SLY User Manual



version 1.0.42

Written for SLIME Luke Gorrie and others, rewritten by João Távora for SLY.
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1 Introduction

SLY is Sylvester the Cat's Common Lisp IDE. It extends Emacs with support for interactive programming in Common Lisp.

The features are centered around an Emacs minor-mode called `sly-mode`, which complements the standard major-mode `lisp-mode` for editing Lisp source files. `sly-mode` adds support for interacting with a running Common Lisp process for compilation, debugging, documentation lookup, and so on.

SLY attempts to follow the example of Emacs's own native Emacs-Lisp environment. Many of the keybindings and interface concepts used to interact with Emacs's Elisp machine are reused in SLY to interact with the underlying Common Lisp run-times. Emacs makes requests to these processes, asking them to compile files or code snippets; deliver introspection information various objects; or invoke commands or debugging restarts.

Internally, SLY's user-interface, written in Emacs Lisp, is connected via sockets to one or more instances of a server program called "Slynk" that is running in the Lisp processes.

The two sides communicate using a Remote Procedure Call (RPC) protocol. The Lisp-side server is primarily written in portable Common Lisp. However, because some non-standard functionality is provided differently by each Lisp implementation (SBCL, CMUCL, Allegro, etc...) the Lisp-side server is again split into two parts – portable and non-portable implementation – which communicate using a well-defined interface. Each Lisp implementation provides a separate implementation of that interface, making SLY as a whole readily portable.

SLY is a direct fork of SLIME, the "Superior Lisp Interaction Mode for Emacs", which itself derived from previous Emacs programs such as SLIM and ILISP. If you already know SLIME, SLY's closeness to it is immediately apparent. However, where SLIME has traditionally focused on the stability of its core functionality, SLY aims for a richer feature set, a more consistent user interface, and an experience generally closer to Emacs' own.

To understand the differences between the two projects read SLY's NEWS.md file. For a hand-on approach to these differences you might want to Chapter 3 [A SLY tour for SLIME users], page 5.

2 Getting started

This chapter tells you how to get SLY up and running.

2.1 Supported Platforms

SLY supports a wide range of operating systems and Lisp implementations. SLY runs on Unix systems, Mac OSX, and Microsoft Windows. GNU Emacs versions 24.4 and above are supported. *XEmacs or Emacs 23 are notably not supported.*

The supported Lisp implementations, roughly ordered from the best-supported, are:

- CMU Common Lisp (CMUCL), 19d or newer
- Steel Bank Common Lisp (SBCL), 1.0 or newer
- Clozure Common Lisp (CCL), version 1.3 or newer
- LispWorks, version 4.3 or newer
- Allegro Common Lisp (ACL), version 6 or newer
- CLISP, version 2.35 or newer
- Armed Bear Common Lisp (ABCL)
- Scieneer Common Lisp (SCL), version 1.2.7 or newer
- Embedded Common Lisp (ECL)
- ManKai Common Lisp (MKCL)
- Clasp

Most features work uniformly across implementations, but some are prone to variation. These include the precision of placing compiler-note annotations, XREF support, and fancy debugger commands (like "restart frame").

2.2 Downloading SLY

By far the easiest method for getting SLY up and running is using Emacs' package system configured to the popular MELPA repository. This snippet of code should already be in your configuration:

```
(add-to-list 'package-archives
             '("melpa" . "https://melpa.org/packages/"))
(package-initialize)
```

You should now be able to issue the command *M-x package-install*, choose *sly* and have it be downloaded and installed automatically. If you don't find it in the list, ensure you run *M-x package-refresh-contents* first.

In other situations, such as when developing SLY itself, you can access the Git repository directly:

```
git clone https://github.com/joaotavora/sly.git
```

If you want to hack on SLY, use Github's *fork* functionality and submit a *pull request*. Be sure to first read the CONTRIBUTING.md file first.

2.3 Basic setup

If you installed SLY from MELPA, it is quite possible that you don't need any more configuration, provided that SLY can find a suitable Lisp executable in your `PATH` environment variable.

Otherwise, you need to tell it where a Lisp program can be found, so customize the variable `inferior-lisp-program` (see Section 7.1.3 [Defcustom variables], page 42) or add a line like this one to your `~/.emacs` or `~/.emacs.d/init.el` (see [Emacs Init File], page 40).

```
(setq inferior-lisp-program "/opt/sbcl/bin/sbcl")
```

After evaluating this, you should be able to execute *`M-x sly`* and be greeted with a REPL.

If you cloned from the Git repository, you'll have to add a couple of more lines to your initialization file configuration:

```
(add-to-list 'load-path "~/dir/to/cloned/sly")
(require 'sly-autoloads)
```

2.4 Running SLY

SLY can either ask Emacs to start its own Lisp subprocesss or connect to a running process on a local or remote machine.

The first alternative is more common for local development and is started via *`M-x sly`*. The "inferior" Lisp process thus started is told to load the Lisp-side server known as "Slynk" and then a socket connection is established between Emacs and Lisp. Finally a REPL buffer is created where you can enter Lisp expressions for evaluation.

The second alternative uses *`M-x sly-connect`*. This assumes that that a Slynk server is running on some local or remote host, and listening on a given port. *`M-x sly-connect`* prompts the user for these values, and upon connection the REPL is established.

2.5 Basic customization

A big part of Emacs, and Emacs's extensions, are its near-infinite customization possibilities. SLY is no exception, because it runs on both Emacs and the Lisp process, there are layers of Emacs-side customization and Lisp-side customization. But don't be put off by this! SLY tries hard to provide sensible defaults that don't "hide" any fanciness beneath layers of complicated code, so that even a setup with no customization at all exposes SLY's most important functionality.

Emacs-side customization is usually done via Emacs-lisp code snippets added to the user's initialization file, usually `$HOME/.emacs` or `$HOME/.emacs.d/init.el` (see [Emacs Init File], page 40).

90% of Emacs-lisp customization happens in either "keymaps" or "hooks" (see Section 7.1 [Emacs-side], page 40). Still on the Emacs side, there is also a separate interface, appropriately called `customize` (or sometimes just `custom`), that uses a nicer UI with mouse-clickable buttons to set some special variables. See See Section 7.1.3 [Defcustom variables], page 42.

Lisp-side customization is done exclusively via Common Lisp code snippets added to the user's `$HOME/.slynkrc` file. See See Section 7.2 [Lisp-side customization], page 43.

As a preview, take this simple example of a frequently customized part of SLY: its keyboard shortcuts, known as "keybindings". In the following snippet *M-h* is added to `sly-prefix-map` thus yielding *C-c M-h* as a shortcut to the `sly-documentation-lookup` command.

```
(eval-after-load 'sly
  `(define-key sly-prefix-map (kbd "M-h") 'sly-documentation-lookup))
```

2.6 Multiple Lisps

By default, the command *M-x sly* starts the program specified with `inferior-lisp-program`, a variable that you can customize (see Section 7.1.3 [Defcustom variables], page 42). However, if you invoke *M-x sly* with a *prefix argument*, meaning you type *C-u M-x sly* then Emacs prompts for the program which should be started instead.

If you need to do this frequently or if the command involves long filenames it's more convenient to set the `sly-lisp-implementations` variable in your initialization file (see [Emacs Init File], page 40). For example here we define two programs:

```
(setq sly-lisp-implementations
      '((cmucl ("cmucl" "-quiet"))
        (sbcl ("/opt/sbcl/bin/sbcl") :coding-system utf-8-unix)))
```

Now, if you invoke SLY with a *negative* prefix argument, *M-- M-x sly*, you can select a program from that list. When called without a prefix, either the name specified in `sly-default-lisp`, or the first item of the list will be used. The elements of the list should look like

```
(NAME (PROGRAM PROGRAM-ARGS...) &key CODING-SYSTEM INIT INIT-FUNCTION ENV)
```

`NAME` is a symbol and is used to identify the program.

`PROGRAM` is the filename of the program. Note that the filename can contain spaces.

`PROGRAM-ARGS`
: is a list of command line arguments.

`CODING-SYSTEM`
: the coding system for the connection. (see [sly-net-coding-system], page 42)x

`INIT` should be a function which takes two arguments: a filename and a character encoding. The function should return a Lisp expression as a string which instructs Lisp to start the Slynk server and to write the port number to the file. At startup, SLY starts the Lisp process and sends the result of this function to Lisp's standard input. As default, `sly-init-command` is used. An example is shown in [Loading Slynk faster], page 49.

`INIT-FUNCTION`
: should be a function which takes no arguments. It is called after the connection is established. (See also [sly-connected-hook], page 43.)

`ENV` specifies a list of environment variables for the subprocess. E.g.

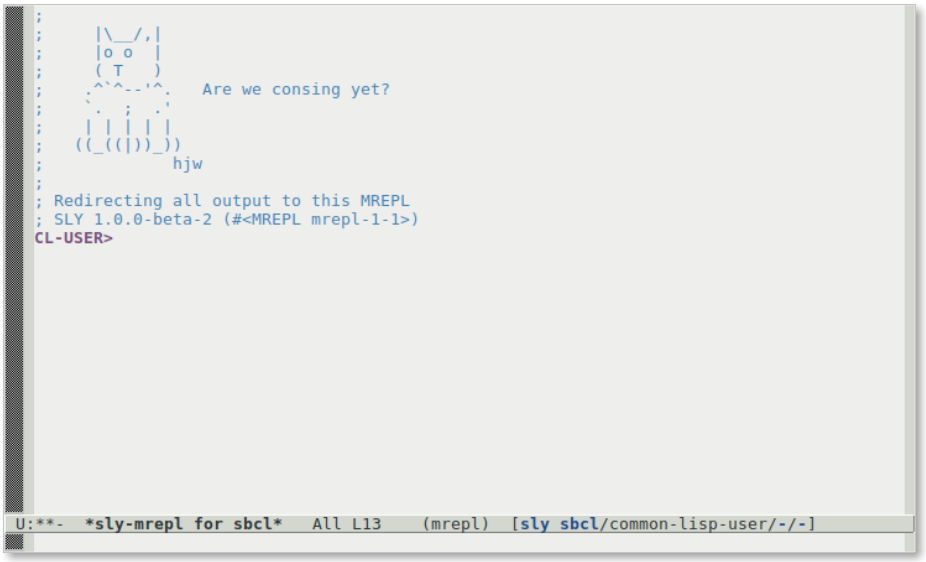
```
(sbcl-cvs ("/home/me/sbcl-cvs/src/runtime/sbcl"
           "--core" "/home/me/sbcl-cvs/output/sbcl.core")
          :env ("SBCL_HOME=/home/me/sbcl-cvs/contrib/"))
```

initializes `SBCL_HOME` in the subprocess.

3 A SLY tour for SLIME users

The chances are that if you're into Common Lisp, you already know about SLIME, the project that originated SLY. Itself originating in older Emacs extensions SLIM and ILISP, SLIME has been around for at least a decade longer than SLY and is quite an amazing IDE. It's likely that most Lispers have some experience with it, making it a good idea to provide, in the shape of a quick tutorial, a hands-on overview of some of the improvements of SLY over SLIME.

When you start SLY with *`M-x sly`* (see Section 2.3 [Basic setup], page 3) you are greeted with its REPL, a common starting point of Lisp hacking sessions. This has been completely redesigned in SLY: you can spawn multiple REPL sessions with `sly-mrepl-new`; copy objects from most places directly into it (with *`M-RET`* and *`M-S-RET`*); use powerful incremental history search (with *`C-r`*) found in most modern shells; and get real-time assistance when "backreferecing" previous evaluation values in your Lisp input.



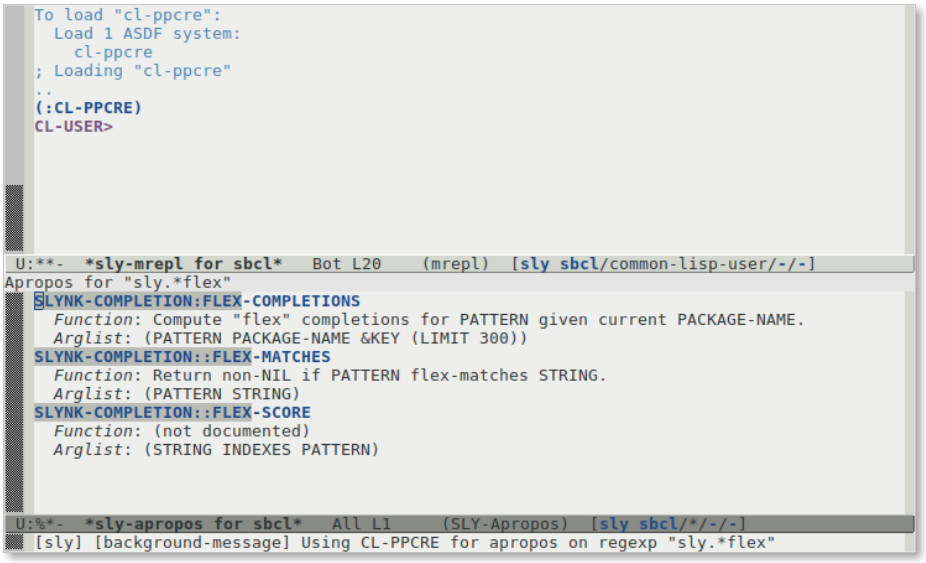
Starting from the new REPL, let's showcase some of SLY's features. Let's pretend we want to hack an existing Lisp project. We'll pick SLY itself, or rather its Lisp server, called Slynk. Let's pretend we're intrigued by the way its "flex"-style completion works. What is flex completion, you ask? Well, if you're at the REPL you can try it now: it's a way of *`TAB`*-completing (see Section 5.3 [Completion], page 18) symbol names based on educated guesses of a few letters. Thus if we type `mvbind`, SLY guesses that we probably meant `multiple-value-bind`, and if we type `domat` it might possibly guess `cl-ppcre:do-matches`. Let's dig into the code that makes this happen.

But how? Where to begin, given we know so little about this project?

Well, a good starting point is always the *apropos* functionality, which is a `grep` of sorts, but aware of the symbols loaded in your Lisp, rather the contents of text files. Furthermore, in SLY, `sly-apropos` will do a regular-expression-enabled symbol search, which will help us here since we don't yet know any symbols names of this mysterious flex feature.

To enable regular expression searches you need the `CL-PPCRE` library is loaded (else `sly-apropos` falls back to regex-less mode). If you have Quicklisp (`https://www.quicklisp.org/beta/`) installed (you do, right?) you need only type `(ql:quickload :cl-ppcre)` now from the REPL.

Thus, if we want to hack SLY's flex completion, and *don't* known any of its symbol's names, we type *`C-c C-d C-z`* (the shortcut for *`M-x sly-apropos-all`*) and then type in "sly.*flex" at the prompt. We follow with *`enter`* or *`return`* (abbreviated `RET` or *`C-m`*). SLY should now present all Lisp symbols matching your search pattern.



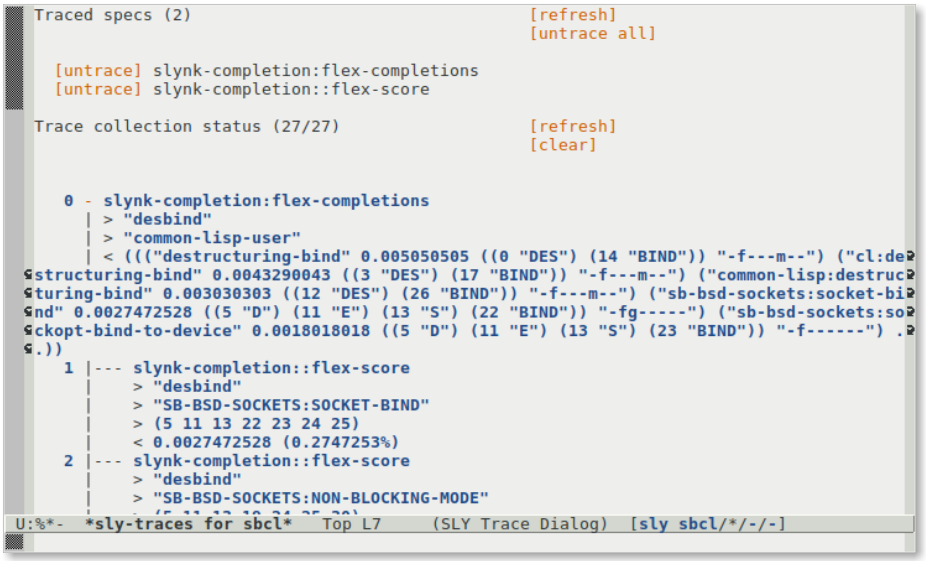
In the `apropos` buffer, let's grab the mouse and right-click the symbol `SLYNK-COMPLETIONS:FLEX-COMPLETIONS`. We'll be presented with a context menu with options for describing the symbol, inspecting it, or navigating to its source definition. In general, the Lisp-side objects that SLY presents — symbols, CLOS objects, function calls, etc... — are right-clickable buttons with such a context menu (see Section 5.4 [Interactive objects], page 19). For now, let's navigate to the source definition of the symbol by choosing "Go To source" from the menu. Alternatively, we could also have just pressed *`M-.`* on the symbol, of course.

From the Lisp source buffer that we landed on (probably `slynk-completion.lisp`), let's *trace* the newly found function `SLYNK-COMPLETIONS:FLEX-COMPLETIONS`. However, instead of using the regular `CL:TRACE`, we'll use SLY's Trace Dialog functionality. This is how we set it up:

1. first type *`C-c C-t`* on the function's name, or enter that in the minibuffer prompt;
2. now, open the Trace Dialog in a new window by typing *`C-c T`* (that's a capital `T`). We should already see our traced function under the heading "Traced specs";
3. thirdly, for good measure, let's also trace the nearby function `SLYNK-COMPLETIONS::FLEX-SCORE` by also typing *`C-c C-t`* on its name, or just entering it in the minibuffer prompt.

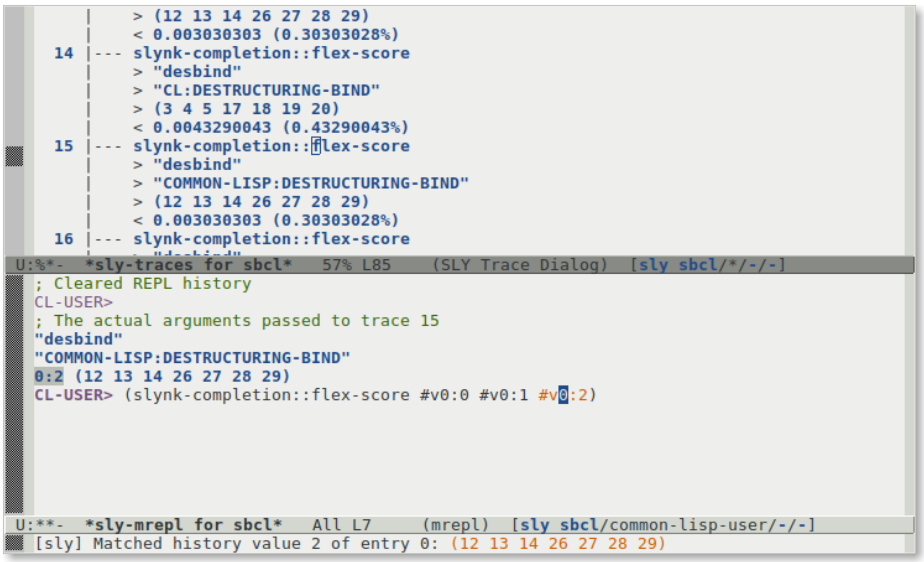
Now let's return to the REPL by switching to its `*sly-mrepl ...` buffer or typing *C-c C-z*. To exercise the code we just traced, let's type something like `desbind`, followed by tab, and see if it suggest `destructuring-bind` as the top match. We could now select some completion from the list, but instead let's just type *C-g* to dismiss the completion, since we wanted to test completion, not write any actual `destructuring-bind` expression.

Remember the traced functions in the Trace Dialog? Time to see if we got any traces. let's type *C-c T* to switch to that buffer, and then type capital *G*. This should produce a fair number of traces organized in a call graph.



We can later learn more about this mode (see Section 6.4 [Trace Dialog], page 32), but for now let's again pretend we expected the function `FLEX-SCORE` to return a wildly different score for `COMMON-LISP:DESTRUCTURING-BIND`. In that case we should like to witness said `FLEX-SCORE` function respond to any implementation improvements we perform. To do so, it's useful to be able to surgically re-run that function with those very same arguments. Let's do this by finding the function call in the Trace Dialog window, right-clicking it with the mouse and selecting "Copy call to REPL". Pressing *M-S-RET* on it should accomplish the same. We are automatically transported to the REPL again, where the desired function call has already been typed out for us at the command prompt, awaiting a confirmation *RET*, which will run the function call:

```
; The actual arguments passed to trace 15
"desbind"
"COMMON-LISP:DESTRUCTURING-BIND"
(12 13 14 26 27 28 29)
SLYNK-COMPLETION> (slynk-completion::flex-score #v1:0 #v1:1 #v1:2)
0.003030303 (0.30303028%)
SLYNK-COMPLETION>
```



If those `#v...`'s look odd, here's what's going on: to copy the call to the REPL, SLY first copied over its actual arguments, and then wrote the function using special *backreferences* to those arguments in the correct place. These are the `#v4:0` and `#v4:1` bits seen at the command prompt. If one puts the cursor on them or hovers with the mouse, this highlights the corresponding object a few lines above in the buffer. Later, you can also try typing "#v" at the REPL to incrementally write your own backreferences (see Section 6.1.3 [REPL backreferences], page 28).

For one final demonstration, let's now suppose say we are still intrigued by how that function (`FLEX-SCORE`) works internally. So let's navigate to its definition using *M-.* again (or just open the `slynk-completion.lisp` buffer that you probably still have open). The function's code might look like this:

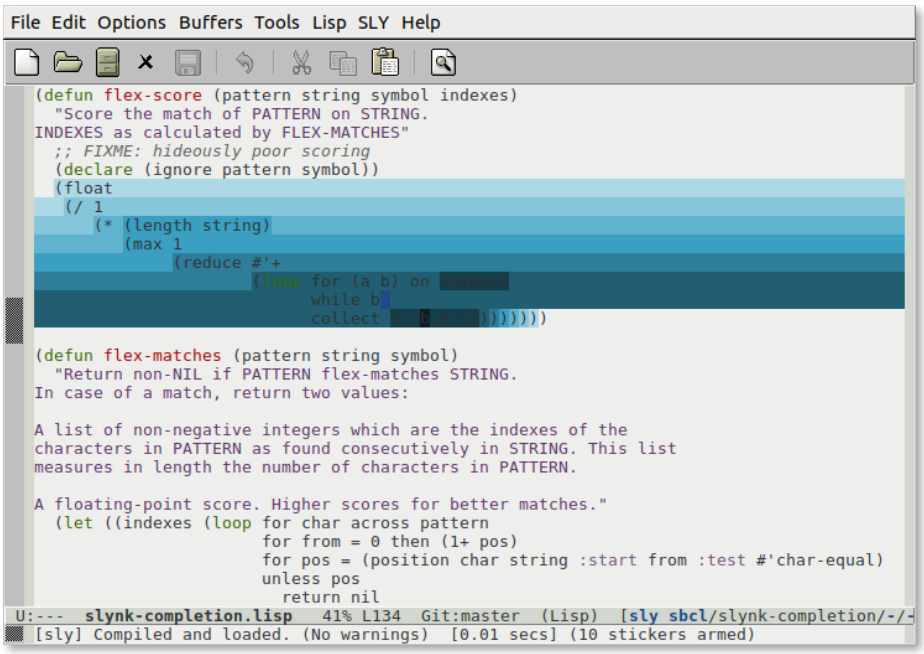
```
(defun flex-score (pattern string indexes)
  "Score the match of PATTERN on STRING.
INDEXES as calculated by FLEX-MATCHES"
  ;; FIXME: hideously naive scoring
  (declare (ignore pattern))
  (float
   (/ 1
      (* (length string)
         (max 1
              (reduce #'+
                      (loop for (a b) on indexes
                            while b
                            collect (- b a 1))))))))
```

Can this function be working correctly? What do all those expressions return? Should we reach for good old C-style `printf`? Let's try "stickers" instead. SLY's stickers are a form of non-intrusive function instrumentation that work like carefully crafted `print` or `(format t ...)`), but are much easier to work with. You can later read more about them

(see Section 6.5 [Stickers], page 35), but for now you can just think of them as colorful labels placed on s-exp's. Let's place a bunch here, like this:

1. on the last line of `flex-score`, place your cursor on the first open parenthesis of that line (the opening parenthesis of the expression `(- b a 1)`) and press *C-c C-s C-s*;
2. now do the same for the symbol `indexes` a couple of lines above;
3. again, the same for the expressions `(loop...)`, `(reduce...)`, `(max...)`, `(length...)`, `(*...)`, `(/... )` and `(float...)`. You could have done this in any order, by the way;

Now let's recompile this definition with *C-c C-c*. Beside the minibuffer note something about stickers being "armed" our function should now look like a rainbow in blue.

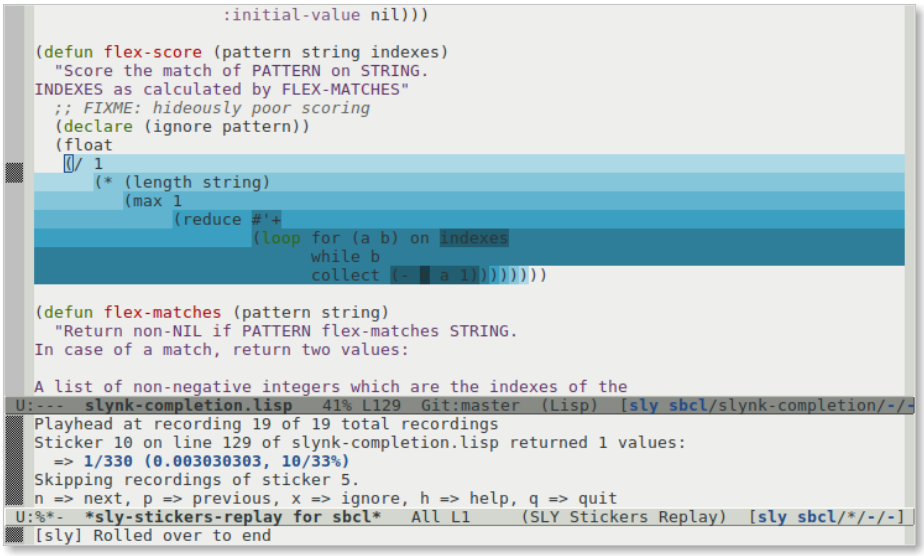


Now we return to the SLY REPL, but this time let's use *C-c ~* (that's *C-c* followed by "tilde") to do so. This syncs the REPL's local package and local directory to the Lisp file that we're visiting. This is something not strictly necessary here but generally convenient when hacking on a system, because you can now call functions from the file you came from without package-qualification.

Now, to re-run the newly instrumented function, by calling it with the same arguments. No need to type all that again, because this REPL supports reverse history i-search, remember? So just type the binding *C-r* and then type something like *scor* to search history backwards and arrive at the function call copied to the REPL earlier. Type *RET* once to confirm that's the call your after, and *RET* again to evaluate it. Because those `#v...` back-references are still trained specifically on those very same function arguments, you can be sure that the function call is equivalent.

We can now use the *C-c C-s C-r* to *replay* the sticker recordings of this last function call. This is a kind of slow walk-through conducted in separate navigation window called `*sly-stickers-replay*` which pops up. There we can see the Lisp value(s) that each

sticker `eval`'ed to each time (or a note if it exited non-locally). We can navigate recordings with *n* and *p*, and do the usual things allowed by interactive objects like inspecting them and returning them to the REPL. If you need help, toggle help by typing *h*. There are lots of options here for navigating stickers, ignoring some stickers, etc. When we're done in this window, we press *q* to quit.



Finally, we declare that we're finished debugging `FLEX-MATCHES`. Even though stickers don't get saved to the file in any way, we decide we're not interested in them anymore. So let's open the "SLY" menu in the menu bar, find the "Delete stickers from top-level form" option under the "Stickers" sub-menu, and click it. Alternatively, we could have typed *C-u C-c C-s C-s*.

4 Working with source files

SLY's commands when editing a Lisp file are provided via `sly-editing-mode`, a minor-mode used in conjunction with Emacs's `lisp-mode`.

This chapter describes SLY's commands for editing and working in Lisp source buffers. There are, of course, more SLY's commands that also apply to these buffers (see Chapter 5 [Common functionality], page 16), but with very few exceptions these commands will always be run from a `.lisp` file.

4.1 Evaluating code

These commands each evaluate a Common Lisp expression in a different way. Usually they mimic commands for evaluating Emacs Lisp code. By default they show their results in the echo area, but a prefix argument *C-u* inserts the results into the current buffer, while a negative prefix argument *M--* sends them to the kill ring.

C-x C-e
M-x sly-eval-last-expression
: Evaluate the expression before point and show the result in the echo area.

C-M-x
M-x sly-eval-defun
: Evaluate the current toplevel form and show the result in the echo area. 'C-M-x' treats 'defvar' expressions specially. Normally, evaluating a 'defvar' expression does nothing if the variable it defines already has a value. But 'C-M-x' unconditionally resets the variable to the initial value specified in the 'defvar' expression. This special feature is convenient for debugging Lisp programs.

If *C-M-x* or *C-x C-e* is given a numeric argument, it inserts the value into the current buffer, rather than displaying it in the echo area.

C-c :
M-x sly-interactive-eval
: Evaluate an expression read from the minibuffer.

C-c C-r
M-x sly-eval-region
: Evaluate the region.

C-c C-p
M-x sly-pprint-eval-last-expression
: Evaluate the expression before point and pretty-print the result in a fresh buffer.

C-c E
M-x sly-edit-value
: Edit the value of a setf-able form in a new buffer `*Edit <form>*`. The value is inserted into a temporary buffer for editing and then set in Lisp when committed with *C-c C-c*.

C-c C-u
M-x sly-undefine-function
: Undefine the function, with `fmakunbound`, for the symbol at point.

M-x sly-remove-method
: Remove a specific method of a generic function at point.

4.2 Compiling functions and files

SLY has fancy commands for compiling functions, files, and packages. The fancy part is that notes and warnings offered by the Lisp compiler are intercepted and annotated directly onto the corresponding expressions in the Lisp source buffer. (Give it a try to see what this means.)

C-c C-c
M-x sly-compile-defun
: Compile the top-level form at point. The region blinks shortly to give some feedback which part was chosen.

  With (positive) prefix argument the form is compiled with maximal debug settings (*C-u C-c C-c*). With negative prefix argument it is compiled for speed (*M-- C-c C-c*). If a numeric argument is passed set debug or speed settings to it depending on its sign.

  The code for the region is executed after compilation. In principle, the command writes the region to a file, compiles that file, and loads the resulting code.

  This compilation may arm stickers (see Section 6.5 [Stickers], page 35).

C-c C-k
M-x sly-compile-and-load-file
: Compile and load the current buffer's source file. If the compilation step fails, the file is not loaded. It's not always easy to tell whether the compilation failed: occasionally you may end up in the debugger during the load step.

  With (positive) prefix argument the file is compiled with maximal debug settings (*C-u C-c C-k*). With negative prefix argument it is compiled for speed (*M-- C-c C-k*). If a numeric argument is passed set debug or speed settings to it depending on its sign.

  This compilation may arm stickers (see Section 6.5 [Stickers], page 35).

C-c M-k
M-x sly-compile-file
: Compile (but don't load) the current buffer's source file.

C-c C-l
M-x sly-load-file
: Load a Lisp file. This command uses the Common Lisp LOAD function.

M-x sly-compile-region
: Compile the selected region.

  This compilation may arm stickers (see Section 6.5 [Stickers], page 35).

The annotations are indicated as underlining on source forms. The compiler message associated with an annotation can be read either by placing the mouse over the text or with the selection commands below.

M-n
M-x sly-next-note
: Move the point to the next compiler note and displays the note.

M-p
M-x sly-previous-note
: Move the point to the previous compiler note and displays the note.

C-c M-c
M-x sly-remove-notes
: Remove all annotations from the buffer.

C-x `
M-x next-error
: Visit the next-error message. This is not actually a SLY command but SLY creates a hidden buffer so that most of the Compilation mode commands (See Info file `emacs`, node '`Compilation Mode`') work similarly for Lisp as for batch compilers.

4.3 Autodoc

SLY automatically shows information about symbols near the point. For function names the argument list is displayed, and for global variables, the value. Autodoc is implemented by means of `eldoc-mode` of Emacs.

M-x sly-arglist NAME
: Show the argument list of the function NAME.

M-x sly-autodoc-mode
: Toggles autodoc-mode on or off according to the argument, and toggles the mode when invoked without argument.

M-x sly-autodoc-manually
: Like sly-autodoc, but when called twice, or after sly-autodoc was already automatically called, display multiline arglist.

If `sly-autodoc-use-multiline-p` is set to non-nil, allow long autodoc messages to resize echo area display.

`autodoc-mode` is a SLY extension and can be turned off if you so wish (see Chapter 9 [Extensions], page 51)

4.4 Semantic indentation

SLY automatically discovers how to indent the macros in your Lisp system. To do this the Lisp side scans all the macros in the system and reports to Emacs all the ones with `&body` arguments. Emacs then indents these specially, putting the first arguments four spaces in and the "body" arguments just two spaces, as usual.

This should "just work." If you are a lucky sort of person you needn't read the rest of this section.

To simplify the implementation, SLY doesn't distinguish between macros with the same symbol-name but different packages. This makes it fit nicely with Emacs's indentation code.

However, if you do have several macros with the same symbol-name then they will all be indented the same way, arbitrarily using the style from one of their arglists. You can find out which symbols are involved in collisions with:

`(slynk:print-indentation-lossage)`

If a collision causes you irritation, don't have a nervous breakdown, just override the Elisp symbol's `sly-common-lisp-indent-function` property to your taste. SLY won't override your custom settings, it just tries to give you good defaults.

A more subtle issue is that imperfect caching is used for the sake of performance.[1]

In an ideal world, Lisp would automatically scan every symbol for indentation changes after each command from Emacs. However, this is too expensive to do every time. Instead Lisp usually just scans the symbols whose home package matches the one used by the Emacs buffer where the request comes from. That is sufficient to pick up the indentation of most interactively-defined macros. To catch the rest we make a full scan of every symbol each time a new Lisp package is created between commands – that takes care of things like new systems being loaded.

You can use *M-x sly-update-indentation* to force all symbols to be scanned for indentation information.

4.5 Reader conditional fontification

SLY automatically evaluates reader-conditional expressions, like `#+linux`, in source buffers and "grays out" code that will be skipped for the current Lisp connection.

4.6 Macro-expansion commands

C-c C-m
M-x sly-expand-1
: Macroexpand (or compiler-macroexpand) the expression at point once. If invoked with a prefix argument use macroexpand instead or macroexpand-1 (or compiler-macroexpand instead of compiler-macroexpand-1).

M-x sly-macroexpand-1
: Macroexpand the expression at point once. If invoked with a prefix argument, use macroexpand instead of macroexpand-1.

C-c M-m
M-x sly-macroexpand-all
: Fully macroexpand the expression at point.

M-x sly-compiler-macroexpand-1
: Display the compiler-macro expansion of sexp at point.

M-x sly-compiler-macroexpand
: Repeatedly expand compiler macros of sexp at point.

M-x sly-format-string-expand
: Expand the format-string at point and display it. With prefix arg, or if no string at point, prompt the user for a string to expand.

[1] *Of course* we made sure it was actually too slow before making the ugly optimization.

Within a sly macroexpansion buffer some extra commands are provided (these commands are always available but are only bound to keys in a macroexpansion buffer).

C-c C-m
M-x sly-macroexpand-1-inplace
: Just like sly-macroexpand-1 but the original form is replaced with the expansion.

g
M-x sly-macroexpand-1-inplace
: The last macroexpansion is performed again, the current contents of the macroexpansion buffer are replaced with the new expansion.

q
M-x sly-temp-buffer-quit
: Close the expansion buffer.

C-_
M-x sly-macroexpand-undo
: Undo last macroexpansion operation.

5 Common functionality

This chapter describes the commands available throughout SLY-enabled buffers, which are not only Lisp source buffers, but every auxiliary buffer created by SLY, such as the REPL, Inspector, etc (see Chapter 6 [The REPL and other special buffers], page 25) In general, it's a good bet that if the buffer's name starts with `*sly-...*`, these commands and functionality will be available there.

5.1 Finding definitions

One of the most used keybindings across all of SLY is the familiar *M-.* binding for *sly-edit-definition*.

Here's the gist of it: when pressed with the cursor over a symbol name, that symbol's name definition is looked up by the Lisp process, thus producing a Lisp source location, which might be a file, or a file-less buffer. For convenience, a type of "breadcrumb" is left behind at the original location where *M-.* was pressed, so that another keybinding *M-,* takes the user back to the original location. Thus multiple *M-.* trace a path through lisp sources that can be traced back with an equal number of *M-,*.

M-.
M-x sly-edit-definition
: Go to the definition of the symbol at point.

M-,
*M-**
M-x sly-pop-find-definition-stack
: Go back to the point where *M-.* was invoked. This gives multi-level backtracking when *M-.* has been used several times.

C-x 4 .
M-x sly-edit-definition-other-window
: Like `sly-edit-definition` but switches to the other window to edit the definition in.

C-x 5 .
M-x sly-edit-definition-other-frame
: Like `sly-edit-definition` but opens another frame to edit the definition in.

The behaviour of the *M-.* binding is sometimes affected by the type of symbol you are giving it.

- For single functions or variables, *M-.* immediately switches the current window's buffer and position to the target `defun` or `defvar`.
- For symbols with more than one associated definition, say, generic functions, the same *M-.* finds all methods and presents these results in separate window displaying a special `*sly-xref*` buffer (see Section 5.2 [Cross-referencing], page 17).

5.2 Cross-referencing

Finding and presenting the definition of a function is actually the most elementary aspect of broader *cross-referencing* facilities framework in SLY. There are other types of questions about the source code relations that you can ask the Lisp process.[1]

The following keybindings behave much like the `M-.` keybinding (see Section 5.1 [Finding definitions], page 16): when pressed as is they make a query about the symbol at point, but with a `C-u` prefix argument they prompt the user for a symbol. Importantly, they always popup a transient `*sly-xref*` buffer in a different window.

`M-?`
`M-x sly-edit-uses`
: Find all the references to this symbol, whatever the type of that reference.

`C-c C-w C-c`
`M-x sly-who-calls`
: Show function callers.

`C-c C-w C-w`
`M-x sly-calls-who`
: Show all known callees.

`C-c C-w C-r`
`M-x sly-who-references`
: Show references to global variable.

`C-c C-w C-b`
`M-x sly-who-binds`
: Show bindings of a global variable.

`C-c C-w C-s`
`M-x sly-who-sets`
: Show assignments to a global variable.

`C-c C-w C-m`
`M-x sly-who-macroexpands`
: Show expansions of a macro.

`M-x sly-who-specializes`
: Show all known methods specialized on a class.

There are two further "List callers/callees" commands that operate by rummaging through function objects on the heap at a low-level to discover the call graph. They are only available with some Lisp systems, and are most useful as a fallback when precise XREF information is unavailable.

`C-c <`
`M-x sly-list-callers`
: List callers of a function.

[1] This depends on the underlying implementation of some of these facilities: for systems with no built-in XREF support SLY queries a portable XREF package, which is taken from the *CMU AI Repository* and bundled with SLY.

C-c >
M-x sly-list-callees
: List callees of a function.

In the resulting `*sly-xref*` buffer, these commands are available:

RET
M-x sly-show-xref
: Show definition at point in the other window. Do not leave the `*sly-xref` buffer.

Space
M-x sly-goto-xref
: Show definition at point in the other window and close the `*sly-xref` buffer.

C-c C-c
M-x sly-recompile-xref
: Recompile definition at point. Uses prefix arguments like `sly-compile-defun`.

C-c C-k
M-x sly-recompile-all-xrefs
: Recompile all definitions. Uses prefix arguments like `sly-compile-defun`.

5.3 Auto-completion

Completion commands are used to complete a symbol or form based on what is already present at point. Emacs has many completion mechanisms that SLY tries to mimic as much as possible.

SLY provides two styles of completion. The choice between them happens in the Emacs customization variable see [sly-complete-symbol-function], page 42, which can be set to two values, or methods:

1. `sly-flex-completions` This method is speculative. It assumes that the letters you've already typed aren't necessarily an exact prefix of the symbol you're thinking of. Therefore, any possible completion that contains these letters, in the order that you have typed them, is potentially a match. Completion matches are then sorted according to a score that should reflect the probability that you really meant that them.

   Flex completion implies that the package-qualification needed to access some symbols is automatically discovered for you. However, to avoid searching too many symbols unnecessarily, this method makes some minimal assumptions that you can override: it assumes, for example, that you don't normally want to complete to fully qualified internal symbols, but will do so if it finds two consecutive colons (`::`) in your initial pattern. Similarly, it assumes that if you start a completion on a word starting `:`, you must mean a keyword (a symbol from the keyword package.)

   Here are the top results for some typical searches.

```
CL-USER> (quiloa<TAB>)          ->  (ql:quickload)
CL-USER> (mvbind<TAB>)          ->  (multiple-value-bind)
CL-USER> (scan<TAB>)            ->  (ppcre:scan)
CL-USER> (p::scan<TAB>)         ->  (ppcre::scanner)
CL-USER> (setf locadirs<TAB>)   ->  (setf ql:*local-project-directories*)
```

```
CL-USER> foobar                  ->  asdf:monolithic-binary-op
```

2. `sly-simple-completions` This method uses "classical" completion on an exact prefix. Although poorer, this is simpler, more predictable and closer to the default Emacs completion method. You type a prefix for a symbol reference and SLY let's you choose from symbols whose beginnings match it exactly.

As an enhancement in SLY over Emacs' built-in completion styles, when the `*sly-completions*` buffer pops up, some keybindings are momentarily diverted to it:

C-n
<down>
M-x sly-next-completion
: Select the next completion.

C-p
<up>
M-x sly-prev-completion
: Select the previous completion.

tab
RET
M-x sly-choose-completion
: Choose the currently selected completion and enter it at point.

As soon as the user selects a completion or gives up by pressing *C-g* or moves out of the symbol being completed, the `*sly-completions*` buffer is closed.

5.4 Interactive objects

In many buffers and modes in SLY, there are snippets of text that represent objects "living" in the Lisp process connected to SLY. These regions are known in SLY as interactive values or objects. You can tell these objects from regular text by their distinct "face", is Emacs parlance for text colour, or decoration. Another way to check if bit of text is an interactive object is to hover above it with the mouse and right-click (*<mouse-3>*) it: a context menu will appear listing actions that you can take on that object.

Depending on the mode, different actions may be active for different types of objects. Actions can also be invoked using keybindings active only when the cursor is on the button.

M-RET, ``Copy to REPL''
: Copy the object to the main REPL (see Section 6.1.2 [REPL output], page 26, and see Section 6.1.3 [REPL backreferences], page 28).

M-S-RET, ``Copy call to REPL''
: An experimental feature. On some backtrace frames in the Debugger (see Section 6.3 [Debugger], page 30) and Trace Dialog (see Section 6.4 [Trace Dialog], page 32), copy the object to the main REPL. That's *meta-shift-return*, by the way, there's no capital "S".

.,''Go To Source''
: For function symbols, debugger frames, or traced function calls, go to the Lisp source, much like with *M-.*.

v,''Show Source''
: For function symbols, debugger frames, or traced function calls, show the Lisp source in another window, but don't switch to it.

p,''Pretty Print''
: Pretty print the object in a separate buffer, much like `sly-pprint-eval-last-expression`.

i,''Inspect''
: Inspect the object in a separate inspector buffer (see Section 6.2 [Inspector], page 29).

d,''Describe''
: Describe the object in a separate buffer using Lisp's `CL:DESCRIBE`.

5.5 Documentation commands

SLY's online documentation commands follow the example of Emacs Lisp. The commands all share the common prefix *C-c C-d* and allow the final key to be modified or unmodified (see Section 7.1.1 [Keybindings], page 40.)

M-x sly-info
: This command should land you in an electronic version of this very manual that you can read inside Emacs.

C-c C-d C-d
M-x sly-describe-symbol
: Describe the symbol at point.

C-c C-d C-f
M-x sly-describe-function
: Describe the function at point.

C-c C-d C-a
M-x sly-apropos
: Perform an apropos search on Lisp symbol names for a regular expression match and display their documentation strings. By default the external symbols of all packages are searched. With a prefix argument you can choose a specific package and whether to include unexported symbols.

C-c C-d C-z
M-x sly-apropos-all
: Like `sly-apropos` but also includes internal symbols by default.

C-c C-d C-p
M-x sly-apropos-package
: Show apropos results of all symbols in a package. This command is for browsing a package at a high-level. With package-name completion it also serves as a rudimentary Smalltalk-ish image-browser.

C-c C-d C-h
M-x sly-hyperspec-lookup
: Lookup the symbol at point in the *Common Lisp Hyperspec*. This uses the familiar `hyperspec.el` to show the appropriate section in a web browser. The

Hyperspec is found either on the Web or in `common-lisp-hyperspec-root`, and the browser is selected by `browse-url-browser-function`.

Note: this is one case where *C-c C-d h* is *not* the same as *C-c C-d C-h*.

C-c C-d ~
M-x hyperspec-lookup-format
: Lookup a *format character* in the *Common Lisp Hyperspec*.

C-c C-d #
M-x hyperspec-lookup-reader-macro
: Lookup a *reader macro* in the *Common Lisp Hyperspec*.

5.6 Multiple connections

SLY is able to connect to multiple Lisp processes at the same time. The *M-x sly* command, when invoked with a prefix argument, will offer to create an additional Lisp process if one is already running. This is often convenient, but it requires some understanding to make sure that your SLY commands execute in the Lisp that you expect them to.

Some SLY buffers are tied to specific Lisp processes. It's easy read that from the buffer's name which will usually be `*sly-<something> for <connection>*`, where `connection` is the name of the connection.

Each Lisp connection has its own main REPL buffer (see Section 6.1 [REPL], page 25), and all expressions entered or SLY commands invoked in that buffer are sent to the associated connection. Other buffers created by SLY are similarly tied to the connections they originate from, including SLY-DB buffers (see Section 6.3 [Debugger], page 30), apropos result listings, and so on. These buffers are the result of some interaction with a Lisp process, so commands in them always go back to that same process.

Commands executed in other places, such as `sly-mode` source buffers, always use the "default" connection. Usually this is the most recently established connection, but this can be reassigned via the "connection list" buffer:

C-c C-x c
M-x sly-list-connections
: Pop up a buffer listing the established connections.

C-c C-x n
M-x sly-next-connection
: Switch to the next Lisp connection by cycling through all connections.

C-c C-x p
M-x sly-prev-connection
: Switch to the previous Lisp connection by cycling through all connections.

The buffer displayed by `sly-list-connections` gives a one-line summary of each connection. The summary shows the connection's serial number, the name of the Lisp implementation, and other details of the Lisp process. The current "default" connection is indicated with an asterisk.

The commands available in the connection-list buffer are:

RET
M-x sly-goto-connection
: Pop to the REPL buffer of the connection at point.

d
M-x sly-connection-list-make-default
: Make the connection at point the "default" connection. It will then be used for commands in `sly-mode` source buffers.

g
M-x sly-update-connection-list
: Update the connection list in the buffer.

q
M-x sly-temp-buffer-quit
: Quit the connection list (kill buffer, restore window configuration).

R
M-x sly-restart-connection-at-point
: Restart the Lisp process for the connection at point.

M-x sly-connect
: Connect to a running Slynk server. With prefix argument, asks if all connections should be closed first.

M-x sly-disconnect
: Disconnect all connections.

M-x sly-abort-connection
: Abort the current attempt to connect.

5.7 Disassembly commands

C-c M-d
M-x sly-disassemble-symbol
: Disassemble the function definition of the symbol at point.

C-c C-t
M-x sly-toggle-trace-fdefinition
: Toggle tracing of the function at point. If invoked with a prefix argument, read additional information, like which particular method should be traced.

M-x sly-untrace-all
: Untrace all functions.

5.8 Abort/Recovery commands

C-c C-b
M-x sly-interrupt
: Interrupt Lisp (send `SIGINT`).

M-x sly-restart-inferior-lisp
: Restart the `inferior-lisp` process.

C-c ~
M-x sly-mrepl-sync
: Synchronize the current package and working directory from Emacs to Lisp.

M-x sly-cd
: Set the current directory of the Lisp process. This also changes the current directory of the REPL buffer.

M-x sly-pwd
: Print the current directory of the Lisp process.

5.9 Temporary buffers

Some SLY commands create temporary buffers to display their results. Although these buffers usually have their own special-purpose major-modes, certain conventions are observed throughout.

Temporary buffers can be dismissed by pressing *q*. This kills the buffer and restores the window configuration as it was before the buffer was displayed. Temporary buffers can also be killed with the usual commands like `kill-buffer`, in which case the previous window configuration won't be restored.

Pressing *RET* is supposed to "do the most obvious useful thing." For instance, in an apropos buffer this prints a full description of the symbol at point, and in an XREF buffer it displays the source code for the reference at point. This convention is inherited from Emacs's own buffers for apropos listings, compilation results, etc.

Temporary buffers containing Lisp symbols use `sly-mode` in addition to any special mode of their own. This makes the usual SLY commands available for describing symbols, looking up function definitions, and so on.

Initial focus of those "description" buffers depends on the variable `sly-description-autofocus`. If `nil` (the default), description buffers do not receive focus automatically, and vice versa.

5.10 Multi-threading

If the Lisp system supports multi-threading, SLY spawns a new thread for each request, e.g., *C-x C-e* creates a new thread to evaluate the expression. An exception to this rule are requests from the REPL: all commands entered in the REPL buffer are evaluated in a dedicated REPL thread.

You can see a listing of the threads for the current connection with the command `M-x sly-list-threads`, or `C-c C-x t`. This pops open a `*sly-threads*` buffer, where some keybindings to control threads are active, if you know what you are doing. The most useful is probably *k* to kill a thread, but type *C-h m* in that buffer to get a full listing.

Some complications arise with multi-threading and special variables. Non-global special bindings are thread-local, e.g., changing the value of a let bound special variable in one thread has no effect on the binding of the variables with the same name in other threads. This makes it sometimes difficult to change the printer or reader behaviour for new threads. The variable `slynk:*default-worker-thread-bindings*` was introduced for such situations: instead of modifying the global value of a variable, add a binding the

`slynk:*default-worker-thread-bindings*`. E.g., with the following code, new threads will read floating point values as doubles by default:

```
(push '(*read-default-float-format* . double-float)
      slynk:*default-worker-thread-bindings*).
```

6 The REPL and other special buffers

6.1 The REPL: the "top level"

SLY uses a custom Read-Eval-Print Loop (REPL, also known as a "top level", or listener):

- Conditions signalled in REPL expressions are debugged with the integrated SLY debugger.
- Return values are interactive values (see Section 5.4 [Interactive objects], page 19) distinguished from printed output by separate Emacs faces (colors).
- Output from the Lisp process is inserted in the right place, and doesn't get mixed up with user input.
- Multiple REPLs are possible in the same Lisp connection. This is useful for performing quick one-off experiments in different packages or directories without disturbing the state of an existing REPL.
- The REPL is a central hub for much of SLY's functionality, since objects examined in the inspector (see Section 6.2 [Inspector], page 29), debugger (see Section 6.3 [Debugger], page 30), and other extensions can be returned there.

Switching to the REPL from anywhere in a SLY buffer is a very common task. One way to do it is to find the `*sly-mrepl...*` buffer in Emacs's buffer list, but there are other ways to reach a REPL.

C-c C-z
M-x sly-mrepl
: Start or select an existing main REPL buffer.

M-x sly-mrepl-new
: Start a new secondary REPLsession, prompting for a nickname.

C-c ~
M-x sly-mrepl-sync
: Go to the REPL, switching package and default directory as applicable. More precisely the Lisp variables `*package*` and `*default-pathname-defaults*` are affected by the location where the command was issued. In a specific position of a `.lisp` file, for instance the current package and that file's directory are chosen.

6.1.1 REPL commands

RET
M-x sly-mrepl-return
: Evaluate the expression at prompt and return the result.

TAB
M-x sly-mrepl-indent-and-complete-symbol
: Indent the current line. If line already indented complete the symbol at point (see Section 5.3 [Completion], page 18). If there is not symbol at point show the argument list of the most recently enclosed function or macro in the minibuffer.

M-p
M-x sly-mrepl-previous-input-or-button
: When at the current prompt, fetches previous input from the history, otherwise jumps to the previous interactive value (see Section 5.4 [Interactive objects], page 19) representing a Lisp object.

M-n
M-x sly-mrepl-next-input-or-button
: When at the current prompt, fetches next input from the history, otherwise jumps to the previous interactive value representing a Lisp object.

C-r
M-x isearch-backward
: This regular Emacs keybinding, when invoked at the current REPL prompt, starts a special transient mode turning the prompt into the string "History-isearch backward". While in this mode, the user can compose a string used to search backwards through history, and reverse the direction of search by pressing *C-s*. When invoked outside the current REPL prompt, does a normal text search through the buffer contents.

C-c C-b
M-x sly-interrupt
: Interrupts the current thread of the inferior-lisp process.

  For convenience this function is also bound to *C-c C-c*.

C-M-p
M-x sly-button-backward
: Jump to the previous interactive value representing a Lisp object.

C-M-n
M-x sly-button-forward
: Jump to the next interactive value representing a Lisp object.

C-c C-o
M-x sly-mrepl-clear-recent-output
: Clear output between current and last REPL prompts, keeping results.

C-c M-o
M-x sly-mrepl-clear-repl
: Clear the whole REPL of output and results.

6.1.2 REPL output

REPLs wouldn't be much use if they just took user input and didn't print anything back. In SLY the output printed to the REPL can come from four different places:

- A function's return values. One line per return value is printed. Each line of printed text, called a REPL result, persists after more expressions are evaluated, and is actually a button (see Section 5.4 [Interactive objects], page 19) presenting the Lisp-side object. You can, for instance, inspect it (see Section 6.2 [Inspector], page 29) or re-return it to right before the current command prompt so that you may conjure it up again, as usual in Lisp REPLs, with the special variable `*`.

In the SLY REPL, in addition to the `*`, `**` and `***` special variables, return values can also be accessed through a special backreference (see Section 6.1.3 [REPL backreferences], page 28).

- An object may be copied to the REPL from some other part in SLY, such as the Inspector (see Section 6.2 [Inspector], page 29), Debugger (see Section 6.3 [Debugger], page 30), etc. using the familiar *`M-RET`* binding, or by selecting "Copy to REPL" from the context menu of an interactive object. Aside from not having been produced by the evaluation of a Lisp form in the REPL, these objects behaves exactly like a REPL result.
- The characters printed to the standard Lisp streams `*standard-output*`, `*error-output*` and `*trace-output*` as a *synchronous* and direct result of the evaluation of an expression in the REPL.
- The characters printed to the standard Lisp streams `*standard-output*`, `*error-output*` and `*trace-output*` printed, perhaps *asynchronously*, from others threads, for instance. This feature is optional and controlled by the variable `SLYNK:*GLOBALLY-REDIRECT-IO*`.

For advanced users, there are some Lisp-side Slynk variables affecting the way Slynk transmits REPL output to SLY.

`SLYNK:*GLOBALLY-REDIRECT-IO*`
: This variable controls the global redirection of the the standard streams (`*standard-output*`, etc) to the REPL in Emacs. The default value is `:started-from-emacs`, which means that redirection should only take place upon `M-x sly` invocations. When `t`, global redirection happens even for sessions started with `M-x sly-connect`, meaning output may be diverted from wherever you started the Lisp server originally.

  When `NIL` these streams are only temporarily redirected to Emacs using dynamic bindings while handling requests, meaning you only see output caused by the commands you issued to the REPL.

  Note that `*standard-input*` is currently never globally redirected into Emacs, because it can interact badly with the Lisp's native REPL by having it try to read from the Emacs one.

  Also note that secondary REPLs (those started with *`sly-mrepl-new`*) don't receive any redirected output.

`SLYNK:*USE-DEDICATED-OUTPUT-STREAM*`
: This variable controls whether to use a separate socket solely for Lisp to send printed output to Emacs through, which is more efficient than sending the output in protocol messages to Emacs.

  The default value is `:started-from-emacs`, which means that the socket should only be established upon `M-x sly` invocations. When `t`, it's established even for sessions started with `M-x sly-connect`. When `NIL` usual protocol messages are used for sending input to the REPL.

  Notice that using a dedicated output stream makes it more difficult to communicate to a Lisp running on a remote host via SSH (see Section 8.1 [Connecting

to a remote Lisp], page 47). If you connect via `M-x sly-connect`, the default `:started-from-emacs` value should ensure this isn't a problem.

`SLYNK:*DEDICATED-OUTPUT-STREAM-PORT*`
When `*USE-DEDICATED-OUTPUT-STREAM*` is `t` the stream will be opened on this port. The default value, `0`, means that the stream will be opened on some random port.

`SLYNK:*DEDICATED-OUTPUT-STREAM-BUFFERING*`
For efficiency, some Lisps backends wait until a certain conditions are met in a Lisp character stream before flushing that stream's contents, thus sending it to the SLY REPL. Be advised that this sometimes works poorly on some implementations, so it's probably best to leave alone. Possible values are `nil` (no buffering), `t` (enable buffering) or `:line` (enable buffering on EOL)

6.1.3 REPL backreferences

In a regular Lisp REPL, the objects produced by evaluating expressions at the command prompt can usually be referenced in future commands using the special variables `*`, `**` and `***`. This is also true of the SLY REPL, but it also provides a different way to re-conjure these objects through a special Lisp reader macro character available only in the REPL. The macro character, which is `#v` by default takes, in a terse syntax, two indexes specifying the precise objects in all of the SLY REPL's recorded history.

Consider this fragment of a REPL session:

```
; Cleared REPL history
CL-USER> (values 'a 'b 'c)
A
B
C
CL-USER> (list #v0)
(A)
CL-USER> (list #v0:1 #v0:2)
(B C)
CL-USER> (append #v1:0 #v2:0)
(A B C)
CL-USER>
```

Admittedly, while useful, this doesn't seem terribly easy to use at first sight. There are a couple of reasons, however, that should make it worth considering:

- Backreference annotation and highlighting

  As soon as the SLY REPL detects that you have pressed `#v`, all the REPL results that can possibly be referenced are temporarily annotated on their left with two special numbers. These numbers are in the syntax accepted by the `#v` macro-character, namely `#vENTRY-IDX:VALUE-IDX`.

  Furthermore, as soon as you type a number for `ENTRY-IDX`, only that entries values remain highlighted. Then, as you finish the entry with `VALUE-IDX`, only that exact object remains highlighted. If you make a mistake (say, by typing a letter or an invalid number) while composing `#v` syntax, SLY lets you know by painting the backreference red.

Highlighting also happens when you place the cursor over existing valid `#v` expressions.

- Returning functions calls

  An experimental feature in SLY allows copying *function calls* to the REPL from the Debugger (see Section 6.3 [Debugger], page 30) and the Trace Dialog (see Section 6.4 [Trace Dialog], page 32). In those buffers, pressing keybinding *`M-S-RET`* over objects that represent function calls will copy the *call*, and not the object, to the REPL. This works by first copying over the argument objects in order to the REPL results, and then composing an input line that includes the called function's name and backreferences to those arguments (see Section 6.1.3 [REPL backreferences], page 28).

  Naturally, this call isn't *exactly* the same because it doesn't evaluate in the same dynamic environment as the original one. But it's a useful debug technique because backreferences are stable[1], so repeating that very same function call with the very same arguments is just a matter of textually copying the previous expression into the command prompt, no matter how far ago it happened. And that, in turn, is as easy as using *`C-r`* and some characters (see Section 6.1.1 [REPL commands], page 25) to arrive and repeat the desired REPL history entry.

6.2 The Inspector

The SLY inspector is a Emacs-based alternative to the standard `INSPECT` function. The inspector presents objects in Emacs buffers using a combination of plain text, hyperlinks to related objects.

The inspector can easily be specialized for the objects in your own programs. For details see the `inspect-for-emacs` generic function in `slynk-backend.lisp`.

`C-c I`
`M-x sly-inspect`
: Inspect the value of an expression entered in the minibuffer.

The standard commands available in the inspector are:

`RET`
`M-x sly-inspector-operate-on-point`
: If point is on a value then recursively call the inspector on that value. If point is on an action then call that action.

`D`
`M-x sly-inspector-describe-inspectee`
: Describe the slot at point.

`e`
`M-x sly-inspector-eval`
: Evaluate an expression in the context of the inspected object. The variable `*` will be bound to the inspected object.

`v`
`M-x sly-inspector-toggle-verbose`
: Toggle between verbose and terse mode. Default is determined by 'slynk:*inspector-verbose*'.

[1] until you clear the REPL's output, that is

l
M-x sly-inspector-pop
: Go back to the previous object (return from *RET*).

n
M-x sly-inspector-next
: The inverse of *l*. Also bound to *SPC*.

g
M-x sly-inspector-reinspect
: Reinspect.

h
M-x sly-inspector-history
: Show the previously inspected objects.

q
M-x sly-inspector-quit
: Dismiss the inspector buffer.

>
M-x sly-inspector-fetch-all
: Fetch all inspector contents and go to the end.

M-RET
M-x sly-mrepl-copy-part-to-repl
: Store the value under point in the variable '*'. This can then be used to access the object in the REPL.

TAB, M-x forward-button
S-TAB, M-x backward-button
: Jump to the next and previous inspectable object respectively.

6.3 The SLY-DB Debugger

SLY has a custom Emacs-based debugger called SLY-DB. Conditions signalled in the Lisp system invoke SLY-DB in Emacs by way of the Lisp `*DEBUGGER-HOOK*`.

SLY-DB pops up a buffer when a condition is signalled. The buffer displays a description of the condition, a list of restarts, and a backtrace. Commands are offered for invoking restarts, examining the backtrace, and poking around in stack frames.

6.3.1 Examining frames

Commands for examining the stack frame at point.

t
M-x sly-db-toggle-details
: Toggle display of local variables and `CATCH` tags.

v
M-x sly-db-show-frame-source
: View the frame's current source expression. The expression is presented in the Lisp source file's buffer.

e
M-x sly-db-eval-in-frame
: Evaluate an expression in the frame. The expression can refer to the available local variables in the frame.

d
M-x sly-db-pprint-eval-in-frame
: Evaluate an expression in the frame and pretty-print the result in a temporary buffer.

D
M-x sly-db-disassemble
: Disassemble the frame's function. Includes information such as the instruction pointer within the frame.

i
M-x sly-db-inspect-in-frame
: Inspect the result of evaluating an expression in the frame.

C-c C-c
M-x sly-db-recompile-frame-source
: Recompile frame. *C-u C-c C-c* for recompiling with maximum debug settings.

6.3.2 Invoking restarts

a
M-x sly-db-abort
: Invoke the `ABORT` restart.

q
M-x sly-db-quit
: "Quit" – For SLY evaluation requests, invoke a restart which restores to a known program state. For errors in other threads, See [*SLY-DB-QUIT-RESTART*], page 44.

c
M-x sly-db-continue
: Invoke the `CONTINUE` restart.

0 ... 9
M-x sly-db-invoke-restart-n
: Invoke a restart by number.

Restarts can also be invoked by pressing *RET* or *Mouse-2* on them in the buffer.

6.3.3 Navigating between frames

n, M-x sly-db-down
p, M-x sly-db-up
: Move between frames.

M-n, *M-x sly-db-details-down*
M-p, *M-x sly-db-details-up*
: Move between frames "with sugar": hide the details of the original frame and display the details and source code of the next. Sugared motion makes you see the details and source code for the current frame only.

>
M-x sly-db-end-of-backtrace
: Fetch the entire backtrace and go to the last frame.

<
M-x sly-db-beginning-of-backtrace
: Go to the first frame.

6.3.4 Miscellaneous Commands

r
M-x sly-db-restart-frame
: Restart execution of the frame with the same arguments it was originally called with. (This command is not available in all implementations.)

R
M-x sly-db-return-from-frame
: Return from the frame with a value entered in the minibuffer. (This command is not available in all implementations.)

B
M-x sly-db-break-with-default-debugger
: Exit SLY-DB and debug the condition using the Lisp system's default debugger.

C
M-x sly-db-inspect-condition
: Inspect the condition currently being debugged.

:
M-x sly-interactive-eval
: Evaluate an expression entered in the minibuffer.

A
M-x sly-db-break-with-system-debugger
: Attach debugger (e.g. gdb) to the current lisp process.

6.4 Trace Dialog

The SLY Trace Dialog, in package `sly-trace-dialog`, is a tracing facility, similar to Common Lisp's `trace`, but interactive rather than purely textual.

You use it just like you would regular `trace`: after tracing a function, calling it causes interesting information about that particular call to be reported.

However, instead of printing the trace results to the the `*trace-output*` stream (usually the REPL), the SLY Trace Dialog collects and stores them in your Lisp environment until, on user's request, they are fetched into Emacs and displayed in a dialog-like interactive view.

After starting up SLY, SLY's Trace Dialog installs a *Trace* menu in the menu-bar of any `sly-mode` buffer and adds two new commands, with respective key-bindings:

C-c C-t
M-x sly-trace-dialog-toggle-trace

If point is on a symbol name, toggle tracing of its function definition. If point is not on a symbol, prompt user for a function.

With a *C-u* prefix argument, and if your lisp implementation allows it, attempt to decipher lambdas, methods and other complicated function signatures.

The function is traced for the SLY Trace Dialog only, i.e. it is not found in the list returned by Common Lisp's `trace`.

C-c T
M-x sly-trace-dialog

Pop to the interactive Trace Dialog buffer associated with the current connection (see Section 5.6 [Multiple connections], page 21).

Consider the (useless) program:

```
(defun foo (n) (if (plusp n) (* n (bar (1- n))) 1))
(defun bar (n) (if (plusp n) (* n (foo (1- n))) 1))
```

After tracing both `foo` and `bar` with *C-c M-t*, calling call `(foo 2)` and moving to the trace dialog with *C-c T*, we are presented with this buffer.

```
Traced specs (2)                                        [refresh]
                                                        [untrace all]
  [untrace] common-lisp-user::bar
  [untrace] common-lisp-user::foo

Trace collection status (3/3)                           [refresh]
                                                        [clear]

   0 - common-lisp-user::foo
     | > 2
     | < 2
   1 `--- common-lisp-user::bar
        | > 1
        | < 1
   2    `-- common-lisp-user::foo
             > 0
             < 1
```

The dialog is divided into sections displaying the functions already traced, the trace collection progress and the actual trace tree that follow your program's logic. The most important key-bindings in this buffer are:

g
M-x sly-trace-dialog-fetch-status
: Update information on the trace collection and traced specs.

G
M-x sly-trace-dialog-fetch-traces
: Fetch the next batch of outstanding (not fetched yet) traces. With a *C-u* prefix argument, repeat until no more outstanding traces.

C-k
M-x sly-trace-dialog-clear-fetched-traces
: Prompt for confirmation, then clear all traces, both fetched and outstanding.

The arguments and return values below each entry are interactive buttons. Clicking them opens the inspector (see Section 6.2 [Inspector], page 29). Invoking *M-RET* (`sly-trace-dialog-copy-down-to-repl`) returns them to the REPL for manipulation (see Section 6.1 [REPL], page 25). The number left of each entry indicates its absolute position in the calling order, which might differ from display order in case multiple threads call the same traced function.

`sly-trace-dialog-hide-details-mode` hides arguments and return values so you can concentrate on the calling logic. Additionally, `sly-trace-dialog-autofollow-mode` will automatically display additional detail about an entry when the cursor moves over it.

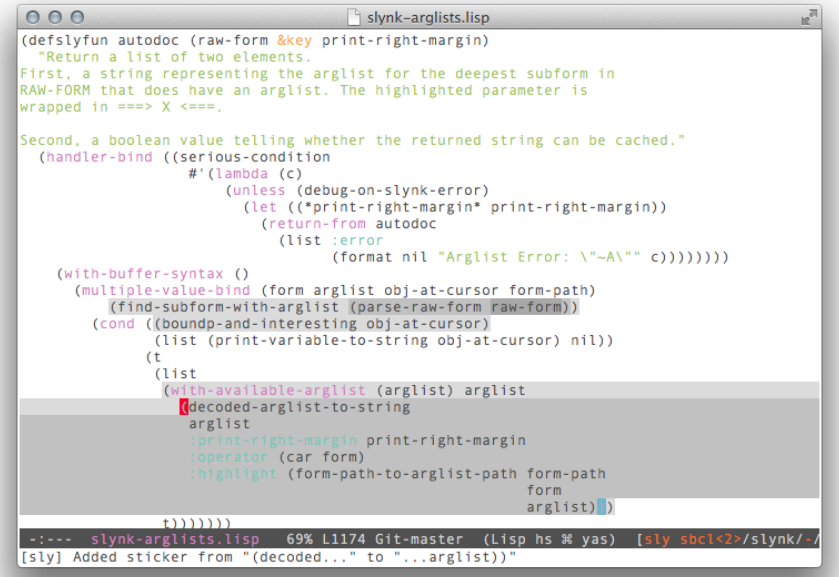
6.5 Stickers

SLY Stickers, implemented as the `sly-stickers` contrib (see Chapter 9 [Extensions], page 51), is a tool for "live" code annotations. It's an alternative to the `print` or `break` statements you add to your code when debugging.

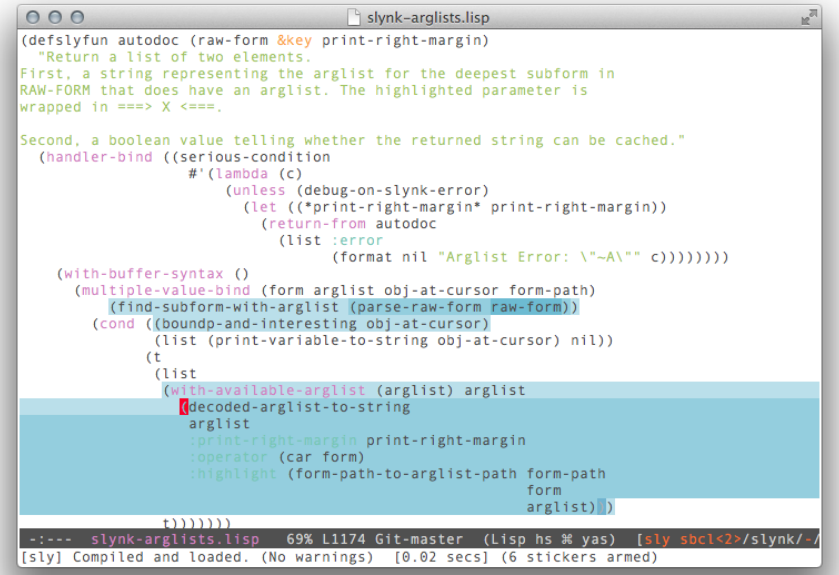
Contrary to these techniques, "stickers" are non-intrusive, meaning that saving your file doesn't save your debug code along with it.

Here's the general workflow:

- In Lisp source files, using *C-c C-s C-s* or `M-x sly-stickers-dwim` places a sticker on any Lisp form. Stickers can exist inside other stickers.

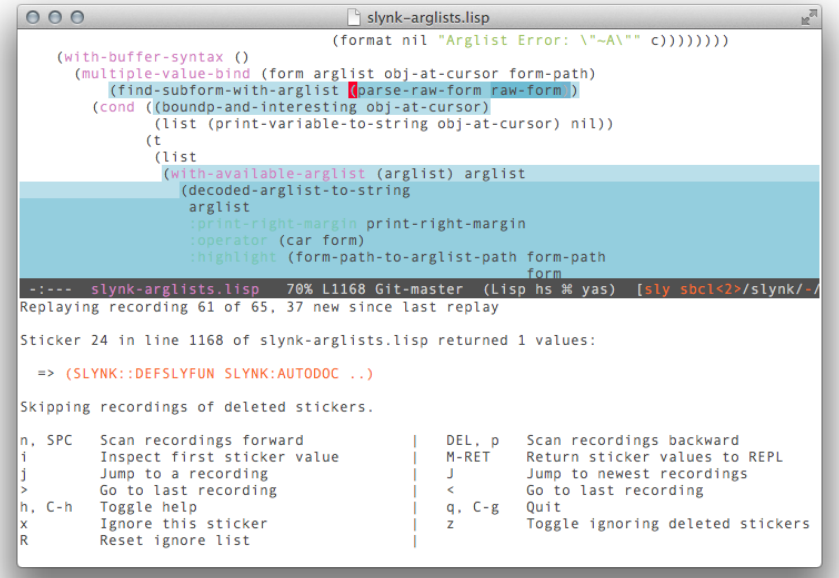


- Stickers are "armed" when a definition or a file is compiled with the familiar *C-c C-c* (`M-x sly-compile-defun`) or *C-c C-k* (`M-x sly-compile-file`) commands. An armed sticker changes color from the default grey background to a blue background.

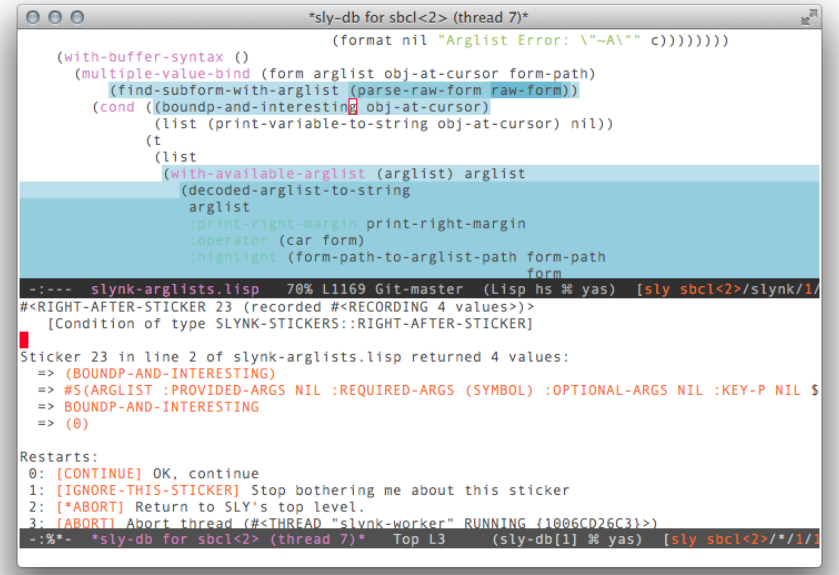


From this point on, when the Lisp code is executed, the results of evaluating the underlying forms are captured in the Lisp side. Stickers help you examine your program's behaviour in three ways:

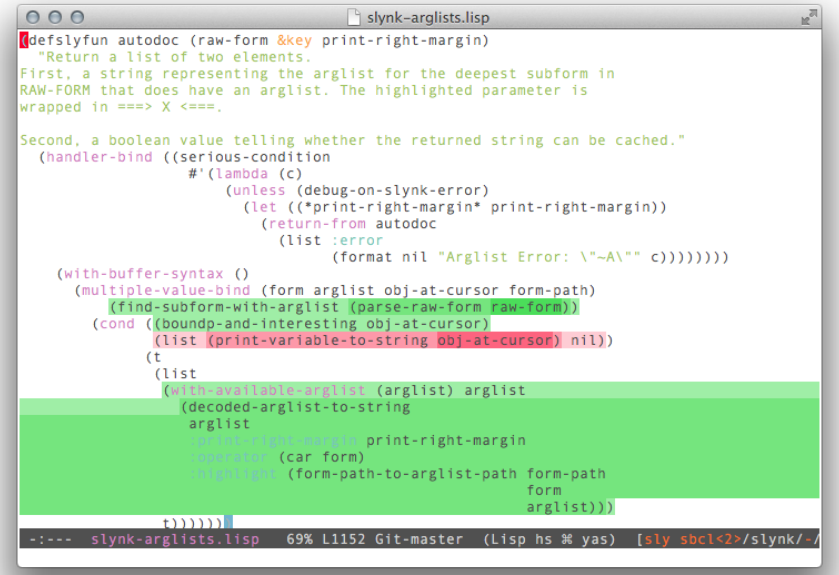
1. `C-c C-s C-r` (or `M-x sly-stickers-replay`) interactively walks the user through recordings in the order that they occurred. In the created `*sly-stickers-replay*` buffer, type `h` for a list of keybindings active in that buffer.



2. To step through stickers as your code is executed, ensure that "breaking stickers" are enabled via `M-x sly-stickers-toggle-break-on-stickers`. Whenever a sticker-covered expression is reached, the debugger comes up with useful restarts and interactive for the values produced. You can tweak this behaviour by setting the Lisp-side variable `SLYNK-STICKERS:*BREAK-ON-STICKERS*` to a list with the elements `:before` and `:after`, making SLY break before a sticker, after it, or both.



3. *C-c C-s S* (`M-x sly-stickers-fetch`) populates the sticker overlay with the latest captured results, called "recordings". If a sticker has captured any recordings, it will turn green, otherwise it will turn red. A sticker whose Lisp expression has caused a non-local exit, will be also be marked with a special face.



At any point, stickers can be removed with the same `sly-stickers-dwim` keybinding, by placing the cursor at the beginning of a sticker. Additionally adding prefix arguments to `sly-stickers-dwim` increase its scope, so *C-u C-c C-s C-s* will remove all stickers from the current function and *C-u C-u C-c C-s C-s* will remove all stickers from the current file.

Stickers can be nested inside other stickers, so it is possible to record the value of an expression inside another expression which is also annotated.

Stickers are interactive parts just like any other part in SLY that represents Lisp-side objects, so they can be inspected and returned to the REPL, for example. To move through the stickers with the keyboard use the existing keybindings to move through compilation notes (*M-p* and *M-n*) or use *C-c C-s p* and *C-c C-s n* (`sly-stickers-prev-sticker` and `sly-stickers-next-sticker`).

There are some caveats when using SLY Stickers:

- Stickers on unevaluated forms (such as `let` variable bindings, or other constructs) are rejected, though the function is still compiled as usual. To let the user know about this, these stickers remain grey, and are marked as "disarmed". A message also appears in the echo area.
- Stickers placed on expressions inside backquoted expressions in macros are always armed, even though they may come to provoke a runtime error when the macro's expansion is run. Think of this when setting a sticker inside a macro definition.

7 Customization

7.1 Emacs-side

7.1.1 Keybindings

In general we try to make our key bindings fit with the overall Emacs style.

We never bind `C-h` anywhere in a key sequence. This is because Emacs has a built-in default so that typing a prefix followed by `C-h` will display all bindings starting with that prefix, so `C-c C-d C-h` will actually list the bindings for all documentation commands. This feature is just a bit too useful to clobber!

> *"Are you deliberately spiting Emacs's brilliant online help facilities? The gods will be angry!"*

This is a brilliant piece of advice. The Emacs online help facilities are your most immediate, up-to-date and complete resource for keybinding information. They are your friends:

`C-h k <key>`
: `describe-key` *"What does this key do?"*
Describes current function bound to `<key>` for focus buffer.

`C-h b`
: `describe-bindings` *"Exactly what bindings are available?"*
Lists the current key-bindings for the focus buffer.

`C-h m`
: `describe-mode` *"Tell me all about this mode"*
Shows all the available major mode keys, then the minor mode keys, for the modes of the focus buffer.

`C-h l`
: `view-lossage` *"Woah, what key chord did I just do?"*
Shows you the literal sequence of keys you've pressed in order.

For example, you can add one of the following to your Emacs init file (usually `~/.emacs` or `~/.emacs.d/init.el`, but see Section "Emacs Init File" in *The Emacs Manual*).

```
(eval-after-load 'sly
  `(define-key sly-prefix-map (kbd "M-h") 'sly-documentation-lookup))
```

SLY comes bundled with many extensions (called "contribs" for historical reasons, see Chapter 9 [Extensions], page 51) which you can customize just like SLY's code. To make `C-c C-c` clear the last REPL prompt's output, for example, use

```
(eval-after-load 'sly-mrepl
   `(define-key sly-mrepl-mode-map (kbd "C-c C-k")
                'sly-mrepl-clear-recent-output))
```

7.1.2 Keymaps

Emacs's keybindings "live" in keymap variables. To customize a particular binding and keep it from trampling on other important keys you should do it in one of SLY's keymaps. The following non-exhaustive list of SLY-related keymaps is just a reference: the manual will go over each associated functionality in detail.

`sly-doc-map`
: Keymap for documentation commands (see Section 5.5 [Documentation], page 20) in SLY-related buffers, accessible by the `C-c C-d` prefix.

`sly-who-map`
: Keymap for cross-referencing ("who-calls") commands (see Section 5.2 [Cross-referencing], page 17) in SLY-related buffers, accessible by the `C-c C-w` prefix.

`sly-selector-map`
: A keymap for SLY-related functionality that should be available in globally in all Emacs buffers (not just SLY-related buffers).

`sly-mode-map`
: A keymap for functionality available in all SLY-related buffers.

`sly-editing-mode-map`
: A keymap for SLY functionality available in Lisp source files.

`sly-popup-buffer-mode-map`
: A keymap for functionality available in the temporary "popup" buffers that SLY displays (see Section 5.9 [Temporary buffers], page 23)

`sly-apropos-mode-map`
: A keymap for functionality available in the temporary SLY "apropos" buffers (see Section 5.5 [Documentation], page 20).

`sly-xref-mode-map`
: A keymap for functionality available in the temporary `xref` buffers used by cross-referencing commands (see Section 5.2 [Cross-referencing], page 17).

`sly-macroexpansion-minor-mode-map`
: A keymap for functionality available in the temporary buffers used for macroexpansion presentation (see Section 4.6 [Macro-expansion], page 14).

`sly-db-mode-map`
: A keymap for functionality available in the debugger buffers used to debug errors in the Lisp process (see Section 6.3 [Debugger], page 30).

`sly-thread-control-mode-map`
: A keymap for functionality available in the SLY buffers dedicated to controlling Lisp threads (see Section 5.10 [Multi-threading], page 23).

`sly-connection-list-mode-map`
: A keymap for functionality available in the SLY buffers dedicated to managing multiple Lisp connections (see Section 5.6 [Multiple connections], page 21).

`sly-inspector-mode-map`
: A keymap for functionality available in the SLY buffers dedicated to inspecting Lisp objects (see Section 6.2 [Inspector], page 29).

`sly-mrepl-mode-map`
: A keymap for functionality available in SLY's REPL buffers (see Section 6.1 [REPL], page 25).

`sly-trace-dialog-mode-map`
: A keymap for functionality available in SLY's "Trace Dialog" buffers (see Section 6.4 [Trace Dialog], page 32).

7.1.3 Defcustom variables

The Emacs part of SLY can be configured with the Emacs `customize` system, just use *`M-x customize-group sly RET`*. Because the customize system is self-describing, we only cover a few important or obscure configuration options here in the manual.

`sly-truncate-lines`
: The value to use for `truncate-lines` in line-by-line summary buffers popped up by SLY. This is `t` by default, which ensures that lines do not wrap in backtraces, apropos listings, and so on. It can however cause information to spill off the screen.

`sly-complete-symbol-function`
: The function to use for completion of Lisp symbols. Two completion styles are available: `sly-simple-completions` and `sly-flex-completions` (see Section 5.3 [Completion], page 18).

`sly-filename-translations`
: This variable controls filename translation between Emacs and the Lisp system. It is useful if you run Emacs and Lisp on separate machines which don't share a common file system or if they share the filesystem but have different layouts, as is the case with SMB-based file sharing.

`sly-net-coding-system`
: If you want to transmit Unicode characters between Emacs and the Lisp system, you should customize this variable. E.g., if you use SBCL, you can set:

```
(setq sly-net-coding-system 'utf-8-unix)
```

To actually display Unicode characters you also need appropriate fonts, otherwise the characters will be rendered as hollow boxes. If you are using Allegro CL and GNU Emacs, you can also use `emacs-mule-unix` as coding system. GNU Emacs has often nicer fonts for the latter encoding. (Different encodings can be used for different Lisps, see Section 2.6 [Multiple Lisps], page 4.)

`sly-keep-buffers-on-connection-close`
: This variable holds a list of keywords indicating SLY buffer types that should be kept around when a connection closes. For example, if the variable's value includes `:mrepl` (which is the default), REPL buffer is kept around while all other stale buffers (debugger, inspector, etc..) are automatically killed.

The following customization variables affect the behaviour of the REPL (see Section 6.1 [REPL], page 25):

`sly-mrepl-shortcut`
: The key to use to trigger the REPL's "comma shortcut". We recommend you keep the default setting which is the comma (`,`) key, since there's special logic in the REPL to discern if you're typing a comma inside a backquoted list or not.

`sly-mrepl-prompt-formatter`
: Holds a function that can be set from your Emacs init file (see Section "Emacs Init File" in *The Emacs Manual*) to change the way the prompt is rendered. It takes a number of arguments describing the prompt and should return a

propertized Elisp string. See the default value, `sly-mrepl-default-prompt`, for how to implement such a prompt.

`sly-mrepl-history-file-name`
: Holds a string designating the file to use for keeping the shared REPL histories persistently. The default is to use a hidden file named `.sly-mrepl-history` in the user's home directory.

`sly-mrepl-prevent-duplicate-history`
: A symbol. If non-nil, prevent duplicate entries in input history. If the non-nil value is the symbol `move`, the previously occuring entry is moved to a more recent spot.

`sly-mrepl-eli-like-history-navigation`
: If non-NIL, navigate history like in ELI, Franz's Common Lisp IDE for Emacs.

7.1.4 Hooks

`sly-mode-hook`
: This hook is run each time a buffer enters `sly-mode`. It is most useful for setting buffer-local configuration in your Lisp source buffers. An example use is to enable `sly-autodoc-mode` (see Section 4.3 [Autodoc], page 13).

`sly-connected-hook`
: This hook is run when SLY establishes a connection to a Lisp server. An example use is to pop to a new REPL.

`sly-db-hook`
: This hook is run after SLY-DB is invoked. The hook functions are called from the SLY-DB buffer after it is initialized. An example use is to add `sly-db-print-condition` to this hook, which makes all conditions debugged with SLY-DB be recorded in the REPL buffer.

7.2 Lisp-side (Slynk)

The Lisp server side of SLY (known as "Slynk") offers several variables to configure. The initialization file `~/.slynk.lisp` is automatically evaluated at startup and can be used to set these variables.

7.2.1 Communication style

The most important configurable is `SLYNK:*COMMUNICATION-STYLE*`, which specifies the mechanism by which Lisp reads and processes protocol messages from Emacs. The choice of communication style has a global influence on SLY's operation.

The available communication styles are:

`NIL`
: This style simply loops reading input from the communication socket and serves SLY protocol events as they arise. The simplicity means that the Lisp cannot do any other processing while under SLY's control.

`:FD-HANDLER`
: This style uses the classical Unix-style "`select()`-loop." Slynk registers the communication socket with an event-dispatching framework (such as `SERVE-EVENT` in CMUCL and SBCL) and receives a callback when data is available.

In this style requests from Emacs are only detected and processed when Lisp enters the event-loop. This style is simple and predictable.

`:SIGIO` This style uses *signal-driven I/O* with a `SIGIO` signal handler. Lisp receives requests from Emacs along with a signal, causing it to interrupt whatever it is doing to serve the request. This style has the advantage of responsiveness, since Emacs can perform operations in Lisp even while it is busy doing other things. It also allows Emacs to issue requests concurrently, e.g. to send one long-running request (like compilation) and then interrupt that with several short requests before it completes. The disadvantages are that it may conflict with other uses of `SIGIO` by Lisp code, and it may cause untold havoc by interrupting Lisp at an awkward moment.

`:SPAWN` This style uses multiprocessing support in the Lisp system to execute each request in a separate thread. This style has similar properties to `:SIGIO`, but it does not use signals and all requests issued by Emacs can be executed in parallel.

The default request handling style is chosen according to the capabilities of your Lisp system. The general order of preference is `:SPAWN`, then `:SIGIO`, then `:FD-HANDLER`, with `NIL` as a last resort. You can check the default style by calling `SLYNK-BACKEND::PREFERRED-COMMUNICATION-STYLE`. You can also override the default by setting `SLYNK:*COMMUNICATION-STYLE*` in your Slynk init file (see Section 7.2 [Lisp-side customization], page 43).

7.2.2 Other configurables

These Lisp variables can be configured via your `~/.slynk.lisp` file:

`SLYNK:*CONFIGURE-EMACS-INDENTATION*`
This variable controls whether indentation styles for `&body`-arguments in macros are discovered and sent to Emacs. It is enabled by default.

`SLYNK:*GLOBAL-DEBUGGER*`
When true (the default) this causes `*DEBUGGER-HOOK*` to be globally set to `SLYNK:SLYNK-DEBUGGER-HOOK` and thus for SLY to handle all debugging in the Lisp image. This is for debugging multithreaded and callback-driven applications.

`SLYNK:*SLY-DB-QUIT-RESTART*`
This variable names the restart that is invoked when pressing `q` (see [sly-db-quit], page 31) in SLY-DB. For SLY evaluation requests this is *unconditionally* bound to a restart that returns to a safe point. This variable is supposed to customize what `q` does if an application's thread lands into the debugger (see `SLYNK:*GLOBAL-DEBUGGER*`).

```
(setf slynk:*sly-db-quit-restart* 'sb-thread:terminate-thread)
```

`SLYNK:*BACKTRACE-PRINTER-BINDINGS*`
`SLYNK:*MACROEXPAND-PRINTER-BINDINGS*`
`SLYNK:*SLY-DB-PRINTER-BINDINGS*`
`SLYNK:*SLYNK-PPRINT-BINDINGS*`

These variables can be used to customize the printer in various situations. The values of the variables are association lists of printer variable names with the corresponding value. E.g., to enable the pretty printer for formatting backtraces in SLY-DB, you can use:

```
(push '(*print-pretty* . t) slynk:*sly-db-printer-bindings*).
```

The fact that most SLY output (in the REPL for instance, see Section 6.1 [REPL], page 25) uses `SLYNK:*SLYNK-PPRINT-BINDINGS*` may surprise you if you expected it to use a global setting for, say, `*PRINT-LENGTH*`. The rationale for this decision is that output is a very basic feature of SLY, and it should keep operating normally even if you (mistakenly) set absurd values for some `*PRINT-...*` variable. You, of course, override this protection:

```
(setq slynk:*slynk-pprint-bindings*
      (delete '*print-length*
              slynk:*slynk-pprint-bindings* :key #'car))
```

`SLYNK:*STRING-ELISION-LENGTH*`
`SLYNK:*STRING-ELISION-LENGTH*`

This variable controls the maximum length of strings before their pretty printed representation in the Inspector, Debugger, REPL, etc is elided. Don't set this variable directly, create a binding for this variable in `SLYNK:*SLYNK-PPRINT-BINDINGS*` instead.

`SLYNK:*ECHO-NUMBER-ALIST*`
`SLYNK:*PRESENT-NUMBER-ALIST*`

These variables hold function designators used for displaying numbers when SLY presents them in its interface.

The difference between the two functions is that `*PRESENT-NUMBER-ALIST*`, if non-nil, overrides `*ECHO-NUMBER-ALIST*` in the context of the REPL, Trace Dialog and Stickers (see Section 6.1 [REPL], page 25, Section 6.4 [Trace Dialog], page 32, and Section 6.5 [Stickers], page 35), while the latter is used for commands like *C-x C-e* or the inspector (see Section 4.1 [Evaluation], page 11, Section 6.2 [Inspector], page 29).

If in doubt, use `*ECHO-NUMBER-ALIST*`.

Both variables have the same structure: each element in the alist takes the form `(TYPE . FUNCTIONS)`, where `TYPE` is a type designator and `FUNCTIONS` is a list of function designators for displaying that number in SLY. Each function takes the number as a single argument and returns a string, or nil, if that particular representation is to be disregarded.

Additionally if a given function chooses to return `t` as its optional second value, then all the remaining functions following it in the list are disregarded.

For integer numbers, the default value of this variable holds function designators that echo an integer number in its binary, hexadecimal and octal representation. However, if your application is using integers to represent Unix Epoch

Times you can use this function to display a human-readable time whenever you evaluate an integer.

```
(defparameter *day-names* '("Monday" "Tuesday" "Wednesday"
                            "Thursday" "Friday" "Saturday"
                            "Sunday"))

(defun fancy-unix-epoch-time (integer)
  "Format INTEGER as a Unix Epoch Time if within 10 years from now."
  (let ((now (get-universal-time))
        (tenyears (encode-universal-time 0 0 0 1 1 1910 0))
        (unix-to-universal
          (+ integer
             (encode-universal-time 0 0 0 1 1 1970 0))))
    (when (< (- now tenyears) unix-to-universal (+ now tenyears))
      (multiple-value-bind
            (second minute hour date month year day-of-week dst-p tz)
          (decode-universal-time unix-to-universal)
        (declare (ignore dst-p))
        (format nil "~2,'0d:~2,'0d:~2,'0d on ~a, ~d/~2,'0d/~d (GMT~@d)"
                hour minute second (nth day-of-week *day-names*)
                month date year (- tz))))))

(pushnew 'fancy-unix-epoch-time
         (cdr (assoc 'integer slynk:*echo-number-alist*)))

42 ; => 42 (6 bits, #x2A, #o52, #b101010)
1451404675 ; => 1451404675 (15:57:55 on Tuesday, 12/29/2015 (GMT+0), 31 bits
```

`SLYNK-APROPOS:*PREFERRED-APROPOS-MATCHER*`

This variable holds a function used for performing apropos searches. It defaults to `SLYNK-APROPOS:MAKE-FLEX-MATCHER`, but can also be set to `SLYNK-APROPOS:MAKE-CL-PPCRE-MATCHER` (to use a regex-able matcher) or `SLYNK-APROPOS:MAKE-PLAIN-MATCHER`, for example.

`SLYNK:*LOG-EVENTS*`

Setting this variable to `t` causes all protocol messages exchanged with Emacs to be printed to `*TERMINAL-IO*`. This is useful for low-level debugging and for observing how SLY works "on the wire." The output of `*TERMINAL-IO*` can be found in your Lisp system's own listener, usually in the buffer `*inferior-lisp*`.

8 Tips and Tricks

8.1 Connecting to a remote Lisp

One of the advantages of the way SLY is implemented is that we can easily run the Emacs side (`sly.el` and friends) on one machine and the Lisp backend (Slynk) on another. The basic idea is to start up Lisp on the remote machine, load Slynk and wait for incoming SLY connections. On the local machine we start up Emacs and tell SLY to connect to the remote machine. The details are a bit messier but the underlying idea is that simple.

8.1.1 Setting up the Lisp image

The easiest way to load Slynk "standalone" (i.e. without having `M-x sly` start a Lisp that is subsidiary to a particular Emacs), is to load the ASDF system definition for Slynk.

Make sure the path to the directory containing Slynk's `.asd` file is in `ASDF:*CENTRAL-REGISTRY*`. This file lives in the `slynk` subdirectory of SLY. Type:

```
(push #p"/path/to/sly/slynk/" ASDF:*CENTRAL-REGISTRY*)
(asdf:require-system :slynk)
```

inside a running Lisp image[1].

Now all we need to do is startup our Slynk server. A working example uses the default settings:

```
(slynk:create-server)
```

This creates a "one-connection-only" server on port 4005 using the preferred communication style for your Lisp system. The following parameters to `slynk:create-server` can be used to change that behaviour:

`:PORT` Port number for the server to listen on (default: 4005).

`:DONT-CLOSE`
Boolean indicating if the server will continue to accept connections after the first one (default: `NIL`). For "long-running" Lisp processes to which you want to be able to connect from time to time, specify `:dont-close t`

`:STYLE` See See Section 7.2.1 [Communication style], page 43.

So a more complete example will be

```
(slynk:create-server :port 4006  :dont-close t)
```

Finally, since section we're going to be tunneling our connection via SSH[2] we'll only have one port open we must tell Slynk's REPL contrib (see REPL) to not use an extra connection for output, which it will do by default.

```
(setf slynk:*use-dedicated-output-stream* nil)
```

[3]

---

[1] SLY also SLIME's old-style `slynk-loader.lisp` loader which does the same thing, but ASDF is preferred

[2] there is a way to connect without an SSH tunnel, but it has the side-effect of giving the entire world access to your Lisp image, so we're not going to talk about it

[3] Alternatively, a separate tunnel for the port set in `slynk:*dedicated-output-stream-port*` can also be used if a dedicated output is essential.

8.1.2 Setting up Emacs

Now we need to create the tunnel between the local machine and the remote machine. Assuming a UNIX command-line, this can be done with:

```
ssh -L4005:localhost:4005 youruser@remote.example.com
```

This incantation creates a SSH tunnel between the port 4005 on our local machine and the port 4005 on the remote machine, where `youruser` is expected to have an account.[4].

Finally we start SLY with `sly-connect` instead of the usual `sly`:

```
M-x sly-connect RET RET
```

The *RET RET* sequence just means that we want to use the default host (`localhost`) and the default port (`4005`). Even though we're connecting to a remote machine the SSH tunnel fools Emacs into thinking it's actually `localhost`.

8.1.3 Setting up pathname translations

One of the main problems with running slynk remotely is that Emacs assumes the files can be found using normal filenames. if we want things like `sly-compile-and-load-file` (*C-c C-k*) and `sly-edit-definition` (*M-.*) to work correctly we need to find a way to let our local Emacs refer to remote files.

There are, mainly, two ways to do this. The first is to mount, using NFS or similar, the remote machine's hard disk on the local machine's file system in such a fashion that a filename like `/opt/project/source.lisp` refers to the same file on both machines. Unfortunately NFS is usually slow, often buggy, and not always feasible. Fortunately we have an ssh connection and Emacs' `tramp-mode` can do the rest. (See See Info file `tramp`, node '`Top`'.)

What we do is teach Emacs how to take a filename on the remote machine and translate it into something that tramp can understand and access (and vice versa). Assuming the remote machine's host name is `remote.example.com`, `cl:machine-instance` returns "remote" and we login as the user "user" we can use `sly-tramp` contrib to setup the proper translations by simply doing:

```
(add-to-list 'sly-filename-translations
             (sly-create-filename-translator
              :machine-instance "remote"
              :remote-host "remote.example.com"
              :username "user"))
```

8.2 Loading Slynk faster

In this section, a technique to load Slynk faster on South Bank Common Lisp (SBCL) is presented. Similar setups should also work for other Lisp implementations.

A pre-canned solution that automates this technique was developed by Pierre Neidhardt (`https://gitlab.com/ambrevar/lisp-repl-core-dumper`).

[4] By default Slynk listens for incoming connections on port 4005, had we passed a `:port` parameter to `slynk:create-server` we'd be using that port number instead

For SBCL, we recommend that you create a custom core file with socket support and POSIX bindings included because those modules take the most time to load. To create such a core, execute the following steps:

```
shell$ sbcl
* (mapc 'require '(sb-bsd-sockets sb-posix sb-introspect sb-cltl2 asdf))
* (save-lisp-and-die "sbcl.core-for-sly")
```

After that, add something like this to your `~/.emacs` or `~/.emacs.d/init.el` (see [Emacs Init File], page 40):

```
(setq sly-lisp-implementations '((sbcl ("sbcl" "--core"
      "sbcl.core-for-sly"))))
```

For maximum startup speed you can include the Slynk server directly in a core file. The disadvantage of this approach is that the setup is a bit more involved and that you need to create a new core file when you want to update SLY or SBCL. The steps to execute are:

```
shell$ sbcl
* (load ".../sly/slynk-loader.lisp")
* (slynk-loader:dump-image "sbcl.core-with-slynk")
```

Then add this to the Emacs initializion file:

```
(setq sly-lisp-implementations
      '((sbcl ("sbcl" "--core" "sbcl.core-with-slynk")
              :init (lambda (port-file _)
                      (format "(slynk:start-server %S)\n" port-file)))))
```

8.3 Connecting to SLY automatically

To make SLY connect to your lisp whenever you open a lisp file just add this to your `~/.emacs` or `~/.emacs.d/init.el` (see [Emacs Init File], page 40):

```
(add-hook 'sly-mode-hook
          (lambda ()
            (unless (sly-connected-p)
              (save-excursion (sly)))))
```

8.4 REPLs and "Game Loops"

When developing Common Lisp video games or graphical applications, a REPL (see Section 6.1 [REPL], page 25) is just as useful as anywhere else. But it is often the case that one needs to control exactly the timing of REPL requests and ensure they do not interfere with the "game loop". In other situations, the choice of communication style (see Section 7.2.1 [Communication style], page 43) to the Slynk server may invalidate simultaneous multi-threaded operation of REPL and game loop.

Instead of giving up on the REPL or using a complicated solution, SLY's REPL can be built into your game loop by using a couple of Slynk Common Lisp functions, `SLYNK-MREPL:SEND-PROMPT` and `SLYNK:PROCESS-REQUESTS`.

```
(defun my-repl-aware-game-loop ()
  (loop initially
          (princ "Starting our game")
```

```
  (slynk-mrepl:send-prompt)
for i from 0
do (with-simple-restart (abort "Skip rest of this game loop iteration")
     (when (zerop (mod i 10))
       (fresh-line)
       (princ "doing high-priority 3D game loop stuff"))
     (sleep 0.1)
     ;; When you're ready to serve a potential waiting
     ;; REPL request, just do this non-blocking thing:
     (with-simple-restart (abort "Abort this game REPL evaluation")
       (slynk:process-requests t)))))
```

Note that this function is to be called *from the REPL*, and will enter kind of "sub-REPL" inside it. It'll likely "just work" in this situation. However, if you need you need to call this from anywhere else (like, say, another thread), you must additionally arrange for the variable `SLYNK-API:*CHANNEL*` to be bound to the value it is bound to in whatever SLY REPL you wish to interact with your game.

8.5 Controlling SLY from outside Emacs

If your application has a non-SLY, non-Emacs user interface (graphical or otherwise), you can use it to exert some control over SLY functionality, such as its REPL (see Section 6.1 [REPL], page 25) and inspector (see Section 6.2 [Inspector], page 29). This requires that you first set, in Emacs, variable `sly-enable-evaluate-in-emacs` to non-nil. As the name suggests, it lets outside Slynk servers evaluate code in your Elisp runtime. It is set to `nil` by default for security purposes.

Once you've done that, you can call `SLYNK-MREPL:COPY-TO-REPL-IN-EMACS` from your CL code with some objects you'd like to manipulate in the REPL. Then you can have this code run from some UI event handler:

```
(lambda ()
  (slynk-mrepl:copy-to-repl-in-emacs
     (list 42 'foo)
     :blurb "Just a forty-two and a foo"))
```

And see those objects pop up in your REPL for inspection and manipulation.

You can also use the functions `SLYNK:INSPECT-IN-EMACS`, `SLYNK:ED-IN-EMACS`, and in general, any exported function ending in `IN-EMACS`. See their docstrings for details.

9 Extensions

Extensions, also known as "contribs" are Emacs packages that extend SLY's functionality. Contrasting with its ancestor SLIME (see Chapter 1 [Introduction], page 1), most contribs bundled with SLY are active by default, since they are a decent way to split SLY into pluggable modules. The auto-documentation (see Section 4.3 [Autodoc], page 13), trace (see Section 6.4 [Trace Dialog], page 32) and Stickers (see Section 6.5 [Stickers], page 35) are contribs enabled by default, for example.

Usually, contribs differ from regular Emacs plugins in that they are partly written in Emacs-lisp and partly in Common Lisp. The former is usually the UI that queries the latter for information and then presents it to the user. SLIME used to load all the contribs' Common Lisp code upfront, but SLY takes care to loading these two parts at the correct time. In this way, developers can write third-party contribs that live independently of SLY perhaps even in different code repositories. The `sly-macrostep` contrib (`https://github.com/joaotavora/sly-macrostep`) is one such example.

A special `sly-fancy` contrib package is the only one loaded by default. You might never want to fiddle with it (it is the one that contains the default extensions), but if you find that you don't like some package or you are having trouble with a package, you can modify your setup a bit. Generally, you set the variable `sly-contribs` with the list of package-names that you want to use. For example, a setup to load only the `sly-scratch` and `sly-mrepl` packages looks like:

```
;; Setup load-path and autoloads
(add-to-list 'load-path "~/dir/to/cloned/sly")
(require 'sly-autoloads)

;; Set your lisp system and some contribs
(setq inferior-lisp-program "/opt/sbcl/bin/sbcl")
(setq sly-contribs '(sly-scratch sly-mrepl))
```

After starting SLY, the commands of both packages should be available.

9.1 Loading and unloading "on the fly"

We recommend that you setup the `sly-contribs` variable *before* starting SLY via *`M-x sly`*, but if you want to enable more contribs *after* you that, you can set new `sly-contribs` variable to another value and call `M-x sly-setup` or `M-x sly-enable-contrib`. Note this though:

- If you've removed contribs from the list they won't be unloaded automatically.
- If you have more than one SLY connection currently active, you must manually repeat the `sly-setup` step for each of them.

Short of restarting Emacs, a reasonable way of unloading contribs is by calling an Emacs Lisp function whose name is obtained by adding `-unload` to the contrib's name, for every contrib you wish to unload. So, to remove `sly-mrepl`, you must call `sly-mrepl-unload`. Because the unload function will only, if ever, unload the Emacs Lisp side of the contrib, you may also need to restart your lisps.

9.2 More contribs

9.2.1 TRAMP

The package `sly-tramp` provides some functions to set up filename translations for TRAMP. (see Section 8.1.3 [Setting up pathname translations], page 48)

9.2.2 Scratch Buffer

The SLY scratch buffer, in contrib package `sly-scratch`, imitates Emacs' usual `*scratch*` buffer. If `sly-scratch-file` is set, it is used to back the scratch buffer, making it persistent. The buffer is like any other Lisp buffer, except for the command bound to *C-j*.

C-j
M-x sly-eval-print-last-expression
: Evaluate the expression sexp before point and insert a printed representation of the return values into the current buffer.

M-x sly-scratch
: Create a `*sly-scratch*` buffer. In this buffer you can enter Lisp expressions and evaluate them with *C-j*, like in Emacs's `*scratch*` buffer.

10 Credits

The soppy ending...

Hackers of the good hack

SLY is a fork of SLIME which is itself an Extension of SLIM by Eric Marsden. Please consult the Git repository for a list of authors and code-contributors of SLY, as well as the bundled code from `hyperspec.el`, *CLOCC*, and the *CMU AI Repository*.

Many people on the `sly-devel` mailing list have made non-code contributions to SLY.

Thanks!

We're indebted to the good people of `common-lisp.net` for their hosting and help, and for rescuing us from "Sourceforge hell."

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