

Onyx Manual, Version 5.1.2

Jason Evans <jasone@canonicalware.com>

March 16, 2005

Preface

This manual primarily documents the Onyx programming language. However, Onyx is designed to be run either as a stand alone program or as an embeddable interpreter, so the manual also documents different aspects of the implementation that are important when embedding Onyx into another program.

Onyx came into existence when the author started working on a text editor (since mothballed) that was meant to be extensible. One of the goals was to provide robust multi-threading. Unfortunately, when work began on the text editor in 1999, the author was unable to find any embeddable scripting languages that provided adequate support for threads. Thus Onyx was born. The author was familiar and enamored with Adobe's PostScriptTM language, which has basic threading support when used in a Display PostScriptTM environment, so Onyx started off looking very similar. As Onyx matured, it deviated to the point that it is now a truly different language, with different syntax, additional and more powerful data types, better debugging capabilities, POSIX-related functionality, more powerful threading, regular expressions, etc.

As this project grew far beyond what was originally expected, it became clear that in order to justify the effort being put into Onyx's design and implementation, Onyx would have to be usable for more than just a text editor. Therefore, Onyx has been structured such that it can be configured in a myriad of ways, with the hope that others will be able to easily make it fit their needs. This manual documents Onyx in its full glory without mention that features may be disabled, so there are portions that do not apply to Onyx interpreters that have been configured without Onyx's full feature set.

For software distributions, news, and additional project information, see <http://www.canonware.com/onyx/>. The author is interested in hearing how people are using Onyx, so please do not hesitate to email him comments or questions.

Contents

1 Onyx Language Tutorial	1
1.1 Syntax	1
1.2 Data types	2
1.3 Execution	3
1.4 Memory management	3
1.5 Stacks	3
1.5.1 Efficiency issues	4
1.5.2 Using stacks as queues	5
1.5.3 Using the operand stack as two stacks	5
1.6 Dictionaries	5
1.6.1 Efficiency issues	6
1.7 Regular expressions	6
1.7.1 Matching	6
1.7.2 Splitting	7
1.7.3 Substituting	8
1.8 Code organization	8
1.8.1 Procedures	9
1.8.2 Modules	9
1.9 Error handling	9
1.10 Introspection	10
1.11 Threads	11
1.11.1 Implicit synchronization	11
1.11.2 General threading concerns	11
1.12 Optimization	12

1.13 Debugging	12
2 Onyx Language Reference	15
2.1 Objects	15
2.2 Syntax	19
2.3 Stacks	22
2.4 Standard I/O	23
2.5 Interpreter recursion	23
2.6 Error handling	24
2.7 Threads	25
2.7.1 Implicit synchronization	25
2.7.2 Explicit synchronization	26
2.8 Memory management	26
2.9 Regular expressions	27
2.10 Object-oriented programming	28
2.11 Dictionary reference	28
2.11.1 currenterror	28
2.11.2 envdict	34
2.11.3 errordict	34
2.11.4 gdict	36
2.11.5 globaldict	39
2.11.6 onyxdict	39
2.11.7 outputsdict	41
2.11.8 sprintsdict	51
2.11.9 systemdict	63
2.11.10threaddict	228
2.11.11threadsdict	230
2.11.12userdict	230
2.12 Class reference	230
2.12.1 vclass	230
2.12.2 mclass	238
2.12.3 module	240

2.13	Module reference	245
2.13.1	modclopt	245
3	The onyx program	259
3.1	Usage	259
3.2	Environment variables	259
3.3	Initialization for interactive sessions	260
3.4	Language differences	260
4	The libonyx library	261
4.1	Compilation	262
4.2	Global variables	262
4.3	Multiple interpreters	262
4.4	Threads	262
4.5	Garbage collection	263
4.6	Exceptions	263
4.7	Integration issues	263
4.7.1	Thread creation	263
4.7.2	Restarted interrupted system calls	263
4.7.3	Signals	264
4.8	Guidelines for writing extensions	264
4.9	API	264
4.10	Classes	269
4.10.1	ch	269
4.10.2	cnd	272
4.10.3	dch	274
4.10.4	mb	276
4.10.5	mem	277
4.10.6	mq	280
4.10.7	mtx	283
4.10.8	nx	284
4.10.9	nxa	287
4.10.10	nxm	290

4.10.11	nxn	292
4.10.12	nxo	292
4.10.13	nxo_array	295
4.10.14	nxo_boolean	297
4.10.15	nxo_class	298
4.10.16	nxo_condition	300
4.10.17	nxo_dict	301
4.10.18	nxo_file	303
4.10.19	nxo_fino	310
4.10.20	nxo_handle	310
4.10.21	nxo_instance	312
4.10.22	nxo_integer	314
4.10.23	nxo_mark	315
4.10.24	nxo_mutex	315
4.10.25	nxo_name	316
4.10.26	nxo_no	317
4.10.27	nxo_null	317
4.10.28	nxo_operator	317
4.10.29	nxo_pmark	318
4.10.30	nxo_real	318
4.10.31	nxo_regex	319
4.10.32	nxo_regsub	322
4.10.33	nxo_stack	324
4.10.34	nxo_string	328
4.10.35	nxo_thread	330
4.10.36	ql	340
4.10.37	qr	344
4.10.38	qs	346
4.10.39	thd	348
4.10.40	tsd	351
4.10.41	xep	352
4.11	Dictionaries	355

4.11.1	gcdict	355
4.11.2	systemdict	355
LICENSES		363
Index		365

List of Tables

2.1	Simple and composite types	16
2.2	Interpretation/evaluation of objects by type and attribute	17
2.3	Substitution template special characters	28
2.4	currenterror summary	29
2.5	errordict summary	34
2.6	gdict summary	36
2.7	onyxdict summary	39
2.8	outputsdict summary	41
2.9	sprintsdict summary	52
2.10	systemdict summary	63
2.11	threaddict summary	229
2.12	vclass summary	231
2.13	mclass summary	238
2.14	module summary	241
2.15	clopt summary	245

Chapter 1

Onyx Language Tutorial

This manual includes a comprehensive Onyx Language Reference chapter, which explains the details of what Onyx is. However, that chapter is rather dry, and more importantly, it does not discuss how to best utilize Onyx. This chapter introduces concepts that are important when designing and implementing Onyx programs, though it is not a complete language tutorial. You will need to read the first several sections of Chapter 2 in order to absorb all of the information in this chapter. However, you should be able to read this chapter first, then come back to it and glean additional understanding after having read later chapters.

Onyx is a stack-based language, so although the ideas that are important to program design in other more traditional languages still apply in many cases, there are different ways of approaching certain problems that integrate better with the facilities provided by Onyx. The most obvious example of this is that Onyx programs are more efficient if written to use named variables as little as possible, relying instead on the power of the operand stack. Another example is error handling. It is possible to write procedures that check for every error condition, but Onyx provides a form of exception handling that, if used correctly, can significantly improve code readability and performance.

Accomplished PostScript programmers will find little new in this chapter; Onyx differs from PostScript in the details, but the concepts are very similar. Accomplished Forth programmers will already be comfortable with stack management, but the rest of the chapter discusses concepts that either have no Forth equivalent, or that are significantly different from Forth, as is the case for dictionaries.

1.1 Syntax

Onyx syntax is extremely simple. Code is essentially composed of tokens that are delimited by whitespace or a list of self-delimiting tokens (see Section 2.2 for details). As such, there are very few ways for a syntax error to occur, but typographical mistakes may instead produce other errors. For example, say that a C programmer forgets he is writing Onyx code and types the following at the interactive *onyx* prompt:

```
onyx:0> 1000L {'Hello\n' print} repeat
```

The intention is to print `Hello` 1000 times, but `1000L` is invalid syntax for an integer, so Onyx creates an executable name object instead, and then tries to execute the name, resulting in the following error:

```
Error $undefined
```

```
ostack: ()
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      1000L
1:      -file-
2:      --start--
```

This is typical of the simple errors encountered when writing Onyx code. The Onyx scanner uses a simple state machine to try to create objects of various types, and when it fails, the input is instead used to create an executable name.

The scanner only deals with a few types (ignoring procedures for the moment): integers, reals, names, and strings. There are many other object types, but none of them are created directly by the scanner.

{ and } are used to delimit procedure bodies, which in actuality are executable arrays. { puts the scanner into deferred execution mode until the matching } is scanned. {} pairs can be nested, so execution is deferred until matching } characters have been scanned for all { characters. Deferred execution means that the scanner creates objects as it scans code, but does not execute any of them. While not a strictly necessary language feature, this greatly simplifies the task of constructing executable arrays, which can then be treated as procedures.

Following are equivalent examples of how a procedure associated with the name `double` can be defined:

```
onyx:0> $double {2 mul} def
onyx:0> $double [ 2 $mul load ] cvx def
```

As mentioned earlier, there are few ways of generating a syntax error, but it is possible. The most common syntax errors are due to unmatched ' and } characters. Generating other syntax errors is left as an exercise for the reader.

1.2 Data types

Onyx includes a rich set of data types. In fact, Onyx code is represented as data, which means that there is a whole range of possibilities when writing Onyx programs that are difficult or impossible with compiled languages such as C. This aspect of Onyx is discussed in Section 1.10.

Onyx is dynamically typed, which means that errors due to object type incompatibilities are detected during program execution. For example, the following code will always run without an error, even though the arguments that would be passed to the **add** operator are invalid.

```
false {
  'a string' [1] add
} {
  'This is always printed' 1 sprint
} ifelse
```

Dynamic typing has advantages in the flexibility that it offers, but it also means that type errors can go undetected in code for long periods of time before the invalid code is executed.

Onyx has a fixed set of basic types which cannot be extended. However, object-oriented programming is supported, so the fixed set of object types is not a limitation in practice. Object-oriented programming is discussed more in Section 2.10.

1.3 Execution

Onyx code is never compiled, nor is it preprocessed by the interpreter. Onyx code is simply consumed. This has some interesting implications, some of which are not typical of even other interpreted languages:

- If a source file is modified during interpreter execution, the changes may affect the currently running program, usually in unpleasant ways.
- Syntax errors are not discovered until the malformed code is scanned. In order to be sure that there are no syntax errors, a source file must be completely scanned.

In practice, these are only minor inconveniences, but it is important to keep them in mind when developing.

1.4 Memory management

Since Onyx includes an automatic mark and sweep garbage collector, memory management typically requires little thought. There is no risk of leaking memory in such a way that it cannot be freed. However, it is possible to consume large amounts of memory by creating objects, then keeping references to them long after they have outlived their usefulness.

Onyx objects fall into two categories according to type: simple and composite. Simple objects take up no virtual memory of their own; they are embedded into other composite objects. For example, an integer on the operand stack takes up only the space that the stack requires to store it. The same is true of an integer that is stored as an element of an array. Composite objects are composed of references that fit into the same places that an integer is stored, plus additional structures stored elsewhere in virtual memory. There can be multiple references to the same composite object, and as there is a chain of references that makes it possible to reach a composite object, the garbage collector will leave it alone.

It is usually pretty obvious how to remove references to objects. Objects on the operand stack can be popped off. Definitions in the dictionary stack can be undefined. However, there may be situations such as an array that contains references to various objects, and the array cannot be discarded as a whole, but individual elements are no longer needed. The null type is useful for clobbering such references, and can even be effectively used to clobber portions of procedures, since when a null object is executed it does absolutely nothing. This unique aspect of null objects may not seem significant, but consider that all other objects, when executed, are either pushed onto the execution stack and executed, or pushed onto the operand stack. Doing nothing at all can be useful.

1.5 Stacks

Stacks in Onyx are pretty typical, and a rich set of stack manipulation operators is provided. Objects are implicitly or explicitly pushed onto stacks by operators, and the stack contents can be rearranged

and removed. Although stacks are a first class object in Onyx, most Onyx programs are mainly concerned with the operand stack, often referred to as `ostack`. `ostack` is used as a place to store objects, pass arguments into operators and procedures, and return results.

Onyx is a postfix language, which means that code is written such that operands precede operators. For example, the following code Calculates $5 \times (3 + 4)$ and prints the result:

```
onyx:0> 5 3 4 add mul
onyx:1> 1 sprint
35
onyx:0>
```

There are no parentheses to clarify operator precedence, because precedence is implicit in the code.

Stacks are either written bottom to top on one line, or top to bottom on separate lines, as in the following examples. The example stack contains the numbers 0, 1, and 2, where 0 is the top object and 2 is the bottom object:

```
onyx:0> 2 1 0
onyx:3> ostack 1 sprint
(2 1 0)
onyx:3> pstack
0
1
2
onyx:3>
```

Learning to efficiently (and accurately) manage stacks is a mind-warping process that no amount of reading is likely to impress upon the reader. There are general concepts presented here, but ultimately, the reader will have to write a good bit of code to get a handle on stacks. The author of Onyx found himself stumbling over stacks well after Onyx was complete, despite limited exposure to stack-based languages beforehand. The problem seems to be that programmers learn to think in a different way that doesn't exercise the parts of the brain necessary for stack manipulation. Some people might argue that stack manipulation is the job of the compiler. In any case, stack manipulation is an acquired skill that requires practice.

1.5.1 Efficiency issues

Stacks are implemented such that accessing an object is a constant-time operation, regardless of its depth in a stack. However, only the top and bottom of a stack may be modified in constant time.

Typically, the cost of stack manipulations is proportional to the number of objects being touched. So, rolling the top ten objects is five times as costly as exchanging the top two objects. Likewise, rotating the stack by ten positions is typically five times as expensive as rotating the stack by two positions. Costs for rolling and rotation are approximately proportional to each other, though pathological cases for rotation incur a slightly higher overhead (a constant factor more expensive, when amortized).

Stacks have more memory and performance overhead than arrays, so unless growing or shrinking is important, arrays are a better choice for indexed access. Dictionaries are always a better choice for keyed access.

1.5.2 Using stacks as queues

Since pushing and popping is efficient for both ends of stacks, this means that stacks are suitable for use as queues. Either orientation for input/output is fine.

1.5.3 Using the operand stack as two stacks

The ability to efficiently manipulate both ends of the operand stack means that the operand stack can effectively be thought of as two stacks. This can be very useful in situations where more than a handful of objects are being manipulated, and an additional location to temporarily stash objects would be useful. If a program is repeatedly doing large stack rolls or rotations, using the bottom of the stack can often help to simplify the code and reduce stack manipulation overhead.

1.6 Dictionaries

Dictionaries are known by various other names, including hashes and associative arrays. Dictionaries in Onyx associate keys with values. Keys and values can be of any type, but for each dictionary, all keys are unique. For example, the following dictionary cannot exist:

```
<
  42 'Some value'
  42 'Another value'
>
```

To demonstrate this, the following example creates a dictionary with the first key/value pair listed above, then inserts the second key/value pair.

```
onyx:0> <42 'Some value'>
onyx:1> dup 1 sprint
<42 'Some value'>
onyx:1> dup 42 'Another value' put
onyx:1> dup 1 sprint
<42 'Another value'>
onyx:1>
```

When the second key/value pair is inserted, it replaces the first pair.

Actually, there is one way to create a dictionary, then modify it such that multiple entries have the same key. However, doing so is a very bad idea, and is only discussed here as an example of something *not* to do. Dictionary keys are merely references (in the case of composite objects), so if a string is modified after being used as a dictionary key, the dictionary will no longer be able to access the key/value pair associated with that string. The following code creates a dictionary with two key/value pairs, then changes one of the keys.

```
onyx:0> $foostr 'foo' def
onyx:0> $barstr 'bar' def
onyx:0> $d <foostr 0 barstr 1> def
```

```
onyx:0> foostr barstr copy pop
onyx:0> d 1 sprint
<'foo' 1 'foo' 1>
onyx:0> d 'foo' undef
onyx:0> d 1 sprint
<'foo' 0>
onyx:0>
```

Bad things are clearly happening here, and in fact there are other similar problems that surface, even if a key remains unique after being changed. This is because during insertion, the key string is hashed, and inserted into a hash table accordingly. A different string is likely to hash to a different slot in the hash table, which means that the key/value pair becomes inaccessible.

In summary, do not change strings while they are being used as dictionary keys. Onyx does not prevent the use of strings for dictionary keys, since it would be limiting, but this feature can be abused.

1.6.1 Efficiency issues

Although dictionaries can handle keys of any type, they are optimized to use names as keys. The performance penalty for other key types is slight, but can be exacerbated by the cost of comparison for other types. Name comparison is a constant time operation, but string comparison is not. Therefore, use names rather than strings whenever possible.

1.7 Regular expressions

Onyx provides regular expression support that is very similar to what the Perl programming language provides. There are two special data types, `regex` and `regsub`, that are specific to regular expressions, but there is no special language syntax devoted to regular expressions, unlike Perl. Instead, patterns and substitution templates are specified via normal strings, and flags are specified via dictionaries.

Regular expression syntax is similar to that of Perl. See Section 2.9 for more information.

1.7.1 Matching

The following snippet iteratively searches for capitalized words:

```
'This is an Onyx string.'
```

```
{dup '[A-Z]\w+' <$g true> match}{
  0 submatch 1 sprint
} while
```

The above code generates the following output:

```
'This'
'Onyx'
```

The `$g` flag to the **match** operator says to start searching where the previous match ended, which is what makes the `while` loop possible. The **submatch** operator gets the substring of the input string that the regular expression most recently matched.

With a slight modification to the previous example, it is possible to get at the capital letters, rather than the entire capitalized words. This is achieved by using a set of capturing parentheses, and changing the argument to **submatch**:

```
'This is an Onyx string.'  
  
{dup '([A-Z])\w+' <$g true> match}{  
    1 submatch 1 sprint  
} while
```

This generates the following output:

```
'T'  
'O'
```

This is a trivial example of how capturing subpatterns can be used, but the possibilities are wide and varied.

1.7.2 Splitting

Sometimes it is desirable to **split** a string into pieces, such as when dealing with a comma-delimited file:

```
'Jason Evans, jasone@canonical.com, http://www.canonical.com/~jasone/'  
  
'\s*' split  
1 sprint
```

This generates the following output:

```
['Jason Evans' 'jasone@canonical.com' 'http://www.canonical.com/~jasone/']
```

If for some reason preserving the delimiters is important, capturing parentheses can be added to the splitting pattern:

```
'Jason Evans, jasone@canonical.com, http://www.canonical.com/~jasone/'  
  
'(,)\s*' split  
1 sprint
```

This generates the following output:

```
['Jason Evans' ',' 'jasone@canonical.com' ',' 'http://www.canonical.com/~jasone/']
```

1.7.3 Substituting

The **match** and **split** operators provide enough power that with some effort, it is possible to find regular expression matches, modify the matched text, and create a modified string as output. However, this is a common operation when using regular expressions for text processing, so the **subst** operator is also provided as a more convenient interface for the most common types of substitution.

Suppose that a list of email addresses needs to be converted from one format to another. The following snippet does such a conversion:

```
`Jason Evans (jasone@canonical.com)
Jason O. Evans ( jasone@canonical.com )
'

'(\w[A-Za-z. ]*\w) \(\s*([^\s]+\s*)\)' '"\1" <\2>' <$g true> subst pop
stdout exch write pop
```

This generates the following output:

```
"Jason Evans" <jasone@canonical.com>
"Jason O. Evans" <jasone@canonical.com>
```

1.8 Code organization

As mentioned earlier, Onyx does not have named variables in the same way as most other languages do. However, it does have the dictionary stack (dstack), which is dynamically used for name lookups whenever an executable name is interpreted. This section talks about how to effectively manage the namespace provided by dstack.

When the Onyx interpreter is first initialized, there are four dictionaries on dstack:

- userdict
- globaldict
- systemdict
- threaddict

dstack can be manipulated any way the application sees fit, though it is generally dangerous to remove or significantly modify systemdict or threaddict, since there are definitions in those dictionaries that are critical to the correct functioning of the interpreter.

Each thread has its own userdict, which provides a thread-local namespace. globaldict is shared among all threads, so it provides a global namespace. systemdict contains all of the default global definitions, and threaddict contains the default thread-local definitions.

For some applications, it may be desirable to add definitions to systemdict, but care should be taken not to overwrite existing definitions unless you really know what you are doing. In most cases, using globaldict is a better way to go.

1.8.1 Procedures

Named procedures can be created by associating a name with a procedure in one of the dictionaries on `dstack`. There is nothing magical about this, but some care should be taken in choosing procedure names, and in deciding how to manage the namespace. Onyx uses only numbers and lowercase letters in the names of its definitions on `dstack`, so it is easy to avoid namespace collisions by using some other character in program definitions. There is nothing wrong with using all numbers and lowercase letters for names in your programs, though some extra care is warranted when doing so.

An important consideration in program design is determining what belongs in the global namespace. For an example of how Onyx partitions its namespace, look at `gcdict`. There are several operators defined in `gcdict` that are only of interest when manipulating the garbage collector, so those definitions are stashed out of the way. Your program can do the same for definitions that are not of regular interest.

1.8.2 Modules

Onyx provides the infrastructure for loadable modules, which can be implemented as Onyx code and/or dynamically loaded machine code (shared libraries). At the lowest level, **`modload`** can be used to load a shared object. At a higher level, **`mrequire`** can be used to find a shared object in one of the directories specified by the module path, then **`modload`** it. At the highest level, the *`mclass`* and *`module`* classes provide methods for loading, introspecting, and unloading modules. The lower level APIs are typically only utilized when writing modules, and the highest level APIs are utilized when using modules.

When writing a module that is meant as a library of additional functionality, some choices have to be made about how to organize the module. Some of the obvious choices for how to organize the loaded definitions are:

- Insert definitions into `globaldict`.
- Create a new dictionary full of definitions, and insert the dictionary into `globaldict` as, say, `foodict`.
- Insert definitions into `systemdict` (questionable practice).

Depending on the nature of the module, any of the above solutions may be the right choice. There are tradeoffs between convenience and cleanliness that should be carefully weighed.

1.9 Error handling

Onyx includes a powerful generic error handling mechanism that can be extended and customized at several levels. The **`throw`** procedure is used to throw an error, and virtually every aspect of the error handling machinery can be customized, extended, or replaced, since it is all written in Onyx.

Errors have names, with which error handlers can be associated in `errordict`. `errordict`'s **`handleerror`** procedure can be modified or replaced. In fact, with some care, an entirely custom `errordict` can be defined, then undefined once it is no longer needed.

Following is the standard idiom for setting up and tearing down custom error handling:

```
# Set up custom error handling...
```

```
{
    # Do error-prone stuff...
} stopped {
    # An error occurred. Do additional cleanup...
} if
# Restore error handling machinery...
```

The possibilities are extensive. However, a few words of caution are in order. If you mess something up in the error handling machinery, bad things will happen, and you will have a terrible time debugging the problem. Be careful.

1.10 Introspection

The following code defines a named procedure that calculates factorials:

```
#n factorial #result
$factorial {
    dup 1 gt {
        #n-1 factorial
        dup 1 sub factorial
    }{
        # Terminate recursion.
        1
    } ifelse

    mul
} def
```

What this code actually does is create an executable array, which can be examined and modified. The following transcript shows the effects of modifying the code:

```
onyx:0> 3 factorial 1 sprint
6
onyx:0> $factorial load 2 sprint
{dup 1 gt {dup 1 sub factorial} {1} ifelse mul}
onyx:0> $factorial load 4 {1 pstack} put
onyx:0> 3 factorial
1
1
2
3
onyx:1> 1 sprint
6
onyx:0>
```

First 3! is calculated. Then the “else” clause of the ifelse construct is modified to print the stack and 3! is recalculated. As can be seen, the stack is printed during the calculation.

1.11 Threads

The original impetus for Onyx's creation was the need for scalable threading. Onyx's threading is therefore truly powerful, though it comes at a cost. Threading makes asynchronous garbage collection a necessity, which in turn makes many aspects of Onyx's implementation a bit more heavyweight than would be necessary for a single-threaded interpreter.

1.11.1 Implicit synchronization

Onyx provides mechanisms for implicit object synchronization. To see why implicit object synchronization is necessary, consider what happens when two threads concurrently modify `globaldict` (a perfectly legitimate thing to do, by the way). The internals of a dictionary are rather complex, and if two modifications were interleaved, havoc would ensue. Therefore, `globaldict` is implicitly locked. That is a good thing, except that it slows down every access to `globaldict`. In contrast, `userdict` is a per-thread dictionary, so it is not implicitly locked.

Implicit locking for new objects is controlled via **setlocking**, and can be queried via **currentlocking**. Implicit locking is turned off by default when Onyx is started up, so if an application needs to create an object that is shared among threads, it should temporarily turn on implicit locking. For example, the following code creates a stack in `globaldict` that can be used as a simple message queue:

```
currentlocking # Save for later restoration.
true setlocking

# Push globaldict onto dstack before calling def.
globaldict begin
$queue stack def
end # globaldict

# Restore implicit locking mode.
setlocking
```

For additional details on the mechanics of implicit synchronization, see Section 2.7.1.

1.11.2 General threading concerns

Onyx's basic threading mechanisms are typical of those found in modern threading implementations. One of the aspects of Onyx's threading implementation to be aware of is that since the operating system's threading implementation is used, there are many types of programming errors that can cause undefined behavior. With some effort, it is possible to crash the Onyx interpreter without the use of threads. However, it requires skill and discipline to *not* crash the Onyx interpreter when using threads. This was a conscious design decision for Onyx; doing otherwise would have limited the scalability of threading.

1.12 Optimization

There are many fine points to optimizing Onyx code, but they can primarily be distilled down to the following simple rules:

- Avoid allocating composite objects, in order to reduce pressure on the garbage collector. This means being very careful about string manipulation in the fast path. The **cat** operator is convenient, but not friendly to the garbage collector.
- Write code with as few objects as possible, to reduce the number of times through the interpreter loop. This means getting very familiar with the stack manipulation operators.
- Use the operand stack rather than named variables.
- Use the **bind** operator for procedure definitions whenever possible, in order to reduce dstack lookups.
- Avoid the **exit**, **stop**, **escape**, and **quit** operators when possible, since they are implemented via *longjmp()*.

1.13 Debugging

Onyx does not have an integrated interactive debugger per se, because the introspective power of Onyx is adequate for almost all debugging purposes. In cases where it is impractical to interactively debug an application via the main thread, it is possible to launch a thread that listens for connections on a socket (or a fifo pair) and provides an interactive session.

Following is a contrived example of debugging some bad code, interleaved with explanations. The intention is to calculate $1 + 5$.

```
onyx:0> 1 5L add
Error $undefined
ostack: (1)
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      5L
1:      -file-
2:      --start--
onyx:2> pstack
5L
1
```

5L is not a number, nor is it defined in dstack. Try replacing 5L with \$five.

```
onyx:2> pop $five resume
Error $typecheck
ostack: (1 $five)
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
```



```
estack/istack trace (0..2):
0:      --add--
1:      -file-
2:      --start--
onyx:3> pstack
--add--
$five
1
```

\$five is a literal name, so no errors occur directly due to scanning it. However, the **add** operator expects two numbers, and \$five is not a number. Replace it with 5 and evaluate the operator.

```
onyx:3> nip 5 exch eval
onyx:1> pstack
6
```

The result is as desired. However, we forgot to **resume** after the last error.

```
onyx:1> estack 1 sprint
(--start-- -file- --add-- --ifelse-- --eval-- -array- -file- --estack--)
onyx:1> resume
```

Now the estack contents should be back to normal.

```
onyx:1> estack 1 sprint
(--start-- -file- --estack--)
onyx:1>
```

The above example only demonstrates the flavor of typical interactive debugging, but there is no magic involved in debugging, so your debugging ability should improve automatically as you gain an improved understanding of Onyx.

Chapter 2

Onyx Language Reference

Onyx is a stack-based, threaded, interpreted language. Its closest relative is Adobe PostScriptTM, followed by Forth. Experienced PostScript programmers should find most aspects of Onyx familiar, but there are significant differences that will prevent a knowledgeable PostScript programmer from programming in Onyx without first skimming this chapter. This chapter does not assume specific knowledge of other programming languages, so stands as a definitive reference for Onyx.

Onyx is different from most languages in that it is not compiled, but rather consumed. For example, there are mechanisms for creating the equivalent of named procedures that can be called at a later time, but behind the scenes, the code is actually being interpreted as it is scanned in such a way that an executable object is created. As such, Onyx is not suited for compilation, native or byte code. However, the language syntax is very simple and the scanner/parser is extremely fast. There is also an operator called **bind** that optimizes interpreted code execution to approximately the same performance level as would be expected of a byte code interpreter.

Onyx is implemented as a C library that can be embedded in other programs. Mechanisms are provided for extending the set of operators available. This manual only documents the base language; see application-specific documentation for any language extensions.

Following is a list of basic language features that are discussed in more detail later in this chapter:

- Stack-based. There are no named variables as in procedural languages. Operations are done using various stacks, so Onyx operations are coded in postfix order.
- Threaded. Onyx's threading uses the native POSIX threads implementation of the operating system (or GNU pthread, if so configured).
- Interpreted. Onyx code is never compiled, but is instead interpreted as it is encountered.
- Garbage-collected. There is no need to manually track memory allocation, since the interpreter has an integrated automatic mark and sweep garbage collector.

2.1 Objects

An Onyx object has three aspects: type, attribute, and value.

Objects fall into two categories according to type: simple and composite. A simple object takes up no memory of its own; it uses space within another object (typically a stack, array, or dictionary). A

composite object requires space of its own in addition to the space taken up in another object to refer to the composite object. See Table 2.1 for object type classifications.

Simple	Composite
boolean	array
fino	class
integer	condition
mark	dict
name	file
null	handle
operator	instance
pmark	mutex
real	regex
	regsub
	stack
	string
	thread

Table 2.1: Simple and composite types

There can be multiple references that refer to the same memory backing composite objects. In most cases, composite objects that refer to the same memory are indistinguishable, but for arrays and strings, composite objects may only be able to access a subset of the total memory backing them. This behavior is described in detail later.

All objects have a literal, executable, evaluable, callable, invocable, or fetchable attribute associated with them. Composite objects each have their own attribute, even for composite objects that share the same backing memory. Objects are “interpreted” when they are encountered directly by the interpreter. Objects can also be “evaluated”. Objects are handled as one of the following cases when interpreted or evaluated:

code: An object may be treated as code and be executed. When executed, an object is pushed onto the execution stack and executed.

data: An object may be treated as data. A data object is push onto the operand stack. All literal objects are treated as data.

mkey: A callable object is executed and treated as a method key. When a callable object is executed, the following steps are taken:

1. The topmost object on the operand stack is pushed onto the context stack, then popped off of the operand stack.
2. The callable object is used as a key to search for a method in the class hierarchy of the topmost object on the context stack.
3. The method found in the previous step is evaluated.
4. All objects on the context stack down to and including the object pushed in step 1 are popped off of the context stack.

cmkey: A invocable object is executed and treated as a method key in the context of the topmost object on the context stack. When a invocable object is executed, the following steps are taken:

1. The invocable object is used as a key to search for a method in the class hierarchy of the topmost object on the context stack.

2. The method found in the previous step is evaluated.

cdkey: A fetchable object is executed and treated as a data key in the context of the topmost object on the context stack. When a fetchable object is executed, the following steps are taken:

1. The fetchable object is used as a key to search for data in the data dictionary of the topmost object on the context stack.
2. The data found in the previous step is pushed onto the operand stack.

Table 2.2 enumerates what action is taken during interpretation/evaluation for all object type/attribute combinations. Note that executable arrays are the only objects that behave differently when interpreted versus evaluated.

Attributes are not considered in equality test operations.

Type	Attribute					
	literal	executable	evaluatable	callable	invokable	fetchable
array	data	data/code	code	mkey	cmkey	cdkey
boolean	data	data	data	mkey	cmkey	cdkey
class	data	data	data	mkey	cmkey	cdkey
condition	data	data	data	mkey	cmkey	cdkey
dict	data	data	data	mkey	cmkey	cdkey
file	data	code	code	mkey	cmkey	cdkey
fino	data	data	data	mkey	cmkey	cdkey
handle	data	code	code	mkey	cmkey	cdkey
instance	data	data	data	mkey	cmkey	cdkey
integer	data	data	data	mkey	cmkey	cdkey
mark	data	data	data	mkey	cmkey	cdkey
mutex	data	data	data	mkey	cmkey	cdkey
name	data	code	code	mkey	cmkey	cdkey
null	data	code	code	mkey	cmkey	cdkey
operator	data	code	code	mkey	cmkey	cdkey
pmark	data	data	data	mkey	cmkey	cdkey
real	data	data	data	mkey	cmkey	cdkey
regex	data	data	data	mkey	cmkey	cdkey
regsub	data	data	data	mkey	cmkey	cdkey
stack	data	data	data	mkey	cmkey	cdkey
string	data	code	code	mkey	cmkey	cdkey
thread	data	data	data	mkey	cmkey	cdkey

Table 2.2: Interpretation/evaluation of objects by type and attribute

array: An array is an ordered sequence of objects of any type. The sequence of objects contained in an array is indexed starting at 0. References to existing arrays may be constructed such that a contiguous subsequence is visible. The following code creates such an array:

```
[0 1 2 3 4]
1 3 getinterval
```

After the code executes, the array left on the operand stack looks like:

[1 2 3]

Executable arrays are in effect procedures. When an array is executed, its elements are sequentially interpreted.

boolean: A boolean can have two values: true or false.

class: A class is a class, in the object-oriented sense of the word. Class objects provide explicit object-oriented programming support. Classes allow single inheritance, and provide dynamic lookup/dispatch capabilities.

condition: A condition is used for thread synchronization. The standard operations on a condition are to wait and to signal.

dict: A dict (short for dictionary) is a collection of key/value pairs, where all keys in a dict are unique. Other names for dictionaries include “associative array” and “hash”. A key can be of any type, though in most cases, keys are of type name. A value can also be of any type.

file: A file is a handle to an ordered sequence of bytes with a current position. Read and write permissions are set when a file object is created.

When an executable file is executed, it is used as a source of Onyx code. Data are sequentially read from the file and interpreted until the end of the file is reached.

fino: A fino (first in, never out) is used as a stack marker when constructing stacks.

handle: The handle type is not used by the core Onyx language. It can be used by applications that extend the interpreter as a container object. Handles can be executed, but the results are application dependent.

Each handle has a tag associated with it that can be used by C extension code as a form of type checking. By default, the tag is a null object. In most cases, an application that extends the interpreter using handle objects will set handle tags to be name objects.

instance: An instance is an instance of a class, in the object-oriented sense of the word. Instances primarily depend on classes for their functionality, but they also have per-instance data storage.

integer: An integer is a signed integer in the range -2^{63} to $2^{63} - 1$.

mark: A mark is used as a stack marker for various stack operations.

mutex: A mutex is a mutual exclusion lock. Mutexes cannot be acquired recursively, and the application must take care to unlock mutexes before allowing them to be garbage collected (whether during normal program execution or at program termination).

name: A name is a key that uniquely identifies a sequence of characters. Two name objects that correspond to the same sequence of characters can be compared for equality with the same approximate cost as comparing two integers for equality. Names are typically used as keys in dictionaries.

When an executable name is executed, the topmost value in the dictionary stack associated with the name is evaluated.

null: A null has no significance other than its existence. When an executable null is executed, it does nothing. Executable nulls can be useful as place holders that can later be replaced with useful code, or for replacing obsolete code so that the code is no longer executed.

operator: An operator is an operation that is built in to the interpreter. Operators can be executed.

pmark: A pmark is used as a stack marker when creating procedures in deferred execution mode (i.e. procedures that use the “{ }” syntax). The application will only encounter pmarks in error conditions, and there is never a reason for an application to explicitly create a pmark.

real: A real is a double precision (64 bit) floating point number.

regex: A regex encapsulates a regular expression and associated flags, which can be used to find substring matches within an input string.

regsub: A regsub encapsulates a regular expression, substitution template, and associated flags, which can be used to do substring substitutions and create an output string from an input string.

stack: A stack provides LIFO (last in, first out) access to objects that it contains, as well as some more advanced access methods. An application can create, then manipulate stacks in much the same way that the operand stack can be manipulated.

string: A string is an ordered sequence of 8 bit characters. The bytes contained in an string are indexed starting at 0. References to existing strings may be constructed such that a contiguous subsequence is visible. The following code creates such a string:

```
'abcde'
1 3 getinterval
```

After the code executes, the string left on the operand stack looks like:

```
'bcd'
```

When an executable string is executed, its contents are used as a source of Onyx code.

thread: A thread object serves as a handle for operations such as detaching and joining.

2.2 Syntax

Onyx’s syntax is very simple in comparison to most languages. The scanner and parser are implemented as a human-understandable finite state machine (nested C switch statements with a couple of auxiliary variables), which should give the reader an idea of the simplicity of the language syntax.

CRNL (carriage return, newline) pairs are in all important cases converted to newlines during scanning.

The characters “#”, “!”, “,”, “;”, “:”, “\$”, “~”, “[”, “]”, “{”, “}”, “(”, “)”, “‘”, “’”, “<”, and “>” are special. In most cases, any of the special characters and whitespace (space, tab, newline, formfeed, null) terminate any preceding token. All other characters including non-printing characters are considered regular characters.

A comment starts with a “#” character outside of a string context and extends to the next newline or formfeed.

Procedures are actually executable arrays, but Onyx provides special syntax for declaring procedures. Procedures are delimited by “{” and “}”, and can be nested. Normally, the interpreter executes code as it is scanned, but inside of procedure declarations, execution is deferred. Instead of executing a procedure body as it is encountered, the tokens of the procedure body are pushed onto the operand stack until the closing “}” is encountered, at which time an executable array is constructed from the tokens in the procedure body and pushed onto the operand stack.

A partial grammar specification, using BNF notation (where convenient) is as follows:

<program> ::= <statement>

<statement> ::= <procedure> <statement> | <object> <statement> | ϵ

<procedure> ::= {<statement>}

<object> ::= <integer> | <real> | <name> | <string>

<integer> ::= <dec_integer> | <radix_integer>

<real> ::= <dec_real> | <exp_real>

<name> : Any token that cannot be interpreted as a number or a string is interpreted as an executable name. There are seven syntaxes for names: executable, evaluable, callable, invokable, fetchable, literal, and immediately evaluated. Executable and evaluable names are looked up in the dictionary stack and executed (unless execution is deferred). Evaluable names behave the same as executable names, except when being processed by the **bind** operator. Callable, invokable, fetchable, and literal names are handled the same as for all other types; the special syntax for names with these attributes are merely a programming convenience. Immediately evaluated names are replaced by their values as defined in the dictionary stack, even if execution is deferred. Examples include:

```
foo      # executable
4noth3r # executable
!bar     # evaluable
:method  # callable
;method  # invokable
,data    # fetchable
$biz     # literal
~baz     # immediately evaluated
```

If the result of an immediately evaluated name is an executable array, the evaluable attribute is set for the array so that when the array is interpreted, it is executed. This allows immediate evaluation to be indiscriminately used without concern for whether the result is an executable array or, say, an executable operator.

<string> ::= A string delimited by “`“`” and “`”`”. Ticks may be embedded in the string without escaping them, as long as the unescaped ticks are balanced. The following sequences have special meaning when escaped by a “`\`” character:

- `‘ ‘` character.
- `’ ’` character.
- `\ \` character.
- 0** Nul.
- n** Newline.
- r** Carriage return.
- t** Tab.
- b** Backspace.
- f** Formfeed.
- a** Alarm.
- e** Escape.
- x[0-9a-fA-F][0-9a-fA-F]** Hex encoding for a byte.

c[a-zA-Z] Control character.

\n (newline) Ignore.

\r\n (carriage return, newline) Ignore.

“\” has no special meaning unless followed by a character in the above list. This is especially convenient when specifying regular expressions.

Examples include:

```
' '
'A string.'
'An embedded \n newline.'
'Another embedded
newline.'
'An ignored \
newline.'
'Balanced ` and ` are allowed.'
'Manually escaped ` ` tick.'
'Manually escaped ` ` tick and `balanced unescaped ticks`.'
'An actual \\ backslash.'
'Another actual \ backslash.'
```

<dec integer> : Signed decimal integer in the range -2^{63} to $2^{63} - 1$. The sign is optional. Examples include:

```
0
42
-365
+17
```

<radix integer> : Signed integer with explicit base between 2 and 36, inclusive, in the range -2^{63} to $2^{63} - 1$. Integer digits are composed of decimal numbers and lower or upper case letters. The sign is optional. Examples include:

```
2@101
16@ff
16@Ff
16@FF
-10@42
10@42
+10@42
9@18
35@7r3x
35@7R3x
```

<dec real> : Double precision floating point number in decimal notation. At least one decimal digit and a decimal point are required. Examples include:

```
0.
.0
3.
.141
3.141
42.75
+3.50
-5.0
```

<exp_real> : Floating point number in exponential notation. The format is the same as for <dec_real>, except that an exponent is appended. The exponent is composed of an “e” or “E”, an optional sign, and a base 10 integer that is limited by the precision of the floating point format (approximately −308 to 307). Examples include:

```
6.022e23
60.22e22
6.022e+23
1.661e-24
1.661E-24
```

Arrays do not have explicit syntactic support, but the [and] operators support their construction. Examples of array construction include:

```
[]
[0 'A string' 'Another string.' true]
[5
42
false]
```

Dictionaries do not have explicit syntactic support, but the < and > operators support their construction. Examples of dictionary construction include:

```
<>
<$answer 42 $question 'Who knows' $translate {babelfish} >
```

Stacks do not have explicit syntactic support, but the (and) operators support their construction. Examples of stack construction include:

```
()
(1 2 mark 'a')
```

2.3 Stacks

Stacks in Onyx are the core data structure that programs act on. Stacks store objects in a last in, first out (LIFO) order. Onyx includes a number of operators that manipulate stacks.

Each Onyx thread has five program-visible stacks associated with it:

Operand stack (ostack): Most direct object manipulations are done using the operand stack. Operators use the operand stack for inputs and outputs, and code generally uses the operand stack for a place to store objects as they are being manipulated.

Dictionary stack (dstack): The dictionary stack is used for looking up names. Each thread starts with with four dictionaries on its dictionary stack, which are, from top to bottom:

- userdict
- globaldict
- systemdict

- `threaddict`

The dictionary stack is normally manipulated via the **begin** and **end** operators. The initial dictionaries on the dictionary stack should not generally be removed, since doing so can cause interpreter crashes.

Context stack (cstack): The context stack supports Onyx’s object-oriented programming facilities. The topmost object on the context stack (either a class or an instance) is used by the Onyx interpreter to look up methods and data. That object is known as “this” in object-oriented programming parlance, and can be quickly accessed via the **this** operator.

Execution stack (estack): The interpreter uses the execution stack to store objects that are being executed. The application generally does not need to explicitly manipulate the execution stack, but its contents are accessible, mainly for debugging purposes.

Index stack (istack): The interpreter uses the index stack to store execution offsets for arrays that are being executed. There is a one to one correspondence of the elements of the execution stack to the elements of the index stack, even though the elements of the index stack that do not correspond to arrays have no meaning. The index stack does not affect execution, and exists purely to allow useful execution stack traces when errors occur.

The application can also create additional stacks and manipulate them in much the same way as the operand stack can be manipulated.

2.4 Standard I/O

Onyx provides operators to access the standard I/O file objects: **stdin**, **stdout**, and **stderr**. Under normal circumstances, these operators are adequate for all standard I/O operations. However, it may be desirable to replace these files on a per-thread basis. This can be accomplished using **setstdin**, **setstdout**, and **setstderr**. Furthermore, the file objects that are inherited by new threads can be accessed and modified via **gstdin**, **gstdout**, **gstderr**, **setgstdin**, **setgstdout**, and **setgstderr**.

2.5 Interpreter recursion

During typical Onyx interpreter initialization, the **start** operator is executed, which in turn executes a file object corresponding to `stdin`. However, depending on how the interpreter is invoked, the initial execution stack state may differ.

The interpreter can be recursively invoked. For example, if the following code is executed, the **eval** operator recursively invokes the interpreter to interpret the string.

```
`2 2 add' cvx eval
```

The depth of the execution stack directly corresponds to the recursion depth of the interpreter. Execution stack depth is limited in order to catch unbounded recursion.

By default, Onyx converts tail calls in order to prevent unbounded execution stack growth due to tail recursion. For example, the following code does not cause the execution stack to grow:

```
$foo {foo} def
foo
```

The following code will result in an execution stack overflow:

```
$foo {foo 'filler'} def
foo
```

Whether tail call conversion is enabled can be queried and set via **tailopt**, **gtailopt**, **settailopt**, and **setgtailopt**.

Name lookups are effectively treated as tail calls, so if tail call optimization is disabled, names will be left in place on the execution stack, and their associated values will be recursively executed.

2.6 Error handling

The error handling mechanisms in Onyx are simple but flexible. When an error occurs, **throw** is called. An error can have any name, but only the following error names are generated internally by Onyx:

argcheck: Incorrect argument value.

cstackunderflow: Not enough objects on cstack.

estackoverflow: Maximum interpreter recursion was exceeded.

invalidaccess: Permission error.

invalidcontinue: The **continue** operator was called outside of any loop. This error is generated as a result of catching a continue, so the execution state for where the error really happened is gone.

invalidexit: The **exit** operator was called outside of any loop. This error is generated as a result of catching an exit, so the execution state for where the error really happened is gone.

invalidfileaccess: Insufficient file permissions.

ioerror: I/O error (read(), write(), etc.).

limitcheck: Value outside of legal range.

neterror: Network error (refused connection, timeout, unreachable net, etc.).

rangecheck: Out of bounds string or array access, or out of bounds value.

regexerror: Regular expression syntax error.

stackunderflow: Not enough objects on stack.

syntaxerror: Scanner syntax error.

typecheck: Incorrect argument type.

undefined: Name not defined in any of the dictionaries on dstack, or in the case of class method dispatch, name not defined in the class hierarchy.

undefinedfilename: Bad filename.

undefinedresult: Attempt to divide by 0.

unmatchedfino: No fino on ostack.

unmatchedmark: No mark on ostack.

unregistered: Non-enumerated error.

The Onyx scanner handles syntax errors specially, in that it pushes an executable string onto the operand stack that represents the code that caused the syntax error and records the line and column numbers in `currenterror` before invoking **throw**.

The Onyx scanner also handles immediate name evaluation errors specially, in that it pushes the name that could not be evaluated onto ostack before invoking **throw**.

In addition to the **throw** operator, there are several other operators that exist specifically for the purpose of error handling. The **start** operator silently catches any uncaught **stop**, **exit**, **continue**, **escape**, or **quit** calls. The **start** operator is the first operator called by the Onyx interpreter during startup, and it can also be used by applications to limit execution stack unwinding. The **stopped** operator is useful for catching **stop** calls, since it reports whether a **stop** call was caught, allowing conditional error recovery.

2.7 Threads

Onyx supports multiple threads of execution by using the operating system's native threading facilities. Along with threads comes the need for methods of synchronization between threads.

2.7.1 Implicit synchronization

Implicit synchronization is a mandatory language feature, since objects such as **globaldict** are implicitly accessed by the interpreter, which makes it impossible to require the user to explicitly handle all synchronization. Onyx provides optional implicit synchronization capabilities for composite objects on an object by object basis. Each thread has a setting which can be accessed via **currentlocking** (initially set to false) and set via **setlocking**. If implicit locking is active, then new objects will be created such that simple accesses are synchronized.

Implicit synchronization can be a source of deadlock, so care must be taken when accessing implicitly locked objects. For example, if two threads copy two implicitly locked strings to the other string, deadlock can result.

```
# Initialization.
$A 'aaaaaa'
$B 'bbbbbb'

...

# In thread A:
A B copy

...

# In thread B:
B A copy
```

The following are descriptions of the implicit locking semantics for each type of composite object:

array: Array copying is protected. Array element modifications are protected, but element reads are not protected.

class: No implicit locking is done for classes.

condition: No implicit locking is done for conditions.

dict: All dict operations are protected.

file: All file operations are protected. There are no potential deadlocks due to implicit file locking.

handle: No implicit locking is done for handles.

instance: No implicit locking is done for instances.

mutex: No implicit locking is done for mutexes.

regex: No implicit locking is done for regexes.

regsub: No implicit locking is done for regsubs.

stack: All stack operations are protected. There are no potential deadlocks due to implicit stack locking. However, there are races in stack copying, such that the results of copying a stack that is concurrently being modified are unpredictable. In addition, removing an object that is being concurrently accessed from a stack is unsafe.

string: String copying is protected. Character access is protected by many operators, but string copying is the only potential cause of deadlock for string access.

thread: Implicit locking is not done for thread operations, since other synchronization is adequate to protect thread objects.

2.7.2 Explicit synchronization

Onyx includes a foundation of mutexes and condition variables, with which all other synchronization primitives can be constructed.

2.8 Memory management

Onyx programs do not need to track memory allocations, since memory reclamation is done implicitly via automatic garbage collection. Onyx uses an atomic mark and sweep garbage collector.

The atomic nature of garbage collection may sound worrisome with regard to performance, but in fact there are tangible benefits and no significant negative impacts for most applications. Total throughput is improved, since minimal locking is necessary. Concurrent garbage collection would impose a significant locking overhead.

On the down side, atomic garbage collection cannot make strong real-time guarantees. However, the garbage collector is very efficient, and for typical applications, garbage collection delays are measured in microseconds up to tens of milliseconds on current hardware as of the year 2000. For interactive applications, anything under about 100 milliseconds is undetectable by the user, so under normal circumstances the user will not notice that garbage collection is happening.

There are three parameters that can be used to control garbage collection:

1. The garbage collector can be turned off for situations where many objects are being created over a short period of time.
2. The garbage collector runs whenever a certain number of bytes of memory have been allocated since the last collection. This threshold can be changed or disabled.
3. If no composite objects have been created for an extended period of time (seconds), the garbage collector will run if any composite objects have been allocated since the last collection. This idle timeout period can be changed or disabled.

There is one situation in which it is possible for garbage to never be collected, despite the garbage collector being properly configured. Suppose that a program creates some objects, the garbage collector runs, then the program enters a code path that clobbers object references, such that the objects could be collected, but no new objects are allocated. In such a situation, neither the allocation inactivity timer (period), nor the object allocation threshold will trigger a collection, and garbage will remain uncollected. In practice this situation is unlikely, and is not a significant problem since the program size is not growing.

Garbage collection is controlled via the `gcdict` dictionary, which is described in Section 2.11.4.

2.9 Regular expressions

Regular expression support is provided by the PCRE library package, which is open source software, written by Philip Hazel, and copyright by the University of Cambridge, England. PCRE stands for “Perl-compatible regular expressions”. This manual only documents how Onyx interfaces with PCRE. For more information about how PCRE’s regular expressions work, see the following:

- The `pcre(3)` manual page.
- The official PCRE download site: <ftp://ftp.csx.cam.ac.uk/pub/software/programming/pcre/>.
- The unofficial PCRE website: <http://www.pcre.org/>.

For general information about Perl regular expressions, the following are recommended:

- Perl 5.6.1 regular expression documentation: <http://www.perldoc.com/perl5.6.1/pod/perlre.html>.
- Mastering Regular Expressions, 2nd Ed., by Jeffrey E. F. Friedl. ISBN 0-596-00289-0.
- Perl 5 Pocket Reference, 3rd Ed., by Johan Vromans. ISBN 0-596-00032-4.
- Programming Perl, 3rd Ed., by Larry Wall, Tom Christiansen, and Jon Orwant. ISBN 0-596-00027-8.

There are two special Onyx object types that support regular expressions: `regex` and `regsub`. Objects of these types are created via the **regex** and **regsub** operators, respectively. The **match** operator applies a regular expression to an input string, the **submatch** operator returns a matched substring of the input string, and the **offset** operator returns the offset of a substring match relative to the beginning of the input string. The **split** operator creates an array of substrings that are separated by

strings that match a regular expression. The **subst** operator finds regular expression matches within an input string and applies a substitution template to the matches, thereby creating an output string. See Section 2.11.9 for detailed documentation on the above-mentioned operators.

Regular expressions are written as strings in Onyx, so all of the standard special sequences within strings are interpreted directly by the Onyx scanner. Note that the `\` character is only special within strings if it is followed by a special sequence. This allows regular expressions to seamlessly extend the set of special sequences within strings while maintaining a reasonably consistent syntax.

The following sequences have special meaning within strings that specify substitution templates:

Table 2.3: Substitution template special characters

Sequence	Description
<code>\1.. \9</code>	Refer to captured expressions 1 through 9.

2.10 Object-oriented programming

Onyx provides basic mechanisms for programming in an object-oriented style. The class and instance types, additional attributes (callable, invocable, and fetchable), a set of operators, and `vclass`, provide all the necessary functionality. The object-oriented programming support can be summarized by the following feature list:

- Single inheritance.
- Reasonably fast fully dynamic method dispatch.
- No hindrances, such as private/protected/public data/method distinctions.
- Full introspection capabilities.

Very little policy is built into the operators that implement the foundation for object-oriented programming support. See Section 2.12.1 for details on the policies that are set by `vclass`, which is provided as a default base class.

2.11 Dictionary reference

All operators built in to Onyx have corresponding names that are composed entirely of lower case letters and numbers (with the exception of syntax-supporting operators like `[]`). In order to avoid any possibility of namespace collisions with names defined by current and future versions of Onyx, use at least one character that is not a lower case letter or a number in names (for example, capital letters, underscore, etc.). In practice, namespace collisions usually aren't a problem, even if they happen, since the only effect is that the program-defined definition shadows the built in definition during name lookups.

2.11.1 currenterror

Each thread has its own `currenterror` dictionary, which is used by the error handling machinery to store error state.

Table 2.4: currenterror summary

Input(s) Op/Proc/Var Output(s)	Description
– newerror boolean	Set to true during error handling.
– errorname name	Name of most recent error.
– origin string/null	Get origin of syntax error.
– line number	Get line number of syntax error.
– column number	Get column number of syntax error.
– ostack stack	ostack snapshot.
– dstack stack	dstack snapshot.
– cstack stack	cstack snapshot.
– estack stack	estack snapshot.
– istack stack	istack snapshot.

– **column** *integer*:**Input(s):** None.**Output(s):****integer:** Column number, valid only if the error was a syntaxerror. Column numbering starts at 0.**Error(s):** None.**Description:** Get the column number that a syntaxerror occurred on.**Example(s):**

```

onyx:0> '1 2 3}' cvx eval
At line 1, column 5: Error $syntaxerror
ostack: (1 2 3 '}'')
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..3):

```

```

0:      '1 2 3}'
1:      --eval--
2:      -file-
3:      --start--
onyx:5> currenterror $column get 1 sprint
5
onyx:5>

```

– **cstack** *stack*:

Input(s): None.

Output(s):

stack: A cstack snapshot.

Error(s): None.

Description: Get a stack that is a cstack snapshot as of the most recent error.

Example(s):

```

onyx:0> x
Error $undefined
ostack: ()
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      x
1:      -file-
2:      --start--
onyx:1> currenterror begin cstack end 1 sprint
()
onyx:1>

```

– **dstack** *stack*:

Input(s): None.

Output(s):

stack: A dstack snapshot.

Error(s): None.

Description: Get a stack that is a dstack snapshot as of the most recent error.

Example(s):

```

onyx:0> x
Error $undefined
ostack: ()
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      x
1:      -file-
2:      --start--
onyx:1> currenterror begin dstack end 1 sprint
(-dict- -dict- -dict- -dict-)
onyx:1>

```

– **errorname** *name*:

Input(s): None.

Output(s):

name: Name of the most recent error.

Error(s): None.

Description: Get the name of the most recent error.

Example(s):

```
onyx:0> x
Error $undefined
ostack: ()
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      x
1:      -file-
2:      --start--
onyx:1> currenterror begin errorname end 1 sprint
$undefined
onyx:1>
```

- estack *stack*:

Input(s): None.

Output(s):

stack: An estack snapshot.

Error(s): None.

Description: Get a stack that is an estack snapshot as of the most recent error.

Example(s):

```
onyx:0> x
Error $undefined
ostack: ()
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      x
1:      -file-
2:      --start--
onyx:1> currenterror begin estack end 1 sprint
(--start-- -file- x)
onyx:1>
```

- istack *stack*:

Input(s): None.

Output(s):

stack: An istack snapshot.

Error(s): None.

Description: Get a stack that is an istack snapshot as of the most recent error.

Example(s):

```
onyx:0> x
Error $undefined
ostack: ()
dstack: (-dict- -dict- -dict- -dict-)
```

```

cstack: ()
estack/istack trace (0..2):
0:      x
1:      -file-
2:      --start--
onyx:1> currenterror begin istack end 1 sprint
(0 0 0)
onyx:1>

```

– **newerror** *boolean*:

Input(s): None.

Output(s):

boolean: False if there has been no error since the last time newerror was reset; true otherwise.

Error(s): None.

Description: Get a boolean that represents whether there has been an error since the last time newerror was set to false (as during interpreter initialization). It is the application's responsibility to reset newerror after each error if it expects the value to be useful across multiple errors.

Example(s):

```

onyx:0> currenterror begin
onyx:0> newerror 1 sprint
false
onyx:0> x
Error $undefined
ostack: ()
dstack: (-dict- -dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      x
1:      -file-
2:      --start--
onyx:1> newerror 1 sprint
true
onyx:1> $newerror false def
onyx:1> newerror 1 sprint
false
onyx:1> resume
onyx:1> y
Error $undefined
ostack: (x)
dstack: (-dict- -dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      y
1:      -file-
2:      --start--
onyx:2> newerror 1 sprint
true
onyx:2>

```

– **line** *integer*:

Input(s): None.

Output(s):

integer: Line number, valid only if the error was a syntaxerror. Line numbering starts at 1.

Error(s): None.

Description: Get the line number that a syntaxerror occurred on.

Example(s):

```
onyx:0> '1 2 3}' cvx eval
At line 1, column 5: Error $syntaxerror
ostack: (1 2 3 '}'')
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..3):
0:      '1 2 3}'
1:      --eval--
2:      -file-
3:      --start--
onyx:5> currenterror $line get 1 sprint
1
onyx:5>
```

– **origin *string/null*:**

Input(s): None.

Output(s):

string/null: Origin string if the error was a syntaxerror, null otherwise.

Error(s): None.

Description: Get the origin of a syntaxerror.

Example(s):

```
onyx:0> 1 2 3}
At *stdin*:1:5: Error $syntaxerror
ostack: (1 2 3 '}'')
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..1):
0:      -file-
1:      --start--
onyx:5> currenterror $origin get 1 sprint
'*stdin*'
onyx:5>
```

– **ostack *stack*:**

Input(s): None.

Output(s):

stack: An ostack snapshot.

Error(s): None.

Description: Get a stack that is an ostack snapshot as of the most recent error.

Example(s):

```
onyx:0> x
Error $undefined
```

```

ostack: ( )
dstack: (-dict- -dict- -dict- -dict-)
cstack: ( )
estack/istack trace (0..2):
0:      x
1:      -file-
2:      --start--
onyx:1> currenterror begin ostack end 1 sprint
( )
onyx:1>

```

2.11.2 envdict

The envdict dictionary contains keys of type name and values of type string that correspond to the environment passed into the program. All threads share the same envdict, which is implicitly locked. Modifications to envdict should be made via the **setenv** and **unsetenv** operators. If envdict is modified directly, the changes will not be visible to programs such as *ps*.

2.11.3 errordict

Each thread has its own errordict, which is used by default by the error handling machinery.

Table 2.5: errordict summary

Input(s) Op/Proc/Var Output(s)	Description
– handleerror –	Print a state dump.
– stop –	Last operation during error handling.

– handleerror –:

Input(s): None.

Output(s): None.

Error(s): Under normal conditions, no errors occur. However, it is possible for the application to corrupt the error handling machinery to the point that an error will occur. If that happens, the result is possible infinite recursion, and program crashes are a real possibility.

Description: Print a dump of the most recent error recorded in the currenterror dictionary.

Example(s):

```

onyx:0> {true {true 1 sprint x y} if} eval
true
Error $undefined
ostack: ( )
dstack: (-dict- -dict- -dict- -dict-)

```

```

cstack: ( )
estack/istack trace (0..5):
0:      x
1: {
      true
      1
      sprint
3:--> x
      y
}
2:      --if--
3:      --eval--
4:      -file-
5:      --start--
onyx:1> errordict begin handleerror end
Error $undefined
ostack: ( )
dstack: (-dict- -dict- -dict- -dict-)
cstack: ( )
estack/istack trace (0..5):
0:      x
1: {
      true
      1
      sprint
3:--> x
      y
}
2:      --if--
3:      --eval--
4:      -file-
5:      --start--
onyx:1>

```

- stop -:**Input(s):** None.**Output(s):** None.**Error(s):** None.**Description:** This is called as the very last operation when an error occurs. Initially, its value is the same as that for the **stop** operator in systemdict.**Example(s):**

```

onyx:0> errordict begin
onyx:0> $stop {'Custom stop\n' print flush quit} def
onyx:0> x
Error $undefined
ostack: ( )
dstack: (-dict- -dict- -dict- -dict- -dict-)
cstack: ( )
estack/istack trace (0..2):
0:      x
1:      -file-
2:      --start--

```

Custom stop

2.11.4 gdict

The gdict dictionary provides garbage collection control and status capabilities.

Table 2.6: gdict summary

Input(s) Op/Proc/Var Output(s)	Description
Control operators	
– collect –	Force a garbage collection.
boolean setactive –	Set whether the garbage collector is active.
seconds setperiod –	Set the inactivity period before the garbage collector will run.
count setthreshold –	Set the number of bytes of memory allocation that will trigger a garbage collection.
State and statistics operators	
– active boolean	Get whether the garbage collector is active.
– period seconds	Get the inactivity period before the garbage collector will run.
– threshold count	Get the number of bytes of memory allocation that will trigger a garbage collection.
– stats array	Get garbage collection statistics.

– active *boolean*:

Input(s): None.

Output(s):

boolean: If true, the garbage collector is active; otherwise it is not active.

Error(s): None.

Description: Get whether the garbage collector is active.

Example(s):

```
onyx:0> gdict begin active end 1 sprint
false
```

– collect –:

Input(s): None.

Output(s): None.

Error(s): None.

Description: Force a garbage collection.

Example(s):

```
onyx:0> gcdict begin collect end
onyx:0>
```

– period *seconds*:

Input(s): None.

Output(s):

seconds: The minimum number of seconds since the last object allocation that the garbage collector will wait before doing a garbage collection. 0 is treated specially to mean forever.

Error(s): None.

Description: Get the minimum number of seconds of object allocation inactivity that the garbage collector will wait before doing a garbage collection. This setting is disjoint from the threshold setting, and does not prevent garbage collection due to the threshold having been reached.

Example(s):

```
onyx:0> gcdict begin period end 1 sprint
60
onyx:0>
```

***boolean* setactive –:**

Input(s):

boolean: If true (initial setting), activate the garbage collector; otherwise deactivate the garbage collector.

Output(s): None.

Error(s):

stackunderflow.
typecheck.

Description: Set whether the garbage collector is active. This setting takes effect asynchronously, so it is possible for the garbage collector to run even after it has been deactivated. This setting overrides the allocation inactivity period and allocation threshold settings, so that if this setting is set to false, the other settings have no effect.

Example(s):

```
onyx:0> gcdict begin false setactive end
onyx:0>
```

***seconds* setperiod –:**

Input(s):

seconds: The minimum number of seconds since the last object allocation that the garbage collector will wait before doing a garbage collection. 0 is treated specially to mean forever.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

limitcheck.

Description: Set the minimum number of seconds of object allocation inactivity that the garbage collector will wait before doing a garbage collection. This setting is disjoint from the threshold setting, and does not prevent garbage collection due to the threshold having been reached.

Example(s):

```
onyx:0> gcdict begin 60 setperiod end
onyx:0>
```

count setthreshold -:

Input(s):

count: Number of bytes of memory allocation since the last garbage collection that will trigger a garbage collection. 0 is treated specially to mean infinity.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

limitcheck.

Description: Set the number of bytes of memory allocation since the last garbage collection that will trigger a garbage collection. This setting is disjoint from the inactivity period setting, and does not prevent garbage collection due to the allocation inactivity period having been exceeded.

Example(s):

```
onyx:0> gcdict begin 40000 setthreshold end
onyx:0>
```

- stats array:

Input(s): None.

Output(s):

array: An array with the format [collections count [ccount cmark] [mcount mmark] [scount smark]], where the fields have the following meanings:

collections: Total number of collections the garbage collector has performed.

count: Current number of bytes of memory allocated.

ccount: Number of bytes of memory allocated as of the end of the most recent garbage collection.

cmark: Number of microseconds taken by the most recent garbage collection mark phase.

mcount: Largest number of bytes of memory ever allocated at any point in time.

mmark: Maximum number of microseconds taken by any garbage collection mark phase.

scount: Total number of bytes of memory ever allocated.

smark: Total number of microseconds taken by all garbage collection mark phases.

Error(s): None.

Description: Get statistics about the garbage collector.

Example(s):

```
onyx:0> gcdict begin
onyx:0> stats 2 sprint
[28 280921 [118328 852] [904779 1007] [5707551 24205]]
onyx:0>
```

– threshold *count*:**Input(s):** None.**Output(s):****count:** Number of bytes of memory allocation since the last garbage collection that will trigger a garbage collection. 0 is treated specially to mean infinity.**Error(s):** None.**Description:** Get the number of bytes of memory allocation since the last garbage collection that will trigger a garbage collection. This setting is disjoint from the inactivity period setting, and does not prevent garbage collection due to the allocation inactivity period having been exceeded.**Example(s):**

```

onyx:0> gcdict begin threshold end 1 sprint
65536
onyx:0>

```

2.11.5 globaldict

All threads share the same globaldict, which is meant as a repository for globally shared objects. globaldict is empty when the Onyx interpreter is initialized, and is implicitly locked.

2.11.6 onyxdict

Various portions of Onyx use the onyxdict dictionary for storage of miscellaneous objects that normally should not be part of the namespace visible to dstack searches.

Table 2.7: onyxdict summary

Input(s) Op/Proc/Var Output(s)	Description
– mpath_post array	Get path searched by mrequire.
– mpath_pre array	Get path searched by mrequire.
– rpath_post array	Get path searched by require.
– rpath_pre array	Get path searched by require.

– mpath_post *array*:**Input(s):** None.**Output(s):**

array: An array of strings.

Error(s): None.

Description: Get an array of strings used by `mrequire` as prefixes for file searches. The elements of the array are tried in the order listed.

Example(s):

```
onyx:0> onyxdict $mpath_post get 1 sprint
[ '/usr/local/share/onyx-3.0.0/nxm' ]
onyx:0>
```

– mpath_pre array:

Input(s): None.

Output(s):

array: An array of strings.

Error(s): None.

Description: Get an array of strings used by `mrequire` as prefixes for file searches. The elements of the array are tried in the order listed.

Example(s):

```
onyx:0> onyxdict $mpath_pre get 1 sprint
[ ' ' '. ' ]
onyx:0>
```

– rpath_post array:

Input(s): None.

Output(s):

array: An array of strings.

Error(s): None.

Description: Get an array of strings used by `require` as prefixes for file searches. The elements of the array are tried in the order listed.

Example(s):

```
onyx:0> onyxdict $rpath_post get 1 sprint
[ '/usr/local/share/onyx-3.0.0/nx' ]
onyx:0>
```

– rpath_pre array:

Input(s): None.

Output(s):

array: An array of strings.

Error(s): None.

Description: Get an array of strings used by `require` as prefixes for file searches. The elements of the array are tried in the order listed.

Example(s):

```
onyx:0> onyxdict $rpath_pre get 1 sprint
[ ' ' '. ' ]
onyx:0>
```

2.11.7 outputsdict

The outputsdict dictionary is primarily used to support **outputs**, but its contents may be of use to an application that wishes to extend or modify formatted printing.

There is an entry in outputsdict for each Onyx type. Each entry renders objects that correspond to its name using optional flags stored in a dictionary. The following flags are supported for all types:

- \$n: Maximum length, in bytes. Default: disabled.
- \$w: Minimum length, in bytes. Default: disabled.
- \$j: Justification. Legal values:
 - \$l: Left.
 - \$c: Center.
 - \$r: Right (default).
- \$p: Padding character. Default: ' '.
- \$r: Syntactic rendering recursion depth. Default: 1.

The following additional flags are supported for integers:

- \$b: Base, from 2 to 36. Default: 10.
- \$s: Sign. Legal values:
 - \$-: Only print sign if output is negative (default).
 - \$+: Always print sign.

The following additional flags are supported for reals:

- \$d: Digits of precision past decimal point. Default: 6.
- \$e: Exponential notation, if true. Default: false.

Table 2.8: outputsdict summary

Input(s) Op/Proc/Var Output(s)	Description
array flags arraytype string	Create formatted string from array.
boolean flags booleantype string	Create formatted string from boolean.
class flags classtype string	Create formatted string from class.

Continued on next page...

Table 2.8: *continued*

Input(s) Op/Proc/Var Output(s)	Description
condition flags conditiontype string	Create formatted string from condition.
dict flags dicttype string	Create formatted string from dict.
file flags filetype string	Create formatted string from file.
fino flags finotype string	Create formatted string from fino.
handle flags handletype string	Create formatted string from handle.
instance flags instancetype string	Create formatted string from instance.
integer flags integertype string	Create formatted string from integer.
mark flags marktype string	Create formatted string from mark.
mutex flags mutextype string	Create formatted string from mutex.
name flags nametype string	Create formatted string from name.
null flags nulltype string	Create formatted string from null.
operator flags operatorotype string	Create formatted string from operator.
pmark flags pmarktype string	Create formatted string from pmark.
real flags realttype string	Create formatted string from real.
regex flags regextype string	Create formatted string from regex.

Continued on next page...

Table 2.8: *continued*

Input(s) Op/Proc/Var Output(s)	Description
regsub flags regsubtype string	Create formatted string from regsub.
stack flags stacktype string	Create formatted string from stack.
string flags stringtype string	Create formatted string from string.
thread flags threadtype string	Create formatted string from thread.

array flags arraytype string:**Input(s):****array:** An array object.**flags:** Formatting flags.**Output(s):****string:** Formatted string representation of *array*.**Error(s):****stackunderflow.****typecheck.****Description:** Create a formatted string representation of *array*.**Example(s):**

```

onyx:0> outputsdict begin
onyx:0> [1 [2 3] 4]
onyx:1> dup <$w 9 $p '_' $r 0> arraytype print '\n' print flush
__-array-
onyx:1> dup <$w 9 $p '_' $r 1> arraytype print '\n' print flush
[1 -array- 4]
onyx:1>

```

boolean flags booleantype string:**Input(s):****boolean:** A boolean object.**flags:** Formatting flags.**Output(s):****string:** Formatted string representation of *boolean*.**Error(s):****stackunderflow.****typecheck.****Description:** Create a formatted string representation of *boolean*.

Example(s):

```

onyx:0> outputsdict begin
onyx:0> false
onyx:1> dup <$n 3> booleantype print '\n' print flush
fal
onyx:1> dup <$n 7> booleantype print '\n' print flush
false
onyx:1>

```

class flags classtype string:**Input(s):**

class: A class object.
flags: Formatting flags.

Output(s):

string: Formatted string representation of *class*.

Error(s):

stackunderflow.
typecheck.

Description: Create a formatted string representation of *class*.

Example(s):

```

onyx:0> outputsdict begin
onyx:0> vclass
onyx:1> <$w 30 $p '.' $j $c> classtype print '\n' print flush
.....-class-.....
onyx:0>

```

condition flags conditiontype string:**Input(s):**

condition: A condition object.
flags: Formatting flags.

Output(s):

string: Formatted string representation of *condition*.

Error(s):

stackunderflow.
typecheck.

Description: Create a formatted string representation of *condition*.

Example(s):

```

onyx:0> outputsdict begin
onyx:0> condition
onyx:1> <$w 15 $p '_' $j $c> booleantype print '\n' print flush
__-condition-__
onyx:0>

```

dict flags dicttype string:**Input(s):**

dict: A dict object.
flags: Formatting flags.

Output(s):

string: Formatted string representation of *dict*.

Error(s):

stackunderflow.

typecheck.

Description: Create a formatted string representation of *dict*.

Example(s):

```
onyx:0> outputsdict begin
onyx:0> <$foo 'foo'> <$w 30 $p `.' $j $r> dicttype print '\n' print flush
.....<$foo 'foo'>
onyx:0>
```

file flags filetype string:

Input(s):

file: A file object.

flags: Formatting flags.

Output(s):

string: Formatted string representation of *file*.

Error(s):

stackunderflow.

typecheck.

Description: Create a formatted string representation of *file*.

Example(s):

```
onyx:0> outputsdict begin
onyx:0> stdin
onyx:1> <$w 30 $p `.' $j $c> filetype print '\n' print flush
.....-file-.....
onyx:0>
```

fino flags finotype string:

Input(s):

fino: A fino object.

flags: Formatting flags.

Output(s):

string: Formatted string representation of *fino*.

Error(s):

stackunderflow.

typecheck.

Description: Create a formatted string representation of *fino*.

Example(s):

```
onyx:0> outputsdict begin
onyx:0> (
onyx:1> <$w 30 $p `.' $j $c> finotype print '\n' print flush
.....-fino-.....
onyx:0>
```

handle flags handletype string:

Input(s):

handle: A handle object.

flags: Formatting flags.

Output(s):

string: Formatted string representation of *handle*.

Error(s):

stackunderflow.

typecheck.

Description: Create a formatted string representation of *handle*.

Example(s): The following example is a bit contrived, since there is no way to create a handle object with a stock onyx interpreter. Therefore, imagine that an operator named `taggedhandle` exists that creates a handle with a tag that is the name “tagged”.

```
onyx:0> outputsdict begin
onyx:0> taggedhandle
onyx:1> <$w 30 $p \.' $j $l handletype print '\n' print flush
=tagged=.....
onyx:0>
```

instance flags instancetype string:

Input(s):

instance: An instance object.

flags: Formatting flags.

Output(s):

string: Formatted string representation of *instance*.

Error(s):

stackunderflow.

typecheck.

Description: Create a formatted string representation of *instance*.

Example(s):

```
onyx:0> outputsdict begin
onyx:0> vinstance
onyx:1> <$w 30 $p \.' $j $c> instancetype print '\n' print flush
.....-instance-.....
onyx:0>
```

integer flags integertype string:

Input(s):

integer: An integer object.

flags: Formatting flags.

Output(s):

string: Formatted string representation of *integer*.

Error(s):

stackunderflow.

typecheck.

Description: Create a formatted string representation of *integer*.

Example(s):

```

onyx:0> outputsdict begin
onyx:0> 42 <$w 6 $p '_' $j $c $s $-> integertype print '\n' print flush
__42__
onyx:0> 42 <$w 6 $p '_' $j $c $s $+> integertype print '\n' print flush
__+42__
onyx:0> '0x' print 42 <$w 6 $p '0' $b 16> integertype print '\n' print flush
0x00002a
onyx:0>

```

mark flags marktype string:**Input(s):**

mark: A mark object.
flags: Formatting flags.

Output(s):

string: Formatted string representation of *mark*.

Error(s):

stackunderflow.
typecheck.

Description: Create a formatted string representation of *mark*.

Example(s):

```

onyx:0> outputsdict begin
onyx:0> mark
onyx:1> <$w 30 $p '.' $j $c> marktype print '\n' print flush
.....-mark-.....
onyx:0>

```

mutex flags mutextype string:**Input(s):**

mutex: A mutex object.
flags: Formatting flags.

Output(s):

string: Formatted string representation of *mutex*.

Error(s):

stackunderflow.
typecheck.

Description: Create a formatted string representation of *mutex*.

Example(s):

```

onyx:0> outputsdict begin
onyx:0> mutex
onyx:1> <$w 30 $p '.' $j $c> mutextype print '\n' print flush
.....-mutex-.....
onyx:0>

```

name flags nametype string:**Input(s):**

name: A name object.
flags: Formatting flags.

Output(s):

string: Formatted string representation of *name*.

Error(s):

stackunderflow.

typecheck.

Description: Create a formatted string representation of *name*.

Example(s):

```
onyx:0> outputsdict begin
onyx:0> $foo
onyx:1> <$w 30 $p `.' $j $c> nametype print '\n' print flush
.....$foo.....
onyx:0>
```

null flags nulltype string:**Input(s):**

null: A null object.

flags: Formatting flags.

Output(s):

string: Formatted string representation of *null*.

Error(s):

stackunderflow.

typecheck.

Description: Create a formatted string representation of *null*.

Example(s):

```
onyx:0> outputsdict begin
onyx:0> null
onyx:1> <$w 30 $p `.' $j $c> nulltype print '\n' print flush
.....null.....
onyx:0>
```

operator flags operatortype string:**Input(s):**

operator: An operator object.

flags: Formatting flags.

Output(s):

string: Formatted string representation of *operator*.

Error(s):

stackunderflow.

typecheck.

Description: Create a formatted string representation of *operator*.

Example(s): The following example shows an operator printed out with two leading and trailing dashes. If the interpreter cannot determine the name associated with an operator, as will be the case for custom operators, the operator will be printed as `-operator-`.

```
onyx:0> outputsdict begin
onyx:0> ~realtime
onyx:1> <$w 30 $p `.' $j $c> operatortype print '\n' print flush
.....--realtime--.....
onyx:0>
```


regex: A regex object.
flags: Formatting flags.

Output(s):

string: Formatted string representation of *regex*.

Error(s):

stackunderflow.
typecheck.

Description: Create a formatted string representation of *regex*.

Example(s):

```
onyx:0> outputsdict begin
onyx:0> `` regex
onyx:1> <$w 30 $p `.` $j $c> regextype print `\\n' print flush
.....-regex-.....
onyx:0>
```

***regex* sub flags regsubtype string:**

Input(s):

regsub: A regsub object.
flags: Formatting flags.

Output(s):

string: Formatted string representation of *regsub*.

Error(s):

stackunderflow.
typecheck.

Description: Create a formatted string representation of *regsub*.

Example(s):

```
onyx:0> outputsdict begin
onyx:0> `` `` regsub
onyx:1> <$w 30 $p `.` $j $c> regsubtype print `\\n' print flush
.....-regsub-.....
onyx:0>
```

***stack* flags stacktype string:**

Input(s):

stack: A stack object.
flags: Formatting flags.

Output(s):

string: Formatted string representation of *stack*.

Error(s):

stackunderflow.
typecheck.

Description: Create a formatted string representation of *stack*.

Example(s):

```
onyx:0> outputsdict begin
onyx:0> (1 (2 3) 4)
onyx:1> dup <$w 9 $p `_' $r 0> stacktype print `\\n' print flush
__-stack-
```

```

onyx:1> <$w 9 $p '_' $r 1> stacktype print '\n' print flush
(1 -stack- 4)
onyx:0>

```

string flags stringtype string:**Input(s):****string:** A string object.**flags:** Formatting flags.**Output(s):****string:** Formatted string representation of *string*.**Error(s):****stackunderflow.****typecheck.****Description:** Create a formatted string representation of *string*.**Example(s):**

```

onyx:0> outputsdict begin
onyx:0> 'A string'
onyx:1> <$w 30 $p '.' $j $c> stringtype print '\n' print flush
.....A string.....
onyx:0>

```

thread flags threadtype thread:**Input(s):****thread:** A thread object.**flags:** Formatting flags.**Output(s):****string:** Formatted string representation of *thread*.**Error(s):****stackunderflow.****typecheck.****Description:** Create a formatted string representation of *thread*.**Example(s):**

```

onyx:0> outputsdict begin
onyx:0> () {} thread
onyx:1> <$w 30 $p '.' $j $c> threadtype print '\n' print flush
.....-thread-.....
onyx:0>

```

2.11.8 sprintsdict

The sprintsdict dictionary is primarily used to support **sprints**, but its contents may be of use to an application that wishes to extend or modify syntactical printing.

There is an entry in sprintsdict for each Onyx type. If there is a syntactically valid representation for an object and the recursion depth is greater than 0, the corresponding operator creates a string that syntactically represents the object. Otherwise, a string with a non-syntactical representation of the object is created, except for booleans, integers, names, nulls, reals, and strings, for which the results

are always syntactical. If the recursion depth is greater than 0, the operators will recursively convert any contained objects.

The implementation of **sprints** is useful in illustrating a useful method of doing type-dependent operations:

```
$sprints {
    1 idup type $sprintsdict load exch get eval
} def
```

Table 2.9: sprintsdict summary

Input(s) Op/Proc/Var Output(s)	Description
array depth arraytype string	Create syntactical string from array.
boolean depth booleantype string	Create syntactical string from boolean.
class depth classtype string	Create syntactical string from class.
condition depth conditiontype string	Create syntactical string from condition.
dict depth dicttype string	Create syntactical string from dict.
file depth filetype string	Create syntactical string from file.
fino depth finotype string	Create syntactical string from fino.
handle depth handletype string	Create syntactical string from handle.
instance depth instancetype string	Create syntactical string from instance.
integer depth integertype string	Create syntactical string from integer.
mark depth marktype string	Create syntactical string from mark.
mutex depth mutextype string	Create syntactical string from mutex.

Continued on next page...

Table 2.9: *continued*

Input(s) Op/Proc/Var Output(s)	Description
name depth nametype string	Create syntactical string from name.
null depth nulltype string	Create syntactical string from null.
operator depth operatortype string	Create syntactical string from operator.
pmark depth pmarktype string	Create syntactical string from pmark.
real depth realttype string	Create syntactical string from real.
regex depth regextype string	Create syntactical string from regex.
regsub depth regsubtype string	Create syntactical string from regsub.
stack depth stacktype string	Create syntactical string from stack.
string depth stringtype string	Create syntactical string from string.
thread depth threadtype string	Create syntactical string from thread.

array depth arraytype string:**Input(s):****array:** An array object.**depth:** Recursion depth.**Output(s):****string:** Syntactical string representation of *array*.**Error(s):****stackunderflow.****typecheck.****Description:** Create a syntactical string representation of *array*.**Example(s):**

onyx:0> sprintsdict begin

```
onyx:0> [1 [2 3] 4]
onyx:1> dup 0 arraytype print '\n' print flush
-array-
onyx:1> dup 1 arraytype print '\n' print flush
[1 -array- 4]
onyx:1> dup 2 arraytype print '\n' print flush
[1 [2 3] 4]
onyx:1>
```

boolean depth booleantype string:**Input(s):**

boolean: A boolean object.
depth: Recursion depth.

Output(s):

string: Syntactical string representation of *boolean*.

Error(s):

stackunderflow.
typecheck.

Description: Create a syntactical string representation of *boolean*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> true
onyx:1> dup 0 booleantype print '\n' print flush
true
onyx:1>
```

class depth classtype string:**Input(s):**

class: A class object.
depth: Recursion depth.

Output(s):

string: Syntactical string representation of *class*.

Error(s):

stackunderflow.
typecheck.

Description: Create a syntactical string representation of *class*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> vclass
onyx:1> dup 0 classtype print '\n' print flush
-class-
onyx:1> dup 1 classtype print '\n' print flush
-class-
onyx:1>
```

condition depth conditiontype string:**Input(s):**

condition: A condition object.
depth: Recursion depth.

Output(s):

string: Syntactical string representation of *condition*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *condition*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> condition
onyx:1> dup 0 conditiontype print '\n' print flush
-condition-
onyx:1> dup 1 conditiontype print '\n' print flush
-condition-
onyx:1>
```

dict depth dicttype string:**Input(s):**

dict: A dict object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *dict*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *dict*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> <$a 'a' $subdict <$b 'b'>>
onyx:1> dup 0 dicttype print '\n' print flush
-dict-
onyx:1> dup 1 dicttype print '\n' print flush
<$subdict -dict- $a 'a'>
onyx:1> dup 2 dicttype print '\n' print flush
<$subdict <$b 'b'> $a 'a'>
onyx:1>
```

file depth filetype string:**Input(s):**

file: A file object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *file*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *file*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> stdout
onyx:1> dup 0 filetype print '\n' print flush
-file-
onyx:1> dup 1 filetype print '\n' print flush
-file-
onyx:1>
```

fino depth finotype string:**Input(s):**

fino: A fino object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *fino*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *fino*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> (
onyx:1> dup 0 finotype print '\n' print flush
-fino-
onyx:1> dup 1 finotype print '\n' print flush
-fino-
onyx:1>
```

handle depth handletype string:**Input(s):**

handle: A handle object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *handle*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *handle*.

Example(s): The following example is a bit contrived, since there is no way to create a handle object with a stock onyx interpreter. Therefore, imagine that an operator named `taggedhandle` exists that creates a handle with a tag that is the name “tagged”, and that an operator named `untaggedhandle` exists that creates an untagged handle.

```
onyx:0> sprintsdict begin
onyx:0> taggedhandle
onyx:1> dup 0 handletype print '\n' print flush
=tagged=
onyx:1> 1 handletype print '\n' print flush
```

```
=tagged=
onyx:0> untaggedhandle
onyx:1> dup 0 handletype print '\n' print flush
-handle-
onyx:1> 1 handletype print '\n' print flush
-handle-
onyx:0>
```

instance depth instancetype string:

Input(s):

instance: An instance object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *instance*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *instance*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> vinstance
onyx:1> dup 0 instancetype print '\n' print flush
-instance-
onyx:1> dup 1 instancetype print '\n' print flush
-instance-
onyx:1>
```

integer depth integertype string:

Input(s):

integer: An integer object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *integer*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *integer*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> 42
onyx:1> dup 0 integertype print '\n' print flush
42
onyx:1> dup 1 integertype print '\n' print flush
42
onyx:1>
```

mark depth marktype string:

Input(s):

mark: A mark object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *mark*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *mark*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> mark
onyx:1> dup 0 marktype print '\n' print flush
-mark-
onyx:1> dup 1 marktype print '\n' print flush
-mark-
onyx:1>
```

mutex depth mutextype string:

Input(s):

mutex: A mutex object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *mutex*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *mutex*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> mutex
onyx:1> dup 0 mutextype print '\n' print flush
-mutex-
onyx:1> dup 1 mutextype print '\n' print flush
-mutex-
onyx:1>
```

name depth nametype string:

Input(s):

name: A name object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *name*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *name*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> $foo
onyx:1> dup 0 nametype print '\n' print flush
$foo
onyx:1> dup 1 nametype print '\n' print flush
$foo
onyx:1>
```

null depth nulltype string:**Input(s):**

null: A null object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *null*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *null*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> null
onyx:1> dup 0 nulltype print '\n' print flush
-null-
onyx:1> dup 1 nulltype print '\n' print flush
-null-
onyx:1>
```

operator depth operortype string:**Input(s):**

operator: An operator object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *operator*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *operator*.

Example(s): The following example shows an operator printed out with two leading and trailing dashes. If the interpreter cannot determine the name associated with an operator, as will be the case for custom operators, the operator will be printed as *-operator-*.

```
onyx:0> sprintsdict begin
onyx:0> ~realtime
onyx:1> dup 0 operortype print '\n' print flush
--realtime--
onyx:1> 1 operortype print '\n' print flush
--realtime--
onyx:0>
```

pmark depth pmarktype string:**Input(s):****pmark:** A pmark object.**depth:** Recursion depth.**Output(s):****string:** Syntactical string representation of *pmark*.**Error(s):****stackunderflow.****typecheck.****Description:** Create a syntactical string representation of *pmark*.**Example(s):**

```

onyx:0> sprintsdict begin
onyx:0> { ~x
Error $undefined
ostack: (-pmark- $x)
dstack: (-dict- -dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..1):
0:      -file-
1:      --start--
onyx:3> pop pop resume
onyx:1> dup 0 pmarktype print '\n' print flush
-pmark-
onyx:1> dup 1 pmarktype print '\n' print flush
-pmark-
onyx:1>

```

regex depth regextype string:**Input(s):****regex:** A regex object.**depth:** Recursion depth.**Output(s):****string:** Syntactical string representation of *regex*.**Error(s):****stackunderflow.****typecheck.****Description:** Create a syntactical string representation of *regex*.**Example(s):**

```

onyx:0> sprintsdict begin
onyx:0> `` regex
onyx:1> dup 0 regextype print '\n' print flush
-regex-
onyx:1> dup 1 regextype print '\n' print flush
-regex-
onyx:1>

```

regsub depth regsubtype string:**Input(s):**

regsub: A regsub object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *regsub*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *regsub*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> ' ' ' ' regsub
onyx:1> dup 0 regsubtype print '\n' print flush
-regsub-
onyx:1> dup 1 regsubtype print '\n' print flush
-regsub-
onyx:1>
```

real depth realtype string:

Input(s):

real: A real object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *real*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *real*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> 42.0
onyx:1> dup 0 realtype print '\n' print flush
4.200000e+01
onyx:1> dup 1 realtype print '\n' print flush
4.200000e+01
onyx:1>
```

stack depth stacktype string:

Input(s):

stack: A stack object.

depth: Recursion depth.

Output(s):

string: Syntactical string representation of *stack*.

Error(s):

stackunderflow.

typecheck.

Description: Create a syntactical string representation of *stack*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> (1 (2 3) 4)
onyx:1> dup 0 stacktype print '\n' print flush
-stack-
onyx:1> dup 1 stacktype print '\n' print flush
(1 -stack- 4)
onyx:1> dup 2 stacktype print '\n' print flush
(1 (2 3) 4)
onyx:1>
```

string depth stringtype string:**Input(s):**

string: A string object.
depth: Recursion depth.

Output(s):

string: Syntactical string representation of *string*.

Error(s):

stackunderflow.
typecheck.

Description: Create a syntactical string representation of *string*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> 'abcd'
onyx:1> dup 0 stringtype print '\n' print flush
'abcd'
onyx:1> dup 1 stringtype print '\n' print flush
'abcd'
onyx:1>
```

thread depth threadtype string:**Input(s):**

thread: A thread object.
depth: Recursion depth.

Output(s):

string: Syntactical string representation of *thread*.

Error(s):

stackunderflow.
typecheck.

Description: Create a syntactical string representation of *thread*.

Example(s):

```
onyx:0> sprintsdict begin
onyx:0> thread
onyx:1> dup 0 threadtype print '\n' print flush
-thread-
onyx:1> dup 1 threadtype print '\n' print flush
-thread-
onyx:1>
```

2.11.9 systemdict

The systemdict dictionary contains most of the operators that are of general use. Although there are no mechanisms that prevent modification of systemdict, programs should not normally need to modify systemdict, since globaldict provides a place for storing globally shared objects. All threads share the same systemdict, which is implicitly locked.

Table 2.10 summarizes the contents of systemdict, and is broken into the following categories:

- Operand stack operators
- Execution, control, and execution stack operators
- Stack operators
- Number (integer, real) and math operators
- String operators
- Name operators
- Array operators
- Dictionary and dictionary stack operators
- Class, instance, and handle operators
- File and filesystem operators
- Socket and networking operators
- Logical and bitwise operators
- Type, conversion, and attribute operators
- Threading and synchronization operators
- Regular expression operators
- Miscellaneous operators

Table 2.10: systemdict summary

Input(s) Op/Proc/Var Output(s)	Description
Operand stack operators	
— mark mark	Create a mark.
,,,obj aup obj ,,,	Rotate stack up one position.
obj ,,, adn ,,,obj	Rotate stack down one position.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
– count count	Get the number of objects on ostack.
mark ... counttomark mark ... count	Get the depth of the topmost mark on ostack.
obj dup obj dup	Duplicate an object.
obj ,,, bdup obj ,,,dup	Duplicate bottom object.
objects count ndup objects objects	Duplicate objects.
obj ... index idup obj ... dup	Duplicate object on ostack at index.
... obj ,,,index ibdup ... obj ,,,dup	Duplicate object on ostack at index from bottom.
a b tuck b a b	Tuck duplicate of top object under second object.
a b under a a b	Duplicate second object.
a b over a b a	Duplicate second object.
a b exch b a	Exchange top two objects.
a b c up c a b	Roll top three objects up one.
a ... b count nup b a ...	Roll count objects up one.
a b c dn b c a	Roll top three objects down one.
a ... b count ndn ... b a	Roll count objects down one.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
... amount rot ...	Rotate stack up by <i>amount</i> .
region count amount roll rolled	Roll <i>count</i> objects up by <i>amount</i> .
obj pop —	Remove object.
obj ,, bpop ,,	Remove bottom object.
objects count npop —	Remove count objects.
objects ... count nbpop ...	Remove count objects from bottom.
obj ... index ipop ...	Remove object at index.
... obj ,,index ibpop ...,,	Remove object at index from bottom.
a b nip b	Remove second object.
objects clear —	Pop all objects off ostack.
mark ... cleartomark —	Remove objects from ostack through topmost mark.
— ostack stack	Get a current ostack snapshot.
thread threadostack stack	Get a reference to thread's ostack.
Execution, control, and execution stack operators	
obj eval —	Evaluate object.
boolean obj if —	Conditionally evaluate object.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
boolean obj unless —	Conditionally evaluate object.
boolean a b ifelse —	Conditionally evaluate one of two objects.
init inc limit proc for —	Iterate with a control variable.
count proc repeat —	Iterate a set number of times.
cond proc while —	Loop while cond is true.
proc cond until —	Loop until cond is false.
proc loop —	Loop indefinitely.
array proc foreach — dict proc foreach — stack proc foreach — string proc foreach —	Iterate on array elements. Iterate on dictionary key/value pairs. Iterate on stack elements. Iterate on string elements.
— continue —	Skip to next iteration of innermost looping context.
— exit —	Terminate innermost looping context.
file/string token false file/string token rem obj true	Unsuccessfully scan for a token. Successfully scan for a token
obj start —	Evaluate object.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
– quit –	Unwind to innermost start context.
obj stopped boolean	Evaluate object.
– stop –	Unwind to innermost stopped or start context.
obj trapped false	Snapshot stacks and evaluate object.
obj trapped arg true	Snapshot stacks, evaluate object, catch escape , restore snapshot.
arg escape –	Unwind to innermost trapped or start context.
name throw obj	Throw an error.
– maxestack count	Get maximum allowable estack depth.
– gmaxestack count	Get default maximum allowable estack depth.
count setmaxestack –	Set maximum allowable estack depth.
count setgmaxestack –	Set default maximum allowable estack depth.
– tailopt boolean	Get whether tail optimization is in effect.
– gtailopt boolean	Get default tail optimization setting.
boolean settailopt –	Set whether to use tail optimization.
boolean setgtailopt –	Set default tail optimization setting.
– estack stack	Get a current estack snapshot.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
– estack stack	Get a current estack snapshot.
thread threadestack stack	Get a reference to thread's estack.
– countestack count	Get current estack depth.
– istack stack	Get a current istack snapshot.
thread threadistack stack	Get a reference to thread's istack.
status die –	Exit program.
path symbol modload –	Load a module.
file symbol mrequire –	Search for and load a module.
file require –	Search for and evaluate a source file.
prog path path/null	Search PATH for prog.
args exec –	Overlay a new program and execute it.
args forkexec pid	Fork and exec a new process.
args redirects forkexec pid	Fork and exec a new process.
pid waitpid status	Wait for a program to terminate.
args system status	Execute a program.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
pid sig kill —	Send a signal to a process.
\$SIG GETMASK oset sigmask oset	Get signal mask.
how set sigmask —	Modify signal mask.
how set oset sigmask oset	Modify signal mask.
set sigpending set	Get pending signals.
set sigsuspend —	Suspend until interrupted by a signal.
set sigwait sig	Wait for a signal.
— pid pid	Get process ID.
— ppid pid	Get parent's process ID.
— uid uid	Get the process's user ID.
uid setuid boolean	Set the process's user ID.
— euid uid	Get the process's effective user ID.
uid seteuid boolean	Set the process's effective user ID.
— gid gid	Get the process's group ID.
gid setgid boolean	Set the process's group ID.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
– egid gid	Get the process's effective group ID.
gid setegid boolean	Set the process's effective group ID.
pid getpgid pgid	Get process group ID.
pid pgid setpgid –	Set process group ID.
pid getsid sid	Get session ID.
– setsid sid	Create new session.
– realtime nsecs	Get the number of nanoseconds since the epoch.
nsecs localtime dict	Get a dict with local time definitions.
nanoseconds nsleep –	Nanosleep.
Stack operators	
– (fino	Begin a stack declaration.
fino objects) stack	Create a stack.
– stack stack	Create a stack.
stack obj spush –	Push object onto stack.
stack obj sbpush –	Push object onto bottom of stack.
stack scount count	Get the number of objects on a stack.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
stack scounttomark count	Get the depth of the topmost mark on stack.
stack sdup —	Duplicate an object.
stack sbdup —	Duplicate bottom object.
stack count sndup —	Duplicate objects on stack.
stack index sidup —	Duplicate object on stack at index.
stack index sibdup —	Duplicate object on stack at index from bottom.
stack stuck —	Tuck duplicate of top object on stack under next object on stack.
stack sunder —	Duplicate second object on stack.
stack sover —	Duplicate second object on stack.
stack sexch —	Exchange top objects on stack.
stack sup —	Roll top three objects on stack up one.
stack count snu —	Roll count objects on stack up one.
stack saup —	Roll objects on stack up one.
stack sdn —	Roll top three objects on stack down one.
stack count sndn —	Roll count objects on stack down one.
stack sadn —	Roll objects on stack down one.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
stack amount srot —	Rotate objects on stack up by <i>amount</i> .
stack count amount sroll —	Roll objects on stack.
stack spop obj	Pop object off stack.
stack sbpop obj	Pop object off bottom of stack.
stack count snpop array	Pop count objects off stack.
stack count snbpop array	Pop count objects off bottom of stack.
stack index sipop obj	Remove object on stack at index.
stack index sibpop obj	Remove object on stack at index from bottom.
stack snip obj	Remove second object on stack.
stack sclear —	Remove all objects on stack.
stack scleartomark —	Remove objects from stack down through topmost mark.
(a) (b) cat (a b)	Catenate two stacks.
stacks count ncat stack	Catenate stacks.
srcstack dststack copy dststack	Copy stack contents.
Number (integer, real) and math operators	
a b add r	Add a and b.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
a inc r	Add 1 to a.
a b sub r	Subtract b from a.
a dec r	Subtract 1 from a.
a b mul r	Multiply a and b.
a b div r	Divide a by b.
a b idiv r	Divide a by b (integers).
a b mod r	Mod a by b (integers and reals).
a b pow r	Raise a to the power of b.
x exp r	e (base of natural logarithm) raised to x.
a sqrt r	Square root.
a ln r	Natural log.
a log r	Base 10 log.
a abs r	Get the absolute value of a.
a neg r	Get the negative of a.
a ceiling r	Integer ceiling of a real.
a floor r	Integer floor of a real.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
a round r	Real rounded to integer.
a trunc r	Integer from real with truncated fractional.
a sin r	Sine in radians.
a sinh r	Hyperbolic sine.
a asin r	Arcsine.
a asinh r	Hyperbolic arcsine.
a cos r	Cosine in radians.
a cosh r	Hyperbolic cosine.
a acos r	Arc cosine.
a acosh r	Hyperbolic arc cosine.
x tan r	Tangent of x in radians.
x tanh r	Hyperbolic tangent.
x atan r	Arctangent.
y x atan2 r	Arctangent in radians of $\frac{y}{x}$.
x atanh r	Hyperbolic arctangent.
seed srand —	Seed pseudo-random number generator.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
– rand integer	Get a pseudo-random number.
String operators	
length string string	Create a string.
string length count	Get string length.
string index get integer	Get string element.
string index integer put –	Set string element.
string index length getinterval substring	Get a string interval.
string index substring putinterval –	Copy substring into string.
‘a’ ‘b’ cat ‘ab’	Catenate two strings.
strings count ncat string	Catenate strings.
srcstring dststring copy dstsubstring	Copy string.
obj depth sprints string	Create syntactical string from object.
obj flags outputs string	Create formatted string from object.
Name operators	
name length count	Get name length.
Array operators	
– [mark	Begin an array declaration.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
mark objects] array	Construct an array.
length array array	Create an array.
array length count	Get array length.
array index get obj	Get array element.
array index obj put -	Set array element.
array index length getinterval subarray	Get an array interval.
array index subarray putinterval -	Copy subarray into array.
[a] [b] cat [a b]	Catenate two arrays.
arrays count ncat array	Catenate arrays.
srcarray dstarray copy dstsubarray	Copy array.
- argv args	Get program arguments.
Dictionary and dictionary stack operators	
- < mark	Begin a dictionary declaration.
mark kvpairs > dict	Construct a dictionary.
- dict dict	Create a dictionary.
dict begin -	Push dict onto dstack.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
– end –	Pop a dictionary off dstack.
key val def –	Define key/value pair.
dict key undef –	Undefine key in dict.
key load val	Look up a key's value.
dict key known boolean	Check for key in dict.
key where false	Unsuccessfully get topmost dstack dictionary that defines key.
key where dict true	Successfully get topmost dstack dictionary that defines key.
dict length count	Get number of dictionary key/value pairs.
dict key get value	Get dict value associate with key.
dict key value put –	Set dict key/value pair.
srdict dstdict copy dstdict	Copy dictionary contents.
– currentdict dict	Get topmost dstack dictionary.
– dstack stack	Get dstack snapshot.
thread threaddstack stack	Get a reference to thread's dstack.
– countdstack count	Get number of stacks on dstack.
– gcdict dict	Get gcdict.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
– userdict dict	Get userdict.
– globaldict dict	Get globaldict.
– systemdict dict	Get systemdict.
– onyxdict dict	Get onyxdict.
– sprintsdict dict	Get sprintsdict.
– outputsdict dict	Get outputsdict.
– envdict dict	Get envdict.
– threadsdict dict	Get threadsdict.
key val setenv –	Set environment variable.
key unsetenv –	Unset environment variable.
Class, instance, and handle operators	
– class class	Create class.
class name implementor class/null	Get class that implements name.
class name implements boolean	Does class implement name?
class name method method	Get class method by name.
class classname class/null	Get class's name.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
class name/null setclassname —	Set class's name.
class super super/null	Get class's superclass.
class super/null setsuper —	Set class's superclass.
class methods dict/null	Get methods dict for class.
class dict/null setmethods —	Set methods dict for class.
class/instance data dict/null	Get data for class/instance.
class/instance dict/null setdata —	Set data for class/instance.
— instance instance	Create an instance.
instance isa class/null	Get class for instance.
instance class/null setisa —	Set class for instance.
instance class kind boolean	Is class in instance's inheritance hierarchy?
name super data methods cdef —	Create and define a class.
— this method/instance	Get topmost object on cstack.
— cstack stack	Get cstack snapshot.
thread threadcstack stack	Get a reference to thread's cstack.
handle handletag tag	Get handle tag.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
– vclass class	Get vclass.
File and filesystem operators	
filename flags open file	Open a file.
filename flags mode open file	Open a file, creation mode specified.
– pipe rfile wfile	Create a pipe.
file close –	Close file.
file read integer boolean	Read from file.
file string read substring boolean	Read from file.
file readline string boolean	Read a line from file.
<file dict ...> timeout poll [file ...]	Wait for file(s) to change status.
file bytesavailable count	Get number of buffered readable bytes.
file iobuf count	Get size of I/O buffer.
file count setiobuf –	Set size of I/O buffer.
file nonblocking boolean	Get non-blocking mode.
file boolean setnonblocking –	Set non-blocking mode.
file integer/string write false	Write to file.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
file integer/string write integer/substring true	Write to file.
string print —	Print string to stdout.
obj depth sprint —	Syntactically print object to stdout.
obj flags output —	Formatted print to stdout.
— pstack —	Syntactically print ostack elements.
file flushfile —	Flush file buffer.
— flush —	Flush stdout buffer.
file length truncate —	Truncate file.
file offset seek —	Move file position pointer.
file tell offset	Get file position pointer offset.
path mkdir —	Create a directory.
path mode mkdir —	Create a directory, mode specified.
path mkfifo —	Create a named pipe.
path mode mkfifo —	Create a named pipe, mode specified.
old new rename —	Rename a file or directory.
file/filename mode chmod —	Change file permissions.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
file/filename uid gid chown —	Change file owner and group.
filename linkname link —	Create a hard link.
filename linkname symlink —	Create a symbolic link.
filename unlink —	Unlink a file.
path rmdir —	Remove an empty directory.
file/filename flag test boolean	Test a file.
file/filename status dict	Get file information.
linkname readlink string	Get symbolic link data.
path proc dirforeach —	Iterate on directory entries.
— pwd path	Get present working directory.
path cd —	Change present working directory.
path chroot —	Change root directory.
— stdin file	Get thread's stdin.
— stdout file	Get thread's stdout.
— stderr file	Get thread's stderr.
— gstdin file	Get global stdin.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
– gstdout file	Get global stdout.
– gstderr file	Get global stderr.
file setstdin –	Set thread's stdin.
file setstdout –	Set thread's stdout.
file setstderr –	Set thread's stderr.
file setgstdin –	Set global stdin.
file setgstdout –	Set global stdout.
file setgstderr –	Set global stderr.
Socket and networking operators	
family type proto socket sock	Create a socket.
family type socket sock	Create a socket.
sock addr port bindsocket –	Bind socket to address/port.
sock addr bindsocket –	Bind socket to address.
sock path bindsocket –	Bind socket to port.
sock backlog listen –	Listen for socket connections.
sock listen –	Listen for socket connections.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
sock accept sock	Accept a socket connection.
sock addr port connect — sock path connect —	Connect a socket. Connect a socket.
service serviceport port	Get port number for service name.
sock sockname dict	Get socket information.
sock level optname sockopt optval sock optname sockopt optval	Get socket option. Get socket option.
sock level optname optval setsockopt — sock optname optval setsockopt —	Set socket option. Set socket option.
sock peername dict	Get peer socket information.
sock mesg flags send nsend sock mesg send count	Send a message. Send a message.
sock string flags recv substring sock string recv substring	Receive a message. Receive a message.
family type proto socketpair sock sock	Create a socket pair.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
family type socketpair sock sock	Create a socket pair.
Logical and bitwise operators	
a b lt boolean	a less than b? (integer/real, string)
a b le boolean	a less than or equal to b? (integer/real, string)
a b eq boolean	a equal to b? (any type)
a b ne boolean	a not equal to b? (any type)
a b ge boolean	a greater than or equal to b? (integer/real, string)
a b gt boolean	a greater than b? (integer/real, string)
a b and r	Logical/bitwise and. (boolean/integer)
a b or r	Logical/bitwise or. (boolean/integer)
a b xor r	Logical/bitwise exclusive or. (boolean/integer)
a not r	Logical/bitwise not. (boolean/integer)
a shift shift integer	Bitwise shift.
— false false	Return true.
— true true	Return false.
Type, conversion, and attribute operators	
obj type name	Get object type.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
obj lcheck boolean	Literal?
obj xcheck boolean	Executable?
obj eccheck boolean	Evaluable?
obj xeccheck boolean	Executable or evaluable?
obj ccheck boolean	Callable?
obj icheck boolean	Invokable?
obj fcheck boolean	Fetchable?
obj cvl obj	Set literal attribute.
obj cve obj	Set evaluable attribute.
obj cvx obj	Set executable attribute.
obj cvc obj	Set callable attribute.
obj cvi obj	Set invokable attribute.
obj cvf obj	Set fetchable attribute.
string cvn name	Convert string to name.
obj cvs string	Convert object to string.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
integer radix cvrs string	Convert integer to radix string.
real precision cvds string	Convert real to decimal string.
real precision cves string	Convert real to exponential string.
Threading and synchronization operators	
stack entry thread thread	Create and run a thread.
– self thread	Get a thread object for the running thread.
thread join –	Wait for thread to exit.
thread detach –	Detach thread.
– yield –	Voluntarily yield the processor.
– mutex mutex	Create a mutex.
mutex proc monitor –	Evaluate an object under the protection of a mutex.
mutex lock –	Acquire mutex.
mutex trylock boolean	Try to acquire mutex.
mutex unlock –	Release mutex.
– condition condition	Create a condition variable.
condition mutex wait –	Wait on condition.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
condition mutex timeout timedwait boolean	Wait on condition with timeout.
condition signal —	Signal a condition waiter.
condition broadcast —	Signal all condition waiters.
— currentlocking boolean	Get implicit locking mode.
boolean setlocking —	Set implicit locking mode.
obj ilocked boolean	Implicitly locked?
Regular expression operators	
string flags regex regex	Create a regex object.
string regex regex	Create a regex object.
input pattern flags match boolean	Find pattern matches in input string.
input pattern match boolean	Find pattern matches in input string.
input regex match boolean	Find regex matches in input string.
input pattern flags limit split array	Split input into an array of substrings.
input pattern flags split array	Split input into an array of substrings.
input pattern limit split array	Split input into an array of substrings.
input pattern split array	Split input into an array of substrings.

Continued on next page...

Table 2.10: *continued*

Input(s) Op/Proc/Var Output(s)	Description
input regex limit split array	Split input into an array of substrings.
input regex split array	Split input into an array of substrings.
integer submatch substring	Get capturing subpattern match.
input submatch offset offset	Get submatch offset from beginning of input.
pattern template flags regsub regsub	Create a regsub object.
pattern template regsub regsub	Create a regsub object.
input pattern template flags subst output count	Substitute template for pattern matches.
input pattern template subst output count	Substitute template for pattern matches.
input regsub subst output count	Substitute.
Miscellaneous operators	
– product string	Get the product string.
– version string	Get the version string.
proc bind proc	Bind names to operators.
– null null	Create a null object.

– (*fino*:**Input(s):** None.**Output(s):****fino:** A fino object.

Error(s): None.

Description: Push a fino object onto ostack to denote the bottom of a stack that has not yet been constructed.

Example(s):

```
onyx:0> (  
onyx:1> pstack  
-fino-  
onyx:1>
```

fino objects) stack:

Input(s):

fino: A fino object, usually created by the) operator.

objects: 0 or more objects.

Output(s):

stack: A stack object.

Error(s):

unmatchedfino.

Description: Create a stack object and move all objects from ostack down to the first fino object to the new stack.

Example(s):

```
onyx:0> (  
onyx:1> 1 sprint  
(  
onyx:0> (1 2  
onyx:3> pstack  
2  
1  
-fino-  
onyx:3> )  
onyx:1> 1 sprint  
(1 2)  
onyx:0>
```

- < mark:

Input(s): None.

Output(s):

mark: A mark object.

Error(s): None.

Description: Begin a dictionary declaration. See the & operator documentation for more details on dictionary construction.

Example(s):

```
onyx:0> < 1 sprint  
-mark-  
onyx:0>
```

mark kvpairs > dict:

Input(s):

mark: A mark object.

kvpairs: Zero or more pairs of non-mark objects, where the first is a key and the second is an associated value.

Output(s):

dict: A dictionary that contains *kvpairs*.

Error(s):

rangecheck.

unmatchedmark.

Description: Construct a dictionary that contains *kvpairs*.

Example(s):

```
onyx:0> <
onyx:1> $foo 'foo'
onyx:3> $bar 'bar'
onyx:5> $biz 'biz'
onyx:7> $pop ~pop
onyx:9> >
onyx:1> pstack
<$pop --pop-- $biz 'biz' $bar 'bar' $foo 'foo'>
onyx:1>
```

- [mark:

Input(s): None.

Output(s):

mark: A mark object.

Error(s): None.

Description: Begin an array declaration. See the] operator documentation for more details on array construction.

Example(s):

```
onyx:0> [ 1 sprint
-mark-
onyx:0>
```

mark objects] array:

Input(s):

mark: A mark object.

objects: Zero or more non-mark objects.

Output(s):

array: An array that contains *objects*.

Error(s):

unmatchedmark.

Description: Construct an array that contains all *objects* on ostack down to the first *mark*.

Example(s):

```
onyx:0> mark 1 2 3 ] 1 sprint
[1 2 3]
```

a abs r:

Input(s):

a: An integer or real.

Output(s):

r: Absolute value of a .

Error(s):

stackunderflow.

typecheck.

Description: Return the absolute value of a .

Example(s):

```
onyx:0> 5 abs 1 sprint
5
onyx:0> -5 abs 1 sprint
5
onyx:0> 3.14 abs 1 sprint
3.140000e+00
onyx:0> -3.14 abs 1 sprint
3.140000e+00
onyx:0>
```

sock accept sock:**Input(s):**

sock: A listening socket.

Output(s):

sock: A socket that is connected to a client.

Error(s):

argcheck.

invalidfileaccess.

ioerror.

neterror.

rangecheck.

stackunderflow.

typecheck.

unregistered.

Description: Accept a connection and create a socket that is connected to a client.

Example(s):

```
onyx:0> $AF_INET $SOCK_STREAM socket
onyx:1> dup 'localhost' 7777 bindsocket
onyx:1> dup listen
onyx:1> dup accept
onyx:2> dup peername 1 sprint
<$family $AF_INET $address 2130706433 $port 33742>
onyx:2>
```

a acos r:**Input(s):**

a: An integer or real.

Output(s):

r: Arc cosine of a in radians.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Return the arc cosine of a in radians.

Example(s):

```
onyx:0> 1 acos 1 sprint
0.000000e+00
onyx:0>
```

a acosh r :

Input(s):

a: An integer or real.

Output(s):

r: Hyperbolic arc cosine of a .

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Return the hyperbolic arc cosine of a .

Example(s):

```
onyx:0> 10 acosh 1 sprint
2.993223e+00
onyx:0>
```

a b add r :

Input(s):

a: An integer or real.

b: An integer or real.

Output(s):

r: The sum of a and b .

Error(s):

stackunderflow.

typecheck.

Description: Return the sum of a and b .

Example(s):

```
onyx:0> 2 2 add 1 sprint
4
onyx:0> -1 3 add 1 sprint
2
onyx:0> 2.0 3.1 add 1 sprint
5.100000e+00
onyx:0> -1.5 +3e1 add 1 sprint
2.850000e+01
onyx:0>
```

obj $,,,$ adn $,,,obj$:

Input(s):

obj: An object.

,,,: Zero or more objects.

Output(s):

,,,: Zero or more objects.

obj: An object.

Error(s):

stackunderflow.

Description: Rotate stack down one position.

Example(s):

```
onyx:0> 1 2 3 adn pstack
1
3
2
onyx:3>
```

a b* and *r*:*Input(s):**

a: An integer or boolean.

b: The same type as *a*.

Output(s):

r: If *a* and *b* are integers, their bitwise and, otherwise their logical and.

Error(s):

stackunderflow.

typecheck.

Description: Return the bitwise and of two integers, or the logical and of two booleans.

Example(s):

```
onyx:0> false true and 1 sprint
false
onyx:0> true true and 1 sprint
true
onyx:0> 5 3 and 1 sprint
1
onyx:0>
```

- argv *args*:

Input(s): None.

Output(s):

args: An array of strings. The first string in *args* is the path of this program, and any additional array elements are the arguments that were passed during invocation.

Error(s): None.

Description: Get the argument vector that was used to invoke this program.

Example(s):

```
onyx:0> argv 1 sprint
[ '/usr/local/bin/onyx' ]
onyx:0>
```

length* array *array*:*Input(s):**

length: Non-negative number of array elements.

Output(s):

array: An array of *length* elements.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Create an array of *length* elements. The elements are initialized to null objects.

Example(s):

```
onyx:0> 3 array 1 sprint
[null null null]
onyx:0> 0 array 1 sprint
[]
onyx:0>
```

***a* asin *r*:**

Input(s):

a: An integer or real.

Output(s):

r: Arc sine of *a* in radians.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Return the arc sine of *a* in radians.

Example(s):

```
onyx:0> -1 asin 1 sprint
-1.570796e+00
onyx:0>
```

***a* asinh *r*:**

Input(s):

a: An integer or real.

Output(s):

r: Hyperbolic arc sine of *a*.

Error(s):

stackunderflow.

typecheck.

Description: Return the hyperbolic arc sine of *a*.

Example(s):

```
onyx:0> 10 asinh 1 sprint
2.998223e+00
onyx:0>
```

***x* atan *r*:**

Input(s):

x: An integer or real.

Output(s):

r: Arctangent of *x* in radians.

Error(s):**stackunderflow.****typecheck.****Description:** Return the arctangent of x in radians.**Example(s):**

```
onyx:0> 1 atan 1 sprint
7.853982e-01
onyx:0>
```

 y x atan2 r :**Input(s):****y:** An integer or real.**x:** An integer or real.**Output(s):****r:** Arctangent of $\frac{y}{x}$ in radians.**Error(s):****stackunderflow.****typecheck.****Description:** Return the arctangent of $\frac{y}{x}$ in radians.**Example(s):**

```
onyx:0> 1 1 atan2 1 sprint
7.853982e-01
onyx:0> 0 1 atan2 1 sprint
0.000000e+00
onyx:0> -1.0 0 atan2 1 sprint
-1.570796e+00
onyx:0>
```

 x atanh r :**Input(s):****x:** An integer or real.**Output(s):****r:** Hyperbolic arctangent of x .**Error(s):****stackunderflow.****typecheck.****rangecheck.****Description:** Return the hyperbolic arctangent of x .**Example(s):**

```
onyx:0> 0.5 atanh 1 sprint
5.493061e-01
onyx:0>
```

,,,obj* *aup* *obj* *,,,*:*Input(s):****,,,:** Zero or more objects.**obj:** An object.

Output(s):

obj: An object.
,,,: Zero or more objects.

Error(s):

stackunderflow.

Description: Rotate stack up one position.

Example(s):

```
onyx:0> 1 2 3 aup pstack
2
1
3
onyx:3>
```

obj* ,,, bdup *obj* ,,,dup:*Input(s):**

obj: An object.
,,,: Zero or more objects.

Output(s):

obj: An object.
,,,: Zero or more objects.
dup: A duplicate of *obj*.

Error(s):

stackunderflow.

Description: Create a duplicate of the bottom object on ostack and put it on top of ostack.

Example(s):

```
onyx:0> 1 2 3
onyx:3> bdup pstack
1
3
2
1
onyx:4>
```

dict* begin -:*Input(s):**

dict: A dictionary.

Output(s): None.

Error(s):

stackunderflow.
typecheck.

Description: Push *dict* onto dstack, thereby adding its keys to the namespace.

Example(s):

```
onyx:0> <$foo 'foo'> begin
onyx:0> foo 1 sprint
'foo'
onyx:0>
```

***proc* bind *proc*:**

Input(s):

proc: A procedure (array). *proc* will be bound even if it is literal, but contained literal arrays will not be recursively bound.

Output(s):

proc: The same procedure as was passed in.

Error(s):

stackunderflow.

typecheck.

Description: Recursively bind unbound procedures. Executable names within a procedure are replaced with their values if defined in dstack, in any of the following cases:

- The value is a literal object.
- The value is an executable or evaluable operator.
- The value is an executable or evaluable handle.
- The value is an executable or evaluable array.

Binding has a large positive impact on performance, since name lookups are thereafter avoided. However, binding is not done by default because there are situations where it is useful to leave procedures unbound:

- Debugging is easier, since the names associated with objects are still available.
- Behavior is more dynamic. It is possible to replace a definition on dstack and have it immediately take effect on unbound procedures. Note however that care must be taken when relying on this, since binding is recursive, and a lack of complete understanding of what procedures reference each other can result in undesired bound procedures. For this reason, it is generally best to make dynamic behavior explicit by using evaluable names.
- There are situations where a program needs to do some setup before binding a procedure, and providing manual control over when binding happens allows more sophisticated use of binding.

Example(s):

```
onyx:0> {pop sprint {pop sprint}}
onyx:1> dup 2 sprint
{pop sprint {pop sprint}}
onyx:1> bind
onyx:1> dup 2 sprint
{--pop-- _{sprints --print-- '\n' --print-- --flush--}_ {--pop-- -array-}}
```

sock addr port bindsocket -:

sock addr bindsocket -:

sock path bindsocket -:

Input(s):

sock: A socket.

addr: An IPv4 address or DNS hostname.

port: An IPv4 port number. If not specified, the OS chooses a port number.

path: A filesystem path for a Unix-domain socket.

Output(s): None.

Error(s):

argcheck.
invalidfileaccess.
neterror.
rangecheck.
stackunderflow.
typecheck.
unregistered.

Description: Bind an address/port to an IPv4 socket, or a filesystem path to a Unix-domain socket.

Example(s):

```

onyx:0> $AF_INET $SOCK_STREAM socket
onyx:1> dup 'localhost' 7777 bindsocket
onyx:1> dup sockname 1 sprint
<$family $AF_INET $address 2130706433 $port 7777>
onyx:1> close
onyx:0> $AF_LOCAL $SOCK_STREAM socket
onyx:1> dup '/tmp/socket' bindsocket
onyx:1> dup sockname 1 sprint
<$family $AF_LOCAL $path '/tmp/socket'>
onyx:1>

```

obj,,, bpop,,,:

Input(s):

,,,: Zero or more objects.
obj: An object.

Output(s):

,,,: Zero or more objects.

Error(s):

stackunderflow.

Description: Remove the bottom object from ostack and discard it.

Example(s):

```

onyx:0> 1 2
onyx:2> bpop pstack
2
onyx:1>

```

condition broadcast -:

Input(s):

condition: A condition object.

Output(s): None.

Error(s):

stackunderflow.
typecheck.

Description: Signal all threads that are waiting on *condition*. If there are no waiters, this operator has no effect.

Example(s):

```

onyx:0> condition mutex dup lock ostack
onyx:3> {dup lock exch broadcast unlock}

```

```

onyx:4> thread 3 1 roll
onyx:3> dup 3 1 roll
onyx:4> wait unlock join
onyx:0>

```

file bytesavailable count:

Input(s):

file: A file object.

Output(s):

count: Number of buffered readable bytes.

Error(s):

stackunderflow.

typecheck.

Description: Get the number of buffered readable bytes that can be read without the possibility of blocking.

Example(s):

```

onyx:0> '/tmp/foo' 'w+' open
onyx:1> dup 'Hello\n' write
onyx:1> dup 'Goodbye\n' write
onyx:1> dup 0 seek
onyx:1> dup readline 1 sprint 1 sprint
false
'Hello'
onyx:1> dup bytesavailable 1 sprint
8
onyx:1>

```

[a] [b] cat [a b]:

(a) (b) cat (a b):

'a' 'b' cat 'ab':

Input(s):

a: An array, stack, or string.

b: An array, stack, or string.

Output(s):

ab: The catenation of *a* and *b*.

Error(s):

stackunderflow.

typecheck.

Description: Catenate two arrays, strings, or stacks.

Example(s):

```

onyx:0> ['a'] ['b'] cat
onyx:1> 1 sprint
['a' 'b']
onyx:0> ('a') ('b') cat
onyx:1> 1 sprint
('a' 'b')
onyx:0> 'a' 'b' cat
onyx:1> 1 sprint
'ab'
onyx:0>

```


obj ccheck boolean:**Input(s):**

obj: An object.

Output(s):

boolean: True if *obj* has the callable attribute, false otherwise.

Error(s):

stackunderflow.

Description: Check *obj* for callable attribute.

Example(s):

```
onyx:0> $name ccheck 1 sprint
false
onyx:0> $name cvc ccheck 1 sprint
true
onyx:0>
```

path cd -:**Input(s):**

path: A string that represents a filesystem path.

Output(s): None.

Error(s):

invalidaccess.

ioerror.

stackunderflow.

typecheck.

Description: Change the present working directory to *path*.

Example(s):

```
onyx:0> pwd 1 sprint
`/usr/local`
onyx:0> `bin` cd
onyx:0> pwd 1 sprint
`/usr/local/bin`
onyx:0>
```

name super data methods cdef -:**Input(s):**

name: An object (usually a name) to set the class's name to and associate the class with.

super: A superclass, or null.

data: A dictionary of data definitions, or null.

methods: A dictionary of method definitions, or null.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Create a new class with *name* as its name, *super* as its superclass, *data* as its data definitions, and *methods* as its method definitions. Define *name* in **currentdict** to be the class.

Example(s):

```
onyx:0> $fooclass vclass <$foodata 'foo'> <$foomethod {'hi' 1 sprint}> cdef
onyx:0> fooclass 1 sprint
-class-
onyx:0> fooclass:foomethod
'hi'
onyx:0>
```

a* ceiling *r*:*Input(s):**

a: An integer or real.

Output(s):

r: Integer ceiling of *a*.

Error(s):

stackunderflow.

typecheck.

Description: Return the integer ceiling of *a*.

Example(s):

```
onyx:0> -1.51 ceiling 1 sprint
-1
onyx:0> -1.49 ceiling 1 sprint
-1
onyx:0> 0 ceiling 1 sprint
0
onyx:0> 1.49 ceiling 1 sprint
2
onyx:0> 1.51 ceiling 1 sprint
2
onyx:0>
```

file/filename mode chmod -:**Input(s):**

file: A file object.

filename: A string that represents a filename.

mode: An integer that represents a Unix file mode.

Output(s): None.

Error(s):

invalidfileaccess.

ioerror.

rangecheck.

stackunderflow.

typecheck.

unregistered.

Description:

Example(s):

```
onyx:0> '/tmp/tdir' 8@755 mkdir
onyx:0> '/tmp/tdir' status $mode get 1 sprint
16877
```

```
onyx:0> '/tmp/tdir' 'r' open
onyx:1> dup 8@555 chmod
onyx:1> '/tmp/tdir' status $mode get 1 sprint
16749
onyx:1>
```

file/filename uid gid chown -:

Input(s):

file: A file object.
filename: A string that represents a filename.
uid: An integer that represents a user ID.
gid: An integer that represents a group ID.

Output(s): None.

Error(s):

invalidfileaccess.
ioerror.
rangecheck.
stackunderflow.
typecheck.
unregistered.

Description: Change the owner and group of a file.

Example(s):

```
onyx:0> '/tmp/tdir' 8@755 mkdir
onyx:0> '/tmp/tdir' status
onyx:1> dup $uid get 1 sprint
1001
onyx:1> $gid get 1 sprint
0
onyx:0> '/tmp/tdir' 1001 1001 chown
onyx:0> '/tmp/tdir' status
onyx:1> dup $uid get 1 sprint
1001
onyx:1> $gid get 1 sprint
1001
onyx:0>
```

path chroot -:

Input(s):

path: A string that represents a filesystem path.

Output(s): None.

Error(s):

invalidaccess.
ioerror.
stackunderflow.
typecheck.

Description: Change the root directory to *path*. This operator requires super-user privileges.

Example(s):

```
onyx:0> pwd 1 sprint
'/home/jasone/cw/devroot'
onyx:0> '/home/jasone' chroot
onyx:0> pwd 1 sprint
'/cw/devroot'
onyx:0>
```

- class *class*:**Input(s):** None.**Output(s):****class:** A class object.**Error(s):** None.**Description:** Create a class object.**Example(s):**

```
onyx:0> class 1 sprint
-class-
onyx:0>
```

class* *classname* -:*Input(s):****class:** A class object.**Output(s):****name/null:** A name or null object.**Error(s):****stackunderflow.****typecheck.****Description:** Get *class*'s name.**Example(s):**

```
onyx:0> class classname 1 sprint
null
onyx:0> vclass classname 1 sprint
$vclass
onyx:0>
```

objects* clear -:*Input(s):****objects:** All objects on ostack.**Output(s):** None.**Error(s):** None.**Description:** Pop all objects off of ostack.**Example(s):**

```
onyx:0> 1 2 3 pstack
3
2
1
onyx:3> clear pstack
onyx:0>
```

mark ... cleartomark -:**Input(s):**

...: Zero or more objects.

mark: A mark object.

Output(s): None.

Error(s):

unmatchedmark.

Description: Remove objects from ostack down to and including the topmost mark.

Example(s):

```
onyx:0> 3 mark 1 0 pstack
0
1
-mark-
3
onyx:4> cleartomark pstack
3
onyx:1>
```

file close -:**Input(s):**

file: A file object.

Output(s): None.

Error(s):

ioerror.

stackunderflow.

typecheck.

Description: Close a file.

Example(s):

```
onyx:0> '/tmp/foo' 'w' open
onyx:1> close
onyx:0>
```

- condition condition:

Input(s): None.

Output(s):

condition: A condition object.

Error(s): None.

Description: Create a condition object.

Example(s):

```
onyx:0> condition 1 sprint
-condition-
onyx:0>
```

sock addr port connect -:***sock path connect -:*****Input(s):**

sock: A socket.

addr: An IPv4 address or DNS hostname.
port: An IPv4 port number. If not specified, the OS chooses a port number.
path: A filesystem path for a Unix-domain socket.

Output(s): None.

Error(s):

argcheck.
invalidfileaccess.
neterror.
stackunderflow.
typecheck.
unregistered.

Description: Connect *sock*.

Example(s):

```
onyx:0> $AF_INET $SOCK_STREAM socket
onyx:1> dup 'localhost' 7777 connect
onyx:1>
```

– continue –:

Input(s): None.

Output(s): None.

Error(s): None.

Description: Terminate the current iteration of the innermost enclosing context, and start at the beginning of the next iteration. This operator can be called within the looping context of **for**, **repeat**, **while**, **until**, **loop**, **foreach**, and **dirforeach**.

Example(s):

```
onyx:0> 1 1 5 {1 sprint continue bang} for
1
2
3
4
5
onyx:0>
```

srcarray dstarray copy dstsubarray:

srdict dstdict copy dstdict:

srcstack dststack copy dststack:

srcstring dststring copy dstsubstring:

Input(s):

srcarray: An array object.
srdict: A dict object.
srcstack: A stack object.
srcstring: A string object.
dstarray: An array object, at least as long as *srcarray*.
dstdict: A dict object.
dststack: A stack object.
dststring: A string object, at least as long as *srcstring*.

Output(s):

dstsubarray: A subarray of *dstarray*, with the same contents as *srcarray*.

dstdict: The same object as the input *dstdict*, but with the contents of *srcdict* inserted.

dststack: The same object as the input *dststack*, but with the contents of *srcstack* pushed.

dstsubstring: A substring of *dststring*, with the same contents as *srcstring*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Copy from one object to another. Array and string copying are destructive; dictionary and stack copying are not.

Example(s):

```
onyx:0> ['a'] ['b' 'c'] copy 1 sprint
['a']
onyx:0> <$foo 'foo'> <$bar 'bar'> copy 1 sprint
<$bar 'bar' $foo 'foo'>
onyx:1> (1 2) (3 4) copy 1 sprint
(3 4 1 2)
onyx:1> 'a' 'bc' copy 1 sprint
'a'
onyx:1>
```

a* cos *r*:*Input(s):**

a: An integer or real.

Output(s):

r: Cosine of *a* in radians.

Error(s):

stackunderflow.

typecheck.

Description: Return the cosine of *a* in radians.

Example(s):

```
onyx:0> 0 cos 1 sprint
1.000000e+00
onyx:0> 3.14 cos 1 sprint
-9.999987e-01
onyx:0> 3.1415927 cos 1 sprint
-1.000000e+00
onyx:0>
```

a* cosh *r*:*Input(s):**

a: An integer or real.

Output(s):

r: Hyperbolic cosine of *a* in radians.

Error(s):

stackunderflow.

typecheck.

Description: Return the hyperbolic cosine of a in radians.

Example(s):

```
onyx:0> 3 cosh 1 sprint
1.006766e+01
onyx:0>
```

– count count:

Input(s): None.

Output(s):

count: The number of objects on ostack.

Error(s): None.

Description: Get the number of objects on ostack.

Example(s):

```
onyx:0> 2 1 0 count pstack
3
0
1
2
onyx:4>
```

– countdstack count:

Input(s): None.

Output(s):

count: Number of dictionaries on dstack.

Error(s): None.

Description: Get the number of dictionaries on dstack.

Example(s):

```
onyx:0> countdstack 1 sprint
4
onyx:0> dict begin
onyx:0> countdstack 1 sprint
5
onyx:0>
```

– countestack count:

Input(s): None.

Output(s):

count: The number of objects currently on the execution stack (recursion depth).

Error(s): None.

Description: Get the current number of objects on the execution stack.

Example(s):

```
onyx:0> countestack 1 sprint
3
onyx:0> estack 1 sprint
(--start-- -file- --estack--)
onyx:0>
```

mark ... counttomark mark ... count:

Input(s):

...: Zero or more objects.

mark: A mark object.

Output(s):

...: *count* objects.

mark: The same mark that was passed in.

count: The depth of *mark* on ostack.

Error(s):

unmatchedmark.

Description: Get the depth of the topmost mark on ostack.

Example(s):

```
onyx:0> 4 mark 2 1 0 counttomark 1 sprint
3
onyx:5>
```

– cstack *stack*:

Input(s): None.

Output(s):

stack: A snapshot of cstack.

Error(s): None.

Description: Get a snapshot of cstack.

Example(s):

```
onyx:0> cstack 1 sprint
()
onyx:0>
```

– currentdict *dict*:

Input(s): None.

Output(s):

dict: Topmost stack on dstack.

Error(s): None.

Description: Get the topmost dictionary on dstack.

Example(s):

```
onyx:0> <$foo 'foo'> begin
onyx:0> currentdict 1 sprint
<$foo 'foo'>
onyx:0>
```

– currentlocking *boolean*:

Input(s): None.

Output(s):

boolean: If false, new objects are created with implicit locking disabled. Otherwise, new objects are created with implicit locking enabled.

Error(s): None.

Description: Get the current implicit locking mode. See Section 2.7.1 for implicit synchronization details.

Example(s):

```
onyx:0> currentlocking 1 sprint
false
onyx:0> true setlocking
onyx:0> currentlocking 1 sprint
true
onyx:0>
```

obj cvc obj:**Input(s):**

obj: An object.

Output(s):

obj: The same object that was passed in, but with the callable attribute set.

Error(s):

stackunderflow.

Description: Set the callable attribute for *obj*.

Example(s):

```
onyx:0> $foo cvc 1 sprint
:foo
onyx:0>
```

real precision cvds string:**Input(s):**

real: A real.

precision: Number of digits after the decimal point to show. If negative, do not show trailing zeros.

Output(s):

string: A string representation of *real* in decimal form with *precision* digits of decimal precision.

Error(s):

stackunderflow.

typecheck.

Description: Convert *real* to a string representation in decimal notation, with *precision* digits of decimal precision.

Example(s):

```
onyx:0> 42.3 0 cvds 1 sprint
'42'
onyx:0> 42.3 1 cvds 1 sprint
'42.3'
onyx:0> -42.3 4 cvds 1 sprint
'-42.3000'
onyx:0> -43.3 -4 cvds 1 sprint
'-42.3'
onyx:0>
```

obj cve obj:**Input(s):**

obj: An object.

Output(s):

obj: The same object that was passed in, but with the evaluable attribute set.

Error(s):

stackunderflow.

Description: Set the evaluable attribute for *obj*.

Example(s):

```
onyx:0> [1 2 3] cve 1 sprint
_{1 2 3}_
onyx:0>
```

real precision cves string:

Input(s):

real: A real.

precision: Number of digits after the decimal point to show.

Output(s):

string: A string representation of *real* in exponential form with *precision* digits of decimal precision.

Error(s):

stackunderflow.

typecheck.

Description: Convert *real* to a string representation in exponential notation, with *precision* digits of decimal precision.

Example(s):

```
onyx:0> 42.3 0 cves 1 sprint
'4e+01'
onyx:0> 42.3 1 cves 1 sprint
'4.2e+01'
onyx:0> 42.3 2 cves 1 sprint
'4.23e+01'
onyx:0> -42.3 5 cves 1 sprint
'-4.23000e+01'
onyx:0>
```

obj cvf obj:

Input(s):

obj: An object.

Output(s):

obj: The same object that was passed in, but with the fetchable attribute set.

Error(s):

stackunderflow.

Description: Set the fetchable attribute for *obj*.

Example(s):

```
onyx:0> $foo cvf 1 sprint
,foo
onyx:0>
```

obj cvi obj:

Input(s):

obj: An object.

Output(s):

obj: The same object that was passed in, but with the invocable attribute set.

Error(s):

stackunderflow.

Description: Set the invocable attribute for *obj*.

Example(s):

```
onyx:0> $foo cvi 1 sprint
;foo
onyx:0>
```

obj cvl obj:**Input(s):**

obj: An object.

Output(s):

obj: The same object that was passed in, but with the literal attribute set.

Error(s):

stackunderflow.

Description: Set the literal attribute for *obj*.

Example(s):

```
onyx:0> {1 2 3} cvl 1 sprint
[1 2 3]
onyx:0>
```

string cvn name:**Input(s):**

string: A string.

Output(s):

name: A literal name that corresponds to *string*.

Error(s):

stackunderflow.

typecheck.

Description: Convert *string* to a literal name.

Example(s):

```
onyx:0> 'foo' cvn 1 sprint
$foo
onyx:0>
```

integer radix cvrs string:**Input(s):**

integer: An integer.

radix: A numerical base, from 2 to 36, inclusive.

Output(s):

string: A string representation of *integer* in base *radix*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Convert *integer* to a string representation in base *radix*.

Example(s):

```
onyx:0> 42 2 cvrs 1 sprint
'101010'
onyx:0> 42 16 cvrs 1 sprint
'2a'
onyx:0>
```

***obj* cvs *string*:**

Input(s):

obj: An object.

Output(s):

string: A string representation of *obj*. The string depends on the type of *obj*:

boolean: 'true' or 'false'.

name: The string representation of the name.

integer: The integer in base 10.

operator: The string representation of the operator name or '-operator-'.

real: The real in exponential notation.

string: A printable representation of *obj*. The result can be evaluated to produce the original string.

Other types: '--nostringval--'.

Error(s):

stackunderflow.

Description: Convert *obj* to a string representation.

Example(s):

```
onyx:0> true cvs 1 sprint
'true'
onyx:0> $foo cvs 1 sprint
'foo'
onyx:0> 42 cvs 1 sprint
'42'
onyx:0> ~pop cvs 1 sprint
'pop'
onyx:0> 42.0 cvs 1 sprint
'4.200000e+01'
onyx:0> 'foo\nbar\\biz\'baz' cvs 1 sprint
'\foo\nbar\\\\biz\\\'baz\''
onyx:0> mutex cvs 1 sprint
'--nostringval--'
onyx:0>
```

***obj* cvx *obj*:**

Input(s):

obj: An object.

Output(s):

obj: The same object that was passed in, but with the executable attribute set.

Error(s):

stackunderflow.

Description: Set the executable attribute for *obj*.

Example(s):

```
onyx:0> [1 2 3] cvx 1 sprint
{1 2 3}
onyx:0>
```

class/instance data dict/null:**Input(s):**

class/instance: A class or instance object.

Output(s):

dict/null: A dict or null object.

Error(s):

stackunderflow.

typecheck.

Description: Get the data associated with *class* or *instance*.

Example(s):

```
onyx:0> vclass data 1 sprint
<>
onyx:0>
```

a dec r:**Input(s):**

a: An integer.

Output(s):

r: $a - 1$.

Error(s):

stackunderflow.

typecheck.

Description: Subtract one from *a*.

Example(s):

```
onyx:0> 1 dec 1 sprint
0
onyx:0>
```

key val def -:**Input(s):**

key: An object.

val: A value associated with *key*.

Output(s): None.**Error(s):**

stackunderflow.

Description: Define *key* with associated value *val* in the topmost dictionary on dstack. If *key* is already defined in that dictionary, the old definition is replaced.

Example(s):

```
onyx:0> $foo 'foo' def
onyx:0> foo 1 sprint
'foo'
onyx:0> $foo 'FOO' def
onyx:0> foo 1 sprint
'FOO'
onyx:0>
```

thread detach* –:*Input(s):**

thread: A thread object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Detach *thread* so that its resources will be automatically reclaimed after it exits. A thread may only be detached or joined once; any attempt to do so more than once results in undefined behavior (likely crash).

Example(s):

```
onyx:0> (1 2) {add 1 sprint self detach} thread
3
onyx:1>
```

***dict dict*:**

Input(s): None.

Output(s):

dict: An empty dictionary.

Error(s): None.

Description: Create an empty dictionary.

Example(s):

```
onyx:0> dict 1 sprint
<>
onyx:0>
```

status die* –:*Input(s):**

status: A integer from 0 to 255 that is used as the program exit code.

Output(s): None.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Exit the program with exit code *status*.

Example(s):

```
onyx:0> 1 die
```

path proc dirforeach* –:*Input(s):**

path: A string that represents a filesystem path.

proc: An object to be executed.

Output(s): None.

Error(s):

invalidaccess.

ioerror.

stackunderflow.

typecheck.

Description: For each entry in the directory represented by *path* except for “.” and “..”, push a string that represents the entry onto ostack and execute *proc*. This operator supports the **continue** and **exit** operators.

Example(s):

```
onyx:0> pwd {1 sprint} dirforeach
'CVS'
'.cvsignore'
'Cookfile'
'Cookfile.inc'
'latex'
'Cookfile.inc.in'
onyx:0> pwd {'Cookfile.inc' match
        {pop 'Yes: ' print 1 sprint pop exit}
        {'Not: ' print 1 sprint} ifelse
} dirforeach
Not: 'CVS'
Not: '.cvsignore'
Not: 'Cookfile'
Yes: 'Cookfile.inc'
onyx:0>
```

a b div r:

Input(s):

a: An integer or real.

b: A non-zero integer or real.

Output(s):

r: The quotient of *a* divided by *b*.

Error(s):

stackunderflow.

typecheck.

undefinedresult.

Description: Return the quotient of *a* divided by *b*.

Example(s):

```
onyx:0> 4 2 div 1 sprint
2.000000e+00
onyx:0> 5 2.0 div 1 sprint
2.500000e+00
onyx:0> 5.0 0 div
Error $undefinedresult
ostack: (5.000000e+00 0)
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      --div--
1:      -file-
2:      --start--
onyx:3>
```

a b c dn b c a:

Input(s):

a: An object.
b: An object.
c: An object.

Output(s):

b: An object.
c: An object.
a: An object.

Error(s):

stackunderflow.

Description: Rotate the top three objects on ostack down one position.

Example(s):

```
onyx:0> 'a' 'b' 'c' 'd' dn pstack
'b'
'd'
'c'
'a'
onyx:4>
```

- dstack *stack*:

Input(s): None.

Output(s):

stack: A snapshot of dstack.

Error(s): None.

Description: Get a snapshot of dstack.

Example(s):

```
onyx:0> dstack 1 sprint
(-dict- -dict- -dict- -dict-)
onyx:0>
```

obj dup obj dup*:*Input(s):**

obj: An object.

Output(s):

obj: The same object that was passed in.
dup: A duplicate of *obj*.

Error(s):

stackunderflow.

Description: Create a duplicate of the top object on ostack. For composite objects, the new object is a reference to the same composite object.

Example(s):

```
onyx:0> 1 dup pstack
1
1
onyx:2>
```

***obj echeck boolean*:**

Input(s):**obj:** An object.**Output(s):****boolean:** True if *obj* has the evaluable attribute, false otherwise.**Error(s):****stackunderflow.****Description:** Check *obj* for evaluable attribute.**Example(s):**

```

onyx:0> {1 2 3} cve
onyx:1> dup 1 sprint
_{1 2 3}_
onyx:1> echeck 1 sprint
true
onyx:0> {1 2 3} echeck 1 sprint
false
onyx:0> [1 2 3] echeck 1 sprint
false
onyx:0>

```

- egid *gid*:**Input(s):** None.**Output(s):****gid:** Process's effective group ID.**Error(s):** None.**Description:** Get the process's effective group ID.**Example(s):**

```

onyx:0> egid 1 sprint
1001
onyx:0>

```

- end -:**Input(s):** None.**Output(s):** None.**Error(s):****stackunderflow.****Description:** Pop the topmost dictionary off dstack, thereby removing its contents from the namespace.**Example(s):**

```

onyx:0> <$foo 'foo'> begin
onyx:0> foo 1 sprint
'foo'
onyx:0> end
onyx:0> foo 1 sprint
Error $undefined
ostack: ( )
dstack: (-dict- -dict- -dict- -dict-)
cstack: ( )
estack/istack trace (0..2):

```

```

0:      foo
1:      -file-
2:      --start--
onyx:1>

```

– envdict *dict*:**Input(s):** None.**Output(s):****dict:** A dictionary.**Error(s):** None.**Description:** Get envdict. See Section 2.11.2 for details on envdict.**Example(s):**

```

onyx:0> envdict 0 sprint
-dict-
onyx:0>

```

arg escape –:**Input(s):****arg:** Argument to be returned by the **trapped** operator invocation that traps this **escape**.**Output(s):** None.**Error(s):****stackunderflow.****Description:** Unwind the execution stack to the innermost **trapped** or **start** context.**Example(s):**

```

onyx:0> {$arg escape} trapped {1 sprint} if
$arg
onyx:0>

```

a b eq boolean:**Input(s):****a:** An object.**b:** An object.**Output(s):****boolean:** True if *a* is equal to *b*, false otherwise.**Error(s):****stackunderflow.****Description:** Compare two objects for equality. Equality has the following meaning, depending on the types of *a* and *b*:**array, condition, dict, file, handle, mutex, stack, thread:** *a* and *b* are equal iff they refer to the same memory.**operator:** *a* and *b* are equal iff they refer to the same function.**name, string:** *a* and *b* are equal iff they are lexically equivalent. A name can be equal to a string.**boolean:** *a* and *b* are equal iff they are the same value.**integer, real:** *a* and *b* are equal iff they are the same value.

Example(s):

```
onyx:0> mutex mutex eq 1 sprint
false
onyx:0> mutex dup eq 1 sprint
true
onyx:0> $foo 'foo' eq 1 sprint
true
onyx:0> true true eq 1 sprint
true
onyx:0> true false eq 1 sprint
false
onyx:0> 1 1 eq 1 sprint
true
onyx:0> 1 2 eq 1 sprint
false
onyx:0> 1.0 1 eq 1 sprint
true
onyx:0> 1.0 1.1 eq 1 sprint
false
onyx:0>
```

- estack *stack*:

Input(s): None.

Output(s):

stack: A current snapshot (copy) of the execution stack.

Error(s): None.

Description: Get a current snapshot of the execution stack.

Example(s):

```
onyx:0> estack 1 sprint
(--start-- -file- --estack--)
onyx:0>
```

- euid *uid*:

Input(s): None.

Output(s):

uid: Process's effective user ID.

Error(s): None.

Description: Get the process's effective user ID.

Example(s):

```
onyx:0> euid 1 sprint
1001
onyx:0>
```

obj eval -:

Input(s):

obj: An object.

Output(s): None.

Error(s):

stackunderflow.

Description: Evaluate object. See Section 2.1 for details on object evaluation.

Example(s):

```
onyx:0> ``hi' 1 sprint' cvx eval
`hi'
onyx:0>
```

***a b* *exch* *b a*:**

Input(s):

a: An object.

b: An object.

Output(s):

b: The same object that was passed in.

a: The same object that was passed in.

Error(s):

stackunderflow.

Description: Exchange the top two objects on ostack.

Example(s):

```
onyx:0> 1 2 pstack
2
1
onyx:2> exch pstack
1
2
onyx:2>
```

***args* *exec* -:**

Input(s):

args: An array of strings. The first string in *args* is the path of the program to invoke, and any additional array elements are passed as command line arguments to the invoked program.

Output(s): None (this operator does not return).

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Overlay a new program and execute it. The current contents of envdict are used to construct the new program's environment.

Example(s):

```
onyx:0> 'Old program'
onyx:1> ['/usr/local/bin/onyx'] exec
Canonware Onyx, version 1.0.0.
onyx:0>
```

- *exit* -:

Input(s): None.

Output(s): None.

Error(s): None.

Description: Exit the innermost enclosing looping context immediately. This operator can be called within the looping context of **for**, **repeat**, **while**, **until**, **loop**, **foreach**, and **dirforeach**.

Example(s):

```
onyx:0> {'hi' 1 sprint exit 'bye' 1 sprint} loop
'hi'
onyx:0>
```

b exp r:

Input(s):

a: An integer or real.

Output(s):

r: e raised to the b power.

Error(s):

stackunderflow.

typecheck.

Description: Return e (the base of natural logarithm) raised to the b power.

Example(s):

```
onyx:0> 3 exp 1 sprint
2.008554e+01
onyx:0>
```

- false false:

Input(s): None.

Output(s):

false: The boolean value false.

Error(s): None.

Description: Return false.

Example(s):

```
onyx:0> false 1 sprint
false
onyx:0>
```

obj fcheck boolean:

Input(s):

obj: An object.

Output(s):

boolean: True if *obj* has the fetchable attribute, false otherwise.

Error(s):

stackunderflow.

Description: Check *obj* for fetchable attribute.

Example(s):

```
onyx:0> $name fcheck 1 sprint
false
onyx:0> $name cvf fcheck 1 sprint
true
onyx:0>
```

***a* floor *r*:**

Input(s):

a: An integer or real.

Output(s):

r: Integer floor of *a*.

Error(s):

stackunderflow.

typecheck.

Description: Return the integer floor of *a*.

Example(s):

```
onyx:0> -1.51 floor 1 sprint
-2
onyx:0> -1.49 floor 1 sprint
-2
onyx:0> 0 floor 1 sprint
0
onyx:0> 1.49 floor 1 sprint
1
onyx:0> 1.51 floor 1 sprint
1
onyx:0>
```

- flush -:

Input(s): None.

Output(s): None.

Error(s):

ioerror.

Description: Flush any buffered data associated with stdout.

Example(s):

```
onyx:0> 'Hi\n' print
onyx:0> flush
Hi
onyx:0>
```

file flushfile -:

Input(s):

file: A file object.

Output(s): None.

Error(s):

ioerror.

stackunderflow.

typecheck.

Description: Flush any buffered data associated with *file*.

Example(s):

```
onyx:0> 'Hi\n' print
onyx:0> stdout flushfile
Hi
onyx:0>
```

init inc limit proc for -:**Input(s):**

init: Initial value of control variable.

inc: Amount to increment control variable by at the end of each iteration.

limit: Inclusive upper bound for control variable if less than or equal to *init*, otherwise inclusive lower bound for control variable.

proc: An object.

Output(s): At the beginning of each iteration, the current value of the control variable is pushed onto ostack.

Error(s):

stackunderflow.

typecheck.

Description: Iteratively evaluate *proc*, pushing a control variable onto ostack at the beginning of each iteration, until the control variable has exceeded *limit*. This operator supports the **continue** and **exit** operators.

Example(s):

```
onyx:0> 0 1 3 {1 sprint} for
0
1
2
3
onyx:0> 0 -1 -3 {1 sprint} for
0
-1
-2
-3
onyx:0> 0 2 7 {1 sprint} for
0
2
4
6
onyx:0> 0 1 1000 {dup 1 sprint 3 eq {exit} if} for
0
1
2
3
onyx:0>
```

array proc foreach -:***dict proc foreach -:******stack proc foreach -:******string proc foreach -:*****Input(s):**

array: An array object.

dict: A dict object.

stack: A stack object.

string: A string object.

Output(s): None.

Error(s):**stackunderflow.****typecheck.**

Description: For each entry in the first input argument (*array*, *dict*, *stack*, or *string*), push the entry onto ostack and execute *proc*. This operator supports the **continue** and **exit** operators. The object being iterated over can be modified during iteration, with the expectation of no ill consequences, and in most cases the modifications are immediately apparent. However, there are some cases in which behavior does not follow this guideline:

- Objects inserted into a dictionary during iteration may or may not be iterated over.
- In the case of stack iteration, a snapshot is taken before iteration begins, so any changes to the stack during iteration will not affect iteration in any way.

Example(s):

```
onyx:0> [1 2] {1 sprint} foreach
1
2
onyx:0> <$foo 'foo' $bar 'bar'> {pstack clear} foreach
'bar'
$bar
'foo'
$foo
onyx:0> (1 2) {pstack clear} foreach
2
1
onyx:0> 'ab' {pstack clear} foreach
97
98
onyx:0>
```

args* forkexec *pid*:**args* redirects forkexec *pid*:****Input(s):**

args: An array of strings. The first string in *args* is the path of the program to invoke, and any additional array elements are passed as command line arguments to the invoked program.

redirects: A dictionary of file redirections. Each key/value pair specifies that the file descriptor associated with the key should be replaced by the file descriptor associated with the value. The file descriptor associated with the key is kept open across the exec.

Output(s):

pid: Process identifier for the new process, or 0 if the child process.

Error(s):**argcheck.****limitcheck.****rangecheck.****stackunderflow.****typecheck.**

Description: Fork and exec a new process. The current contents of envdict are used to construct the new program's environment.

Example(s):

```
onyx:0> ['/bin/date'] forkexec dup 1 sprint waitpid 1 sprint
6516
Sat Jul 13 20:47:54 PDT 2002
0
onyx:0>
```

- gdict dict:

Input(s): None.

Output(s):

dict: A dictionary.

Error(s): None.

Description: Get gdict. See Section 2.11.4 for details on gdict.

Example(s):

```
onyx:0> gdict 0 sprint
-dict-
onyx:0>
```

a b ge boolean:

Input(s):

a: A number (integer or real) or string.

b: An object of a type compatible with *a*.

Output(s):

boolean: True if *a* is greater than or equal to *b*, false otherwise.

Error(s):

stackunderflow.

typecheck.

Description: Compare two numbers or strings.

Example(s):

```
onyx:0> 1 2 ge 1 sprint
false
onyx:0> 1 1 ge 1 sprint
true
onyx:0> 2 1 ge 1 sprint
true
onyx:0> 1 1.1 ge 1 sprint
false
onyx:0> 1.1 1.1 ge 1 sprint
true
onyx:0> 1.1 1 ge 1 sprint
true
onyx:0> 'a' 'b' ge 1 sprint
false
onyx:0> 'a' 'a' ge 1 sprint
true
onyx:0> 'b' 'a' ge 1 sprint
true
onyx:0>
```

array index get obj:

dict key get value:

string index get integer:

Input(s):

array: An array object.

dict: A dict object.

string: A string object.

index: Offset of *array* element or *string* element.

key: A key in *dict*.

Output(s):

obj: The object in *array* at offset *index*.

value: The value in *dict* corresponding to *key*.

integer: The ascii value of the character in *string* at offset *index*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

undefined.

Description: Get an element of *array*, a value in *dict*, or an element of *string*.

Example(s):

```
onyx:0> ['a' 'b' 'c'] 1 get 1 sprint
'b'
onyx:0> <$foo 'foo' $bar 'bar'> $bar get 1 sprint
'bar'
onyx:0> 'abc' 1 get 1 sprint
98
onyx:0>
```

array index length getinterval subarray:

string index length getinterval substring:

Input(s):

array: An array object.

string: A string object.

index: The offset into *array* or *string* to get the interval from.

length: The length of the interval in *array* or *string* to get.

Output(s):

subarray: A subarray of *array* at offset *index* and of length *length*.

substring: A substring of *string* at offset *index* and of length *length*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Get an interval of *array* or *string*.

Example(s):

```
onyx:0> [0 1 2 3] 1 2 getinterval 1 sprint
[1 2]
onyx:0> 'abcd' 1 2 getinterval 1 sprint
'bc'
onyx:0>
```

pid getpgid pgid:**Input(s):**

pid: Process ID, or 0 (same as specifying the calling process's ID).

Output(s):

pgid: Process group ID.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Get the process group ID for the process with ID *pid*.

Example(s):

```
onyx:0> 0 getpgid 1 sprint
15864
onyx:0>
```

pid getsid sid:**Input(s):**

pid: Process ID, or 0 (same as specifying the calling process's ID).

Output(s):

sid: Session ID.

Error(s):

stackunderflow.

typecheck.

Description: Get the session ID for the process with ID *pid*.

Example(s):

```
onyx:0> 0 getsid 1 sprint
1120
onyx:0>
```

- gid gid:

Input(s): None.

Output(s):

gid: Process's group ID.

Error(s): None.

Description: Get the process's group ID.

Example(s):

```
onyx:0> gid 1 sprint
1001
onyx:0>
```

- globaldict dict:

Input(s): None.

Output(s):

dict: A dictionary.

Error(s): None.

Description: Get globaldict. See Section 2.11.5 for details on globaldict.

Example(s):

```
onyx:0> globaldict 1 sprint
<>
onyx:0>
```

– gmaxestack count:**Input(s):** None.**Output(s):****count:** Default maximum allowable estack depth.**Error(s):** None.**Description:** Get the default maximum allowable estack depth. This value is used when creating new threads.**Example(s):**

```
onyx:0> gmaxestack 1 sprint
256
onyx:0>
```

– gstderr file:**Input(s):** None.**Output(s):****file:** A file object corresponding to the global stderr.**Error(s):** None.**Description:** Get the global stderr that is inherited by new threads. See Section 2.4 for standard I/O details.**Example(s):**

```
onyx:0> gstderr pstack
-file-
onyx:1>
```

– gstdin file:**Input(s):** None.**Output(s):****file:** A file object corresponding to the global stdin.**Error(s):** None.**Description:** Get the global stdin that is inherited by new threads. See Section 2.4 for standard I/O details.**Example(s):**

```
onyx:0> gstdin pstack
-file-
onyx:1>
```

– gstdout file:**Input(s):** None.**Output(s):****file:** A file object corresponding to the global stdout.**Error(s):** None.**Description:** Get the global stdout that is inherited by new threads. See Section 2.4 for standard I/O details.

Example(s):

```
onyx:0> gstdout pstack
-file-
onyx:1>
```

a b gt boolean:**Input(s):**

- a:** A number (integer or real) or string.
- b:** An object of a type compatible with *a*.

Output(s):

boolean: True if *a* is greater than *b*, false otherwise.

Error(s):

stackunderflow.
typecheck.

Description: Compare two numbers or strings.

Example(s):

```
onyx:0> 1 1 gt 1 sprint
false
onyx:0> 2 1 gt 1 sprint
true
onyx:0> 1.1 1.1 gt 1 sprint
false
onyx:0> 1.1 1 gt 1 sprint
true
onyx:0> 'a' 'a' gt 1 sprint
false
onyx:0> 'b' 'a' gt 1 sprint
true
onyx:0>
```

- gtailopt boolean:

Input(s): None.

Output(s):

boolean: True if tail call optimization is enabled by default for new threads, false otherwise.

Error(s): None.

Description: Get whether tail call optimization is enabled by default for new threads.

Example(s):

```
onyx:0> gtailopt 1 sprint
true
onyx:0>
```

handle handletag tag:**Input(s):**

handle: A handle object.

Output(s):

tag: The tag associated with *handle*.

Error(s):

stackunderflow.

typecheck.

Description: Get the tag associated with *handle*.

... *obj* ,,,*index* ibdup ... *obj* ,,,*dup*:

Input(s):

...: *index* objects.

obj: An object.

...: Zero or more objects.

index: Offset from bottom of ostack, counting from 0.

Output(s):

...: *index* objects.

obj: An object.

...: Zero or more objects.

dup: Duplicate of *obj*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Create a duplicate of the object on ostack that is at offset *index* from the bottom of ostack.

Example(s):

```
onyx:4> 2 ibdup pstack
2
3
2
1
0
onyx:5>
```

... *obj* ,,,*index* ibpop ... ,,,:

Input(s):

...: *index* objects.

obj: An object.

...: Zero or more objects.

index: Offset from bottom of ostack, counting from 0.

Output(s):

...: *index* objects.

...: Zero or more objects.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Remove the object from ostack that is at offset *index* from the bottom of ostack.

Example(s):

```

onyx:0> 0 1 2 3
onyx:4> 2 ibpop pstack
3
1
0
onyx:3>

```

obj* icheck *boolean*:*Input(s):**

obj: An object.

Output(s):

boolean: True if *obj* has the invocable attribute, false otherwise.

Error(s):

stackunderflow.

Description: Check *obj* for invocable attribute.

Example(s):

```

onyx:0> $name icheck 1 sprint
false
onyx:0> $name cvi icheck 1 sprint
true
onyx:0>

```

a b* idiv *r*:*Input(s):**

a: An integer.

b: A non-zero integer.

Output(s):

r: The integer quotient of *a* divided by *b*.

Error(s):

stackunderflow.

typecheck.

undefinedresult.

Description: Return the integer quotient of *a* divided by *b*.

Example(s):

```

onyx:0> 4 2 idiv 1 sprint
2
onyx:0> 5 2 idiv 1 sprint
2
onyx:0> 5 0 idiv
Error $undefinedresult
ostack: (5 0)
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      --idiv--
1:      -file-
2:      --start--
onyx:3>

```


obj ... index idup obj ... dup:

Input(s):

obj: An object.

index: Offset from top of ostack, counting from 0, not counting *index*, of the object to duplicate on ostack.

Output(s):

obj: The same object that was passed in.

dup: A duplicate of *obj*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Create a duplicate of the object on ostack at *index*.

Example(s):

```
onyx:0> 3 2 1 0 2 idup pstack
2
0
1
2
3
onyx:5>
```

boolean obj if -:

Input(s):

boolean: A boolean.

obj: An object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Evaluate *obj* if *boolean* is true.

Example(s):

```
onyx:0> true {'yes' 1 sprint} if
'yes'
onyx:0> false {'yes' 1 sprint} if
onyx:0>
```

boolean a b ifelse -:

Input(s):

boolean: A boolean.

a: An object.

b: An object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Evaluate *a* if *boolean* is true, evaluate *b* otherwise. See Section 2.1 for details on object evaluation.

Example(s):

```
onyx:0> true {'yes'}{'no'} ifelse 1 sprint
'yes'
onyx:0> false {'yes'}{'no'} ifelse 1 sprint
'no'
onyx:0>
```

***obj* ilocked *boolean*:**

Input(s):

obj: An array, dict, file, or string.

Output(s):

boolean: True if *obj* is implicitly locked, false otherwise.

Error(s):

stackunderflow.

typecheck.

Description: Check if *obj* is implicitly locked.

Example(s):

```
onyx:0> false setlocking
onyx:0> [1 2 3] ilocked 1 sprint
false
onyx:0> true setlocking
onyx:0> [1 2 3] ilocked 1 sprint
true
onyx:0>
```

***class name* implementor *class/null*:**

Input(s):

class: A class object.

name: An object of any type, usually a name object.

Output(s):

class/null: A class or null object.

Error(s):

stackunderflow.

typecheck.

Description: Search up *class*'s inheritance hierarchy and return the first class that implements *name*, or a null object if *name* is not implemented.

Example(s):

```
onyx:0> class dup vclass setsuper
onyx:1> $new implementor classname 1 sprint
$vc
onyx:0>
```

***class name* implements *boolean*:**

Input(s):

class: A class object.

name: An object of any type, usually a name object.

Output(s):

boolean: True if *name* is implemented by *class*, false otherwise.

Error(s):

stackunderflow.

typecheck.

Description: Return true if *name* is implemented by *class*; return false otherwise.

Example(s):

```
onyx:1> vclass $new implements 1 sprint
true
onyx:1> vclass $foo implements 1 sprint
false
onyx:1>
```

a inc r:**Input(s):**

a: An integer.

Output(s):

r: $a + 1$.

Error(s):

stackunderflow.

typecheck.

Description: Add one to *a*.

Example(s):

```
onyx:0> 1 inc 1 sprint
2
onyx:0>
```

- instance instance:

Input(s): None.

Output(s):

instance:

Error(s): None.

Description: Create an instance object.

Example(s):

```
onyx:0> instance 1 sprint
-instance-
onyx:0>
```

file iobuf count:**Input(s):**

file: A file object.

Output(s):

count: The size in bytes of the I/O buffer associated with *file*.

Error(s):

stackunderflow.

typecheck.

Description: Get the size of the I/O buffer associated with *file*.

Example(s):

```
onyx:0> stdout iobuf 1 sprint
512
onyx:0> stderr iobuf 1 sprint
0
onyx:0>
```

obj...index ipop...:**Input(s):**

obj: An object.

index: Offset from top of ostack, counting from 0, not counting *index*, of the object to remove from ostack.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Remove the *obj* at *index* from ostack.

Example(s):

```
onyx:0> 2 1 0
onyx:3> 1 ipop pstack
0
2
onyx:2>
```

instance isa class/null:**Input(s):**

instance: An instance object.

Output(s):

class/null: A class or null object.

Error(s):

stackunderflow.

typecheck.

Description: Get the class *object* that *instance* is an instance of.

Example(s):

```
onyx:0> instance isa 1 sprint
null
onyx:0> instance dup vclass setisa
onyx:1> isa classname 1 sprint
$vclass
onyx:0>
```

- istack stack:

Input(s): None.

Output(s):

stack: A current snapshot (copy) of the index stack.

Error(s): None.

Description: Get a current snapshot of the index stack.

Example(s):

```
onyx:0> istack 1 sprint
(0 0 0)
onyx:0>
```

thread join* -:*Input(s):**

thread: A thread object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Wait for *thread* to exit. A thread may only be detached or joined once; any attempt to do so more than once results in undefined behavior (likely crash).

Example(s):

```
onyx:0> (1 2) {add 1 sprint} thread join 'Done\n' print flush
3
Done
onyx:0>
```

pid sig kill* -:*Input(s):**

pid: An integer. If *pid* is greater than 0, it specifies a process ID. If *pid* is 0, it specifies the calling program's process group. If *pid* is -1, the signal is sent to all non-system processes with ID 1. If *pid* is less than -1, its absolute value specifies a process group.

sig: An integer, or one of the following names:

- \$SIGABRT
- \$SIGALRM
- \$SIGBUS
- \$SIGCHLD
- \$SIGCONT
- \$SIGFPE
- \$SIGHUP
- \$SIGILL
- \$SIGINT
- \$SIGKILL
- \$SIGPIPE
- \$SIGQUIT
- \$SIGSEGV
- \$SIGSTOP
- \$SIGTERM
- \$SIGTSTP
- \$SIGTTIN
- \$SIGTTOU
- \$SIGUSR1
- \$SIGUSR2
- \$SIGPOLL (may not be present)

- \$SIGPROF
- \$SIGSYS
- \$SIGTRAP
- \$SIGURG
- \$SIGVTALRM (may not be present)
- \$SIGXCPU
- \$SIGXFSZ

Output(s): None.

Error(s):

argcheck.
invalidaccess.
limitcheck.
rangecheck.
stackunderflow.
typecheck.
unregistered.

Description: Send the signal specified by *sig* to the process or process group specified by *pid*.

Example(s):

```
onyx:0> pid $SIGCONT kill
onyx:0>
```

instance class kind boolean:

Input(s):

instance: An instance object.
class: A class object.

Output(s):

boolean: True if *class* is in *instance*'s inheritance hierarchy, false otherwise.

Error(s):

stackunderflow.
typecheck.

Description: Determine whether *class* is in *instance*'s inheritance hierarchy.

Example(s):

```
onyx:0> $fooclass class dup vclass setsuper def
onyx:0> instance dup fooclass setisa
onyx:1> dup fooclass kind 1 sprint
true
onyx:1> dup vclass kind 1 sprint
true
onyx:1>
```

dict key known boolean:

Input(s):

dict: A dictionary.
key: A key to look for in *dict*.

Output(s):

boolean: True if *key* is defined in *dict*, false otherwise.

Error(s):**stackunderflow.****typecheck.****Description:** Check whether *key* is defined in *dict*.**Example(s):**

```
onyx:1> <$foo 'foo'> $foo known 1 sprint
true
onyx:1> <$foo 'foo'> $bar known 1 sprint
false
onyx:1>
```

obj* lcheck boolean:*Input(s):****obj:** An object.**Output(s):****boolean:** True if *obj* has the literal attribute, false otherwise.**Error(s):****stackunderflow.****Description:** Check *obj* for literal attribute.**Example(s):**

```
onyx:0> {1 2 3} lcheck 1 sprint
false
onyx:0> [1 2 3] lcheck 1 sprint
true
onyx:0>
```

a b* le boolean:*Input(s):****a:** A number (integer or real) or string.**b:** An object of a type compatible with *a*.**Output(s):****boolean:** True if *a* is less than or equal to *b*, false otherwise.**Error(s):****stackunderflow.****typecheck.****Description:** Compare two numbers or strings.**Example(s):**

```
onyx:0> 1 2 le 1 sprint
true
onyx:0> 1 1 le 1 sprint
true
onyx:0> 2 1 le 1 sprint
false
onyx:0> 1 1.1 le 1 sprint
true
onyx:0> 1.1 1.1 le 1 sprint
true
onyx:0> 1.1 1 le 1 sprint
```

```
false
onyx:0> 'a' 'b' le 1 sprint
true
onyx:0> 'a' 'a' le 1 sprint
true
onyx:0> 'b' 'a' le 1 sprint
false
onyx:0>
```

array length count:

dict length count:

name length count:

string length count:

Input(s):

array: An array object.

dict: A dict object.

name: A name object.

string: A string object.

Output(s):

count: Number of elements in *array*, number of entries in *dict*, number of characters in *name*, or number of characters in *string*.

Error(s):

stackunderflow.

typecheck.

Description: Get the number of elements in *array*, number of entries in *dict*, number of characters in *name*, or number of characters in *string*.

Example(s):

```
onyx:0> [1 2 3] length 1 sprint
3
onyx:0> <$foo 'foo' $bar 'bar'> length 1 sprint
2
onyx:0> $foo length 1 sprint
3
onyx:0> 'foo' length 1 sprint
3
onyx:0>
```

filename linkname link -:

Input(s):

filename: A string that represents a filename.

linkname: A string that represents a filename.

Output(s): None.

Error(s):

invalidfileaccess.

ioerror.

stackunderflow.

typecheck.

undefinedfilename.

unregistered.

Description: Create a hard link from *linkname* to *filename*.

Example(s):

```
onyx:0> '/tmp/foo' 'w' open
onyx:1> dup 'Hello\n' write
onyx:1> dup flushfile
onyx:1> close
onyx:0> '/tmp/foo' '/tmp/bar' link
onyx:0> '/tmp/bar' 'r' open
onyx:1> readline
onyx:2> pstack
false
'Hello'
onyx:2>
```

sock backlog listen -:

sock listen -:

Input(s):

sock: A socket.

backlog: Maximum backlog of connections to listen for. If not specified, the maximum backlog is used.

Output(s): None.

Error(s):

invalidfileaccess.

neterror.

rangecheck.

stackunderflow.

typecheck.

unregistered.

Description: Listen for connections on a socket.

Example(s):

```
onyx:0> $AF_INET $SOCK_STREAM socket
onyx:1> dup 'localhost' 7777 bindsocket
onyx:1> dup listen
onyx:1>
```

a ln r:

Input(s):

a: An integer or real.

Output(s):

r: Natural logarithm of *a*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Return the natural logarithm of *a*.

Example(s):

```
onyx:0> 5 ln 1 sprint
1.609438e+00
onyx:0> 8.5 ln 1 sprint
2.140066e+00
onyx:0>
```

key load val:**Input(s):**

key: A key to look up in dstack.

Output(s):

val: The value associated with the topmost definition of *key* in dstack.

Error(s):

stackunderflow.
undefined.

Description: Get the topmost definition of *key* in dstack.

Example(s):

```
onyx:1> <$foo 'foo'> begin
onyx:1> <$foo 'FOO'> begin
onyx:1> $foo load 1 sprint
'FOO'
onyx:1>
```

nsecs localtime dict:**Input(s):**

nsecs: Number of nanoseconds since the epoch.

Output(s):

dict: A dictionary that contains the following entries:

sec: Seconds (0-59).
min: Minutes (0-59).
hour: Hours (0-23).
mday: Month day (1-31).
mon: Month (0-11).
year: Year.
wday: Week day (0-6, Sunday is 0).
yday: Year day (0-365).
isdst: Is daylight savings time (true or false).
zone: Time zone (string).
gmtoff: Offset from UTC in seconds.

Error(s):

stackunderflow.
rangecheck.
typecheck.

Description: Convert a time, as returned by realtime, to a dictionary that contains time information in a more human-usable format.

Example(s):

```

onyx:0> $date {
    realtime localtime

    ['Sunday' 'Monday' 'Tuesday' 'Wednesday' 'Thursday' 'Friday' 'Saturday']
    over $wday get
    get
    ' ' cat

    over $year get cvs
    '/' 3 ncat

    over $mon get inc <$w 2 $p '0'> outputs
    '/' 3 ncat

    over $mday get <$w 2 $p '0'> outputs
    ' ' 3 ncat

    over $hour get <$w 2 $p '0'> outputs
    ':' 3 ncat

    over $min get <$w 2 $p '0'> outputs
    ':' 3 ncat

    over $sec get <$w 2 $p '0'> outputs
    ' (' 3 ncat

    exch $zone get
    ')\n' 3 ncat

    print flush
} def
onyx:0> date
Monday 2003/03/17 01:31:49 (PST)
onyx:0>

```

mutex* lock -:*Input(s):****mutex:** A mutex object.**Output(s):** None.**Error(s):****stackunderflow.****typecheck.****Description:** Acquire *mutex*, waiting if necessary. Attempting to acquire *mutex* recursively will result in undefined behavior (likely deadlock or crash).**Example(s):**

```

onyx:0> mutex dup lock unlock
onyx:0>

```

a* log r:*Input(s):**

a: An integer or real.

Output(s):

r: Base 10 logarithm of a .

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Return the base 10 logarithm of a .

Example(s):

```
onyx:0> 5 log 1 sprint
6.989700e-01
onyx:0> 8.5 log 1 sprint
9.294189e-01
onyx:0>
```

***proc* loop –:**

Input(s):

proc: An object to evaluate.

Output(s): None.

Error(s):

stackunderflow.

Description: Repeatedly evaluate *proc* indefinitely. This operator supports the **continue** and **exit** operators.

Example(s):

```
onyx:0> 0 {1 add dup 1 sprint dup 3 eq {pop exit} if} loop
1
2
3
onyx:0>
```

***a b* lt *boolean*:**

Input(s):

a: A number (integer or real) or string.

b: An object of a type compatible with a .

Output(s):

boolean: True if a is less than b , false otherwise.

Error(s):

stackunderflow.

typecheck.

Description: Compare two numbers or strings.

Example(s):

```
onyx:0> 1 2 lt 1 sprint
true
onyx:0> 1 1 lt 1 sprint
false
onyx:0> 1 1.1 lt 1 sprint
true
```

```
onyx:0> 1.1 1.1 lt 1 sprint
false
onyx:0> 1.1 1 lt 1 sprint
false
onyx:0> 'a' 'b' lt 1 sprint
true
onyx:0> 'a' 'a' lt 1 sprint
false
onyx:0>
```

– **mark *mark*:**

Input(s): None.

Output(s):

mark: A mark object.

Error(s): None.

Description: Push a mark onto ostack.

Example(s):

```
onyx:0> mark pstack
-mark-
onyx:1>
```

– **maxestack *count*:**

Input(s): None.

Output(s):

count: Maximum allowable estack depth.

Error(s): None.

Description: Get the maximum allowable estack depth.

Example(s):

```
onyx:0> maxestack 1 sprint
256
onyx:0>
```

input pattern flags match boolean:

input pattern match boolean:

input regex match boolean:

Input(s):

input: An input string to find matches in.

pattern: A string that specifies a regular expression. See Section 2.9 for syntax.

flags: A dictionary of optional flags:

\$c: Continue where previous match ended. Don't update the offset to start the next match from unless this match is successful. Defaults to false.

\$g: Continue where previous match ended. If the match is unsuccessful, update the offset to start the next match from to the beginning of *input*. Defaults to false.

\$i: Case insensitive. Defaults to false.

\$m: Treat input as a multi-line string. Defaults to false.

\$s: Treat input as a single line, so that the dot metacharacter matches any character, including a newline. Defaults to false.

regex: A regex object.

Output(s):

boolean:

true: Match successful.

false: No match found.

Error(s):

regexerror.

stackunderflow.

typecheck.

Description: Look in *input* for a match to the regular expression specified by *regex/pattern/flags*.

Example(s):

```
onyx:0> 'input' 'I' <$i true> match {0 submatch 1 sprint} if
'i'
onyx:0> 'input' 'I' <$i true> regex match {0 submatch 1 sprint} if
'i'
onyx:0> 'input' 'I' match {0 submatch 1 sprint} if
onyx:0>
```

class name method method:

Input(s):

class: A class object.

name: An object of any type, usually a name object.

Output(s):

method: The bottommost method associated with *name* in *class*'s inheritance hierarchy.

Error(s):

stackunderflow.

typecheck.

undefined.

Description: Get the bottommost method associated with *name* in *class*'s inheritance hierarchy.

Example(s):

```
onyx:0> $fooclass class dup vclass setsuper def
onyx:0> fooclass $new method 1 sprint
{--instance-- --dup-- --dn-- --setisa-- --dup-- --dict-- --setdata--}
onyx:0>
```

class methods dict/null:

Input(s):

class: A class object.

Output(s):

dict/null: A dict or null object.

Error(s):

stackunderflow.

typecheck.

Description: Get the methods associated with *class*.

Example(s):

```
onyx:0> vclass methods 0 sprint
-dict-
onyx:0>
```

path mkdir -:***path mode mkdir -:*****Input(s):**

path: A string object that represents a directory path.

mode: An integer that represents a Unix file mode.

Output(s): None.

Error(s):

invalidfileaccess.

ioerror.

rangecheck.

stackunderflow.

typecheck.

unregistered.

Description: Create a directory.

Example(s):

```
onyx:0> `/tmp/tdir' 8@755 mkdir
onyx:0> `/tmp/tdir' {1 sprint} dirforeach
`.`
`..`
onyx:0>
```

path mkfifo -:***path mode mkfifo -:*****Input(s):**

path: A string object that represents a directory path.

mode: An integer that represents a Unix file mode.

Output(s): None.

Error(s):

invalidfileaccess.

ioerror.

rangecheck.

stackunderflow.

typecheck.

unregistered.

Description: Create a named pipe.

Example(s):

```
onyx:0> `/tmp/fifo' mkfifo
onyx:0>
```

a b mod r:**Input(s):**

a: An integer or real.

b: A non-zero integer or real.

Output(s):

r: The modulus of a and b .

Error(s):

stackunderflow.

typecheck.

undefinedresult.

Description: Return the modulus of a and b . Note that a and b can be any combination of integers and reals.

Example(s):

```
onyx:0> 4 2 mod 1 sprint
0
onyx:0> 5 2 mod 1 sprint
1
onyx:0> 5 0 mod
Error $undefinedresult
ostack: (5 0)
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      --mod--
1:      -file-
2:      --start--
onyx:3>
```

path symbol modload -:

Input(s):

path: A string that represents a module filename.

symbol: A string that represents the symbol name of a module initialization function to be executed.

Output(s): None.

Error(s):

invalidfileaccess.

stackunderflow.

typecheck.

undefined.

Description: Dynamically load a module, create a handle object that encapsulates the handle returned by `dlopen(3)` (handle data pointer) and the module initialization function (handle evaluation function), and evaluate the handle.

All objects that refer to code and/or data that are part of the module must directly and/or indirectly maintain a reference to the handle that is evaluated by this operator, since failing to do so would allow the garbage collector to unload the module, which could result in dangling pointers to unmapped memory regions.

Loadable modules present a problem for the garbage collector during the sweep phase. All objects that refer to memory that is dynamically mapped as part of the module must be destroyed before the module is unloaded. Destruction ordering constraints show up in other situations as well, but in the case of loadable modules, there is no reasonable solution except

to explicitly order the destruction of objects. Therefore, by default, the handle that is evaluated by `modload` is destroyed during the second sweep pass (count starts at 0). It is possible for a module to override what sweep pass the handle is destroyed on, in cases where there are additional ordering constraints for the objects created by a module. This isn't important from the Onyx language perspective, but is important to understand when implementing modules.

Example(s):

```
onyx:0> '/usr/local/share/onyx/nxm/modprompt.nxm' 'modprompt_init'
onyx:2> modload
onyx:0>
```

mutex proc monitor* -:*Input(s):**

mutex: A mutex.
proc: Any object.

Output(s): None.

Error(s):

stackunderflow.
typecheck.

Description: Execute *proc* while holding *mutex*.

Example(s):

```
onyx:0> mutex {'hello\n' print} monitor flush
hello
onyx:0>
```

file symbol mrequire* -:*Input(s):**

file: A string that represents a module filename.
symbol: A string that represents the symbol name of a module initialization function to be executed.

Output(s): None.

Error(s):

invalidfileaccess.
stackunderflow.
typecheck.
undefined.
undefinedfilename.

Description: Search for and load a module. The module is searched for by concatenating a prefix, a “/”, and *file* to form a file path. Prefixes are tried in the following order:

1. The ordered elements of the `mpath_pre` array, which is defined in `onyxdict`.
2. If defined, the ordered elements of the `ONYX_MPATH` environment variable, which is a colon-separated list.
3. The ordered elements of the `mpath_post` array, which is defined in `onyxdict`.

Example(s):

```
onyx:0> 'modgtk.nxm' 'modgtk_init' mrequire
onyx:0>
```

***a b mul r*:**

Input(s):

a: An integer or real.

b: An integer or real.

Output(s):

r: The product of a and b .

Error(s):

stackunderflow.

typecheck.

Description: Return the product of a and b .

Example(s):

```
onyx:0> 3 17 mul 1 sprint
51
onyx:0> -5 -6 mul 1 sprint
30
onyx:0> 3.5 4.0 mul 1 sprint
1.400000e+01
onyx:0> -1.5 3 mul 1 sprint
-4.500000e+00
onyx:0>
```

– mutex *mutex*:

Input(s): None.

Output(s):

mutex: A mutex object.

Error(s): None.

Description: Create a mutex.

Example(s):

```
onyx:0> mutex 1 sprint
-mutex-
onyx:0>
```

objects ... count nbpop ...:**Input(s):**

objects: Zero or more objects.

count: Number of *objects* to pop.

Output(s): None.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Remove the bottom *count* *objects* from ostack and discard them.

Example(s):

```
onyx:0> 'a' 'b' 'c' 2 nbpop pstack
'c'
onyx:1>
```

arrays count ncat array:

stacks count ncat stack:

strings count ncat string:

Input(s):

arrays: *count* arrays.

stacks: *count* stacks.

strings: *count* strings.

count: Number of *arrays*, *stacks*, or *strings* to catenate.

Output(s):

obj: The catenation of *arrays*, *stacks*, or *strings*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Catenate *count* *arrays*, *stacks*, or *strings*.

Example(s):

```
onyx:0> ['a'] ['b'] ['c'] 3 ncat 1 sprint
['a' 'b' 'c']
onyx:0> ('a') ('b') ('c') 3 ncat 1 sprint
('a' 'b' 'c')
onyx:0> 'a' 'b' 'c' 3 ncat 1 sprint
'abc'
onyx:0>
```

a ... b count ndn ... b a:

Input(s):

a: An object.

...: *count* – 2 objects.

b: An object.

count: Number of objects to rotate downward.

Output(s):

...: *count* – 2 objects.

b: An object.

a: An object.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Rotate *count* objects on ostack down one position.

Example(s):

```
onyx:0> 'a' 'b' 'c' 'd' 'e' 4 ndn pstack
'b'
'e'
'd'
'c'
'a'
onyx:5>
```

objects count ndup objects objects:**Input(s):****objects:** Zero or more objects.**count:** The number of *objects* to duplicate.**Output(s):****objects:** The same objects that were passed in.**Error(s):****rangecheck.****stackunderflow.****typecheck.****Description:** Create duplicates of the top *count* objects on ostack. For composite objects, the new object is a reference to the same composite object.**Example(s):**

```

onyx:0> 'a' 'b' 'c' 2 ndup pstack
'c'
'b'
'c'
'b'
'a'
onyx:5>

```

a b ne boolean:**Input(s):****a:** An object.**b:** An object.**Output(s):****boolean:** True if *a* is not equal to *b*, false otherwise.**Error(s):****stackunderflow.****Description:** Compare two objects for inequality. Inequality has the following meaning, depending on the types of *a* and *b*:**array, condition, dict, file, handle, mutex, stack, thread:** *a* and *b* are not equal unless they refer to the same memory.**operator:** *a* and *b* are not equal unless they refer to the same function.**name, string:** *a* and *b* are not equal iff they are lexically equivalent. A name can be equal to a string.**boolean:** *a* and *b* are not equal unless they are the same value.**integer, real:** *a* and *b* are not equal unless they are the same value.**Example(s):**

```

onyx:0> mutex mutex ne 1 sprint
true
onyx:0> mutex dup ne 1 sprint
false
onyx:0> $foo 'foo' ne 1 sprint
false
onyx:0> $foo $bar ne 1 sprint
true

```

```

onyx:0> true false ne 1 sprint
true
onyx:0> true true ne 1 sprint
false
onyx:0> 1 1 ne 1 sprint
false
onyx:0> 1 2 ne 1 sprint
true
onyx:0> 1.0 1 ne 1 sprint
false
onyx:0> 1.0 1.1 ne 1 sprint
true
onyx:0>

```

a neg r:**Input(s):****a:** An integer.**Output(s):****r:** The negative of *a*.**Error(s):****stackunderflow.****typecheck.****Description:** Return the negative of *a*.**Example(s):**

```

onyx:0> 0 neg 1 sprint
0
onyx:0> 5 neg 1 sprint
-5
onyx:0> -5 neg 1 sprint
5
onyx:0> 3.14 neg 1 sprint
-3.140000e+00
onyx:0> -3.14 neg 1 sprint
3.140000e+00
onyx:0>

```

a b nip b:**Input(s):****a:** An object.**b:** An object.**Output(s):****b:** An object.**Error(s):****stackunderflow.****Description:** Remove the second to top object from ostack.**Example(s):**

```

onyx:0> 'a' 'b' 'c'
onyx:3> nip pstack
'c'
'a'
onyx:2>

```

file nonblocking boolean:**Input(s):**

file: A file object.

Output(s):

boolean: Nonb-blocking mode for *file*.

Error(s):

stackunderflow.

typecheck.

Description: Get non-blocking mode for *file*.

Example(s):

```
onyx:0> '/tmp/foo' 'w' open
onyx:1> dup nonblocking 1 sprint
false
onyx:1> dup true setnonblocking
onyx:1> dup nonblocking 1 sprint
true
onyx:1>
```

a not r:**Input(s):**

a: An integer or boolean.

Output(s):

r: If *a* is an integer, the bitwise negation of *a*, otherwise the logical negation of *a*.

Error(s):

stackunderflow.

typecheck.

Description: Return the bitwise negation of an integer, or the logical negation of a boolean.

Example(s):

```
onyx:0> true not 1 sprint
false
onyx:0> false not 1 sprint
true
onyx:0> 1 not 1 sprint
-2
onyx:0>
```

objects count npop -:**Input(s):**

objects: Zero or more objects.

count: Number of *objects* to pop.

Output(s): None.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Remove the top *count* *objects* from ostack and discard them.

Example(s):

```
onyx:0> 'a' 'b' 'c' 2 npop pstack
'a'
onyx:1>
```

nanoseconds nsleep* –:*Input(s):**

nanoseconds: Minimum number of nanoseconds to sleep. Must be greater than 0.

Output(s): None.**Error(s):**

rangecheck.
stackunderflow.
typecheck.

Description: Sleep for at least *nanoseconds* nanoseconds.

Example(s):

```
onyx:0> 1000 nsleep
onyx:0>
```

– null *null*:**Input(s):** None.**Output(s):**

null: A null object.

Error(s): None.

Description: Create a null object.

Example(s):

```
onyx:0> null pstack
null
onyx:1>
```

a ... b count nup b a ...*:*Input(s):**

a: An object.
...: *count* – 2 objects.
b: An object.
count: Number of objects to rotate upward.

Output(s):

b: An object.
a: An object.
...: *count* – 2 objects.

Error(s):

rangecheck.
stackunderflow.
typecheck.

Description: Rotate *count* objects on ostack up one position.

Example(s):

```

onyx:0> 'a' 'b' 'c' 'd' 'e' 4 nup pstack
'd'
'c'
'b'
'e'
'a'
onyx:5>

```

input submatch offset offset:**Input(s):****input:** A string.**submatch:** A substring of *input*.**Output(s):****offset:** The integer offset of *submatch*, relative to the beginning of *input*.**Error(s):****rangecheck.****stackunderflow.****typecheck.****Description:** Get the offset of *submatch*, relative to the beginning of *input*. *submatch* must be a substring of *input*.**Example(s):**

```

onyx:0> 'input' dup 'n(p)u' match {1 submatch offset 1 sprint} if
2
onyx:0>

```

– onyxdict *dict*:**Input(s):** None.**Output(s):****dict:** A dictionary.**Error(s):** None.**Description:** Get onyxdict. See Section 2.11.6 for details on onyxdict.**Example(s):**

```

onyx:0> onyxdict 1 sprint
<$rpath_pre -array- $rpath_post -array- $mpath_pre -array- $mpath_post -array->
onyx:0>

```

filename flags open file:***filename flags mode open file:*****Input(s):****filename:** A string that represents a filename.**flags:** A string that represents a file mode:**'r':** Read only.**'r+':** Read/write, starting at offset 0.**'w':** Write only. Create file if necessary. Truncate file if non-zero length.**'w+':** Read/write, starting at offset 0. Create file if necessary.**'a':** Write only, starting at end of file.

'a+': Read/write, starting at end of file.

mode: Mode to use when creating a new file (defaults to 0777). Note that the process's umask also affects creation mode.

Output(s):

file: A file object.

Error(s):

invalidfileaccess.

ioerror.

limitcheck.

rangecheck.

stackunderflow.

typecheck.

Description: Open a file.

Example(s):

```
onyx:0> '/tmp/foo' 'w' open pstack
-file-
onyx:1>
```

a b or r:

Input(s):

a: An integer or boolean.

b: The same type as *a*.

Output(s):

r: If *a* and *b* are integers, their bitwise or, otherwise their logical or.

Error(s):

stackunderflow.

typecheck.

Description: Return the bitwise or of two integers, or the logical or of two booleans.

Example(s):

```
onyx:0> false false or 1 sprint
false
onyx:0> true false or 1 sprint
true
onyx:0> 5 3 or 1 sprint
7
onyx:0>
```

array origin false:

array origin string line true:

Input(s):

array:

Output(s):

string: A string (typically a filename) that tells what the origin of *array* was.

line: An integer that represents the line within *string* that *array* started at.

false/true: If false, no origin is recorded for *array*. If true, the origin is recorded for *array*, and *string* and *line* are also returned.

Error(s):**stackunderflow.****typecheck.**

Description: If the origin of *array* is recorded, return the *string* and *line* that represent the origin.

Example(s):

```
onyx:0> {} origin {exch 1 sprint 1 sprint} if
'*stdin*'
1
onyx:0> [] origin {exch 1 sprint 1 sprint} if
onyx:0>
```

– ostack *stack*:**Input(s):** None.**Output(s):****stack:** A current snapshot (copy) of ostack.**Error(s):** None.**Description:** Get a current snapshot of ostack.**Example(s):**

```
onyx:0> 1 2 3 ostack pstack
(1 2 3)
3
2
1
onyx:4>
```

obj depth* output –:*Input(s):****obj:** An object to print syntactically.**depth:** Maximum recursion depth.**Output(s):** None.**Error(s):****ioerror.****stackunderflow.****typecheck.****Description:** Syntactically print *obj*. See Section 2.11.7 for format specifier details.**Example(s):**

```
onyx:0> [1 [2 3] 4] <$w 20 $p '_' $j $c $r 1> output '\n' print flush
____[1 -array- 4]____
onyx:0> [1 [2 3] 4] <$w 20 $p '_' $j $c $r 2> output '\n' print flush
____[1 [2 3] 4]____
onyx:0> 4242 <$s $+> output '\n' print flush
+4242
onyx:0> '0x' print 4242 <$b 16> output '\n' print flush
0x1092
onyx:0> '0x' 4242 <$b 16> outputs cat <$w 10 $p '.'>
onyx:2> output '\n' print flush
....0x1092
```

```

onyx:0> '0x' print 4242 <$w 8 $p '0' $b 16> output '\n' print flush
0x00001092
onyx:0>

```

obj flags outputs string:**Input(s):****obj:** An object to print syntactically.**depth:** Formatting flags. See Section 2.11.7 for details on the supported flags.**Output(s):****string:** A formatted string representation of *obj*. See Section 2.11.7 for format specifier details.**Error(s):****stackunderflow.****typecheck.****Description:** Create a formatted string representation of *obj*.**Example(s):**

```

onyx:0> [1 [2 3] 4] <$w 20 $p '_' $j $c $r 1> outputs print '\n' print flush
____[1 -array- 4]_____
onyx:0> [1 [2 3] 4] <$w 20 $p '_' $j $c $r 2> outputs print '\n' print flush
____[1 [2 3] 4]_____
onyx:0> 4242 <$s $+> outputs print '\n' print flush
+4242
onyx:0> '0x' print 4242 <$b 16> outputs print '\n' print flush
0x1092
onyx:0> '0x' 4242 <$b 16> outputs cat <$w 10 $p '.'> outputs
onyx:1> print '\n' print flush
....0x1092
onyx:0> '0x' print 4242 <$w 8 $p '0' $b 16> outputs print '\n' print flush
0x00001092
onyx:0>

```

– outputsdict *dict*:**Input(s):** None.**Output(s):****dict:** A dictionary.**Error(s):** None.**Description:** Get outputsdict. See Section 2.11.7 for details on outputsdict.**Example(s):**

```

onyx:0> outputsdict 0 sprint
-dict-
onyx:0>

```

a b over a b a:**Input(s):****a:** An object.**b:** An object.**Output(s):****a:** An object.**b:** An object.

Error(s):**stackunderflow.****Description:** Create a duplicate of the second object on ostack and push it onto ostack.**Example(s):**

```
onyx:0> 0 1 2 over pstack
1
2
1
0
onyx:4>
```

prog path path/null:**Input(s):****prog:** A string that specifies a program to search for in the PATH environment variable.**Output(s):****path:** A string that specifies the path to *prog*.**null:** *prog* was not found.**Error(s):****stackunderflow.****typecheck.****Description:** Search for *prog* in the PATH, and return a string that is suitable for subsequent calls to operators such as **exec**, **forkexec**, and **system**.**Example(s):**

```
onyx:0> 'cat' path 1 sprint
'/bin/cat'
onyx:0>
```

sock peername dict:**Input(s):****sock:** A socket.**Output(s):****dict:** A dictionary of information about the peer end of *sock*. Depending on the socket family, the following entries may exist:**family:** Socket family.**address:** IPv4 address.**port:** IPv4 port.**path:** Unix-domain socket path.**Error(s):****argcheck.****ioerror.****neterror.****stackunderflow.****typecheck.****unregistered.****Description:** Get information about the peer end of *sock*.

Example(s):

```

onyx:0> $AF_INET $SOCK_STREAM socket
onyx:1> dup 'localhost' 7777 bindsocket
onyx:1> dup listen
onyx:1> dup accept
onyx:2> dup peername 1 sprint
<$family $AF_INET $address 2130706433 $port 33746>
onyx:2>

```

– pid *pid*:**Input(s):** None.**Output(s):****pid:** Process identifier.**Error(s):** None.**Description:** Get the process ID of the running process.**Example(s):**

```

onyx:0> pid 1 sprint
80624
onyx:0>

```

– pipe *rfile wfile*:**Input(s):** None.**Output(s):****rfile:** A readable file object. Data read from *rfile* were previously written to *wfile*.**wfile:** A writeable file object. Data written to *wfile* can subsequently be read from *rfile*.**Error(s):****ioerror.****unregistered.****Description:** Create a pipe.**Example(s):**

```

onyx:0> pipe
onyx:2> $wfile exch def
onyx:1> $rfile exch def
onyx:0> wfile 'foo\n' write
onyx:0> wfile flushfile
onyx:0> rfile readline pop 1 sprint
'foo'
onyx:0>

```

<file flags ...> timeout poll [file ...]:**Input(s):****<...>:** A dictionary of *file/flags* key/value pairs.**file:** A file object.**flags:** A dictionary that contains keys corresponding to file status attributes to poll.
The following keys are heeded:**\$POLLIN:** Normal or priority data are available for reading.**\$POLLRDNORM:** Normal data are available for reading.**\$POLLRDBAND:** Priority data are available for reading.

\$POLLPRI: High-priority data are available for reading.

\$POLLOUT: Normal data can be written.

\$POLLWRNORM: Normal data can be written.

\$POLLWRBAND: Priority data can be written.

The values associated with the keys are disregarded, but are set appropriately before **poll** returns (true/false).

timeout: Timeout, in milliseconds (maximum $2^{31} - 1$). -1 is treated specially to mean infinite timeout.

Output(s):

[...]: An array containing a reference to each *file* in $\langle \dots \rangle$ for which a non-zero number of status attributes is set to true. A zero-length array indicates that the poll timed out.

file: A reference to a file object passed in that has one or more attributes set to true.

Although $\langle \dots \rangle$ is not returned, its contents are modified.

flags: The dictionary passed in. For recognized key that is defined, the associated value is set to true or false, depending on the status of *file*. In addition, the following keys may be defined (if not already defined) with a value of true in the case of errors:

\$POLLERR: An error has occurred.

\$POLLHUP: Hangup has occurred.

\$POLLNVAL: *file* is not an open file.

Error(s):

stackunderflow.

rangecheck.

typecheck.

Description: Wait for any of the *flags* associated with a *file* in $\langle \dots \rangle$ to be true.

Example(s):

```
onyx:0> <stdout <$POLLOUT null> stderr <$POLLWRNORM null>> dup 0 poll
onyx:2> 2 sprint 2 sprint
[-file- -file-]
<-file- <$POLLWRNORM true> -file- <$POLLOUT true>>
onyx:0>
```

obj pop -:

Input(s):

obj: An object.

Output(s): None.

Error(s):

stackunderflow.

Description: Remove the top object from ostack and discard it.

Example(s):

```
onyx:0> 1 2
onyx:2> pstack
2
1
onyx:2> pop
onyx:1> pstack
1
onyx:1>
```

a b pow r:

Input(s):

a: An integer or real.

b: An integer or real.

Output(s):

r: *a* to the *b* power.

Error(s):

stackunderflow.

typecheck.

Description: Return *a* to the *b* power. If a negative exponent is specified, the result will always be a real, even if both arguments are integers.

Example(s):

```
onyx:0> 5 0 pow 1 sprint
1
onyx:0> 5 1 pow 1 sprint
5
onyx:0> 5 2 pow 1 sprint
25
onyx:0> -5 3 pow 1 sprint
-125
onyx:0> 5 -3 pow 1 sprint
8.000000e-03
onyx:0> 2.1 3.5 pow 1 sprint
1.342046e+01
onyx:0> 100 .01 pow 1 sprint
1.000000e+02
onyx:0>
```

– *ppid pid:*

Input(s): None.

Output(s):

pid: Process identifier.

Error(s): None.

Description: Get the process ID of the running process's parent.

Example(s):

```
onyx:0> ppid 1 sprint
352
onyx:0>
```

string print –:

Input(s):

string: A string object.

Output(s): None.

Error(s):

ioerror.

stackunderflow.

typecheck.

Description: Print *string* to stdout.

Example(s):

```
onyx:0> 'Hi\n' print flush
Hi
onyx:0>
```

- product *string*:**Input(s):** None.**Output(s):****string:** A string that contains the product name, normally 'Canonware Onyx'.**Error(s):** None.**Description:** Get the product string. The string returned is a reference to the original product string.**Example(s):**

```
onyx:0> product pstack
'Canonware Onyx'
onyx:1>
```

- pstack -:**Input(s):** None.**Output(s):** None.**Error(s):****ioerror.****Description:** Syntactically print the elements of ostack, one per line.**Example(s):**

```
onyx:0> 'a' 1 mark $foo [1 2 3] (4 5 6)
onyx:6> pstack
(4 5 6)
[1 2 3]
$foo
-mark-
1
'a'
onyx:6>
```

array index obj put -:***dict key value put -:******string index integer put -:*****Input(s):****array:** An array object.**dict:** A dict object.**string:** A string object.**index:** Offset in *array* or *string* to put *obj* or *integer*, respectively.**key:** An object to use as a key in *dict*.**obj:** An object to insert into *array* at offset *index*.**value:** An object to associate with *key* in *dict*.**integer:** The ascii value of a character to insert into *string* at offset *index*.**Output(s):** None.

Error(s):

rangecheck.
stackunderflow.
typecheck.

Description: Insert into *array*, *dict*, or *string*.

Example(s):

```
onyx:0> 3 array dup 1 'a' put 1 sprint  
[null 'a' null]  
onyx:0> dict dup $foo 'foo' put 1 sprint  
<$foo 'foo'>  
onyx:0> 3 string dup 1 97 put 1 sprint  
'\x00a\x00'  
onyx:0>
```

array index subarray putinterval -:

string index substring putinterval -:

Input(s):

array: An array object.
string: A string object.
index: Offset into *array* or *string* to put *subarray* or *substring*, respectively.
subarray: An array object to put into *array* at offset *index*. When inserted *subarray* must not extend past the end of *array*.
substring: A string object to put into *string* at offset *index*. When inserted *substring* must not extend past the end of *string*.

Output(s): None.

Error(s):

rangecheck.
stackunderflow.
typecheck.

Description: Replace a portion of *array* or *string*.

Example(s):

```
onyx:0> 4 array dup 1 ['a' 'b'] putinterval 1 sprint  
[null 'a' 'b' null]  
onyx:0> 4 string dup 1 'ab' putinterval 1 sprint  
'\x00ab\x00'  
onyx:0>
```

- pwd *path*:

Input(s): None.

Output(s):

path: A string that represents the present working directory.

Error(s):

invalidaccess.

Description: Push a string onto ostack that represents the present working directory.

Example(s):

```
onyx:0> pwd  
onyx:1> pstack  
'/usr/local/bin'  
onyx:1>
```

- quit -:**Input(s):** None.**Output(s):** None.**Error(s):** None.**Description:** Unwind the execution stack to the innermost **start** context. Under normal circumstances, there is always at least one such context.**Example(s):**

```

onyx:0> stdin cvx start
onyx:0> estack 1 sprint
(--start-- -file- --start-- -file- --estack--)
onyx:0> quit
onyx:0> estack 1 sprint
(--start-- -file- --estack--)
onyx:0>

```

- rand integer:**Input(s):** None.**Output(s):****integer:** A pseudo-random non-negative integer, with 63 bits of psuedo-randomness.**Error(s):** None.**Description:** Return a pseudo-random integer.**Example(s):**

```

onyx:0> 0 srand
onyx:0> rand 1 sprint
9018578418316157091
onyx:0> rand 1 sprint
8979240987855095636
onyx:0>

```

file read integer boolean:***file string read substring boolean:*****Input(s):****file:** A file object.**string:** A string object.**Output(s):****integer:** An integer that represents the ascii value of a character that was read from *file*.**substring:** A substring of *string* that contains data read from *file*.**boolean:** If true, end of file reached during read.**Error(s):****ioerror.****stackunderflow.****typecheck.****Description:** Read from *file*.**Example(s):**

```

onyx:0> '/tmp/foo' 'w+' open
onyx:1> dup 'Hello\n' write
onyx:1> dup flushfile

```

```
onyx:1> dup 0 seek
onyx:1> dup 10 string read
onyx:3> pop 1 sprint
'Hello\n'
```

file* readline *string* *boolean*:*Input(s):**

file: A file object.

Output(s):

string: A string that contains a line of text from *file*.

boolean: If true, end of file reached during read.

Error(s):

ioerror.

stackunderflow.

typecheck.

Description: Read a line of text from *file*. Lines are separated by “\n” or “\r\n”, which is removed. The last line in a file may not have a newline at the end.

Example(s):

```
onyx:0> '/tmp/foo' 'w+' open
onyx:1> dup 'Hello\n' write
onyx:1> dup 'Goodbye\n' write
onyx:1> dup 0 seek
onyx:1> dup readline 1 sprint 1 sprint
false
'Hello'
onyx:1> dup readline 1 sprint 1 sprint
false
'Goodbye'
onyx:1> dup readline 1 sprint 1 sprint
true
''
onyx:1>
```

linkname* readlink *string*:*Input(s):**

linkname: A string that represents the path of a symbolic link.

Output(s):

string: A string that represents the link data associated with *linkname*.

Error(s):

invalidaccess.

invalidfileaccess.

ioerror.

stackunderflow.

typecheck.

undefinedfilename.

unregistered.

Description: Get the data for the symbolic link at *linkname*.

Example(s):

```
onyx:0> 'bar' 'foo' symlink
onyx:0> 'foo' readlink 1 sprint
'bar'
onyx:0>
```

– realtime *nsecs*:

Input(s): None.

Output(s):

nsecs: Number of nanoseconds since the epoch (midnight on 1 January 1970).

Error(s): None.

Description: Get the number of nanoseconds since the epoch.

Example(s):

```
onyx:0> realtime 1 sprint
993539837806479000
onyx:0>
```

sock string flags recv substring:***sock string recv substring:*****Input(s):**

sock: A socket.

string: A string to use as a buffer for the message being received.

flags: An array of flag names. The following flags are supported:

\$MSG_OOB

\$MSG_PEEK

\$MSG_WAITALL

Output(s):

substring: A substring of *string* that contains message data.

Error(s):

argcheck.

neterror.

stackunderflow.

typecheck.

unregistered.

Description:**Example(s):**

```
onyx:0> $AF_INET $SOCK_DGRAM socket
onyx:1> dup 'localhost' 7777 bindsocket
onyx:1> dup true setnonblocking
onyx:1> dup 10 string recv
onyx:2> 1 sprint
'hello'
onyx:1>
```

string flags regex regex:***string regex regex:*****Input(s):**

string: A string that specifies a regular expression. See Section 2.9 for syntax.

flags: A dictionary of optional flags:

\$c: Continue where previous match ended. Don't update the offset to start the next match from unless this match is successful. Defaults to false.

\$g: Continue where previous match ended. If the match is unsuccessful, update the offset to start the next match from to the beginning of *input*. Defaults to false.

\$i: Case insensitive. Defaults to false.

\$m: Treat input as a multi-line string. Defaults to false.

\$s: Treat input as a single line, so that the dot metacharacter matches any character, including a newline. Defaults to false.

Output(s):

regex: A regex object.

Error(s):

regexerror.

stackunderflow.

typecheck.

Description: Create a regex object, according to *string* and *flags*.

Example(s):

```
onyx:0> 'pattern' regex 1 sprint
-regex-
onyx:0> 'pattern' <$g true> regex 1 sprint
-regex-
onyx:0>
```

pattern template flags regsub regsub:

pattern template regsub regsub:

Input(s):

pattern: A string that specifies a regular expression. See Section 2.9 for syntax.

template: A string that specifies a substitution template. See Section 2.9 for syntax.

flags: A dictionary of optional flags:

\$g: Substitute all matches, if true, rather than just the first match. Defaults to false.

\$i: Case insensitive. Defaults to false.

\$m: Treat input as a multi-line string. Defaults to false.

\$s: Treat input as a single line, so that the dot metacharacter matches any character, including a newline. Defaults to false.

Output(s):

regsub: A regsub object.

Error(s):

regexerror.

stackunderflow.

typecheck.

Description: Create a regsub object, according to *pattern*, *template*, and *flags*.

Example(s):

```
onyx:0> '([a-z]+)' '<\1>' <$g true> regsub
onyx:1> 1 sprint
-regsub-
onyx:0>
```

old new rename -:**Input(s):**

old: A string object that represents a file path.

new: A string object that represents a file path.

Output(s): None.

Error(s):

invalidfileaccess.

ioerror.

limitcheck.

stackunderflow.

typecheck.

undefinedfilename.

Description: Rename a file or directory from *old* to *new*.

Example(s):

```
onyx:0> '/tmp/tdir' 8@755 mkdir
onyx:0> '/tmp/tdir' '/tmp/ndir' rename
onyx:0> '/tmp/ndir' {1 sprint} dirforeach
' .'
'..'
onyx:0>
```

count proc repeat -:**Input(s):**

count: Number of times to evaluate *proc* (non-negative).

proc: An object to evaluate.

Output(s): None.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Evaluate *proc* *count* times. This operator supports the **continue** and **exit** operators.

Example(s):

```
onyx:0> 3 {'hi' 1 sprint} repeat
'hi'
'hi'
'hi'
onyx:0>
```

file require -:**Input(s):**

file: A string that represents a module filename.

Output(s): None.

Error(s):

invalidfileaccess.

stackunderflow.

typecheck.

undefined.

undefinedfilename.

Description: Search for and evaluate an Onyx source file. The file is searched for by concatenating a prefix, a “/”, and *file* to form a file path. Prefixes are tried in the following order:

1. The ordered elements of the `rpath_pre` array, which is defined in `onyxdict`.
2. If defined, the ordered elements of the `ONYX.RPATH` environment variable, which is a colon-separated list.
3. The ordered elements of the `rpath_post` array, which is defined in `onyxdict`.

Example(s):

```
onyx:0> 'modgtk/modgtk_defs.nx' require
onyx:0>
```

***path* rmdir -:**

Input(s):

path: A string object that represents a directory path.

Output(s): None.

Error(s):

invalidfileaccess.

ioerror.

stackunderflow.

typecheck.

unregistered.

Description: Remove an empty directory.

Example(s):

```
onyx:0> '/tmp/tdir' 8@755 mkdir
onyx:0> '/tmp/tdir' rmdir
onyx:0>
```

region count amount roll rolled:

Input(s):

region: 0 or more objects to be rolled.

count: Number of objects in *region*.

amount: Amount by which to roll. If positive, roll upward. If negative, roll downward.

Output(s):

rolled: Rolled version of *region*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Roll the top *count* objects on ostack (not counting *count* and *amount*) by *amount* positions. A positive *amount* indicates an upward roll, whereas a negative *amount* indicates a downward roll.

Example(s):

```
onyx:0> 3 2 1 0
onyx:4> pstack
0
1
```

```

2
3
onyx:4> 3 1 roll
onyx:4> pstack
1
2
0
3
onyx:4> 3 -2 roll
onyx:4> pstack
2
0
1
3
onyx:4> 4 0 roll
onyx:4> pstack
2
0
1
3
onyx:4>

```

a* round *r*:*Input(s):****a:** An integer or real.**Output(s):****r:** Integer round of *a*.**Error(s):****stackunderflow.****typecheck.****Description:** Round *a* to the nearest integer and return the result.**Example(s):**

```

onyx:0> -1.51 round 1 sprint
-2
onyx:0> -1.49 round 1 sprint
-1
onyx:0> 0 round 1 sprint
0
onyx:0> 1.49 round 1 sprint
1
onyx:0> 1.51 round 1 sprint
2
onyx:0>

```

...*amount* rot ...:**Input(s):****...:** One or more objects.**amount:** Number of positions to rotate the stack upward. A negative value causes downward rotation.**Output(s):**

...: One or more objects.

Error(s):

stackunderflow.

typecheck.

Description: Rotate the stack contents up *amount* positions.

Example(s):

```
onyx:0> 1 2 3 4 5 2 rot pstack clear
3
2
1
5
4
onyx:0> 1 2 3 4 5 -2 rot pstack clear
2
1
5
4
3
onyx:0>
```

stack sadn -:**Input(s):**

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Rotate the contents of *stack* down one position.

Example(s):

```
onyx:0> (1 2 3 4) dup sadn 1 sprint
(2 3 4 1)
onyx:0>
```

stack saup -:**Input(s):**

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Rotate the contents of *stack* up one position.

Example(s):

```
onyx:0> (1 2 3 4) dup saup 1 sprint
(4 1 2 3)
onyx:0>
```

stack sbdup -:**Input(s):**

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Duplicate the bottom object on *stack* and push it onto *stack*.

Example(s):

```
onyx:0> (2 1 0) dup sbdup pstack
(2 1 0 2)
onyx:1>
```

stack sbpop obj:

Input(s):

stack: A stack object.

Output(s):

obj: An object.

Error(s):

stackunderflow.

typecheck.

Description: Pop *obj* off the bottom of *stack*.

Example(s):

```
onyx:0> (1 2 3) dup sbpop pstack
1
(2 3)
onyx:2>
```

stack obj sbpush -:

Input(s):

stack: A stack object.

obj: An object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Push *obj* onto the bottom of *stack*.

Example(s):

```
onyx:0> (0) dup 1 sbpush
onyx:1> pstack
(1 0)
onyx:1>
```

stack sclear -:

Input(s):

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Remove all objects on *stack*.

Example(s):

```
onyx:0> (1 2 3 4) dup sclear pstack
()
onyx:1>
```

***stack* scleartomark -:**

Input(s):

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

unmatchedmark.

Description: Remove objects from *stack* down to and including the topmost mark.

Example(s):

```
onyx:0> (3 mark 1 0) dup scleartomark pstack
(3)
onyx:1>
```

***stack* scout count:**

Input(s):

stack: A stack object.

Output(s):

count: The number of objects on *stack*.

Error(s):

stackunderflow.

typecheck.

Description: Get the number of objects on *stack*.

Example(s):

```
onyx:0> (1 2) scout 1 sprint
2
onyx:0>
```

***stack* scouttomark count:**

Input(s):

stack: A stack object.

Output(s):

count: The depth of the topmost mark on *stack*.

Error(s):

stackunderflow.

typecheck.

unmatchedmark.

Description: Get the depth of the topmost mark on *stack*.

Example(s):

```
onyx:0> (3 mark 1 0) scouttomark 1 sprint
2
onyx:0>
```

stack sdn -:**Input(s):**

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Rotate the top three objects on *stack* down one position.

Example(s):

```
onyx:0> (3 2 1 0) dup sdn pstack
(3 1 0 2)
onyx:1>
```

stack sdup -:**Input(s):**

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Duplicate the top object on *stack* and push it onto *stack*.

Example(s):

```
onyx:0> (1) dup sdup 1 sprint
(1 1)
onyx:0>
```

file offset seek -:**Input(s):**

file: A file object.

offset: Offset in bytes from the beginning of *file* to move the file position pointer to.

Output(s): None.

Error(s):

ioerror.

stackunderflow.

typecheck.

Description: Move the file position pointer for *file* to *offset*.

Example(s):

```
onyx:0> '/tmp/foo' 'w+' open
onyx:1> dup 'Hello\n' write
onyx:1> dup 0 seek
onyx:1> readline pstack
false
'Hello'
onyx:2>
```

– self *thread*:

Input(s): None.

Output(s):

thread: A thread object that corresponds to the running thread.

Error(s): None.

Description: Get a thread object for the running thread.

Example(s):

```
onyx:0> self 1 sprint
-thread-
onyx:0>
```

sock mesg flags send nsend*:**sock mesg send nsend*:**

Input(s):

sock: A socket.

mesg: A message string.

flags: An array of flag names. The following flags are supported:

\$MSG_OOB

\$MSG_PEEK

\$MSG_WAITALL

Output(s):

nsend: Number of bytes of *mesg* actually sent.

Error(s):

argcheck.

neterror.

stackunderflow.

typecheck.

unregistered.

Description: Send a message.

Example(s):

```
onyx:0> $AF_INET $SOCK_DGRAM socket
onyx:1> dup 'localhost' 7777 connect
onyx:1> dup 'hello' send
onyx:2> 1 sprint
5
onyx:1>
```

***service serviceport port*:**

Input(s):

service: A string that represents a network service name.

Output(s):

port: The port number corresponding to *service*, or 0 if the service is unknown.

Error(s):

stackunderflow.

typecheck.

Description:

Example(s):

```
onyx:0> 'ftp' serviceport 1 sprint
21
onyx:0>
```

class name/null setclassname -:**Input(s):**

class: A class object.

name/null: A name or null object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set *class*'s name.

Example(s):

```
onyx:0> class dup $foo setclassname
onyx:1> classname 1 sprint
$foo
onyx:0>
```

class/instance dict/null setdata -:**Input(s):**

class/instance: A class or instance object.

dict/null: A dict or null object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set the data associated with *class* or *instance*.

Example(s):

```
onyx:0> class dup <$foo 'foo'> setdata
onyx:1> data 1 sprint
<$foo 'foo'>
onyx:0>
```

gid setegid boolean:**Input(s):**

gid: A group ID.

Output(s):

boolean: If false, success, otherwise failure.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Set the process's effective group ID to *gid*.

Example(s):

```
onyx:0> 1001 setegid 1 sprint
false
onyx:0> 0 setegid 1 sprint
true
onyx:0>
```

key val setenv -:**Input(s):**

key: A name object.

val: A value to associate with *key*.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set an environment variable named *key* and associate *val* with it. If *val* is not a string, it is converted to a string using the **cvs** operator before the environment variable is set. A corresponding entry is also created in the envdict dictionary.

Example(s):

```
onyx:0> $foo 'foo' setenv
onyx:0> envdict $foo known 1 sprint
true
onyx:0> envdict $foo get 1 sprint
'foo'
onyx:0> $foo unsetenv
onyx:0> envdict $foo known 1 sprint
false
onyx:0>
```

uid seteuid boolean:**Input(s):**

uid: A user ID.

Output(s):

boolean: If false, success, otherwise failure.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Set the process's effective user ID to *uid*.

Example(s):

```
onyx:0> 1001 seteuid 1 sprint
false
onyx:0> 0 seteuid 1 sprint
true
onyx:0>
```

gid setgid boolean:**Input(s):**

gid: A group ID.

Output(s):

boolean: If false, success, otherwise failure.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Set the process's group ID to *gid*.

Example(s):

```
onyx:0> 1001 setgid 1 sprint
false
onyx:0> 0 setgid 1 sprint
true
onyx:0>
```

count* setgmaxestack -:*Input(s):**

count: Default maximum allowable estack depth.

Output(s): None.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Set the default maximum allowable estack depth to *count*. This value is used when creating new threads.

Example(s):

```
onyx:0> 128 setgmaxestack
onyx:0>
```

file* setgstderr -:*Input(s):**

file: A file to set the global stderr to.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set the global stderr to *file*. See Section 2.4 for standard I/O details.

Example(s):

```
onyx:0> '/tmp/stderr' 'w' open dup 0 setiobuf setgstderr
onyx:0> () {stderr 'Some text\n' write} thread join
onyx:0> '/tmp/stderr' 'r' open readline pop 1 sprint
'Some text'
onyx:0>
```

file* setgstdin -:*Input(s):**

file: A file to set the global stdin to.

Output(s): None.

Error(s):**stackunderflow.****typecheck.****Description:** Set the global stdin to *file*. See Section 2.4 for standard I/O details.**Example(s):** Under normal interactive operation, stdin is pushed onto estack during interpreter initialization and evaluated until EOF is reached. Therefore, changing stdin has no effect on the file descriptor already on estack. The following example recursively evaluates stdin after redefining it.

```
lawine:~> cat /tmp/stdin
1 2 3 pstack
lawine:~> onyx
onyx:0> `/tmp/stdin' `r' open cvx setgstdin
onyx:0> () {stdin eval} thread join
3
2
1
onyx:0>
```

file* setgstdout -:*Input(s):****file:** A file to set the global stdout to.**Output(s):** None.**Error(s):****stackunderflow.****typecheck.****Description:** Set the global stdout to *file*. See Section 2.4 for standard I/O details.**Example(s):** In the following example, the prompt continues to be printed, even though stdout has been redefined, because the prompt module was initialized to print to file descriptor 1. This demonstrates the only known exception in the stock Onyx interpreter where redefining stdout will not redirect output.

```
onyx:0> `/tmp/stdout' `w' open dup 0 setiobuf setgstdout
onyx:0> () {'Some text\n' print} thread join
onyx:0> `/tmp/stdout' `r' open readline pop 1 sprint
'Some text'
onyx:0>
```

boolean* setgtailopt -:*Input(s):****boolean:** If true, enable tail call optimization by default for new threads. Otherwise, do not enable tail call optimization by default for new threads.**Output(s):** None.**Error(s):****stackunderflow.****typecheck.****Description:** Set whether to enable tail call optimization for new threads.

Example(s):

```
onyx:0> false setgtailopt
onyx:0>
```

file count setiobuf -:**Input(s):**

file: A file object.

count: The size in bytes to set the I/O buffer associated with *file* to.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set the size of the I/O buffer associated with *file*.

Example(s):

```
onyx:0> stdout iobuf 1 sprint
512
onyx:0> stdout 0 setiobuf
onyx:0> stdout iobuf 1 sprint
0
onyx:0>
```

instance class/null setisa -:**Input(s):**

instance: An instance object.

class/null: A class or null object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set the class associated with *instance*.

Example(s):

```
onyx:0> instance dup vclass setisa
onyx:1> isa classname 1 sprint
$vclass
onyx:0>
```

boolean setlocking -:**Input(s):**

boolean: A boolean to set the implicit locking mode to.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set the current implicit locking mode. See Section 2.7.1 for implicit synchronization details.

Example(s):

```
onyx:0> currentlocking 1 sprint
false
onyx:0> true setlocking
onyx:0> currentlocking 1 sprint
true
onyx:0>
```

count* setmaxestack -:*Input(s):**

count: Maximum allowable estack depth.

Output(s): None.

Error(s):

rangecheck.
stackunderflow.
typecheck.

Description: Set the maximum allowable estack depth to *count*.

Example(s):

```
onyx:0> 128 setmaxestack
onyx:0>
```

class dict/null* setmethods -:*Input(s):**

class: A class object.
dict/null: A dict or null object.

Output(s): None.

Error(s):

stackunderflow.
typecheck.

Description: Set the methods associated with *class*.

Example(s):

```
onyx:0> class dup <$foo 'foo'> setmethods
onyx:1> methods 1 sprint
<$foo 'foo'>
onyx:0>
```

file boolean* setnonblocking -:*Input(s):**

file: A file object.
boolean: Non-blocking mode to set *file* to.

Output(s): None.

Error(s):

ioerror.
stackunderflow.
typecheck.

Description: Set non-blocking mode for *file* to *boolean*.

Example(s):

```

onyx:0> `/tmp/foo' `w' open
onyx:1> dup nonblocking 1 sprint
false
onyx:1> dup true setnonblocking
onyx:1> dup nonblocking 1 sprint
true
onyx:1>

```

pid pgid setpgid -:**Input(s):**

pid: Process ID, or 0 (same as specifying the calling process's ID).

pgid: Process group ID.

Output(s): None.

Error(s):

invalidaccess.

limitcheck.

rangecheck.

stackunderflow.

typecheck.

Description:**Example(s):**

```

onyx:0> pid pid setpgid
onyx:0>

```

- setsid sid:

Input(s): None.

Output(s):

sid: Session ID.

Error(s):

invalidaccess.

stackunderflow.

typecheck.

Description: Create a new session.

Example(s):

```

onyx:0> setsid
Error $invalidaccess
ostack: ()
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..2):
0:      --setsid--
1:      -file-
2:      --start--
onyx:1>

```

sock level optname optval setsockopt -:***sock optname optval setsockopt -:***

Input(s):**sock:** A socket.**level:** Level at which to set the socket option. If not specified, `$SOL_SOCKET` is used.**optname:** Name of option to set the value of. The following option names are supported:`$SO_DEBUG``$SO_REUSEADDR``$SO_REUSEPORT``$SO_KEEPAIVE``$SO_DONTROUTE``$SO_BROADCAST``$SO_OOBINLINE``$SO_SNDBUF``$SO_RCVBUF``$SO_SNDLOWAT``$SO_RCVLOWAT``$SO_TYPE`**\$SO_ERROR:** *optval* is an integer.**\$SO_LINGER:** *optval* is a dictionary, and the following entries are defined:**\$on:** Boolean.**\$time:** Linger time in seconds.`$SO_SNDTIMEO`**\$SO_RCVTIMEO:** *optval* is an integer, in nanoseconds.**optval:** Value to associate with *optname*.**Output(s):** None.**Error(s):****argcheck.****stackunderflow.****typecheck.****unregistered.****Description:** Set a socket option.**Example(s):**

```

onyx:0> $AF_INET $SOCK_STREAM socket
onyx:1> dup $SO_OOBINLINE sockopt 1 sprint
0
onyx:1> dup $SO_OOBINLINE 1 setsockopt
onyx:1> dup $SO_OOBINLINE sockopt 1 sprint
1
onyx:1>

```

file* setstderr -:*Input(s):****file:** A file to set the calling thread's stderr to.**Output(s):** None.**Error(s):****stackunderflow.****typecheck.**

Description: Set the thread's stderr to *file*. See Section 2.4 for standard I/O details.

Example(s):

```
onyx:0> `/tmp/stderr' `w' open dup 0 setiobuf setstderr
onyx:0> stderr 'Some text\n' write
onyx:0> `/tmp/stderr' `r' open readline pop 1 sprint
'Some text'
onyx:0>
```

file setstdin -:

Input(s):

file: A file to set the calling thread's stdin to.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set the thread's stdin to *file*. See Section 2.4 for standard I/O details.

Example(s): Under normal interactive operation, stdin is pushed onto estack during interpreter initialization and evaluated until EOF is reached. Therefore, changing stdin has no effect on the file descriptor already on estack. The following example recursively evaluates stdin after redefining it.

```
lawine:~> cat /tmp/stdin
1 2 3 pstack
lawine:~> onyx
onyx:0> `/tmp/stdin' `r' open cvx setstdin
onyx:0> stdin eval
3
2
1
onyx:3>
```

file setstdout -:

Input(s):

file: A file to set the calling thread's stdout to.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set the thread's stdout to *file*. See Section 2.4 for standard I/O details.

Example(s): In the following example, the prompt continues to be printed, even though stdout has been redefined, because the prompt module was initialized to print to file descriptor 1. This demonstrates the only known exception in the stock Onyx interpreter where redefining stdout will not redirect output.

```
onyx:0> `/tmp/stdout' `w' open dup 0 setiobuf setstdout
onyx:0> 'Some text\n' print
onyx:0> gstdout setstdout
onyx:0> `/tmp/stdout' `r' open readline pop 1 sprint
'Some text'
onyx:0>
```

class super/null* setsuper -:*Input(s):**

class: A class object.

super/null: A class or null object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Set *class*'s superclass.

Example(s):

```
onyx:0> class dup vclass setsuper
onyx:1> super classname 1 sprint
$vc
onyx:0>
```

boolean* settailopt -:*Input(s):**

boolean: If true, enable tail call optimization for this thread. Otherwise, disable tail call optimization for this thread.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description:

Example(s):

```
onyx:0> $bar {estack 2 sprint} def
onyx:0> $foo {bar} def
onyx:0> foo
(--start-- -file- {estack 2 sprint} --estack--)
onyx:0> false settailopt
onyx:0> foo
(--start-- -file- {bar} {estack 2 sprint} --estack--)
onyx:0>
```

uid* setuid *boolean*:*Input(s):**

uid: A user ID.

Output(s):

boolean: If false, success, otherwise failure.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Set the process's user ID to *uid*.

Example(s):

```
onyx:0> 1001 setuid 1 sprint
false
onyx:0> 0 setuid 1 sprint
true
onyx:0>
```

stack sexch -:**Input(s):**

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Exchange the top two objects on *stack*.

Example(s):

```
onyx:0> (1 2 3) dup sexch pstack
(1 3 2)
onyx:1>
```

- shift -:**Input(s):**

a: An integer.

shift: An integer that represents a bitwise shift amount. Negative means right shift, and positive means left shift.

Output(s):

r: *a* shifted by *shift* bits.

Error(s):

stackunderflow.

typecheck.

Description: Shift an integer bitwise.

Example(s):

```
onyx:0> 4 1 shift 1 sprint
8
onyx:0> 4 -1 shift 1 sprint
2
onyx:0>
```

stack index sibdup -:**Input(s):**

stack: A stack object.

index: Offset from bottom of *stack*, counting from 0, of the object to duplicate.

Output(s): None.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Create a duplicate of the object on *stack* that is at offset *index* from the bottom of *stack* and push it onto *stack*.

Example(s):

```
onyx:0> (3 2 1 0) dup 2 sibdup pstack
(3 2 1 0 1)
onyx:1>
```

stack index sibpop obj:

Input(s):

stack: A stack object.

index: Offset from bottom of *stack*, counting from 0, of the object to remove from *stack*.

Output(s):

obj: An object removed from *stack*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Remove the *obj* from *stack* that is at offset *index* from the bottom of *stack*.

Example(s):

```
onyx:0> (0 1 2 3) dup 2 sibpop pstack
2
(0 1 3)
onyx:2>
```

stack index sidup -:

Input(s):

stack: A stack object.

index: Depth (count starts at 0) of the object to duplicate in *stack*.

Output(s): None.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Create a duplicate of the object on *stack* at depth *index* and push it onto *stack*.

Example(s):

```
onyx:0> (3 2 1 0) dup 2 sidup
onyx:1> 1 sprint
(3 2 1 0 2)
onyx:0>
```

\$SIG_GETMASK oset sigmask oset:

how set sigmask -:

how set oset sigmask oset:

Input(s):

how: A name object:

\$SIG_BLOCK: Mask the union of the old mask set and the signals in *set* whose values are set to true.

\$SIG_UNBLOCK: Unmask the signals in *set* whose values are set to true.

\$SIG_GETMASK: Get the current signal mask.

\$SIG_SETMASK: Set the signal mask to the signals in *set* whose values are set to true.

set: A dictionary of signal name and/or integers keys, with associated true/false values. A value of true indicates set membership. The recognized names are:

- \$SIGABRT
- \$SIGALRM
- \$SIGBUS
- \$SIGCHLD
- \$SIGCONT
- \$SIGFPE
- \$SIGHUP
- \$SIGILL
- \$SIGINT
- \$SIGKILL
- \$SIGPIPE
- \$SIGQUIT
- \$SIGSEGV
- \$SIGSTOP
- \$SIGTERM
- \$SIGTSTP
- \$SIGTTIN
- \$SIGTTOU
- \$SIGUSR1
- \$SIGUSR2
- \$SIGPOLL (may not be present)
- \$SIGPROF
- \$SIGSYS
- \$SIGTRAP
- \$SIGURG
- \$SIGVTALRM (may not be present)
- \$SIGXCPU
- \$SIGXFSZ

oset: A dictionary of signal name keys, with associated true/false values. This dictionary contains the signal mask as it was prior to execution of this operator.

Output(s):

oset: The same dictionary as was passed in as *oset*.

Error(s):

argcheck.

stackunderflow.

typecheck.

Description: Get or set the calling thread's current signal mask.

Example(s):

```

onyx:0> $SIG_GETMASK <> sigmask 1 sprint
<$SIGHUP true $SIGINT true $SIGQUIT true $SIGTERM true>
onyx:0> $SIG_BLOCK <$SIGPIPE true> <> sigmask 1 sprint
<$SIGHUP true $SIGINT true $SIGQUIT true $SIGTERM true>
onyx:0> $SIG_GETMASK <> sigmask 1 sprint
<$SIGHUP true $SIGINT true $SIGPIPE true $SIGQUIT true $SIGTERM true>
onyx:0> $SIG_UNBLOCK <$SIGPIPE true> <> sigmask 1 sprint
<$SIGHUP true $SIGINT true $SIGPIPE true $SIGQUIT true $SIGTERM true>
onyx:0> $SIG_GETMASK <> sigmask 1 sprint
<$SIGHUP true $SIGINT true $SIGQUIT true $SIGTERM true>
onyx:0>

```

condition* signal -:*Input(s):**

condition: A condition object.

Output(s): None.**Error(s):**

stackunderflow.

typecheck.

Description: Signal a thread that is waiting on *condition*. If there are no waiters, this operator has no effect.

Example(s):

```

onyx:0> condition mutex dup lock ostack
onyx:3> {dup lock exch signal unlock}
onyx:4> thread 3 1 roll
onyx:3> dup 3 1 roll
onyx:4> wait unlock join
onyx:0>

```

set* sigpending *set*:*Input(s):**

set: A dictionary.

Output(s):

set: The same dictionary as the input *set*. A dictionary of signal name keys, with associated true values. A value of true indicates set membership. The supported names are:

- \$SIGABRT
- \$SIGALRM
- \$SIGBUS
- \$SIGCHLD
- \$SIGCONT
- \$SIGFPE
- \$SIGHUP
- \$SIGILL
- \$SIGINT
- \$SIGKILL
- \$SIGPIPE
- \$SIGQUIT
- \$SIGSEGV

- \$SIGSTOP
- \$SIGTERM
- \$SIGTSTP
- \$SIGTTIN
- \$SIGTTOU
- \$SIGUSR1
- \$SIGUSR2
- \$SIGPOLL (may not be present)
- \$SIGPROF
- \$SIGSYS
- \$SIGTRAP
- \$SIGURG
- \$SIGVTALRM (may not be present)
- \$SIGXCPU
- \$SIGXFSZ

Error(s):

stackunderflow.

typecheck.

Description: Get pending signals.

Example(s):

```
onyx:0> <> sigpending 1 sprint
<>
onyx:0>
```

set sigsuspend -:**Input(s):**

set: A dictionary of signal name and/or integers keys, with associated true/false values. A value of true indicates set membership. The recognized names are:

- \$SIGABRT
- \$SIGALRM
- \$SIGBUS
- \$SIGCHLD
- \$SIGCONT
- \$SIGFPE
- \$SIGHUP
- \$SIGILL
- \$SIGINT
- \$SIGKILL
- \$SIGPIPE
- \$SIGQUIT
- \$SIGSEGV
- \$SIGSTOP
- \$SIGTERM
- \$SIGTSTP
- \$SIGTTIN
- \$SIGTTOU

- \$SIGUSR1
- \$SIGUSR2
- \$SIGPOLL (may not be present)
- \$SIGPROF
- \$SIGSYS
- \$SIGTRAP
- \$SIGURG
- \$SIGVTALRM (may not be present)
- \$SIGXCPU
- \$SIGXFSZ

Output(s): None.

Error(s):

argcheck.

stackunderflow.

typecheck.

Description: Suspend the calling thread until one of the signals in *set* is caught.

Example(s):

```
onyx:0> <> sigsuspend
onyx:0>
```

set sigwait sig:

Input(s):

set: A dictionary of signal name and/or integers keys, with associated true/false values. A value of true indicates set membership. The recognized names are:

- \$SIGABRT
- \$SIGALRM
- \$SIGBUS
- \$SIGCHLD
- \$SIGCONT
- \$SIGFPE
- \$SIGHUP
- \$SIGILL
- \$SIGINT
- \$SIGKILL
- \$SIGPIPE
- \$SIGQUIT
- \$SIGSEGV
- \$SIGSTOP
- \$SIGTERM
- \$SIGTSTP
- \$SIGTTIN
- \$SIGTTOU
- \$SIGUSR1
- \$SIGUSR2
- \$SIGPOLL (may not be present)
- \$SIGPROF

- \$SIGSYS
- \$SIGTRAP
- \$SIGURG
- \$SIGVTALRM (may not be present)
- \$SIGXCPU
- \$SIGXFSZ

Output(s):

sig: One of the signal names that was specified in *set*.

Error(s):

argcheck.

stackunderflow.

typecheck.

Description: Wait for one of the signals in *set*, and return the name of the signal that was caught.

Example(s):

```
onyx:0> $SIG_BLOCK <$SIGXCPU true> sigmask
onyx:0> <$SIGXCPU true> sigwait
onyx:1> 1 sprint
$SIGXCPU
onyx:0>
```

 $a \sin r$:**Input(s):**

a: An integer or real.

Output(s):

r: Sine of a in radians.

Error(s):

stackunderflow.

typecheck.

Description: Return the sine of a in radians.

Example(s):

```
onyx:0> 0 sin 1 sprint
0.000000e+00
onyx:0> 1.570796 sin 1 sprint
1.000000e+00
onyx:0> 0.7853982 sin 1 sprint
7.071068e-01
onyx:0>
```

 $a \sinh r$:**Input(s):**

a: An integer or real.

Output(s):

r: Hyperbolic sine of a .

Error(s):

stackunderflow.

typecheck.

Description: Return the hyperbolic sine of a .

Example(s):

```
onyx:0> 3 sinh 1 sprint
1.001787e+01
onyx:0>
```

stack index sipop obj:

Input(s):

stack: A stack object.

index: Offset from top of *stack*, counting from 0, of the object to remove from *stack*.

Output(s):

obj: An object removed from *stack*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Remove the *obj* at *index* from *stack*.

Example(s):

```
onyx:0> (3 2 1 0) dup 2 sipop pstack
2
(3 1 0)
onyx:2>
```

stack count snbpop array:

Input(s):

stack: A stack object.

count: Number of objects to pop off the bottom of *stack*.

Output(s):

array: An array of objects popped off the bottom of *stack*, with the same object ordering as when on *stack*.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Pop *count* objects off the bottom of *stack* and put them into an array.

Example(s):

```
onyx:0> (1 2 3 4) dup 2 snbpop pstack
[1 2]
(3 4)
onyx:2>
```

stack count sndn -:

Input(s):

stack: A stack object.

count: Number of objects on *stack* to rotate down one position.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Rotate *count* objects on *stack* down one position.

Example(s):

```
onyx:0> (5 4 3 2 1 0) dup 4 sdn pstack
(5 4 2 1 0 3)
onyx:1>
```

stack count sndup -:

Input(s):

stack: A stack object.

count: Number of objects on *stack* to duplicate.

Output(s): None.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Create duplicates of the top *count* objects on *stack*.

Example(s):

```
onyx:0> (3 2 1 0) dup 2 sndup pstack
(3 2 1 0 1 0)
onyx:1>
```

stack snip obj:

Input(s):

stack: A stack object.

Output(s):

obj: The object that was the second to top object on *stack*.

Error(s):

stackunderflow.

typecheck.

Description: Remove the second to top object from *stack*.

Example(s):

```
onyx:0> (2 1 0) dup snip pstack
1
(2 0)
onyx:2>
```

stack count snpop array:

Input(s):

stack: A stack object.

count: Number of objects to pop off of *stack*.

Output(s):

array: An array of objects popped off of *stack*, with the same object ordering as when on *stack*.

Error(s):

rangecheck.

stackunderflow.**typecheck.****Description:** Pop *count* objects off of *stack* and put them into an array.**Example(s):**

```

onyx:0> (1 2 3 4) dup 2 snpop pstack
[3 4]
(1 2)
onyx:2>

```

stack count snup -:**Input(s):****stack:** A stack object.**count:** Number of objects on *stack* to rotate up one position.**Output(s):** None.**Error(s):****rangecheck.****stackunderflow.****typecheck.****Description:** Rotate *count* objects on *stack* up one position.**Example(s):**

```

onyx:0> (5 4 3 2 1 0) dup 4 snup pstack
(5 4 0 3 2 1)
onyx:1>

```

family type proto socket sock:***family type socket sock:*****Input(s):****family:** The name of a socket address family, either `$AF_INET` or `$AF_LOCAL`.**type:** The name of a socket type, either `$SOCK_STREAM` or `$SOCK_DGRAM`.**proto:** The name of a socket protocol. This argument is not useful, given the current limited choice of address families.**Output(s):****sock:** A socket.**Error(s):****argcheck.****invalidaccess.****stackunderflow.****typecheck.****unregistered.****Description:** Create a socket.**Example(s):**

```

onyx:0> $AF_INET $SOCK_STREAM socket
onyx:1> $AF_LOCAL $SOCK_DGRAM socket
onyx:2>

```

family type proto socketpair sock sock:***family type socketpair sock sock:***

Input(s):

family: The name of a socket address family, either `$AF_INET` or `$AF_LOCAL`.

type: The name of a socket type, either `$SOCK_STREAM` or `$SOCK_DGRAM`.

proto: The name of a socket protocol. This argument is not useful, given the current limited choice of address families.

Output(s):

sock: A connected socket. There are no functional differences between the two sockets that are returned.

Error(s):

argcheck.

invalidaccess.

stackunderflow.

typecheck.

unregistered.

Description: Create a pair of sockets that are connected to each other.

Example(s):

```
onyx:0> $AF_LOCAL $SOCK_STREAM socketpair
onyx:2> pstack
-file-
-file-
onyx:2>
```

sock* sockname dict:*Input(s):**

sock: A socket.

Output(s):

dict: A dictionary of information about *sock*. Depending on the socket family, the following entries may exist:

family: Socket family.

address: IPv4 address.

port: IPv4 port.

path: Unix-domain socket path.

Error(s):

argcheck.

ioerror.

neterror.

stackunderflow.

typecheck.

unregistered.

Description: Get information about *sock*.

Example(s):

```
onyx:0> $AF_INET $SOCK_STREAM socket
onyx:1> dup 'localhost' bindsocket
onyx:1> dup sockname 1 sprint
<$family $AF_INET $address 2130706433 $port 33745>
onyx:1> close
onyx:0> $AF_LOCAL $SOCK_STREAM socket
```

```

onyx:1> dup '/tmp/socket' bindsocket
onyx:1> dup sockname 1 sprint
<$family $AF_LOCAL $path '/tmp/socket'>
onyx:1>

```

sock level optname sockopt optval:

sock optname sockopt optval:

Input(s):

sock: A socket.

level: Level at which to get the socket option. If not specified, \$SOL_SOCKET is used.

optname: Name of option to get the value of. The following option names are supported:

\$SO_DEBUG

\$SO_REUSEADDR

\$SO_REUSEPORT

\$SO_KEEPAIVE

\$SO_DONTROUTE

\$SO_BROADCAST

\$SO_OOBINLINE

\$SO_SNDBUF

\$SO_RCVBUF

\$SO_SNDLOWAT

\$SO_RCVLOWAT

\$SO_TYPE

\$SO_ERROR: *optval* is an integer.

\$SO_LINGER: *optval* is a dictionary, and the following entries are defined:

\$on: Boolean.

\$time: Linger time in seconds.

\$SO_SNDTIMEO

\$SO_RCVTIMEO: *optval* is an integer, in nanoseconds.

Output(s):

optval: Value associated with *optname*.

Error(s):

argcheck.

stackunderflow.

typecheck.

unregistered.

Description: Get a socket option.

Example(s):

```

onyx:0> $AF_INET $SOCK_STREAM socket
onyx:1> dup $SO_SNDBUF sockopt 1 sprint
16384
onyx:1>

```

stack sover --:

Input(s):

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Create a duplicate of the second object on *stack* and push it onto *stack*.

Example(s):

```
onyx:0> (2 1 0) dup sover pstack
(2 1 0 1)
onyx:1>
```

input pattern flags limit split array:

input pattern flags split array:

input pattern limit split array:

input pattern split array:

input regex limit split array:

input regex split array:

Input(s):

input: An input string to find matches in.

pattern: A string that specifies a regular expression. See Section 2.9 for syntax.

flags: A dictionary of optional flags:

\$i: Case insensitive. Defaults to false.

\$m: Treat input as a multi-line string. Defaults to false.

\$s: Treat input as a single line, so that the dot metacharacter matches any character, including a newline. Defaults to false.

regex: A regex object.

limit: Split *input* into no more than *limit* substrings. 0 is treated as infinity. Defaults to 0.

Output(s):

array: An array of substrings containing the text between pattern matches.

Error(s):

rangecheck.

regexerror.

stackunderflow.

typecheck.

Description: Create an array of substrings from *input* that are separated by portions of *input* that match a regular expression.

If there are capturing subpatterns in the regular expression, also create substrings for those capturing subpatterns and insert them into the substring array.

As a special case, if the regular expression matches the empty string, split a single character. This avoids an infinite loop.

Example(s):

```
onyx:0> 'a:b:c' ':' split 1 sprint
['a' 'b' 'c']
onyx:0> 'a:b:c' ':' 2 split 1 sprint
['a' 'b:c']
onyx:0> 'a:b:c' '(:)' split 1 sprint
```

```
['a' ':' 'b' ':' 'c']
onyx:0> 'a:b:c' ':' split 1 sprint
['a' ':' 'b' ':' 'c']
onyx:0>
```

stack spop obj:**Input(s):**

stack: A stack object.

Output(s):

obj: The object that was popped off of *stack*.

Error(s):

stackunderflow.

typecheck.

Description: Pop an object off of *stack* and push it onto *ostack*.

Example(s):

```
onyx:0> (1 2) dup spop
onyx:2> pstack
2
(1)
onyx:2>
```

obj depth sprint -:**Input(s):**

obj: An object to print syntactically.

depth: Maximum recursion depth.

Output(s): None.

Error(s):

ioerror.

stackunderflow.

typecheck.

Description: Syntactically print *obj*. See Section 2.11.8 for printing details.

Example(s):

```
onyx:0> [1 [2 3] 4]
onyx:1> dup 0 sprint
-array-
onyx:1> dup 1 sprint
[1 -array- 4]
onyx:1> dup 2 sprint
[1 [2 3] 4]
onyx:1>
```

obj depth sprints string:**Input(s):**

obj: An object to print syntactically.

depth: Maximum recursion depth.

Output(s):

string: A syntactical string representation of *obj*. See Section 2.11.8 for printing details.

Error(s):

stackunderflow.
typecheck.

Description: Create a syntactical string representation of *obj*.

Example(s):

```
onyx:0> [1 [2 3] 4]
onyx:1> dup 0 sprints print '\n' print flush
-array-
onyx:1> dup 1 sprints print '\n' print flush
[1 -array- 4]
onyx:1> dup 2 sprints print '\n' print flush
[1 [2 3] 4]
onyx:1>
```

– **sprintsdict *dict*:**

Input(s): None.

Output(s):

dict: A dictionary.

Error(s): None.

Description: Get sprintsdict. See Section 2.11.8 for details on sprintsdict.

Example(s):

```
onyx:0> sprintsdict 0 sprint
-dict-
onyx:0>
```

stack obj spush –:

Input(s):

stack: A stack object.

obj: An object.

Output(s): None.

Error(s):

stackunderflow.
typecheck.

Description: Push *obj* onto *stack*.

Example(s):

```
onyx:0> (0) dup 1 spush
onyx:1> pstack
(0 1)
onyx:1>
```

a sqrt r:

Input(s):

a: A non-negative integer or real.

Output(s):

r: Square root of *a*.

Error(s):

rangecheck.
stackunderflow.

typecheck.

Description: Return the square root of a .

Example(s):

```
onyx:0> 4 sqrt 1 sprint
2.000000e+00
onyx:0> 2.0 sqrt 1 sprint
1.414214e+00
onyx:0>
```

seed srand -:

Input(s):

seed: A non-negative integer.

Output(s): None.

Error(s):

rangecheck.
stackunderflow.
typecheck.

Description: Seed the pseudo-random number generator with *seed*.

Example(s):

```
onyx:0> 5 srand
onyx:0>
```

stack count amount sroll -:

Input(s):

stack: A stack object.

count: Number of objects to roll in *stack*.

amount: Amount by which to roll. If positive, roll upward. If negative, roll downward.

Output(s): None.

Error(s):

rangecheck.
stackunderflow.
typecheck.

Description: Roll the top *count* objects on *stack* by *amount* positions. A positive *amount* indicates an upward roll, whereas a negative *amount* indicates a downward roll.

Example(s):

```
onyx:0> (3 2 1 0)
onyx:1> dup 3 1 sroll pstack
(3 0 2 1)
onyx:1> dup 3 -2 sroll pstack
(3 1 0 2)
onyx:1> dup 4 0 sroll pstack
(3 1 0 2)
onyx:1>
```

stack amount srot -:

Input(s):

stack: One or more objects.

amount: Number of positions to rotate *stack* upward. A negative value causes downward rotation.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Rotate *stack* up *count* positions.

Example(s):

```
onyx:0> (1 2 3 4 5) dup 2 srot 1 sprint
(4 5 1 2 3)
onyx:0> (1 2 3 4 5) dup -2 srot 1 sprint
(3 4 5 1 2)
onyx:0>
```

– **stack stack:**

Input(s): None.

Output(s):

stack: An empty stack object.

Error(s): None.

Description: Create a new stack object and push it onto ostack.

Example(s):

```
onyx:0> stack
onyx:1> pstack
()
```

obj start –:

Input(s):

obj: An object.

Output(s): None.

Error(s):

stackunderflow.

Description: Evaluate *obj*. This operator provides a context that silently terminates execution stack unwinding due to the **exit**, **quit**, and **stop** operators.

Example(s):

```
onyx:0> stdin cvx start
onyx:0> quit
onyx:0>
```

file/filename status dict:

Input(s):

file: A file object.

filename: A string that represents a filename.

Output(s):

dict: A dictionary that contains the following entries:

dev: Inode's device.

ino: Inode's number.

mode: Inode permissions.

nlink: Number of hard links.
uid: User ID of the file owner.
gid: Group ID of the file owner.
rdev: Device type.
size: File size in bytes.
atime: Time of last access, in nanoseconds since the epoch.
mtime: Time of last modification, in nanoseconds since the epoch.
ctime: Time of last file status change, in nanoseconds since the epoch.
blksize: Optimal block size for I/O.
blocks: Number of blocks allocated.

Error(s):

invalidfileaccess.
ioerror.
stackunderflow.
typecheck.
unregistered.

Description: Get status information about a file.

Example(s):

```
onyx:0> `/tmp' status 1 sprint
<$dev 134405 $ino 2 $mode 17407 $nlink 5 $uid 0 $gid 0 $rdev 952 $size 3584
$atime 9948830410000000000 $mtime 9948830410000000000 $ctime 9948830410000000000
$blksize 0 $blocks 8>
onyx:0>
```

– stderr *file*:

Input(s): None.

Output(s):

file: A file object corresponding to the calling thread's stderr.

Error(s): None.

Description: Get the thread's stderr. See Section 2.4 for standard I/O details.

Example(s):

```
onyx:0> stderr pstack
-file-
onyx:1>
```

– stdin *file*:

Input(s): None.

Output(s):

file: A file object corresponding to the calling thread's stdin.

Error(s): None.

Description: Get the thread's stdin. See Section 2.4 for standard I/O details.

Example(s):

```
onyx:0> stdin pstack
-file-
onyx:1>
```

– stdout *file*:

Input(s): None.

Output(s):

file: A file object corresponding to the calling thread's stdout.

Error(s): None.

Description: Get the thread's stdout. See Section 2.4 for standard I/O details.

Example(s):

```
onyx:0> stdout pstack
-file-
onyx:1>
```

- stop -:

Input(s): None.

Output(s): None.

Error(s): None.

Description: Unwind the execution stack to the innermost **stopped** or **start** context.

Example(s):

```
onyx:0> {stop} stopped 1 sprint
true
onyx:0>
```

obj stopped boolean:

Input(s):

obj: An object to evaluate.

Output(s):

boolean: True if **stop** operator was executed, false otherwise.

Error(s):

invalidcontinue.

invalidexit.

stackunderflow.

Description: Evaluate *obj*. This operator provides a context that terminates execution stack unwinding due to the **stop** operator. It will also terminate execution stack unwinding due to the **continue** and **exit** operators, but will throw an **invalidcontinue** or **invalidexit** error, respectively, then do the equivalent of calling **quit**.

Example(s):

```
onyx:0> {stop} stopped 1 sprint
true
onyx:0> {} stopped 1 sprint
false
onyx:0>
```

length string string:

Input(s):

length: Non-negative number of bytes.

Output(s):

string: A string of *length* bytes.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Create a string of *length* bytes. The bytes are initialized to 0.

Example(s):

```
onyx:0> 3 string 1 sprint
'\x00\x00\x00'
onyx:0>
onyx:0> 0 string 1 sprint
''
onyx:0>
```

stack stuck –:

Input(s):

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Tuck duplicate of top object on *stack* under second object on *stack*.

Example(s):

```
onyx:0> (2 1 0) dup stuck pstack
(2 0 1 0)
onyx:1>
```

a b sub r:

Input(s):

a: An integer or real.

b: An integer or real.

Output(s):

r: The value of *b* subtracted from *a*.

Error(s):

stackunderflow.

typecheck.

Description: Subtract *b* from *a* and return the result.

Example(s):

```
onyx:0> 5 3 sub 1 sprint
2
onyx:0> -3 4 sub 1 sprint
-7
onyx:0> 5.1 1.1 sub 1 sprint
4.000000e+00
onyx:0> 5 1.0 sub 1 sprint
4.000000e+00
onyx:0> -3.0 4.1 sub 1 sprint
-7.100000e+00
onyx:0>
```

integer submatch substring:

Input(s):**integer:****0:** Get substring of text that matched the regular expression.**>0:** Get substring of text that matched the specified capturing subpattern.**Output(s):****substring:** A substring of the string that was most recently matched by the **match**, **split**, or **subst** operators.**Error(s):****stackunderflow.****typecheck.****Description:** Get a substring of the input string that was most recently matched against.**Example(s):**

```

onyx:0> 'input' 'n(p)u' match {0 submatch 1 sprint 1 submatch 1 sprint} if
'npu'
'p'
onyx:0>

```

input pattern template flags subst output count:***input pattern template subst output count:******input regsub subst output count:*****Input(s):****input:** An input string.**pattern:** A string that specifies a regular expression. See Section 2.9 for syntax.**template:** A string that specifies a substitution template. See Section 2.9 for syntax.**flags:** A dictionary of optional flags:**\$g:** Substitute all matches, if true, rather than just the first match. Defaults to false.**\$i:** Case insensitive. Defaults to false.**\$m:** Treat input as a multi-line string. Defaults to false.**\$s:** Treat input as a single line, so that the dot metacharacter matches any character, including a newline. Defaults to false.**regsub:** A regsub object.**Output(s):****output:** A string that is created by substituting substrings within *input* that match a regular expression.**count:** Number of substitutions made. If 0 substitutions were made, then *output* is a duplicate of *input*, rather than a copy.**Error(s):****regexerror.****stackunderflow.****typecheck.****Description:** Create a string by substituting according to a template for each substring within *input* that matches a regular expression.**Example(s):**

```

onyx:0> 'Input String' '([a-r])' '[\1]' <$g true> subst pstack
6
'I[n][p]ut St[r][i][n][g]'
onyx:2>

```

stack sunder -:**Input(s):**

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Create a duplicate of the second object on *stack* and put it under the top object on *stack*.

Example(s):

```
onyx:0> (2 1 0) dup sunder pstack
(2 1 1 0)
onyx:1>
```

stack sup -:**Input(s):**

stack: A stack object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Rotate the top three objects on *stack* up one position.

Example(s):

```
onyx:0> (3 2 1 0) dup sup pstack
(3 0 2 1)
onyx:1>
```

class super super/null:**Input(s):**

class: A class object.

Output(s):

super/null: A class or null object.

Error(s):

stackunderflow.

typecheck.

Description: Get the superclass of *class*.

Example(s):

```
onyx:0> class super 1 sprint
null
onyx:0> class dup vclass setsuper
onyx:1> super classname 1 sprint
$vclass
onyx:0>
```

filename linkname symlink -:**Input(s):**

filename: A string that represents a filename.

linkname: A string that represents a filename.

Output(s): None.

Error(s):

invalidfileaccess.

ioerror.

stackunderflow.

typecheck.

undefinedfilename.

unregistered.

Description: Create a symbolic link from *linkname* to *filename*.

Example(s):

```
onyx:0> '/tmp/foo' 'w' open
onyx:1> dup 'Hello\n' write
onyx:1> dup flushfile
onyx:1> close
onyx:0> '/tmp/foo' '/tmp/bar' symlink
onyx:0> '/tmp/bar' 'r' open
onyx:1> readline
onyx:2> pstack
false
'Hello'
onyx:2>
```

– **tailopt *boolean*:**

Input(s): None.

Output(s):

boolean: True if tail call optimization is enabled for this thread; false otherwise.

Error(s): None.

Description: Get whether tail call optimization is enabled for this thread.

Example(s):

```
onyx:0> tailopt 1 sprint
true
onyx:0>
```

args system *status*:

Input(s):

args: An array of strings. The first string in *args* is the path of the program to invoke, and any additional array elements are passed as command line arguments to the invoked program.

Output(s):

status: Exit code of terminated process. A negative value indicates that the process was terminated by a signal (use the **neg** operator to get the signal number), and a non-negative value is the exit code of a program that terminated normally.

Error(s):

rangecheck.

stackunderflow.

typecheck.

Description: Execute a program as a child process and wait for it to terminate.

Example(s):

```
onyx:0> ['/usr/bin/which' 'onyx'] system
/usr/local/bin/onyx
onyx:1> 1 sprint
0
onyx:0>
```

– systemdict *dict*:**Input(s):** None.**Output(s):****dict:** A dictionary.**Error(s):** None.**Description:** Get systemdict. See Section 2.11.9 for details on systemdict.**Example(s):**

```
onyx:0> systemdict 0 sprint
-dict-
onyx:0>
```

a sinh r:**Input(s):****a:** An integer or real.**Output(s):****r:** Tangent of *a* in radians.**Error(s):****rangecheck.****stackunderflow.****typecheck.****Description:** Return the tangent of *a* in radians.**Example(s):**

```
onyx:0> 0.785 tan 1 sprint
9.992040e-01
onyx:0>
```

a tanh r:**Input(s):****a:** An integer or real.**Output(s):****r:** Hyperbolic tangent of *a*.**Error(s):****stackunderflow.****typecheck.****Description:** Return the hyperbolic tangent of *a*.**Example(s):**

```
onyx:0> 3 tanh 1 sprint
9.950548e-01
onyx:0>
```

file tell offset:

Input(s):

fil: A file object.

Output(s):

offset: Offset of the file position pointer for *file*.

Error(s):

ioerror.

stackunderflow.

typecheck.

Description: Get the file position pointer offset for *file*.

Example(s):

```
onyx:0> '/tmp/foo' 'w+' open
onyx:1> dup tell 1 sprint
0
onyx:1> dup 'Hello\n' write
onyx:1> dup tell 1 sprint
6
onyx:1>
```

file/filename flag test boolean:**Input(s):**

file: A file object.

filename: A string that represents a filename.

flag: A single-character string that represents the test to do on *file* or *filename*:

'b': Block special device?

'c': Character special device?

'd': Directory?

'e': Exists?

'f': Regular file?

'g': Setgid?

'k': Sticky?

'p': Named pipe?

'r': Readable?

's': Size greater than 0?

't': tty?

'u': Setuid?

'w': Write bit set?

'x': Executable bit set?

'L': Symbolic link?

'O': Owner matches effective uid?

'G': Group matches effective gid?

'S': Socket?

Output(s):

boolean: If true, the test evaluated to true; false otherwise.

Error(s):

invalidfileaccess.

ioerror.

rangecheck.
stackunderflow.
typecheck.
unregistered.

Description: Test a file for an attribute.

Example(s):

```
onyx:0> '/blah' 'e' test 1 sprint
false
onyx:0> '/tmp' 'e' test 1 sprint
true
onyx:0>
```

– **this class/instance:**

Input(s): None.

Output(s):

class: A class object.
instance: An instance object.

Error(s):

stackunderflow.

Description: Get the topmost object on cstack, which provides the context for execution of invokable and fetchable objects.

Example(s):

```
onyx:0> $fooclass vclass <> <$foomethod {this:classname 1 sprint}> cdef
onyx:0> fooclass:foomethod
$fooclass
onyx:0>
```

stack entry thread thread:

Input(s):

stack: A stack that contains the contents for the new thread's ostack.
entry: An initial object to execute in the new thread.

Output(s):

thread: A thread object that corresponds to the new thread.

Error(s):

stackunderflow.
typecheck.

Description: Create and run a new thread.

Example(s):

```
onyx:0> (1 2) {add 1 sprint} thread join 'Done\n' print flush
3
Done
onyx:0>
```

thread threadcstack stack:

Input(s):

thread: A thread object.

Output(s):

stack: The context stack belonging to *thread*.

Error(s):

stackunderflow.

typecheck.

Description: Get a reference to the context stack belonging to *thread*.

Example(s):

```
onyx:0> self threadstack 1 sprint
()
onyx:0>
```

thread threadstack stack:

Input(s):

thread: A thread object.

Output(s):

stack: The dictionary stack belonging to *thread*.

Error(s):

stackunderflow.

typecheck.

Description: Get a reference to the dictionary stack belonging to *thread*.

Example(s):

```
onyx:0> self threadstack 1 sprint
(-dict- -dict- -dict- -dict-)
onyx:0>
```

thread threadstack stack:

Input(s):

thread: A thread object.

Output(s):

stack: The execution stack belonging to *thread*.

Error(s):

stackunderflow.

typecheck.

Description: Get a reference to the execution stack belonging to *thread*.

Example(s):

```
onyx:0> self threadstack 1 sprint
(-file- -array- --eval-- --ifelse-- -array- --for-- -array-)
onyx:0>
```

thread threadstack stack:

Input(s):

thread: A thread object.

Output(s):

stack: The index stack belonging to *thread*.

Error(s):

stackunderflow.

typecheck.

Description: Get a reference to the index stack belonging to *thread*.

Example(s):

```
onyx:0> self threadistack 1 sprint
(0 0 0 0 7 0 3)
onyx:0>
```

thread threadostack stack:

Input(s):

thread: A thread object.

Output(s):

stack: The operand stack belonging to *thread*.

Error(s):

stackunderflow.

typecheck.

Description: Get a reference to the operand stack belonging to *thread*.

Example(s):

```
onyx:0> self threadostack 1 sprint
(-stack- -stack- -stack- -stack-)
onyx:0>
```

- threadsdict *dict*:

Input(s): None.

Output(s):

dict: A dictionary. Each key is a thread reference. By default, each value is null, but this need not be so, and the value can be redefined for debugging purposes.

Error(s): None.

Description: Get a dictionary containing references to all threads.

Example(s):

```
onyx:0> threadsdict 1 sprint
<-thread- null>
onyx:0>
```

name throw obj:

Input(s):

name: The name of an error.

Output(s):

obj: The object that was being executed when the error was thrown.

Error(s):

stackunderflow.

typecheck.

undefined.

Description: Throw an error, using the following steps:

1. Set newerror in the currenterror dictionary to true.
2. Set errorname in the currenterror dictionary to *name*.
3. Set ostack, dstack, estack, and istack in the currenterror dictionary to be current stack snapshots.
4. Push the object that was being executed before throw was called onto ostack.

5. If there is an error handler in the errordict dictionary that corresponds to *name*, evaluate it. Otherwise, evaluate errordict's **handleerror** and **stop** operators.

Example(s):

```

onyx:0> $unregistered throw
Error $unregistered
ostack: ()
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
estack/istack trace (0..1):
0:      -file-
1:      --start--
onyx:1> pstack
-file-
onyx:1>

```

condition mutex timeout timedwait boolean:**Input(s):**

condition: A condition object.
mutex: A mutex object that this thread currently owns.
timeout: Minimum number of nanoseconds to wait for *condition*.

Output(s):

boolean: If false, success, otherwise timeout.

Error(s):

stackunderflow.
typecheck.

Description: Wait on *condition* for at least *timeout* nanoseconds. *mutex* is atomically released when the current thread blocks, then acquired again before the current thread runs again. Using a mutex that the current thread does not own will result in undefined behavior (likely crash).

Example(s):

```

onyx:0> condition mutex dup lock ostack
onyx:3> {dup lock exch signal unlock}
onyx:4> thread 3 1 roll
onyx:3> dup 3 1 roll
onyx:4> 1000000000 timedwait 1 sprint unlock join
false
onyx:0> mutex condition 1 idup dup lock 1000000000 timedwait 1 sprint unlock
true
onyx:0>

```

file/string token false:***file/string token file/substring obj true:*****Input(s):**

file: A file that is used as onyx source code to scan a token from.
string: A string that is used as onyx source code to scan a token from.

Output(s):

file: The same file object that was passed in.
substring: The remainder of *string* after scanning a token.
obj: An object that was constructed by scanning a token.

false/true: If true, a token was successfully scanned, false otherwise.

Error(s):

stackunderflow.

syntaxerror.

typecheck.

undefined.

Description: Scan a token from a file or string, using onyx syntax rules. If a token is followed by whitespace, one character of whitespace is consumed when the token is scanned.

Example(s):

```
onyx:0> '1 2' token pstack clear
true
1
'2'
onyx:0> 'foo' token pstack clear
true
foo
''
onyx:0> 'foo ' token pstack clear
true
foo
''
onyx:0> 'foo  ' token pstack clear
true
foo
\ '
onyx:0> 'foo$bar' token pstack clear
true
foo
'$bar'
onyx:0> 'foo{' token pstack clear
true
foo
'\{'
onyx:0> \ ' token pstack clear
false
onyx:0>
```

obj trapped false:

obj trapped arg true:

Input(s):

obj: An object to evaluate.

Output(s):

arg: The argument that was passed to the **escape** operator that caused unwinding to this **trapped** context.

false: The **escape** operator was not executed.

true: The **escape** operator was executed.

Error(s):

invalidcontinue.

invalidexit.

stackunderflow.

Description: Evaluate *obj*. This operator provides a context that snapshots the state of *ostack*, *dstack*, and *cstack*, then restores those snapshotted states if the **escape** operator causes the execution stack to unwind to the point where **trapped** was called. It will also terminate execution stack unwinding due to the **continue** and **exit** operators, but will throw an *invalidcontinue* or *invalidexit* error, respectively, then do the equivalent of calling **quit**.

Example(s):

```

onyx:0> {1 2 3 $arg escape} trapped {1 sprint} if
$arg
onyx:0> {1 2 3} trapped {1 sprint}{pstack clear} ifelse
3
2
1
onyx:0>

```

a* trunc *r*:*Input(s):**

a: An integer or real.

Output(s):

r: Integer created from *a* by discarding the fractional portion.

Error(s):

stackunderflow.

typecheck.

Description: Discard the fractional portion of *a* to create an integer, and return the result.

Example(s):

```

onyx:0> -1.51 trunc 1 sprint
-1
onyx:0> -1.49 trunc 1 sprint
-1
onyx:0> 0 trunc 1 sprint
0
onyx:0> 1.49 trunc 1 sprint
1
onyx:0> 1.51 trunc 1 sprint
1
onyx:0>

```

file length* truncate *-*:*Input(s):**

file: A file object.

length: New length for *file*.

Output(s): None.**Error(s):**

ioerror.

rangecheck.

stackunderflow.

typecheck.

Description: Set the length of *file* to *length*. If this causes the file to grow, the appended bytes will have the value zero.

Example(s):

```
onyx:0> '/tmp/foo' 'w+' open
onyx:1> dup 'Hello\n' write
onyx:1> dup flushfile
onyx:1> dup 0 seek
onyx:1> dup 10 string read
onyx:3> pop 1 sprint
'Hello\n'
onyx:1> dup 3 truncate
onyx:1> dup 0 seek
onyx:1> dup 10 string read
onyx:3> pop 1 sprint
'Hel'
onyx:1>
```

- true true:

Input(s): None.

Output(s):

true: The boolean value true.

Error(s): None.

Description: Return true.

Example(s):

```
onyx:0> true 1 sprint
true
onyx:0>
```

mutex trylock boolean:**Input(s):**

mutex: A mutex object.

Output(s):

boolean: If false, *mutex* was successfully acquired. Otherwise the mutex acquisition failed.

Error(s):

stackunderflow.

typecheck.

Description: Try to acquire *mutex*, but return a failure immediately if *mutex* cannot be acquired, rather than blocking.

Example(s):

```
onyx:0> mutex dup
onyx:2> trylock 1 sprint
false
onyx:1> trylock 1 sprint
true
onyx:0>
```

a b tuck b a b:**Input(s):**

a: An object.

b: An object.

Output(s):

:

Error(s):**stackunderflow.****typecheck.**

Description: Create a duplicate of the top object on ostack and put it under the second object on ostack.

Example(s):

```

onyx:0> 'a' 'b' 'c'
oonyx:3> tuck pstack
'c'
'b'
'c'
'a'
onyx:4>

```

obj* type name:*Input(s):****obj:** An object.**Output(s):****name:** An executable name that corresponds to the type of *obj*:**array:** arraytype.**boolean:** booleantype.**condition:** conditiontype.**dict:** dicttype.**file:** filetype.**fino:** finotype.**handle:** handletype.**integer:** integertype.**mark:** marktype.**mutex:** mutextype.**name:** nametype.**null:** nulltype.**operator:** operatortype.**pmark:** pmarktype.**stack:** stacktype.**string:** stringtype.**thread:** threadtype.**Error(s):****stackunderflow.**

Description: Get a name that represent the type of *obj*.

Example(s):

```

onyx:0> true type 1 sprint
booleantype
onyx:0>

```

- uid *uid*:**Input(s):** None.

Output(s):

uid: Process's user ID.

Error(s): None.

Description: Get the process's user ID.

Example(s):

```
onyx:0> uid 1 sprint
1001
onyx:0>
```

nmask umask omask:**Input(s):**

nmask: Value to set umask to.

Output(s):

omask: Old umask.

Error(s):

stackunderflow.

typecheck.

Description: Set the process's umask to *nmask* and return the old umask.

Example(s):

```
onyx:0> 8@777 umask <$b 8 $w 3 $p '0'> output '\n' print flush
022
onyx:0>
```

dict key undef -:**Input(s):**

dict: A dictionary.

val: A key in *dict* to undefine.

Output(s): None**Error(s):**

stackunderflow.

typecheck.

Description: If *key* is defined in *dict*, undefine it.

Example(s):

```
onyx:0> $foo 'foo' def
onyx:0> currentdict $foo undef
onyx:0> currentdict $foo undef
onyx:0>
```

a b under a a b:**Input(s):**

a: An object.

b: An object.

Output(s):

a: An object.

b: An object.

Error(s):

stackunderflow.

Description: Create a duplicate of the second object on ostack and put it under the top object on ostack.

Example(s):

```
onyx:0> 0 1 2 under pstack
2
1
1
0
onyx:4>
```

boolean obj unless -:

Input(s):

boolean: A boolean.

obj: An object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Evaluate *obj* unless *boolean* is true.

Example(s):

```
onyx:0> false {'yes' 1 sprint} unless
'yes'
onyx:0> true {'yes' 1 sprint} unless
onyx:0>
```

filename unlink -:

Input(s):

filename: A string that represents a filename.

Output(s): None.

Error(s):

invalidfileaccess.

ioerror.

stackunderflow.

typecheck.

undefinedfilename.

unregistered.

Description: Unlink *filename*.

Example(s):

```
onyx:0> '/tmp/foo' 'w' open
onyx:1> dup 'Hello\n' write
onyx:1> dup flushfile
onyx:1> close
onyx:0> '/tmp/foo' unlink
onyx:0> '/tmp/foo' 'r' open
Error $invalidfileaccess
ostack: ('/tmp/foo' 'r')
dstack: (-dict- -dict- -dict- -dict-)
cstack: ()
```

```

estack/istack trace (0..2):
0:      --open--
1:      -file-
2:      --start--
onyx:3>

```

mutex unlock* –:*Input(s):****mutex:** A mutex object.**Output(s):** None.**Error(s):****stackunderflow.****typecheck.****Description:** Unlock *mutex*. Unlocking a mutex that the running thread does not own will result in undefined behavior (likely crash).**Example(s):**

```

onyx:0> mutex dup lock unlock
onyx:0>

```

key unsetenv* –:*Input(s):****key:** A name object.**Output(s):** None.**Error(s):****stackunderflow.****typecheck.****Description:** Unset *key* in the environment and in the envdict dictionary, if *key* is defined.**Example(s):**

```

onyx:0> $foo 'foo' setenv
onyx:0> envdict $foo known 1 sprint
true
onyx:0> envdict $foo get 1 sprint
'foo'
onyx:0> $foo unsetenv
onyx:0> envdict $foo known 1 sprint
false
onyx:0>

```

proc cond until* –:*Input(s):****proc:** An object to be repeatedly evaluated.**cond:** An object that, when evaluated, places a boolean on ostack.**Output(s):** None.**Error(s):****stackunderflow.****typecheck.****Description:** Repeatedly evaluate *proc* and *cond*, terminating the first time that *cond* places false on ostack. This operator supports the **continue** and **exit** operators.

Example(s):

```
onyx:0> 0 {inc dup 1 sprint}{dup 3 lt} until pop
1
2
3
onyx:0> 0 {inc dup 1 sprint exit}{dup 3 lt} until pop
1
onyx:0>
```

a b c up c a b:**Input(s):**

a: An object.
b: An object.
c: An object.

Output(s):

c: An object.
a: An object.
b: An object.

Error(s):

stackunderflow.

Description: Rotate the top three objects on ostack up one position.

Example(s):

```
onyx:0> 'a' 'b' 'c' 'd' up pstack
'c'
'b'
'd'
'a'
onyx:4>
```

– userdict *dict*:

Input(s): None.

Output(s):

dict: A dictionary.

Error(s): None.

Description: Get userdict. See Section 2.11.12 for details on userdict.

Example(s):

```
onyx:0> userdict 1 sprint
<>
onyx:0>
```

– vclass *class*:

Input(s): None.

Output(s):

dict: A class.

Error(s): None.

Description: Get vclass. See Section 2.12.1 for details on vclass.

Example(s):

```
onyx:0> vclass 1 sprint
-class-
onyx:0>
```

- version *string*:**Input(s):** None.**Output(s):****string:** A string that contains the version name.**Error(s):** None.**Description:** Get the version string. The string returned is a reference to the original version string.**Example(s):**

```
onyx:0> version pstack
'1.0.0'
onyx:1>
```

condition mutex wait* -:*Input(s):****condition:** A condition object.**mutex:** A mutex object that this thread currently owns.**Output(s):** None.**Error(s):****stackunderflow.****typecheck.****Description:** Wait on *condition*. *mutex* is atomically released when the current thread blocks, then acquired again before the current thread runs again. Using a mutex that the current thread does not own will result in undefined behavior (likely crash).**Example(s):**

```
onyx:0> condition mutex dup lock ostack
onyx:3> {dup lock exch signal unlock}
onyx:4> thread 3 1 roll
onyx:3> dup 3 1 roll
onyx:4> wait unlock join
onyx:0>
```

pid waitpid status*:*Input(s):****pid:** Process identifier.**Output(s):****status:** Exit code of terminated process. A negative value indicates that the process was terminated by a signal (use the **neg** operator to get the signal number), and a non-negative value is the exit code of a program that terminated normally.**Error(s):****stackunderflow.****typecheck.****Description:** Wait for the process with process ID *pid* to exit.

Example(s):

```

onyx:0> ['/bin/date'] forkexec dup 1 sprint waitpid 1 sprint
6516
Sat Jul 13 20:47:54 PDT 2002
0
onyx:0>

```

key where false:**key where dict true:****Input(s):****key:** A key to search for in dstack.**Output(s):****dict:** The topmost dictionary in dstack that contains a definition for *key*.**false/true:** If false, no definition of *key* was found in dstack. Otherwise *dict* is the topmost dictionary in dstack that contains a definition for *key*.**Error(s):****stackunderflow.****Description:** Get the topmost dictionary in dstack that defines *key*.**Example(s):**

```

onyx:0> $foo where pstack clear
false
onyx:0> $threaddict where pstack clear
true
<$threaddict -dict- $userdict -dict- $currenterror -dict- $errordict -dict-
$resume -array->
onyx:0>

```

cond proc while -:**Input(s):****cond:** An object that, when evaluated, places a boolean on ostack.**proc:** An object to be repeatedly evaluated.**Output(s):** None.**Error(s):****stackunderflow.****typecheck.****Description:** Repeatedly evaluate *cond* and *proc*, terminating the first time that *cond* places false on ostack. This operator supports the **continue** and **exit** operators.**Example(s):**

```

onyx:0> 0 {dup 3 lt}{inc dup 1 sprint} while pop
1
2
3
onyx:0> 0 {dup 3 lt}{inc dup 1 sprint exit} while pop
1
onyx:0>

```

file integer/string write false:**file integer/string write integer/substring true:**

Input(s):

file: A file object.

integer: An integer that represents an ascii character value.

string: A string object.

Output(s):

false: Successful complete write.

integer: The *integer* that was passed in.

substring: The substring of *string* that was not written.

true: Successful partial write.

Error(s):

ioerror.

stackunderflow.

typecheck.

Description: Write *integer* or *string* to *file*. Partial writes can only happen for non-blocking files.

Example(s):

```
onyx:0> '/tmp/foo' 'w+' open
onyx:1> dup 'Hello\n' write pop
onyx:1> dup 0 seek
onyx:1> dup readline 1 sprint 1 sprint
false
'Hello'
onyx:1>
```

obj xcheck boolean:**Input(s):**

obj: An object.

Output(s):

boolean: True if *obj* has the executable attribute, false otherwise.

Error(s):

stackunderflow.

Description: Check *obj* for executable attribute.

Example(s):

```
onyx:0> {1 2 3} xcheck 1 sprint
true
onyx:0> [1 2 3] xcheck 1 sprint
false
onyx:0>
```

obj xecheck boolean:**Input(s):**

obj: An object.

Output(s):

boolean: True if *obj* has the executable or evaluable attribute, false otherwise.

Error(s):

stackunderflow.

Description: Check *obj* for executable or evaluable attribute.

Example(s):

```
onyx:0> {1 2 3} xecheck 1 sprint
true
onyx:0> {1 2 3} cve xecheck 1 sprint
true
onyx:0> [1 2 3] xecheck 1 sprint
false
onyx:0>
```

a b xor r:**Input(s):**

a: An integer or boolean.

b: The same type as *a*.

Output(s):

r: If *a* and *b* are integers, their bitwise exclusive or, otherwise their logical exclusive or.

Error(s):

stackunderflow.

typecheck.

Description: Return the bitwise exclusive or of two integers, or the logical exclusive or of two booleans.

Example(s):

```
onyx:0> true false xor 1 sprint
true
onyx:0> true true xor 1 sprint
false
onyx:0> 5 3 xor 1 sprint
6
onyx:0>
```

- yield -:

Input(s): None.

Output(s): None.

Error(s): None.

Description: Voluntarily yield the processor, so that another thread or process may be run.

Example(s):

```
onyx:0> 0 100000 {1 add yield} repeat 1 sprint
100000
onyx:0>
```

2.11.10 threaddict

Each thread has its own threaddict, which is not shared with any other threads. threaddict is meant to be used for thread-specific definitions that would otherwise go in systemdict.

Table 2.11: threaddict summary

Input(s) Op/Proc/Var Output(s)	Description
– threaddict dict	Get threaddict.
– userdict dict	Get userdict.
– currenterror dict	Get currenterror.
– errordict dict	Get errordict.

– **currenterror dict:****Input(s):** None.**Output(s):****dict:** The currenterror dictionary. See Section 2.11.1 for details on currenterror.**Error(s):** None.**Description:** Get currenterror.**Example(s):**

```

onyx:0> currenterror 0 sprint
-dict-
onyx:0>

```

– **errordict dict:****Input(s):** None.**Output(s):****dict:** The errordict dictionary. See Section 2.11.3 for details on errordict.**Error(s):** None.**Description:** Get errordict.**Example(s):**

```

onyx:0> errordict 0 sprint
-dict-
onyx:0>

```

– **threaddict dict:****Input(s):** None.**Output(s):****dict:** The threaddict dictionary.**Error(s):** None.**Description:** Get threaddict.

Example(s):

```
onyx:0> threaddict 0 sprint
-dict-
onyx:0>
```

– userdict *dict*:**Input(s):** None.**Output(s):****dict:** The userdict dictionary. See Section 2.11.12 for details on userdict.**Error(s):** None.**Description:** Get userdict.**Example(s):**

```
onyx:0> userdict 1 sprint
<>
onyx:0>
```

2.11.11 threadsdict

There is one entry in threadsdict for each thread. The key is the thread, and the value is null by default. The value can be safely changed, which can be useful when debugging. However, the key must not be changed, or garbage collection will trigger a horrible death, since the root set will not be complete.

2.11.12 userdict

Each thread has its own userdict, which is not shared with any other threads. userdict is meant to be used for general storage of definitions that do not need to be shared among threads. userdict starts out empty when a thread is created.

2.12 Class reference

The following documents the classes that are built into Onyx.

2.12.1 vclass

The *vclass* class serves as a base class from which a class hierarchy can be built. Although there are no mechanisms that force the use of *vclass* when constructing a class hierarchy, it usually makes sense to do so, since the operators that implement object-oriented programming support provide mechanisms, but almost no policy. *vclass* provides what little policy is needed, such as the naming and invocation of constructors.

Table 2.12: vclass summary

Input(s) Method Output(s)	Description
Class-context methods	
– new instance	Constructor.
– rnew instance	Construction helper.
name implementor class/null	Get class that implements name.
name implements boolean	Does class implement name?
name method method	Get class method by name.
– classname name/null	Get class's name.
name/null setclassname –	Set class's name.
– super super/null	Get class's superclass.
super/null setsuper –	Set class's superclass.
– methods dict/null	Get methods dict for class.
dict/null setmethods –	Set methods dict for class.
Class/instance-context methods	
– data dict/null	Get data for class/instance.
dict/null setdata –	Set data for class/instance.
key val def –	Define key as val in class/instance data dict.
key undef –	Undefine key in class/instance data dict.

Continued on next page...

Table 2.12: *continued*

Input(s) Method Output(s)	Description
Instance-context methods	
– isa class/null	Get class for instance.
class/null setisa –	Set class for instance
class kind boolean	Is class in instance's inheritance hierarchy?

– **classname** *name/null*:**Input(s):** None.**Output(s):****name/null:** A name or null object.**Error(s):****typecheck.****Description:** Class-context method.Call the **classname** operator.**Example(s):**

```

onyx:0> vclass:classname 1 sprint
$vclass
onyx:0>

```

– **data** *dict/null*:**Input(s):** None.**Output(s):****dict/null:** A dict or null object.**Error(s):****typecheck.****Description:** Class/instance-context method.Call the **data** operator.**Example(s):**

```

onyx:0> vclass:data 1 sprint
<>
onyx:0>

```

key val def –:**Input(s):****key:** An object.**val:** An object.**Output(s):** None.

Error(s):**stackunderflow.****Description:** Class/instance-context method.Define *key* as *val* in the data dictionary of the current class or instance.**Example(s):**

```
onyx:0> $fooclass vclass <><$foo_get {,foo}> cdef
onyx:0> $foo 'foo' fooclass:def
onyx:0> fooclass:foo_get
onyx:1> 1 sprint
'foo'
onyx:0>
```

name* implementor *class/null*:*Input(s):****name:** An object of any type, usually a name object.**Output(s):****class/null:** A class or null object.**Error(s):****stackunderflow.****typecheck.****Description:** Class-context method.Call the **implementor** operator.**Example(s):**

```
onyx:0> class dup vclass setsuper
onyx:1> $new exch :implementor:classname 1 sprint
$vclass
onyx:0>
```

name* implements *boolean*:*Input(s):****name:** An object of any type, usually a name object.**Output(s):****boolean:** True if *name* is implemented by *class*, false otherwise.**Error(s):****stackunderflow.****typecheck.****Description:** Class-context method.Call the **implements** operator.**Example(s):**

```
onyx:0> $new vclass:implements 1 sprint
true
onyx:0> $foo vclass:implements 1 sprint
false
onyx:0>
```

– isa *class*:**Input(s):** None.**Output(s):**

class/null: A class or null object.

Error(s):

typecheck.

Description: Instance-context method.

Call the **isa** operator.

Example(s):

```
onyx:0> instance isa 1 sprint
null
onyx:0> vclass:new:isa:classname 1 sprint
$vclass
onyx:0>
```

class kind boolean:

Input(s):

class: A class object.

Output(s):

boolean: True if *class* is in *instance*'s inheritance hierarchy, false otherwise.

Error(s):

typecheck.

Description: Instance-context method.

Call the **kind** operator.

Example(s):

```
onyx:0> $fooclass class dup vclass setsuper def
onyx:1> fooclass over:kind 1 sprint
true
onyx:1> vclass exch:kind 1 sprint
true
onyx:0>
```

name method method:

Input(s):

name: An object of any type, usually a name object.

Output(s):

method: The bottommost method associated with *name* in *class*'s inheritance hierarchy.

Error(s):

stackunderflow.

typecheck.

undefined.

Description: Class-context method.

Call the **method** operator.

Example(s):

```
onyx:0> $fooclass class dup vclass setsuper def
onyx:0> $new fooclass:method 1 sprint
{--instance-- --dup-- --dn-- --setisa-- --dup-- --dict-- --setdata--}
onyx:0>
```

– methods dict/null:

Input(s): None.

Output(s):

dict/null: A dict or null object.

Error(s):

typecheck.

Description: Class-context method.

Call the **methods** operator.

Example(s):

```
onyx:0> vclass:methods 0 sprint
-dict-
onyx:0>
```

– new *instance*:

Input(s): None.

Output(s):

instance: An instance of *class*.

Error(s):

typecheck.

Description: Class-context method.

Constructor.

Example(s):

```
onyx:0> vclass:new 1 sprint
-instance-
onyx:0>
```

– rnew *instance*:

Input(s): None.

Output(s):

instance: An instance of *class* for which the superclass's constructor has been called.

Error(s):

typecheck.

Description: Class-context method.

Recursively call superclass's constructor (**new**). This method is typically only used internally by constructors.

Example(s):

```
onyx:0> $fooclass vclass <><$new {:rnew}> cdef
onyx:0> fooclass:new:isa:classname 1 sprint
$fooclass
onyx:0>
```

name/null setclassname –:**Input(s):**

name/null: A name or null object.

Output(s): None.**Error(s):**

stackunderflow.

typecheck.

Description: Class-context method.

Call the **setclassname** operator.

Example(s):

```
onyx:0> $fooclass class dup vclass setsuper def
onyx:0> $fooclass fooclass:setclassname
onyx:0> fooclass:classname 1 sprint
$fooclass
onyx:0>
```

dict/null setdata -:

Input(s):

dict/null: A dict or null object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Class/instance-context method.

Call the **setdata** operator.

Example(s):

```
onyx:0> $fooclass class dup vclass setsuper def
onyx:0> <$foo 'foo'> fooclass:setdata
onyx:0> fooclass:data 1 sprint
<$foo 'foo'>
onyx:0>
```

class/null setisa -:

Input(s):

class/null: A class or null object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Instance-context method.

Call the **setisa** operator.

Example(s):

```
onyx:0> $fooclass class dup vclass setsuper def
onyx:0> fooclass:new
onyx:1> vclass over:setisa
onyx:1> :isa:classname 1 sprint
$vclass
onyx:0>
```

dict/null setmethods -:

Input(s):

dict/null: A dict or null object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Class-context method.

Call the **setmethods** operator.

Example(s):

```
onyx:0> $fooclass class dup vclass setsuper def
onyx:0> <$foo 'foo'> fooclass:setmethods
onyx:0> fooclass:methods 1 sprint
<$foo 'foo'>
onyx:0>
```

super/null setsuper -:

Input(s):

super/null: A class or null object.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Class-context method.

Call the **setsuper** operator.

Example(s):

```
onyx:0> $fooclass class dup vclass setsuper def
onyx:0> fooclass:super:classname 1 sprint
$vclass
onyx:0>
```

- super super/null:

Input(s): None.

Output(s):

super/null: A class or null object.

Error(s):

typecheck.

Description: Class-context method.

Call the **super** operator.

Example(s):

```
onyx:0> vclass:super 1 sprint
null
onyx:0> $fooclass class dup vclass setsuper def
onyx:0> fooclass:super:classname 1 sprint
$vclass
onyx:0>
```

key undef -:

Input(s):

key: An object.

Output(s): None.

Error(s):

stackunderflow.

Description: Class/instance-context method.

Undefine *key* in the data dictionary of the current class or instance.

Example(s):

```
onyx:0> $fooclass vclass <><$foo_get {,foo}> cdef
onyx:0> $foo 'foo' fooclass:def
onyx:0> fooclass:foo_get
onyx:1> 1 sprint
'foo'
onyx:0> $foo fooclass:undef
onyx:0> fooclass:foo_get
Error $undefined
ostack: ()
dstack: (-dict- -dict- -dict- -dict-)
cstack: (-class-)
estack/istack trace (0..3):
0:      ,foo
1:      :foo_get
2:      -file-
3:      --start--
onyx:1>
```

2.12.2 mclass

The *mclass* class uses the singleton pattern to provide an application-wide interface for loading modules. Additionally, the *mclass:modules* method makes it possible to find out what modules are currently loaded.

Table 2.13: mclass summary

Input(s) Method Output(s)	Description
Class-context methods	
– new instance	Constructor.
– singleton instance	Get an mclass singleton instance.
Instance-context methods	
modname load –	Load a module.
modname unload notify –	Notify the mclass singleton of a module unload.
– modules modules	Get loaded modules.

modname* load -:*Input(s):**

modname: The name of a module.

Output(s): None.**Error(s):**

invalidfileaccess.

ioerror.

limitcheck.

rangecheck.

stackunderflow.

typecheck.

undefinedfilename.

Description: Load the module named *modname*, and define the module name as the module in currentdict.

Example(s):

```
onyx:0> $modclopt mclass:singleton:load
```

```
onyx:0>
```

0

- modules *modules*:**Input(s):** None.**Output(s):**

modules: A dictionary of module names associated with *module* instances.

Error(s): None.

Description: Get a dictionary of loaded modules.

Example(s):

```
onyx:0> mclass:singleton:modules 1 sprint
```

```
<$modprompt -instance=$module- $modclopt -instance=$module->
```

```
onyx:0>
```

- new *instance*:**Input(s):** None.**Output(s):**

instance: An instance of *class*.

Error(s):

typecheck.

Description: Constructor.

Example(s):

```
onyx:0> mclass:new 1 sprint
```

```
-instance-
```

```
onyx:0>
```

- singleton *instance*:**Input(s):** None.**Output(s):**

instance: An *mclass* singleton instance.

Error(s): None.

Description: Get an *mclass* singleton instance.

Example(s):

```
onyx:0> mclass:singleton 1 sprint
-instance=$mclass-
onyx:0>
```

***modname* unload_notify -:**

Input(s):

modname: The name of a module.

Output(s): None.

Error(s):

stackunderflow.

typecheck.

Description: Notify the *mclass* singleton of a module unload. This method is called by the *module:unload* method, and isn't normally called directly by application code.

Example(s): Following is the implementation of *module:unload*:

```
# Unload the module.
#
#instance#
#- unload -
$unload {
    # Evaluate the pre-unload hook.
    ,pre_unload_hook eval

    # Iteratively undefine the module definitions, as recorded in the mdefs
    # dict.
    ,mdefs {
        exch 0 get
        #defdict #defname
        undef
    } foreach

    # Evaluate the post-unload hook.
    ,post_unload_hook eval

    # Notify mclass_singleton of the unload.
    ,name ,mclass_singleton:unload_notify
} bind
```

2.12.3 module

The *module* class works in conjunction with the *mclass* class to encapsulate loaded modules. Each loaded module has a corresponding *module* instance, which can be used to query, configure, or unload modules.

Table 2.14: module summary

Input(s) Method Output(s)	Description
Class-context methods	
– new instance	Constructor.
Instance-context methods	
– version_get version	Get module version.
version version_set –	Set module version.
– deps_get deps	Get module dependencies.
– mdefs_get mdefs	Get module definitions.
defname defval defdict mdef –	Create module definition defname as defval in defdict.
depname dep_load –	Load a dependency module.
hook pre_unload_hook_set –	Store pre-unload hook.
hook post_unload_hook_set –	Store post-unload hook.
– unload –	Unload module.

depname dep_load –:

Input(s):

depname: The name of a module that this module depends on.

Output(s): None.

Error(s):

invalidfileaccess.

ioerror.

limitcheck.

rangecheck.

stackunderflow.

typecheck.

undefinedfilename.

Description: Load the module named *depname*, and record that this module depends on it.

Example(s):

```
modfoo/modfoo.nx:

$modclopt ;dep_load

$foo 'foo' systemdict ;mdef

onyx:0> mclass:singleton:modules 1 sprint
<$modprompt -instance=$module- $modclopt -instance=$module->
onyx:0> $modfoo mclass:singleton:load
onyx:0> mclass:singleton:modules 1 sprint
<$modprompt -instance=$module- $modclopt -instance=$module-
$modfoo -instance=$module->
onyx:0>
```

– deps_get *deps*:

Input(s): None.

Output(s):

deps: A dictionary of module names associated with *module* instances.

Error(s): None.

Description: Get a dictionary of modules that this module depends on.

Example(s):

```
onyx:0> $modclopt mclass:singleton:load
onyx:0> modclopt:deps_get 1 sprint
<>
onyx:0>
```

– mdefs_get *mdefs*:

Input(s): None.

Output(s):

mdefs: A dictionary of array keys, associated with the dictionaries in which the definitions reside. Each array key is a tuple; the first array element is the definition key, and the second array element is the definition value.

Error(s): None.

Description: Get a dictionary of definitions associated with this module.

Example(s):

```
onyx:0> $modclopt mclass:singleton:load
onyx:0> modclopt:mdefs_get 2 sprint
<[$clopt -class=$clopt-] <$modprompt -instance=$module- $clopt -class=$clopt-
$modclopt -instance=$module-> [$modclopt -instance=$module-] <$modprompt
-ininstance=$module- $clopt -class=$clopt- $modclopt -instance=$module->>
onyx:0>
```

defname defval mdef --

Input(s):

defname: A definition key.

defval: A value to be associated with *defname*.

defdict: A dictionary in which to define *defname* as *defval*.

Output(s): None.

Error(s):

typecheck.

Description: Define *defname* as *defval* in *defdict*.

Example(s):

```
modfoo/modfoo.nx:
$modclopt ;dep_load

$foo 'foo' systemdict ;mdef

onyx:0> $modfoo mclass:singleton:load
onyx:0> foo 1 sprint
'foo'
onyx:0>
```

– new *instance*:

Input(s): None.

Output(s):

instance: An instance of *class*.

Error(s):

typecheck.

Description: Constructor.

Example(s):

```
onyx:0> module:new 1 sprint
-instance-
onyx:0>
```

hook post_unload hook_set –:

Input(s):

hook: An object to evaluate after unloading this module.

Output(s): None.

Error(s):

stackunderflow.

Description: Register a post-unload hook, which is evaluated after this module is unloaded.

Example(s):

```
onyx:0> $modclopt mclass:singleton:load
onyx:0> {'Post-unload' 1 sprint} modclopt:post_unload_hook_set
onyx:0> modclopt:unload
'Post-unload'
onyx:0>
```

hook pre_unload hook_set –:

Input(s):

hook: An object to evaluate before unloading this module.

Output(s): None.

Error(s):

stackunderflow.

Description: Register a pre-unload hook, which is evaluated before this module is unloaded.

Example(s):

```
onyx:0> {'Pre-unload' 1 sprint} modclopt:pre_unload_hook_set
onyx:0> modclopt:unload
'Pre-unload'
onyx:0>
```

– unload –:

Input(s): None.

Output(s): None.

Error(s): None, except errors caused by the evaluation of the pre- and post-unload hooks.

Description: Unload this module.

Example(s):

```
onyx:0> $modclopt mclass:singleton:load
onyx:0> modclopt:unload
onyx:0>
```

– version_get *version*:

Input(s): None.

Output(s):

version: The version of this module.

Error(s): None.

Description: Get the version of this module.

Example(s):

```
onyx:0> $modclopt mclass:singleton:load
onyx:0> modclopt:version_get 1 sprint
0
onyx:0>
```

***version* version_set –:**

Input(s):

version: The version of this module.

Output(s): None.

Error(s):

stackunderflow.

Description:

Example(s):

```
onyx:0> $modclopt mclass:singleton:load
onyx:0> modclopt:version_get 1 sprint
0
onyx:0> 1 modclopt:version_set
onyx:0> modclopt:version_get 1 sprint
1
onyx:0>
```


2.13 Module reference

The following documents the modules that are provided with Onyx.

2.13.1 modclopt

The *modclopt* module implements command line option parsing via the *clopt* class. Both short- and long-style arguments are supported. There are also methods that aid in validating and converting arguments.

An application implements a command line parser by loading the *modclopt* module, subclassing the *clopt* class, and defining option-handling methods. At a minimum, this looks something like:

```
$modclopt mclass:singleton:load

$myopts clopt <
><
    '--help' {
        'Help yourself' ;error_print
        1 die
    }
> cdef

argv myopts:new:parse
```

There are five option formats. Handler methods “names” must be strings. The absence or presence of the “:”, “?”, and “=” characters at the ends of the handler method names determines whether the options take arguments:

- '-s': Handle a short-style argument (-s) that has no arguments.
- '-S:': Handle a short-style argument (-S) that must have an argument.
- '--long': Handle a long-style option (--long) that has no arguments.
- '--Long?': Handle a long-style option (--Long) that has an optional argument.
- '--LONG=:': Handle a long-style option (--LONG) that must have an argument.

The -- command line argument terminates argument parsing, and any remaining arguments are returned by the *parse* method.

clopt subclasses *vclass*.

Table 2.15: clopt summary

Input(s) Method Output(s)	Description
Class-context methods	

Continued on next page...

Table 2.15: *continued*

Input(s) Method Output(s)	Description
– new instance	Constructor.
Instance-context methods	
argv parse remainder false	Successfully parse argv.
argv parse true	Unsuccessfully parse argv.
errstr error_print –	Print an error.
errstr error_escape –	Handle an error, and unwind to the parse method.
– progrname_get progrname	Return the program name.
– argv_get argv	Return argv.
– index_get index	Return the current argv index.
– flag_get flag	Return the current option flag.
– arg_get arg	Return the current option argument.
enum arg_enum_get value	Map the current option argument to a value.
– arg_int_get int	Return the current option argument as an integer.
– arg_uint_get uint	Return the current option argument as an unsigned integer.

enum arg_enum_get value:

Input(s):

enum: A dictionary of string keys with associated values, as well as an optional `$default` key and associated value.

Output(s):

value: One of the values in *enum*.

Error(s):

stackunderflow.

typecheck.

Description: Map the current option argument to a value in *enum*, and return that value. This method is only to be called from within an option handler.

Example(s):

```
arg_enum_get.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--verbose?' -
    '--verbose?' {
        'Verbosity: ' print
        <
            $default true
            'yes' true
            'no' false
        > ;arg_enum_get
        1 sprint
    } bind
> cdef

argv myopts:new:parse

$ ./arg_enum_get.nx --verbose
Verbosity: true
$ ./arg_enum_get.nx --verbose=yes
Verbosity: true
$ ./arg_enum_get.nx --verbose=no
Verbosity: false
$
```

- arg_get arg:

Input(s): None.

Output(s):

arg: A string if an argument was specified, null otherwise.

Error(s): None.

Description: Get the argument string associated with the current flag, or null if no argument was specified. This method is only to be called from within an option handler.

Example(s):

```
arg_get.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--foo?' -
    '--foo?' {
;arg_get null ne {
    '--foo --> ' print
    ;arg_get 1 sprint
}{
    '--foo\n' print
} ifelse
    } bind
> cdef

argv myopts:new:parse

$ ./arg_get.nx --foo --foo= --foo=arg --foo
--foo
--foo --> ''
--foo --> 'arg'
--foo
$
```

– **arg_int_get int:**

Input(s): None.

Output(s):

int: An integer.

Error(s): None.

Description: Return the current option argument as an integer. Perform input validation, and cause the *parse* method to return an error if the argument cannot be converted to an integer. This method is only to be called from within an option handler.

Example(s):

```
arg_int_get.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--foo?' -
    '--foo?' {
'--foo --> ' print
;arg_int_get 1 sprint
    } bind
> cdef

argv myopts:new:parse

$ ./arg_int_get.nx --foo=42 --foo=+43 --foo=-44 --foo=hi
--foo --> 42
--foo --> 43
--foo --> -44
arg_int_get.nx: Error parsing value 'hi' for option --foo
$
```

– **arg_uint_get uint:**

Input(s): None.

Output(s):

uint: An unsigned integer.

Error(s): None.

Description: Return the current option argument as an unsigned integer. Perform input validation, and cause the *parse* method to return an error if the argument cannot be converted to an unsigned integer. This method is only to be called from within an option handler.

Example(s):

```
arg_uint_get.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--foo?' -
    '--foo?' {
    '--foo --> ' print
    ;arg_uint_get 1 sprint
    } bind
> cdef

argv myopts:new:parse

$ ./arg_uint_get.nx --foo=0 --foo=42 --foo=+43 --foo=-5
--foo --> 0
--foo --> 42
--foo --> 43
arg_uint_get.nx: Integer must be non-negative for option --foo
$
```

– **argv_get argv:**

Input(s): None.

Output(s):

argv: An array of strings.

Error(s): None.

Description: Get the argument array that was passed in to the *parse* method. This method is only to be called from within an option handler.

Example(s):

```
argv_get.nx:
#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--foo?' -
    '--foo?' {
'argv: ' print
;argv_get 1 sprint
    } bind
> cdef

argv myopts:new:parse

$ ./argv_get.nx --foo -- unprocessed args
argv: ['./argv_get.nx' '--foo' '--' 'unprocessed' 'args']
$
```

errstr **error_escape -:**

Input(s):

errstr: An error string.

Output(s): None (does not return).

Error(s):

ioerror.

stackunderflow.

typecheck.

Description: Call the *error_print* method, then clean up from an error, such that the *parse* method returns an error.

Example(s):

```

error_escape.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--bang' -
    '--bang' {
        'This is an error string' ;error_escape
    } bind
> cdef

argv myopts:new:parse {
    'Parse error\n' print
}{
    'Parse success\n' print
} ifelse

$ ./error_escape.nx
Parse success
$ ./error_escape.nx --bang
error_escape.nx: This is an error string
Parse error
$

```

errstr* error_print -:*Input(s):****errstr:** An error string.**Output(s):** None.**Error(s):****ioerror.****stackunderflow.****typecheck.****Description:** Print *errstr* to stderr. This method is only to be called from within an option handler.**Example(s):**


```
error_print.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--bang' -
    '--bang' {
        'This is an error string' ;error_print
    } bind
> cdef

argv myopts:new:parse

$ ./error_print.nx
$ ./error_print.nx --bang
error_print.nx: This is an error string
$
```

- flag_get *flag*:

Input(s): None.

Output(s):

flag: A string that contains the argument, including any leading dashes, but excluding any trailing argument characters.

Error(s): None.

Description: Get the current argument flag. This method is only to be called from within an option handler.

Example(s):

```
flag_get.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--foo?' -
    '--foo?' {
'--foo --> ' print
;flag_get 1 sprint
    } bind
> cdef

argv myopts:new:parse

$ ./flag_get.nx --foo --foo= --foo=blah
--foo --> '--foo'
--foo --> '--foo'
--foo --> '--foo'
$
```

– **index_get index:**

Input(s): None.

Output(s):

index: Array index of current argument, within the array passed in to the *parse* method.

Error(s): None.

Description: Get the array index of the current argument, within the array passed in to the *parse* method. This method is only to be called from within an option handler.

Example(s):

```

index_get.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--foo?' -
    '--foo?' {
`index: ' print
;index_get 1 sprint
    } bind
> cdef

argv myopts:new:parse

$ ./index_get.nx --foo --foo=42 --foo=
index: 1
index: 2
index: 3
$

```

- new *instance*:**Input(s):** None.**Output(s):****instance:** An instance of clopt.**Error(s):** None.**Description:** Constructor.**Example(s):**

```

onyx:0> $modclopt mclass:singleton:load
onyx:0> clopt:new
onyx:1> 1 sprint
-instance=$clopt-
onyx:0>

```

argv* parse remainder false:**argv* parse true:****Input(s):****argv:** An array of strings. The first element in the array is the program path, and the rest of the array is arguments.

Output(s):

remainder: A subarray of *argv* that contains any remaining unprocessed arguments.

false: Success.

true: An error occurred during parsing.

Error(s):

stackunderflow.

typecheck.

Description: Parse the arguments contained in *argv* and call the appropriate argument handler methods. Stop processing when there is an error, the `--` argument is processed, or the entire input array has been processed.

Example(s):

```
parse.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--foo?' -
    '--foo?' {
;arg_get null ne {
    '--foo --> ' print
    ;arg_get 1 sprint
} {
    '--foo\n' print
} ifelse
    } bind
> cdef

argv myopts:new:parse {
    'Error\n' print
} {
    'Success. Remainder: ' print
    1 sprint
} ifelse

$ ./parse.nx --foo --foo=bar
--foo
--foo --> 'bar'
Success. Remainder: []
$ ./parse.nx --foo --foo=bar -- unprocessed arguments
--foo
--foo --> 'bar'
Success. Remainder: ['unprocessed' 'arguments']
$ ./parse.nx --foo bang
--foo
Success. Remainder: ['bang']
$ ./parse.nx --foo --bang
parse.nx: Error interpreting option --bang
--foo
Error
$
```

– progname_get progname:**Input(s):** None.**Output(s):****progname:** A string that is the basename of the first string in the argument array passed to the *parse* method.**Error(s):** None.**Description:** Get the program name, which is the basename of the first string in the argument array passed to the *parse* method. This method is only to be called from within an option handler.**Example(s):**

```
progname_get.nx:

#!/usr/bin/env onyx

# Load the clopt module.
$modclopt mclass:singleton:load

# Subclass clopt and add option handlers.
$myopts clopt <
><
    #class#
    #- new #instance
    $new {
        ;rnew
        #instance
    } bind

    #instance#
    #- '--foo?' -
    '--foo?' {
    'progname: ' print
    ;progname_get 1 sprint
    } bind
    > cdef

argv myopts:new:parse

$ ./progname_get.nx --foo
progname: 'progname_get.nx'
$
```

Chapter 3

The onyx program

onyx is a stand-alone Onyx interpreter, with an integrated command line editor. The Onyx language is documented in a separate chapter, so this chapter documents only the differences from the main Onyx language documentation.

3.1 Usage

onyx -h

onyx -V

onyx -e <expr>

onyx [-i <expr>]* [-f <file>]* [-s <expr>]

onyx <file> [<args>]

Option descriptions:

- h:** Display usage information and exit.
- V:** Display the version number and exit.
- e <expr>:** Evaluate <expr> as Onyx code.
- i <expr>:** Evaluate initialization <expr>.
- f <file>:** Evaluate initialization <file>.
- s <expr>:** Call **start** with <expr>, rather than with the stdin file.

3.2 Environment variables

ONYX_EDITOR: By default, the command line editor uses emacs key bindings. Use this variable to explicitly set the key bindings to either “emacs” or “vi”.

ONYXRC: If this variable is set to the name of a file, that file will be evaluated as part of the initialization of interactive onyx sessions. A typical setting for this would be “~/ .onyxrc”.

3.3 Initialization for interactive sessions

When *onyx* is run interactively, there are several stages of initialization, some of which can be controlled directly by the user.

1. The interpreter is booted.
2. Standard I/O is set up.
3. The initial thread is created and used by all subsequent steps.
4. The initial thread's stdin is modified to support interactive command line editing.
5. Language changes specific to interactive invocation are made (see Section 3.4).
6. Initialization expressions and scripts (specified by the `-i` and `-s` flags) are evaluated in the order they are specified on the command line.
7. If the `ONYXRC` environment variable is set, then the contents of the file it specifies are evaluated.
8. stdin is evaluated.

3.4 Language differences

If *onyx* is being run interactively:

- The name “stop” is redefined in the initial thread's `errordict` to recursively evaluate the stdin file in a stopped context in order to keep the interpreter from exiting on error. It is possible (though generally unlikely, since the user must type a very long line of code) for buffering of stdin to cause strange things to occur; any additional program execution after an error is a result of this.
- The name “resume” is defined in the initial thread's `threaddict` to clear the state snapshot stored in `currenterror`, then call the stop operator. Thus, when an error occurs, when the user is ready to continue running after addressing any issues the error caused, this provides a convenient way to resume.
- The name “promptstring” is defined in `systemdict`; it takes no arguments and returns a string. The return string is used as the interactive prompt. For the duration of the call to `promptstring`, a temporary definition called “`promptdict`” is stored in the top dictionary on `dstack`, as a side effect of the machinery that makes the interpreter somewhat resilient to errors during the call to `promptstring`.

If *onyx* is being run non-interactively:

- The name “stop” in `errordict` is redefined to call the die operator with an argument of 1.

Chapter 4

The libonyx library

The *libonyx* library implements an embeddable Onyx interpreter. *libonyx* is designed to allow multiple interpreter instances in the same program, though since Onyx is a multi-threaded language, in most cases it makes more sense to use a single interpreter instance with multiple threads.

The Onyx language is described elsewhere in this manual, so this chapter documents the C API with as little information about the Onyx language as possible.

A minimal program that runs the Onyx interpreter interactively looks like:

```
#include <libonyx/libonyx.h>

int
main(int argc, char **argv, char **envp)
{
    cw_nx_t nx;
    cw_nxo_t thread, *nxo;

    /* Initialize libonyx and the Onyx interpreter. */
    libonyx_init(argc, argv, envp);
    nx_new(&nx, NULL);

    /* Create a thread. */
    nxo_thread_new(&thread, &nx);

    /* Set up stdin for evaluation. */
    nxo = nxo_stack_push(nxo_thread_ostack_get(&thread));
    nxo_dup(nxo, nxo_thread_stdin_get(&thread));
    nxo_attr_set(nxo, NXOA_EXECUTABLE);

    /* Start the thread. */
    nxo_thread_start(&thread);

    /* Clean up. */
    nx_delete(&nx);
    libonyx_shutdown();
    return 0;
}
```

In many cases, an application will need to implement additional Onyx operators or handles (and make them accessible from within the Onyx interpreter) in order to make the application accessible/controllable from the Onyx interpreter. If the application user interface is to be interaction with the Onyx interpreter, then little else needs to be done. Note that Onyx supports loadable modules, so it is usually possible to extend Onyx via modules, though embedding *libonyx* directly into the application also works.

4.1 Compilation

Use the following compiler command line to compile applications with *libonyx*.

```
cc `onyx_config --cppflags` <file> `onyx_config --ldflags --libs`
```

4.2 Global variables

libonyx defines the following global variables, which can be used by the application:

cw_g_mema: *mema* instance, wraps the generic global allocator (also accessible via the *mem* APIs).

cw_g_nxaa: *mema* instance, wraps the global allocator that is tied to the garbage collector (also accessible via the *nxa* APIs).

4.3 Multiple interpreters

libonyx supports running multiple interpreters (encapsulated by the *nx* class) in the same process, though as already mentioned, it usually makes more sense to use threads. The values associated with *argv* and *envdict* are shared among all interpreters, but otherwise, no state is shared between interpreters by default. However, since all interpreters share a single garbage collector, C code can create references to the same Onyx object in more than one interpreter, and no problems will result (normal object synchronization issues notwithstanding).

4.4 Threads

libonyx encapsulates each interpreter instance in an *nx* object. An *nx* object supports running multiple concurrent threads. Each thread context is encapsulated by an *nxo* thread object.

In general, each process thread should execute in its own *nxo* thread object context, though the only explicit restriction placed on *nxo* thread object operations is that only one thread can be executing in an *nxo* thread object context at a time. In other words, the *nxo* thread class does not synchronize access to its internals, since there is normally no reason for multiple threads to execute in the same *nxo* thread object context.

4.5 Garbage collection

Since there can be arbitrary threads executing in the interpreter concurrently, there are two ways to implement safe garbage collection: concurrent or atomic. *libonyx* uses atomic garbage collection, which means that during the mark phase, the thread doing garbage collection suspends all other threads that are created via *thd_new*(..., true). In order for this to work, the garbage collector must not do any locking while the other threads are suspended, or else there is a high probability of eventual deadlock. *libonyx* itself meets these criteria, as must any C extensions to the interpreter that are executed by the garbage collector during the mark phase (reference iteration).

4.6 Exceptions

libonyx reserves *xep* exception numbers 0 to 127 and defines the following exceptions:

CW_ONYXX_OOM: Memory allocation error.

CW_ONYXX_CONTINUE: Internal use, for the **continue** operator.

CW_ONYXX_ESCAPE: Internal use, for the **escape** operator.

CW_ONYXX_EXIT: Internal use, for the **exit** operator.

CW_ONYXX_STOP: Internal use, for the **stop** operator.

CW_ONYXX_QUIT: Internal use, for the **quit** operator.

4.7 Integration issues

4.7.1 Thread creation

libonyx's garbage collector uses the *thd* class to suspend and resume all other threads during the mark phase of atomic collection. For this to work, all threads that have any contact with *libonyx* must be created as suspendible threads using the *thd* class.

This can cause integration headaches for existing threaded applications, but there is no other portable way to suspend and resume threads. The only alternative is to assure that only one thread is executing in the interpreter and to disable timeout-based (asynchronous) collection.

4.7.2 Restarted interrupted system calls

As mentioned above, *libonyx* uses thread suspension and resumption to implement garbage collection. This has the side-effect of making restarted interrupted system calls a real possibility. However, the operating system will return with a partial result if the system call was partially complete when it was interrupted. In practice, what this means is that short reads and writes are possible where they otherwise wouldn't happen, so the application should not make any assumptions about interruptible system calls always completing with a full result. See the *thd* class documentation for more details.

4.7.3 Signals

Depending on how *libonyx* is built, *SIGUSR1* and *SIGUSR2* may be reserved by the *thd* class for thread suspension and resumption. Additionally, the *SIGPIPE* signal is ignored by default, since socket operations can cause *SIGPIPE* signals, for which the library has no use.

4.8 Guidelines for writing extensions

When embedding *libonyx* in an application, it is usually desirable to add some operators so that the interpreter can interact with the rest of the application. The *libonyx* source code contains hundreds of operators that can be used as examples when writing new operators. However, there are some very important rules that operators must follow, some of which may not be obvious when reading the code.

- Manually managed (*malloc()*/*free()*) memory should not be allocated unless the code is very careful. If a function recurses into the interpreter (this includes calls to functions such as *nxo_thread_nerror()*), there is the very real possibility that control will never return to the operator due to an exception. Code must either catch all exceptions and clean up allocations, or not recurse into the interpreter.
- Composite objects should never be allocated on the C stack. The garbage collector has no knowledge of such objects, so if the only reference to an object is on the C stack, the object may be collected, which will lead to unpredictable program behavior. Instead of allocating objects on the C stack, use *tstack*, available via *nxo_thread_tstack_get()*, which is a per-thread stack that the garbage collector scans.
- For an object to be safe from garbage collection, there must always be at least one reference to it inside the interpreter. So, if C code obtains a pointer to a composite object, then destroys the last known internal Onyx reference (pops it off a stack, redefines it in a dict, replaces an element of an array, etc.), the pointer is no longer safe to use. The *libonyx* API is structured such that it is invalid to do such a thing, for this reason.
- *tstack* must be cleaned up before returning from a function. This constraint is placed on the code in order to avoid leaking space on *tstack*. In debug versions of *libonyx*, this is enforced by assertions. The one exception to this rule has to do with *xep* exceptions, in which case the catchers of the exceptions are responsible for cleaning up *tstack*. Therefore, it is not necessary to catch exceptions merely to avoid *tstack* leakage.

Since Onyx type checking is dynamic, it is the responsibility of the operators to assure objects are the correct type before calling any of the type-specific *nxo_**() functions. Failure to do so will result in unpredictable behavior and likely crashes.

4.9 API

void *libonyx_init*(int *a_argc*, char *a_argv*, char ***a_envp*):**

Input(s):

***a_argc*:** Number of command line arguments.

***a_argv*:** Pointer to an array of command line argument strings.

***a_envp*:** Pointer to an array of environment variable strings.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Initialize various global state.

void *libonyx_shutdown*(void):

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Clean up the global variables that are initialized by *libonyx_init*().

cw_nxo_t * *libonyx_argv_get*(void):

Input(s): None.

Output(s):

retval: Pointer to the *nxo* corresponding to *argv* .

Exception(s): None.

Description: Return a pointer to the *nxo* corresponding to *argv* .

cw_nxo_t * *libonyx_envdict_get*(void):

Input(s): None.

Output(s):

retval: Pointer to the *nxo* corresponding to *envdict* .

Exception(s): None.

Description: Return a pointer to the *nxo* corresponding to *envdict* .

cw_nxo_t * *libonyx_gcdict_get*(void):

Input(s): None.

Output(s):

retval: Pointer to the *nxo* corresponding to *gcdict* .

Exception(s): None.

Description: Return a pointer to the *nxo* corresponding to *gcdict* .

void * *cw_opaque_alloc_t*(void *a_arg, size_t a_size, const char *a_filename, uint32_t a_line_num):

Input(s):

a_arg: Opaque pointer.

a_size: Size of memory range to allocate.

a_filename: Should be `__FILE__`.

a_line_num: Should be `__LINE__`.

Output(s):

retval: Pointer to a memory range.

Exception(s):

CW_ONYXX_OOM.

Description: Allocate *a_size* of space and return a pointer to it.

void * *cw_opaque_calloc_t*(void *a_arg, size_t a_number, size_t a_size, const char *a_filename, uint32_t a_line_num):

Input(s):

a_arg: Opaque pointer.
a_number: Number of elements to allocate.
a_size: Size of each element to allocate.
a_filename: Should be `__FILE__`.
a_line_num: Should be `__LINE__`.

Output(s):

retval: Pointer to a zeroed memory range.

Exception(s):

CW_ONYXX_OOM.

Description: Allocate a zeroed array of *a_number* objects, each *a_size* bytes long, and return a pointer to the array.

void * *cw_opaque_realloc_t*(void *a_arg, void *a_ptr, size_t a_size, size_t a_old_size, const char *a_filename, uint32_t a_line_num):

Input(s):

a_arg: Opaque pointer.
a_ptr: Pointer to memory range to be reallocated.
a_size: Size of memory range to allocate.
a_old_size: Size of memory range previously pointed to by *a_ptr*.
a_filename: Should be `__FILE__`.
a_line_num: Should be `__LINE__`.

Output(s):

retval: Pointer to a memory range.

Exception(s):

CW_ONYXX_OOM.

Description: Reallocate *a_size* of space and return a pointer to it.

void *cw_opaque_dealloc_t*(void *a_mem, void *a_ptr, size_t a_size, const char *a_filename, uint32_t a_line_num):

Input(s):

a_arg: Opaque pointer.
a_ptr: Pointer to memory range to be freed.
a_size: Size of memory range pointed to by *a_ptr*.
a_filename: Should be `__FILE__`.
a_line_num: Should be `__LINE__`.

Output(s): None.**Exception(s):** None.

Description: Deallocate the memory pointed to by *a_ptr*.

void * *cw_opaque_alloc*(*cw_opaque_alloc_t* *a_func, void *a_arg, size_t a_size):

Input(s):

a_func: Opaque allocator function pointer.
a_arg: Opaque pointer.
a_size: Size of memory range to allocate.

Output(s):**retval:** Pointer to a memory range.**Exception(s):****CW_ONYXX_OOM.****Description:** Allocate *a_size* of space and return a pointer to it.**void *cw_opaque_calloc(cw_opaque_calloc_t *a_func, void *a_arg, size_t a_number, size_t a_size):****Input(s):****a_func:** Opaque allocator function pointer.**a_arg:** Opaque pointer.**a_number:** Number of elements to allocate.**a_size:** Size of each element to allocate.**Output(s):****retval:** Pointer to a zeroed memory range.**Exception(s):****CW_ONYXX_OOM.****Description:** Allocate a zeroed array of *a_number* objects, each *a_size* bytes long, and return a pointer to the array.**void *cw_opaque_realloc(cw_opaque_realloc_t *a_func, void *a_arg, void *a_ptr, size_t a_size, size_t a_old_size):****Input(s):****a_func:** Opaque allocator function pointer.**a_arg:** Opaque pointer.**a_ptr:** Pointer to memory range to be reallocated.**a_size:** Size of memory range to allocate.**a_old_size:** Size of memory range previously pointed to by *a_ptr*.**Output(s):****retval:** Pointer to a memory range.**Exception(s):****CW_ONYXX_OOM.****Description:** Reallocate *a_size* of space and return a pointer to it.**void cw_opaque_dealloc(cw_opaque_dealloc_t *a_func, void *a_mem, void *a_ptr, size_t a_size):****Input(s):****a_func:** Opaque allocator function pointer.**a_arg:** Opaque pointer.**a_ptr:** Pointer to memory range to be freed.**a_size:** Size of memory range pointed to by *a_ptr*.**Output(s):** None.**Exception(s):** None.**Description:** Deallocate the memory pointed to by *a_ptr*.**void cw_onyx_code(cw_nxo_t *a_thread, const char *a_code):****Input(s):**

a.thread: Pointer to a thread *nxo*.

a.code: A `”`-delimited string constant.

Output(s): None.

Exception(s): Depends on actions of *a.code*.

Description: Convenience macro for static embedded Onyx code.

void *cw_assert*(expression):

Input(s):

expression: C expression that evaluates to zero or non-zero.

Output(s): Possible error printed to *stderr*.

Exception(s): None.

Description: If the expression evaluates to zero, print an error message to *stderr* and *abort()*.

Note: This macro is only active if the *CW_ASSERT* cpp macro is defined.

void *cw_dassert*(expression):

Input(s):

expression: C expression that evaluates to zero or non-zero.

Output(s): Possible error printed to *stderr*.

Exception(s): None.

Description: If the expression evaluates to zero, print an error message to *stderr* and *abort()*.

Note: This macro is only active if the *CW_ASSERT* and *CW_DBG* cpp macros are defined.

void *cw_not_reached*(void):

Input(s): None.

Output(s): Error printed to *stderr*.

Exception(s): None.

Description: Abort with an error message.

Note: This macro is only active if the *CW_ASSERT* cpp macro is defined.

void *cw_check_ptr*(a_pointer):

Input(s):

a_pointer: A pointer.

Output(s): Possible error printed to *stderr*.

Exception(s): None.

Description: If *a_pointer* is NULL, print an error message to *stderr* and *abort()*.

Note: This macro is only active if the *CW_ASSERT* cpp macro is defined.

void *cw_error*(const char *a_str):

Input(s):

a_str: Pointer to a NULL-terminated character array.

Output(s): Contents of *a_str*, followed by a carriage return, printed to *stderr*.

Exception(s): None.

Description: Print the contents of *a_str*, followed by a carriage return, to *stderr*.

uint64_t *cw_ntohq*(uint64_t a_val):

Input(s):**a_val:** 64 bit integer.**Output(s):****retval:** 64 bit integer.**Exception(s):** None.**Description:** Convert *a_val* from network byte order to host byte order and return the result.**uint64_t cw_htonq(uint64_t a_val):****Input(s):****a_val:** 64 bit integer.**Output(s):****retval:** 64 bit integer.**Exception(s):** None.**Description:** Convert *a_val* from host byte order to network byte order and return the result.**uint32_t cw_offsetof(<type> a_type, <field_name> a_field):****Input(s):****a_type:** C structure type name.**a_field:** Name of a field within *a_type*.**Output(s):****retval:** Offset of *a_field* into *a_type*.**Exception(s):** None.**Description:** Calculate the offset of *a_field* into *a_type* and return the result.

4.10 Classes

4.10.1 ch

The *ch* class implements chained hashing. It uses a simple bucket chaining hash table implementation. Table size is set at creation time, and cannot be changed, so performance will suffer if a *ch* object is over-filled. The main *cw_ch_t* data structure and the table are contiguously allocated, which means that care must be taken when manually pre-allocating space for the structure. Each item that is inserted into the *ch* object is encapsulated by a *chi* object, for which space can optionally be passed in as a parameter to *ch_insert()*. If no space for the *chi* object is passed in, an opaque allocator function is used internally for allocation.

Multiple entries with the same key are allowed and are stored in LIFO order.

The *ch* class is meant to be small and simple without compromising performance. Note that it is not well suited for situations where the number of items can vary wildly; the *dch* class is designed for such situations.

API

uint32_t CW_CH_TABLE2SIZEOF(uint32_t a_table_size):

Input(s):

a_table_size: Number of slots in the hash table.

Output(s):

retval: Size of a *ch* object with *a_table_size* slots.

Exception(s): None.

Description: Calculate the size of a *ch* object with *a_table_size* slots.

***ch_new*(cw_ch_t *a_ch, cw_mema_t *a_mema, uint32_t a_table_size, cw_ch_hash_t *a_hash, cw_ch_key_comp_t *a_key_comp):**

Input(s):

a_ch: Pointer to space for a *ch* with *a_table_size* slots, or NULL. Use the *CW.CH.TABLE2SIZEOF()* macro to calculate the total space needed for a given table size.

a_mema: Pointer to a memory allocator.

a_table_size: Number of slots in the hash table.

a_hash: Pointer to a hashing function.

a_key_comp: Pointer to a key comparison function.

Output(s):

retval: Pointer to a *ch*.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

void *ch_delete*(cw_ch_t *a_ch):

Input(s):

a_ch: Pointer to a *ch*.

Output(s): None.**Exception(s):** None.

Description: Destructor.

uint32_t *ch_count*(cw_ch_t *a_ch):

Input(s):

a_ch: Pointer to a *ch*.

Output(s):

retval: Number of items in *a_ch*.

Exception(s): None.

Description: Return the number of items in *a_ch*.

void *ch_insert*(cw_ch_t *a_ch, const void *a_key, const void *a_data, cw_chi_t *a_chi):

Input(s):

a_ch: Pointer to a *ch*.

a_key: Pointer to a key.

a_data: Pointer to data associated with *a_key*.

a_chi: Pointer to space for a *chi*, or NULL.

Output(s): None.

Exception(s):**CW_ONYXX_OOM.**

Description: Insert *a_data* into *a_ch*, using key *a_key*. Use *a_chi* for the internal *chi* container if non-NULL.

bool *ch_remove*(*cw_ch_t* **a_ch*, const void **a_search_key*, void *r_key*, void ***r_data*, *cw_chi_t* ***r_chi*):**

Input(s):**a_ch:** Pointer to a *ch*.**a_search_key:** Pointer to the key to search with.**r_key:** Pointer to a key pointer, or NULL.**r_data:** Pointer to a data pointer, or NULL.**r_chi:** Pointer to a *chi* pointer, or NULL.**Output(s):****retval:****false:** Success.**true:** Item with key *a_search_key* not found.***r_key:** If (*r_key* != NULL) and (retval == false), pointer to a key. Otherwise, undefined.***r_data:** If (*r_data* != NULL) and (retval == false), pointer to data. Otherwise, undefined.***r_chi:** If (*r_chi* != NULL) and (retval == false), pointer to space for a *chi*, or NULL. Otherwise, undefined.**Exception(s):** None.

Description: Remove the item from *a_ch* that was most recently inserted with key *a_search_key*. If successful, set **r_key* and **r_data* to point to the key, data, and externally allocated *chi*, respectively.

void *ch_chi_remove*(*cw_ch_t* **a_ch*, *cw_chi_t* **a_chi*):

Input(s):**a_ch:** Pointer to a *ch*.**a_chi:** Pointer to a *chi*.**Output(s):** None.**Exception(s):** None.

Description: Remove the item from *a_ch* that was inserted using *a_chi*.

bool *ch_search*(*cw_ch_t* **a_ch*, const void **a_key*, void *r_data*):**

Input(s):**a_ch:** Pointer to a *ch*.**a_key:** Pointer to a key.**r_data:** Pointer to a data pointer, or NULL.**Output(s):****retval:****false:** Success.**true:** Item with key *a_key* not found in *a_ch*.***r_data:** If (*r_data* != NULL) and (retval == false), pointer to data.**Exception(s):** None.

Description: Search for the most recently inserted item with key *a_key*. If found, **r_data* to point to the associated data.

uint32_t *ch_string_hash*(const void *a_key):

Input(s):

a_key: Pointer to a key.

Output(s):

retval: Hash result.

Exception(s): None.

Description: NULL-terminated string hashing function.

uint32_t *ch_direct_hash*(const void *a_key):

Input(s):

a_key: Pointer to a key.

Output(s):

retval: Hash result.

Exception(s): None.

Description: Direct (pointer) hashing function.

bool *ch_string_key_comp*(const void *a_k1, const void *a_k2):

Input(s):

a_k1: Pointer to a key.

a_k2: Pointer to a key.

Output(s):

retval:

false: Not equal.

true: Equal.

Exception(s): None.

Description: Test two keys (NULL-terminated strings) for equality.

bool *ch_direct_key_comp*(const void *a_k1, const void *a_k2):

Input(s):

a_k1: Pointer to a key.

a_k2: Pointer to a key.

Output(s):

retval:

false: Not equal.

true: Equal.

Exception(s): None.

Description: Test two keys (pointers) for equality.

4.10.2 *cnd*

The *cnd* class implements condition variables, which can be used in conjunction with the *mtx* class to wait for a condition to occur.

API

void *cnd_new*(*cw_cnd_t* **a_cnd*):

Input(s):

a_cnd: Pointer to space for a *cnd*.

Output(s): None.

Exception(s): None.

Description: Constructor.

void *cnd_delete*(*cw_cnd_t* **a_cnd*):

Input(s):

a_cnd: Pointer to a *cnd*.

Output(s): None.

Exception(s): None.

Description: Destructor.

void *cnd_signal*(*cw_cnd_t* **a_cnd*):

Input(s):

a_cnd: Pointer to a *cnd*.

Output(s): None.

Exception(s): None.

Description: Signal one thread waiting on *a_cnd*, if there are any waiters.

void *cnd_broadcast*(*cw_cnd_t* **a_cnd*):

Input(s):

a_cnd: Pointer to a *cnd*.

Output(s): None.

Exception(s): None.

Description: Signal all threads waiting on *a_cnd*.

bool *cnd_timedwait*(*cw_cnd_t* **a_cnd*, *cw_mtx_t* **a_mtx*, const struct timespec **a_timeout*):

Input(s):

a_cnd: Pointer to a *cnd*.

a_mtx: Pointer to a *mtx*.

a_timeout: Timeout, specified as an absolute time interval.

Output(s):

retval:

false: Success.

true: Timeout.

Exception(s): None.

Description: Wait for *a_cnd* for at least *a_time*.

void *cnd_wait*(*cw_cnd_t* **a_cnd*, *cw_mtx_t* **a_mtx*):

Input(s):

a_cnd: Pointer to a *cnd*.

a_mtx: Pointer to a *mtx*.
Output(s): None.
Exception(s): None.
Description: Wait for *a_cnd*.

4.10.3 dch

The *dch* class implements dynamic chained hashing. The *dch* class is a wrapper around the *ch* class that enforces fullness/emptiness constraints and rebuilds the hash table when necessary. Other than this added functionality, the *dch* class behaves almost exactly like the *ch* class. See the *ch* class documentation for additional information.

API

***dch_new*(cw_dch_t *a_dch, cw_mema_t *a_mema, uint32_t a_base_table, uint32_t a_base_grow, uint32_t a_base_shrink, cw_ch_hash_t *a_hash, cw_ch_key_comp_t *a_key_comp):**

Input(s):
a_dch: Pointer to space for a *dch*, or NULL.
a_mema: Pointer to a memory allocator.
a_base_table: Number of slots in the initial hash table.
a_base_grow: Maximum number of items to allow in a *dch* before doubling the hash table size. The same proportions (in relation to *a_base_table*) are used to decide when to double the table additional times.
a_base_shrink: Minimum proportional (with respect to *a_base_table*) emptiness to allow in the hash table before cutting the hash table size in half.
a_hash: Pointer to a hashing function.
a_key_comp: Pointer to a key comparison function.
Output(s):
retval: Pointer to a *dch*.
Exception(s):
CW_ONYXX_OOM.
Description: Constructor.

***void dch_delete*(cw_dch_t *a_dch):**

Input(s):
a_dch: Pointer to a *dch*.
Output(s): None.
Exception(s): None.
Description: Destructor.

***uint32_t dch_count*(cw_dch_t *a_dch):**

Input(s):
a_dch: Pointer to a *dch*.
Output(s):

retval: Number of items in *a_dch*.

Exception(s): None.

Description: Return the number of items in *a_dch*.

bool *dch_shrinkable_get*(cw_dch_t *a_dch):

Input(s):

a_dch: Pointer to a *dch*.

Output(s):

retval:

true: *a_dch* is currently shrinkable (initial default).

false: *a_dch* is not currently shrinkable, so no attempt will be made to shrink the hash table in *dch_remove()* or *dch_remove_iterate()*.

Exception(s): None.

Description: Return whether *a_dch* is currently shrinkable.

void *dch_shrinkable_set*(cw_dch_t *a_dch, bool a_shrinkable):

Input(s):

a_dch: Pointer to a *dch*.

a_shrinkable:

true: Set *a_dch* to be shrinkable.

false: Set *a_dch* to not be shrinkable. No attempt will be made to shrink the hash table in *dch_remove()* or *dch_remove_iterate()* while in this state.

Output(s): None.

Exception(s): None.

Description: Set whether *a_dch* should try to shrink the hash table in *dch_remove()* and *dch_remove_iterate()*.

void *dch_insert*(cw_dch_t *a_dch, const void *a_key, const void *a_data, cw_chi_t *a_chi):

Input(s):

a_dch: Pointer to a *dch*.

a_key: Pointer to a key.

a_data: Pointer to data associated with *a_key*.

a_chi: Pointer to space for a *chi*, or NULL.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Insert *a_data* into *a_dch*, using key *a_key*. Use *a_chi* for the internal *chi* container if non-NULL.

bool *dch_remove*(cw_dch_t *a_dch, const void *a_search_key, void **r_key, void **r_data, cw_chi_t **r_chi):

Input(s):

a_dch: Pointer to a *dch*.

a_search_key: Pointer to the key to search with.

r_key: Pointer to a key pointer, or NULL.

r_data: Pointer to a data pointer, or NULL.

r_chi: Pointer to a *chi* pointer, or NULL.

Output(s):

retval:

false: Success.

true: Item with key *a_search_key* not found.

***r_key:** If (*r_key* != NULL) and (retval == false), pointer to a key. Otherwise, undefined.

***r_data:** If (*r_data* != NULL) and (retval == false), pointer to data. Otherwise, undefined.

***r_chi:** If (*r_chi* != NULL) and (retval == false), pointer to space for a *chi*, or NULL. Otherwise, undefined.

Exception(s): None.

Description: Remove the item from *a_dch* that was most recently inserted with key *a_search_key*. If successful, set **r_key* and **r_data* to point to the key, data, and externally allocated *chi*, respectively.

bool dch_chi_remove(cw_dch_t *a_dch, cw_chi_t *a_chi):

Input(s):

a_dch: Pointer to a *dch*.

a_chi: Pointer to a *chi*.

Output(s): None.

Exception(s): None.

Description: Remove the item from *a_dch* that was inserted using *a_chi*.

bool dch_search(cw_dch_t *a_dch, const void *a_key, void **r_data):

Input(s):

a_dch: Pointer to a *dch*.

a_key: Pointer to a key.

r_data: Pointer to a data pointer, or NULL.

Output(s):

retval:

false: Success.

true: Item with key *a_key* not found in *a_dch*.

***r_data:** If (*r_data* != NULL) and (retval == false), pointer to data.

Exception(s): None.

Description: Search for the most recently inserted item with key *a_key*. If found, **r_data* to point to the associated data.

4.10.4 mb

The *mb* class implements memory barriers. A memory barrier is a low level construct that is sometimes useful for guaranteeing the order in which memory operations take place, even when multiple microprocessors are involved. In most cases, mutexes are the best choice for synchronizing data access, but sometimes it is convenient (and critical to performance) to use memory barriers where weaker access constraints are adequate.

API**void *mb_write*(void):****Input(s):** None.**Output(s):** None.**Exception(s):** None.**Description:** Create a write barrier, so that any memory writes done before the memory barrier are guaranteed to be visible by the time any memory writes after the memory barrier become visible.**4.10.5 mem**

The *mem* class implements a memory allocation (malloc) wrapper. For the debug version of *libonyx*, extra information is hashed for each memory allocation that allows tracking of the following:

- File/line number of allocation.
- Double allocation/deallocation of the same address.
- Memory leaks (memory left allocated at mem destruction time).

If any memory leaks are detected, diagnostic output is printed to *stderr*.

Also, the debug version of *libonyx* sets all newly allocated bytes to 0xa5, and all deallocated bytes to 0x5a (except in the case of *mem_calloc*()). This tends to cause things to break sooner when uninitialized or deallocated memory is referenced.

In general, the *mem* class doesn't need to be used directly. Instead, there are several preprocessor macros that can be used: *cw_malloc*(), *cw_calloc*(), *cw_realloc*(), and *cw_free*().

The *mema* class encapsulates a set of pointers to allocation functions. It is used by the *ch* and *dch* classes.

API

***cw_mema_t * mema_new*(*cw_mema_t *a_mema*, *cw_opaque_alloc_t *a_alloc*, *cw_opaque_calloc_t *a_calloc*, *cw_opaque_realloc_t *a_realloc*, *cw_opaque_dealloc_t *a_dealloc*, *void *a_arg*):**

Input(s):**a_mema:** Pointer to space for a *mema*, or NULL.**a_alloc:** Pointer to an allocation function.**a_calloc:** Pointer to a zero-ing allocation function.**a_realloc:** Pointer to a reallocation function.**a_dealloc:** Pointer to a deallocation function.**a_arg:** Opaque pointer to pass to *a_alloc*(), *a_calloc*(), *a_realloc*(), and *a_dealloc*().**Output(s):****retval:** Pointer to a *mema*.**Exception(s):**

CW_ONYXX_OOM.

Description: Constructor.

void *mema_delete*(cw_mema_t *a_mema):

Input(s):

a_mema: Pointer to a *mema*.

Output(s): None.

Exception(s): None.

Description: Destructor.

cw_opaque_alloc_t * *mema_alloc_get*(cw_mema_t *a_mema):

Input(s):

a_mema: Pointer to a *mema*.

Output(s):

retval: Pointer to an allocation function.

Exception(s): None.

Description: Return a pointer to an allocation function.

cw_opaque_calloc_t * *mema_calloc_get*(cw_mema_t *a_mema):

Input(s):

a_mema: Pointer to a *mema*.

Output(s):

retval: Pointer to a zero-ing allocation function.

Exception(s): None.

Description: Return a pointer to a zero-ing allocation function.

cw_opaque_realloc_t * *mema_realloc_get*(cw_mema_t *a_mema):

Input(s):

a_mema: Pointer to a *mema*.

Output(s):

retval: Pointer to a reallocation function.

Exception(s): None.

Description: Return a pointer to a reallocation function.

cw_opaque_dealloc_t * *mema_dealloc_get*(cw_mema_t *a_mema):

Input(s):

a_mema: Pointer to a *mema*.

Output(s):

retval: Pointer to a deallocation function.

Exception(s): None.

Description: Return a pointer to a deallocation function.

cw_opaque_arg_t * *mema_arg_get*(cw_mema_t *a_mema):

Input(s):

a_mema: Pointer to a *mema*.

Output(s):

retval: Opaque pointer to pass to *a_alloc()*, *a_calloc()*, *a_realloc()*, and *a_dealloc()*.

Exception(s): None.

Description: Return an opaque pointer to pass to the allocation functions returned by *mema_alloc_get(a_mema)*, *mema_calloc_get(a_mema)*, *mema_realloc_get(a_mema)*, and *mema_dealloc_get(a_mema)*.

void * mem_malloc_e(cw_mem_t *a_mem, size_t a_size, const char *a_filename, uint32_t a_line_num):

void * mem_malloc(cw_mem_t *a_mem, size_t a_size):

void * cw_malloc(size_t a_size):

Input(s):

a_mem: Pointer to a *mem*, or NULL.

a_size: Size of memory range to allocate.

a_filename: Should be `__FILE__`.

a_line_num: Should be `__LINE__`.

Output(s):

retval: Pointer to a memory range.

Exception(s):

CW_ONYXX_OOM.

Description: *malloc()* wrapper.

void * mem_calloc_e(cw_mem_t *a_mem, size_t a_number, size_t a_size, const char *a_filename, uint32_t a_line_num):

void * mem_calloc(cw_mem_t *a_mem, size_t a_number, size_t a_size):

void * cw_calloc(size_t a_number, size_t a_size):

Input(s):

a_mem: Pointer to a *mem*, or NULL.

a_number: Number of elements to allocate.

a_size: Size of each element to allocate.

a_filename: Should be `__FILE__`.

a_line_num: Should be `__LINE__`.

Output(s):

retval: Pointer to a zeroed memory range.

Exception(s):

CW_ONYXX_OOM.

Description: *calloc()* wrapper.

void * mem_realloc_e(cw_mem_t *a_mem, void *a_ptr, size_t a_size, size_t a_old_size, const char *a_filename, uint32_t a_line_num):

void * mem_realloc(cw_mem_t *a_mem, void *a_ptr, size_t a_size):

void * cw_realloc(void *a_ptr, size_t a_size):

Input(s):

a_mem: Pointer to a *mem*, or NULL.

a_ptr: Pointer to memory range to be reallocated.

a_size: Size of memory range to allocate.

a_old_size: Size of memory range previously pointed to by *a_ptr*.

a_filename: Should be `__FILE__`.

a_line_num: Should be `__LINE__`.

Output(s):

retval: Pointer to a memory range.

Exception(s):

CW_ONYXX_OOM.

Description: *realloc()* wrapper.

void *mem_free_e*(cw_mem_t *a_mem, void *a_ptr, size_t a_size, const char *a_filename, uint32_t a_line_num):

void *mem_free*(cw_mem_t *a_mem, void *a_ptr, size_t a_size):

void *cw_free*(void *a_ptr):

Input(s):

a_mem: Pointer to a *mem*, or NULL.

a_ptr: Pointer to to memory range to be freed.

a_size: Size of memory range pointed to by *a_ptr*.

a_filename: Should be `__FILE__`.

a_line_num: Should be `__LINE__`.

Output(s): None.

Exception(s): None.

Description: *free()* wrapper.

4.10.6 mq

The *mq* class implements a simple unidirectional message queue. In addition to putting and getting messages, there are methods that control the ability to get or put. This provides a simple out of band state transition capability.

API

void *mq_new*(cw_mq_t *a_mq, cw_mema_t *a_mema, uint32_t a_msg_size):

Input(s):

a_mq: Pointer to space for a *mq*.

a_mema: Pointer to a memory allocator to use internally.

a_msg_size: Size (in bytes) of messages used for all subsequent calls to *mq_get()* and *mq_put()*.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

void *mq_delete*(cw_mq_t *a_mq):

Input(s):

a.mq: Pointer to a *mq*.

Output(s): None.

Exception(s): None.

Description: Destructor.

bool *mq_tryget*(cw_mq_t *a_mq, ...):

Input(s):

a.mq: Pointer to a *mq*.

...: Pointer to space to store a message.

Output(s):

retval:

false: Success.

true: No messages in the queue, or get is in the stop state.

***...:** If *retval* is false, a message. Otherwise, undefined.

Exception(s): None.

Description: Try to get a message, but return true if none are available.

bool *mq_timedget*(cw_mq_t *a_mq, const struct timespec *a_timeout, ...):

Input(s):

a.mq: Pointer to a *mq*.

a.timeout: Timeout, specified as an absolute time interval.

...: Pointer to space to store a message.

Output(s):

retval:

false: Success.

true: No messages in the queue, or get is in the stop state.

***...:** If *retval* is false, a message. Otherwise, undefined.

Exception(s): None.

Description: Get a message. If none are available, block until a message is available, or until timeout.

cw_bool_t *mq_get*(cw_mq_t *a_mq, ...):

Input(s):

a.mq: Pointer to a *mq*.

...: Pointer to space to store a message.

Output(s):

retval:

false: Success.

true: Get is in the stop state.

***...:** If *retval* is false, a message. Otherwise, undefined.

Exception(s): None.

Description: Get a message. If none are available, block until a message is available.

bool *mq_put*(cw_mq_t *a_mq, ...):

Input(s):

a_mq: Pointer to a *mq*.

...: A message.

Output(s):

retval:

false: Success.

true: Failure due to put being in the stop state.

Exception(s):

CW_ONYXX_OOM.

Description: Put a message in *a_mq*.

bool *mq_get_start*(cw_mq_t *a_mq):

Input(s):

a_mq: Pointer to a *mq*.

Output(s):

retval:

false: Success.

true: Error (already in start state).

Exception(s): None.

Description: Change the get operation to the start state (*mq_get()* will not return true).

bool *mq_get_stop*(cw_mq_t *a_mq):

Input(s):

a_mq: Pointer to a *mq*.

Output(s):

retval:

false: Success.

true: Error (already in stop state).

Exception(s): None.

Description: Change the get operation to the stop state (*mq_get()* will return true).

bool *mq_put_start*(cw_mq_t *a_mq):

Input(s):

a_mq: Pointer to a *mq*.

Output(s):

retval:

false: Success.

true: Error (already in start state).

Exception(s): None.

Description: Change the put operation to the start state (*mq_put()* will not return true).

bool *mq_put_stop*(cw_mq_t *a_mq):

Input(s):

a_mq: Pointer to a *mq*.

Output(s):

retval:

false: Success.

true: Error (already in stop state).

Exception(s): None.

Description: Change the put operation to the stop state (*mq_put()* will return true).

4.10.7 *mtx*

The *mtx* class implements typical mutual exclusion locks. Only one thread can hold a lock at a time, and attempting to attain the lock while already owning it has undefined results.

API

void *mtx_new*(cw_mtx_t *a_mtx):

Input(s):

a_mtx: Pointer to space for a *mtx*.

Output(s): None.

Exception(s): None.

Description: Constructor.

void *mtx_delete*(cw_mtx_t *a_mtx):

Input(s):

a_mtx: Pointer to a *mtx*.

Output(s): None.

Exception(s): None.

Description: Destructor.

void *mtx_lock*(cw_mtx_t *a_mtx):

Input(s):

a_mtx: Pointer to a *mtx*.

Output(s): None.

Exception(s): None.

Description: Lock *a_mtx*.

bool *mtx_trylock*(cw_mtx_t *a_mtx):

Input(s):

a_mtx: Pointer to a *mtx*.

Output(s):

retval:

false: Success.

true: Failure.

Exception(s): None.

Description: Try to lock *a_mtx*, but return immediately instead of blocking if *a_mtx* is already locked.

void *mtx_unlock*(*cw_mtx_t* **a_mtx*):

Input(s):

a_mtx: Pointer to a *mtx*.

Output(s): None.

Exception(s): None.

Description: Unlock *a_mtx*.

4.10.8 *nx*

The *nx* class encapsulates an Onyx interpreter instance. It contains a number of interpreter-global objects. The garbage collector is shared among all *nx* instances, so when an *nx* is destroyed, only the objects which no other *nx* references are destroyed.

API

void *cw_thread_start_t*(*cw_nxo_t* **a_thread*, *cw_op_t* **a_start*):

Input(s):

a_thread: Pointer to a thread *nxo*.

a_start: Pointer to a start function.

Output(s): None.

Exception(s): Application dependent.

Description: Type definition for a callback function that is called by *nxo_thread_start()*. This function must call *a_start*, which is the actual start function.

The main use for a start callback function is to create a top level *xep* exception handling context for each thread.

***cw_nx_t* **nx_new*(*cw_nx_t* **a_nx*, *cw_op_t* **a_thread_init*, *cw_thread_start_t* **a_thread_start*):**

Input(s):

a_nx: Pointer to space for an *nx*, or NULL.

a_thread_init: Pointer to an initialization function to be called during thread initialization, or NULL.

a_thread_start: Pointer to a thread start callback function to be called by *nxo_thread_start()*, or NULL. See the *cw_thread_start_t* documentation for details.

Output(s):

retval: Pointer to an *nx*.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

void *nx_delete*(*cw_nx_t* **a_nx*):

Input(s): Pointer to an *nx*.

Output(s): None.

Exception(s): None.

Description: Destructor.

`cw_nxoi_t nx_maxestack_get(cw_nx_t *a_nx):`

Input(s):

a_nx: Pointer to an *nx*.

Output(s):

retval: Default maximum estack depth.

Exception(s): None.

Description: Return the default maximum allowable estack depth. This value is used when creating new threads.

`void nx_maxestack_set(cw_nx_t *a_nx, cw_nxoi_t a_maxestack):`

Input(s):

a_nx: Pointer to an *nx*.

a_maxestack: Default maximum estack depth.

Output(s): None.

Exception(s): None.

Description: Set *a_nx*'s default maximum allowable estack depth to *a_maxestack*.

`bool nx_tailopt_get(cw_nx_t *a_nx):`

Input(s):

a_nx: Pointer to an *nx*.

Output(s):

retval: Default tail optimization setting.

Exception(s): None.

Description: Return the default tail optimization setting. This value is used when creating new threads.

`void nx_tailopt_set(cw_nx_t *a_nx, bool a_tailopt):`

Input(s):

a_nx: Pointer to an *nx*.

a_tailopt: Default tail optimization setting.

Output(s): None.

Exception(s): None.

Description: Set *a_nx*'s default tail optimization setting to *a_tailopt*.

`cw_nxo_t * nx_systemdict_get(cw_nx_t *a_nx):`

Input(s):

a_nx: Pointer to an *nx*.

Output(s):

retval: Pointer to the *nxo* corresponding to *systemdict* .

Exception(s): None.

Description: Return a pointer to the *nxo* corresponding to *systemdict* .

`cw_nxo_t * nx_globaldict_get(cw_nx_t *a_nx):`

Input(s):

a_nx: Pointer to an *nx*.

Output(s):

retval: Pointer to the *nxo* corresponding to *globaldict* .

Exception(s): None.

Description: Return a pointer to the *nxo* corresponding to *globaldict* .

`cw_nxo_t * nx_stdin_get(cw_nx_t *a_nx):`

Input(s):

a_nx: Pointer to an *nx*.

Output(s):

retval: Pointer to the *nxo* corresponding to *stdin* .

Exception(s): None.

Description: Return a pointer to the *nxo* corresponding to *stdin* .

`void nx_stdin_set(cw_nx_t *a_nx, cw_nxo_t *a_stdin):`

Input(s):

a_nx: Pointer to an *nx*.

a_stdin: Pointer to a file *nxo*.

Output(s): None.

Exception(s): None.

Description: Set *a_nx*'s *stdin* to *a_stdin*.

`cw_nxo_t * nx_stdout_get(cw_nx_t *a_nx):`

Input(s):

a_nx: Pointer to an *nx*.

Output(s):

retval: Pointer to the *nxo* corresponding to *stdout* .

Exception(s): None.

Description: Return a pointer to the *nxo* corresponding to *stdout* .

`void nx_stdout_set(cw_nx_t *a_nx, cw_nxo_t *a_stdout):`

Input(s):

a_nx: Pointer to an *nx*.

a_stdout: Pointer to a file *nxo*.

Output(s): None.

Exception(s): None.

Description: Set *a_nx*'s *stdout* to *a_stdout*.

`cw_nxo_t * nx_stderr_get(cw_nx_t *a_nx):`

Input(s):

a_nx: Pointer to an *nx*.

Output(s):**retval:** Pointer to the *nxo* corresponding to *stderr* .**Exception(s):** None.**Description:** Return a pointer to the *nxo* corresponding to *stderr* .**void *nx_stderr_set*(*cx_nx_t* **a_nx*, *cx_nxo_t* **a_stderr*):****Input(s):****a_nx:** Pointer to an *nx*.**a_stderr:** Pointer to a file *nxo*.**Output(s):** None.**Exception(s):** None.**Description:** Set *a_nx*'s *stderr* to *a_stderr*.**4.10.9 nxa**

The *nxa* class implements garbage collection. The garbage collector runs a separate thread that is controlled via an asynchronous message queue.

API

void * *nxa_malloc_e*(void **a_arg*, *size_t* *a_size*, const char **a_filename*, *uint32_t* *a_line_num*):
void * *nxa_malloc*(*size_t* *a_size*):

Input(s):**a_arg:** Unused.**a_size:** Size of memory range to allocate.**a_filename:** Should be *__FILE__*.**a_line_num:** Should be *__LINE__*.**Output(s):****retval:** Pointer to a memory range.**Exception(s):****CW_ONYXX_OOM.****Description:** *malloc()* wrapper.

void * *nxa_calloc_e*(void **a_arg*, *size_t* *a_number*, *size_t* *a_size*, const char **a_filename*, *uint32_t* *a_line_num*):
void * *nxa_calloc*(*size_t* *a_number*, *size_t* *a_size*):

Input(s):**a_arg:** Unused.**a_number:** Number of elements to allocate.**a_size:** Size of each element to allocate.**a_filename:** Should be *__FILE__*.**a_line_num:** Should be *__LINE__*.**Output(s):****retval:** Pointer to a zeroed memory range.

Exception(s):**CW_ONYXX_OOM.****Description:** *calloc()* wrapper.

```
void * nxa_realloc_e(void *a_arg, void *a_ptr, size_t a_size, size_t a_old_size, const char *a_filename,
uint32_t a_line_num):
```

```
void * nxa_realloc(void *a_ptr, size_t a_size, size_t a_old_size):
```

Input(s):**a_arg:** Unused.**a_ptr:** Pointer to memory range to be reallocated.**a_size:** Size of memory range to allocate.**a_old_size:** Size of memory range previously pointed to by *a_ptr*.**a_filename:** Should be `__FILE__`.**a_line_num:** Should be `__LINE__`.**Output(s):****retval:** Pointer to a memory range.**Exception(s):****CW_ONYXX_OOM.****Description:** *realloc()* wrapper.

```
void * nxa_free_e(void *a_arg, void *a_ptr, size_t a_size, const char *a_filename, uint32_t a_line_num):
```

```
void * nxa_free(void *a_ptr, size_t a_size):
```

Input(s):**a_arg:** Unused.**a_ptr:** Pointer to memory range to be freed.**a_size:** Size of memory range pointed to by *a_ptr*.**a_filename:** Should be `__FILE__`.**a_line_num:** Should be `__LINE__`.**Output(s):** None.**Exception(s):** None.**Description:** *free()* wrapper.

```
void nxa_collect(void):
```

Input(s): None.**Output(s):** None.**Exception(s):****CW_ONYXX_OOM.****Description:** Force an asynchronous garbage collection.

```
bool nxa_active_get(void):
```

Input(s): None.**Output(s):****retval:****false:** Garbage collector deactivated.**true:** Garbage collector active.

Exception(s): None.

Description: Return whether the garbage collector is active (runnable).

void *nx_active_set*(bool *a_active*):

Input(s):

a_active:

false: Deactivate garbage collector.

true: Activate garbage collector.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Send a message to the garbage collector to activate or deactivate. The asynchronous nature of the message means that it is possible for the garbage collector to run after this function returns, even if a deactivation message has been sent.

cx_nxoi_t *nx_period_get*(void):

Input(s): None.

Output(s):

retval: Current inactivity period in seconds that the garbage collector waits before doing a collection.

Exception(s): None.

Description: Return the current inactivity period in seconds that the garbage collector waits before doing a collection.

void *nx_period_set*(cx_nxoi_t *a_period*):

Input(s):

a_period: Inactivity period in seconds that the garbage collector should wait before doing a collection. If 0, the garbage collector will never run due to inactivity.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Set the inactivity period in seconds that the garbage collector should wait before doing a collection.

cx_nxoi_t *nx_threshold_get*(void):

Input(s): None.

Output(s):

retval: Number of bytes of memory allocated since the last garbage collection that will trigger the garbage collector to run.

Exception(s): None.

Description: Return the number of bytes of memory allocated since the last garbage collection that will trigger the garbage collector to run.

void *nx_threshold_set*(cx_nxoi_t *a_threshold*):

Input(s):

a.threshold: The number of bytes of memory allocated since the last garbage collection that will trigger the garbage collector to run.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Set the number of bytes of memory allocated since the last garbage collection that will trigger the garbage collector to run.

void *nxa_stats_get*(cw_nxoi_t *r_collections, cw_nxoi_t *r_count, cw_nxoi_t *r_ccount, cw_nxoi_t *r_cmark, cw_nxoi_t *r_mcount, cw_nxoi_t *r_mmark, cw_nxoi_t *r_scount, cw_nxoi_t *r_smark):

Input(s):

r_collections: Pointer to an integer.

r_count: Pointer to an integer.

r_ccount: Pointer to an integer.

r_cmark: Pointer to an integer.

r_mcount: Pointer to an integer.

r_mmark: Pointer to an integer.

r_scount: Pointer to an integer.

r_smark: Pointer to an integer.

Output(s):

***r_collections:** Number of times the garbage collector has run.

***r_count:** Current number of bytes of memory allocated.

***r_ccount:** Number of bytes of memory allocated as of the end of the most recent garbage collection.

***r_cmark:** Number of microseconds spent in the mark phase of the most recent garbage collection.

***r_mcount:** Largest number of bytes of memory ever allocated at any point in time.

***r_mmark:** Largest number of microseconds ever spent in the mark phase of a garbage collection.

***r_scount:** Total number of bytes of memory ever allocated.

***r_smark:** Total number of microseconds spent in the mark phase of all garbage collections.

Exception(s): None.

Description: Return garbage collector statistics.

4.10.10 *nxm*

The *nxm* class provides basic loadable module functionality.

API

cw_nxn_t *nxm_new*(cw_nxo_t *a_nxo, cw_nxo_t *a_path, cw_nxo_t *a_sym):

Input(s):

a_nxo: Pointer to space for a handle *nxo*.

a.path: Pointer to a string *nxo* that specifies the path to a module.

a.sym: Pointer to a string *nxo* that specifies a symbol in the module at *a.path*.

Output(s):

retval: Success.

NXN_invalidfileaccess: Unable to open a module at *a.path*.

NXN_undefined: A symbol named *a.sym* was not found in the module.

a.nxo: A handle *nxo*, with its evaluation function set to the specified symbol.

Exception(s):

CW_ONYXX.OOM.

Description: Open the module at *a.path*, and create a handle with its evaluation function set to the symbol specified by *a.sym*. The module will remain loaded until the handle *nxo* is swept by the garbage collector.

uint32_t nxm_iter_get(cw_nxo_t *a_nxo):

Input(s):

a.nxo: Pointer to a handle *nxo* that was constructed by *nxm_new()*.

Output(s):

retval: Garbage collector sweep iteration during which *a.nxo* will be deleted.

Exception(s): None.

Description: Get the garbage collector sweep iteration during which *a.nxo* will be deleted. By default, this is 1, but it can be changed by *nxm_iter_set()*.

void nxm_iter_set(cw_nxo_t *a_nxo, uint32_t a_iter):

Input(s):

a.nxo: Pointer to a handle *nxo* that was constructed by *nxm_new()*.

a.iter: Garbage collector sweep iteration during which *a.nxo* will be deleted.

Output(s): None.

Exception(s): None.

Description: Set the garbage collector sweep iteration during which *a.nxo* will be deleted.

void * nxm_pre_unload_hook_get(cw_nxo_t *a_nxo):

Input(s):

a.nxo: Pointer to a handle *nxo* that was constructed by *nxm_new()*.

Output(s):

retval: A function pointer, or NULL. If non-NULL, the function will be called just before the module is unloaded.

Exception(s): None.

Description: Get the pre-unload hook function associated with *a.nxo*.

void nxm_pre_unload_hook_set(cw_nxo_t *a_nxo, void (*a_pre_unload_hook)(void)):

Input(s):

a.nxo: Pointer to a handle *nxo* that was constructed by *nxm_new()*.

a.pre_unload_hook: A function pointer, or NULL. If non-NULL, the function will be called just before the module is unloaded.

Output(s): None.

Exception(s): None.

Description: Set the pre-unload hook function associated with *a.nxo*.

4.10.11 `nxn`

The `nxn` class provides access to a table of string constants. The main reason for this class's existence is that often, multiple C files use identical string constants, and this saves memory by allowing all to refer to a single string.

API

`const char * nxn_str(cw_nxn_t a_nxn):`

Input(s):

a_nxn: A number that corresponds to an entry in the string table.

Output(s):

retval: Pointer to a string constant.

Exception(s): None.

Description: Return a pointer to the string constant associated with *a_nxn*.

`uint32_t nxn_len(cw_nxn_t a_nxn):`

Input(s):

a_nxn: A number that corresponds to an entry in the string table.

Output(s):

retval: String length of a string constant.

Exception(s): None.

Description: Return the string length of the string constant associated with *a_nxn*.

4.10.12 `nxo`

The `nxo` class is the basis for the Onyx type system. `nxo` objects can be any of the following types, as determined by the `cw_nxot_t` type:

`NXOT_NO:` *nxo_no*

`NXOT_ARRAY:` *nxo_array*

`NXOT_BOOLEAN:` *nxo_boolean*

`NXOT_CLASS:` *nxo_class*

`NXOT_CONDITION:` *nxo_condition*

`NXOT_DICT:` *nxo_dict*

`NXOT_FILE:` *nxo_file*

`NXOT_FINO:` *nxo_fino*

`NXOT_HANDLE:` *nxo_handle*

`NXOT_INSTANCE:` *nxo_instance*

`NXOT_INTEGER:` *nxo_integer*

NXOT_MARK: *nxo_mark*

NXOT_MUTEX: *nxo_mutex*

NXOT_NAME: *nxo_name*

NXOT_NULL: *nxo_null*

NXOT_OPERATOR: *nxo_operator*

NXOT_PMARK: *nxo_pmark*

NXOT_REAL: *nxo_real*

NXOT_STACK: *nxo_stack*

NXOT_STRING: *nxo_string*

NXOT_THREAD: *nxo_thread*

Due to limitations of the C programming language, it is the responsibility of the application to do type checking to assure that an incompatible *nxo* object is not passed to a type-specific function. For example, passing a file *nxo* to *nxo_string_get()* is prohibited, and will result in undefined behaviour (including crashes).

Composite objects contain a reference to an *nxoe* object. For the most part, the application does not need to be aware of this. The only exception is when writing extensions with the handle type. Handle objects need to be able to iterate over the objects they reference internally, and return *nxoe* references to the garbage collector.

The following functions are applicable to all types of *nxo* objects.

API

int32_t nxo_compare(const cw_nxo_t *a_a, const cw_nxo_t *a_b):

Input(s):

a_a: Pointer to an *nxo*.

a_b: Pointer to an *nxo*.

Output(s):

retval:

-1: For types which it is meaningful (integer, string), *a_a* is less than *a_b*.

0: *a_a* and *a_b* are equal.

1: For types which it is meaningful (integer, string), *a_a* is greater than *a_b*.

2: Incompatible types, or not the same composite object.

Exception(s): None.

Description: Compare *a_a* and *a_b*.

void nxo_dup(cw_nxo_t *a_to, cw_nxo_t *a_from):

Input(s):

a_to: Pointer to an *nxo*.

a_from: Pointer to an *nxo*.

Output(s): None.

Exception(s): None.

Description: Duplicate *a_from* to *a_to*. This does not do a copy of composite objects; rather it creates a new reference to the value of a composite object.

`cw_nxot_t nxo_type_get(const cw_nxo_t *a_nxo):`

Input(s):

`a_nxo`: Pointer to an *nxo*.

Output(s):

`retval`:

`NXOT_NO`: *nxo_no*

`NXOT_ARRAY`: *nxo_array*

`NXOT_BOOLEAN`: *nxo_boolean*

`NXOT_CLASS`: *nxo_class*

`NXOT_CONDITION`: *nxo_condition*

`NXOT_DICT`: *nxo_dict*

`NXOT_FILE`: *nxo_file*

`NXOT_FINO`: *nxo_fino*

`NXOT_HANDLE`: *nxo_handle*

`NXOT_INSTANCE`: *nxo_instance*

`NXOT_INTEGER`: *nxo_integer*

`NXOT_MARK`: *nxo_mark*

`NXOT_MUTEX`: *nxo_mutex*

`NXOT_NAME`: *nxo_name*

`NXOT_NULL`: *nxo_null*

`NXOT_OPERATOR`: *nxo_operator*

`NXOT_PMARK`: *nxo_pmark*

`NXOT_REAL`: *nxo_real*

`NXOT_STACK`: *nxo_stack*

`NXOT_STRING`: *nxo_string*

`NXOT_THREAD`: *nxo_thread*

Exception(s): None.

Description: Return the type of *a_nxo*.

`cw_nxoe_t * nxo_nxoe_get(const cw_nxo_t *a_nxo):`

Input(s):

`a_nxo`: Pointer to an *nxo*.

Output(s):

`retval`: Pointer to the *nxoe* associated with *a_nxo*, or NULL if *a_nxo* is not composite.

Exception(s): None.

Description: Return a pointer to the *nxoe* associated with *a_nxo*.

`bool nxo_ilocked():`

Input(s):

`a_nxo`: Pointer to an array, dict, file, stack, or string *nxo*.

Output(s):

retval:

false: *a_nxo* is not implicitly locked.

true: *a_nxo* is implicitly locked.

Exception(s): None.

Description: For array, dict, file, stack, or string *nxos*, return whether *a_nxo* is implicitly locked.

`cw_nxo_t nxo_attr_get(const cw_nxo_t *a_nxo):`

Input(s):

a_nxo: Pointer to an *nxo*.

Output(s):

retval:

NXOA_LITERAL: *a_nxo* is literal.

NXOA_EXECUTABLE: *a_nxo* is executable.

Exception(s): None.

Description: Return the attribute for *a_nxo*.

`void nxo_attr_set(cw_nxo_t *a_nxo, cw_nxo_t a_attr):`

Input(s):

a_nxo: Pointer to an *nxo*.

a_attr: Value of attribute to set for *a_nxo*.

Output(s): None.

Exception(s): None.

Description: Set the attribute for *a_nxo* to *a_attr*.

4.10.13 nxo_array

The *nxo_array* class is a subclass of the *nxo* class.

API

`void nxo_array_new(cw_nxo_t *a_nxo, bool a_locking, uint32_t a_len):`

Input(s):

a_nxo: Pointer to an array *nxo*.

a_locking: Implicit locking mode.

a_len: Number of array elements.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

`void nxo_array_subarray_new(cw_nxo_t *a_nxo, cw_nxo_t *a_array, uint32_t a_offset, uint32_t a_len):`

Input(s):

a_nxo: Pointer to an array *nxo*.

a_array: Pointer to an array *nxo* to create a subarray of.

a_offset: Offset into *a_array*.

a_len: Number of array elements.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Subarray constructor.

void *nxo_array_copy*(cw_nxo_t *a_to, cw_nxo_t *a_from):

Input(s):

a_to: Pointer to an array *nxo*.

a_from: Pointer to an array *nxo*.

Output(s): None.

Exception(s): None.

Description: Copy the contents of *a_from* to *a_to*. The length of *a_to* must be at least that of *a_from*.

uint32_t *nxo_array_len_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to an array *nxo*.

Output(s):

retval: Number of elements in *a_nxo*.

Exception(s): None.

Description: Return the number of elements in *a_nxo*.

void *nxo_array_el_get*(const cw_nxo_t *a_nxo, cw_nxoi_t a_offset, cw_nxo_t *r_el):

Input(s):

a_nxo: Pointer to an array *nxo*.

a_offset: Offset of element to get.

r_el: Pointer to space to dup an object to.

Output(s):

***r_el:** A dup of the element of *a_nxo* at offset *a_offset*.

Exception(s): None.

Description: Get a dup of the element of *a_nxo* at offset *a_offset*.

void *nxo_array_el_set*(cw_nxo_t *a_nxo, cw_nxo_t *a_el, cw_nxoi_t a_offset):

Input(s):

a_nxo: Pointer to an array *nxo*.

a_el: Pointer to an *nxo*.

a_offset: Offset of element in *a_nxo* to replace with *a_el*.

Output(s): None.

Exception(s): None.

Description: Dup *a_el* into the element of *a_nxo* at offset *a_offset*.

bool *nxo_array_origin_get*(cw_nxo_t *a_nxo, const char **r_origin, uint32_t *r_olen, uint32_t *r_line_num):

Input(s):

- a_nxo:** Pointer to an array *nxo*.
- r_origin:** Pointer to a string pointer.
- r_olen:** Pointer to an unsigned integer.
- r_line_num:** Pointer to an unsigned integer.

Output(s):

- retval:** If false, success, otherwise no origin found.
- *r_origin:** If *retval* is false, a pointer to a string that represents the origin of *a_nxo*.
- *r_olen:** If *retval* is false, the length of the string pointed to by **r_origin*.
- *r_line_num:** If *retval* is false, the line within **r_origin* that *a_nxo* started at.

Exception(s): None.

Description: Get the origin of *a_nxo*, if known.

void *nxo_array_origin_set*(cw_nxo_t *a_nxo, const char *a_origin, uint32_t a_olen, uint32_t a_line_num):

Input(s):

- a_nxo:** Pointer to an array *nxo*.
- a_origin:** Pointer to a string that represents the origin of *a_nxo*.
- a_olen:** The length of the string pointed to by *a_origin*.
- a_line_num:** The line within *a_origin* that *a_nxo* started at.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Set the origin of *a_nxo*. A copy of *a_origin* is made and managed internally.

4.10.14 nxo_boolean

The *nxo_boolean* class is a subclass of the *nxo* class.

API

void *nxo_boolean_new*(cw_nxo_t *a_nxo, bool a_val):

Input(s):

- a_nxo:** Pointer to a boolean *nxo*.
- a_val:** Initial value.

Output(s): None.

Exception(s): None.

Description: Constructor.

bool *nxo_boolean_get*(const cw_nxo_t *a_nxo):

Input(s):**a_nxo:** Pointer to a boolean *nxo*.**Output(s):****retval:** Value of *a_nxo*.**Exception(s):** None.**Description:** Return the value of *a_nxo*.**void *nxo_boolean_set*(*cx_nxo_t* **a_nxo*, bool *a_val*):****Input(s):****a_nxo:** Pointer to a boolean *nxo*.**a_val:** Value to set *a_nxo* to.**Output(s):** None.**Exception(s):** None.**Description:** Set the value of *a_nxo* to *a_val*.

4.10.15 *nxo_class*

The *nxo_class* class is a subclass of the *nxo* class.

API

cx_nxoe_t * *cx_nxo_class_ref_iter_t*(void **a_opaque*, bool *a_reset*):**Input(s):****a_opaque:** Opaque data pointer.**a_reset:****false:** At least one iteration has already occurred.**true:** First iteration.**Output(s):****retval:****non-NULL:** Pointer to an *nxoe*.**NULL:** No more references.**Exception(s):** None.**Description:** Reference iterator function typedef.**bool *cx_nxo_class_delete_t*(void **a_opaque*, uint32_t *a_iter*):****Input(s):****a_opaque:** Opaque data pointer.**a_iter:** Garbage collector sweep iteration count (starts at 0). This value can be used to impose ordering of dependent object deletions.**Output(s):****retval:****false:** Success.**true:** Defer deletion until a later garbage collector sweep iteration.

Exception(s): None.

Description: Destructor function typedef.

void *nxo_class_new*(cw_nxo_t *a_nxo, void *a_opaque, cw_nxo_class_ref_iter_t *a_ref_iter_f, cw_nxo_class_delete_f *a_delete_f):

Input(s):

a_nxo: Pointer to a class *nxo*.

a_opaque: Opaque data pointer to be passed to *a_ref_iter_f* and *a_delete_f*.

a_ref_iter_f: Pointer to a reference iterator function.

a_delete_f: Pointer to a destructor function.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

cw_nxo_t * *nxo_class_name_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a class *nxo*.

Output(s):

retval: Pointer to the name object associated with *a_nxo* (may be of any type).

Exception(s): None.

Description: Return a pointer to the name object associated with *a_nxo*. This object pointer can safely be used for modifying the name object.

cw_nxo_t * *nxo_class_super_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a class *nxo*.

Output(s):

retval: Pointer to the superclass object associated with *a_nxo*.

Exception(s): None.

Description: Return a pointer to the super object associated with *a_nxo*. This object pointer can safely be used for modifying the super object.

cw_nxo_t * *nxo_class_methods_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a class *nxo*.

Output(s):

retval: Pointer to the methods object associated with *a_nxo*.

Exception(s): None.

Description: Return a pointer to the methods object associated with *a_nxo*. This object pointer can safely be used for modifying the methods object.

cw_nxo_t * *nxo_class_data_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a class *nxo*.

Output(s):

retval: Pointer to the data object associated with *a_nxo*.

Exception(s): None.

Description: Return a pointer to the data object associated with *a_nxo*. This object pointer can safely be used for modifying the data object.

void * *nxo_class_opaque_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a class *nxo*.

Output(s):

retval: Opaque data pointer.

Exception(s): None.

Description: Return the opaque data pointer associated with *a_nxo*.

void *nxo_class_opaque_set*(cw_nxo_t *a_nxo, void *a_opaque):

Input(s):

a_nxo: Pointer to a class *nxo*.

a_opaque: Opaque data pointer.

Output(s): None.**Exception(s):** None.

Description: Set the opaque data pointer associated with *a_nxo*.

void *nxo_class_eval*(cw_nxo_t *a_nxo, cw_nxo_t *a_thread):

Input(s):

a_nxo: Pointer to a class *nxo*.

a_thread: Pointer to a thread *nxo*.

Output(s): None.**Exception(s):** Class-specific.

Description: Evaluate the *a_nxo*. If there is no evaluation function associated with *a_nxo*, it is pushed onto ostack.

4.10.16 *nxo_condition*

The *nxo_condition* class is a subclass of the *nxo* class.

API

void *nxo_condition_new*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a condition *nxo*.

Output(s): None.**Exception(s):**

CW_ONYXX_OOM.

Description: Constructor.

void *nxo_condition_signal*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a condition *nxo*.

Output(s): None.

Exception(s): None.

Description: Signal one thread waiting on *a_nxo*, if there are any waiters.

void *nxo_condition_broadcast*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a condition *nxo*.

Output(s): None.

Exception(s): None.

Description: Signal all threads waiting on *a_nxo*.

void *nxo_condition_wait*(cw_nxo_t *a_nxo, cw_nxo_t *a_mutex):

Input(s):

a_nxo: Pointer to a condition *nxo*.

a_mutex: Pointer to a mutex *nxo*.

Output(s): None.

Exception(s): None.

Description: Wait for *a_nxo*.

bool *nxo_condition_timedwait*(cw_nxo_t *a_nxo, cw_nxo_t *a_mutex, const struct timespec *a_timeout):

Input(s):

a_nxo: Pointer to a condition *nxo*.

a_mutex: Pointer to a mutex *nxo*.

a_timeout: Timeout, specified as an absolute time interval.

Output(s):

retval:

false: Success.

true: Timeout.

Exception(s): None.

Description: Wait for *a_nxo* for at least *a_timeout*.

4.10.17 *nxo_dict*

The *nxo_dict* class is a subclass of the *nxo* class.

API

void *nxo_dict_new*(cw_nxo_t *a_nxo, bool a_locking, uint32_t a_dict_size):

Input(s):

a_nxo: Pointer to a dict *nxo*.

a_locking: Implicit locking mode.

a_dict_size: Initial number of slots. Dictionaries dynamically grow and shrink as needed, but if the maximum size of *a_nxo* is known, it should be specified here to save space.

Output(s): None

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

***nxo_dict_copy*(cw_nxo_t *a_to, cw_nxo_t *a_from):**

Input(s):

a_to: Pointer to a dict *nxo*.

a_from: Pointer to a dict *nxo*.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Do a deep copy (actual contents are copied) of *a_from* to *a_to*.

void *nxo_dict_def*(cw_nxo_t *a_nxo, cw_nxo_t *a_key, cw_nxo_t *a_val):

Input(s):

a_nxo: Pointer to a dict *nxo*.

a_key: Pointer to an *nxo*.

a_val: Pointer to an *nxo*.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Define *a_key* with value *a_val* in *a_nxo*.

void *nxo_dict_undef*(cw_nxo_t *a_nxo, cw_nxo_t *a_key):

Input(s):

a_nxo: Pointer to a dict *nxo*.

a_key: Pointer to an *nxo*.

Output(s): None.

Exception(s): None.

Description: Undefine *a_key* in *a_nxo*, if defined.

bool *nxo_dict_lookup*(const cw_nxo_t *a_nxo, const cw_nxo_t *a_key, cw_nxo_t *r_nxo):

Input(s):

a_nxo: Pointer to a dict *nxo*.

a_key: Pointer to an *nxo*.

r_nxo: Pointer to an *nxo*.

Output(s):**retval:****false:** Success.**true:** *a_key* not found.**r_nxo:** If *retval* is false, value associated with *a_key* in *a_nxo*, otherwise unmodified.**Exception(s):** None.**Description:** Find *a_key* in *a_nxo* and dup its associated value to *r_nxo*.**uint32_t nxo_dict_count(const cw_nxo_t *a_nxo):****Input(s):****a_nxo:** Pointer to a dict *nxo*.**Output(s):****retval:** The number of key/value pairs in *a_nxo*.**Exception(s):** None.**Description:** Return the number of key/value pairs in *a_nxo*.**void nxo_dict_iterate(cw_nxo_t *a_nxo, cw_nxo_t *r_nxo):****Input(s):****a_nxo:** Pointer to a dict *nxo*.**r_nxo:** Pointer to an *nxo*.**Output(s):****false:** Success.**true:** *a_nxo* is empty.**r_nxo:** If *retval* is false, A key in *a_nxo*, otherwise unmodified.**Exception(s):** None.**Description:** Iteratively get a key in *a_nxo*. Each successive call to this function will get the next key, and wrap back around to the first key when all keys have been returned.**4.10.18 nxo_file**The *nxo_file* class is a subclass of the *nxo* class.**API****int32_t cw_nxo_file_read_t(void *a_arg, cw_nxo_t *a_file, uint32_t a_len, char *r_str):****Input(s):****a_arg:** Opaque data pointer.**a_file:** Pointer to a file *nxo*.**a_len:** Length of *r_str*.**r_str:** Pointer to space to put read data.**Output(s):****retval:****-1:** Read error.

>= 0: Number of bytes stored in *r_str*.

r_str: If *retval* is non-negative, *retval* bytes of read data, otherwise undefined.

Exception(s): Application specific.

Description: Read up to *a_len* bytes of data from *a_file* and store the result in *r_str*.

bool cw_nxo_file_write_t(void *a_arg, cw_nxo_t *a_file, const char *a_str, uint32_t a_len):

Input(s):

a_arg: Opaque data pointer.

a_file: Pointer to a file *nxo*.

a_str: Pointer to data to write.

a_len: Length of *a_str*.

Output(s):

retval:

false: Success.

true: Write error.

Exception(s): Application specific.

Description: Write *a_len* bytes of data from *a_str* to *a_file*.

cw_nxoe_t * cw_nxo_file_ref_iter_t(void *a_arg, bool a_reset):

Input(s):

a_arg: Opaque data pointer.

a_reset:

false: At least one iteration has already occurred.

true: First iteration.

Output(s):

retval:

non-NULL: Pointer to an *nxoe*.

NULL: No more references.

Exception(s): None.

Description: Reference iterator function typedef.

void cw_nxo_file_delete_t(void *a_arg):

Input(s):

a_arg: Opaque data pointer.

Output(s): None.

Exception(s): None.

Description: Destructor function typedef.

void nxo_file_new(cw_nxo_t *a_nxo, bool a_locking):

Input(s):

a_nxo: Pointer to a file *nxo*.

a_locking: Implicit locking mode.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

void *nxo_file_fd_wrap*(*cx_nxo_t* **a_nxo*, *uint32_t* *a_fd*, *bool* *a_close*):

Input(s):

a_nxo: Pointer to a file *nxo*.

a_fd: File descriptor number.

a_close: If true, close *a_fd* when *a_nxo* is finalized by the garbage collector, otherwise, do not automatically close *a_fd*. This should typically be set to true.

Output(s): None.

Exception(s): None.

Description: Wrap file descriptor *a_fd* so that operations on *a_nxo* will be backed by the file descriptor.

void *nxo_file_synthetic*(*cx_nxo_t* **a_nxo*, *cx_nxo_file_read_t* **a_read*, *cx_nxo_file_write_t* **a_write*, *cx_nxo_file_ref_iter_t* **a_ref_iter*, *cx_nxo_file_delet_t* **a_delete*, *void* **a_arg*):

Input(s):

a_nxo: Pointer to a file *nxo*.

a_read: Pointer to a read function.

a_write: Pointer to a write function.

a_ref_iter: Pointer to a reference iterator function.

a_delete: Pointer to a destructor function.

a_arg: Opaque pointer to be passed to the read and write functions.

Output(s): None.

Exception(s): None.

Description: Set up *a_nxo* to call the specified read and write functions to satisfy file operations.

***cx_nxn_t* *nxo_file_open*(*cx_nxo_t* **a_nxo*, *const char* **a_filename*, *uint32_t* *a_nlen*, *const char* **a_flags*, *uint32_t* *a_flen*):**

Input(s):

a_nxo: Pointer to a file *nxo*.

a_filename: Pointer to a string (not required to be '\0' terminated) that represents a filename.

a_nlen: Length in bytes of *a_filename*.

a_flags: Pointer to a string (not required to be '\0' terminated) that represents a file mode:

“r”: Read only.

“r+”: Read/write, starting at offset 0.

“w”: Write only. Create file if necessary. Truncate file if non-zero length.

“w+”: Read/write, starting at offset 0. Create file if necessary.

“a”: Write only, starting at end of file.

“a+”: Read/write, starting at end of file.

a_flen: Length in bytes of *a_flags*.

Output(s):

retval:

NXN_ZERO.

NXN_ioerror.

NXN_invalidfileaccess.

NXN_limitcheck.

Exception(s): None.

Description: Open a file.

cx_nxn_t nxo_file_close(cx_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a file *nxo*.

Output(s):

retval:

NXN_ZERO.

NXN_ioerror.

Exception(s): None.

Description: Close a file.

void nxo_file_origin_get(cx_nxo_t *a_nxo, const char **r_origin, uint32_t *r_olen):

Input(s):

a_nxo: Pointer to a file *nxo*.

r_origin: Pointer to a string pointer.

r_olen: Pointer to an unsigned integer.

Output(s):

***r_origin:** A pointer to a string that represents the origin of *a_nxo*.

***r_olen:** The length of the string pointed to by *r_origin*.

Exception(s): None.

Description: Get the origin of *a_nxo*.

bool nxo_file_origin_set(cx_nxo_t *a_nxo, const char *a_origin, uint32_t a_olen):

Input(s):

a_nxo: Pointer to a file *nxo*.

a_origin: Pointer to a string that represents the origin of *a_nxo*.

a_olen: The length of the string pointed to by *a_origin*.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Set the origin of *a_nxo*. A copy of *a_origin* is made and managed internally.

int32_t nxo_file_fd_get(const cx_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a file *nxo*.

Output(s):

retval:

-1: Invalid or synthetic file.

>= 0: File descriptor number.

Exception(s): None.

Description: Return the file descriptor associated with *a_nxo*.

bool *nxo_file_nonblocking_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a file *nxo*.

Output(s):

retval:

false: Blocking file.

true: Non-blocking file.

Exception(s): None.

Description: Return the non-blocking mode for *a_nxo*.

bool *nxo_file_nonblocking_set*(cw_nxo_t *a_nxo, bool a_nonblocking):

Input(s):

a_nxo: Pointer to a file *nxo*.

a_nonblocking: Non-blocking mode to set *nxo* to.

Output(s):

retval:

false: Success.

true: I/O error or non-POSIX file.

Exception(s): None.

Description: Set the non-blocking mode for *a_nxo* to *a_nonblocking*.

int32_t *nxo_file_read*(cw_nxo_t *a_nxo, uint32_t a_len, char *r_str):

Input(s):

a_nxo: Pointer to a file *nxo*.

a_len: Length in bytes of *r_str*.

r_str: Pointer to a string to store read data into.

Output(s):

retval:

-1: NXN_ioerror.

>= 0: Number of bytes of data read into *r_str*.

r_str: If *retval* is non-negative, *retval* bytes of read data.

Exception(s): None.

Description: Read data.

cw_nxn_t *nxo_file_readline*(cw_nxo_t *a_nxo, cw_nx_t *a_nx, bool a_locking, cw_nxo_t *r_string, bool *r_eof):

Input(s):

a_nxo: Pointer to a file *nxo*.

a_nx: Pointer to an *nx*.

a_locking: Implicit locking mode.

r_string: Pointer to an *nxo*.

r_eof: Pointer to a bool.

Output(s):**retval:****NXN_ZERO.****NXN_ioerror.****r_string:** If *retval* is **NXN_ZERO**, a string object, otherwise unmodified.***r_eof:****false:** End of file not reached.**true:** End of file reached.**Exception(s):****CW_ONYXX_OOM.****Description:** Read a line, terminated by “\r”, “\r\n”, or EOF.**cw_nxn_t nxo_file_write(cw_nxo_t *a_nxo, const char *a_str, uint32_t a_len, uint32_t *r_count):****Input(s):****a_nxo:** Pointer to a file *nxo*.**a_str:** Pointer to data to write.**a_len:** Length of *a_str*.**r_count:** Pointer to a location to store the number of bytes written, or NULL.**Output(s):****retval:****NXN_ZERO.****NXN_ioerror.*****r_count:** If *r_count* is non-NULL, and *retval* is **NXN_ZERO**, number of bytes written, otherwise undefined.**Exception(s):** None.**Description:** Write the *a_len* bytes of data pointed to *a_str*. If the file is in non-blocking mode, it is possible for **r_count* to be as small as 0 for a successful write.**cw_nxn_t nxo_file_truncate(cw_nxo_t *a_nxo, off_t a_length):****Input(s):****a_nxo:** Pointer to a file *nxo*.**a_length:** Length to set file to.**Output(s):****retval:****NXN_ZERO.****NXN_ioerror.****Exception(s):** None.**Description:** Truncate or extend the file associated with *a_nxo* so that it is *a_length* bytes long.**cw_nxoi_t nxo_file_position_get(cw_nxo_t *a_nxo):****Input(s):****a_nxo:** Pointer to a file *nxo*.**Output(s):****retval:****-1:** **NXN_ioerror.**

>= 0: Current file position.

Exception(s): None.

Description: Get the current file position.

`cxn_t nxo_file_position_set(cxn_t *a_nxo, cxoi_t a_position):`

Input(s):

a_nxo: Pointer to a file *nxo*.

a_position: File position.

Output(s):

retval:

NXN_ZERO.

NXN_ioerror.

Exception(s): None.

Description: Move the current file position to *a_position*.

`uint32_t nxo_file_buffer_size_get(const cxn_t *a_nxo):`

Input(s):

a_nxo: Pointer to a file *nxo*.

Output(s):

retval: Size in bytes of the internal data buffer.

Exception(s): None.

Description: Return the size of the internal data buffer.

`void nxo_file_buffer_size_set(cxn_t *a_nxo, uint32_t a_size):`

Input(s):

a_nxo: Pointer to a file *nxo*.

a_size: Size in bytes of internal buffer to use.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Use an internal buffer of *a_size* bytes.

`cxoi_t nxo_file_buffer_count(const cxn_t *a_nxo):`

Input(s):

a_nxo: Pointer to a file *nxo*.

Output(s):

retval: Current number of buffered bytes available for reading.

Exception(s): None.

Description: Return the current number of buffered bytes available for reading.

`cxn_t nxo_file_buffer_flush(cxn_t *a_nxo):`

Input(s):

a_nxo: Pointer to a file *nxo*.

Output(s):

retval:

NXN_ZERO.

NXN_ioerror.

Exception(s): None.

Description: Flush any buffered write data to disk, and discard any buffered read data.

4.10.19 `nxo_fino`

The *nxo_fino* class is a subclass of the *nxo* class.

API

void *nxo_fino_new*(*cx_nxo_t* **a_nxo*):

Input(s):

***a_nxo*:** Pointer to an *nxo*.

Output(s): None.

Exception(s): None.

Description: Constructor.

4.10.20 `nxo_handle`

The *nxo_handle* class is a subclass of the *nxo* class.

API

void *cx_nxo_handle_eval_t*(void **a_opaque*, *cx_nxo_t* **a_thread*):

Input(s):

***a_opaque*:** Opaque data pointer.

***a_thread*:** Pointer to a thread *nxo*.

Output(s): None.

Exception(s): Handle-dependent.

Description: Evaluation function typedef.

***cx_nxo_t* * *cx_nxo_handle_ref_iter_t*(void **a_opaque*, bool *a_reset*):**

Input(s):

***a_opaque*:** Opaque data pointer.

***a_reset*:**

false: At least one iteration has already occurred.

true: First iteration.

Output(s):

retval:

non-NULL: Pointer to an *nxoe*.

NULL: No more references.

Exception(s): None.

Description: Reference iterator function typedef.

bool *cx_nxo_handle_delete_t*(void **a_opaque*, uint32_t *a_iter*):

Input(s):

***a_opaque*:** Opaque data pointer.

***a_iter*:** Garbage collector sweep iteration count (starts at 0). This value can be used to impose ordering of dependent object deletions.

Output(s):

retval:

false: Success.

true: Defer deletion until a later garbage collector sweep iteration.

Exception(s): None.

Description: Destructor function typedef.

**void *cx_nxo_handle_new*(cx_nxo_t **a_nxo*, void **a_opaque*, cx_nxo_handle_eval_t **a_eval_f*, cx_nxo_handle_ref_i
a_ref_iter_f*, cx_nxo_handle_delete_t **a_delete_f*):

Input(s):

***a_nxo*:** Pointer to a handle *nxo*.

***a_opaque*:** Opaque data pointer to be passed to *a_eval_f*, *a_ref_iter_f*, and *a_delete_f*.

***a_eval_f*:** Pointer to an evaluation function.

***a_ref_iter_f*:** Pointer to a reference iterator function.

***a_delete_f*:** Pointer to a destructor function.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

cx_nxo_t * *cx_nxo_handle_tag_get*(const cx_nxo_t **a_nxo*):

Input(s):

***a_nxo*:** Pointer to a handle *nxo*.

Output(s):

retval: Pointer to the tag object associated with *a_nxo*.

Exception(s): None.

Description: Return a pointer to the tag object associated with *a_nxo*. This object pointer can safely be used for modifying the tag object.

void * *cx_nxo_handle_opaque_get*(const cx_nxo_t **a_nxo*):

Input(s):

***a_nxo*:** Pointer to a handle *nxo*.

Output(s):

retval: Opaque data pointer.

Exception(s): None.

Description: Return the opaque data pointer associated with *a_nxo*.

void *nxo_handle_opaque_set*(*cx_nxo_t* **a_nxo*, void **a_opaque*):

Input(s):

a_nxo: Pointer to a handle *nxo*.
a_opaque: Opaque data pointer.

Output(s): None.

Exception(s): None.

Description: Set the opaque data pointer associated with *a_nxo*.

void *nxo_handle_eval*(*cx_nxo_t* **a_nxo*, *cx_nxo_t* **a_thread*):

Input(s):

a_nxo: Pointer to a handle *nxo*.
a_thread: Pointer to a thread *nxo*.

Output(s): None.

Exception(s): Handle-specific.

Description: Evaluate the *a_nxo*. If there is no evaluation function associated with *a_nxo*, it is pushed onto ostack.

4.10.21 *nxo_instance*

The *nxo_instance* class is a subclass of the *nxo* class.

API

***cx_nxoe_t* * *cx_nxo_instance_ref_iter_t*(void **a_opaque*, bool *a_reset*):**

Input(s):

a_opaque: Opaque data pointer.
a_reset:
false: At least one iteration has already occurred.
true: First iteration.

Output(s):

retval:
non-NULL: Pointer to an *nxoe*.
NULL: No more references.

Exception(s): None.

Description: Reference iterator function typedef.

bool *cx_nxo_instance_delete_t*(void **a_opaque*, uint32_t *a_iter*):

Input(s):

a_opaque: Opaque data pointer.
a_iter: Garbage collector sweep iteration count (starts at 0). This value can be used to impose ordering of dependent object deletions.

Output(s):

retval:

false: Success.

true: Defer deletion until a later garbage collector sweep iteration.

Exception(s): None.

Description: Destructor function typedef.

void *nxo_instance_new*(*cx_nxo_t* **a_nxo*, void **a_opaque*, *cx_nxo_instance_ref_iter_t* **a_ref_iter_f*, *cx_nxo_instance_delete_t* **a_delete_f*):

Input(s):

a_nxo: Pointer to an instance *nxo*.

a_opaque: Opaque data pointer to be passed to *a_eval_f*, *a_ref_iter_f*, and *a_delete_f*.

a_ref_iter_f: Pointer to a reference iterator function.

a_delete_f: Pointer to a destructor function.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

***cx_nxo_t* * *nxo_instance_isa_get*(const *cx_nxo_t* **a_nxo*):**

Input(s):

a_nxo: Pointer to an instance *nxo*.

Output(s):

retval: Pointer to the isa object associated with *a_nxo*.

Exception(s): None.

Description: Return a pointer to the isa object associated with *a_nxo*. This object pointer can safely be used for modifying the isa object.

***cx_nxo_t* * *nxo_instance_data_get*(const *cx_nxo_t* **a_nxo*):**

Input(s):

a_nxo: Pointer to an instance *nxo*.

Output(s):

retval: Pointer to the data object associated with *a_nxo*.

Exception(s): None.

Description: Return a pointer to the data object associated with *a_nxo*. This object pointer can safely be used for modifying the data object.

void * *nxo_instance_opaque_get*(const *cx_nxo_t* **a_nxo*):

Input(s):

a_nxo: Pointer to an instance *nxo*.

Output(s):

retval: Opaque data pointer.

Exception(s): None.

Description: Return the opaque data pointer associated with *a_nxo*.

void *nxo_instance_opaque_set*(*cx_nxo_t* **a_nxo*, void **a_opaque*):

Input(s):**a_nxo:** Pointer to an instance *nxo*.**a_opaque:** Opaque data pointer.**Output(s):** None.**Exception(s):** None.**Description:** Set the opaque data pointer associated with *a_nxo*.**void *nxo_instance_eval*(cw_nxo_t *a_nxo, cw_nxo_t *a_thread):****Input(s):****a_nxo:** Pointer to an instance *nxo*.**a_thread:** Pointer to a thread *nxo*.**Output(s):** None.**Exception(s):** Instance-specific.**Description:** Evaluate the *a_nxo*. If there is no evaluation function associated with *a_nxo*, it is pushed onto ostack.

4.10.22 nxo.integer

The *nxo_integer* class is a subclass of the *nxo* class.

API

void *nxo_integer_new*(cw_nxo_t *a_nxo, cw_nxoi_t a_val):**Input(s):****a_nxo:** Pointer to an integer *nxo*.**a_val:** Initial value.**Output(s):** None.**Exception(s):** None.**Description:** Constructor.**cw_nxoi_t *nxo_integer_get*(const cw_nxo_t *a_nxo):****Input(s):****a_nxo:** Pointer to an integer *nxo*.**Output(s):****retval:** Value of *a_nxo*.**Exception(s):** None.**Description:** Return the value of *a_nxo*.**void *nxo_integer_set*(cw_nxo_t *a_nxo, cw_nxoi_t a_val):****Input(s):****a_nxo:** Pointer to an integer *nxo*.**a_val:** Integer value.**Output(s):** None.**Exception(s):** None.**Description:** Set the value of *a_nxo* to *a_val*.

4.10.23 nxo_mark

The *nxo_mark* class is a subclass of the *nxo* class.

API

void *nxo_mark_new*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to an *nxo*.

Output(s): None.

Exception(s): None.

Description: Constructor.

4.10.24 nxo_mutex

The *nxo_mutex* class is a subclass of the *nxo* class.

API

void *nxo_mutex_new*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a mutex *nxo*.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

void *nxo_mutex_lock*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a mutex *nxo*.

Output(s): None.

Exception(s): None.

Description: Lock *a_nxo*.

bool *nxo_mutex_trylock*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a mutex *nxo*.

Output(s):

retval:

false: Success.

true: Failure.

Exception(s): None.

Description: Try to lock *a_nxo*, but return immediately with an error if unable to do so.

void *nxo_mutex_unlock*(*cx_nxo_t* **a_nxo*):

Input(s):

a_nxo: Pointer to a mutex *nxo*.

Output(s): None.

Exception(s): None.

Description: Unlock *a_nxo*.

4.10.25 *nxo_name*

The *nxo_name* class is a subclass of the *nxo* class.

API

void *nxo_name_new*(*cx_nxo_t* **a_nxo*, const char **a_str*, uint32_t *a_len*, bool *a_is_static*):

Input(s):

a_nxo: Pointer to a name *nxo*.

a_str: Pointer to a character string (not required to be '\0' terminated).

a_len: Length in bytes of *a_str*.

a_is_static:

false: *a_str* may be modified or deallocated during the lifetime of the program.

true: *a_str* will not be modified for the lifetime of the program.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

const char * *nxo_name_str_get*(const *cx_nxo_t* **a_nxo*):

Input(s):

a_nxo: Pointer to a name *nxo*.

Output(s):

retval: Pointer to a string that represents *a_nxo*.

Exception(s): None.

Description: Return a pointer to a string that represents *a_nxo*.

uint32_t *nxo_name_len_get*(const *cx_nxo_t* **a_nxo*):

Input(s):

a_nxo: Pointer to a name *nxo*.

Output(s):

retval: Length in bytes of the name associated with *a_nxo*.

Exception(s): None.

Description: Return the length in bytes of the name associated with *a_nxo*.

4.10.26 `nxo_no`

The `nxo_no` class is a subclass of the `nxo` class.

API

void `nxo_no_new`(`cw_nxo_t` *`a_nxo`):

Input(s):

a_nxo: Pointer to an `nxo`.

Output(s): None.

Exception(s): None.

Description: Constructor.

4.10.27 `nxo_null`

The `nxo_null` class is a subclass of the `nxo` class.

API

void `nxo_null_new`(`cw_nxo_t` *`a_nxo`):

Input(s):

a_nxo: Pointer to an `nxo`.

Output(s): None.

Exception(s): None.

Description: Constructor.

4.10.28 `nxo_operator`

The `nxo_operator` class is a subclass of the `nxo` class.

API

void `nxo_operator_new`(`cw_nxo_t` *`a_nxo`, `cw_op_t` *`a_op`, `cw_nxn_t` `a_nxn`):

Input(s):

a_nxo: Pointer to an operator `nxo`.

a_op: Pointer to an operator function.

a_nxn: `NXN_ZERO`, or an `nxn`.

Output(s): None.

Exception(s): None.

Description: Constructor.

`cw_op_t` *`nxo_operator_f`(`const cw_nxo_t` *`a_nxo`):

Input(s):**a_nxo:** Pointer to an operator *nxo*.**Output(s):****retval:** Pointer to an operator function.**Exception(s):** None.**Description:** Return the operator function associated with *a_nxo*.**4.10.29 nxo_pmark**

The *nxo_pmark* class is a subclass of the *nxo* class.

API

void *nxo_pmark_new*(cw_nxo_t *a_nxo):

Input(s):**a_nxo:** Pointer to an *nxo*.**Output(s):** None.**Exception(s):** None.**Description:** Constructor.

uint32_t *nxo_pmark_line_get*(const cw_nxo_t *a_nxo):

Input(s):**a_nxo:** Pointer to a pmark *nxo*.**Output(s):****retval:** Line number.**Exception(s):** None.**Description:** Return the line number associated with *a_nxo*.

void *nxo_pmark_line_set*(cw_nxo_t *a_nxo, uint32_t a_line):

Input(s):**a_nxo:** Pointer to a pmark *nxo*.**a_line:** Value to set the line number associated with *a_nxo* to.**Output(s):** None.**Exception(s):** None.**Description:** Set the line number associated *a_nxo* to *a_val*.**4.10.30 nxo_real**

The *nxo_real* class is a subclass of the *nxo* class.

API

void *nxo_real_new*(cw_nxo_t *a_nxo, cw_nxor_t a_val):

Input(s):

a_nxo: Pointer to a real *nxo*.
a_val: Initial value.

Output(s): None.

Exception(s): None.

Description: Constructor.

cw_nxor_t *nxo_real_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a real *nxo*.

Output(s):

retval: Value of *a_nxo*.

Exception(s): None.

Description: Return the value of *a_nxo*.

void *nxo_real_set*(cw_nxo_t *a_nxo, cw_nxor_t a_val):

Input(s):

a_nxo: Pointer to a real *nxo*.
a_val: Real value.

Output(s): None.

Exception(s): None.

Description: Set the value of *a_nxo* to *a_val*.

4.10.31 *nxo_regex*

The *nxo_regex* class is a subclass of the *nxo* class.

API

cw_nxn_t *nxo_regex_new*(cw_nxo_t *a_nxo, const char *a_pattern, uint32_t a_len, bool a_cont, bool a_global, bool a_insensitive, bool a_multiline, bool a_singleline):

Input(s):

a_nxo: Pointer to a regex *nxo*.
a_pattern: Pointer to a string that specifies a regular expression.
a_len: Length of *a_pattern*.
a_cont: Continue where last successful match ended if true.
a_global: Continue where last match ended if true.
a_insensitive: Match with case insensitivity if true.
a_multiline: Treat input as a multi-line string if true.
a_singleline: Treat input as a single line, so that the dot metacharacter matches any character, including a newline.

Output(s):**retval:****NXN_ZERO:** Success.**NXN_regexerror:** Regular expression error.**Exception(s):****CW_ONYXX_OOM.****Description:** Constructor.

```
void nxo_regex_match(cw_nxo_t *a_nxo, cw_nxo_t *a_thread, cw_nxo_t *a_input, bool *r_match):
```

Input(s):**a_nxo:** Pointer to a regex *nxo*.**a_thread:** Pointer to a thread *nxo*.**a_input:** Pointer to a string *nxo*.**r_match:** Pointer to a bool.**Output(s):*****r_match:****true:** Match successful.**false:** No match found.**Exception(s):****CW_ONYXX_OOM.****Description:** Look in *a_input* for a match to the regex pointed to by *a_nxo*. As a side effect, set the thread's match cache, which can be queried via *nxo_regex_submatch()*.

```
cw_nxn_t nxo_regex_nonew_match(cw_nxo_t *a_thread, const char *a_pattern, uint32_t a_len, bool a_cont, bool a_global, bool a_insensitive, bool a_multiline, bool a_singleline, cw_nxo_t *a_input, bool *r_match):
```

Input(s):**a_thread:** Pointer to a thread *nxo*.**a_pattern:** Pointer to a string that specifies a regular expression.**a_len:** Length of *a_pattern*.**a_cont:** Continue where last successful match ended if true.**a_global:** Continue where last match ended if true.**a_insensitive:** Match with case insensitivity if true.**a_multiline:** Treat input as a multi-line string if true.**a_singleline:** Treat input as a single line, so that the dot metacharacter matches any character, including a newline.**a_input:** Pointer to a string *nxo*.**r_match:** Pointer to a bool.**Output(s):****retval:****NXN_ZERO:** Success.**NXN_regexerror:** Regular expression error.***r_match:****true:** Match successful.**false:** No match found.**Exception(s):**

CW_ONYXX_OOM.

Description: Look in *a_input* for a match to the regular expression specified by *a_pattern*, *a_len*, *a_cont*, *a_global*, *a_insensitive*, *a_multiline*, and *a_singleline*. As a side effect, set the thread's match cache, which can be queried via *nxo_regex_submatch()*.

This function combines *nxo_regex_new()* and *nxo_regex_match()* in such a way that no Onyx regex object is created, thus providing a more efficient way of doing a one-off match.

```
void nxo_regex_split(cw_nxo_t *a_nxo, cw_nxo_t *a_thread, uint32_t a_limit, cw_nxo_t *a_input, cw_nxo_t *r_array):
```

Input(s):

a_nxo: Pointer to a regex *nxo*.

a_thread: Pointer to a thread *nxo*.

a_limit: Maximum number of substrings to split *a_input* into. 0 is treated as infinity.

a_input: Pointer to a string *nxo*.

r_array: Pointer to an *nxo* to dup an array of substrings to.

Output(s):

***r_array:** An array of substrings.

Exception(s):**CW_ONYXX_OOM.**

Description: Use the regex pointed to by *a_nxo* to find matches in *a_input* and create an array of substrings that contain the data between those matches.

If there are capturing subpatterns in the regular expression, also create substrings for those capturing subpatterns and insert them into the substring array.

As a special case, if the regular expression matches the empty string, split a single character. This avoids an infinite loop.

As a side effect, set the thread's match cache, which can be queried via *nxo_regex_submatch()*. Keep in mind that this function can match multiple times in a single invocation, so only the last match is available in this way.

```
cw_nxn_t nxo_regex_nonew_split(cw_nxo_t *a_thread, const char *a_pattern, uint32_t a_len, bool a_insensitive, bool a_multiline, bool a_singleline, uint32_t a_limit, cw_nxo_t *a_input, cw_nxo_t *r_array):
```

Input(s):

a_thread: Pointer to a thread *nxo*.

a_pattern: Pointer to a string that specifies a regular expression.

a_len: Length of *a_pattern*.

a_insensitive: Match with case insensitivity if true.

a_multiline: Treat input as a multi-line string if true.

a_singleline: Treat input as a single line, so that the dot metacharacter matches any character, including a newline.

a_limit: Maximum number of substrings to split *a_input* into. 0 is treated as infinity.

a_input: Pointer to a string *nxo*.

r_array: Pointer to an *nxo* to dup an array of substrings to.

Output(s):**retval:**

NXN_ZERO: Success.

NXN_regexerror: Regular expression error.

***r_array:** An array of substrings.

Exception(s):

CW_ONYXX_OOM.

Description: Use the regex specified by *a_pattern*, *a_len*, *a_insensitive*, *a_multiline*, and *a_singleline* to find matches in *a_input* and create an array of substrings that contain the data between those matches.

If there are capturing subpatterns in the regular expression, also create substrings for those capturing subpatterns and insert them into the substring array.

As a special case, if the regular expression matches the empty string, split a single character. This avoids an infinite loop.

As a side effect, set the thread's match cache, which can be queried via *nxo_regex_submatch()*. Keep in mind that this function can match multiple times in a single invocation, so only the last match is available in this way.

This function combines *nxo_regex_nex()* and *nxo_regex_split()* in such a way that no Onyx regex object is created, thus providing a more efficient way of doing a one-off split.

void *nxo_regex_submatch*(cw_nxo_t *a_thread, uint32_t a_capture, cw_nxo_t *r_match):

Input(s):

a_thread: Pointer to a thread *nxo*.

a_capture: Index of captured subpattern to create a substring for:

0: Get substring of input text that matched the regular expression.

>0: Get substring of input text that matched the specified capturing subpattern.

r_match: Pointer to an *nxo* to dup a substring reference to.

Output(s):

***r_match:** An *nxo*:

null: Subpattern not matched.

string: A substring of text that corresponds to the captured subpattern specified by *a_capture*.

Exception(s):

CW_ONYXX_OOM.

Description: Create a substring using the calling thread's match cache that corresponds to capturing subpattern *a_capture*.

Each thread has a match cache that is used by various *regex* and *regsub* functions. That cache stores a reference to the string that was most recently matched against, as well as offsets and lengths of the match and capturing subpatterns. Since creating substrings puts pressure on the garbage collector, substring creation is done lazily (i.e. when this function is called). Normally, a program has little need to ask for the same substring twice, so the created substrings are not cached. That means that if this function is called twice in succession with the same arguments, two different (but equivalent) substrings will be returned.

4.10.32 *nxo_regsub*

The *nxo_regsub* class is a subclass of the *nxo* class.

API

`cx_nxn_t nxo_regsub_new(cx_nxo_t *a_nxo, const char *a_pattern, uint32_t a_plen, bool a_global, bool a_insensitive, bool a_multiline, bool a_singleline, const char *a_template, uint32_t a_tlen):`

Input(s):

- a_nxo:** Pointer to a regsub *nxo*.
- a_pattern:** Pointer to a string that specifies a regular expression.
- a_plen:** Length of *a_pattern*.
- a_global:** Substitute as many times as possible if true.
- a_insensitive:** Match with case insensitivity if true.
- a_multiline:** Treat input as a multi-line string if true.
- a_singleline:** Treat input as a single line, so that the dot metacharacter matches any character, including a newline.
- a_template:** Pointer to a string that specifies a substitution template.
- a_tlen:** Length of *a_template*.

Output(s):**retval:**

- NXN_ZERO:** Success.
- NXN_regexerror:** Regular expression error.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

`void nxo_regsub_subst(cx_nxo_t *a_nxo, cx_nxo_t *a_thread, cx_nxo_t *a_input, cx_nxo_t *r_output, uint32_t *r_count):`

Input(s):

- a_nxo:** Pointer to a regsub *nxo*.
- a_thread:** Pointer to a thread *nxo*.
- a_input:** Pointer to a string *nxo*.
- r_output:** Pointer to an *nxo* to dup a string reference to.
- r_count:** Pointer to a uint32_t.

Output(s):

- *r_output:** A string that was created by substituting regular expression matches according to a substitution template.
- *r_count:** Number of substitutions made. If 0 substitutions were made, **r_output* is a duplicate of *a_input*, rather than a copy.

Exception(s):

CW_ONYXX_OOM.

Description: Create a string by substituting according to *a_template* for each substring within *input* that matches a regular expression.

As a side effect, set the thread's match cache, which can be queried via *nxo_regex_submatch()*.

`cx_nxn_t nxo_regsub_nonew_subst(cx_nxo_t *a_thread, const char *a_pattern, uint32_t a_plen, bool a_global, bool a_insensitive, bool a_multiline, bool a_singleline, const char *a_template, uint32_t a_tlen, cx_nxo_t *a_input, cx_nxo_t *r_output, uint32_t *r_count):`

Input(s):

a.thread: Pointer to a thread *nxo*.
a.pattern: Pointer to a string that specifies a regular expression.
a.plen: Length of *a.pattern*.
a.global: Substitute as many times as possible if true.
a.insensitive: Match with case insensitivity if true.
a.multiline: Treat input as a multi-line string if true.
a.singleline: Treat input as a single line, so that the dot metacharacter matches any character, including a newline.
a.template: Pointer to a string that specifies a substitution template.
a.tlen: Length of *a.template*.
a.input: Pointer to a string *nxo*.
r.output: Pointer to an *nxo* to dup a string reference to.
r.count: Pointer to a `uint32_t`.

Output(s):

retval:

NXN_ZERO: Success.
NXN_regexerror: Regular expression error.
***r.output:** A string that was created by substituting regular expression matches (specified by *a.pattern*) according to *a.template*.
***r.count:** Number of substitutions made. If 0 substitutions were made, **r.output* is a duplicate of *a.input*, rather than a copy.

Exception(s):

CW_ONYXX_OOM.

Description: Create a string by substituting according to *a.template* for each substring within *input* that matches a regular expression.

As a side effect, set the thread's match cache, which can be queried via *nxo_regex_submatch()*.

This function combines *nxo_regsub_new()* and *nxo_regsub_subst()* in such a way that no Onyx regsub object is created, thus providing a more efficient way of doing a one-off subst.

4.10.33 nxo_stack

The *nxo_stack* class is a subclass of the *nxo* class.

API

void *nxo_stack_new*(*cw_nxo_t* **a_nxo*, *bool* *a_locking*, *uint32_t* *a_mincount*):

Input(s):

a_nxo: Pointer to a stack *nxo*.
a_locking: Implicit locking mode.
a_mincount: Minimum size to allow the internal array to shrink to.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

void *nxo_stack_copy*(cw_nxo_t *a_to, cw_nxo_t *a_from):

Input(s):

a_to: Pointer to a stack *nxo*.

a_from: Pointer to a stack *nxo*.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Copy the objects in *a_from* onto *a_to*.

uint32_t *nxo_stack_count*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a stack *nxo*.

Output(s):

retval: Number of objects on *a_nxo*.

Exception(s): None.

Description: Return the number of objects on *a_nxo*.

cw_nxo_t * *nxo_stack_push*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a stack *nxo*.

Output(s):

retval: Pointer to a no *nxo* that has been pushed onto *a_nxo*.

Exception(s):

CW_ONYXX_OOM.

Description: Push a no *nxo* onto *a_nxo* and return a pointer to it.

cw_nxo_t * *nxo_stack_bpush*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a stack *nxo*.

Output(s):

retval: Pointer to a no *nxo* that has been pushed onto the bottom of *a_nxo*.

Exception(s):

CW_ONYXX_OOM.

Description: Push a no *nxo* onto the bottom of *a_nxo* and return a pointer to it.

bool *nxo_stack_pop*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a stack *nxo*.

Output(s):

retval:

false: Success.

true: Stack underflow.

Exception(s): None.

Description: Pop an object off of *a_nxo*.

bool nxo_stack_bpop(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a stack *nxo*.

Output(s):

retval:

false: Success.

true: Stack underflow.

Exception(s): None.

Description: Pop an object off the bottom of *a_nxo*.

bool nxo_stack_npop(cw_nxo_t *a_nxo, uint32_t a_count):

Input(s):

a_nxo: Pointer to a stack *nxo*.

a_count: Number of objects to pop off of *a_nxo*.

Output(s):

retval:

false: Success.

true: Stack underflow.

Exception(s): None.

Description: Pop *a_count* objects off of *a_nxo*.

bool nxo_stack_nbpop(cw_nxo_t *a_nxo, uint32_t a_count):

Input(s):

a_nxo: Pointer to a stack *nxo*.

a_count: Number of objects to pop off the bottom of *a_nxo*.

Output(s):

retval:

false: Success.

true: Stack underflow.

Exception(s): None.

Description: Pop *a_count* objects off the bottom of *a_nxo*.

cw_nxo_t * nxo_stack_get(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a stack *nxo*.

Output(s):

retval:

non-NULL: Pointer to the top *nxo* on *a_nxo*.

NULL: Stack underflow.

Exception(s): None.

Description: Return a pointer to the top *nxo* on *a_nxo*.

cw_nxo_t * nxo_stack_bget(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a stack *nxo*.

Output(s):**retval:**

non-NULL: Pointer to the bottom *nxo* on *a_nxo*.

NULL: Stack underflow.

Exception(s): None.

Description: Return a pointer to the bottom *nxo* on *a_nxo*.

cw_nxo_t *nxo_stack_nget(const cw_nxo_t *a_nxo, uint32_t a_index):

Input(s):

a_nxo: Pointer to a stack *nxo*.

a_index: Index of object in *a_nxo* to return a pointer to.

Output(s):**retval:**

non-NULL: Pointer to the *nxo* on *a_nxo* at index *a_index*.

NULL: Stack underflow.

Exception(s): None.

Description: Return a pointer to the *nxo* on *a_nxo* at index *a_index*.

cw_nxo_t *nxo_stack_nbget(const cw_nxo_t *a_nxo, uint32_t a_index):

Input(s):

a_nxo: Pointer to a stack *nxo*.

a_index: Index, counting from the bottom, of object in *a_nxo* to return a pointer to.

Output(s):**retval:**

non-NULL: Pointer to the *nxo* on *a_nxo* at index *a_index*, counting from the bottom.

NULL: Stack underflow.

Exception(s): None.

Description: Return a pointer to the *nxo* on *a_nxo* at index *a_index*, counting from the bottom.

bool nxo_stack_exch(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a stack *nxo*.

Output(s):**retval:**

false: Success.

true: Stack underflow.

Exception(s): None.

Description: Exchange the top two objects on *a_nxo*.

void nxo_stack_rot(cw_nxo_t *a_nxo, int32_t a_amount):

Input(s):

a_nxo: Pointer to a stack *nxo*.

a_amount: Amount to rotate upward. A negative value rotates downward.

Output(s): None.

Exception(s): None.

Description: Rotate *a_nxo* up by *a_amount*.

bool *nxo_stack_roll*(cw_nxo_t *a_nxo, uint32_t a_count, int32_t a_amount):

Input(s):

a_nxo: Pointer to a stack *nxo*.

a_count: Number of objects in roll region.

a_amount: Amount to roll upward. A negative value rolls downward.

Output(s):

retval:

false: Success.

true: Stack underflow.

Exception(s): None.

Description: Roll the top *a_count* objects on *a_nxo* up by *a_amount*.

4.10.34 *nxo_string*

The *nxo_string* class is a subclass of the *nxo* class. Strings are not ‘\0’-terminated, mainly since sub-strings are references to other strings, and the termination character wouldn’t be consistently useful. *nxo_string_cstring*() is useful for creating ‘\0’-terminated copies of strings for situations where other C functions expect terminated strings.

API

void *nxo_string_new*(cw_nxo_t *a_nxo, bool a_locking, uint32_t a_len):

Input(s):

a_nxo: Pointer to a string *nxo*.

a_locking: Implicit locking mode.

a_len: Length in bytes of string to create.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

void *nxo_string_substring_new*(cw_nxo_t *a_nxo, cw_nxo_t *a_string, uint32_t a_offset, uint32_t a_len):

Input(s):

a_nxo: Pointer to a string *nxo*.

a_string: Pointer to a string *nxo* to create a substring of.

a_offset: Offset into *a_string*.

a_len: Length in bytes of substring to create.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Substring constructor.

void *nxo_string_copy*(cw_nxo_t *a_to, cw_nxo_t *a_from):

Input(s):

a_to: Pointer to a string *nxo*.

a_from: Pointer to a string *nxo*.

Output(s): None.

Exception(s): None.

Description: Copy the contents of *a_from* to *a_to*. The length of *a_to* must be at least that of *a_from*.

void *nxo_string_cstring*(cw_nxo_t *a_to, cw_nxo_t *a_from, cw_nxo_t *a_thread):

Input(s):

a_to: Pointer to an *nxo*.

a_from: Pointer to a string or name *nxo*.

a_thread: Pointer to a thread *nxo*.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Create a copy of *a_from*, but append a ‘\0’ character to make it usable in calls to typical C functions that expect a terminated string.

uint32_t *nxo_string_len_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a string *nxo*.

Output(s):

retval: Length of *a_nxo*.

Exception(s): None.

Description: Return the length of *a_nxo*.

void *nxo_string_el_get*(const cw_nxo_t *a_nxo, cw_nxoi_t a_offset, char *r_el):

Input(s):

a_nxo: Pointer to a string *nxo*.

a_offset: Offset of character to get.

r_el: Pointer to space to copy a character to.

Output(s):

***r_el:** A copy of the character of *a_nxo* at offset *a_offset*.

Exception(s): None.

Description: Get a copy of the character of *a_nxo* at offset *a_offset*.

void *nxo_string_el_set*(cw_nxo_t *a_nxo, char a_el, cw_nxoi_t a_offset):

Input(s):

a_nxo: Pointer to a string *nxo*.

a_el: A character.

a.offset: Offset of character in *a_nxo* to replace with *a_el*.

Output(s): None.

Exception(s): None.

Description: Copy *a_el* into the element of *a_nxo* at offset *a_offset*.

void *nxo_string_lock*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a string *nxo*.

Output(s): None.

Exception(s): None.

Description: If implicit locking is activated for *a_nxo*, lock it.

void *nxo_string_unlock*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a string *nxo*.

Output(s): None.

Exception(s): None.

Description: If implicit locking is activated for *a_nxo*, unlock it.

char * *nxo_string_get*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a string *nxo*.

Output(s):

retval: Pointer to the string internal to *a_nxo*.

Exception(s): None.

Description: Return a pointer to the string internal to *a_nxo*.

void *nxo_string_set*(cw_nxo_t *a_nxo, uint32_t a_offset, const char *a_str, uint32_t a_len):

Input(s):

a_nxo: Pointer to a string *nxo*.

a_offset: Offset into *a_nxo* to replace.

a_str: String to replace a range of *a_nxo* with.

a_len: Length in bytes of *a_str*.

Output(s): None.

Exception(s): None.

Description: Replace *a_len* bytes of *a_nxo* at offset *a_offset* with *a_str*.

4.10.35 *nxo_thread*

The *nxo_thread* class is a subclass of the *nxo* class.

The *threadp* class is a helper class that contains scanner position information. The *threadp* state is used when recording syntax errors.

API

void *nxo_threadp_new*(cw_nxo_threadp_t *a_threadp):

Input(s):

a_threadp: Pointer to space for a *threadp*.

Output(s): None.

Exception(s): None.

Description: Constructor.

void *nxo_threadp_delete*(cw_nxo_threadp_t *a_threadp, cw_nxo_t *a_thread):

Input(s):

a_threadp: Pointer to a *threadp*.

a_thread: Pointer to a thread *nxo*.

Output(s): None.

Exception(s): None.

Description: Destructor.

void *nxo_threadp_origin_get*(const cw_nxo_threadp_t *a_threadp, const char **r_origin, uint32_t *r_olen):

Input(s):

a_threadp: Pointer to space for a *threadp*.

r_origin: Pointer to a string pointer.

r_olen: Pointer to an unsigned integer.

Output(s):

***r_origin:** A pointer to a string that represents the origin of *a_nxo*.

***r_olen:** The length of the string pointed to by **r_origin*.

Exception(s): None.

Description: Retrieve the origin.

void *nxo_threadp_origin_set*(cw_nxo_threadp_t *a_threadp, const char *a_origin, uint32_t a_olen):

Input(s):

a_threadp: Pointer to space for a *threadp*.

a_origin: Pointer to a string that represents the origin of *a_nxo*.

a_olen: The length of the string pointed to by *a_origin*.

Output(s): None.

Exception(s): None.

Description: Set the origin. This function does not make a copy of *a_origin*, so the string must exist for the entire time that *a_threadp* retains a reference to the string.

void *nxo_threadp_position_get*(const cw_nxo_threadp_t *a_threadp, uint32_t *r_line, uint32_t *r_column):

Input(s):

a_threadp: Pointer to space for a *threadp*.

r_line: Pointer to a location to store a line number.

r_column: Pointer to a location to store a column number.

Output(s):

***r_line:** Line number.

***r_column:** Column number.

Exception(s): None.

Description: Retrieve the line number and column number.

void *nxo_threadp_position_set*(cw_nxo_threadp_t *a_threadp, uint32_t a_line, uint32_t a_column):

Input(s):

a_threadp: Pointer to space for a *threadp*.

a_line: Line number.

a_column: Column number.

Output(s): None.

Exception(s): None.

Description: Set the line number and column number.

void *nxo_thread_new*(cw_nxo_t *a_nxo, cw_nx_t *a_nx):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_nx: Pointer to an *nx*.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor.

void *nxo_thread_start*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s): None.

Exception(s): Application dependent.

Description: Start a thread running by calling the **start** operator such that the top object on ostack will be executed.

void *nxo_thread_exit*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s): None.

Exception(s): None.

Description: Terminate the thread. This has the same effect as a detached thread exiting. Calling this function may be necessary (depending on the application) to allow the thread to be garbage collected, much the same way as the **detach** and **join** operators do.

void *nxo_thread_thread*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: Create a new thread. The new thread calls *nxo_thread.start()*.

void *nxo_thread.detach*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s): None.

Exception(s): None.

Description: Detach *a_nxo* so that when it exits it can be garbage collected.

void *nxo_thread.join*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s): None.

Exception(s): None.

Description: Wait for *a_nxo* to exit.

cw_nxo_threadds_t *nxo_thread_state*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: The current scanner state of *a_nxo*.

THREADTS_START: Start state.

THREADTS_COMMENT: '%' seen, but no line break yet.

THREADTS_INTEGER: Scanning an integer.

THREADTS_INTEGER_RADIX: Scanning a radix integer.

THREADTS_REAL_FRAC: Scanning the fractional portion of a real.

THREADTS_REAL_EXP: Scanning the exponent porttion of a real.

THREADTS_STRING: Scanning a string.

THREADTS_STRING_NEWLINE_CONT: '\r' seen in a string.

THREADTS_STRING_PROT_CONT: '\\ ' seen in a string.

THREADTS_STRING_CRLF_CONT: '\r' seen in a string.

THREADTS_STRING_CTRL_CONT: '\c' seen in a string.

THREADTS_STRING_HEX_CONT: '\x' seen in a string.

THREADTS_STRING_HEX_FINISH: First hex digit of a "\xDD" string escape sequence seen.

THREADTS_NAME_START: '!', '\$', or '~' seen.

THREADTS_NAME: Scanning a name.

Exception(s): None.

Description: Return the current scanner state. In general this is only useful when implementing an interactive environment for which the prompt behaves differently depending on what state the scanner is in. For example the interactive *onyx* shell needs only to know whether the scanner is in the start state.

bool *nxo_thread.deferred*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):**retval:**

false: Execution is not deferred.

true: Execution is deferred.

Exception(s): None.

Description: Return whether the scanner is currently in deferred execution mode. See Section 2.2 for information on deferred execution. In general this is only useful when implementing an interactive environment for which the prompt behaves differently depending on what state the scanner is in.

void *nxo_thread_reset*(cw_nxo_t *a_nxo):**Input(s):**

a_nxo: Pointer to a thread *nxo*.

Output(s): None.**Exception(s):** None.

Description: Reset the scanner to the start state, and turn deferral off. This is a dangerous feature that should be used with great care. *nxo_no* objects should never be visible from inside the interpreter, so the caller must assure that any *nxo_no* objects are removed before further processing is done in the context of *a_nxo*.

void *nxo_thread_loop*(cw_nxo_t *a_nxo):**Input(s):**

a_nxo: Pointer to a thread *nxo*.

Output(s): None.**Exception(s):** Application specific.

Description: Execute the top object on estack. The caller is responsible for placing the object on estack, but it is removed before this function returns.

void *nxo_thread_interpret*(cw_nxo_t *a_nxo, cw_nxo_threadp_t *a_threadp, const char *a_str, uint32_t a_len):**Input(s):**

a_nxo: Pointer to a thread *nxo*.

a_threadp: A *threadp*.

a_str: Pointer to a string to interpret.

a_len: Length in bytes of *a_str*.

Output(s): None.**Exception(s):** Application specific.

Description: Interpret the string pointed to by *a_str*.

void *nxo_thread_flush*(cw_nxo_t *a_nxo, cw_nxo_threadp_t *a_threadp):**Input(s):**

a_nxo: Pointer to a thread *nxo*.

a_threadp: A *threadp*.

Output(s): None.

Exception(s): Application specific.

Description: Do the equivalent of interpreting a carriage return in order to force acceptance of the previous token if no whitespace has yet followed.

void *nxo_thread_nerror*(cw_nxo_t *a_nxo, cw_nxn_t a_nxn):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_nxn: An nxn corresponding to the name of an error.

Output(s): None.

Exception(s): Application dependent.

Description: Throw an error.

void *nxo_thread_serror*(cw_nxo_t *a_nxo, const char a_str, uint32_t a_len):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_str: Pointer to a string that represents the name of an error.

a_len: The length of *a_str*.

Output(s): None.

Exception(s): Application dependent.

Description: Throw an error.

bool *nxo_thread_dstack_search*(cw_nxo_t *a_nxo, cw_nxo_t *a_key, cw_nxo_t *r_value):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_key: Pointer to an *nxo*.

r_value: Pointer to an *nxo*.

Output(s):

retval:

false: Success.

true: *a_key* not found on dstack.

r_value: Top value in dstack associated with *a_key*.

Exception(s): None.

Description: Search dstack for the topmost definition of *a_key* and dup its value to *r_value*.

bool *nxo_thread_class_hier_search*(cw_nxo_t *a_nxo, cw_nxo_t *a_class, cw_nxo_t *a_key, cw_nxo_t *r_value):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_class: Pointer to a class *nxo*.

a_key: Pointer to an *nxo*.

r_value: Pointer to an *nxo*.

Output(s):

retval:

false: Success.

true: *a_key* not found on in *a_class*'s class hierarchy.

r_value: Value in *a_class*'s class hierarchy farthest from the base class that is associated with *a_key*.

Exception(s): None.

Description: Search *a_class*'s class hierarchy for the definition of *a_key* that is farthest from the base class.

bool *nxo_thread_currentlocking*(const cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval:

false: Implicit locking deactivated for new objects.

true: Implicit locking activated for new objects.

Exception(s): None.

Description: Return whether implicit locking is activated for new objects.

void *nxo_thread_setlocking*(cw_nxo_t *a_nxo, bool a_locking):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_locking:

false: Do not implicitly lock new objects.

true: Implicitly lock new objects.

Output(s): None.

Exception(s): None.

Description: Activate or deactivate implicit locking for new objects.

cw_nxoi_t *nxo_thread_maxestack_get*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Maximum allowable estack depth.

Exception(s): None.

Description: Return *a_nxo*'s maximum allowable estack depth.

void *nxo_thread_maxestack_set*(cw_nxo_t *a_nxo, cw_nxoi_t a_maxestack):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_maxestack: Maximum estack depth.

Output(s): None.

Exception(s): None.

Description: Set *a_nxo*'s maximum allowable estack depth to *a_maxestack*.

bool *nxo_thread_tailopt_get*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Tail optimization setting.

Exception(s): None.

Description: Return *a_nxo*'s tail optimization setting.

void *nxo_thread_tailopt_set*(cw_nxo_t *a_nxo, bool a_tailopt):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_tailopt: Tail optimization setting.

Output(s): None.**Exception(s):** None.

Description: Set *a_nxo*'s tail optimization setting to *a_tailopt*.

cw_nx_t * *nxo_thread_nx_get*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nx*.

Exception(s): None.

Description: Return the *nx* associated with *a_nxo*.

cw_nxo_t * *nxo_thread_userdict_get*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the userdict associated with *a_nxo*.

cw_nxo_t * *nxo_thread_errordict_get*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the errordict associated with *a_nxo*.

cw_nxo_t * *nxo_thread_currenterror_get*(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the current error associated with *a_nxo*.

cw_nxo_t * nxo_thread_ostack_get(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the ostack associated with *a_nxo*.

cw_nxo_t * nxo_thread_dstack_get(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the dstack associated with *a_nxo*.

cw_nxo_t * nxo_thread_estack_get(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the estack associated with *a_nxo*.

cw_nxo_t * nxo_thread_istack_get(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the istack associated with *a_nxo*.

cw_nxo_t * nxo_thread_tstack_get(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the tstack associated with *a_nxo*.

cw_nxo_t * nxo_thread_stdin_get(cw_nxo_t *a_nxo):

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the stdin associated with *a_nxo*.

void *nxo_thread_stdin_set*(*cx_nxo_t* **a_nxo*, *cx_nxo_t* **a_stdin*):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_stdin: Pointer to a file *nxo*.

Output(s): None.

Exception(s): None.

Description: Set *a_nxo*'s stdin to *a_stdin*.

***cx_nxo_t* * *nxo_thread_stdout_get*(*cx_nxo_t* **a_nxo*):**

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the stdout associated with *a_nxo*.

void *nxo_thread_stdout_set*(*cx_nxo_t* **a_nxo*, *cx_nxo_t* **a_stdout*):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_stdout: Pointer to a file *nxo*.

Output(s): None.

Exception(s): None.

Description: Set *a_nxo*'s stdout to *a_stdout*.

***cx_nxo_t* * *nxo_thread_stderr_get*(*cx_nxo_t* **a_nxo*):**

Input(s):

a_nxo: Pointer to a thread *nxo*.

Output(s):

retval: Pointer to an *nxo* that can safely be used without risk of being garbage collected.

Exception(s): None.

Description: Return a pointer to the stderr associated with *a_nxo*.

void *nxo_thread_stderr_set*(*cx_nxo_t* **a_nxo*, *cx_nxo_t* **a_stderr*):

Input(s):

a_nxo: Pointer to a thread *nxo*.

a_stderr: Pointer to a file *nxo*.

Output(s): None.

Exception(s): None.

Description: Set *a_nxo*'s stderr to *a_stderr*.

4.10.36 ql

The *ql* macros implement operations on a list. The type of the list elements and which field of the elements to use are determined by arguments that are passed into the macros. The macros are optimized for speed and code size, which means that there is minimal error checking built in. As a result, care must be taken to assure that these macros are used as intended, or strange things can happen.

Internally, the list is represented as a ring, so with some care, the *ql* and *qr* interfaces can be used in conjunction with each other.

Since a *ql* is actually a ring, it is possible to have multiple *ql* heads that share the same ring. This works just fine, with the caveat that operations on one *ql* can have side-effects on another.

API

***ql_head*(*<ql_type> a_type*):**

Input(s):

a_type: Data type for the *ql* elements.

Output(s): A data structure that can be used as a *ql* head.

Exception(s): None.

Description: Generate code for a *ql* head data structure.

***ql_head_initializer*(*<ql_type> *a_head*):**

Input(s):

a_head: Pointer to a *ql* head.

Output(s): None.

Exception(s): None.

Description: Statically initialize a *ql* head.

***ql_elm*(*<ql_type> a_type*):**

Input(s):

a_type: Data type for the *ql* elements.

Output(s): A data structure that can be used as a *ql* element.

Exception(s): None.

Description: Generate code for a *ql* element data structure.

***void ql_new*(*<ql_head> *a_head*):**

Input(s):

a_head: Pointer to a *ql* head.

Output(s): None.

Exception(s): None.

Description: Constructor.

***void ql_elm_new*(*<ql_type> *a_elm, <field_name> a_field*):**

Input(s):

a_elm: Pointer to an element.

a.field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Constructor.

<ql.type> *ql_first(<ql.head> *a.head):

Input(s):

a.head: Pointer to a *ql* head.

Output(s):

retval:

non-NULL: Pointer to the first element in *a.head*.

NULL: *a.head* is empty.

Exception(s): None.

Description: Return a pointer to the first element in the *ql*.

<ql.type> *ql_last(<ql.head> *a.head, <field.name> a.field):

Input(s):

a.head: Pointer to a *ql* head.

a.field: Field within the *ql* elements to use.

Output(s):

retval:

non-NULL: Pointer to the last element in *a.head*.

NULL: *a.head* is empty.

Exception(s): None.

Description: Return a pointer to the last element in the *ql*.

<ql.type> *ql_next(<ql.head> *a.head, <ql.type> *a.elm, <field.name> a.field):

Input(s):

a.head: Pointer to a *ql* head.

a.elm: Pointer to an element.

a.field: Field within the *ql* elements to use.

Output(s):

retval:

non-NULL: Pointer to the element after *a.elm*.

NULL: *a.elm* is the last element in *a.head*.

Exception(s): None.

Description: Return a pointer to the element in *a.head* after *a.elm*.

<ql.type> *ql_prev(<ql.head> *a.head, <ql.type> *a.elm, <field.name> a.field):

Input(s):

a.head: Pointer to a *ql* head.

a.elm: Pointer to an element.

a.field: Field within the *ql* elements to use.

Output(s):

retval:

non-NULL: Pointer to the element before *a_elm*.

NULL: *a_elm* is the first element in *a_head*.

Exception(s): None.

Description: Return a pointer to the element in *a_head* before *a_elm*.

void *ql_before_insert*(*<ql head> *a_head, <ql type> *a_qlelm, <ql type> *a_elm, <field name> a_field*):

Input(s):

a_head: Pointer to a *ql* head.

a_qlelm: Pointer to an element within *a_head*.

a_elm: Pointer to an element.

a_field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Insert *a_elm* into *a_head* before *a_qlelm*.

void *ql_after_insert*(*<ql type> *a_qlelm, <ql type> *a_elm, <field name> a_field*):

Input(s):

a_qlelm: Pointer to an element within *a_head*.

a_elm: Pointer to an element.

a_field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Insert *a_elm* into *a_head* after *a_qlelm*.

void *ql_head_insert*(*<ql head> *a_head, <ql type> *a_elm, <field name> a_field*):

Input(s):

a_head: Pointer to a *ql* head.

a_elm: Pointer to an element.

a_field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Insert *a_elm* at the head of *a_head*.

void *ql_tail_insert*(*<ql head> *a_head, <ql type> *a_elm, <field name> a_field*):

Input(s):

a_head: Pointer to a *ql* head.

a_elm: Pointer to an element.

a_field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Insert *a_elm* at the tail of *a_head*.

void *ql_remove*(*<ql head> *a_head, <ql type> *a_elm, <field name> a_field*):

Input(s):

a_head: Pointer to a *ql* head.
a_elm: Pointer to an element.
a_field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Remove *a_elm* from *a_head*.

void ql_head_remove(<ql_head> *a_head, <ql_type> a_type, <field_name> a_field):

Input(s):

a_head: Pointer to a *ql* head.
a_type: Data type for the *ql* elements.
a_field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Remove the head element of *a_head*.

void ql_tail_remove(<ql_head> *a_head, <ql_type> a_type, <field_name> a_field):

Input(s):

a_head: Pointer to a *ql* head.
a_type: Data type for the *ql* elements.
a_field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Remove the tail element of *a_head*.

ql_foreach(<ql_type> *a_var, <ql_type> *a_head, <field_name> a_field):

Input(s):

a_var: The name of a temporary variable to use for iteration.
a_head: Pointer to a *ql* head.
a_field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Iterate through the *ql*, storing a pointer to each element in *a_var* along the way.

ql_reverse_foreach(<ql_type> *a_var, <ql_type> *a_head, <field_name> a_field):

Input(s):

a_var: The name of a temporary variable to use for iteration.
a_head: Pointer to a *ql* head.
a_field: Field within the *ql* elements to use.

Output(s): None.

Exception(s): None.

Description: Iterate through the *ql* in the reverse direction, storing a pointer to each element in *a_var* along the way.

4.10.37 **qr**

The *qr* macros implement operations on a ring. The type of the ring elements and which field of the elements to use are determined by arguments that are passed into the macros. The macros are optimized for speed and code size, which means that there is minimal error checking built in. As a result, care must be taken to assure that these are used as intended, or strange things can happen.

API

***qr*(*<qr.type>* *a.type*):**

Input(s):

a.type: Data type for the *qr*.

Output(s): A data structure that can be used for a *qr*.

Exception(s): None.

Description: Generate code for a *qr* data structure.

void *qr_new*(*<qr.type>* **a_qr*, *<field.name>* *a.field*):

Input(s):

a.qr: Pointer to a *qr*.

a.field: Field within the *qr* elements to use.

Output(s): None.

Exception(s): None.

Description: Constructor.

***<qr.type>* * *qr_next*(*<qr.type>* **a_qr*, *<field.name>* *a.field*):**

Input(s):

a.qr: Pointer to a *qr*.

a.field: Field within the *qr* elements to use.

Output(s):

retval: Pointer to the next element in the *qr*.

Exception(s): None.

Description: Return a pointer to the next element in the *qr*.

***<qr.type>* * *qr_prev*(*<qr.type>* **a_qr*, *<field.name>* *a.field*):**

Input(s):

a.qr: Pointer to a *qr*.

a.field: Field within the *qr* elements to use.

Output(s):

retval: Pointer to the previous element in the *qr*.

Exception(s): None.

Description: Return a pointer to the previous element in the *qr*.

void *qr_before_insert*(*<qr.type>* **a_qrelm*, *<qr.type>* **a_qr*, *<field.name>* *a.field*):

Input(s):

a.qrelm: Pointer to an element in a *qr*.

a.qr: Pointer to an element that is the only element in its ring.

a.field: Field within the *qr* elements to use.

Output(s): None.

Exception(s): None.

Description: Insert *a_qr* before *a_qrelm*.

void *qr_after_insert*(<qr.type> *a_qrelm, <qr.type> *a_qr, <field.name> a.field):

Input(s):

a_qrelm: Pointer to an element in a *qr*.

a.qr: Pointer to an element that is the only element in its ring.

a.field: Field within the *qr* elements to use.

Output(s): None.

Exception(s): None.

Description: Insert *a_qr* after *a_qrelm*.

void *qr_meld*(<qr.type> *a_qr_a, <qr.type> *a_qr_b, <qr.type> a.type, <field.name> a.field):

Input(s):

a_qr_a: Pointer to a *qr*.

a_qr_b: Pointer to a *qr*.

a.type: Data type for the *qr* elements.

a.field: Field within the *qr* elements to use.

Output(s): None.

Exception(s): None.

Description: Meld *a_qr_a* and *a_qr_b* into one ring.

void *qr_split*(<qr.type> *a_qr_a, <qr.type> *a_qr_b, <qr.type> a.type, <field.name> a.field):

Input(s):

a_qr_a: Pointer to a *qr*.

a_qr_b: Pointer to a *qr*.

a.type: Data type for the *qr* elements.

a.field: Field within the *qr* elements to use.

Output(s): None.

Exception(s): None.

Description: Split a ring at *a_qr_a* and *a_qr_b*.

void *qr_remove*(<qr.type> *a_qr, <field.name> a.field):

Input(s):

a.qr: Pointer to a *qr*.

a.field: Field within the *qr* elements to use.

Output(s): None.

Exception(s): None.

Description: Remove *a_qr* from the ring.

***qr_foreach*(<qr.type> *a_var, <qr.type> *a_qr, <field.name> a.field):**

Input(s):**a_var:** The name of a temporary variable to use for iteration.**a_qr:** Pointer to a *qr*.**a_field:** Field within the *qr* elements to use.**Output(s):** None.**Exception(s):** None.**Description:** Iterate through the *qr*, storing a pointer to each element in *a_var* along the way.***qr_reverse_foreach*(*<qr_type> *a_var, <qr_type> *a_qr, <field_name> a_field*):****Input(s):****a_var:** The name of a temporary variable to use for iteration.**a_qr:** Pointer to a *qr*.**a_field:** Field within the *qr* elements to use.**Output(s):** None.**Exception(s):** None.**Description:** Iterate through the *qr* in the reverse direction, storing a pointer to each element in *a_var* along the way.

4.10.38 *qs*

The *qs* macros implement operations on a stack. The type of the stack elements and which field of the elements to use are determined by arguments that are passed into the macros. The macros are optimized for speed and code size, which means that there is minimal error checking built in. As a result, care must be taken to assure that these macros are used as intended, or strange things can happen.

API

qs_head*(*<qs_type> a_type*):*Input(s):****a_type:** Data type for the *qs*.**Output(s):** A data structure that can be used as a *qs* head.**Exception(s):** None.**Description:** Generate code for a *qs* head data structure.***qs_head_initializer*(*<qs_type> *a_head*):****Input(s):****a_head:** Pointer to a *qs* head.**Output(s):** None.**Exception(s):** None.**Description:** Statically initialize a *qs* head.***qs_elm*(*<qs_elm_type> a_type*):****Input(s):**

a.type: Data type for the *qs* elements.

Output(s): A data structure that can be used as a *qs* element.

Exception(s): None.

Description: Generate code for a *qs* element data structure.

void *qs_new*(<qs.type> *a.head):

Input(s):

a.head: Pointer to a *qs* head.

Output(s): None.

Exception(s): None.

Description: Constructor.

void *qs_elm_new*(<qs.elm.type> *a.elm, <field.name> a.field):

Input(s):

a.head: Pointer to a *qs* element.

a.field: Field within the *qs* elements to use.

Output(s): None.

Exception(s): None.

Description: Constructor.

<qs.type> **qs_top*(<qs.type> *a.head):

Input(s):

a.head: Pointer to a *qs* head.

Output(s):

retval: Pointer to the top element in the *qs*.

Exception(s): None.

Description: Return a pointer to the top element in the *qs*.

<qs.type> **qs_down*(<qs.elm.type> *a.elm, <field.name> a.field):

Input(s):

a.elm: Pointer to a *qs* element.

a.field: Field within the *qs* elements to use.

Output(s):

retval:

non-NULL: Pointer to the next element in the *qs*.

NULL: *a.elm* is the bottom element in the *qs*.

Exception(s): None.

Description: Return a pointer to the next element in the *qs* below *a.elm*.

void *qs_push*(<qs.type> *a.head, <qs.elm.type> *a.elm, <field.name> a.field):

Input(s):

a.head: Pointer to a *qs* head.

a.elm: Pointer to an element.

a.field: Field within the *qs* elements to use.

Output(s): None.

Exception(s): None.

Description: Push *a_elm* onto the *qs*.

void *qs_under_push*(*<qs_elm_type> *a_qselm, <qs_elm_type> *a_elm, <field_name> a_field*):

Input(s):

a_qselm: Pointer to a *qs* element.

a_elm: Pointer to an element.

a_field: Field within the *qs* elements to use.

Output(s): None.

Exception(s): None.

Description: Push *a_elm* under *a_qselm*.

void *qs_pop*(*<qs_type> *a_head, <field_name> a_field*):

Input(s):

a_head: Pointer to a *qs* head.

a_field: Field within the *qs* elements to use.

Output(s): None.

Exception(s): None.

Description: Pop an element off of *a_head*.

***qs_foreach*(*<qs_elm_type> *a_var, <qs_type> *a_head, <field_name> a_field*):**

Input(s):

a_var: The name of a temporary variable to use for iteration.

a_head: Pointer to a *qs* head.

a_field: Field within the *qs* elements to use.

Output(s): None.

Exception(s): None.

Description: Iterate down the *qs*, storing a pointer to each element in *a_var* along the way.

4.10.39 thd

The *thd* class implements a wrapper around the system POSIX threads library or GNU pthread library. In most regards, this is a thin wrapper around the normal threading functionality, but some extra information is kept in order to allow implementation of thread suspension/resumption, “critical sections”, and “single sections”.

The suspendibility of each thread is determined by the arguments passed to *thd_new*(). The initial thread is always suspendible. Other threads that are created via some mechanism other than *thd_new*() are not suspendible.

Depending on how *libonyx* is built, the additional functionality is implemented with the aid of the *SIGUSR1* and *SIGUSR2* signals. As a result, system calls may be interrupted by signals. The system calls will be automatically restarted if they have made no progress at the time of interruption, but will return a partial result otherwise. Therefore, if any of the additional functionality is utilized, the application must be careful to handle partial system call results. At least the following system calls can be interrupted: *read*(), *write*(), *sendto*(), *recvfrom*(), *sendmsg*(), *recvmsg*(), *ioctl*(), and *wait*(). See the system documentation for additional information.

API

`cw_thd_t * thd_new(void *(*a_start_func)(void *), void *a_arg, bool a_suspensible):`

Input(s):

a_start_func: Pointer to a start function.

a_arg: Argument passed to *a_start_func()*.

a_suspensible:

false: Not suspensible.

true: Suspensible.

Output(s):

retval: Pointer to a *thd*.

Exception(s):

CW_ONYXX_OOM.

Description: Constructor (creates a new thread).

`void thd_delete(cw_thd_t *a_thd):`

Input(s):

a_thd: Pointer to a *thd*.

Output(s): None.

Exception(s): None.

Description: Destructor.

`void * thd_join(cw_thd_t *a_thd):`

Input(s):

a_thd: Pointer to a *thd*.

Output(s):

retval: Return value from thread entry function.

Exception(s): None.

Description: Join (wait for) the thread associated with *a_thd*.

`cw_thd_t * thd_self(void):`

Input(s): None.

Output(s):

retval: Pointer to the calling thread's *thd* structure.

Exception(s): None.

Description: Return a pointer to the *thd* structure that corresponds to the calling thread.

`void thd_yield(void):`

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Give up the rest of the calling thread's time slice.

`int thd_sigmask(int a_how, const sigset_t *a_set, sigset_t *r_aset):`

Input(s):

a.how:

SIG_BLOCK: Block signals in *a.set*.

SIG_UNBLOCK: Unblock signals in *a.set*.

SIG_SETMASK: Set signal mask to *a.set*.

a.set: Pointer to a signal set.

r.oset:

non-NULL: Pointer space to store the old signal mask.

NULL: Ignored.

Output(s):

retval: Always zero, unless the arguments are invalid.

***r.oset:** Old signal set.

Exception(s): None.

Description: Set the calling thread's signal mask.

void *thd_crit_enter*(void):

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Enter a critical region where the calling thread may not be suspended by *thd_suspend()*, *thd_trysuspend()*, or *thd_single_enter()*.

void *thd_crit_leave*(void):

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Leave a critical section; the calling thread may once again be suspended.

void *thd_single_enter*(void):

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Enter a critical region where all other suspensible threads must be suspended.

void *thd_single_leave*(void):

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Leave a critical section where all other threads must be suspended. All threads that were suspended in *thd_single_enter()* are resumed.

void *thd_suspend*(*ew_thd_t* **a_thd*):

Input(s):

a.thd: Pointer to a *thd*.

Output(s): None.

Exception(s): None.

Description: Suspend *a_thd*.

bool *thd_trysuspend*(*cw_thd_t* **a_thd*):

Input(s):

a_thd: Pointer to a *thd*.

Output(s):

retval:

false: Success.

true: Failure.

Exception(s): None.

Description: Try to suspend *a_thd*, but fail if it is in a critical section.

void *thd_resume*(*cw_thd_t* **a_thd*):

Input(s):

a_thd: Pointer to a *thd*.

Output(s): None.

Exception(s): None.

Description: Resume (make runnable) *a_thd*.

4.10.40 *tsd*

The *tsd* class implements thread-specific data. A *tsd* instance can be created, then any number of threads can use that same instance to store and retrieve a thread-specific pointer to data.

API

void *tsd_new*(*cw_tsd_t* **a_tsd*, void (a_func*)(void *):**

Input(s):

a_tsd: Pointer to space for a *tsd*.

a_func: Pointer to a cleanup function, or NULL.

Output(s): None.

Exception(s): None.

Description: Constructor.

void *tsd_delete*(*cw_tsd_t* **a_tsd*):

Input(s):

a_tsd: Pointer to a *tsd*.

Output(s): None.

Exception(s): None.

Description: Destructor.

void * *tsd_get*(*cw_tsd_t* **a_tsd*):

Input(s):**a.tsd:** Pointer to a *tsd*.**Output(s):****retval:** Pointer to thread-specific data.**Exception(s):** None.**Description:** Get thread-specific data pointer.**void *tsd_set*(*cw_tsd_t* **a.tsd*, void **a.val*):****Input(s):****a.tsd:** Pointer to a *tsd*.**a.val:** Pointer to thread-specific data.**Output(s):** None.**Exception(s):** None.**Description:** Set thread-specific data pointer.

4.10.41 xep

The *xep* class implements exception handling, with support for *xep_try* and *xep_catch()* blocks. Minimal use must include at least:

```
xep_begin();
xep_try
{
    /* Code that might throw an exception. */
}
xep_end();
```

A more complete skeleton looks like:

```
xep_begin();
xep_try
{
    /* Code that might throw an exception. */
}
xep_catch(SOME_EXCEPTION)
{
    /* Handle exception... */
    xep_handled();
}
xep_catch(ANOTHER_EXCEPTION)
xep_mcatch(YET_ANOTHER)
{
    /* React to exception, but propagate... */
}
xep_acatch
{
    /* Handle all exceptions not explicitly handled above... */
}
```

```

    xep_handled();
}
xep_end();

```

Note that there is some serious `cpp` macro magic behind the *xep* interface, and as such, if usage deviates significantly from the above templates, compiler errors may result.

Exception values are of type `cw_xepv_t`. *CW_ONYXX_MIN* to *CW_ONYXX_MAX* are reserved by *libonyx*, and other ranges may be reserved by other libraries. See their documentation for details.

An exception is not implicitly handled if an exception handler is executed for that exception. Instead, *xep_handled()* must be manually called to avoid propagating the exception up the handler chain.

It is not legal to return from a function within an exception handling code block, nor is it legal to jump out of an exception handling block; doing so will corrupt the exception handler chain.

API

void *xep_begin*(void):

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Begin an exception handling code block.

void *xep_end*(void):

Input(s): None.

Output(s): None.

Exception(s): None.

Description: End an exception handling block.

***xep_try* ...:**

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Begin a block of code that is to be executed, with the possibility that an exception might be thrown.

***xep_catch*(cw_xepv_t a_xepv) ...:**

Input(s):

a_xepv: Exception number.

Output(s): None.

Exception(s): None.

Description: Begin a block of code that catches an exception. The exception is not considered handled unless *xep_handled()* is called.

***xep_mcatch*(cw_xepv_t a_xepv) ...:**

Input(s):

a_xepv: Exception number.

Output(s): None.

Exception(s): None.

Description: Begin a block of code that catches an exception. Must immediately follow a *xep_catch()* call. This interface is used for the case where more than one exception type is to be handled by the same code block. The exception is not considered handled unless *xep_handled()* is called.

xep_acatch ...:

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Begin a block of code that catches all exceptions not explicitly caught by *xep_catch()* and *xep_mcatch()* blocks. There may only be one *xep_acatch* block within a try/catch block. The exception is not considered handled unless *xep_handled()* is called.

cw_xepv_t xep_value(void):

Input(s): None.

Output(s):

retval: Value of the current exception being handled.

Exception(s): None.

Description: Return the value of the current exception being handled.

const char * xep_filename(void):

Input(s): None.

Output(s):

retval: Filename where the current exception being handled was thrown.

Exception(s): None.

Description: Return the filename where the current exception being handled was thrown.

uint32_t xep_line_num(void):

Input(s): None.

Output(s):

retval: Line number where the current exception being handled was thrown.

Exception(s): None.

Description: Return the line number where the current exception being handled was thrown.

void xep_throw_e(cw_xepv_t a_xepv, const char *a_filename, uint32_t a_line_num):

void xep_throw(cw_xepv_t a_xepv):

Input(s):

a_xepv: Exception number to throw.

a_filename: Should be *__FILE__*.

a_line_num: Should be *__LINE__*.

Output(s): None.

Exception(s):

a_xepv.

Description: Throw an exception.

void xep_retry(void):

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Implicitly handle the current exception and retry the *xep_try* code block.

void xep_handled(void):

Input(s): None.

Output(s): None.

Exception(s): None.

Description: Mark the current exception as handled.

4.11 Dictionaries

4.11.1 gcdict

The *gcdict* functions implement the operators contained in **gcdict**. Only the C API is documented here; see Section 2.11.4 for operator semantics.

API

void gcdict_active(cw_nxo_t *a_thread):

void gcdict_collect(cw_nxo_t *a_thread):

void gcdict_period(cw_nxo_t *a_thread):

void gcdict_setactive(cw_nxo_t *a_thread):

void gcdict_setperiod(cw_nxo_t *a_thread):

void gcdict_setthreshold(cw_nxo_t *a_thread):

void gcdict_stats(cw_nxo_t *a_thread):

void gcdict_threshold(cw_nxo_t *a_thread):

Input(s):

a_thread: Pointer to a thread.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: C interfaces to Onyx operators that control garbage collection.

4.11.2 systemdict

The *systemdict* functions implement the operators contained in **systemdict**. Only the C API is documented here; see Section 2.11.9 for operator semantics.

API

```
void systemdict_abs(cw_nxo_t *a_thread):
void systemdict_accept(cw_nxo_t *a_thread):
void systemdict_acos(cw_nxo_t *a_thread):
void systemdict_acosh(cw_nxo_t *a_thread):
void systemdict_add(cw_nxo_t *a_thread):
void systemdict_adn(cw_nxo_t *a_thread):
void systemdict_and(cw_nxo_t *a_thread):
void systemdict_array(cw_nxo_t *a_thread):
void systemdict_asin(cw_nxo_t *a_thread):
void systemdict_asinh(cw_nxo_t *a_thread):
void systemdict_atan(cw_nxo_t *a_thread):
void systemdict_atan2(cw_nxo_t *a_thread):
void systemdict_atanh(cw_nxo_t *a_thread):
void systemdict_aup(cw_nxo_t *a_thread):
void systemdict_bdup(cw_nxo_t *a_thread):
void systemdict_begin(cw_nxo_t *a_thread):
void systemdict_bind(cw_nxo_t *a_thread):
void systemdict_bindsocket(cw_nxo_t *a_thread):
void systemdict_bpop(cw_nxo_t *a_thread):
void systemdict_broadcast(cw_nxo_t *a_thread):
void systemdict_bytesavailable(cw_nxo_t *a_thread):
void systemdict_cat(cw_nxo_t *a_thread):
void systemdict_ccheck(cw_nxo_t *a_thread):
void systemdict_cd(cw_nxo_t *a_thread):
void systemdict_cdef(cw_nxo_t *a_thread):
void systemdict_ceiling(cw_nxo_t *a_thread):
void systemdict_chmod(cw_nxo_t *a_thread):
void systemdict_chown(cw_nxo_t *a_thread):
void systemdict_chroot(cw_nxo_t *a_thread):
void systemdict_class(cw_nxo_t *a_thread):
void systemdict_classname(cw_nxo_t *a_thread):
void systemdict_clear(cw_nxo_t *a_thread):
void systemdict_cleartomark(cw_nxo_t *a_thread):
void systemdict_close(cw_nxo_t *a_thread):
void systemdict_condition(cw_nxo_t *a_thread):
void systemdict_connect(cw_nxo_t *a_thread):
void systemdict_continue(cw_nxo_t *a_thread):
void systemdict_copy(cw_nxo_t *a_thread):
void systemdict_cos(cw_nxo_t *a_thread):
void systemdict_cosh(cw_nxo_t *a_thread):
void systemdict_count(cw_nxo_t *a_thread):
void systemdict_countdstack(cw_nxo_t *a_thread):
void systemdict_countestack(cw_nxo_t *a_thread):
void systemdict_counttomark(cw_nxo_t *a_thread):
void systemdict_cstack(cw_nxo_t *a_thread):
void systemdict_currentdict(cw_nxo_t *a_thread):
void systemdict_currentlocking(cw_nxo_t *a_thread):
void systemdict_cvc(cw_nxo_t *a_thread):
void systemdict_cvds(cw_nxo_t *a_thread):
void systemdict_cve(cw_nxo_t *a_thread):
void systemdict_cves(cw_nxo_t *a_thread):
```

```
void systemdict_cvf(cw_nxo_t *a_thread):
void systemdict_cvi(cw_nxo_t *a_thread):
void systemdict_cvl(cw_nxo_t *a_thread):
void systemdict_cvn(cw_nxo_t *a_thread):
void systemdict_cvrs(cw_nxo_t *a_thread):
void systemdict_cvs(cw_nxo_t *a_thread):
void systemdict_cvx(cw_nxo_t *a_thread):
void systemdict_data(cw_nxo_t *a_thread):
void systemdict_dec(cw_nxo_t *a_thread):
void systemdict_def(cw_nxo_t *a_thread):
void systemdict_detach(cw_nxo_t *a_thread):
void systemdict_dict(cw_nxo_t *a_thread):
void systemdict_die(cw_nxo_t *a_thread):
void systemdict_dirforeach(cw_nxo_t *a_thread):
void systemdict_div(cw_nxo_t *a_thread):
void systemdict_dn(cw_nxo_t *a_thread):
void systemdict_dstack(cw_nxo_t *a_thread):
void systemdict_dup(cw_nxo_t *a_thread):
void systemdict_echeck(cw_nxo_t *a_thread):
void systemdict_egid(cw_nxo_t *a_thread):
void systemdict_end(cw_nxo_t *a_thread):
void systemdict_eq(cw_nxo_t *a_thread):
void systemdict_escape(cw_nxo_t *a_thread):
void systemdict_estack(cw_nxo_t *a_thread):
void systemdict_euid(cw_nxo_t *a_thread):
void systemdict_eval(cw_nxo_t *a_thread):
void systemdict_exch(cw_nxo_t *a_thread):
void systemdict_exec(cw_nxo_t *a_thread):
void systemdict_exit(cw_nxo_t *a_thread):
void systemdict_exp(cw_nxo_t *a_thread):
void systemdict_fcheck(cw_nxo_t *a_thread):
void systemdict_floor(cw_nxo_t *a_thread):
void systemdict_flush(cw_nxo_t *a_thread):
void systemdict_flushfile(cw_nxo_t *a_thread):
void systemdict_for(cw_nxo_t *a_thread):
void systemdict_foreach(cw_nxo_t *a_thread):
void systemdict_forkexec(cw_nxo_t *a_thread):
void systemdict_ge(cw_nxo_t *a_thread):
void systemdict_get(cw_nxo_t *a_thread):
void systemdict_getinterval(cw_nxo_t *a_thread):
void systemdict_getpgid(cw_nxo_t *a_thread):
void systemdict_getsid(cw_nxo_t *a_thread):
void systemdict_gid(cw_nxo_t *a_thread):
void systemdict_gmaxestack(cw_nxo_t *a_thread):
void systemdict_gstderr(cw_nxo_t *a_thread):
void systemdict_gstdin(cw_nxo_t *a_thread):
void systemdict_gstdout(cw_nxo_t *a_thread):
void systemdict_gt(cw_nxo_t *a_thread):
void systemdict_gtailopt(cw_nxo_t *a_thread):
void systemdict_handletag(cw_nxo_t *a_thread):
void systemdict_ibdup(cw_nxo_t *a_thread):
void systemdict_ibpop(cw_nxo_t *a_thread):
void systemdict_ichack(cw_nxo_t *a_thread):
```

```
void systemdict_idiv(cw_nxo_t *a_thread):
void systemdict_idup(cw_nxo_t *a_thread):
void systemdict_if(cw_nxo_t *a_thread):
void systemdict_ifelse(cw_nxo_t *a_thread):
void systemdict_ilocked(cw_nxo_t *a_thread):
void systemdict_implementor(cw_nxo_t *a_thread):
void systemdict_implements(cw_nxo_t *a_thread):
void systemdict_inc(cw_nxo_t *a_thread):
void systemdict_instance(cw_nxo_t *a_thread):
void systemdict_iobuf(cw_nxo_t *a_thread):
void systemdict_ipop(cw_nxo_t *a_thread):
void systemdict_isa(cw_nxo_t *a_thread):
void systemdict_istack(cw_nxo_t *a_thread):
void systemdict_join(cw_nxo_t *a_thread):
void systemdict_kill(cw_nxo_t *a_thread):
void systemdict_kind(cw_nxo_t *a_thread):
void systemdict_known(cw_nxo_t *a_thread):
void systemdict_lcheck(cw_nxo_t *a_thread):
void systemdict_le(cw_nxo_t *a_thread):
void systemdict_length(cw_nxo_t *a_thread):
void systemdict_link(cw_nxo_t *a_thread):
void systemdict_listen(cw_nxo_t *a_thread):
void systemdict_ln(cw_nxo_t *a_thread):
void systemdict_load(cw_nxo_t *a_thread):
void systemdict_localtime(cw_nxo_t *a_thread):
void systemdict_lock(cw_nxo_t *a_thread):
void systemdict_log(cw_nxo_t *a_thread):
void systemdict_loop(cw_nxo_t *a_thread):
void systemdict_lt(cw_nxo_t *a_thread):
void systemdict_match(cw_nxo_t *a_thread):
void systemdict_maxestack(cw_nxo_t *a_thread):
void systemdict_method(cw_nxo_t *a_thread):
void systemdict_methods(cw_nxo_t *a_thread):
void systemdict_mkdir(cw_nxo_t *a_thread):
void systemdict_mkfifo(cw_nxo_t *a_thread):
void systemdict_mod(cw_nxo_t *a_thread):
void systemdict_modload(cw_nxo_t *a_thread):
void systemdict_monitor(cw_nxo_t *a_thread):
void systemdict_mul(cw_nxo_t *a_thread):
void systemdict_mutex(cw_nxo_t *a_thread):
void systemdict_nbpop(cw_nxo_t *a_thread):
void systemdict_ncat(cw_nxo_t *a_thread):
void systemdict_ndn(cw_nxo_t *a_thread):
void systemdict_ndup(cw_nxo_t *a_thread):
void systemdict_ne(cw_nxo_t *a_thread):
void systemdict_neg(cw_nxo_t *a_thread):
void systemdict_nip(cw_nxo_t *a_thread):
void systemdict_nonblocking(cw_nxo_t *a_thread):
void systemdict_not(cw_nxo_t *a_thread):
void systemdict_npop(cw_nxo_t *a_thread):
void systemdict_nsleep(cw_nxo_t *a_thread):
void systemdict_nup(cw_nxo_t *a_thread):
void systemdict_offset(cw_nxo_t *a_thread):
```

```
void systemdict_open(cw_nxo_t *a_thread):
void systemdict_or(cw_nxo_t *a_thread):
void systemdict_origin(cw_nxo_t *a_thread):
void systemdict_ostack(cw_nxo_t *a_thread):
void systemdict_over(cw_nxo_t *a_thread):
void systemdict_path(cw_nxo_t *a_thread):
void systemdict_peername(cw_nxo_t *a_thread):
void systemdict_pid(cw_nxo_t *a_thread):
void systemdict_pipe(cw_nxo_t *a_thread):
void systemdict_poll(cw_nxo_t *a_thread):
void systemdict_pop(cw_nxo_t *a_thread):
void systemdict_pow(cw_nxo_t *a_thread):
void systemdict_ppid(cw_nxo_t *a_thread):
void systemdict_print(cw_nxo_t *a_thread):
void systemdict_put(cw_nxo_t *a_thread):
void systemdict_putinterval(cw_nxo_t *a_thread):
void systemdict_pwd(cw_nxo_t *a_thread):
void systemdict_quit(cw_nxo_t *a_thread):
void systemdict_rand(cw_nxo_t *a_thread):
void systemdict_read(cw_nxo_t *a_thread):
void systemdict_readline(cw_nxo_t *a_thread):
void systemdict_readlink(cw_nxo_t *a_thread):
void systemdict_realtime(cw_nxo_t *a_thread):
void systemdict_recv(cw_nxo_t *a_thread):
void systemdict_regex(cw_nxo_t *a_thread):
void systemdict_regsub(cw_nxo_t *a_thread):
void systemdict_rename(cw_nxo_t *a_thread):
void systemdict_repeat(cw_nxo_t *a_thread):
void systemdict_rmdir(cw_nxo_t *a_thread):
void systemdict_roll(cw_nxo_t *a_thread):
void systemdict_rot(cw_nxo_t *a_thread):
void systemdict_round(cw_nxo_t *a_thread):
void systemdict_sadn(cw_nxo_t *a_thread):
void systemdict_saup(cw_nxo_t *a_thread):
void systemdict_sbdup(cw_nxo_t *a_thread):
void systemdict_sbpop(cw_nxo_t *a_thread):
void systemdict_sbpush(cw_nxo_t *a_thread):
void systemdict_sclear(cw_nxo_t *a_thread):
void systemdict_scleartomark(cw_nxo_t *a_thread):
void systemdict_scount(cw_nxo_t *a_thread):
void systemdict_scounttomark(cw_nxo_t *a_thread):
void systemdict_sdn(cw_nxo_t *a_thread):
void systemdict_sdup(cw_nxo_t *a_thread):
void systemdict_seek(cw_nxo_t *a_thread):
void systemdict_self(cw_nxo_t *a_thread):
void systemdict_send(cw_nxo_t *a_thread):
void systemdict_serviceport(cw_nxo_t *a_thread):
void systemdict_setclassname(cw_nxo_t *a_thread):
void systemdict_setdata(cw_nxo_t *a_thread):
void systemdict_setegid(cw_nxo_t *a_thread):
void systemdict_setenv(cw_nxo_t *a_thread):
void systemdict seteuid(cw_nxo_t *a_thread):
void systemdict setgid(cw_nxo_t *a_thread):
```

```
void systemdict_setgmaxestack(cw_nxo_t *a_thread):
void systemdict_setgstderr(cw_nxo_t *a_thread):
void systemdict_setgstdin(cw_nxo_t *a_thread):
void systemdict_setgstdout(cw_nxo_t *a_thread):
void systemdict_setgtailopt(cw_nxo_t *a_thread):
void systemdict_setiobuf(cw_nxo_t *a_thread):
void systemdict_setisa(cw_nxo_t *a_thread):
void systemdict_setlocking(cw_nxo_t *a_thread):
void systemdict_setmaxestack(cw_nxo_t *a_thread):
void systemdict_setmethods(cw_nxo_t *a_thread):
void systemdict_setnonblocking(cw_nxo_t *a_thread):
void systemdict_setpgid(cw_nxo_t *a_thread):
void systemdict_setsid(cw_nxo_t *a_thread):
void systemdict_setsockopt(cw_nxo_t *a_thread):
void systemdict_setstderr(cw_nxo_t *a_thread):
void systemdict_setstdin(cw_nxo_t *a_thread):
void systemdict_setstdout(cw_nxo_t *a_thread):
void systemdict_setsuper(cw_nxo_t *a_thread):
void systemdict_settailopt(cw_nxo_t *a_thread):
void systemdict_setuid(cw_nxo_t *a_thread):
void systemdict_sexch(cw_nxo_t *a_thread):
void systemdict_shift(cw_nxo_t *a_thread):
void systemdict_sibdup(cw_nxo_t *a_thread):
void systemdict_sibpop(cw_nxo_t *a_thread):
void systemdict_sidup(cw_nxo_t *a_thread):
void systemdict_sigmask(cw_nxo_t *a_thread):
void systemdict_signal(cw_nxo_t *a_thread):
void systemdict_sigpending(cw_nxo_t *a_thread):
void systemdict_sigsuspend(cw_nxo_t *a_thread):
void systemdict_sigwait(cw_nxo_t *a_thread):
void systemdict_sin(cw_nxo_t *a_thread):
void systemdict_sinh(cw_nxo_t *a_thread):
void systemdict_sipop(cw_nxo_t *a_thread):
void systemdict_snbpop(cw_nxo_t *a_thread):
void systemdict_sndn(cw_nxo_t *a_thread):
void systemdict_sndup(cw_nxo_t *a_thread):
void systemdict_snip(cw_nxo_t *a_thread):
void systemdict_snpop(cw_nxo_t *a_thread):
void systemdict_snup(cw_nxo_t *a_thread):
void systemdict_socket(cw_nxo_t *a_thread):
void systemdict_socketpair(cw_nxo_t *a_thread):
void systemdict_sockname(cw_nxo_t *a_thread):
void systemdict_sockopt(cw_nxo_t *a_thread):
void systemdict_sover(cw_nxo_t *a_thread):
void systemdict_split(cw_nxo_t *a_thread):
void systemdict_spop(cw_nxo_t *a_thread):
void systemdict_spush(cw_nxo_t *a_thread):
void systemdict_sqrt(cw_nxo_t *a_thread):
void systemdict_srand(cw_nxo_t *a_thread):
void systemdict_sroll(cw_nxo_t *a_thread):
void systemdict_srot(cw_nxo_t *a_thread):
void systemdict_stack(cw_nxo_t *a_thread):
void systemdict_start(cw_nxo_t *a_thread):
```

```
void systemdict_status(cw_nxo_t *a_thread):
void systemdict_stderr(cw_nxo_t *a_thread):
void systemdict_stdin(cw_nxo_t *a_thread):
void systemdict_stdout(cw_nxo_t *a_thread):
void systemdict_stop(cw_nxo_t *a_thread):
void systemdict_stopped(cw_nxo_t *a_thread):
void systemdict_string(cw_nxo_t *a_thread):
void systemdict_stuck(cw_nxo_t *a_thread):
void systemdict_sub(cw_nxo_t *a_thread):
void systemdict_submatch(cw_nxo_t *a_thread):
void systemdict_subst(cw_nxo_t *a_thread):
void systemdict_sunder(cw_nxo_t *a_thread):
void systemdict_sup(cw_nxo_t *a_thread):
void systemdict_super(cw_nxo_t *a_thread):
void systemdict_sym_lp(cw_nxo_t *a_thread) (“”):
void systemdict_sym_rp(cw_nxo_t *a_thread) (“”):
void systemdict_sym_gt(cw_nxo_t *a_thread) (“>”):
void systemdict_sym_rb(cw_nxo_t *a_thread) (“]”):
void systemdict_symlink(cw_nxo_t *a_thread):
void systemdict_tailopt(cw_nxo_t *a_thread):
void systemdict_tan(cw_nxo_t *a_thread):
void systemdict_tanh(cw_nxo_t *a_thread):
void systemdict_tell(cw_nxo_t *a_thread):
void systemdict_test(cw_nxo_t *a_thread):
void systemdict_this(cw_nxo_t *a_thread):
void systemdict_thread(cw_nxo_t *a_thread):
void systemdict_threadsdic(cw_nxo_t *a_thread):
void systemdict_threadcstack(cw_nxo_t *a_thread):
void systemdict_threaddstack(cw_nxo_t *a_thread):
void systemdict_threadestack(cw_nxo_t *a_thread):
void systemdict_threadistack(cw_nxo_t *a_thread):
void systemdict_threadostack(cw_nxo_t *a_thread):
void systemdict_timedwait(cw_nxo_t *a_thread):
void systemdict_token(cw_nxo_t *a_thread):
void systemdict_trapped(cw_nxo_t *a_thread):
void systemdict_trunc(cw_nxo_t *a_thread):
void systemdict_truncate(cw_nxo_t *a_thread):
void systemdict_trylock(cw_nxo_t *a_thread):
void systemdict_tuck(cw_nxo_t *a_thread):
void systemdict_type(cw_nxo_t *a_thread):
void systemdict_uid(cw_nxo_t *a_thread):
void systemdict_umask(cw_nxo_t *a_thread):
void systemdict_undef(cw_nxo_t *a_thread):
void systemdict_under(cw_nxo_t *a_thread):
void systemdict_unless(cw_nxo_t *a_thread):
void systemdict_unlink(cw_nxo_t *a_thread):
void systemdict_unlock(cw_nxo_t *a_thread):
void systemdict_unsetenv(cw_nxo_t *a_thread):
void systemdict_until(cw_nxo_t *a_thread):
void systemdict_up(cw_nxo_t *a_thread):
void systemdict_wait(cw_nxo_t *a_thread):
void systemdict_waitpid(cw_nxo_t *a_thread):
void systemdict_where(cw_nxo_t *a_thread):
```

```
void systemdict_while(cw_nxo_t *a_thread):  
void systemdict_write(cw_nxo_t *a_thread):  
void systemdict_xcheck(cw_nxo_t *a_thread):  
void systemdict_xecheck(cw_nxo_t *a_thread):  
void systemdict_xor(cw_nxo_t *a_thread):  
void systemdict_yield(cw_nxo_t *a_thread):
```

Input(s):

a_thread: Pointer to a thread.

Output(s): None.

Exception(s):

CW_ONYXX_OOM.

Description: C interfaces to onyx operators.

LICENSES

Onyx is licensed according to the following terms:

Copyright (C) 1996-2005 Jason Evans <jasone@canonware.com>.

All rights reserved.

Copyright (C) 2002 Zeljko Vrba <mordor@fly.srk.fer.hr>.

All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice(s), this list of conditions and the following disclaimer unmodified other than the allowable addition of one or more copyright notices.
2. Redistributions in binary form must reproduce the above copyright notice(s), this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDER(S) ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER(S) BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Onyx's regular expression support is provided by the PCRE library package, which is open source software, written by Philip Hazel, and copyright by the University of Cambridge, England. The official PCRE distribution site is <ftp://ftp.csx.cam.ac.uk/pub/software/programming/pcre/>. Inclusion of the previous two sentences in this documentation meets the requirements of the PCRE license, both for source and binary distributions of Onyx. See the PCRE source distribution for additional details.

The *modclopt* module optionally uses the libedit library. Following is the license text. Note that the Regents of the University of California have approved the retroactive removal of clause 3 from the license, which means that the advertising clause no longer applies to libedit.

Copyright (c) 1992, 1993

The Regents of the University of California. All rights reserved.

This code is derived from software contributed to Berkeley by
Christos Zoulas of Cornell University.

Redistribution and use in source and binary forms, with or without
modification, are permitted provided that the following conditions
are met:

1. Redistributions of source code must retain the above copyright
notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright
notice, this list of conditions and the following disclaimer in the
documentation and/or other materials provided with the distribution.
3. All advertising materials mentioning features or use of this software
must display the following acknowledgement:
 This product includes software developed by the University of
 California, Berkeley and its contributors.
4. Neither the name of the University nor the names of its contributors
 may be used to endorse or promote products derived from this software
 without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE REGENTS AND CONTRIBUTORS ``AS IS'' AND
ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE
IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
ARE DISCLAIMED. IN NO EVENT SHALL THE REGENTS OR CONTRIBUTORS BE LIABLE
FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL
DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS
OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION)
HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT
LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY
OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF
SUCH DAMAGE.

Index

(, 89
) , 90
<, 90
>, 90
[, 91
], 91

abs, 91
accept, 92
acos, 92
acosh, 93
active, 36
add, 93
adn, 93
and, 94
arg_enum_get, 246
arg_get, 247
arg_int_get, 248
arg_uint_get, 249
argcheck, 24
argv, 94
argv_get, 250
array, 94
arraytype, 43, 53
asin, 95
asinh, 95
atan, 95
atan2, 96
atanh, 96
aup, 96

bdup, 97
begin, 97
bind, 97
bindsocket, 98
booleantype, 43, 54
bpop, 99
broadcast, 99
bytesavailable, 100

cat, 100
ccheck, 100
cd, 101
cdef, 101

ceiling, 102
ch, 269
ch_chi_remove(), 271
ch_count(), 270
ch_delete(), 270
ch_direct_hash(), 272
ch_direct_key_comp(), 272
ch_insert(), 270
ch_new(), 270
ch_remove(), 271
ch_search(), 271
ch_string_hash(), 272
ch_string_key_comp(), 272
chmod, 102
chown, 103
chroot, 103
class, 104
classname, 104, 232
classtype, 44, 54
clear, 104
cleartomark, 104
close, 105
cnd, 272
cnd_broadcast(), 273
cnd_delete(), 273
cnd_new(), 273
cnd_signal(), 273
cnd_timedwait(), 273
cnd_wait(), 273
collect, 36
column, 29
condition, 105
conditiontype, 44, 54
connect, 105
continue, 106
copy, 106
cos, 107
cosh, 107
count, 108
countdstack, 108
countestack, 108
counttomark, 108
cstack, 30, 109
cstackunderflow, 24

- currentdict**, 109
- currenterror**, 28, 229
- currentlocking**, 109
- cvc**, 110
- cvds**, 110
- cve**, 110
- cves**, 111
- cvf**, 111
- cvi**, 111
- cvl**, 112
- cvn**, 112
- cvrs**, 112
- cvs**, 113
- cvx**, 113
- cw_assert()*, 268
- cw_calloc()*, 279
- CW_CH_TABLE2SIZEOF()*, 269
- cw_check_ptr()*, 268
- cw_dassert()*, 268
- cw_error()*, 268
- cw_free()*, 280
- cw_htonq()*, 269
- cw_malloc()*, 279
- cw_not_reached()*, 268
- cw_ntohq()*, 268
- cw_nxo_class_delete_t()*, 298
- cw_nxo_class_ref_iter_t()*, 298
- cw_nxo_file_delete_t()*, 304
- cw_nxo_file_read_t()*, 303
- cw_nxo_file_ref_iter_t()*, 304
- cw_nxo_file_write_t()*, 304
- cw_nxo_handle_delete_t()*, 311
- cw_nxo_handle_eval_t()*, 310
- cw_nxo_handle_ref_iter_t()*, 310
- cw_nxo_instance_delete_t()*, 312
- cw_nxo_instance_ref_iter_t()*, 312
- cw_offsetof()*, 269
- cw_onyx_code()*, 267
- cw_opaque_alloc()*, 266
- cw_opaque_alloc_t()*, 265
- cw_opaque_calloc()*, 267
- cw_opaque_calloc_t()*, 265
- cw_opaque_dealloc()*, 267
- cw_opaque_dealloc_t()*, 266
- cw_opaque_realloc()*, 267
- cw_opaque_realloc_t()*, 266
- cw_realloc()*, 279
- cw_thread_start_t()*, 284
- data**, 114, 232
- dch*, 274
- dch_chi_remove()*, 276
- dch_count()*, 274
- dch_delete()*, 274
- dch_insert()*, 275
- dch_new()*, 274
- dch_remove()*, 275
- dch_search()*, 276
- dch_shrinkable_get()*, 275
- dch_shrinkable_set()*, 275
- dec**, 114
- def**, 114, 232
- dep_load**, 241
- deps_get**, 242
- detach**, 114
- dict**, 115
- dicttype**, 44, 55
- die**, 115
- dirforeach**, 115
- div**, 116
- dn**, 116
- dstack**, 30, 117
- dup**, 117
- eccheck**, 117
- egid**, 118
- end**, 118
- envdict**, 34, 119
- eq**, 119
- error_escape**, 251
- error_print**, 252
- errordict**, 34, 229
- errorname**, 30
- escape**, 119
- estack**, 31, 120
- estackoverflow, 24
- euid**, 120
- eval**, 120
- exch**, 121
- exec**, 121
- exit**, 121
- exp**, 122
- false**, 122
- fcheck**, 122
- filetype**, 45, 55
- finotype**, 45, 56
- flag_get**, 253
- floor**, 122
- flush**, 123
- flushfile**, 123
- for**, 123
- foreach**, 124
- forkexec**, 125
- gcdict*, 355

- gcdict**, 36, 126
 - gcdict_active()*, 355
 - gcdict_collect()*, 355
 - gcdict_period()*, 355
 - gcdict_setactive()*, 355
 - gcdict_setperiod()*, 355
 - gcdict_setthreshold()*, 355
 - gcdict_stats()*, 355
 - gcdict_threshold()*, 355
- ge**, 126
- get**, 126
- getinterval**, 127
- getpgid**, 127
- getsid**, 128
- gid**, 128
- globaldict**, 39, 128
- gmaxestack**, 129
- gstderr**, 129
- gstdin**, 129
- gstdout**, 129
- gt**, 130
- gtailopt**, 130
- handleerror**, 34
- handletag**, 130
- handletype**, 45, 56
- ibdup**, 131
- ibpop**, 131
- icheck**, 132
- idiv**, 132
- idup**, 132
- if**, 133
- ifelse**, 133
- ilocked**, 134
- implementor**, 134, 233
- implements**, 134, 233
- inc**, 135
- index_get**, 254
- instance**, 135
- instancetype**, 46, 57
- integertype**, 46, 57
- invalidaccess**, 24
- invalidcontinue**, 24
- invalidexit**, 24
- invalidfileaccess**, 24
- iobuf**, 135
- ioerror**, 24
- ipop**, 136
- isa**, 136, 233
- istack**, 31, 136
- join**, 137
- kill**, 137
- kind**, 138, 234
- known**, 138
- lcheck**, 139
- le**, 139
- length**, 140
- libonyx_argv_get()*, 265
- libonyx_envdict_get()*, 265
- libonyx_gcdict_get()*, 265
- libonyx_init()*, 264
- libonyx_shutdown()*, 265
- limitcheck**, 24
- line**, 32
- link**, 140
- listen**, 141
- ln**, 141
- load**, 142, 238
- localtime**, 142
- lock**, 143
- log**, 143
- loop**, 144
- lt**, 144
- mark**, 145
- marktype**, 47, 57
- match**, 145
- maxestack**, 145
- mb*, 276
- mb_write()*, 277
- mdef**, 242
- mdefs_get**, 242
- mem*, 277
- mem_calloc()*, 279
- mem_calloc_e()*, 279
- mem_free()*, 280
- mem_free_e()*, 280
- mem_malloc()*, 279
- mem_malloc_e()*, 279
- mem_realloc()*, 279
- mem_realloc_e()*, 279
- mema_alloc_get()*, 278
- mema_arg_get()*, 278
- mema_calloc_get()*, 278
- mema_dealloc_get()*, 278
- mema_delete()*, 278
- mema_new()*, 277
- mema_realloc_get()*, 278
- method**, 146, 234
- methods**, 146, 234
- mkdir**, 147
- mkfifo**, 147
- mod**, 147

- modload**, 148
- modules**, 239
- monitor**, 149
- mpath_post**, 39
- mpath_pre**, 40
- mq*, 280
- mq_delete()*, 280
- mq_get()*, 281
- mq_get_start()*, 282
- mq_get_stop()*, 282
- mq_new()*, 280
- mq_put()*, 281
- mq_put_start()*, 282
- mq_put_stop()*, 282
- mq_timedget()*, 281
- mq_tryget()*, 281
- mrequire**, 149
- mtx*, 283
- mtx_delete()*, 283
- mtx_lock()*, 283
- mtx_new()*, 283
- mtx_trylock()*, 283
- mtx_unlock()*, 284
- mul**, 149
- mutex**, 150
- mutextype**, 47, 58
- nametype**, 47, 58
- nbpop**, 150
- ncat**, 150
- ndn**, 151
- ndup**, 151
- ne**, 152
- neg**, 153
- neterror, 24
- new**, 235, 239, 243, 255
- newerror**, 32
- nip**, 153
- nonblocking**, 153
- not**, 154
- npop**, 154
- nsleep**, 155
- null**, 155
- nulltype**, 48, 59
- nup**, 155
- nx*, 284
- nx_delete()*, 284
- nx_globaldict_get()*, 286
- nx_maxestack_get()*, 285
- nx_maxestack_set()*, 285
- nx_new()*, 284
- nx_stderr_get()*, 286
- nx_stderr_set()*, 287
- nx_stdin_get()*, 286
- nx_stdin_set()*, 286
- nx_stdout_get()*, 286
- nx_stdout_set()*, 286
- nx_systemdict_get()*, 285
- nx_tailopt_get()*, 285
- nx_tailopt_set()*, 285
- nxa*, 287
- nxa_active_get()*, 288
- nxa_active_set()*, 289
- nxa_calloc()*, 287
- nxa_calloc_e()*, 287
- nxa_collect()*, 288
- nxa_free()*, 288
- nxa_free_e()*, 288
- nxa_malloc()*, 287
- nxa_malloc_e()*, 287
- nxa_period_get()*, 289
- nxa_period_set()*, 289
- nxa_realloc()*, 288
- nxa_realloc_e()*, 288
- nxa_stats_get()*, 290
- nxa_threshold_get()*, 289
- nxa_threshold_set()*, 289
- nxm*, 290
- nxm_iter_get()*, 291
- nxm_iter_set()*, 291
- nxm_new()*, 290
- nxm_pre_unload_hook_get()*, 291
- nxm_pre_unload_hook_set()*, 291
- nxn*, 292
- nxn_len()*, 292
- nxn_str()*, 292
- nxo*, 292
- nxo_array*, 295
- nxo_array_copy()*, 296
- nxo_array_el_get()*, 296
- nxo_array_el_set()*, 296
- nxo_array_len_get()*, 296
- nxo_array_new()*, 295
- nxo_array_origin_get()*, 297
- nxo_array_origin_set()*, 297
- nxo_array_subarray_new()*, 295
- nxo_attr_get()*, 295
- nxo_attr_set()*, 295
- nxo_boolean*, 297
- nxo_boolean_get()*, 297
- nxo_boolean_new()*, 297
- nxo_boolean_set()*, 298
- nxo_class*, 298
- nxo_class_data_get()*, 299
- nxo_class_eval()*, 300
- nxo_class_methods_get()*, 299

-
- nxo_class_name_get()*, 299
 - nxo_class_new()*, 299
 - nxo_class_opaque_get()*, 300
 - nxo_class_opaque_set()*, 300
 - nxo_class_super_get()*, 299
 - nxo_compare()*, 293
 - nxo_condition*, 300
 - nxo_condition_broadcast()*, 301
 - nxo_condition_new()*, 300
 - nxo_condition_signal()*, 301
 - nxo_condition_timedwait()*, 301
 - nxo_condition_wait()*, 301
 - nxo_dict*, 301
 - nxo_dict_copy()*, 302
 - nxo_dict_count()*, 303
 - nxo_dict_def()*, 302
 - nxo_dict_iterate()*, 303
 - nxo_dict_lookup()*, 302
 - nxo_dict_new()*, 302
 - nxo_dict_undef()*, 302
 - nxo_dup()*, 293
 - nxo_file*, 303
 - nxo_file_buffer_count()*, 309
 - nxo_file_buffer_flush()*, 309
 - nxo_file_buffer_size_get()*, 309
 - nxo_file_buffer_size_set()*, 309
 - nxo_file_close()*, 306
 - nxo_file_fd_get()*, 306
 - nxo_file_fd_wrap()*, 305
 - nxo_file_new()*, 304
 - nxo_file_nonblocking_get()*, 307
 - nxo_file_nonblocking_set()*, 307
 - nxo_file_open()*, 305
 - nxo_file_origin_get()*, 306
 - nxo_file_origin_set()*, 306
 - nxo_file_position_get()*, 308
 - nxo_file_position_set()*, 309
 - nxo_file_read()*, 307
 - nxo_file_readline()*, 307
 - nxo_file_synthetic()*, 305
 - nxo_file_truncate()*, 308
 - nxo_file_write()*, 308
 - nxo_fino*, 310
 - nxo_fino_new()*, 310
 - nxo_handle*, 310
 - nxo_handle_eval()*, 312
 - nxo_handle_new()*, 311
 - nxo_handle_opaque_get()*, 311
 - nxo_handle_opaque_set()*, 312
 - nxo_handle_tag_get()*, 311
 - nxo_ilocked()*, 294
 - nxo_instance*, 312
 - nxo_instance_data_get()*, 313
 - nxo_instance_eval()*, 314
 - nxo_instance_isa_get()*, 313
 - nxo_instance_new()*, 313
 - nxo_instance_opaque_get()*, 313
 - nxo_instance_opaque_set()*, 313
 - nxo_integer*, 314
 - nxo_integer_get()*, 314
 - nxo_integer_new()*, 314
 - nxo_integer_set()*, 314
 - nxo_mark*, 315
 - nxo_mark_new()*, 315
 - nxo_mutex*, 315
 - nxo_mutex_lock()*, 315
 - nxo_mutex_new()*, 315
 - nxo_mutex_trylock()*, 315
 - nxo_mutex_unlock()*, 316
 - nxo_name*, 316
 - nxo_name_len_get()*, 316
 - nxo_name_new()*, 316
 - nxo_name_str_get()*, 316
 - nxo_no*, 317
 - nxo_no_new()*, 317
 - nxo_null*, 317
 - nxo_null_new()*, 317
 - nxo_nxoe_get()*, 294
 - nxo_operator*, 317
 - nxo_operator_f()*, 317
 - nxo_operator_new()*, 317
 - nxo_pmark*, 318
 - nxo_pmark_line_get()*, 318
 - nxo_pmark_line_set()*, 318
 - nxo_pmark_new()*, 318
 - nxo_real*, 318
 - nxo_real_get()*, 319
 - nxo_real_new()*, 319
 - nxo_real_set()*, 319
 - nxo_regex*, 319
 - nxo_regex_match()*, 320
 - nxo_regex_new()*, 319
 - nxo_regex_nonew_match()*, 320
 - nxo_regex_nonew_split()*, 321
 - nxo_regex_split()*, 321
 - nxo_regex_submatch()*, 322
 - nxo_regsub*, 322
 - nxo_regsub_new()*, 323
 - nxo_regsub_nonew_subst()*, 323
 - nxo_regsub_subst()*, 323
 - nxo_stack*, 324
 - nxo_stack_bget()*, 326
 - nxo_stack_bpop()*, 326
 - nxo_stack_bpush()*, 325
 - nxo_stack_copy()*, 325
 - nxo_stack_count()*, 325

nxo_stack_exch(), 327
nxo_stack_get(), 326
nxo_stack_nbget(), 327
nxo_stack_nbpop(), 326
nxo_stack_new(), 324
nxo_stack_nget(), 327
nxo_stack_npop(), 326
nxo_stack_pop(), 325
nxo_stack_push(), 325
nxo_stack_roll(), 328
nxo_stack_rot(), 327
nxo_string, 328
nxo_string_copy(), 329
nxo_string_cstring(), 329
nxo_string_el_get(), 329
nxo_string_el_set(), 329
nxo_string_get(), 330
nxo_string_len_get(), 329
nxo_string_lock(), 330
nxo_string_new(), 328
nxo_string_set(), 330
nxo_string_substring_new(), 328
nxo_string_unlock(), 330
nxo_thread, 330
nxo_thread_class_hier_search(), 335
nxo_thread_currenterror_get(), 337
nxo_thread_currentlocking(), 336
nxo_thread_deferred(), 333
nxo_thread_detach(), 333
nxo_thread_dstack_get(), 338
nxo_thread_dstack_search(), 335
nxo_thread_errordict_get(), 337
nxo_thread_estack_get(), 338
nxo_thread_exit(), 332
nxo_thread_flush(), 334
nxo_thread_interpret(), 334
nxo_thread_istack_get(), 338
nxo_thread_join(), 333
nxo_thread_loop(), 334
nxo_thread_maxestack_get(), 336
nxo_thread_maxestack_set(), 336
nxo_thread_nerror(), 335
nxo_thread_new(), 332
nxo_thread_nx_get(), 337
nxo_thread_ostack_get(), 338
nxo_thread_reset(), 334
nxo_thread_serror(), 335
nxo_thread_setlocking(), 336
nxo_thread_start(), 332
nxo_thread_state(), 333
nxo_thread_stderr_get(), 339
nxo_thread_stderr_set(), 339
nxo_thread_stdin_get(), 338

nxo_thread_stdin_set(), 339
nxo_thread_stdout_get(), 339
nxo_thread_stdout_set(), 339
nxo_thread_tailopt_get(), 336
nxo_thread_tailopt_set(), 337
nxo_thread_thread(), 332
nxo_thread_tstack_get(), 338
nxo_thread_userdict_get(), 337
nxo_threadp_delete(), 331
nxo_threadp_new(), 331
nxo_threadp_origin_get(), 331
nxo_threadp_origin_set(), 331
nxo_threadp_position_get(), 331
nxo_threadp_position_set(), 332
nxo_type_get(), 294

offset, 156
onyxdict, 39, 156
open, 156
operatortype, 48, 59
or, 157
origin, 33, 157
ostack, 33, 158
output, 158
outputs, 159
outputsdict, 41, 159
over, 159

parse, 255
path, 160
peername, 160
period, 37
pid, 161
pipe, 161
pmarktype, 49, 60
poll, 161
pop, 162
post_unload_hook_set, 243
pow, 162
ppid, 163
pre_unload_hook_set, 243
print, 163
product, 164
progname_get, 257
promptstring, 260
pstack, 164
put, 164
putinterval, 165
pwd, 165

ql, 340
ql_after_insert(), 342
ql_before_insert(), 342

- ql_elm()*, 340
- ql_elm_new()*, 340
- ql_first()*, 341
- ql_foreach()*, 343
- ql_head()*, 340
- ql_head_initializer()*, 340
- ql_head_insert()*, 342
- ql_head_remove()*, 343
- ql_last()*, 341
- ql_new()*, 340
- ql_next()*, 341
- ql_prev()*, 341
- ql_remove()*, 342
- ql_reverse_foreach()*, 343
- ql_tail_insert()*, 342
- ql_tail_remove()*, 343
- qr*, 344
- qr()*, 344
- qr_after_insert()*, 345
- qr_before_insert()*, 344
- qr_foreach()*, 345
- qr_meld()*, 345
- qr_new()*, 344
- qr_next()*, 344
- qr_prev()*, 344
- qr_remove()*, 345
- qr_reverse_foreach()*, 346
- qr_split()*, 345
- qs*, 346
- qs_down()*, 347
- qs_elm()*, 346
- qs_elm_new()*, 347
- qs_foreach()*, 348
- qs_head()*, 346
- qs_head_initializer()*, 346
- qs_new()*, 347
- qs_pop()*, 348
- qs_push()*, 347
- qs_top()*, 347
- qs_under_push()*, 348
- quit**, 165
- rand**, 166
- rangecheck, 24
- read**, 166
- readline**, 167
- readlink**, 167
- realtime**, 168
- realtype**, 49, 61
- recv**, 168
- regex**, 168
- regexerror, 24
- regextype**, 49, 60
- regsub**, 169
- regsubtype**, 50, 60
- rename**, 169
- repeat**, 170
- require**, 170
- resume**, 260
- rmdir**, 171
- rnew**, 235
- roll**, 171
- rot**, 172
- round**, 172
- rpath_post**, 40
- rpath_pre**, 40
- sadn**, 173
- saup**, 173
- sbdup**, 173
- sbpop**, 174
- sbpush**, 174
- sclear**, 174
- scleartomark**, 175
- scount**, 175
- scounttomark**, 175
- sdn**, 176
- sdup**, 176
- seek**, 176
- self**, 176
- send**, 177
- serviceport**, 177
- setactive**, 37
- setclassname**, 178, 235
- setdata**, 178, 236
- setegid**, 178
- setenv**, 179
- seteuid**, 179
- setgid**, 179
- setgmaxestack**, 180
- setgstderr**, 180
- setgstdin**, 180
- setgstdout**, 181
- setgtailopt**, 181
- setiobuf**, 182
- setisa**, 182, 236
- setlocking**, 182
- setmaxestack**, 183
- setmethods**, 183, 236
- setnonblocking**, 183
- setperiod**, 37
- setpgid**, 184
- setsid**, 184
- setsockopt**, 184
- setstderr**, 185
- setstdin**, 186

- setstdout**, 186
- setsuper**, 187, 237
- settailopt**, 187
- setthreshold**, 38
- setuid**, 187
- sexch**, 188
- shift**, 188
- sibdup**, 188
- sibpop**, 189
- sidup**, 189
- sigmask**, 189
- signal**, 191
- sigpending**, 191
- sigsuspend**, 192
- sigwait**, 193
- sin**, 194
- singleton**, 239
- sinh**, 194
- sipop**, 195
- snbpop**, 195
- sndn**, 195
- sndup**, 196
- snip**, 196
- snpop**, 196
- snup**, 197
- socket**, 197
- socketpair**, 197
- sockname**, 198
- sockopt**, 199
- sover**, 199
- split**, 200
- spop**, 201
- sprint**, 201
- sprints**, 201
- sprintsdict**, 51, 202
- spush**, 202
- sqrt**, 202
- srnd**, 203
- sroll**, 203
- srot**, 203
- stack**, 204
- stacktype**, 50, 61
- stackunderflow, 24
- start**, 204
- stats**, 38
- status**, 204
- stderr**, 205
- stdin**, 205
- stdout**, 205
- stop**, 35, 206, 260
- stopped**, 206
- string**, 206
- stringtype**, 51, 62
- stuck**, 207
- sub**, 207
- submatch**, 207
- subst**, 208
- sunder**, 208
- sup**, 209
- super**, 209, 237
- symlink**, 209
- syntaxerror, 24
- system**, 210
- systemdict*, 355
- mclass**, 238
- modclopt**, 245
- module**, 240
- systemdict**, 63, 211
- vclass**, 230
- systemdict_abs()*, 356
- systemdict_accept()*, 356
- systemdict_acos()*, 356
- systemdict_acosh()*, 356
- systemdict_add()*, 356
- systemdict_adn()*, 356
- systemdict_and()*, 356
- systemdict_array()*, 356
- systemdict_asin()*, 356
- systemdict_asinh()*, 356
- systemdict_atan()*, 356
- systemdict_atan2()*, 356
- systemdict_atanh()*, 356
- systemdict_aup()*, 356
- systemdict_bdup()*, 356
- systemdict_begin()*, 356
- systemdict_bind()*, 356
- systemdict_bindsocket()*, 356
- systemdict_bpop()*, 356
- systemdict_broadcast()*, 356
- systemdict_bytesavailable()*, 356
- systemdict_cat()*, 356
- systemdict_ccheck()*, 356
- systemdict_cd()*, 356
- systemdict_cdef()*, 356
- systemdict_ceiling()*, 356
- systemdict_chmod()*, 356
- systemdict_chown()*, 356
- systemdict_chroot()*, 356
- systemdict_class()*, 356
- systemdict_classname()*, 356
- systemdict_clear()*, 356
- systemdict_cleartomark()*, 356
- systemdict_close()*, 356
- systemdict_condition()*, 356
- systemdict_connect()*, 356
- systemdict_continue()*, 356

-
- systemdict_copy()*, 356
systemdict_cos(), 356
systemdict_cosh(), 356
systemdict_count(), 356
systemdict_countdstack(), 356
systemdict_countestack(), 356
systemdict_counttomark(), 356
systemdict_cstack(), 356
systemdict_currentdict(), 356
systemdict_currentlocking(), 356
systemdict_cvc(), 356
systemdict_cvds(), 356
systemdict_cve(), 356
systemdict_cves(), 356
systemdict_cvf(), 356
systemdict_cvi(), 357
systemdict_cvl(), 357
systemdict_cvn(), 357
systemdict_cvrs(), 357
systemdict_cvs(), 357
systemdict_cvx(), 357
systemdict_data(), 357
systemdict_dec(), 357
systemdict_def(), 357
systemdict_detach(), 357
systemdict_dict(), 357
systemdict_die(), 357
systemdict_dirforeach(), 357
systemdict_div(), 357
systemdict_dn(), 357
systemdict_dstack(), 357
systemdict_dup(), 357
systemdict_echeck(), 357
systemdict_egid(), 357
systemdict_end(), 357
systemdict_eq(), 357
systemdict_escape(), 357
systemdict_estack(), 357
systemdict_euid(), 357
systemdict_eval(), 357
systemdict_exch(), 357
systemdict_exec(), 357
systemdict_exit(), 357
systemdict_exp(), 357
systemdict_fcheck(), 357
systemdict_floor(), 357
systemdict_flush(), 357
systemdict_flushfile(), 357
systemdict_for(), 357
systemdict_foreach(), 357
systemdict_forkexec(), 357
systemdict_ge(), 357
systemdict_get(), 357
systemdict_getinterval(), 357
systemdict_getpgid(), 357
systemdict_getsid(), 357
systemdict_gid(), 357
systemdict_gmaxestack(), 357
systemdict_gstderr(), 357
systemdict_gstdin(), 357
systemdict_gstdout(), 357
systemdict_gt(), 357
systemdict_gtailopt(), 357
systemdict_handletag(), 357
systemdict_ibdup(), 357
systemdict_ibpop(), 357
systemdict_ichack(), 357
systemdict_idiv(), 357
systemdict_idup(), 358
systemdict_if(), 358
systemdict_ifelse(), 358
systemdict_ilocked(), 358
systemdict_implementor(), 358
systemdict_implements(), 358
systemdict_inc(), 358
systemdict_instance(), 358
systemdict_iobuf(), 358
systemdict_ipop(), 358
systemdict_isa(), 358
systemdict_istack(), 358
systemdict_join(), 358
systemdict_kill(), 358
systemdict_kind(), 358
systemdict_known(), 358
systemdict_lcheck(), 358
systemdict_le(), 358
systemdict_length(), 358
systemdict_link(), 358
systemdict_listen(), 358
systemdict_ln(), 358
systemdict_load(), 358
systemdict_localtime(), 358
systemdict_lock(), 358
systemdict_log(), 358
systemdict_loop(), 358
systemdict_lt(), 358
systemdict_match(), 358
systemdict_maxestack(), 358
systemdict_method(), 358
systemdict_methods(), 358
systemdict_mkdir(), 358
systemdict_mkfifo(), 358
systemdict_mod(), 358
systemdict_modload(), 358
systemdict_monitor(), 358
systemdict_mul(), 358

-
- systemdict_mutex()*, 358
 - systemdict_nbpop()*, 358
 - systemdict_ncat()*, 358
 - systemdict_ndn()*, 358
 - systemdict_ndup()*, 358
 - systemdict_ne()*, 358
 - systemdict_neg()*, 358
 - systemdict_nip()*, 358
 - systemdict_nonblocking()*, 358
 - systemdict_not()*, 358
 - systemdict_npop()*, 358
 - systemdict_nsleep()*, 358
 - systemdict_nup()*, 358
 - systemdict_offset()*, 358
 - systemdict_open()*, 358
 - systemdict_or()*, 359
 - systemdict_origin()*, 359
 - systemdict_ostack()*, 359
 - systemdict_over()*, 359
 - systemdict_path()*, 359
 - systemdict_peername()*, 359
 - systemdict_pid()*, 359
 - systemdict_pipe()*, 359
 - systemdict_poll()*, 359
 - systemdict_pop()*, 359
 - systemdict_pow()*, 359
 - systemdict_ppid()*, 359
 - systemdict_print()*, 359
 - systemdict_put()*, 359
 - systemdict_putinterval()*, 359
 - systemdict_pwd()*, 359
 - systemdict_quit()*, 359
 - systemdict_rand()*, 359
 - systemdict_read()*, 359
 - systemdict_readline()*, 359
 - systemdict_readlink()*, 359
 - systemdict_realtime()*, 359
 - systemdict_recv()*, 359
 - systemdict_regex()*, 359
 - systemdict_regsub()*, 359
 - systemdict_rename()*, 359
 - systemdict_repeat()*, 359
 - systemdict_rmdir()*, 359
 - systemdict_roll()*, 359
 - systemdict_rot()*, 359
 - systemdict_round()*, 359
 - systemdict_sadn()*, 359
 - systemdict_saup()*, 359
 - systemdict_sbdup()*, 359
 - systemdict_sbpop()*, 359
 - systemdict_sbpush()*, 359
 - systemdict_sclear()*, 359
 - systemdict_scleartomark()*, 359
 - systemdict_scount()*, 359
 - systemdict_scounttomark()*, 359
 - systemdict_sdn()*, 359
 - systemdict_sdup()*, 359
 - systemdict_seek()*, 359
 - systemdict_self()*, 359
 - systemdict_send()*, 359
 - systemdict_serviceport()*, 359
 - systemdict_setclassname()*, 359
 - systemdict_setdata()*, 359
 - systemdict_setegid()*, 359
 - systemdict_setenv()*, 359
 - systemdict seteuid()*, 359
 - systemdict_setgid()*, 359
 - systemdict_setgmaxestack()*, 359
 - systemdict_setgstderr()*, 360
 - systemdict_setgstdin()*, 360
 - systemdict_setgstdout()*, 360
 - systemdict_setgtailopt()*, 360
 - systemdict_setiobuf()*, 360
 - systemdict_setisa()*, 360
 - systemdict_setlocking()*, 360
 - systemdict_setmaxestack()*, 360
 - systemdict_setmethods()*, 360
 - systemdict_setnonblocking()*, 360
 - systemdict_setpgid()*, 360
 - systemdict_setsid()*, 360
 - systemdict_setsockopt()*, 360
 - systemdict_setstderr()*, 360
 - systemdict_setstdin()*, 360
 - systemdict_setstdout()*, 360
 - systemdict_setsuper()*, 360
 - systemdict settailopt()*, 360
 - systemdict_setuid()*, 360
 - systemdict_sexch()*, 360
 - systemdict_shift()*, 360
 - systemdict_sibdup()*, 360
 - systemdict_sibpop()*, 360
 - systemdict_sidup()*, 360
 - systemdict_sigmask()*, 360
 - systemdict_signal()*, 360
 - systemdict_sigpending()*, 360
 - systemdict sigsuspend()*, 360
 - systemdict_sigwait()*, 360
 - systemdict_sin()*, 360
 - systemdict sinh()*, 360
 - systemdict sipop()*, 360
 - systemdict_snbpop()*, 360
 - systemdict_sndn()*, 360
 - systemdict_sndup()*, 360
 - systemdict_snip()*, 360
 - systemdict_snpop()*, 360
 - systemdict snup()*, 360

- systemdict_socket()*, 360
- systemdict_socketpair()*, 360
- systemdict_sockname()*, 360
- systemdict_sockopt()*, 360
- systemdict_socket()*, 360
- systemdict_split()*, 360
- systemdict_spop()*, 360
- systemdict_spush()*, 360
- systemdict_sqrt()*, 360
- systemdict_srand()*, 360
- systemdict_sroll()*, 360
- systemdict_srot()*, 360
- systemdict_stack()*, 360
- systemdict_start()*, 360
- systemdict_status()*, 360
- systemdict_stderr()*, 361
- systemdict_stdin()*, 361
- systemdict_stdout()*, 361
- systemdict_stop()*, 361
- systemdict_stopped()*, 361
- systemdict_string()*, 361
- systemdict_stuck()*, 361
- systemdict_sub()*, 361
- systemdict_submatch()*, 361
- systemdict_subst()*, 361
- systemdict_sunder()*, 361
- systemdict_sup()*, 361
- systemdict_super()*, 361
- systemdict_sym_gt()*, 361
- systemdict_sym_lp()*, 361
- systemdict_sym_rb()*, 361
- systemdict_sym_rp()*, 361
- systemdict_symlink()*, 361
- systemdict_tailopt()*, 361
- systemdict_tan()*, 361
- systemdict_tanh()*, 361
- systemdict_tell()*, 361
- systemdict_test()*, 361
- systemdict_this()*, 361
- systemdict_thread()*, 361
- systemdict_threadcstack()*, 361
- systemdict_threaddstack()*, 361
- systemdict_threadestack()*, 361
- systemdict_threadistack()*, 361
- systemdict_threadostack()*, 361
- systemdict_threadsdict()*, 361
- systemdict_timedwait()*, 361
- systemdict_token()*, 361
- systemdict_trapped()*, 361
- systemdict_trunc()*, 361
- systemdict_truncate()*, 361
- systemdict_trylock()*, 361
- systemdict_tuck()*, 361
- systemdict_type()*, 361
- systemdict_uid()*, 361
- systemdict_umask()*, 361
- systemdict_undef()*, 361
- systemdict_under()*, 361
- systemdict_unless()*, 361
- systemdict_unlink()*, 361
- systemdict_unlock()*, 361
- systemdict_unsetenv()*, 361
- systemdict_until()*, 361
- systemdict_up()*, 361
- systemdict_wait()*, 361
- systemdict_waitpid()*, 361
- systemdict_where()*, 361
- systemdict_while()*, 361
- systemdict_write()*, 362
- systemdict_xcheck()*, 362
- systemdict_xecheck()*, 362
- systemdict_xor()*, 362
- systemdict_yield()*, 362
- tailopt**, 210
- tan**, 211
- tanh**, 211
- tell**, 211
- test**, 212
- thd*, 348
- thd_crit_enter()*, 350
- thd_crit_leave()*, 350
- thd_delete()*, 349
- thd_join()*, 349
- thd_new()*, 349
- thd_resume()*, 351
- thd_self()*, 349
- thd_sigmask()*, 349
- thd_single_enter()*, 350
- thd_single_leave()*, 350
- thd_suspend()*, 350
- thd_trysuspend()*, 351
- thd_yield()*, 349
- this**, 213
- thread**, 213
- threadcstack**, 213
- threaddict**, 228, 229
- threaddstack**, 214
- threadestack**, 214
- threadistack**, 214
- threadostack**, 215
- threadsdict**, 215, 230
- threadtype**, 51, 62
- threshold**, 38
- throw**, 215
- timedwait**, 216

-
- token**, 216
 - trapped**, 217
 - true**, 219
 - trunc**, 218
 - truncate**, 218
 - trylock**, 219
 - tsd*, 351
 - tsd_delete()*, 351
 - tsd_get()*, 351
 - tsd_new()*, 351
 - tsd_set()*, 352
 - tuck**, 219
 - type**, 220
 - typecheck, 24

 - uid**, 220
 - umask**, 221
 - undef**, 221, 237
 - undefined, 24
 - undefinedfilename, 24
 - undefinedresult, 24
 - under**, 221
 - unless**, 222
 - unlink**, 222
 - unload**, 244
 - unload_notify**, 240
 - unlock**, 223
 - unmatchedfino, 24
 - unmatchedmark, 25
 - unregistered, 25
 - unsetenv**, 223
 - until**, 223
 - up**, 224
 - userdict**, 224, 230

 - vclass**, 224
 - version**, 225
 - version_get**, 244
 - version_set**, 244

 - wait**, 225
 - waitpid**, 225
 - where**, 226
 - while**, 226
 - write**, 226

 - xcheck**, 227
 - xecheck**, 227
 - xep*, 352
 - xep_acatch*, 354
 - xep_begin()*, 353
 - xep_catch()*, 353
 - xep_end()*, 353
 - xep_filename()*, 354
 - xep_handled()*, 355
 - xep_line_num()*, 354
 - xep_mcatch()*, 353
 - xep_retry()*, 355
 - xep_throw()*, 354
 - xep_throw_e()*, 354
 - xep_try*, 353
 - xep_value()*, 354
 - xor**, 228

 - yield**, 228