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# Larceny User Manual

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# 1. Larceny

Larceny implements the Scheme programming language as defined by IEEE Standard 1178-1990, the Revised<sup>5</sup> Report, the Revised<sup>6</sup> Report, and ERR5RS. Those language standards serve as Larceny's primary documentation.

This manual describes aspects of Larceny that are not described by the IEEE standard, the Revised Reports, or ERR5RS. For the most current version of this manual, please see Larceny's online documentation page [<http://larceny.ccs.neu.edu/doc>]. For links to the Common Larceny User Manual and the Larceny mailing list, please visit Larceny's main web page [<http://larceny.ccs.neu.edu/>].

To report bugs, please send email to the Larceny developers at <[larceny@ccs.neu.edu](mailto:larceny@ccs.neu.edu)>, or submit a bug

ticket using Larceny's Trac system [<http://larceny.ccs.neu.edu/trac/>].

## 2. Installing Larceny

### 2.1. Varieties of Larceny

There are three main varieties of Larceny.

Native Larceny is the fastest and most convenient variety of Larceny. It compiles directly to native machine code for Intel x86-32 or SPARC microprocessors running Windows, Linux, MacOS X, or Solaris operating systems.

Petit Larceny compiles to C instead of machine code. It runs on most Unix machines, including PowerPC Macintoshes with MacOS X.

Common Larceny compiles to JIT-compiled IL on Microsoft's Common Language Runtime (CLR) or Mono. It provides access to the .NET libraries from Scheme.

### 2.2. Downloading

The current versions of Larceny are available for download at Larceny's main web page [<http://larceny.ccs.neu.edu/>].

Twobit and Larceny are distributed in two forms: as a precompiled binary, or as source code that can be used to reconstruct any of the precompiled binary distributions. Unless you intend to modify Larceny yourself, you do not need to download the source code.

### 2.3. Installing the programs

If you are installing or running Common Larceny, please consult the Common Larceny User Manual [<http://larceny.ccs.neu.edu/>] instead of becoming confused by the instructions in this manual.

Unpack the distribution files with an appropriate command such as one of the following:

```
tar -xzf larceny-X.Y-bin-native-sparc-solaris.tar.gz
tar -xzf larceny-X.Y-bin-native-ia32-macosx.tar.gz
tar -xzf larceny-X.Y-bin-native-ia32-linux86.tar.gz
tar -xzf larceny-X.Y-bin-native-ia32-win32.tar.gz
tar -xzf larceny-X.Y-bin-petit-stdc-macosx.tar.gz
tar -xzf larceny-X.Y-src.tar.gz
```

That will create a directory with a similar name (but without the `.tar.gz` suffix) in your current working directory. That is the Larceny root directory, which you may rename to something shorter, such as `larceny`; the rest of this section will refer to it by that name.

Assuming you have unpacked a binary distribution, the `larceny` directory will contain the following files:

<code>larceny.bin</code>	Run-time system
<code>larceny.heap</code>	Heap image with all libraries, FFI, and compiler
<code>larceny</code>	Shell script that runs <code>larceny.heap</code>
<code>scheme-script</code>	Shell script that runs Scheme scripts
<code>compile-stale</code>	Scheme script that compiles ERR5RS/R6RS libraries
<code>startup.sch</code>	Pathnames for the <code>require</code> and <code>autoload</code> features

If you unpacked a binary distribution, then you should be able to run it immediately by making the `larceny` directory your current working directory and invoking `./larceny` or perhaps just `larceny`.

If you unpacked the source code there will be many other files and directories, but `larceny.bin` and `larceny.heap` will not be present.

### Tip

You can reconstruct the `larceny.bin` and `larceny.heap` files from their source code, but that process requires a working version of Larceny or PLT Scheme v37x; unless you're porting Larceny or Petit Larceny to a brand new target architecture, it's easier to obtain those files from a binary distribution of Larceny.

You may add the `larceny` directory to your standard path, or you may install Larceny into a directory that is already part of your standard path.

Suppose, for example, that you want to install Larceny in `/usr/local/bin` and `/usr/local/lib/larceny`. Copy `larceny` and `scheme-script` to `/usr/local/bin` and edit the definition of `LARCENY_PATH` at the head of each file to point to the correct directory:

```
LARCENY_PATH=/usr/local/lib/larceny
```

Then move the entire `larceny` directory to `/usr/local/lib/larceny`, or copy `larceny.bin`, `larceny.heap`, `startup.sch`, and the `lib` directory to `/usr/local/lib/larceny`.

You should now be able to run Larceny from any directory by typing "larceny" at a prompt.

## 2.4. Compiling the R6RS standard libraries

Before you can run Larceny in ERR5RS or R6RS modes, you may have to compile the ERR5RS/R6RS runtime and standard libraries. This step is definitely required if you are using Petit Larceny or building any variety of Larceny from source code. With the prebuilt native varieties of Larceny, however, this step should not be necessary unless you change one of the files in `lib/R6RS` or `lib/SRFI`.

### Tip

If the `lib/R6RS` directory and its subdirectories are read-only, then the standard libraries will not be touched, modified, or recompiled by accident.

Compiling the ERR5RS/R6RS runtime and standard libraries is accomplished as follows:

```
$ ./larceny
Larceny v0.96 "Fluoridation" (...)
> (require 'r6rsmode)
> (larceny:compile-r6rs-runtime)
> (exit)
```

### Warning

Compiling the ERR5RS/R6RS runtime as shown above causes all previously compiled ERR5RS/R6RS libraries and top-level programs to become stale. That means those previously compiled files will need to be recompiled or removed.

## 3. Running Larceny

Larceny runs in any of four distinct modes:

R5RS	traditional read/eval/print loop (the default)
ERR5RS	ERR5RS read/eval/print loop
R6RS	batch execution of R6RS top-level programs
Scheme script	batch execution of R6RS Scheme scripts

These modes correspond to the four distinct kinds of Scheme programs that are described by the current de facto standards for Scheme. (IEEE/ANSI Std 1178 is so similar to the R5RS standard that Larceny implements both languages in R5RS mode.)

### 3.1. R5RS mode

When you start Larceny in R5RS mode (the default), you will be presented with a banner message and the read-eval-print loop's prompt:

```
% larceny
Larceny vX.Y "<version_name>" (MMM DD YYYY HH:MM:SS, ...)
larceny.heap, built ...

>
```

You can enter a Scheme expression at the prompt. After a complete expression has been read, it will be evaluated and its results printed.

#### Note

In native Larceny, the expression is evaluated by compiling it to native machine code, which is then executed. In Petit Larceny, the expression is evaluated by an interpreter because compiling to C, running the C compiler, and loading the compiled C code would take too long. Interpreted code behaves like compiled code, so most of what this manual says about the compiler is also true of Petit Larceny's interpreter.

By default, Larceny's Twobit compiler makes several assumptions that allow it to generate faster code; for example, the compiler assumes Scheme's standard procedures will not be redefined. To obtain strict conformance to R5RS semantics, see the section of this user manual devoted to performance.

### 3.2. ERR5RS mode

To interact with Larceny's ERR5RS read/eval/print loop, specify the `-err5rs` option on Larceny's command line:

```
% larceny -err5rs
Larceny v0.95 "First Safety" (...)
ERR5RS mode (no libraries have been imported)
```

Since no libraries have been imported, the only forms you can evaluate are constant literals, variable references (but no variables have been imported!), procedure calls (but no procedure values are accessible!), library definitions, and import forms. The first thing you'll want to do is to import some libraries, such as:

```
> (import (rnrs base))
```

```
(rnrs io simple)
(err5rs records syntactic))
```

Once you have imported `(rnrs base)` or a composite library that includes it, you can evaluate definitions and use all other syntax and variables you have imported.

### 3.2.1. Automatic loading

As an extension to ERR5RS, Larceny attempts to load libraries automatically when they are first imported. Autoloading makes interactive development and separate compilation much more convenient.

All of Larceny's predefined libraries can be autoloaded.

To enable autoloading of other ERR5RS/R6RS libraries, you can:

- use the `-path` command-line option
- use the `LARCENY_LIBPATH` environment variable
- use `current-require-path`
- edit `startup.sch` in Larceny's root directory
- add the libraries to Larceny's `lib` directory

### 3.2.2. Dynamic loading

Larceny automatically loads ERR5RS/R6RS libraries when they are first imported. This is usually the most convenient way to load a library, but autoloading can't be used to load a top-level program. Explicit loading is needed for top-level programs, for libraries that don't reside in Larceny's `current-require-path`, and for libraries that are defined in files whose names do not follow Larceny's standard naming conventions.

Explicit loading is the only portable way for ERR5RS programs to load a library.

Explicit loading also makes it possible to write portable programs whose source files conform to both the R5RS and ERR5RS. Two different configuration files, one for the R5RS and one for ERR5RS, can perform all of the imports and loads needed to run the program.

For explicit loading of nonstandard libraries, top-level programs, or unadorned R5RS-style code from a file, you must first import a suitable load procedure:

```
> (import (err5rs load))
```

Loading a library does not automatically import it. To use the variables and syntax that are exported by a library, you must import that library explicitly:

```
> (load "lib/R6RS/larceny/benchmarking.sls")
> (import (larceny benchmarking))
> (time (vector-for-each + (make-vector 1000000 0)))
Words allocated: 3095752
Words reclaimed: 0
Elapsed time...: 111 ms (User: 104 ms; System: 8 ms)
```

```
Elapsed GC time: 4 ms (CPU: 4 in 8 collections.)
```

In Larceny, you may omit the call to `load` because the `(larceny benchmarking)` library will be autoloaded when it is imported. In other ERR5RS systems, however, you may have to load all of the nonstandard libraries that will be imported by a top-level program or library before you load that top-level program or library.

You do not have to import those libraries into the ERR5RS top level, however, unless you want to use the variables and syntax exported by those libraries in the expressions and definitions you evaluate at the top level.

### 3.2.3. Predefined libraries

Larceny predefines several nonstandard libraries in addition to the standard ERR5RS and R6RS libraries, and autoloads them for your convenience. The predefined, autoloadable libraries include:

R6RS standard libraries:

```
(rnrs base (6))           ; R6RS chapter 9
(rnrs unicode (6))       ; R6RS library chapter 1
(rnrs bytevectors (6))   ; R6RS library chapter 2
(rnrs lists (6))         ; R6RS library chapter 3
(rnrs sorting (6))      ; R6RS library chapter 4
(rnrs control (6))      ; R6RS library chapter 5
(rnrs exceptions (6))   ; R6RS library section 7.1
(rnrs conditions (6))   ; R6RS library sections 7.2 and 7.3
(rnrs io ports (6))     ; R6RS library sections 8.1 and 8.2
(rnrs io simple (6))    ; R6RS library sections 8.1 and 8.3
(rnrs files (6))        ; R6RS library chapter 9
(rnrs programs (6))     ; R6RS library chapter 10
(rnrs arithmetic fixnums (6)) ; R6RS library section 11.2
(rnrs arithmetic flonums (6)) ; R6RS library section 11.3
(rnrs arithmetic bitwise (6)) ; R6RS library section 11.4
(rnrs syntax-case (6))  ; R6RS library chapter 12
(rnrs hashtables (6))  ; R6RS library chapter 13
(rnrs enums)           ; R6RS library chapter 14
(rnrs (6))             ; R6RS library chapter 15
(rnrs eval (6))        ; R6RS library chapter 16
(rnrs mutable-pairs (6)) ; R6RS library chapter 17
(rnrs mutable-strings (6)) ; R6RS library chapter 18
(rnrs r5rs (6))        ; R6RS library chapter 19
```

R6RS standard libraries that are autoloadable but deprecated in Larceny:

```
(rnrs records procedural (6)) ; R6RS library section 6.3
(rnrs records inspection (6)) ; R6RS library section 6.4
(rnrs records syntactic (6))  ; R6RS library section 6.2
```

SRFI libraries (which follow the SRFI 97 naming convention):

```
(srfi :1 lists)           ; list library
(srfi :2 and-let*)       ; extended `and` and `let*`
(srfi :5 let)            ; extended version of `let`
(srfi :6 basic-string-ports) ; basic string ports
(srfi :8 receive)        ; binding to multiple values
(srfi :9 records)        ; defining record types
(srfi :11 let-values)    ; syntax for multiple values
(srfi :13 strings)       ; string libraries
(srfi :14 char-set)      ; character-set library
(srfi :16 case-lambda)   ; syntax for variable arity
(srfi :17 generalized-set!) ; generalized set!
```

```
(srfi :19 time) ; time data types and procedures
(srfi :23 error) ; error reporting mechanism
(srfi :25 multi-dimensional-arrays) ; multi-dimensional array primitives
(srfi :26 cut) ; specializing without currying
(srfi :27 random-bits) ; sources of random bits
(srfi :28 basic-format-strings) ; basic format strings
(srfi :29 localization) ; localization
(srfi :38 with-shared-structure) ; i/o for data with shared structure
(srfi :39 parameters) ; parameter objects
(srfi :41 streams) ; streams
(srfi :42 eager-comprehensions) ; eager comprehensions
(srfi :43 vectors) ; vector library
(srfi :45 lazy) ; iterative lazy algorithms
(srfi :48 intermediate-format-strings) ; format
(srfi :51 rest-values) ; rest values hackery
(srfi :54 cat) ; still more formatting
(srfi :59 vicinities) ; vicinity
(srfi :61 cond) ; a more general cond clause
(srfi :63 arrays) ; homogeneous, heterogeneous arrays
(srfi :64 testing) ; an API for test suites
(srfi :67 compare-procedures) ; three-way comparison procedures
(srfi :78 lightweight-testing) ; lightweight testing
(srfi :87 case) ; a more general case clause
(srfi :98 os-environment-variables) ; environment variables
(srfi :99 records) ; ERR5RS records (composite library)
(srfi :99 records procedural) ; ERR5RS records (procedural API)
(srfi :99 records inspection) ; ERR5RS records (inspection API)
(srifi :99 records syntactic) ; ERR5RS records (syntactic API)
```

SRFI libraries that are autoloadable but deprecated in Larceny, usually because they have been superseded in whole or in part by R6RS syntax or libraries:

```
(srfi :60 integer-bits) ; integers as bits
(srfi :66 octet-vectors) ; octet vectors
(srfi :69 basic-hash-tables) ; basic hash tables
(srfi :71 let) ; extensions of let, let*, letrec
(srfi :74 blobs) ; octet-addressed binary blocks
(srfi :86 mu-and-nu) ; mu and nu simulating values etc
(srifi :95 sorting-and-merging) ; sorting and merging
```

Other autoloadable libraries:

```
(err5rs records procedural) ; ERR5RS records (procedural API)
(err5rs records inspection) ; ERR5RS records (inspection API)
(err5rs records syntactic) ; ERR5RS records (syntactic API)
(err5rs load) ; ERR5RS load procedure
(rnrs load) ; equivalent to (err5rs load)
(larceny load) ; extension of (err5rs load)
(larceny compiler) ; separate compilation (ERR5RS/R6RS)
(larceny benchmarking) ; timing facilities
(larceny profiling) ; profiling of Scheme code
(larceny records printer) ; custom printing of records
(larceny shivers-syntax) ; syntax favored by Olin Shivers
(r5rs) ; approximates the R5RS top level
(explicit-renaming) ; macros with explicit renaming
```

### 3.2.4. Library path

Larceny's autoload feature locates ERR5RS/R6RS libraries by performing a depth-first search of the directories that belong to Larceny's current-require-path. Libraries will not be autoloaded unless they are defined in files whose names follow Larceny's standard conventions.

The current-require-path is initialized by the `startup.sch` file in Larceny's root directory.



Larceny's `-path` command-line option adds one or more directories to the directories in the `current-require-path`.

The `LARCENY_LIBPATH` environment variable can also be used to add one or more directories to the directories in the `current-require-path`.

### 3.2.5. Importing Larceny's standard procedures

Any of Larceny's R5RS-mode top-level procedures can be imported into an ERR5RS or R6RS library or program by using an `import` declaration with a `primitives` clause that names the R5RS procedures to be imported. For example:

```
(import (primitives random current-seconds
        getenv setenv system
        current-directory file-modification-time
        system-features vector-like-cas!)
 (rnrs base)
 (rnrs control))
```

#### Warning

This feature is non-portable. Other implementations of ERR5RS or the R6RS may not even have an underlying implementation of the R5RS.

## 3.3. R6RS mode

To execute a top-level R6RS program that is contained within a file named `pgm`, type:

```
larceny -r6rs -program pgm
```

The `-program` option can be omitted, in which case Larceny will read the top-level program from standard input:

```
larceny -r6rs < pgm
```

If you omit the `-program` option and do not redirect standard input, then Larceny will wait patiently for you to type a complete top-level program into standard input, terminating it with an end-of-file.

You probably don't want to do that. Had you wanted to type R6RS code at Larceny, you'd be using ERR5RS mode instead.

By default, Larceny's Twobit compiler uses settings that make good sense for production code but violate some absolute requirements of the R6RS. For maximal adherence to R6RS requirements (at the expense of portability, interoperability, and/or performance), see the discussion of `compiler-switches` in the section on the `(larceny compiler)` library.

### 3.3.1. Predefined libraries

The R6RS standard does not specify any way for a top-level program to define its own libraries. Portable R6RS programs are therefore limited to importing a subset of the R6RS standard libraries.

As an extension to the R6RS, Larceny allows R6RS top-level programs and Scheme scripts to import any libraries that are predefined in Larceny's ERR5RS mode.

### 3.3.2. Library path

As another extension to the R6RS, Larceny allows R6RS top-level programs to import any libraries that can be found in the directories specified by the `-path` option on Larceny's command line using Larceny's standard translation from library names to file names. On most systems, you can specify multiple directories by separating them with a colon; under Windows, use a semicolon as separator instead. The first directory listed will be searched first.

#### Tip

If you have a set of portable libraries that run under more than one implementation of the R6RS, and you want to have a special version of some of those libraries for Larceny, you can put all your portable versions in one directory and the Larceny-specific versions in another. When you run Larceny, use the `-path` option and specify the Larceny-specific directory first.

#### Note

The `-path` option cannot be used by Scheme scripts, because command-line options are passed along to the Scheme script without being interpreted by the `scheme-script` processor.

#### Warning

We emphasize that this extension is non-portable. Other implementations of the R6RS may not provide anything comparable to Larceny's `-path` option. Even if they do, their mappings from library names to file names may be incompatible with Larceny's.

### 3.3.3. Library environment variable

As another extension to the R6RS, Larceny allows R6RS top-level programs to import any libraries that can be found in directories specified by the `LARCENY_LIBPATH` environment variable. The value of that environment variable should be a string in the same format as for Larceny's `-path` command-line option, described above.

#### Warning

We emphasize that this extension is non-portable. Other implementations of the R6RS may not support anything comparable to Larceny's `LARCENY_LIBPATH` environment variable. Even if they do, their mappings from library names to file names may be incompatible with Larceny's.

### 3.3.4. Defining libraries

As an extension to the R6RS, Larceny allows a top-level program or Scheme script to define R6RS libraries within the file that contains the top-level program or Scheme script, before the `import` form that begins the top-level program. These libraries must be arranged so that no library depends upon libraries that come later in the file.

#### Warning

We emphasize that this extension is non-portable. Other implementations of the R6RS may not allow R6RS programs to define their own libraries.

### 3.3.5. Importing procedures from Larceny's underlying R5RS

## system

As an extension to the R6RS, Larceny allows any of the procedures that are predefined at top level in Larceny's R5RS mode to be imported by using a `primitives` clause in an `import` declaration.

### Warning

This extension is highly non-portable. Other implementations of the R6RS may not even have an underlying implementation of the R5RS.

## 3.4. Scheme scripts

On most Unix systems (including MacOS X and Linux), Larceny's `scheme-script` will execute Scheme scripts as described in R6RS non-normative appendix D, with or without the optional script header. To make Scheme scripts executable in their own right, without executing `scheme-script` directly, add Larceny's root directory to your path as described in `doc/HOWTO-INSTALL`.

Suppose, for example, that `/home/myself/hello` is an R6RS Scheme script whose first line is the optional script header shown below:

```
#!/usr/bin/env scheme-script
```

If you do not have execute permission for this script, or Larceny's root directory is not in your path, you can still run the script from Larceny's root directory as follows:

```
% ./scheme-script /home/myself/hello
```

If you have execute permission for the script, and Larceny's root directory is in your path, you can also run the script as follows:

```
% /home/myself/hello
```

If, in addition, the directory that contains the script is in your path, you can run the script as follows:

```
% hello
```

You may also pass command-line arguments to a Scheme script.

### Warning

We emphasize that Scheme scripts are not portable. Scheme scripts are specified only by a non-binding appendix to the R6RS, not by the R6RS proper. Other implementations of the R6RS may not support Scheme scripts at all, or may give them a semantics incompatible with Larceny's.

On Unix systems, standard input and output can be redirected in the usual way. In Larceny, standard input corresponds to the textual port initially returned by `current-input-port`, and standard output corresponds to the textual port initially returned by `current-output-port`.

### Warning

We emphasize that redirection of standard input and output is non-portable. Other

implementations of the R6RS may not allow redirection, or may identify the standard input and output with ports other than those initially returned by `current-input-port` and `current-output-port`.

## 3.5. R5RS scripting

Suppose `hello.sch` contains the following R5RS code:

```
(display "Hello world!")
(newline)
(exit)
```

You can run `hello.sch` as a script by executing Larceny as follows:

```
% larceny -nobanner -- hello.sch
```

You can redirect Larceny's standard input, in which case you may want to eliminate the herald announcement and the read/eval/print loop's prompt:

```
% larceny -nobanner -- -e "(begin (herald #f) (repl-prompt values))" \
< hello.sch
```

For an explanation of why that works, which may suggest other creative uses of Larceny, ask for help:

```
% larceny -help
```

## 3.6. Errors

In R6RS modes, errors should result in an error message followed by a clean exit from the program.

If your program encounters an error in an interactive mode (R5RS or ERR5RS), it will enter the debugger; this is believed to be a feature.

Despite its crudity, and to some extent because of it, Larceny's debugger works at least as well with optimized compiled code as with interpreted code.

If you type a question mark at the debugger prompt, the debugger will print a help message. That message is more helpful if you understand the Twobit compiler and Larceny's internal representations and invariants, but this manual is not the place to explain those things.

The debugging context is saved so you can exit the debugger and re-enter it from the main read/eval/print loop's prompt:

```
> (debug)
```

The debugger is pretty much a prototype; you don't need to tell us how bad it is.

## 3.7. Troubleshooting

### 3.7.1. Errors when starting Larceny

When attempting to run an R6RS program, you may see a warning about "loading source in favor of stale fasl file", following by a long series of error messages about syntactic keywords used as a variable, ending with the kind of error you'd expect to see when a large R6RS program is fed to a Scheme compiler that was expecting to see R5RS-compatible code. That means the R6RS runtime and standard libraries were not installed correctly, or their source files have been touched or modified since they were last compiled. To fix the problem, recompile the R6RS standard libraries as described in step 4 of `doc/HOWTO-BUILD`.

The precompiled binary forms of Larceny should run on most machines with the appropriate processor and operating system, but the executable program "larceny.bin" may be incompatible with very old or with very new versions of the processor or operating system. If that appears to be the case, you should see whether a newer version of Larceny fixes the problem. If not, please report the problem to us at `larceny@ccs.neu.edu`. Please report success stories as well.

### 3.7.2. Errors when compiling the ERR5RS/R6RS runtime

If something goes wrong while compiling the ERR5RS/R6RS runtime, make sure you are running the copy of Larceny you think you are running and have read and write permission for `lib/R6RS`, `lib/SRFI`, and all their subdirectories and files. If you get an error message about something being "expanded against a different build of this library", then one or more of the compiled files in `lib/R6RS` or `lib/SRFI` or its subdirectories has gone stale. Removing all `.slfasl` files from `lib/R6RS` and `lib/SRFI` and their subdirectories will eliminate the stale file(s).

#### Warning

Don't remove the `.sch` or `.sls` files.

### 3.7.3. Autoloading errors

If Larceny attempts to autoload an imported ERR5RS/R6RS library but cannot find the library, then the library may be defined in a file that doesn't follow Larceny's standard naming conventions. Another possibility is that the `-path` option was omitted or incorrect.

If an ERR5RS/R6RS library is compiled, then all compiled libraries and top-level programs that depend upon it must also be recompiled. In particular, recompiling the standard R6RS runtime will invalidate all compiled libraries and top-level programs. Larceny's `compile-stale` script and the `compile-stale-libraries` procedure of `(larceny compiler)` make it convenient to recompile all of the libraries and top-level programs within any given directory in an order consistent with their dependencies.

### 3.7.4. Crashes

Please report all crashes with as much information is possible; a backtrace from a debugger or a core dump is ideal (but please do not mail the core dump without contacting us first). Larceny's run-time system is compiled with full debugging information by default and a debugger like GDB should be able to provide at least some clues.

## 3.8. Performance

By default, Larceny's Twobit compiler makes several assumptions that allow it to generate faster code; for example, the compiler assumes Scheme's standard procedures will not be redefined.

To disable certain compiler optimizations that are incompatible with the R6RS, see the section that describes the `(larceny compiler)` library.

To obtain strict conformance to R5RS semantics at the expense of slower code, evaluate the expression

```
(compiler-switches 'standard)
```

To make the compiler generate faster code, you can promise not to redefine standard procedures *and* not to redefine any top-level procedure while it is running. To make this promise, evaluate

```
(compiler-switches 'fast-safe)
```

To view the current settings of Twobit's numerous compiler switches, evaluate

```
(compiler-switches)
```

All of Twobit's compiler switches are procedures whose setting can be changed by passing the new value of the switch as an argument.

For more information, evaluate

```
(help)
```

### Note

Some of the help information that will be printed may be irrelevant to the heap image you are using.

## 4. Lexical syntax

Larceny's default lexical syntax extends the lexical syntax required by the R5RS, R6RS, and ERR5RS standards.

The R6RS forbids most lexical extensions, however, so Larceny provides several mechanisms for turning its lexical extensions on and off.

### 4.1. Flags

By default, Larceny recognizes several Larceny-specific flags of the form permitted by the R6RS. The flag you are most likely to encounter represents one of Larceny's unspecified values:

```
#!unspecified
```

Certain other flags have special meanings to Larceny's `read` and `get-datum` procedures. They are described below.

### 4.2. Case-sensitivity

By default, Larceny is case-sensitive. This global default can be overridden by specifying `-foldcase` or `-nofoldcase` on Larceny's command line, or by changing the value of Larceny's `case-sensitive?`

parameter.

The case-sensitivity of a particular textual input port is affected by reading one of the following flags from the port using the `read` or `get-datum` procedures:

```
#!fold-case
#!no-fold-case
```

The `#!fold-case` flag enables case-folding on data read from the port by the `read` and `get-datum` procedures, while the `#!no-fold-case` flag disables case-folding. The behavior established by one of these flags extends to the next flag read from the port by `read` or `get-datum`.

Both `#!fold-case` and `#!no-fold-case` evaluate to an unspecified value. To obtain the effect of one of these flags while treating it as a comment, place `#;` in front of the flag.

## 4.3. Lexical extensions

When a port is first opened, the Larceny-specific lexical extensions that are accepted on the port are determined by Larceny's lexical parameters.

The following flags change the case-sensitivity and lexical extensions on the specific port from which they are read:

```
#!r6rs      ; implies #!no-fold-case, negates other flags
#!r5rs      ; implies #!fold-case, #!err5rs
#!err5rs    ; allows Larceny-specific extensions
#!larceny   ; implies #!no-fold-case, #!err5rs
```

The `#!r6rs` flag is a comment, while all of Larceny's other flags evaluate to an unspecified value. To obtain the effect of a flag other than `#!r6rs` while treating it as a comment, place `#;` in front of the flag.

### Warning

The R6RS requires implementations to treat `#!r6rs` as a comment; it is the only flag that implementations of the R6RS are required to treat as a comment. Since the `#!r6rs` flag behaves differently from all other flags, it is deprecated.

## 4.4. Lexical parameters

When given no argument, these parameters return the current default for some aspect of the lexical syntax that will be accepted on newly created ports. When given an argument, these procedures change the default as specified by the argument.

*Procedure case-sensitive?*

```
(case-sensitive? ) => boolean
```

```
(case-sensitive? boolean)
```

Determines whether newly created textual ports default to case-sensitive.

*Procedure read-larceny-weirdness?*

```
(read-larceny-weirdness? ) => boolean
```

```
(read-larceny-weirdness? boolean)
```

Determines whether newly created textual ports allow Larceny's usual extensions to R5RS lexical syntax. This parameter also determines whether newly created ports allow # as an insignificant digit; this is required by the R5RS, but disallowed by the R6RS.

*Procedure read-traditional-weirdness?*

```
(read-traditional-weirdness? ) => boolean
```

```
(read-traditional-weirdness? boolean)
```

Determines whether newly created textual ports allow certain lexical extensions that are deprecated in Larceny. These extensions include symbols enclosed by vertical bars and read-time evaluation.

For the current semantics of these parameters, please consult the Larceny developers' web page that describes Larceny's lexical syntax [<https://github.com/larcenists/larceny/wiki/LexicalConversion>].

## 5. File naming conventions

### 5.1. Suffixes

In Larceny, file names generally follow Unix conventions, even on Windows. The following suffixes have special meanings to some components of Larceny.

`.sls` is the preferred suffix for files that consist of ERR5RS/R6RS-compatible library definitions.

`.sch` is the preferred suffix for files that contain R5RS source code.

`.scm` is an alternative suffix for files that contain R5RS source code.

`.slfasl` is the suffix for files that contain the pre-compiled form of ERR5RS/R6RS-compatible code.

`.fasl` is the suffix for files that contain the pre-compiled form of R5RS code.

`.mal` is the preferred suffix for files that contain MacScheme assembly language in symbolic form.

`.lap` is the suffix for files that contain MacScheme assembly language.

`.lop` is the suffix for files that contain machine code segments in the form expected by Larceny's heap linker.

`.heap` is the suffix for files that contain an executable heap image (must be combined with the `larceny.bin` runtime).

### 5.2. Directories

Larceny's root directory should contain the following files:

```
larceny
scheme-script
larceny.bin
larceny.heap
```



```
startup.sch
```

The following subdirectories are also essential for correct operation of some features of some modes in some varieties of Larceny:

```
include
lib
lib/Base
lib/Debugger
lib/Ffi
lib/MzScheme
lib/R6RS
lib/SRFI
lib/Standard
lib/TeachPacks
```

The `include` subdirectory is used when compiling files with Petit Larceny.

The `startup.sch` file tells Larceny's `require` procedure to search some of the `lib` subdirectories for libraries that are loaded dynamically.

## 5.3. Resolving references to libraries

The R6RS does not specify any mapping from library names to files or to other locations at which the code for a library might be found. As R6RS non-normative appendix E puts it:

Implementations may take radically different approaches to storing source code for libraries, among them: files in the file system where each file contains an arbitrary number of library forms, files in the file system where each file contains exactly one library form, records in a database, and data structures in memory....Implementations may provide a means for importing libraries....

---

In other words, implementations are allowed to extend the R6RS with arbitrary mechanisms for resolving references to imported libraries, but R6RS programs that rely on such mechanisms are not portable. In particular, R6RS libraries are not portable.

Larceny provides five distinct Larceny-specific mechanisms that non-portable R6RS programs can use to import or to define libraries:

1. ERR5RS and R6RS standard libraries may be imported. Their code is located automagically.
2. Nonstandard libraries, such as `(larceny compiler)`, may be placed in one of the directories that are searched by Larceny's autoload feature, provided those libraries are located in files that follow Larceny's standard naming conventions as described in the next section.
3. R6RS top-level programs may use Larceny's `-path` option to specify directories that contain other libraries the program may import, provided those libraries are located in files that follow Larceny's standard naming conventions as described in the next section.
4. R6RS top-level programs may use Larceny's `LARCENY_LIBPATH` environment variable to specify directories that contain other libraries the program may import, provided those libraries are located in files that follow Larceny's standard naming conventions as described in the next section.

5. R6RS top-level programs and Scheme scripts may define their own libraries in the same file that contains the top-level program or Scheme script.

ERR5RS programs may use any of those five mechanisms, and may also use a sixth mechanism: An ERR5RS program can be written as a little configuration program that loads the program's libraries from files before any libraries are imported. This sixth mechanism is portable, but is not available to R6RS programs.

## 5.4. Mapping library names to files (ERR5RS/R6RS)

Suppose Larceny's `-path` option is used to specify a certain *directory*, and the program imports a nonstandard library whose name is of the form `(name1 name2 ... lastname)`. Larceny will search for that library in the following files:

- `directory/name1/name2/.../lastname.larceny.slfasl`
- `directory/name1/name2/.../lastname.larceny.sls`
- `directory/name1/name2/.../lastname.slfasl`
- `directory/name1/name2/.../lastname.sls`
- ...
- `directory/name1/name2.larceny.slfasl`
- `directory/name1/name2.larceny.sls`
- `directory/name1/name2.slfasl`
- `directory/name1/name2.sls`
- `directory/name1.larceny.slfasl`
- `directory/name1.larceny.sls`
- `directory/name1.slfasl`
- `directory/name1.sls`

The search starts with the first of those file names, continues with the following file names in order, and ends when a file with one of those names is found. The imported library *must* be one of the libraries defined within the first file found by this search, since the search is not continued after that first file is found (except as noted in the next paragraph).

If the search ends by finding a file whose name ends with `.slfasl`, then Larceny checks to see whether there is a file in the same directory with the same root name but ending with `.sls` instead of `.slfasl`. If the `.sls` file has been modified since the `.slfasl` file was last modified, then a warning is printed and the `.sls` file is loaded instead of the `.slfasl` file. Otherwise the `.slfasl` file is loaded.

### Note

The R6RS allows arbitrary mappings from library names to library code. Larceny takes advantage of this by ignoring version numbers when mapping library names to files, and by (virtually) rewriting any version number that may be specified in the definition of a library so it matches any version specification that appears within the `import` form. Furthermore Larceny allows different versions of the same library to be imported, but Larceny's algorithm for resolving library references ensures that the different versions of a library will be identical except for their version numbers, which have no meaningful semantics. Although Larceny's treatment of versions conforms to the R6RS specification, it should be clear that version numbers serve no purpose in Larceny. Since the R6RS version feature has no usefully portable semantics, it is deprecated.

## 5.5. Mapping library names to files (R5RS)

In R5RS mode, Larceny's `-path` option and `LARCENY_LIBPATH` environment variable may be used to specify directories to be searched by the `require` procedure, which takes a single symbol *libname* as its argument. The `require` procedure will search for the following files in every directory that is part of the current require path, starting with the directories specified by `LARCENY_LIBPATH` and the `-path` option:

- *libname.fasl*
- *libname.sch*
- *libname.scm*

These files are expected to contain R5RS code, not library definitions. Otherwise the search proceeds much the same as when searching for an ERR5RS/R6RS library.

### Note

The `require` path is specified by `startup.sch` in Larceny's root directory, but may be changed dynamically using the `current-require-path` parameter. Changing the `require` path is not recommended, however, because Larceny relies on the `require` path for dynamic loading of libraries used by several important features of Larceny, notably ERR5RS and R6RS modes.

### Procedure *require*

```
(require libname)
```

*libname* must be a symbol that names an R5RS-compatible library within the current require path.

If the library has not already been loaded, then it is located and loaded. If the library is found and loaded successfully, then `require` returns true; otherwise an error is signalled.

If the library has already been loaded, then `require` returns false without loading the library a second time.

### Procedure *current-require-path*

```
(current-require-path ) => stringlist
```

```
(current-require-path stringlist)
```

The optional argument is a list of directory names (without slashes at the end) that should be searched by `require` and (in ERR5RS/R6RS modes) by Larceny's autoload feature. Returns the list of directory names that will be searched.

## 6. Compiling files and libraries

This chapter explains how you can use Larceny to compile Scheme source code to native machine code.

The native varieties of Larceny have a just-in-time compiler that compiles to native code automatically whenever you evaluate an expression, load a source file, or import a source library. Even so, files will load faster if they are compiled ahead of time.

Petit Larceny does not have a just-in-time compiler, so compiling ahead of time is the only way to enjoy the speed of native machine code in Petit Larceny.

Common Larceny uses an interpreter for expressions that are typed at the interactive read/eval/print loop, but files will be compiled as they are loaded if you specify `Larceny.fasl` on the command line. For more information on compiling files in Common Larceny, please consult the Common Larceny User Manual [<http://larceny.ccs.neu.edu>].

The main disadvantage of compiling files and libraries is that compiled code goes *stale* when its original source code is changed or when a library on which the compiled code depends is changed or recompiled. Stale compiled code can be dangerously inconsistent with libraries on which it depends, so Larceny checks for staleness and refuses to execute a stale library or program.

### 6.1. Compiling ERR5RS/R6RS libraries

On Unix machines, the most convenient way to compile a group of ERR5RS/R6RS libraries and top-level programs is to use the `compile-stale` script in Larceny's root directory. If Larceny's root directory is in your execution path, then there are just two steps:

1. Use `cd` to change to the directory that contains the ERR5RS/R6RS files you want to compile. (Files that lie within subdirectories of that directory will be compiled also.)
2. Run the `compile-stale` script.

For example:

```
% cd lib/R6RS
% compile-stale
```

On non-Unix machines, you can accomplish the same thing using Larceny's ERR5RS mode and the `(larceny compiler)` library:

```
% pushd lib\R6RS
% ..\..\larceny.bat -err5rs
Larceny v0.96 "Fluoridation"
ERR5RS mode (no libraries have been imported)

> (import (larceny compiler))

> (compile-stale-libraries)
```

To compile individual files, use the `compile-file` or `compile-library` procedures that are exported by `(larceny compiler)`.

## 6.2. Compiling R5RS source files

*Procedure compile-file*

`(compile-file sourcefile)`

Compiles *sourcefile*, which must be a string naming a file that contains R5RS source code. If *fastfile* is supplied as a second argument, then it must be a string naming the file that will contain the compiled code; otherwise the name of the compiled file is obtained from *sourcefile* by replacing the `".sch"` or `".scm"` suffix with `".fasl"`.

For ERR5RS/R6RS libraries and top-level programs, see above.

## 7. ERR5RS standard libraries

ERR5RS is still being developed, so the specifications described below are subject to change as its standard libraries are revised.

### 7.1. Load

This section describes the `(err5rs load)` library.

*Procedure load*

`(load filename)`

Loads ERR5RS code from *filename*, evaluating each form as though it had been entered at the interactive read/eval/print loop.

#### **Warning**

The `load` procedure should be used only at an interactive top level and in files that will be loaded into an interactive top level. Calls to the `load` procedure have no effect at compile time, and should not appear in files that will be compiled separately; use the `library` and `import` syntaxes instead.

### 7.2. Records

When a procedure is said to be equivalent to an R6RS procedure, the equivalence holds only when all arguments have the properties required of them by the R6RS specification. ERR5RS does not mandate R6RS exception semantics for programs that violate the specification.

#### 7.2.1. Procedural layer

This section describes the `(err5rs records procedural)` library.

*Procedure make-rtd*

```
(make-rtd name fieldspecs)
```

```
(make-rtd name fieldspecs parent-rtd)
```

```
(make-rtd name fieldspecs parent-rtd option ...)
```

*name* is a symbol, which matters only to the `rtd-name` procedure of the inspection layer. *fieldspecs* is a vector of field specifiers, where each field specifier is one of

- a symbol naming the (mutable) field;
- a list of the form `(mutable name)`, where *name* is a symbol naming the mutable field;
- a list of the form `(immutable name)`, where *name* is a symbol naming the immutable field.

The optional parent is an rtd or `#f`. It is an error for any of the symbols in *fieldspecs* to name more than one of the fields specified by *fieldspecs*, but the field names in *fieldspecs* may shadow field names in the parent rtd.

`make-rtd` returns an R6RS-compatible record-type descriptor.

Larceny allows the following optional arguments to follow the optional *parent-rtd* argument:

- the symbol `sealed` means the new rtd cannot be used as the parent of other rtds;
- the symbol `opaque` means the `record?` predicate will not recognize instances of the new rtd;
- the symbol `uid`, followed by another symbol *id*, means the new rtd is non-generative with uid *id*; the semantics of this extension is the same as in the R6RS.

These Larceny-specific options may be used in any combination, giving Larceny's ERR5RS records the same expressive power as R6RS records, with which they are fully interoperable.

#### *Procedure rtd?*

```
(rtd? obj)
```

This predicate returns true if and only if its argument is a record-type descriptor. `rtd?` is equivalent to the `record-type-descriptor?` procedure of the R6RS.

#### *Procedure rtd-constructor*

```
(rtd-constructor rtd)
```

```
(rtd-constructor rtd fieldspecs)
```

*rtd* is a record-type descriptor, and *fieldspecs* is an optional vector of symbols.

If no *fieldspecs* argument is supplied, then `rtd-constructor` returns a procedure that expects one argument for each field of the record-type described by *rtd* and returns an instance of that record-type with its fields initialized to the corresponding arguments. Arguments that correspond to the fields of the

record-type's parent (if any) come first.

If *fieldspecs* is supplied, then `rtd-creator` returns a procedure that expects one argument for each element of *fieldspecs* and returns an instance of the record-type described by *rtd* with the named fields initialized to the corresponding arguments.

It is an error if some symbol occurs more than once in *fieldspecs*. Fields of a derived record-type shadow fields of the same name in its parent; the *fieldspecs* argument cannot be used to initialize a shadowed field.

#### *Procedure rtd-predicate*

```
(rtd-predicate rtd)
```

Equivalent to the `record-predicate` procedure of the R6RS.

#### *Procedure rtd-accessor*

```
(rtd-accessor rtd field)
```

*field* is a symbol that names a field of the record-type described by the record-type descriptor *rtd*. Returns a unary procedure that accepts instances of *rtd* (or any record-type that inherits from *rtd*) and returns the current value of the named field.

Fields in derived record-types shadow fields of the same name in a parent record-type.

#### *Procedure rtd-mutator*

```
(rtd-mutator rtd field)
```

*field* is a symbol that names a field of the record-type described by the record-type descriptor *rtd*. Returns a binary procedure that accepts instances of *rtd* (or any record-type that inherits from *rtd*) and a new value to be stored into the named field, performs that side effect, and returns an unspecified value.

Fields in derived record-types shadow fields of the same name in a parent record-type.

## 7.2.2. Inspection layer

This section describes the `(err5rs records inspection)` library.

#### *Procedure record?*

```
(record? obj)
```

Equivalent to its R6RS namesake.

#### *Procedure record-rtd*

```
(record-rtd record)
```

Equivalent to its R6RS namesake.

#### *Procedure rtd-name*

```
(rtd-name rtd)
```

Equivalent to the `record-type-name` procedure of the R6RS.

*Procedure `rtd-parent`*

```
(rtd-parent rtd)
```

Equivalent to the `record-type-parent` procedure of the R6RS.

*Procedure `rtd-field-names`*

```
(rtd-field-names rtd)
```

Equivalent to the `record-type-field-names` procedure of the R6RS. (That is, it returns a vector of the symbols that name the fields of the record-type represented by *rtd*, excluding the fields of parent record-types.)

*Procedure `rtd-all-field-names`*

```
(rtd-all-field-names rtd)
```

Returns a vector of the symbols that name the fields of the record-type represented by *rtd*, including the fields of its parent record-types, if any, with the fields of parent record-types coming before the fields of its children, with each subsequence in the same order as in the vectors that would be returned by calling `rtd-field-names` on *rtd* and on all its ancestral record-type descriptors.

*Procedure `rtd-field-mutable?`*

```
(rtd-field-mutable? rtd field)
```

*rtd* is a record-type descriptor, and *field* is a symbol naming a field of the record-type described by *rtd*. Returns `#t` if the named field is mutable; otherwise returns `#f`.

## 7.2.3. Syntactic layer

This section describes the `(err5rs records syntactic)` library.

The syntactic layer consists of SRFI 9 [<http://srfi.schemers.org/srfi-9/>] extended with single inheritance and (optional) implicit naming.

All ERR5RS record-type definitions are generative (unless Larceny's optional `uid` feature is used), but ERR5RS drops the SRFI 9 restriction to top level, mainly because the R6RS allows generative definitions wherever a definition may appear.

The syntax of an ERR5RS record-type definition is

```
<definition>
  -> <record type definition>           ; addition to 7.1.6 in R5RS

<record type definition>
  -> (define-record-type <type spec>
      <constructor spec>
      <predicate spec>
      <field spec> ...)

<type spec>  -> <type name>
              -> (<type name> <parent>)
```



```
<constructor spec>
  -> #f
  -> #t
  -> <constructor name>
  -> (<constructor name> <field name> ...)

<predicate spec>
  -> #f
  -> #t
  -> <predicate name>

<field spec> -> <field name>
  -> (<field name>)
  -> (<field name> <accessor name>)
  -> (<field name> <accessor name> <mutator name>)

<parent>      -> <expression>

<type name>   -> <identifier>
<constructor name> -> <identifier>
<predicate name> -> <identifier>
<accessor name>  -> <identifier>
<mutator name>  -> <identifier>
<field name>    -> <identifier>
```

The semantics of a record type definition is the same as in SRFI 9: the record type definition macro-expands into a cluster of definitions that

- defines the `<type name>` as the record-type descriptor for the new record-type;
- defines a constructor for instances of the new record-type (unless the constructor spec is `#f`);
- defines a predicate that recognizes instances of the new record-type and its subtypes (unless the predicate spec is `#f`);
- defines an accessor for each field name;
- defines a mutator for each mutable field name.

An ERR5RS record type definition extends SRFI 9 with the following additional options:

- If a `<parent>` expression is specified, then it must evaluate to an rtd that serves as the parent record-type for the record-type being defined.
- If `#f` is specified for the constructor or predicate, then no constructor or predicate procedure is defined. (This is useful when the record-type being defined will be used as an abstract base class.)
- If `#t` is specified for the constructor or predicate, then the name of the constructor is the type name prefixed by `make-`, and the name of the predicate is the type name followed by a question mark (?).
- If the constructor name is specified as `#t` or as an identifier, then the constructor's arguments correspond to the fields of the parent (if any) followed by the new fields added by this record-type definition.
- If a field spec consists of a single identifier, then
  - the field is immutable;

- the name of its accessor is the type name followed by a hyphen (-) followed by the field name.
- If a field spec consists of a list of one identifier, then
  - the field is mutable;
  - the name of its accessor is the type name followed by a hyphen (-) followed by the field name;
  - the name of its mutator is the type name followed by a hyphen (-) followed by the field name followed by `-set!`.

## 7.2.4. Record identity

Two `ERR5RS` records with fields are `eqv?` if and only if they were created by the same (dynamic) call to some record constructor. Two `ERR5RS` records are `eq?` if and only if they are `eqv?`.

Apart from the usual constraint that equivalence according to `eqv?` implies equivalence according to `equal?`, the behavior of `equal?` on `ERR5RS` records is unspecified. (This is compatible with the `R6RS`.)

A `define-record-type` form macro-expands into code that calls `make-rtd` each time the expanded record-type definition is executed. Two `ERR5RS` record-type descriptors are `eqv?` if and only if they were created by the same (dynamic) call to `make-rtd`.

# 8. R6RS standard libraries

This chapter explains which features of the `R6RS` standard libraries are available in each of Larceny's major modes of execution.

Larceny was the first substantially complete implementation of the `R6RS`. Any features that are missing from `R6RS` modes are missing because of bugs or because the features are deprecated in Larceny. The most up-to-date listing of Larceny's known deviations from the `R6RS` standard can be found on the web page that describes the current status of Larceny's `R6RS`-compatible mode [<https://github.com/larcenists/larceny/wiki/DargoMode>].

Larceny is `R6RS`-compatible but not `R6RS`-conforming. When Larceny is said to support a feature of the `R6RS`, that means the feature is present and will behave as specified by the `R6RS` so long as no exception is raised. Larceny does not always raise the specific conditions specified by the `R6RS`, and does not perform all of the checking for portability problems that is mandated by the `R6RS`. These deviations do not affect the execution of production code, and do not compromise Larceny's traditional safety.

## 8.1. Base library

`ERR5RS` and `R6RS` modes support all procedures and syntaxes exported by the `(rnrs base)` library.

Larceny's `R5RS` mode does not support `library`, `import`, or `identifier-syntax`.

### Note

The semantics of `quasiquote`, `let-syntax`, and `letrec-syntax` differ between the `R5RS` and the `R6RS`. Larceny's `R5RS` mode still supports the `R5RS` semantics.

## 8.2. Unicode

All of Larceny's modes support all features of the `(rnrs unicode)` library.

Larceny v0.97 conforms to The Unicode Standard, Version 5.0.

## 8.3. Bytevectors

ERR5RS and R6RS modes support all procedures and syntaxes exported by `(rnrs bytevectors)`, but the `endianness` syntax is deprecated because it is redundant with `quote`. Larceny's R5RS mode does not support `endianness`.

In Larceny, any symbol names a supported endianness. The symbols `big` and `little` have their expected meanings. All other symbols mean `(native-endianness)` with respect to integer operations, but mean the opposite of `(native-endianness)` with respect to IEEE-754 operations. For string operations, the endianness must be the symbol `big` or the symbol `little`. All of these extensions are permitted by the R6RS standard.

Larceny's `utf16->string` and `utf32->string` accept one, two, or three arguments. The R6RS specification of these procedures does not allow them to accept a single argument, but that is believed to be an error in the R6RS.

## 8.4. Lists

All of Larceny's modes support all features of the `(rnrs lists)` library.

## 8.5. Sorting

All of Larceny's modes support all features of the `(rnrs sorting)` library.

## 8.6. Control

All of Larceny's modes support all features of the `(rnrs control)` library.

## 8.7. Records

ERR5RS and R6RS modes support all procedures and syntaxes exported by `(rnrs records procedural)`, `(rnrs records inspection)`, and `(rnrs records syntactic)`.

Those libraries are deprecated, however; the `make-record-constructor-descriptor` procedure does not simplify unusually complex cases enough to justify the complexity it adds to typical cases, and the entire syntactic layer is gratuitously incompatible with the procedural layer.

Larceny's R5RS mode supports all features of the deprecated `(rnrs records procedural)` and `(rnrs records inspection)` libraries. R5RS mode does not support `(rnrs records syntactic)`.

All of Larceny's modes support all features of the `(err5rs records procedural)` and `(err5rs records inspection)` libraries. ERR5RS and R6RS modes also support the `(err5rs records syntactic)` library. These libraries are equivalent to the `(srfi :99 records procedural)`, `(srfi :99 records inspection)`, and `(srfi :99 records syntactic)` libraries.

The record definition syntax of SRFI 9 [<http://srfi.schemers.org/srfi-9/>] is a proper subset of the syntax provided by the `(err5rs records syntactic)` library. In R5RS mode, SRFI 9 can be loaded dynamically using the `require` procedure:

```
> (require 'srfi-9)
```

We recommend the ERR5RS and/or SRFI 9 libraries be used instead of the corresponding R6RS libraries.

### Warning

The R6RS spouts some tendentious nonsense about procedural records being slower than syntactic records, but this is not true of Larceny's records, and is unlikely to be true of other implementations either.

### Warning

Larceny continues to support its old-style records, which are almost but not quite compatible with ERR5RS and R6RS records. This can be confusing, since some of Larceny's procedures have the same names as R6RS procedures. That has made it necessary to overload those procedures to work with both old-style and R6RS records. We apologize for the mess.

## 8.8. Exceptions and conditions

All of Larceny's modes support all features of the `(rnrs exceptions)` and `(rnrs conditions)` libraries.

## 8.9. Input and output

ERR5RS and R6RS modes support all names exported by the `(rnrs io ports)`, `(rnrs io simple)`, and `(rnrs files)` libraries.

The `buffer-mode`, `eol-style`, and `error-handling-mode` syntaxes are deprecated because they are redundant with `quote`. These deprecated syntaxes may be provided in the form of procedures rather than syntax, but this deviation from R6RS semantics cannot be detected by portable R6RS programs.

Larceny's R5RS mode supports all non-deprecated features of those libraries.

Larceny supports four distinct buffer modes: `none`, `line`, `datum`, and `block`. The R6RS requires the `buffer-mode` syntax to raise an exception for the `datum` buffer mode, which is the buffer mode Larceny uses for interactive output ports.

In Larceny, any symbol names a supported end-of-line style. All end-of-line and error-handling-mode symbols whose meanings are not described by the R6RS have locale-dependent meanings, which is an extension permitted by the R6RS standard.

Although Larceny supports the UTF-16 codec, it is not really useful on Windows machines (where it should be most useful) because Larceny's low-level file system mimics a byte-oriented Unix file system even on Windows. This problem should be addressed in some future version of Larceny.

The most up-to-date list of known deviations from R6RS io semantics can be found on the web page that describes the current status of Larceny's R6RS-compatible mode [<https://github.com/larcenists/larceny/wiki/DargoMode>].

## 8.10. Programs

ERR5RS and R6RS modes support the `(rnrs programs)` library.

Larceny's R5RS mode provides the `exit` procedure but not the `command-line` procedure of that library. Larceny's traditional `command-line-arguments` procedure can be used to implement an approximation to `command-line`. For a definition, see `lib/R6RS/rnrs/programs.sls`.

## 8.11. Arithmetic

All of Larceny's modes support all features of the `(rnrs arithmetic fixnums)`, `(rnrs arithmetic flonums)`, and `(rnrs arithmetic bitwise)` libraries.

### Note

R6RS fixnum and flonum operations may be slower than the corresponding generic operations, since the fixnum and flonum operations are required to check their arguments and may also have to check their results. Isolated operations in small micro-benchmarks are likely to be slower than groups of similar operations in larger programs, however, because the Twobit compiler removes redundant checks and propagates type information.

## 8.12. Syntax-case

ERR5RS and R6RS modes support the `(rnrs syntax-case)` library. Larceny's R5RS mode does not.

## 8.13. Hashtables

All of Larceny's modes support all features of the `(rnrs hashtables)` library.

### Note

Larceny's traditional `make-hashtable` procedure has been renamed to `make-oldstyle-hashtable`.

### Note

When you use Larceny's R5RS or ERR5RS mode to dump a heap image that contains `eq?` or `equiv?` hashtables you have created, they are automatically reset so they will rehash themselves whenever you begin a new session with the dumped heap.

## 8.14. Enumeration sets

ERR5RS and R6RS modes support the `(rnrs enums)` library. Larceny's R5RS mode provides all of the procedures exported by `(rnrs enums)` but does not provide the `define-enumeration` syntax.

## 8.15. Eval

ERR5RS and R6RS modes support the `(rnrs eval)` library. Larceny's R5RS mode provides an R5RS-compatible `eval` procedure, not an R6RS-compatible `eval` procedure, and does not provide the `environment` procedure.

## 8.16. Mutable pairs and strings

All of Larceny's modes support all features of the `(rnrs mutable-pairs)` and `(rnrs mutable-strings)` libraries.

## 8.17. R5RS

All of Larceny's modes support all features of the `(rnrs r5rs)` library.

# 9. Larceny's ERR5RS/R6RS libraries

Larceny provides libraries for loading and compiling ERR5RS/R6RS libraries and for timing benchmarks. Future versions of Larceny will offer more ERR5RS/R6RS libraries.

## 9.1. Load

The `(larceny load)` library exports both the `load` procedure of `(err5rs load)` and `r5rs:require`, which is a renaming of the `require` procedure used by Larceny's R5RS mode.

In Larceny's ERR5RS mode, the `load` procedure can load R5RS libraries and programs as well as ERR5RS/R6RS libraries.

The `r5rs:require` procedure should be used only for dynamic loading of R5RS libraries into Larceny's underlying R5RS system. The variables defined by that library can be imported into an ERR5RS session or ERR5RS/R6RS library or program using a `primitives` clause in an `import` form.

### Warning

These procedures should be used only at an interactive top level and in files that will be loaded into an interactive top level. Calls to these procedures have no effect at compile time, and should not appear in files that will be compiled separately; use the `library` and `import` syntaxes instead.

## 9.2. Compiler

The `(larceny compiler)` library exports the `load` and `r5rs:require` procedures of `(larceny load)`, the `current-require-path` procedure, the `compile-file`, `compile-library`, and `compile-stale-libraries` procedures described below, and the `compiler-switches` procedure.

These procedures can be used to compile ERR5RS/R6RS libraries and top-level programs before they are imported or executed. This is especially important for Petit Larceny, which would otherwise use an interpreter. For native Larceny, whose just-in-time compiler generates native machine code as source libraries and programs are loaded, imported, or executed, the main advantage of separate compilation is that compiled libraries and programs will load much faster than source libraries and programs.

The main disadvantage of separate compilation is that compiled libraries and programs go *stale* when their source code is changed or when a library on which they depend is changed or recompiled. Stale libraries and programs can be dangerously inconsistent with libraries on which they depend, so Larceny checks for staleness and refuses to execute a stale library or program. The `compile-stale-libraries` procedure provides a convenient way to recompile stale libraries and programs.

```
(compile-file sourcefile [slfaslfile])
```

Compiles *sourcefile*, which must be a string naming a file that contains source code for one or more ERR5RS/R6RS libraries or a top-level program. If *slfaslfile* is supplied as a second argument, then it must be a string naming the file that will contain the compiled code; otherwise the name of the compiled file is obtained from *sourcefile* by replacing the ".sls" suffix with ".slfasl".

#### *Procedure compile-library*

```
(compile-library sourcefile [slfaslfile])
```

Compiles *sourcefile*, which must be a string naming a file that contains source code for one or more ERR5RS/R6RS libraries. Apart from its unwillingness to compile top-level programs, `compile-library` behaves the same as `compile-file` above.

#### *Procedure compile-stale-libraries*

```
(compile-stale-libraries )
```

```
(compile-stale-libraries changedfile)
```

If no argument is supplied, then all ".sls" files that lie within the current directory or a subdirectory are recompiled.

If *changedfile* is supplied, then it must be a string giving the absolute pathname of a file. (In typical usage, *changedfile* is a source file that has been modified, making it necessary to recompile all files that depend upon it.) Compiles all ERR5RS/R6RS library files that lie within the same directory as *changedfile* or a subdirectory, and have not yet been compiled or whose compiled files are older than *changedfile*.

### **Note**

In future versions of Larceny, `compile-stale-libraries` might compile only the source files that depend upon *changedfile*.

#### *Procedure compiler-switches*

```
(compiler-switches )
```

```
(compiler-switches mode)
```

If no argument is supplied, then the current settings of all compiler switches are displayed. Each of those switches is itself a parameter that is exported by the `(larceny compiler)` library. Calling any individual compiler switch with no arguments will return its current setting. Calling any individual compiler switch with an argument (usually a boolean) will change its setting to that argument.

The `compiler-switches` procedure may also be called with one of the following symbols as its argument:

`default` sets most compiler switches to their default settings.

`fast-safe` enables all optimizations but continues to generate code to perform all run-time type and range checks that are needed for safety (in the traditional sense, not the R6RS sense).

`fast-unsafe` enables all optimizations and also disables type and range checking. This setting is deprecated because it compromises safety (in the traditional sense).

`slow` turns off all optimizations.

`standard` sets compiler switches for maximal conformance to the R5RS and R6RS standards.

## Warning

The `standard` setting is deprecated because it generates very slow code (because the R5RS makes it difficult to inline standard procedures), disables most compile-time checking (because the R6RS forbids rejection of programs with obvious errors unless the R6RS classifies the errors as syntactic), and may also compromise the portability or interoperability of ERR5RS/R6RS libraries and programs (because the R6RS outlaws several extensions that Larceny uses to improve its compatibility with other implementations of the R5RS and R6RS as well as interoperability between Larceny's own R5RS and ERR5RS/R6RS modes).

## Tip

Selective toggling of compiler switches is almost always better than using the `standard` setting. To improve R5RS conformance without sacrificing too much performance, set the `benchmark-mode` switch to false and set the `integrate-procedures` switch to false only when compiling files that need to be sensitive to redefinitions of standard procedures. For R6RS libraries and programs, setting the `benchmark-mode` and `global-optimization` switches to false will eliminate a couple of minor conformance issues with only a small loss of performance and without sacrificing compile-time checking or portability.

## 9.3. Benchmarking

The `(larceny benchmarking)` library exports the `time` syntax and `run-benchmark` procedure described below.

*Syntax time*

`(time expression)`

Evaluates *expression* and returns its result after printing approximations to the storage allocated and time taken during evaluation of *expression*.

```
> (time (fib 30))
Words allocated: 0
Words reclaimed: 0
Elapsed time...: 49 ms (User: 48 ms; System: 0 ms)
Elapsed GC time: 0 ms (CPU: 0 in 0 collections.)
832040
```

`(run-benchmark name iterations thunk predicate)`

Given the *name* of a benchmark, the number of *iterations* to be performed, a zero-argument procedure *thunk* that runs the benchmark, and a unary *predicate* that checks the result of *thunk*, prints approximations to the storage allocated and time taken by *iterations* calls to *thunk*.

```
> (run-benchmark "fib30"
  100
```



```
(lambda () (fib 30))  
(lambda (x) (= x 832040)))
```

```
-----  
fib30  
Words allocated: 0  
Words reclaimed: 0  
Elapsed time...: 4828 ms (User: 4824 ms; System: 4 ms)  
Elapsed GC time: 0 ms (CPU: 0 in 0 collections.)
```

## 9.4. Records printer

The `(larceny records printer)` library exports the two procedures described below. These procedures can be used to override Larceny's usual printing of records and opaque types that were defined using the records libraries.

### *Procedure `rtd-printer`*

```
(rtd-printer rtd) => maybe-procedure
```

Given a record type descriptor, returns its custom print procedure, or returns false if the rtd has no custom print procedure.

### *Procedure `rtd-printer-set!`*

```
(rtd-printer-set! rtd printer)
```

Given a record type descriptor *rtd* and a *printer* for instances of that rtd, installs *printer* as a custom print procedure for *rtd*. The *printer* should be a procedure that, given an instance of the rtd and a textual output port, writes a representation of the instance to the port.

## 10. Larceny's R5RS libraries

The procedures described in this chapter are nonstandard. Some are deprecated after being rendered obsolete by ERR5RS or R6RS standard libraries. Others still provide useful capabilities that the standard libraries don't.

### 10.1. Strings

Larceny provides Unicode strings with R6RS [<http://www.r6rs.org/>] semantics.

The `string-downcase` and `string-upcase` procedures perform Unicode-compatible case folding, which can result in a string whose length is different from that of the original.

Larceny may still provide `string-downcase!` and `string-upcase!` procedures, but they are deprecated.

### 10.2. Bytevectors

A *bytevector* is a data structure that stores bytes — exact 8-bit unsigned integers. Bytevectors are useful in constructing system interfaces and other low-level programming. In Larceny, many bytevector-like structures — bignums, for example — are implemented in terms of a lower-level *bytevector-like* data type. The operations on generic bytevector-like structures are particularly fast but useful largely in code

that manipulates Larceny's data representations.

The (rnrs bytevectors) library now provides a large set of procedures that, in Larceny, are defined using the procedures described below.

### *Integrable procedure make-bytevector*

(make-bytevector *length*) => *bytevector*

(make-bytevector *length fill*) => *bytevector*

Returns a bytevector of the desired length. If no second argument is given, then the bytevector has not been initialized and most likely contains garbage.

### *Operations on bytevector structures*

(bytevector? *obj*) => *boolean*

(bytevector-length *bytevector*) => *integer*

(bytevector-ref *bytevector offset*) => *byte*

(bytevector-set! *bytevector offset byte*) => *unspecified*

(bytevector-equal? *bytevector1 bytevector2*) => *boolean*

(bytevector-fill! *bytevector byte*) => *unspecified*

(bytevector-copy *bytevector*) => *bytevector*

These procedures do what you expect. All are integrable, except `bytevector-equal?` and `bytevector-copy`. The `bytevector-equal?` name is deprecated, since the R6RS calls it `bytevector=?`.

### *Operations on bytevector-like structures*

(bytevector-like? *obj*) => *boolean*

(bytevector-like-length *bytevector*) => *integer*

(bytevector-like-ref *bytevector offset*) => *byte*

(bytevector-like-set! *bytevector offset byte*) => *unspecified*

(bytevector-like-equal? *bytevector1 bytevector2*) => *boolean*

```
(bytevector-like-copy bytevector) => bytevector
```

A bytevector-like structure is a low-level representation for indexed arrays of uninterpreted bytes. Bytevector-like structures are used to represent types such as bignums and flonums.

There is no way to construct a "generic" bytevector-like structure; use the constructors for specific bytevector-like types.

The bytevector-like operations operate on all bytevector-like structures. All are integrable, except `bytevector-like-equal?` and `bytevector-like-copy`. All are deprecated because they violate abstraction barriers and make your code representation-dependent; they are useful mainly to Larceny developers, who might otherwise be tempted to write some low-level operations in C or assembly language.

## 10.3. Vectors

*Procedure vector-copy*

```
(vector-copy vector) => vector
```

Returns a shallow copy of its argument.

*Operations on vector-like structures*

```
(vector-like? object) => boolean
```

```
(vector-like-length vector-like) => fixnum
```

```
(vector-like-ref vector-like k) => object
```

```
(vector-like-set! vector-like k object) => unspecified
```

A vector-like structure is a low-level representation for indexed arrays of Scheme objects. Vector-like structures are used to represent types such as vectors, records, symbols, and ports.

There is no way to construct a "generic" vector-like structure; use the constructors for specific data types.

The vector-like operations operate on all vector-like structures. All are integrable. All are deprecated because they violate abstraction barriers and make your code representation-dependent; they are useful mainly to Larceny developers, who might otherwise be tempted to write some low-level operations in C or assembly language.

## 10.4. Procedures

*Operations on procedures*

```
(make-procedure length) => procedure
```

```
(procedure-length procedure) => fixnum
```

`(procedure-ref procedure offset) => object`

`(procedure-set! procedure offset object) => unspecified`

These procedures operate on the representations of procedures and allow user programs to construct, inspect, and alter procedures.

#### *Procedure procedure-copy*

`(procedure-copy procedure) => procedure`

Returns a shallow copy of the procedure.

The procedures above are deprecated because they violate abstraction barriers and make your code representation-dependent; they are useful mainly to Larceny developers, who might otherwise be tempted to write some low-level operations in C or assembly language.

The rest of this section describes some procedures that reach through abstraction barriers in a more controlled way to extract heuristic information from procedures for debugging purposes.

### **Note**

The following text is copied from a straw proposal authored by Will Clinger and sent to rrr-authors on 09 May 1996. The text has been edited lightly. See the end for notes about the Larceny implementation.

The procedures that extract heuristic information from procedures are permitted to return any result whatsoever. If the type of a result is not among those listed below, then the result represents an implementation-dependent extension to this interface, which may safely be interpreted as though no information were available from the procedure. Otherwise the result is to be interpreted as described below.

#### *Procedure procedure-arity*

`(procedure-arity proc)`

Returns information about the arity of *proc*. If the result is #*f*, then no information is available. If the result is an exact non-negative integer *k*, then *proc* requires exactly *k* arguments. If the result is an inexact non-negative integer *n*, then *proc* requires *n* or more arguments. If the result is a pair, then it is a list of non-negative integers, each of which indicates a number of arguments that will be accepted by *proc*; the list is not necessarily exhaustive.

#### *Procedure procedure-documentation-string*

`(procedure-documentation-string proc)`

Returns general information about *proc*. If the result is #*f*, then no information is available. If the result is a string, then it is to be interpreted as a "documentation string" (see Common Lisp).

#### *Procedure procedure-name*

`(procedure-name proc)`

Returns information about the name of *proc*. If the result is #*f*, then no information is available. If the

result is a symbol or string, then it represents a name. If the result is a pair, then it is a list of symbols and/or strings representing a path of names; the first element represents an outer name and the last element represents an inner name.

*Procedure procedure-source-file*

`(procedure-source-file proc)`

Returns information about the name of a file that contains the source code for *proc*. If the result is #f, then no information is available. If the result is a string, then the string is the name of a file.

*Procedure procedure-source-position*

`(procedure-source-position proc)`

Returns information about the position of the source code for *proc* within the source file specified by *procedure-source-file*. If the result is #f, then no information is available. If the result is an exact integer *k*, then *k* characters precede the opening parenthesis of the source code for *proc* within that source file.

*Procedure procedure-expression*

`(procedure-expression proc)`

Returns information about the source code for *proc*. If the result is #f, then no information is available. If the result is a pair, then it is a lambda expression in the traditional representation of a list.

*Procedure procedure-environment*

`(procedure-environment proc)`

Returns information about the environment of *proc*. If the result is #f, then no information is available. In any case the result may be passed to any of the environment inquiry functions.

**Notes on the Larceny implementation**

Twobit does not yet produce data for all of these functions, so some of them always return #f.

## 10.5. Pairs and Lists

The `(rnrs lists)` library now provides a set of procedures that may supersede some of the procedures described below. If one of Larceny's procedures duplicates the semantics of an R6RS procedure whose name is different, then Larceny's name is deprecated.

*Procedure append!*

`(append! list1 list2 ... obj) => object`

`append!` destructively appends its arguments, which must be lists, and returns the resulting list. The last argument can be any object. The argument lists are appended by changing the `cdr` of the last pair of each argument except the last to point to the next argument.

*Procedure every?*

`(every? procedure list1 list2 ...) => object`

*every?* applies *procedure* to each element tuple of *list\_s* in *first-to-last* order, and returns #f as soon as *\_procedure* returns #f. If *procedure* does not return #f for any element tuple of *list\_s*, then the value returned by *\_procedure* for the last element tuple of *\_list\_s* is returned.

#### *Procedure last-pair*

```
(last-pair list-structure) => pair
```

*last-pair* returns the last pair of the *list structure*, which must be a sequence of pairs linked through the *cdr* fields.

#### *Procedure list-copy*

```
(list-copy list-copy) => list
```

*list-copy* makes a shallow copy of the *list* and returns that copy.

#### *Procedure remove*

```
(remove key list) => list
```

#### *Procedure remq*

```
(remq key list) => list
```

#### *Procedure remv*

```
(remv key list) => list
```

#### *Procedure remp*

```
(remp pred? list) => list
```

Each of these procedures returns a new list which contains all the elements of *list* in the original order, except that those elements of the original list that were equal to *key* (or that satisfy *pred?*) are not in the new list. *Remove* uses *equal?* as the equivalence predicate; *remq* uses *eq?*, and *remv* uses *eqv?*.

#### *Procedure remove!*

```
(remove! key list) => list
```

#### *Procedure remq!*

```
(remq! key list) => list
```

#### *Procedure remv!*

```
(remv! key list) => list
```

#### *Procedure remp!*

```
(remp! pred? list) => list
```

These procedures are like *remove*, *remq*, *remv*, and *remp*, except they modify *list* instead of returning a fresh list.

#### *Procedure reverse!*

```
(reverse! list) => list
```

*reverse!* destructively reverses its argument and returns the reversed list.

### *Procedure some?*

```
(some? procedure list1 list2 ...) => object
```

`some?` applies *procedure* to each element tuple of *list\_s* in *first-to-last order*, and returns the first non-*false* value returned by *\_procedure*. If *procedure* does not return a true value for any element tuple of *\_list\_s*, then `some?` returns `#f`.

## 10.6. Sorting

The `(rnrs sorting)` library now provides a small set of procedures that supersede most of the procedures described below. All of the procedures described below are therefore deprecated.

### *Procedures sort and sort!*

```
(sort list less?) => list
```

```
(sort vector less?) => vector
```

```
(sort! list less?) => list
```

```
(sort! vector less?) => vector
```

These procedures sort their argument (a list or a vector) according to the predicate *less?*, which must implement a total order on the elements in the data structures that are sorted.

`sort` returns a fresh data structure containing the sorted data; `sort!` sorts the data structure in-place.

## 10.7. Records

### Note

Larceny's records have been extended to implement all ERR5RS [[http://scheme-punks.org/wiki/index.php?title=Main\\_Page](http://scheme-punks.org/wiki/index.php?title=Main_Page)] and R6RS [<http://www.r6rs.org/>] procedures from

```
(err5rs records procedural)
(err5rs records inspection)
(rnrs records procedural)
(rnrs records inspection)
```

We recommend that Larceny programmers use the ERR5RS APIs instead of the R6RS APIs. This should entail no loss of portability, since the standard reference implementation of ERR5RS records should run efficiently in any implementation of the R6RS that permits new libraries to be defined at all.

Larceny now has two kinds of records: old-style and ERR5RS/R6RS. Old-style records cannot be created in R6RS-conforming mode, so our extension of R6RS procedures to accept old-style records does not affect R6RS conformance.

### Note

The following specification describes Larceny's old-style record API, which is now deprecated. It

is based on a proposal posted by Pavel Curtis to rrrs-authors on 10 Sep 1989, and later re-posted by Norman Adams to comp.lang.scheme on 5 Feb 1992. The authorship and copyright status of the original text are unknown to me.

This document differs from the original proposal in that its record types are extensible, and that it specifies the type of record-type descriptors.

## 10.7.1. Specification

### *Procedure make-record-type*

`(make-record-type type-name field-names)`

Returns a "record-type descriptor", a value representing a new data type, disjoint from all others. The *type-name* argument must be a string, but is only used for debugging purposes (such as the printed representation of a record of the new type). The *field-names* argument is a list of symbols naming the "fields" of a record of the new type. It is an error if the list contains any duplicates.

If the *parent-rtd* argument is provided, then the new type will be a subtype of the type represented by *parent-rtd*, and the field names of the new type will include all the field names of the parent type. It is an error if the complete list of field names contains any duplicates.

Record-type descriptors are themselves records. In particular, record-type descriptors have a field printer that is either `#f` or a procedure. If the value of the field is a procedure, then the procedure will be called to print records of the type represented by the record-type descriptor. The procedure must accept two arguments: the record object to be printed and an output port.

### *Procedure record-constructor*

`(record-constructor rtd)`

Returns a procedure for constructing new members of the type represented by *rtd*. The returned procedure accepts exactly as many arguments as there are symbols in the given list, *field-names*; these are used, in order, as the initial values of those fields in a new record, which is returned by the constructor procedure. The values of any fields not named in that list are unspecified. The *field-names* argument defaults to the list of field-names in the call to *make-record-type* that created the type represented by *rtd*; if the *field-names* argument is provided, it is an error if it contains any duplicates or any symbols not in the default list.

### *Procedure record-predicate*

`(record-predicate rtd)`

Returns a procedure for testing membership in the type represented by *rtd*. The returned procedure accepts exactly one argument and returns a true value if the argument is a member of the indicated record type or one of its subtypes; it returns a false value otherwise.

### *Procedure record-accessor*

`(record-accessor rtd field-name)`

Returns a procedure for reading the value of a particular field of a member of the type represented by *rtd*. The returned procedure accepts exactly one argument which must be a record of the appropriate type; it returns the current value of the field named by the symbol *field-name* in that record. The symbol



field-name must be a member of the list of field-names in the call to make-record-type that created the type represented by *rtd*, or a member of the field-names of the parent type of the type represented by *rtd*.

*Procedure record-updater*

(record-updater *rtd field-name*)

Returns a procedure for writing the value of a particular field of a member of the type represented by *rtd*. The returned procedure accepts exactly two arguments: first, a record of the appropriate type, and second, an arbitrary Scheme value; it modifies the field named by the symbol *field-name* in that record to contain the given value. The returned value of the updater procedure is unspecified. The symbol *field-name* must be a member of the list of field-names in the call to make-record-type that created the type represented by *rtd*, or a member of the field-names of the parent type of the type represented by *rtd*.

(record? *obj*)

Returns a true value if *obj* is a record of any type and a false value otherwise. Note that `record?` may be true of any Scheme value; of course, if it returns true for some particular value, then `record-type-descriptor` is applicable to that value and returns an appropriate descriptor.

*Procedure record-type-descriptor*

(record-type-descriptor *record*)

Returns a record-type descriptor representing the type of the given record. That is, for example, if the returned descriptor were passed to `record-predicate`, the resulting predicate would return a true value when passed the given record. Note that it is not necessarily the case that the returned descriptor is the one that was passed to `record-constructor` in the call that created the constructor procedure that created the given record.

*Procedure record-type-name*

(record-type-name *rtd*)

Returns the type-name associated with the type represented by *rtd*. The returned value is `eqv?` to the type-name argument given in the call to `make-record-type` that created the type represented by *rtd*.

*Procedure record-type-field-names*

(record-type-field-names *rtd*)

Returns a list of the symbols naming the fields in members of the type represented by *rtd*.

*Procedure record-type-parent*

(record-type-parent *rtd*)

Returns a record-type descriptor for the parent type of the type represented by *rtd*, if that type has a parent type, or a false value otherwise. The type represented by *rtd* has a parent type if the call to `make-record-type` that created *rtd* provided the *parent-rtd* argument.

*Procedure record-type-extends?*

(record-type-extends? *rtd1 rtd2*)

Returns a true value if the type represented by *rtd1* is a subtype of the type represented by *rtd2* and a false value otherwise. A type *s* is a subtype of a type *t* if *s=t* or if the parent type of *s*, if it exists, is a subtype of *t*.

## 10.7.2. Implementation

The R6RS spouts some tendentious nonsense about procedural records being slower than syntactic records, but this is not true of Larceny's records, and is unlikely to be true of other implementations either. Larceny's procedural records are fairly efficient already, and will become even more efficient in future versions as interlibrary optimizations are added.

## 10.8. Input, Output, and Files

The (`rnrs io ports`) and (`rnrs files`) libraries now provide a set of procedures that may supersede some of the procedures described below. If one of Larceny's procedures duplicates the semantics of an R6RS procedure whose name is different, then Larceny's name is deprecated.

*Procedure close-open-files*

```
(close-open-files ) => unspecified
```

Closes all open files.

*Procedure console-input-port*

```
(console-input-port ) => input-port
```

Returns a character input port such that no read from the port has signalled an error or returned the end-of-file object.

*Rationale:* `console-input-port` and `console-output-port` are artifacts of Unix interactive I/O conventions, where an interactive end-of-file does not mean "quit" but rather "done here". Under these conventions the console port should be reset following an end-of-file. Resetting conflicts with the semantics of ports in Scheme, so `console-input-port` and `console-output-port` return a new port if the current port is already at end-of-file.

Since it is convenient to handle errors in the same manner as end-of-file, these procedures also return a new port if an error has been signalled during an I/O operation on the port.

`console-input-port` and `console-output-port` simply call the port generators installed in the parameters `console-input-port-factory` and `console-output-port-factory`, which allow user programs to install their own console port generators.

*Procedure console-output-port*

```
(console-output-port ) => output-port
```

Returns a character output port such that no write to the port has signalled an error.

See `console-input-port` for a full explanation.

*Parameter console-input-port-factory*

The value of this parameter is a procedure that returns a character input port such that no read from the port has signalled an error or returned the end-of-file object.

See `console-input-port` for a full explanation.

*Parameter console-output-port-factory*

The value of this parameter is a procedure that returns a character output port such that no write the port has signalled an error.

See `console-input-port` for a full explanation.

*Parameter current-input-port*

The value of this parameter is a character input port.

*Parameter current-output-port*

The value of this parameter is a character output port.

*Procedure delete-file*

```
(delete-file filename) => unspecified
```

Deletes the named file. No error is signalled if the file does not exist.

*Procedure eof-object*

```
(eof-object ) => end-of-file object
```

*Eof-object* returns an end-of-file object.

*Procedure file-exists?*

```
(file-exists? filename) => boolean
```

*File-exists?* returns `#t` if the named file exists at the time the procedure is called.

*Procedure file-modification-time*

```
(file-modification-time filename) => vector or #f
```

*File-modification-time* returns the time of last modification of the file as a vector, or `#f` if the file does not exist. The vector has six elements: year, month, day, hour, minute, second, all of which are exact nonnegative integers. The time returned is relative to the local timezone.

```
(file-modification-time "larceny") => #(1997 2 6 12 51 13)
```

```
(file-modification-time "geekdom") => #f
```

*Procedure flush-output-port*

```
(flush-output-port ) => unspecified
```

```
(flush-output-port port) => unspecified
```

Write any buffered data in the port to the underlying output medium.

*Procedure get-output-string*

```
(get-output-string string-output-port) => string
```

Retrieve the output string from the given string output port.

*Procedure open-input-string*

```
(open-input-string string) => input-port
```

Creates an input port that reads from *string*. The string may be shared with the caller. A string input port does not need to be closed, although closing it will prevent further reads from it.

*Procedure open-output-string*

```
(open-output-string ) => output-port
```

Creates an output port where any output is written to a string. The accumulated string can be retrieved with *get-output-string* at any time.

*Procedure port?*

```
(port? object) => boolean
```

Tests whether its argument is a port.

*Procedure port-name*

```
(port-name port) => string
```

Returns the name associated with the port; for file ports, this is the file name.

*Procedure port-position*

```
(port-position port) => fixnum
```

Returns the number of characters that have been read from or written to the port.

*Procedure rename-file*

```
(rename-file from to) => unspecified
```

Renames the file *from* and gives it the name *to*. No error is signalled if *from* does not exist or *to* exists.

*Procedure reset-output-string*

```
(reset-output-string port) => unspecified
```

Given a *port* created with *open-output-string*, deletes from the port all the characters that have been output so far.

*Procedure with-input-from-port*

`(with-input-from-port input-port thunk) => object`

Calls *thunk* with current input bound to *input-port* in the dynamic extent of *thunk*. Returns whatever value was returned from *thunk*.

#### *Procedure with-output-to-port*

`(with-output-to-port output-port thunk) => object`

Calls *thunk* with current output bound to *output-port* in the dynamic extent of *thunk*. Returns whatever value was returned from *thunk*.

## 10.9. Operating System Interface

#### *Procedure command-line-arguments*

`(command-line-arguments ) => vector`

Returns a vector of strings: the arguments supplied to the program by the user or the operating system.

#### *Procedure dump-heap*

`(dump-heap filename procedure) => unspecified`

Dump a heap image to the named file that will start up with the supplied procedure. Before *procedure* is called, command line arguments will be parsed and any init procedures registered with `add-init-procedure!` will be called.

*Note: Currently, heap dumping is only available with the stop-and-copy collector (-stopcopy command line option), although the heap image can be used with all the other collectors.*

#### *Procedure dump-interactive-heap*

`(dump-interactive-heap filename) => unspecified`

Dump a heap image to the named file that will start up with the standard read-eval-print loop. Before the read-eval-print loop is called, command line arguments will be parsed and any init procedures registered with `add-init-procedure!` will be called.

*Note: Currently, heap dumping is only available with the stop-and-copy collector (-stopcopy command line option), although the heap image can be used with all the other collectors.*

#### *Procedure getenv*

`(getenv key) => string or #f`

Returns the operating system environment mapping for the string *key*, or `#f` if there is no mapping for *key*.

#### *Procedure system*

`(system command) => status`

Send the *command* to the operating system's command processor and return the command's exit status, if any. On Unix, *command* is a string and *status* is an exact integer.

## 10.10. Fixnum primitives

Fixnums are small exact integers that are likely to be represented without heap allocation. Larceny never represents a number that can be represented as a fixnum any other way, so programs that can use fixnums will do so automatically. However, operations that work only on fixnums can sometimes be substantially faster than generic operations, and the following primitives are provided for use in those programs that need especially good performance.

The `(rnrs arithmetic fixnums)` library now provides a large set of procedures that, in Larceny, are defined using the procedures described below. If one of Larceny's procedures duplicates the semantics of an R6RS procedure whose name is different, then Larceny's name is deprecated.

All arguments to the following procedures must be fixnums.

*Procedure* `fixnum?`

```
(fixnum? obj) => boolean
```

Returns `#t` if its argument is a fixnum, and `#f` otherwise.

*Procedure* `fx+`

```
(fx+ fix1 fix2) => fixnum
```

Returns the fixnum sum of its arguments. If the result is not representable as a fixnum, then an error is signalled (unless error checking has been disabled).

*Procedure* `fx-`

Returns the fixnum difference of its arguments. If the result is not representable as a fixnum, then an error is signalled.

*Procedure* `fx—`

```
(fx- fix1) => fixnum
```

Returns the fixnum negative of its argument. If the result is not representable as a fixnum, then an error is signalled.

*Procedure* `fx*`

```
(fx* fix1 fix2) => fixnum
```

Returns the fixnum product of its arguments. If the result is not representable as a fixnum, then an error is signalled.

*Procedure* `fx=`

```
(fx= fix1 fix2) => boolean
```

Returns `#t` if its arguments are equal, and `#f` otherwise.

*Procedure* `fx<`

`(fx< fix1 fix2) => boolean`

Returns #t if *fix1* is less than *fix2*, and #f otherwise.

*Procedure fx<=*

`(fx<= fix1 fix2) => boolean`

Returns #t if *fix1* is less than or equal to *fix2*, and #f otherwise.

*Procedure fx>*

`(fx> fix1 fix2) => boolean`

Returns #t if *fix1* is greater than *fix2*, and #f otherwise.

*Procedure fx>=*

`(fx>= fix1 fix2) => boolean`

Returns #t if *fix1* is greater than or equal to *fix2*, and #f otherwise.

*Procedure fxnegative?*

`(fxnegative? fix) => boolean`

Returns #t if its argument is less than zero, and #f otherwise.

*Procedure fxpositive?*

`(fxpositive? fix) => boolean`

Returns #t if its argument is greater than zero, and #f otherwise.

*Procedure fxzero?*

`(fxzero? fix) => boolean`

Returns #t if its argument is zero, and #f otherwise.

*Procedure fxlogand*

`(fxlogand fix1 fix2) => fixnum`

Returns the bitwise *and* of its arguments.

*Procedure fxlogior*

`(fxlogior fix1 fix2) => fixnum`

Returns the bitwise *inclusive or* of its arguments.

*Procedure fxlognot*

`(fxlognot fix) => fixnum`

Returns the bitwise *not* of its argument.

*Procedure fxlogxor*

```
(fxlogxor fix1 fix2) => fixnum
```

Returns the bitwise *exclusive or* of its arguments.

*Procedure fxlsh*

```
(fxlsh fix1 fix2) => fixnum
```

Returns *fix1* shifted left *fix2* places, shifting in zero bits at the low end. If the shift count exceeds the number of bits in the machine's word size, then the results are machine-dependent.

*Procedure most-positive-fixnum*

```
(most-positive-fixnum ) => fixnum
```

Returns the largest representable positive fixnum.

*Procedure most-negative-fixnum*

```
(most-negative-fixnum ) => fixnum
```

Returns the smallest representable negative fixnum.

*Procedure fxrsha*

```
(fxrsha fix1 fix2) => fixnum
```

Returns *fix1* shifted right *fix2* places, shifting in a copy of the sign bit at the left end. If the shift count exceeds the number of bits in the machine's word size, then the results are machine-dependent.

*Procedure fxrshl*

```
(fxrshl fix1 fix2) => fixnum
```

Returns *fix1* shifted right *fix2* places, shifting in zero bits at the high end. If the shift count exceeds the number of bits in the machine's word size, then the results are machine-dependent.

## 10.11. Numbers

Larceny has six representations for numbers: *fixnums* are small, exact integers; *bignums* are unlimited-precision exact integers; *ratnums* are exact rationals; *flonums* are inexact rationals; *rectnums* are exact complexes; and *compnums* are inexact complexes.

*Number-representation predicates*

```
(fixnum? obj) => boolean
```

```
(bignum? obj) => boolean
```



```
(ratnum? obj) => boolean
```

```
(flonum? obj) => boolean
```

```
(rectnum? obj) => boolean
```

```
(compnum? obj) => boolean
```

These predicates test whether an object is a number of a particular representation and return #t if so, #f if not.

### *Procedure random*

```
(random limit) => exact integer
```

Returns a pseudorandom nonnegative exact integer in the range 0 through *limit*-1.

## 10.12. Hashtables and hash functions

Hashtables represent finite mappings from keys to values. If the hash function is a good one, then the value associated with a key may be looked up in constant time (on the average).

### **Note**

The R6RS hashtables library are a big improvement over Larceny's traditional hash tables, and should be used instead of the API described below.

### **Note**

To resolve a clash of names and semantics with the R6RS `make-hashtable` procedure, Larceny's traditional `make-hashtable` procedure has been renamed to `make-oldstyle-hashtable`.

### 10.12.1. Hash tables

#### *Procedure make-oldstyle-hashtable*

```
(make-oldstyle-hashtable hash-function bucket-searcher size) => hashtable
```

Returns a newly allocated mutable hash table using *hash-function* as the hash function and *bucket-searcher*, e.g. `assq`, `assv`, `assoc`, to search a bucket with *size* buckets at first, expanding the number of buckets as needed. The *hash-function* must accept a key and return a non-negative exact integer.

```
(make-oldstyle-hashtable hash-function bucket-searcher) => hashtable
```

Equivalent to `(make-oldstyle-hashtable hash-function bucket-searcher n)` for some value of *n* chosen by the implementation.

```
(make-oldstyle-hashtable hash-function) => hashtable
```

Equivalent to `(make-oldstyle-hashtable hash-function assv)`.

`(make-oldstyle-hashtable ) => hashtable`

Equivalent to `(make-oldstyle-hashtable object-hash assv)`.

*Procedure hashtable-contains?*

`(hashtable-contains? hashtable key) => bool`

Returns true iff the *hashtable* contains an entry for *key*.

*Procedure hashtable-fetch*

`(hashtable-fetch hashtable key flag) => object`

Returns the value associated with *key* in the *hashtable* if the *hashtable* contains *key*; otherwise returns *flag*.

*Procedure hashtable-get*

`(hashtable-get hashtable key) => object`

Equivalent to `(hashtable-fetch #f)`.

*Procedure hashtable-put!*

`(hashtable-put! hashtable key value) => unspecified`

Changes the *hashtable* to associate *key* with *value*, replacing any existing association for *key*.

*Procedure hashtable-remove!*

`(hashtable-remove! hashtable key) => unspecified`

Removes any association for *key* within the *hashtable*.

*Procedure hashtable-clear!*

`(hashtable-clear! hashtable) => unspecified`

Removes all associations from the *hashtable*.

*Procedure hashtable-size*

`(hashtable-size hashtable) => integer`

Returns the number of keys contained within the *hashtable*.

*Procedure hashtable-for-each*

`(hashtable-for-each procedure hashtable) => unspecified`

The *procedure* must accept two arguments, a key and the value associated with that key. Calls the *procedure* once for each key-value association in *hashtable*. The order of these calls is indeterminate.

### *Procedure hashtable-map*

`(hashtable-map procedure hashtable)`

The *procedure* must accept two arguments, a key and the value associated with that key. Calls the *procedure* once for each key-value association in *hashtable*, and returns a list of the results. The order of the calls is indeterminate.

### *Procedure hashtable-copy*

`(hashtable-copy hashtable) => hashtable`

Returns a copy of the *hashtable*.

## 10.12.2. Hash functions

The *hash values* returned by these functions are nonnegative exact integer suitable as hash values for the hashtable functions.

### *Procedure equal-hash*

`(equal-hash object) => integer`

Returns a hash value for *object* based on its contents.

### *Procedure object-hash*

`(object-hash object) => integer`

Returns a hash value for *object* based on its identity.

### **Warning**

This hash function performs extremely poorly on pairs, vectors, strings, and bytevectors, which are the objects with which it is mostly likely to be used. For efficient hashing on object identity, create the hashtable with `make-eq-hashtable` or `make-eqv-hashtable` of the `(rnrs hashtables)` library.

### *Procedure string-hash*

`(string-hash string) => fixnum`

Returns a hash value for *string* based on its content.

### *Procedure symbol-hash*

`(symbol-hash symbol) => fixnum`

Returns a hash value for *symbol* based on its print name. The `symbol-hash` is very fast, because the hash code is cached in the symbol data structure.

## 10.13. Parameters

Parameters are procedures that serve as containers for values; parts of the system that do not operate in the

same namespace can still share parameters and thereby read and write shared state.

A parameter takes zero or one arguments. If called with no arguments, it returns the current value of the parameter. If called with one argument, it sets the parameter's value to that of the argument and returns the new value.

#### *Procedure make-parameter*

```
(make-parameter name value [predicate]) => procedure
```

Create a parameter with name *name*, initial value *value*, and optional setter predicate *predicate*. When the parameter is set the new value is first passed to *predicate*, and if it returns #f then an error is signalled. *Name* can be a symbol or a string.

#### *Syntax parameterize*

```
(parameterize ((parameter0 value0) ...) expr0 expr1 ...)
```

Parameterize overrides the values of a set of parameters in a dynamic scope — it is like fluid-let for parameters.

## 10.13.1. Larceny parameters

The following list of parameters does not yet include the reader or compiler switches, which are also parameters.

Parameter `break-handler` [[debugging.html#proc:break-handler](#)]

Parameter `console-input-port-factory` [[io.html#proc:console-input-port-factory](#)]

Parameter `console-output-port-factory` [[io.html#proc:console-output-port-factory](#)]

Parameter `current-input-port` [[io.html#proc:current-input-port](#)]

Parameter `current-output-port` [[io.html#proc:current-output-port](#)]

Parameter `error-handler` [[control.html#proc:error-handler](#)]

Parameter `evaluator` [[control.html#proc:evaluator](#)]

Parameter `herald` [[repl.html#proc:herald](#)]

Parameter `interaction-environment` [[environ.html#proc:interaction-environment](#)]

Parameter `keyboard-interrupt-handler` [[control.html#proc:keyboard-interrupt-handler](#)]

Parameter `load-evaluator` [[control.html#proc:load-evaluator](#)]

Parameter `quit-handler` [[control.html#proc:quit-handler](#)]

Parameter `repl-level` [[repl.html#proc:repl-level](#)]

Parameter `repl-evaluator` [[repl.html#proc:repl-evaluator](#)]

Parameter `repl-printer` [`repl.html#proc:repl-printer`]

Parameter `reset-handler` [`control.html#proc:reset-handler`]

Parameter `standard-timeslice` [`control.html#proc:standard-timeslice`]

Parameter `structure-comparator` [`structures.html#proc:structure-comparator`]

Parameter `structure-printer` [`structures.html#proc:structure-printer`]

Parameter `timer-interrupt-handler` [`control.html#proc:timer-interrupt-handler`]

## 10.14. Property Lists

The *property list* of a symbol is an association list that is attached to that symbol. The association list maps *properties*, which are themselves symbols, to arbitrary values.

*Procedure putprop*

```
(putprop symbol property obj) => unspecified
```

If an association exists for *property* on the property list of *symbol*, then its value is replaced by the new value *obj*. Otherwise, a new association is added to the property list of *symbol* that associates *property* with *obj*.

*Procedure getprop*

```
(getprop symbol property) => obj
```

If an association exists for *property* on the property list of *symbol*, then its value is returned. Otherwise, `#f` is returned.

*Procedure remprop*

```
(remprop symbol property) => unspecified
```

If an association exists for *property* on the property list of *symbol*, then that association is removed. Otherwise, this is a no-op.

## 10.15. Symbols

*Procedure gensym*

```
(gensym string) => symbol
```

*Gensym* returns a new uninterned symbol, the name of which contains the given *string*.

*Procedure oblist*

```
(oblist ) => list
```

*Oblist* returns the list of interned symbols.

*Procedure oblist-set!*

```
(oblist-set! list) => unspecified
```

```
(oblist-set! list table-size) => unspecified
```

`oblist-set!` sets the list of interned symbols to those in the given *list* by clearing the symbol hash table and storing the symbols in *list* in the hash table. If the optional *table-size* is given, it is taken to be the desired size of the new symbol table.

See also: `symbol-hash`.

## 10.16. System Control and Performance Measurement

*Procedure collect*

```
(collect ) => unspecified
```

```
(collect generation) => unspecified
```

```
(collect generation method) => unspecified
```

`Collect` initiates a garbage collection. If the system has multiple generations, then the optional arguments are interpreted as follows. The *generation* is the generation to collect, where 0 is the youngest generation. The *method* determines how the collection is performed. If *method* is the symbol `collect`, then a full collection is performed in that generation, whatever that means — in a normal multi-generational copying collector, it means that all live objects in the generation's current semispace and all live objects from all younger generations are copied into the generation's other semispace. If *method* is the symbol `promote`, then live objects are promoted from younger generations into the target generation — in our example collector, that means that the objects are copied into the target generation's current semispace.

The default value for *generation* is 0, and the default value for *method* is `collect`.

Note that the collector's internal policy settings may cause it to perform a more major type of collection than the one requested; for example, an attempt to collect generation 2 could cause the collector to promote all live data into generation 3.

*Procedure gc-counter*

```
(gc-counter ) => fixnum
```

`gc-counter` returns the number of garbage collections performed since startup. On a 32-bit system, the counter wraps around every 1,073,741,824 collections.

`gc-counter` is a primitive and compiles to a single load instruction on the SPARC.

*Procedure major-gc-counter*

```
(major-gc-counter ) => fixnum
```

`major-gc-counter` returns the number of major garbage collections performed since startup, where a major collection is defined as a collection that may change the address of objects that have already survived a previous collection. On a 32-bit system, the counter wraps around every 1,073,741,824 collections.

*major-gc-counter* is a primitive and compiles to a single load instruction on the SPARC. Its primary use to implement efficient hashtables that hash on object identity (make-eq-hashtable and make-eqv-hashtable).

### Procedure *gcctl*

```
(gcctl heap-number operation operand) => unspecified
```

*[GCCTL is largely obsolete in the new garbage collector but may be resurrected in the future. It can still be used to control the non-predictive collector.]*

*gcctl* controls garbage collection policy on a heap-wise basis. The *heap-number* is the heap to operate on, like for the command line switches: heap 1 is the youngest. If the given heap number does not correspond to a heap, *gcctl* fails silently.

The *operation* is a symbol that selects the operation to perform, and the *operand* is the operand to that operation, always a number. For the non-predictive garbage collector, the following operator/operand pairs are meaningful:

- *j-fixed*, *n*: after a collection, the collector parameter *j* should be set to the value *n*, if possible. (Non-predictive heaps only.)
- *j-percent*, *n*: after a collection, the collector parameter *j* should be set to be *n* percent of the number of free steps. (Non-predictive heaps only.)
- *incr-fixed*, *n*: when growing the heap, the growing should be done in increments of *n*. In the non-predictive heap, *n* is the number of steps. In other heaps, *n* denotes kilobytes.
- *incr-percent*, *n*: when growing the heap, the growing should be done in increments of *n* percent.

**Example:** if the non-predictive heap is heap number 2, then the expressions

```
(gcctl 2 'j-fixed 0)  
(gcctl 2 'incr-fixed 1)
```

makes the non-predictive collector simulate a normal stop-and-copy collector (because *j* is always set to 0), and grows the heap only one step at a time as necessary. This may be useful for certain kinds of experiments.

**Example:** ditto, the expressions

```
(gcctl 2 'j-percent 50)  
(gcctl 2 'incr-percent 20)
```

selects the default policy settings.

**Note:** The *gcctl* facility is experimental. A more developed facility will allow controlling heap contraction policy, as well as setting all the watermarks. Certainly one can envision other uses, too. Finally, it needs to be possible to get current values.

**Note:** Currently the non-predictive heap (*np-sc-heap.c*) and the standard stop-and-copy "old" heap (*old-heap.c*) are supported, but not the standard "young" heap (*young-heap.c*), nor the stop-and-copy

collector (sc-heap.c).

### *Procedure sro*

```
(sro pointer-tag type-tag limit) => vector
```

SRO ("standing room only") is a system primitive that traverses the entire heap and returns a vector that contains all live objects in the heap that satisfy the constraints imposed by its parameters:

- If *pointer-tag* is -1, then object type is unconstrained; otherwise, the object type is constrained to have a pointer tag that matches *pointer-tag*. You can read all about pointer tags here, but the short story is that 1=pair, 3=vector-like, 5=bytevector-like, and 7=procedure-like.
- If *type-tag* is -1, then object type is unconstrained by type-tag; otherwise, only objects with a matching type-tag are selected (after selection by pointer tag). Pairs don't have type-tags, but other objects do. You can read all about type-tags here.
- *Limit* constrains the selected objects by the number of references. If *limit* is -1, then no constraints are imposed; otherwise, only objects (selected by pointer-tag and type-tag) with no more than *limit* references to them are selected.

For example, (sro -1 -1 -1) returns a vector that contains all live objects (not including the vector), and (sro 5 2 3) returns a vector containing all live flonums (bytevector-like, with typetag 2) that are referred to in no more than 3 places.

### *Procedure stats-dump-on*

```
(stats-dump-on filename) => unspecified
```

Stats-dump-on turns on garbage collection statistics dumping. After each collection, a complete RTS statistics dump is appended to the file named by *filename*.

The file format and contents are documented in a banner written at the top of the output file. In addition, accessor procedures for the output structure are defined in the program Util/process-stats.sch.

Stats-dump-on does not perform an initial dump when the file is first opened; only at the first collection is the first set of statistics dumped. The user might therefore want to initiate a minor collection just after turning on dumping in order to have a baseline set of data.

### *Procedure stats-dump-off*

```
(stats-dump-off ) => unspecified
```

Stats-dump-off turns off garbage collection statistics dumping (which was turned on with stats-dump-on). It does not dump a final set of statistics before closing the file; therefore, the user may wish to initiate a minor collection before calling this procedure.

### *Procedure system-features*

```
(system-features ) => alist
```

System-features returns an association lists of system features. Most entries are self-explanatory. The following are a more subtle:



- The value of `architecture-name` is Larceny's notion of the architecture for which it was compiled, not the architecture the program is currently running on. For example, the value of this feature is "Standard-C" if you're running Petit Larceny.
- The value of `heap-area-info` is a vector of vectors, one subvector for each heap area in the running system. The subvector has four entries: the generation number, the area type, the current size, and additional information.

### *Procedure display-memstats*

```
(display-memstats vector) => unspecified
```

```
(display-memstats vector minimal) => unspecified
```

```
(display-memstats vector minimal full) => unspecified
```

`display-memstats` takes as its argument a vector as returned by `memstats` and displays the contents of the vector in human-readable form on the current output port. By default, not all of the values in the vector are displayed.

If the symbol `minimal` is passed as the second argument, then only a small number of statistics generally relevant to running benchmarks are displayed.

If the symbol `full` is passed as the second argument, then all statistics are displayed.

### *Procedure memstats*

```
(memstats ) => vector
```

`Memstats` returns a freshly allocated vector containing run-time-system resource usage statistics. Many of these will make no sense whatsoever to you unless you also study the RTS sources. A listing of the contents of the vector is available [here](#).

### *Procedure run-with-stats*

```
(run-with-stats thunk) => obj
```

`Run-with-stats` evaluates `thunk`, then prints a short summary of run-time statistics, as with

```
(display-memstats ... 'minimal),
```

and then returns the result of evaluating `thunk`.

### *Procedure run-benchmark*

```
(run-benchmark name k thunk ok?) => obj
```

`Run-benchmark` prints a short banner (including the identifying `name`) to identify the benchmark, then runs `thunk` `k` times, and finally tests the value returned from the last call to `thunk` by applying the predicate `ok?` to it. If the predicate returns true, then `run-benchmark` prints summary statistics, as with

```
([display-memstats][5] ... 'minimal).
```

If the predicate returns false, an error is signalled.

## 10.17. SRFI Support

The SRFIs (Scheme Requests For Implementations) is an Internet-based collection of Scheme code designed and provided by Scheme programmers. The SRFI effort is open to anyone, and is described at <http://srfi.schemers.org>.

The fundamental SRFI is SRFI-0, "Feature-based conditional expansion construct", which allows a program to query the underlying implementation about the available SRFIs (and potentially about other implementation features) at macro expansion time. The design documents for this and other SRFIs are available at the web site shown above.

Larceny currently supports many SRFIs, but not as many as it should. Some SRFIs are built into Larceny, but most must be loaded dynamically using Larceny's `require` procedure:

```
> (require 'srfi-0)
```

Larceny provides the following nonstandard SRFI keys for use in SRFI 0:

```
larceny
```

## 10.18. SLIB support

SLIB [<http://www-swiss.ai.mit.edu/~jaffer/SLIB.html>] is a large collection of useful libraries that have been written or collected by Aubrey Jaffer.

Larceny supports SLIB via SRFI 96 [<http://srfi.schemers.org/srfi-96/>], but SLIB itself is not shipped with Larceny; it must be downloaded separately and then installed. For the most up-to-date information on installing and using SLIB with Larceny, see `doc/HOWTO-SLIB`.

## 10.19. Foreign-Function Interface to C

Larceny provides a general foreign-function interface (FFI) substrate on which other FFIs can be built; see Larceny Note #7 [[LarcenyNotes/note7-ffi.html](#)]. The FFI described in this manual section is a simple example of a derived FFI. It is not yet fully evolved, but it is useful.

### Warning

This section has undergone significant revision, but not all of the material has been properly vetted. Some of the information in this section may be out of date.

### Note

Some of the text below is adapted from the 2008 Scheme Workshop paper, "The Layers of Larceny's Foreign Function Interface," by Felix S Klock II. That paper may provide additional insight for those searching for implementation details and motivations.

### 10.19.1. Introducing the FFI

There are a number of different potential ways to use the FFI. One client may want to develop code in C

and load it into Larceny. Another client may want to load native libraries provided by the host operating system, enabling invocation of foreign code from Scheme expressions without developing any C code or even running a C compiler. Larceny's FFI can be used for both of these cases, but many of its facilities target a third client in between the two extremes: a client with a C compiler and the header files and object code for the foreign libraries, but who wishes to avoid writing glue code in C to interface with the libraries.

There are four main steps to interacting with foreign code:

1. identifying the space of values manipulated by the foreign code that will also be manipulated in Scheme,
2. describing how to marshal values between foreign and Scheme code,
3. loading library file(s) holding foreign object code, and
4. linking procedures from the loaded library.

Step 1 is conceptual, while steps 2 through 4 yield artifacts in Scheme source code.

## 10.19.2. The space of foreign values

At the machine code level, foreign values are uninterpreted sequences of bits. Often foreign object code is oriented around manipulating word-sized bit-sequences (*words*) or arrays and tuples of words.

Many libraries are written with a particular interpretation of such values. In C code, explicit types are often used hints to guide such interpretation; for example, a 0 of type `bool` is usually interpreted as *false*, while a 1 (or other non-zero value) of type `bool` is usually interpreted as *true*. Another example are C enumerations (or *enums*). An enum declaration defines a set of named integral constants. After the C declaration:

```
enum months { JAN = 1, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC };
```

a `JAN` in C code now denotes 1, `FEB` is 2, and so on. Furthermore, tools like debuggers may render a variable `x` dynamically assigned the value 2 (and of static type `enum months`) as `FEB`. Thus the enum declaration introduces a new interpretation for a finite set of integers.

This leads to questions for a client of an FFI; we explore some below.

- Should foreign words be passed over to the Scheme world as uninterpreted numbers (and thus be converted into Scheme integers, usually `fixnums`), or should they be marshaled into interpreted values, such as `#f` and `#t` for the `bool` type, or the Scheme symbols `{JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC}` for the `enum months` type?
- Similarly, how should Scheme values be marshaled into foreign words?
- A foreign library might leave the mapping of names like `FEB` to words like `2` *unspecified* in the library interface. That is, while the C compiler will know `FEB` maps to 2 according to a particular version of the library's header file, the library designer may intend to change this mapping in the future, and clients writing C code should *only* use the names to refer to a `enum months` value, and *not* integer expressions.

- How should this constraint be handled in the FFI; should the library client revise their code in reaction to such changes to the mapping?
- Or should the system derive the mapping from the header files, in the same manner that the C compiler does?
- Foreign libraries often manipulate mutable entities, like arrays of words where modifications can be observed (often by design).
  - How should such values be marshaled?
  - Is it sound to copy such values to the Scheme heap? If so, is a shallow copy sufficient?
- Will the foreign code hold references to heap-allocated objects? Heap-allocated objects that *leak* out to foreign memory must be treated with care; garbage collection presents two main problems.
  - First, such objects must not move during a garbage collection; Larceny supports this via special-purpose allocation routines: `cons-nonrelocatable`, `make-nonrelocatable-bytevector`, and `make-nonrelocatable-vector`.
  - Second, the garbage collector must know to hold on to (i.e. trace) such values as long as they are needed by foreign code; otherwise the objects or their referents may be collected without the knowledge of the foreign code.

Answering these questions may require deep knowledge of the intended usage of the foreign library.

The Larceny FFI attempts to ease interfacing with foreign code in the presence of the above concerns, but the nature of the header files included with most foreign libraries means that the FFI cannot infer the answers unassisted.

### Note

Foreign C code developed to work in concert with Larceny could hypothetically be written to cope with holding handles for objects managed by the the garbage collector, but there is currently no significant support for this use-case.

### Note

One class of foreign values is not addressed by the Larceny FFI: structures passed by value (as opposed to by reference, ie pointers to structures). There is no way to describe the interface to a foreign procedure that accepts or produces a C `struct` (at least not properly nor portably).

This tends to not matter for many foreign libraries (since many C programmers eschew passing structures by value), but it can arise.

If the foreign library of interest has procedures that accept or produce a C `struct`, we currently recommend either avoiding such procedures, or writing adapter code in C that marshals between values handled by the FFI and the C `struct`.

The conclusion is: when designing an interface to a foreign library, you should analyze the values manipulated on the foreign side and identify their relationship with values on the Scheme side. After you have identified the domains of interest, you then describe how the values will be marshaled back and forth

between the two domains.

### 10.19.3. Marshalling via ffi-attributes

This section describes the marshalling protocol defined in `lib/Base/std-ffi.sch`.

Foreign functions automatically marshal their inputs and outputs according to type-descriptors attached to each foreign function.

Type-descriptors are S-expressions formed according to the following grammar:

```

TypeDesc ::= CoreAttr | ArrowT | MaybeT | OneOfT
CoreAttr ::= PrimAttr | VoidStar | ---
PrimAttr ::= CurrentPrimAttr | DeprecatedPrimAttr
CurrentPrimAttr
  ::= int | uint | byte | short | ushort | char | uchar
   | long | ulong | longlong | ulonglong
   | size_t | float | double | bool | string | void
DeprecatedPrimAttr
  ::= unsigned | boxed
VoidStar ::= void* | ---
ArrowT   ::= (-> (TypeDesc ...) TypeDesc)
MaybeT  ::= (maybe TypeDesc)
OneOfT   ::= (oneof (Any Fixnum) ... TypeDesc)

```

where `---` represents a user-extensible part of the grammar (see below), `Any` represents any Scheme value, and `Fixnum` represents any word-sized integer.

A central registry maps `CoreAttr`'s to a foreign representation and two conversion routines: one to convert a Scheme value to a foreign argument, and another to convert a foreign result back to a Scheme value. The denoted components are collectively referred to as a *type* within the FFI documentation. The registry is extensible; the `ffi-add-attribute-core-entry!` procedure adds new `CoreAttr`'s to the registry, and one can alternatively add short-hands for type-descriptors via the `ffi-add-alias-of-attribute-entry!` procedure. Finally, one can add new `VoidStar` productions (subtypes of the `void*` type-descriptor) via the `ffi-install-void*-subtype` procedure (defined in the `lib/Standard/foreign-stdlib.sch` library).

#### 10.19.3.1. Primitive Attribute Types

The following is a list of the accepted types and their conversions at the boundary between Scheme and foreign code:

```

int
  Exact integer values in the range  $[-2^{31}, 2^{31}-1]$ . Scheme integers in that range are converted to and from C "int".

```

```

uint
  Exact integer values in the range  $[0, 2^{32}-1]$ . Scheme integers in that ranges are converted to and from C "unsigned int".

```

byte

Synonymous with `int` in the current implementation.

short

Synonymous with `int` in the current implementation.

ushort

Synonymous with `unsigned` in the current implementation.

char

Scheme ASCII characters are converted to and from C "`char`".

uchar

Scheme ASCII characters are converted to and from C "`unsigned char`".

long

Synonymous with `int` in the current implementation.

ulong

Synonymous with `unsigned` in the current implementation.

longlong

Exact integer values in the range  $[-2^{63}, 2^{63}-1]$ . Scheme integers in that range are converted to and from C "`long long`".

ulonglong

Exact integer values in the range  $[0, 2^{64}-1]$ . Scheme integers in that range are converted to and from C "`unsigned long long`".

size\_t

Synonymous with `uint` in the current implementation.

float

Scheme flonums are converted to and from C "`float`". The conversion to `float` is performed via a C `(float)` cast from a C `double`.

double

Scheme flonums are converted to and from C "`double`".

bool

Scheme objects are converted to C "`int`"; `#f` is converted to 0, and all other objects to 1. In the reverse direction, 0 is converted to `#f` and all other integers to `#t`.

string

A Scheme string holding ASCII characters is *copied* into a NUL-terminated bytevector, passing a pointer to its first byte to the foreign procedure; `#f` is converted to a C "`(char*)0`" value. In the reverse direction, a pointer to a NUL-terminated sequence of bytes interpreted as ASCII characters is copied into a freshly allocated Scheme string; a NULL pointer is converted to `#f`.

void

No return value. (Only used in return position for foreign functions; all Scheme procedures passed to the FFI are invoked in a context expecting one value.)

unsigned

Synonymous with `uint`; deprecated.

`boxed`

Any heap-allocated data structure (pair, bytevector-like, vector-like, procedure) is converted to a C `"void*"` to the first element of the structure. The value `#f` is also acceptable. It is converted to a C `"(void*)0"` value. (Only used in argument position for foreign functions; foreign functions are not expected to return direct references to heap-allocated values.)

### 10.19.3.2. Extending the Core Attribute Registry

The public interface to many foreign libraries is written in terms of types defined within that foreign library. One can introduce new types to the Larceny FFI by extending the core attribute entry table.

*Procedure* `ffi-add-attribute-core-entry!`

`(ffi-add-attribute-core-entry! entry-name rep-sym marshal unmarshal) => unspecified`

`ffi-add-attribute-core-entry!` extends the internal registry with the new entry specified by its arguments.

- *entry-name* is a symbol (the symbolic type name being introduced to the ffi).
- *rep-name* is a low-level type descriptor symbol, one of `signed32`, `unsigned32`, `signed64`, `unsigned64` (representing varieties of fixed width integers), `ieee32` (representing “floats”), `ieee64` (representing “doubles”), or `pointer` (representing “(void\*)” in C).
- *marshal* is a marshaling function that accepts a Scheme object and a symbol (the name of the invoking procedure); it is responsible for checking the Scheme object's validity and then producing a corresponding instance of the low-level representation.
- *unmarshal* is either `#f` or an unmarshalling function that accepts an instance of the low-level representation and produces a corresponding Scheme object.

### 10.19.3.3. Attribute Type Constructors

Core attributes suffice for linking to simple functions. Constructured FFI attributes express more complex marshaling protocols

**Arrow Type Constructors.** A structured FFI attribute of the form `(-> (s_1 ... s_n) s_r)` (called an *arrow type*) allows passing functions from Scheme to C and back again. Each of the `s_1`, ..., `s_n`, `s_r` is an FFI attribute. When an arrow type describes an input to a foreign function, it marshals a Scheme procedure to a C function pointer by generating glue code to hook the two together and marshal values as described by the FFI attributes within the arrow type. Likewise, when an arrow type describes an output from a foreign function, it marshals a C function pointer to a Scheme procedure, again by generating glue code. These two mappings naturally generalize to arbitrary nesting of arrow types, so one can create callbacks that consume callouts, return callouts that consume callbacks, and so on.

#### Warning

The current implementation of arrow types introduces an unnecessary space leak, because none of Larceny's current garbage collectors attempt to reclaim some of the structure allocated (in particular, the so-called trampolines) when functions are marshaled via arrow types.

The FFI could be revised to reduce the leak (e.g. it could keep a cache of generated trampolines and reuse them, but currently do not do so).

Many foreign libraries have a structure where one only sets up a fixed set of callbacks, and then all further computation does not require arrow type marshaling. This is one reason why fixing this problem has been a low priority item for the Larceny development team.

**Maybe Type Constructor.** (`maybe t`) captures the pattern of passing `NULL` in C and `#f` in Scheme to represent the absence of information. The FFI attribute `t` within the maybe type describes the typical information passed; the constructed maybe type marshals `#f` to the foreign null pointer or `0` (as appropriate), and otherwise applies the marshaling of `t`. Likewise, it unmarshals the foreign null pointer and `0` to `#f`, and otherwise applies the unmarshaling of `t`.

(There are a few other built-in type constructors, such as the `oneof` type constructor, but they are not as fully-developed as the two above, and are intended for use only for internal development for now.)

### 10.19.3.4. void\* Type Hierarchies

Using the `void*` attribute wraps foreign addresses up in a Larceny record, so that standard numeric operations cannot be directly applied by accident. The FFI uses two features of Larceny's record system: the record type descriptor is a first class value with an inspectable name, and record types are extensible via single-inheritance.

**Basic Operations on void\*.** The FFI provides `void*-rt`, a record type descriptor with a single field (a wrapped address). There is also a family of functions for dereferencing the pointer within a `void*-rt` and manipulating the state it references.

*Procedure void\*->address*

`(void*->address x) => number`  
Extracts the underlying address held in a `void*`.

*Procedure void\*?*

`(void*? x) => boolean`  
Distinguishes `void*`'s from other Scheme values.

*Procedure void\*-byte-ref*

`(void*-byte-ref x idx) => number`  
Extracts byte at offset from address within `x`.

*Procedure void\*-byte-set!*

`(void*-byte-set! x idx val) => unspecified`  
Modifies byte at offset from address within `x`.

*Procedure void\*-word-ref*

`(void*-word-ref x idx) => number`  
Extracts word-sized integer at offset from address within `x`.

*Procedure void\*-word-set!*



```
(void*-word-set! x idx val) => unspecified
```

Modifies word-sized integer at offset from address within *x*.

*Procedure void\*-void\*-ref*

```
(void*-void*-ref x idx) => void*
```

Extracts address (and wraps it in a `void*`) at offset from address within *x*.

*Procedure void\*-void\*-set!*

```
(void*-void*-set! x idx val) => unspecified
```

Modifies address at offset from address within *x*.

*Procedure void\*-double-ref*

```
(void*-double-ref x idx) => number
```

Extracts 64-bit flonum at offset from address within *x*.

*Procedure void\*-double-set!*

```
(void*-double-set! x idx val) => unspecified
```

Modifies 64-bit flonum at offset from address within *x*.

**Type Hierarchies.** Procedures for establishing type hierarchies are provided by the `lib/Standard/foreign-stdlib.sch` library; see `ffi-install-void*-subtype` and `establish-void*-subhierarchy!`.

## 10.19.4. Creating loadable modules

You must first compile your C code and create one or more loadable object modules. These object modules may then be loaded into Larceny, and Scheme foreign functions may link to specific functions in the loaded module. Defining foreign functions in Scheme is covered in a later section.

The method for creating a loadable object module varies from platform to platform. In the following, assume you have to C source files `file1.c` and `file2.c` that define functions that you want to make available as foreign functions in Larceny.

### 10.19.4.1. SunOS 4

Compile your source files and create a shared library. Using GCC, the command line might look like this:

```
gcc -fPIC -shared file1.c file2.c -o my-library.so
```

The command creates `my-library.so` in the current directory. This library can now be loaded into Larceny using `foreign-file`. Any other shared libraries used by your library files should also be loaded into Larceny using `foreign-file` before any procedures are linked using `foreign-procedure`.

By default, `/lib/libc.so` is made available to the dynamic linker and to the foreign function interface, so there is no need for you to load that library explicitly.

### 10.19.4.2. SunOS 5

Compile your source files and create a shared library, linking with all the necessary libraries. Using GCC,

the command line might look like this:

```
gcc -fPIC -shared file1.c file2.c -lc -lm -lsocket -o my-library.so
```

Now you can use `foreign-file` to load `my-library.so` into Larceny.

By default, `/lib/libc.so` is made available to the foreign function interface, so there is no need for you to load that library explicitly.

## 10.19.5. The Interface

### 10.19.5.1. Procedures

#### *Procedure `foreign-file`*

```
(foreign-file filename) => unspecified
```

`foreign-file` loads the named object file into Larceny and makes it available for dynamic linking.

Larceny uses the operating system provided dynamic linker to do dynamic linking. The operation of the dynamic linker varies from platform to platform:

- On some versions of SunOS 4, if the linker is given a file that does not exist, it will terminate the process. (Most likely this is a bug.) This means you should never call `foreign-file` with the name of a file that does not exist.
- On SunOS 5, if a foreign file is given to `foreign-file` without a directory specification, then the dynamic linker will search its load path (the `LD_LIBRARY_PATH` environment variable) for the file. Hence, a foreign file in the current directory should be `./file.so`, not `file.so`.

#### *Procedure `foreign-procedure`*

```
(foreign-procedure name (arg-type ...) return-type) => unspecified
```

**FIXME:** The interface to this function has been extended to support hooking into Windows procedures that use the Pascal calling convention instead of the C one. The way to select which convention to use should be documented.

Returns a Scheme procedure  $p$  that calls the foreign procedure whose name is  $name$ . When  $p$  is called, it will convert its parameters to representations indicated by the  $arg$ -types and invoke the foreign procedure, passing the converted values as parameters. When the foreign procedure returns, its return value is converted to a Scheme value according to  $return$ -type.

Types are described below.

The address of the foreign procedure is obtained by searching for  $name$  in the symbol tables of the foreign files that have been loaded with `foreign-file`.

#### *Procedure `foreign-null-pointer`*

```
(foreign-null-pointer ) => integer
```

Returns a foreign null pointer.

*Procedure foreign-null-pointer?*

```
(foreign-null-pointer? integer) => boolean
```

Tests whether its argument is a foreign null pointer.

## 10.19.6. Foreign Data Access

### 10.19.6.1. Raw memory access

The two primitives *peek-bytes* and *poke-bytes* are provided for reading and writing memory at specific addresses. These procedures are typically used for copying data from foreign data structures into Scheme bytevectors for subsequent decoding.

(The use of *peek-bytes* and *poke-bytes* can often be avoided by keeping foreign data in a Scheme bytevector and passing the bytevector to a call-out using the **boxed** parameter type. However, this technique is inappropriate if the foreign code retains a pointer to the Scheme datum, which may be moved by the garbage collector.)

*Procedure peek-bytes*

```
(peek-bytes addr bytevector count) => unspecified
```

*Addr* must be an exact nonnegative integer. *Count* must be a fixnum. The bytes in the range from *addr* through *addr+count-1* are copied into *bytevector*, which must be long enough to hold that many bytes.

If any address in the range is not an address accessible to the process, unpredictable things may happen. Typically, you'll get a segmentation fault. Larceny does not yet catch segmentation faults.

*Procedure poke-bytes*

```
(poke-bytes addr bytevector count) => unspecified
```

*Addr* must be an exact nonnegative integer. *Count* must be a fixnum. The *count* first bytes from *bytevector* are copied into memory in the range from *addr* through *addr+count-1*.

If any address in the range is not an address accessible to the process, unpredictable things may happen. Typically, you'll get a segmentation fault. Larceny does not yet catch segmentation faults.

Also, it's possible to corrupt memory with *poke-bytes*. Don't do that.

### 10.19.6.2. Foreign data sizes

The following variables constants define the sizes of basic C data types:

- **sizeof:short** The size of a "short int".
- **sizeof:int** The size of an "int".
- **sizeof:long** The size of a "long int".

- **sizeof:pointer** The size of any pointer type.

### 10.19.6.3. Decoding foreign data

Foreign data is visible to a Scheme program either as an object pointed to by a memory address (which is itself represented as an integer), or as a bytevector that contains the bytes of the foreign datum.

A number of utility procedures that make reading and writing data of common C primitive types have been written for both these kinds of foreign objects.

#### *Bytevector accessor procedures*

```
(%get16 bv i) => integer
```

```
(%get16u bv i) => integer
```

```
(%get32 bv i) => integer
```

```
(%get32u bv i) => integer
```

```
(%get-int bv i) => integer
```

```
(%get-unsigned bv i) => integer
```

```
(%get-short bv i) => integer
```

```
(%get-ushort bv i) => integer
```

```
(%get-long bv i) => integer
```

```
(%get-ulong bv i) => integer
```

```
(%get-pointer bv i) => integer
```

These procedures decode bytevectors that contain the bytes of foreign objects. In each case, *bv* is a bytevector and *i* is the offset of the first byte of a field in that bytevector. The field is fetched and returned as an integer (signed or unsigned as appropriate).

#### *Bytevector updater procedures*

```
(%set16 bv i val) => unspecified
```

```
(%set16u bv i val) => unspecified
```

```
(%set32 bv i val) => unspecified
```

```
(%set32u bv i val) => unspecified
```

```
(%set-int bv i val) => unspecified
```

```
(%set-unsigned bv i val) => unspecified
```

`(%set-short bv i val) => unspecified`

`(%set-ushort bv i val) => unspecified`

`(%set-long bv i val) => unspecified`

`(%set-ulong bv i val) => unspecified`

`(%set-pointer bv i val) => unspecified`

These procedures update bytevectors that contain the bytes of foreign objects. In each case, *bv* is a bytevector, *i* is an offset of the first byte of a field in that bytevector, and *val* is a value to be stored in that field. The values must be exact integers in a range implied by the data type.

#### *Foreign-pointer accessor procedures*

`(%peek8 addr) => integer`

`(%peek8u addr) => integer`

`(%peek16 addr) => integer`

`(%peek16u addr) => integer`

`(%peek32 addr) => integer`

`(%peek32u addr) => integer`

`(%peek-int addr) => integer`

`(%peek-long addr) => integer`

`(%peek-unsigned addr) => integer`

`(%peek-ulong addr) => integer`

`(%peek-short addr) => integer`

`(%peek-ushort addr) => integer`

`(%peek-pointer addr) => integer`

`(%peek-string addr) => integer`

These procedures read raw memory. In each case, *addr* is an address, and the value stored at that address (the size of which is indicated by the name of the procedure) is fetched and returned as an integer.

*%Peek-string* expects to find a NUL-terminated string of 8-bit bytes at the given address. It is returned as a Scheme string.

#### *Foreign-pointer updater procedures*

```
(%poke8 addr val) => unspecified
(%poke8u addr val) => unspecified
(%poke16 addr val) => unspecified
(%poke16u addr val) => unspecified
(%poke32 addr val) => unspecified
(%poke32u addr val) => unspecified

(%poke-int addr val) => unspecified
(%poke-long addr val) => unspecified
(%poke-unsigned addr val) => unspecified
(%poke-ulong addr val) => unspecified
(%poke-short addr val) => unspecified
(%poke-ushort addr val) => unspecified
(%poke-pointer addr val) => unspecified
```

These procedures update raw memory. In each case, *addr* is an address, and *val* is a value to be stored at that address.

## 10.19.7. Heap dumping and the FFI

If foreign functions are linked into Larceny using the FFI, and a Larceny heap image is subsequently dumped (with `dump-interactive-heap` or `dump-heap`), then the foreign functions are not saved as part of the heap image. When the heap image is subsequently loaded into Larceny at startup, the FFI will attempt to re-link all the foreign functions in the heap image.

During the relinking phase, foreign files will again be loaded into Larceny, and Larceny's FFI will use the file names *as they were originally given to the FFI* when it tries to load the files. In particular, if relative pathnames were used, Larceny will not have converted them to absolute pathnames.

An error during relinking will result in Larceny aborting with an error message and returning to the operating system. This is considered a feature.

## 10.19.8. Examples

### 10.19.8.1. Change directory

This procedure uses the `chdir()` system call to set the process's current working directory. The string parameter type is used to pass a Scheme string to the C procedure.

```
(define cd
  (let ((chdir (foreign-procedure "chdir" '(string) 'int)))
```

```
(lambda (newdir)
  (if (not (zero? (chdir newdir)))
      (error "cd: " newdir " is not a valid directory name.")
      (unspecified))))
```

### 10.19.8.2. Print Working Directory

This procedure uses the `getcwd()` (get current working directory) system call to retrieve the name of the process's current working directory. A bytevector is created and passed in as a buffer in which to store the return value — a 0-terminated ASCII string. Then the FFI utility function `ffi/ascii->string` is called to convert the bytevector to a string.

```
(define pwd
  (let ((getcwd (foreign-procedure "getcwd" '(boxed int) 'int)))
    (lambda ()
      (let ((s (make-bytevector 1024)))
        (getcwd s 1024)
        (ffi/ascii->string s))))))
```

### 10.19.8.3. Quicksort

#### Warning

this example is bogus. It is not safe to pass a collectable object into a C procedure when the callback invocation might cause a garbage collection, thus moving the object and invalidating the address stored in the C machine context.

This demonstrates how to use a callback such as the comparator argument to `qsort`. It is specified in the type signature using `->` as a type constructor. (Note that one should probably use the built-in sort routines rather than call out like this; this example is for demonstrating callbacks, not how to sort.)

```
(define qsort!
  (foreign-procedure "qsort" '(boxed ushort ushort (-> (void* void*) int)) 'void))
```

```
(let ((bv (list->vector '(40 10 30 20 1 2 3 4))))
  (qsort! bv 8 4
    (lambda (x y)
      (let ((x (/ (void*-word-ref x 0) 4))
            (y (/ (void*-word-ref y 0) 4)))
        (- x y))))
  bv)
```

```
(let ((bv (list->bytevector '(40 10 30 20 1 2 3 4))))
  (qsort! bv 8 1
    (lambda (x y)
      (let ((x (void*-byte-ref x 0))
            (y (void*-byte-ref y 0)))
        (- x y))))
  bv)
```

### 10.19.8.4. Other examples

The Experimental directory contains several examples of use of the FFI. See in particular the files `unix.sch` (Unix system calls) and `socket.sch` (procedures for communicating over sockets).

## 10.19.9. Higher level layers

The general foreign-function interface functionality described above is powerful but awkward to use in practice. A user might be tempted to hard code values of offsets or constants that are compiler dependent. Also, the FFI will marshal some low-level values such as strings or integers, but other values such as enumerations which could be naturally mapped to sets of symbols are not marshalled since the host environment does not provide the necessary type information to the FFI.

This section documents a collection of libraries to mitigate these and other problems.

### 10.19.9.1. foreign-ctools

Foreign data access is performed by peeking at manually calculated addresses, but in practice one often needs to inspect fields of C structures, whose offsets are dependant on the application binary interface (ABI) of the host environment. Similarly, C programs often use refer to values via constant macro definitions; since the values of such names are not provided by the object code and Scheme programs do not have a C preprocessor run on them prior to execution, it is difficult to refer to the same value without encoding "magic numbers" into the Scheme source code.

The `foreign-ctools` library is meant to mitigate problems like the two described above. It provides special forms for introducing global definitions of values typically available at compile-time for a C program. The library assumes the presence of a C compiler (such as `cc` on Unix systems or `cl.exe` on Windows systems). The special forms work by dynamically generating, compiling, and running C code at expansion time to determine the desired values of structure offsets or macro constants.

Here is a grammar for the `define-c-info` form provided by the `foreign-ctools` library.

```

<exp>      ::= (define-c-info <c-decl> ... <c-defn> ...)
<c-decl>   ::= (compiler <cc-spec>)
              | (path <include-path>)
              | (include <header>)
              | (include<> <header>)
<cc-spec> ::= cc | cl
<c-defn>   ::= (const <id> <c-type> <c-expr>)
              | (sizeof <id> <c-type-expr>)
              | (struct <c-name> <field-clause> ...)
              | (fields <c-name> <field-clause> ...)
              | (ifdefconst <id> <c-type> <c-name>)
<c-type>   ::= int | uint | long | ulong
<include-path>
             ::= <string-literal>
<header>   ::= <string-literal>
<field-clause>
             ::= (<offset-id> <c-field>)
              | (<offset-id> <c-field> <size-id>)
<c-expr>   ::= <string-literal>
<c-type-expr>
             ::= <string-literal>
<c-name>   ::= <string-literal>
<c-field>  ::= <string-literal>

```

*Syntax define-c-info*



```
(define-c-info <c-decl> ... <c-defn> ...)
```

The `<c-decl>` clauses of `define-c-info` control how header files are processed. The `compiler` clause selects between `cc` (the default UNIX system compiler) and `cl` (the compiler included with Microsoft's Windows SDK). The `path` clause adds a directory to search when looking for header files. The `include` and `include<>` clauses indicate header files to include when executing the `<c-defn>` clauses; the two variants correspond to the quoted and bracketed forms of the C preprocessor's `#include` directive.

The `<c-defn>` clauses bind identifiers. A `(const x t "ae")` clause binds `x` to the integer value of `ae` according to the C language; `ae` can be any C arithmetic expression that evaluates to a value of type `t`. (The expected usage is for `ae` to be an expression that the C preprocessor expands to an arithmetic expression.)

The remaining clauses provide similar functionality:

- `(sizeof x "te")` binds `x` to the size occupied by values of type `te`, where `te` is any C type expression.
- `(struct "cn" ... (x "cf" y) ...)` binds `x` to the offset from the start of a structure of type `struct cn` to its `cf` field, and binds `y`, if present, to the field's size. A `fields` clause is similar, but it applies to structures of type `cn` rather than `struct cn`.
- `(ifdefconst x t "cn")` binds `x` to the value of `cn` if `cn` is defined; `x` is otherwise bound to Larceny's unspecified value.

### 10.19.9.2. foreign-sugar

The `foreign-procedure` function is sufficient to link in dynamically loaded C procedures, but it can be annoying to use when there are many procedures to define that all follow a regular pattern where one could infer a mapping between Scheme identifiers and C function names.

For example, some libraries follow a naming convention where a words within a name are separated by underscores; such functions could be immediately mapped to Scheme names where the underscores have been replaced by dashes.

The `foreign-sugar` library provides a special form, `define-foreign`, which gives the user a syntax for defining foreign functions using a syntax where one provides only the Scheme name, the argument types, and the return type. The `define-foreign` form then attempts to infer what C function the name was meant to refer to.

*Syntax `define-foreign`*

```
(define-foreign (name arg-type ...) result-type)
```

#### Note

There is other functionality provided allowing the user to introduce new rules for inferring C function names, but they are undocumented because they will probably have to change when we switch to an R6RS macro expander.

### 10.19.9.3. foreign-stdlib

*Procedure `stdlib/malloc`*

```
(stdlib/malloc rtd [ctor]) => procedure
```

Given a record extension of *void\*-rt*, returns an allocator that uses the C `malloc` procedure to allocate instances of such an object. Note that the client is responsible for eventually freeing such objects with `stdlib/free`.

#### *Procedure stdlib/free*

```
(stdlib/free void*-obj)
```

Frees objects produced by allocators returned from `stdlib/malloc`.

#### *Procedure ffi-install-void\*-subtype*

```
(ffi-install-void*-subtype rtd) => rtd
```

```
(ffi-install-void*-subtype string [parent-rtd]) => rtd
```

```
(ffi-install-void*-subtype symbol [parent-rtd]) => rtd
```

`ffi-install-void*-subtype` extends the core attribute registry with a new primitive entry for *subtype*. The *parent-rtd* argument should be a subtype of *void\*-rt* and defaults to *void\*-rt*. In the case of the *symbol* or *string* inputs, the procedure constructs a new record type subtyping the *parent* argument. In the case of the *rtd* input, the *rtd* record type must extend *void\*-rt*. `ffi-install-void*-subtype` returns the subtype record type.

The returned record type represents a tagged wrapped C pointer, allowing one to encode type hierarchies.

#### *Procedure establish-void\*-subhierarchy!*

```
(establish-void*-subhierarchy! symbol-tree) => unspecified
```

`establish-void*-subhierarchy!` is a convenience function for constructing large object hierarchies. It descends the *symbol-tree*, creates a record type descriptor for each symbol (where the root of the tree has the parent *void\*-rt*), and invokes `ffi-install-void*-subtype` on all of the introduced types.

#### *Type char\** extends *void\** Procedure *string->char\**

```
(string->char* string) => char*
```

#### *Procedure char\*-strlen*

```
(char*-strlen char*) => fixnum
```

#### *Procedure char\*->string*

```
(char*->string char*) => string
```

```
(char*->string char* len) => string
```

#### *Procedure call-with-char\**

```
(call-with-char* string string-function) => value
```

#### *Type char\*\** extends *void\** Procedure *call-with-char\*\**

```
(call-with-char** string-vector function) => value
```

#### *Type int\** extends *void\** Procedure *call-with-int\**

---

```
(call-with-int* fixnum-vector function) => value
Type short* extends void* Procedure call-with-short*
```

```
(call-with-short* fixnum-vector function) => value
Type double* extends void* Procedure call-with-double*
```

```
(call-with-double* num-vector function) => value
```

FIXME: (There are other functions, but I want to test and document the ones above first...)

#### 10.19.9.4. foreign-cstructs

The `foreign-cstructs` library provides a more direct interface to C structures. It provides the `define-c-struct` special form. This form is layered on top of `define-c-info`; the latter provides the structure field offsets and sizes used to generate constructors (which produce appropriately sized bytevectors, not record instances). The `define-c-struct` form combines these with marshaling and unmarshaling procedures to provide high-level access to a structure.

The grammar for the `define-c-struct` form is presented below.

```
<exp> ::= (define-c-struct (<struct-type> <ctor-id> <c-decl> ...)
                    <field-clause> ...)
<field-clause> ::= (<c-field> <getter>) | (<c-field> <getter> <setter>)
<getter> ::= (<id>) | (<id> <unmarshal>)
<setter> ::= (<id>) | (<id> <marshal>)
<marshal> ::= <ffi-attr-symbol> | <marshal-proc-exp>
<unmarshal> ::= <ffi-attr-symbol> | <unmarshal-proc-exp>
<struct-type> ::= <string-literal>
```

#### 10.19.9.5. foreign-cenums

This library provides the special forms `define-c-enum` and `define-c-enum-set`, which associate the identifiers of a C `enum` type declaration with the integer values they denote.

The `define-c-enum` form describes enums encoding a discriminated sum; `define-c-enum-set` describes bitmasks, mapping them to R<sup>6</sup>RS `enum-sets` in Scheme.

The `(define-c-enum en (<c-decl> ...) (x "cn") ...)` form adds the `en` FFI attribute. The attribute marshals each symbol `x` to the integer value that `cn` denotes in C; unmarshaling does the inverse translation.

The `(define-c-enum-set ens (<c-decl> ...) (x "cn") ...)` form binds `ens` to an R<sup>6</sup>RS `enum-set` constructor with universe resulting from `(make-enumeration '(x ...))`; it also adds the `ens` FFI attribute. The attribute marshals an `enum-set` `s` constructed by `ens` to the corresponding bitmask in C (that is, the integer one would get by logically or'ing all `cn` such that the corresponding `x` is in `s`). Unmarshaling attempts to do the inverse translation.

The grammar for the two forms is presented below.

```
<exp> ::= (define-c-enum <enum-id> (<c-decl> ...)
```

```
(<id> <c-name>) ...)  
<exp> ::= (define-c-enum-set <enum-id> (<c-decl> ...)  
          (<id> <c-name>) ...)  
<enum-id> ::= <id>
```

## 11. Debugging

Larceny's debugging functionality is implemented in Scheme, using some of Larceny's extensions for catching exceptions and inspecting the continuation structure.

### 11.1. Entering the debugger

When Larceny detects an error or a keyboard interrupt, or when it hits a breakpoint, it signals the condition by printing a message on the console. Larceny then enters the debugger, which signals its presence with a short banner and the debugger prompt:

```
Entering debugger; type "?" for help.  
debug>
```

You can also re-enter the debugger by evaluating (debug).

### 11.2. Debugger commands

The debugger is still in an immature state. The following commands are available (commands can be typed in upper or lower case):

**B** Print backtrace of continuation.

**C** Print source code of procedure, if available.

**D** Move down to previous (earlier) activation record.

**E n expr** *Expr* is evaluated in the current interaction environment and must evaluate to a procedure. It is passed the contents of slot *n* from the current activation record, and the result, if not unspecified, is printed.

**E (n1 ... nk) expr** *Expr* is evaluated in the current interaction environment and must evaluate to a procedure. It is passed the contents of slots *n1* through *nk* from the current activation record, and the result, if not unspecified, is printed.

**I n** Inspect the procedure in slot *n* of the current activation record.

**I @\_** Inspect the active procedure.

**Q** Quit the debugger and abort the computation.

**R** Return from the debugger and continue the computation.

**S** Summarize the contents of the current activation record.

**U** Up to the next (later) activation record.

**X** Examine the contents of the current activation record.

The **B**, **D**, and **U** commands can be prefixed with a count, for example, 5 U moves up five activation records, and 10 B displays the next 10 activation records. The default for **B** is to display all the activations; the default count for **D** and **U** is 1.

## 11.3. Breakpoints

You can set breakpoints either in program text with the break primitive or interactively at the start of a procedure with the break-entry procedure. When Larceny reaches a breakpoint during execution, the program is suspended and the debugger is entered to allow you to inspect the program.

*Procedure larceny-break*

(larceny-break )

Invokes the breakpoint handler.

*Procedure break-entry*

(break-entry *procedure*)

Set a breakpoint at the start of the *procedure*.

*Procedure unbreak*

(unbreak *procedure* ...)

(unbreak )

In the first form, remove any breakpoint set by break-entry at the start of the *procedure\_s*. In the second form, remove all breakpoints set by *\_break-entry*.

## 11.4. Tracing

*Procedure trace-entry*

(trace-entry *procedure*)

Set a trace point on entry to the *procedure*, removing any other trace points on the procedure. When the *procedure* is entered, information about the call is printed on the console: the name of the procedure and the actual arguments.

*Procedure trace-exit*

(trace-exit *procedure*)

Set a trace point on exit from the *procedure*, removing any other trace points on the procedure. When the *procedure* returns, information about the return is printed on the console: the name of the procedure and the returned values.

Note that trace-exit destroys the tail recursion properties of the instrumented procedure. Where the

*procedure* would normally "return" by tail-calling another procedure, the instrumented procedure will call the other procedure by a non-tail call and then return, at which point the procedure name and return values will be printed. Thus use of trace-exit may destroy the space properties of the program.

#### *Procedure trace*

(trace *procedure*)

Set trace points on *procedure* both at entry and exit.

#### *Procedure untrace*

(untrace *procedure* ...)

(untrace )

The first form removes any trace points from the specified procedures. The second form removes all untrace points.

## 11.5. Other functionality

#### *Parameter break-handler*

The value of break-handler is a procedure that is called when a breakpoint or tracepoint is encountered. The procedure takes two arguments: the procedure in which the breakpoint was set, and the byte offset within the procedure's code vector of the breakpoint.

## 12. Standards

### 12.1. Scheme standards

IEEE Standard 1178-1990, "IEEE Standard for the Scheme Programming Language", IEEE, 1991. ISBN 1-55937-125-0. May be ordered from IEEE by calling 1-800-678-IEEE or 908-981-1393 or writing IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, and using order number SH14209.

Richard Kelsey, William Clinger, and Jonathan Rees [editors]. Revised<sup>5</sup> Report on the Algorithmic Language Scheme [<http://www.brics.dk/~hosc/11-1/>]. *Journal of Higher Order and Symbolic Computation*, 11(1), 1998, pages 7-105. Also appears in *ACM SIGPLAN Notices* 33(9), September 1998. Available online in various formats [<http://www.schemers.org/Documents/Standards/R5RS/>].

Michael Sperber, R Kent Dybvig, Matthew Flatt, and Anton van Straaten [editors]. Revised<sup>6</sup> Report on the Algorithmic Language Scheme [<http://www.r6rs.org/>].

Various SchemePunks [editors]. ERR5RS [[http://scheme-punks.org/wiki/index.php?title=Main\\_Page](http://scheme-punks.org/wiki/index.php?title=Main_Page)] is under construction.

### 12.2. Other relevant standards

IEEE Standard 754-1985, "IEEE Standard for Binary Floating-Point Arithmetic", IEEE, 1985.

A revision of IEEE Std 754-1985 [[http://en.wikipedia.org/wiki/IEEE\\_754r](http://en.wikipedia.org/wiki/IEEE_754r)] has been underway since 2000. The IEEE Microprocessor Standards Committee (MSC) accepted a candidate draft on 9 October 2006. The candidate draft 1.2.6 was approved by 79% of 70 votes, which exceeded the required supermajority of 75%. Because there were negative votes and several hundred comments, however, a revised draft 1.3.0 was prepared and approved by 84% of 73 votes. Since there were over a hundred comments on the second candidate draft as well, a third candidate draft 1.4.0 was prepared and another vote taken in April 2007. After a total of eight ballots, with the last four being approved by more than 90% of the voters, the Ballot Review Committee decided in May 2008 that maximum possible timely consensus has been obtained [<http://www.validlab.com/754R/>], and the consensus draft was submitted to IEEE-SA RevCom. IEEE-754r was approved on 12 June 2008.

The Unicode Consortium. The Unicode 5.0 Standard [<http://www.unicode.org/>]. Addison-Wesley Professional, 2006.

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