes	*index*	*setEntry*
allItems	*isEmpty*	*setMethod*
at	*items*	*supplier*
empty	*makeArray*	*unknown*
entry	*put*	*unsetMethod*
hasEntry	*remove*	
Properties		
load (Class method)		
[]=	*load*	*setProperty*
getLogical	*put*	*setWhole*
getProperty	*save*	
getWhole	*setLogical*	

5.3.12.1. load (Class method)



Loads a set of properties from *source* and returns them as a new Properties object. The load *source* can be either the string name of a file, a File object, or a Stream object. Properties are read from *source* as individual lines using *lineIn*. Blank lines and lines with a Rexx line comment ("--") as the first non-blank characters are ignored. Otherwise, the lines are assumed to be of the form "name=value" and are added to the receiver Properties value using name as the index for the value.

5.3.12.2. new (Class method)

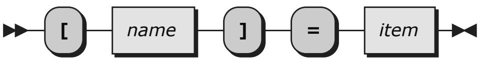


Returns an empty Properties object.

If you specify *size*, a hint how large the new Properties object is expected to grow, this is used to optimize the initial allocation.

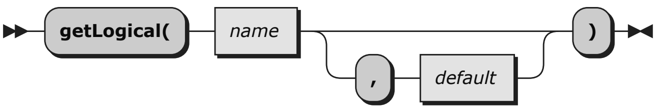
size must be a non-negative whole number.

5.3.12.3. []=



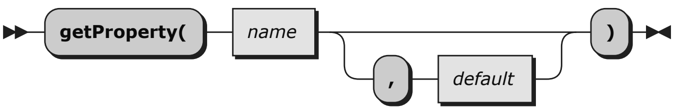
Adds *item* using the index *index*. This method is the same as the *put* method.

5.3.12.4. getLogical



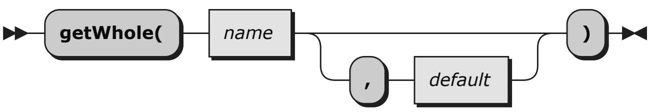
Returns the value of *name* as either `.true` or `.false`. The raw value of the *name* may be either the numeric values "0" or "1" or the string values "true" or "false". Any other value will raise a syntax error. If the property *name* does not exist and *default* has been specified, the default value will be returned. If *default* has not been specified, a syntax error is raised for missing values.

5.3.12.5. getProperty



Returns the value of *name*. If property *name* does not exist and *default* has been specified, the default value will be returned. If *default* has not been specified, `.nil` is returned.

5.3.12.6. getWhole



Returns the value of *name*, validated as being a Rexx whole number. If property *name* does not exist and *default* has been specified, the default value will be returned. If *default* has not been specified, a syntax error is raised for missing values.

5.3.12.7. load

```
>>-load(--source--)-><
```

Loads a set of properties into the receiving Properties object from *source*. The load *source* can be either the string name of a file, a File object, or a Stream object. Properties are read from the source as individual lines using *lineIn*. Blank lines and lines with a Rexx line comment ("--") as the first non-blank characters are ignored. Otherwise, the lines are assumed to be of the form "name=value" and are added to the receiver Properties value using name as the index for the value.

Properties loaded from *source* that have the same names as existing items will replace the current entries.

5.3.12.8. put

```
>>-put(--item--,--name--)-><
```

Makes the object *item* a member item of the collection and associates it with index *name*. The item value must be a character string. The new item replaces any existing item or method associated with index *name*.

5.3.12.9. save

```
>>-save(--target--)-><
```

Saves a set of properties into *target*. The save *target* can be either the string name of a file, a File object, or a Stream object. Properties are stored as individual lines using *lineOut*. The lines are written in the form "name=value". A saved Properties file can be reloaded using the Properties *load* method.

5.3.12.10. setLogical

```
>>-setLogical(--name--,--value--)-><
```

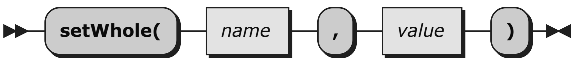
Sets a logical value in the property bundle. The *value* argument must be either the numbers "0" or "1", or the logical values `.true` or `.false`. The property value will be added with *value* converted in to the appropriate "true" or "false" string value.

5.3.12.11. setProperty

```
>>-setProperty(--name--,--value--)-><
```

Sets a named property in the property bundle. The *value* argument must be a character string value.

5.3.12.12. setWhole



Sets a whole number value in the property bundle. The *value* argument must be a valid Rexx whole number.

5.3.13. Queue Class

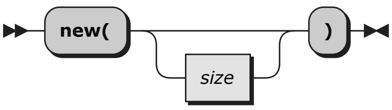
A **Queue** is a non-sparse sequenced collection with whole-number indexes. The indexes specify the position of an item relative to the head (first item) of the queue. Adding or removing an item changes the association of an index to its queue item. You can add items at either the tail or the head of the queue.

Table 5.23. Queue Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ OrderedCollection (Mixin Class)		
Methods inherited from the *OrderedCollection class*		
append (Abstract Method)	*intersection*	*sortWith*
appendAll	*last (Abstract Method)*	*stableSort*
delete (Abstract Method)	*lastItem (Abstract Method)*	*stableSortWith*
difference	*next (Abstract Method)*	*subset*
first (Abstract Method)	*previous (Abstract Method)*	*union*
firstItem (Abstract Method)	*section (Abstract Method)*	*xor*
insert (Abstract Method)	*sort*	
Queue		
new (Class Method)		
of (Class Method)		
[]	*hasItem*	*pull*
[]=	*index*	*push*
allIndexes	*insert*	*put*
allItems	*isEmpty*	*queue*
append	*items*	*remove*
at	*last*	*removeItem*
delete	*lastItem*	*section*
empty	*makeArray*	*size*
first	*next*	*supplier*
firstItem	*peek*	

hasIndex	*previous*

5.3.13.1. new (Class Method)

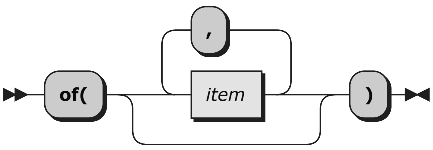


Returns a new empty Queue object.

If you specify *size*, a hint how large the new Queue object is expected to grow, this is used to optimize the initial allocation.

size must be a non-negative whole number.

5.3.13.2. of (Class Method)

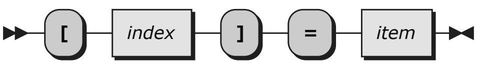


Returns a newly created queue containing the specified *item* objects in the order specified.

5.3.13.3. []

Returns the item located at index *index*. This method is the same as the *at* method.

5.3.13.4. []=



Replaces item at *index* with *item*. This method is the same as the *put* method.

5.3.13.5. allIndexes

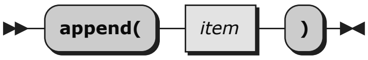
Returns an array of all index values for the queue.

For the Queue class, the indices are integers from **1** to *items*.

5.3.13.6. allItems

Returns an array of all items contained in the queue, in queue order.

5.3.13.7. append

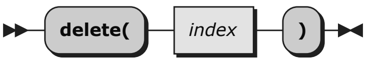


Appends *item* to the end of the queue, returning the index of the inserted item.

5.3.13.8. at

Returns the item associated with index *index*. Returns **`.nil`** if the Queue has no item associated with *index*.

5.3.13.9. delete



Returns and deletes the member item with the specified *index* from the queue. If there is no item with the specified *index*, **`.nil`** is returned and no item is deleted. All elements following the deleted item will be moved up in the queue ordering and the item indexes will be adjusted for the deletion. The size of the queue will be reduced by one element. The `delete` method and the `remove` method produce the same result for the queue class.

Example 5.202. Queue class — delete method

```
a = .queue~of("Fred", "Mike", "Rick", "David")
a~delete(2)   -- removes "Mike", resulting in the queue
              -- ("Fred", "Rick", "David")
```

5.3.13.10. empty

Returns the receiving Queue with all items removed.

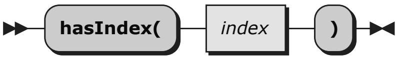
5.3.13.11. first

Returns the index of the first item in the queue or **`.nil`** if the queue is empty. The index will always be 1 for non-empty queues.

5.3.13.12. firstItem

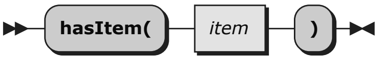
Returns the first item in the queue or **`.nil`** if the queue is empty.

5.3.13.13. hasIndex



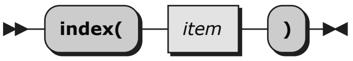
Returns **.true** if the queue contains any item associated with index *index*, or **.false**.

5.3.13.14. hasItem



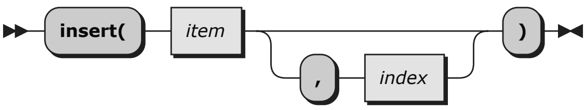
Returns **.true** if the queue contains the *item* at any index position or otherwise returns **.false**. Item equality is determined by using the == method of *item*.

5.3.13.15. index



Returns the index of the specified item within the queue. If the target item appears at more than one index, the first located index will be returned. Returns **.nil** if the queue does not contain the specified item. Item equality is determined by using the == method of *item*.

5.3.13.16. insert



Returns a queue-supplied index for *item*, which is added to the queue. The inserted item follows any existing item with index *index* in the queue ordering. If *index* is **.nil**, *item* is inserted at the head of the queue. If you omit *index*, *item* becomes the last item in the queue.

Inserting an item in the queue at position *index* will cause the items in the queue after position *index* to have their indexes modified by the queue object.

Example 5.203. Queue class — insert method

```
musketeers=.queue~of("Porthos","Athos","Aramis) /* Creates queue MUSKETEERS       */
                                                /* consisting of: Porthos         */
                                                /*                Athos           */
                                                /*                Aramis          */
index=musketeers~first                     /* Gives index of first item      */
musketeers~insert("D'Artagnan",index) /* Adds D'Artagnan after Porthos  */
                                     /* List is now: Porthos           */
                                     /*              D'Artagnan   */
                                     /*              Athos             */
                                     /*              Aramis            */
/* Alternately, you could use */
musketeers~insert("D'Artagnan",.nil)  /* Adds D'Artagnan before Porthos */
                                     /* List is now:  D'Artagnan  */
                                     /*               Porthos          */
                                     /*               Athos            */
                                     /*               Aramis           */
/* Alternately, you could use */
musketeers~insert("D'Artagnan")       /* Adds D'Artagnan after Aramis   */
                                     /* List is now:  Porthos          */
```

```
                                  /*              Athos            */
                                  /*              Aramis           */
                                  /*              D'Artagnan   */
```

5.3.13.17. isEmpty

Returns `.true` if the queue is empty. Returns `.false` otherwise.

5.3.13.18. items

Returns the number of items in the queue.

See also method *size* , which is a synonym for `items`.

5.3.13.19. last

Returns the index of the last item in the queue or `.nil` if the queue is empty.

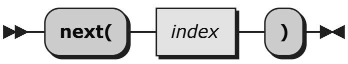
5.3.13.20. lastItem

Returns the last item in the queue or `.nil` if the queue is empty.

5.3.13.21. makeArray

Returns a single-dimensional Array containing the receiver queue items. The array indexes range from `1` to the number of items. The order in which the queue items appear in the array is the same as their queuing order, with the head of the queue as index 1.

5.3.13.22. next

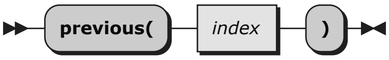


Returns the index of the item that follows the queue item having index *index* or returns `.nil` if the item having that index is last in the queue.

5.3.13.23. peek

Returns the item at the head of the queue. Returns `.nil` if the queue is empty. The collection remains unchanged.

5.3.13.24. previous

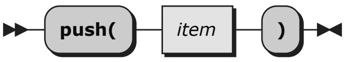


Returns the index of the item that precedes the queue item having index *index* or `.nil` if the item having that index is first in the queue.

5.3.13.25. pull

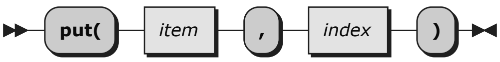
Returns and removes the item at the head of the queue. Returns `.nil` if the queue is empty.

5.3.13.26. push



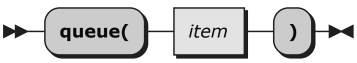
Adds the object *item* to the head of the queue.

5.3.13.27. put



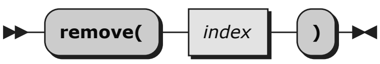
Replaces any existing item associated with the specified *index* with the new item. If the *index* does not exist in the queue, an error is raised.

5.3.13.28. queue



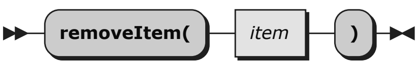
Adds the object *item* to the tail of the queue.

5.3.13.29. remove



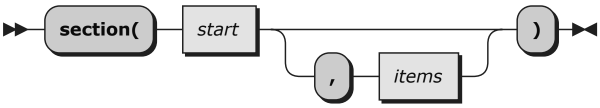
Returns and removes from a collection the member item with index *index*. Returns `.nil` if no item has index *index*.

5.3.13.30. removeItem



Removes an item from the queue. If the target item exists at more than one index, the first located item is removed. The return value is the removed item. Item equality is determined by using the == method of *item*.

5.3.13.31. section



Returns a new queue (of the same class as the receiver) containing selected items from the receiver. The first item in the new queue is the item corresponding to index *start* in the receiver. Subsequent items in the new queue correspond to those in the receiver (in the same sequence). If you specify the whole number *items*, the new queue contains only this number of items (or the number of subsequent items in the receiver, if this is less than *items*). If you do not specify *items*, the new queue contains all subsequent items from the receiver. The receiver queue remains unchanged.

5.3.13.32. size

Returns the size, which is the number of items in the queue.

See also method *items* for which this method is a synonym.

5.3.13.33. supplier

Returns a *Supplier* object for the queue. The supplier allows you to iterate over the index/item pair contained in the queue at the time the supplier was created. The supplier iterates the items in their queuing order, with the head of the queue first.

5.3.14. Relation Class

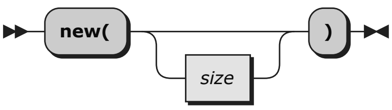
A **`Relation`** is a collection with indexes that can be any object. In a Relation, each item is associated with a single index, but there can be more than one item with the same index (unlike a *Table*, which can contain only one item for any index).

Table 5.24. Relation Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*

allItems (Abstract Method) *at (Abstract Method)* *difference* *disjoint*	*index (Abstract Method)* *intersection* *items* *makeArray*	*union* *xor*
+ MapCollection (Mixin Class)		
Methods inherited from the *MapCollection class* *of (Class Method)* *makeArray* *putAll*		
Relation		
new (Class Method)		
[] *[]=* *allAt* *allIndex* *allIndexes* *allItems* *at* *difference* *empty*	*hasIndex* *hasItem* *index* *intersection* *isEmpty* *items* *makeArray* *put* *remove*	*removeAll* *removeItem* *subset* *supplier* *union* *uniqueIndexes* *xor*

5.3.14.1. new (Class Method)



Returns an empty Relation object.

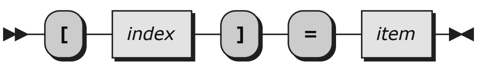
If you specify *size*, a hint how large the new Relation object is expected to grow, this is used to optimize the initial allocation.

size must be a non-negative whole number.

5.3.14.2. []

Returns an item associated with *index*. This method is the same as the *at* method.

5.3.14.3. []=



Adds *item* to the relation associated with index *index*. This method is the same as the *put* method.

5.3.14.4. allAt

```
>>-allAt(--index--)--><
```

Returns a single-dimensional Array containing all the items associated with index *index*. Items in the array appear in an unspecified order. Index equality is determined by using the == method of *index*.

5.3.14.5. allIndex

```
>>-allIndex(--item--)--><
```

Returns a single-dimensional Array containing all indexes for item *item*, in an unspecified order. Item equality is determined by using the == method of *item*.

5.3.14.6. allIndexes

```
>>-allIndexes--><
```

Returns an array of all indexes contained in the Relation. The returned array will have one index for every item stored in the relation, including duplicates. To retrieve the indexes without duplicates, use the *uniqueIndexes* method.

5.3.14.7. allItems

```
>>-allItems--><
```

Returns an array of all items contained in the relation.

5.3.14.8. at

```
>>-at(--index--)--><
```

Returns the item associated with index *index*. If the relation contains more than one item associated with index *index*, the item returned is unspecified. (The program should not rely on any particular item being returned.) Returns **`.nil`** if the relation has no item associated with index *index*. Index equality is determined by using the == method of *index*.

5.3.14.9. difference

```
>>-difference(--argument--)--><
```

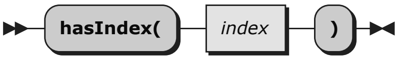
Returns a new Relation containing only those items that the *argument* collection does not contain (with the same associated index). The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.14.10. empty

```
>>-empty--><
```

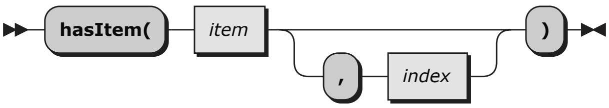
Returns the receiving Relation with all items removed.

5.3.14.11. hasIndex



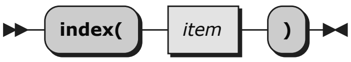
Returns `.true` if the Relation contains any item associated with index *index*, or `.false`. Index equality is determined by using the == method of *index*.

5.3.14.12. hasItem



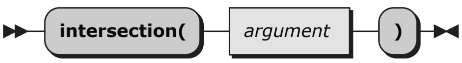
Returns `.true` if the relation contains the member item *item*, `.false`. If *index* is specified, `hasItem` will only return `.true` if the relation contains the pairing of *item* associated with index *index*. Item and index equality is determined by using the == method.

5.3.14.13. index



Returns the index for item *item*. If there is more than one index associated with item *item*, the one returned is not defined. Item equality is determined by using the == method of *item*.

5.3.14.14. intersection

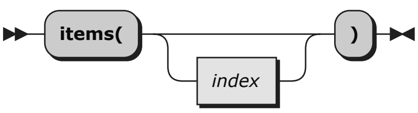


Returns a new collection (of the same class as the receiver) containing only those items that are in both the receiver collection and the *argument* collection with the same associated index. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.14.15. isEmpty

Returns `.true` if the relation is empty. Returns `.false` otherwise.

5.3.14.16. items

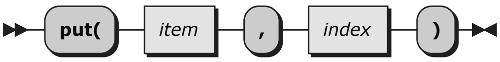


Returns the number of relation items with index *index*. If you specify no *index*, this method returns the total number of items associated with all indexes in the relation. Index equality is determined by using the == method of *index*.

5.3.14.17. makeArray

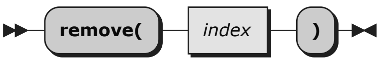
Returns a single-dimensional Array containing the index objects. The collection items appear in the array in an unspecified order.

5.3.14.18. put



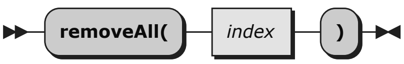
Makes the object *item* a member item of the relation and associates it with index *index*. If the relation already contains any items with index *index*, this method adds a new member item *item* with the same index, without removing any existing member items.

5.3.14.19. remove



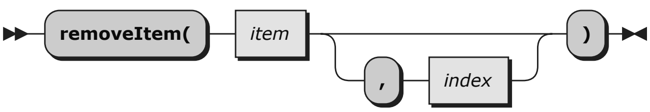
Returns and removes from a relation the member item with index *index*. If the relation contains more than one item associated with index *index*, the item returned and removed is unspecified. Returns **`.nil`** if no item has index *index*. Index equality is determined by using the == method of *index*.

5.3.14.20. removeAll



Returns and removes from a relation all member items with index *index*. All removed items are returned in an array containing each of the removed items. The order of the returned items is unspecified. If no items have the specified index, an empty array is returned. Index equality is determined by using the == method of *index*.

5.3.14.21. removeItem

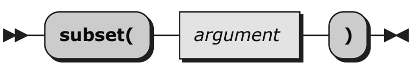


If *index* is not specified, returns and removes from a relation the member item *item*. If the relation contains *item* associated with more than one index, the item returned and removed is unspecified.

If *index* is specified, returns and removes the member item *item* associated with index *index*. If *item* is the only member with *index*, then the *index* is also removed from the Relation.

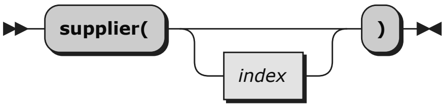
Returns **`.nil`** if *item* is not a member item (associated with index *index*, if specified).

5.3.14.22. subset



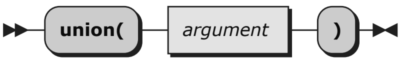
Returns `.true` if all items in the receiver Relation are also contained in the *argument* collection with the same associated index; returns `.false` otherwise. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.14.23. supplier



Returns a *Supplier* object for the relation. The supplier allows you to iterate over all index/item pairs in the relation at the time the supplier was created. The supplier enumerates the items in an unspecified order. If you specify *index*, the supplier contains all of the items with the specified index.

5.3.14.24. union

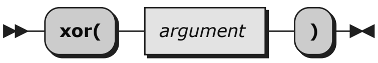


Returns a new collection containing all items from the receiver collection and the *argument* collection. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.14.25. uniqueIndexes

Returns an array of all indexes contained in the Relation, with no duplicates.

5.3.14.26. xor



Returns a new collection of the same class as the receiver that contains all items from the receiver collection and the *argument* collection. All index-item pairs that appear in both collections are removed. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method.

5.3.14.27. Examples

Example 5.204. Relation class — examples

```
/* Use a relation to express parent-child relationships */
family = .relation~new
family["Henry"] = "Peter"    /* Peter is Henry's child   */
family["Peter"] = "Bridget"  /* Bridget is Peter's child */
family["Henry"] = "Jane"     /* Jane is Henry's child    */

/* Show all children of Henry recorded in the family relation */
henrys_kids = family~allAt("Henry")
Say "Here are all the listed children of Henry:"
Do kid Over henrys_kids
```

```
  Say " "kid
End

/* Show all parents of Bridget recorded in the family relation */
bridgets_parents = family~allIndex("Bridget")
Say "Here are all the listed parents of Bridget:"
Do parent Over bridgets_parents
  Say " "parent
End

/* Display all the grandparent relationships we know about. */
checked_for_grandkids = .set~new         /* Records those we have checked      */
Do grandparent Over family               /* Iterate for each index in family   */
  If checked_for_grandkids~hasIndex(grandparent)
    Then Iterate                         /* Already checked this one           */
  kids = family~allat(grandparent)       /* Current grandparent's children     */
  Do kid Over kids                       /* Iterate for each item in kids      */
    grandkids = family~allAt(kid)        /* Current kid's children             */
    Do grandkid Over grandkids           /* Iterate for each item in grandkids */
      Say grandparent "has a grandchild named" grandkid"."
    End
  End
  checked_for_grandkids~put(grandparent) /* Add to already-checked set         */
End
```

5.3.15. Set Class

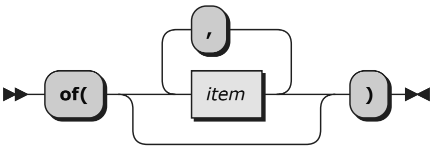
A **Set** is a collection containing member items where the index is the same as the item (similar to a *Bag* collection). Any object can be placed in a Set. There can be only one occurrence of any object in a Set (unlike a **Bag** collection). Item equality is determined by using the == method.

Table 5.25. Set Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ SetCollection (Mixin Class)
Methods inherited from the *SetCollection class* (no class or instance methods)
+ Collection (Mixin Class)
Methods inherited from the *Collection class* *[] (Abstract Method)* *[]= (Abstract Method)* *allIndexes (Abstract Method)* *allItems (Abstract Method)* *at (Abstract Method)* *difference* *disjoint* *equivalent* *hasIndex* *hasItem* *index (Abstract Method)* *intersection* *items* *makeArray* *put (Abstract Method)* *subset* *supplier* *union* *xor*
+ MapCollection (Mixin Class)
Methods inherited from the *MapCollection class* *of (Class Method)* *makeArray* *putAll*

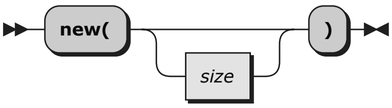
Set		
new (Class Method)		
of (Class Method)		
[]	*hasItem*	*putAll*
[]=	*index*	*remove*
allIndexes	*intersection*	*removeItem*
allItems	*isEmpty*	*subset*
at	*items*	*supplier*
empty	*makeArray*	*union*
hasIndex	*put*	*xor*

5.3.15.1. of (Class Method)



Returns a newly created set containing the specified *item* objects.

5.3.15.2. new (Class Method)



Returns an empty Set object.

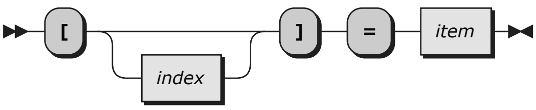
If you specify *size*, a hint how large the new Set object is expected to grow, this is used to optimize the initial allocation.

size must be a non-negative whole number.

5.3.15.3. []

Returns the item associated with *index*. This method is the same as the *at* method.

5.3.15.4. []=



Adds an item to the Set. If specified, *index* must be the same object as *item*.

This method is the same as the *put* method.

5.3.15.5. allIndexes

Returns an array of all indexes contained in the set.

5.3.15.6. allItems

Returns an array of all items contained in the set.

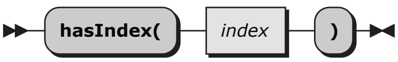
5.3.15.7. at

Returns the item associated with index *index*. Returns `.nil` if the Set has no item associated with *index*.

5.3.15.8. empty

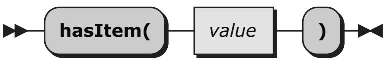
Returns the receiving Set with all items removed.

5.3.15.9. hasIndex



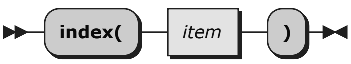
Returns `.true` if the Relation contains any item associated with index *index*, or `.false`.

5.3.15.10. hasItem



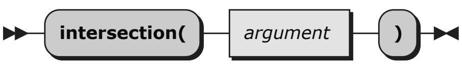
Returns `.true` if the Relation contains the specified item at any index location. Returns `.false` otherwise.

5.3.15.11. index



Returns the index of the specified item within the set. If the target item appears at more than one index, the first located index will be returned. Returns `.nil` if the set does not contain the specified item. Item equality is determined by using the == method of *item*.

5.3.15.12. intersection



Returns a new collection (of the same class as the receiver) containing only those items from the receiver whose indexes are in both the receiver collection and the *argument* collection. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.15.13. isEmpty

Returns **`.true`** if the set is empty. Returns **`.false`** otherwise.

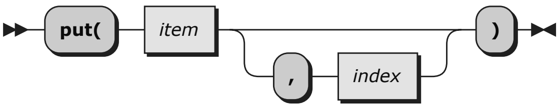
5.3.15.14. items

Returns the number of items in the collection.

5.3.15.15. makeArray

Returns a single-dimensional Array containing the index objects. The array indexes range from **`1`** to the number of items. The collection items appear in the array in an unspecified order.

5.3.15.16. put

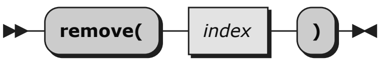


Adds *item* to the Set. If there is an equivalent item in the Set, the exiting item will be replaced by the new instance. Item equality is determined by using the == method of *item*. If *index* is specified, it must be the same as *item*.

5.3.15.17. putAll

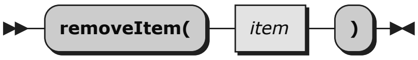
Returns the receiving Set with all items in *collection* added to it. The *collection* argument can be any object that supports a `supplier` method. Items from *collection* are added using the item values returned by the supplier. If duplicate items exist in *collection*, the last item provided by the supplier will overwrite previous items with the same index.

5.3.15.18. remove



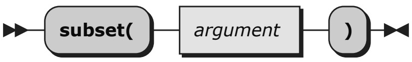
Returns and removes the set item with index *index*. Returns **`.nil`** if no item has index *index*.

5.3.15.19. removeItem



Removes an item from the set. If the target item exists at more than one index, the first located item is removed. The return value is the removed item. Item equality is determined by using the == method of *item*.

5.3.15.20. subset

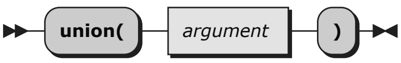


Returns **`.true`** if all items in the receiver collection are also contained in the *argument* collection; returns **`.false`** otherwise. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.15.21. supplier

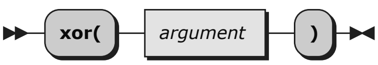
Returns a *Supplier* object for the collection. The supplier allows you iterate over the index/item pairs contained in the table at the time the supplier was created. The supplier iterates over the items in an unspecified order.

5.3.15.22. union



Returns a new Set contains all the items from the receiver collection and selected items from the *argument* collection. This method includes an item from *argument* in the new collection only if there is no item already in the in the receiver collection and the method has not already included a matching item. The order in which this method selects items in *argument* is unspecified. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.15.23. xor



Returns a new Set that contains all items from the receiver collection and the *argument* collection; all items that appear in both collections are removed. The *argument* can be a **`Collection`** object or any other object that supports a `makeArray` method. The *argument* must also allow all of the index values in the receiver collection.

5.3.16. Stem Class

A **`Stem`** object is a collection with unique indexes that are character strings.

Table 5.26. Stem Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ MapCollection (Mixin Class)		
Methods inherited from the *MapCollection class*		
of (Class Method)		
makeArray		
putAll		
Stem		
new (Class Method)		
[]	*hasItem*	*removeItem*
[]=	*index*	*request*
allIndexes	*isEmpty*	*supplier*
allItems	*items*	*toDirectory*
at	*makeArray*	*unknown*
empty	*put*	
hasIndex	*remove*	

Stems are automatically created whenever a Rexx stem variable or Rexx compound variable is used. For example:

Example 5.205. Stem class — examples

```
a.1 = 2
```

creates a new stem collection with the name **A.** and assigns it to the Rexx variable **A.**; it also assigns the value 2 to entry 1 in the collection.

The value of an uninitialized stem index is the stem object NAME concatenated with the derived stem index.

Example 5.206. Stem class — examples

```
say a.[1,2]  -- implicitly creates stem object with name "A."
-- displays "A.1.2"

a = .stem~new("B.")
```

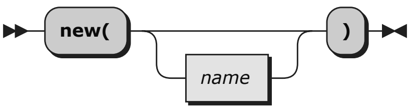
```
say a[1,2]     -- displays "B.1.2"
```

In addition to the items explicitly assigned to the collection indexes, a value may be assigned to all possible stem indexes. The `[]=` method (with no index argument) will assign the target value to all possible stem indexes. Following assignment, a reference to any index will return the new value until another value is assigned or the index is dropped.

The `[]` method (with no index specified) will retrieve any globally assigned value. By default, this returns the stem NAME value.

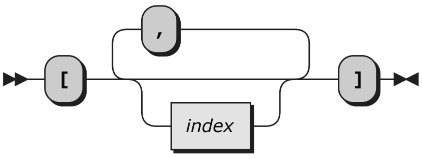
In addition to the methods defined in the following, the Stem class removes the methods =, ==, \=, \==, <>, and >< using the DEFINE method.

5.3.16.1. new (Class Method)



Returns a new stem object. If you specify a string *name*, this value is used to create the derived name of compound variables. The default stem name is a null string ("").

5.3.16.2. []



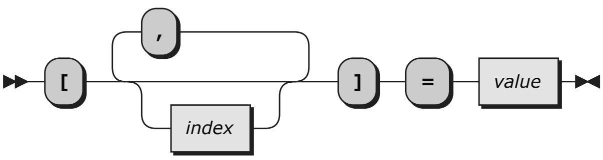
Returns the item associated with the specified *index*es. Each *index* is an expression; use commas to separate the expressions. The Stem object concatenates the *index* string values, separating them with a period (.), to create a derived index. A null string ("") is used for any omitted expressions. The resulting string is the index of the target stem item. If the stem has no item associated with the specified final *index*, the stem default value is returned. If a default value has not been set, the stem name concatenated with the final index string is returned.

If you do not specify *index*, the stem default value is returned. If no default value has been assigned, the stem name is returned.

Note

You cannot use the `[]` method in a DROP or PROCEDURE instruction.

5.3.16.3. []=



Makes *value* a member item of the stem collection and associates it with the specified index. The final index is derived by concatenation of each of the *index* arguments together with a "." separator. If you specify no *index* arguments, a new default stem value is assigned. Assigning a new default value will re-initialize the stem and remove all existing assigned indexes.

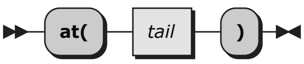
5.3.16.4. allIndexes

Returns an array of all the stem tail names used in the stem.

5.3.16.5. allItems

Returns an array of all items contained in the stem.

5.3.16.6. at

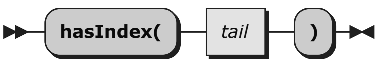


Returns the item associated with the specified *tail*. `.nil` is returned if the stem has no item associated with the specified *tail*.

5.3.16.7. empty

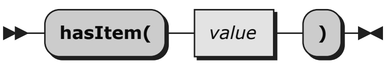
Returns the receiving Stem object with all items removed.

5.3.16.8. hasIndex



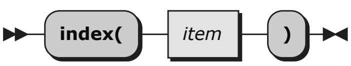
Returns `.true` if the Stem contains any item associated with a stem tail *tail*, or `.false`.

5.3.16.9. hasItem



Returns `.true` if the Stem contains the *value* at any tail position or otherwise returns `.false`. Item equality is determined by using the == method of *item*.

5.3.16.10. index



Returns the index of the specified item within the stem. Returns **`.nil`** if the stem does not contain the specified item. Item equality is determined by using the == method of *item*.

5.3.16.11. isEmpty

Returns **`.true`** if the stem is empty. Returns **`.false`** otherwise.

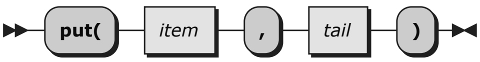
5.3.16.12. items

Returns the number of items in the collection.

5.3.16.13. makeArray

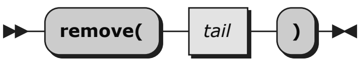
Returns an array of all stem indexes that currently have an associated value. The items appear in the array in an unspecified order.

5.3.16.14. put



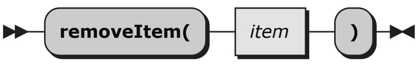
Replaces any existing item associated with the specified *tail* with the new item *item*.

5.3.16.15. remove



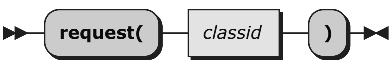
Returns and removes from the stem the member item with index *tail*. Returns **`.nil`** if no item has index *tail*.

5.3.16.16. removeItem



Removes an item from the stem. If the target item exists at more than one tail, the first located item is removed. Item equality is determined by using the == method of *item*. The return value is the removed item.

5.3.16.17. request



This method requests conversion to a specific class. All conversion requests except Array are forwarded to the stem's current stem default value. Returns the result of the Stem class `makeArray` method, if the requested class is Array. For all other classes, `request` forwards the message to the stem object's default value.

5.3.16.18. supplier

```
>>-supplier-><
```

Returns a *Supplier* object for the stem. The supplier allows you to iterate though the index/item pairs contained in the Stem object at the time the supplier was created. The supplier iterates the items in an unspecified order.

5.3.16.19. toDirectory

```
>>-toDirectory-><
```

Returns a *Directory* object for the stem. The directory will contain a name/value pair for each stem index with a directly assigned value.

5.3.16.20. unknown

```
>>-unknown(-messagename-,-messageargs-)-><
```

Reissues or forwards all unknown messages to the stem's current default value. For additional information, see *Section 4.2.6, “Defining an UNKNOWN Method”*.

5.3.17. StringTable Class

A **`StringTable`** is a *MapCollection* using unique character string indexes. The items of a StringTable can be any valid Rexx object.

See also *Directory Class*, a **`MapCollection`** similar to **`StringTable`**, but with additional methods `setMethod` and `unsetMethod`.

Table 5.27. StringTable Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	

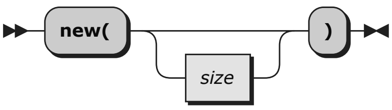
disjoint	*makeArray*	
+ MapCollection (Mixin Class)		
Methods inherited from the *MapCollection class* *of (Class Method)* *makeArray* *putAll*		
StringTable		
new (Class Method)		
[] *[]=* *allIndexes* *allItems* *at* *empty* *entry*	*hasEntry* *hasIndex* *hasItem* *index* *isEmpty* *items* *makeArray*	*put* *remove* *removeEntry* *removeItem* *setEntry* *supplier* *unknown*

In addition to the standard `put`, `[]=`, `at`, and `[]` methods defined for Collections, StringTable provides access to items using methods. For example:

```
sTable = .StringTable~new
sTable~name = "Mike"    -- same as sTable~put("Mike", "NAME")
say sTable~name         -- same as say sTable["NAME"]
```

Note that **`StringTable`** does not provide methods `setMethod` and `unsetMethod` as the *Directory* class does.

5.3.17.1. new (Class Method)

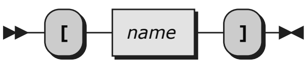


Returns an empty StringTable object.

If you specify *size*, a hint how large the new StringTable object is expected to grow, this is used to optimize the initial allocation.

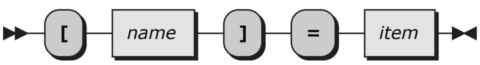
size must be a non-negative whole number.

5.3.17.2. []



Returns the item corresponding to *name*. This method is the same as the *at* method.

5.3.17.3. []=



Adds or replaces the entry at index *name*. This method is the same as the *put* method.

5.3.17.4. allIndexes

Returns an array of all the StringTable indexes.

5.3.17.5. allItems

Returns an array of all items contained in the StringTable.

5.3.17.6. at

Returns the item associated with index *name*. If the StringTable has no item associated with index *name*, **`.nil`** is returned.

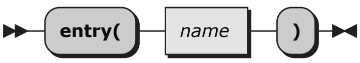
Example 5.207. StringTable class — at method

```
say .environment~at("OBJECT")   /* Produces: "The Object class" */
```

5.3.17.7. empty

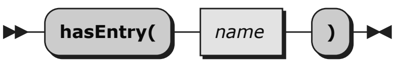
Returns the receiving StringTable with all items removed.

5.3.17.8. entry



Returns the StringTable entry with index *name* (translated to uppercase). If there is no entry for *name*, **`.nil`** is returned.

5.3.17.9. hasEntry



Returns **`.true`** if the StringTable has an entry for index *name* (translated to uppercase), or **`.false`**.

5.3.17.10. hasIndex

```
>>-hasIndex(-name-)-><
```

Returns **.true** if the StringTable contains any item associated with index *name*, or **.false**.

5.3.17.11. hasItem

```
>>-hasItem(-item-)-><
```

Returns **.true** if the StringTable contains the *item* at any index position or otherwise returns **.false**. Item equality is determined by using the == method of *item*.

5.3.17.12. index

```
>>-index(-item-)-><
```

Returns the index of the specified item within the StringTable. If the target item appears at more than one index, the first located index will be returned. If the StringTable does not contain the specified item, **.nil** is returned. Item equality is determined by using the == method of *item*.

5.3.17.13. isEmpty

```
>>-isEmpty-><
```

Returns **.true** if the StringTable is empty. Returns **.false** otherwise.

5.3.17.14. items

```
>>-items-><
```

Returns the number of items in the collection.

5.3.17.15. makeArray

```
>>-makeArray-><
```

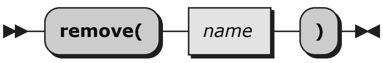
Returns a single-dimensional Array containing the index objects. The array indexes range from **1** to the number of items. The collection items appear in the array in an unspecified order. (The program should not rely on any order.)

5.3.17.16. put

```
>>-put(-item-,-name-)-><
```

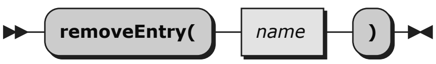
Makes the object *item* a member item of the collection and associates it with index *name*. The new item replaces any existing item or method associated with index *name*.

5.3.17.17. remove



Removes and returns the member item with index *name* from the StringTable. If there is no item with index *name*, **`.nil`** is returned.

5.3.17.18. removeEntry

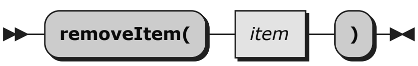


Removes and returns the member item with index *name* (translated to uppercase) from the StringTable. If there is no item with index *name*, **`.nil`** is returned.

See also

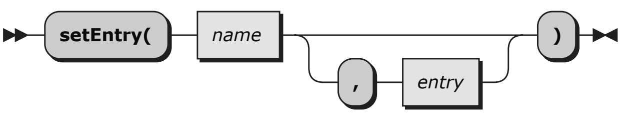
- method *setEntry*,
- method *hasEntry*, and
- method *entry*.

5.3.17.19. removeItem



Removes an item from the StringTable. If the target item exists at more than one index, the first located item is removed. The return value is the removed item. Item equality is determined by using the == method of *item*.

5.3.17.20. setEntry

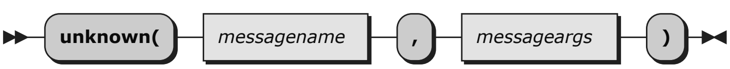


Sets the StringTable entry with index *name* (translated to uppercase) to the object *entry*, replacing any existing entry or method for *name*. If you omit *entry*, this method removes any entry or method with this *name*.

5.3.17.21. supplier

Returns a *Supplier* object for the collection. The supplier allows you to iterate over the index/item pairs in the StringTable at the time the supplier was created. The supplier iterates the items in an unspecified order.

5.3.17.22. unknown



Runs either the *entry* or *setEntry* method, depending on whether *messagename* ends with an equal sign.

If *messagename* does not end with an equal sign, this method runs the `entry` method, passing *messagename* as its argument. The *messageargs* argument is ignored. The `entry` method is the return result.

If *messagename* does end with an equal sign, this method runs the `setEntry` method, passing the first part of *messagename* (up to, but not including, the final equal sign) as its first argument, and the first item in the array *messageargs* as its second argument. In this case, `unknown` returns no result.

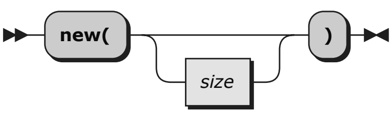
5.3.18. Table Class

A **`Table`** is a collection with indexes that can be any object. In a Table, each item is associated with a single index, and there can be only one item for each index (unlike a *Relation*, which can contain more than one item with the same index). Index equality is determined by using the == method.

Table 5.28. Table Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Collection (Mixin Class)		
Methods inherited from the *Collection class*		
[] (Abstract Method)	*equivalent*	*put (Abstract Method)*
[]= (Abstract Method)	*hasIndex*	*subset*
allIndexes (Abstract Method)	*hasItem*	*supplier*
allItems (Abstract Method)	*index (Abstract Method)*	*union*
at (Abstract Method)	*intersection*	*xor*
difference	*items*	
disjoint	*makeArray*	
+ MapCollection (Mixin Class)		
Methods inherited from the *MapCollection class*		
of (Class Method)		
makeArray		
putAll		
Table		
new (Class Method)		
[]	*hasIndex*	*put*
[]=	*hasItem*	*remove*
allIndexes	*index*	*removeItem*
allItems	*isEmpty*	*supplier*
at	*items*	
empty	*makeArray*	

5.3.18.1. new (Class Method)



Returns an empty Table object.

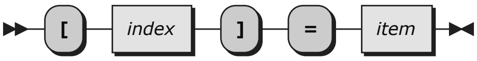
If you specify *size*, a hint how large the new Table object is expected to grow, this is used to optimize the initial allocation.

size must be a non-negative whole number.

5.3.18.2. []

Returns the item associated with *index*. This method is the same as the *at* method.

5.3.18.3. []=



Adds *item* to the table at index *index*. This method is the same as the *put* method.

5.3.18.4. allIndexes

Returns an array of all indexes contained in the table.

5.3.18.5. allItems

Returns an array of all items contained in the table.

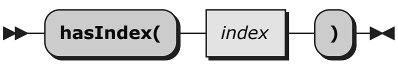
5.3.18.6. at

Returns the item associated with index *index*. Returns `.nil` if the Table has no item associated with *index*.

5.3.18.7. empty

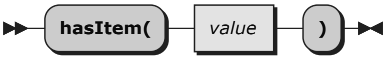
Returns the receiving Table with all items removed.

5.3.18.8. hasIndex



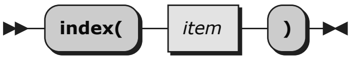
Returns **`.true`** if the Table contains any item associated with index *index*, or **`.false`**.

5.3.18.9. hasItem



Returns **`.true`** if the Table contains the *value* at any index position or otherwise returns **`.false`**. Item equality is determined by using the == method of *item*.

5.3.18.10. index



Returns the index of the specified item within the table. If the target item appears at more than one index, the first located index will be returned. Returns **`.nil`** if the table does not contain the specified item. Item equality is determined by using the == method of *item*.

5.3.18.11. isEmpty

Returns **`.true`** if the table is empty. Returns **`.false`** otherwise.

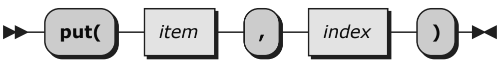
5.3.18.12. items

Returns the number of items in the collection.

5.3.18.13. makeArray

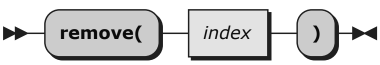
Returns a single-dimensional Array containing the index objects. The array indexes range from **`1`** to the number of items. The collection items appear in the array in an unspecified order.

5.3.18.14. put



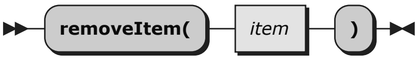
Makes the object *item* a member item of the collection and associates it with index *index*. The new item replaces any existing items associated with index *index*.

5.3.18.15. remove



Returns and removes the table item with index *index*. Returns **`.nil`** if no item has index *index*.

5.3.18.16. removeItem



Removes an item from the table. If the target item exists at more than one index, the first located item is removed. The return value is the removed item. Item equality is determined by using the == method of *item*.

5.3.18.17. supplier

Returns a *Supplier* object for the collection. The supplier allows you iterate over the index/item pairs contained in the table at the time the supplier was created. The supplier iterates over the items in an unspecified order.

5.3.19. Sorting Ordered Collections

Any ordered collection, such as non-sparse Arrays or Lists can have its elements placed into sorted order using the `sort` method. The simplest sort is sorting an array of strings.

Example 5.208. Array class — sorting

```
myArray = .array~of("Zoe", "Fred", "Xavier", "Andy")
myArray~sort

do name over myArray
   say name
end
```

will display the names in the order "Andy", "Fred", "Xavier", "Zoe".

The `sort` method orders the strings by using the `compareTo` method of the String class. The `compareTo` method knows how to compare one string to another, and returns the values -1 (less than), 0 (equal), or 1 (greater than) to indicate the relative ordering of the two strings.

5.3.19.1. Sorting non-strings

Sorting is not limited to string values. Any object that inherits the **`Comparable`** MIXIN class and implements a `compareTo` method can be sorted. The *DateTime class* and *TimeSpan class* are examples of built-in Rexx classes that can be sorted. Any user-created class may also implement a `compareTo` method to enable sorting. For example, consider the following simple class:

Example 5.209. Non-string sorting

```
::class Employee inherit Comparable

::attribute id
::attribute name
```

```
::method init
  expose id name
  use arg id, name

::method compareTo
  expose id
  use arg other
  return id~compareTo(other~id) -- comparison performed using employee id

::method string
  expose name
  return "Employee" name
```

The Employee class implements its sort order using the employee identification number. When the `sort` method needs to compare two Employee instances, it will call the `compareTo` method on one of the instances, passing the second instance as an argument. The `compareTo` method tells the `sort` method which of the two instances should be first.

Example 5.210. Comparison during sorting

```
    a = .array~new
    a[1] = .Employee~new(654321, "Fred")
    a[2] = .Employee~new(123456, "George")
    a[3] = .Employee~new(333333, "William")

    a~sort

    do employee over a
       say employee    -- sorted order is "George", "William", "Fred"
    end
```

5.3.19.2. Sorting with more than one order

The String class `compareTo` method only implements a sort ordering for an ascending sort using a strict comparison. Frequently it is desirable to override a class-defined sort order or even to sort items that do not implement a `compareTo` method. To change the sorting criteria, use the `sortWith` method. The `sortWith` method takes a single argument, which is a Comparator object that implements a `compare` method. The `compare` method performs comparisons between pairs of items. Different comparators can be customized for different comparison purposes. For example, the Rexx language provides a DescendingComparator class that will sort items into descending order:

Example 5.211. Multi-order sorting

```
::CLASS 'DescendingComparator' MIXINCLASS Comparator
::METHOD compare
use strict arg left, right
return -left~compareTo(right)
```

The DescendingComparator merely inverts the result returned by the item `compareTo` method. Our previous example

Example 5.212. Descending compare sorting

```
myArray = .array~of("Zoe", "Fred", "Xavier", "Andy")
myArray~sortWith(.DescendingComparator~new)
```

```
do name over myArray
   say name
end
```

now displays in the order "Zoe", "Xavier", "Fred", "Andy".

Custom Comparators are simple to create for any sorting purpose. The only requirement is implementing a `compare` method that knows how to compare pairs of items in some particular manner. For example, to sort our Employee class by name instead of the default employee id, we can use the following simple comparator class:

Example 5.213. Custom compare sorting

```
::CLASS EmployeeNameSorter MIXINCLASS Comparator
::METHOD compare
  use strict arg left, right
  return left~name~compareTo(right~name)  -- do the comparison using the names
```

5.3.19.3. Builtin Comparators

Rexx includes a number of built-in Comparators for common sorting operations.

Comparator Class
: Base comparator. The Comparator class just uses the `compareTo` method of the first argument to generate the result. Using `sortWith` and a Comparator instance is equivalent to using the `sort` method and no comparator.

CaselessComparator Class
: Like the base comparator, but uses the `caselessCompareTo` method to determine order. The String class implements `caselessCompareTo`, so the CaselessComparator can be used to sort arrays of strings independent of case.

ColumnComparator Class
: The ColumnComparator will sort string items using specific substrings within each string item. If sorting is performed on multiple column positions, the `stableSortWith` method is recommended to ensure the results of previous sort operations are retained.

CaselessColumnComparator Class
: Like the ColumnComparator, but the substring comparisons are done independently of case.

DescendingComparator Class
: The reverse of the Comparator class. The DescendingComparator can be used to sort items in descending order.

CaselessDescendingComparator Class
: The reverse of the CaselessComparator class. The CaselessDescendingComparator can be used to sort items in descending order with comparisons done independently of case.

InvertingComparator Class
: The InvertingComparator will invert the result returned by another Comparator instance. This comparator can be combined with another comparator instance to reverse the sort order.

NumericComparator Class
: Performs comparisons of strings using numeric comparison rules. Use the NumericComparator to sort collections of numbers.

5.3.19.4. Stable and Unstable Sorts

Note

The current implementation is using the same stable sort algorithm for both the *sort* and the *stableSort* method of the **Array** class.

As such, below discussion of the difference between a stable and an unstable sort does not apply currently.

The default sorting algorithm is an *unstable* sort. In an unstable sort, items are not guaranteed to maintain their original positions if they compare equal during the sort. Consider the following simple example:

Example 5.214. Unstable sort

```
a = .array~of("Fred", "George", "FRED", "Mike", "fred")
a~sortwith(.caselesscomparator~new)
do name over a
  say name
end
```

This example displays the 3 occurrences of Fred in the order "Fred", "fred", "FRED", even though they compare equal using a caseless comparison.

The Array class implements a second sort algorithm that is available using the `stableSort` and `stableSortWith` methods. These methods use a Mergesort algorithm, which is less efficient than the default Quicksort and requires additional memory. The Mergesort is a stable algorithm that maintains the original relative ordering of equivalent items. Our example above, sorted with `stableSortWith`, would display "Fred", "FRED", "fred".

5.3.20. Concept of Set Operations

The following sections describe the concept of set operations to help you work with set operators, in particular if the receiver collection class differs from the argument collection class.

Rexx provides the following set-operator methods:

- difference
- intersection
- subset
- union
- xor

These methods are available to instances of the following collection classes:

- The OrderedCollections Array, List, Queue, and CircularQueue

- The MapCollections Directory, Stem, Table, IdentityTable, and Relation
- The SetCollections Set and Bag.

```
result = receiver~setoperator(argument)
```

where:

receiver
: is the collection object receiving the set-operator message.

setoperator
: is the set-operator method used.

argument
: is the argument collection supplier supplied to the method. It can be an instance of one of the Rexx collection classes or any object that implements a `makearray` method or `supplier` method, depending on class of *receiver*.

The result object is of the same class as the *receiver* collection object.

5.3.20.1. Principles of Operation

A set operation is performed by iterating over the elements of the *receiver* collection to compare each element of the *receiver* with each element of the *argument* collection. The element is defined as the tuple (*index, item*) (see *Section 5.3.20.4, “Determining the Identity of an Item”*). Depending on the set-operator method and the result of the comparison, an element of the receiver collection is, or is not, included in the resulting collection. A receiver collection that allows for duplicate elements can, depending on the set-operator method, also accept elements of the argument collection after they have been coerced to the type of the receiver collection.

The following examples are to help you understand the semantics of set operations. The collections are represented as a list of elements enclosed in curly brackets. The list elements are separated by a comma.

5.3.20.2. Set Operations on Collections without Duplicates

Assume that the example sets are **`A={a,b}`** and **`B={b,c,d}`**. Except for `subset`, `equivalent`, and `disjoint`, the result of a set operation is another set. Using the collection **A** and **B**, the different set operators produce the following:

UNION operation
: All elements of **A** and **B** are united:

```
A UNION B = {a,b,c,d}
```

DIFFERENCE operation
: The resulting collection contains all elements of the first set except for those that also appear in the second set. The system iterates over the elements of the second set and removes them from the first set one by one.

```
A DIFFERENCE B = {a}
```

```
B DIFFERENCE A = {c,d}
```

XOR operation

The resulting collection contains all elements of the first set that are not in the second set and all elements of the second set that are not in the first set:

```
A XOR B = {a,c,d}
```

INTERSECTION operation

The resulting collection contains all elements that appear in both sets:

```
A INTERSECTION B = {b}
```

SUBSET operation

Returns **`.true`** if the first set contains only elements that also appear in the second set, otherwise it returns **`.false`**:

```
A SUBSET B = .false
B SUBSET A = .false
```

EQUIVALENT operation

Returns **`.true`** if the first set contains only elements that also appear in the second set and the two sets have the same number of elements, otherwise it returns **`.false`**:

```
A EQUIVALENT B = .false
B EQUIVALENT A = .false
```

DISJOINT operation

Returns **`.true`** if there are no elements that appear in both sets, otherwise it returns **`.false`**:

```
A DISJOINT B = .false
B DISJOINT A = .false
```

5.3.20.3. Set-Like Operations on Collections with Duplicates

Assume that the example bags are **`A={a,b,b}`** and **`B={b,b,c,c,d}`**. Except for `subset`, `equivalent`, and `disjoint`, the result of any set-like operation is a collection, in this case a bag. Using the collections **`A`** and **`B`**, the different set-like operators produce the following:

UNION operation

All elements of **`A`** and **`B`** are united:

```
A UNION B = {a,b,b,b,b,c,c,d}
```

DIFFERENCE operation

The resulting collection contains all elements of the first bag except for those that also appear in the second bag. The system iterates over the elements of the second bag and removes them from the first bag one by one.

```
A DIFFERENCE B = {a}
B DIFFERENCE A = {c,c,d}
```

XOR operation
: The resulting collection contains all elements of the first bag that are not in the second bag and all elements of the second bag that are not in the second bag:

```
A XOR B = {a,c,c,d}
```

INTERSECTION operation
: The resulting collection contains all elements that appear in both bags:

```
A INTERSECTION B = {b,b}
```

SUBSET operation
: Returns **`.true`** if the first set contains only elements that also appear in the second set, otherwise it returns **`.false`**:

```
A SUBSET B = .false
B SUBSET A = .false
```

EQUIVALENT operation
: Returns **`.true`** if the first set contains only elements that also appear in the second set and the two sets have the same number of elements, otherwise it returns **`.false`**:

```
A EQUIVALENT B = .false
B EQUIVALENT A = .false
```

DISJOINT operation
: Returns **`.true`** if there are no elements that appear in both sets, otherwise it returns **`.false`**:

```
A DISJOINT B = .false
B DISJOINT A = .false
```

5.3.20.4. Determining the Identity of an Item

Set operations require the definition of the identity of an element to determine whether a certain element exists in the receiver collection. The element of a collection is conceived as the tuple (*index, item*). The *index* is used as the identification tag associated with the item. Depending on the collection class, the index is an instance of a particular class, for example, the string class for a directory element, an integer for an array, or any arbitrary class for a relation. The Array class is an exception because it can be multi-dimensional having more than one index. However, as a collection, it is conceptionally linearized by the set operator.

For collection classes that require unique indexes, namely the Set, IdentityTable, Table, Directory, and Stem, an item is identified by its *index*. For collections of collection classes that allow several items to have the same index, namely the Relation class, an item is identified by both its *index* and its *item*. For the Bag and the Set subclasses, where several items can have the same index but *index* and *item* must be identical, the item is identified by its *index*. For Array, List, and Queue classes, the index is derived from an object's position within the collection's order. Items are identified using only *item*.

When collections with different index semantics are used in set operations, the argument collection is coerced into a collection of the same type as the receiver, and the operation is then performed using the converted collection. The coercion process differs based on the types of both the receiver and the argument collection. According to this concept, an item of a collection is identified for the different *receiver* categories as follows:

Map Collection

If *argument* is a MapCollection, then *index* values are used to determine membership, and items are inserted into the result using the *index* and *item* pairs.

If *argument* is an OrderedCollection or SetCollection, *argument* is converted into a MapCollection using the collection items as both index and item values. Since the argument collection may contain duplicate items, the converted collection is effectively a Relation instance.

For all other *argument* objects, the `makearray` method is used to obtain a set of values which are used as if *argument* was an OrderedCollection.

Ordered Collection and Set Collection

If *argument* is an instance of Collection, the matching set is obtained from the `allItems` method. For any other class of object, the `makearray` method is used. The `hasItem` method is used to perform the matching operations between the two collections.

Relation

If *argument* is a MapCollection, then *index* values are used to determine membership, and items are inserted into the result using the *index* and *item* pairs.

If *argument* is an OrderedCollection or SetCollection, *argument* is converted into a MapCollection using the collection items as both index and item values. Since the argument collection may contain duplicate items, the converted collection is effectively a Relation instance.

For all other *argument* objects, the `makearray` method is used to obtain a set of values which are used as if *argument* was an OrderedCollection. All tests for result membership are made using both the index and item values.

5.4. Utility Classes

This section describes

- *MutableBuffer Class*,
- *File Class*,
- Date-, time-, and timing-related classes *DateTime*, *TimeSpan*, *Alarm*, *Ticker*, and the notification classes *AlarmNotification* and *MessageNotification*,
- the synchronization classes *EventSempahore* and *MutexSempahore*,
- *Comparable* class and *Orderable* class,
- eight *Comparator* classes used for sorting *(Caseless)Comparator*, *(Caseless)ColumnComparator*, *(Caseless)DescendingComparator*, *InvertingComparator*, and *NumericComparator*, and
- other miscellaneous classes *Buffer*, *Monitor*, *Pointer*, *RegularExpression*, *RexxContext*, *RexxInfo*, *RexxQueue*, *StackFrame*, *StreamSupplier*, *Supplier*, *Validate*, *VariableReference*, and *WeakReference*.

5.4.1. Alarm Class

An **`Alarm`** object provides timing and notification capability by sending a notification message to a notification target at the trigger time.

An **`Alarm`** can be cancelled before it triggers. If cancelled, an **`Alarm`** will also send a notification message to the notification target.

Table 5.29. Alarm Class

Object

Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
Alarm		
attachment	*canceled/cancelled*	*scheduledTime*
cancel	*init*	*triggered*

5.4.1.1. attachment

Returns the object that has been attached to the **`Alarm`** instance upon creation. Returns **`.nil`** if no object is attached.

See also method *init*.

Example 5.215. Alarm class — attachment method

```
oneSecond = .Alarm~new(1, .Target~new, "a second has passed")
call SysSleep 1.5                       -- give Alarm time to trigger
oneSecond~cancel

::class Target inherit AlarmNotification
::method triggered                      -- called when Alarm triggers
  use arg alarm
  say alarm~attachment                  -- displays "a second has passed"
```

5.4.1.2. cancel

Cancels the pending **`Alarm`** request represented by the receiver. Takes no action if the specified time has already been reached.

5.4.1.3. canceled/cancelled

Returns **`.true`** if the alarm was cancelled before triggering. Returns **`.false`** otherwise.

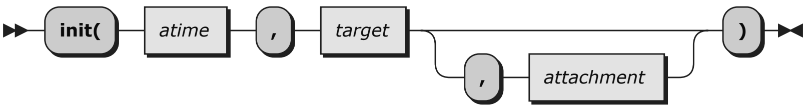
See also method *cancel*.

Example 5.216. Alarm class — canceled/cancelled method

```
alarm = .Alarm~new(1 ,.message~new(.stdout, "SAY", "I", "Alarm went off"))
call SysSleep 0.5
alarm~cancel
```

```
say "Alarm" alarm~cancelled~?("cancelled", "not cancelled")    -- Alarm cancelled
```

5.4.1.4. init



Sets up an **Alarm** for a future time *atime*. At this time, the **Alarm** sends message `triggered` to the specified notification *target*.

The *target* must be an object that implements the *AlarmNotification interface*. It must inherit from or be a subclass of the **AlarmNotification** class, or a *Message* object (as the **Message** class inherits from **AlarmNotification**). If *target* is a **Message** object, the *triggered* method of the **Message** class will respond by simply sending the specified message.

The *atime* can be a *DateTime*, a *TimeSpan*, or a *String* object. If it is

- a **DateTime** object, it specifies the time when the alarm will be triggered. The specified time must be in the future.
- a **TimeSpan,** the **Alarm** will be set to the current time plus the specified time span. The time span must not be a negative interval.
- a **String**, you can specify this as a date and time (**hh:mm:ss**) or as a number of seconds starting at the present time. If you use the date and time format, you can specify a date in the default format (**dd Mmm yyyy**) after the time with a single blank separating the time and date. Leading and trailing whitespace characters are not allowed in the *atime*. If you do not specify a date, the **Alarm** uses the first future occurrence of the specified time.

If specified, *attachment* can be an arbitrary object that will be attached to the alarm instance, and can later be retrieved in the event handler. See method *attachment*.

You can use the *cancel* method to cancel a pending alarm. If cancelled, the alarm sends message `cancel` to the specified notification *target*.

The following code sets up an alarm at 5:10 p.m. on December 15, 2017. (Assume today's date/time is prior to December 15, 2017.)

Example 5.217. Alarm class

```
/* Alarm Examples */

PersonalMessage = .MyMessageClass~new("Call the Bank")
msg = .Message~new(PersonalMessage, "RemindMe")

time = .DateTime~fromIsoDate("2017-12-15T17:10:00.000000")

a = .Alarm~new(time, msg)
exit

::class MyMessageClass public
::method init
  expose inmsg
  use arg inmsg

::method RemindMe
  expose inmsg
  say "It is now" time("C")". Please" inmsg
```

```
/* On the specified data and time, displays the following message: */
/* "It is now 5:10pm. Please Call the Bank" */
```

For the following example, the user uses the same code as in the preceding example to define *msg*, a message object to run at the specified time. The following code sets up an alarm to run the *msg* message object in 30 seconds from the current time:

Example 5.218. Alarm class

```
a = .Alarm~new(30, msg)
```

5.4.1.5. scheduledTime

Returns a *DateTime* object representing the time for which the alarm has initially been scheduled.

5.4.1.6. triggered

Returns **`.true`** if the alarm has triggered. Returns **`.false`** if the alarm has been cancelled or hasn't yet triggered.

5.4.2. AlarmNotification Class

The **`AlarmNotification`** class implements the notification interface for the *Alarm* and the *Ticker* class.

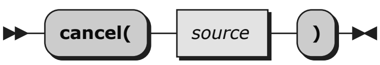
For any Alarm or Ticker object, notifications of alarm triggering and alarm cancellation are sent to the notification target specified when creating the Alarm or Ticker instance. The notification target must implement this alarm notification interface. Upon alarm triggering a `triggered` message is sent to the notification target, and upon alarm cancellation a `cancel` message is sent to the notification target.

This class is defined as a MIXIN class.

Table 5.30. AlarmNotification Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
AlarmNotification (Mixin Class)
cancel *triggered (Abstract method)*

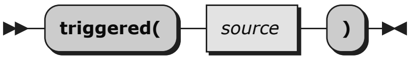
5.4.2.1. cancel



Whenever an *Alarm* or *Ticker* is cancelled, this method of the alarm notification target will be called. The Alarm or Ticker object that was cancelled will be provided as argument *source*.

It is defined as a no-op and doesn't necessarily have to be implemented by an inheriting class.

5.4.2.2. triggered (Abstract method)



Whenever an *Alarm* or *Ticker* triggers, this method of the alarm notification target will be called. The Alarm or Ticker object which triggered will be provided as argument *source*.

It is an abstract method and must be implemented by an inheriting class.

For an example see **`Alarm`** class *attachment method example*.

5.4.3. Buffer Class

A **`Buffer`** instance is a Rexx interpreter managed block of storage. This class is designed primarily for writing methods and functions in native code and can only be created using the native code application programming interfaces. The *new (Class Method)* method will raise an error if invoked.

Table 5.31. Buffer Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
Buffer
new (Class Method)

5.4.3.1. new (Class Method)

Creating **`Buffer`** object instances directly from Rexx code is not supported. Method `new` will raise an error if invoked.

5.4.4. Comparable Class

This class is defined as a MIXIN class.

Table 5.32. Comparable Class

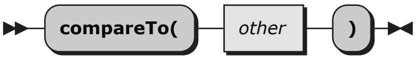
Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
Comparable (Mixin Class)

compareTo

5.4.4.1. compareTo

This method compares the receiving object to the object supplied in the *other* argument.

This is a default implementation which compares two items based on their *identityHash*.



This method returns **`-1`** if the *other* is larger than the receiving object, **`0`** if the two objects are equal, and **`1`** if *other* is smaller than the receiving object.

> **Note**
>
> Classes inheriting from **`Comparable`** (like builtin classes *File*, *DateTime*, or *TimeSpan*) are strongly encouraged to forward to this default implementation for comparison cases not covered by their class-specific `compareTo` implementation.

5.4.5. Comparator Classes

This section describes eight Comparator classes used for sorting, *(Caseless)Comparator*, *(Caseless)ColumnComparator*, *(Caseless)DescendingComparator*, *InvertingComparator*, and *NumericComparator*.

5.4.5.1. Comparator Class

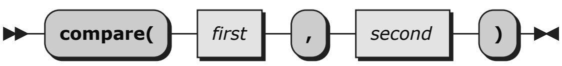
The **`Comparator`** class is the base class for implementing **`Comparator`** objects that can be used with the *sortWith* or *stableSortWith* methods. The `compare` method implements some form of comparison that determines the relative ordering of two objects. Many **`Comparator`** implementations are specific to particular object types.

It is defined as a MIXIN class.

Table 5.33. Comparator Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
Comparator (Mixin Class)
compare

5.4.5.1.1. compare



Returns **`-1`** if *second* is larger than *first*, **`0`** if the two objects are equal, and **`1`** if *second* is smaller than *first*.

The default **`Comparator`** `compare` method assumes that *first* is an object that implements the **`Comparable`** *compareTo* method. Subclasses may override this to implement more specific comparisons.

Example 5.219. Comparator class

```
wine = .Array~of("Strawberries", "cherries", "angel's kiss")
wine~sortWith(.Comparator~new)         -- Strawberries, angel's kiss, cherries
```

5.4.5.2. CaselessComparator Class

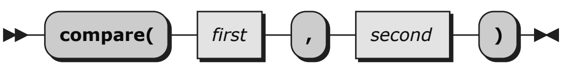
The **`CaselessComparator`** class performs caseless orderings of string objects.

It is defined as a MIXIN class.

Table 5.34. CaselessComparator Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ Comparator (Mixin Class)
Methods inherited from the *Comparator class* *compare*
CaselessComparator (Mixin Class)
compare

5.4.5.2.1. compare



Returns **`-1`** if *second* is larger than *first*, **`0`** if the two objects are equal, and **`1`** if *second* is smaller than *first*.

The two strings are compared using a caseless comparison.

Example 5.220. CaselessComparator class

```
wine = .Array~of("Strawberries", "cherries", "angel's kiss")
wine~sortWith(.CaselessComparator~new) -- angel's kiss, cherries, Strawberries
```

5.4.5.3. ColumnComparator Class

The **`ColumnComparator`** class performs orderings based on specific substrings of string objects.

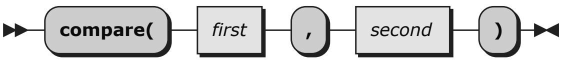
It is defined as a MIXIN class.

Table 5.35. ColumnComparator Class

Object

Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ Comparator (Mixin Class)
Methods inherited from the *Comparator class* *compare*
ColumnComparator (Mixin Class)
compare *init*

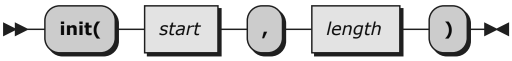
5.4.5.3.1. compare



Returns **-1** if *second* is larger than *first*, **0** if the two objects are equal, and **1** if *second* is smaller than *first*.

Only the defined columns of the strings are compared.

5.4.5.3.2. init



Initializes a **ColumnComparator** to sort strings starting at position *start* for *length* characters.

Example 5.221. ColumnComparator class

```
wine = .Array~of("1. Strawberries", "2. cherries", "3. angel's kiss")
wine~sortWith(.ColumnComparator~new(3, 100))
                                       -- 1. Strawberries, 3. angel's kiss, 2. cherries
```

5.4.5.4. CaselessColumnComparator Class

The **CaselessColumnComparator** class performs caseless orderings of specific substrings of string objects.

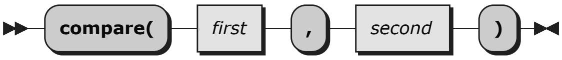
It is defined as a MIXIN class.

Table 5.36. CaselessColumnComparator Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ Comparator (Mixin Class)
Methods inherited from the *Comparator class* *compare*
CaselessColumnComparator (Mixin Class)

compare *init*

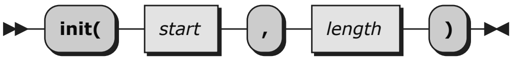
5.4.5.4.1. compare



Returns **`-1`** if *second* is larger than *first*, **`0`** if the two objects are equal, and **`1`** if *second* is smaller than *first*.

Only the defined columns of the strings are compared, using a caseless comparison.

5.4.5.4.2. init



Initializes a **`CaselessColumnComparator`** to sort strings starting at position *start* for *length* characters.

Example 5.222. CaselessColumnComparator class

```
wine = .Array~of("1. Strawberries", "2. cherries", "3. angel's kiss")
wine~sortWith(.CaselessColumnComparator~new(3, 100))
                                       -- 3. angel's kiss, 2. cherries, 1. Strawberries
```

5.4.5.5. DescendingComparator Class

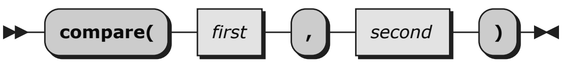
The **`DescendingComparator`** class performs string sort orderings in descending order. This is the inverse of a *Comparator* sort order.

This class is defined as a MIXIN class.

Table 5.37. DescendingComparator Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ Comparator (Mixin Class)
Methods inherited from the *Comparator class* *compare*
DescendingComparator (Mixin Class)
compare

5.4.5.5.1. compare



Returns **1** if *second* is larger than *first*, **0** if the two objects are equal, and **-1** if *second* is smaller than *first*, resulting in a descending sort sequence.

The **DescendingComparator** assumes the *first* object implements the **Comparable** *compareTo* method.

Example 5.223. DescendingComparator class

```
wine = .Array~of("Strawberries", "cherries", "angel's kiss")
wine~sortWith(.DescendingComparator~new)    -- cherries, angel's kiss, Strawberries
```

5.4.5.6. CaselessDescendingComparator Class

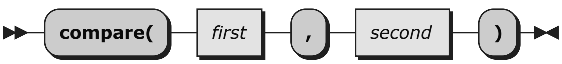
The **CaselessDescendingComparator** class performs caseless string sort orderings in descending order. This is the inverse of a *CaselessComparator* sort order.

This class is defined as a MIXIN class.

Table 5.38. CaselessDescendingComparator Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ Comparator (Mixin Class)
Methods inherited from the *Comparator class* *compare*
CaselessDescendingComparator (Mixin Class)
compare

5.4.5.6.1. compare



Returns **1** if *second* is larger than *first*, **0** if the two objects are equal, and **-1** if *second* is smaller than *first*, resulting in a descending sort sequence.

The two strings are compared using a caseless comparison.

Example 5.224. CaselessDescendingComparator class

```
wine = .Array~of("Strawberries", "cherries", "angel's kiss")
wine~sortWith(.CaselessDescendingComparator~new) -- Strawberries, cherries, angel's kiss
```

5.4.5.7. InvertingComparator Class

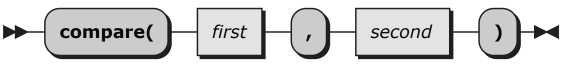
The **InvertingComparator** class inverts the comparison results of another Comparator object to reverse the resulting sort order.

This class is defined as a MIXIN class.

Table 5.39. InvertingComparator Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ Comparator (Mixin Class)
Methods inherited from the *Comparator class* *compare*
InvertingComparator (Mixin Class)
compare *init*

5.4.5.7.1. compare



The **`InvertingComparator`** will invert the ordering returned by the *comparator* it was initialized with.

5.4.5.7.2. init

Initializes an **`InvertingComparator`** to sort strings using an inversion of the result from the *comparator* `compare` method.

Example 5.225. InvertingComparator class

```
wine = .Array~of("1. Strawberries", "2. cherries", "3. angel's kiss")
wine~sortWith(.InvertingComparator~new(.LengthComparator~new))
                                       -- 3. angel's kiss, 1. Strawberries, 2. cherries

-- compare 1. by length, 2. by standard comparison
::class LengthComparator mixinclass Comparator public
::method compare
  use strict arg left, right

  lengthDelta = left~length - right~length
  if lengthDelta = 0 then
    return left~compareTo(right)
  else
    return lengthDelta~sign
```

5.4.5.8. NumericComparator Class

The NumericComparator class compares strings using numeric comparison rules rather than string comparison rules.

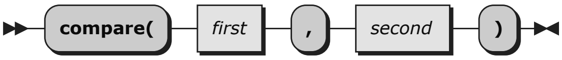
It is defined as a MIXIN class.

Table 5.40. NumericComparator Class

Object

Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
+ Comparator (Mixin Class)
Methods inherited from the *Comparator class* *compare*
NumericComparator (Mixin Class)
compare *init*

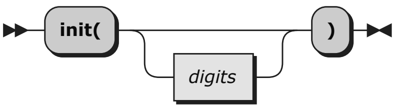
5.4.5.8.1. compare



Returns **`-1`** if *second* is larger than *first*, **`0`** if the two objects are equal, and **`1`** if *second* is smaller than *first*.

Comparisons are performed using numeric comparison rules, so the collection strings must be valid numeric values.

5.4.5.8.2. init



Initializes a **`NumericComparator`** to sort strings using numeric comparison rules using the **`Comparator`** *compare* method. If *digits* is specified, the comparisons will be performed using the provided precision. The default precision is **`9`**.

Example 5.226. NumericComparator class

```
primes = .Array~of(23, 19, 17, 13, 11, 7, 5, 3, 2)
primes~sortWith(.NumericComparator~new)  -- 2, 3, 5, 7, 11, 13, 17, 19, 23
```

5.4.6. DateTime Class

A **`DateTime`** instance represents a timestamp between 1 January 0001 at 00:00.000000 and 31 December 9999 at 23:59:59.999999. It has methods to allow formatting a date or time in various formats, as well as allowing arithmetic operations between timestamps.

Note

`DateTime` does not support leap seconds like December 31, 2016 at 23:59:60 UTC.

Table 5.41. DateTime Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Orderable (Mixin Class)		
Methods inherited from the *Orderable class* *Comparison Methods* = == < <= << <<= <> > >= >< >> >>= \= \== \< \<< \> \>> *compareTo*		
+ Comparable (Mixin Class)		
Methods inherited from the *Comparable class* *compareTo*		
DateTime		
new (Inherited Class Method)	*fromOrdinalDate (Class Method)*	
fromBaseDate (Class Method)	*fromStandardDate (Class Method)*	
fromCivilTime (Class Method)	*fromTicks (Class Method)*	
fromEuropeanDate (Class Method)	*fromUsaDate (Class Method)*	
fromIsoDate (Class Method)	*fromUtcIsoDate (Class Method)*	
fromLongTime (Class Method)	*fromWeekNumberDate (Class Method)*	
fromNormalDate (Class Method)	*maxDate (Class Method)*	
fromNormalTime (Class Method)	*minDate (Class Method)*	
fromOrderedDate (Class Method)	*today (Class Method)*	
Arithmetic Methods + -	*elapsed*	*ordinalDate*
addDays	*europeanDate*	*seconds*
addHours	*fullDate*	*standardDate*
addMicroseconds	*hashCode*	*string*
addMinutes	*hours*	*ticks*
addSeconds	*init*	*timeOfDay*
addWeeks	*isLeapYear*	*toLocalTime*
addYears	*isoDate*	*toTimezone*
baseDate	*languageDate*	*toUtcTime*
civilTime	*longTime*	*usaDate*
compareTo	*makeString*	*utcDate*
date	*microseconds*	*utcIsoDate*
day	*minutes*	*weekDay*
dayMicroseconds	*month*	*weekNumber*
dayMinutes	*monthName*	*weekNumberDate*
dayName	*normalDate*	*weekNumberYear*
daySeconds	*normalTime*	*weeksInYear*
daysInMonth	*offset*	*year*
daysInYear	*orderedDate*	*yearDay*

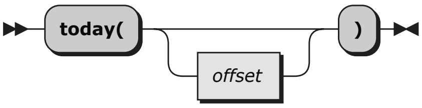
5.4.6.1. minDate (Class Method)

Returns a **`DateTime`** instance representing the minimum supported Rexx date, 1 January 0001 at 00:00:00.000000.

5.4.6.2. maxDate (Class Method)

Returns a **`DateTime`** instance representing the maximum supported Rexx date, 31 December 9999 at 23:59:59.999999.

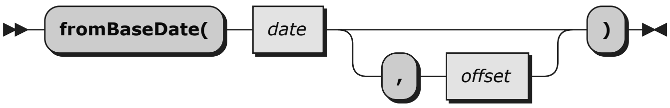
5.4.6.3. today (Class Method)



Returns a **`DateTime`** instance for the current day, with a time value of 00:00:00.000000.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

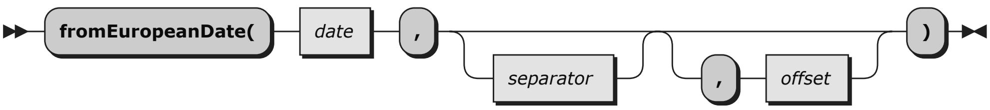
5.4.6.4. fromBaseDate (Class Method)



Returns a new **`DateTime`** object, created from a string in the format returned by the **`Base`** option of the *DATE* built-in function (**`dddddd`**). The time component will be set to 00:00:00.000000.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

5.4.6.5. fromEuropeanDate (Class Method)

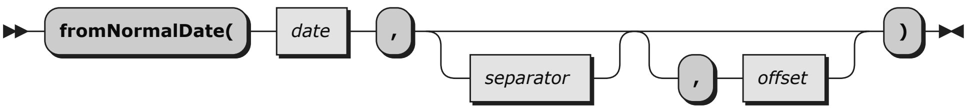


Returns a new **`DateTime`** object, created from a string in the format returned by the **`European`** option of the *DATE* built-in function (**`dd/mm/yy`**). The time component will be set to 00:00:00.000000.

If specified, *separator* identifies the field separator character used in the string. The separator must be a single character or the null string (""). A slash ("/") is the default separator. The time component will be set to 00:00:00.000000.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

5.4.6.6. fromNormalDate (Class Method)

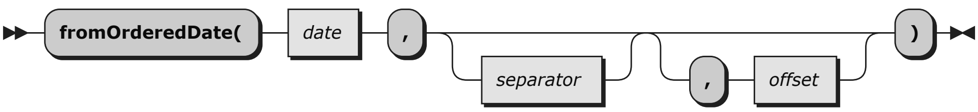


Returns a new **DateTime** object, created from a string in the format returned by the **Normal** option of the *DATE* built-in function (**dd mon yyyy**). The time component will be set to 00:00:00.000000.

If specified, *separator* identifies the field separator character used in the string. The separator must be a single character or the null string (""). A blank (" ") is the default separator.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

5.4.6.7. fromOrderedDate (Class Method)

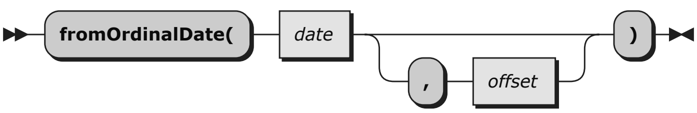


Returns a new **DateTime** object, created from a string in the format returned by the **Ordered** option of the *DATE* built-in function (**yy/mm/dd**). The time component will be set to 00:00:00.000000.

If specified, *separator* identifies the field separator character used in the string. The separator must be a single character or the null string (""). A slash ("/") is the default separator. The time component will be set to 00:00:00.000000.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

5.4.6.8. fromOrdinalDate (Class Method)



Returns a new **DateTime** object, created from a string in ISO ordinal date format. The time component will be set to 00:00:00.000000.

Both the basic format **yyyyddd** and the extended format **yyyy-ddd** are accepted, where **ddd** is the ordinal number of a day within year **yyyy**. The allowed range for **ddd** is 1 through the number of days in year **yyyy**, which is either 365 or 366. Leading zeros are required for both **yyyy** and **ddd**.

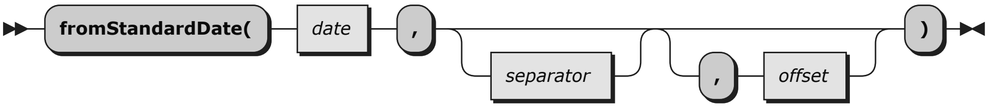
If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

See also method *ordinalDate*.

Example 5.227. DateTime class — fromOrdinalDate method

```
say .DateTime~fromOrdinalDate("2020-041")    -- 2020-02-10T00:00:00.000000
```

5.4.6.9. fromStandardDate (Class Method)

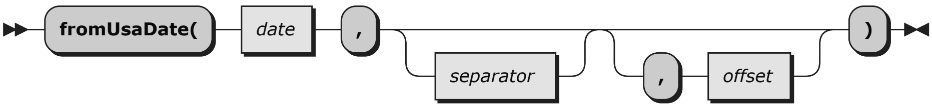


Returns a new **DateTime** object, created from a string in the format returned by the **Standard** option of the *DATE* built-in function (**yyyymmdd**). The time component will be set to 00:00:00.000000.

If specified, *separator* identifies the field separator character used in the string. The separator must be a single character or the null string (""). A null string ("") is the default separator.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

5.4.6.10. fromUsaDate (Class Method)

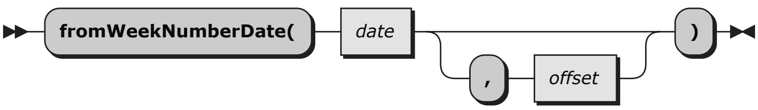


Returns a new **DateTime** object, created from a string in the format returned by the **Usa** option of the *DATE* built-in function (**mm/dd/yy**). The time component will be set to 00:00:00.000000.

If specified, *separator* identifies the field separator character used in the string. The separator must be a single character or the null string (""). A slash ("/") is the default separator.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

5.4.6.11. fromWeekNumberDate (Class Method)



Returns a new **DateTime** object, created from a string in ISO week date format. The time component will be set to 00:00:00.000000.

Both the basic format **yyyyWwwd** and the extended format **yyyy-Www-d** are accepted, where **ww** is the ordinal number of an ISO week within year **yyyy**, and **d** is the ordinal number of the calender day within the week. The allowed range for **ww** is 1 through the number of ISO weeks in year **yyyy**, which is either 52 or 53. Leading zeros are required for both **yyyy** and **ww**. The allowed range for **d** is 1 through 7, where Monday is 1, Tuesday is 2, running through 7 for Sunday.

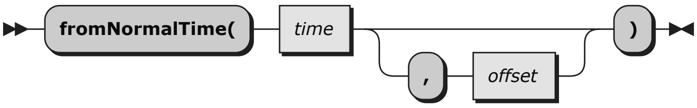
If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

See also methods *weekNumberDate*, *weekNumberYear*, and *weekDay*.

Example 5.228. DateTime class — fromWeekNumberDate method

```
say .DateTime~fromWeekNumberDate("2020-W07-1")    -- 2020-02-10T00:00:00.000000
```

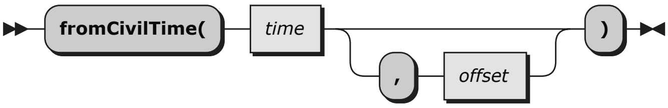
5.4.6.12. fromNormalTime (Class Method)



Returns a new **DateTime** object, created from a string in the format returned by the **Normal** option of the *TIME* built-in function (**hh:mm:ss**). The date component will be set to 1 January 0001.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

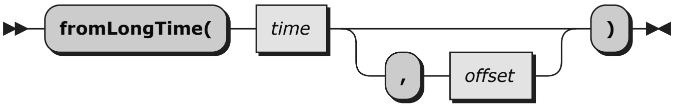
5.4.6.13. fromCivilTime (Class Method)



Returns a new **DateTime** object, created from a string in the format returned by the **Civil** option of the *TIME* built-in function (**hh:mmxx**). The date component will be set to 1 January 0001.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

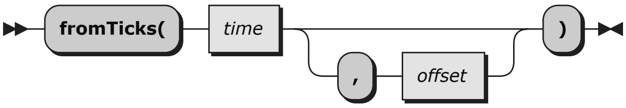
5.4.6.14. fromLongTime (Class Method)



Returns a new **DateTime** object, created from a string in the format returned by the **Long** option of the *TIME* built-in function (**hh:mm:ss.uuuuuu**). The date component will be set to 1 January 0001.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

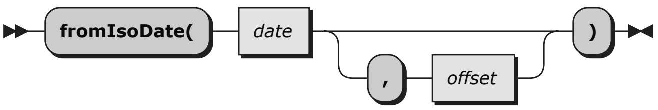
5.4.6.15. fromTicks (Class Method)



Returns a new **DateTime** object, created from a string in the format returned by the **Ticks** option of the *DATE* or *TIME* built-in functions (**ddddddddddd**).

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

5.4.6.16. fromIsoDate (Class Method)

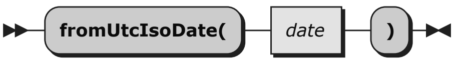


Returns a new **DateTime** object, created from a string in extended ISO format **yyyy-mm-ddThh:mm:ss.uuuuuu**.

The *isoDate* and the *string* methods return a string in extended ISO format as the string form of a **DateTime** instance.

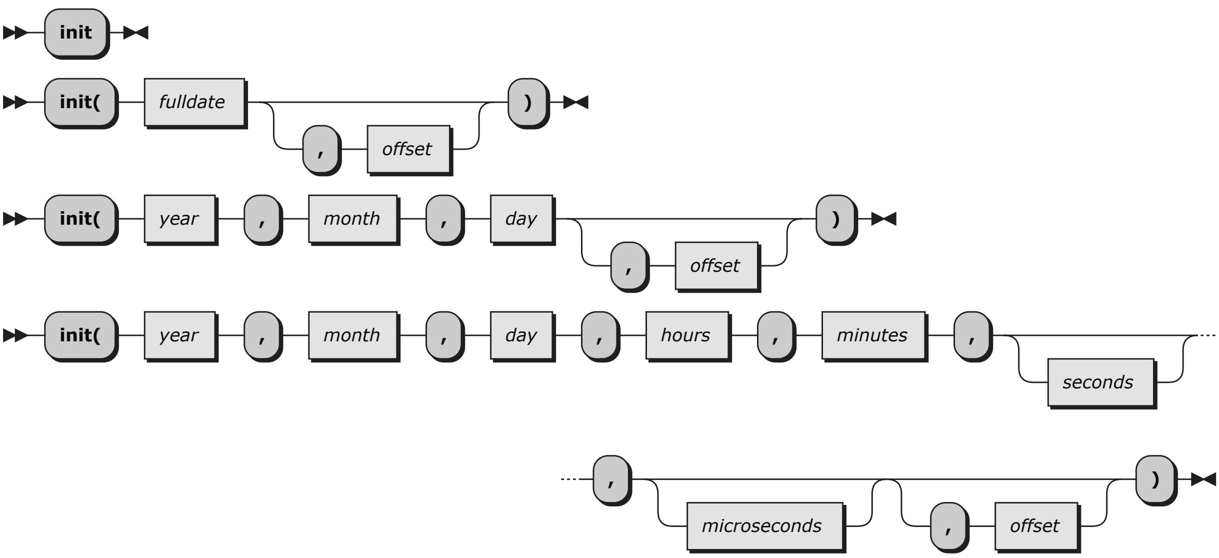
If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

5.4.6.17. fromUtcIsoDate (Class Method)



Returns a new **DateTime** object, created from a string in timezone-qualified extended ISO format **yyyy-mm-ddThh:mm:ss.uuuuuu+hh:mm**.

5.4.6.18. init



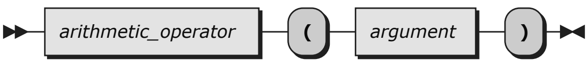
Initializes a new **DateTime** instance. If no arguments are specified, the instance is set to the current date and time. If the single *fulldate* argument is used, the instance is initialized to the date and time calculated by adding *fulldate* microseconds to 0001-01-01T00:00:00.000000. If the *year*, *month*, *day*, form is used, the instance is initialized to 00:00:00.000000 on the indicated date. Otherwise, the instance is initialized to the *year*, *month*, *day*, *hours*, *minutes*, *seconds*, and *microseconds* components. Each of these components must be a valid whole number within the acceptable range for the given component. For example, *year* must be in the range 1-9999, while *minutes* must be in the range 0-59.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is the current system timezone offset.

Example 5.229. DateTime class

```
today = .DateTime~new                               -- current date and time
day = .DateTime~new(date('F', "20170630", "S"))  -- 2017-06-30T00:00:00.000000
day = .DateTime~new(2017, 6, 30)                   -- 2017-06-30T00:00:00.000000
day = .DateTime~new(2017, 6, 30, 11, 8, 50)        -- 2017-06-30T11:08:50.000000
```

5.4.6.19. Arithmetic Methods



Note

The syntax diagram above is for the non-prefix operators. For the prefix operators, omit the parentheses and *argument*.

Returns the result of performing the specified arithmetic operation on the receiver **`DateTime`** instance. Depending on the operation, the *argument* may be either a *TimeSpan* object or a **`DateTime`** instance. See the description of the individual operations for details. The *arithmetic_operator* can be:

+
: Addition. Adds a TimeSpan to the DateTime object, returning a new DateTime instance. The receiver DateTime object is not changed. The TimeSpan may be either positive or negative.

-
: Subtraction. If *argument* is a DateTime object, the two times are subtracted, and a TimeSpan object representing the interval between the two times is returned. If the receiver DateTime is less than the *argument* argument DateTime, a negative TimeSpan interval is returned. The receiver DateTime object is not changed.

  If *argument* is a TimeSpan object, subtracts the TimeSpan from the DateTime object, returning a new DateTime instance. The receiver DateTime object is not changed. The TimeSpan may be either positive or negative.

Prefix **-**
: A prefix - operation on a DateTime object will raise a SYNTAX error condition.

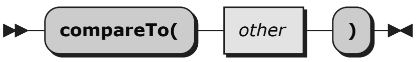
Prefix **+**
: Returns a new **`DateTime`** object with the same time value.

> **Note**
>
> When adding or subtracting **`DateTime`** and **`TimeSpan`** objects, leap seconds (like the one which happened on December 31, 2016 at 23:59:60 UTC) are not taken into account.

Example 5.230. DateTime class — arithmetic

```
t = .dateTime~new~timeOfDay       -- returns TimeSpan for current time
say t                             -- displays "17:30:41.482000", perhaps
d = .dateTime~new(2016, 12, 31)   -- creates new date

future = d + t                    -- adds timespan to d
say future                        -- displays "2016-12-31T17:30:41.482000"

-- does not take leap second into account
say d + .TimeSpan~new(24, 0, 1)   -- 2017-01-01T00:00:01.000000

                                  -- "real" start of next century
nextCentury = .dateTime~new(2101, 1, 1)
-- "The next century starts in 29547.07:15:42.721000 days", perhaps
say "The next century starts in" (nextCentury - .dateTime~new) "days"
```

5.4.6.20. compareTo



Returns **`-1`** if the *other* is larger than the receiving object, **`0`** if the two objects are equal, and **`1`** if *other* is smaller than the receiving object.

5.4.6.21. weekNumber

Returns the timestamp's ISO week number.

Any given year will have week numbers either between 1 and 52, or between 1 and 53.

See also methods *weekNumberYear*, *weekNumberDate*, and *weeksInYear*.

Example 5.231. DateTime class — weekNumber method

```
say weekNumber(2018, 12, 31)    -- 1 2019-W01-1
say weekNumber(2019,  1,  1)    -- 1 2019-W01-2

say weekNumber(2020, 12, 31)    -- 53 2020-W53-4
say weekNumber(2021,  1,  1)    -- 53 2020-W53-5
return

weekNumber: procedure
  date = .DateTime~new(arg(1), arg(2), arg(3))
  return date~weekNumber date~weekNumberDate
```

5.4.6.22. weekNumberDate

Returns the timestamp formatted as a string in extended ISO week number date format **`yyyy-Www-d`** with leading zeros as required.

See also methods *fromWeekNumberDate (Class Method)* and *weekNumberYear*, and *weekDay*.

Example 5.232. DateTime class — weekNumberDate method

```
say .DateTime~new(2018, 12, 31)~weekNumberDate    -- 2019-W01-1
say .DateTime~new(2019,  1,  1)~weekNumberDate    -- 2019-W01-2

say .DateTime~new(2020, 12, 31)~weekNumberDate    -- 2020-W53-4
say .DateTime~new(2021,  1,  1)~weekNumberDate    -- 2020-W53-5
```

5.4.6.23. weekNumberYear

Returns the year associated with this date's ISO week number. The returned year may be the next or the previous year for dates at the beginning or end of the year.

See also methods *weekNumber*, *weekNumberDate*, and *weeksInYear*.

Example 5.233. DateTime class — weekNumberYear method

```
say weekNumber(2018, 12, 31)    -- 2019 2019-W01-1
say weekNumber(2019,  1,  1)    -- 2019 2019-W01-2

say weekNumber(2020, 12, 31)    -- 2020 2020-W53-4
say weekNumber(2021,  1,  1)    -- 2020 2020-W53-5
return

weekNumber: procedure
  date = .DateTime~new(arg(1), arg(2), arg(3))
  return date~weekNumberYear date~weekNumberDate
```

5.4.6.24. weeksInYear

Returns the number of weeks in this date's year according to the ISO week number rules.

There are either 52 or 53 ISO weeks in any given year.

See also methods *weekNumber*, *weekNumberYear*, and *weekNumberDate*.

Example 5.234. DateTime class — weeksInYear method

```
do year = 2010 to 2030
```

```
  d = .DateTime~new(year, 6, 30)
  if d~weeksInYear \= 52 then
    say year":" d~weeksinYear -- 2015: 53, 2020: 53, 2026: 53
end
```

5.4.6.25. year

Returns the timestamp year.

5.4.6.26. month

Returns the timestamp month.

5.4.6.27. day

Returns the timestamp day.

5.4.6.28. hours

Returns number of whole hours in the timestamp since midnight.

5.4.6.29. minutes

Returns the minutes portion of the timestamp time-of-day.

5.4.6.30. ordinalDate

Returns the timestamp formatted as a string in extended ISO ordinal date format **yyyy-ddd** with leading zeros as required.

See also methods *fromOrdinalDate (Class Method)* and *yearDay*.

Example 5.235. DateTime class — ordinalDate method

```
say .DateTime~new(2020, 2, 10)~ordinalDate    -- 2020-041
```

5.4.6.31. seconds

Returns the seconds portion of the timestamp time-of-day.

5.4.6.32. makeString

Returns the timestamp formatted as a string in extended ISO format **`yyyy-mm-ddThh:mm:ss.uuuuuu`**. This is an alias of the *string* method.

5.4.6.33. microseconds

Returns the microseconds portion of the timestamp time-of-day.

5.4.6.34. dayMinutes

Returns the number of minutes since midnight in the timestamp time-of-day.

5.4.6.35. daySeconds

Returns the number of seconds since midnight in the timestamp time-of-day.

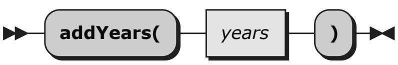
5.4.6.36. dayMicroseconds

Returns the number of microseconds since midnight in the timestamp time-of-day.

5.4.6.37. hashCode

Returns a string value for the timestamp that is used as a hash value for a *MapCollection class*.

5.4.6.38. addYears



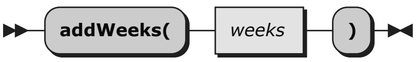
Returns a new **`DateTime`** instance with a number of years added to the timestamp. The receiving instance is unchanged. The *years* value must be a valid whole number. Negative values result in *years* being subtracted.

The `addYears` method will take leap years into account. If the addition result would fall on February 29th of a non-leap year, the day will be rolled back to the 28th.

Example 5.236. DateTime class — addYears method

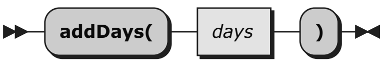
```
date = .DateTime~new(2016, 6, 30)
say date              -- displays "2016-06-30T00:00:00.000000"
say date~addYears(1)  -- displays "2017-06-30T00:00:00.000000"
```

5.4.6.39. addWeeks



Returns a new **`DateTime`** instance with a number of weeks added to the timestamp. The receiving instance is unchanged. The *weeks* value must be a valid number, including fractional values. Negative values result in *weeks* being subtracted.

5.4.6.40. addDays

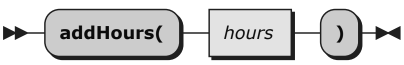


Returns a new **`DateTime`** instance with a number of days added to the timestamp. The receiving instance is unchanged. The *days* value must be a valid number, including fractional values. Negative values result in days being subtracted.

Example 5.237. DateTime class — addDays method

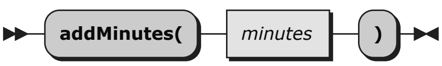
```
date = .DateTime~new(2016, 6, 30)
say date              -- displays "2016-06-30T00:00:00.000000"
say date~addDays(1.5) -- displays "2016-07-01T12:00:00.000000"
```

5.4.6.41. addHours



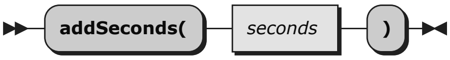
Returns a new **`DateTime`** instance with a number of hours added to the timestamp. The receiving instance is unchanged. The *hours* value must be a valid number, including fractional values. Negative values result in hours being subtracted.

5.4.6.42. addMinutes



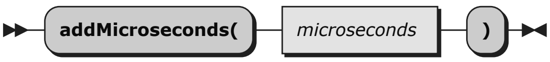
Returns a new **`DateTime`** instance with a number of minutes added to the timestamp. The receiving instance is unchanged. The *minutes* value must be a valid number, including fractional values. Negative values result in minutes being subtracted.

5.4.6.43. addSeconds



Returns a new **`DateTime`** instance with a number of seconds added to the timestamp. The receiving instance is unchanged. The *seconds* value must be a valid number, including fractional values. Negative values result in seconds being subtracted.

5.4.6.44. addMicroseconds



Returns a new **`DateTime`** instance with a number of microseconds added to the timestamp. The receiving instance is unchanged. The *microseconds* value must be a valid whole number. Negative values result in microseconds being subtracted.

5.4.6.45. isoDate

Returns the timestamp formatted as a string in extended ISO format **`yyyy-mm-ddThh:mm:ss.uuuuuu`**.

The *string* method will also return this value.

5.4.6.46. utcIsoDate

Returns the timestamp formatted as a string in extended timezone-qualified ISO format. If the timezone offset is 0, the format is **`yyyy-mm-ddThh:mm:ss.uuuuuuZ`**. If the offset is positive, the string is formatted as **`yyyy-mm-ddThh:mm:ss.uuuuuu+hh:mm`**. If the offset is negative, the result will be in the format **`yyyy-mm-ddThh:mm:ss.uuuuuu-hh:mm`**.

5.4.6.47. baseDate

Returns the number of complete days (that is, not including the timestamp day) since and including the base date, 1 January 0001, in the format **dddddd** (no leading zeros or whitespace characters).

The base date of 1 January 0001 is determined by extending the current Gregorian calendar backward (365 days each year, with an extra day every year that is divisible by 4 except century years that are not divisible by 400). It does not take into account any errors in the calendar system that created the Gregorian calendar originally.

5.4.6.48. yearDay

Returns the number of days, including the timestamp day, that have passed in the year the timestamp represents in the format **ddd** (no leading zeros or blanks).

See also method *ordinalDate*.

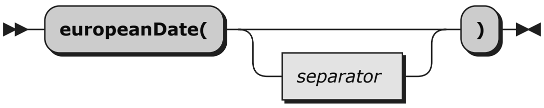
Example 5.238. DateTime class — yearDay method

```
say .DateTime~new(2020, 2, 10)~yearDay    -- 41
```

5.4.6.49. weekDay

Returns the timestamp weekday as an integer. The values returned use the ISO convention for day numbering. Monday is **1**, Tuesday is **2**, running through **7** for Sunday.

5.4.6.50. europeanDate



Returns the timestamp date formatted as a string in the format **dd/mm/yy**. If specified, *separator* identifies the field separator character used in the returned string. The separator must be a single character or the null string (""). A slash ("/") is the default separator.

5.4.6.51. languageDate

Returns the timestamp date formatted as a string in an implementation- and language-dependent, or local, date format. The format is **dd month yyyy**. The name of the month is according to the national language installed on the system. If no local date format is available, the default format is returned.

Note

This format is intended to be used as a whole. Rexx programs must not make any assumptions about the form or content of the returned string.

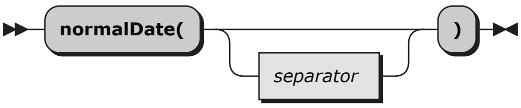
5.4.6.52. monthName

Returns the name of the timestamp month, in English.

5.4.6.53. dayName

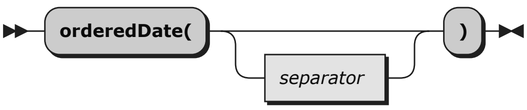
Returns the name of the timestamp weekday, in English.

5.4.6.54. normalDate



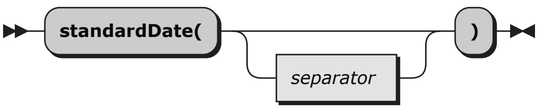
Returns the timestamp date formatted as a string in the format **`dd mon yyyy`**. If specified, *separator* identifies the field separator character used in the returned date. The separator must be a single character or the null string (""). A blank (" ") is the default separator.

5.4.6.55. orderedDate



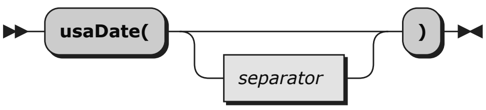
Returns the timestamp date formatted as a string in the format **`yy/mm/dd`**. If specified, *separator* identifies the field separator character used in the returned date. The separator must be a single character or the null string (""). A slash ("/") is the default separator.

5.4.6.56. standardDate



Returns the timestamp date formatted as a string in the format **`yyyymmdd`**. If specified, *separator* identifies the field separator character used in the returned date. The separator must be a single character or the null string (""). A null string ("") is the default separator.

5.4.6.57. usaDate



Returns the timestamp date formatted as a string in the format **`mm/dd/yy`**. If specified, *separator* identifies the field separator character used in the returned date. The separator must be a single character or the null string (""). A slash ("/") is the default separator.

5.4.6.58. civilTime

Returns the timestamp time formatted as a string in **`Civil`** format **`hh:mmxx`**. The hours can take the values **`1`** through **`12`**, and the minutes the values **`00`** through **`59`**. The minutes are followed immediately by the letters **`am`** or **`pm`**. This distinguishes times in the morning (12 midnight through

11:59 a.m.—appearing as **12:00am** through **11:59am**) from noon and afternoon (12 noon through 11:59 p.m.—appearing as **12:00pm** through **11:59pm**). The hour has no leading zero. The minute field shows the current minute (rather than the nearest minute) for consistency with other TIME results.

5.4.6.59. normalTime

Returns the timestamp time formatted as a string in the default format **hh:mm:ss**. The hours can have the values **00** through **23**, and minutes and seconds, **00** through **59**. There are always two digits. Any fractions of seconds are ignored (times are never rounded).

5.4.6.60. longTime

Returns the timestamp time formatted as a string in the format **hh:mm:ss.uuuuuu** (where **uuuuuu** are microseconds).

5.4.6.61. fullDate

Returns the timestamp's number of microseconds since 00:00:00.000000 on 1 January 0001, in the format **dddddddddddddddddd** (no leading zeros or blanks).

5.4.6.62. utcDate

Returns the timestamp converted to UTC time as the number of microseconds since 00:00:00.000000 on 1 January 0001, in the format **dddddddddddddddddd** (no leading zeros or blanks).

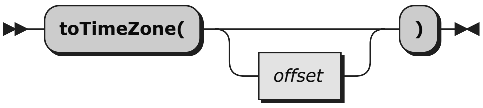
5.4.6.63. toLocalTime

Returns a new **DateTime** instance representing the time for the local timezone.

5.4.6.64. toUtcTime

Returns a new **DateTime** instance representing the time for the UTC timezone (offset 0).

5.4.6.65. toTimezone



Returns a new **`DateTime`** instance representing the time for the timezone indicated by *offset*.

If specified, *offset* is the offset from UTC, in minutes. The *offset* must be a valid whole number between -900 and 900 or an equivalent *TimeSpan* instance. The default *offset* is **`0`**, which creates a DateTime object for UTC.

5.4.6.66. ticks

Returns the timestamp's number of seconds since 00:00:00.000000 on 1 January 1970, in the format **`ddddddddddd`** (no leading zeros or blanks). Times prior to 1 January 1970 are returned as a negative value.

5.4.6.67. offset

Returns the timestamp timezone as an offset in minutes from UTC. Timezones east of UTC will return a positive offset. Timezones west of UTC will return a negative offset.

5.4.6.68. date

Returns a new **`DateTime`** instance for the timestamp date, with the time component set to 00:00:00.000000.

5.4.6.69. timeOfDay

Returns the interval since 00:00:00.000000 of the timestamp day as a *TimeSpan* object.

5.4.6.70. elapsed

Returns the difference between the current date/time and the timestamp date/time as a *TimeSpan* object. The time span will be negative if the receiving instance represents a time in the future.

5.4.6.71. isLeapYear

Returns `.true` if the timestamp year is a leap year. Returns `.false` otherwise.

5.4.6.72. daysInMonth

Returns the number of days in the timestamp month. For example, for dates in January, 31 is returned. The `daysInMonth` method takes leap years into account, returning **28** for February in non-leap years, and **29** for leap years.

5.4.6.73. daysInYear

Returns the number of days in the timestamp year. For leap years, **366** is returned, and **365** for non-leap years.

5.4.6.74. string

Returns the timestamp formatted as a string in extended ISO format **yyyy-mm-ddThh:mm:ss.uuuuuu**.

The *isoDate* method will also return this value.

5.4.7. EventSemaphore Class

An event semaphore is a synchronization mechanism that can be used to indicate to activities when a particular condition—the event—has become true.

An event can be set by posting the event semaphore, or cleared by resetting it. An activity, a *concurrent* chain of execution, can choose to get suspended while waiting for the event to become true, at which point the activity is released and continues to execute.

Table 5.42. EventSemaphore Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
EventSemaphore		
new (Class Method)		
isPosted	*reset*	*wait*
post	*uninit*	

5.4.7.1. new (Class Method)

Returns a new **`EventSemaphore`** instance. Initially the semaphore is in the cleared state.

5.4.7.2. isPosted

Returns **`.true`** if the event semaphore is in the posted state, **`.false`** if it is currently cleared.

See also methods *post* and *reset*.

Example 5.239. EventSemaphore class — isPosted method

```
sem = .EventSemaphore~new
say sem~isPosted    -- 0
sem~post
say sem~isPosted    -- 1
```

5.4.7.3. post

Sets the event semaphore to the posted state. All suspended activities *waiting* for this event are released. Activities calling the `wait` method while the event semapahore is already in the posted state will continue executing without getting suspended.

See also method *reset*.

5.4.7.4. reset

Clears the event semaphore. During the time the semaphore is cleared, any activities starting a blocking *wait* get suspended.

See also method *post*.

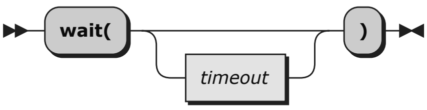
5.4.7.5. uninit

This method cleans up the event semaphore when it is garbage collected.

Note

`uninit` should not be invoked directly except via an uninit method of a subclass of the EventSemaphore class. Any such subclassed uninit method must forward to the superclass uninit method.

5.4.7.6. wait



Returns **`.true`** if waiting for the event semaphore to get posted has been successful or the semaphore is already in the posted state, and **`.false`** if a timeout occurred while waiting.

If *timeout* is specified it must be a *TimeSpan* instance or a valid Rexx number. If the value is negative or if *timeout* is omitted, `wait` suspends the current activity until the semaphore gets posted.

If *timeout* is zero, `wait` immediately returns with a return value as if *isPosted* had been called.

If the *timeout* period is positive, `wait` suspends the current activity for *timeout* seconds or until the semaphore gets posted, whatever comes first.

Any number of activities can wait for an event semaphore. When the semaphore is posted, all waiting activities are released. The exact order in which released activities resume execution is unspecified and should not be relied upon.

Example 5.240. EventSemaphore class — wait method

```
event = .EventSemaphore~new

say "main starts tasks"
do nr = 1 to 5
  .task~new~waitFor(event, "task" nr)
end
call SysSleep 0.1

say "main posts"
event~post
say "main ends"

::class Task

::method waitFor
  reply
  use strict arg event, name
  say name "waits"
  event~wait
  say name "runs"
```

may output

```
main starts tasks
task 2 waits
task 5 waits
```

```
task 1 waits
task 3 waits
task 4 waits
main posts
main ends
task 4 runs
task 3 runs
task 1 runs
task 2 runs
task 5 runs
```

5.4.8. File Class

The **File** class provides services which are common to all Rexx-supported filesystems. A **File** object represents a path to a file or directory. The path can be relative or absolute.

If you create a **File** object with a relative path, the absolute path will be calculated using the current default directory. This absolute path is memorized on the **File** object, and will not change if you change the default directory.

Table 5.43. File Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
+ Orderable (Mixin Class)		
Methods inherited from the *Orderable class* *Comparison Methods* = == < <= << <<= <> > >= >< >> >>= \= \== \< \<< \> \>> *compareTo*		
+ Comparable (Mixin Class)		
Methods inherited from the *Comparable class* *compareTo*		
File		
isCaseSensitive (Class Method) *listRoots (Class Method)* *pathSeparator (Class Method)*	*searchPath (Class Method)* *separator (Class Method)* *temporaryPath (Class Method)*	
absoluteFile *absolutePath* *canRead* *canWrite* *compareTo* *delete* *exists* *extension* *hashCode* *init* *isCaseSensitive*	*isDirectory* *isFile* *isHidden* *lastAccessed (Attribute)* *lastModified (Attribute)* *length* *list* *listFiles* *makeDir* *makeDirs* *makeString*	*name* *parent* *parentFile* *path* *pathSeparator* *renameTo* *separator* *setReadOnly* *setWritable* *string*

5.4.8.1. isCaseSensitive (Class Method)

Returns the case-sensitivity, `.true` or `.false`, of root (`/`) on Unix-like systems. On Windows, returns the case-sensitivity of the Windows system directory.

See also instance method *isCaseSensitive*.

5.4.8.2. listRoots (Class Method)

Returns the file system root elements, as an array of strings. On Windows, each of the drives is a root element in the format `d:\`. On Unix-like systems, there is just one root (`/`).

Example 5.241. File class

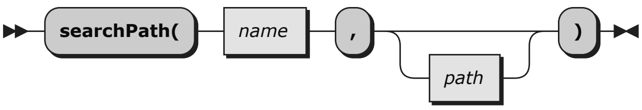
```
say .File~listRoots~toString(, " ")   -- C:\ D:\ E:\ R:\ (e. g. on Windows)
say .File~listRoots~toString(, " ")   -- / (Unix-like system)
```

5.4.8.3. pathSeparator (Class Method)

Returns the separator used for file search paths, "`;`" on Windows and "`:`" on Unix-like systems.

See also instance method *pathSeparator*.

5.4.8.4. searchPath (Class Method)



Returns a new File instance of the file *name*, if it can be located along *path*. Returns `.nil` otherwise.

The *name* must be a valid file name without wildcard characters and may optionally include a relative path. The *path* must be a String, a Collection, or any object that provides a `makeArray` method. Specified *path* items must be valid directories separated by the platform's *path separator*. If omitted, *path* defaults to the value of the **PATH** environment variable.

See also RexxUtil function *SysSearchPath*.

Example 5.242. File class — searchPath method

```
say .File~searchPath("rexx.exe")     -- e. g. C:\Program Files\ooRexx\rexx.exe
say .File~searchPath("rexx")         -- e. g. /usr/local/bin/rexx
```

5.4.8.5. separator (Class Method)

Returns the file name separator used by the file system ("\" on Windows, "/" on Unix-like systems).

This query method is available as both an instance and class method.

Example 5.243. File class — separator method

```
file = .File~new("dir1" || .File~separator || "dir2" || .File~separator || "file")
-- "dir1/dir2/file" on Unix-like systems, "dir1\dir2\file" on Windows
```

5.4.8.6. temporaryPath (Class Method)

temporaryPath

Returns the full path to the user's temporary directory as a new instance of File.

On Windows this method returns the value of the environment variable **`TMP`**, **`TEMP`** or **`USERPROFILE`**, whichever is defined in this sequence. If none of them are defined it returns the current directory. On Unix-like systems it returns the value of the environment variable **`TMPDIR`**, or returns **`/tmp`** if **`TMPDIR`** is undefined.

See also RexxUtil function *SysTempFileName*.

Example 5.244. File class — temporaryPath method

```
say .File~temporaryPath    -- (Windows e.g.) C:\Users\USER~1\AppData\Local\Temp
say .File~temporaryPath    -- (Unix-like system e.g.) /tmp
```

5.4.8.7. absoluteFile

absoluteFile

Returns the fully qualified path as a new instance of File.

Example 5.245. File class — absoluteFile method

```
/* On Windows */
'cd c:\program files\oorexx'
say .File~new("my file")~absoluteFile~class        -- The File class
say .File~new("my file")~absoluteFile              -- c:\program files\oorexx\my file
say .File~new("..\my file")~absoluteFile           -- c:\program files\my file
say .File~new("..\..\my file")~absoluteFile        -- c:\my file
say .File~new("..\..\my dir\my file")~absoluteFile -- c:\my dir\my file

/* On Linux */
'cd /opt/ooRexx'
say .File~new("my file")~absoluteFile              -- /opt/ooRexx/my file
say .File~new("../my file")~absoluteFile           -- /opt/my file
```

5.4.8.8. absolutePath

absolutePath

Returns the fully qualified path as a string.

Example 5.246. File class — absolutePath method

```
/* On Windows */
'cd c:\program files\oorexx'
say .File~new("my file")~absolutePath~class        -- The String class
say .File~new("my file")~absolutePath              -- c:\program files\oorexx\my file
say .File~new("..\my file")~absolutePath           -- c:\program files\my file
say .File~new("..\..\my file")~absolutePath        -- c:\my file
say .File~new("..\..\my dir\my file")~absolutePath -- c:\my dir\my file

/* On Linux */
'cd /opt/ooRexx'
say .File~new("my file")~absolutePath              -- /opt/ooRexx/my file
say .File~new("../my file")~absolutePath           -- /opt/my file
```

5.4.8.9. canRead

Returns **.true** if the file exists and is readable. Otherwise returns **.false**.

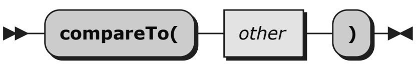
See also methods *canWrite*. *setReadOnly*. *setWritable*.

5.4.8.10. canWrite

Returns **.true** if the file exists and is writable. Otherwise returns **.false**.

See also methods *canRead*, and *setReadOnly*. *setWritable*.

5.4.8.11. compareTo



Performs a sorting comparison of the target File object to the *other* File object. The comparison is made on the absolute paths (strings) of both File objects. If the filesystem is case-sensitive then the paths comparison is case-sensitive, otherwise the comparison is caseless. If the two paths are equal, 0 is returned. If the target path is larger, 1 is returned. -1 if the *other* argument is the larger path.

Example 5.247. File class — compareTo method

```
call directory .File~listRoots[1]
file1 = .File~new("file", "dir")
file2 = .File~new("FILE", "DIR")
file1~compareTo(file2)  -- 0 on Windows (both Files denote the same path)
file1~compareTo(file2)  -- 1 on Unix-like system ("/dir/file" is greater than "/DIR/FILE")
```

5.4.8.12. delete

Deletes the file or directory denoted by the absolute path of the target File object. Only empty directories can be deleted.

Returns **`.true`** if the deletion was successful, otherwise returns **`.false`**.

5.4.8.13. exists

Returns **`.true`** if the file or directory (denoted by the absolute path of the target File object) exists. Otherwise returns **`.false`**.

5.4.8.14. extension

Returns the file's extension, the portion of the file name after the last dot.

See also method *name*.

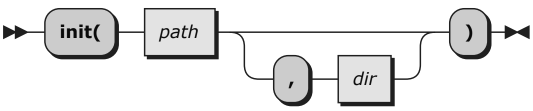
Example 5.248. File class — extension method

```
say .File~new("/usr/local/lib/rexx.img")~extension    -- img
say .File~new("/")~name                               -- ""
```

5.4.8.15. hashCode

Returns a string value that is used as a hash value for MapCollection such as Table, Relation, Set, Bag, and Directory.

5.4.8.16. init



Initializes a new File instance with the path *path* (after normalization).

If specified, *dir* is a parent path that is prepended to *path*. If *dir* is a File object then the absolute path of *dir* is prepended, otherwise *dir* is prepended as-is (after normalization). The normalization consists in adjusting the separators to the platform's convention and removing the final separator (if any).

Example 5.249. File class — init method

```
/* Windows */
file = .File~new("file")                     -- file
file = .File~new("c:\program files\")        -- c:\program files
```

```
file = .File~new("file", "c:/program files") -- c:\program files\file
'cd c:\program files\oorexx'
samples = .File~new("samples")                -- samples
file = .File~new("file", "samples")           -- samples\file
file = .File~new("file", samples)             -- c:\program files\oorexx\samples\file

/* Unix-like system */
file = .File~new("/opt/ooRexx/")              -- /opt/ooRexx
'cd /opt/ooRexx'
samples = .File~new("samples")                -- samples
file = .File~new("file", "samples")           -- samples/file
file = .File~new("file", samples)             -- /opt/ooRexx/samples/file
```

5.4.8.17. isCaseSensitive

Returns the case-sensitivity, **`.true`** or **`.false`**, of the file or directory represented by the absolute path of the target File object. If the referenced file or directory does not exist, the case-sensitivity of the final existing folder along the referenced absolute path is returned.

See also class method *isCaseSensitive (Class Method)*.

5.4.8.18. isDirectory

Returns **`.true`** if the absolute path of the target File object references a directory. Otherwise returns **`.false`**.

5.4.8.19. isFile

Returns **`.true`** if the absolute path of the target File object references a file. Otherwise returns **`.false`**.

5.4.8.20. isHidden

Returns **`.true`** if the absolute path of the target File object references an existing file or directory which is hidden. Otherwise returns **`.false`**.

On Windows, a file or directory is hidden when its attribute FILE_ATTRIBUTE_HIDDEN is set.

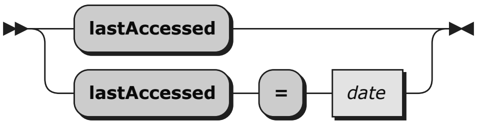
On Unix-like systems, a file or directory is hidden when its name starts with a period character (".") or when one of its parent directories has a name starting with a period character.

Example 5.250. File class — isHidden method

```
/* Unix-like system, when file exists */
say .File~new("/tmp/file")~isHidden              -- 0
```

```
say .File~new("/tmp/.file")~isHidden            -- 1
say .File~new("/tmp/.dir/file")~isHidden        -- 1
```

5.4.8.21. lastAccessed (Attribute)



lastAccessed get:

Returns the last access date of the file or directory denoted by the absolute path of the receiver object. The result is a *DateTime* object, or **`.nil`** if the file or directory doesn't exist or the last access time stamp cannot be retrieved.

lastAccessed set:

If the file or directory denoted by the absolute path of the receiver object exists, this sets the last access date of the file or directory. Otherwise it does nothing.

The *date* parameter must be a *DateTime* object.

See also method *lastModified (Attribute)*.

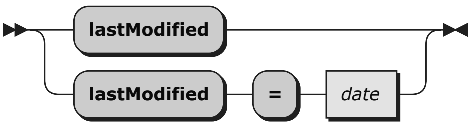
Note

File last access time stamps may not be available on all file systems. Also, on Windows last access time is not updated for NTFS volumes by default.

Example 5.251. File class — lastAccessed attribute

```
say .File~new(".")~lastAccessed  -- e. g. 2020-02-06T13:03:42.143095
```

5.4.8.22. lastModified (Attribute)



lastModified get:

Returns the last modified date of the file or directory denoted by the absolute path of the receiver object. The result is a *DateTime* object, or **`.nil`** if the file or directory doesn't exist or the last modified time stamp cannot be retrieved.

lastModified set:

If the file or directory denoted by the absolute path of the receiver object exists, this sets the last modified date of the file or directory. Otherwise it does nothing.

The *date* parameter must be a **`DateTime`** object.

See also method *lastAccessed (Attribute)*.

Example 5.252. File class — lastModified attribute

```
/* On Windows */
say .File~new("C:\Program Files")~lastModified~class  -- The DateTime class
say .File~new("C:\Program Files")~lastModified        -- e.g. 2018-06-18T11:20:17.000000
say .File~new("dummy")~lastModified                   -- e.g. The NIL object


/* A possible implementation of : touch -c -m -r referenceFile file
   -c, --no-create             do not create any files
   -m                          change only the modification time
   -r, --reference=FILE        use this file's time instead of current time
*/
parse arg referenceFilePath filePath .
file = .File~new(filePath)
if \file~exists then
  return 0          -- OK, not an error
referenceFile = .File~new(referenceFilePath)
referenceDate = referenceFile~lastModified
if referenceDate == .nil then
  return 1          -- KO
file~lastModified = referenceDate
return 0            -- OK
```

5.4.8.23. length

Returns the size in bytes of the file/directory denoted by the absolute path of the receiver object.

5.4.8.24. list

Returns an array of files/directories names which are immediate children of the directory denoted by the absolute path of the receiver object. The order in which the names are returned is dependent on the file system (not necessarily alphabetic order). The special names "." and ".." are not returned.

The result is an array of strings. If the receiver object is not a directory then the result is **`.nil`**.

Example 5.253. File class — list method

```
names = .File~new("c:\program files\oorexx\samples")~list
say names~toString
/* Possible output */
api
ccreply.rex
complex.rex
drives.rex
factor.rex
(etc...)
```

5.4.8.25. listFiles

▶▶— listFiles —▶◀

Returns an array of files/directories which are immediate children of the directory denoted by the absolute path of the receiver object. The order in which the names are returned is dependent on the file system (not necessarily alphabetic order). The special names "." and ".." are not returned.

The result is an array of File objects. If the receiver object is not a directory then the result is **.nil**.

Example 5.254. File class — listFiles method

```
do file over deepListFiles("c:\program files\oorexx\samples")
    say file
end

-- Depth first iteration
::routine deepListFiles
use strict arg directory, accumulator=(.List~new)
files = .File~new(directory)~listFiles
if files == .nil then return accumulator
do file over files
    accumulator~append(file)
    if file~isDirectory then call deepListFiles file~absolutePath, accumulator
end
return accumulator

/* Possible output */
c:\program files\oorexx\samples\api
c:\program files\oorexx\samples\api\callrxnt
c:\program files\oorexx\samples\api\callrxnt\backward.fnc
c:\program files\oorexx\samples\api\callrxnt\callrxnt.c
c:\program files\oorexx\samples\api\callrxnt\callrxnt.exe
c:\program files\oorexx\samples\api\callrxnt\callrxnt.ico
c:\program files\oorexx\samples\api\callrxnt\callrxnt.mak
c:\program files\oorexx\samples\api\callrxwn
c:\program files\oorexx\samples\api\callrxwn\backward.fnc
(etc...)
```

5.4.8.26. makeDir

▶▶— makeDir —▶◀

Makes just the directory represented by the last *name* portion of the receiver object's absolute path. Does not create any parent directories, which must all exist for a successful creation of the leaf directory.

Returns **.true** if the creation was successful, otherwise returns **.false**. If the directory already exists then the result is **.false**.

5.4.8.27. makeDirs

▶▶— makeDirs —▶◀

Creates the entire directory hierarchy represented by the absolute path of the receiver object.

Returns **.true** if the creation was successful, otherwise returns **.false**. If the directory already exists then the result is **.false**.

5.4.8.28. makeString

```
>>--makeString--><
```

Returns the fully qualified path as a string. This is an alias of the *absolutePath* method.

5.4.8.29. name

```
>>--name--><
```

Returns the name portion of the receiver object's absolute path. This is everything after the last path separator. The file's extension is part of the name.

See also method *extension*.

Example 5.255. File class — name method

```
/* On Windows */
say .File~new("c:\program files\oorexx\rexx.exe")~name   -- rexx.exe
say .File~new("c:\")~name                               -- empty string

/* On Unix-like system */
say .File~new("/usr/local/lib/rexx.img")~name           -- rexx.img
say .File~new("/")~name                                 -- empty string
```

5.4.8.30. parent

```
>>--parent--><
```

Returns the parent directory portion of the receiver object's absolute path. If no separator is found or the absolute path ends with a separator (which means this is a root path) then returns **`.nil`**.

Example 5.256. File class — parent method

```
/* On Windows */
say .File~new("c:\program files\oorexx\rexx.exe")~parent   -- c:\program files\oorexx
say .File~new("c:\")~parent                               -- The NIL object
say .File~new("c:")~parent                                -- The NIL object

/* On Unix-like system */
say .File~new("/opt/ooRexx/bin/rexx.img")~parent           -- /opt/ooRexx/bin
say .File~new("/")~parent                                 -- The NIL object
```

5.4.8.31. parentFile

```
>>--parentFile--><
```

Returns the *parent* directory portion as a File object. If no separator is found or the absolute path ends with a separator (which means this is a root path) then returns **`.nil`**.

5.4.8.32. path

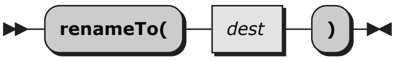
Returns the original path (after normalization) used to create the File object. The normalization consists in adjusting the separators to the platform's convention and removing the final separator (if any).

5.4.8.33. pathSeparator

Returns the separator used for file search paths, "`;`" on Windows and "`:`" on Unix-like systems.

See also class method *pathSeparator (Class Method)*.

5.4.8.34. renameTo



Changes the name of the file/directory denoted by the absolute path of the target object. The new name is *dest*.

Returns **`.true`** if the renaming was successful, otherwise returns **`.false`**.

On Windows, this method calls the `MoveFile` API to perform the action.

On Unix-like systems, this method calls the `rename` API to perform the action.

5.4.8.35. separator

Returns the file name separator used by the file system ("\" on Windows, "/" on Unix-like systems).

This query method is available as both an instance and class method.

5.4.8.36. setReadOnly

Sets the read-only flag of the file or directory denoted by the absolute path of the target object.

See also methods *setWritable*, *canRead*, and *canWrite*.

5.4.8.37. setWritable

Clears the read-only flag of the file or directory denoted by the absolute path of the target object.

See also methods *setReadOnly*. *canRead*, and *canWrite*.

5.4.8.38. string

Returns a string that indicates the path used to create the File object.

5.4.9. MessageNotification Class

The **`MessageNotification`** class implements the notification interface for the *Message* class.

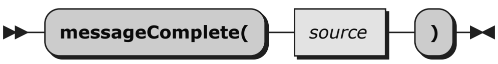
For any message, notification of completion of the message can be requested by using the *notify* method of the Message class. This method requires as its argument a notification target, that implements this message notification interface. If notification was requested, upon message completion a `messageComplete` message is sent to the notification target.

This class is defined as a MIXIN class.

Table 5.44. MessageNotification Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
MessageNotification (Mixin Class)
messageComplete (Abstract Method)

5.4.9.1. messageComplete (Abstract Method)



Whenever a message completes processing, for which notification was requested by using the *notify* method of the Message class, this method of the message notification target will be called. The Message object which completed processing will be provided as argument *source*.

It is an abstract method and must be implemented in a subclass.

5.4.10. Monitor Class

The **`Monitor`** class acts as a proxy for other objects. Messages sent to the Monitor object are forwarded to a different target object. The message target can be changed dynamically.

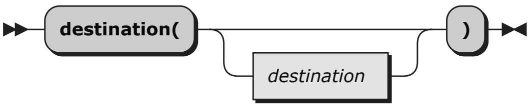
Table 5.45. Monitor Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
Monitor

5.4.10.1. current

Returns the current destination object.

5.4.10.2. destination

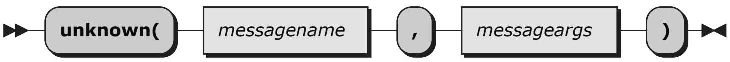


Returns a new destination object. If you specify *destination*, this becomes the new destination for any forwarded messages. If you omit *destination*, the previous destination object becomes the new destination for any forwarded messages.

5.4.10.3. init

Initializes the newly created monitor object.

5.4.10.4. unknown



Reissues or forwards to the current monitor destination all unknown messages sent to a monitor object. For additional information, see *Section 4.2.6, "Defining an UNKNOWN Method"*.

5.4.10.5. Examples

Example 5.257. Class MONITOR

```
.local~setentry("output",.monitor~new(.stream~new("my.new")~~command("open nobuffer")))

/* The following sets the destination */
previous_destination=.output~destination(.stream~new("my.out")~~command("open write"))
/* The following resets the destination */
.output~destination

.output~destination(.Stdout)
current_output_destination_stream_object=.output~current
```

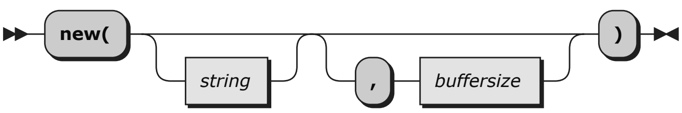
5.4.11. MutableBuffer Class

The **`MutableBuffer`** class is a buffer on which certain string operations such as concatenation can be performed very efficiently. Unlike String objects, MutableBuffers can be altered without requiring a new object allocation. A MutableBuffer object can provide better performance for algorithms that involve frequent concatenations to build up longer string objects because it creates fewer intermediate objects.

Table 5.46. MutableBuffer Class

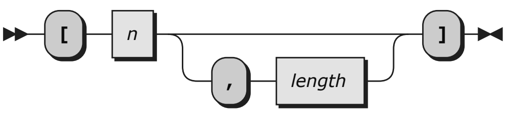
Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
MutableBuffer		
new (Class Method)		
[]	*countStr*	*setText*
[]=	*delete / delStr*	*space*
append	*delWord*	*startsWith*
caselessChangeStr	*endsWith*	*string*
caselessContains	*getBufferSize*	*subChar*
caselessContainsWord	*insert*	*substr*
caselessCountStr	*lastPos*	*subWord*
caselessEndsWith	*length*	*subWords*
caselessLastPos	*lower*	*translate*
caselessMatch	*makeArray*	*upper*
caselessMatchChar	*makeString*	*verify*
caselessPos	*match*	*word*
caselessStartsWith	*matchChar*	*wordIndex*
caselessWordPos	*overlay*	*wordLength*
changeStr	*pos*	*wordPos*
contains	*replaceAt*	*words*
containsWord	*setBufferSize*	

5.4.11.1. new (Class Method)



Initialize the buffer, optionally assign a buffer content and a starting *buffer size*. The default size is 256; the buffer size increases to the length of *string* if the string does not fit into the buffer.

5.4.11.2. []



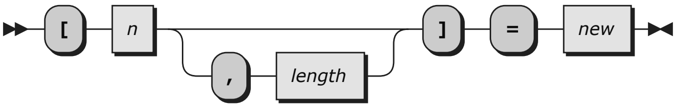
Returns a substring of the receiving buffer that begins at the *n*'th character and is of length *length*. The *n* must be a positive whole number. If *length* is omitted, it defaults to **1**. If *n* is greater than the length of the receiving string, a null string is returned.

See also methods *substr* and *subChar*.

Example 5.258. MutableBuffer class — [] method

```
s = .MutableBuffer~new(xrange("a", "z"))
say s[5]        -- "e"
say s[18, 3]    -- "rst"
say s[25,10]    -- "yz"
say s[30]       -- ""
```

5.4.11.3. []=



Returns the receiving buffer with the characters from the *n*th character for *length* characters replaced with *new*. The replacement position and length can extend beyond the end of the receiving string. The starting position, *n*, is required and must be a positive whole number. The *length* is optional and must be a positive whole number or zero. If *length* is omitted, it defaults to the length of *new*.

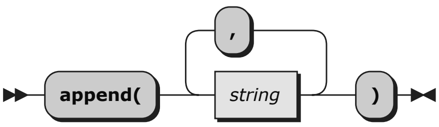
If *n* is greater than the length of the receiving string, blanks are added before the *new* string.

See also the similar MutableBuffer method *replaceAt*.

Example 5.259. MutableBuffer class — []= method

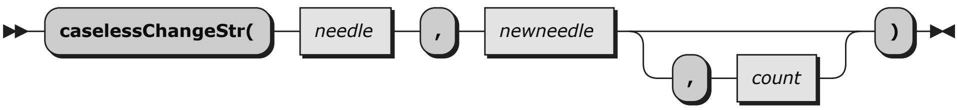
```
s = .MutableBuffer~new(xrange("a", "z"))
s[5] = "E"              -- "abcdEfghijklmnopqrstuvwxyz"
s[5] = "XXXX"           -- "abcdXXXXijklmnopqrstuvwxyz"
s[5] = ""               -- "abcdXXXXijklmnopqrstuvwxyz"
s[5, 1] = "="           -- "abcd=XXXijklmnopqrstuvwxyz"
s[5, 4] = "="           -- "abcd=ijklmnopqrstuvwxyz"
s[10, 2] = "REPLACE"    -- "abcd=ijklREPLACEopqrstuvwxyz"
s[4, 99] = ""           -- "abc"
```

5.4.11.4. append



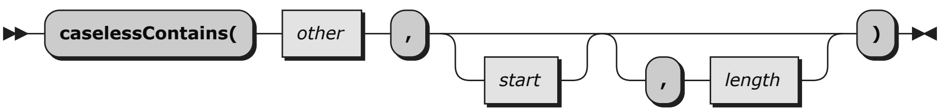
Returns the receiving buffer with all *string*s appended to the buffer content. The buffer size is increased if necessary.

5.4.11.5. caselessChangeStr



Returns the receiver MutableBuffer with *newneedle* replacing occurrences of *needle*. If *count* is not specified, all occurrences of *needle* are replaced. If *count* is specified, it must be a non-negative, whole number that gives the maximum number of occurrences to be replaced. The *needle* searches are performed using caseless comparisons.

5.4.11.6. caselessContains



Returns **`.true`** if the receiving buffer contains the *other* string. It returns **`.false`** if *other* is the null string or is not found within the receiving buffer. The search is performed using caseless comparisons.

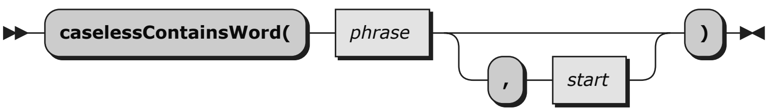
By default, the search starts at the first character of the receiving buffer and continues to the end of the buffer. You can override this by specifying *start*, the point at which the search starts, and *length*, the bounding limit for the search. If specified, *start* must be a positive whole number and *length* must be a non-negative whole number.

See also methods *contains*, *caselessStartsWith*, *caselessEndsWith*, and *caselessPos*.

Example 5.260. MutableBuffer class — caselessContains method

```
say .mutablebuffer~new('-abcdef-')~caselessContains('EF')        -- 1
say .mutablebuffer~new('-abcdef-')~caselessContains('-', 2, 6)    -- 0
```

5.4.11.7. caselessContainsWord



Returns **`.true`** if *phrase* is found in the receiving buffer. Returns **`.false`** if *phrase* contains no words or if *phrase* is not found. Word matches are made independent of case. Multiple whitespace characters between words in either *phrase* or the receiving buffer are treated as a single blank for the comparison, but, otherwise, the words must match, except for case.

By default the search starts at the first word in the receiving buffer. You can override this by specifying *start* (which must be a positive whole number), the word at which the search is to be started.

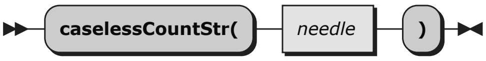
See also methods *containsWord* and *caselessWordPos* (`caselessContainsWord` returns **`.false`** exactly if `caselessWordPos` would have returned **`0`**.)

Example 5.261. MutableBuffer class — caselessContainsWord method

```
good = .MutableBuffer~new("Now is the time for all good men")
good~caselessContainsWord("the")          -- .true
good~caselessContainsWord("The")          -- .true
good~caselessContainsWord("is the")       -- .true
good~caselessContainsWord("is   the ")    -- .true
```

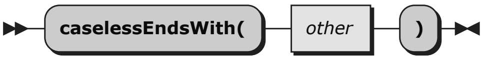
```
good~caselessContainsWord("is time")      -- .false
good~caselessContainsWord("time")         -- .true
good~caselessContainsWord("time", 5)      -- .false
```

5.4.11.8. caselessCountStr



Returns a count of the occurrences of *needle* in the receiving MutableBuffer that do not overlap. All matches are made using caseless comparisons.

5.4.11.9. caselessEndsWith

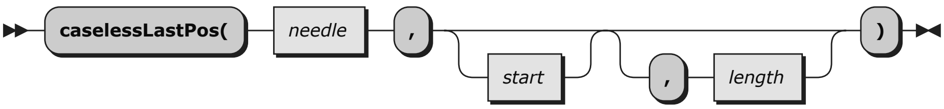


Returns **`.true`** if the characters of the *other* match the characters at the end of the target buffer. Returns **`.false`** if the characters are not a match, or if *other* is the null string. The match is made using caseless comparisons.

The caselessEndsWith method is useful for efficient string parsing as it does not require new string objects be extracted from the target buffer.

See also methods *caselessStartsWith*, *endsWith*, and *caselessMatch*.

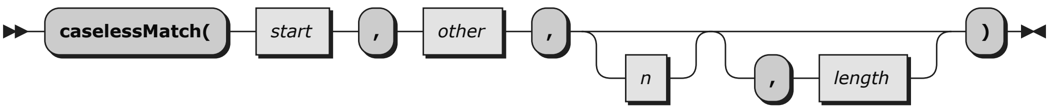
5.4.11.10. caselessLastPos



Returns the position of the last occurrence of a string, *needle*, in the receiving buffer. It returns **`0`** if *needle* is the null string or not found. By default, the search starts at the last character of the receiving buffer and scans backward to the beginning of the string. You can override this by specifying *start*, the point at which the backward scan starts and *length*, the range of characters to scan. The *start* must be a positive whole number and defaults to **`receiving_buffer~length`** if larger than that value or omitted. The *length* must be a non-negative whole number and defaults to *start*. The search is performed using caseless comparisons.

See also methods *lastPos* and *caselessPos*.

5.4.11.11. caselessMatch



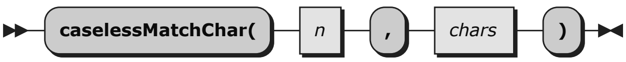
Returns **`.true`** if the characters of the *other* match the characters of the target buffer beginning at position *start*. Returns **`.false`** if the characters are not a match. The matching is performed using caseless comparisons. *start* must be a positive whole number.

If *n* is specified, the match will be performed starting with character *n* of *other*. The default value for *n* is "1". *n* must be a positive whole number less than or equal to the length of *other*.

If *length* is specified, it defines a substring of *other* that is used for the match. *length* must be a positive whole number and the combination of *n* and *length* must be a valid substring within the bounds of *other*.

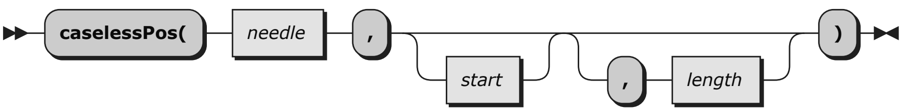
The caselessMatch method is useful for efficient string parsing as it does not require new string objects be extracted from the target string.

5.4.11.12. caselessMatchChar



Returns **.true** if the character at position *n* matches any character of the string *chars*. Returns **.false** if the character does not match any of the characters in the reference set. The match is made using caseless comparisons. The argument *n* must be a positive whole number.

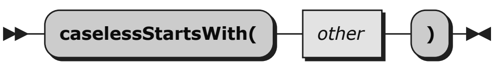
5.4.11.13. caselessPos



Returns the position in the receiving buffer of a *needle* string. It returns **0** if *needle* is the null string or is not found or if *start* is greater than the length of the receiving buffer. The search is performed using caseless comparisons. By default, the search starts at the first character of the receiving buffer (that is, the value of *start* is **1**), and continues to the end of the buffer. You can override this by specifying *start*, the point at which the search starts, and *length*, the bounding limit for the search. If specified, *start* must be a positive whole number and *length* must be a non-negative whole number.

See also method *lastPos*.

5.4.11.14. caselessStartsWith

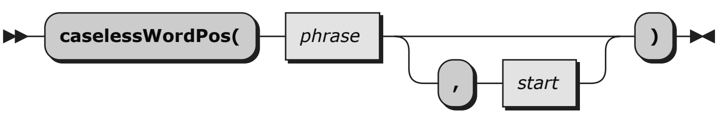


Returns **.true** if the characters of the *other* match the characters at the start of the target buffer. Returns **.false** if the characters are not a match, or if *other* is the null string. The match is made using caseless comparisons.

The caselessStartsWith method is useful for efficient string parsing as it does not require new string objects be extracted from the target buffer.

See also methods *startsWith*, *caselessEndsWith*, and *caselessMatch*.

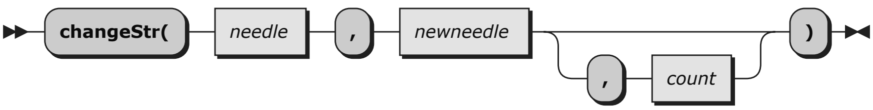
5.4.11.15. caselessWordPos



Returns the word number of the first word of *phrase* found in the receiving buffer, or **0** if *phrase* contains no words or if *phrase* is not found. Word matches are made independent of case. Multiple whitespace characters between words in either *phrase* or the receiving buffer are treated as a single blank for the comparison, but, otherwise, the words must match exactly.

By default the search starts at the first word in the receiving string. You can override this by specifying *start* (which must be positive), the word at which the search is to be started.

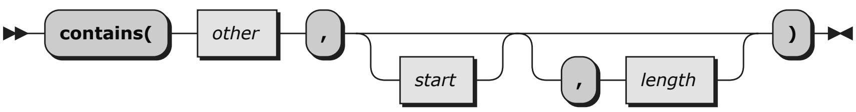
5.4.11.16. changeStr



Returns the receiver MutableBuffer with *newneedle* replacing occurrences of *needle*.

If *count* is not specified, all occurrences of *needle* are replaced. If *count* is specified, it must be a non-negative, whole number that gives the maximum number of occurrences to be replaced.

5.4.11.17. contains



Returns **`.true`** if the receiving buffer contains the *other* string. It returns **`.false`** if *other* is the null string or is not found within the receiving buffer.

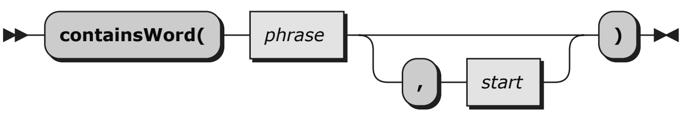
By default, the search starts at the first character of the receiving buffer and continues to the end of the buffer. You can override this by specifying *start*, the point at which the search starts, and *length*, the bounding limit for the search. If specified, *start* must be a positive whole number and *length* must be a non-negative whole number.

See also methods *caselessContains*, *startsWith*, *endsWith*, and *pos*.

Example 5.262. MutableBuffer class — caselessContains method

```
say .mutablebuffer~new('-abcdef-')~contains('ef')         -- 1
say .mutablebuffer~new('-abcdef-')~contains('-', 2, 6)    -- 0
```

5.4.11.18. containsWord



Returns **`.true`** if *phrase* is found in the receiving buffer. Returns **`.false`** if *phrase* contains no words or if *phrase* is not found. Multiple whitespace characters between words in either *phrase* or the receiving buffer are treated as a single blank for the comparison, but, otherwise, the words must match exactly.

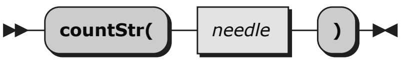
By default the search starts at the first word in the receiving buffer. You can override this by specifying *start* (which must be positive whole number), the word at which the search is to be started.

See also methods *caselessContainsWord* and *wordPos* (`containsWord` returns **`.false`** exactly if `wordPos` would have returned **`0`**.)

Example 5.263. MutableBuffer class — containsWord method

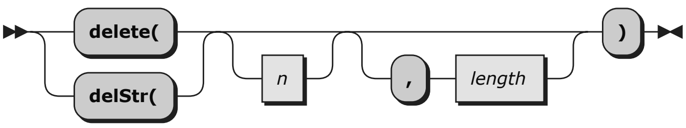
```
good = .MutableBuffer~new("Now is the time for all good men")
good~containsWord("the")           -- .true
good~containsWord("The")           -- .false
good~containsWord("is the")        -- .true
good~containsWord("is   the ")     -- .true
good~containsWord("is time")       -- .false
good~containsWord("time")          -- .true
good~containsWord("time", 5)       -- .false
```

5.4.11.19. countStr



Returns a count of the occurrences of *needle* in the receiving buffer that do not overlap.

5.4.11.20. delete / delStr

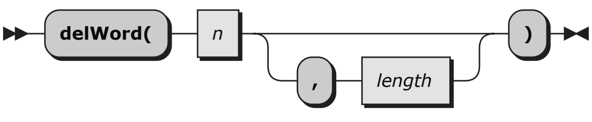


Returns the receiver MutableBuffer with *length* characters deleted from the buffer beginning at the *n*'th character. If *n* is omitted, it defaults to 1. If *length* is omitted, or if *length* is greater than the number of characters from *n* to the end of the buffer, the method deletes the remaining buffer contents (including the *n*'th character). The *length* must be a positive integer or zero. The *n* must be a positive integer. If *n* is greater than the length of the buffer or *length* is zero, the method does not modify the buffer content.

Note

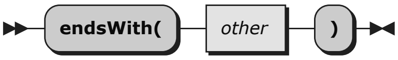
The `delete` method and the `delStr` method are identical. `delStr` is provided for polymorphism with the String class.

5.4.11.21. delWord



Deletes a substring from the MutableBuffer that starts at the *n*th word and is of *length* whitespace-delimited words. If you omit *length*, or if *length* is greater than the number of words from *n* to the end of the receiving buffer, the method deletes the remaining words in the receiving buffer (including the *n*th word). The *length* must be a positive whole number or zero. The *n* must be a positive whole number. If *n* is greater than the number of words in the receiving buffer, the method returns the receiving buffer unchanged. The portion deleted includes any whitespace characters following the final word involved but none of the whitespace characters preceding the first word involved.

5.4.11.22. endsWith



Returns **.true** if the characters of the *other* match the characters at the end of the target buffer. Returns **.false** if the characters are not a match, or if *other* is the null string.

The endsWith method is useful for efficient string parsing as it does not require new string objects be extracted from the target buffer.

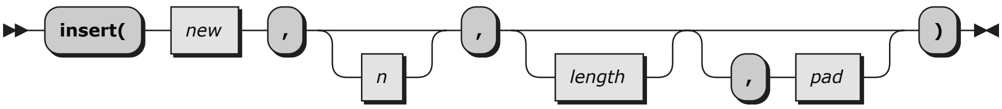
See also methods *startsWith*, *caselessEndsWith*, and *match*.

5.4.11.23. getBufferSize

Retrieves the current buffer size.

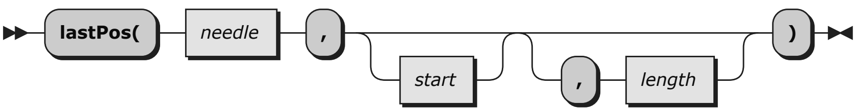
See also method *setBufferSize*.

5.4.11.24. insert



Returns the receiving buffer with the string *new*, padded or truncated to length *length*, inserted into the MutableBuffer after the *n*'th character. The default value for *n* is 0, which means insertion at the beginning of the string. If specified, *n* and length must be positive integers or zeros. If *n* is greater than the length of the buffer contents, the string new is padded at the beginning. The default value for *length* is the length of *new*. If length is less than the length of string *new*, insert truncates *new* to length *length*. The default *pad* character is a blank.

5.4.11.25. lastPos



Returns the position of the last occurrence of a string, *needle*, in the receiving buffer. It returns **0** if *needle* is the null string or not found. By default, the search starts at the last character of the receiving buffer and scans backward to the beginning of the string. You can override this by specifying *start*, the point at which the backward scan starts and *length*, the range of characters to scan. The *start* must be a positive whole number and defaults to **receiving_buffer~length** if larger than that value or omitted. The *length* must be a non-negative whole number and defaults to *start*.

See also methods *caselessLastPos* and *pos*.

Example 5.264. MutableBuffer class — lastPos method

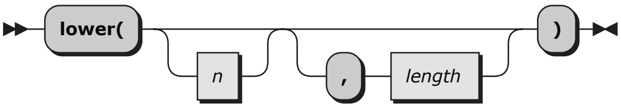
```
x1 = .mutablebuffer~new("abc def ghi")
```

```
x1~lastPos(" ")      ->    8
x1 = .mutablebuffer~new("abcdefghi")
x1~lastPos(" ") -> 0
x1 = .mutablebuffer~new("efgxyz")
x1~lastPos("xy")     ->    4
x1 = .mutablebuffer~new("abc def ghi")
x1~lastPos(" ",7) -> 4
```

5.4.11.26. length

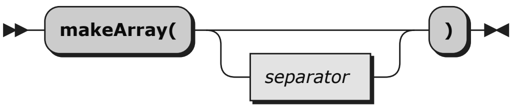
Returns length of data in buffer.

5.4.11.27. lower



Returns the receiving buffer with the characters of the target string beginning with character *n* for *length* characters converted to lowercase. If *n* is specified, it must be a positive whole number. If *n* is not specified, the case conversion will start with the first character. If *length* is specified, it must be a non-negative whole number. If *length* is not specified, the default is to convert the remainder of the buffer.

5.4.11.28. makeArray



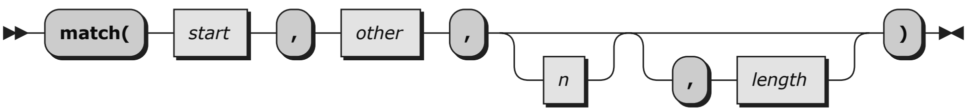
This method returns an Array of the receiving MutableBuffer's substrings that were separated by the *separator* string. *separator* may be any string, including the null string. If the null string is used, an Array containing each character of the MutableBuffer is returned. If the target MutableBuffer starts with the separator, the first Array item will be a null string. If the MutableBuffer ends with a separator, no extra null string item will be added. If *separator* isn't specified, any *line-end* indicator is honored.

5.4.11.29. makeString

Returns the content of the buffer as the string representation of the receiving buffer.

See also method *string*.

5.4.11.30. match



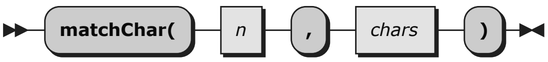
Returns **`.true`** if the characters of the *other* match the characters of the target buffer beginning at position *start*. Returns **`.false`** if the characters are not a match. *start* must be a positive whole number.

If *n* is specified, the match will be performed starting with character *n* of *other*. The default value for *n* is "1". *n* must be a positive whole number less than or equal to the length of *other*.

If *length* is specified, it defines a substring of *other* that is used for the match. *length* must be a positive whole number and the combination of *n* and *length* must be a valid substring within the bounds of *other*.

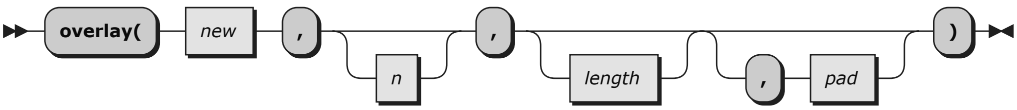
The match method is useful for efficient string parsing as it does not require new string objects be extracted from the target buffer.

5.4.11.31. matchChar



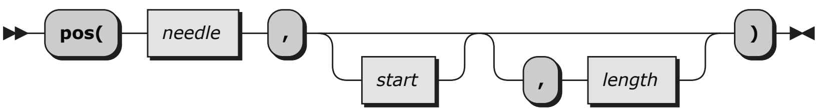
Returns **`.true`** if the character at position *n* matches any character of the string *chars*. Returns **`.false`** if the character does not match any of the characters in the reference set. The argument *n* must be a positive whole number.

5.4.11.32. overlay



Returns the receiving buffer after overlaying it, starting at the *n*'th character, with the string *new*, padded or truncated to length *length*. The overlay can extend beyond the end of the buffer. In this case the buffer size will be increased. If you specify *length*, it must be a positive integer or zero. The default value for *length* is the length of *new*. If *n* is greater than the length of the buffer content, padding is added before the new string. The default *pad* character is a blank, and the default value for *n* is 1. If you specify *n*, it must be a positive integer.

5.4.11.33. pos



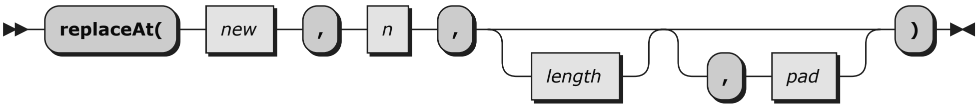
Returns the position in the receiving buffer of another string, *needle*. It returns **`0`** if *needle* is the null string or is not found or if *start* is greater than the length of the receiving buffer. By default, the search starts at the first character of the receiving buffer (that is, the value of *start* is **`1`**), and continues to the end of the string. You can override this by specifying *start*, the point at which the search starts, and *length*, the bounding limit for the search. If specified, *start* must be a positive whole number and *length* must be a non-negative whole number.

See also method *lastPos*.

Example 5.265. MutableBuffer class — pos method

```
x1 = .mutablebuffer~new("Saturday")
x1~pos("day")       ->    6
x1 = .mutablebuffer~new("abc def ghi")
x1~pos("x")         ->    0
x1~pos(" ")         ->    4
x1~pos(" ",5)       ->    8
```

5.4.11.34. replaceAt

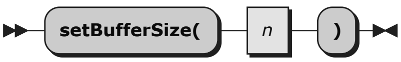


Returns the receiving buffer with the characters from the *n*th character for *length* characters replaced with *new*. The replacement position and length can extend beyond the end of the receiving string. The starting position, *n*, is required and must be a positive whole number. The *length* is optional and must be a positive whole number or zero. If *length* is omitted, it defaults to the length of *new*.

If *n* is greater than the length of the receiving string, padding is added before the *new* string. The default *pad* character is a blank.

See also the similar MutableBuffer method *[]=*.

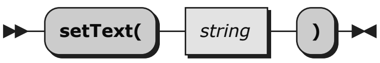
5.4.11.35. setBufferSize



Returns the receiving buffer with buffer size set to *n*. If *n* is less than the length of buffer content, the content is truncated. If *n* is 0, the entire content is erased and the new buffer size is the value given in the `init` method.

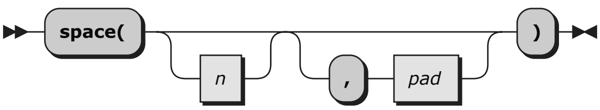
See also method *getBufferSize*.

5.4.11.36. setText



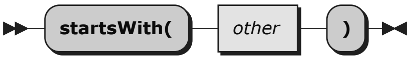
Returns the receiving buffer, with the buffer contents set to *string*.

5.4.11.37. space



Returns the target MutableBuffer, with *n* *pad* characters between each whitespace-delimited word. If you specify *n*, it must be a positive whole number or zero. If it is **`0`**, all whitespace characters are removed. Leading and trailing whitespace characters are always removed. The default for *n* is **`1`**, and the default *pad* character is a blank.

5.4.11.38. startsWith



Returns `.true` if the characters of the *other* match the characters at the start of the target buffer. Returns `.false` if the characters are not a match, or if *other* is the null string.

The startsWith method is useful for efficient string parsing as it does not require new string objects be extracted from the target buffer.

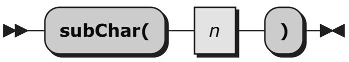
See also methods *caselessStartsWith*, *endsWith*, and *match*.

5.4.11.39. string

Retrieves the content of the buffer as a string.

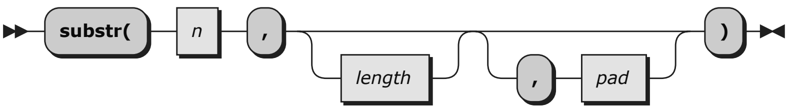
See also method *makeString* .

5.4.11.40. subChar



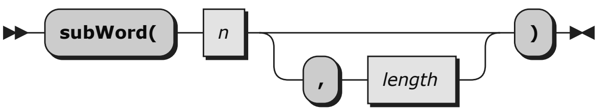
Returns the *n*'th character of the receiving buffer. *n* must be a positive whole number. If *n* is greater than the length of the receiving buffer then a zero-length string is returned.

5.4.11.41. substr



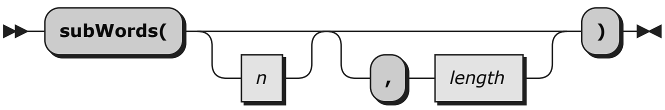
Returns a substring from the buffer content that begins at the *n*'th character and is of length *length*, padded with *pad* if necessary. The *n* must be a positive integer. If *n* is greater than the length of the receiving buffer, only *pad* characters are returned. If you omit *length*, the remaining buffer content is returned. The default *pad* character is a blank.

5.4.11.42. subWord



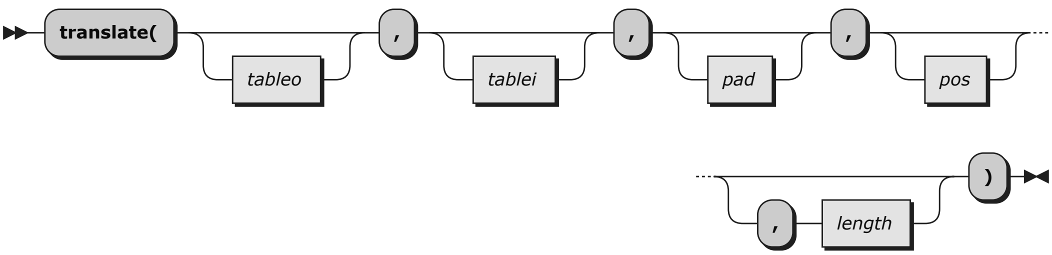
Returns the substring of the receiving buffer that starts at the *n*th word and is up to *length* whitespace-delimited words. The *n* must be a positive whole number. If you omit *length*, it defaults to the number of remaining words in the receiving buffer. The returned string never has leading or trailing whitespace characters, but includes all whitespace characters between the selected words.

5.4.11.43. subWords



Returns an array containing all words within the substring of the receiving mutablebuffer that starts at the *n*th word and is up to *length* whitespace-delimited words. The *n* must be a positive whole number. If you omit *n*, it defaults to 1. If you omit *length*, it defaults to the number of remaining words in the receiving mutablebuffer. The strings in the returned array never have leading or trailing whitespace.

5.4.11.44. translate



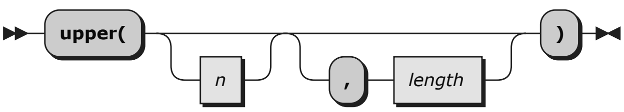
Returns the receiving buffer with each character translated to another character or unchanged.

The output table is *tableo* and the input translation table is *tablei*. `translate` searches *tablei* for each character in the receiving buffer. If the character is found, the corresponding character in *tableo* is replaces the character in the buffer. If there are duplicates in *tablei*, the first (leftmost) occurrence is used. If the character is not found, the original character in the receiving buffer is unchanged.

The tables can be of any length. If you specify neither translation table and omit *pad*, the receiving string is translated to uppercase (that is, lowercase **`a-z`** to uppercase **`A-Z`**), but if you include *pad* the buffer translates the entire string to *pad* characters. *tablei* defaults to **`XRANGE('00'x, 'ff'x)`**, and *tableo* defaults to the null string and is padded with *pad* or truncated as necessary. The default *pad* is a blank.

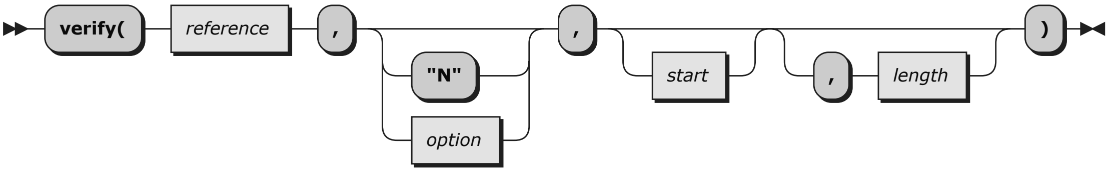
n is the position of the first character of the translated range. The default starting position is 1. *length* is the range of characters to be translated. If *length* is omitted, the remainder of the buffer from the starting position to the end is used.

5.4.11.45. upper



Returns the receiving buffer with the characters of the target string beginning with character *n* for *length* characters converted to uppercase. If *n* is specified, it must be a positive whole number. If *n* is not specified, the case conversion will start with the first character. If *length* is specified, it must be a non-negative whole number. If *length* is not specified, the default is to convert the remainder of the buffer.

5.4.11.46. verify



Returns a number that, by default, indicates whether the receiving buffer is composed only of characters from *reference*. It returns **0** if all characters in the receiving buffer are in *reference* or returns the position of the first character in the receiving buffer not in *reference*.

The *option* can be either **Nomatch** (the default) or **Match**. (You need to specify only the first capitalized and highlighted letter; all characters following the first character are ignored, which can be in uppercase or lowercase.)

If you specify **Match**, the method returns the position of the first character in the receiving buffer that is in *reference*, or returns **0** if none of the characters are found.

The default for *start* is **1**. Thus, the search starts at the first character of the receiving buffer. You can override this by specifying a different *start* point, which must be a positive whole number.

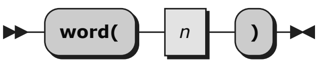
The default for *length* is the length of the buffer from *start* to the end of the buffer. Thus, the search proceeds to the end of the receiving buffer. You can override this by specifying a different *length*, which must be a non-negative whole number.

If the receiving string is null, the method returns **0**, regardless of the value of the *option*. Similarly, if *start* is greater than **receiving_buffer~length**, the method returns **0**. If *reference* is null, the method returns **0** if you specify **Match**. Otherwise, the method returns the *start* value.

Example 5.266. MutableBuffer class — verify method

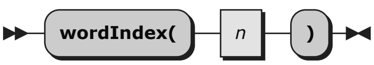
```
.mutablebuffer~new('123')~verify('1234567890')            ->    0
.mutablebuffer~new('1Z3')~verify('1234567890')            ->    2
.mutablebuffer~new('AB4T')~verify('1234567890')           ->    1
.mutablebuffer~new('AB4T')~verify('1234567890','M')       ->    3
.mutablebuffer~new('AB4T')~verify('1234567890','N')       ->    1
.mutablebuffer~new('1P3Q4')~verify('1234567890', ,3)      ->    4
.mutablebuffer~new('123')~verify("",N,2)                  ->    2
.mutablebuffer~new('ABCDE')~verify("", ,3)                ->    3
.mutablebuffer~new('AB3CD5')~verify('1234567890','M',4)   ->    6
.mutablebuffer~new('ABCDEF')~verify('ABC',"N",2,3)        ->    4
.mutablebuffer~new('ABCDEF')~verify('ADEF',"M",2,3)       ->    4
```

5.4.11.47. word



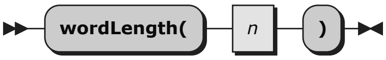
Returns the *n*th whitespace-delimited word in the receiving buffer or the null string if the receiving buffer has fewer than *n* words. The *n* must be a positive whole number. This method is exactly equivalent to **receiving_buffer~subWord(n, 1)**.

5.4.11.48. wordIndex



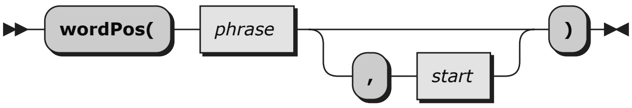
Returns the position of the first character in the *n*th whitespace-delimited word in the receiving buffer. It returns **`0`** if the receiving buffer has fewer than *n* words. The *n* must be a positive whole number.

5.4.11.49. wordLength



Returns the length of the *n*th whitespace-delimited word in the receiving buffer or **`0`** if the receiving buffer has fewer than *n* words. The *n* must be a positive whole number.

5.4.11.50. wordPos



Returns the word number of the first word of *phrase* found in the receiving buffer, or **`0`** if *phrase* contains no words or if *phrase* is not found. Multiple whitespace characters between words in either *phrase* or the receiving buffer are treated as a single blank for the comparison, but, otherwise, the words must match exactly.

By default the search starts at the first word in the receiving buffer. You can override this by specifying *start* (which must be positive), the word at which the search is to be started.

5.4.11.51. words

Returns the number of whitespace-delimited words in the receiving buffer.

5.4.12. MutexSemaphore Class

A mutex, or mutual exclusion semaphore is a synchronization mechanism which concurrent activities can use to control access to a common resource.

Mutual exclusion is the requirement that one activity, a *concurrent* chain of execution, never enters its critical section at the same time that another concurrent activity enters its own critical section.

An activity acquires the mutex semaphore before entering its critical section, and releases it after the critical section.

See also keyword instructions *GUARD ON and GUARD OFF*.

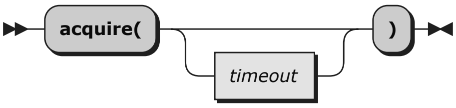
Table 5.47. MutexSemaphore Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
MutexSemaphore

5.4.12.1. new (Class Method)

Returns a new **MutexSemaphore** instance. Initially the mutex semaphore is in the released state.

5.4.12.2. acquire



Returns **.true** if the current activity has already owned or has just acquired the mutex semaphore. Returns **.false** if the mutex is owned by a different activity, or a timeout has occurred.

Nested acquires, from an activity already owning the mutex semaphore, are allowed, with each `acquire` increasing the mutex nesting level by one. An equivalent number of calls to *release* are needed to make the mutex available again to another activity.

If *timeout* is specified it must be a *TimeSpan* instance or a valid Rexx number. If the value is negative or if *timeout* is omitted, `acquire` suspends the current activity until it can get ownership of the mutex.

If *timeout* is zero, `acquire` immediately returns **.true** if the mutex was acquired, or **.false** otherwise.

If the *timeout* period is positive, `acquire` suspends the current activity for *timeout* seconds or until the current activity can acquire the mutex, whatever comes first.

If an activity still owns mutex semaphores when it ends, these semaphores will be automatically released by the interpreter.

See also method *release*.

Example 5.267. MutexSemaphore class — acquire method

```
mutex = .MutexSemaphore~new
.Task~new~startWork(mutex, "work 1")
.Task~new~startWork(mutex, "work 2")
say "work tasks started"

::class Task

::method startWork unguarded
  expose mutex name
  use strict arg mutex, name
  reply
  self~doWork(1)
```

```
::method doWork unguarded
  expose mutex name
  use strict arg level
  -- five levels of nested acquires
  if level > 5 then
    return
  mutex~acquire
  say name level
  self~doWork(level + 1)
```

may output

```
work tasks started
work 2 1
work 2 2
work 2 3
work 2 4
work 2 5
work 1 1
work 1 2
work 1 3
work 1 4
work 1 5
```

5.4.12.3. release

Returns `.true` if the mutex semaphore had been owned by the current activity, returns `.false` otherwise.

A successful release decreases the mutex nesting level. If the nesting level has reached zero, one of the activities, if any, waiting to acquire the mutex gets released and becomes the new owner of the mutex.

See also method *acquire*.

5.4.12.4. uninit

This method cleans up the mutex semaphore when it is garbage collected.

Note

`uninit` should not be invoked directly except via an uninit method of a subclass of the MutexSemaphore class. Any such subclassed uninit method must forward to the superclass uninit method.

5.4.13. Orderable Class

The **`Orderable`** class can be inherited by classes which wish to provide each of the comparison operator methods without needing to implement each of the individual methods. The inheriting class need only implement the **`Comparable`** *compareTo* method.

The **`Orderable`** class is defined as a MIXIN class.

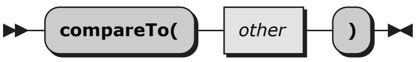
Table 5.48. Orderable Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
Orderable (Mixin Class)
Comparison Methods = == < <= << <<= <> > >= >< >> >>= \= \== \< \<< \> \>>   *compareTo*

5.4.13.1. compareTo

This method compares the receiving object to the object supplied in the *other* argument.

This is a default implementation which compares two items based on their *identityHash*.

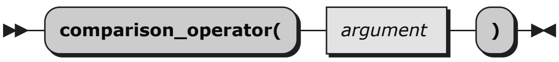


This method returns **`-1`** if the *other* is larger than the receiving object, **`0`** if the two objects are equal, and **`1`** if *other* is smaller than the receiving object.

Note

Classes inheriting from **`Orderable`** (like builtin classes *File*, *DateTime*, or *TimeSpan*) are strongly encouraged to forward to this default implementation for comparison cases not covered by their class-specific `compareTo` implementation.

5.4.13.2. Comparison Methods



Returns **`.true`** or **`.false`**, the result of performing the specified comparison operation. The receiver object and the *argument* are the terms compared.

The comparison operators you can use in a message are:

=	**`.true`** if the terms are equal
\=, ><, <>	**`.true`** if the terms are not equal (inverse of =)
>	Greater than
<	Less than

>=	Greater than or equal to
\<	Not less than
<=	Less than or equal to
\>	Not greater than

All strict comparison operations have one of the characters doubled that define the operator. The Orderable strict comparison operators produce the same results as the non-strict comparisons.

The strict comparison operators you can use in a message are:

==	`.true` if terms are strictly equal
\==	`.true` if the terms are NOT strictly equal (inverse of ==)
>>	Strictly greater than
<<	Strictly less than
>>=	Strictly greater than or equal to
\<<	Strictly NOT less than
<<=	Strictly less than or equal to
\>>	Strictly NOT greater than

5.4.14. Pointer Class

A **`Pointer`** instance is a wrapper around a native pointer value. This class is designed primarily for writing methods and functions in native code and can only be created using the native code application programming interfaces. The Pointer class new method will raise an error if invoked.

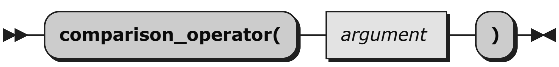
Table 5.49. Pointer Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
Pointer
new (Class Method)
Comparison Methods = == \= \== *isNull*

5.4.14.1. new (Class Method)

Creating Pointer object instances directly from Rexx code is not supported. The Pointer class new method will raise an error if invoked.

5.4.14.2. Comparison Methods



Returns **.true** or **.false**, the result of performing a specified comparison operation.

For the Pointer class, the argument object must be a pointer object instance and the wrappered pointer value must be the same.

The comparison operators you can use in a message are:

=, ==	**.true** if the wrappered pointer values are the same.
\=, ><, <>, \==	**.true** if the wrappered pointer values are not the same.

5.4.14.3. isNull

Returns **.true** if the wrappered pointer value is a NULL pointer (0) value. Returns **.false** if the pointer value is non-zero.

5.4.15. RegularExpression Class

This class provides support for regular expressions. A regular expression is a pattern you can use to match strings.

Note

The **RegularExpression** class is not a built-in class and is **not** preloaded. Use **::requires "rxregexp.cls"** to activate its functionality.

Table 5.50. RegularExpression Class

Object	
Methods inherited from the *Object class*	
Class (Metaclass)	
Methods inherited from the *Class class*	
RegularExpression	
new (Class Method)	
match	*pos*
parse	*position*

Here is a description of the syntax:

|	OR operator between the left and right expression
?	Matches any single character
*****	Matches the previous expression zero or more times
+	Matches the previous expression one or more times

****	"Escape" symbol: use the next character literally
(...**)**	Expression in parenthesis (use where needed)
{*n***}**	Matches previous expression *n* times (*n* > 1)
[...**]**	Set definition: matches any single character out of the defined set. A "**^**" right after the opening bracket means that none of the following characters should be matched. A "**-**" (if not used with "\\") defines a range between the last specified character and the one following "**-**". If it is the first character in the set definition, it is used literally.

The following symbolic names (they must start and end with "**:**") can be used to abbreviate common sets:

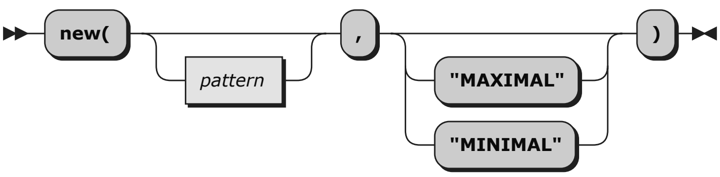
:alpha:	Characters in the range **A**-**Z** and **a**-**z**
:lower:	Characters in the range **a**-**z**
:upper:	Characters in the range **A**-**Z**
:digit:	Characters in the range **0**-**9**
:alnum:	Characters in **:digit:** and **:alpha:**
:xdigit:	Characters in **:digit:**, **A**-**F** and **a**-**f**
:blank:	Space and tab characters
:space:	Characters **'09'x** to **'0d'x** and space
:cntrl:	Characters **'00'x** to **'1f'x** and **'7f'x**
:print:	Characters in the range **'20'x** to **'7e'x**
:graph:	Characters in **:print:** without space
:punct:	All **:print:** characters without space and not in **:alnum:**

Example 5.268. RegularExpression class

```
::requires "rxregexp.cls"

     "(Hi|Hello) World"      Matches "Hi World" and
                             "Hello World".
     "file.???"              Matches any file with three
                             characters after "."
     "file.?{3}"             Same as above.
     "a *b"                  Matches all strings that begin with
                             "a" and end with "b" and have an
                             arbitrary number of spaces in between
                             both.
     "a +b"                  Same as above, but at least one space
                             must be present.
     "file.[bd]at"           Matches "file.bat" and "file.dat".
     "[A-Za-z]+"             Matches any string containing only
                             letters.
     "[:alpha:]+"            Same as above, using symbolic names.
     "[^0-9]*"               Matches any string containing no
                             numbers, including the empty string.
     "[:digit::lower:]"      A single character, either a digit or
                             a lower case character.
     "This is (very )+nice." Matches all strings with one or more
                             occurrences of "very " between
```

```
                "This is " and "nice.".
```

5.4.15.1. new (Class Method)



Instantiates a **RegularExpression** instance. Use the optional parameter *pattern* to define a regular expression pattern that will be used to match strings. You can select the type of regular expression matching to be “greedy” by specifying option **MAXIMAL**, or to be “lazy” by specifying option **MINIMAL**. Option **MAXIMAL** is the default.

Both *pattern* and match type can be changed with the *parse* method.

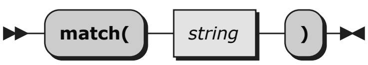
Important

RegularExpression defines its own `init` method. Any subclass which also defines its own `init` method, must forward to its superclass to complete object initialization. For details see *Section 4.2.9, “Initialization”*.

Example 5.269. RegularExpression class — new method

```
re1 = .RegularExpression~new
re2 = .RegularExpression~new("Hello?*")
```

5.4.15.2. match



This method tries to match *string* to the regular expression set by calls to the *new* or *parse* method.

With option **MAXIMAL** in effect, it will successfully match only if the whole *string* matches. With option **MINIMAL** in effect, any successful match will always start at the first character of *string*, but doesn't necessarily have to cover the full *string*. Thus a match will always be a leading part of *string*.

Method `match` returns **0** for an unsuccessful match and **1** for a successful match.

Example 5.270. RegularExpression class — match method

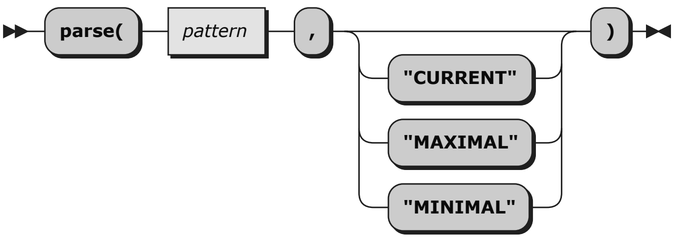
```
str = "<p>Paragraph 1</p><p>Paragraph 2</p>"
re1 = .RegularExpression~new("<p>?*</p>", "MINIMAL")
re1~match(str)
re2 = .RegularExpression~new("<p>?*</p>", "MAXIMAL")
re2~match(str)

say "re1 (minimal) matched" str~substr(1, re1~position)
say "re2 (maximal) matched" str~substr(1, re2~position)
```

```
::requires "rxregexp.cls"
```

Output:

```
re1 (minimal) matched <p>Paragraph 1</p>
re2 (maximal) matched <p>Paragraph 1</p><p>Paragraph 2</p>
```

5.4.15.3. parse



Returns **`0`** after setting and successfully parsing the regular expression *pattern*. The new *pattern* will be used to match strings specified with methods *match* or *pos*. Returns an error code otherwise.

The type of regular expression matching can be set to “greedy” by specifying option **`MAXIMAL`**, or to “lazy” by specifying option **`MINIMAL`**. The default is to use the current matching type.

Return values:

0
: Regular expression was parsed successfully.

1
: An unexpected symbol was met during parsing.

2
: A missing ')' was found.

3
: An illegal set was defined.

4
: The regular expression ended unexpectedly.

5
: An illegal number was specified.

6
: An undefined symbolic set name was specified.

Example 5.271. RegularExpression class — parse method

```
patterns = "A [:alpha:]{4} fl?*.", -
           "?*[l|e]?*e?*[r|g]?*", -
           "[invalid"
texts = "A nice flower.", -
        "A yellow flower.", -
```

```
        "A blue flag."

re = .RegularExpression~new
do pattern over patterns
  code = re~parse(pattern)
  if code == 0 then
    do text over texts
      say text~left(16) -
       re~match(text)~?("matches", "doesn't match") "regex" pattern
    end
  else
    say "error" code "parsing pattern" pattern
  say
end

::requires rxregexp.cls
```

Output:

```
A nice flower.   matches regex A [:alpha:]{4} fl?*.
A yellow flower. doesn't match regex A [:alpha:]{4} fl?*.
A blue flag.     matches regex A [:alpha:]{4} fl?*.

A nice flower.   matches regex ?*[l|e]?*e?*[r|g]?*
A yellow flower. matches regex ?*[l|e]?*e?*[r|g]?*
A blue flag.     matches regex ?*[l|e]?*e?*[r|g]?*

error 3 parsing pattern [invalid
```

Example 5.272. RegularExpression class — parse method

```
nrs = 1, 42, 0, 5436412, "1A", "f43g"
re = .RegularExpression~new("[1-9][0-9]*")
do nr over nrs
  say nr "is" re~match(nr)~?("a valid", "an invalid") "number"
end
say

-- allow hexadecimal numbers and a single 0
re~parse("0|([1-9a-fA-F][:xdigit:]*)")
do nr over nrs
  say nr "is" re~match(nr)~?("a valid", "an invalid") "number"
end

::requires rxregexp.cls
```

Output:

```
1 is a valid number
42 is a valid number
0 is an invalid number
5436412 is a valid number
1A is an invalid number
f43g is an invalid number

1 is a valid number
42 is a valid number
0 is a valid number
5436412 is a valid number
```

```
1A is a valid number
f43g is an invalid number
```

5.4.15.4. pos

This method tries to locate the regular expression set by calls to the *new* or *parse* method in the given *haystack* string.

Method `pos` returns **0** for an unsuccessful match, or the starting position for a successful match. The end position of the match can be retrieved with the *position* method.

Example 5.273. RegularExpression class — haystack method

```
text = "It's the year 2016!"
re = .RegularExpression~new("[1-9][0-9]*")
begin = re~pos(text)
if begin > 0 then
  do
    year = text~substr(begin, re~position - begin + 1)
    say "Found the number" year "in this sentence."
  end

::requires rxregexp.cls
```

Output:

```
Found the number 2016 in this sentence.
```

5.4.15.5. position

Returns the character position at which the last *parse*, *pos*, or *match* method ended.

Example 5.274. RegularExpression class — position method

```
re = .RegularExpression~new
re~parse("[abc")                    -- illegal set definition
say re~position                     -- will be 4

re = .RegularExpression~new("[abc]12")
re~match("c12")
say re~position                     -- will be 3

re~match("a13")                     -- unsuccessful match
say re~position                     -- will be 2 (failure to match)

::requires "rxregexp.cls"
```

5.4.16. RexxContext Class

The **`RexxContext`** class gives access to context information about the currently executing Rexx code. Instances of the RexxContext class can only be obtained via the *.CONTEXT environment symbol*. They cannot be directly created by the user. It is a subclass of the *Object class*.

Table 5.51. RexxContext Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
RexxContext		
args	*form*	*package*
condition	*fuzz*	*rs*
digits	*line*	*stackFrames*
executable	*name*	*variables*

5.4.16.1. args

```
args
```

Returns the arguments used to invoke the current context as an array. This is equivalent to using the *ARG*`(1, 'A')` built-in function.

5.4.16.2. condition

```
condition
```

Returns the current context condition object, or **`.nil`** if the context does not currently have a trapped condition. This is equivalent to using the *CONDITION*`('O')` built-in function.

5.4.16.3. digits

```
digits
```

Returns the current context digits setting. This is equivalent to using the *DIGITS* built-in function.

5.4.16.4. executable

```
executable
```

Returns the current executable object for the current context. The executable will be either a *Routine object* or a *Method object*, depending on the type of the active context.

5.4.16.5. form

```
form
```

Returns the current context form setting. This is equivalent to using the *FORM* built-in function.

5.4.16.6. fuzz

```
fuzz
```

Returns the current context fuzz setting. This is equivalent to using the *FUZZ* built-in function.

5.4.16.7. line

```
line
```

Returns the context current execution line. This is equivalent to using the *.LINE* environment symbol.

5.4.16.8. name

```
name
```

Returns the name used to invoke the current context. If the current context is a method, *name* is the message name used to invoke the method. If the current context is a routine invoked as an external call, *name* is the name used to call the routine. If the current context is an internal routine call, *name* is the name of the label used to invoke the call. If the context is the main part of the program, *name* will be the package name.

5.4.16.9. package

```
package
```

Returns the *Package* object associated with the current executable object.

5.4.16.10. rs

```
rs
```

Returns the context current return status value. If no host commands have been issued in the current context, **`.nil`** is returned. This is equivalent to using the *.RS* environment symbol.

5.4.16.11. stackFrames

```
stackFrames
```

Returns an Array of *StackFrame* objects representing the current call stack. The first item will represent the current Rexx context and subsequent elements are earlier elements in the call stack.

5.4.16.12. variables

```
variables
```

Returns a directory object containing all of the variables in the current execution context. The directory keys will be the variable names and the mapped values are the values of the variables. The directory will only contain simple variables and stem variables, but no compound variables. Compound variable values may be accessed by using the stem objects that are returned for the stem variable names.

See also Rexx Utility function *SysDumpVariables*.

Example 5.275. RexxContext class — variables method

```
a = 2
b.1 = a
c. = .stem~new
c.[] = 1
c.["one"] = 11
dir = .Directory~new
dir["item"] = "index"
array = .Array~of("a", "e", "i")

say "SysDumpVariables:"
call SysDumpVariables
drop result

say ".context~variables:"
variables = .context~variables
do name over variables
  say "Name="name"," "Value='"variables[name]"'"
  if name~right(1) = ".", variables[name]~isA(.Stem) then
    do tail over variables[name]
      say "Name="name||tail"," "Value='"variables[name][tail]"'"
    end
end
```

will output

```
SysDumpVariables:
Name=C.one, Value='11'
Name=DIR, Value='a Directory'
Name=B.1, Value='2'
Name=ARRAY, Value='an Array'
Name=A, Value='2'
.context~variables:
Name=ARRAY, Value='an Array'
Name=B., Value='B.'
Name=B.1, Value='2'
Name=A, Value='2'
Name=DIR, Value='a Directory'
Name=C., Value='1'
Name=C.one, Value='11'
```

5.4.17. RexxInfo Class

The **`RexxInfo`** class gives access to Rexx language information and other platform-specific information in a single place. Only one instance of the RexxInfo class can be obtained via the *.REXXINFO environment symbol*, other instances cannot be created or copied.

`RexxInfo` provides read-only attribute methods to get

- the default settings for NUMERIC *digits*, *fuzz*, and *form*,
- *internalMaxNumber*, *internalMinNumber*, and *internalDigits*, the allowed maximum, minimum, and the number of digits of internal whole numbers used e. g. as arguments to built-in functions, as the right-hand operand of the power (`**`) operator, or as the values of *exprr* and *exprf* in a DO or LOOP instruction,

- *maxExponent* and *minExponent*, the maximum and minimum allowed exponent values of numbers in scientific notation,
- the language processor *version* and its sub-components *majorVersion*, *release*, and *modification*, and supplemental to that, the source code version control system's *revision*,
- the language processor's descriptive *name*, its *languageLevel*, and release *date*,
- the interpreter's *debug*, *platform*, addressing mode of its *architecture*, full *executable* path, shared/dynamic *libraryPath*, and whether the interpreter is a *debug* version,
- and the platform-specific values for *endofline*, *pathSeparator*, *directorySeparator*, *caseSensitiveFiles*, *maxPathLength*, and *maxArraySize*.

Table 5.52. RexxInfo Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
RexxInfo		
architecture	*internalDigits*	*modification*
caseSensitiveFiles	*internalMaxNumber*	*name*
date	*internalMinNumber*	*package*
debug	*languageLevel*	*pathSeparator*
digits	*libraryPath*	*platform*
directorySeparator	*majorVersion*	*release*
endofline	*maxArraySize*	*revision*
executable	*maxExponent*	*version*
form	*maxPathLength*	
fuzz	*minExponent*	

5.4.17.1. architecture

Returns the interpreter's addressing mode, specified as a number in bits.

See also method *name*.

Example 5.276. RexxInfo class — architecture method

```
say .RexxInfo~architecture    -- 32 /* ooRexx 32-bit */
say .RexxInfo~architecture    -- 64 /* ooRexx 64-bit */
```

5.4.17.2. caseSensitiveFiles

Returns **.true** if the file system is case-sensitive. Otherwise returns **.false**.

On Unix-like systems where both case-sensitive and case-insensitive file systems may be mounted, this method returns **.true** if the file system root "**/**" is case-sensitive, and otherwise **.false**.

See also **File** class method *isCaseSensitive* which returns the same information.

Example 5.277. RexxInfo class — caseSensitiveFiles method

```
say .RexxInfo~caseSensitiveFiles    -- 0 /* e. g. Windows */
say .RexxInfo~caseSensitiveFiles    -- 1 /* e. g. Unix-like system */
```

5.4.17.3. date

Returns the language processor release date as a string in the default format of the *DATE built-in function*.

See also
- method *name* and
- keyword instruction *PARSE VERSION*,

which both also return this date as the third to fifth token of their result.

Example 5.278. RexxInfo class — date method

```
say .RexxInfo~date    -- 9 Dec 2016 /* e. g. */
```

5.4.17.4. debug

Returns .true if the interpreter is a debug version, .false if it is a release version.

Example 5.279. RexxInfo class — debug method

```
say .RexxInfo~debug    -- 0 /* release version */, 1 /* debug version */
```

5.4.17.5. digits

Returns the language processor default for the NUMERIC DIGITS setting.

See also
- **Package** method *digits*,
- **RexxContext** method *digits*, and
- built-in function *DIGITS*.

Example 5.280. RexxInfo class — digits method

```
say .RexxInfo~digits    -- 9
```

5.4.17.6. directorySeparator

Returns the platform-specific directory separator used by the file system, "\" on Windows, and "/" on Unix-like systems.

See also **`File`** method *separator*, which provides the same information.

Example 5.281. RexxInfo class — directorySeparator method

```
say .RexxInfo~directorySeparator    -- "\" /* Windows */
say .RexxInfo~directorySeparator    -- "/" /* Unix-like system */
```

5.4.17.7. endofline

Returns a platform-specific string representing the *line-end* characters. It returns **`'0d 0a'x`** (carriage-return, line-feed) on Windows, and **`'0a'x`** (line-feed) on Unix-like systems.

See also the environment symbol *.ENDOFLINE*, which provides the same information.

Example 5.282. RexxInfo class — endofline method

```
say .RexxInfo~endofline    -- '0d 0a'x /* Windows */
say .RexxInfo~endofline    -- '0a'x /* Unix-like system */
```

5.4.17.8. executable

Returns a new File instance of the full path of the currently executing interpreter.

See also method *libraryPath*.

Example 5.283. RexxInfo class — executable method

```
say .RexxInfo~executable    -- (Windows e.g.) C:\Program Files\ooRexx\rexx.exe
say .RexxInfo~executable    -- (Unix-like system e.g.) /usr/local/bin/rexx
```

5.4.17.9. form

Returns the language processor default for the NUMERIC FORM setting.

See also

- **`Package`** method *form*,
- **`RexxContext`** method *form*, and
- built-in function *FORM*.

Example 5.284. RexxInfo class — form method

```
say .RexxInfo~form    -- SCIENTIFIC
```

5.4.17.10. fuzz

Returns the language processor default for the NUMERIC FUZZ setting.

See also

- **`Package`** method *fuzz*,
- **`RexxContext`** method *fuzz*, and
- built-in function *FUZZ*.

Example 5.285. RexxInfo class — fuzz method

```
say .RexxInfo~fuzz    -- 0
```

5.4.17.11. internalDigits

Returns the NUMERIC DIGITS setting that the built-in functions use internally, which is 9 digits, when running in 32-bit addressing mode, and 18 digits, when running in a 64-bit addressing mode.

See also method *name*.

Example 5.286. RexxInfo class — internalDigits method

```
say .RexxInfo~internalDigits    -- 9  /* 32-bit addressing mode */
say .RexxInfo~internalDigits    -- 18 /* 64-bit addressing mode */
```

5.4.17.12. internalMaxNumber

Returns the maximum allowed value for internal whole numbers used e. g. as arguments to built-in functions, as the right-hand operand of the power (`**`) operator, or as the values of *exprr* and *exprf* in a DO or LOOP instruction.

See also methods *internalMinNumber* and *internalDigits*.

Example 5.287. RexxInfo class — internalMaxNumber method

```
say .RexxInfo~internalMaxNumber  -- 999999999          /* 32-bit addressing mode */
say .RexxInfo~internalMaxNumber  -- 999999999999999999 /* 64-bit addressing mode */
```

5.4.17.13. internalMinNumber

Returns the minimum allowed value for internal whole numbers used e. g. as arguments to built-in functions, as the right-hand operand of the power (`**`) operator, or as the values of *exprr*, and *exprf*, in a DO or LOOP instruction.

See also methods *internalMaxNumber* and *internalDigits*.

Example 5.288. RexxInfo class — internalMinNumber method

```
say .RexxInfo~internalMinNumber  -- -999999999          /* 32-bit addressing mode */
say .RexxInfo~internalMinNumber  -- -999999999999999999 /* 64-bit addressing mode */
```

5.4.17.14. languageLevel

Returns the language processor's language level as a decimal number.

See also
- method *name* and
- keyword instruction *PARSE VERSION*,

which both also return the language level as the second token of their result.

Example 5.289. RexxInfo class — languageLevel method

```
say .RexxInfo~languageLevel    -- 6.05 /* e. g. ooRexx 5.0.0 */
```

5.4.17.15. libraryPath

Returns a new File instance of the path of the shared or dynamic libraries for the currently running Rexx interpreter.

See also method *executable*.

Example 5.290. RexxInfo class — libraryPath method

```
say .RexxInfo~libraryPath    -- (Windows e.g.) C:\Program Files\ooRexx
```

```
say .RexxInfo~libraryPath    -- (Unix-like systems e.g.) /usr/local/lib/
```

5.4.17.16. majorVersion

Returns the major version number of the language processor. The major version number is the first part of the language processor *version*.

See also

- methods *release* and *modification*, and
- keyword instruction *PARSE VERSION*.

Example 5.291. RexxInfo class — majorVersion method

```
say .RexxInfo~majorVersion    -- 5 /* e. g. ooRexx 5.0.0 */
```

5.4.17.17. maxArraySize

Returns the implementation-defined maximum allocation size allowed for **`Array`** and **`Queue`**.

Example 5.292. RexxInfo class — maxArraySize method

```
say .RexxInfo~maxArraySize  -- 100000000          /* 32-bit addressing mode */
say .RexxInfo~maxArraySize  -- 100000000000000000 /* 64-bit addressing mode */
```

5.4.17.18. maxExponent

Returns the maximum allowed exponent value of a number in scientific notation.

See also method *minExponent*.

Example 5.293. RexxInfo class — maxExponent method

```
say .RexxInfo~maxExponent    -- 999999999
```

5.4.17.19. maxPathLength

Returns the maximum allowed file system path length of a fully qualified path including any filename portion.

Example 5.294. RexxInfo class — maxPathLength method

```
say .RexxInfo~maxPathLength    -- 259  /* e. g. on Windows */
say .RexxInfo~maxPathLength    -- 4096 /* e. g. on Linux */
```

5.4.17.20. minExponent

Returns the minimum allowed exponent value of a number in scientific notation.

See also method *maxExponent*.

Example 5.295. RexxInfo class — minExponent method

```
say .RexxInfo~minExponent    -- -999999999
```

5.4.17.21. modification

Returns the modification number of the language processor. The modification number is the third part of the language processor *version* string.

See also
- methods *majorVersion* and *release*, and
- keyword instruction *PARSE VERSION*.

Example 5.296. RexxInfo class — modification method

```
say .RexxInfo~modification    -- 0 /* e. g. ooRexx 5.0.0 */
```

5.4.17.22. name

Returns the language processor's descriptive name in the format that is also returned by *PARSE VERSION*, which is
- an interpreter identification string (that includes *version* and *architecture*),
- the interpreter *languageLevel* and
- the interpreter build *date*.

See also methods *version* and *languageLevel*, and keyword instruction *PARSE VERSION*.

Example 5.297. RexxInfo class — name method

```
say .RexxInfo~name    -- REXX-ooRexx_5.0.0(MT)_64-bit 6.05 22 Dec 2018 /* e. g. */
```

5.4.17.23. package

Returns a Package instance of all Rexx-defined (namespace "REXX") classes.

See *Package class*.

Example 5.298. RexxInfo class — package method

```
say .RexxInfo~package~publicClasses~items -
 "Rexx-defined public classes"   -- 56 Rexx-defined public classes /* e. g. */
```

5.4.17.24. pathSeparator

Returns the platform-specific path separator used used for file search paths, ";" on Windows, and ":" on Unix-like systems.

See also **`File`** method *pathSeparator*.

Example 5.299. RexxInfo class — pathSeparator method

```
say .RexxInfo~pathSeparator    -- ";" (Windows)
say .RexxInfo~pathSeparator    -- ":" (Unix-like system)
```

5.4.17.25. platform

Returns the name of the interpreter operating system as a string, e. g. **`WindowsNT`** for a Windows, or **`LINUX`** for a Linux system.

See also keyword instruction *PARSE SOURCE*, which returns the same information as its first token.

Example 5.300. RexxInfo class — platform method

```
say .RexxInfo~platform    -- WindowsNT
say .RexxInfo~platform    -- LINUX
```

5.4.17.26. release

Returns the release number of the language processor. The release number is the second part of the language processor *version* string.

See also

- methods *majorVersion* and *modification*, and
- keyword instruction *PARSE VERSION*.

Example 5.301. RexxInfo class — release method

```
say .RexxInfo~release    -- 0 /* e. g. ooRexx 5.0.0 */
```

5.4.17.27. revision

▸▸— **revision** —▸◂

Returns the source code version control system's revision from which this language processor was built. Rexx code should not rely on the format returned.

See also keyword instruction *PARSE VERSION*.

Example 5.302. RexxInfo class — revision method

```
say .RexxInfo~revision    -- 11636 /* e. g. */
```

5.4.17.28. version

▸▸— **version** —▸◂

Returns the version number of the language processor. The version number consists of the *majorVersion*, followed by a decimal point, the *release*, followed by another decimal point, and the *modification*.

Example 5.303. RexxInfo class — version method

```
say .RexxInfo~version    -- 5.0.0 /* e. g. */
```

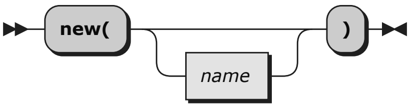
5.4.18. RexxQueue Class

The **`RexxQueue`** class provides object-style access to Rexx *external data queues*.

Table 5.53. RexxQueue Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
RexxQueue
new (Inherited Class Method) *create (Class Method)* *delete (Class Method)*

5.4.18.1. new



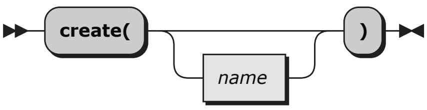
Returns a new RexxQueue instance associated with the Rexx external data queue named *name*.

If *name* is omitted, the **`SESSION`** queue is used. If *name* is specified as **`.nil`** the new RexxQueue instance is associated with a newly created Rexx external data queue with a system-generated name. If *name* is specified and an external data queue named *name* exists, it is opened. If such a data queue does not exist, it is created.

Example 5.304. RexxQueue class — new method

```
q = .RexxQueue~new
q~queue("line")
q~push("header")
say q~queued q~pull    -- 2 header
q~delete
```

5.4.18.2. create (Class Method)



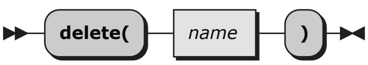
Returns the name of a newly created Rexx external data queue, which will be either *name* if no external data queue named *name* already exists, or, a system-generated name if *name* is omitted or the external data queue *name* already exists.

See also method *open (Class Method)*.

Example 5.305. RexxQueue class — create method

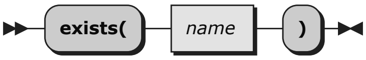
```
-- no MYQUEUE queue exists
say .RexxQueue~create("myqueue")    -- MYQUEUE
-- MYQUEUE queue already exists
say .RexxQueue~create("myqueue")    -- S0000000000004B48Q000001E1BEE66F20 (e. g.)
```

5.4.18.3. delete (Class Method)



Returns **`0`** if the external Rexx named queue named *name* was successfully deleted. Non-zero results are the error codes from the RexxDeleteQueue() programming interface.

5.4.18.4. exists (Class Method)

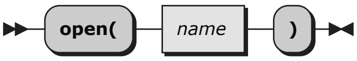


Returns **`.true`** if the external data queue *name* currently exists, otherwise returns **`.false`**.

Example 5.306. RexxQueue class — exists method

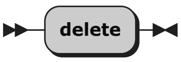
```
say .RexxQueue~exists("SESSION")    -- 1
```

5.4.18.5. open (Class Method)



Returns **`0`** if the external Rexx named queue *name* exists, or, if it doesn't exist, can be successfully created. Non-zero results are the error codes from the RexxOpenQueue() programming interface.

5.4.18.6. delete



Returns **`0`** if the external Rexx named queue associated with this RexxQueue instance was successfully deleted. Non-zero results are the error codes from the RexxDeleteQueue() programming interface.

Calling the *lineOut*, *pull*, *push*, *queue*, or *say* method of a RexxQueue instance with a deleted external data queue will result in an error.

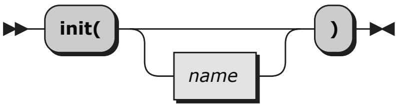
5.4.18.7. empty

Removes all items from the Rexx external queue associated with this RexxQueue instance. Returns **`0`** upon success, non-zero results are the error codes from the RexxClearQueue() programming interface.

5.4.18.8. get

Returns the name of the Rexx external queue associated with this instance.

5.4.18.9. init



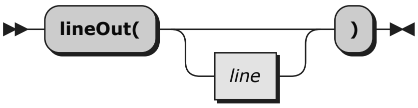
Important

`RexxQueue` defines its own `init` method. Any subclass which also defines its own `init` method, must forward to its superclass to complete object initialization. For details see *Section 4.2.9, “Initialization”*.

5.4.18.10. lineIn

Reads a single line from the Rexx external queue. If the queue is empty, `lineIn` will wait until a line is added to the queue.

5.4.18.11. lineOut



Adds a line to the Rexx external queue in first-in-first-out (FIFO) order. If *line* is not specified, a null string ("") is added.

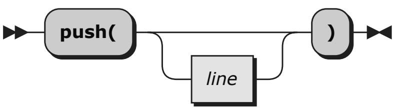
5.4.18.12. makeArray

Returns a single-index array with the same number of items as the receiver object. Items in the new array will have the same order as the items in the external queue. The external queue is emptied.

5.4.18.13. pull

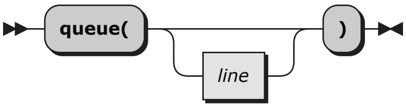
Reads a line from the Rexx external queue. If the queue is currently empty, this method will immediately return **`.nil`** without waiting for lines to be added to the queue.

5.4.18.14. push



Adds a line to the Rexx external queue in last-in-last-out (LIFO) order. If *line* is not specified, a null string ("") is added.

5.4.18.15. queue

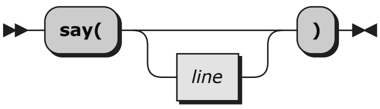


Adds a line to the Rexx external queue in first-in-first-out (FIFO) order. If *line* is not specified, a null string ("") is added.

5.4.18.16. queued

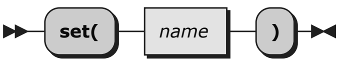
Returns the count of lines currently in the Rexx external queue.

5.4.18.17. say



Adds a line to the Rexx external queue in first-in-first-out (FIFO) order. If *line* is not specified, a null string ("") is added.

5.4.18.18. set



Switches the Rexx external queue associated with the RexxQueue instance. The new queue must have been previously created. The method return value is the name of current queue being used by the instance.

5.4.19. Singleton Class (Metaclass)

The **`Singleton`** class is a *metaclass* (a subclass of the ooRexx metaclass **`Class`**) which can be used for any ooRexx class, if the programmer wishes only a single instance of a class to be created. In this case the class directive needs to denote **`Singleton`** in its *METACLASS* option.

This class is defined as a MXIN class.

Table 5.54. Singleton Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
Singleton
new (Class Method)

5.4.19.1. new (Class Method)

This metaclass makes sure that only a *single instance* of a class can be created, a **singleton**. After a singleton got created each time a `NEW` message gets sent to the class will cause that singleton to be returned. The metaclass **`Singleton`** makes also sure that the singleton object will return itself upon receiving the `COPY` message by defining a proper `COPY` method for the singleton.

Example 5.307. Employing the Singleton (meta)class

The following program defines a class **`TEST`** which makes sure that each instance has a unique number in its instance attribute `nr`. The **`TESTSINGLETON`** subclass uses the *METACLASS Singleton* option to make sure that it only creates a single instance, a singleton. The program will loop over the classes **`TEST`** and **`TESTSINGLETON`**, creates three instances of each and displays the value of the instance attribute `nr` and the `identityHash` value of each instance, which uniquely identifies each each instance of a class (cf. the `MAKESTRING` definition).

```
#!/usr/bin/env rexx
do clz over .test, .testSingleton   -- iterate over the two classes
   rounds=3
   say "creating" rounds "objects of type:" clz
   do i=1 to rounds
      say "   round #" i":" clz~new -- create new instance
   end
   say
end

/* ======================================================================== */
/** This Test class counts the number of instances that get created for it.  */
::class Test
/* ------------- class method and class attribute definitions -------------- */
::method init class  -- class constructor
  expose counter
  counter=0          -- make sure attribute is initialized to 0

::attribute counter get private class  -- getter method that increases counter
  expose counter     -- access attribute
  counter+=1         -- increase counter by 1
  return counter     -- return new counter value
/* ------------- instance method and instance attribute definitions -------- */
::attribute nr get   -- getter method

::method init        -- constructor that sets the value of attribute nr
  expose nr          -- expose attribute
  nr=self~class~counter -- new instance: fetch new counter from class and save it

::method makestring  -- a string representation of the object
  expose nr          -- expose attribute
                     -- return a string representation
  return "a" self~class~id"[nr="nr",identityHash="self~identityHash"]"

/* ======================================================================== */
/** This class makes sure that only a single instance of it gets created by
*   using Singleton as its metaclass.
*/
::class TestSingleton subclass Test metaclass Singleton
```

Output of running the above program (the hash values may differ on each run):

```
creating 3 objects of type: The TEST class
   round # 1: a TEST[nr=1,identityHash=-49085937]
   round # 2: a TEST[nr=2,identityHash=-49089489]
```

```
   round # 3: a TEST[nr=3,identityHash=-49093009]

creating 3 objects of type: The TESTSINGLETON class
   round # 1: a TESTSINGLETON[nr=1,identityHash=-49114993]
   round # 2: a TESTSINGLETON[nr=1,identityHash=-49114993]
   round # 3: a TESTSINGLETON[nr=1,identityHash=-49114993]
```

As can be seen from the output there are three distinct instances of the class **`TEST`**, however the three instances of the class **`TESTSINGLETON`** are identical (cf. the values of `nr` and `identityHash`).

5.4.20. StackFrame Class

The **`StackFrame`** class gives access to execution information about an executing Rexx activity. Instances of the StackFrame class can be obtained via the *.CONTEXT environment symbol* or from a *condition object* created for a trapped condition. A StackFrame instance represents an instance of an execution unit on the current activity's call stack. It provides information on code location, arguments, etc. that are useful for debugging and problem determination. StackFrame instances cannot be directly created by the user.

Table 5.55. StackFrame Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
StackFrame		
arguments	*makeString*	*target*
executable	*name*	*traceLine*
line	*string*	*type*

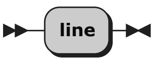
5.4.20.1. arguments

Returns the arguments used to invoke the execution frame represented by the StackFrame instance.

5.4.20.2. executable

Returns the executable object for the StackFrame context. The executable will be either a *Routine* object or a *Method* object, depending on the type of the StackFrame element.

5.4.20.3. line



Returns the current line number of the StackFrame context. If the frame instance is not Rexx code (e. g. compiled native code), **`.nil`** is returned.

5.4.20.4. makeString

Returns the frame *traceLine* value as the object's string value.

5.4.20.5. name

Returns the name associated with the stack frame context. The name meaning depends on the type of context.

- If the stack frame context is a method invocation, *name* is the message name used to invoke the method.
- If the stack frame context is a routine invocation, *name* is the routine.
- If the stack frame context is an internal routine invocation, *name* is the label name used to invoke the internal routine.
- If the stack frame context is the initial main part of a Rexx program, *name* is the name of the file containing the program.
- If the stack frame context is an INTERPRET instruction, a zero-length string is returned.

5.4.20.6. string

Returns the frame *traceLine* value as the object's string value.

5.4.20.7. target

Returns the object the method was invoked against, if the StackFrame *type* is **`METHOD`**. Returns **`.nil`** for all other StackFrame types.

5.4.20.8. traceLine

Returns the trace back line that would be displayed for error message trace. When possible, this will be the source line of the Rexx code in the call stack. If source is not available, the trace back will identify the method or routine belonging to the stack frame.

5.4.20.9. type

Returns the type of invocation for this stack frame. Possible values are:

PROGRAM
: The stack frame is the top level of a program.

METHOD
: The stack frame is a method invocation.

ROUTINE
: The stack frame is a routine invocation.

INTERPRET
: The stack frame is code created by an INTERPRET instruction.

INTERNALCALL
: The stack frame is a subroutine or function call to an internal label.

COMPILE
: The stack frame for compiling Rexx code for execution. Many syntax errors will be reported by a COMPILE frame.

Example 5.308. StackFrame class — type method

```
interpret "call level2" 21

::routine level2
  call level3 31, 32
  return

  level3: procedure
    signal on syntax
    .Method~new("", "~~")
    return

    syntax:
    do f over condition("o")["STACKFRAMES"]
      say (f~type f~name"("f~arguments~makeString(, ",")")")~left(27) f~line":" -
       f~traceLine~strip
    end
```

may output

```
COMPILE ()                  1: 1 *-* ~~
METHOD NEW(,~~)             The NIL object: *-* Compiled method "NEW" with scope "Method".
INTERNALCALL LEVEL3(31,32)  9: 9 *-*   .Method~new("", "~~")
ROUTINE LEVEL2(21)          4: 4 *-* call level3 31, 32
INTERPRET ()                1: 1 *-*   call level2 21
PROGRAM C:\stackFrame.rex() 1: 1 *-* interpret "call level2" 21
```

5.4.21. StreamSupplier Class

A subclass of the *Supplier Class* that provides stream lines using supplier semantics. This allows the programmer to iterate over the remaining lines in a stream. A **StreamSupplier** object provides a snapshot of the stream at the point in time it is created, including the current line read position. In general, the iteration is not affected by later changes to the read and write positioning of the stream. However, forces external to the iteration may change the *content* of the remaining lines as the iteration progresses.

Table 5.56. StreamSupplier Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
Supplier		
Methods inherited from the *Supplier class* *new (Class Method)*		
allIndexes	*index*	*supplier*
allItems	*item*	
available	*next*	
StreamSupplier		
available	*init*	*next*
index	*item*	

5.4.21.1. available

Returns `.true` if an item is available from the supplier (that is, if the `item` method would return a value). It returns `.false` if the collection is empty or the supplier has already enumerated the entire collection.

5.4.21.2. index

Returns the index of the current item in the collection. If no item is available, that is, if `available` would return `.false`, the supplier raises an error.

5.4.21.3. init

Initializes the object instance.

5.4.21.4. item

Returns the current item in the collection. If no item is available, that is, if `available` would return `.false`, the supplier raises an error.

5.4.21.5. next

Moves to the next item in the collection. By repeatedly sending `next` to the supplier (as long as `available` returns **`.true`**), you can enumerate all items in the collection. If no item is available, that is, if `available` would return **`.false`**, the supplier raises an error.

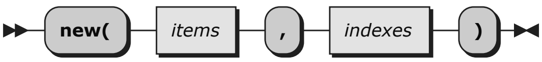
5.4.22. Supplier Class

A **`Supplier`** object is an iterator that allows the enumeration of an *items* Collection together with an *indexes* Collection. All objects inheriting from *Collection Class* provide a *supplier* method, that returns a snapshot of the Collection as a Supplier object, which allows iteration using the *DO/LOOP WITH* instruction. The iteration results are not affected by later changes to the source Collection object.

Table 5.57. Supplier Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
Supplier		
new (Class Method)		
allIndexes	*index*	*supplier*
allItems	*item*	
available	*next*	

5.4.22.1. new (Class Method)



Returns a new supplier object. The *items* argument must be an array of objects over which the supplier iterates. The *indexes* argument is an array of index values with a one-to-one correspondence to the objects contained in the *items* array. The created supplier iterates over the arrays, returning elements of the values array in response to `items` messages, and elements of the indexes array in response to `index` messages. The supplier iterates for the number of items contained in the values array, returning **`.nil`** for any nonexistent items in either array.

5.4.22.2. allIndexes

Returns an array of all index values from the current supplier position to the end of the supplier. Once `allIndexes` is called, no additional items can be retrieved from the supplier. Calls to `available` will return **`.false`**.

5.4.22.3. allItems

Returns an array of all items from the current supplier position to the end of the supplier. Once `allItems` is called, no additional items can be retrieved from the supplier. Calls to `available` will return **`.false`**.

5.4.22.4. available

Returns **`.true`** if an item is available from the supplier (that is, if the `item` method would return a value). It returns **`.false`** if the collection is empty or the supplier has already enumerated the entire collection.

5.4.22.5. index

Returns the index of the current item in the collection. If no item is available, that is, if `available` would return **`.false`**, the supplier raises an error.

5.4.22.6. item

Returns the current item in the collection. If no item is available, that is, if `available` would return **`.false`**, the supplier raises an error.

5.4.22.7. next

Moves to the next item in the collection. By repeatedly sending `next` to the supplier (as long as `available` returns **`.true`**), you can enumerate all items in the collection. If no item is available, that is, if `available` would return **`.false`**, the supplier raises an error.

5.4.22.8. Examples

Example 5.309. Supplier class

```
desserts=.array~of(apples, peaches, pumpkins, 3.14159) /* Creates array */
say "The desserts we have are:"
baker=desserts~supplier             /* Creates supplier object named BAKER */
do while baker~available            /* Array suppliers are sequenced       */
  if baker~index=4
  then say baker~item "is pi, not pie!!!"
  else say baker~item
  baker~next
end

/* Produces: */
/* The desserts we have are: */
/* APPLES                    */
```

```
/* PEACHES                  */
/* PUMPKINS                 */
/* 3.14159 is pi, not pie!!! */
```

5.4.22.9. supplier

Returns the target supplier as a result. This method allows an existing supplier to be passed to methods that expect an object that implements a `supplier` method as an argument.

5.4.23. Ticker Class

The **`Ticker`** class provides a repeating notification capability by sending a notification message to a notification target each trigger interval.

A Ticker object can be cancelled any time. If cancelled, a cancel notification message will be sent to the notification target.

Table 5.58. Ticker Class

Object		
Methods inherited from the *Object class*		
Class (Metaclass)		
Methods inherited from the *Class class*		
Ticker		
attachment	*canceled/cancelled*	*interval*
cancel	*init*	

5.4.23.1. attachment

Returns the object that has been attached to the Ticker instance upon creation. Returns **`.nil`** if no object is attached.

See method *init* .

Example 5.310. Ticker class — attachment method

```
eachSecond = .Ticker~new(1, .Target~new, "once each second")
call SysSleep 1.5                      -- will trigger once
eachSecond~cancel

::class Target inherit AlarmNotification
::method triggered                     -- called each interval
  use arg ticker
  say ticker~attachment                -- displays "once each second"
```

5.4.23.2. cancel

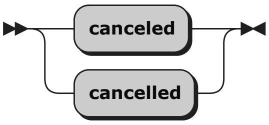
Cancels the Ticker represented by the receiver.

See also method *canceled/cancelled* .

Example 5.311. Ticker class — cancel method

```
twiceASecond = .Ticker~new(0.5, .Target~new)
call SysSleep 0.25                      -- too short for Ticker
twiceASecond~cancel                     -- "ticker cancelled"

::class Target inherit AlarmNotification
::method triggered                      -- called each interval
  say "ticker triggered"
::method cancel                         -- called when cancelled
  say "ticker cancelled"
```

5.4.23.3. canceled/cancelled



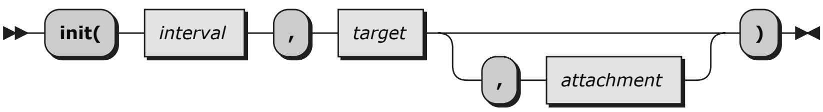
Returns **.true** if the ticker has been cancelled. Returns **.false** otherwise.

See also method *cancel* .

Example 5.312. Ticker class — canceled/cancelled method

```
tick = .Ticker~new(0.5 ,.message~new(.stdout, "SAY", "I", "knock, knock"))
call SysSleep 0.75                                          -- knock, knock
say "Ticker" tick~cancelled~?("cancelled", "not cancelled")  -- Ticker not cancelled
call SysSleep 0.5                                           -- knock, knock
tick~cancel
say "Ticker" tick~cancelled~?("cancelled", "not cancelled")  -- Ticker cancelled
```

5.4.23.4. init



Sets up a Ticker with a specified *interval*. After each *interval*, the Ticker sends a message `triggered` to the specified notification *target*.

The *target* must be an object that implements the *AlarmNotification interface*. It must inherit from or be a subclass of the AlarmNotification class, or a Message object (as the Message class inherits from AlarmNotification). If *target* is a Message object, the *triggered* method of the Message class will respond by simply sending the specified message.

The *interval* can be a TimeSpan or a String object. If it is

- a TimeSpan, it must be of a non-negative length, which specifies the interval time length.
- a String, it must be a non-negative number which specifies the interval time length in seconds.

If specified, *attachment* can be an arbitrary object that will be attached to the Ticker instance, and can later be retrieved in the event handler. See method *attachment* .

You can use the *cancel* method at any time to cancel a Ticker. If cancelled, the Ticker sends message `cancel` to the specified notification *target*.

The following code uses a Ticker to display progress information during a long-running task.

Example 5.313. Ticker class — init method

```
.Progress~new(0.5)~monitor(.Task~new, "tenSeconds")

-- defines tasks together with their "progress" methods
::class Task

-- long-running task
::method tenSeconds unguarded
  expose m n
  n = 1000
  do m = 1 to n                         -- long-running task
    call SysSleep 0.01
  end
  return

-- returns running value to be displayed as progress
::method "tenSeconds-progress" unguarded
  expose m n
  return m"/"n "steps done"


-- runs task while displaying progress text at each interval
::class Progress inherit AlarmNotification

-- set progress interval
::method init unguarded
  expose interval
  use strict arg interval = 1

-- starts ticker, runs task, and returns task result
-- (requires names of task and progress methods)
::method monitor
  expose interval object progress
  use strict arg object, task, progress = (task"-progress")
  tick = .Ticker~new(interval, self)
  object~send(task)
  tick~cancel

-- displays progress text at each ticker interval
::method triggered unguarded
  expose object progress
  .stdout~charOut(object~send(progress) '0d'x)
```

5.4.23.5. interval

Returns a *TimeSpan* object representing the interval to which the Ticker has been set.

See also method *init* .

Example 5.314. Ticker class — interval method

```
say .Ticker~new(.TimeSpan~fromSeconds(60), -
 .Message~new(.stdout, "say", "i", -
```

```
"another minute has passed"))~interval      -- 00:01:00.000000
```

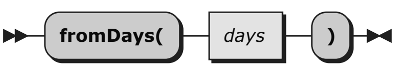
5.4.24. TimeSpan Class

A **`TimeSpan`** object represents a time interval with microsecond resolution. The interval may be positive or negative, with a maximum duration of 3652059 days less one microsecond (which approximately equals 9999 years less one microsecond). A TimeSpan object has methods to allow retrieving components like days or seconds, adding to components, as well as allowing arithmetic operations between TimeSpan objects.

Table 5.59. TimeSpan Class

<table>
<tr><th colspan="3">Object</th></tr>
<tr><td colspan="3">Methods inherited from the Object class</td></tr>
<tr><th colspan="3">Class (Metaclass)</th></tr>
<tr><td colspan="3">Methods inherited from the Class class</td></tr>
<tr><th colspan="3">+ Orderable (Mixin Class)</th></tr>
<tr><td colspan="3">Methods inherited from the Orderable class
Comparison Methods = == < <= << <<= <> > >= >< >> >>= \= \== \< \<< \> \>>
compareTo</td></tr>
<tr><th colspan="3">+ Comparable (Mixin Class)</th></tr>
<tr><td colspan="3">Methods inherited from the Comparable class
compareTo</td></tr>
<tr><th colspan="3">TimeSpan</th></tr>
<tr><td colspan="2">new (Inherited Class Method)
fromCivilTime (Class Method)
fromDays (Class Method)
fromHours (Class Method)
fromLongTime (Class Method)</td><td>fromMicroseconds (Class Method)
fromMinutes (Class Method)
fromNormalTime (Class Method)
fromSeconds (Class Method)
fromStringFormat (Class Method)</td></tr>
<tr><td>Arithmetic Methods + - * / // %
addDays
addHours
addMicroseconds
addMinutes
addSeconds
addWeeks
compareTo</td><td>days
duration
hashCode
hours
init
makeString
microseconds
minutes</td><td>seconds
sign
string
totalDays
totalHours
totalMicroseconds
totalMinutes
totalSeconds</td></tr>
</table>

5.4.24.1. fromDays (Class Method)



Creates a TimeSpan object from a number of days. The *days* argument must be a valid Rexx number.

5.4.24.2. fromHours (Class Method)

```
>>-fromHours(--hours--)--><
```

Creates a TimeSpan object from a number of hours. The *hours* argument must be a valid Rexx number.

5.4.24.3. fromMinutes (Class Method)

```
>>-fromMinutes(--minutes--)--><
```

Creates a TimeSpan object from a number of minutes. The *minutes* argument must be a valid Rexx number.

5.4.24.4. fromSeconds (Class Method)

```
>>-fromSeconds(--seconds--)--><
```

Creates a TimeSpan object from a number of seconds. The *seconds* argument must be a valid Rexx number.

5.4.24.5. fromMicroseconds (Class Method)

```
>>-fromMicroseconds(--microseconds--)--><
```

Creates a TimeSpan object from a number of microseconds. The *microseconds* argument must be a valid Rexx number.

5.4.24.6. fromNormalTime (Class Method)

```
>>-fromNormalTime(--time--)--><
```

Creates a TimeSpan object from a string returned by the Normal option of the *TIME* built-in function (hh:mm:ss). The TimeSpan will contain an interval equal to the time of day represented by the string.

5.4.24.7. fromCivilTime (Class Method)

```
>>-fromCivilTime(--time--)--><
```

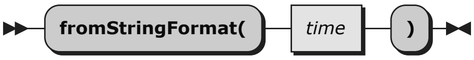
Creates a TimeSpan object from a string returned by the Civil option of the *TIME* built-in function (hh:mmxx). The TimeSpan will contain an interval equal to the time of day represented by the string.

5.4.24.8. fromLongTime (Class Method)

```
>>-fromLongTime(--time--)--><
```

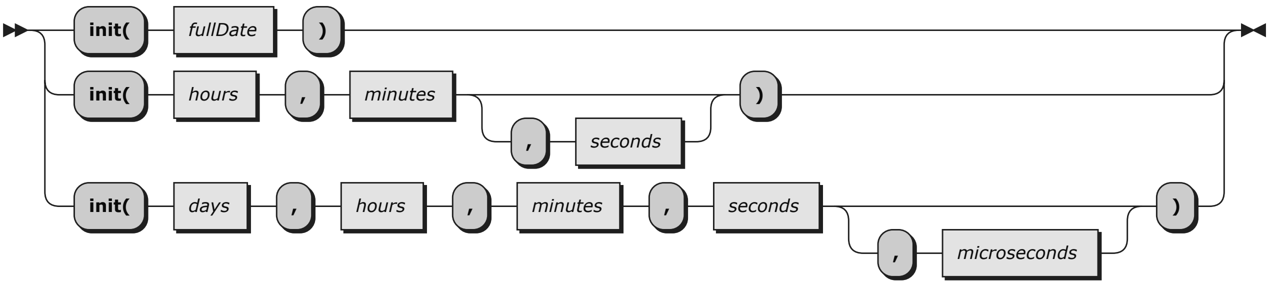
Creates a TimeSpan object from a string returned by the Long option of the *TIME* built-in function (hh:mm:ss.uuuuuu). The TimeSpan will contain an interval equal to the time of day represented by the string.

5.4.24.9. fromStringFormat (Class Method)



Creates a TimeSpan object from a string in the format returned by the TimeSpan *string* method.

5.4.24.10. init

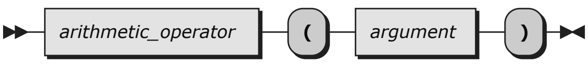


Initializes a new TimeSpan instance. If the single *fulldate* argument is used, the TimeSpan argument is initialized to the time span *fulldate* microseconds. Otherwise, the TimeSpan instance is initialized to either the *hours*, *minutes*, and *seconds* or the *days*, *hours*, *minutes*, *seconds*, and *microseconds* components. Each of these components must be a valid whole number within the acceptable range for the given component. For example, *hours* must be in the range 0-23, while *minutes* must be in the range 0-59.

Example 5.315. TimeSpan class

```
span = .TimeSpan~new(time('F', "15:37:30", "N"))  -- 15:37:30.000000
span = .TimeSpan~new(15, 37, 30)                  -- 15:37:30.000000
span = .TimeSpan~new(6, 4, 33, 15, 100)           -- 6.04:33:15.000100
```

5.4.24.11. Arithmetic Methods



Note

The syntax diagram above is for the non-prefix operators. For the prefix operators, omit the parentheses and *argument*.

Returns the result of performing the specified arithmetic operation on the receiver TimeSpan object. Depending on the operation, the *argument* be either a TimeSpan object, a DateTime object, or a number. See the description of the individual operations for details. The *arithmetic_operator* can be:

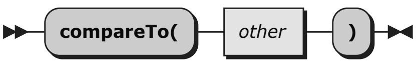
+
: Addition. If *argument* is a DateTime object, the TimeSpan is added to the DateTime object, returning a new DateTime instance. Neither the receiver TimeSpan or the argument DateTime object is altered by this operation. The TimeSpan may be either positive or negative.

	If *argument* is a TimeSpan object, the two TimeSpans are added together, and a new TimeSpan instance is returned. Neither the TimeSpan object is altered by this operation.
-	Subtraction. The *argument* must be a TimeSpan object. The *argument* TimeSpan is subtracted from the receiver TimeSpan and a new TimeSpan instance is returned. Neither the TimeSpan object is altered by this operation.
*	Multiplication. The *argument* must be a valid Rexx number. The TimeSpan is multiplied by the *argument* value, and a new TimeSpan instance is returned. The receiver TimeSpan object is not altered by this operation.
/	Division. The *argument* must be a valid Rexx number. The TimeSpan is divided by the *argument* value, and a new TimeSpan instance is returned. The receiver TimeSpan object is not altered by this operation. The / operator and % produce the same result.
%	Integer Division. The *argument* must be a valid Rexx number. The TimeSpan is divided by the *argument* value, and a new TimeSpan instance is returned. The receiver TimeSpan object is not altered by this operation. The / operator and % produce the same result.
//	Remainder Division. The *argument* must be a valid Rexx number. The TimeSpan is divided by the *argument* value and the division remainder is returned as a new TimeSpan instance. The receiver TimeSpan object is not altered by this operation.
Prefix -	The TimeSpan is negated, returning a new TimeSpan instance. The receiver TimeSpan is not altered by this operation.
Prefix +	Returns a new instance of the TimeSpan object with the same time value.

Example 5.316. TimeSpan class

```
t1 = .timespan~fromHours(1)
t2 = t1 * 2
-- displays "01:00:00.000000 02:00:00.000000 03:00:00.000000"
say t1 t2 (t1 + t2)
```

5.4.24.12. compareTo



This method returns **-1** if the *other* is larger than the receiving object, **0** if the two objects are equal, and **1** if *other* is smaller than the receiving object.

5.4.24.13. duration

Returns a new TimeSpan object containing the absolute value of the receiver TimeSpan object.

5.4.24.14. days

Returns the number of whole days in the TimeSpan, as a positive number.

5.4.24.15. hours

Returns the hours component of the TimeSpan, as a positive number.

5.4.24.16. minutes

Returns the minutes component of the TimeSpan, as a positive number.

5.4.24.17. seconds

Returns the seconds component of the TimeSpan, as a positive number.

5.4.24.18. makeString

Returns the time span formatted as a string in the format **`-dddddddd.hh:mm:ss.uuuuuu`**. This is an alias of the *string* method.

5.4.24.19. microseconds

Returns the microseconds component of the TimeSpan, as a positive number.

5.4.24.20. totalDays

Returns the time span expressed as a number of days. The result includes any fractional part and retains the sign of the receiver TimeSpan.

5.4.24.21. totalHours

Returns the time span expressed as a number of hours. The result includes any fractional part and retains the sign of the receiver TimeSpan.

5.4.24.22. totalMinutes

Returns the time span expressed as a number of minutes. The result includes any fractional part and retains the sign of the receiver TimeSpan.

5.4.24.23. totalSeconds

Returns the time span expressed as a number of seconds. The result includes any fractional part and retains the sign of the receiver TimeSpan.

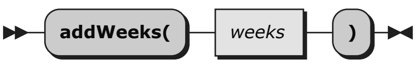
5.4.24.24. totalMicroseconds

Returns the time span expressed as a number of microseconds. The result retains the sign of the receiver TimeSpan.

5.4.24.25. hashCode

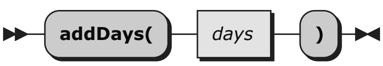
Returns a string value that is used as a hash value for MapCollection such as Table, Relation, Set, Bag, and Directory.

5.4.24.26. addWeeks



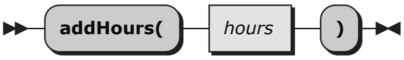
Adds weeks to the TimeSpan object, returning a new TimeSpan instance. The receiver TimeSpan object is unchanged. The *weeks* value must be a valid number, including fractional values. Negative values result in week being subtracted from the TimeSpan value.

5.4.24.27. addDays



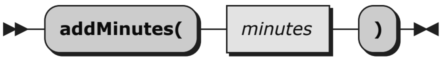
Adds days to the TimeSpan object, returning a new TimeSpan instance. The receiver TimeSpan object is unchanged. The *days* value must be a valid number, including fractional values. Negative values result in days being subtracted from the TimeSpan value.

5.4.24.28. addHours



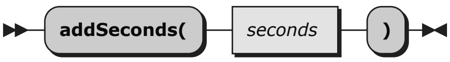
Adds hours to the TimeSpan object, returning a new TimeSpan instance. The receiver TimeSpan object is unchanged. The *hours* value must be a valid number, including fractional values. Negative values result in hours being subtracted from the TimeSpan value.

5.4.24.29. addMinutes



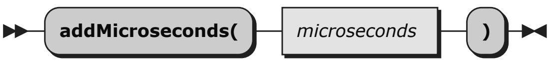
Adds minutes to the TimeSpan object, returning a new TimeSpan instance. The receiver TimeSpan object is unchanged. The *minutes* value must be a valid number, including fractional values. Negative values result in minutes being subtracted from the TimeSpan value.

5.4.24.30. addSeconds



Adds seconds to the TimeSpan object, returning a new TimeSpan instance. The receiver TimeSpan object is unchanged. The *seconds* value must be a valid number, including fractional values. Negative values result in seconds being subtracted from the TimeSpan value.

5.4.24.31. addMicroseconds



Adds microseconds to the TimeSpan object, returning a new TimeSpan instance. The receiver TimeSpan object is unchanged. The *microseconds* value must be a valid whole number. Negative values result in microseconds being subtracted from the TimeSpan value.

5.4.24.32. sign

Returns **`-1`** if the TimeSpan duration is negative, **`1`** if it is positive, and **`0`** if it is zero.

See also method *duration*.

5.4.24.33. string

Returns TimeSpan formatted as a string. The string value is in the format **`-dddddddd.hh:mm:ss.uuuuuu`**. If the TimeSpan is positive or zero, the sign is omitted. The days field will be formatted without leading zeros or blanks. If the TimeSpan duration is less than a day, the days field and the period separator will be omitted.

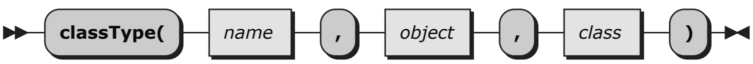
5.4.25. Validate Class

The **`Validate`** class provides class methods helping with validating arguments being of correct class, logical or numeric type, or within a numeric range.

Table 5.60. Validate Class

Object	
Methods inherited from the *Object class*	
Class (Metaclass)	
Methods inherited from the *Class class*	
Validate	
classType (Class Method)	*position (Class Method)*
length (Class Method)	*positiveNumber (Class Method)*
logical (Class Method)	*positiveWholeNumber (Class Method)*
nonNegativeNumber (Class Method)	*requestClassType (Class Method)*
nonNegativeWholeNumber (Class Method)	*wholeNumber (Class Method)*
number (Class Method)	*wholeNumberRange (Class Method)*
numberRange (Class Method)	

5.4.25.1. classType (Class Method)

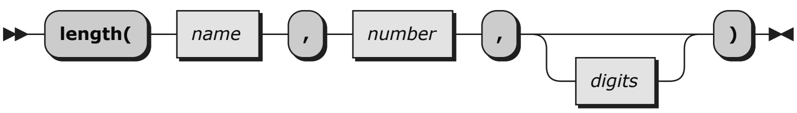


Validates that *object* is an instance of class *class*.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also method *requestClassType (Class Method)*.

5.4.25.2. length (Class Method)

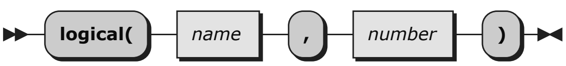


Validates that *number* is zero or a positive whole number under NUMERIC DIGITS *digits*. If *digits* is not specfied, it defaults to *internalDigits*.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also methods *position* and *nonNegativeWholeNumber*.

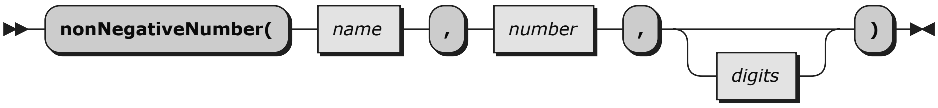
5.4.25.3. logical (Class Method)



Validates that *number* is either **`.true`** or **`.false`**.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

5.4.25.4. nonNegativeNumber (Class Method)

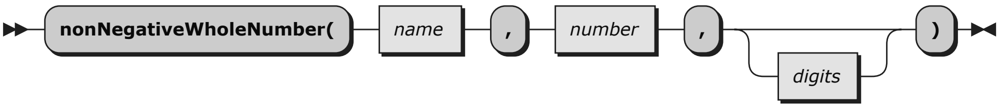


Validates that *number* is zero or a positive Rexx number under NUMERIC DIGITS *digits*. If *digits* is not specfied, it defaults to **9**.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also methods *positiveNumber* and *nonNegativeWholeNumber*.

5.4.25.5. nonNegativeWholeNumber (Class Method)

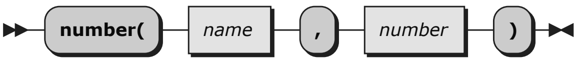


Validates that *number* is zero or a positive whole number under NUMERIC DIGITS *digits*. If *digits* is not specfied, it defaults to **9**.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also methods *positiveWholeNumber* and *nonNegativeNumber*.

5.4.25.6. number (Class Method)

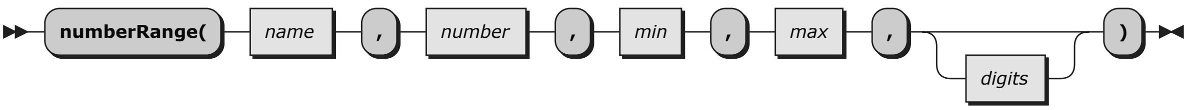


Validates that *number* is a valid Rexx number.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also method *wholeNumber*.

5.4.25.7. numberRange (Class Method)

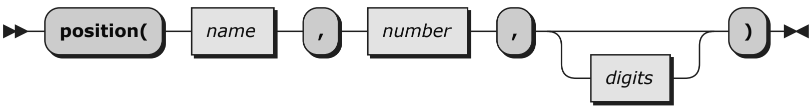


Validates that *number* is a valid Rexx number in the range *min* to *max*, with comparisons done under NUMERIC DIGITS *digits*. If *digits* is not specfied, it defaults to **9**.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also method *wholeNumberRange*.

5.4.25.8. position (Class Method)

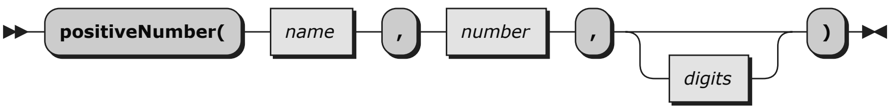


Validates that *number* is a positive whole number under NUMERIC DIGITS *digits*. If *digits* is not specfied, it defaults to *internalDigits*.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also methods *length* and *positiveWholeNumber*.

5.4.25.9. positiveNumber (Class Method)

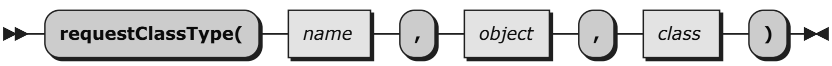


Validates that *number* is a positive Rexx number under NUMERIC DIGITS *digits*. If *digits* is not specfied, it defaults to **9**.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also methods *nonNegativeNumber* and *positiveWholeNumber*.

5.4.25.10. requestClassType (Class Method)

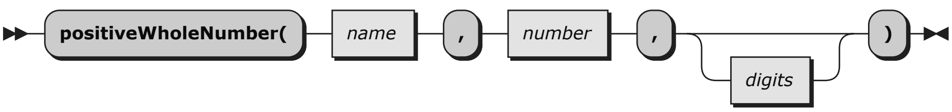


Validates that *object* can be converted to an instance of class *class* by sending it a `request` message.

If successful, it returns the converted object, otherwise it raises a syntax error for argument *name*.

See also method *classType (Class Method)*.

5.4.25.11. positiveWholeNumber (Class Method)

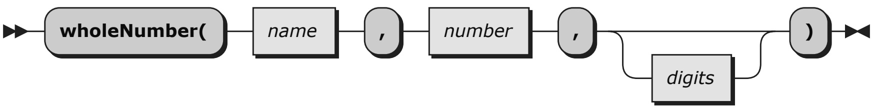


Validates that *number* is a positive whole number under NUMERIC DIGITS *digits*. If *digits* is not specfied, it defaults to **9**.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also methods *nonNegativeWholeNumber* and *positiveNumber*.

5.4.25.12. wholeNumber (Class Method)

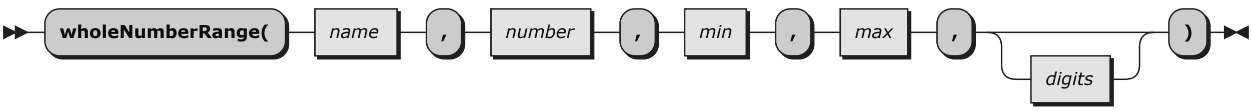


Validates that *number* is a whole number under NUMERIC DIGITS *digits*. If *digits* is not specfied, it defaults to **9**.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also method *number*.

5.4.25.13. wholeNumberRange (Class Method)



Validates that *number* is a valid whole number in the range *min* to *max*, with comparisons done under NUMERIC DIGITS *digits*. If *digits* is not specfied, it defaults to **9**.

Raises a syntax error for argument *name* if the validation fails, else returns with no result.

See also method *numberRange*.

5.4.26. VariableReference Class

A **`VariableReference`** instance maintains a reference to another object. It can only be created using a *Variable Reference Term*. Calling the `new` method to create a VariableReference instance is not allowed.

Table 5.61. VariableReference Class

Object	
Methods inherited from the *Object class*	
Class (Metaclass)	
Methods inherited from the *Class class*	
VariableReference	
name	*unknown*
request	*value (Attribute)*

5.4.26.1. name

Returns the name of the variable referenced.

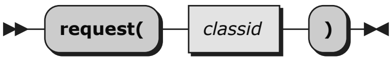
See also method *value (Attribute)*.

Example 5.317. VariableReference class — name method

```
variable = 123
```

```
say >variable~name    -- VARIABLE
```

5.4.26.2. request

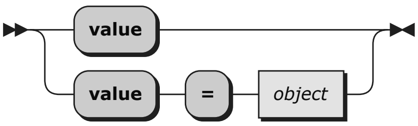


Forwards to the `request` method of the referenced variable.

5.4.26.3. unknown

Forwards to the `unknown` method of the referenced variable.

5.4.26.4. value (Attribute)



value get:
Returns the current value of the referenced variable.

value set:
Sets the value of the referenced variable to *object*.

See also method *name*.

Example 5.318. VariableReference class — value method

```
array = 1, 2, 3

say >array~class~id                   -- VariableReference
say >array~value~class~id             -- Array

say >array~value~toString(, ", ")     -- 1, 2, 3
-- this also works because we have an UNKNOWN method
say >array~toString(, ", ")           -- 1, 2, 3
```

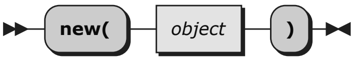
5.4.27. WeakReference Class

A WeakReference instance maintains a non-pinning reference to another object. A non-pinning reference does not prevent an object from getting garbage collected or having its uninit method run when there are no longer normal references maintained to the object. Once the referenced object is eligible for garbage collection, the reference inside the WeakReference instance will be cleared and the *value* method will return **`.nil`** on all subsequent calls. WeakReferences are useful for maintaining caches of objects without preventing the objects from being reclaimed by the garbage collector when needed.

Table 5.62. WeakReference Class

Object
Methods inherited from the *Object class*
Class (Metaclass)
Methods inherited from the *Class class*
WeakReference
new (Class Method) *value*

5.4.27.1. new (Class Method)



Returns a new WeakReference instance containing a reference to *object*.

5.4.27.2. value

Returns the referenced object. If the object has been garbage collected, `.nil` is returned.

Rexx Runtime Objects

In addition to the class objects described in the previous chapter, the Rexx runtime environment also provides objects that are accessible via *environment symbols*.

6.1. The Environment Directory (.ENVIRONMENT)

The Environment object is a directory of public objects that are always accessible. The Environment object is automatically searched when environment symbols are used, or the Environment object may be directly accessed using the .ENVIRONMENT symbol. Entries stored in the Environment use the same name as the corresponding environment symbol, but without a leading period. For example:

```
say .true                   -- Displays "1"
say .environment~true       -- Also displays "1"
say .environment["TRUE"]    -- "1"
say .environment["true"]    -- The NIL object
```

The Environment object directory contains all of the Rexx built-in classes (Array, etc.), the special Rexx constants *.NIL*, *.TRUE*, *.FALSE*, *.ENDOFLINE*, and the *.RexxInfo object*.

6.1.1. The ENDOFLINE Constant (.ENDOFLINE)

The ENDOFLINE object is a string constant representing the *line-end* characters. It is **`'0d 0a'x`** (carriage-return, line-feed) on Windows, and **`'0a'x`** (line-feed) on Unix-like systems.

6.1.2. The FALSE Constant (.FALSE)

The FALSE object is the constant "0" representing a FALSE result for logical and comparison operations.

6.1.3. The NIL Object (.NIL)

The Nil object is a special object that does not contain data. It usually represents the absence of an object, as a null string represents a string with no characters. It has only the methods of the Object class. Note that you use the Nil object (rather than the null string ("")) to test for the absence of data in an array or other Collection class entry:

```
if .nil = board[row,col]   /* .NIL rather than "" */
then ...
```

6.1.4. The RexxInfo Object (.RexxInfo)

The RexxInfo object returns the only instance of the *RexxInfo class* and gives access to Rexx language information and other platform-specific information in a single place.

```
say .RexxInfo~name    -- REXX-ooRexx_5.0.0(MT)_64-bit 6.05 1 Sep 2016 /* e. g. */
```

6.1.5. The TRUE Constant (.TRUE)

The TRUE object is the constant "1", representing a true result for logical and comparison operations.

6.2. The Local Directory (.LOCAL)

The Local environment object is a directory of interpreter instance objects that are always accessible. You can access objects in the Local environment object in the same way as objects in the Environment object. The Local object contains

- the *.INPUT*, *.OUTPUT*, *.ERROR*, *.DEBUGINPUT*, and *.TRACEOUTPUT* Monitor objects used for console I/O,
- the *.STDIN*, *.STDOUT*, and *.STDERR* output streams that are the default I/O targets,
- the *.STDQUE* RexxQueue instance used for Rexx external queue operations,
- and the *.SYSCARGS* array of program command line options.

Because both .ENVIRONMENT and .LOCAL are **`Directory`** objects, you can place objects into, or retrieve objects from, these environments by using any of the **`Directory`** methods `[]`, `[]=`, `put`, `at`, `setEntry`, `entry`, or `setMethod`). To avoid potential name clashes with built-in objects and public objects that Rexx provides, each object that your programs add to these environments should have a period in its index.

Example 6.1. .LOCAL

```
/* .LOCAL example--places something in the Local environment directory */
.local~my.alarm = theAlarm
/* To retrieve it                                                       */
say .local~my.alarm
```

```
/* Another .LOCAL example (Windows) */
.environment["MYAPP.PASSWORD"] = "topsecret"
.environment["MYAPP.UID"] = 200

/* Create a local directory for my stuff */
.local["MYAPP.LOCAL"] = .directory~new

/* Add log file for my local directory                                  */
.myapp.local["LOG"] = .stream~new("myapp.log")
say .myapp.password                    /* Displays "topsecret"         */
say .myapp.uid                         /* Displays "200"               */

/* Write a line to the log file */
.myapp.local~log~lineout("Logon at "time()" on "date())

/* Redirect SAY lines into a file:  */
.output~destination(.stream~new("SAY_REDIRECT.TXT"))
say "This goes into a file, and not onto the screen!"
```

```
/* .LOCAL example--get the individual command line arguments */
cmdargs = .local~syscargs
do carg over cmdargs
   say carg
end
```

6.3. The Debug Input Monitor (.DEBUGINPUT)

This *Monitor* object holds the default interactive debug input stream object (see *Chapter 14, Input and Output Streams*). This input stream is the source for all input for interactive debug mode.

The default for this object's initial source is the .INPUT monitor.

6.4. The Error Monitor (.ERROR)

This *Monitor* object holds the error stream object. You can redirect the trace output in the same way as with the output object in the Monitor class example.

The default for this object's initial destination is the .STDERR stream.

6.5. The Input Monitor (.INPUT)

This *Monitor* object holds the default input stream object (see *Chapter 14, Input and Output Streams*). This input stream is the source for the PARSE LINEIN instruction, the LINEIN method of the Stream class, and, if you specify no stream name, the LINEIN built-in function. It is also the source for the PULL and PARSE PULL instructions if the external data queue is empty.

The default for this object's initial source is the .STDIN stream.

6.6. The Output Monitor (.OUTPUT)

This *Monitor* object holds the default output stream object (see *Chapter 14, Input and Output Streams*). This is the destination for output from the SAY instruction, the LINEOUT method (.OUTPUT~LINEOUT), and, if you specify no stream name, the LINEOUT built-in function. You can replace this object in the environment to direct such output elsewhere (for example, to a transcript window).

The default for this object's initial destination is the .STDOUT stream.

6.7. The Trace Output Monitor (.TRACEOUTPUT)

This *Monitor* object holds the trace output target object. You can redirect the trace output in the same way as with the output object in the Monitor class example.

The default for this object's initial destination is the .ERROR monitor.

6.8. The STDERR Stream (.STDERR)

This *Stream* object is the default stream used for trace and error message output.

6.9. The STDIN Stream (.STDIN)

This *Stream* object is representing the standard input file of a process. It is the startup default stream for the .INPUT object.

6.10. The STDOUT Stream (.STDOUT)

This *Stream* object is representing the standard output file of a process. It is the startup default stream for the .OUTPUT object.

6.11. The STDQUE Queue (.STDQUE)

This *RexxQueue* object is the destination for the PUSH and QUEUE instruction, and the source for queue lines for the PULL and PARSE PULL instructions.

6.12. The SYSCARGS Array (.SYSCARGS)

The .SysCArgs object is an Array of all command-line arguments supplied to the program. Normally all command-line arguments are combined into a single string and passed to the Rexx program as an argument retrievable via the *ARG (Argument)* built-in function. .SYSCARGS is a direct collection of the individual C arguments passed to the program.

Example:

Example 6.2. SysCArgs Array

```
say .SysCArgs~items "SysCArgs" .SysCArgs~makeString(, ",")
say arg() "ARGs" arg(1, "A")~makeString(, ",")

/* when called with command line parameters 1 "2 3" 4, displays:
3 SysCArgs 1,2 3,4
1 ARGs 1 "2 3" 4
*/
```

Note

.SysCArgs may not be available in all situations, e. g. in program code that gets run via "rexx -e".

6.13. The Rexx Context (.CONTEXT)

The .CONTEXT environment symbol accesses a *RexxContext* instance for the currently active Rexx execution environment. The returned context object is only active until the current method call, routine call, or program terminates. Once the context object is deactivated, an error will be raised if any of the RexxContext methods are called.

6.14. The Line Number (.LINE)

.LINE is set to the line number of the instruction currently being executed. If the current instruction is defined within an INTERPRET instruction, the line number of INTERPRET instruction is returned.

6.15. The METHODS StringTable (.METHODS)

The .METHODS environment symbol identifies a *StringTable* of methods that *::ATTRIBUTE*, *::CONSTANT*, or *::METHOD* directives in the currently running program define. The StringTable indexes are the *method* names. The StringTable values are the method objects.

Only methods or attributes that are not preceded by a ::CLASS directive are in the .METHODS StringTable. These are known as *floating methods*. If there are no such methods, the .METHODS symbol has the default value of **.METHODS**.

Example 6.3. .METHODS

```
/* .methods contains one entry with the index (method name) "TALK" */
o=.object~enhanced(.methods)  /* create object, enhance it with methods */
o~talk("echo this text")  /* test "TALK" method */
::method talk  /* floating method by the name of "TALK" */
  use arg text  /* retrieve the argument */
  say text  /* display received argument */
```

6.16. The ROUTINES StringTable (.ROUTINES)

The .ROUTINES environment symbol identifies a *StringTable* of routines that *::ROUTINE* directives in the currently running program define. The StringTable indexes are the *routine* names. The StringTable values are the routine objects.

If there are no ::ROUTINE directives, the .ROUTINES symbol has the default value of **.ROUTINES**.

Example 6.4. .ROUTINES

```
/* .routines contains one entry with the index (routine name) "TALK" */
.routines~talk~call("echo this text")  /* test talk routine */
::routine talk  /* floating routine by the name of "TALK" */
  use arg text  /* retrieve the argument */
  say text  /* display received argument */
```

6.17. The RESOURCES StringTable (.RESOURCES)

The .RESOURCES environment symbol identifies a *StringTable* of data resources that *::RESOURCE* directives in the currently running program define. The StringTable indexes are the resource names, the StringTable values are arrays of individual resource data lines.

If there are no ::RESOURCE directives, the .RESOURCES symbol has the default value of **.RESOURCES**.

Example 6.5. .RESOURCE

```
do name over .resources
  say name":" .resources[name]~items "lines"
  say .resources[name]~makeString
end

::resource greyCat end "-"
La nuit, tous les chats sont gris
```

```
--------------------------------

::resource "brown fox"
The quick brown fox jumps over the lazy dog
::END

::resource nollop end ANONYMOUS
     The wicked peon quivered,
then gazed balefully at the judges
         who examined him.
ANONYMOUS TYPESETTER

/* Displays:
GREYCAT: 1 lines
La nuit, tous les chats sont gris
BROWN FOX: 1 lines
The quick brown fox jumps over the lazy dog
NOLLOP: 3 lines
     The wicked peon quivered,
then gazed balefully at the judges
         who examined him.
*/
```

6.18. The Return Status (.RS)

.RS is set to the return status from any executed command (including those submitted with the ADDRESS instruction). The .RS environment symbol has a value of **-1** when a command returns a FAILURE condition, a value of **1** when a command returns an ERROR condition, and a value of **0** when a command indicates successful completion. The value of .RS is also available after trapping the ERROR or FAILURE condition.

Note

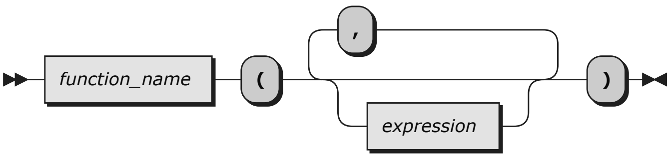
Commands executed manually during interactive tracing do not change the value of .RS. The initial value of .RS is **.RS**.

Functions

A function is an internal, built-in, or external routine that returns a single result object. (A subroutine is a function that is an internal, built-in, or external routine that might return a result and is called with the CALL instruction.)

7.1. Syntax

A function call is a term in an expression calling a routine that carries out some procedures and returns an object. This object replaces the function call in the continuing evaluation of the expression. You can include function calls to internal and external routines in an expression anywhere that a data term (such as a string) would be valid, using the following notation:



The *function_name* is a literal string or a single symbol, which is taken to be a constant.

There can be any number of expressions, separated by commas, between the parentheses. These expressions are called the arguments to the function. Each argument expression can include further function calls.

Note that the left parenthesis must be adjacent to the name of the function, with no whitespace characters in between. (A blank operator would be assumed at this point instead.) Only a comment can appear between the name and the left parenthesis.

The arguments are evaluated in turn from left to right and the resulting objects are then all passed to the function. This function then runs some operation (usually dependent on the argument objects passed, though arguments are not mandatory) and eventually returns a single object. This object is then included in the original expression as though the entire function reference had been replaced by the name of a variable whose value is the returned object.

For example, the function SUBSTR is built into the language processor and could be used as:

```
N1="abcdefghijk"
Z1="Part of N1 is: "substr(N1,2,7)
/* Sets Z1 to "Part of N1 is: bcdefgh" */
```

A function can have a variable number of arguments. You need to specify only those required. For example, **`SUBSTR("ABCDEF",4)`** would return **`DEF`**.

7.2. Functions and Subroutines

Functions and subroutines are called in the same way. The only difference between functions and subroutines is that functions must return data, whereas subroutines need not.

The following types of routines can be called as functions:

Internal
: If the routine name exists as a label in the program, the current processing status is saved for a later return to the point of invocation to resume execution. Control is then passed to the first label in the program that matches the name. As with a routine called by the CALL instruction, status

information, such as TRACE and NUMERIC settings, is saved too. See the *CALL* instruction for details.

If you call an internal routine as a function, you must specify an expression in any RETURN instruction so that the routine can return. This is not necessary if it is called as a subroutine.

Example 7.1. Recursive internal function execution

```
arg x
say x"! =" factorial(x)
exit
factorial: procedure   /* Calculate factorial by    */
  arg n                /*   recursive invocation.   */
  if n=0 then return 1
  return  factorial(n-1) * n
```

FACTORIAL is unusual in that it calls itself (this is recursive invocation). The PROCEDURE instruction ensures that a new variable **n** is created for each invocation.

Built-in
These functions are always available and are defined in *Section 7.4, "Built-in Functions"*.

External
You can write or use functions that are external to your program and to the language processor. An external routine can be written in any language, including Rexx, that supports the system-dependent interfaces the language processor uses to call it. You can call a Rexx program as a function and, in this case, pass more than one argument string. The ARG, PARSE ARG, or USE ARG instruction or the ARG built-in function can retrieve these argument strings. When called as a function, a program must return data to the caller.

Notes:

1. Calling an external Rexx program as a function is similar to calling an internal routine. For an external routine, however, the caller's variables are hidden. To leave the called Rexx program, you can use either EXIT or RETURN. In either case, you must specify an expression.

2. You can use the INTERPRET instruction to process a function with a variable function name. However, avoid this if possible because it reduces the clarity of the program.

7.2.1. Search Order

Functions are searched in the following sequence: internal routines, built-in functions, external functions.

Function calls or subroutines may use a name that is specified as a symbol or a literal string. For example, these calls are equivalent:

```
call MyProcedure
call 'MYPROCEDURE'
```

Note that the name value when specified as a symbol is the symbol name translated to upper case. Both of the calls above will search for a routine named "MYPROCEDURE". When the name is specified as a literal string, then the literal string value is used as-is. Thus the following two calls are not equivalent:

```
call MyProcedure    -- calls "MYPROCEDURE"
call 'MyProcedure'  -- calls "MyProcedure"
```

Some steps of the function and subroutine search order are case sensitive, so some care may need to be exercised that the correct name form is used:

- Internal routines. Normally, labels are specified as a symbol followed by a ":". These labels have a name value that's all uppercase. Since unquoted (symbol) names also have uppercase values, these will match easily. It is also possible to use literal strings for label names. If these labels contain lowercase characters, they will not be located using normal call mechanisms

- Built-in functions. The built-in function names are all uppercase, so using a mixed-case literal string built-in function name will fail to locate the function.

```
x = wordPos(needle, haystack)     -- calls "WORDPOS", which works
x = "wordPos"(needle, haystack)   -- calls "wordPos", which will fail
```

- External routines. Some steps of the external function search order may be case sensitive, depending on the system. This may occasionally require a function or subroutine name to be specified as a mixed case literal string to be located.

If the call or function invocation uses a literal string, then the search for internal label is bypassed. This bypass mechanism allows you to extend the capabilities of an existing internal function, for example, and call it as a built-in function or external routine under the same name as the existing internal function. To call the target built-in or external routine from inside your internal routine, you must use a literal string for the function name.

Example 7.2. DATE function — overriding

```
/* This internal DATE function modifies the          */
/* default for the DATE function to standard date.   */
date: procedure
  arg in
  if in="" then in="Standard"
  -- This calls the DATE built-in function rather than recursively
  -- calling the DATE: internal routine.  Note that the name needs to
  -- be all uppercase because built-in functions have uppercase names.
  return "DATE"(in)
```

Since built-in functions have uppercase names the literal string must also be in uppercase for the search to succeed.

External functions and subroutines have a system-defined search order.

The search order for external functions is as follows:

1. Functions defined on ::ROUTINE directives within the program.

2. Public functions defined on ::ROUTINE directives of programs referenced with ::REQUIRES.

3. Functions that have been loaded into the macrospace for preorder execution. (See the *Open Object Rexx: Application Programming Interfaces* for details.)

4. Functions that are part of a function package or library package. (See the *Open Object Rexx: Application Programming Interfaces* for details.)

5. Rexx functions located in an external file. See below for how these external files are located.

6. Functions that have been loaded into the macrospace for postorder execution.

7.2.1.1. Locating External Rexx Files

Rexx uses an extensive search procedure for locating program files. The first element of the search procedure is the locations that will be checked for files. The locations, in order of checking, are:

1. The same directory the program invoking the external routine is located. If this is an initial program execution or the calling program was loaded from the macrospace, this location is skipped. Checking in this directory allows related program files to be called without requiring the directory be added to the search path.

2. The current filesystem directory.

3. Some applications using Rexx as a scripting language may define an extension path used to locate called programs. If the Rexx program was invoked directly from the system command line, then no extension path is defined.

4. Any directories specified via the REXX_PATH environment variable.

5. Any directories specified via the PATH environment variable.

The second element of the search process is the file extension. If the routine name contains at least one period, then this routine is extension qualified. The search locations above will be checked for the target file unchanged, and no additional steps will be taken. If the routine name is not extension qualified, then additional searches will be performed by adding file extensions to the name. All directory locations will be checked for a given extension before moving to the next potential extension. The following extensions may be used:

1. If the searched file is requested by a *::REQUIRES directive* without a **`LIBRARY`** option, or the **`Package`** methods *new* and *loadPackage* when only the *name* argument is specified, an attempt to locate a file using the extension **`.cls`** is made.

2. If the calling program has a file extension, then the interpreter will attempt to locate a file using the same extension as the caller.

3. Some applications using Rexx as a scripting language may define additional extension types. For example, an editor might define a preferred extension that should be used for editor macros. This extension would be searched next.

4. The default system extension, which is **`.REX`** on Windows, and both **`.rex`** and **`.REX`** on Unix-like systems.

5. If the target file has not been located using any of the above extensions, the file name is tried without an added extension.

There are some file system considerations involved when searching for files. Windows file systems typically are case insensitive, so files can be located regardless of how the call is specified. Unix-like systems typically have a case sensitive file system, so files must be exact case matches in order to be located. For these systems, each time a file name probe is attempted, the name will be tried in the case specified and also as a lower case name. The check is not performed on the very last step that uses the file name without an extension to avoid unintentional conflicts with other executable files.

Note that for function or subroutine calls using an unquoted name, the target name is the string value of the name symbol, which will be an uppercase value. Thus calls to myfunc(), MyFunc(), and myFUNC() all trigger a search for a function named "MYFUNC". Calls specified as a quoted string will maintain the original string case. Thus 'myfunc'() and 'MyFunc'() would search for different names.

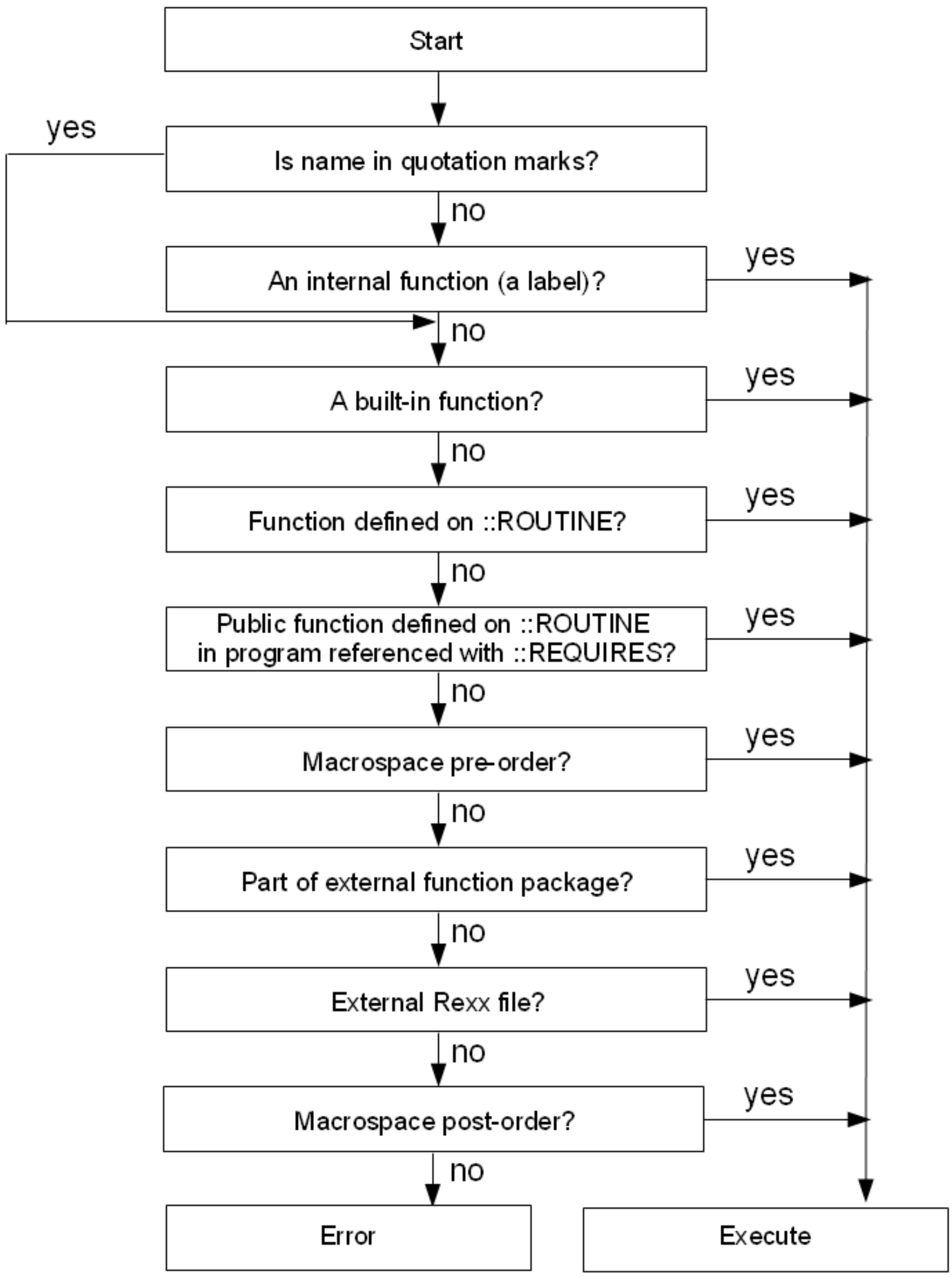


Figure 7.1. Function and Routine Resolution and Execution

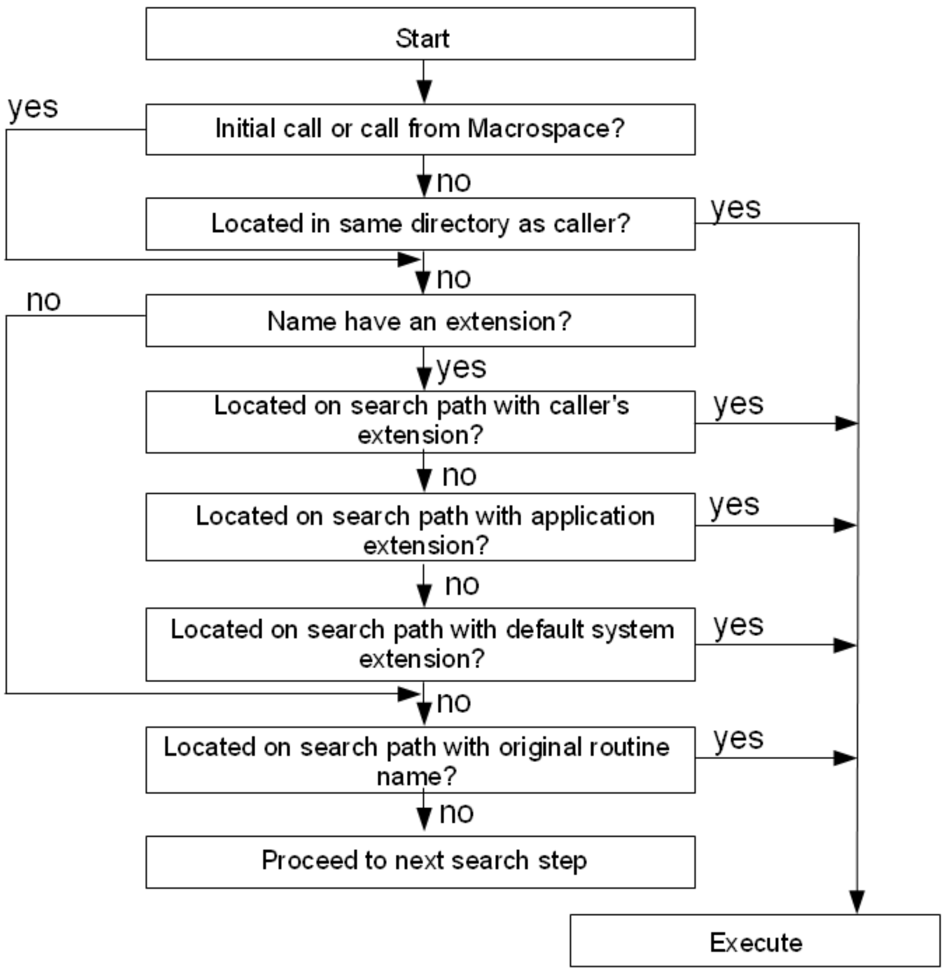


Figure 7.2. Function and Routine External File Resolution

7.2.2. Errors during Execution

If an external or built-in function detects an error, the language processor is informed, and a syntax error results. Syntax errors can be trapped in the caller using SIGNAL ON SYNTAX and recovery might be possible. If the error is not trapped, the program is ended.

7.3. Return Values

A function usually returns a value that is substituted for the function call when the expression is evaluated.

How the value returned by a function (or any Rexx routine) is handled depends on whether it is called by a function call or as a subroutine with the CALL instruction.

- A routine called as a subroutine: If the routine returns a value, that value is stored in the special variable named RESULT. Otherwise, the RESULT variable is dropped, and its value is the string **RESULT**.
- A routine called as a function: If the function returns a value, that value is substituted in the expression at the position where the function was called. Otherwise, the language processor stops with an error message.

Here are some examples of how to call a Rexx procedure:

Example 7.3. How to call Rexx procedures

```
call Beep 500, 100         /* Example 1: a subroutine call */
```

The built-in function BEEP is called as a Rexx subroutine. The return value from BEEP is placed in the Rexx special variable **RESULT**.

```
bc = Beep(500, 100)        /* Example 2: a function call   */
```

BEEP is called as a Rexx function. The return value from the function is substituted for the function call. The clause itself is an assignment instruction; the return value from the BEEP function is placed in the variable **bc**.

```
Beep(500, 100)             /* Example 3: result passed as  */
                           /*            a command         */
```

The BEEP function is processed and its return value is substituted in the expression for the function call, like in the preceding example. In this case, however, the clause as a whole evaluates to a single expression. Therefore, the evaluated expression is passed to the current default environment as a command.

Note

Many other languages, such as C, throw away the return value of a function if it is not assigned to a variable. In Rexx, however, a value returned like in the third example is passed on to the current environment or subcommand handler. If that environment is the default, the operating system performs a disk search for what seems to be a command.

7.4. Built-in Functions

Rexx provides a set of built-in functions, including character manipulation, conversion, and information functions. The following are general notes on the built-in functions:

- The parentheses in a function are always needed, even if no arguments are required. The first parenthesis must follow the name of the function with no whitespace in between.
- The built-in functions internally work with NUMERIC DIGITS 9 for 32-bit systems or NUMERIC DIGITS 18 for 64-bit systems, and NUMERIC FUZZ 0 and are unaffected by changes to the NUMERIC settings, except where stated. Any argument named as a *number* is rounded, if necessary, according to the current setting of NUMERIC DIGITS (as though the number had been added to 0) and checked for validity before use. This occurs in the following functions: ABS, FORMAT, MAX, MIN, SIGN, and TRUNC, and for certain options of DATATYPE.
- Any argument named as a *string* can be a null string.
- If an argument specifies a *length*, it must be a positive whole number or zero. If it specifies a *start* character or word in a string, it must be a positive whole number, unless otherwise stated.

- If the last argument is optional, you can always include a comma to indicate that you have omitted it. For example, **`DATATYPE(1,)`**, like **`DATATYPE(1)`**, would return **`NUM`**. You can include any number of trailing commas; they are ignored. If there are actual parameters, the default values apply.

- If you specify a *pad* character, it must be exactly one character long. A pad character extends a string, usually on the right. For an example, see the *LEFT* built-in function.

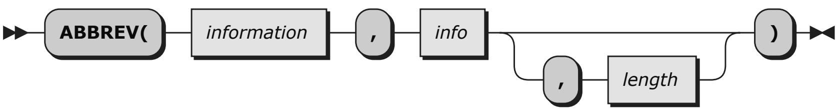
- If a function has an *option* that you can select by specifying the first character of a string, that character can be in uppercase or lowercase.

- Many of the built-in functions invoke methods of the *String* class. For the functions ABBREV, ABS, BITAND, BITOR, BITXOR, B2X, CENTER, CENTRE, CHANGESTR, COMPARE, COPIES, COUNTSTR, C2D, C2X, DATATYPE, DELSTR, DELWORD, D2C, D2X, FORMAT, LEFT, LENGTH, LOWER, MAX, MIN, REVERSE, RIGHT, SIGN, SPACE, STRIP, SUBSTR, SUBWORD, TRANSLATE, TRUNC, UPPER, VERIFY, WORD, WORDINDEX, WORDLENGTH, WORDS, X2B, X2C, and X2D, the first argument to the built-in function is used as the receiver object for the message sent, and the remaining arguments are used in the same order as the message arguments. For example, **`SUBSTR("abcde", 3, 2)`** is equivalent to **`"abcde"~substr(3, 2)`**.

  For the functions INSERT, LASTPOS, OVERLAY, POS, and WORDPOS, the second argument to the built-in functions is used as the receiver object for the message sent, and the other arguments are used in the same order as the message arguments. For example, **`POS("a", "Haystack",3)`** is equivalent to **`"Haystack"~pos("a", 3)`**.

- The language processor evaluates all built-in function arguments to produce character strings.

7.4.1. ABBREV (Abbreviation)



Returns **`1`** if *info* is equal to the leading characters of *information* and the length of *info* is not less than *length*. It returns **`0`** if either of these conditions is not met.

If you specify *length*, it must be a positive whole number or zero. The default for *length* is the number of characters in *info*.

Here are some examples:

Example 7.4. Builtin function ABBREV examples

```
ABBREV("Print","Pri")      ->    1
ABBREV("PRINT","Pri")      ->    0
ABBREV("PRINT","PRI",4)    ->    0
ABBREV("PRINT","PRY")      ->    0
ABBREV("PRINT","")         ->    1
ABBREV("PRINT","",1)       ->    0
```

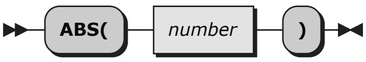
Note

A null string always matches if a length of **0**, or the default, is used. This allows a default keyword to be selected automatically if desired; for example:

Example 7.5. Builtin function ABBREV example

```
say "Enter option:";   pull option .
select  /* keyword1 is to be the default */
  when abbrev("keyword1",option) then ...
  when abbrev("keyword2",option) then ...
  ...
  otherwise nop;
end;
```

7.4.2. ABS (Absolute Value)



Returns the absolute value of *number*. The result has no sign and is formatted according to the current NUMERIC settings.

Here are some examples:

Example 7.6. Builtin function ABS

```
ABS("12.3")       ->    12.3
ABS(" -0.307")    ->    0.307
```

7.4.3. ADDRESS

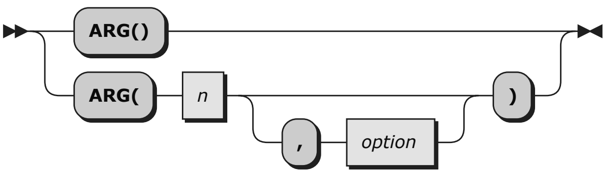
Returns the name of the environment to which commands are currently submitted. Trailing whitespace characters are removed from the result.

Here is an example:

Example 7.7. Builtin function ADDRESS

```
ADDRESS()     ->     "CMD"    // default for Windows

ADDRESS()     ->     "sh"     // default for Unix-like systems
```

7.4.4. ARG (Argument)



Returns one or more arguments, or information about the arguments to a program, internal routine, or method.

If you do not specify any argument, the number of arguments passed to the program or internal routine is returned.

If you specify only *n*, the *n*th argument object is returned. If the argument object does not exist, the null string is returned. *n* must be a positive whole number.

If you specify *option*, the value returned depends on the value of *option*. The following are valid *option*s. (Only the capitalized letter is needed; all characters following it are ignored.)

`Array`
: returns a single-index array containing the arguments, starting with the *n*th argument. The array indexes correspond to the argument positions, so that the *n*th argument is at index 1, the following argument at index 2, and so on. If any arguments are omitted, their corresponding indexes are absent.

`Exists`
: returns **`1`** if the *n*th argument exists; that is, if it was explicitly specified when the routine was called. Otherwise, it returns **`0`**.

`Normal`
: returns the *n*th argument, if it exists, or a null string.

`Omitted`
: returns **`1`** if the *n*th argument was omitted; that is, if it was not explicitly specified when the routine was called. Otherwise, it returns **`0`**.

Here are some examples:

Example 7.8. Builtin function ARG

```
/*  following "Call name;" (no arguments) */
ARG()         ->    0
ARG(1)        ->    ""
ARG(2)        ->    ""
ARG(1,"e")    ->    0
ARG(1,"O")    ->    1
ARG(1,"a")    ->    .array~of()

/*  following "Call name 'a', ,'b';" */
ARG()         ->    3
ARG(1)        ->    "a"
ARG(2)        ->    ""
ARG(3)        ->    "b"
ARG(n)        ->    ""     /* for n>=4 */
ARG(1,"e")    ->    1
ARG(2,"E")    ->    0
ARG(2,"O")    ->    1
ARG(3,"o")    ->    0
ARG(4,"o")    ->    1
ARG(1,"A")    ->    .array~of(a, ,b)
ARG(3,"a")    ->    .array~of(b)
```

Notes:

1. The number of argument strings is the largest number *n* for which **ARG(n,"e")** returns **1** or **0** if there are no explicit argument strings. That is, it is the position of the last explicitly specified argument string.

2. Programs called as commands can have only 0 or 1 argument strings. The program has 0 argument strings if it is called with the name only and has 1 argument string if anything else (including whitespace characters) is included in the command.

3. Programs called by the RexxStart entry point can have several argument strings. (See the *Open Object Rexx: Application Programming Interfaces* for information about RexxStart.)

4. You can access the argument objects of a program with the *USE* instruction.

5. You can retrieve and directly parse the argument strings of a program or internal routine with the ARG or PARSE ARG instructions.

7.4.5. B2X (Binary to Hexadecimal)

▶▶ **B2X(** *binary_string* **)** ▶◀

Returns a string, in character format, that represents *binary_string* converted to hexadecimal.

The *binary_string* is a string of binary (**0** or **1**) digits. It can be of any length. You can optionally include whitespace characters in *binary_string* (at 4-digit boundaries only, not leading or trailing) to improve readability; they are ignored.

The returned string uses uppercase alphabetical characters for the values **A**-**F**, and does not include blanks or horizontal tabs.

If *binary_string* is the null string, B2X returns a null string. If the number of binary digits in *binary_string* is not a multiple of 4, then up to three **0** digits are added on the left before the conversion to make a total that is a multiple of 4.

Here are some examples:

Example 7.9. Builtin function B2X

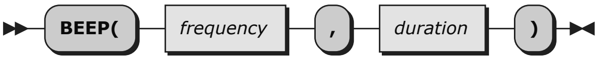
```
B2X("11000011")    ->   "C3"
B2X("10111")       ->   "17"
B2X("101")         ->   "5"
B2X("1 1111 0000") ->   "1F0"
```

You can combine B2X with the functions X2D and X2C to convert a binary number into other forms. For example:

Example 7.10. Builtin function B2X combined with X2D function

```
X2D(B2X("10111"))  ->   "23"   /* decimal 23 */
```

7.4.6. BEEP



Sounds the speaker at *frequency* Hertz for *duration* milliseconds. The *frequency* can be any whole number in the range 37 to 32767 Hertz. The *duration* can be any whole number in the range 0 to 60000 milliseconds.

This routine is most useful when called as a subroutine. A null string is returned.

Notes

On Unix-like systems, to sound the speaker at a specified frequency, a console with ioctl KDMKTONE support must be available, which typically requires root access. If there is no console with KDMKTONE support (e. g. on BSD or Darwin), a bell character is sent to the console instead.

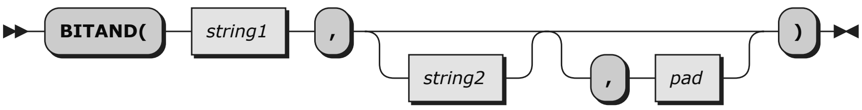
On Windows beeps may have been deactivated. To check the status of the Windows beep service, use the Service Control Manager command **`sc qc beep`**. To permanently enable the system beep service, run the command **`sc config beep start= auto`** in a Command window with Administrator rights, and then reboot your system.

Here is an example for Windows:

Example 7.11. Builtin function BEEP

```
-- C scale
note.1 = 262    -- Do,  middle C
note.2 = 294    -- Re,  D
note.3 = 330    -- Mi,  E
note.4 = 349    -- Fa,  F
note.5 = 392    -- Sol, G
note.6 = 440    -- La,  A
note.7 = 494    -- Si,  B, H
note.8 = 523    -- Do,  C

do i = 1 to 8
  call beep note.i, 250 -- hold each note for 1/4 second
end
```

7.4.7. BITAND (Bit by Bit AND)



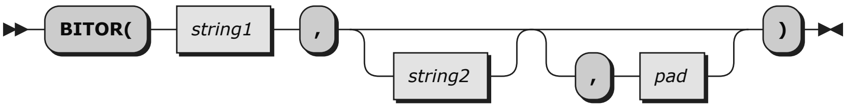
Returns a string composed of the two input strings logically ANDed, bit by bit. (The encodings of the strings are used in the logical operation.) The length of the result is the length of the longer of the two strings. If no *pad* character is provided, the AND operation stops when the shorter of the two strings is exhausted, and the unprocessed portion of the longer string is appended to the partial result. If *pad* is provided, it extends the shorter of the two strings on the right before carrying out the logical operation. The default for *string2* is the zero-length (null) string.

Here are some examples:

Example 7.12. Builtin function BITAND

```
BITAND("12"x)                   ->    "12"x
BITAND("73"x,"27"x)             ->    "23"x
BITAND("13"x,"5555"x)           ->    "1155"x
BITAND("13"x,"5555"x,"74"x)     ->    "1154"x
BITAND("pQrS", ,"DF"x)          ->    "PQRS"      /* ASCII   */
```

7.4.8. BITOR (Bit by Bit OR)



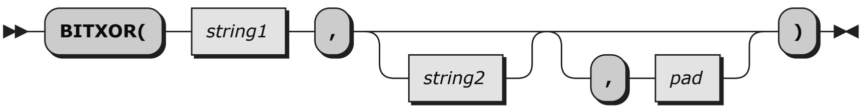
Returns a string composed of the two input strings logically inclusive-ORed, bit by bit. (The encodings of the strings are used in the logical operation.) The length of the result is the length of the longer of the two strings. If no *pad* character is provided, the OR operation stops when the shorter of the two strings is exhausted, and the unprocessed portion of the longer string is appended to the partial result. If *pad* is provided, it extends the shorter of the two strings on the right before carrying out the logical operation. The default for *string2* is the zero-length (null) string.

Here are some examples:

Example 7.13. Builtin function BITOR

```
BITOR("12"x)                    ->    "12"x
BITOR("15"x,"24"x)              ->    "35"x
BITOR("15"x,"2456"x)            ->    "3556"x
BITOR("15"x,"2456"x,"F0"x)      ->    "35F6"x
BITOR("1111"x, ,"4D"x)          ->    "5D5D"x
BITOR("pQrS", ,"20"x)           ->    "pqrs" /* ASCII   */
```

7.4.9. BITXOR (Bit by Bit Exclusive OR)



Returns a string composed of the two input strings logically eXclusive-ORed, bit by bit. (The encodings of the strings are used in the logical operation.) The length of the result is the length of the longer of the two strings. If no *pad* character is provided, the XOR operation stops when the shorter of the two strings is exhausted, and the unprocessed portion of the longer string is appended to the partial result. If *pad* is provided, it extends the shorter of the two strings on the right before carrying out the logical operation. The default for *string2* is the zero-length (null) string.

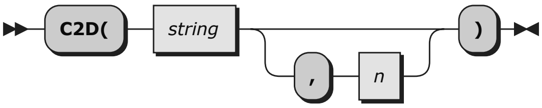
Here are some examples:

Example 7.14. Builtin function BITXOR

```
BITXOR("12"x)                      ->  "12"x
BITXOR("12"x,"22"x)                ->  "30"x
BITXOR("1211"x,"22"x)              ->  "3011"x
BITXOR("1111"x,"444444"x)          ->  "555544"x
```

```
BITXOR("1111"x,"444444"x,"40"x)   ->  "555504"x
BITXOR("1111"x, ,"4D"x)           ->  "5C5C"x
BITXOR("C711"x,"222222"x," ")     ->  "E53302"x  /* ASCII  */
```

7.4.10. C2D (Character to Decimal)



Returns the decimal value of the binary representation of *string*. If the result cannot be expressed as a whole number, an error results. That is, the result must not have more digits than the current setting of NUMERIC DIGITS. If you specify *n*, it is the length of the returned result. If you do not specify *n*, *string* is processed as an unsigned binary number.

If *string* is null, **`0`** is returned.

Here are some examples:

Example 7.15. Builtin function C2D

```
C2D("09"X)      ->        9
C2D("81"X)      ->      129
C2D("FF81"X)    ->    65409
C2D("")         ->        0
C2D("a")        ->       97     /*  ASCII   */
```

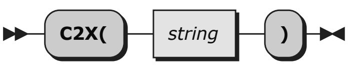
If you specify *n*, the string is taken as a signed number expressed in *n* characters. The number is positive if the leftmost bit is off, and negative if the leftmost bit is on. In both cases, it is converted to a whole number, which can be negative. The *string* is padded on the left with "00"x characters (not "sign-extended"), or truncated on the left to *n* characters. This padding or truncation is as though **`RIGHT(string, n,"00"x)`** had been processed. If *n* is **`0`**, C2D always returns **`0`**.

Here are some examples:

Example 7.16. Builtin function C2D

```
C2D("81"X,1)      ->     -127
C2D("81"X,2)      ->      129
C2D("FF81"X,2)    ->     -127
C2D("FF81"X,1)    ->     -127
C2D("FF7F"X,1)    ->      127
C2D("F081"X,2)    ->    -3967
C2D("F081"X,1)    ->     -127
C2D("0031"X,0)    ->        0
```

7.4.11. C2X (Character to Hexadecimal)



Returns a string, in character format, that represents *string* converted to hexadecimal. The returned string contains twice as many bytes as the input string. On an ASCII system, C2X(1) returns **31** because the ASCII representation of the character 1 is "31"X.

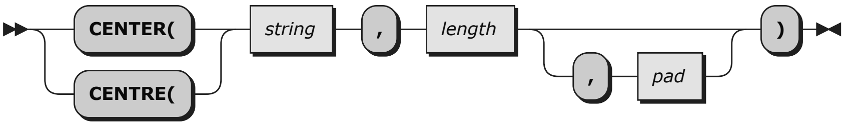
The string returned uses uppercase alphabetical characters for the values **A**-**F** and does not include whitespace characters. The *string* can be of any length. If *string* is null, a null string is returned.

Here are some examples:

Example 7.17. Builtin function C2X

```
C2X("0123"X)    ->    "0123"   /* "30313233"X     in ASCII */
C2X("ZD8")      ->    "5A4438" /* "354134343338"X in ASCII */
```

7.4.12. CENTER (or CENTRE)



Returns a string of length *length* with *string* centered in it and with *pad* characters added as necessary to make up length. The *length* must be a positive whole number or zero. The default *pad* character is blank. If the string is longer than *length*, it is truncated at both ends to fit. If an odd number of characters is truncated or added, the right-hand end loses or gains one more character than the left-hand end.

Here are some examples:

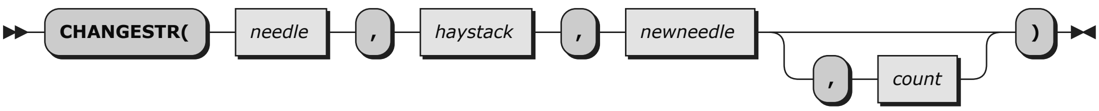
Example 7.18. Builtin function CENTER

```
CENTER(abc,7)               ->    "  ABC  "
CENTER(abc,8,"-")           ->    "--ABC---"
CENTRE("The blue sky",8)    ->    "e blue s"
CENTRE("The blue sky",7)    ->    "e blue "
```

Note

To avoid errors because of the difference between British and American spellings, this function can be called either CENTRE or CENTER.

7.4.13. CHANGESTR



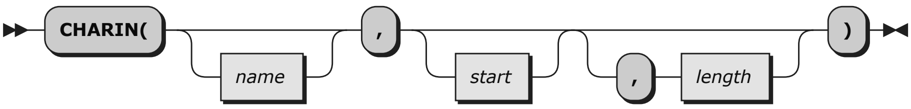
Returns a copy of *haystack* in which *newneedle* replaces occurrences of *needle*. If *count* is not specified, all occurrences of *needle* are replaced. If *count* is specified, it must be a non-negative, whole number that gives the maximum number of occurrences to be replaced.

Here are some examples:

Example 7.19. Builtin function CHANGESTR

```
CHANGESTR("1","101100","")      ->    "000"
CHANGESTR("1","101100","X")     ->    "X0XX00"
CHANGESTR("1","101100","X", 1) ->    "X01100"
```

7.4.14. CHARIN (Character Input)



Returns a string of up to *length* characters read from the character input stream *name*. (To understand the input and output functions, see *Chapter 14, Input and Output Streams*.) If you omit *name*, characters are read from STDIN, which is the default input stream. The default *length* is **1**.

For persistent streams, a read position is maintained for each stream. Any read from the stream starts at the current read position by default. When the language processor completes reading, the read position is increased by the number of characters read. You can give a *start* value to specify an explicit read position. This read position must be a positive whole number and within the bounds of the stream, and must not be specified for a transient stream. A value of **1** for *start* refers to the first character in the stream. If *start* is not a positive whole number the appropriate syntax condition is raised. When the read position is past the bounds of the stream, the empty string is returned and the NOTREADY condition is raised.

If you specify a *length* of **0**, then the read position is set to the value of *start*, but no characters are read and the null string is returned.

In a transient stream, if there are fewer than *length* characters available, the execution of the program generally stops until sufficient characters become available. If, however, it is impossible for those characters to become available because of an error or another problem, the NOTREADY condition is raised (see *Section 14.5, "Errors during Input and Output"*) and CHARIN returns with fewer than the requested number of characters.

Here are some examples:

Example 7.20. Builtin function CHARIN

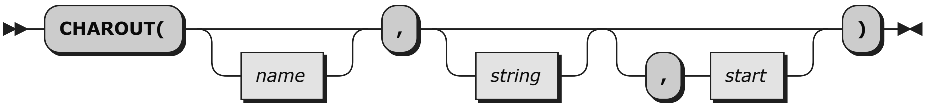
```
CHARIN(myfile,1,3)    ->    "MFC"    /* the first 3        */
                                     /* characters         */
CHARIN(myfile,1,0)    ->    ""       /* now at start       */
CHARIN(myfile)        ->    "M"      /* after last call    */
CHARIN(myfile, ,2)    ->    "FC"     /* after last call    */

/* Reading from the default input (here, the keyboard)    */
/* User types "abcd efg"                                   */
CHARIN()              ->    "a"      /* default is         */
                                     /* 1 character        */
CHARIN(, ,5)          ->    "bcd e"
```

Notes:

1. CHARIN returns all characters that appear in the stream, including control characters such as *line-end* and *end-of-file*.

2. When CHARIN reads from the keyboard, program execution stops until you press the Enter key.

7.4.15. CHAROUT (Character Output)



Returns the count of characters remaining after attempting to write *string* to the character output stream *name*. (To understand the input and output functions, see *Chapter 14, Input and Output Streams*.) If you omit *name*, characters in *string* are written to STDOUT (generally the display), which is the default output stream. The *string* can be a null string, in which case no characters are written to the stream, and **`0`** is always returned.

For persistent streams, a write position is maintained for each stream. Any write to the stream starts at the current write position by default. When the language processor completes writing, the write position is increased by the number of characters written. When the stream is first opened, the write position is at the end of the stream so that calls to CHAROUT append characters to the end of the stream.

You can give a *start* value to specify an explicit write position for a persistent stream. This write position must be a positive whole number. A value of **`1`** for *start* refers to the first character in the stream.

You can omit the *string* for persistent streams. In this case, the write position is set to the value of *start* that was given, no characters are written to the stream, and **`0`** is returned. If you do not specify *start* or *string*, the stream is closed and **`0`** is returned.

Execution of the program usually stops until the output operation is complete.

For example, when data is sent to a printer, the system accepts the data and returns control to Rexx, even though the output data might not have been printed. Rexx considers this to be complete, even though the data has not been printed. If, however, it is impossible for all the characters to be written, the NOTREADY condition is raised (see *Section 14.5, “Errors during Input and Output”*) and CHAROUT returns with the number of characters that could not be written (the residual count).

Here are some examples:

Example 7.21. Builtin function CHAROUT

```
CHAROUT(myfile,"Hi")      ->   0   /* typically        */
CHAROUT(myfile,"Hi",5)    ->   0   /* typically        */
CHAROUT(myfile, ,6)       ->   0   /* now at char 6    */
CHAROUT(myfile)           ->   0   /* at end of stream */
CHAROUT(,"Hi")            ->   0   /* typically        */
CHAROUT(,"Hello")         ->   2   /* maybe            */
```

Note

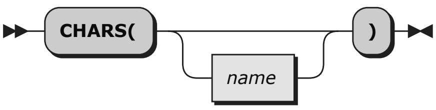
This routine is often best called as a subroutine. The residual count is then available in the variable RESULT.

For example:

Example 7.22. Builtin function CHAROUT

```
Call CHAROUT myfile,"Hello"
Call CHAROUT myfile,"Hi",6
Call CHAROUT myfile
```

7.4.16. CHARS (Characters Remaining)



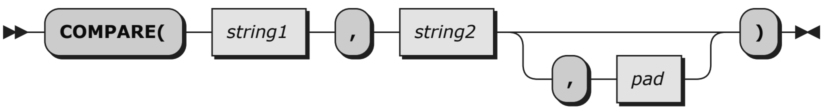
Returns the total number of characters remaining in the character input stream *name*. The count includes any line separator characters, if these are defined for the stream. In the case of persistent streams, it is the count of characters from the current read position. (See *Chapter 14, Input and Output Streams* for a discussion of Rexx input and output.) If you omit *name*, the number of characters available in the default input stream (STDIN) is returned.

The total number of characters remaining cannot be determined for some streams (for example, STDIN or Windows/Unix-like system devices). For these streams, the CHARS function returns **1** to indicate that data is present, or **0** if no data is present.

Example 7.23. Builtin function CHARS

```
CHARS(myfile)      ->   42    /* perhaps */
CHARS(nonfile)     ->   0
CHARS()            ->   1     /* perhaps */
```

7.4.17. COMPARE

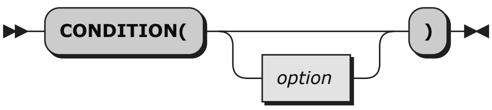


Returns **0** if the strings *string1* and *string2* are identical. Otherwise, it returns the position of the first character that does not match. The shorter string is padded on the right with *pad* if necessary. The default *pad* character is a blank.

Example 7.24. Builtin function COMPARE

```
COMPARE("abc","abc")          ->    0
COMPARE("abc","ak")           ->    2
COMPARE("ab ","ab")           ->    0
COMPARE("ab ","ab"," ")       ->    0
COMPARE("ab ","ab","x")       ->    3
COMPARE("ab-- ","ab","-")     ->    5
```

7.4.18. CONDITION



Returns the condition information associated with the current trapped condition. (See *Chapter 11, Conditions and Condition Traps* for a description of condition traps.) You can request the following pieces of information:

- The name of the current trapped condition
- Any descriptive string associated with that condition
- Any condition-specific information associated with the current trapped condition
- The instruction processed as a result of the condition trap (CALL or SIGNAL)
- The status of the trapped condition

In addition, you can request a condition object containing all of the preceding information.

To select the information to be returned, use the following *option*s. (Only the capitalized letter is needed; all characters following it are ignored.)

`Additional`
: returns any additional object information associated with the current trapped condition. See *Section 11.3.2, "Additional Object Information"* for a list of possible values. If no additional object information is available or no condition has been trapped, the language processor returns **`.nil`**.

`Condition name`
: returns the name of the current trapped condition. For user conditions, the returned string is a concatenation of the word **`USER`** and the user condition name, separated by a whitespace character.

`Description`
: returns any descriptive string associated with the current trapped condition. See *Section 11.3.1, "Descriptive Strings"* for the list of possible values. If no description is available or no condition has been trapped, it returns a null string.

`Extra`
: returns the Rexx error subcode associated with a trapped SYNTAX condition. If no SYNTAX condition has been trapped, it returns a null string.

`Instruction`
: returns either **`CALL`** or **`SIGNAL`**, the keyword for the instruction processed when the current condition was trapped. This is the default if you omit *option*. If no condition has been trapped, it returns a null string.

`Object`
: returns an object that contains all the information about the current trapped condition. See *Section 11.3.5, "Condition Object"* for more information. If no condition has been trapped, it returns **`.nil`**.

`Reset`
: resets any currently trapped condition and returns the null string. After a reset, all CONDITION options will return their default values, as if no condition has been trapped.

`Status`

returns the status of the current trapped condition. This can change during processing, and is one of the following:

- **`ON`** - the condition is enabled
- **`OFF`** - the condition is disabled
- **`DELAY`** - any new occurrence of the condition is delayed or ignored

If no condition has been trapped, a null string is returned.

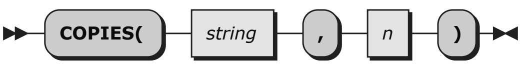
Example 7.25. Builtin function CONDITION

```
CONDITION()              ->     "CALL"         /* perhaps */
CONDITION("C")           ->     "FAILURE"
CONDITION("I")           ->     "CALL"
CONDITION("D")           ->     "FailureTest"
CONDITION("S")           ->     "OFF"         /* perhaps */
```

Note

The CONDITION function returns condition information that is saved and restored across subroutine calls (including those a CALL ON condition trap causes). Therefore, after a subroutine called with CALL ON *trapname* has returned, the current trapped condition reverts to the condition that was current before the CALL took place (which can be none). CONDITION returns the values it returned before the condition was trapped.

7.4.19. COPIES

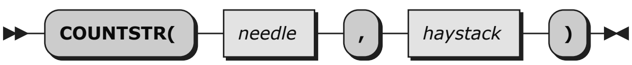


Returns *n* concatenated copies of *string*. The *n* must be a positive whole number or zero.

Example 7.26. Builtin function COPIES

```
COPIES("abc",3)    ->    "abcabcabc"
COPIES("abc",0)    ->    ""
```

7.4.20. COUNTSTR



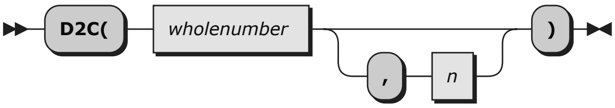
Returns a count of the occurrences of *needle* in *haystack* that do not overlap.

Example 7.27. Builtin function COUNTSTR

```
COUNTSTR("1","101101")        ->    4
```

```
COUNTSTR("KK","J0KKK0")        ->    1
```

7.4.21. D2C (Decimal to Character)



Returns a string, in character format, that is the ASCII representation of the decimal number. If you specify *n*, it is the length of the final result in characters; leading "00"x (for a positive *wholenumber*) or "FF"x (for a negative *wholenumber*) characters are added to the result string as necessary. *n* must be a positive whole number or zero.

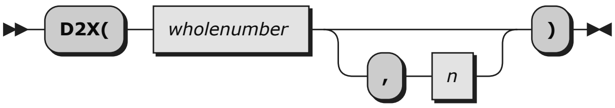
Wholenumber must not have more digits than the current setting of NUMERIC DIGITS.

If you omit *n*, *wholenumber* must be a positive whole number or zero, and the result length is as needed. Therefore, the returned result has no leading "00"x characters.

Example 7.28. Builtin function D2C

```
D2C(65)      ->   "A"      /* "41"x is an ASCII "A"              */
D2C(65,1)    ->   "A"
D2C(65,2)    ->   " A"     /* the leading character is a "00"x    */
D2C(65,5)    ->   "    A"  /* the leading characters are "00"x    */
D2C(109)     ->   "m"      /* "6D"x  is an ASCII "m"             */
D2C(-109,1)  ->   "ô"      /* "93"x is an ASCII "ô"   */
D2C(76,2)    ->   " L"     /* "4C"x  is an ASCII "L"             */
D2C(-180,2)  ->   " L"     /* the leading character is a "FF"x    */
```

7.4.22. D2X (Decimal to Hexadecimal)



Returns a string, in character format, that represents *wholenumber*, a decimal number, converted to hexadecimal. The returned string uses uppercase alphabetics for the values **A-F** and does not include whitespace characters.

Wholenumber must not have more digits than the current setting of NUMERIC DIGITS.

If you specify *n*, it is the length of the final result in characters. After conversion the input string is sign-extended to the required length. If the number is too big to fit *n* characters, it is truncated on the left. *n* must be a positive whole number or zero.

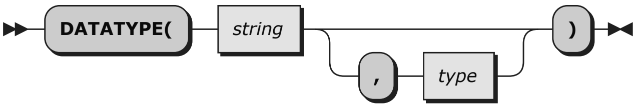
If you omit *n*, *wholenumber* must be a positive whole number or zero, and the returned result has no leading zeros.

Example 7.29. Builtin function D2X

```
D2X(9)         ->    "9"
D2X(129)       ->    "81"
D2X(129,1)     ->    "1"
D2X(129,2)     ->    "81"
D2X(129,4)     ->    "0081"
```

```
D2X(257,2)      ->     "01"
D2X(-127,2)     ->     "81"
D2X(-127,4)     ->     "FF81"
D2X(12,0)       ->     ""
```

7.4.23. DATATYPE



Returns **NUM** if you specify only *string* and if *string* is a valid Rexx number that can be added to 0 without error; returns **CHAR** if *string* is not a valid number.

If you specify *type*, it returns **1** if *string* matches the type. Otherwise, it returns **0**. If *string* is null, the function returns **0** (except when the *type* is **X** or **B**, for which DATATYPE returns **1** for a null string). The following are valid *type*s. (Only the capitalized letter, or **9** for the **9Digits** option, is needed; all characters following it are ignored. For example, for the **heXadecimal** option, you must start your string specifying the name of the option with **X** rather than **H**.)

Alphanumeric
: returns **1** if *string* contains only characters from the ranges **a-z**, **A-Z**, and **0-9**.

Binary
: returns **1** if *string* contains only the characters **0** or **1**, or whitespace. Whitespace characters can appear only between groups of 4 binary characters. It also returns **1** if *string* is a null string, which is a valid binary string.

Internal whole number
: returns **1** if *string* is a Rexx whole number that *built-in functions* will accept. Rexx built-in functions internally work with NUMERIC DIGITS 9 for 32-bit systems or NUMERIC DIGITS 18 for 64-bit systems.

Lowercase
: returns **1** if *string* contains only characters from the range **a-z**.

Mixed case
: returns **1** if *string* contains only characters from the ranges **a-z** and **A-Z**.

Number
: returns **1** if **DATATYPE(string)** returns **NUM**.

lOgical
: returns **1** if the string is exactly "0" or "1". Otherwise it returns **0**.

Symbol
: returns **1** if *string* is a valid symbol, that is, if **SYMBOL(string)** does not return **BAD**. (See *Section 1.10.4.4, “Symbols”*.) Note that both uppercase and lowercase alphabetics are permitted.

Uppercase
: returns **1** if *string* contains only characters from the range **A-Z**.

Variable
: returns **1** if *string* could appear on the left-hand side of an assignment without causing a SYNTAX condition.

`Whole number`
: returns **`1`** if *string* is a Rexx whole number under the current setting of NUMERIC DIGITS.

`heXadecimal`
: returns **`1`** if *string* contains only characters from the ranges **`a-f`**, **`A-F`**, **`0-9`**, and whitespace (as long as the whitespace characters appear only between pairs of hexadecimal characters). It also returns **`1`** if *string* is a null string, which is a valid hexadecimal string.

`9 digits`
: returns **`1`** if **`DATATYPE(string,"W")`** returns **`1`** when NUMERIC DIGITS is set to **`9`**.

Here are some examples:

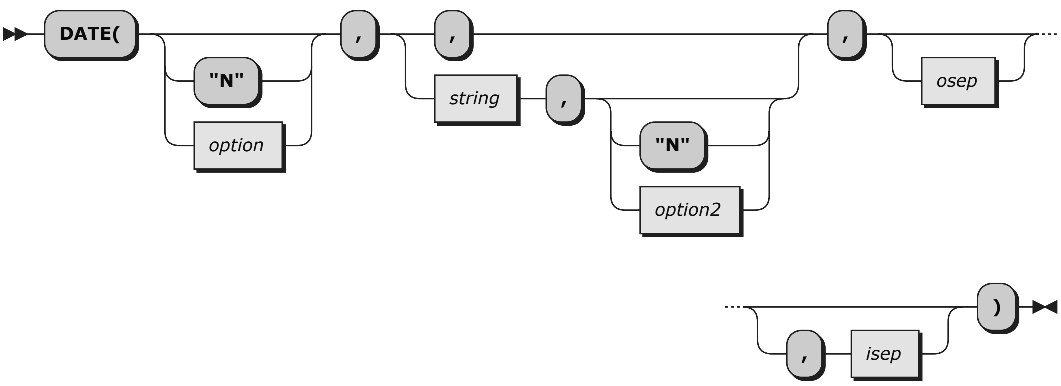
Example 7.30. Builtin function DATATYPE

```
DATATYPE(" 12 ")          ->   "NUM"
DATATYPE("")              ->   "CHAR"
DATATYPE("123*")          ->   "CHAR"
DATATYPE("12.3","N")      ->    1
DATATYPE("12.3","W")      ->    0
DATATYPE("Fred","M")      ->    1
DATATYPE("Fred","U")      ->    0
DATATYPE("Fred","L")      ->    0
DATATYPE("?20K","s")      ->    1
DATATYPE("BCd3","X")      ->    1
DATATYPE("BC d3","X")     ->    1
DATATYPE("1","O")         ->    1
DATATYPE("11,"O")         ->    0
```

Note

The DATATYPE function tests the meaning or type of characters in a string, independent of the encoding of those characters (for example, ASCII or EBCDIC).

7.4.24. DATE



Returns, by default, the local date in the format: *dd mon yyyy* (day month year—for example, **`14 May 2017`**), with no leading zero or blank on the day. The first three characters of the English name of the month are used.

You can use the following *option*s to obtain specific formats. (Only the capitalized letter is needed; all characters following it are ignored.)

`Base`

returns the number of complete days (that is, not including the current day) since and including the base date, 1 January 0001, in the format: *dddddd* (no leading zeros or whitespace). The expression **`DATE("B")//7`** returns a number in the range **`0-6`** that corresponds to the current day of the week, where **`0`** is Monday and **`6`** is Sunday.

> **Note**
>
> The base date of 1 January 0001 is determined by extending the current Gregorian calendar backward (365 days each year, with an extra day every year that is divisible by 4 except century years that are not divisible by 400). It does not take into account any errors in the calendar system that created the Gregorian calendar originally.

`Days`

returns the number of days, including the current day, that have passed this year in the format *ddd* (no leading zeros or whitespace).

`European`

returns the date in the format dd/mm/yy.

`Full`

returns the number of microseconds since 00:00:00.000000 on 1 January 0001, in the format: *dddddddddddddddddd* (no leading zeros or whitespace).

> **Notes**
>
> The base date of 1 January 0001 is determined by extending the current Gregorian calendar backward (365 days each year, with an extra day every year that is divisible by 4 except century years that are not divisible by 400). It does not take into account any errors in the calendar system that created the Gregorian calendar originally.

The value returned by Date('F') can be used to calculate the interval between any two dates. Note, however, that values returned generally contain more digits than the default NUMERIC DIGITS setting. The NUMERIC DIGITS setting should be increased to a minimum value of 18 when performing timestamp arithmetic.

`ISO`

Returns the date according to the format specified by ISO 8601. The format is *yyyy-mm-dd* with leading zeroes if required.

`Language`

returns the date in an implementation- and language-dependent, or local, date format. The format is *dd month yyyy*. The name of the month is according to the national language installed on the system. If no local date format is available, the default format is returned.

Note

This format is intended to be used as a whole; Rexx programs must not make any assumptions about the form or content of the returned string.

`Month`
: returns the full English name of the current month, for example, **`August`**.

`Normal`
: returns the date in the format *dd mon yyyy*. This is the default.

`Ordered`
: returns the date in the format *yy/mm/dd* (suitable for sorting, for example).

`Standard`
: returns the date in the format *yyyymmdd* (suitable for sorting, for example).

`Ticks`
: returns the number of seconds since 00:00:00.000000 on 1 January 1970, in the format: *ddddddddddd* (no leading zeros or whitespace).

The value returned by Date('T') can be used to calculate the interval between any two dates. Note, however, that values returned generally contain more digits than the default NUMERIC DIGITS setting. The NUMERIC DIGITS setting should be increased to a minimum value of 12 when performing timestamp arithmetic.

Date('T') will return a negative number for dates prior to 1 January 1970.

`Usa`
: returns the date in the format *mm/dd/yy*.

`Weekday`
: returns the English name for the day of the week, in mixed case, for example, **`Tuesday`**.

Here are some examples, assuming today is 24 Nov 2016:

Example 7.31. Builtin function DATE

```
DATE()        -- 24 Nov 2016
DATE("B")     -- 736291
DATE("D")     -- 329
DATE("E")     -- 24/11/16
DATE("F")     -- 63615600688459000
DATE("I")     -- 2016-11-24
DATE("L")     -- 24 November 2016
DATE("M")     -- November
DATE("N")     -- 24 Nov 2016
DATE("O")     -- 16/11/24
DATE("S")     -- 20161124
DATE("T")     -- 1480003888
DATE("U")     -- 11/24/16
DATE("W")     -- Thursday
```

Note

The first call to DATE or TIME in one clause causes a time stamp to be made that is then used for all calls to these functions in that clause. Therefore, several calls to any of the DATE or TIME functions, or both, in a single expression or clause are consistent with each other.

If you specify *string*, DATE returns the date corresponding to *string* in the format *option*. The *string* must be supplied in the format *option2*. The *option2* format must specify day, month, and year (that is, not "D", "L", "M", or "W"). The default for *option2* is "N", so you need to specify *option2* if *string* is not in the Normal format. Here are some examples:

Example 7.32. Builtin function DATE set

```
DATE("O", "13 Feb 1923")              -->    "23/02/13"
DATE("O", "06/01/50", "U")            -->    "50/06/01"
DATE("N", "63630372300000000", "f") -->    "14 May 2017"
```

If you specify an output separator character *osep*, the days, month, and year returned are separated by this character. Any nonalphanumeric character or an empty string can be used. A separator character is only valid for the formats "E", "I", "N", "O", "S", and "U". Here are some examples:

Example 7.33. Builtin function DATE set

```
DATE("S", "13 Feb 2017", "N", "-")  -->    "2017-02-13"
DATE("N", "13 Feb 2017", "N", "")   -->    "13Feb2017"
DATE("N", "13 Feb 2017", "N", "-")  -->    "13-Feb-2017"
DATE("O", "06/01/50", "U","")       -->    "500601"
DATE("E", "02/13/17", "U",".")      -->    "13.02.17"
DATE("N", , ,"_")                   -->    "14_May_2017"  (today)
```

In this way, formats can be created that are derived from their respective default format, which is the format associated with *option* using its default separator character. The default separator character for each of these formats is:

Option	Default separator
European	"/"
ISO	"-"
Normal	" "
Ordered	"/"
Standard	"" (empty string)
Usa	"/"

If you specify a *string* containing a separator that is different from the default separator character of *option2*, you must also specify *isep* to indicate which separator character is valid for *string*. Basically, any date format that can be generated with any valid separator character can be used as input date *string* as long as its format has the generalized form specified by *option2* and its separator character matches the character specified by *isep*.

Here are some examples:

Example 7.34. Builtin function DATE set

```
DATE("S", "2017-11-13", "S", "", "-")  -->    "20171113"
DATE("S", "13-Nov-2017", "N", "", "-") -->    "20171113"
DATE("O", "06*01*50","U", "", "*")     -->    "500601"
DATE("U", "13.Feb.2017", "N", , ".")   -->    "02/13/17"
```

You can determine the number of days between two dates; for example:

Example 7.35. Builtin function DATE days

```
say date("B", "12/25/17", "USA") - date("B") "shopping days till Christmas!"
```

If *string* does not include the century but *option* defines that the century be returned as part of the date, the century is determined depending on whether the year to be returned is within the past 50 years or the next 49 years. Assume, for example, that you specify 10/15/61 for *string* and today's date is 10/27/2016. In this case, 1961 would be 55 years ago and 2061 would be 45 years in the future. So, 10/15/2061 would be the returned date.

Note

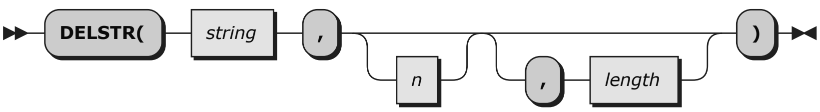
This rule is suitable for dates that are close to today's date. However, when working with birth dates, it is recommended that you explicitly provide the century.

When requesting dates to be converted to Full format or Ticks format, a time value of "00:00:00.000000" is used for the conversion. A time stamp for a time and date combination can be created by combining a value from Time() for the time of day.

Example 7.36. Builtin function DATE timestamp

```
numeric digits 18  -- needed to add the timestamps
timestamp = date("f", "20170123", "S") + time("f", "08:14:22", "N")
```

7.4.25. DELSTR (Delete String)

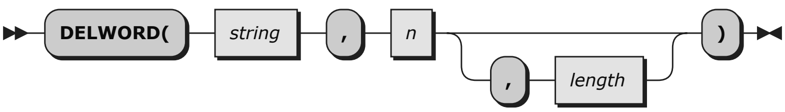


Returns *string* after deleting the substring that begins at the *n*th character and is of *length* characters. If *n* is omitted, it defaults to 1. If you omit *length*, or if *length* is greater than the number of characters from *n* to the end of *string*, the function deletes the rest of *string* (including the *n*th character). The *length* must be a positive whole number or zero. *n* must be a positive whole number. If *n* is greater than the length of *string*, the function returns *string* unchanged.

Example 7.37. Builtin function DELSTR

```
DELSTR("abcd",3)       ->    "ab"
DELSTR("abcde",3,2)    ->    "abe"
DELSTR("abcde",6)      ->    "abcde"
```

7.4.26. DELWORD (Delete Word)



Returns *string* after deleting the substring that starts at the *n*th word and is of *length* whitespace-delimited words. If you omit *length*, or if *length* is greater than the number of words from *n* to the end of *string*, the function deletes the remaining words in *string* (including the *n*th word). The *length* must be a positive whole number or zero. *n* must be a positive whole number. If *n* is greater than the number of words in *string*, the function returns *string* unchanged. The string deleted includes any whitespace characters following the final word involved but none of the whitespace preceding the first word involved.

Example 7.38. Builtin function DELWORD

```
DELWORD("Now is the  time",2,2)  ->  "Now time"
DELWORD("Now is the time ",3)    ->  "Now is "
DELWORD("Now is the  time",5)    ->  "Now is the  time"
DELWORD("Now is   the time",3,1) ->  "Now is   time"
DELWORD("Now is the  time",2,2)  ->  "Now time"
```

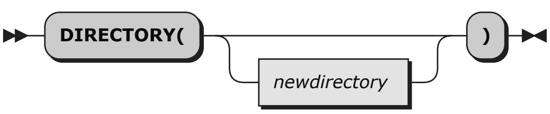
7.4.27. DIGITS

Returns the current setting of *NUMERIC DIGITS*.

Example 7.39. Builtin function DIGITS

```
DIGITS()    ->    9      /* by default */
```

7.4.28. DIRECTORY



Returns the current directory, first changing it to *newdirectory* if an argument is supplied and the named directory exists. If *newdirectory* is not specified, the name of the current directory is returned. Otherwise, an attempt is made to change to the specified *newdirectory*. If successful, the name of the *newdirectory* is returned; if an error occurred, null is returned.

On Windows the returned string includes a drive letter prefix as the first two characters of the directory name. Specifying a drive letter prefix as part of newdirectory causes the specified drive to become the current drive. If a drive letter is not specified, the current drive remains unchanged

For example, the following program fragment saves the current directory and switches to a new directory; it performs an operation there, and then returns to the former directory.

Example 7.40. Builtin function DIRECTORY

```
/* get current directory      */
curdir = directory()
/* go play a game             */
newdir = directory("/usr/games")    /* Linux type subdirectory */
if newdir = "/usr/games" then
  do
  fortune   /* tell a fortune */
/* return to former directory */
  call directory curdir
end
else
  say "Can't find /usr/games"
```

7.4.29. ENDLOCAL (Linux only)

ENDLOCAL()

Restores the directory and environment variables in effect before the last *SETLOCAL* function was run. If ENDLOCAL is not included in a procedure, the initial environment saved by SETLOCAL is restored upon exiting the procedure.

ENDLOCAL returns a value of 1 if the initial environment is successfully restored and a value of 0 if no SETLOCAL was issued or the action is otherwise unsuccessful.

Example 7.41. Builtin function ENDLOCAL

```
n = SETLOCAL()                    /* saves the current environment */
          /*
          The program can now change environment variables
          (with the VALUE function) and then work in the
          changed environment.
          */
n = ENDLOCAL()                    /* restores the initial environment */
```

For additional examples, see *Section 7.4.56, “SETLOCAL (Linux only)”*.

7.4.30. ERRORTEXT

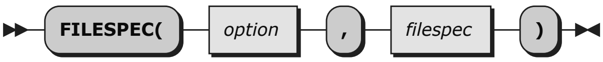
ERRORTEXT(n)

Returns the Rexx error message associated with error number *n*. *n* must be in the range **0-99**. It returns the null string if *n* is in the allowed range but is not a defined Rexx error number. See *Appendix C, Error Numbers and Messages* for a complete description of error numbers and messages.

Example 7.42. Builtin function ERRORTEXT

```
ERRORTEXT(16)    ->    "Label not found."
ERRORTEXT(60)    ->    ""
```

7.4.31. FILESPEC



Returns a selected element of *filespec*, given file specification, identified by one of the following *option* strings. Only the capitalized *option* letter is needed; all characters following it are ignored.

`Drive`
: On Windows, returns the drive letter of the given *filespec*. On Unix-like systems, returns a null string ("").

`Path`
: Returns the directory path of the given *filespec*.

`Location`
: Returns the full location portion of the given *filespec*. On Windows, this will include both the Drive and Path information. On other platforms, this returns the same result as the Path option.

`Name`
: Returns the file name of the given *filespec*.

`Extension`
: Returns the extension portion of the *filespec* file name.

If *filespec* does not contain the requested information, FILESPEC returns a null string ("").

Example 7.43. Builtin function FILESPEC

```
thisfile = "C:\WINDOWS\UTIL\SYSTEM.INI"
say FILESPEC("drive",thisfile)     /* says "C:"              */
say FILESPEC("path",thisfile)      /* says "\WINDOWS\UTIL\"  */
say FILESPEC("location",thisfile)  /* says "C:\WINDOWS\UTIL\"  */
say FILESPEC("name",thisfile)      /* says "SYSTEM.INI"      */
say FILESPEC("extension",thisfile) /* says "INI"      */
part = "name"
say FILESPEC(part,thisfile)        /* says "SYSTEM.INI"      */
```

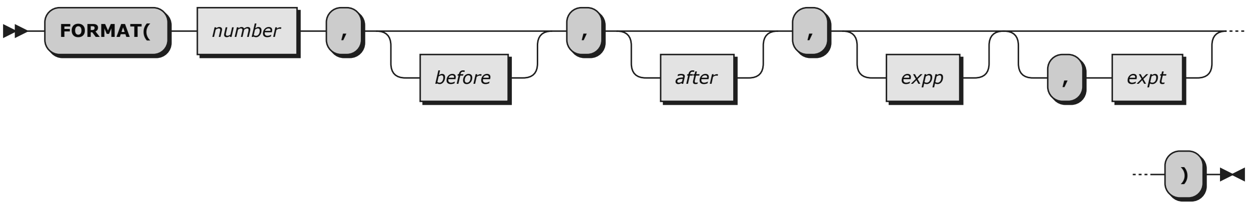
7.4.32. FORM

Returns the current setting of *NUMERIC FORM*.

Example 7.44. Builtin function FORM

```
FORM()    ->    "SCIENTIFIC"  /* by default */
```

7.4.33. FORMAT



Returns *number*, rounded and formatted.

The *number* is first rounded according to standard Rexx rules, as though the operation **number+0** had been carried out. The result is precisely that of this operation if you specify only *number*. If you specify any other options, the *number* is formatted as described in the following.

The *before* and *after* options describe how many characters are used for the integer and decimal parts of the result, respectively. If you omit either or both of them, the number of characters used for that part is as needed.

If *before* is not large enough to contain the integer part of the number (plus the sign for a negative number), an error results. If *before* is larger than needed for that part, the number is padded on the left with blanks. If *after* is not the same size as the decimal part of the number, the number is rounded (or extended with zeros) to fit. Specifying **0** causes the number to be rounded to an integer.

Example 7.45. Builtin function FORMAT

```
FORMAT("3",4)            ->    "   3"
FORMAT("1.73",4,0)       ->    "   2"
FORMAT("1.73",4,3)       ->    "   1.730"
FORMAT("-.76",4,1)       ->    "  -0.8"
FORMAT("3.03",4)         ->    "   3.03"
FORMAT(" - 12.73", ,4)   ->    "-12.7300"
FORMAT(" - 12.73")       ->    "-12.73"
FORMAT("0.000")          ->    "0"
```

The first three arguments are as described previously. In addition, *expp* and *expt* control the exponent part of the result, which, by default, is formatted according to the current NUMERIC settings of DIGITS and FORM. *expp* sets the number of places for the exponent part; the default is to use as many as needed (which can be zero). *expt* specifies when the exponential expression is used. The default is the current setting of NUMERIC DIGITS.

If *expp* is **0**, the number is not in exponential notation. If *expp* is not large enough to contain the exponent, an error results.

If the number of places needed for the integer or decimal part exceeds *expt* or twice *expt*, respectively, the exponential notation is used. If *expt* is **0**, the exponential notation is always used unless the exponent would be **0**. (If *expp* is **0**, this overrides a **0** value of *expt*.) If the exponent would be **0** when a nonzero *expp* is specified, then *expp*+2 blanks are supplied for the exponent part of the result. If the exponent would be **0** and *expp* is not specified, the number is not an exponential expression.

Example 7.46. Builtin function FORMAT

```
FORMAT("12345.73", , ,2,2)  ->    "1.234573E+04"
FORMAT("12345.73", ,3, ,0)  ->    "1.235E+4"
FORMAT("1.234573", ,3, ,0)  ->    "1.235"
FORMAT("12345.73", , ,3,6)  ->    "12345.73"
FORMAT("1234567e5", ,3,0)   ->    "123456700000.000"
```

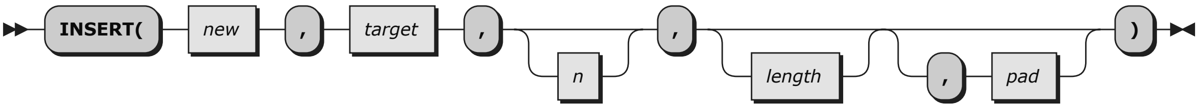
7.4.34. FUZZ

Returns the current setting of *NUMERIC FUZZ*.

Example 7.47. Builtin function FUZZ

```
FUZZ()    ->    0     /* by default */
```

7.4.35. INSERT



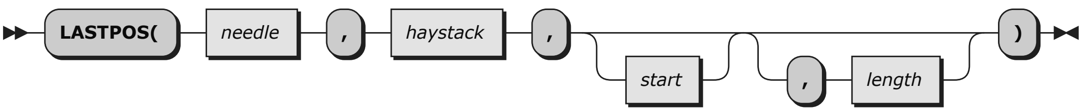
Inserts the string *new*, padded or truncated to length *length*, into the string *target* after the *n*th character. The default value for *n* is **0**, which means insertion before the beginning of the string. If specified, *n* and *length* must be positive whole numbers or zero. If *n* is greater than the length of the target string, the string *new* is padded at the beginning. The default value for *length* is the length of *new*. If *length* is less than the length of the string *new*, then INSERT truncates *new* to length *length*. The default *pad* character is a blank.

Here are some examples:

Example 7.48. Builtin function INSERT

```
INSERT(" ","abcdef",3)          ->    "abc def"
INSERT("123","abc",5,6)         ->    "abc  123   "
INSERT("123","abc",5,6,"+")     ->    "abc++123+++"
INSERT("123","abc")             ->    "123abc"
INSERT("123","abc", ,5,"-")     ->    "123--abc"
```

7.4.36. LASTPOS (Last Position)



Returns the position of the last occurrence of one string, *needle*, in another, *haystack*. It returns **0** if *needle* is a null string or not found. By default, the search starts at the last character of *haystack* and scans backward to the beginning of the string. You can override this by specifying *start*, the point at which the backward scan starts and *length*, the range of characters to scan. The *start* must be a positive whole number and defaults to the length of *haystack* if larger than that value or omitted. The *length* must be a non-negative whole number and defaults to *start*.

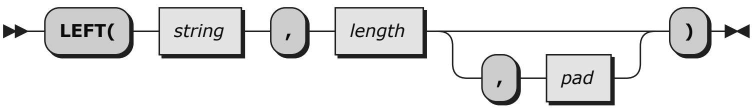
See also *POS* built-in function.

Here are some examples:

Example 7.49. Builtin function LASTPOS

```
LASTPOS(" ","abc def ghi")      ->    8
LASTPOS(" ","abcdefghi")        ->    0
LASTPOS("xy","efgxyz")          ->    4
LASTPOS(" ","abc def ghi",7)    ->    4
LASTPOS(" ","abc def ghi",7,3)  ->    0
```

7.4.37. LEFT



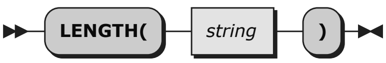
Returns a string of length *length*, containing the leftmost *length* characters of *string*. The string returned is padded with *pad* characters, or truncated, on the right as needed. The default *pad* character is a blank. *length* must be a positive whole number or zero. The LEFT function is equivalent to **SUBSTR(***string***, 1,** *length* **[,** *pad***]).**

Here are some examples:

Example 7.50. Builtin function LEFT

```
LEFT("abc d",8)         ->    "abc d   "
LEFT("abc d",8,".")     ->    "abc d..."
LEFT("abc  def",7)      ->    "abc  de"
```

7.4.38. LENGTH



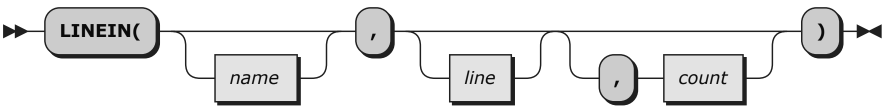
Returns the length of *string*.

Here are some examples:

Example 7.51. Builtin function LENGTH

```
LENGTH("abcdefgh")     ->    8
LENGTH("abc defg")     ->    8
LENGTH("")             ->    0
```

7.4.39. LINEIN (Line Input)



Returns *count* lines read from the character input stream *name*. The *count* must be **1** or **0** (To understand the input and output functions, see *Chapter 14, Input and Output Streams*.) If you omit *name*, the line is read from the default input stream, STDIN. The default *count* is **1**.

For persistent streams, a read position is maintained for each stream. Any read from the stream starts at the current read position by default. Under certain circumstances, a call to LINEIN returns a partial line. This can happen if the stream has already been read with the CHARIN function, and part but not all of a line (and its termination, if any) has already been read. When the language processor completes reading, the read position is moved to the beginning of the next line.

A *line* number may be given to set the read position to the start of a specified line. This line number must be positive and within the bounds of the stream, and must not be specified for a transient stream. The read position can be set to the beginning of the stream by giving *line* a value of **1**.

If you give a *count* of **0**, then no characters are read and a null string is returned.

For transient streams, if a complete line is not available in the stream, then execution of the program usually stops until the line is complete. If, however, it is impossible for a line to be completed because of an error or another problem, the NOTREADY condition is raised (see *Section 14.5, "Errors during Input and Output"*) and LINEIN returns whatever characters are available.

Here are some examples:

Example 7.52. Builtin function LINEIN

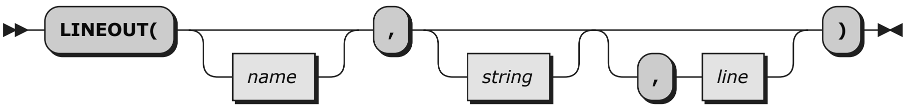
```
LINEIN()                             /* Reads one line from the    */
                                     /* default input stream;      */
                                     /* usually this is an entry   */
                                     /* typed at the keyboard      */
myfile = "ANYFILE.TXT"
LINEIN(myfile)     -> "Current line" /* Reads one line from        */
                                     /* ANYFILE.TXT, beginning     */
                                     /* at the current read        */
                                     /* position. (If first call,  */
                                     /* file is opened and the     */
                                     /* first line is read.)       */

LINEIN(myfile,1,1) ->  "first line"  /* Opens and reads the first  */
                                     /* line of ANYFILE.TXT (if    */
                                     /* the file is already open,  */
                                     /* reads first line); sets    */
                                     /* read position on the       */
                                     /* second line.               */

LINEIN(myfile,1,0) ->  ""            /* No read; opens ANYFILE.TXT */
                                     /* (if file is already open,  */
                                     /* sets the read position to  */
                                     /* the first line).           */

LINEIN(myfile, ,0)  ->  ""           /* No read; opens ANYFILE.TXT */
                                     /* (no action if the file is  */
                                     /* already open).             */

LINEIN("QUEUE:")   ->  "Queue line" /* Read a line from the queue. */
                                    /* If the queue is empty, the  */
                                    /* program waits until a line  */
                                    /* is put on the queue.        */
```

Note

If you want to read complete lines from the default input stream, as in a dialog with a user, use the *PULL* or *PARSE PULL* instruction.

The *PARSE LINEIN* instruction is also useful in certain cases.

7.4.40. LINEOUT (Line Output)



Returns **0** if successful in writing *string* to the character output stream *name*, or **1** if an error occurs while writing the line. (To understand the input and output functions, see *Chapter 14, Input and Output Streams*.) If you specify *line*, this positions the write pointer before writing. If you omit both *string* and *line*, the stream is closed. LINEOUT adds platform-specific *line-end* characters to the end of *string*.

If you omit *name*, the line is written to the default output stream STDOUT (usually the display).

For persistent streams, a write position is maintained for each stream. Any write to the stream starts at the current write position by default. (Under certain circumstances the characters written by a call to LINEOUT can be added to a partial line previously written to the stream with the CHAROUT routine. LINEOUT stops a line at the end of each call.) When the language processor completes writing, the write position is set to the beginning of the line following the one just written. When the stream is first opened, the write position is at the end of the stream, so that calls to LINEOUT append lines to the end of the stream.

You can specify a *line* number to set the write position to the start of a particular line in a persistent stream. This line number must be positive and within the bounds of the stream unless it is a binary stream (though it can specify the line number immediately after the end of the stream). A value of **1** for *line* refers to the first line in the stream. Note that, unlike CHAROUT, you cannot specify a position beyond the end of the stream for non-binary streams.

You can omit the *string* for persistent streams. If you specify *line*, the write position is set to the start of the *line* that was given, nothing is written to the stream, and the function returns **0**. If you specify neither *line* nor *string*, the stream is closed. Again, the function returns **0**.

Execution of the program usually stops until the output operation is effectively complete. For example, when data is sent to a printer, the system accepts the data and returns control to Rexx, even though the output data might not have been printed. Rexx considers this to be complete, even though the data has not been printed. If, however, it is impossible for a line to be written, the NOTREADY condition is raised (see *Section 14.5, "Errors during Input and Output"*), and LINEOUT returns a result of **1**, that is, the residual count of lines written.

Here are some examples:

Example 7.53. Builtin function LINEOUT

```
LINEOUT(,"Display this")          /* Writes string to the default   */
                                  /* output stream (usually, the    */
```

```
                                  /* display); returns 0 if         */
                                  /* successful                     */

myfile = "ANYFILE.TXT"
LINEOUT(myfile,"A new line")      /* Opens the file ANYFILE.TXT and */
                                  /* appends the string to the end. */
                                  /* If the file is already open,   */
                                  /* the string is written at the   */
                                  /* current write position.        */
                                  /* Returns 0 if successful.       */

LINEOUT(myfile,"A new start",1)   /* Opens the file (if not already */
                                  /* open); overwrites first line   */
                                  /* with a new line.               */
                                  /* Returns 0 if successful.       */

LINEOUT(myfile, ,1)               /* Opens the file (if not already */
                                  /* open). No write; sets write    */
                                  /* position at first character.   */

LINEOUT(myfile)                   /* Closes ANYFILE.TXT             */
```

LINEOUT is often most useful when called as a subroutine. The return value is then available in the variable RESULT. For example:

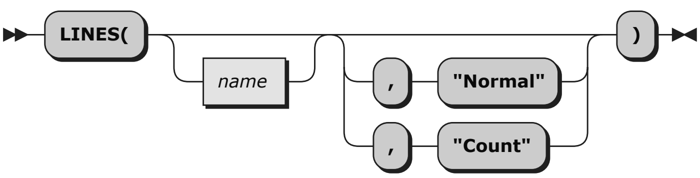
Example 7.54. Builtin function LINEOUT call

```
Call LINEOUT "A:rexx.bat","Shell",1
Call LINEOUT ,"Hello"
```

Note

If the lines are to be written to the default output stream without the possibility of error, use the SAY instruction instead.

7.4.41. LINES (Lines Remaining)



Returns **1** if any data remains between the current read position and the end of the character input stream *name*, and no option or option **Normal** is specified. It returns **0** if no data remains. As such, LINES reports whether a read action that *CHARIN* or *LINEIN* performs will succeed. Option **Normal** is the default.

If option **Count** is specified, LINES returns the actual number of lines remaining in the stream, irrespective of how long this operation takes.

For an explanation of input and output, see *Chapter 14, Input and Output Streams*.

Here are some examples:

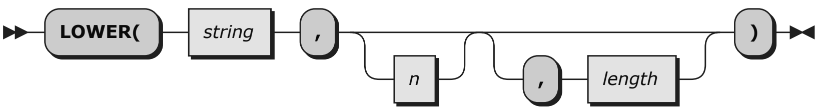
Example 7.55. Builtin function LINES

```
LINES(myfile)    ->    0    /* at end of the file   */
LINES()          ->    1    /* data remains in the  */
                            /* default input stream */
                            /* STDIN:               */
```

Note

The CHARS function returns the number of characters in a persistent stream or the presence of data in a transient stream.

7.4.42. LOWER



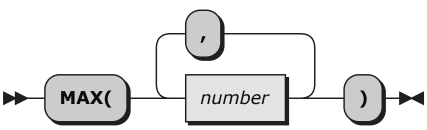
Returns a new string with the characters of *string* beginning with character *n* for *length* characters converted to lowercase. If *n* is specified, it must be a positive whole number. If *n* is not specified, the case conversion will start with the first character. If *length* is specified, it must be a non-negative whole number. If *length* is not specified, the default is to convert the remainder of the string.

Here are some examples:

Example 7.56. Builtin function LOWER

```
lower("Albert Einstein")      ->     "albert einstein"
lower("ABCDEF", 4)            ->     "ABCdef"
lower("ABCDEF", 3, 2)         ->     "ABcdEF"
```

7.4.43. MAX (Maximum)



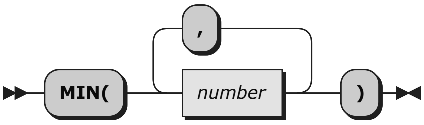
Returns the largest number of the list specified, formatted according to the current NUMERIC settings. You can specify any number of *number*s.

Here are some examples:

Example 7.57. Builtin function MAX

```
MAX(12,6,7,9)                                             ->    12
MAX(17.3,19,17.03)                                        ->    19
MAX(-7,-3,-4.3)                                           ->    -3
MAX(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21)   ->    21
```

7.4.44. MIN (Minimum)



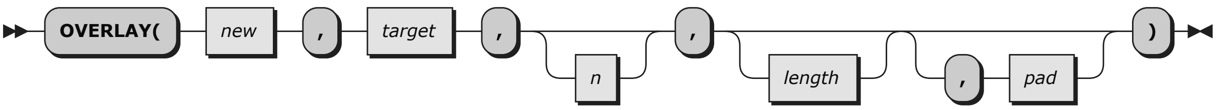
Returns the smallest number of the list specified, formatted according to the current NUMERIC settings. You can specify any number of *number*s.

Here are some examples:

Example 7.58. Builtin function MIN

```
MIN(12,6,7,9)                                            ->   6
MIN(17.3,19,17.03)                                       ->  17.03
MIN(-7,-3,-4.3)                                          ->  -7
MIN(21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1)   ->   1
```

7.4.45. OVERLAY



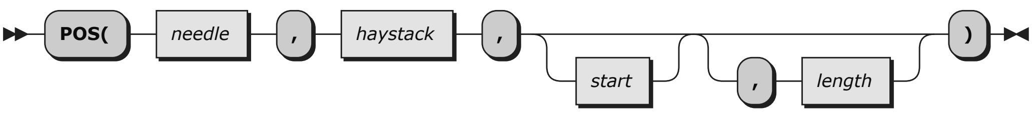
Returns the string *target*, which, starting at the *n*th character, is overlaid with the string *new*, padded or truncated to length *length*. The overlay may extend beyond the end of the original *target* string. If you specify *length*, it must be a positive whole number or zero. The default value for *length* is the length of *new*. If *n* is greater than the length of the target string, the string *new* is padded at the beginning. The default *pad* character is a blank, and the default value for *n* is **1**. If you specify *n*, it must be a positive whole number.

Here are some examples:

Example 7.59. Builtin function OVERLAY

```
OVERLAY(" ","abcdef",3)         ->    "ab def"
OVERLAY(".","abcdef",3,2)       ->    "ab. ef"
OVERLAY("qq","abcd")            ->    "qqcd"
OVERLAY("qq","abcd",4)          ->    "abcqq"
OVERLAY("123","abc",5,6,"+")    ->    "abc+123+++"
```

7.4.46. POS (Position)



Returns the position of one string, *needle*, in another, *haystack*. It returns **0** if *needle* is a null string or not found or if *start* is greater than the length of *haystack*. By default, the search starts at the first character of the receiving string (that is, the value of *start* is **1**), and continues to the end of the string. You can override this by specifying *start*, the point at which the search starts, and *length*, the bounding limit for the search. If specified, *start* must be a positive whole number and *length* must be a non-negative whole number.

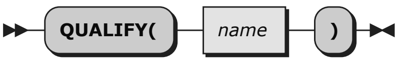
See also *LASTPOS* built-in function.

Here are some examples:

Example 7.60. Builtin function POS

```
POS("day","Saturday")        ->    6
POS("x","abc def ghi")       ->    0
POS(" ","abc def ghi")       ->    4
POS(" ","abc def ghi",5)     ->    8
POS(" ","abc def ghi",5,3)  ->    0
```

7.4.47. QUALIFY



Returns the fully qualified path for *name* by expanding the file name into a path with absolute directory information. The file does not need to exist to generate the full name.

7.4.48. QUEUED

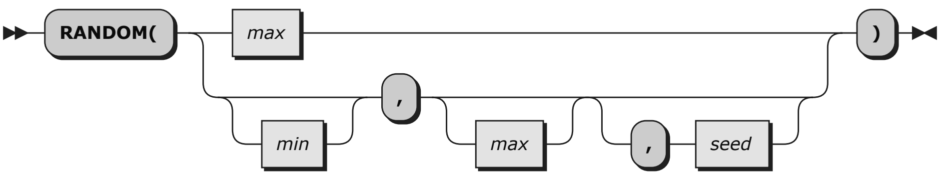
Returns the number of lines remaining in the external data queue when the function is called. (See *Chapter 14, Input and Output Streams* for a discussion of Rexx input and output.)

Here is an example:

Example 7.61. Builtin function QUEUED

```
QUEUED()    ->    5    /* Perhaps */
```

7.4.49. RANDOM



Returns a quasi-random whole number in the range *min* to *max* inclusive. If you specify *max* or *min,max*, then *max* minus *min* cannot exceed 999999999. *min* and *max* default to **`0`** and **`999`**, respectively. To start a repeatable sequence of results, use a specific *seed* as the third argument. This *seed* must be a whole number from 0 to 999999999.

Here are some examples:

Example 7.62. Builtin function RANDOM

```
RANDOM()              -- 305  /* 0 to 999      */
RANDOM(5, 8)          --   7  /* 5 to 8        */
```

```
RANDOM(2)            --   0  /* 0 to 2       */
RANDOM(, , 3257)     -- 123  /* reproducible */
RANDOM(-5, 5)        --  -3
```

Notes:

1. To obtain a predictable sequence of quasi-random numbers, use RANDOM a number of times, but specify a *seed* only the first time. For example, to simulate 40 throws of a 6-sided, unbiased die:

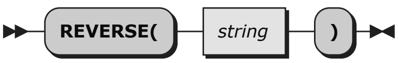
   Example 7.63. Builtin function RANDOM with seed

   ```
   sequence = RANDOM(1,6,12345)  /* any number would */
                                 /* do for a seed    */
   do 39
     sequence = sequence RANDOM(1,6)
   end
   say sequence
   ```

   The numbers are generated mathematically, using the initial *seed*, so that as far as possible they appear to be random. Running the program again produces the same sequence; using a different initial *seed* almost certainly produces a different sequence. If you do not supply a *seed*, the first time RANDOM is called, an arbitrary seed is used. Hence, your program usually gives different results each time it is run.

2. The random number generator is global for an entire program; the current seed is not saved across internal routine calls.

7.4.50. REVERSE



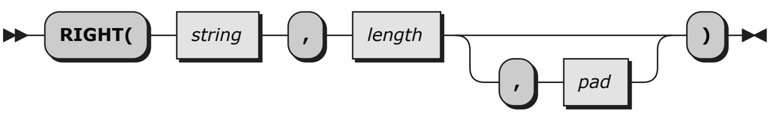
Returns *string* reversed.

Here are some examples:

Example 7.64. Builtin function REVERSE

```
REVERSE("ABc.")    ->    ".cBA"
REVERSE("XYZ ")    ->    " ZYX"
```

7.4.51. RIGHT



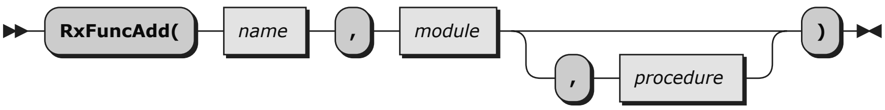
Returns a string of length *length* containing the rightmost *length* characters of *string*. The string returned is padded with *pad* character, or truncated, on the left as needed. The default *pad* character is a blank. The *length* must be a positive whole number or zero.

Here are some examples:

Example 7.65. Builtin function RIGHT

```
RIGHT("abc  d",8)     ->    "  abc  d"
RIGHT("abc def",5)    ->    "c def"
RIGHT("12",5,"0")     ->    "00012"
```

7.4.52. RXFUNCADD



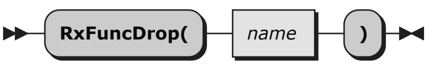
Registers the function, making it available to Rexx procedures. The *module* is the name of an external library where the native function is located. In some environments, such as Unix-like systems, the library name is case sensitive. The *procedure* is the name of the exported procedure inside of *module*. If procedure is not specified, it defaults to *name*. The *procedure* is generally case-sensitive. RxFuncAdd will attempt to resolve the procedure address using the name as specified and if that attempt fails, will retry using an uppercased name.

A return value 0 signifies successful registration and that the registered function has been located in the specified *module*. A return value 1 signifies that the function could not be resolved.

Example 7.66. Builtin function RXFUNCADD

```
// 0 if rxcalcsqrt can be located, else 1
rxfuncadd("rxcalcsqrt", "rxmath", "rxcalcsqrt")
```

7.4.53. RXFUNCDROP

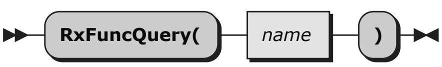


Removes (deregisters) the function *name* from the list of available functions. A zero return value signifies successful removal.

Example 7.67. Builtin function RXFUNCDROP

```
rxfuncdrop("SysLoadFuncs")         -> 0 /* if successfully removed   */
```

7.4.54. RXFUNCQUERY

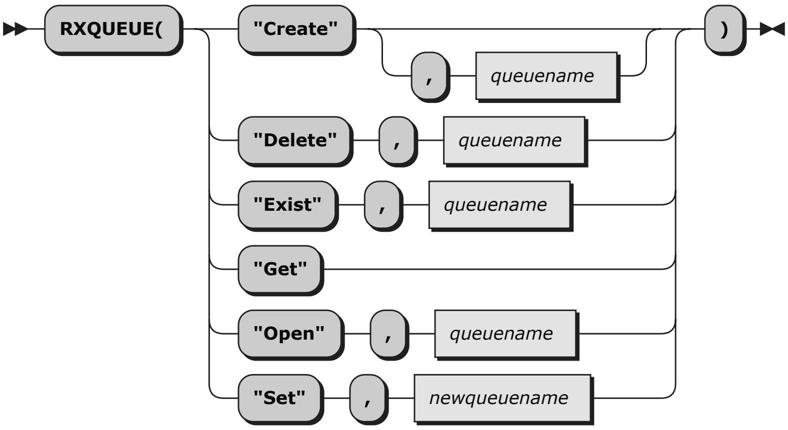


Queries the list of available functions for the function *name*. It returns a value of **0** if the function is registered, and a value of **1** if it is not.

Example 7.68. Builtin function RXFUNCQUERY

```
rxfuncquery("SysLoadFuncs")        -> 0 /* if registered             */
```

7.4.55. RXQUEUE



Creates and deletes external data queues. It also sets and queries their names.

`Create`

creates a queue with the name *queuename* if you specify *queuename* and if no queue of that name exists already. You must not use SESSION as a *queuename*. If you specify no *queuename*, then the language processor provides a name. The name of the queue is returned in either case.

The maximum length of *queuename* can be 250 characters.

Many queues can exist at the same time, and most systems have sufficient resources available to support several hundred queues at a time. If a queue with the specified name exists already, a queue is still created with a name assigned by the language processor. The assigned name is then returned to you.

`Delete`

deletes the named queue. It returns 0 if successful or a nonzero number if an error occurs. Possible return values are:

0
: Queue has been deleted.

5
: Not a valid queue name or tried to delete queue named "SESSION".

9
: Specified queue does not exist.

10
: Queue is busy; wait is active.

12
: A memory failure has occurred.

1002
: Failure in memory manager.

`Get`

returns the name of the queue currently in use.

`Exist`

returns **`.true`** if the specified *queuename* exists. Returns **`.false`** otherwise.

`Open`

tests if the specified *queuename* exists and creates if it does not.

`Set`

sets the name of the current queue to *newqueuename* and returns the previously active queue name.

The first parameter determines the function. Only the first character of the first parameter is significant. The parameter can be entered in any case. The syntax for a valid queue name is the same as for a valid Rexx symbol.

The second parameter specified for Create, Set, and Delete must follow the same syntax rules as the Rexx variable names. There is no connection, however, between queue names and variable names. A program can have a variable and a queue with the same name. The actual name of the queue is the uppercase value of the name requested.

Named queues prevent different Rexx programs that are running in a single session from interfering with each other. They allow Rexx programs running in different sessions to synchronize execution and pass data. LINEIN("QUEUE:") is especially useful because the calling program stops running until another program places a line on the queue.

Example 7.69. Builtin function RXQUEUE

```
/* default queue                                    */
rxqueue("Get")             -> "SESSION"
/* assuming FRED does not already exist             */
rxqueue("Create", "Fred")  -> "FRED"
/* assuming SESSION had been active                 */
rxqueue("Set", "Fred")     -> "SESSION"
/* assuming FRED exists                             */
rxqueue("delete", "Fred")  -> "0"
```

7.4.56. SETLOCAL (Linux only)

Saves the current working directory and the current values of the environment variables that are local to the current process.

For example, SETLOCAL can be used to save the current environment before changing selected settings with the *VALUE* function. To restore the directory and environment, use the *ENDLOCAL* function.

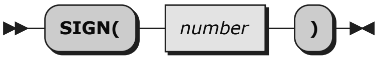
SETLOCAL returns a value of 1 if the initial directory and environment are successfully saved and a value of 0 if unsuccessful. If SETLOCAL is not followed by an ENDLOCAL function in a procedure, the initial environment saved by SETLOCAL is restored upon exiting the procedure.

Here is an example:

Example 7.70. Builtin function SETLOCAL

```
/* Current path is "user/bin" */
n = SETLOCAL()            /* saves all environment settings */
/* Now use the VALUE function to change the PATH variable */
p = VALUE("Path","home/user/bin"."ENVIRONMENT")
/* Programs in directory home/user/bin can now be run */
n = ENDLOCAL()            /* restores initial environment including */
                          /* the changed PATH variable, which is    */
                          /* "user/bin"                             */
```

7.4.57. SIGN



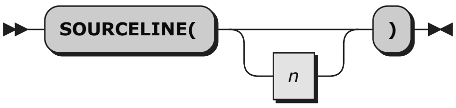
Returns a number that indicates the sign of *number*. The *number* is first rounded according to standard Rexx rules, as though the operation **number+0** had been carried out. It returns **-1** if *number* is less than **0**, **0** if it is **0**, and **1** if it is greater than **0**.

Here are some examples:

Example 7.71. Builtin function SIGN

```
SIGN("12.3")       ->     1
SIGN(" -0.307")    ->    -1
SIGN(0.0)          ->     0
```

7.4.58. SOURCELINE



Returns the line number of the final line in the program if you omit *n*. If you specify *n*, returns the *n*th line in the program if available at the time of execution. Otherwise, it returns a null string. If specified, *n* must be a positive whole number and must not exceed the number that a call to SOURCELINE with no arguments returns.

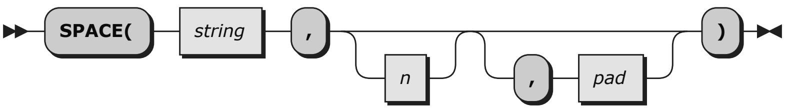
If the Rexx program is in *translated format*, this function returns **0** if *n* is omitted, and raises an error for all attempts to retrieve a line of the program.

Here are some examples:

Example 7.72. Builtin function SOURCELINE

```
SOURCELINE()    ->   10
SOURCELINE(1)   ->   "/* This is a 10-line Rexx program */"
```

7.4.59. SPACE



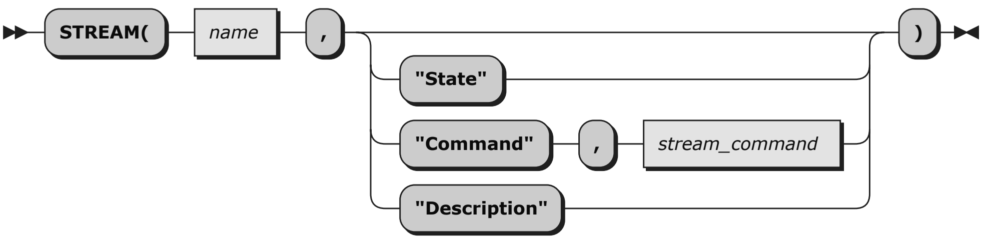
Returns the whitespace-delimited words in *string* with *n* *pad* characters between each word. If you specify *n*, it must be a positive whole number or zero. If it is **`0`**, all whitespace characters are removed. Leading and trailing whitespace characters are always removed. The default for *n* is **`1`**, and the default *pad* character is a blank.

Here are some examples:

Example 7.73. Builtin function SPACE

```
SPACE("abc  def  ")          ->    "abc def"
SPACE("  abc def",3)         ->    "abc   def"
SPACE("abc  def  ",1)        ->    "abc def"
SPACE("abc  def  ",0)        ->    "abcdef"
SPACE("abc  def  ",2,"+")    ->    "abc++def"
```

7.4.60. STREAM



Returns a string describing the state of, or the result of an operation upon, the character stream *name*. The result may depend on characteristics of the stream that you have specified in other uses of the STREAM function. (To understand the input and output functions, see *Chapter 14, Input and Output Streams*.) This function requests information on the state of an input or output stream or carries out some specific operation on the stream.

The first argument, *name*, specifies the stream to be accessed. The second argument can be one of the following strings that describe the action to be carried out. (Only the capitalized letter is needed; all characters following it are ignored.)

`Command`
: an operation (specified by the *stream_command* given as the third argument) is applied to the selected input or output stream. The string that is returned depends on the command performed and can be a null string. The possible input strings for the *stream_command* argument are described later.

`Description`
: returns any descriptive string associated with the current state of the specified stream. It is identical to the State operation, except that the returned string is followed by a colon and, if available, additional information about the ERROR or NOTREADY states.

`State`
: returns a string that indicates the current state of the specified stream. This is the default operation.

The returned strings are as described in **`Stream`** class method *state*.

> **Note**
>
> The state (and operation) of an input or output stream is global to a Rexx program; it is not saved and restored across internal function and subroutine calls (including those calls that a CALL ON condition trap causes).

7.4.60.1. Stream Commands

The following stream commands are used to:

- Open a stream for reading, writing, or both.
- Close a stream at the end of an operation.
- Position the read or write position within a persistent stream (for example, a file).
- Get information about a stream (its existence, size, and last edit date).

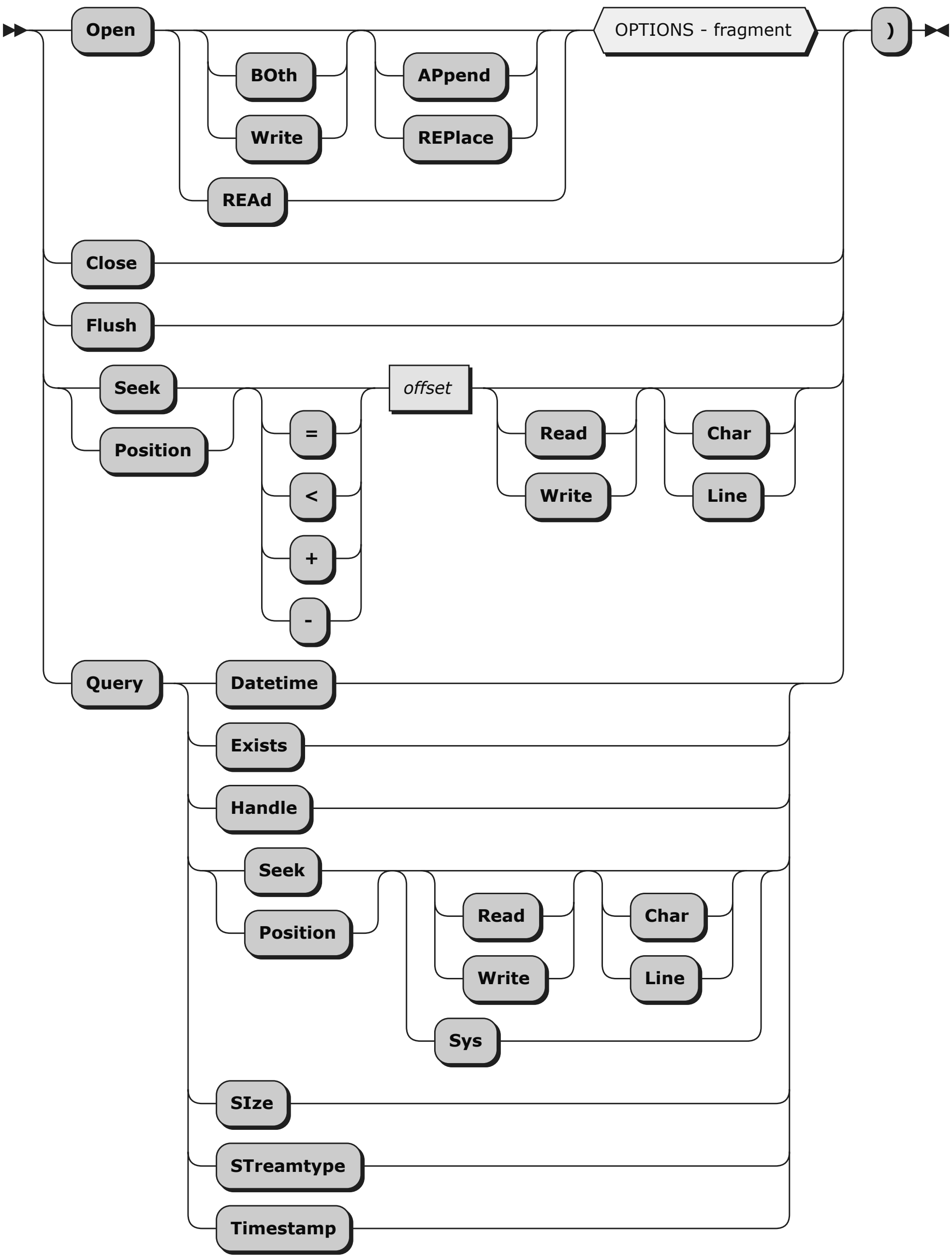
The *stream_command* argument must be used when—and only when--you select the operation C (command). The syntax is:

In this form, the STREAM function itself returns a string corresponding to the given *stream_command* if the command is successful. If the command is unsuccessful, STREAM returns an error message string in the same form as the `D` (Description) operation supplies.

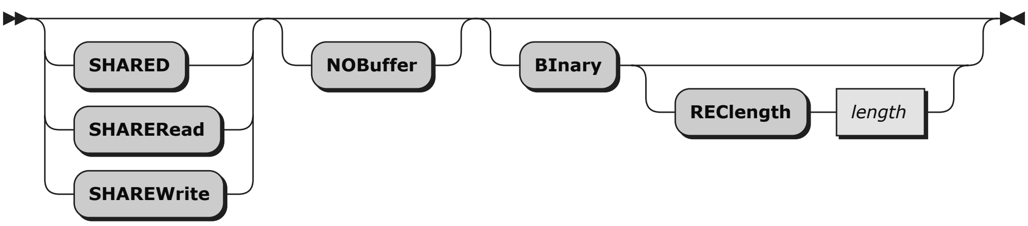
For most error conditions, the additional information is in the form of a numeric return code. This return code is the value of *ERRNO* that is set whenever one of the file system primitives returns with a -1.

7.4.60.1.1. Command Strings

The argument *stream_command* can be any expression that the language processor evaluates to a command string that corresponds to the following diagram:



OPTIONS:



OPEN

opens the named stream. The default for OPEN is to open the stream for both reading and writing data, for example, **"OPEN BOTH"**.

The STREAM function itself returns a description string similar to the one that the **D** option provides, for example, "READY:" if the named stream is successfully opened, or "ERROR:2" if the named stream is not found.

The following is a description of the options for OPEN:

READ
: opens the stream for reading only.

WRITE
: opens the stream for writing only.

BOTH
: opens the stream for both reading and writing. (This is the default.) Separate read and write pointers are maintained.

APPEND
: positions the write pointer at the end of the stream. (This is the default.) The write pointer cannot be moved anywhere within the extent of the file as it existed when the file was opened.

REPLACE
: sets the write pointer to the beginning of the stream and truncates the file. In other words, this option deletes all data that was in the stream when opened.

SHARED
: Enables another process to work with the stream in a shared mode. This mode must be compatible with the shared mode (SHARED, SHAREREAD, or SHAREWRITE) used by the process that opened the stream.

SHAREREAD
: Enables another process to read the stream in a shared mode.

SHAREWRITE
: Enables another process to write the stream in a shared mode.

NOBUFFER
: turns off buffering of the stream. Thus, all data written to the stream is flushed immediately to the operating system for writing. This option can severely affect output performance. Therefore, use it only when data integrity is a concern, or to force interleaved output to a stream to appear in the exact order in which it was written.

BINARY
: causes the stream to be opened in binary mode. This means that *line-end* characters are ignored and treated as data. This is intended to force file operations that are compatible with other Rexx language processors that run on record-based systems, or to process binary data using the line operations.

> **Note**
>
> Specifying the BINARY option for a stream that does not exist but is opened for writing also requires the RECLENGTH option to be specified. Omitting the RECLENGTH option in this case raises an error condition.

RECLENGTH *length*
: allows the specification of an exact length for each line in a stream. This allows line operations on binary-mode streams to operate on individual fixed-length records. Without this option, line

operations on binary-mode files operate on the entire file (for example, as if the **RECLENGTH** option were specified with a length equal to that of the file). *length* must be 1 or greater.

Here are some examples:

Example 7.74. Builtin function STREAM

```
stream(strout,"c","open")
stream(strout,"c","open write")
stream(strinp,"c","open read")
stream(strinp,"c","open read shared")
```

CLOSE

closes the named stream. The STREAM function itself returns **READY:** if the named stream is successfully closed, or an appropriate error message. If an attempt is made to close an unopened file, STREAM returns a null string ("").

Example 7.75. Builtin function STREAM on unopened file

```
stream("STRM.TXT","c","close")
```

FLUSH

forces any data currently buffered for writing to be written to this stream.

SEEK *offset*

sets the read or write position within a persistent stream. If the stream is opened for both reading and writing and no SEEK option is specified, both the read and write positions are set.

Note

See *Chapter 14, Input and Output Streams* for a discussion of read and write positions in a persistent stream.

To use this command, the named stream must first be opened with the OPEN stream command or implicitly with an input or output operation. One of the following characters can precede the *offset* number:

=

explicitly specifies the *offset* from the beginning of the stream. This is the default if no prefix is supplied. **Line Offset=1** means the beginning of stream.

<

specifies *offset* from the end of the stream.

+

specifies *offset* forward from the current read or write position.

-

specifies *offset* backward from the current read or write position.

The STREAM function itself returns the new position in the stream if the read or write position is successfully located or an appropriate error message otherwise.

The following is a description of the options for SEEK:

READ
: specifies that the read position is to be set by this command.

WRITE
: specifies that the write position is to be set by this command.

CHAR
: specifies that the positioning is to be done in terms of characters. This is the default.

LINE
: specifies that the positioning is to be done in terms of lines. For non-binary streams, this is an operation that can take a long time to complete, because, in most cases, the file must be scanned from the top to count line-end characters. However, for binary streams with a specified record length, this results in a simple multiplication of the new resulting line number by the record length, and then a simple character positioning. See *Section 14.1.5, "Line versus Character Positioning"* for a detailed discussion of this issue.

> **Note**
>
> If you do line positioning in a file open only for writing, you receive an error message.

Example 7.76. Builtin function STREAM examples

```
stream(name,"c","seek =2 read")
stream(name,"c","seek +15 read")
stream(name,"c","seek -7 write line")
fromend  = 125
stream(name,"c","seek <"fromend read)
```

POSITION
: is a synonym for SEEK.

7.4.60.1.2. QUERY Stream Commands

Used with these stream commands, the STREAM function returns specific information about a stream. Except for QUERY HANDLE and QUERY SEEK/POSITION, the language processor returns the query information even if the stream is not open. The language processor returns UNKNOWN for QUERY STREAMTYPE and the null string for nonexistent streams.

Note that technically although a directory is persistent, it is not a stream. If the directory exists, the date / time queries return the time stamp of the directory, QUERY SIZE returns 0, and QUERY STREAMTYPE returns UNKNOWN. The other commands return the null string.

QUERY DATETIME
returns the date and time stamps of a stream in US format.

Example 7.77. Builtin function STREAM QUERY examples

```
stream("..\file.txt","c","query datetime")
```

A sample output might be:

```
11-12-98 03:29:12
```

QUERY EXISTS
returns the full path specification of the named stream, if it exists, or a null string.

Example 7.78. Builtin function STREAM QUERY EXISTS examples

```
stream("..\file.txt","c","query exists")
```

A sample output might be:

```
c:\data\file.txt
```

QUERY HANDLE
returns the handle associated with the open stream.

Example 7.79. Builtin function STREAM QUERY HANDLE examples

```
stream("..\file.txt","c","query handle")
```

A sample output might be:

```
3
```

QUERY POSITION
returns the current read or write position for the stream, as qualified by the following options:

READ
returns the current read position.

WRITE
returns the current write position.

Note

If the stream is open for both reading and writing, the default is to return the read position. Otherwise, it returns the appropriate position by default.

CHAR
returns the position in terms of characters. This is the default.

LINE
returns the position in terms of lines. For non-binary streams, this operation can take a long time to complete, because the language processor starts tracking the current line number if not already doing so. Thus, it might require a scan of the stream from the top to count line-end characters. See *Section 14.1.5, "Line versus Character Positioning"* for a detailed discussion of this issue.

Example 7.80. Builtin function STREAM QUERY POSITION examples

```
stream("myfile","c","query position write")
```

A sample output might be:

```
247
```

SYS
returns the operating-system stream position in terms of characters.

QUERY SIZE
returns the size, in bytes, of a persistent stream.

Example 7.81. Builtin function STREAM QUERY SIZE examples

```
stream("..\file.txt","c","query size")
```

A sample output might be:

```
1305
```

QUERY STREAMTYPE
returns a string indicating whether the stream is **PERSISTENT**, **TRANSIENT**, or **UNKNOWN**.

QUERY TIMESTAMP
returns the date and time stamps of a stream in an international format. This is the preferred method of getting the date and time because it provides the full 4-digit year.

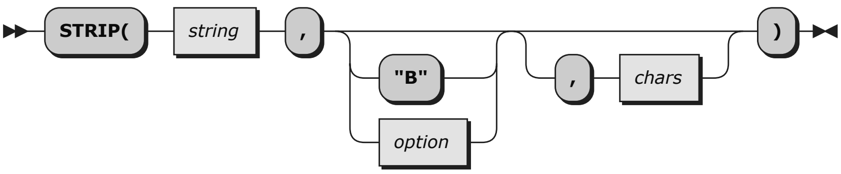
Example 7.82. Builtin function STREAM QUERY TIMESTAMP examples

```
stream("..\file.txt","c","query timestamp")
```

A sample output might be:

```
2016-11-12 03:29:12
```

7.4.61. STRIP



Returns *string* with leading characters, trailing characters, or both, removed, based on the *option* you specify. The following are valid *option*s. (Only the capitalized letter is needed; all characters following it are ignored.)

`Both`
: removes both leading and trailing characters from *string*. This is the default.

`Leading`
: removes leading characters from *string*.

`Trailing`
: removes trailing characters from *string*.

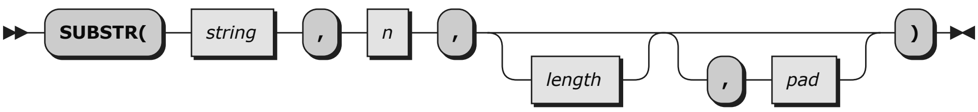
The third argument, *chars*, specifies the set of characters to be removed, and the default is to remove all whitespace characters (spaces and horizontal tabs). If *chars* is a null string, then no characters are removed. Otherwise, any occurrences of the characters in *chars* will be removed.

Here are some examples:

Example 7.83. Builtin function STRIP

```
STRIP("  ab c  ")        ->    "ab c"
STRIP("  ab c  ","L")    ->    "ab c  "
STRIP("  ab c  ","t")    ->    "  ab c"
STRIP("12.7000", ,0)     ->    "12.7"
STRIP("0012.700", ,0)    ->    "12.7"
STRIP("12.0000", "T", '.0') -> "12"
```

7.4.62. SUBSTR (Substring)



Returns the substring of *string* that begins at the *n*th character and is of length *length*, padded with *pad* if necessary. *n* must be a positive whole number. If *n* is greater than **`LENGTH(`***string***`)`**, only pad characters are returned.

See also *LEFT* and *RIGHT* builtin-functions.

If you omit *length*, the rest of the string is returned. The default *pad* character is a blank.

Here are some examples:

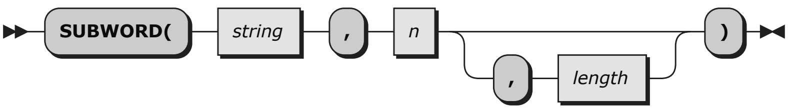
Example 7.84. Builtin function SUBSTR

```
SUBSTR("abc",2)          ->    "bc"
SUBSTR("abc",2,4)        ->    "bc  "
SUBSTR("abc",2,6,".")    ->    "bc...."
```

Note

In some situations the positional (numeric) patterns of parsing templates are more convenient for selecting substrings, especially if more than one substring is to be extracted from a string.

7.4.63. SUBWORD



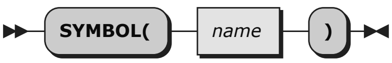
Returns the substring of *string* that starts at the *n*th word, and is up to *length* whitespace-delimited words. *n* must be a positive whole number. If you omit *length*, it defaults to the number of remaining words in *string*. The returned string never has leading or trailing whitespace, but includes all whitespace characters between the selected words.

Here are some examples:

Example 7.85. Builtin function SUBWORD

```
SUBWORD("Now is the  time",2,2)    ->    "is the"
SUBWORD("Now is the  time",3)      ->    "the  time"
SUBWORD("Now is the  time",5)      ->    ""
```

7.4.64. SYMBOL



Returns the state of the symbol named by *name*. It returns **`BAD`** if *name* is not a valid Rexx symbol. It returns **`VAR`** if it is the name of a variable, that is, a symbol that has been assigned a value. Otherwise, it returns **`LIT`**, indicating that it is either a constant symbol or a symbol that has not yet been assigned a value, that is, a literal.

As with symbols in Rexx expressions, lowercase characters in *name* are translated to uppercase and substitution in a compound name occurs if possible.

Note

You should specify *name* as a literal string, or it should be derived from an expression, to prevent substitution before it is passed to the function.

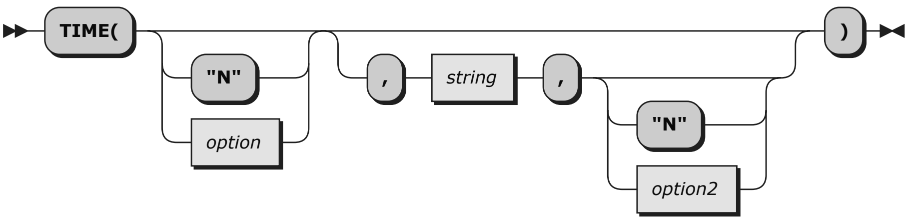
Here are some examples:

Example 7.86. Builtin function SYMBOL

```
/* following: Drop A.3;  J=3 */
```

```
SYMBOL("J")       ->   "VAR"
SYMBOL(J)         ->   "LIT" /* has tested "3"     */
SYMBOL("a.j")     ->   "LIT" /* has tested A.3     */
SYMBOL(2)         ->   "LIT" /* a constant symbol  */
SYMBOL("*")       ->   "BAD" /* not a valid symbol */
```

7.4.65. TIME



Returns the local time in the 24-hour clock format hh:mm:ss (hours, minutes, and seconds) by default, for example, **`04:41:37`**.

You can use the following *option*s to obtain alternative formats, or to gain access to the elapsed-time clock. (Only the capitalized letter is needed; all characters following it are ignored.)

`Civil`

returns the time in Civil format hh:mmxx. The hours can take the values **`1`** through **`12`**, and the minutes the values **`00`** through **`59`**. The minutes are followed immediately by the letters **`am`** or **`pm`**. This distinguishes times in the morning (12 midnight through 11:59 a.m.--appearing as **`12:00am`** through **`11:59am`**) from noon and afternoon (12 noon through 11:59 p.m.--appearing as **`12:00pm`** through **`11:59pm`**). The hour has no leading zero. The minute field shows the current minute (rather than the nearest minute) for consistency with other TIME results.

`Elapsed`

returns sssssssss.uuuuuu, the number of seconds and microseconds since the elapsed-time clock (described later) was started or reset. The returned number has no leading zeros or whitespace, and the setting of NUMERIC DIGITS does not affect it.

The language processor calculates elapsed time by subtracting the time at which the elapsed-time clock was started or reset from the current time. It is possible to change the system time clock while the system is running. This means that the calculated elapsed time value might not be a true elapsed time. If the time is changed so that the system time is earlier than when the Rexx elapsed-time clock was started (so that the elapsed time would appear negative), the language processor raises an error and disables the elapsed-time clock. To restart the elapsed-time clock, trap the error through SIGNAL ON SYNTAX.

The clock can also be changed by programs on the system. Many LAN-attached programs synchronize the system time clock with the system time clock of the server during startup. This causes the Rexx elapsed time function to be unreliable during LAN initialization.

`Full`

returns the number of microseconds since 00:00:00.000000 on 1 January 0001, in the format: *dddddddddddddddddd* (no leading zeros or whitespace).

Notes

The base date of 1 January 0001 is determined by extending the current Gregorian calendar backward (365 days each year, with an extra day every year that is divisible by 4 except century years that are not divisible by 400). It does not take into account any errors in the calendar system that created the Gregorian calendar originally.

The value returned by Time('F') can be used to calculate the interval between any two times. Note, however, that values returned generally contain more digits than the default NUMERIC DIGITS setting. The NUMERIC DIGITS setting should be increased to a minimum value of 18 when performing timestamp arithmetic.

`Hours`
: returns up to two characters giving the number of hours since midnight in the format hh (no leading zeros or whitespace, except for a result of **`0`**).

`Long`
: returns time in the format hh:mm:ss.uuuuuu (where uuuuuu are microseconds).

`Minutes`
: returns up to four characters giving the number of minutes since midnight in the format mmmm (no leading zeros or whitespace, except for a result of **`0`**).

`Normal`
: returns the time in the default format hh:mm:ss. The hours can have the values **`00`** through **`23`**, and minutes and seconds, **`00`** through **`59`**. There are always two digits. Any fractions of seconds are ignored (times are never rounded). This is the default.

`Offset`
: returns the offset of the local time from UTC in microseconds. The offset value will be negative for timezones west of the Prime Meridian and positive for timezones east of Prime Meridian. The local time('F') value can be converted to UTC by subtracting the time('O') value.

`Reset`
: returns sssssssss.uuuuuu, the number of seconds and microseconds since the elapsed-time clock (described later) was started or reset and also resets the elapsed-time clock to zero. The returned number has no leading zeros or whitespace, and the setting of NUMERIC DIGITS does not affect it.

  See the Elapsed option for more information on resetting the system time clock.

`Seconds`
: returns up to five characters giving the number of seconds since midnight in the format sssss (no leading zeros or whitespace, except for a result of **`0`**).

`Ticks`
: returns the number of seconds since 00:00:00.000000 on 1 January 1970, in the format: *dddddddddddd* (no leading zeros or whitespace).

Notes

The base date of 1 January 1970 is determined by extending the current Gregorian calendar backward (365 days each year, with an extra day every year that is divisible by 4 except century years that are not divisible by 400). It does not take into account any errors in the calendar system that created the Gregorian calendar originally.

The value returned by Time('T') can be used to calculate the interval between any two times. Note, however, that values returned generally contain more digits than the default NUMERIC DIGITS setting. The NUMERIC DIGITS setting should be increased to a minimum value of 12 when performing timestamp arithmetic.

Time('T') will return a negative number for dates prior to 1 January 1970.

Here are some examples, assuming that the time is 4:54 p.m.:

Example 7.87. Builtin function TIME

```
TIME()        ->   "16:54:22"
TIME("C")     ->   "4:54pm"
TIME("H")     ->   "16"
TIME("L")     ->   "16:54:22.120000"   /* Perhaps */
TIME("M")     ->   "1014"           /* 54 + 60*16 */
TIME("N")     ->   "16:54:22"
TIME("S")     ->   "60862"  /* 22 + 60*(54+60*16) */
```

The elapsed-time clock:

You can use the TIME function to measure real (elapsed) time intervals. On the first call in a program to **`TIME("E")`** or **`TIME("R")`**, the elapsed-time clock is started, and either call returns **`0`**. From then on, calls to **`TIME("E")`** and **`TIME("R")`** return the elapsed time since that first call or since the last call to **`TIME("R")`**.

The clock is saved across internal routine calls, which means that an internal routine inherits the time clock that its caller started. Any timing the caller is doing is not affected, even if an internal routine resets the clock. An example of the elapsed-time clock:

Example 7.88. Builtin function TIME elapsed

```
time("E")     ->    0          /* The first call */
                  /* pause of one second here */
time("E")     ->    1.020000   /* or thereabouts */
                  /* pause of one second here */
time("R")     ->    2.030000   /* or thereabouts */
                  /* pause of one second here */
time("R")     ->    1.050000   /* or thereabouts */
```

> **Note**
>
> The elapsed-time clock is synchronized with the other calls to TIME and DATE, so several calls to the elapsed-time clock in a single clause always return the same result. For this reason, the interval between two usual TIME/DATE results can be calculated exactly using the elapsed-time clock.

If you specify *string*, TIME returns the time corresponding to *string* in the format *option*. The *string* must be supplied in the format *option2*. The default for *option2* is "N". So you need to specify *option2* only if *string* is not in the Normal format. *option2* must specify the current time, for example, not "E" or "R". Here are some examples:

Example 7.89. Builtin function TIME formatting

```
time("C","11:27:21")    ->    11:27am
time("N","11:27am","C") ->    11:27:00
time("N", "63326132161828000", "F")   ->   08:16:01
```

You can determine the difference between two times; for example:

Example 7.90. Builtin function TIME difference

```
If TIME("M","5:00pm","C")-TIME("M")<=0
then say "Time to go home"
else say "Keep working"
```

The TIME returned is the earliest time consistent with *string*. For example, if the result requires components that are not specified in the source format, then those components of the result are zero. If the source has components that the result does not need, then those components of the source are ignored.

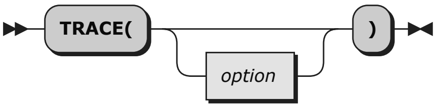
When requesting times be converted to Full or Ticks format, a date value of 1 January 0001 is used for the conversion. A time stamp for a time and date combination can be created by combining a value from Date('F') for the time of day.

Example 7.91. Builtin function TIME with F option

```
numeric digits 18  -- needed to add the timestamps
timestamp = date("f", "20170123", "S") + time("f", "08:14:22", "N")
```

Implementation maximum: If the number of seconds in the elapsed time exceeds nine digits (equivalent to over 31.6 years), an error results.

7.4.66. TRACE



Returns trace actions currently in effect and, optionally, alters the setting.

If you specify *option*, it selects the trace setting. It must be the valid prefix **?**, one of the alphabetic character options associated with the TRACE instruction (that is, starting with **A**, **C**, **E**, **F**, **I**, **L**, **N**, **O**, or **R**), or both. (See the TRACE instruction in *Section 2.29.1, "Trace Alphabetic Character (Word) Options"* for full details.)

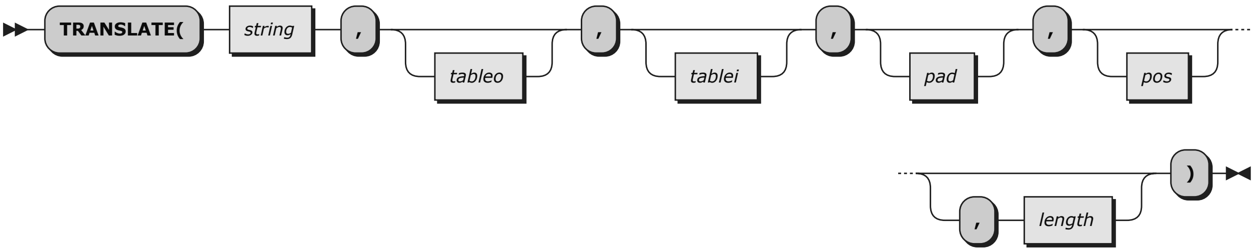
Unlike the TRACE instruction, the TRACE function alters the trace action even if interactive debugging is active. Also unlike the TRACE instruction, *option* cannot be a number.

Here are some examples:

Example 7.92. Builtin function TRACE

```
TRACE()       ->   "?R" /* maybe */
TRACE("O")    ->   "?R" /* also sets tracing off */
TRACE("?I")   ->   "O"  /* now in interactive debugging */
```

7.4.67. TRANSLATE



Returns *string* with each character translated to another character or unchanged. You can also use this function to reorder the characters in *string*.

The output table is *tableo* and the input translation table is *tablei*. TRANSLATE searches *tablei* for each character in *string*. If the character is found, the corresponding character in *tableo* is used in the result string; if there are duplicates in *tablei*, the first (leftmost) occurrence is used. If the character is not found, the original character in *string* is used. The result string is always the same length as *string*.

The tables can be of any length. If you specify neither table and omit *pad*, *string* is simply translated to uppercase (that is, lowercase **a-z** to uppercase **A-Z**), but, if you include *pad*, the language processor translates the entire string to *pad* characters. *tablei* defaults to **XRANGE("00"x,"FF"x)**, and *tableo* defaults to the null string and is padded with *pad* or truncated as necessary. The default *pad* is a blank.

pos is the position of the first character of the translated range. The default starting position is 1. *length* is the range of characters to be translated. If *length* is omitted, the remainder of the string from the starting position to the end is used.

Here are some examples:

Example 7.93. Builtin function TRANSLATE

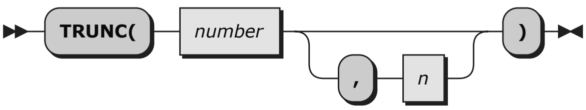
```
TRANSLATE("abcdef")                     ->    "ABCDEF"
TRANSLATE("abcdef", , , , 2, 3)         ->    "aBCDef"
```

```
TRANSLATE("abcdef", "12", "ec")             ->    "ab2d1f"
TRANSLATE("abcdef", "12", "abcd", ".")      ->    "12..ef"
TRANSLATE("APQRV", , "PR")                  ->    "A Q V"
TRANSLATE("APQRV", XRANGE("00"X, "Q"))      ->    "APQ  "
TRANSLATE("4123", "abcd", "1234", , 2, 2)  ->    "4ab3"
TRANSLATE("4123", "abcd", "1234")           ->    "dabc"
```

Note

The last example shows how to use the TRANSLATE function to reorder the characters in a string. The last character of any four-character string specified as the second argument is moved to the beginning of the string.

7.4.68. TRUNC (Truncate)



Returns the integer part of *number* and *n* decimal places. The default *n* is **0** and returns an integer with no decimal point. If you specify *n*, it must be a positive whole number or zero. The *number* is rounded according to standard Rexx rules, as though the operation **number+0** had been carried out. Then it is truncated to *n* decimal places or trailing zeros are added to reach the specified length. The result is never in exponential form. If there are no nonzero digits in the result, any minus sign is removed.

Here are some examples:

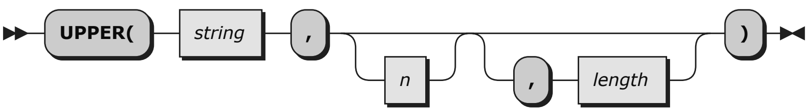
Example 7.94. Builtin function TRUNC

```
TRUNC(12.3)            ->    12
TRUNC(127.09782,3)     ->    127.097
TRUNC(127.1,3)         ->    127.100
TRUNC(127,2)           ->    127.00
```

Note

The *number* is rounded according to the current setting of NUMERIC DIGITS, if necessary, before the function processes it.

7.4.69. UPPER



Returns a new string with the characters of *string* beginning with character *n* for *length* characters converted to uppercase. If *n* is specified, it must be a positive whole number. If *n* is not specified, the case conversion will start with the first character. If *length* is specified, it must be a non-negative whole number. If *length* is not specified, the default is to convert the remainder of the string.

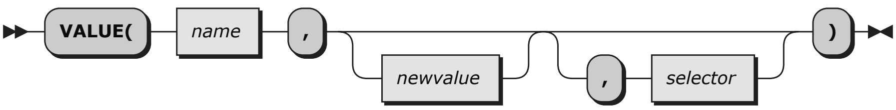
Example 7.95. Builtin function UPPER

```
upper("Albert Einstein")      ->    "ALBERT EINSTEIN"
upper("abcdef", 4)            ->    "abcDEF"
upper("abcdef", 3, 2)         ->    "abCDef"
```

7.4.70. USERID

The return value is the active user identification.

7.4.71. VALUE



Returns the value of the symbol that *name* (often constructed dynamically) represents and optionally assigns a new value to it. By default, VALUE refers to the current Rexx-variables environment, but other, external collections of variables can be selected. If you use the function to refer to Rexx variables, *name* must be a valid Rexx symbol. (You can confirm this by using the SYMBOL function.) Lowercase characters in *name* are translated to uppercase for the local environment. For the global environment lowercase characters are not translated because the global environment supports mixed-case identifiers. Substitution in a compound name (see *Section 1.13.5, “Compound Symbols”*) occurs if possible.

If you specify *newvalue*, the named variable is assigned this new value. This does not affect the result returned; that is, the function returns the value of *name* as it was before the new assignment.

Here are some examples:

Example 7.96. Builtin function VALUE

```
/* After: Drop A3; A33=7; K=3; fred="K"; list.5="Hi" */
VALUE("a"k)     ->  "A3" /* looks up A3                */
VALUE("a"k||k)  ->  "7"
VALUE("fred")   ->  "K"  /* looks up FRED              */
VALUE(fred)     ->  "3"  /* looks up K                 */
VALUE(fred,5)   ->  "3"  /* looks up K and             */
                         /* then sets K=5              */
VALUE(fred)     ->  "5"  /* looks up K                 */
VALUE("LIST."k) ->  "Hi" /* looks up LIST.5            */
```

Notes:

1. If the VALUE function refers to an uninitialized Rexx variable, the default value of the variable is always returned. The NOVALUE condition is not raised.

2. The VALUE function is used when a variable contains the name of another variable, or when a name is constructed dynamically. If you specify *name* as a single literal string and omit

newvalue and *selector*, the symbol is a constant and the string between the quotation marks can usually replace the whole function call. For example, **`fred=VALUE("k");`** is identical with the assignment **`fred=k;`**, unless the NOVALUE condition is trapped. See *Chapter 11, Conditions and Condition Traps*.

7.4.71.1. Operating System environment variables

To use VALUE to manipulate Windows or Unix-like system environment variables, *selector* must be **`ENVIRONMENT`**. In this case, the variable *name* need not be a valid Rexx symbol. On Unix-like systems environment variable names are case-sensitive.

VALUE returns the null string for undefined environment variables. You cannot determine whether an environment variable is undefined or has been set to the null string.

Environment variables set by VALUE are not kept after program termination.

Restriction

The values assigned to the variables must not contain any character that is a hexadecimal zero ("00"X). For example:

```
Call VALUE "MYVAR", "FIRST" || "00"X || "SECOND", "ENVIRONMENT"
```

sets MYVAR to "FIRST", truncating "00"x and "SECOND".

Here are some more examples:

Example 7.97. Builtin function VALUE

```
/* Given that an external variable FRED has a value of 4         */
share = "ENVIRONMENT"
say VALUE("fred",7,share)      /* says "4" and assigns           */
                               /* FRED a new value of 7          */

say VALUE("fred", ,share)      /* says "7"                       */

/* Accessing and changing Windows environment entries            */
env = "ENVIRONMENT"
new = "C:\EDIT\DOCS;"
say value("PATH",new,env)   /* says "C:\WINDOWS" (perhaps)       */
                            /* and sets PATH = "C:\EDIT\DOCS;"   */

say value("PATH", ,env)     /* says "C:\EDIT\DOCS;"              */
```

To delete an environment variable use **`.nil`** as the *newvalue*. To delete the environment variable "MYVAR" specify: value("MYVAR", .NIL, "ENVIRONMENT"). If you specify an empty string as the *newvalue* like in value("MYVAR", "", "ENVIRONMENT") the value of the external environment variable is set to an empty string which on Windows and Unix-like systems is not the same as deleting the environment variable.

Note

Any changes to Windows or Unix-like system environment variables are not kept after program termination.

7.4.71.2. Global environment variables

You can use the VALUE function to return a value from the Rexx *global environment directory*. To do so, omit *newvalue* and specify *selector* as the null string. The language processor sends the message *name* (without arguments) to the current environment object. The environment returns the object identified by *name*. If there is no such object, it returns, by default, the string *name* with an added initial period (an environment symbol - see *Section 1.13.6, “Environment Symbols”*).

Here are some examples:

Example 7.98. Builtin function VALUE

```
-- assume the environment name MYNAME identifies the string "Simon"
name = value("MYNAME", , "")        -- sends MYNAME message to the environment
say "Hello," name                   -- "Hello, Simon"

-- Assume the environment name NONAME does not exist
name = value("NONAME", , "")        -- sends NONAME message to the environment
say "Hello," name                   -- "Hello, .NONAME"
```

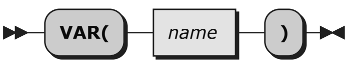
You can use the VALUE function to change a value in the global environment directory. Include a *newvalue* and specify *selector* as the null string. The language processor sends the message *name* (with **=** appended) and the single argument *newvalue* to the environment object. After receiving this message, the environment identifies the object *newvalue* by the name *name*.

Here is an example:

Example 7.99. Builtin function VALUE

```
call value "MYNAME", "David", ""   -- sends MYNAME=("David") message to the environment
say "Hello," value("MYNAME", , "") -- "Hello, David"
```

7.4.72. VAR



Returns **1** if *name* is the name of a variable (that is, a symbol that has been assigned a value), or **0**.

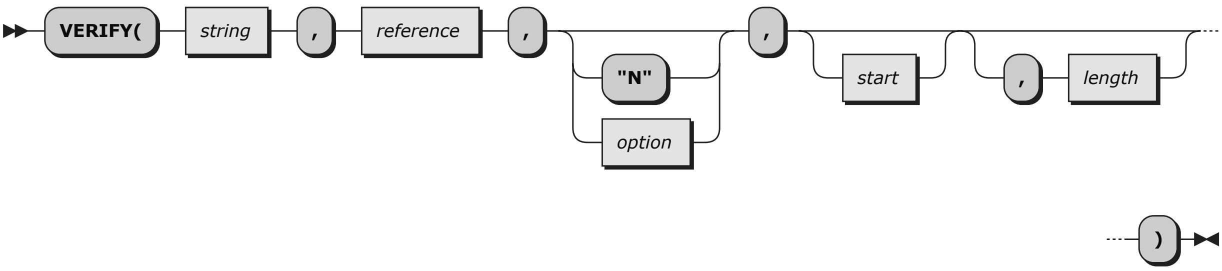
Here are some examples:

Example 7.100. Builtin function VAR

```
/* Following: DROP A.3; J=3  */
VAR("J")       -> 1
VAR(J)         -> 0  /* has tested "3"    */
```

```
VAR("a.j")      -> 0  /* has tested "A.3"  */
VAR(2)          -> 0  /* a constant symbol */
VAR("*")        -> 0  /* an invalid symbol */
```

7.4.73. VERIFY



Returns a number that, by default, indicates whether *string* is composed only of characters from *reference*. It returns **`0`** if all characters in *string* are in *reference*, or returns the position of the first character in *string* that is not in *reference*.

The *option* can be either **`Nomatch`** (the default) or **`Match`**. (Only the capitalized and highlighted letter is needed. All characters following it are ignored, and it can be in uppercase or lowercase characters.) If you specify **`Match`**, the function returns the position of the first character in the *string* that is in *reference*, or returns **`0`** if none of the characters are found.

The default for *start* is **`1`**; thus, the search starts at the first character of *string*. You can override this by specifying a different *start* point, which must be a positive whole number.

The default for *length* is the length of the string from *start* to the end of the string. Thus, the search proceeds to the end of the receiving string. You can override this by specifying a different *length*, which must be a non-negative whole number.

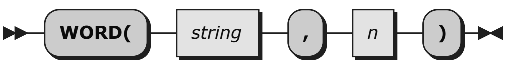
If *string* is null, the function returns **`0`**, regardless of the value of the third argument. Similarly, if *start* is greater than **`LENGTH(string)`**, the function returns **`0`**. If *reference* is null, the function returns **`0`** if you specify **`Match`**; otherwise, the function returns the *start* value.

Here are some examples:

Example 7.101. Builtin function VERIFY

```
VERIFY("123","1234567890")             ->    0
VERIFY("1Z3","1234567890")             ->    2
VERIFY("AB4T","1234567890")            ->    1
VERIFY("AB4T","1234567890","M")        ->    3
VERIFY("AB4T","1234567890","N")        ->    1
VERIFY("1P3Q4","1234567890", ,3)       ->    4
VERIFY("123","",N,2)                   ->    2
VERIFY("ABCDE","", ,3)                 ->    3
VERIFY("AB3CD5","1234567890","M",4)    ->    6
VERIFY("ABCDEF","ABC","N",2,3)         ->    4
VERIFY("ABCDEF","ADEF","M",2,3)        ->    4
```

7.4.74. WORD



Returns the *n*th whitespace-delimited word in *string* or returns the null string if less than *n* words are in *string*. *n* must be a positive whole number. This function is equivalent to **`SUBWORD(`***string*, *n*, **`1)`**.

Here are some examples:

Example 7.102. Builtin function WORD

```
WORD("Now is the time",3)    ->    "the"
WORD("Now is the time",5)    ->    ""
```

7.4.75. WORDINDEX

Returns the position of the first character in the *n*th whitespace-delimited word in *string* or returns **`0`** if less than *n* words are in *string*. *n* must be a positive whole number.

Here are some examples:

Example 7.103. Builtin function WORDINDEX

```
WORDINDEX("Now is the time",3)    ->    8
WORDINDEX("Now is the time",6)    ->    0
```

7.4.76. WORDLENGTH

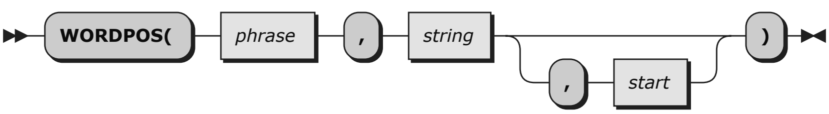
Returns the length of the *n*th whitespace-delimited word in the *string* or returns **`0`** if less than *n* words are in the *string*. *n* must be a positive whole number.

Here are some examples:

Example 7.104. Builtin function WORDLENGTH

```
WORDLENGTH("Now is the time",2)       ->    2
WORDLENGTH("Now comes the time",2)    ->    5
WORDLENGTH("Now is the time",6)       ->    0
```

7.4.77. WORDPOS (Word Position)



Returns the word number of the first word of *phrase* found in *string* or returns **`0`** if *phrase* contains no words or if *phrase* is not found. Several whitespace characters between words in either *phrase* or *string* are treated as a single blank for the comparison, but otherwise the words must match exactly.

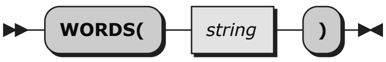
By default, the search starts at the first word in *string*. You can override this by specifying *start* (which must be positive), the word at which to start the search.

Here are some examples:

Example 7.105. Builtin function WORDPOS

```
WORDPOS("the","now is the time")              ->  3
WORDPOS("The","now is the time")              ->  0
WORDPOS("is the","now is the time")           ->  2
WORDPOS("is   the","now is the time")         ->  2
WORDPOS("is   time ","now is   the time")     ->  0
WORDPOS("be","To be or not to be")            ->  2
WORDPOS("be","To be or not to be",3)          ->  6
```

7.4.78. WORDS



Returns the number of whitespace-delimited words in *string*.

Here are some examples:

Example 7.106. Builtin function WORDS

```
WORDS("Now is the time")    ->    4
WORDS(" ")                  ->    0
```

7.4.79. X2B (Hexadecimal to Binary)

Returns a string, in character format, that represents *hexstring* converted to binary. The *hexstring* is a string of hexadecimal characters. It can be of any length. Each hexadecimal character is converted to a string of 4 binary digits. You can optionally include whitespace characters in *hexstring* (at byte boundaries only, not leading or trailing) to improve readability; they are ignored.

The returned string has a length that is a multiple of 4, and does not include any whitespace.

If *hexstring* is null, the function returns a null string.

Here are some examples:

Example 7.107. Builtin function X2B

```
X2B("C3")        ->  "11000011"
X2B("7")         ->  "0111"
X2B("1 C1")      ->  "000111000001"
```

You can combine X2B with the functions D2X and C2X to convert numbers or character strings into binary form.

Here are some examples:

Example 7.108. Builtin function X2B

```
X2B(C2X("C3"x))  ->  "11000011"
X2B(D2X("129"))  ->  "10000001"
X2B(D2X("12"))   ->  "1100"
```

7.4.80. X2C (Hexadecimal to Character)

Returns a string, in character format, that represents *hexstring* converted to character. The returned string has half as many bytes as the original *hexstring*. *hexstring* can be of any length. If necessary, it is padded with a leading zero to make an even number of hexadecimal digits.

You can optionally include whitespace characters in *hexstring* (at byte boundaries only, not leading or trailing) to improve readability; they are ignored.

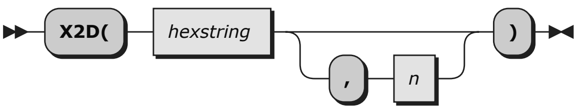
If *hexstring* is null, the function returns a null string.

Here are some examples:

Example 7.109. Builtin function X2C

```
X2C("4865 6c6c 6f") ->  "Hello"     /*  ASCII             */
X2C("3732 73")      ->  "72s"       /*  ASCII             */
```

7.4.81. X2D (Hexadecimal to Decimal)



Returns the decimal representation of *hexstring*. The *hexstring* is a string of hexadecimal characters. If the result cannot be expressed as a whole number, an error occurs. That is, the result must not have more digits than the current setting of NUMERIC DIGITS.

You can optionally include whitespace characters in *hexstring* (at byte boundaries only, not leading or trailing) to aid readability; they are ignored.

If *hexstring* is null, the function returns **0**.

If you do not specify *n*, the *hexstring* is processed as an unsigned binary number.

Here are some examples:

Example 7.110. Builtin function X2D

```
X2D("0E")        ->    14
X2D("81")        ->    129
X2D("F81")       ->    3969
X2D("FF81")      ->    65409
X2D("46 30"X)    ->    240          /*  ASCII   */
```

```
X2D("66 30"X)    ->    240          /*  ASCII   */
```

If you specify *n*, the string is taken as a signed number expressed in *n* hexadecimal digits. If the leftmost bit is off, then the number is positive; otherwise, it is a negative number. In both cases it is converted to a whole number, which can be negative. If *n* is **0**, the function returns **0**.

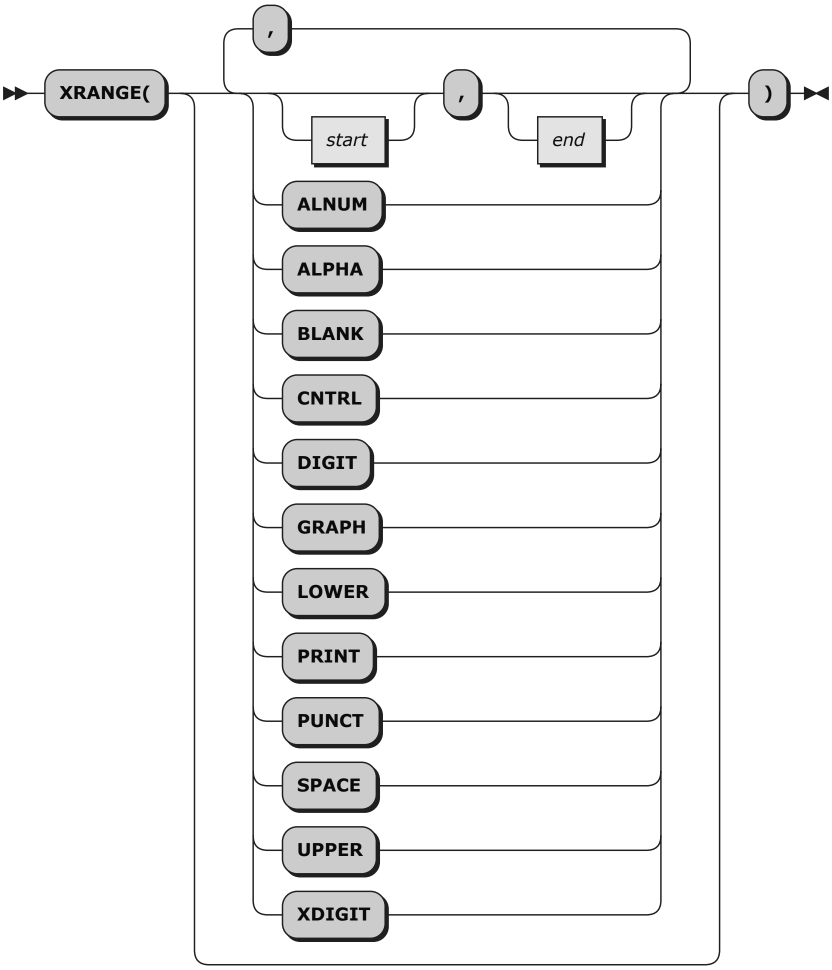
If necessary, *hexstring* is padded on the left with **0** characters (not "sign-extended"), or truncated on the left to *n* characters.

Here are some examples:

Example 7.111. Builtin function X2D

```
X2D("81",2)      ->    -127
X2D("81",4)      ->    129
X2D("F081",4)    ->    -3967
X2D("F081",3)    ->    129
X2D("F081",2)    ->    -127
X2D("F081",1)    ->    1
X2D("0031",0)    ->    0
```

7.4.82. XRANGE (Hexadecimal Range)



Returns a string of all valid 1-byte encodings (in ascending order) between and including the values *start* and *end*, or a character sequence representing a POSIX character class name. Any number of *start* / *end* bytes and character class names can be specified, and all resulting sequences are returned as a concatenated string.

The default value for *start* is **'00'x**, and the default value for *end* is **'ff'x**. If *start* is greater than *end*, the values wrap from **'ff'x** to **'00'x**. If specified, *start* and *end* must be single characters.

The characters in a sequence representing a POSIX character class name are returned in ascending order. The following POSIX character class names can be specified:

<table>
<tr><th>Name</th><th>Description</th><th>Returned sequence</th></tr>
<tr><td>ALNUM</td><td>Alphanumeric characters</td><td>0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz</td></tr>
<tr><td>ALPHA</td><td>Alphabetic characters</td><td>ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz</td></tr>
<tr><td>BLANK</td><td>Space and tab</td><td>'09 20'x</td></tr>
<tr><td>CNTRL</td><td>Control characters</td><td>'00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F 7F'x</td></tr>
<tr><td>DIGIT</td><td>Digits</td><td>0123456789</td></tr>
<tr><td>GRAPH</td><td>Visible characters</td><td>!"#$%&'()*+,-./0123456789:;<=>? @ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_` abcdefghijklmnopqrstuvwxyz{|}~</td></tr>
<tr><td>LOWER</td><td>Lowercase letters</td><td>abcdefghijklmnopqrstuvwxyz</td></tr>
<tr><td>PRINT</td><td>Visible characters and space character</td><td> !"#$%&'()*+,-./0123456789:;<=>? @ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_` abcdefghijklmnopqrstuvwxyz{|}~</td></tr>
<tr><td>PUNCT</td><td>Punctuation characters</td><td>!"#$%&'()*+,-./:;<=>?@[\]^_`{|}~</td></tr>
<tr><td>SPACE</td><td>Whitespace characters</td><td>'09 0A 0B 0C 0D 20'x</td></tr>
<tr><td>UPPER</td><td>Uppercase letters</td><td>ABCDEFGHIJKLMNOPQRSTUVWXYZ</td></tr>
<tr><td>XDIGIT</td><td>Hexadecimal digits</td><td>0123456789ABCDEFabcdef</td></tr>
</table>

Here are some examples:

Example 7.112. Builtin function XRANGE

```
XRANGE("a", "f")                     --> "abcdef"
XRANGE('03'x, '07'x)                 --> '0304050607'x
XRANGE(, '04'x)                      --> '0001020304'x
XRANGE('FE'x, '02'x)                 --> 'FEFF000102'x
XRANGE("t", "t", "h", "i", "r", "t") --> "thirst"
XRANGE('xdigit')                     --> "0123456789ABCDEFabcdef"
XRANGE("a", "f", "A", "F", "digit")  --> "abcdefABCDEF0123456789"
```

Rexx Utilities (RexxUtil)

RexxUtil is a function package for Windows and Unix-like systems. It contains functions to:

- Manipulate operating system files and directories
- Manipulate Windows classes and objects
- Perform text screen input and output

All of the RexxUtil functions are registered by the Rexx interpreter on startup so there is no need to manually register the functions.

8.1. A Note on Error Codes

Some of the RexxUtil functions return operating system error codes on failure. The *SysGetErrorText* function can be used to retrieve the description of a system error code.

On Windows, the meaning of these error return codes can be looked up in the Windows System Error Codes documentation provided by Microsoft, currently at *https://docs.microsoft.com/en-us/windows/win32/debug/system-error-codes*.

8.2. List of Rexx Utility Functions

The following table lists all of the RexxUtil functions and the platforms on which they are available.

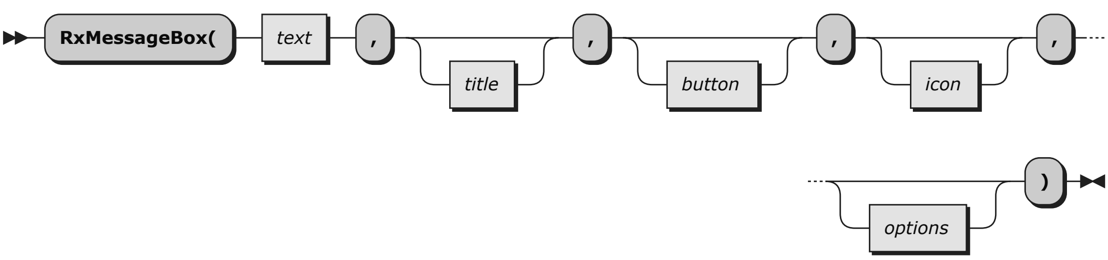
Table 8.1. Rexx Utility Library Functions

Function Name	Exists on Platform		Remarks
	Windows	Unix-like	
RxMessageBox (Windows only)	Yes	No	
RxWinExec (Windows only)	Yes	No	
SysAddRexxMacro	Yes	Yes	
SysBootDrive (Windows only)	Yes	No	
SysClearRexxMacroSpace	Yes	Yes	
SysCls	Yes	Yes	
SysCreatePipe (Unix-like systems only)	No	Yes	
SysCurPos (Windows only)	Yes	No	
SysCurState (Windows only)	Yes	No	
SysDriveInfo (Windows only)	Yes	No	
SysDriveMap (Windows only)	Yes	No	
SysDropRexxMacro	Yes	Yes	
SysDumpVariables	Yes	Yes	
SysFileCopy	Yes	Yes	
SysFileDelete	Yes	Yes	
SysFileExists	Yes	Yes	
SysFileMove	Yes	Yes	

Function Name	Exists on Platform		Remarks
	Windows	Unix-like	
SysFileSearch	Yes	Yes	
SysFileSystemType (Windows only)	Yes	No	
SysFileTree	Yes	Yes	Works differently
SysFork (Unix-like systems only)	No	Yes	
SysFormatMessage	Yes	Yes	
SysFromUnicode (Windows only)	Yes	No	
SysGetErrorText	Yes	Yes	
SysGetFileDateTime	Yes	Yes	
SysGetKey	Yes	Yes	
SysGetLongPathName (Windows only)	Yes	No	
SysGetMessage (Unix-like systems only)	No	Yes	
SysGetMessageX (Unix-like systems only)	No	Yes	
SysGetShortPathName (Windows only)	Yes	No	
SysIni (Windows only)	Yes	No	
SysIsFile	Yes	Yes	
SysIsFileCompressed (Windows only)	Yes	No	
SysIsFileDirectory	Yes	Yes	
SysIsFileEncrypted (Windows only)	Yes	No	
SysIsFileLink	Yes	Yes	
SysIsFileNotContentIndexed (Windows only)	Yes	No	
SysIsFileOffline (Windows only)	Yes	No	
SysIsFileSparse (Windows only)	Yes	No	
SysIsFileTemporary (Windows only)	Yes	No	
SysLinVer (Linux Only)	No	No*	*) Linux only
SysLoadRexxMacroSpace	Yes	Yes	
SysMkDir	Yes	Yes	
SysQueryProcess	Yes	Yes	Works differently
SysQueryRexxMacro	Yes	Yes	
SysReorderRexxMacro	Yes	Yes	
SysRmDir	Yes	Yes	
SysSaveRexxMacroSpace	Yes	Yes	
SysSearchPath	Yes	Yes	
SysSetFileDateTime	Yes	Yes	
SysSetPriority	Yes	Yes	
SysShutdownSystem (Windows only)	Yes	No	
SysSleep	Yes	Yes	
SysStemCopy	Yes	Yes	

Function Name	Exists on Platform		Remarks
	Windows	Unix-like	
SysStemDelete	Yes	Yes	
SysStemInsert	Yes	Yes	
SysStemSort	Yes	Yes	
SysSwitchSession (Windows only)	Yes	No	
SysSystemDirectory (Windows only)	Yes	No	
SysTempFileName	Yes	Yes	
SysTextScreenRead (Windows only)	Yes	No	
SysTextScreenSize (Windows only)	Yes	No	
SysToUnicode (Windows only)	Yes	No	
SysUtilVersion	Yes	Yes	
SysVersion	Yes	Yes	
SysVolumeLabel (Windows only)	Yes	No	
SysWait (Unix-like systems only)	No	Yes	
SysWaitNamedPipe (Windows only)	Yes	No	
SysWinDecryptFile (Windows only)	Yes	No	
SysWinEncryptFile (Windows only)	Yes	No	
SysWinGetPrinters (Windows only)	Yes	No	
SysWinGetDefaultPrinter (Windows only)	Yes	No	
SysWinSetDefaultPrinter (Windows only)	Yes	No	
SysWinVer (Windows only)	Yes	No	

8.3. RxMessageBox (Windows only)



Displays a modal dialog box with a title, a message text, an optional icon, and a set of buttons. The dialog box is displayed using the Windows MessageBox() function.

RxMessageBox returns one of the following integer values indicating which button the user clicked.

1
: The **OK** button was pressed

2
: The **Cancel** button was pressed

3
: The **Abort** button was pressed

4
: The **Retry** button was pressed

5
: The **Ignore** button was pressed

6
: The **Yes** button was pressed

7
: The **No** button was pressed

10
: The **Try Again** button was pressed

11
: The **Continue** button was pressed

If a message box has a **Cancel** button, the function returns the value 2 if either the ESC key is pressed or the **Cancel** button is selected. If the message box has no **Cancel** button, pressing ESC will have no effect unless an **OK** button is present. If an **OK** is displayed and the user presses ESC, the return value will be 1.

If the Windows MessageBox() function fails, the return value is zero.

text
: The message box text.

title
: The message box title. The default title is `Error`.

button
: The message box push button style.

  `OK`
  : The message box contains one push button: **OK**. This is the default.

  `OKCANCEL`
  : The message box contains two push buttons: **OK** and **Cancel**.

  `RETRYCANCEL`
  : The message box contains two push buttons: **Retry** and **Cancel**.

  `ABORTRETRYIGNORE`
  : The message box contains three push buttons: **Abort**, **Retry**, and **Ignore**.

  `CANCELTRYCONTINUE`
  : The message box contains three push buttons: **Cancel**, **Try Again**, and **Continue**. Use this message box button style instead of **`ABORTRETRYIGNORE`**.

  `YESNO`
  : The message box contains two push buttons: **Yes** and **No**.

  `YESNOCANCEL`
  : The message box contains three push buttons: **Yes**, **No**, and **Cancel**.

icon

The message box icon. The default is **`NONE`**. Allowed icons are:

`NONE`

No icon is displayed.

`INFORMATION`, **`ASTERISK`**

A stop-sign icon appears in the message box.

`WARNING`, **`EXCLAMATION`**

An exclamation-point icon appears in the message box.

`ERROR`, **`HAND`**, **`STOP`**

An icon consisting of a lowercase letter i in a circle appears in the message box.

`QUESTION`, **`QUERY`**

A question-mark icon appears in the message box. This icon is no longer recommended.

option

More than one of the following options may be specified. If neither **`DEFBUTTON2`**, **`DEFBUTTON3`**, nor **`DEFBUTTON4`** is specified, the first button is the default button. Allowed options are:

`DEFBUTTON2`

The second button is the default button.

`DEFBUTTON3`

The third button is the default button.

`DEFBUTTON4`

The fourth button is the default button.

`RIGHT`

The message box text is right-justified.

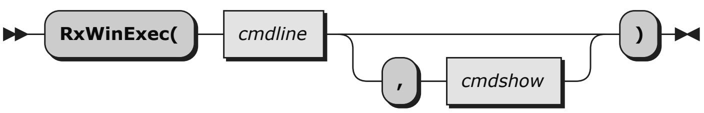
`TOPMOST`

The message box is placed above all non-topmost windows and stays above them, even when the window is deactivated.

Example 8.1. RexxUtil — RxMessageBox

```
-- Give option to quit
if RxMessageBox("Shall we continue?", "", "YesNo", "Question") = 7
  then exit  -- "No" button clicked, exit
```

8.4. RxWinExec (Windows only)



Starts (executes) the application as specified in *cmdline*.

Parameters:

cmdline

A string containing a file name and optional parameters for the application to be executed. If the name of the executable file in *cmdline* does not contain a directory path, RxWinExec searches for the executable file in this sequence:

1

The directory from which ooRexx was loaded.

2

The current directory.

3

The Windows system directory.

4

The Windows directory.

5

The directories listed in the PATH environment variable.

cmdshow

Specifies how a Windows-based application window is to be shown. For a non-Windows-based application, the PIF file, if any, for the application determines the window state.

SHOWNORMAL

Activates and displays a window.

SHOWNOACTIVATE

Displays the window while the current active window remains active.

SHOWMINNOACTIVE

Displays the window as a minimized window, the current active window remains active.

SHOWMINIMIZED

Activates the window and displays it as a minimized window.

SHOWMAXIMIZED

Activates the window and displays it as a maximized window.

HIDE

Hides the window and activates another window.

MINIMIZE

Minimizes the specified window and activates the next top-level window in the Z order.

Return codes:

If the application is started successfully, the process id (PID) is returned. If an error occurs the returned value is less than 32.

Error return codes correspond to a *Windows System Error code*. If the Windows system error code is greater than 32 it is negated. This is to prevent confusion between a legitimate error code and a PID.

Some common error returns for this function are as follows.

2

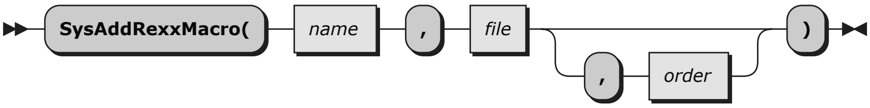
The specified file was not found.

3
: The specified path was not found.

11
: The EXE file is invalid.

-53
: The network path is invalid.

8.5. SysAddRexxMacro



Adds a routine to the Rexx macrospace. SysAddRexxMacro returns the RexxAddMacro return code.

Parameters:

name
: The name of the function added to the macrospace.

file
: The file containing the Rexx program.

order
: The macrospace search order. The order can be "B" (Before), which is default, or "A" (After).

8.6. SysBootDrive (Windows only)

Returns the drive used to boot Windows, for example, "C:".

8.7. SysClearRexxMacroSpace

Clears the Rexx macrospace. SysClearRexxMacroSpace returns the RexxClearMacroSpace return code.

8.8. SysCls

Clears the screen.

Example 8.2. RexxUtil — SysCls

```
call SysCls
```

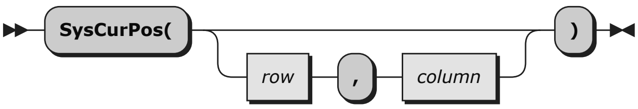
8.9. SysCreatePipe (Unix-like systems only)

Creates an unnamed pipe.

Returns:

Returns a string like **`"handle handle"`** where the first handle is for read and the second handle for write.

8.10. SysCurPos (Windows only)



Returns the cursor position in the form **`row col`** and optionally moves the cursor to a new location.

Parameters:

row
: The row to move to.

col
: The column to move to.

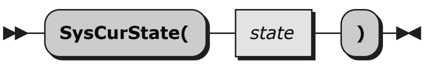
> **Note**
>
> Position (0,0) is the upper left corner.

You can call SysCurPos without a column and row position to obtain the cursor position without moving the cursor.

Example 8.3. RexxUtil — SysCurPos

```
say SysCurPos() -- (e. g.) 10 0
```

8.11. SysCurState (Windows only)



Hides or displays the cursor.

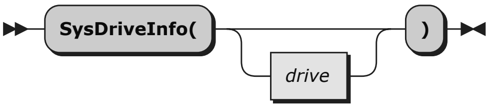
Parameter:

state
: The new cursor state. Allowed states are:

"ON"
: Display the cursor

"OFF"
: Hide the cursor

8.12. SysDriveInfo (Windows only)



Returns drive information in the form **`drive free total label`**, where **`drive`** is the drive identifier, **`free`** is the total number of unused bytes, **`total`** is the total size in bytes, and **`label`** is the volume label of the specified *drive*. Returns the null string if the drive is not accessible.

If *drive* is omitted, the current drive is used.

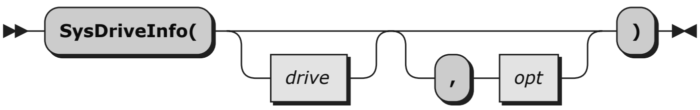
Parameter:

drive
: A drive specification like **`d:\`** or **`\\share\path`**.

Example 8.4. RexxUtil — SysDriveInfo

```
say SysDriveInfo() -- e. g. C: 23989809152 254721126400 Windows
```

8.13. SysDriveMap (Windows only)



Returns a string listing accessible drives (separated by blanks) in the form: **`C: D: ...`**.

Parameters:

drive
: The first drive letter of the drive map. The default is "C:".

opt
: The drivemap option. This can be:

"USED"
: returns the drives that are accessible or in use, including all local and remote drives. This is the default.

"FREE"
: returns drives that are free or not in use.

"LOCAL"
: returns only local drives.

"REMOTE"
: returns only remote drives, such as redirected LAN resources or installable file system (IFS) attached drives.

"REMOVABLE"
: returns removable drives.

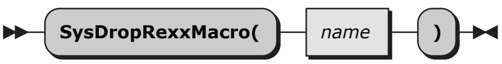
"CDROM"
: returns CD-ROM drives.

"RAMDISK"
: returns drives assigned from RAM.

Example 8.5. RexxUtil — SysDriveMap

```
say SysDriveMap("C:", "USED") -- C: M: N: O: P: R: Z:
```

8.14. SysDropRexxMacro

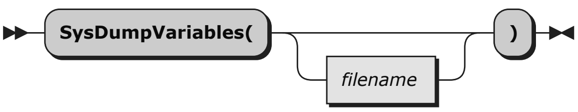


Removes a routine from the Rexx macrospace. SysDropRexxMacro returns the RexxDropMacro return code.

Parameter:

name
: The name of the function removed from the macrospace.

8.15. SysDumpVariables



Dumps all variables in the current scope either to the specified file *filename* (new data is appended) or to STDOUT if you omit *filename*. The format of the data is, with one variable per line:

```
Name=MYVAR, Value='This is the content of MYVAR'
```

Parameter:

filename
: The name of the file to which variables are appended. The dump is written to STDOUT if you omit this parameter.

Return codes:

0
: Dump completed successfully.

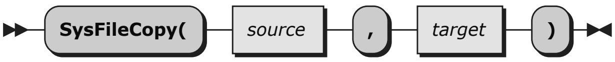
-1
: Dump failed.

See also **`RexxContext`** method *variables*.

Example 8.6. RexxUtil — SysDumpVariables

```
Call SysDumpVariables "MyVars.Lst" /* append vars to file */
Call SysDumpVariables              /* list vars on STDOUT */
```

8.16. SysFileCopy



Copies a file from one location to another. Wildcard file specifications are not allowed.

Parameter:

source
: The path/name of the file to be copied. The *source* and the *target* path does not support wildcard characters. On Unix-like systems, if the first character is a **~** (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

target
: The path/name of the target location where the file is to be copied.

Return codes:

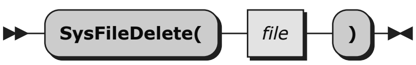
0
: File copied successfully.

Other
: A *Windows System Error code*.

Example 8.7. RexxUtil — SysFileCopy

```
call SysFileCopy "c:\temp\myfile.txt", "d:\myfolder\myCopy.txt"
call SysFileCopy "/tmp/myfile.txt", "~/myCopy.txt"
```

8.17. SysFileDelete



Deletes a file.

Parameter:

file

The name of the file to be deleted. The name does not support wildcard characters. On Unix-like systems, if the first character is a **~** (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

Return codes:

0

File deleted successfully.

Other

An *operating system error code*. On Windows, this may be one of the following, but could be others.

2

File not found.

3

Path not found.

5

Access denied or busy.

26

Not DOS disk.

32

Sharing violation.

36

Sharing buffer exceeded.

87

Does not exist.

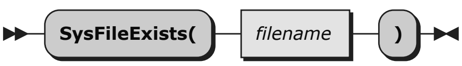
206

File name exceeds range error.

Example 8.8. RexxUtil — SysFileDelete

```
parse arg InputFile OutputFile
call SysFileDelete OutputFile  -- unconditionally erase output file
```

8.18. SysFileExists



Checks for the existence of a file. Returns **1** if any file system entity with the given name exists. In particular, this will return **1** for both regular files and directories.

Parameters:

filename

The name of the file to check for the existence of. The name does not support wildcard characters. On Unix-like systems, if the first character is a **~** (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

Returns:

0

The file does not exist.

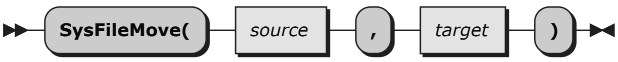
1

The file exists.

Example 8.9. RexxUtil — SysFileExists

```
if SysFileExists(InputFile) then say "File Exists!"
else say "File does not exist."
```

8.19. SysFileMove



Moves a file from one location to another. Wildcard file specifications are not allowed.

Parameter:

source

The path/name of the file to be moved. The filename does not support wildcard characters. On Unix-like systems, if the first character is a **~** (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

target

The path of the target location where the file is to be moved.

Return codes:

0

File copied successfully.

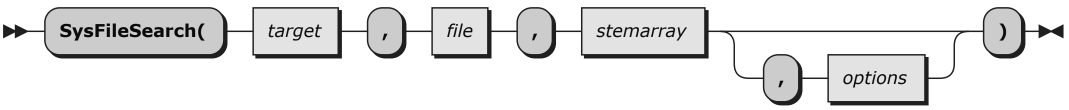
Other

An *operating system error code*.

Example 8.10. RexxUtil — SysFileMove

```
call SysFileMove "c:\temp\myfile.txt", "d:\myfolder\myCopy.txt"
call SysFileMove "/tmp/myfile.txt", "~/myCopy.txt"
```

8.20. SysFileSearch



Returns a list of all file lines containing the target string.

Parameters:

target

The target search string.

file

The searched file.

stemarray

A Rexx stem or array variable for the returned lines. If a stem variable, *stem*`.0` is set to *n*, the number of lines returned, and the lines are returned in *stem*`.1` to *stem.n*.

options

Any combination of the following one-character options:

C

Conducts a case-sensitive search.

I

Conducts a case-insensitive search.

N

Prepends file line numbers to any returned lines.

The default is a case-insensitive search without line numbers.

Return codes:

0

Successful.

2

Not enough memory.

3

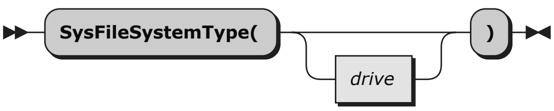
Error opening file.

Example 8.11. RexxUtil — SysFileSearch

```
/* Find DEVICE statements in CONFIG.SYS */
call SysFileSearch "DEVICE", "C:\CONFIG.SYS", "file."
do i=1 to file.0
say file.i
end

/* Output */
DEVICE=C:\SB16\DRV\CTSB16.SYS /UNIT=0 /BLASTER=A:240 I:5 D:1 H:5
DEVICE=C:\SB16\DRV\CTMMSYS.SYS
rem ****    DOS SCSI CDROM device drivers ***
DEVICE=C:\SCSI\ASPI8DOS.SYS /D
DEVICE=C:\SCSI\ASPICD.SYS /D:ASPICD0
rem **** IDE CDROM device drivers
```

```
DEVICE=C:\DOS\HIMEM.SYS
DEVICE=C:\SBCD\DRV\SBIDE.SYS /V /D:MSCD001  /P:1f0,14
DEVICE=C:\DOS\SETVER.EXE
DEVICE=C:\WINDOWS\SMARTDRV.EXE /DOUBLE_BUFFER
DEVICE=C:\WINDOWS\IFSHLP.SYS

/* Find DEVICE statements in CONFIG.SYS (along with */
/* line numbers)                                    */
call SysFileSearch "DEVICE", "C:\CONFIG.SYS", "file.", "N"
do i=1 to file.0
say file.i
end

/* Output */
1 DEVICE=C:\SB16\DRV\CTSB16.SYS /UNIT=0 /BLASTER=A:240 I:5 D:1
H:5
2 DEVICE=C:\SB16\DRV\CTMMSYS.SYS
4 rem ****    DOS SCSI CDROM device drivers ***
5 DEVICE=C:\SCSI\ASPI8DOS.SYS /D
6 DEVICE=C:\SCSI\ASPICD.SYS /D:ASPICD0
8 rem **** IDE CDROM device drivers
9 DEVICE=C:\DOS\HIMEM.SYS
10 DEVICE=C:\SBCD\DRV\SBIDE.SYS /V /D:MSCD001  /P:1f0,14
13 DEVICE=C:\DOS\SETVER.EXE
16 DEVICE=C:\WINDOWS\SMARTDRV.EXE /DOUBLE_BUFFER
17 DEVICE=C:\WINDOWS\IFSHLP.SYS
```

8.21. SysFileSystemType (Windows only)



Returns the type of file system (e. g. FAT or NTFS) used on a drive. Returns the null string if the drive is not accessible.

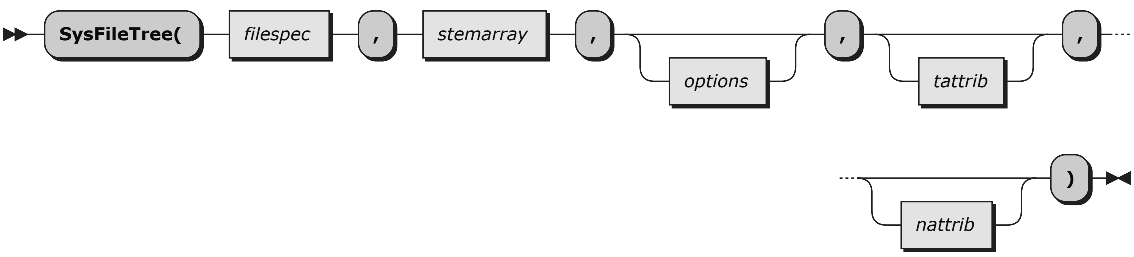
Parameter:

drive
: A drive specification like **`d:\`** or **`\\share\path`**. If omitted, the current drive is used.

Example 8.12. RexxUtil — SysFileSystemType

```
say SysFileSystemType("C:\")    -- NTFS
```

8.22. SysFileTree



Returns a list of all files that match a file specification. SysFileTree can return file information like date, time, size, attributes, and file name. The default format for date and time is platform specific.

SysFileTree uses operating system APIs to find the files. The found files are placed in the returned list in the order they are found by the operating system. No specific order can be assumed.

Parameters:

filespec [required]

The search pattern, the search file specification. This can not be the empty string.

The search pattern can be a full or partial path with wildcard characters in the last part of the path information, e. g. **`*.bat`**, or **`../../*.sh`**, or **`c:\temp`**. Windows supports wildcard characters **`*`** and **`?`**, Unix-like systems additionally support character classes in **`[ ]`** brackets, including - for ranges and **`!`** for negation.

stemarray [required]

A Rexx stem or array variable for the returned matches. If a stem variable, *stem*`.0` is set to *n*, the number of matches returned, and the matching files or directories are returned in *stem*`.1` to *stem.n*.

options [optional]

A string with any combination of the following. If this argument is omitted, it defaults to **`B`**.

`B`

Search for both files and directories. This is the default.

`D`

Search for directories only.

`F`

Search for files only.

`H`

Returns correct file sizes for files larger than 9999999999 bytes (approx. 10 GB). Without this option, the maximum file size returned is 9999999999, even if the file is larger than this.

`I`

Perform a case-insensitive search for file names or directories. This option is only used on system that support case-sensitive file names and is ignored on systems like Windows where the file system is case-insensitive by default.

`L`

Returns the file date and time in the form **`YYYY-MM-DD HH:MM:SS`**.

`O`

Returns only the fully-qualified file name.

`S`

Search subdirectories recursively.

`T`

Returns the file date and time in the form **`YY/MM/DD/HH/MM`**. If the **`L`** option is also specified then this option will be ignored.

tattrib [optional] [Windows only]

The target attribute mask for file specification matches. Only files that match the target mask are returned. The default mask is `*****`. This returns all files regardless of the settings (clear or set) of the Archive, Directory, Hidden, Read-Only, and System attributes. The target mask attributes must appear in the order **ADHRS**. This argument is Windows only. It is allowed but ignored on Unix-like systems.

Target Mask Options

*****

The file attribute may be any state.

+

The file attribute must be set.

-

The file attribute must be cleared.

Target Mask Examples

`***+*`

Find all files with the Read-Only attribute set.

`+**+*`

Find all files with the Read-Only and Archive attributes set.

`*++**`

Find all hidden subdirectories.

`---+-`

Find all files with only the Read-Only attribute set.

nattrib [optional] [Windows only]

The new attribute mask for setting the attributes of each matching file. The default mask is `*****`. This means not to change the Archive, Directory, Hidden, Read-Only, and System attributes. The target mask attributes must appear in the order **ADHRS**. This argument is Windows only. It is allowed but ignored on Unix-like operating systems.

New Attribute Mask Options

*****

Do not change the file attribute.

+

Set the file attribute.

-

Clear the file attribute.

New Attribute Mask Examples

`***+*`

Set the Read-Only attribute on all files.

`-**+*`

Set the Read-Only attribute and clear the Archive attribute of each file.

+*+++
: Set all file attributes, except the directory attribute.

: Clear all attributes on all files.

> **Note**
>
> You cannot set the directory attribute on non-directory files. SysFileTree returns the file attribute settings after the new attribute mask has been applied.

Return codes:

0
: Successful.

2
: Not enough memory.

other
: On Windows, the return code may be any System Error Code returned by the operating system.

Example 8.13. RexxUtil — SysFileTree

```
/* Find all subdirectories on C: */
call SysFileTree "c:\*.*", "file", "SD"

/* Find all executable (.exe) files under Program Files*/
ret = SysFileTree('C:\Program Files\*.exe', f, 'FS')

/* Find all Read-Only files */
call SysFileTree "c:\*.*", "file", "S", "***+*"

/* Clear Archive and Read-Only attributes of files that have them set */
call SysFileTree "c:\*.*", "file", "S", "+**+*", "-**-*"

/****<< Sample Code and Output Example.>>********/

call SysFileTree "c:\win*", file., "b"
do i = 1 to file.0
  say file.i   -- 3/12/21   1:56p           0  -D---   c:\Windows
end
```

8.23. SysFork (Unix-like systems only)

Returns

Returns the process id to the parent process.

Returns **0** to the spawned process.

Example:

This is a complete working example. It can be cut and pasted into a file and executed on a Unix-like system.

Example 8.14. RexxUtil — SysFork

```
/* Example SysFork() and SysWait() */

  pid = SysFork()

  if pid == 0 then do
    say "I am the child."
    code = executeChild()
    say "Child : done with execution, will exit with" code
    exit code
  end
  else do
    say 'I am the parent, child pid is:' pid
    code = executeParent()
    say 'Parent: going to wait for child.'
    code = SysWait()
    say 'Parent: back from waiting. Child exit code:' code
  end

  say 'Operating system version:' SysVersion()

::routine executeChild

    say 'Child : will sleep 1 second.'
    j = SysSleep(1)
    say 'Child : done sleeping 1. Will do some calculations.'

    total = 0
    do 786
      total += 3
    end
    say 'Child : 3 * 786 is:' total

    say 'Child : will sleep 2 seconds.'
    j = SysSleep(2)
    say 'Child : done sleeping 2. Will do some calculations.'

    total = 0
    do 1865
      total += 7
    end
    say 'Child : 7 * 1865 is:' total

    say 'Child : will sleep 2 seconds.'
    j = SysSleep(2)
    say 'Child : done sleeping 2.'
    say 'Child : done executing, will return 0.'
    return 0

::routine executeParent

    say 'Parent: 3 * 786 is:' (3 * 786)
    j = SysSleep(2)
    say 'Parent: 7 * 1865 is:' (7 * 1865)
    return 0
```

8.24. SysFormatMessage

Formats and returns a message text, replacing placeholders **&***n* with specified message inserts. SysFormatMessage can replace up to nine placeholders.

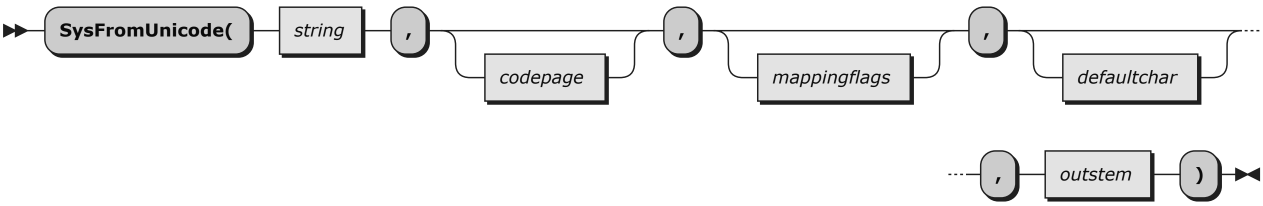
message
: The message text. This string may include up to nine placeholders **&1**, **&2** … **&9** in any order.

substitutions
: Text inserts for message placeholders. This can a be a single string, an Array of strings, or any other object supporting a `makeArray` method. The first array item is used to replace the **&1** placeholder, the second item replaces **&2**, up to a maximum of nine items.

Example 8.15. RexxUtil — SysFormatMessage

```
s = .Stream~new("xyzzy")
if \s~open("read")~startsWith("READY") then
  -- Cannot read file 'xyzzy': ERROR:2 No such file or directory
  say SysFormatMessage("Cannot read file '&1': &2", (s~string, s~description))
```

8.25. SysFromUnicode (Windows only)



Maps a Unicode character string to an ASCII character string. The new character string and additional information is returned in the outstem.

Parameters:

string
: A string containing the Unicode characters to be mapped.

codepage
: Specifies the code page used to perform the conversion. This parameter can be the value of any code page that is installed or available in the system. The default is the current original equipment manufacturer (OEM) code-page identifier for the system.

  You can also specify one of the following values:

  ACP
  : ANSI code page.

  OEMCP
  : OEM code page.

  SYMBOL
  : symbol code page.

THREAD_ACP
: current thread's ANSI code page.

UTF7
: translate using UTF-7.

UTF8
: translate using UTF-8. When this is set, **`mappingflags`** must be set.

mappingflags

Specifies the handling of unmapped characters. The function performs more quickly when none of these flags is set.

The following flags can be used:

COMPOSITECHECK
: Converts composite characters to precomposed characters.

SEPCHARS
: Generates separate characters during conversion. This is the default conversion behavior.

DISCARDNS
: Discards nonspacing characters during conversion.

DEFAULTCHAR
: Replaces non-convertible characters with the default character during conversion.

When **`compositecheck`** is specified, the function converts composite characters to precomposed characters. A composite character consists of a base character and a nonspacing character, each having different character values. A precomposed character has a single character value for a combination of a base and a nonspacing character. In the character è, the "e" is the base character, and the "grave" accent mark is the nonspacing character.

When **`compositecheck`** is specified, it can use the last three flags in this list (**`discardns,`** **`sepchars`**, and **`defaultchar`**) to customize the conversion to precomposed characters. These flags determine the function's behavior when there is no precomposed mapping for a combination of a base and a nonspace character in a Unicode character string. These last three flags can be used only if the **`compositecheck`** flag is set. The function's default behavior is to generate separate characters (**`sepchars`**) for unmapped composite characters.

defaultchar

Character to be used if a Unicode character cannot be represented in the specified code page. If this parameter is NULL, a system default value is used. The function is faster when **`defaultchar`** is not used.

outstem

The name of the stem variable that will contain the converted result. If the conversion was successful the stem will be composed of the following value(s):

outstem.!USEDDEFAULTchar
: This variable will be set to "1" if the *defaultchar* was used during the conversion and "0" if it was not.

outstem.!TEXT
: This variable will contain the converted string.

Return codes:

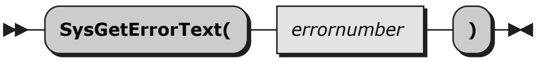
0
: No errors.

Other
: An *operating system error code*. On Windows, this may be one of the following, but could be others.

87
: Incorrect code page or **codepage** value.

1004
: Invalid mapping flags.

8.26. SysGetErrorText



Obtains a string describing the system error identified by the error number.

Returns a string with the description of the error, or an empty string if no description is available.

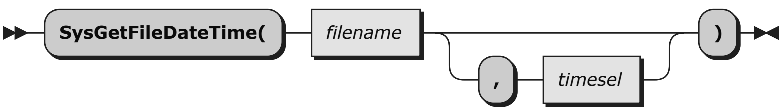
Parameter:

errornumber
: The error number for which a description is to be retrieved. Note that both the error number and the descriptive text are operating-system specific.

Example 8.16. RexxUtil — SysGetErrorText

```
-- Windows: Cannot create a file when that file already exists.
say SysGetErrorText(SysMkDir("\Users"))

-- Unix-like system: File exists
say SysGetErrorText(SysMkDir("/usr"))
```

8.27. SysGetFileDateTime



Returns a file timestamp.

Parameters

filename
: The name of a file or directory for which a timestamp should be returned. The name does not support wildcard characters. On Unix-like systems, if the first character is a **~** (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

timesel

An optional selector specifying the type of timestamp to be returned. Depending on the operating system and the file system, one of the following timestamps may be selected (only the first letter is required):

`ACCESS`

The date and time when the file was last accessed. Not available on FAT file systems.

`CREATE`

The creation date and time. Not available on Unix-like systems or on FAT file systems.

`WRITE`

The date and time the file was last modified. This is the default if *timesel* is omitted.

Returns

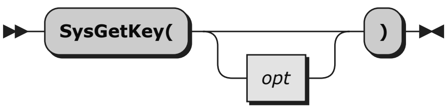
The file timestamp in the format **`yyyy-mm-dd hh:mm:ss`**, or **`-1`** to indicate that the timestamp is unavailable or could not be retrieved.

See also **`File`** methods *lastAccessed (Attribute)* and *lastModified (Attribute)*, and Rexxutil *SysSetFileDateTime*.

Example 8.17. RexxUtil — SysGetFileDateTime

```
say SysGetFileDateTime(".")           -- (e. g.) 2020-04-01 17:45:20
say SysGetFileDateTime("main.c", "w") -- (e. g.) 2020-02-11 05:00:00
```

8.28. SysGetKey



Reads and returns the next key from the keyboard buffer. If the keyboard buffer is empty, SysGetKey waits until a key is pressed. Unlike the CHARIN built-in function, SysGetKey does not wait until the Enter key is pressed.

Parameter:

opt

An option controlling screen echoing. Allowed values are:

"ECHO"

Echo the pressed key to the screen. This is the default.

"NOECHO"

Do not echo the pressed key.

8.29. SysGetLongPathName (Windows only)

Returns the long version of the specified *path*.

Parameter:

path

A relative or a fully qualified path of an existing file or directory.

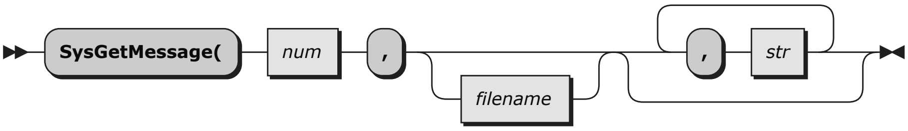
Returns:

The long version of *path*, or the null string, if *path* doesn't exist or the call to the Windows API `GetLongPathName` fails for any other reason.

Example 8.18. RexxUtil — SysGetLongPathName

```
say SysGetLongPathName("C:\progra~1")             -- C:\Program Files
say SysGetLongPathName("\windows\explorer.exe")   -- \Windows\explorer.exe
```

8.30. SysGetMessage (Unix-like systems only)



Returns a message retrieved from a Unix message catalog, with placeholders replaced with specified message inserts.

SysGetMessage is implemented on Unix-like systems only. It always retrieves messages from the catalog's message set 1. To retrieve messages from a specified message set, use *SysGetMessageX (Unix-like systems only)*.

To create a Unix message catalog use the **`gencat`** command.

Parameters:

num

The message number.

filename

The name of the catalog file containing the message. If *filename* is omitted or specified as **`rexx.cat`** the internal Rexx message catalog is searched. Otherwise the Unix message catalog is located using the absolute *filename* path or searched along the **`NLSPATH`** environment variable.

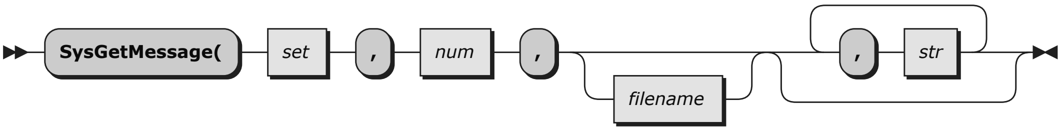
str

Zero to nine replacement strings for placeholders in the message. The first replacement string is for placeholder **`&1`**, the second for **`&2`**, up to placeholder **`&9`**. If a placeholder has no replacement string specified, it is replaced by the null string. Any unused replacement string is ignored. Other placeholders like **`%s`** are not replaced and are returned unchanged with the message.

Example 8.19. RexxUtil — SysGetMessage

```
say SysGetMessage(485, "rexx.cat", "foo") -- Class "foo" not found.
```

8.31. SysGetMessageX (Unix-like systems only)



Returns a message retrieved from a Unix message catalog, with placeholders replaced with specified message inserts.

SysGetMessageX is implemented on Unix-like systems only.

To create a Unix message catalog use the **`gencat`** command.

Parameters:

set
: The message set.

num
: The message number.

filename
: The name of the catalog file containing the message. If *filename* is omitted or specified as **`rexx.cat`** the internal Rexx message catalog is searched. Otherwise the Unix message catalog is located using the absolute *filename* path or searched along the **`NLSPATH`** environment variable.

str
: Zero to nine replacement strings for placeholders in the message. The first replacement string is for placeholder **`&1`**, the second for **`&2`**, up to placeholder **`&9`**. If a placeholder has no replacement string specified, it is replaced by the null string. Any unused replacement string is ignored. Other placeholders like **`%s`** are not replaced and are returned unchanged with the message.

Example 8.20. RexxUtil — SysGetMessageX

```
say SysGetMessageX(1, 485, "rexx.cat", "foo") -- Class "foo" not found.
```

8.32. SysGetShortPathName (Windows only)

Returns the short version of the specified *path*.

Parameter:

path
: A relative or a fully qualified path of an existing file or directory.

Returns:

The short version of *path*, or the null string, if *path* doesn't exist or the call to the Windows API `GetShortPathName` fails for any other reason.

Example 8.21. RexxUtil — SysGetShortPathName

```
say SysGetShortPathName("C:\Program Files")       -- C:\PROGRA~1
```

```
say SysGetShortPathName("\windows\explorer.exe")  -- \windows\explorer.exe
```

8.33. SysIni (Windows only)

Allows limited access to INI file variables. Variables are stored in the INI file under Application Names and their associated key names or keywords. You can use SysIni to share variables between applications or as a way of implementing GLOBALV in the Windows operating system. Be careful when changing application profile information.

Note

SysIni works on all types of data stored in an INI file (text, numeric, or binary).

When SysIni successfully sets or deletes key values, it returns "". For a successful query, it returns the value of the specified application keyword.

SysIni may return the string **`ERROR:`** when an error occurs. Possible error conditions include:

- An attempt was made to query or delete an application/key pair that does not exist.
- An error opening the profile file occurred. You may have specified the current user or system INI file with a relative file specification. Make sure to use the full file specification (specify drive, path, and file name).

Parameters:

inifile
: The name of the INI file with which you would like to work. The default is WIN.INI.

Note

If this argument does not contain a fully qualified file name, the Windows operating system searches for the file in the Windows directory. Therefore to work with a file outside of the Windows directory, specify the full path name of the file.

app
: The application name or some other meaningful value with which you want to store keywords (some sort of data).

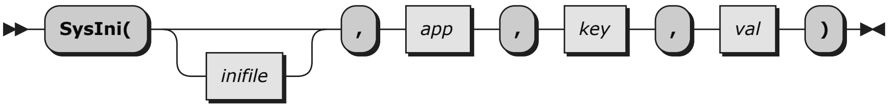
key
: The name of a keyword to hold data.

val
: The value to associate with the keyword of the specified application. This can be **`"DELETE:"`** or **`"ALL:"`**.

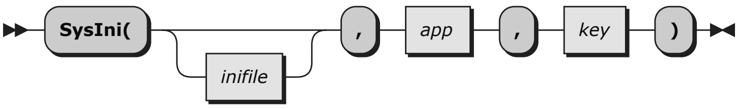
stemarray

A Rexx stem or array variable for the returned names. If a stem variable, *stem*`.0` is set to *n*, the number of names returned, and the names are returned in *stem*`.1` to *stem.n*.

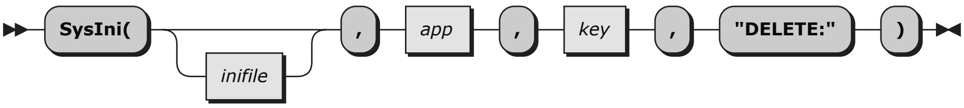
SysIni has six modes. The modes and the syntax variations are as follows:



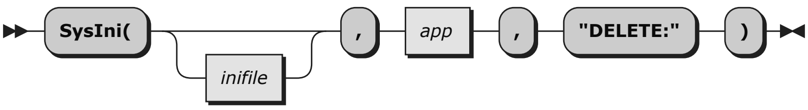
Sets a single key value.



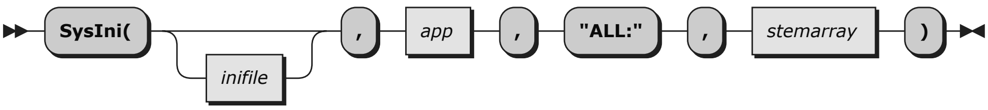
Queries a single key value.



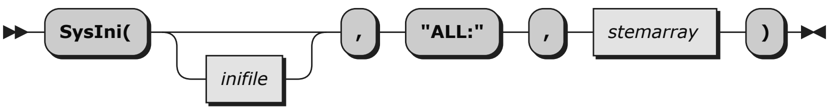
Deletes a single key.



Deletes an application and all associated keys.



Queries names of all keys associated with a certain application.



Queries the names of all applications.

Example 8.22. RexxUtil — SysIni

```
/***  Save the user entered name under the key "NAME" of *****
****  the application "MYAPP".                          ****/
pull name .
call SysIni , "MYAPP", "NAME", name /* Save the value        */
say  SysIni(, "MYAPP", "NAME")      /* Query the value       */
call SysIni , "MYAPP"               /* Delete all MYAPP info */
exit
```

Example 8.23. RexxUtil — SysIni

```
/****  Type all WIN.INI file information to the screen  *****/
call SysIni "WIN.INI", "All:", "Apps."
if Result \= "ERROR:" then
```

```
do i = 1 to Apps.0
call SysIni "WIN.INI", Apps.i, "All:", "Keys"
if Result \= "ERROR:" then
do j=1 to Keys.0
val = SysIni("WIN.INI", Apps.i, Keys.j)
say left(Apps.i, 20) left(Keys.j, 20),
"Len=x"Left(d2x(length(val)),4) left(val, 20)
end
end
exit
```

8.34. SysIsFile

```
>>--SysIsFile(--filename--)--><
```

Checks for the existence of a file.

On Unix-like systems block devices are also considered to be regular files by this function.

Parameters:

filename
: The name of the file to check for the existence of. The name does not support wildcard characters. On Unix-like systems, if the first character is a **~** (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

Returns:

0
: The file does not exist.

1
: The file exists.

Example 8.24. RexxUtil — SysIsFile

```
if SysIsFile(InputFile) then say "File Exists!"
else say "File does not exist."
```

8.35. SysIsFileCompressed (Windows only)

```
>>--SysIsFileCompressed(--filename--)--><
```

Checks if a file is compressed. This function does not support wildcard specifications.

Parameters:

filename
: The name of the file to check.

Returns:

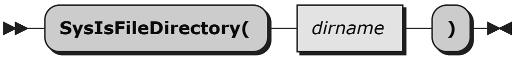
0
: The file is not compressed or does not exist.

1
: The file is compressed.

Example 8.25. RexxUtil — SysIsFileCompressed

```
if SysIsFileCompressed(InputFile) then say "File is compressed!"
else say "File is not compressed or does not exist."
```

8.36. SysIsFileDirectory



Checks for the existence of a subdirectory.

Parameters:

dirname
: The name of the subdirectory to check for the existence of. The directory name does not support wildcard characters. On Unix-like systems, if the first character is a ~ (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

Returns:

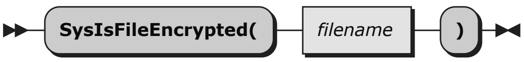
0
: The subdirectory does not exist.

1
: The subdirectory exists.

Example 8.26. RexxUtil — SysIsFileDirectory

```
if SysIsFileDirectory(InputFile) then say "Subdirectory Exists!"
else say "Subdirectory does not exist."
```

8.37. SysIsFileEncrypted (Windows only)



Checks if a file is encrypted. This function does not support wildcard specifications.

Parameters:

filename
: The name of the file to check.

Returns:

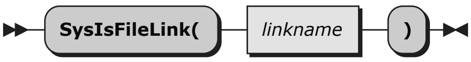
0
: The file is not encrypted or does not exist.

1
: The file is encrypted.

Example 8.27. RexxUtil — SysIsFileEncrypted

```
if SysIsFileEncrypted(InputFile) then say "File is encrypted!"
else say "File is not encrypted or does not exist."
```

8.38. SysIsFileLink



Checks for the existence of a link.

Parameters:

linkname
: The name of the link to check for the existence of. The name does not support wildcard characters. On Unix-like systems, if the first character is a ~ (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

Returns:

0
: The link does not exist or it is not a link.

1
: The link exists.

Example 8.28. RexxUtil — SysIsFileLink

```
if SysIsFileLink(InputFile) then say "Link Exists!"
else say "Link does not exist."
```

8.39. SysIsFileNotContentIndexed (Windows only)

Checks if a file is flagged to be indexed by the Index Service. This function does not support wildcard specifications.

Parameters:

filename
: The name of the file to check.

Returns:

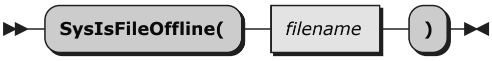
0
: The file is not flagged to be Indexed or does not exist.

1
: The file is flagged to be Indexed.

Example 8.29. RexxUtil — SysIsFileNotContentIndexed

```
if SysIsFileNotContentIndexed(InputFile) then say "File is flagged to be Indexed!"
else say "File is not flagged to be Indexed."
```

8.40. SysIsFileOffline (Windows only)



Checks if a file is flagged as Offline. This function does not support wildcard specifications.

Parameters:

filename
The name of the file to check.

Returns:

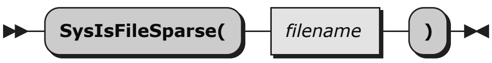
0
The file is not flagged as Offline or does not exist.

1
The file is flagged as Offline.

Example 8.30. RexxUtil — SysIsFileOffline

```
if SysIsFileOffline(InputFile) then say "File is flagged as Offline!"
else say "File is not flagged as Offline."
```

8.41. SysIsFileSparse (Windows only)



Checks if a file is flagged as Sparse. This function does not support wildcard specifications.

Parameters:

filename
The name of the file, subdirectory or link to check.

Returns:

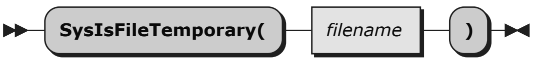
0
The file is not flagged as Sparse or does not exist.

1
The file is flagged as Sparse.

Example 8.31. RexxUtil — SysIsFileSparse

```
if SysIsFileSparse(InputFile) then say "File is Sparse!"
else say "File is not Sparse."
```

8.42. SysIsFileTemporary (Windows only)



Checks if a file is flagged as Temporary. This function does not support wildcard specifications.

Parameters:

filename
: The name of the file, subdirectory or link to check.

Returns:

0
: The file is not flagged as Temporary or does not exist.

1
: The file is flagged as Temporary.

Example 8.32. RexxUtil — SysIsFileTemporary

```
if SysIsFileTemporary(InputFile) then say "File is Temporary!"
else say "File is not Temporary."
```

8.43. SysLinVer (Linux Only)

Returns a string identifying the Linux system version. The first word of the returned string is **`Linux`** and the remaining part of the string identifies the version. Rexx code should not rely on the exact format returned.

Possible output might be:

Example 8.33. RexxUtil — SysLinVer

```
-- CentOS 7
say SysVersion() -- Linux 3.10.0-957.10.1.el7.x86_64
-- Ubuntu 16.04
say SysVersion() -- Linux 4.4.0-154-generic
-- Raspbian
say SysVersion() -- Linux 4.14.70-v7+
-- SLES/390
say SysVersion() -- Linux 3.12.74-60.64.40-default
```

See also functions *SysVersion* and *SysWinVer (Windows only)*.

8.44. SysLoadRexxMacroSpace

Loads functions from a saved macrospace file. SysLoadRexxMacroSpace returns the RexxLoadMacroSpace return code.

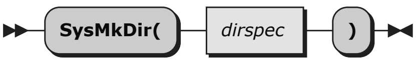
Parameter:

file

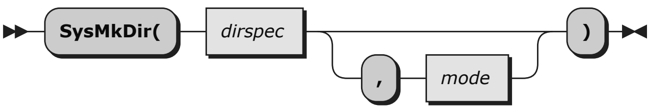
The file used to load functions into the Rexx macrospace. SysSaveRexxMacroSpace must have created the file.

8.45. SysMkDir

Windows:



Unix-like systems:



Creates the specified directory. This function will only create the final directory in the path, all intermediate directories must already exist.

Parameter:

dirspec

The directory to be created. The directory name does not support wildcard characters. On Unix-like systems, if the first character is a ~ (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

mode (Unix-like systems only)

The file permission bits of the new directory as a decimal number between 0 (octal 000) and 511 (octal 777). If not specified, *mode* defaults to 511 (octal 777).

Any mode restrictions specified by **`umask`** will always be taken into account.

Return codes:

0

Directory creation was successful.

Other

An *operating system error code*. On Windows, this may be one of the following, but could be others.

2

File not found.

3

Path not found.

5

Access denied.

26

Not a DOS disk.

87
: Invalid parameter.

108
: Drive locked.

183
: Directory already exists.

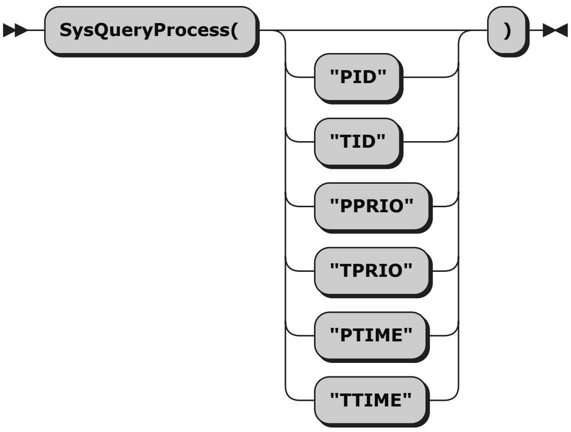
206
: File name exceeds range.

Example 8.34. RexxUtil — SysMkDir

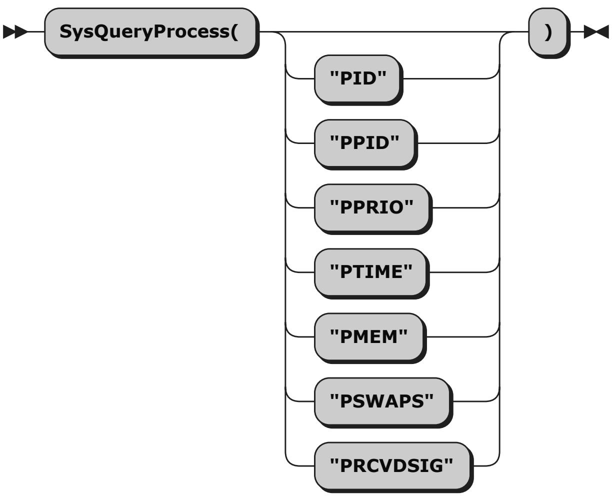
```
call SysMkDir "backup"
```

8.46. SysQueryProcess

Windows



Unix-like systems



Retrieves information about the current process or Windows thread.

Parameter:

info

The kind of information requested:

PID
: Returns the process ID of the current process.

PPID
: Returns the parent process ID of the current process.

TID
: Returns the thread ID of the current thread.

PPRIO
: Returns the priority class of the current process.

TPRIO
: Returns the relative priority of the current thread.

PTIME
: Returns time information on the current process.

TTIME
: Returns time information on the current thread.

PMEM
: Returns the maximum memory (RSS) used by the current process.

PRCVDSIG
: Returns the number of signals that have been received by the process.

Return codes:

- For PID, PPID or TID: an ID
- For Windows PPRIO: "IDLE", "NORMAL", "HIGH", "REALTIME", or "UNKNOWN"
- For Unix-like systems PPRIO: a number from -20 to +20.
- For TPRIO: "IDLE", "LOWEST", "BELOW_NORMAL", "NORMAL", "ABOVE_NORMAL", "HIGHEST", "TIME_CRITICAL", or "UNKNOWN"
- For Windows PTIME or TTIME: the creation date and time, the amount of time that the process executed in kernel mode, and the amount of time that the process executed in user mode
- For Unix-like systems PTIME: the summary and the duration that the process executed in kernel mode, and the duration that the process executed in user mode

8.47. SysQueryRexxMacro

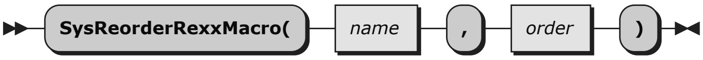
Queries the existence of a macrospace function. SysQueryRexxMacro returns the placement order of the macrospace function or a null string ("") if the function does not exist in the macrospace.

Parameter:

name

The name of a function in the Rexx macrospace.

8.48. SysReorderRexxMacro



Reorders a routine loaded in the Rexx macrospace. SysReorderRexxMacro returns the RexxReorderMacro return code.

Parameters:

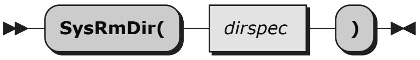
name

The name of a function in the macrospace.

order

The new macro search order. The order can be "B" (Before) or "A" (After).

8.49. SysRmDir



Deletes a specified file directory without your confirmation.

Parameter:

dirspec

The directory that should be deleted. The name does not support wildcard characters. On Unix-like systems, if the first character is a ~ (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

Return codes:

0

Directory removal was successful.

Other

An *operating system error code*. On Windows, this may be one of the following, but could be others.

2

File not found.

3

Path not found.

5

Access denied or busy.

16

Current directory.

26

Not a DOS disk.

32
: Sharing violation.

108
: Drive locked.

123
: Invalid name.

145
: Directory not empty.

146
: Is Subst Path.

147
: Is Join Path.

206
: File name exceeds range.

Example 8.35. RexxUtil — SysRmDir

```
call SysRmDir "backup"
```

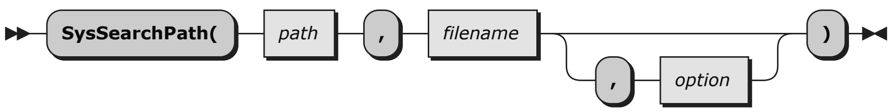
8.50. SysSaveRexxMacroSpace

Saves the Rexx macrospace. SysSaveRexxMacroSpace returns the RexxSaveMacroSpace return code.

Parameter:

file
: The file used to save the functions in the Rexx macrospace.

8.51. SysSearchPath



Returns the absolute path of *filename* if it can be found along any of the paths specified in environment variable *path*. Returns the null string otherwise.

Parameters

path
: An environment variable name. The environment variable must contain a list of paths, like in **PATH**.

filename

The name of the file to be searched. The name can optionally include a relative or an absolute path, but the name part must be a file, not a directory. If the name specified with an absolute path, it is returned without searching along the environment variable's paths. The name does not support wildcard characters. On Unix-like systems, if the first character is a **~** (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

option

Specifies where the search starts.

C

Starts the search at the current directory and then along the specified *path*. This is the default.

N

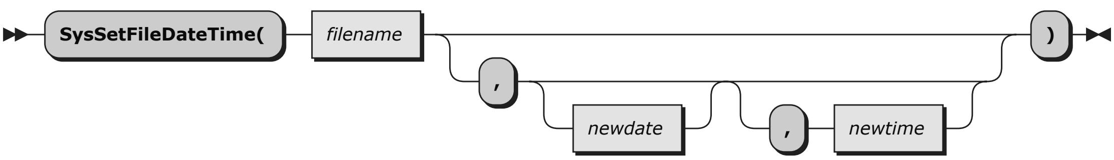
Only searches along *path*.

See also **File** method *searchPath (Class Method)*.

Example 8.36. RexxUtil — SysSearchPath

```
say SysSearchPath("PATH", "rexx")      -- (Unix e.g.) /usr/local/bin/rexx
say SysSearchPath("PATH", "rexx.exe")  -- (Windows e.g.) C:\Program Files\ooRexx\rexx.exe
```

8.52. SysSetFileDateTime



Sets the last-modified timestamp of a file.

If both *newdate* and *newtime* are omitted, the last-modified timestamp is set to the current date and time, similar to what the **touch** command on Unix-like systems does.

If only one of the *newdate* and *newtime* arguments is supplied, the respective other last-modified date/time portion stays unchanged.

Parameters

filename

The name of a file or directory for which the last-modified timestamp should be updated. The name does not support wildcard characters. On Unix-like systems, if the first character is a **~** (tilde) character optionally followed by a username, it is replaced by the current or specified user's home directory.

newdate

An optional new date in the format **yyyy-mm-dd**. On Windows **yyyy** must be greater than or equal to **1800**.

newtime

An optional new time in the format **hh:mm:ss** (24-hour format).

Return codes

0
: The file date and/or time were updated successfully.

-1
: The timestamp update failed.

See also **`File`** methods *lastModified (Attribute)* and *lastModified (Attribute)*, and Rexxutil *SysGetFileDateTime*.

Example 8.37. RexxUtil — SysSetFileDateTime

```
call SysSetFileDateTime "."                         -- touch current directory
call SysSetFileDateTime "main.c", , "05:00:00"     -- change file time only
```

8.53. SysSetPriority

Changes the priority of the current process. A return code of 0 indicates no error.

Parameters:

class
: The new process priority class. The allowed classes are:
  0 or "IDLE"
  : Idle time priority

  1 or "NORMAL"
  : Regular priority

  2 or "HIGH"
  : High or time-critical priority

  3 or "REALTIME"
  : Real-time priority

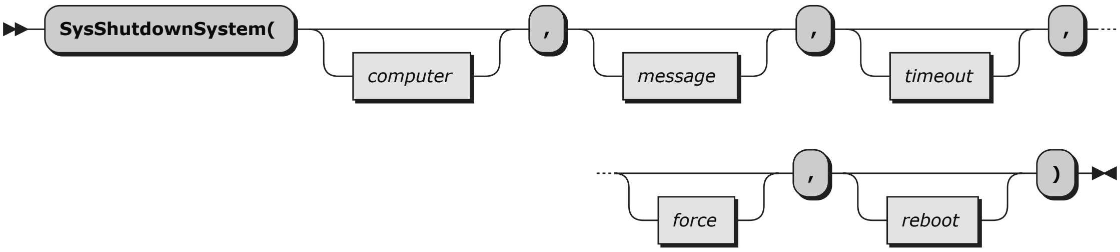
delta
: The change applied to the process priority level. *delta* must be in the range -15 to +15. It can also be a symbolic name:
  - "IDLE" for -15
  - "LOWEST" for -2
  - "BELOW_NORMAL" for -1
  - "NORMAL" for 0
  - "ABOVE_NORMAL" for 1
  - "HIGHEST" for 2
  - "TIME_CRITICAL" for 15

0
: No errors.

Other
: An *operating system error code*. On Windows, this may be one of the following, but could be others.

307
: Invalid priority class.

8.54. SysShutdownSystem (Windows only)



> **Warning**
>
> Once this function has been called, the initiated shutdown cannot be aborted—data loss may occur!

Provides an interface to the **`InitiateSystemShutdown()`** API on Windows. If the user has sufficient privileges, this function can be used to shut down the local machine or a remote system. In general all users have sufficient privileges to shut down the local machine and only Administrators have sufficient privileges to shut down remote machines.

The user of this function is **strongly** encouraged to read the Microsoft documentation for **`InitiateSystemShutdown()`** to understand the finer points to using this function. The documentation is freely available online. A Google search using *InitiateSystemShutdown MSDN* will provide a link to the documentation. In particular, this function can be used to force a shut down of a system while users are logged on and applications have unsaved data.

If the *timeout* argument is not 0, a shut down dialog is displayed on the machine being shut down, naming the user who initiated the shut down, a timer counting down the seconds until the machine is shut down, and prompting the user to log off. This dialog can be moved but it can not be closed and remains on top of all other windows on the system.

If any open application has unsaved data, the operating system gives the application a chance to prompt the user to save and close the application. If the *force* argument is false, the shut down will be delayed until the user responds, and ultimately the user could cancel the shut down. If the *force* argument is true the system will force the application closed whether the data gets saved or not. The application is still given a chance to prompt the user to save the data, but the user only has a few seconds to respond before the system forcibly closing the application.

The implications of the preceding two paragraphs are this, if the *timeout* argument is 0 and the *force* argument is true, the system immediately shuts down and any unsaved data is forever lost. This is why the user of this function is encouraged to fully understand this function before using it.

Parameters:

computer
: Indicates which system to shut down. If omitted or the empty string, the local machine is shut down. Otherwise this should be the network name of the remote machine.

message
: An additional message that is added to the shut down dialog. If omitted, no additional message is added.

timeout
: The time, in seconds, before the system is shut down. If this value is 0, the system is immediately shut down and no shut down dialog is displayed. The shut down can not be aborted. If omitted the default time out is 30 seconds.

force
: If this argument is true, applications with unsaved data will be forced close by the system whether the data is saved or not. If false, the shut down is delayed until applications with unsaved data responds. If an application does not respond, the user will be prompted by the system to end the application. At this point, if the user chooses not to forcibly end the application, the shut down will be aborted.

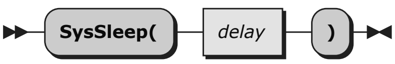
  Please **note** some consequences of this argument as described by Microsoft. If this argument is false, i.e. applications are not forced to close, and an application with unsaved changes is running on the console session, the shutdown will remain in progress until the user logged into the console session aborts the shutdown, saves changes, closes the application, or forces the application to close. During this period, the shutdown *may not be* aborted except by the console user, and another shutdown *may not be* initiated. Using true for this argument prevents that situation. But, using true can also result in unsaved data being lost.

reboot
: If this argument is true, the system is rebooted after the shut down. If it is false, the system is shut down. The default if omitted is false.

Returns:

Returns `0` for success or a Windows *System Error code* for failure. For instance a return of 1300 would indicate the user does not have sufficient privileges to shut down the named system. Use *SysGetErrorText* to get a generic text description for any Windows System Error code. For example, the description for error code 1300 is *Not all privileges referenced are assigned to the caller.*

8.55. SysSleep



Pauses a Rexx program for a specified time interval.

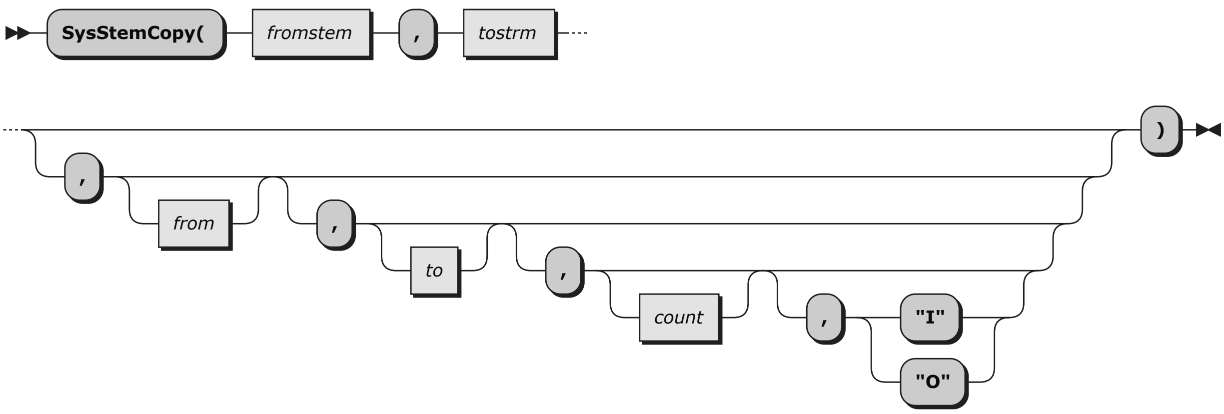
Parameter:

delay
: The number of seconds for which the program is to be paused, which must be in the range 0 to 2147483 for Windows, and 0 to 999999999 for Unix-like systems.

Example 8.38. RexxUtil — SysSleep

```
Say "Now paused for 2 seconds ..."
Call SysSleep 2
Say "Now paused for 0.1234567 seconds ..."
Call SysSleep 0.1234567
```

8.56. SysStemCopy



Copies items from the source stem to the target stem. Items in the source stem are copied starting at the *from* index (default is 1) into the target stem beginning at the *to* index (default is 1). The number of items to be copied to the target stem can be specified with the count. The default is to copy all items in the source stem.

You can also specify that the items are to be inserted into the target stem at the position and the existing items are shifted to the end.

This function operates only on stem arrays that specify the number of items in stem.0 and all items must be numbered from 1 to n without omitting an index.

Parameters:

fromstem
: The name of the source stem.

tostem
: The name of the target stem.

from
: The first index in the source stem to be copied.

to
: The position at which the items are to be inserted in the target stem.

count
: The number of items to be copied or inserted.

insert
: Either of the following values:

  I
  : Insert items.

O
: Overwrite items.

Return codes:

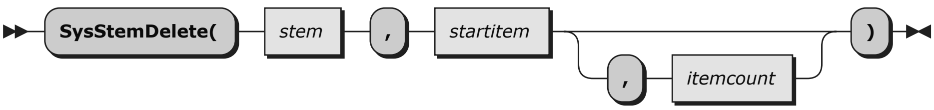
0
: The stem was copied successfully.

-1
: Copying the stem failed.

Example 8.39. RexxUtil — SysStemCopy

```
Source.0 = 3
Source.1 = "Hello"
Source.2 = "from"
Source.3 = "Rexx"
Call SysStemCopy "Source.", "Target."

Call SysStemCopy "Source.", "Target.", 1, 5, 2, "I"
```

8.57. SysStemDelete



Deletes the specified item at the index *startitem* in the stem. If more than one item is to be deleted the *itemcount* must be specified. After deleting the requested items the stem is compacted, which means that items following the deleted items are moved to the vacant positions.

This function operates only on stem arrays that specify the number of items in stem.0 and all items must be numbered from 1 to n without omitting an index.

Parameters:

stem
: The name of the stem from which the item is to be deleted.

startitem
: The index of the item to be deleted.

itemcount
: The number of items to be deleted if more than one.

Return codes:

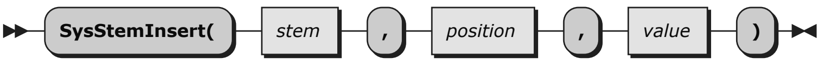
0
: Deleting was successful.

-1
: Deleting failed.

Example 8.40. RexxUtil — SysStemDelete

```
Call SysStemDelete "MyStem.", 5
Call SysStemDelete "MyStem.", 5, 4
```

8.58. SysStemInsert



Inserts a new item at *position* in the stem. All items in the stem following this position are shifted down by one position.

This function operates only on stem arrays that specify the number of items in stem.0 and all items must be numbered from 1 to n without omitting an index.

Parameters:

stem
: The name of the stem in which an item is to be inserted.

position
: The index at which the new item is to be inserted.

value
: The value of the new item.

Return codes:

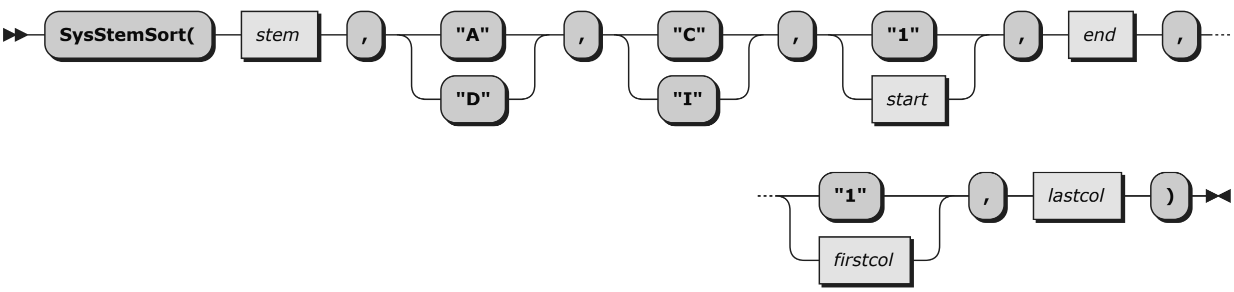
0
: Inserting was successful.

-1
: Inserting failed.

Example 8.41. RexxUtil — SysStemInsert

```
Call SysStemInsert "MyStem.", 5, "New value for item 5"
```

8.59. SysStemSort



Sorts all or the specified items in the stem. The items can be sorted in ascending or descending order and the case of the strings being compared can be respected or ignored. Sorting can be further narrowed by specifying the first and last item to be sorted or the columns used as sort keys. Because the sort uses a quick-sort algorithm, the order of sorted items according to the sort key is undetermined.

This function operates only on stems that specify the number of items in stem.0 and all items must be numbered from 1 to n without omitting an index. A value of 0 in stem.0 is also valid but no sort will be performed.

Parameters:

stem
: The name of the stem to be sorted.

order
: Either "A" for ascending or "D" for descending. The default is "A".

type
: The type of comparison: either "C" for case or "I" for ignore. The default is "C".

start
: The index at which the sort is to start. The default is 1.

end
: The index at which the sort is to end. The default is the last item.

firstcol
: The first column to be used as sort key. The default is 1.

lastcol
: The last column to be used as sort key. The default is the last column.

Return codes:

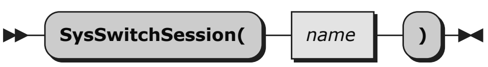
0
: The sort was successful.

-1
: The sort failed.

Example 8.42. RexxUtil — SysStemSort

```
/* sort all elements descending, use cols 5 to 10 as key */
Call SysStemSort "MyStem.", "D", , , ,5, 10

/* sort all elements ascending, ignore the case */
Call SysStemSort "MyStem.", "A", "I"

/* sort elements 10 to 20 ascending, use cols 1 to 10 as key */
Call SysStemSort "MyStem.", , ,10, 20, 1, 10
```

8.60. SysSwitchSession (Windows only)



Brings the named window to the foreground. Modern versions of Windows do not always allow a window to be brought to the foreground programmatically. Instead, the icon for the window on the task bar is set to flashing.

Parameter:

name

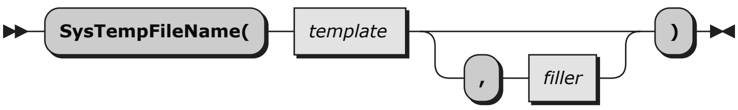
The name of the window you want to be the foreground window. The name of the window must exactly match the title of the window, but is not case sensitive. The title of a window is the text displayed in its title bar.

0 is returned on success and a Windows *System Error code* on failure.

8.61. SysSystemDirectory (Windows only)

Returns the Windows system directory.

8.62. SysTempFileName



Returns a unique name for a file or directory that does not currently exist. If an error occurs or SysTempFileName cannot create a unique name from the template, it returns a null string. SysTempFileName is useful when a program requires a temporary file.

Parameters:

template

The *template* is a valid file or directory specification including a path, with between one and nine filler characters.

SysTempFileName generates filler character replacements with a random number algorithm. If the resulting file or directory already exists, SysTempFileName increments the replacement value until all possibilities have been exhausted.

The file path and name of the template can be of any length. If the template contains no or more than nine filler characters, SysTempFileName returns a null string. Filler characters are allowed both in the path and the name part of *template*. The unique name is created solely by substituting a random numeric digit for each filler character. If there is a directory name part of the template in addition to the file name part, and the directory name part contains a non-existent directory, the function will succeed. However, the temporary file will not be writable unless the user first creates the non-existent directory, or directories.

filler

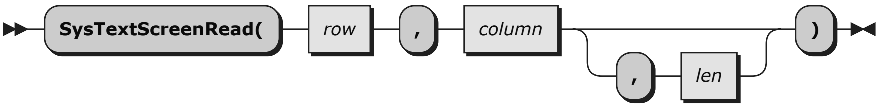
The filler character used in *template*. SysTempFileName replaces each filler character in *template* with a random numeric digit. The resulting string represents a file or directory that does not exist. The default filler character is **?**.

See also *File* method *temporaryPath (Class Method)*.

Example 8.43. RexxUtil — SysTempFileName

```
say SysTempFileName("file???")                 -- (e. g.) C:\Users\User1\file392
                                               -- (e. g.) /home/user1/file384
say SysTempFileName("/temp/myfile.***", "*")  -- (e. g.) C:\temp\myfile.938
                                               -- (e. g.) /temp/myfile.341
```

8.63. SysTextScreenRead (Windows only)



Returns characters from a specified console screen buffer location.

Parameters:

row

The row from which to start reading. Console screen buffer rows are numbered from top to bottom starting with **0**.

col

The column from which to start reading. Console screen buffer columns are numbered from left to right starting with **0**.

len

The number of characters to read. The default is to read to the end of the console screen buffer.

Limitation

This function reads in only screen characters and does not consider the color attributes of each character read. When restoring a character string to the screen with SAY or the CHAROUT built-in function, the previous color settings are lost.

Note

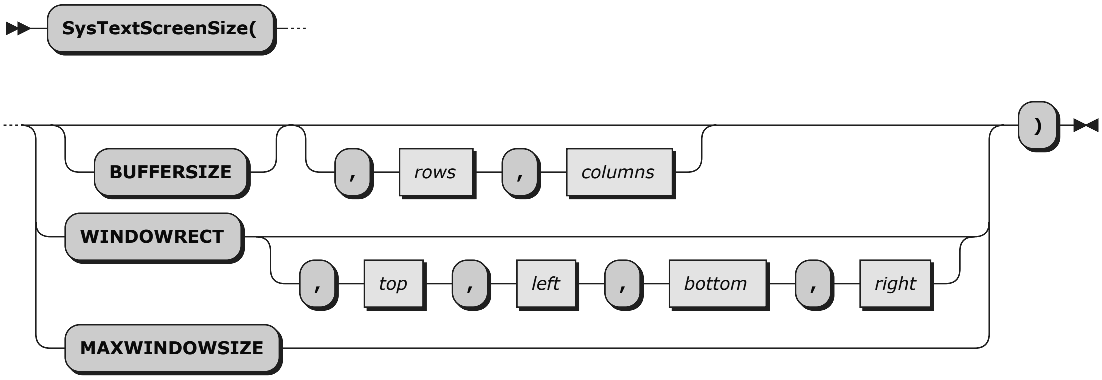
The Windows API used by function is not recommended any more.

Example 8.44. RexxUtil — SysTextScreenRead

```
// read the entire console screen buffer
screen = SysTextScreenRead(0, 0)

// read one screen buffer line
```

```
parse value SysTextScreenSize() with rows columns
line = SysTextScreenRead(2, 0, columns)
```

8.64. SysTextScreenSize (Windows only)



Returns or sets the size of the console screen buffer, returns or sets the position of the current console window rectangle, or returns the maximum possible console window size.

Parameters:

option

Specifies which size or position is to be returned or set.

`BUFFERSIZE`

Returns or sets the size of the current console buffer. This is the default.

If a size is returned, it is a string of the form ***`rows columns`***, where *rows* is the height and *columns* is the width in terms of character cells. If no character-mode console is attached, the string **`0 0`** is returned.

rows, *columns*

If both optional *rows* and *columns* are specified, the console buffer size is changed to the height and width given by *rows* and *columns*. The buffer size cannot be smaller than the size of the current console window. If the function succeeds, it returns **`0`**, otherwise a Windows System Error code is returned.

`WINDOWRECT`

Returns or sets the position of the current console window rectangle.

If a position is returned, it is a string of the form ***`top left bottom right`***, where (*top*, *left*) and (*bottom*, *right*) are absolute character-cell coordinates in the current console buffer, with the origin (0, 0) at the upper-left corner. If no character-mode console is attached, the string **`0 0 0 0`** is returned.

top, *left*, *bottom*, *right*

If all optional arguments *top*, *left*, *bottom*, and *right* are specified, the position of the current console window rectangle is changed to the given (*top*, *left*) and (*bottom*, *right*) positions. Both positions must be within the boundaries of the current console buffer. If the function succeeds, it returns **`0`**, otherwise a Windows System Error code is returned.

`MAXWINDOWSIZE`

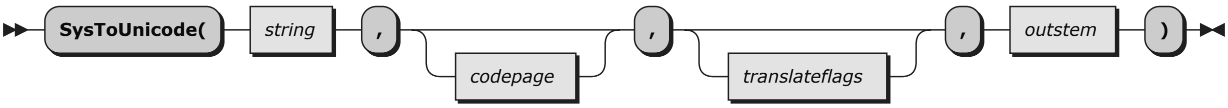
Returns the maximum possible console window size, considering the size of the current console screen buffer, the chosen window font, and the screen size.

The size is returned as a string of the form ***`rows columns`***, where *rows* is the height and *columns* is the width in terms of character cells. If no character-mode console is attached, the string **`0 0`** is returned.

Example 8.45. RexxUtil — SysTextScreenSize

```
parse value SysTextScreenSize() with rows columns
parse value SysTextScreenSize("windowrect") with top left bottom right
say "current console buffer is" rows "rows by" columns "columns"
say "current window rectangle is ("top"," left") ("bottom"," right")"
```

8.65. SysToUnicode (Windows only)



Maps a character string to a Unicode string.

Parameters:

string
: A string that should be mapped to Unicode characters.

codepage
: Specifies the code page used to perform the conversion. This parameter can be the value of any code page that is installed or available in the system. The default is the current original equipment manufacturer (OEM) code-page identifier for the system.

You can also specify one of the following values:

ACP
: ANSI code page.

OEMCP
: OEM code page.

SYMBOL
: symbol code page.

THREAD_ACP
: current thread's ANSI code page.

UTF7
: translate using UTF-7.

UTF8
: translate using UTF-8. When this is set, **`translateflags`** must be set.

translateflags
: Indicates whether to translate to precomposed or composite-wide characters (if a composite form exists), whether to use glyph characters in place of control characters, and how to deal with invalid characters.

You can specify a combination of the following flags:

PRECOMPOSED
: Always use precomposed characters, that is, characters in which a base character and a nonspacing character have a single character value. This is the default translation option. Cannot be used with COMPOSITE.

COMPOSITE
: Always use composite characters, that is, characters in which a base character and a nonspacing character have different character values. Cannot be used with PRECOMPOSED.

ERR_INVALID_CHARS
: If the function encounters an invalid input character, it fails and returns "1113".

USEGLYPHCHARS
: Use glyph characters instead of control characters.

A composite character consists of a base character and a nonspacing character, each having different character values. A precomposed character has a single character value for a base-nonspacing character combination. In the character è, the "e" is the base character and the "grave" accent mark is the nonspacing character. The function's default behavior is to translate to the precomposed form. If a precomposed form does not exist, the function attempts to translate to a composite form.

The flags PRECOMPOSED and COMPOSITE are mutually exclusive. The USEGLYPHCHARS flag and the ERR_INVALID_CHARS can be set regardless of the state of the other flags.

outstem
: The name of the stem variable that will contain the converted result. If the conversion was successful the stem will be composed of the following value(s):

outstem.!TEXT
: This variable will contain the converted string.

Return codes:

0
: No errors.

Other
: An error occurred. A *Windows System Error code* is returned. This may be one of the following, but could be others.

87
: Incorrect code page or **codepage** value.

1004
: Invalid translate flags.

1113
: No mapping for the Unicode character exists in the target code page.

8.66. SysUtilVersion

SysUtilVersion()

Returns a version number that identifies the current level of the Rexx Utilities package.

Return code: The RexxUtil version number in the format **`n.m.l`**.

8.67. SysVersion

SysVersion()

Returns a string to identify the operating system and version. The first word of the returned string contains the identifier for the operating system and the rest of the string contains an operating system specific version string. Rexx code should not rely on the exact format returned.

Possible output may be:

Example 8.46. RexxUtil — SysVersion

```
-- CentOS 7
say SysVersion() -- Linux 3.10.0-957.10.1.el7.x86_64
-- Ubuntu 16.04
say SysVersion() -- Linux 4.4.0-154-generic
-- macOS 10.13
say SysVersion() -- Darwin 18.7.0
-- Raspbian
say SysVersion() -- Linux 4.14.70-v7+
-- SLES/390
say SysVersion() -- Linux 3.12.74-60.64.40-default
-- Windows 10
say SysVersion() -- Windows 10.0.18363
```

See also functions *SysWinVer (Windows only)* and *SysLinVer (Linux Only)*.

8.68. SysVolumeLabel (Windows only)

SysVolumeLabel(*drive*)

Returns the volume label for the specified drive.

Parameter:

drive
: A drive specification like **`d:\`** or **`\\share\path`**. If omitted, the current drive is used.

8.69. SysWait (Unix-like systems only)

SysWait()

Waits for all child processes to end.

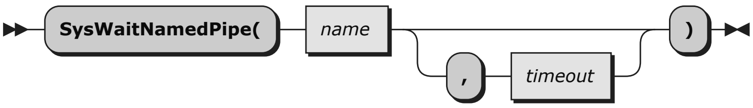
Returns:

The exit code from the child process.

Example:

SysFork (Unix-like systems only) has an example that uses **`wait()`**.

8.70. SysWaitNamedPipe (Windows only)



Performs a timed wait on a named pipe and returns the WaitNamedPipe return code.

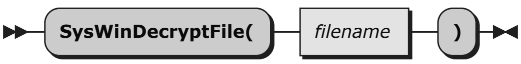
Parameters:

name
: The name of the pipe in the form "\\servername\pipe\pipename."

timeout
: The number of microseconds to be waited. If you omit *timeout* or specify 0, SysWaitNamedPipe uses the default timeout value. To wait until the pipe is no longer busy, you can use a value of -1.

Returns 0 on success. A *Windows System Error code* is returned on error.

8.71. SysWinDecryptFile (Windows only)



Decrypts a given file.

Parameter:

filename
: The file to be decrypted.

Return codes:

0
: Decryption was successful.

Other
: A *Windows System Error code*. This may be one of the following, but could be others.

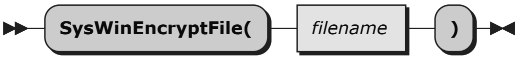
2
: File not found.

4
: Cannot open file.

5
: Access denied.

82
: Cannot decrypt.

8.72. SysWinEncryptFile (Windows only)



Encrypts a given file.

Parameter:

filename
: The file to be encrypted.

Return codes:

0
: Encryption was successful.

Other
: A *Windows System Error code*. This may be one of the following, but could be others.

2
: File not found.

4
: Cannot open file.

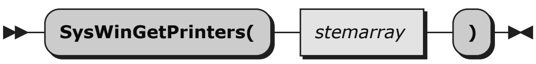
5
: Access denied.

82
: Cannot encrypt.

8.73. SysWinGetDefaultPrinter (Windows only)

Returns the current default printer in the form "Printername,Drivername,Portname".

8.74. SysWinGetPrinters (Windows only)



Returns a list of available printer descriptions.

Parameters:

stemarray
: A Rexx stem or array variable for the returned printers. If a stem variable, *stem*`.0` is set to *n*, the number of printers returned, and the printers are returned in *stem*`.1` to *stem.n*.

Each entry is of the form "Printername,Drivername,Portname".

Return codes:

0
: Success

1
: Failure

8.75. SysWinSetDefaultPrinter (Windows only)

Sets the default printer.

Parameter:

description
: A string identifying the printer. This can be either just the printer name, or be of the form "Printername,Drivername,Portname".

> **Note**
>
> Either form of the description string is accepted. However, using just the printer name is the preferred method. Using the "Printername,Drivername,Portname" form will invoke an outdated Windows API that Microsoft has deprecated.

Return codes:

0
: Success

non-zero
: A *Windows System Error code*. You can use *SysGetErrorText* to get a description of the error.

Example 8.47. RexxUtil — SysWinGetPrinters and SysWinGetDefaultPrinter

```
/* set default printer */

default = SysWinGetDefaultPrinter()
parse var default default",".
say 'The Default printer is:' default
say

if SysWinGetPrinters(list.) == 0 then do
  say "List of available printers (* = default):"
  do i=1 to list.0
    parse var list.i pname",".
    if pname == default then
      say i list.i "*"
    else
      say i list.i
  end
  say
  say "Please enter number of new default printer (0 = keep default)"
```

```
  pull i

  numberOk = .false

  if i~datatype('W') then do
    if 0 <= i & i <= list.0 then do
      numberOK = .true

      if i > 0 then do
        parse var list.i pname",".
        ret = SysWinSetDefaultPrinter(pname)
        if ret <> 0 then do
          say "Error setting default printer ("ret"):" SysGetErrorText(ret)
        end
        else do
          say "The new default printer is:" pname
        end
      end
    end
  end

  if \ numberOk then do
    say "You did not enter a valid printer number."
  end
end
else do
  say "Failed to get a list of the available printers."
end
```

8.76. SysWinVer (Windows only)

Returns a string specifying the Windows operating system version information. Rexx code should not rely on the exact format returned.

Possible output might be:

Example 8.48. RexxUtil — SysWinVer

```
-- Windows 7
say SysWinVer()  -- Windows 6.01.7601
-- Windows 10
say SysWinVer()  -- Windows 10.0.18363
```

See also functions *SysVersion* and *SysLinVer (Linux Only)*.

Parsing

The parsing instructions are *ARG*, *PARSE*, and *PULL*.

The data to be parsed is a source string. Parsing splits the data in a source string and assigns pieces of it to the variables named in a template. A template is a model specifying how to split the source string. The simplest kind of template consists of a list of variable names. Here is an example:

```
variable1 variable2 variable3
```

This kind of template parses the source string into whitespace-delimited words. More complicated templates contain patterns in addition to variable names:

String patterns
: Match the characters in the source string to specify where it is to be split. (See *Section 9.2, "Templates Containing String Patterns"* for details.)

Positional patterns
: Indicate the character positions at which the source string is to be split. (See *Section 9.3, "Templates Containing Positional (Numeric) Patterns"* for details.)

Parsing is essentially a two-step process:

1. Parse the source string into appropriate substrings using patterns.

2. Parse each substring into words.

9.1. Simple Templates for Parsing into Words

Here is a parsing instruction:

Example 9.1. Parsing templates

```
parse value "time and tide" with var1 var2 var3
```

The template in this instruction is: **`var1 var2 var3`**. The data to be parsed is between the keywords **`PARSE VALUE`** and the keyword **`WITH`**, the source string **`time and tide`**. Parsing divides the source string into whitespace-delimited words and assigns them to the variables named in the template as follows:

```
var1="time"
var2="and"
var3="tide"
```

In this example, the source string to be parsed is a literal string, **`time and tide`**. In the next example, the source string is a variable.

Example 9.2. Parse value

```
/* PARSE VALUE using a variable as the source string to parse    */
string="time and tide"
parse value string with var1 var2 var3           /* same results */
```

PARSE VALUE does not convert lowercase **a-z** in the source string to uppercase **A-Z**. If you want to convert characters to uppercase, use PARSE UPPER VALUE. See *Section 9.5, “Using UPPER, LOWER, and CASELESS”* for a summary of the effect of parsing instructions on the case.

Note that if you specify the CASELESS option on a PARSE instruction, the string comparisons during the scanning operation are made independently of the alphabetic case. That is, a letter in uppercase is equal to the same letter in lowercase.

All of the parsing instructions assign the parts of a source string to the variables named in a template. There are various parsing instructions because of the differences in the nature or origin of source strings. For a summary of all the parsing instructions, see *Section 9.6, “Parsing Instructions Summary”*.

The PARSE VAR instruction is similar to PARSE VALUE except that the source string to be parsed is always a variable. In PARSE VAR, the name of the variable containing the source string follows the keywords **PARSE VAR**. In the next example, the variable **stars** contains the source string. The template is **star1 star2 star3**.

Example 9.3. Parse var

```
/* PARSE VAR example                                            */
stars="Sirius Polaris Rigil"
parse var stars star1 star2 star3             /* star1="Sirius"   */
/* star2="Polaris" */
/* star3="Rigil"   */
```

All variables in a template receive new values. If there are more variables in the template than words in the source string, the leftover variables receive null (empty) values. This is true for the entire parsing: for parsing into words with simple templates and for parsing with templates containing patterns. Here is an example of parsing into words:

```
/* More variables in template than (words in) the source string  */
satellite="moon"
parse var satellite Earth Mercury               /* Earth="moon"   */
/* Mercury=""    */
```

If there are more words in the source string than variables in the template, the last variable in the template receives all leftover data. Here is an example:

```
/* More (words in the) source string than variables in template  */
satellites="moon Io Europa Callisto..."
parse var satellites Earth Jupiter              /* Earth="moon"   */
/* Jupiter="Io Europa Callisto..."*/
```

Parsing into words removes leading and trailing whitespace characters from each word before it is assigned to a variable. The exception to this is the word or group of words assigned to the last variable. The last variable in a template receives leftover data, preserving extra leading and trailing whitespace characters. Here is an example:

Example 9.4. Parse var

```
/* Preserving extra blanks                                      */
solar5="Mercury Venus  Earth   Mars     Jupiter  "
parse var solar5 var1 var2 var3 var4
/* var1  ="Mercury"                                             */
/* var2  ="Venus"                                               */
```

```
/* var3  ="Earth"                                          */
/* var4  ="  Mars     Jupiter  "                           */
```

In the source string, **Earth** has two leading blanks. Parsing removes both of them (the word-separator blank and the extra blank) before assigning **var3="Earth"**. **Mars** has three leading blanks. Parsing removes one word-separator blank and keeps the other two leading blanks. It also keeps all five blanks between **Mars** and **Jupiter** and both trailing blanks after **Jupiter**.

Parsing removes no whitespace characters if the template contains only one variable. For example:

```
parse value "   Pluto   " with var1        /* var1="   Pluto   "*/
```

9.1.1. Message Term Assignments

In addition to assigning values to variables, the PARSE instruction also allows any message term value that can be used on the left side of an assignment instruction (See *Section 1.13, “Assignments and Symbols”*). For example:

Example 9.5. Parse with Message Terms Assignments

```
string = "1 one two 3 4"
a = .Array~new
d = .Directory~new
parse var string n a[n] a[n + 1] d~three d~four
-- a[1] = one
-- a[2] = two
-- d~three = 3
-- d~four = 4
```

9.1.2. The Period as a Placeholder

A period in a template is a placeholder. It is used instead of a variable name, but it receives no data. It is useful as a "dummy variable" in a list of variables or to collect unwanted information at the end of a string. And it saves the overhead of unneeded variables.

The period in the first example is a placeholder. Be sure to separate adjacent periods with whitespace; otherwise, an error results.

Example 9.6. Period placeholder

```
/* Period as a placeholder                                 */
stars="Arcturus Betelgeuse Sirius Rigil"
parse var stars . . brightest .            /* brightest="Sirius" */

/* Alternative to period as placeholder                    */
stars="Arcturus Betelgeuse Sirius Rigil"
parse var stars drop junk brightest rest   /* brightest="Sirius" */
```

9.2. Templates Containing String Patterns

A string pattern matches characters in the source string to indicate where to split it. A string pattern can be either of the following:

Literal string pattern
: One or more characters within quotation marks.

Variable string pattern
: A variable within parentheses with no plus (**+**), minus (**-**), or equal sign (**=**) before the left parenthesis. (See *Section 9.4, "Parsing with Variable Patterns"* for details.)

Here are two templates, a simple template and a template containing a literal string pattern:

```
var1 var2          /* simple template                            */
var1 ", " var2     /* template with literal string pattern       */
```

The literal string pattern is: **", "**. This template puts characters:

- From the start of the source string up to (but not including) the first character of the match (the comma) into **var1**
- Starting with the character after the last character of the match (the character after the blank that follows the comma) and ending with the end of the string into **var2**

A template with a string pattern can omit some of the data in a source string when assigning data to variables. The next two examples contrast simple templates with templates containing literal string patterns.

Example 9.7. Template string patterns

```
/* Simple template                                                */
name="Smith, John"
parse var name ln fn                         /* Assigns: ln="Smith," */
/*          fn="John"    */
```

Notice that the comma remains (the variable **ln** contains **"Smith,"**). In the next example the template is **ln ", " fn**. This removes the comma.

Example 9.8. Template string patterns

```
/* Template with literal string pattern                           */
name="Smith, John"
parse var name ln ", " fn                    /* Assigns: ln="Smith"  */
                                             /*          fn="John"   */
```

First, the language processor scans the source string for ", ". It splits the source string at that point. The variable **ln** receives data starting with the first character of the source string and ending with the last character before the match. The variable **fn** receives data starting with the first character after the match and ending with the end of string.

A template with a string pattern omits data in the source string that matches the pattern. (There is a special case (see *Section 9.8.2, "Combining String and Positional Patterns"*) in which a template with a string pattern does not omit matching data in the source string.) The pattern **", "** (with a blank) is used instead of **","** (no blank) because, without the blank in the pattern, the variable **fn** receives " John" (including a blank).

If the source string does not contain a match for a string pattern, any variables preceding the unmatched string pattern get all the data in question. Any variables after that pattern receive the null string.

A null string is never found. It always matches the end of the source string.

9.3. Templates Containing Positional (Numeric) Patterns

A positional pattern is a number that identifies the character position at which the data in the source string is to be split. The number must be a whole number.

An absolute positional pattern is:

- A number with no plus (**+**) or minus (**-**) sign preceding it or with an equal sign (**=**) preceding it.
- An expression in parentheses with an equal sign before the left parenthesis. (See *Section 9.4, "Parsing with Variable Patterns"* for details on variable positional patterns.)

The number specifies the absolute character position at which the source string is to be split.

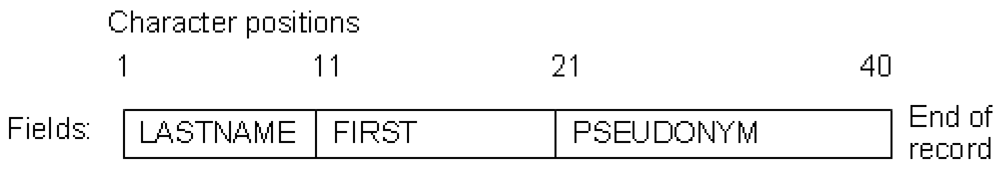
Here is a template with absolute positional patterns:

```
variable1 11 variable2 21 variable3
```

The numbers **11** and **21** are absolute positional patterns. The number **11** refers to the 11th position in the input string, **21** to the 21st position. This template puts characters:

- 1 through 10 of the source string into **variable1**
- 11 through 20 into **variable2**
- 21 to the end into **variable3**

Positional patterns are probably most useful for working with a file of records, such as:



The following example uses this record structure:

Example 9.9. Parsing stems

```
/* Parsing with absolute positional patterns in template         */
record.1="Clemens   Samuel    Mark Twain          "
record.2="Evans     Mary Ann  George Eliot        "
record.3="Munro     H.H.      Saki                "
```

```
do n=1 to 3
  parse var record.n lastname 11 firstname 21 pseudonym
  If lastname="Evans" & firstname="Mary Ann" then say "By George!"
end                          /* Says "By George!" after record 2  */
```

The source string is split at character position 11 and at position 21. The language processor assigns characters 1 to 10 to **lastname**, characters 11 to 20 to **firstname**, and characters 21 to 40 to **pseudonym**.

The template could have been:

```
1 lastname 11 firstname 21 pseudonym
```

instead of

```
lastname 11 firstname 21 pseudonym
```

Specifying **1** is optional.

Optionally, you can put an equal sign before a number in a template. An equal sign is the same as no sign before a number in a template. The number refers to a particular character position in the source string. These two templates are equal:

```
lastname  11 first  21 pseudonym
```

```
lastname =11 first =21 pseudonym
```

A *relative positional pattern* is a number with a plus (**+**) or minus (**-**) sign preceding it. It can also be a variable within parentheses, with a plus (**+**) or minus (**-**) sign preceding the left parenthesis; for details see *Section 9.4, "Parsing with Variable Patterns"*.

The number specifies the relative character position at which the source string is to be split. The plus or minus indicates movement right or left, respectively, from the start of the string (for the first pattern) or from the position of the last match. The position of the last match is the first character of the last match. Here is the same example as for absolute positional patterns done with relative positional patterns:

Example 9.10. Parsing with relative positional patterns

```
/* Parsing with relative positional patterns in template         */
record.1="Clemens   Samuel    Mark Twain          "
record.2="Evans     Mary Ann  George Eliot        "
record.3="Munro     H.H.      Saki                "
do n=1 to 3
  parse var record.n lastname +10 firstname + 10 pseudonym
  If lastname="Evans" & firstname="Mary Ann" then say "By George!"
end                                                /* same results  */
```

Whitespace characters between the sign and the number are insignificant. Therefore, **+10** and **+ 10** have the same meaning. Note that +0 is a valid relative positional pattern.

Absolute and relative positional patterns are interchangeable except in the special case (see *Section 9.8.2, "Combining String and Positional Patterns"*) when a string pattern precedes a variable name and a positional pattern follows the variable name. The templates from the examples of absolute and relative positional patterns give the same results.

	lastname 11 lastname + 10	firstname 21 firstname + 10	pseudonym pseudonym
(Implied starting point is position 1)	Put characters 1 through10 in lastname. (non-inclusive stopping point is 11 (1 + 10)	Put characters 1 through10 in firstname. (non-inclusive stopping point is 21 (11 + 10)	Put characters 21 through end of string in pseudonym.

With positional patterns, a matching operation can back up to an earlier position in the source string. Here is an example using absolute positional patterns:

```
/* Backing up to an earlier position (with absolute positional)  */
string="astronomers"
parse var string 2 var1 4 1 var2 2 4 var3 5 11 var4
say string "study" var1||var2||var3||var4
/* Displays: "astronomers study stars"                          */
```

The absolute positional pattern **1** backs up to the first character in the source string.

With relative positional patterns, a number preceded by a minus sign backs up to an earlier position. Here is the same example using relative positional patterns:

```
/* Backing up to an earlier position (with relative positional)  */
string="astronomers"
parse var string 2 var1 +2 -3 var2 +1 +2 var3 +1 +6 var4
say string "study" var1||var2||var3||var4      /* same results   */
```

In the previous example, the relative positional pattern **-3** backs up to the first character in the source string.

The templates in the previous two examples are equivalent.

2 2	var1 4 var2 +2	1 -3	var2 3 var2 +1	4 var3 5 +2 var3 +1	11 var4 +6 var4
Start at 2.	Noninclusive stopping point is 4 (2 + 2 = 4).	Go to 1 (4-3=1).	Non-inclusive stopping point is 2 (1+1=2).	Go to 4 (2+2=4). Noninclusive stopping point is 5 (4+1=5).	Go to 11 (5+6=11).

You can use templates with positional patterns to make several assignments:

```
/* Making several assignments                                    */
books="Silas Marner, Felix Holt, Daniel Deronda, Middlemarch"
parse var books 1 Eliot 1 Evans
/* Assigns the (entire) value of books to Eliot and to Evans.    */
```

A *length positional pattern* is a number with a (**>**) or (**<**) preceding it. It can also be an expression within parentheses, with a (**>**) or (**<**) preceding the left parenthesis; for details see *Section 9.4, "Parsing with Variable Patterns"*.

The number specifies the length at which the source string is to be split, relative to the current position.. The > or < indicates movement right or left, respectively, from the start of the string (for the first pattern) or from the position of the last match. The position of the last match is the first character of the last match. Here is the same example as for relative positional patterns done with length positional patterns:

Example 9.11. Parsing with relative positional patterns

```
/* Parsing with relative positional patterns in template         */
record.1="Clemens   Samuel    Mark Twain          "
record.2="Evans     Mary Ann  George Eliot        "
record.3="Munro     H.H.      Saki                "
do n=1 to 3
  parse var record.n lastname >10 firstname >10 pseudonym
  If lastname="Evans" & firstname="Mary Ann" then say "By George!"
end                                              /* same results  */
```

Whitespace characters between the trigger and the number are insignificant. Therefore, **>10** and **> 10** have the same meaning. Note that >0 <0 and are valid length positional pattern.

The > length pattern and the + relative positional pattern are interchangeable except in the special case of the value 0. A >0 pattern will split the string into a null string and leave the match position unchanged. This is particularly useful for parsing off length-qualified fields from a string.

Example 9.12. Parsing with length patterns

```
/* Parsing with length patterns in template         */
line = "04Mark0005Twain"
parse var line len +2 first >(len) len +2 middle >(len) len +2 last >(len)
say '"'first'" "'middle'" "'last'"'  -- displays "Mark" "" "Twain"

/* parsing with relative patterns only */
parse var line len +2 first +(len) len +2 middle +(len) len +2 last +(len)
say '"'first'" "'middle'" "'last'"'  -- displays "Mark" "05Twain" "Twain"
```

The < length pattern will move the position the indicated position to the left, and split the string between the original position and the movement position. At of the operation, the current position is returned to the original position. This movement is equivalent to using a negative relative pattern followed by a positive relative pattern for the same length. This operation allows for easy extraction of characters that precede a string match.

Example 9.13. Parsing with length patterns

```
/* Parsing with length patterns in template         */
parse value '12345.6789' with '.' digit <1    -- digit -> "5"

/* parsing with relative patterns only */
parse value '12345.6789' with '.' -1 digit +1    -- digit -> "5"
```

9.3.1. Combining Patterns and Parsing into Words

If a template contains patterns that divide the source string into sections containing several words, string and positional patterns divide the source string into substrings. The language processor then applies a section of the template to each substring, following the rules for parsing into words.

Example 9.14. Combining string patterns

```
/* Combining string pattern and parsing into words              */
name="    John      Q.   Public"
parse var name fn init "." ln        /* Assigns: fn="John"       */
/*          init="     Q"                                        */
/*          ln="   Public"                                       */
```

The pattern divides the template into two sections:

- **fn init**
- **ln**

The matching pattern splits the source string into two substrings:

- **"   John   Q"**
- **"   Public"**

The language processor parses these substrings into words based on the appropriate template section.

John has three leading blanks. All are removed because parsing into words removes leading and trailing blanks except from the last variable.

Q has six leading blanks. Parsing removes one word-separator blank and keeps the rest because **init** is the last variable in that section of the template.

For the substring **"   Public"**, parsing assigns the entire string into **ln** without removing any blanks. This is because **ln** is the only variable in this section of the template. (For details about treatment of whitespace characters, see *Section 9.1, "Simple Templates for Parsing into Words"*.)

Example 9.15. Combining positional patterns

```
/* Combining positional patterns with parsing into words         */
string="R E X X"
parse var string var1 var2 4 var3 6 var4   /* Assigns: var1="R"  */
/*          var2="E"                                             */
/*          var3=" X"                                            */
/*          var4=" X"                                            */
```

The pattern divides the template into three sections:

- **var1 var2**
- **var3**
- **var4**

The matching patterns split the source string into three substrings that are individually parsed into words:

- **"R E"**
- **" X"**
- **" X"**

The variable **var1** receives **"R"**; **var2** receives **"E"**. Both **var3** and **var4** receive **" X"** (with a blank before the **X**) because each is the only variable in its section of the template. (For details on treatment of whitespace characters, see *Section 9.1, "Simple Templates for Parsing into Words"*.)

9.4. Parsing with Variable Patterns

You might want to specify a pattern by using the value of a variable or expression instead of a fixed string or number. You do this by placing an expression in parentheses. This is a variable reference. Whitespace characters are not necessary inside or outside the parentheses, but you can add them if you wish.

The template in the next parsing instruction contains the following literal string pattern **". "**.

```
parse var name fn  init ". " ln
```

Here is how to specify that pattern as a variable string pattern:

```
strngptrn=". "
parse var name fn init (strngptrn) ln
```

If no equal, plus sign, minus sign, >, or < precedes the parenthesis that is before the variable name, the character string value of the variable is then treated as a string pattern. The expression can reference variables that have been set earlier in the same template.

Example 9.16. Combining variables in patterns

```
/* Using a variable as a string pattern                        */
/*  The variable (delim) is set in the same template           */
SAY "Enter a date (mm/dd/yy format). =====> " /* assume 11/15/98 */
pull date
parse var date month 3 delim +1 day +2 (delim) year
/* Sets: month="11"; delim="/"; day="15"; year="98"   */
```

If an equal, a plus, a minus sign, > or < precedes the left parenthesis, the value of the expression is treated as an absolute, relative positional, or length positional pattern. The value of the expression must be a positive whole number or zero.

The expression can reference variables that have has been set earlier in the same template. In the following example, the first two fields specify the starting-character positions of the last two fields.

Example 9.17. Combining variables and positional patterns

```
/* Using a variable as a positional pattern                     */
dataline = "12 26 .....Samuel ClemensMark Twain"
parse var dataline pos1 pos2 6 =(pos1) realname =(pos2) pseudonym
/* Assigns: realname="Samuel Clemens"; pseudonym="Mark Twain"    */
```

The positional pattern **6** is needed in the template for the following reason: Word parsing occurs after the language processor divides the source string into substrings using patterns. Therefore, the positional pattern **=(pos1)** cannot be correctly interpreted as **=12** until after the language processor has split the string at column 6 and assigned the whitespace-delimited words **12** and **26** to **pos1** and **pos2**, respectively.

9.5. Using UPPER, LOWER, and CASELESS

Specifying UPPER on any of the PARSE instructions converts lowercase **a-z** to uppercase **A-Z** before parsing.

The ARG instruction is a short form of PARSE UPPER ARG. The PULL instruction is a short form of PARSE UPPER PULL. If you do not desire uppercase translation, use PARSE ARG instead of ARG or PARSE UPPER ARG, and PARSE PULL instead of PULL or PARSE UPPER PULL.

Specifying LOWER on any of the PARSE instructions converts uppercase **A-Z** to lowercase **a-z** before parsing.

Specifying CASELESS means the comparisons during parsing are independent of the case—that is, a letter in uppercase is equal to the same letter in lowercase.

9.6. Parsing Instructions Summary

All parsing instructions assign parts of the source string to the variables named in the template. The following table summarizes where the source string comes from.

Table 9.1. Parsing Source Strings

Instruction	Where the source string comes from
ARG	Arguments you list when you call the program or arguments in the call to a subroutine or function.
PARSE ARG	Arguments you list when you call the program or arguments in the call to a subroutine or function.
PARSE LINEIN	Next line in the default input stream.
PULL	The string at the head of the external data queue. (If the queue is empty, it uses default input, typically the terminal.)
PARSE PULL	The string at the head of the external data queue. (If the queue is empty, it uses default input, typically the terminal.)
PARSE SOURCE	System-supplied string giving information about the executing program.
PARSE VALUE	Expression between the keywords VALUE and WITH in the instruction.
PARSE VAR *name*	Parses the value of *name*.
PARSE VERSION	System-supplied string specifying the language, language level, and (three-word) date.

9.7. Parsing Instructions Examples

All examples in this section parse source strings into words.

ARG

Example 9.18. ARG with source string named in Rexx program invocation

```
/* ARG with source string named in Rexx program invocation       */
/*  Program name is PALETTE.  Specify 2 primary colors (yellow,  */
/*   red, blue) on call.   Assume call is: palette red blue      */
arg var1 var2                /* Assigns: var1="RED"; var2="BLUE" */
If var1<>"RED" & var1<>"YELLOW" & var1<>"BLUE" then signal err
If var2<>"RED" & var2<>"YELLOW" & var2<>"BLUE" then signal err
total=length(var1)+length(var2)
```

```
SELECT;
  When total=7 then new="purple"
  When total=9 then new="orange"
  When total=10 then new="green"
Otherwise new=var1                         /* entered duplicates */
END
Say new; exit                              /* Displays: "purple" */

Err:
say 'Input error--color is not "red" or "blue" or "yellow"'; exit
```

ARG converts alphabetic characters to uppercase before parsing. An example of ARG with the arguments in the CALL to a subroutine is in *Section 9.8.1, "Parsing Several Strings"*.

PARSE ARG is similar to ARG except that PARSE ARG does not convert alphabetic characters to uppercase before parsing.

PARSE LINEIN

Example 9.19. PARSE LINEIN

```
parse linein "a=" num1 "c=" num2     /* Assume: 8 and 9          */
sum=num1+num2                        /* Enter: a=8 b=9 as input  */
say sum                              /*  Displays: "17"          */
```

PARSE PULL

Example 9.20. PARSE PULL

```
PUSH "80 7"                /* Puts data on queue                     */
parse pull fourscore seven /* Assigns: fourscore="80"; seven="7" */
SAY fourscore+seven        /* Displays: "87"                     */
```

PARSE SOURCE

Example 9.21. PARSE SOURCE

```
parse source sysname .
Say sysname                         /* Possibly Displays:        */
                                    /* "Windows"                 */
```

PARSE VAR examples are throughout the chapter, starting with *Chapter 9, Parsing*.

PARSE VERSION

Example 9.22. PARSE VERSION

```
parse version . level .
say level                /* Displays: "6.02" */
```

PULL is similar to PARSE PULL except that PULL converts alphabetic characters to uppercase before parsing.

9.8. Advanced Topics in Parsing

This section includes parsing several strings and flow charts illustrating a conceptual view of parsing.

9.8.1. Parsing Several Strings

Only ARG and PARSE ARG can have more than one source string. To parse several strings, you can specify several comma-separated templates. Here is an example:

```
parse arg template1, template2, template3
```

This instruction consists of the keywords PARSE ARG and three comma-separated templates. For an ARG instruction, the source strings to be parsed come from arguments you specify when you call a program or CALL a subroutine or function. Each comma is an instruction to the parser to move on to the next string.

Example:

Example 9.23. Parsing variable strings

```
/* Parsing several strings in a subroutine                         */
num="3"
musketeers="Porthos Athos Aramis D'Artagnan"
CALL Sub num,musketeers  /* Passes num and musketeers to sub     */
SAY total; say fourth /* Displays: "4" and " D'Artagnan"         */
EXIT

Sub:
  parse arg subtotal, . . . fourth
  total=subtotal+1
  RETURN
```

Note that when a Rexx program is started as a command, only one argument string is recognized. You can pass several argument strings for parsing if:

- One Rexx program calls another Rexx program with the CALL instruction or a function call
- Programs written in other languages start a Rexx program

If there are more templates than source strings, each variable in a leftover template receives a null string. If there are more source strings than templates, the language processor ignores leftover source strings. If a template is empty (two subsequent commas) or contains no variable names, parsing proceeds to the next template and source string.

9.8.2. Combining String and Positional Patterns

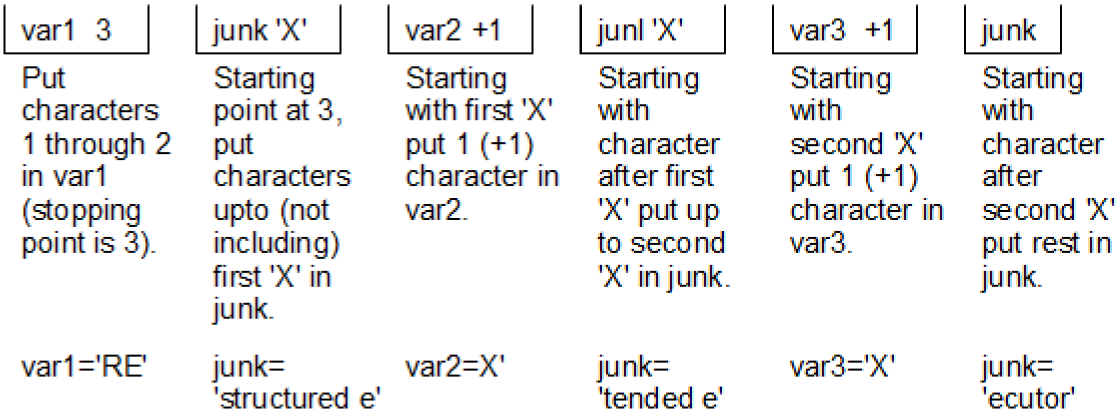
There is a special case in which absolute and relative positional patterns do not work identically. Parsing with a template containing a string pattern skips the data in the source string that matches the pattern (see *Section 9.2, "Templates Containing String Patterns"*). But a template containing the sequence string pattern, variable name, and relative position pattern does not skip the matching data.

A relative positional pattern moves relative to the first character matching a string pattern. As a result, assignment includes the data in the source string that matches the string pattern.

Example 9.24. Combining string and positional patterns

```
/* Template containing string pattern, then variable name, then  */
/*  relative positional pattern does not skip any data.          */
string="REstructured eXtended eXecutor"
parse var string var1 3 junk "X" var2 +1 junk "X" var3 +1 junk
say var1||var2||var3 /* Concatenates variables; displays: "REXX" */
```

Here is how this template works:



9.8.3. Conceptual Overview of Parsing

The following figures are to help you understand the concept of parsing.

The figures include the following terms:

string start
: is the beginning of the source string (or substring).

string end
: is the end of the source string (or substring).

length
: is the length of the source string.

match start
: is in the source string and is the first character of the match.

match end
: is in the source string. For a string pattern, it is the first character after the end of the match. For a positional pattern, it is the same as match start.

match position
: is in the source string. For a string pattern, it is the first matching character. For a positional pattern, it is the position of the matching character.

token

is a distinct syntactic element in a template, such as a variable, a period, a pattern, or a comma.

value

is the numeric value of a positional pattern. This can be either a constant or the resolved value of a variable.

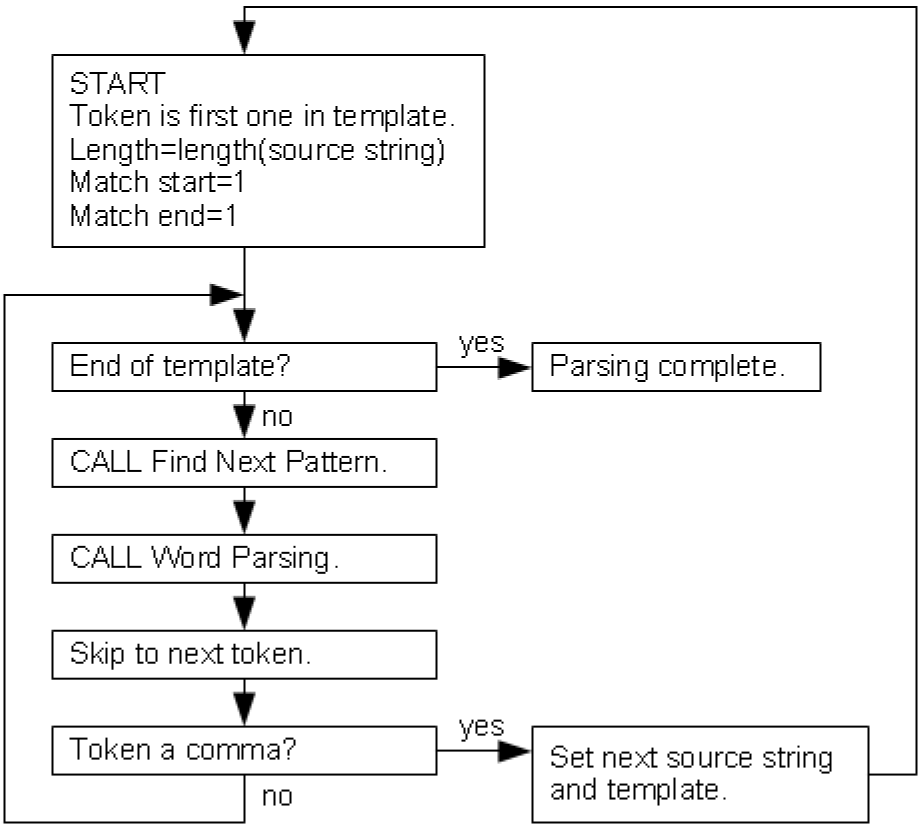


Figure 9.1. Conceptual Overview of Parsing

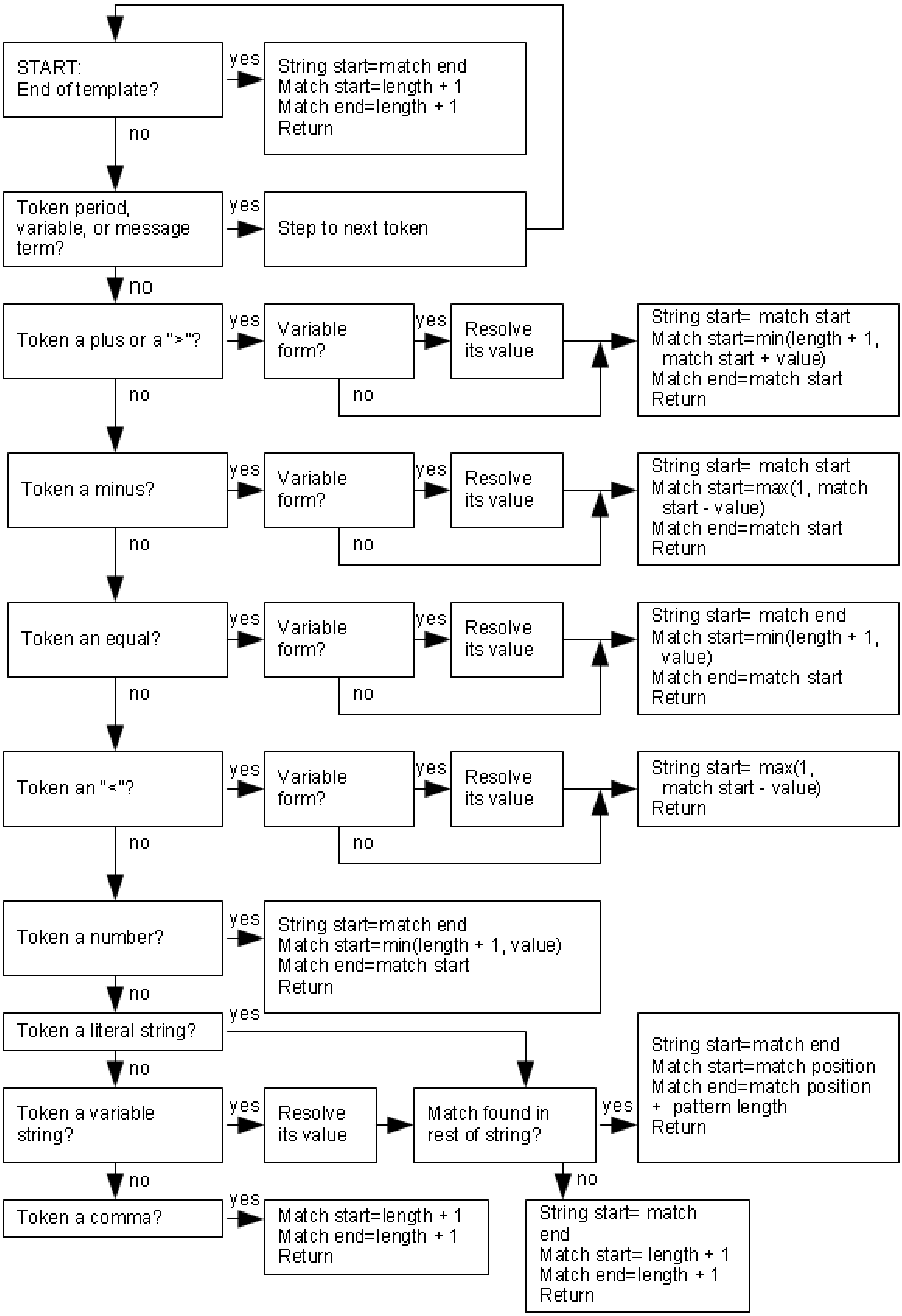


Figure 9.2. Conceptual View of Finding Next Pattern

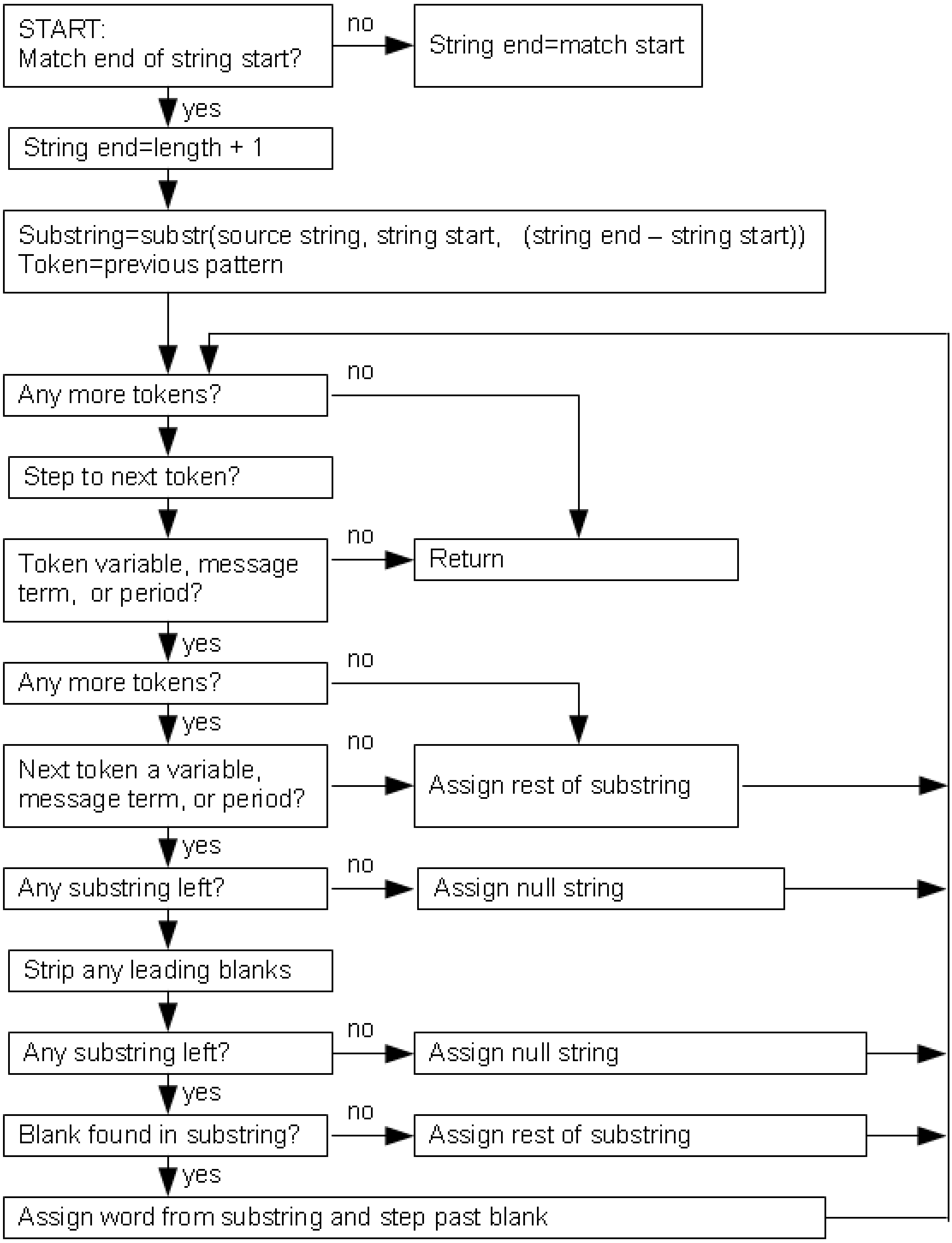


Figure 9.3. Conceptual View of Word Parsing

Note

The figures do not include error cases.

Numbers and Arithmetic

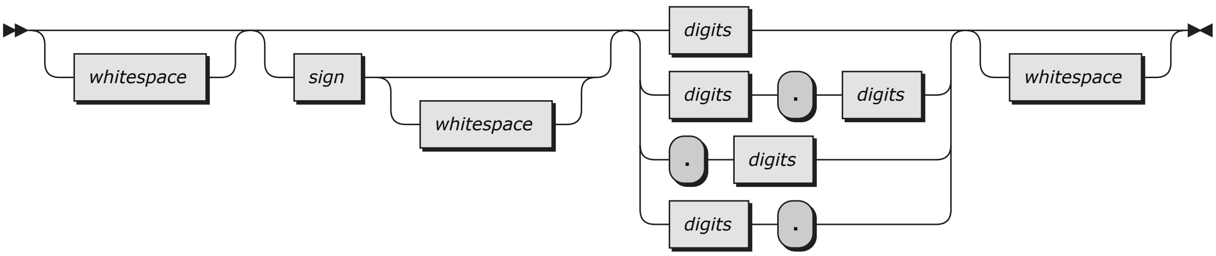
This chapter gives an overview of the arithmetic facilities of the Rexx language.

Numbers can be expressed flexibly. Leading and trailing whitespace characters are permitted, and exponential notation can be used. Valid numbers are, for example:

Example 10.1. Numbers

```
12              /* a whole number                      */
"-76"           /* a signed whole number               */
12.76           /* decimal places                      */
" +  0.003 "    /* blanks around the sign and so forth */
17.             /* same as 17                          */
.5              /* same as 0.5                         */
4E9             /* exponential notation                */
0.73e-7         /* exponential notation                */
```

Ignoring *Exponential Notation*, a number in Rexx is defined as follows:



whitespace
: are one or more blanks or horizontal tab characters.

sign
: is either **+** or **-**.

digits
: are one or more of the decimal digits **0**-**9**.

Note that a single period alone is not a valid number.

The arithmetic operators include addition (**+**), subtraction (**-**), multiplication (*****), power (******), division (**/**), prefix plus (**+**), and prefix minus (**-**). In addition, it includes integer divide (**%**), which divides and returns the integer part, and remainder (**//**), which divides and returns the remainder. For examples of the arithmetic operators, see *Section 10.2.4, "Operator Examples"*.

The result of an arithmetic operation is formatted as a character string according to specific rules. The most important rules are:

- Results are calculated up to a maximum number of significant digits. The default is **9**, but can be overridden on a source-file basis with the *::OPTIONS* directive. The default setting can be altered with the NUMERIC DIGITS instruction. Thus, with NUMERIC DIGITS 9, if a result requires more than 9 digits, it is rounded to 9 digits. For example, the division of 2 by 3 results in 0.666666667.
- Except for division and power, trailing zeros are preserved. For example:

Example 10.2. Arithmetic

```
2.40 + 2    ->    4.40
2.40 - 2    ->    0.40
2.40 * 2    ->    4.80
2.40 / 2    ->    1.2
```

If necessary, you can remove trailing zeros with the **`String`** *strip* method, the *STRIP* built-in function, or by division by 1.

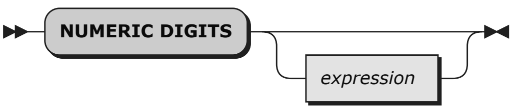
- A zero result is always expressed as the single digit **`0`**.
- Exponential form is used for a result depending on its value and the setting of NUMERIC DIGITS. If the number of places needed before the decimal point exceeds the NUMERIC DIGITS setting, or the number of places after the point exceeds twice the NUMERIC DIGITS setting, the number is expressed in exponential notation:

Example 10.3. Arithmetic

```
1e6 * 1e6     ->    1E+12           /* not 1000000000000 */
1 / 3E10      ->    3.33333333E-11  /* not 0.0000000000333333333 */
```

10.1. Precision

Precision is the maximum number of significant digits that can result from an operation. This is controlled by the instruction:



The *expression* is evaluated and must result in a positive whole number. This defines the precision (number of significant digits) of a calculation. Results are rounded to that precision, if necessary.

If you do not specify *expression* in this instruction, or if no NUMERIC DIGITS instruction has been processed since the start of a program, the default precision is used. The Rexx standard for the default precision is **`9`**. The default may be overridden on a source-file basis using the *::OPTIONS* directive.

NUMERIC DIGITS can set values smaller than nine. However, use small values with care because the loss of precision and rounding affects all Rexx computations, including, for example, the computation of new values for the control variable in DO loops.

10.2. Arithmetic Operators

Rexx arithmetic is performed by the operators **`+`**, **`-`**, **`*`**, **`/`**, **`%`**, **`//`**, and **`**`** (add, subtract, multiply, divide, integer divide, remainder, and power).

Before every arithmetic operation, the terms operated upon have leading zeros removed (noting the position of any decimal point, and leaving only one zero if all the digits in the number are zeros). They are then truncated, if necessary, to DIGITS + 1 significant digits before being used in the computation. The extra digit improves accuracy because it is inspected at the end of an operation, when a number is rounded to the required precision. When a number is truncated, the LOSTDIGITS condition is raised if a SIGNAL ON LOSTDIGITS condition trap is active. The operation is then carried out under up to double that precision. When the operation is completed, the result is rounded, if necessary, to the precision specified by the NUMERIC DIGITS instruction.

The values are rounded as follows: 5 through 9 are rounded up, and 0 through 4 are rounded down.

10.2.1. Power

The ** (power) operator raises a number to a power, which can be positive, negative, or **0**. The power must be a whole number. The second term in the operation must be a whole number and is rounded to DIGITS digits, if necessary, as described in *Section 10.5, “Limits and Errors when Rexx Uses Numbers Directly”*. If negative, the absolute value of the power is used, and the result is inverted (that is, the number 1 is divided by the result). For calculating the power, the number is multiplied by itself for the number of times expressed by the power. Trailing zeros are then removed as though the result were divided by 1.

10.2.2. Integer Division

The % (integer divide) operator divides two numbers and returns the integer part of the result. The result is calculated by repeatedly subtracting the divisor from the dividend as long as the dividend is larger than the divisor. During this subtraction, the absolute values of both the dividend and the divisor are used: the sign of the final result is the same as that which would result from regular division.

If the result cannot be expressed as a whole number, the operation is in error and fails—that is, the result must not have more digits than the current setting of NUMERIC DIGITS. For example, **10000000000%3** requires 10 digits for the result (3333333333) and would, therefore, fail if **NUMERIC DIGITS 9** were in effect.

10.2.3. Remainder

The // (remainder) operator returns the remainder from an integer division and is defined to be the residue of the dividend after integer division. The sign of the remainder, if nonzero, is the same as that of the original dividend.

This operation fails under the same conditions as integer division, that is, if integer division on the same two terms fails, the remainder cannot be calculated.

10.2.4. Operator Examples

Example 10.4. Operators

```
/* With:  NUMERIC DIGITS 5 */
12+7.00     ->    19.00
1.3-1.07    ->     0.23
1.3-2.07    ->    -0.77
1.20*3      ->     3.60
7*3         ->    21
0.9*0.8     ->     0.72
1/3         ->     0.33333
2/3         ->     0.66667
```

```
5/2          ->     2.5
1/10         ->     0.1
12/12        ->     1
8.0/2        ->     4
2**3         ->     8
2**-3        ->     0.125
1.7**8       ->    69.758
2%3          ->     0
2.1//3       ->     2.1
10%3         ->     3
10//3        ->     1
-10//3       ->    -1
10.2//1      ->     0.2
10//0.3      ->     0.1
3.6//1.3     ->     1.0
```

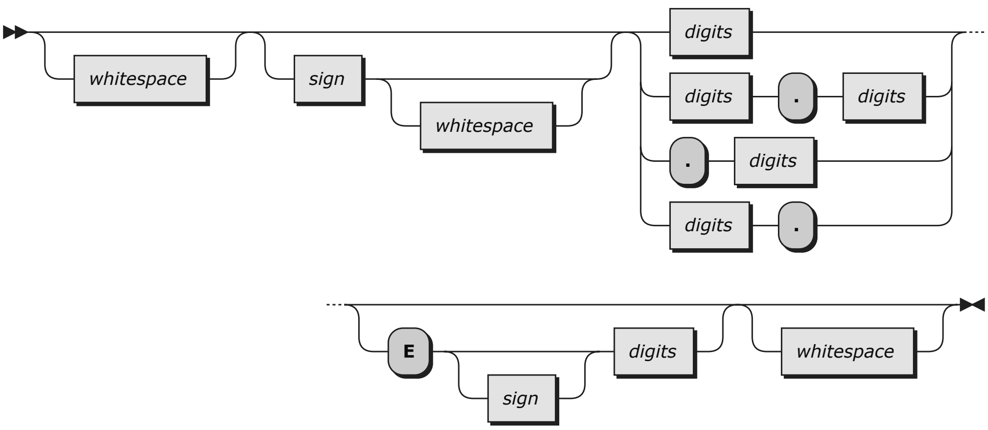
10.3. Exponential Notation

For both large and small numbers, an exponential notation can be useful. For example:

```
numeric digits 5
say 54321*54321
```

would display **2950800000** in the long form. Because this is misleading, the result is expressed as **2.9508E+9** instead.

The definition of numbers is, therefore, extended as follows:



The integer following the **E** represents a power of ten that is to be applied to the number. The **E** can be in uppercase or lowercase.

Certain character strings are numbers even though they do not appear to be numeric, such as **0E123** (0 times 10 raised to the power of 123) and **1E342** (1 times 10 raised to the power of 342). Also, a comparison such as **0E123=0E567** gives a true result of **1** (0 is equal to 0). To prevent problems when comparing nonnumeric strings, use the strict comparison operators.

Here are some examples:

Example 10.5. Exponential notation

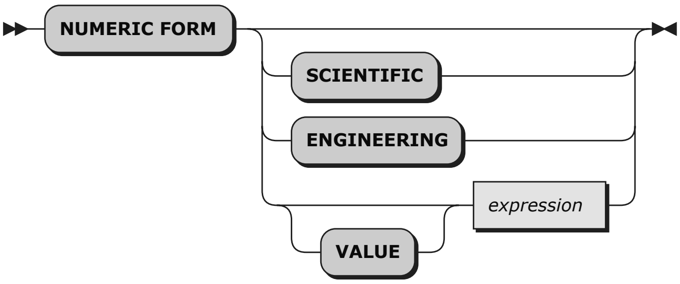
```
12E7    =    120000000           /* Displays "1" */
12E-5   =    0.00012             /* Displays "1" */
```

```
-12e4   =    -120000              /* Displays "1" */
0e123   =    0e456                /* Displays "1" */
0e123   ==   0e456                /* Displays "0" */
```

The results of calculations are returned in either conventional or exponential form, depending on the setting of NUMERIC DIGITS. If the number of places needed before the decimal point exceeds DIGITS, or the number of places after the point exceeds twice DIGITS, the exponential form is used. The exponential form the language processor generates always has a sign following the **E** to improve readability. If the exponent is **0**, the exponential part is omitted—that is, an exponential part of **E+0** is not generated.

You can explicitly convert numbers to exponential form, or force them to be displayed in the long form, by using the *FORMAT* built-in function.

Scientific notation is a form of exponential notation that adjusts the power of ten so that the number contains only one nonzero digit before the decimal point. Engineering notation is a form of exponential notation in which up to three digits appear before the decimal point, and the power of ten is always a multiple of three. The integer part can, therefore, range from **1** through **999**. You can control whether scientific or engineering notation is used with the following instruction:



Scientific notation is the default.

Example 10.6. Scientific notation

```
/* after the instruction */
Numeric form scientific

123.45 * 1e11     ->     1.2345E+13

/* after the instruction */
Numeric form engineering

123.45  * 1e11    ->    12.345E+12
```

10.4. Numeric Comparisons

The comparison operators are listed in *Section 1.11.2.3, “Comparison”*. You can use any of them for comparing numeric strings. However, you should not use **==**, **\==**, **¬==**, **>>**, **\>>**, **¬>>**, **<<**, **\<<**, and **¬<<** for comparing numbers because leading and trailing whitespace characters and leading zeros are significant with these operators.

Numeric values are compared by subtracting the two numbers (calculating the difference) and then comparing the result with 0. That is, the operation:

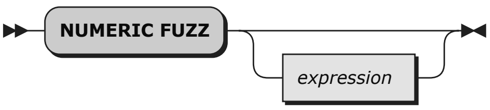
```
A ? Z
```

where **?** is any numeric comparison operator, is identical with:

```
(A - Z) ? "0"
```

It is, therefore, the difference between two numbers, when subtracted under Rexx subtraction rules, that determines their equality.

Fuzz affects the comparison of two numbers. It controls how much two numbers can differ and still be considered equal in a comparison. The FUZZ value is set by the following instruction:



expression must result in a positive whole number or zero. The default is **`0`**.

Fuzz is to temporarily reduce the value of DIGITS. That is, the numbers are subtracted with a precision of DIGITS minus FUZZ digits during the comparison. The FUZZ setting must always be less than DIGITS.

If, for example, DIGITS = 9 and FUZZ = 1, the comparison is carried out to 8 significant digits, just as though **`NUMERIC DIGITS 8`** had been put in effect for the duration of the operation.

Example 10.7. Comparison

```
Numeric digits 5
Numeric fuzz 0
say  4.9999 = 5     /* Displays "0"    */
say  4.9999 < 5     /* Displays "1"    */
Numeric fuzz 1
say  4.9999 = 5     /* Displays "1"    */
say  4.9999 < 5     /* Displays "0"    */
```

10.5. Limits and Errors when Rexx Uses Numbers Directly

When Rexx uses numbers directly, that is, numbers that have not been involved in an arithmetic operation, they are rounded, if necessary, according to the setting of NUMERIC DIGITS. The normal whole number limit depends on the default NUMERIC DIGITS setting. The default setting is 9, making the normal whole number limit 999999999.

The following table shows which numbers must be whole numbers and what their limits are:

Table 10.1. Whole Number Limits

Power values (right-hand operand of the power operator)	The platform whole number limit.
Values of *exprr* and *exprf* in the DO instruction	The platform whole number limit
Values given for DIGITS or FUZZ in the NUMERIC instruction	The platform whole number limits (Note: FUZZ must always be less than DIGITS.)
Positional patterns in parsing templates	The platform whole number limit
Number given for *option* in the TRACE instruction	The platform whole number limit

When Rexx uses numbers directly, the following types of errors can occur:

- Overflow or underflow.

  This error occurs if the exponential part of a result exceeds the range that the language processor can handle, when the result is formatted according to the current settings of NUMERIC DIGITS and NUMERIC FORM. The language defines a minimum capability for the exponential part, namely the largest number that can be expressed as an exact integer in default precision. Because the default precision is **9**, you can use exponents in the range **-999999999** through **999999999**.

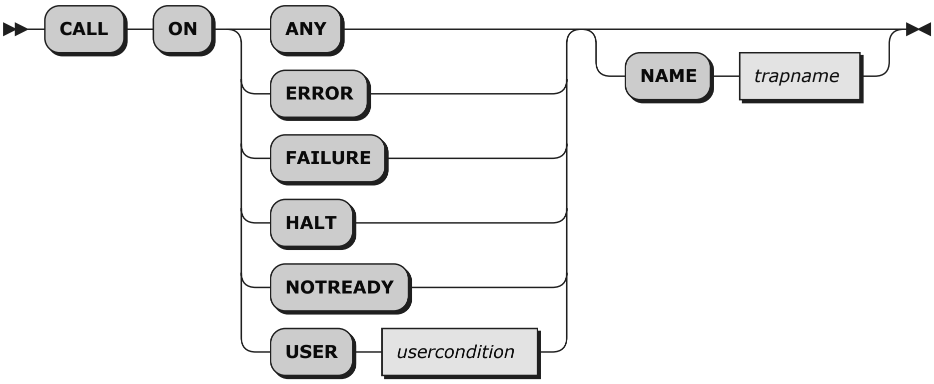
  Because this allows for (very) large exponents, overflow or underflow is treated as a syntax error.

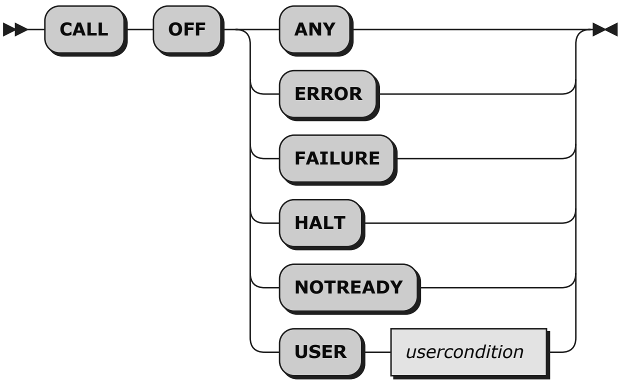
- Insufficient storage.

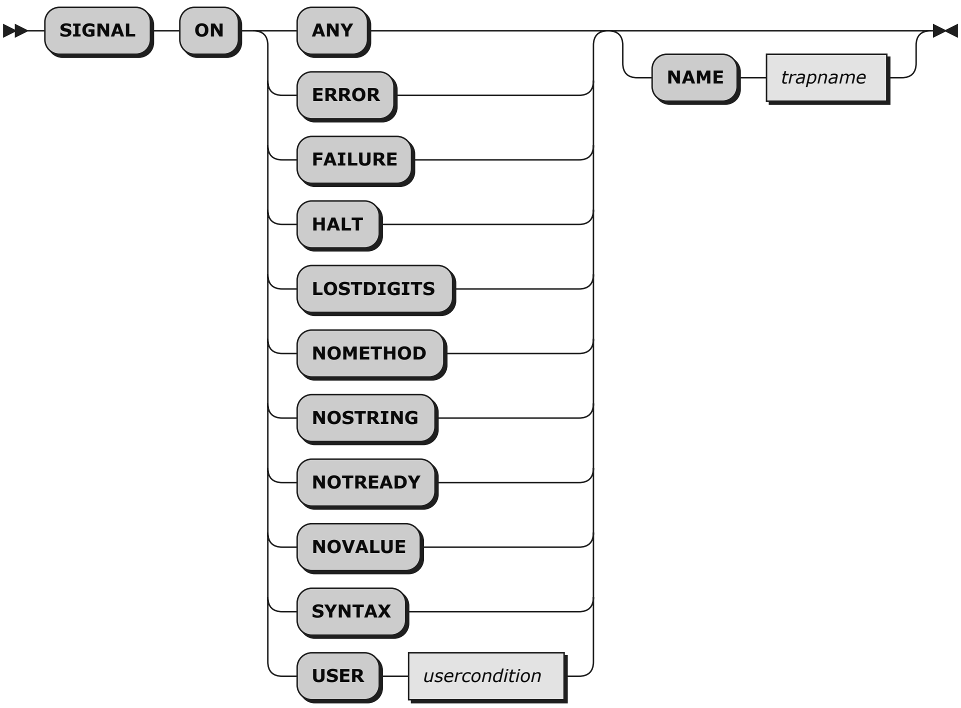
  Storage is needed for calculations and intermediate results, and if an arithmetic operation fails because of lack of storage. This is considered as a terminating error.

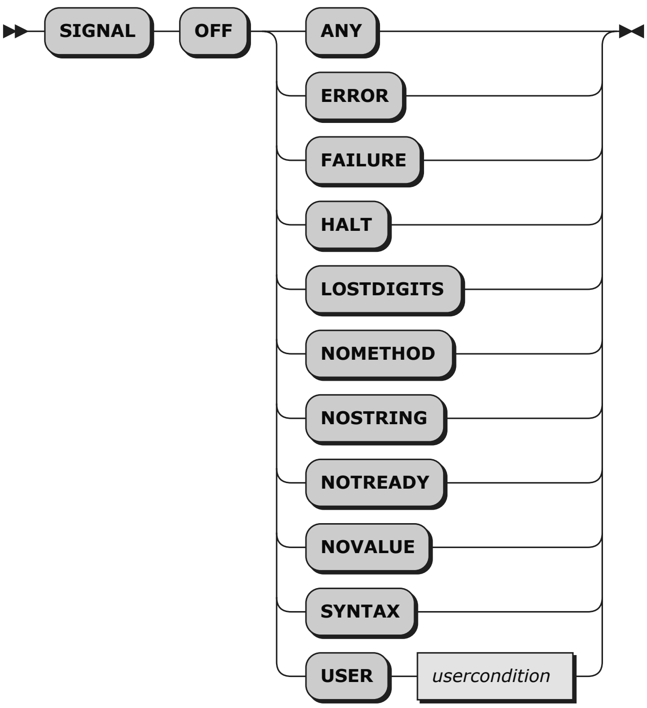
Conditions and Condition Traps

A condition is an event or state that CALL ON or SIGNAL ON can trap. A condition trap can modify the flow of execution in a Rexx program. Condition traps are turned on or off using the ON or OFF subkeywords of the *SIGNAL* and *CALL* instructions.









condition, *usercondition*, and *trapname* are single symbols that are taken as constants. Following one of these instructions, a condition trap is set to either ON (enabled) or OFF (disabled). The initial setting for all condition traps is OFF.

If a condition trap is enabled and the specified *condition* or *usercondition* occurs, control passes to the routine or label *trapname* if you have specified *trapname*. Otherwise, control passes to the routine or label *usercondition* or *condition*. CALL or SIGNAL is used, depending on whether the most recent trap for the condition was set using CALL ON or SIGNAL ON, respectively.

If you use CALL, the *trapname* can be an internal label, a built-in function, or an external routine. When calling *trapname*, the current *Condition Object* is supplied as an argument.

If you use SIGNAL, the *trapname* can only be an internal label.

The conditions and their corresponding events that can be trapped are:

ANY
: traps any condition that a more specific condition trap does not trap. For example, if NOVALUE is raised and there is no NOVALUE trap enabled, but there is a SIGNAL ON ANY trap, the ANY trap is called for the NOVALUE condition. For example, a CALL ON ANY trap is ignored if NOVALUE is raised because CALL ON NOVALUE is not allowed.

ERROR
: raised if a command indicates an error condition upon return. It is also raised if any command indicates failure and none of the following is active:

- CALL ON FAILURE
- SIGNAL ON FAILURE
- CALL ON ANY
- SIGNAL ON ANY

The condition is raised at the end of the clause that called the command but is ignored if the ERROR condition trap is already in the delayed state. The delayed state is the state of a condition trap when the condition has been raised but the trap has not yet been reset to the enabled (ON) or disabled (OFF) state.

If the package contains an *::OPTIONS* ERROR SYNTAX directive and ERROR is not trapped with CALL/SIGNAL ON/OFF ERROR/ANY, a SYNTAX condition is raised instead.

FAILURE
: raised if a command indicates a failure condition upon return. The condition is raised at the end of the clause that called the command but is ignored if the FAILURE condition trap is already in the delayed state.

An attempt to enter a command to an unknown subcommand environment also raises a FAILURE condition.

If the package contains an *::OPTIONS* FAILURE SYNTAX directive and FAILURE is not trapped with CALL/SIGNAL ON/OFF FAILURE/ANY, a SYNTAX condition is raised instead.

HALT
: raised if an external attempt is made to interrupt and end execution of the program. The condition is usually raised at the end of the clause that was processed when the external interruption occurred. When a Rexx program is running in a full-screen or command prompt session, the Ctrl+Break key combination raises the halt condition. However, if Ctrl+Break is pressed while a command or non-Rexx external function is processing, the command or function ends.

Notes:

1. Application programs that use the Rexx language processor might use the RXHLT exit or the RexxStart programming interface to halt the execution of a Rexx macro. (See the *Open Object Rexx: Application Programming Interfaces* for details about exits.)

2. Only SIGNAL ON HALT or CALL ON HALT can trap error 4, described in *Appendix C, Error Numbers and Messages*.

LOSTDIGITS
: raised if a number used in an arithmetic operation has more digits than the current setting of NUMERIC DIGITS. Leading zeros are not counted in this comparison. You can specify the LOSTDIGITS condition only for SIGNAL ON.

If the package contains an *::OPTIONS* LOSTDIGITS SYNTAX directive and LOSTDIGITS is not trapped with SIGNAL ON/OFF LOSTDIGITS/ANY, a SYNTAX condition is raised instead.

NOMETHOD
: raised if an object receives a message for which it has no method defined, and the object does not have an UNKNOWN method. You can specify the NOMETHOD condition only for SIGNAL ON.

NOSTRING
: raised when the language processor requires a string value from an object and the object does not directly provide a string value. See *Section 4.2.11, “Required String Values”* for more information. You can specify the NOSTRING condition only for SIGNAL ON.

If the package contains an *::OPTIONS* NOSTRING SYNTAX directive and NOSTRING is not trapped with SIGNAL ON/OFF NOSTRING/ANY, a SYNTAX condition is raised instead.

NOTREADY
: raised if an error occurs during an input or output operation. See *Section 14.5, “Errors during Input and Output”*. This condition is ignored if the NOTREADY condition trap is already in the delayed state.

If the package contains an *::OPTIONS* NOTREADY SYNTAX directive and NOTREADY is not trapped with CALL/SIGNAL ON/OFF NOTREADY/ANY, a SYNTAX condition is raised instead.

NOVALUE
raised if an uninitialized variable is used as:

- A term in an expression
- The *name* following the VAR subkeyword of a PARSE instruction
- A variable reference in a parsing template, an EXPOSE instruction, a PROCEDURE instruction, or a DROP instruction
- A method selection override specifier in a message term

Notes:

NOVALUE is not raised for any uninitialized variables in tails in compound variables.

If the package contains an *::OPTIONS* NOVALUE SYNTAX directive and NOVALUE is not trapped with SIGNAL ON/OFF NOVALUE/ANY, a SYNTAX condition is raised instead.

Example 11.1. NOVALUE not raised for stems

```
/* The following does not raise NOVALUE. */
signal on novalue
a.=0
say a.z
say "NOVALUE is not raised."
exit

novalue:
say "NOVALUE is raised."
```

You can specify this condition only for SIGNAL ON.

SYNTAX
raised if any language-processing error is detected while the program is running. This includes all kinds of processing errors:

- True syntax errors
- "Run-time" errors (such as attempting an arithmetic operation on nonnumeric terms)
- Syntax errors propagated from higher call or method invocation levels
- Untrapped HALT conditions
- Untrapped NOMETHOD conditions

You can specify this condition only for SIGNAL ON.

Notes:

1. SIGNAL ON SYNTAX cannot trap the errors 3 and 5.
2. SIGNAL ON SYNTAX can trap the errors 6 and 30 only if they occur during the execution of an INTERPRET instruction.

For information on these errors, refer to *Appendix C, Error Numbers and Messages*.

USER

raised if a condition specified on the USER option of CALL ON or SIGNAL ON occurs. USER conditions are raised by a RAISE instruction that specifies a USER option with the same *usercondition* name. The specified *usercondition* can be any symbol, including those specified as possible values for *condition*.

Any ON or OFF reference to a condition trap replaces the previous state (ON, OFF, or DELAY, and any *trapname*) of that condition trap. Thus, a CALL ON HALT replaces any current SIGNAL ON HALT (and a SIGNAL ON HALT replaces any current CALL ON HALT), a CALL ON or SIGNAL ON with a new trap name replaces any previous trap name, and any OFF reference disables the trap for CALL or SIGNAL.

11.1. Action Taken when a Condition Is Not Trapped

When a condition trap is currently disabled (OFF) and the specified condition occurs, the default action depends on the condition:

- For HALT and NOMETHOD, a SYNTAX condition is raised with the appropriate Rexx error number.
- For SYNTAX conditions, the clause in error is terminated, and a SYNTAX condition is propagated to each CALL instruction, INTERPRET instruction, message instruction, or clause with function or message invocations active at the time of the error, terminating each instruction if a SYNTAX trap is not active at the instruction level. If the SYNTAX condition is not trapped at any of the higher levels, processing stops, and a message (see *Appendix C, Error Numbers and Messages*) describing the nature of the event that occurred usually indicates the condition.
- For all other conditions, the condition is ignored and its state remains OFF.

11.2. Action Taken when a Condition Is Trapped

When a condition trap is currently enabled (ON) and the specified condition occurs, a CALL *trapname* or SIGNAL *trapname* instruction is processed automatically. You can specify the *trapname* after the NAME subkeyword of the CALL ON or SIGNAL ON instruction. If you do not specify a *trapname*, the name of the condition itself (for example, ERROR or FAILURE) is used.

For example, the instruction **`call on error`** enables the condition trap for the ERROR condition. If the condition occurred, then a call to the routine identified by the name ERROR is made. The instruction **`call on error name commanderror`** would enable the trap and call the routine COMMANDERROR if the condition occurred, and the caller usually receives an indication of failure.

The sequence of events, after a condition has been trapped, varies depending on whether a SIGNAL or CALL is processed:

- If the action taken is a SIGNAL, execution of the current instruction ceases immediately, the condition is disabled (set to OFF), and *SIGNAL* proceeds as usually.

  If any new occurrence of the condition is to be trapped, a new CALL ON or SIGNAL ON instruction for the condition is required to re-enable it when the label is reached. For example, if SIGNAL ON SYNTAX is enabled when a SYNTAX condition occurs, a usual syntax error termination occurs if the SIGNAL ON SYNTAX label name is not found.

- If the action taken is a CALL, the *CALL* *trapname* proceeds in the usual way when the instruction completes. The call does not affect the special variable RESULT. If the routine should RETURN any data, that data is ignored.

When the condition is raised, and before the CALL is made, the condition trap is put into a delayed state. This state persists until the RETURN from the CALL, or until an explicit CALL (or SIGNAL) ON (or OFF) is made for the condition. This delayed state prevents a premature condition trap at the start of the routine called to process a condition trap. When a condition trap is in the delayed state, it remains enabled, but if the condition is raised again, it is either ignored (for ERROR and FAILURE) or (for the other conditions) any action (including the updating of the condition information) is delayed until one of the following events occurs:

1. A CALL ON or SIGNAL ON for the delayed condition is processed. In this case, a CALL or SIGNAL takes place immediately after the new CALL ON or SIGNAL ON instruction has been processed.

2. A CALL OFF or SIGNAL OFF for the delayed condition is processed. In this case, the condition trap is disabled and the default action for the condition occurs at the end of the CALL OFF or SIGNAL OFF instruction.

3. A RETURN is made from the subroutine. In this case, the condition trap is no longer delayed and the subroutine is called again immediately.

On RETURN from the CALL, the original flow of execution is resumed, that is, the flow is not affected by the CALL.

Notes:

1. In all cases, the condition is raised immediately upon detection. If SIGNAL ON traps the condition, the current instruction is ended, if necessary. Therefore, the instruction during which an event occurs can only be partly processed. For example, if SYNTAX is raised during the evaluation of the expression in an assignment, the assignment does not take place. Note that the CALL for traps for which CALL ON is enabled can only occur at clause boundaries. If these conditions arise in the middle of an INTERPRET instruction, execution of INTERPRET can be interrupted and resumed later. Similarly, other instructions, for example DO or SELECT, can be temporarily interrupted by a CALL at a clause boundary.

2. The state (ON, OFF, or DELAY, and any *trapname*) of each condition trap is saved on entry to a subroutine and is then restored on RETURN. This means that CALL ON, CALL OFF, SIGNAL ON, and SIGNAL OFF can be used in a subroutine without affecting the conditions set up by the caller. See *Section 2.3, “CALL”* for details of other information that is saved during a subroutine call.

3. The state of condition traps is not affected when an external routine is called by a CALL, even if the external routine is a Rexx program. On entry to any Rexx program, all condition traps have an initial setting of OFF.

4. While user input is processed during interactive tracing, all condition traps are temporarily set OFF. This prevents any unexpected transfer of control—for example, should the user accidentally use an uninitialized variable while SIGNAL ON NOVALUE is active. For the same reason, a syntax error during interactive tracing does not cause the exit from the program but is trapped specially and then ignored after a message is given.

5. The system interface detects certain execution errors either before the execution of the program starts or after the program has ended. SIGNAL ON SYNTAX cannot trap these errors.

Note that a label is a clause consisting of a single symbol followed by a colon. Any number of successive clauses can be labels; therefore, several labels are allowed before another type of clause.

11.3. Condition Information

When a condition is trapped and causes a SIGNAL or CALL, this becomes the current trapped condition, and certain condition information associated with it is recorded. You can inspect this information by using the *CONDITION* built-in function.

The condition information includes:

- The name of the current trapped condition
- The name of the instruction processed as a result of the condition trap (CALL or SIGNAL)
- The status of the trapped condition
- A descriptive string (see *Section 11.3.1, "Descriptive Strings"*) associated with that condition
- Optional additional object information (see *Section 11.3.2, "Additional Object Information"*)

The current condition information is replaced when control is passed to a label as the result of a condition trap (CALL ON or SIGNAL ON). Condition information is saved and restored across subroutine or function calls, including one because of a CALL ON trap and across method invocations. Therefore, a routine called by CALL ON can access the appropriate condition information. Any previous condition information is still available after the routine returns.

11.3.1. Descriptive Strings

The descriptive string varies, depending on the condition trapped:

ERROR
: The string that was processed and resulted in the error condition.

FAILURE
: The string that was processed and resulted in the failure condition.

HALT
: Any string associated with the halt request. This can be the null string if no string was provided.

LOSTDIGITS
: The number with excessive digits that caused the LOSTDIGITS condition.

NOMETHOD
: The name of the method that could not be found.

NOSTRING
: The readable string representation of the object causing the NOSTRING condition.

NOTREADY
: The name of the stream being manipulated when the error occurred and the NOTREADY condition was raised. If the stream was a default stream with no defined name, then the null string might be returned.

NOVALUE
: The derived name of the variable whose attempted reference caused the NOVALUE condition.

SYNTAX
: Any string the language processor associated with the error. This can be the null string if you did not provide a specific string. Note that the special variables RC and SIGL provide information on the nature and position of the processing error. You can enable the SYNTAX condition trap only by using SIGNAL ON.

USER
: Any string specified by the DESCRIPTION option of the RAISE instruction that raised the condition. If a description string was not specified, a null string is used.

11.3.2. Additional Object Information

The language processor can provide additional information, depending on the condition trapped:

NOMETHOD
: The object that raised the NOMETHOD condition.

NOSTRING
: The object that caused the NOSTRING condition.

NOTREADY
: The stream object that raised the NOTREADY condition.

SYNTAX
: An array containing the objects substituted into the secondary error message (if any) for the syntax error. If the message did not contain substitution values, a zero element array is used.

USER
: Any object specified by an ADDITIONAL or ARRAY option of the RAISE instruction that raised the condition.

11.3.3. The Special Variable RC

When an ERROR or FAILURE condition is trapped, the Rexx special variable RC is set to the command return code before control is transferred to the target label (whether by CALL or by SIGNAL).

Similarly, when SIGNAL ON SYNTAX traps a SYNTAX condition, the special variable RC is set to the syntax error number before control is transferred to the target label.

11.3.4. The Special Variable SIGL

Following any transfer of control because of a CALL or SIGNAL, the program line number of the clause causing the transfer of control is stored in the special variable SIGL. If the transfer of control is because of a condition trap, the line number assigned to SIGL is that of the last clause processed (at the current subroutine level) before the CALL or SIGNAL took place. The setting of SIGL is especially useful after a SIGNAL ON SYNTAX trap when the number of the line in error can be used, for example, to control a text editor. Typically, code following the SYNTAX label can PARSE SOURCE to find the source of the data and then call an editor to edit the source file, positioned at the line in error. Note that in this case you might have to run the program again before any changes made in the editor can take effect.

Alternatively, SIGL can help determine the cause of an error (such as the occasional failure of a function call) as in the following example:

Example 11.2. SIGL

```
signal on syntax
a = a + 1      /* This is to create a syntax error */
say "SYNTAX error not raised"
exit

/* Standard handler for SIGNAL ON SYNTAX */
syntax:
say "Rexx error" rc "in line" sigl":" "ERRORTEXT"(rc)
say "SOURCELINE"(sigl)
trace ?r; nop
```

This code first displays the error code, line number, and error message. It then displays the line in error, and finally drops into debug mode to let you inspect the values of the variables used at the line in error.

11.3.5. Condition Object

A condition object is a **`Directory`** returned by the **`Object`** option of the *CONDITION* built-in function. This directory contains all information currently available on a trapped condition. The information varies with the trapped condition. **`.nil`** is returned for any entry not available to the condition. The following entries can be found in a condition object:

ADDITIONAL
: The additional information object associated with the condition. This is the same object that the Additional option of the CONDITION built-in function returns. The ADDITIONAL information may be specified with the ADDITIONAL or ARRAY options of the RAISE instruction.

DESCRIPTION
: The string describing the condition. The Description option of the CONDITION built-in function also returns this value.

INSTRUCTION
: The keyword for the instruction executed when the condition was trapped, either **`CALL`** or **`SIGNAL`**. The Instruction option of the CONDITION built-in function also returns this value.

CONDITION
: The name of the trapped condition. The Condition name option of the CONDITION built-in function also returns this value.

RESULT
: Any result specified on the RETURN or EXIT options of a RAISE instruction.

RC
: The major Rexx error number for a SYNTAX condition. This is the same error number assigned to the special variable RC.

CODE
: The detailed identification of the error that caused a SYNTAX condition. This number is a nonnegative number in the form *nn.nnn*. The integer portion is the Rexx major error number (the same value as the RC entry). The fractional portion is a subcode that gives a precise indication of the error that occurred.

ERRORTEXT
: The primary error message for a SYNTAX condition. This is the same message available from the ERRORTEXT built-in function.

MESSAGE
: The secondary error message for a SYNTAX condition. The message also contains the content of the ADDITIONAL information.

PACKAGE
: The Package object associated with the program where a condition was raised.

POSITION
: The line number in source code at which a condition was raised.

PROGRAM
: The name of the program where a condition was raised.

STACKFRAMES
: A single-index list of *StackFrame* instances.

TRACEBACK
: A single-index list of formatted traceback lines.

PROPAGATED
: **`.false`** if the condition was raised at the same level as the condition trap or the value **`.true`** if the condition was reraised with RAISE PROPAGATE.

Concurrency

Conceptually, each Rexx object is like a small computer with its own processor to run its methods, its memory for object and method variables, and its communication links to other objects for sending and receiving messages. This is object-based concurrency. It lets more than one method run at the same time. Any number of objects can be active (running) at the same time, exchanging messages to communicate with, and synchronize, each other.

12.1. Early Reply

Early reply provides concurrent processing. A running method returns control, and possibly a result, to the point from which it was called; meanwhile it continues running. The following figure illustrates this concept.

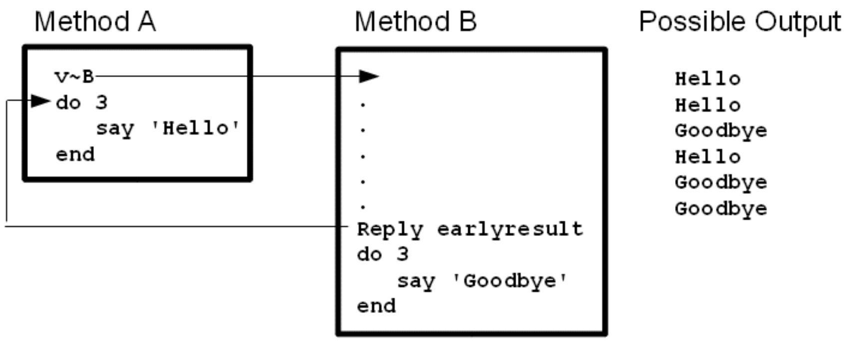


Figure 12.1. Early Reply

Method A includes a call to Method B. Method B contains a REPLY instruction. This returns control and a result to method A, which continues processing with the line after the call to Method B. Meanwhile, Method B also continues running.

The chains of execution represented by method A and method B are called activities. An activity is a thread of execution that can run methods concurrently with methods on other activities.

An activity contains a stack of invocations that represent the Rexx programs running on the activity. An invocation can be a main program invocation, an internal function or subroutine call, an external function or subroutine call, an INTERPRET instruction, or a message invocation. An invocation is activated when an executable unit is invoked and removed (popped) when execution completes. In *Figure 12.1, “Early Reply”*, the programs begins with a single activity. The activity contains a single invocation, method A. When method A invokes method B, a second invocation is added to the activity.

When method B issues a REPLY, a new activity is created (activity 2). Method B's invocation is removed from activity 1, and pushed on to activity 2. Because activities can execute concurrently, both method A and method B continue processing. The following figures illustrate this concept.

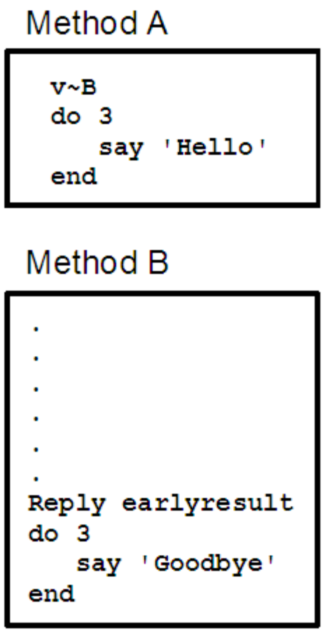


Figure 12.2. Before REPLY

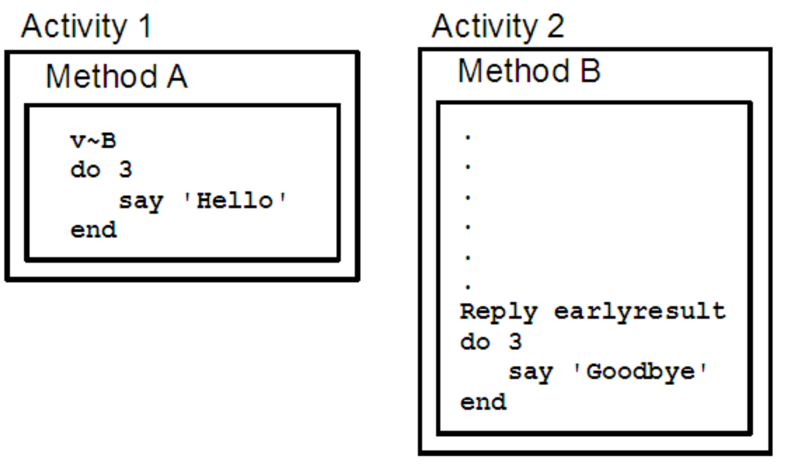


Figure 12.3. After REPLY

Here is an example of using early reply to run methods concurrently.

Example 12.1. REPLY instruction

```
/* Example of early reply */

object1 = .example~new
object2 = .example~new

say object1~repeat(10, "Object 1 running")
say object2~repeat(10, "Object 2 running")
say "Main ended."
exit

::class example
::method repeat
use arg reps,msg
reply "Repeating" msg"," reps "times."
do reps
  say msg
end
```

12.2. Message Objects

A *Message* object is an intermediary between two objects that enables concurrent processing. All objects inherit the *start* method from the **Object** class. To obtain a message object, an object sends a `start` message to the object to which the message object will convey a message. The message is an argument to the `start` message as in the following example:

```
a=p~start("REVERSE")
```

This line of code creates a message object, **A**, and sends it a start message. The message object then sends the REVERSE message to object **P**. Object **P** receives the message, performs any needed processing, and returns a result to message object **A**. Meanwhile the object that obtained message object **A** continues its processing. When message object **A** returns, it does not interrupt the object that obtained it. It waits until this object requests the information. Here is an example of using a message object to run methods concurrently.

Example 12.2. Message object usage

```
/* Example of using a message object */

object1 = .example~new
object2 = .example~new

a = object1~start("REPEAT",10,"Object 1 running")
b = object2~start("REPEAT",10,"Object 2 running")

say a~result
say b~result
say "Main ended."
exit

::class example
::method repeat
use arg reps,msg
do reps
  say msg
end
return "Repeated" msg"," reps "times."
```

12.3. Default Concurrency

The instance methods of a class use the EXPOSE instruction to define a set of object variables. This collection of variables belonging to an object is called its object variable pool. The methods a class defines and the variables these methods can access is called a scope. Rexx's default concurrency exploits the idea of scope. The object variable pool is a set of object subpools, each representing the set of variables at each scope of the inheritance chain of the class from which the object was created. Only methods at the same scope can access object variables at any particular scope. This prevents any name conflicts between classes and subclasses, because the object variables for each class are in different scopes.

If you do not change the defaults, only one method of a given scope can run on a single object at a time. Once a method is running on an object, the language processor blocks other methods on other activities from running in the same object at the same scope until the method that is running completes. Thus, if different activities send several messages within a single scope to an object the methods run sequentially.

The next example shows how the default concurrency works.

Example 12.3. Default concurrency for methods

```
/* Example of default concurrency for methods of different scopes */

object1 = .subexample~new

say object1~repeat(8, "Object 1 running call 1")   /* These calls run */
say object1~repeater(8, "Object 1 running call 2") /*   concurrently  */
say "Main ended."
exit

::class example
::method repeat
use arg reps,msg
reply "Repeating" msg"," reps "times."
do reps
  say msg
end

::class subexample subclass example
::method repeater
use arg reps,msg
reply "Repeating" msg"," reps "times."
do reps
  say msg
end
```

The preceding example produces output such as the following:

```
Repeating Object 1 running call 1, 8 times.
Object 1 running call 1
Repeating Object 1 running call 2, 8 times.
Object 1 running call 1
Object 1 running call 2
Main ended.

Object 1 running call 1
Object 1 running call 2
Object 1 running call 1
Object 1 running call 2
Object 1 running call 1
Object 1 running call 2
Object 1 running call 1
Object 1 running call 2
Object 1 running call 1
Object 1 running call 2
Object 1 running call 1
Object 1 running call 2
Object 1 running call 2
```

The following example shows that methods of the same scope do not run concurrently by default.

Example 12.4. Default concurrency for methods

```
/* Example of methods with the same scope not running concurrently*/

object1 = .example~new

say object1~repeat(10,"Object 1 running call 1") /* These calls   */
say object1~repeat(10,"Object 1 running call 2") /* cannot run    */
```

```
say "Main ended."                                /* concurrently. */
exit

::class example
::method repeat
use arg reps,msg
reply "Repeating" msg"," reps "times."
do reps
  say msg
end
```

The REPEAT method includes a REPLY instruction, but the methods for the two REPEAT messages in the example cannot run concurrently. This is because REPEAT is called twice at the same scope and requires exclusive access to the object variable pool. The REPLY instruction causes the first REPEAT message to transfer its exclusive access to the object variable pool to a new activity and continue execution. The second REPLY message also requires exclusive access and waits until the first method completes.

If the original activity has more than one method active (nested method calls) with exclusive variable access, the first REPLY instruction is unable to transfer its exclusive access to the new activity and must wait until the exclusive access is again available. This may allow another method on the same object to run while the first method waits for exclusive access.

12.3.1. Sending Messages within an Activity

Whenever a message is invoked on an object, the activity acquires exclusive access (a lock) for the object's scope. Other activities that send messages to the same object that required the locked scope waits until the first activity releases the lock.

Suppose object A is running method Y, which includes:

```
self~z
```

Sequential processing does not allow method Z to begin until method Y has completed. However, method Y cannot complete until method Z runs. A similar situation occurs when a subclass's overriding method does some processing and passes a message to its superclasses' overriding method. Both cases require a special provision: If an invocation running on an activity sends another message to the same object, this method is allowed to run because the activity has already acquired the lock for the scope. This allows nested, nonconcurrent method invocations on a single activity without causing a deadlock situation. The language processor regards these additional messages as subroutine calls.

Here is an example showing the special treatment of single activity messages. The REPEATER and REPEAT methods have the same scope. REPEAT runs on the same object at the same time as the REPEATER method because a message to SELF runs the REPEAT method. The language processor treats this as a subroutine call rather than as concurrently running two methods.

Example 12.5. Sending a message to SELF

```
/* Example of sending message to SELF */

object1 = .example~new
object2 = .example~new

say object1~repeater(10, "Object 1 running")
say object2~repeater(10, "Object 2 running")

say "Main ended."
```

```
exit

::class example
::method repeater
use arg reps,msg
reply "Entered repeater."
say self~repeat(reps,msg)
::method repeat
use arg reps,msg
do reps
  say msg
end
return "Repeated" msg"," reps "times."
```

The activity locking rules also allow indirect object recursion. The following figure illustrates indirect object recursion.

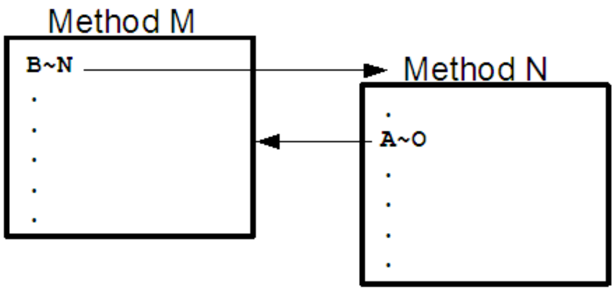


Figure 12.4. Indirect Object Recursion

Method M in object A sends object B a message to run method N. Method N sends a message to object A, asking it to run method O. Meanwhile, method M is still running in object A and waiting for a result from method N. A deadlock would result. Because the methods are all running on the same activity, no deadlock occurs.

12.4. Using Additional Concurrency Mechanisms

Rexx has additional concurrency mechanisms that can add full concurrency so that more than one method of a given scope can run in an object at a time:

- The SETUNGUARDED method of the Method class and the UNGUARDED option of the METHOD directive provide unconditional concurrency
- GUARD OFF and GUARD ON control a method's exclusive access to an object's scope

12.4.1. SETUNGUARDED Method and UNGUARDED Option

The SETUNGUARDED method of the Method class and the UNGUARDED option of the ::METHOD directive control locking of an object's scope when a method is invoked. Both let a method run even if another method is active on the same object.

Use the SETUNGUARDED method or UNGUARDED option only for methods that do not need exclusive use of their object variable pool, that is, methods whose execution can interleave with another method's execution without affecting the object's integrity. Otherwise, concurrent methods can produce unexpected results.

To use the SETUNGUARDED method for a method you have created with the NEW method of the Method class, you specify:

```
methodname~SETUNGUARDED
```

(See *Section 5.1.3.19, "setUnguarded"* for details about SETUNGUARDED.)

Alternately, you can define a method with the ::METHOD directive, specifying the UNGUARDED option:

```
::METHOD methodname UNGUARDED
```

12.4.2. GUARD ON and GUARD OFF

You might not be able to use the SETUNGUARDED method or UNGUARDED option in all cases. A method might need exclusive use of its object variables, then allow methods on other activities to run, and perhaps later need exclusive use again. You can use GUARD ON and GUARD OFF to alternate between exclusive use of an object's scope and allowing other activities to use the scope.

By default, a method must wait until a currently running method is finished before it begins. GUARD OFF lets another method (running on a different activity) that needs exclusive use of the same object variables become active on the same object. See *Section 2.9, "GUARD"* for more information.

12.4.3. Guarded Methods

Concurrency requires the activities of concurrently running methods to be synchronized. Critical data must be safeguarded so diverse methods on other activities do not perform concurrent updates. Guarded methods satisfy both these needs.

A guarded method combines the UNGUARDED option of the ::METHOD directive or the SETUNGUARDED method of the Method class with the GUARD instruction.

The UNGUARDED option and the SETUNGUARDED method both provide unconditional concurrency. Including a GUARD instruction in a method makes concurrency conditional:

```
GUARD ON WHEN expression
```

If the *expression* on the GUARD instruction evaluates to **`.true`**, the method continues to run. If the *expression* on the GUARD instruction evaluates to **`.false`**, the method does not continue running. GUARD reevaluates the *expression* whenever the value of an exposed object variable changes. When the expression evaluates to **`1`**, the method resumes running. You can use GUARD to block running any method when proceeding is not safe. (See *Section 2.9, "GUARD"* for details about GUARD.)

Note

It is important to ensure that you use an expression that can be fulfilled. If the condition expression cannot be met, GUARD ON WHEN puts the program in a continuous wait condition. This can occur in particular when several activities run concurrently. In this case, a second activity can make the condition expression invalid before GUARD ON WHEN can use it.

To avoid this, ensure that the GUARD ON WHEN statement is executed before the condition is set to true. Keep in mind that the sequence of running activities is not determined by the calling sequence, so it is important to use a logic that is independent of the activity sequence.

12.4.4. Additional Examples

The following example uses REPLY in a method for a write-back cache.

Example 12.6. Method Write_Back

```
/* Method Write_Back                                  */
use arg data            /* Save data to be written    */
reply 0                 /* Tell the sender all was OK */
self~disk_write(data)  /* Now write the data         */
```

The REPLY instruction returns control to the point at which method Write_Back was called, returning the result **0**. The caller of method Write_Back continues processing from this point; meanwhile, method Write_Back also continues processing.

The following example uses a message object. It reads a line asynchronously into the variable **nextline**:

Example 12.7. Message to INFILE

```
mymsg = infile~start("READLINE") /* Gets message object to carry    */
/* message to INFILE                                                */
/* do other work */
nextline=mymsg~result            /* Gets result from message object */
```

This creates a message object that waits for the read to finish while the sender continues with other work. When the line is read, the **mymsg** message object obtains the result and holds it until the sender requests it.

Semaphores and monitors (bounded buffers) synchronize concurrency processes. Giving readers and writers concurrent access is a typical concurrency problem. The following sections show how to use guarded methods to code semaphore and monitor mechanisms and to provide concurrency for readers and writers.

12.4.4.1. Semaphores

A semaphore is a mechanism that controls access to resources, for example, preventing simultaneous access. Synchronization often uses semaphores. Here is an example of a semaphore class:

Example 12.8. Example of a Rexx Semaphore Class

```
/******************************************************************************/
/*  A Rexx Semaphore Class.                                                   */
/*                                                                            */
/* This file implements a semaphore class in Rexx.  The class is defined to   */
/* the Global Rexx Environment.  The following methods are defined for        */
/* this class:                                                                */
/*   init - Initializes a new semaphore.  Accepts the following positional    */
/*          parameters:                                                       */
/*                             'name' - global name for this semaphore        */
/*                                if named default to set name in             */
```

```
/*                                the class semDirectory                      */
/*                             noshare -  do not define named semaphore       */
/*                                in class semDirectory                       */
/*                             Initial state (0 or 1)                         */
/*   setInitialState - Allow for subclass to have some post-initialization,   */
/*     and do setup based on initial state of semaphore                       */
/*   Waiting  - Is the number of objects waiting on this semaphore.           */
/*   Shared   - Is this semaphore shared (Global).                            */
/*   Named    - Is this semaphore named.                                      */
/*   Name     - Is the name of a named semaphore.                             */
/*   setSem   - Sets the semaphore and returns previous state.                */
/*   resetSem - Sets state to unSet.                                          */
/*   querySem - Returns current state of semaphore.                           */
/*                                                                            */
/* SemaphoreMeta - Is the metaclass for the semaphore classes.  This class is */
/*   set up so that when a namedSemaphore is shared, it maintains these       */
/*   named/shared semaphores as part of its state.  These semaphores are      */
/*   maintained in a directory, and an UNKNOWN method is installed on the     */
/*   class to forward unknown messages to the directory.  In this way the     */
/*   class can function as a class and "like" a directory, so [] syntax can   */
/*   be used to retrieve a semaphore from the class.                          */
/*                                                                            */
/*                                                                            */
/* The following are in the subclass EventSemaphore.                          */
/*                                                                            */
/*   Post  - Posts this semaphore.                                            */
/*   Query - Queries the number of posts since the last reset.                */
/*   Reset - Resets the semaphore.                                            */
/*   Wait  - Waits on this semaphore.                                         */
/*                                                                            */
/*                                                                            */
/* The following are in the subclass MutexSemaphore                           */
/*                                                                            */
/*   requestMutex - Gets exclusive use of semaphore.                          */
/*   releaseMutex - Releases to allow someone else to use semaphore.          */
/*        NOTE: Currently anyone can issue a release (need not be the owner).  */
/******************************************************************************/
/* ========================================================================== */
/* ===         Start of Semaphore class.                                ===== */
/* ========================================================================== */
::class SemaphoreMeta subclass class
::method init
  expose semDict
                                          /* Be sure to initialize parent     */
  .message~new(self, .array~of("INIT", super), "a", arg(1,"a"))~send
  semDict = .directory~new

::method unknown
  expose semDict
  use arg msgName, args
                                          /* Forward all unknown messages     */
                                          /* to the semaphore dictionary      */
  .message~new(semDict, msgName, "a", args)~send
  if var("RESULT") then
    return result
  else
    return


::class Semaphore subclass object metaclass SemaphoreMeta

::method init
  expose sem waits shared name
  use arg semname, shr, state

  waits = 0                               /* No one waiting                   */
  name = ""                               /* Assume unnamed                   */
```

```
  shared = 0                                /* Assume not shared               */
  sem = 0                                   /* Default to not posted           */

  if state = 1 Then                         /* Should initial state be set?    */
    sem = 1
                                            /* Was a name specified?           */
  if VAR("SEMNAME") & semname \= "" Then Do
    name = semname                          /* Yes, so set the name            */


    if shr \= "NOSHARE" Then Do             /* Do we want to share this sem?   */
      shared = 1                            /* Yes, mark it shared             */
                                            /* Shared add to semDict           */
      self~class[name] = self
    End

  End
  self~setInitialState(sem)                 /* Initialize initial state        */

::method setInitialState
                                            /* This method intended to be      */
nop                                         /* overridden by subclasses        */
::method setSem
expose sem
oldState = sem
sem = 1                                     /* Set new state to 1              */
return oldState

::method resetSem
expose sem
sem = 0
return 0

::method querySem
expose sem
return sem


::method shared
expose shared
return shared                               /* Return .true or .false          */

::method named
expose name
                                            /* Does semaphore have a name?     */
if name = "" Then return 0                  /* No, not named                   */
Else return 1                               /* Yes, it is named                */

::method name
expose name
return name                                 /* Return name or ""               */

::method incWaits
expose waits
waits = waits + 1                           /* One more object waiting         */

::method decWaits
expose Waits
waits = waits - 1                           /* One object less waiting         */

::method Waiting
expose Waits
return waits                                /* Return number of objects waiting */
/* ========================================================================== */
/* ===         Start of EventSemaphore class.                             === */
/* ========================================================================== */
```

```
::class EventSemaphore subclass Semaphore public
::method setInitialState
  expose posted posts
  use arg posted

  if posted  then posts = 1
  else posts = 0
::method post
  expose posts posted

  self~setSem                   /* Set semaphore state            */
  posted = 1                    /* Mark as posted                 */
  reply
  posts = posts + 1             /* Increase the number of posts   */

::method wait
  expose posted

  self~incWaits                 /* Increment number waiting       */
  guard off
  guard on when posted          /* Now wait until posted          */
  reply                         /* Return to caller               */
  self~decWaits                 /* Cleanup, 1 less waiting        */

::method reset
  expose posts posted

  posted = self~resetSem        /* Reset semaphore                */
  reply                         /* Do an early reply              */
  posts = 0                     /* Reset number of posts          */

::method query
  expose posts
                                /* Return number of times         */
  return posts                  /* Semaphore has been posted      */
/* ================================================================== */
/* ===         Start of MutexSemaphore class.                     === */
/* ================================================================== */

::class MutexSemaphore subclass Semaphore public

::method setInitialState
  expose owned
  use arg owned


::method requestMutex
  expose Owned

  Do forever                           /* Do until we get the semaphore  */
    owned = self~setSem
    if Owned = 0                       /* Was semaphore already set?     */
      Then leave                       /* Wasn't owned; we now have it   */
    else Do
      self~incWaits
      guard off                        /* Turn off guard status to let   */
                                       /* others come in                 */
      guard on when \Owned             /* Wait until not owned and get   */
                                       /* guard                          */
      self~decWaits                    /* One less waiting for MUTEX     */
    End
                                       /* Go up and see if we can get it */
  End


::method releaseMutex
  expose owned
```

```
  owned = self~resetSem                      /* Reset semaphore                */
```

Note

See also semaphore classes *EventSemaphore Class* and *MutexSemaphore Class*.

12.4.4.2. Monitors (Bounded Buffer)

A monitor object consists of a number of client methods, WAIT and SIGNAL methods for client methods to use, and one or more condition variables. Guarded methods provide the functionality of monitors. Do not confuse this with the Monitor class (see *Section 5.4.10, "Monitor Class"*).

Example 12.9. Example of a Rexx Monitor Class

```
::method init
/* Initialize the bounded buffer */
expose size in out n
use arg size
in = 1
out = 1
n = 0

::method append unguarded
/* Add to the bounded buffer if not full */
expose n size b. in
guard on when n < size
use arg b.in
in = in//size+1
n = n+1

::method take
/* Remove from the bounded buffer if not empty */
expose n b. out size
guard on when n > 0
reply b.out
out = out//size+1
n = n-1
```

12.4.4.3. Readers and Writers

The concurrency problem of the readers and writers requires that writers exclude writers and readers, whereas readers exclude only writers. The UNGUARDED option is required to allow several concurrent readers.

Example 12.10. Example of a Rexx Readers and Writers

```
::method init
expose readers writers
readers = 0
writers = 0

::method read unguarded
/* Read if no one is writing */
expose writers readers
guard on when writers = 0
```

```
readers = readers + 1
guard off

/* Read the data */
say "Reading (writers:" writers", readers:" readers")."
guard on
readers = readers - 1

::method write unguarded
/* Write if no-one is writing or reading */
expose writers readers
guard on when writers + readers = 0
writers = writers + 1

/* Write the data */
say "Writing (writers:" writers", readers:" readers")."
writers = writers - 1
```

The Security Manager

The security manager provides a special environment that is safe even if agent programs try to perform unexpected actions. The security manager is called if an agent program tries to:

- Call an external function
- Use a host command
- Use the ::REQUIRES directive
- Access the .LOCAL directory
- Access the .ENVIRONMENT directory
- Use a stream name in the input and output built-in functions (CHARIN, CHAROUT, CHARS, LINEIN, LINEOUT, LINES, and STREAM)
- Send a message for a protected method to an object

13.1. Calls to the Security Manager

When the language processor reaches any of the defined security checkpoints, it sends a message to the security manager for the particular checkpoint. The message has a single argument, a directory of information that pertains to the checkpoint. If the security manager chooses to handle the action instead of the language processor, the security manager uses the checkpoint information directory to pass information back to the language processor.

Security manager methods must return a value of either **`.false`** or **`.true`** to the language processor. A value of **`.false`** indicates that the program is authorized to perform the indicated action. In this case, processing continues as usual. A value of **`.true`** indicates that the security manager performed the action itself. The security manager sets entries in the information directory to pass results for the action back to the language processor. The security manager can also use the RAISE instruction to raise a program error for a prohibited access. Error message 98.948 indicates authorization failures.

The defined checkpoints, with their arguments and return values, are:

CALL

sent for all external function calls. The information directory contains the following entries:

NAME

The name of the invoked function.

ARGUMENTS

An array of the function arguments.

When the CALL method returns **`.false`**, indicating that it handled the external call, the entry RESULT (if any) in the information directory is used as the function call result.

COMMAND

sent for all host command instructions. The information directory contains the following entries:

COMMAND

The string that represents the host command.

ADDRESS

The name of the target ADDRESS environment for the command.

When the COMMAND method returns **`.false`**, indicating that it handled the command, the security manager uses the following information directory entries to return the command results:

RC
: The command return code. If the entry is not set, a return code of **`.true`** is used.

FAILURE
: If a FAILURE entry is added to the information directory, a Rexx FAILURE condition is raised.

ERROR
: If an ERROR entry is added to the information directory, a Rexx ERROR condition is raised. The ERROR condition is raised only if the FAILURE entry is not set.

REQUIRES

sent whenever a ::REQUIRES directive in the file is processed. The information directory contains the following entry:

NAME
: The name of the file specified on the ::REQUIRES directive.

When the REQUIRES method returns **`.false`**, indicating that it handled the request, the entry NAME in the information directory is used as the actual file to load for the request. The REQUIRES method can also provide a security manager to be used for the program loaded by the ::REQUIRES directive by setting the information directory entry SECURITYMANAGER to the desired security manager object.

LOCAL

sent whenever Rexx is going to access an entry in the .LOCAL directory as part of the resolution of the environment symbol name. The information directory contains the following entry:

NAME
: The name of the target directory entry.

When the LOCAL method returns **`.false`**, indicating that it handled the request, the information directory entry RESULT contains the directory entry. When RESULT is not set and the method returns **`.false`**, this is the same as a failure to find an entry in the .LOCAL directory. Rexx continues with the next step in the name resolution.

ENVIRONMENT

sent whenever Rexx is going to access an entry in the .ENVIRONMENT directory as part of the resolution of the environment symbol name. The information directory contains the following entry:

NAME
: The name of the target directory entry.

When the ENVIRONMENT method returns **`.false`**, indicating that it handled the request, the information directory entry RESULT contains the directory entry. When RESULT is not set and the method returns **`.false`**, this is the same as a failure to find an entry in the .ENVIRONMENT directory. Rexx continues with the next step in the name resolution.

STREAM

sent whenever one of the Rexx input and output built-in functions (CHARIN, CHAROUT, CHARS, LINEIN, LINEOUT, LINES, or STREAM) needs to resolve a stream name. The information directory contains the following entry:

NAME
: The name of the target stream.

When the STREAM method returns `.false`, indicating that it handled the request, the information directory entry STREAM must be set to an object to be used as the stream target. This should be a stream object or another object that supports the Stream class methods.

METHOD

sent whenever a secure program attempts to send a message for a protected method (see the ::METHOD directive *Section 3.5, “::METHOD”*) to an object. The information directory contains the following entries:

OBJECT
: The object the protected method is issued against.

NAME
: The name of the protected method.

ARGUMENTS
: An array containing the method arguments.

When the METHOD method returns `.false`, indicating that it handled the request, the entry RESULT (if any) in the information directory is used as the method result.

13.1.1. Example

The following agent program includes all the actions for which the security manager defines checkpoints (for example, by calling an external function).

Example 13.1. Agent Program

```
/* Agent */
"echo Hello There"
call rxfuncadd "rxcalcsqrt", "rxmath", "rxcalcsqrt"
say result
say syssleep(1)
say linein("./profile")
say .methods
.json~define("")
::requires json.cls
```

The following server implements the security manager with three levels of security. For each action the security manager must check (for example, by calling an external routine):

1. The audit manager (Dumper class) writes a record of the event but then permits the action.

2. The closed cell manager (noWay class) does not permit the action to take place and raises an error.

3. The replacement execution environment (Replacer class, a subclass of the noWay class) replaces the prohibited action with a different action.

Example 13.2. Example of Server Implementing Security Manager

```
/* Server implements security manager */
parse arg program
routine = .Routine~newFile(program)
say "Calling program" program "with an audit manager:"
pull
routine~setSecurityManager(.Dumper~new(.stderr))
routine~call
```

```
say "Calling program" program "with a function replacement execution environment:"
pull
routine~setSecurityManager(.Replacer~new)
routine~call
say "Calling program" program "with a closed cell manager:"
pull
routine~setSecurityManager(.noWay~new)
signal on syntax
routine~call
exit

syntax:
  say "Agent program terminated with an authorization failure"
  say condition("additional")
  exit

-- A Security Manager that keeps an audit record, and permits the request to run
::class Dumper public
::method init
  -- save our target stream for output
  expose stream
  use arg stream

-- unknown will trap all Security Manager checkpoints
::method unknown
  expose stream                 -- we write to our target stream
  use arg name, args            -- actual message name and arguments
  -- write an audit record
  stream~lineout(.DateTime~new "Called for event" name)
  info = args[1]                -- info directory is the first arg
  do name over info             -- write the info directory contents
    stream~lineout(.DateTime~new "Info item" name":" info[name])
  end
return 0                        -- allow this to proceed


-- A closed cell Security Manager blocking all requests
::class noWay
-- unknown will trap all Security Manager checkpoints
::method unknown
  -- raise an error for each checkpoint
  raise syntax 98.948 array(arg(1) "blocked by Security manager")


-- A Security Manager that replaces prohibited actions with a different one
::class Replacer subclass noWay  -- inherit restrictive UNKNOWN method
-- command checkpoint
::method command
  use arg info
  info~rc = 1234                -- replace the command return code
  info~failure = .true          -- raise a FAILURE condition
  return 1 -- we handled this

-- external call checkpoint
::method call
  use arg info
  info~result = "blocked"
  return 1 -- we handled this

-- STREAM checkpoint
::method stream
  use arg info
  -- always replace with a different stream
  info~stream = .stream~new("SecurityManager.txt")
  return 1 -- we handled this

-- .local variable lookup
```

```
::method local
  return 1 -- handle. but return no value

-- .environment variable lookup
::method environment
  return 1 -- handle. but return no value

-- protected method invocation
::method method
  use arg info
  info~result = "blocked"
  return 1 -- we handled this

-- ::REQUIRES directive
::method requires
  use arg info
  info~name = "SecurityManager.cls"
  info~securitymanager = self -- load under this authority
  return 1 -- we handled this
```

Input and Output Streams

Rexx defines Stream class methods to handle input and output and maintains the I/O functions for input and output externals. Using a mixture of Rexx I/O methods and Rexx I/O functions can cause unpredictable results. For example, using the LINEOUT method and the LINEOUT function on the same persistent stream object can cause overlays.

When a Rexx I/O function creates a stream object, the language processor maintains the stream object. When a Rexx I/O method creates a stream object, it is returned to the program to be maintained. Because of this, when Rexx I/O methods and Rexx I/O functions referring to the same stream are in the same program, there are two separate stream objects with different read and write pointers. The program needs to synchronize the read and write pointers of both stream objects, or overlays occur.

To obtain a stream object (for example, **`MYFIL`**), you could use:

Example 14.1. Obtaining a stream object

```
MyStream = .stream~new("MYFIL")
```

You can manipulate stream objects with character or line methods:

Example 14.2. Performing input on a stream object

```
nextchar = MyStream~charin()
nextline = MyStream~linein()
```

In addition to stream objects, the language processor defines an external data queue object for interprogram communication. This queue object understands line functions only.

A stream object can have a variety of sources or destinations including files, serial interfaces, displays, or networks. It can be transient or dynamic, for example, data sent or received over a serial interface, or persistent in a static form, for example, a disk file.

Housekeeping for stream objects (opening and closing files, for example) is not explicitly part of the language definition. However, Rexx provides methods, such as CHARIN and LINEIN, that are independent of the operating system and include housekeeping. The COMMAND method provides the *stream_command* argument for those situations that require more granular access to operating system interfaces.

14.1. The Input and Output Model

The model of input and output for Rexx consists of the following logically distinct parts:

- One or more input stream objects
- One or more output stream objects
- One or more external data queue objects

The Rexx methods, instructions, and built-in routines manipulate these elements as follows.

14.1.1. Input Streams

Input to Rexx programs is in the form of a serial character stream generated by user interaction or has the characteristics of one generated this way. You can add characters to the end of some stream objects asynchronously; other stream objects might be static or synchronous.

The methods and instructions you can use on input stream objects are:

- CHARIN method—reads input stream objects as characters.
- LINEIN method—reads input stream objects as lines.
- PARSE PULL and PULL instructions—read the default input stream object (**`.INPUT`**), if the external data queue is empty. PULL is the same as PARSE UPPER PULL.
- PARSE LINEIN instruction—reads lines from the default input stream object regardless of the state of the external data queue. Usually, you can use PULL or PARSE PULL to read the default input stream object.

In a persistent stream object, the Rexx language processor maintains a current read position. For a persistent stream:

- The CHARS method returns the number of characters currently available in an input stream object from the read position through the end of the stream (including any line-end characters).
- The LINES method determines if any data remains between the current read position and the end of the input stream object.
- You can move the read position to an arbitrary point in the stream object with:
  - The SEEK or POSITION method of the Stream class
  - The COMMAND method's SEEK or POSITION argument
  - The *start* argument of the CHARIN method
  - The *line* argument of the LINEIN method

  When the stream object is opened, this position is the start of the stream.

In a transient stream, no read position is available. For a transient stream:

- The CHARS and LINES methods attempt to determine if data is present in the input stream object. These methods return the value **`1`** for a device if data is waiting to be read or a determination cannot be made. Otherwise, these methods return **`0`**.
- The SEEK and POSITION methods of the Stream class and the COMMAND method's **`SEEK`** and **`POSITION`** arguments are not applicable to transient streams.

14.1.2. Output Streams

Output stream methods provide for output from a Rexx program. Output stream methods are:

- SAY instruction—writes to the default output stream object (**`.OUTPUT`**).
- CHAROUT method—writes in character form to either the default or a specified output stream object.

- LINEOUT method—writes in lines to either the default or a specified output stream object.

LINEOUT and SAY write *line-end* characters at the end of each line. Depending on the operating system or hardware, other modifications or formatting can be applied; however, the output data remains a single logical line.

The Rexx language processor maintains the current write position in a stream. It is separate from the current read position. Write positioning is usually at the end of the stream (for example, when the stream object is first opened), so that data can be appended to the end of the stream. For persistent stream objects, you can set the write position to the beginning of the stream to overwrite existing data by giving a value of **`1`** for the CHAROUT *start* argument or the LINEOUT *line* argument. You can also use the CHAROUT *start* argument, the LINEOUT *line* argument, the SEEK or POSITION method, or the COMMAND method's **`SEEK`** or **`POSITION`** *stream_command* to direct sequential output to some arbitrary point in the stream.

Note

Once data is in a transient output stream object (for example, a network or serial link), it is no longer accessible to Rexx.

14.1.3. External Data Queue

Rexx provides queuing services entirely separate from interprocess communications queues.

The external data queue is a list of character strings that only line operations can access. It is external to Rexx programs in that other Rexx programs can have access to the queue.

The external data queue forms a Rexx-defined channel of communication between programs. Data in the queue is arbitrary; no characters have any special meaning or effect.

Apart from the explicit Rexx operations described here, no detectable change to the queue occurs while a Rexx program is running, except when control leaves the program and is manipulated by external means (such as when an external command or routine is called).

There are two kinds of queues in Rexx. Both kinds are accessed and processed by name.

14.1.3.1. Unnamed Queues

One unnamed queue is automatically provided for each Rexx program in operation. Its name is always "QUEUE:", and the language processor creates it when Rexx is called and no queue is currently available. All processes that are children of the process that created the queue can access it as long as the process that created it is still running. However, other processes cannot share the same unnamed queue. The queue is deleted when the process that created it ends.

14.1.3.2. Named Queues

Your program creates (and deletes) named queues. You can name the queue yourself or leave the naming to the language processor. Your program must know the name of the queue to use a named queue. To obtain the name of the queue, use the RXQUEUE function:

```
previous_queue=rxqueue("set",newqueuename)
```

This sets the new queue name and returns the name of the previous queue.

The following Rexx instructions manipulate the queue:

- PULL or PARSE PULL—reads a string from the head of the queue. If the queue is empty, these instructions take input from .INPUT.
- PUSH—stacks a line on top of the queue (LIFO).
- QUEUE—adds a string to the tail of the queue (FIFO).

Rexx functions that manipulate QUEUE: as a device name are:

- LINEIN("QUEUE:")--reads a string from the head of the queue. If the queue is empty the program waits for an entry to be placed on the queue.
- LINEOUT("QUEUE:","string")--adds a string to the tail of the queue (FIFO).
- QUEUED—returns the number of items remaining in the queue.

Here is an example of using a queue:

Example 14.3. Sample Rexx Procedure Using a Queue

```
/*                                                                         */
/* push/pull WITHOUT multiprogramming support                              */
/*                                                                         */
push date() time()                                /* push date and time      */
do 1000                                           /* let's pass some time    */
  nop                                             /* doing nothing           */
end                                               /* end of loop             */
pull a b                                          /* pull them               */
say "Pushed at " a b ", Pulled at " date() time() /* say now and then        */

/*                                                                         */
/*              push/pull WITH multiprogramming support                    */
/*        (no error recovery, or unsupported environment tests)            */
/*                                                                         */
newq = RXQUEUE("Create")                          /* create a unique queue   */
oq = RXQUEUE("Set",newq)                          /* establish new queue     */
push date() time()                                /* push date and time      */
do 1000                                           /* let's spend some time   */
  nop                                             /* doing nothing           */
end                                               /* end of loop             */
pull a b                                          /* get pushed information  */
say "Pushed at " a b ", Pulled at " date() time() /* tell user               */
call RXQUEUE "Delete",newq                   /* destroy unique queue created */
call RXQUEUE "Set",oq                  /* reset to default queue (not required) */
```

Special considerations:

- External programs that must communicate with a Rexx procedure through defined data queues can use the Rexx-provided queue or the queue that QUEUE: references (if the external program runs in a child process), or they can receive the data queue name through some interprocess communication technique, including argument passing, placement on a prearranged logical queue, or the use of usual interprocess communication mechanisms (for example, pipes, shared memory, or IPC queues).

- Named queues are available across the entire system. Therefore, the names of queues must be unique within the system. If a queue named **anyque** exists, using the following function:

  ```
  newqueue = RXQUEUE("Create", "ANYQUE")
  ```

  results in an error.

14.1.3.3. Multiprogramming Considerations

The top-level Rexx program in a process tree owns an unnamed queue. However, any child process can modify the queue at any time. No specific process or user owns a named queue. The operations that affect the queue are atomic—the subsystem serializes the resource so that no data integrity problems can occur. However, you are responsible for the synchronization of requests so that two processes accessing the same queue get the data in the order it was placed on the queue.

A specific process owns (creates) an unnamed queue. When that process ends, the language processor deletes the queue. Conversely, the named queues created with **`RxQueue("Create", queuename)`** exist until you explicitly delete them. The end of a program or procedure that created a named queue does not force the deletion of the private queue. When the process that created a queue ends, any data on the queue remains until the data is read or the queue is deleted. (The function call **`RxQueue("Delete", queuename)`** deletes a queue.)

If a data queue is deleted by its creator, a procedure, or a program, the items in the queue are also deleted.

14.1.4. Default Stream Names

A stream name can be a file, a queue, a pipe, or any device that supports character-based input and output. If the stream is a file or device, the name can be any valid file specification.

Windows and Unix-like systems define three default streams:

- stdin (file descriptor 0) - standard input
- stdout (file descriptor 1) - standard output
- stderr (file descriptor 2) - standard error (output)

Rexx provides .INPUT and .OUTPUT public objects. They default to the default input and output streams of the operating system. The appropriate default stream object is used when the call to a Rexx I/O function includes no stream name. The following Rexx statements write a line to the default output stream of the operating system:

```
Lineout(,"Hello World")
.Output~lineout("Hello World")
```

Rexx reserves the names **`STDIN`**, **`STDOUT`**, and **`STDERR`** to allow Rexx functions to refer to these stream objects. The checks for these names are not case-sensitive; for example, **`STDIN`**, **`stdin`**, and **`sTdIn`** all refer to the standard input stream object. If you need to access a file with one of these names, qualify the name with a directory specification, for example, **`\stdin`**.

Rexx also provides access to arbitrary file descriptors that are already open when Rexx is called. The stream name used to access the stream object is **`HANDLE:x`**. **`x`** is the number of the file descriptor you wish to use. You can use **`HANDLE:x`** as any other stream name; it can be the receiver of a Stream class method. If the value of **`x`** is not a valid file descriptor, the first I/O operation to that object fails.

Notes:

1. Once you close a **`HANDLE:x`** stream object, you cannot reopen it.

2. **`HANDLE:x`** is reserved. If you wish to access a file or device with this name, include a directory specification before the name. For example, **`\HANDLE:x`** accesses the file HANDLE:x in the current directory.

3. Programs that use the .INPUT and .OUTPUT public objects are independent of the operating environment.

14.1.5. Line versus Character Positioning

Rexx lets you move the read or write position of a persistent stream object to any location within the stream. You can specify this location in terms of characters or lines.

Character positioning is based upon the view of a stream as a simple collection of bytes of data. No special meaning is given to any single character. Character positioning alone can move the stream pointer. For example:

```
MyStream~charin(10,0)
```

moves the stream pointer so that the tenth character in MyStream is the next character read. But this does not return any data. If MyStream is opened for reading or writing, any output that was previously written but is still buffered is eliminated. Moving the write position always causes any buffered output to be written.

Line positioning views a stream as a collection of lines of data. There are two ways of positioning by lines. If you open a stream in binary mode and specify a record length of *x* on the open, a line break occurs every *x* characters. Line positioning in this case is an extension of character positioning. For example, if you open a stream in binary mode with record length 80, then the following two lines are exactly equivalent.

```
MyStream~command(position 5 read line)
MyStream~command(position 321 read char)
```

Remember that streams and other Rexx objects are indexed starting with one rather than zero.

The second way of positioning by lines is for non-binary streams. *Line-end* characters separate lines in non-binary streams. Because the line separator is contained within the stream, ensure accurate line positioning. For example, it is possible to change the line number of the current read position by writing extra line-end characters ahead of the read position or by overwriting existing line-end characters. Thus, line positioning in a non-binary stream object has the following characteristics:

- To do line positioning, it is necessary to read the stream in circumstances such as switching from character methods to line methods or positioning from the end of the stream.

- If you rewrite a stream at a point prior to the read position, the line number of the current read position could become inaccurate.

Note that for both character and line positioning, the index starts with one rather than zero. Thus, character position 1 and line position 1 are equivalent, and both point to the top of the persistent stream object. The Rexx I/O processing uses certain optimizations for positioning. These require that no other process is writing to the stream concurrently and no other program uses or manipulates the same low-level drive, directory specification, and file name that the language processor uses to open the file. If you need to work with a stream in these circumstances, use the system I/O functions.

14.2. Implementation

Usually, the dialog between a Rexx program and you as the user takes place on a line-by-line basis and is, therefore, carried out with the SAY, PULL, or PARSE PULL instructions. This technique considerably enhances the usability of many programs, because they can be converted to programmable dialogs by using the external data queue to provide the input you generally type. Use the PARSE LINEIN instruction only when it is necessary to bypass the external data queue.

When a dialog is not on a line-by-line basis, use the serial interfaces the CHARIN and CHAROUT methods provide. These methods are important for input and output in transient stream objects, such as keyboards, printers, or network environments.

Opening and closing of persistent stream objects, such as files, is largely automatic. Generally the first CHARIN, CHAROUT, CHARS, LINEIN, LINEOUT, or LINES message sent to a stream object opens that stream object. It remains open until you explicitly close it with a CHAROUT or LINEOUT or until the program ends. Using the LINEOUT method with only the name of a stream object (and no output *string* or *line*) closes the named stream object. The Stream class also provides OPEN and CLOSE methods and the COMMAND method, which can explicitly open or close a stream object.

If you open a stream with the CHARIN, CHAROUT, LINEIN, or LINEOUT methods, it is opened for both reading and writing, if possible. You can use the OPEN method or the COMMAND method to open a stream for read-only or write-only operations.

14.3. Operating System Specifics

The COMMAND method of the Stream class determines the state of an input or output stream object and carries out specific operations (see *Section 5.2.4.8, “command”*). It allows Rexx programs to open and close selected stream objects for read-only, write-only, or read and write operations, to move the read and write position within a stream object, to control the locking and buffering characteristics, and to obtain information (such as the size and the date of the last update).

14.4. Examples of Input and Output

In most circumstances, communication with a user running a Rexx program uses the default input and output stream objects. For a question and answer dialog, the recommended technique is to use the SAY and PULL instructions on the .INPUT and .OUTPUT objects. (You can use PARSE PULL if case-sensitive input is needed.)

It is generally necessary to write to, or read from, stream objects other than the default. For example, the following program copies the contents of one stream to another.

Example 14.4. FILECOPY program

```
/* FILECOPY.CMD */
/* This routine copies, as lines, the stream or     */
/* file that the first argument names to the stream */
/* or file the second argument names. It is assumed */
/* that the name is not an object, as it could be   */
/* if it is passed from another Rexx program.       */
```

```
parse arg inputname, outputname

inputobject = .stream~new(inputname)
outputobject = .stream~new(outputname)

signal on notready

do forever
  outputobject~lineout(inputobject~linein)
end
exit

notready:
return
```

As long as lines remain in the named input stream, a line is read and is then immediately written to the named output stream. This program is easy to change so that it filters the lines before writing them.

The following example illustrates how character and line operations can be mixed in a communications program. It converts a character stream into lines.

Example 14.5. COLLECT program

```
/* COLLECT.CMD */
/* This routine collects characters from the stream */
/* the first argument names until a line is         */
/* complete, and then places the line on the        */
/* external data queue.                             */
/* The second argument is a single character that   */
/* identifies the end of a line.                    */
parse arg inputname, lineendchar
inputobject = .stream~new(inputname)

buffer=""      /* zero-length character accumulator */
do forever
  nextchar=inputobject~charin
  if nextchar=lineendchar then leave
  buffer=buffer||nextchar          /* add to buffer */
  end
queue buffer /* place it on the external data queue */
```

Here each line is built up in a variable called **BUFFER**. When the line is complete (for example, when the user presses the Enter key) the loop ends and the language processor places the contents of **BUFFER** on the external data queue. The program then ends.

14.5. Errors during Input and Output

The Rexx language offers considerable flexibility in handling errors during input or output. This is provided in the form of a NOTREADY condition that the CALL ON and SIGNAL ON instructions can trap. The STATE and DESCRIPTION methods can elicit further information.

When an error occurs during an input or output operation, the function or method called usually continues without interruption (the output method returns a nonzero count). Depending on the nature of the operation, a program has the option of raising the NOTREADY condition. The NOTREADY condition is similar to the ERROR and FAILURE conditions associated with commands in that it does not cause a terminating error if the condition is raised but is not trapped. After NOTREADY has been raised, the following possibilities exist:

- If the NOTREADY condition is not trapped, processing continues without interruption. The NOTREADY condition remains in the OFF state.
- If SIGNAL ON NOTREADY traps the NOTREADY condition, the NOTREADY condition is raised. Processing of the current clause stops immediately, and the SIGNAL takes place as usual for condition traps.
- If CALL ON NOTREADY traps the NOTREADY condition, the NOTREADY condition is raised, but execution of the current clause is not halted. The NOTREADY condition is put into the delayed state, and processing continues until the end of the current clause. While processing continues, input methods that refer to the same stream can return the null string and output methods can return an appropriate count, depending on the form and timing of the error. At the end of the current clause, the CALL takes place as usual for condition traps.
- If the NOTREADY condition is in the DELAY state (CALL ON NOTREADY traps the NOTREADY condition, which has already been raised), processing continues, and the NOTREADY condition remains in the DELAY state.

After the NOTREADY condition has been raised and is in DELAY state, the **`"O"`** option of the CONDITION function returns the stream object being processed when the stream error occurred.

The STATE method of the Stream class returns the stream object state as **`ERROR`**, **`NOTREADY`**, or **`UNKNOWN`**. You can obtain additional information by using the DESCRIPTION method of the Stream class.

Note

`SAY .OUTPUT` and **`PULL .INPUT`** never raise the NOTREADY condition. However, the STATE and DESCRIPTION methods can return NOTREADY.

14.6. Summary of Rexx I/O Instructions and Methods

The following lists Rexx I/O instructions and methods:

- **`Stream`** method *charIn*
- **`Stream`** method *charOut*
- **`Stream`** method *chars*
- **`Stream`** method *close*
- **`Stream`** method *command*
- **`Stream`** method *description*
- **`Stream`** method *flush*
- **`Stream`** method *lineIn*
- **`Stream`** method *lineOut*
- **`Stream`** method *lines*
- **`Stream`** method *makeArray*
- **`Stream`** method *open*
- instruction *PARSE LINEIN*
- instruction *PARSE PULL*
- **`Stream`** method *position*

- instruction *PULL*
- instruction *PUSH*
- **`Stream`** method *qualify*
- **`Stream`** method *query*
- instruction *QUEUE*
- built-in function *QUEUED*
- instruction *SAY*
- **`Stream`** method *seek*
- **`Stream`** method *state*

Debugging Aids

In addition to the *TRACE* instruction there are the following debugging aids.

15.1. Interactive Debugging of Programs

The debug facility permits interactively controlled execution of a program. Adding the prefix character ? to the TRACE instruction, the TRACE function, or TRACE keyword of the ::OPTIONS directive. For example, **`TRACE ?I`**, **`TRACE(?I)`**, or **`::OPTIONS TRACE ?I`**) turns on interactive debugging and indicates to the user that interactive debugging is active. Further TRACE instructions in the program are ignored, and the language processor pauses after nearly all instructions that are traced at the console (see *Section 15.2, "Debugging Aids"* for the exceptions). When the language processor pauses, the following debug actions are available:

- Entering a null line causes the language processor to continue with the execution until the next pause for debugging input. Repeatedly entering a null line, therefore, steps from pause point to pause point. For **`TRACE ?A`**, for example, this is equivalent to single-stepping through the program.

- Entering an equal sign (=) with no surrounding whitespace causes the language processor to reexecute the clause last traced. For example, if an IF clause is about to take the wrong branch, you can change the value of the variables on which it depends, and then reexecute it.

  Once the clause has been reexecuted, the language processor pauses again.

- Anything else entered is treated as a line of one or more clauses, and processed immediately (that is, as though DO; line; END; had been inserted in the program). The same rules apply as for the INTERPRET instruction (for example, DO-END constructs must be complete). If an instruction contains a syntax error, a standard message is displayed and you are prompted for input again. Similarly, all other SIGNAL conditions are disabled while the string is processed to prevent unintentional transfer of control.

  During interpretation of the string, no tracing takes place, except that nonzero return codes from commands are displayed. The special variable RC and the environment symbol .RS are not set by commands executed from the string. Once the string has been processed, the language processor pauses again for further debugging input.

Interactive debug is turned off in either of the following cases:

- A TRACE instruction uses the ? prefix while interactive debug is in effect

- At any time, if **`TRACE O`** or **`TRACE`** with no options is entered

15.2. Debugging Aids

The numeric form of the TRACE instruction can be used to allow sections of the program to be executed without pause for debugging input. **`TRACE n`** (that is, a positive result) allows execution to continue, skipping the next **n** pauses (when interactive debugging is or becomes active). **`TRACE -n`** (that is, a negative result) allows execution to continue without pause and with tracing inhibited for **n** clauses that would otherwise be traced. The trace action a TRACE instruction selects is saved and restored across subroutine calls. This means that if you are stepping through a program (for example, after using **`TRACE ?R`** to trace results) and then enter a subroutine in which you have no interest, you can enter **`TRACE O`** to turn off tracing. No further instructions in the subroutine are traced, but on return to the caller, tracing is restored.

Similarly, if you are interested only in a subroutine, you can put a **TRACE ?R** instruction at its start. Having traced the routine, the original status of tracing is restored and, if tracing was off on entry to the subroutine, tracing and interactive debugging are turned off until the next entry to the subroutine.

Because any instructions can be executed in interactive debugging you have considerable control over the execution.

The following are some examples:

Example 15.1. Character inout and output

```
Say expr     /* displays the result of evaluating the          */
             /* expression                                     */

name=expr    /* alters the value of a variable                 */

Trace O      /* (or Trace with no options) turns off           */
             /* interactive debugging and all tracing          */

Trace ?A     /* turns off interactive debugging but            */
             /* continues tracing all clauses                  */

exit         /* terminates execution of the program            */

do i=1 to 10; say stem.i; end
             /* displays ten elements of the array stem.       */
```

Exceptions: Some clauses cannot safely be reexecuted, and therefore the language processor does not pause after them, even if they are traced. These are:

- Any repetitive DO clause, on the second or subsequent time around the loop.
- All END clauses.
- All THEN, ELSE, OTHERWISE, or null clauses.
- All RETURN and EXIT clauses.
- All SIGNAL clauses (but the language processor pauses after the target label is traced).
- Any clause that causes a syntax error. They can be trapped by SIGNAL ON SYNTAX, but cannot be reexecuted.

A pause occurs after a REPLY instruction, but the REPLY instruction cannot be reexecuted.

15.3. RXTRACE Variable

When the interpreter starts, it checks the setting of the special environment variable, *RXTRACE*. If *RXTRACE* has been set to **ON** (not case-sensitive), each time when starting a new Rexx procedure, the interpreter starts in interactive debug mode as if the Rexx instruction **TRACE '?R'** had been the first interpretable instruction. All other settings of *RXTRACE* are ignored. *RXTRACE* is only checked when starting a new Rexx interpreter, it is not checked each time when starting a new Rexx procedure.

Use the SET command to set or query an environment variable or query all environment variables. To delete an environment variable, use SET *variable*=.

Reserved Keywords

Keywords can be used as ordinary symbols in many unambiguous situations. The precise rules are given in this chapter.

The free syntax of Rexx implies that some symbols are reserved for use by the language processor in certain contexts.

Within particular instructions, some symbols can be reserved to separate the parts of the instruction. These symbols are referred to as keywords. Examples of Rexx keywords are the WHILE keyword in a DO instruction and the THEN keyword, which acts as a clause terminator in this case, following an IF or WHEN clause.

Apart from these cases, only simple symbols that are the first token in a clause and that are not followed by an "=" or ":" are checked to see if they are instruction keywords. The symbols can be freely used elsewhere in clauses without being understood as keywords.

Be careful with host commands or subcommands with the same name as Rexx keywords. To avoid problems, enclose at least the command or subcommand in quotation marks. For example:

```
"DELETE" Fn"."Ext
```

You can then also use the SIGNAL ON NOVALUE condition to check the integrity of an executable.

Alternatively, you can precede such command strings with two adjacent quotation marks to concatenate the null string to the beginning. For example:

```
""Erase Fn"."Ext
```

A third option is to enclose the entire expression, or the first symbol, in parentheses. For example:

```
(Erase Fn"."Ext)
```

Special Variables

A special variable can be set automatically during processing of a Rexx program. There are five special variables:

RC
: is set to the return code from any executed command (including those submitted with the ADDRESS instruction). After the trapping of ERROR or FAILURE conditions, it is also set to the command return code. When the SYNTAX condition is trapped, RC is set to the syntax error number (1-99). RC is unchanged when any other condition is trapped.

Note

Commands executed manually during interactive tracing do not change the value of RC.

RESULT
: is set by a *RETURN* instruction in a subroutine that has been called, or a method that was activated by a message instruction, if the RETURN instruction specifies an expression. If the RETURN instruction has no expression, RESULT is dropped (becomes uninitialized). Note that an *EXIT* or *REPLY* instruction also sets RESULT.

SELF
: is set when a method is activated. Its value is the object that forms the execution context for the method (that is, the receiver object of the activating message). You can use SELF to:

- Run a method in an object in which a method is already running. For example, a Find_Clues method is running in an object called Mystery_Novel. When Find_Clues finds a clue, it sends a Read_Last_Page message to Mystery_Novel:

```
self~Read_Last_Page
```

- Pass references about an object to the methods of other objects. For example, a Sing method is running in object Song. The code **`Singer2~Duet(self)`** would give the Duet method access to the same Song.

SIGL
: is set to the line number of the last instruction that caused a transfer of control to a label (that is, any SIGNAL, CALL, internal function call, or trapped condition). See *Section 11.3.4, "The Special Variable SIGL"*.

SUPER
: is set when a method is activated. Its value is the class object that is the usual starting point for a superclass method lookup for the SELF object. This is the first immediate superclass of the class that defined the method currently running. (See *Section 1.7, "Classes and Instances"*.) If the current method was defined by a class in the direct inheritance chain, SUPER will always refer to the immediate superclass of that class. If the current method is defined by a mixin class, the SUPER variable will always be the superclass of the mixin class.

The special variable SUPER lets you call a method in the superclass of an object. For example, the following Savings class has INIT methods that the Savings class, Account class, and Object class define.

Example 17.1. Using the SUPER variable

```
::class Account

::method INIT
expose balance
use arg balance
self~init:super          /* Forwards to the Object INIT method  */

::method TYPE
return "an account"

::method name attribute

::class Savings subclass Account

::method INIT
expose interest_rate
use arg balance, interest_rate
self~init:super(balance) /* Forwards to the Account INIT method */

::method type
return "a savings account"
```

When the INIT method of the Savings class is called, the variable SUPER is set to the Account class object. The instruction:

```
self~init:super(balance) /* Forwards to the Account INIT method */
```

calls the INIT method of the Account class rather than recursively calling the INIT method of the Savings class. When the INIT method of the Account class is called, the variable SUPER is assigned to the Object class.

Example 17.2. Forwarding an event

```
self~init:super          /* Forwards to the Object INIT method  */
```

calls the INIT method that the Object class defines.

You can alter these variables like any other variable, but the language processor continues to set RC, RESULT, and SIGL automatically when appropriate. The EXPOSE, PROCEDURE, USE and DROP instructions also affect these variables.

Rexx also supplies functions that indirectly affect the execution of a program. An example is the name that the program was called by and the source of the program (which are available using the PARSE SOURCE instruction). In addition, PARSE VERSION makes available the language version and date of Rexx implementation that is running. The built-in functions ADDRESS, DIGITS, FUZZ, FORM, and TRACE return other settings that affect the execution of a program.

Useful Services

The following section describes useful commands and services.

18.1. Windows Commands

COPY
: copies files.

DELETE
: deletes files.

DIR
: displays disk directories.

ERASE
: erases files.

MODE
: controls input and output device characteristics.

PATH
: defines or displays the search path for commands and Rexx programs. See also *Section 7.2.1, "Search Order"*.

SET
: displays or changes Windows environment variables. See also *Section 7.4.71, "VALUE"*.

18.2. Linux Commands

Most Commonly used commands are:

cp
: copies files and directories.

mv
: moves files and directories.

rm
: removes files and directories.

ls
: displays files and directories.

echo $path
: defines or displays the search path for commands and Rexx programs. See also *Section 7.2.1, "Search Order"*.

env
: displays or changes Linux environment variables.

Any other Linux command can be used. For a description of these commands, see the respective Linux documentation (for example, man-pages).

18.3. Subcommand Handler Services

For a complete subcommand handler description, see the *Open Object Rexx: Application Programming Interfaces*.

18.3.1. The RXSUBCOM Command

The RXSUBCOM command registers, drops, and queries Rexx subcommand handlers. A Rexx procedure or script file can use RXSUBCOM to register dynamic-link library subcommand handlers. Once the subcommand handler is registered, a Rexx program can send commands to the subcommand handler with the Rexx ADDRESS instruction. For example, Rexx Dialog Manager programs use RXSUBCOM to register the ISPCIR subcommand handler.

Example 18.1. Command RXSUBCOM — REGISTER option

```
"RXSUBCOM REGISTER ISPCIR ISPCIR ISPCIR"
Address ispcir
```

See *Section 2.1, "ADDRESS"* for details of the ADDRESS instruction.

18.3.1.1. RXSUBCOM REGISTER

RXSUBCOM REGISTER registers a dynamic-link library subcommand handler. This command makes a command environment available to Rexx.

Parameters:

envname
: The subcommand handler name. The Rexx ADDRESS instruction uses *envname* to send commands to the subcommand handler.

dllname
: The name of the dynamic-link library file containing the subcommand handler routine.

procname
: The name of the dynamic-link library procedure within *dllname* that Rexx calls as a subcommand handler.

Return codes:

0
: The command environment has been registered.

10
: A duplicate registration has occurred. An *envname* subcommand handler in a different dynamic-link library has already been registered. Both the new subcommand handler and the existing subcommand handler can be used.

30
: The registration has failed. Subcommand handler *envname* in library *dllname* is already registered.

1002

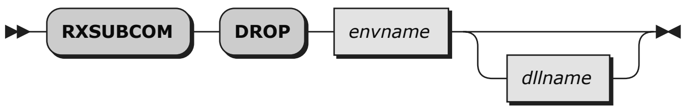
RXSUBCOM was unable to obtain the memory necessary to register the subcommand handler.

-1

A parameter is missing or incorrectly specified.

18.3.1.2. RXSUBCOM DROP

RXSUBCOM DROP deregisters a subcommand handler.



Parameters:

envname

The name of the subcommand handler.

dllname

The name of the dynamic-link file containing the subcommand handler routine.

Return codes:

0

The subcommand handler was successfully deregistered.

30

The subcommand handler does not exist.

40

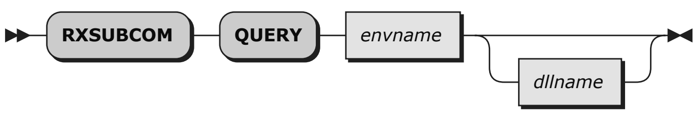
The environment was registered by a different process as RXSUBCOM_NONDROP.

-1

A parameter is missing or specified incorrectly.

18.3.1.3. RXSUBCOM QUERY

RXSUBCOM QUERY checks the existence of a subcommand handler. The query result is returned.



Parameters:

envname

The name of the subcommand handler.

dllname

The name of the dynamic-link file containing the subcommand handler routine.

Return codes:

0

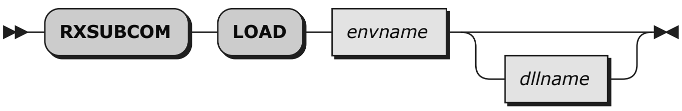
The subcommand handler is registered.

30
: The subcommand handler is not registered.

-1
: A parameter is missing or specified incorrectly.

18.3.1.4. RXSUBCOM LOAD

RXSUBCOM LOAD loads a subcommand handler dynamic-link library.



Parameters:

envname
: The name of the subcommand handler.

dllname
: The name of the dynamic-link file containing the subcommand handler routine.

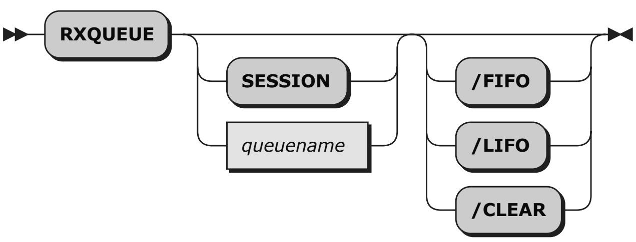
Return codes:

0
: The dynamic-link library was located and loaded successfully.

50
: The dynamic-link library was not located or could not be loaded.

-1
: A parameter is missing or incorrectly specified.

18.4. The RXQUEUE Filter



The RXQUEUE filter usually operates on the default queue named **`SESSION`**. However, if an environment variable named RXQUEUE exists, the RXQUEUE value is used for the queue name.

For a full description of Rexx queue services for applications programming, see *Section 14.1.3, "External Data Queue"*.

Parameters:

queuename
: The name of the named Rexx queue to stack or queue items to. If no *queuename* is given, **`SESSION`** is used.

/FIFO
: queues items from STDIN first in, first out (FIFO) on the Rexx queue. This is the default.

/LIFO
: stacks items from STDIN last in, first out (LIFO) on the Rexx queue.

/CLEAR
: removes all lines from the Rexx queue.

RXQUEUE takes output lines from another program and places them on a Rexx queue. There is currently a limit of 65472 characters for a single line. If a line contains more characters than the limit, those characters are discarded.

A Rexx procedure can use RXQUEUE to capture operating system command and program output for processing. RXQUEUE can direct output to any Rexx queue, either FIFO (first in, first out) or LIFO (last in, first out).

RXQUEUE uses the environment variable RXQUEUE for the default queue name. When RXQUEUE does not have a value, RXQUEUE uses **SESSION** for the queue name.

The following example obtains the Windows version number with RXQUEUE:

Example 18.2. Command RXQUEUE

```
/* Sample program to show simple use of RXQUEUE */
/* Find out the Windows version number, using the  */
/* VER command.  VER produces two lines of      */
/* output; one blank line, and one line with the*/
/* format "The Windows Version is n.nn"            */

"VER |RXQUEUE"         /* Put the data on the Queue      */
pull .                 /* Get and discard the blank line */
Pull . "VERSION" number "]" /* The bracket is required for
Windows 95, not for Windows NT */
Say "We are running on Windows Version" number
```

Note that the syntax of the version string that is returned by Windows can vary, so the parsing syntax for retrieving the version number may be different.

The following example processes output from the DIR command:

Example 18.3. Command RXQUEUE

```
/* Sample program to show how to use the RXQUEUE filter */
/* This program filters the output from a DIR command,  */
/* ignoring small files.  It displays a list of the     */
/* large files, and the total of the sizes of the large */
/* files.                                               */

size_limit = 10000            /* The dividing line      */
/* between large and small*/
size_total = 0                /* Sum of large file sizes*/
NUMERIC DIGITS 12             /* Set up to handle very  */
/* large numbers          */

/* Create a new queue so that this program cannot       */
/* interfere with data placed on the queue by another   */
/* program.                                             */
```

```
queue_name = rxqueue("Create")
Call rxqueue "Set", queue_name

"DIR /N | RXQUEUE" queue_name

/* DIR output starts with five header lines             */
Do 5
Pull .                     /* discard header line    */
End

/* Now all the lines are file or directory lines,       */
/* except for one at the end.                           */

Do queued() - 1               /* loop for lines we want */
Parse Pull . . size . name ./* get one name and size */
/* If the size field says "<DIR>", we ignore this    */
/* line.                                             */
If size <> "<DIR>" Then
/* Now check size, and display                    */
If size > size_limit Then Do
Say format(size,12) name
size_total = size_total + size
End
End

Say "The total size of those files is" size_total

/* Now we are done with the queue.  We delete it, which */
/* discards the line remaining in it.                   */

Call rxqueue "DELETE", queue_name
```

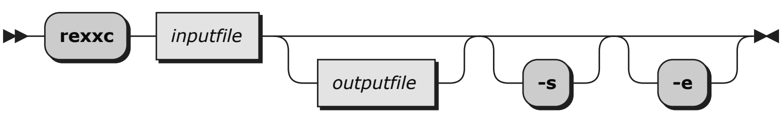
18.5. Distributing Programs without Source

Open Object Rexx comes with a utility called **`rexxc`**. You can use this utility to produce versions of your programs that do not include the original program source. You can use these programs to replace any Rexx program file that includes the source, with the following restrictions:

1. The *SOURCELINE* built-in function returns **`0`** for the number of lines in the program and raises an error for all attempts to retrieve a line.

2. A sourceless program may not be traced. The *TRACE* instruction runs without error, but no tracing of instruction lines, expression results, or intermediate expression values occurs.

The syntax of the **`rexxc`** utility is:



If you specify the *outputfile*, the language processor processes the *inputfile* and writes the executable version of the program to the *outputfile*. If the *outputfile* already exists, it is replaced.

If the language processor detects a syntax error while processing the program, it reports the error and stops processing without creating a new output file. If you omit the *outputfile*, the language processor performs a syntax check on the program without writing the executable version to a file.

You can use the **`-s`** option to suppress the display of the information about the interpreter used, and the **`-e`** option to create the *outputfile* in base64-encoded format, suitable when a 7-bit encoding is required.

On Windows, the **`-s`** and **`-e`** options can alternatively be specified as **`/s`** and **`/e`**.

Note

You can use the in-storage capabilities of the RexxStart programming interface to process the file image of the output file.

Appendix A. Using DO and LOOP

This appendix provides you with additional information about the DO and LOOP keyword instructions.

A.1. Simple DO Group

If you specify neither *repetitor* nor *conditional*, the DO construct only groups a number of instructions together. They are processed once. For example:

Example A.1. Simple DO block

```
/* The two instructions between DO and END are both  */
/* processed if A has the value "3".                 */
If a=3 then Do
   a=a+2
   Say "Smile!"
End
```

A.2. Repetitive Loops

If a DO or LOOP instruction has a repetitor phrase, a conditional phrase, or both, the group of instructions forms a repetitive loop. The instructions are processed according to the repetitor phrase, optionally modified by the conditional phrase. (See *Section A.3, “Conditional Phrases (WHILE and UNTIL)”*.)

A.2.1. Simple Repetitive Loops

A simple repetitive loop is a repetitive loop in which the repetitor phrase is an expression that evaluates to a count of the iterations.

If *repetitor* is omitted but there is a *conditional* or if the *repetitor* is FOREVER, the group of instructions is processed until the condition is satisfied or a Rexx instruction ends the loop (for example, LEAVE).

In the simple form of a repetitive loop, *exprr* is evaluated immediately (and must result in a positive whole number or zero), and the loop is then processed that many times.

Example A.2. Simple LOOP block

```
/* This displays "Hello" five times */
Loop 5
say "Hello"
end
```

Note that, similar to the distinction between a command and an assignment, if the first token of *exprr* is a symbol and the second token is (or starts with) **=**, the controlled form of *repetitor* is expected.

A.2.2. Controlled Repetitive Loops

The controlled form specifies *control1*, a *control variable* that is assigned an initial value (the result of *expri*, formatted as though **0** had been added) before the first execution of the instruction list. The variable is then stepped by adding the result of *exprb* before the second and subsequent times that the instruction list is processed.

The instruction list is processed repeatedly as long as the end condition (determined by the result of *exprt*) is not met. If *exprb* is positive or **0**, the loop is ended when *control1* is greater than *exprt*. If negative, the loop is ended when *control1* is less than *exprt*.

The *expri*, *exprt*, and *exprb* options must result in numbers. They are evaluated only once, before the loop begins and before the control variable is set to its initial value. The default value for *exprb* is **1**. If *exprt* is omitted, the loop runs infinitely unless some other condition stops it.

Example A.3. Simple LOOP block with conditions

```
Loop I=3 to -2 by -1      /* Displays:   */
  say i                   /*      3      */
end                       /*      2      */
                          /*      1      */
                          /*      0      */
                          /*     -1      */
                          /*     -2      */
```

The numbers do not have to be whole numbers:

Example A.4. Simple LOOP block with conditions

```
I=0.3                     /* Displays:   */
Do Y=I to I+4 by 0.7      /*     0.3     */
  say Y                   /*     1.0     */
end                       /*     1.7     */
                          /*     2.4     */
                          /*     3.1     */
                          /*     3.8     */
```

The control variable can be altered within the loop, and this can affect the iteration of the loop. Altering the value of the control variable is not considered good programming practice, though it can be appropriate in certain circumstances.

Note that the end condition is tested at the start of each iteration (and after the control variable is stepped, on the second and subsequent iterations). Therefore, if the end condition is met immediately, the group of instructions can be skipped entirely. Note also that the control variable is referred to by name. If, for example, the compound name **A.I** is used for the control variable, altering **I** within the loop causes a change in the control variable.

The execution of a controlled loop can be limited further by a FOR phrase. In this case, you must specify *exprf*, and it must evaluate to a positive whole number or zero. This acts like the repetition count in a simple repetitive loop, and sets a limit to the number of iterations around the loop if no other condition stops it. Like the TO and BY expressions, it is evaluated only once—when the instruction is first processed and before the control variable receives its initial value. Like the TO condition, the FOR condition is checked at the start of each iteration.

Example A.5. Simple LOOP block with limits

```
Loop Y=0.3 to 4.3 by 0.7 for 3  /* Displays:    */
  say Y                         /*     0.3      */
end                             /*     1.0      */
```

```
                                    /*     1.7      */
```

In a controlled loop, the *control1* name describing the control variable can be specified on the END clause. This *name* must match *control1* in the DO or LOOP clause in all respects except the case (note that no substitution for compound variables is carried out). Otherwise, a syntax error results. This enables the nesting of loops to be checked automatically, with minimal overhead.

Example A.6. Simple LOOP block with limits

```
Loop K=1 to 10
...
...
End k  /* Checks that this is the END for K loop */
```

Note

The NUMERIC settings can affect the successive values of the control variable because Rexx arithmetic rules apply to the computation of stepping the control variable.

A.2.3. Repetitive Loops over Collections

A collection loop specifies a control variable, *control2*, which receives a different value on each repetition of the loop. (For more information on *control2*, see *Section 2.4, "DO"*.) These different values are taken from successive values of *collection*. The *collection* is any expression that evaluates to an object that provides a `makeArray` method, including stem variables. The collection returned determines the set of values and their order. Array, List, and Queue items return an array with the items in the appropriate order, as do Streams. Tables, Stems, Directories, etc. are not ordered so the items get placed in the array in no particular order.

If the collection is a stem variable, the values are the tail names that have been explicitly assigned to the given stem. The order of the tail names is unspecified, and a program should not rely on any order.

For other collection objects, the `makeArray` method of the specific collection class determines the values assigned to the control variable.

All values for the loop iteration are obtained at the beginning of the loop. Therefore, changes to the target collection object do not affect the loop iteration. For example, using DROP to change the set of tails associated with a stem or using a new value as a tail does not change the number of loop iterations or the values over which the loop iterates.

As with controlled repetition, you can specify the symbol that describes the control variable on the END clause. The control variable is referenced by name, and you can change it within the loop (although this would not usually be useful). You can also specify the control variable name on an ITERATE or LEAVE instruction.

Example A.7. Simple LOOP block over a collection

```
Astem.=0
Astem.3="CCC"
Astem.24="XXX"
```

```
loop k over Astem.
   say k Astem.k
end k
```

This example can produce:

```
3 CCC
24 XXX
```

or:

```
24 XXX
3 CCC
```

See *Figure A.1, “Concept of a Loop”* for a diagram.

A.2.4. Repetitive Loops over Suppliers

A supplier loop specifies one or two control variables, *index*, and *item*, which receive a different value on each repetition of the loop. (For more information on *index* and *item*, see *Section 2.4, “DO”*.) These different values are taken from successive values of *supplier*. The *supplier* is any expression that evaluates to an object that provides a `supplier` method. The supplier returned determines the set of values and their order.

All values for the loop iteration are obtained at the beginning of the loop. Therefore, changes to the target object do not affect the loop iteration.

If you want to specify a *name* on the END clause or on an ITERATE or LEAVE instruction, you have to specify the LABEL keyword.

Example A.8. LOOP WITH over a supplier

```
loop with index name item method over .numericComparator~methods(.nil)
  say name method~isPrivate method~isProtected method~isGuarded
end
```

This example can produce:

```
COMPARE 0 0 1
INIT 0 0 1
```

A.3. Conditional Phrases (WHILE and UNTIL)

A conditional phrase can modify the iteration of a repetitive loop. It can cause the termination of a loop. It can follow any of the forms of *repetitor* (none, FOREVER, simple, controlled, OVER, or WITH). If you specify WHILE or UNTIL, *exprw* or *expru*, respectively, is evaluated after each loop using the latest values of all variables, and the loop is ended if *exprw* evaluates to **`0`** or *expru* evaluates to **`1`**.

For a WHILE loop, the condition is evaluated at the top of the group of instructions. For an UNTIL loop, the condition is evaluated at the bottom—before the control variable has been stepped.

Example A.9. Simple LOOP block with conditions

```
Loop I=1 to 10 by 2 until i>6
   say i
end
/* Displays: "1" "3" "5" "7" */
```

Note

Using the LEAVE or ITERATE instructions can also modify the execution of repetitive loops.

A.4. LABEL Phrase

The LABEL phrase may be used to specify a *name* for the DO or LOOP. The label can optionally be used for

- a LEAVE instruction to identify the block to be left
- an ITERATE instruction to identify the loop to be iterated
- the END clause of the block, for additional checking.

Example A.10. Simple LOOP block with label

```
Loop label outer I=1 to 10 by 2
   ...
   if i > 5 then do label inner
      ...
      if a = b then leave inner
      ...
      if c = b then iterate outer
   end inner
   ...
   say i
end outer
/* Displays: "1" "3" "5" "7" */
```

In this example, the LEAVE instruction will exit the inner DO block. The ITERATE instruction will iterate the out LOOP instruction.

If a LABEL phrase is used on a DO or LOOP, it overrides any name derived from any control variable name. That is, if label is used, the control variable cannot be used on a LEAVE, ITERATE, or END instruction to identify the block. Only the label name is valid.

A.5. COUNTER Phrase

The COUNTER phrase may be used on repetitive DO or LOOP instructions to specify a *ctr* variable that provides a count value for each repetition. *ctr* starts with **1** and increases by **1** for each repetition.

After the loop finishes, *ctr* will have the count value of the last repetition, or, if the loop had zero repetitions, *ctr* will be **`0`**.

Example A.11. Controlled DO loop with COUNTER

```
do counter ct x = -0.3 to 0.4 by 0.2
  say ct x
end
/* Displays: 1 -0.3, 2 -0.1, 3 0.1, 4 0.3 */
```

A.6. Conceptual Model of Loops

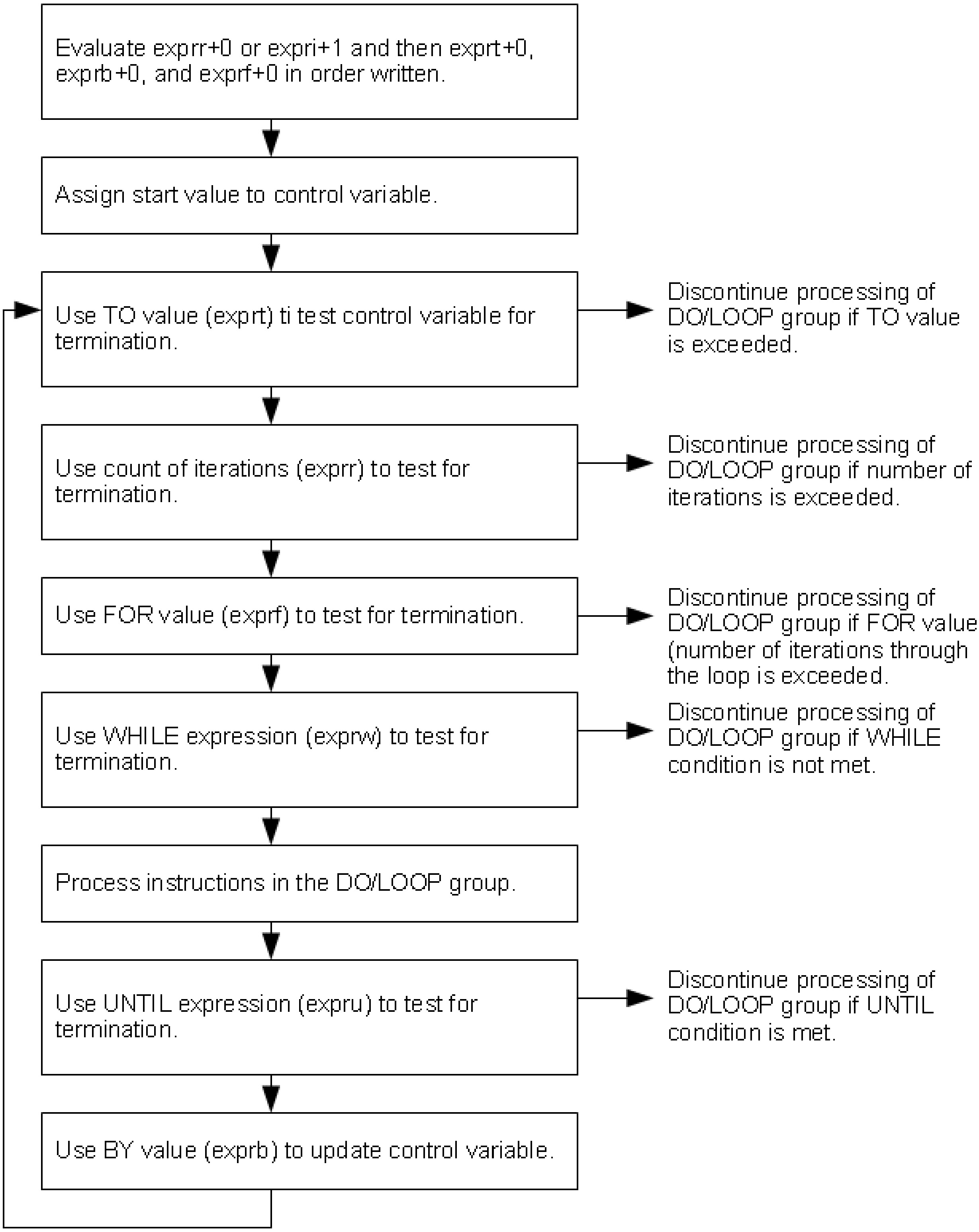


Figure A.1. Concept of a Loop

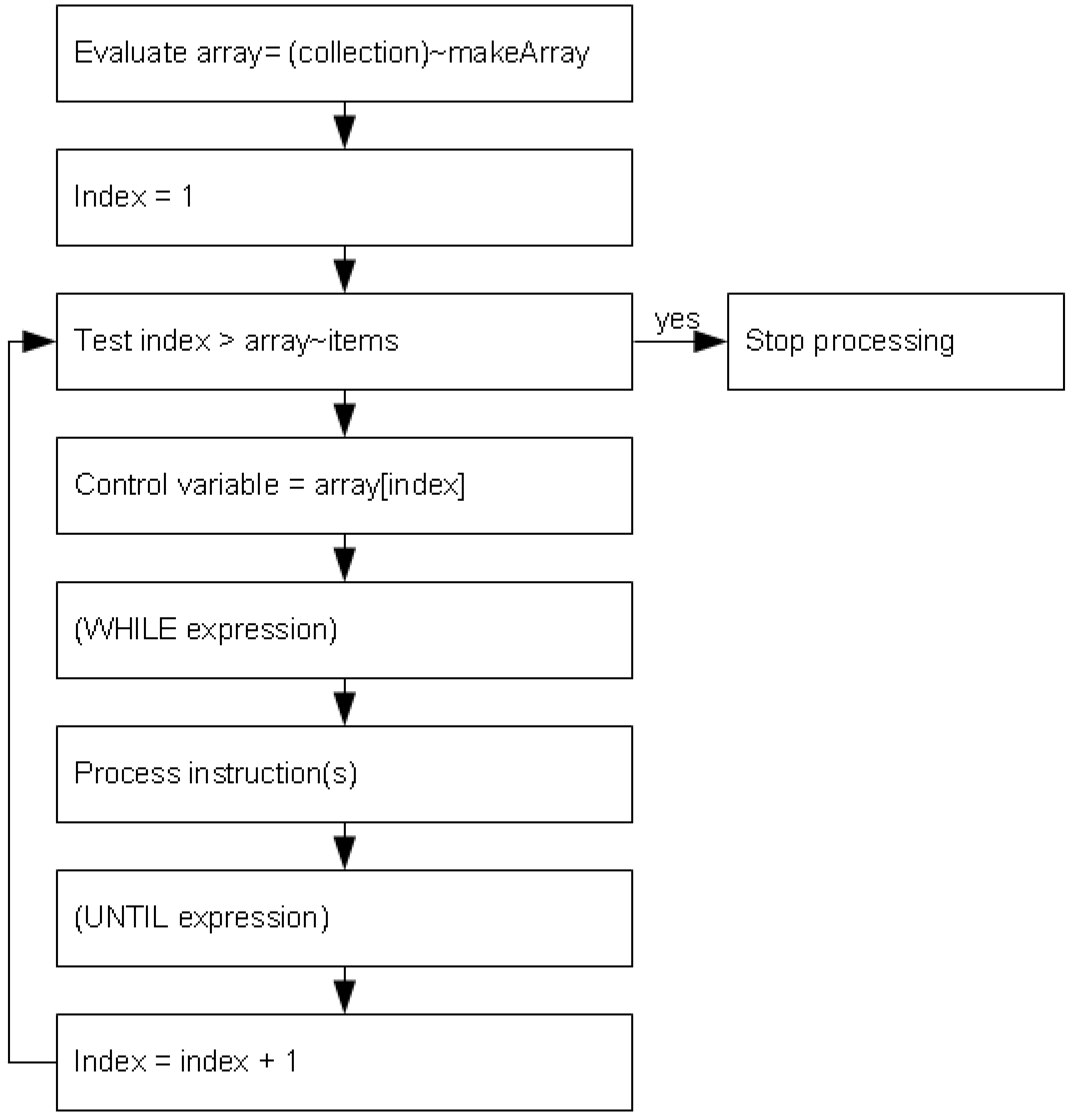


Figure A.2. Concept of Repetitive Loop over Collection

Appendix B. Migration

This appendix lists some differences between Open Object Rexx 5.0 and earlier versions of Open Object Rexx.

B.1. Incompatible ooRexx features

Functions or features which have been changed in ooRexx 5.0 in a way that will lead to incompatibilities with prior versions.

B.1.1. RexxUtil SysTempFileName

SysTempFileName on Unix-like platforms now behaves identically to SysTempFileName on Windows. It no longer uses only the first five characters of the file name part of the template, appending a random string to make it unique. It also no more prepends an operating system-chosen writable path if no path is given in the template. Instead it now uses the same filler-based mechanism as the Windows version does.

Existing ooRexx programs using SysTempFileName on Unix-like platforms will need to be amended.

B.2. Deprecated Rexx features

In exceptional circumstances, ooRexx may deprecate functions or features, which means the use of these functions is discouraged, documentation is no longer provided, and bug reports against deprecated functions will not be accepted. Reasons for deprecation include broken functionality, features that were never officially documented, or functions no longer required.

Although existing code using deprecated functions is expected to continue to work as-is, you are strongly encouraged to migrate to the replacement functionality, as these functions may be removed from future releases of the interpreter.

B.2.1. RexxUtil Semaphore functions

The following RexxUtil functions related to semaphore-processing have been deprecated.

SysCloseEventSem	SysPostEventSem
SysCloseMutexSem	SysPulseEventSem
SysCreateEventSem	SysReleaseMutexSem
SysCreateMutexSem	SysRequestMutexSem
SysOpenEventSem	SysResetEventSem
SysOpenMutexSem	SysWaitEventSem

They have been superseded by the new *EventSemaphore Class* and *MutexSemaphore Class*.

B.2.2. RexxUtil SysLoadFuncs/SysDropFuncs

The RexxUtil functions SysLoadFuncs and SysDropFuncs have been deprecated. Since ooRexx 4.0.0 these functions do nothing.

B.2.3. ::OPTIONS NOVALUE ERROR directive

The ::OPTIONS NOVALUE ERROR directive has been deprecated. It was renamed to *::OPTIONS* NOVALUE SYNTAX.

B.2.4. Class ArgUtil

The ArgUtil class and all of it methods have been deprecated. It has been superseded by *Validate Class*.

Appendix C. Error Numbers and Messages

The error numbers produced by syntax errors during the processing of Rexx programs are all in the range 1 to 99. Errors are raised in response to conditions, for example, SYNTAX, NOMETHOD, and PROPAGATE. When the condition is SYNTAX, the value of the error number is placed in the variable RC when SIGNAL ON SYNTAX is trapped.

You can use the ERRORTEXT built-in function to return the text of an error message.

Some errors have associated subcodes. A subcode is a one- to three-digit decimal extension to the error number, for example, **`115`** in **`40.115`**. When an error subcode is available, additional information that further defines the source of the error is given. The ERRORTEXT built-in function cannot retrieve the secondary message, but it is available from the condition object created when SIGNAL ON SYNTAX traps an error.

C.1. Error List

C.1.1. Error 3 - Failure during initialization.

Explanation:

The REXX program could not be read from the disk.

The associated subcodes are:

001
: Failure during initialization: File "*filename*" is unreadable.

900
: *message*.

901
: Failure during initialization: Program "*program*" was not found.

902
: Error writing output file "*file*".

903
: Program "*program_name*" cannot be run by this version of the REXX interpreter.

905
: Encoded compiled program "*program_name*" cannot be decoded.

C.1.2. Error 4 - Program interrupted.

Explanation:

The system interrupted the execution of your program because of an error or a user request.

The associated subcodes are:

001
: Program interrupted with *condition* condition.

900
: *message*.

C.1.3. Error 5 - System resources exhausted.

Explanation:

While trying to execute a program, the language processor was unable to get the resources it needed to continue. For example, it could not get the space needed for its work areas or variables. The program that called the language processor might itself have already used up most of the available storage. Or a request for storage might have been for more than the implementation maximum.

The associated subcodes are:

900
: *message*.

C.1.4. Error 6 - Unmatched "/*" or quote.

Explanation:

A comment or literal string was started but never finished. This could be because the language processor detected:

- The end of the program (or the end of the string in an INTERPRET instruction) without finding the ending "*/" for a comment or the ending quotation mark for a literal string
- The end of the line for a literal string.

The associated subcodes are:

001
: Unmatched comment delimiter ("/*") on line *line_number*.

002
: Unmatched single quote (').

003
: Unmatched double quote (").

900
: *message*.

C.1.5. Error 7 - WHEN or OTHERWISE expected.

Explanation:

At least one WHEN construct (and possibly an OTHERWISE clause) is expected within a SELECT instruction. This message is issued if any other instruction is found or there is no WHEN construct before the OTHERWISE or all WHEN expressions are false and an OTHERWISE is not present. A common cause of this error is if you forget the DO and END around the list of instructions following a WHEN. For example:

```
WRONG                   RIGHT

Select                  Select
When a=c then           When a=c then DO
Say 'A equals C'        Say 'A equals C'
exit                    exit
```

```
Otherwise nop              end
end                      Otherwise nop
end
```

The associated subcodes are:

001
: SELECT on line *line_number* requires WHEN.

002
: SELECT on line *line_number* requires WHEN, OTHERWISE, or END.

003
: All WHEN expressions of SELECT are false; OTHERWISE expected.

C.1.6. Error 8 - Unexpected THEN or ELSE.

Explanation:

A THEN or an ELSE clause was found that does not match a corresponding IF or WHEN clause. This often occurs because of a missing END or DO...END in the THEN part of a complex IF...THEN...ELSE construction. For example:

```
WRONG                     RIGHT

if a = b then do          if a = b then do
  say "equals"              say "equals"
  exit                      exit
else                      end
  say "not equals"        else
                            say "not equals"
```

The associated subcodes are:

001
: THEN has no corresponding IF or WHEN clause.

002
: ELSE has no corresponding THEN clause.

C.1.7. Error 9 - Unexpected WHEN or OTHERWISE.

Explanation:

A WHEN or OTHERWISE was found outside of a SELECT construction. You might have accidentally enclosed the instruction in a DO...END construction by leaving out an END, or you might have tried to branch to it with a SIGNAL instruction (which does not work because the SELECT is then ended).

The associated subcodes are:

001
: WHEN has no corresponding SELECT.

002
: OTHERWISE has no corresponding SELECT.

C.1.8. Error 10 - Unexpected or unmatched END.

Explanation:

More ENDs were found in your program than DO, LOOP, or SELECT instructions, or the ENDs did not match the DO, LOOP, or SELECT instructions. This message also occurs if you try to transfer control into the middle of a loop using SIGNAL. In this case, the language processor does not expect the END because it did not process the previous DO instruction. Remember also that SIGNAL deactivates any current loops, so it cannot transfer control from one place inside a loop to another.

Another cause for this message is placing an END immediately after a THEN or ELSE subkeyword or specifying a name on the END keyword that does not match the name following DO or LOOP. Putting the name of the control variable on ENDs that close repetitive loops can also help locate this kind of error.

The associated subcodes are:

001
: END has no corresponding DO, LOOP, or SELECT.

002
: Symbol following END ("*symbol*") must match block specification name ("*control_variable*") on line *line_number* or be omitted.

003
: END corresponding to block on line *symbol* must not have a symbol following it because there is no LABEL or control variable; found "*line_number*".

004
: Symbol following END ("*symbol*") must match LABEL of SELECT specification ("*control_variable*") on line *line_number* or be omitted.

005
: END must not immediately follow THEN.

006
: END must not immediately follow ELSE.

007
: END corresponding to SELECT on line *symbol* must not have a symbol following it because there is no LABEL; found "*line_number*".

C.1.9. Error 11 - Control stack full.

Explanation:

Your program exceeds the nesting level limit for control structures (for example, DO...END and IF...THEN...ELSE). This could be because of a looping INTERPRET instruction, such as:

```
line='INTERPRET line'
INTERPRET line
```

These lines loop until they exceed the nesting level limit and the language processor issues this message. Similarly, a recursive subroutine or internal function that does not end correctly can loop until it causes this message.

The associated subcodes are:

001
: Insufficient control stack space; cannot continue execution.

900
: *message*.

C.1.10. Error 13 - Invalid character in program.

Explanation:

A character was found outside a literal (quoted) string that is not a whitespace character or one of the valid alphanumeric and special characters.

The associated subcodes are:

001
: Incorrect character in program "*character*" ('*hex_character*'X).

900
: *message*.

C.1.11. Error 14 - Incomplete DO/LOOP/SELECT/IF.

Explanation:

At the end of the program or the string for an INTERPRET instruction, a DO, LOOP, or SELECT instruction was found without a matching END or an IF clause that is not followed by a THEN clause. Putting the name of the control variable on each END closing a controlled loop can help locate this kind of error.

The associated subcodes are:

001
: DO instruction on line *line_number* requires matching END.

002
: SELECT instruction on line *line_number* requires matching END.

003
: THEN on line *line_number* must be followed by an instruction.

004
: ELSE on line *line_number* must be followed by an instruction.

005
: DO or LOOP instruction on line *line_number* requires matching END.

901
: OTHERWISE on line *line_number* requires matching END.

C.1.12. Error 15 - Invalid hexadecimal or binary string.

Explanation:

Hexadecimal strings must not have leading or trailing whitespace characters and whitespace can only be embedded at byte boundaries. Only the digits 0-9 and the letters a-f and A-F are allowed. The following are valid hexadecimal strings:

```
'13'x
'A3C2 1c34'x
```

```
        '1de8'x
```

Binary strings can have whitespace only at the boundaries of groups of four binary digits. Only the digits 0 and 1 are allowed. These are valid binary strings:

```
        '1011'b
        '110 1101'b
        '101101 11010011'b
```

You might have mistyped one of the digits, for example, typing a letter O instead of the number 0. Or you might have used the one-character symbol X or B (the name of the variable X or B, respectively) after a literal string when the string is not intended as a hexadecimal or binary specification. In this case, use the explicit concatenation operator (||) to concatenate the string to the value of the symbol.

The associated subcodes are:

001
: Incorrect location of whitespace character in position *position* in hexadecimal string.

002
: Incorrect location of whitespace character in position *position* in binary string.

003
: Only 0-9, a-f, A-F, and whitespace characters are valid in a hexadecimal string; found "*character*".

004
: Only 0, 1, and whitespace characters are valid in a binary string; found "*character*".

005
: Hexadecimal strings must be grouped in units that are multiples of two characters.

006
: Binary strings must be grouped in units that are multiples of four characters.

C.1.13. Error 16 - Label not found.

Explanation:

A SIGNAL instruction has been executed or an event for which a trap was set with SIGNAL ON has occurred, and the language processor could not find the label specified. You might have mistyped the label or forgotten to include it.

The associated subcodes are:

001
: Label "*label_name*" not found.

C.1.14. Error 17 - Unexpected PROCEDURE.

Explanation:

A PROCEDURE instruction was encountered at an incorrect position. This could occur because no internal routines are active or because the PROCEDURE instruction was not the first instruction processed after the CALL instruction or function call. One cause for this error is dropping through to an internal routine, rather than calling it with a CALL instruction or a function call.

The associated subcodes are:

001
PROCEDURE is valid only when it is the first instruction executed after an internal CALL or function invocation.

901
INTERPRET data must not contain PROCEDURE.

C.1.15. Error 18 - THEN expected.

Explanation:

A THEN clause must follow each REXX IF or WHEN clause. The language processor found another clause before it found a THEN clause.

The associated subcodes are:

001
IF instruction on line *line_number* requires matching THEN clause.

002
WHEN instruction on line *line_number* requires matching THEN clause.

C.1.16. Error 19 - String or symbol expected.

Explanation:

A symbol or string was expected after the CALL or SIGNAL keywords but none was found. You might have omitted the string or symbol or inserted a special character (such as a parenthesis).

The associated subcodes are:

001
String or symbol expected after ADDRESS keyword.

002
String or symbol expected after CALL keyword.

003
String or symbol expected after NAME keyword.

004
String or symbol expected after SIGNAL keyword.

006
String or symbol expected after TRACE keyword.

007
String or symbol expected after PARSE keyword.

900
message.

901
String or symbol expected after ::CLASS keyword.

902
String or symbol expected after ::METHOD keyword.

903
String or symbol expected after ::ROUTINE keyword.

904
String or symbol expected after ::REQUIRES keyword.

905
String expected after EXTERNAL keyword.

906
String or symbol expected after METACLASS keyword.

907
String or symbol expected after SUBCLASS keyword.

908
String or symbol expected after INHERIT keyword.

909
String or symbol expected after tilde (~).

911
String or symbol expected after superclass colon (:).

912
String or symbol expected after STREAM keyword.

913
String or symbol expected after MIXINCLASS keyword.

914
String or symbol expected as ::ATTRIBUTE directive name.

915
String or symbol expected as ::CONSTANT directive name.

916
String or symbol expected as ::CONSTANT value.

917
String or symbol expected as DIGITS value.

918
String or symbol expected as FUZZ value.

919
String or symbol expected as TRACE value.

920
String or symbol expected as ::RESOURCE directive name.

921
String or symbol expected after ::RESOURCE END keyword.

922
String or symbol expected after *keyword* keyword.

923
: Symbol or string expected as ::ANNOTATE attribute value; found "*name*".

924
: Symbol or string expected as ::ANNOTATE attribute value.

925
: Symbol or string expected after *directive keyword* keyword.

C.1.17. Error 20 - Symbol expected.

Explanation:

A symbol is expected after CALL ON, CALL OFF, END, ITERATE, LEAVE, NUMERIC, PARSE, SIGNAL ON, or SIGNAL OFF. Also, a list of symbols or variable references is expected after DROP, EXPOSE, and PROCEDURE EXPOSE. Either there was no symbol when one was required or the language processor found another token.

The associated subcodes are:

900
: *message*.

901
: Symbol expected after DROP keyword.

902
: Symbol expected after EXPOSE keyword.

903
: Symbol expected after PARSE keyword.

904
: Symbol expected after PARSE VAR.

905
: NUMERIC must be followed by one of the keywords DIGITS, FORM, or FUZZ; found "*symbol*".

906
: Symbol expected after "(" of a variable reference.

907
: Symbol expected after LEAVE keyword.

908
: Symbol expected after ITERATE keyword.

909
: Symbol expected after END keyword.

911
: Symbol expected after ON keyword.

912
: Symbol expected after OFF keyword.

913
: Symbol expected after USE ARG.

914
: Symbol expected after RAISE keyword.

915
: Symbol expected after USER keyword.

916
: Symbol expected after ::.

917
: Symbol expected after superclass colon (:).

918
: Symbol expected after LABEL keyword.

919
: Symbol expected as ::ANNOTATE attribute name; found "*name*".

920
: Symbol expected after NAMESPACE keyword.

921
: Symbol expected as a class name of qualified class name.

922
: Symbol expected as a routine name of qualified CALL instruction.

923
: Symbol expected as a name of namespace-qualified symbol.

924
: Symbol expected for the ::ANNOTATE type.

925
: Symbol expected after the FORM keyword.

926
: Symbol expected after the DELEGATE keyword.

927
: Symbol expected after USE LOCAL.

928
: Symbol expected as an indirect variable name; found "*token*".

929
: Symbol expected after *keyword* keyword.

930
: Simple variable or stem symbol expected after > or < prefix operator; found *token*.

931
: Simple variable or stem symbol expected after > or < USE ARG reference operator; found *token*.

932
Stem symbol expected after STEM keyword.

933
Symbol expected after WITH keyword.

934
Symbol expected after COUNTER keyword.

C.1.18. Error 21 - Invalid data on end of clause.

Explanation:

A clause such as SELECT or NOP is followed by a token other than a comment.

The associated subcodes are:

900
message.

901
Data must not follow the NOP keyword; found "*data*".

902
Data must not follow the SELECT keyword; found "*data*".

903
Data must not follow the NAME keyword; found "*data*".

904
Data must not follow the condition name; found "*data*".

905
Data must not follow the SIGNAL label name; found "*data*".

906
Data must not follow the TRACE setting; found "*data*".

907
Data must not follow the LEAVE control variable name; found "*data*".

908
Data must not follow the ITERATE control variable name; found "*data*".

909
Data must not follow the END control variable name; found "*data*".

911
Data must not follow the NUMERIC FORM specification; found "*data*".

912
Data must not follow the GUARD OFF specification; found "*data*".

913
Data must not follow the ::CONSTANT value; found "*data*".

914
: Data must not follow the ::RESOURCE directive; found "*data*".

C.1.19. Error 22 - Invalid character string.

Explanation:

A literal string contains character codes that are not valid. This might be because some characters are not possible, or because the character set is extended and certain character combinations are not allowed.

The associated subcodes are:

001
: Incorrect character string "*character_string*" ('*hex_string*'X).

900
: *message*.

901
: Incorrect double-byte character.

C.1.20. Error 23 - Invalid data string.

Explanation:

A data string (that is, the result of an expression) contains character codes that are not valid. This might be because some characters are not possible, or because the character set is extended and certain character combinations are not allowed.

The associated subcodes are:

001
: Incorrect data string "*string*" ('*hex_string*'X).

900
: *message*.

C.1.21. Error 24 - Invalid TRACE request.

Explanation:

This message is issued when:

- The option on a TRACE instruction or the argument to the built-in function does not start with A, C, E, F, I, L, N, O, or R.
- In interactive debugging, you entered a number that is not a whole number.

The associated subcodes are:

001
: TRACE request letter must be one of "ACEFILNOR"; found "*value*".

901
: Numeric TRACE requests are valid only from interactive debugging.

C.1.22. Error 25 - Invalid subkeyword found.

Explanation:

An unexpected token was found at his position of an instruction where a particular subkeyword was expected. For example, in a NUMERIC instruction, the second token must be DIGITS, FUZZ, or FORM.

The associated subcodes are:

001
: CALL ON must be followed by one of the keywords ERROR, FAILURE, HALT, NOTREADY, USER, or ANY; found "*word*".

002
: CALL OFF must be followed by one of the keywords ERROR, FAILURE, HALT, NOTREADY, USER, or ANY; found "*word*".

003
: SIGNAL ON must be followed by one of the keywords ERROR, FAILURE, HALT, LOSTDIGITS, NOTREADY, NOMETHOD, NOSTRING, NOVALUE, SYNTAX, USER, or ANY; found "*word*".

004
: SIGNAL OFF must be followed by one of the keywords ERROR, FAILURE, HALT, LOSTDIGITS, NOTREADY, NOMETHOD, NOSTRING, NOVALUE, SYNTAX, USER, or ANY; found "*word*".

011
: NUMERIC FORM must be followed by one of the keywords SCIENTIFIC or ENGINEERING; found "*word*".

012
: PARSE must be followed by optional keywords LOWER or UPPER, by an optional keyword CASELESS, and by one of the keywords ARG, LINEIN, PULL, SOURCE, VALUE, VAR, or VERSION; found "*word*".

015
: NUMERIC must be followed by one of the keywords DIGITS, FORM, or FUZZ; found "*word*".

017
: PROCEDURE must be followed by the keyword EXPOSE or nothing; found "*word*".

900
: *message*.

901
: Unknown keyword on ::CLASS directive; found "*word*".

902
: Unknown keyword on ::METHOD directive; found "*word*".

903
: Unknown keyword on ::ROUTINE directive; found "*word*".

904
: Unknown keyword on ::REQUIRES directive; found "*word*".

905
USE must be followed by the keyword ARG, LOCAL or STRICT; found "*word*".

906
RAISE must be followed by one of the keywords ERROR, FAILURE, HALT, LOSTDIGITS, NOMETHOD, NOSTRING, NOTREADY, NOVALUE, PROPAGATE, SYNTAX, or USER; found "*word*".

907
Unknown keyword on RAISE instruction; found "*word*".

908
Duplicate DESCRIPTION keyword found.

909
Duplicate ADDITIONAL or ARRAY keyword found.

911
Duplicate RETURN or EXIT keyword found.

912
GUARD ON or GUARD OFF must be followed by the keyword WHEN; found "*word*".

913
GUARD must be followed by the keyword ON or OFF; found "*word*".

914
CALL ON condition must be followed by the keyword NAME; found "*word*".

915
SIGNAL ON condition must be followed by the keyword NAME; found "*word*".

916
Unknown keyword on FORWARD instruction; found "*keyword*".

917
Duplicate TO keyword found.

918
Duplicate ARGUMENTS or ARRAY keyword found.

919
Duplicate RETURN or CONTINUE keyword found.

921
Duplicate CLASS keyword found.

922
Duplicate MESSAGE keyword found.

923
SELECT must be followed by the keyword LABEL or CASE; found "*word*".

924
Unknown keyword on ::OPTIONS directive; found "*word*".

925
: Unknown keyword on ::ATTRIBUTE directive; found "*word*".

926
: Unknown keyword on ::RESOURCE directive; found "*word*".

927
: Unknown keyword following "*keyword*"; found "*word*".

928
: Unknown keyword on ::ANNOTATE directive; found "*word*".

929
: USE STRICT must be followed by the keyword ARG; found "*word*".

930
: Duplicate INPUT keyword found.

931
: Duplicate OUTPUT keyword found.

932
: Duplicate ERROR keyword found.

933
: Acceptable ADDRESS WITH I/O types are NORMAL, STEM, STREAM, and USING; found "*word*".

934
: WITH must be followed by one of the keywords INPUT, OUTPUT, or ERROR; found "*word*".

C.1.23. Error 26 - Invalid whole number.

Explanation:

An expression was found that did not evaluate to a whole number or is greater than the limit (the default is 999,999,999 for 32-bit system and 999,999,999,999,999,999 for 64-bit systems):

- The positional patterns in parsing templates (including variable positional patterns)
- The operand to the right of the power operator
- The values of exprr and exprf in the DO and LOOP instructions
- The values given for DIGITS or FUZZ in the NUMERIC instruction
- The number used in the option of the TRACE setting
- This error is also raised if the value is not permitted (for example, a negative repetition count in a DO instruction), or the division performed during an integer divide or remainder operation does not result in a whole number.

The associated subcodes are:

002
: Value of repetition count expression in DO or LOOP instruction must be zero or a positive whole number; found "*value*".

003
: Value of FOR expression in DO or LOOP instruction must be zero or a positive whole number; found "*value*".

004
: Positional pattern of PARSE template must be a whole number; found "*value*".

005
: DIGITS value must be a positive whole number; found "*value*".

006
: FUZZ value must be zero or a positive whole number; found "*value*".

007
: Number used in TRACE setting must be a whole number; found "*value*".

008
: Operand to the right of the power operator (**) must be a whole number; found "*value*".

011
: Result of % operation did not result in a whole number.

012
: Result of // operation did not result in a whole number.

900
: *message*.

901
: Result of a method call did not result in a whole number; found "*value*".

902
: Result of a COMPARETO method call did not result in a whole number; found "*value*".

903
: Result of a COMPARE method call did not result in a whole number; found "*value*".

904
: Stem "*stem*" element 0 is not a whole number; found "*count*".

C.1.24. Error 27 - Invalid DO or LOOP syntax.

Explanation:

A syntax error was found in a DO or LOOP instruction. You probably used BY, TO, FOR, WHILE, or UNTIL twice, used a WHILE and an UNTIL, or used BY, TO, or FOR when there is no control variable specified.

The associated subcodes are:

001
: Only one WHILE or UNTIL condition can be used on the same loop.

901
: Incorrect data following FOREVER keyword on the loop; found "*data*".

902
: DO or LOOP keyword *keyword* can be specified only once.

903
: No INDEX or ITEM control variable specified on a WITH loop.

904
: OVER keyword expected for a WITH loop.

905
: COUNTER keyword not allowed on a simple DO instruction.

C.1.25. Error 28 - Invalid LEAVE or ITERATE.

Explanation:

A LEAVE or ITERATE instruction was found at an incorrect position. Either no loop was active, or the name specified on the instruction did not match the control variable of any active loop. Note that internal routine calls and the INTERPRET instruction protect loops by making them inactive. Therefore, for example, a LEAVE instruction in a subroutine cannot affect a DO loop in the calling routine. You probably tried to use the SIGNAL instruction to transfer control within or into a loop. Because a SIGNAL instruction ends all active loops, any ITERATE or LEAVE instruction causes this message.

The associated subcodes are:

001
: LEAVE is valid only within a repetitive loop or labeled block instruction.

002
: ITERATE is valid only within a repetitive loop.

003
: Symbol following LEAVE ("*symbol*") must either match the label of a current loop or block instruction.

004
: Symbol following ITERATE ("*symbol*") must either match the label of a current loop or be omitted.

005
: Symbol following ITERATE ("*symbol*") does not match a repetitive block instruction.

C.1.26. Error 29 - Environment name too long.

Explanation:

The environment name specified on the ADDRESS instruction is longer than permitted for the system under which the interpreter is running.

The associated subcodes are:

001
: Environment name exceeds *limit* characters; found "*environment_name*".

C.1.27. Error 30 - Name or symbol too long.

Explanation:

A variable name, label name, or symbol has exceeded the allowed limit of 250 characters.

The associated subcodes are:

001
: Name or symbol exceeds 250 characters: "*name*".

900
: *message*.

C.1.28. Error 31 - Name starts with number or ".".

Explanation:

A variable was found whose name begins with a numeric digit or a period. You cannot assign a value to such a variable because you could then redefine numeric constants.

The associated subcodes are:

001
: A value cannot be assigned to a number; found "*number*".

002
: Variable symbol must not start with a number; found "*symbol*".

003
: Variable symbol must not start with a "."; found "*symbol*".

900
: *message*.

C.1.29. Error 33 - Invalid expression result.

Explanation:

The result of an expression was found not to be valid in the context in which it was used.

The associated subcodes are:

001
: Value of NUMERIC DIGITS ("*value*") must exceed value of NUMERIC FUZZ ("*value*").

002
: Value of NUMERIC DIGITS ("*value*") must not exceed *value*.

900
: *message*.

901
: Incorrect expression result following VALUE keyword of ADDRESS instruction.

902
: Incorrect expression result following VALUE keyword of SIGNAL instruction.

903
: Incorrect expression result following VALUE keyword of TRACE instruction.

904
: Incorrect expression result following SYNTAX keyword of RAISE instruction.

C.1.30. Error 34 - Logical value not 0 or 1.

Explanation:

An expression was found in an IF, WHEN, WHILE, or UNTIL phrase that did not result in a 0 or 1. Any value operated on by a logical operator must result in a 0 or 1. For example, the phrase "If result then exit rc" fails if result has a value other than 0 or 1.

The associated subcodes are:

001
: Value of expression following IF keyword must be exactly "0" or "1"; found "*value*".

002
: Value of expression following WHEN keyword must be exactly "0" or "1"; found "*value*".

003
: Value of expression following WHILE keyword must be exactly "0" or "1"; found "*value*".

004
: Value of expression following UNTIL keyword must be exactly "0" or "1"; found "*value*".

005
: Value of expression to the left of the logical operator "*operator*" must be exactly "0" or "1"; found "*value*".

006
: Value of logical list expression element must be exactly "0" or "1"; found "*value*".

900
: *message*.

901
: Logical value must be exactly "0" or "1"; found "*value*".

902
: Value of expression following GUARD keyword must be exactly "0" or "1"; found "*value*".

903
: Authorization return value must be exactly "0" or "1"; found "*value*".

904
: Property logical value must be exactly "0", "1", "true", or "false"; found "*value*".

905
: SELECT CASE comparison result must be exactly "0" or "1"; found "*value*".

906
: Supplier AVAILABLE method did not return exactly "0" or "1"; found "*value*".

C.1.31. Error 35 - Invalid expression.

Explanation:

An expression contains a grammatical error. Possible causes:

- An expression is missing when one is required
- You ended an expression with an operator
- You specified, in an expression, two operators next to one another with nothing in between them
- You did not specify a right parenthesis when one was required
- You used special characters (such as operators) in an intended character expression without enclosing them in quotation marks

The associated subcodes are:

001
: Incorrect expression detected at "*token*".

900
: *message*.

901
: Prefix operator "*operator*" is not followed by an expression term.

902
: Missing conditional expression following IF keyword.

903
: Missing conditional expression following WHEN keyword.

904
: Missing initial expression for DO or LOOP control variable.

905
: Missing expression following BY keyword.

906
: Missing expression following TO keyword.

907
: Missing expression following FOR keyword.

908
: Missing expression following WHILE keyword.

909
: Missing expression following UNTIL keyword.

911
: Missing expression following OVER keyword.

912
: Missing expression following INTERPRET keyword.

913
: Missing expression following OPTIONS keyword.

914
Missing expression following VALUE keyword of an ADDRESS instruction.

915
Missing expression following VALUE keyword of a SIGNAL instruction.

916
Missing expression following VALUE keyword of a TRACE instruction.

917
Missing expression following VALUE keyword of a NUMERIC FORM instruction.

918
Missing expression following assignment instruction.

919
Operator "*operator*" is not followed by an expression term.

921
Missing expression following GUARD keyword.

922
Missing expression following DESCRIPTION keyword of a RAISE instruction.

923
Missing expression following ADDITIONAL keyword of a RAISE instruction.

924
Missing "(" on expression list of the ARRAY keyword.

925
Missing expression following TO keyword of a FORWARD instruction.

926
Missing expression following ARGUMENTS keyword of a FORWARD instruction.

927
Missing expression following MESSAGE keyword of a FORWARD instruction.

928
Missing expression following CLASS keyword of a FORWARD instruction.

929
Missing expression in logical expression list.

930
Invalid or missing expression following "=" token of a USE ARG instruction.

931
Missing expression following "(" of parse template.

932
Missing expression for calculated CALL name.

933
Missing expression following CASE keyword of a SELECT instruction.

934
: Missing expression in WHEN case expression list.

935
: Missing expression following *keyword* keyword of a *instruction* instruction.

936
: Missing expression on ::CONSTANT directive.

C.1.32. Error 36 - Unmatched "(" or "[" in expression.

Explanation:

A matched parenthesis or bracket was found within an expression. There are more left parentheses than right parentheses or more left brackets than right brackets. To include a single parenthesis in a command, enclose it in quotation marks.

The associated subcodes are:

900
: *message*.

901
: Left parenthesis "(" in position *position* on line *line_number* requires a corresponding right parenthesis ")".

902
: Square bracket "[" in position *position* on line *line_number* requires a corresponding right square bracket "]".

C.1.33. Error 37 - Unexpected ",", ")", or "]".

Explanation:

Either a comma was found outside a function invocation, or there are too many right parentheses or right square brackets in an expression. To include a comma in a character expression, enclose it in quotation marks. For example, write the instruction:

```
Say Enter A, B, or C
```

as follows:

```
Say 'Enter A, B, or C'
```

The associated subcodes are:

001
: Unexpected ",".

002
: Unmatched ")" in expression.

900
: *message*.

901
: Unexpected "]".

C.1.34. Error 38 - Invalid template or pattern.

Explanation:

A special character that is not allowed within a parsing template (for example, "%") has been found, or the syntax of a variable pattern is incorrect (that is, no symbol was found after a left parenthesis). This message is also issued if you omit the WITH subkeyword in a PARSE VALUE instruction.

The associated subcodes are:

001
: Incorrect PARSE template detected at "*column_position*".

002
: Incorrect PARSE position detected at "*column_position*".

003
: PARSE VALUE instruction requires WITH keyword.

900
: *message*.

901
: Missing PARSE relative position.

C.1.35. Error 39 - Evaluation stack overflow.

Explanation:

The expression is too complex to be evaluated by the language processor.

C.1.36. Error 40 - Incorrect call to routine.

Explanation:

An incorrect call to a routine was found. Possible causes:

- You passed incorrect data (arguments) to the built-in or external routine.
- You passed too many arguments to the built-in, external, or internal routine.
- The external routine called was not compatible with the language processor.

If you did not try to call a routine, you might have a symbol or a string adjacent to a "(" when you meant it to be separated by a blank or other operator. The language processor would treat this as a function call. For example, write TIME(4+5) as follows: TIME*(4+5)

The associated subcodes are:

001
: External routine "*routine*" failed.

003
: Not enough arguments in invocation of *routine*; minimum expected is *number*.

004
: Too many arguments in invocation of *routine*; maximum expected is *number*.

005
: Missing argument in invocation of *routine*; argument *argument_number* is required.

011
function_name argument *argument_number* must be a number; found "*value*".

012
function_name argument *argument_number* must be a whole number; found "*value*".

013
function_name argument *argument_number* must be zero or positive; found "*value*".

014
function_name argument *argument_number* must be positive; found "*value*".

019
function_name argument 2, "*value*", is not in the format described by argument 3, "*value*".

021
function_name argument *argument_number* must not be a null string.

022
function_name argument *argument_number* must be a single character or null; found "*value*".

023
function_name argument *argument_number* must be a single character; found "*value*".

024
function_name argument *argument_number* must be a binary string; found "*value*".

025
function_name argument *argument_number* must be a hexadecimal string; found "*value*".

026
function_name argument *argument_number* must be a valid symbol; found "*value*".

027
function_name argument 1 must be a valid stream name; found "*value*".

028
function_name argument *argument_number* must be a character class name or a single character; found "*value*".

029
function_name conversion to format "*value*" is not allowed.

032
RANDOM difference between argument 1 ("*value*") and argument 2 ("*value*") must not exceed 999,999,999.

033
RANDOM argument 1 ("*argument*") must be less than or equal to argument 2 ("*argument*").

034
SOURCELINE argument 1 ("*argument*") must be less than or equal to the number of lines in the program (*argument*).

035
X2D argument 1 cannot be expressed as a whole number; found "*value*".

043
: *function_name* argument *number* must be a single non-alphanumeric character or the null string; found "*value*".

044
: *function_name* argument *number*, "*value*", is a format incompatible with the separator specified in argument *number*.

900
: *message*.

901
: Result returned by *routine* is longer than *length*: "*value*".

902
: *function_name* argument *argument_number* must not exceed the whole number limit.

903
: *function_name* argument *argument_number* must be in the range 0-99; found "*value*".

904
: *function_name* argument *argument_number* must be one of *values*; found "*value*".

905
: TRACE setting letter must be one of "ACEFILNOR"; found "*value*".

912
: *function_name* argument *argument_number* must be a single-dimensional array; found "*value*".

913
: *function_name* argument *argument_number* must have a string value; found "*value*".

914
: Unknown VALUE function variable environment selector; found "*value*".

915
: *function_name* cannot be used with QUEUE:.

916
: Cannot read from a write-only property.

917
: Cannot write to a read-only property or typelib element.

918
: Invalid native function signature specification.

919
: Argument *argument* must have a stem object or stem name value; found "*value*".

920
: *function_name* argument *name* must be one of "*option*"; found "*value*".

921
: Argument *first option* ("*first value*") must be greater than argument *second option* ("*second value*").

922
: Stem argument does not have a valid count for element 0.

923
: The operation is outside the size of the stem array ("*value*").

924
: Stem element at position "*position*" is not set.

925
: Argument *argument* must be an array object, a stem object, or a stem name value; found "*value*".

C.1.37. Error 41 - Bad arithmetic conversion.

Explanation:

A term in an arithmetic expression is not a valid number or has an exponent outside the allowed range of whole number range.

You might have mistyped a variable name, or included an arithmetic operator in a character expression without putting it in quotation marks.

The associated subcodes are:

001
: Nonnumeric value ("*value*") used in arithmetic operation.

003
: Nonnumeric value ("*value*") used with prefix operator.

004
: Value of TO expression of DO or LOOP instruction must be numeric; found "*value*".

005
: Value of BY expression of DO or LOOP instruction must be numeric; found "*value*".

006
: Value of control variable expression of DO or LOOP instruction must be numeric; found "*value*".

007
: Exponent exceeds *number* digits; found "*value*".

900
: *message*.

901
: Value of RAISE instruction SYNTAX expression must be numeric; found "*value*".

C.1.38. Error 42 - Arithmetic overflow/underflow.

Explanation:

The result of an arithmetic operation requires an exponent that is greater than the platform limit of nine digits.

This error can occur during the evaluation of an expression (often as a result of trying to divide a number by 0) or while stepping a loop control variable.

The associated subcodes are:

001
: Arithmetic overflow detected at: "*value operator value*".

002
: Arithmetic underflow detected at: "*value operator value*".

003
: Arithmetic overflow; divisor must not be zero.

900
: *message*.

901
: Arithmetic overflow; exponent ("*exponent*") exceeds *number* digits.

902
: Arithmetic underflow; exponent ("*exponent*") exceeds *number* digits.

903
: Arithmetic underflow; zero raised to a negative power.

C.1.39. Error 43 - Routine not found.

Explanation:

A function has been invoked within an expression or a subroutine has been invoked by a CALL, but it cannot be found. Possible reasons:

- The specified label is not in the program
- It is not the name of a built-in function
- The language processor could not locate it externally

Check if you mistyped the name.

If you did not try to call a routine, you might have put a symbol or string adjacent to a "(" when you meant it to be separated by a blank or another operator. The language processor then treats it as a function call. For example, write the string 3(4+5) as 3*(4+5).

The associated subcodes are:

001
: Could not find routine "*routine*".

900
: *message*.

901
: Could not find file "*file*" for ::REQUIRES.

902
: Routine "*routineName*" not found in namespace "*namespace*".

C.1.40. Error 44 - Function or message did not return data.

Explanation:

The language processor called an external routine within an expression. The routine seemed to end without error, but it did not return data for use in the expression.

You might have specified the name of a program that is not intended for use as a REXX function. Call it as a command or subroutine instead.

The associated subcodes are:

001
: No data returned from function "*function*".

900
: *message*.

C.1.41. Error 45 - No data specified on function RETURN.

Explanation:

A REXX program has been called as a function, but returned without passing back any data.

The associated subcodes are:

001
: Data expected on RETURN instruction because routine "*routine*" was called as a function.

C.1.42. Error 46 - Invalid variable reference.

Explanation:

Within an ARG, DROP, EXPOSE, PARSE, PULL, or PROCEDURE instruction, the syntax of a variable reference (a variable whose value is to be used, indicated by its name being enclosed in parentheses) is incorrect. The right parenthesis that must immediately follow the variable name might be missing or the variable name might be misspelled.

The associated subcodes are:

001
: Extra token ("*token*") found in variable reference list; ")" expected.

900
: *message*.

901
: Missing ")" in variable reference.

902
: Extra token ("*token*") found in USE ARG variable reference; "," or end of instruction expected.

C.1.43. Error 47 - Unexpected label.

Explanation:

A label was used in the expression being evaluated for an INTERPRET instruction or in an expression entered during interactive debugging.

The associated subcodes are:

001
: INTERPRET data must not contain labels; found "*label*".

C.1.44. Error 48 - Failure in system service.

Explanation:

The language processor stopped processing the program because a system service, such as stream input or output or the manipulation of the external data queue, has failed to work correctly.

The associated subcodes are:

001
: Failure in system service: *service*.

900
: *message*.

C.1.45. Error 49 - Interpretation error.

Explanation:

A severe error was detected in the language processor or execution process during internal self-consistency checks.

The associated subcodes are:

001
: Interpretation error: unexpected failure initializing the interpreter.

002
: Interpretation error: unmatched *type number*.

900
: *message*.

C.1.46. Error 88 - Invalid argument.

Explanation:

An argument passed to a method, function, or routine was not valid.

The associated subcodes are:

900
: *message*.

901
: Missing argument; argument *argument* is required.

902
: The *argument* argument must be a number; found "*value*".

903
: The *argument* argument must be a whole number; found "*value*".

904
: The *argument* argument must be zero or a positive whole number; found "*value*".

905
: Argument *argument* must be a positive whole number; found "*value*".

906
: Argument *argument* must not exceed *limit*; found "*value*".

907
: Argument *argument* must be in the range *min* to *max*; found "*value*".

908
: Argument *argument* must not be a null string.

909
: Argument *argument* must have a string value.

910
: Argument *argument* is an invalid pad or character argument; found "*value*".

911
: Argument *argument* is an invalid length value; found "*value*".

912
: Argument *argument* is an invalid position value; found "*value*".

913
: Argument *argument* must be a single-dimensional array.

914
: Argument *argument* must be an instance of the *class* class.

915
: Argument *argument* could not be converted to a *type* type.

916
: Argument *argument* must be one of *values*; found "*value*".

917
: Argument *argument reason*.

918
: Argument *argument* is not in a valid format; found "*value*".

919
: Argument *argument* is not in valid pointer format; found "*value*".

920
: Argument *argument* must be a stem object or stem name; found "*value*".

921
: Argument *argument* must be a valid double value; found "*value*".

922
: Too many arguments in invocation; *number* expected.

923
: *name* argument *argument_number* must be a single-dimensional array; found "*value*".

924
: *name* argument *argument_number* must be an array with exactly *count* items.

925

The *argument* argument must be zero or a positive number; found "*value*".

926

The *argument* argument must be a positive number; found "*value*".

927

The *argument* argument must be exactly "0" or "1"; found "*value*".

928

The *argument* argument must be a VariableReference instance; found "*value*".

929

The *argument* argument must be a VariableReference for a Stem variable; found "*value*".

930

The *argument* argument must be a VariableReference for a simple variable; found "*value*".

931

Argument *argument* was omitted. A VariableReference argument is required.

932

Date template *template* contains an invalid pattern; found "*value*".

933

Unable to parse date "*date*" with template "*template*".

C.1.47. Error 89 - Variable or message term expected.

Explanation:

An instruction was expecting either a single Rexx variable symbol or a message term to be used for an assignment.

The associated subcodes are:

001

The USE instruction requires a comma-separated list of variables or assignment message terms.

002

The PARSE instruction was expecting a variable or a message term.

C.1.48. Error 90 - External name not found.

Explanation:

An external method or routine (specified with the EXTERNAL option on an ::ATTRIBUTE, a ::METHOD, or a ::ROUTINE directive) cannot be found.

The associated subcodes are:

900

message.

997

Unable to find external class "*class*".

998

Unable to find external method "*method*".

999

Unable to find external routine "*routine*".

C.1.49. Error 91 - No result object.

Explanation:

A message term requires a result object, but the method did not return one.

The associated subcodes are:

900

message.

999

Message "*message*" did not return a result.

C.1.50. Error 92 - OLE error.

The associated subcodes are:

900

message.

901

An unknown OLE error occurred (HRESULT=*hresult*).

902

Cannot convert OLE VARIANT to REXX object: The conversion of the VARIANT type *varianttype* into a REXX object failed.

903

Cannot convert REXX object to OLE VARIANT: The conversion of *rexx_object* into a VARIANT failed.

904

The number of elements provided to the method or property is different from the number of parameters accepted by it.

905

One of the parameters is not a valid VARIANT type.

906

OLE exception: *exc_name*.

907

The requested method does not exist, or you tried to set the value of a read-only property.

908

One of the parameters could not be coerced to the desired type.

909

One or more of the parameters could not be coerced to the desired type. The first parameter with incorrect type is argument *index*.

910
: A required parameter was omitted.

911
: Could not create OLE instance.

912
: The object invoked has disconnected from its clients.

C.1.51. Error 93 - Incorrect call to method.

Explanation:

The specified method, built-in function, or external routine exists, but you used it incorrectly.

The associated subcodes are:

900
: *message*.

901
: Not enough arguments for method; *number* expected.

902
: Too many arguments in invocation of method; *number* expected.

903
: Missing argument in method; argument *argument* is required.

904
: Method argument *argument* must be a number; found "*value*".

905
: Method argument *argument* must be a whole number; found "*value*".

906
: Method argument *argument* must be zero or a positive whole number; found "*value*".

907
: Method argument *argument* must be a positive whole number; found "*value*".

908
: Method argument *argument* must not exceed *limit*; found "*value*".

909
: Method argument *argument* must be in the range 0-99; found "*value*".

911
: Method argument *argument* must not be null.

912
: Method argument *argument* must be a hexadecimal string; found "*value*".

913
: Method argument *argument* must be a valid symbol; found "*value*".

914
: Method argument *argument* must be one of *arguments*; found "*value*".

915
: Method option must be one of "*arguments*"; found "*value*".

917
: Method *method* does not exist.

918
: Incorrect list index "*index*".

919
: Incorrect array position "*position*".

921
: Argument missing on binary operator.

922
: Incorrect pad or character argument specified; found "*value*".

923
: Invalid length argument specified; found "*value*".

924
: Invalid position argument specified; found "*value*".

925
: Not enough subscripts for array; *number* expected.

926
: Too many subscripts for array; *number* expected.

927
: Length must be specified to convert a negative value.

928
: D2X value must be a valid whole number; found "*value*".

929
: D2C value must be a valid whole number; found "*value*".

931
: Incorrect location of whitespace character in position *position* in hexadecimal string.

932
: Incorrect location of whitespace character in position *position* in binary string.

933
: Only 0-9, a-f, A-F, and whitespace characters are valid in a hexadecimal string; character found "*character*".

934
: Only 0, 1, and whitespace characters are valid in a binary string; character found "*character*".

935
: X2D result is not a valid whole number with NUMERIC DIGITS *digits*.

936
: C2D result is not a valid whole number with NUMERIC DIGITS *digits*.

937
: No more supplier items available.

938
: Method argument *argument* must have a string value.

939
: Method argument *argument* must have a single-dimensional array value.

940
: *method* method target must be a whole number; found "*value*".

941
: Exponent of "*exponent*" is too large for *number* spaces.

942
: Integer part of "*integer*" is too large for *number* spaces.

943
: *method* method target must be a number; found "*value*".

944
: Method argument *argument* must be a message object.

945
: Missing argument in message array; argument *argument* is required.

946
: A message array must be a single-dimensional array with 2 elements.

947
: Method SECTION can be used only on single-dimensional arrays.

948
: Method argument *argument* must be of the *class* class.

949
: The value and index objects must be the same for PUT to an index-only collection.

951
: Incorrect alarm time; found "*time*".

952
: Method argument *argument* is an array and does not contain all string values.

953
: Method argument *argument* could not be converted to type *type*.

954
: Method "*method*" can be used only on a single-dimensional array.

956
Element *element* of the array must be a string.

957
Target object "*object*" is not a subclass of the message override scope (*scope*).

958
Positioning of transient streams is not valid.

959
An array cannot contain more than *size* elements.

961
The *argument* argument must be a string or array object.

962
Invalid Base64 encoded string.

963
Call to unsupported or unimplemented method.

964
Application error: *message*.

965
Method *name* is ABSTRACT and cannot be directly invoked.

966
Incorrect queue index "*index*".

967
NEW method is not supported for the *name* class.

968
Invalid native method signature specification.

969
Method argument *argument* must have a stem object value; found "*value*".

970
COPY method is not supported for object *object*.

971
Method argument *argument* cannot have more than a single dimension.

972
A message name argument must be a string or an array with 2 elements; found "*value*".

973
ORDERABLE comparison method "*method*" argument cannot be .nil.

974
The *argument* argument must be a string, array, or method object.

975
Invalid *option* value; found "*value*".

976
: Hexadecimal strings must be grouped in units that are multiples of two characters.

977
: Binary strings must be grouped in units that are multiples of four characters.

978
: Method argument *argument* could not be converted to type *type*; found "*value*".

C.1.52. Error 97 - Object method not found.

Explanation:

The object does not have a method with the given name. A frequent cause of this error is an uninitialized variable.

The associated subcodes are:

001
: Object "*object*" does not understand message "*message*".

002
: Object "*object*" cannot accept private message "*message*" from this context.

003
: Object "*object*" cannot accept package scope message "*message*" from a different package caller.

004
: Constant "*name*" of object "*object*" has not been initialized.

005
: An unhandled NOMETHOD condition has been raised.

900
: *message*.

C.1.53. Error 98 - Execution error.

Explanation:

The language processor detected a specific error during execution. The associated error gives the reason for the error.

The associated subcodes are:

900
: *message*.

901
: Object "*object*" was not correctly initialized.

902
: Unable to convert object "*object*" to a double-float value.

903
: Unable to load library "*name*".

904
: Abnormal termination occurred.

905
: Deadlock detected on a guarded method.

906
: Incorrect object reference detected.

907
: Object of type "*type*" was required.

908
: Metaclass "*metaclass*" not found.

909
: Class "*class*" not found.

911
: Cyclic inheritance in program "*program*".

913
: Unable to convert object "*object*" to a single-dimensional array value.

914
: Unable to convert object "*object*" to a string value.

915
: A message object that was sent a START message cannot be sent another START, SEND, or REPLY message.

916
: Message object "*object*" received an error from message "*message*".

917
: Incorrect condition object received for RAISE OBJECT; found "*value*".

918
: No active condition available for PROPAGATE.

919
: Unable to convert object "*object*" to a method.

920
: Unable to open file "*file*" for writing; open result was "*error*".

921
: Address environment "*address*" does not support input/output redirection.

922
: REPLACE or APPEND cannot be specified with a RexxQueue object USING target.

923
: Address command redirection failed (*oserror*).

924
: Object "*object*" is not a valid ADDRESS WITH INPUT source.

935
: REPLY can be issued only once per method invocation.

936
: RETURN cannot return a value after a REPLY.

937
: EXIT cannot return a value after a REPLY.

938
: Message search overrides can be used only from methods of the target object.

939
: Additional information for SYNTAX errors must be a single-dimensional array of values.

941
: Unknown error number specified on RAISE SYNTAX; found "*number*".

942
: Class "*class*" must be a MIXINCLASS for INHERIT.

943
: Class "*class*" is not a subclass of "*class*" base class "*class*".

944
: Class "*class*" cannot inherit from itself, a superclass, or a subclass ("*class*").

945
: Class "*class*" has not inherited class "*class*".

946
: FORWARD arguments must be a single-dimensional array of values.

947
: FORWARD can only be issued in an object method invocation.

948
: Authorization failure: *value*.

951
: Concurrency not supported.

952
: Circular ::REQUIRES references detected with *name*.

970
: External command "*command*" ended with return code *rc*.

971
: External command "*command*" failed with return code *rc*.

972
: Number *number* has more digits than the current precision.

973
: Object "*object*" does not have a string representation.

974
: Stream "*object*" is not ready.

975
: Missing array element at position *position*.

976
: Stem object default value cannot be another stem object.

978
: Unable to load method "*name*" from library "*library*".

979
: Unable to load routine "*name*" from library "*library*".

980
: Unable to load native routine "*name*".

981
: Target RexxContext is no longer active.

982
: Library "*name*" is not compatible with current interpreter version.

983
: Execution thread does not match API thread context.

984
: User additions are not allowed to the REXX package.

985
: User additions are not allowed to the REXX language classes.

986
: Reference to unassigned variable "*name*".

987
: Namespace "*namespace*" not found in package "*package*".

988
: Class "*className*" not found in namespace "*namespace*".

989
: Class *name* is ABSTRACT and cannot be directly created.

990
: Class *name* is a metaclass and cannot be made ABSTRACT.

991
: Method *name* may only be invoked from a method of the same object or one of its classes.

992
: The EXPOSE instruction may only be used from method invocations.

993
: The USE LOCAL instruction may only be used from method invocations.

994
: Unable to convert object "*object*" to a supplier object.

995
: Unable to reference variable "*object*"; it must be an uninitialized local variable.

996
: Object "*object*" is not a valid ADDRESS WITH OUTPUT or ERROR target.

997
: REPLACE or APPEND cannot be specified with a Stream object USING target.

998
: Stem "*object*" does not contain a size count in element 0.

999
: Unable to open file "*file*" for reading; open result was "*error*".

C.1.54. Error 99 - Translation error.

Explanation:

An error was detected in the language syntax. The associated error subcode identifies the syntax error.

The associated subcodes are:

900
: *message*.

901
: Duplicate ::CLASS directive instruction.

902
: Duplicate ::METHOD directive instruction.

903
: Duplicate ::ROUTINE directive instruction.

904
: Duplicate ::REQUIRES directive instruction.

905
: CLASS keyword on ::METHOD directive requires a matching ::CLASS directive.

906
: A ::CONSTANT directive with an expression requires a matching ::CLASS directive.

907
: EXPOSE must be the first instruction executed after a method invocation.

908
: INTERPRET data must not contain EXPOSE.

909
GUARD must be the first instruction executed after EXPOSE or USE.

910
USE LOCAL must be the first instruction executed after a method invocation.

911
GUARD can only be issued in an object method invocation.

912
INTERPRET data must not contain GUARD.

913
GUARD instruction did not include references to exposed variables.

914
INTERPRET data must not contain directive instructions.

915
INTERPRET data must not contain USE LOCAL.

916
Unrecognized directive instruction.

917
Incorrect external name specification "*name*".

918
USE ARG requires a "," between variable names; found "*token*".

919
REPLY can only be issued in an object method invocation.

921
Incorrect program line in method source array.

922
::REQUIRES directives must appear before other directive instructions.

923
INTERPRET data must not contain FORWARD.

924
INTERPRET data must not contain REPLY.

925
An ATTRIBUTE method name must be a valid variable name; found "*name*".

926
Incorrect class external; too many parameters.

927
"*classname*" is not a valid metaclass.

928
Incorrect class external; class name missing or invalid.

929
Incorrect class external; invalid class server "*servername*".

930
The "..." argument marker can only appear at the end of the argument list.

931
Duplicate ::ATTRIBUTE directive instruction.

932
Duplicate ::CONSTANT directive instruction.

933
Abstract methods cannot have a method body.

934
Attribute methods cannot have a method body.

935
External attributes cannot have a method body.

936
External methods cannot have a method body.

937
Attribute methods without a SET or GET designation cannot have a method body.

938
Constant methods cannot have a method body.

939
External routines cannot have a code body.

940
Abstract attributes cannot have a method body.

941
Method or routine code may not contain directive instructions.

942
Duplicate ::RESOURCE directive instruction.

943
Missing ::RESOURCE end marker "*endmarker*" for resource "*resourcename*".

944
The REXX name is reserved for the language-provided namespace.

945
::ANNOTATE target *type* "*name*" not found.

946
Delegate methods cannot have a method body.

947
Delegate attributes cannot have a method body.

948
: USE LOCAL cannot process compound variables; found "*variable*".

949
: "*classname*" is not a valid class.

950
: A USE ARG default value is not allowed for variable references.

C.2. RXSUBCOM Utility Program

RXSUBCOM issues the following errors:

C.2.1. Error 116 - The RXSUBCOM REGISTER parameters are incorrect.

Explanation:

RXSUBCOM REGISTER requires the following parameters:

RXSUBCOM REGISTER envname dllname procname

envname
: is the name of the subcommand handler.

. dllname
: is the name of the file containing the subcommand handler routine.

. procname
: is the name of the procedure that REXX calls as a subcommand handler.

C.2.2. Error 117 - The RXSUBCOM DROP parameters are incorrect.

Explanation:

RXSUBCOM DROP requires the environment name be specified.

RXSUBCOM DROP envname [dllname]

envname
: is the name of the subcommand handler.

. dllname
: is the name of the file containing the subcommand handler routine (optional).

C.2.3. Error 118 - The RXSUBCOM LOAD parameters are incorrect.

Explanation:

RXSUBCOM LOAD requires the environment name be specified.

RXSUBCOM LOAD envname [dllname]

envname
: is the name of the subcommand handler.

. dllname
: is the name of the file containing the subcommand handler routine (optional).

C.2.4. Error 125 - The RXSUBCOM QUERY parameters are incorrect.

Explanation:

RXSUBCOM QUERY requires the environment name be specified.

RXSUBCOM QUERY envname [dllname]

envname
: is the name of the subcommand handler.

dllname
: is the name of the file containing the subcommand handler routine (optional).

C.3. RXQUEUE Utility Program

RXQUEUE issues the following errors:

C.3.1. Error 119 - The REXX rxapi queuing system is not available.

C.3.2. Error 120 - The size of the data is incorrect.

Explanation:

The data supplied to the RXQUEUE command is too long. The RXQUEUE program accepts data records containing 0 - 65472 bytes. A record exceeded the allowable limits.

C.3.3. Error 121 - Storage for data queues is exhausted.

Explanation:

The queuing system is out of memory. No more storage is available to store queued data.

C.3.4. Error 122 - The name %1 is not a valid queue name.

Explanation:

The queue name contains an invalid character. Only the following characters can appear in queue names:

```
        'A' .. 'Z', '0' .. '9', '.', '!', '?', '_'
```

C.3.5. Error 123 - The queue access mode is not correct.

Explanation:

An internal error occurred in RXQUEUE. The RXQUEUE program tried to access a queue with an incorrect access mode. Correct access modes are LIFO and FIFO.

C.3.6. Error 124 - The queue %1 does not exist.

Explanation:

The command attempted to access a nonexistent queue.

C.3.7. Error 131 - The syntax of the command is incorrect.

C.3.8. Error 132 - System error occurred while processing the command.

C.4. rexxc Utility Program

When rexxc encounters a syntax error in a Rexx program while translating or syntax checking it, it returns the negated ooRexx error code. In addition, rexxc issues the following errors:

C.4.1. Error 127 - The rexxc command parameters are incorrect.

Explanation:

The rexxc utility was invoked with zero or more than two parameters. rexxc accepts the following parameters:

- To check the syntax of a REXX program: rexxc inputfile [-s]
- To translate a REXX program into a sourceless executable file: rexxc inputfile outputfile [-s] [-e]
- The -s option suppresses the copyright banner and the -e option generates the outputfile in base64-encoded format.
- On Windows the -s and -e options can alternatively be specified as /s and /e.

C.4.2. Error 128 - Output file name must be different from input file name.

C.4.3. Error 129 - SYNTAX: rexxc inputfile [outputfile] [-s] [-e]

C.4.4. Error 130 - Without outputfile rexxc only performs a syntax check.

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Revision 0-0 **Aug 2016**

Initial creation for 5.0

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