Control Flow in Common Lisp

aka Why Lisp Doesn't Need To Throw Exceptions

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- This includes loops
- This includes switches
- This includes error handling
- This includes restart handling
- **The above four groups are implemented in Common Lisp itself**

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- Relatively small but active community
- Continuously used for commercial projects and research

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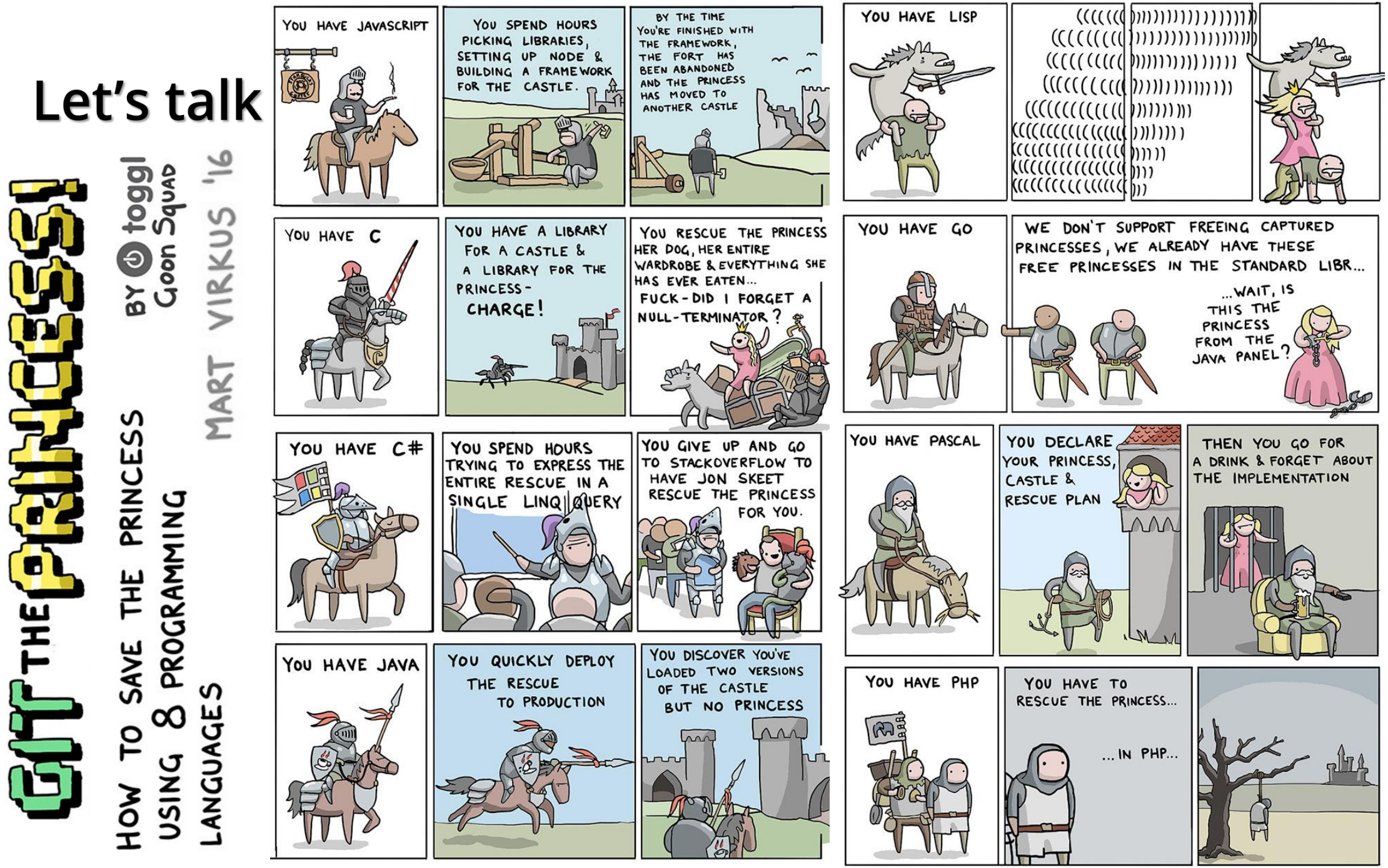
Let's talk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BY toggl Goon Squad
MART VIRKUS '16
YOU HAVE JAVASCRIPT
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BY THE TIME YOU'RE FINISHED WITH THE FRAMEWORK, THE FORT HAS BEEN ABANDONED AND THE PRINCESS HAS MOVED TO ANOTHER CASTLE
YOU HAVE C
YOU HAVE A LIBRARY FOR A CASTLE & A LIBRARY FOR THE PRINCESS - CHARGE!
YOU RESCUE THE PRINCESS HER DOG, HER ENTIRE WARDROBE & EVERYTHING SHE HAS EVER EATEN... FUCK - DID I FORGET A NULL-TERMINATOR?
YOU HAVE C#
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YOU GIVE UP AND GO TO STACKOVERFLOW TO HAVE JON SKEET RESCUE THE PRINCESS FOR YOU.
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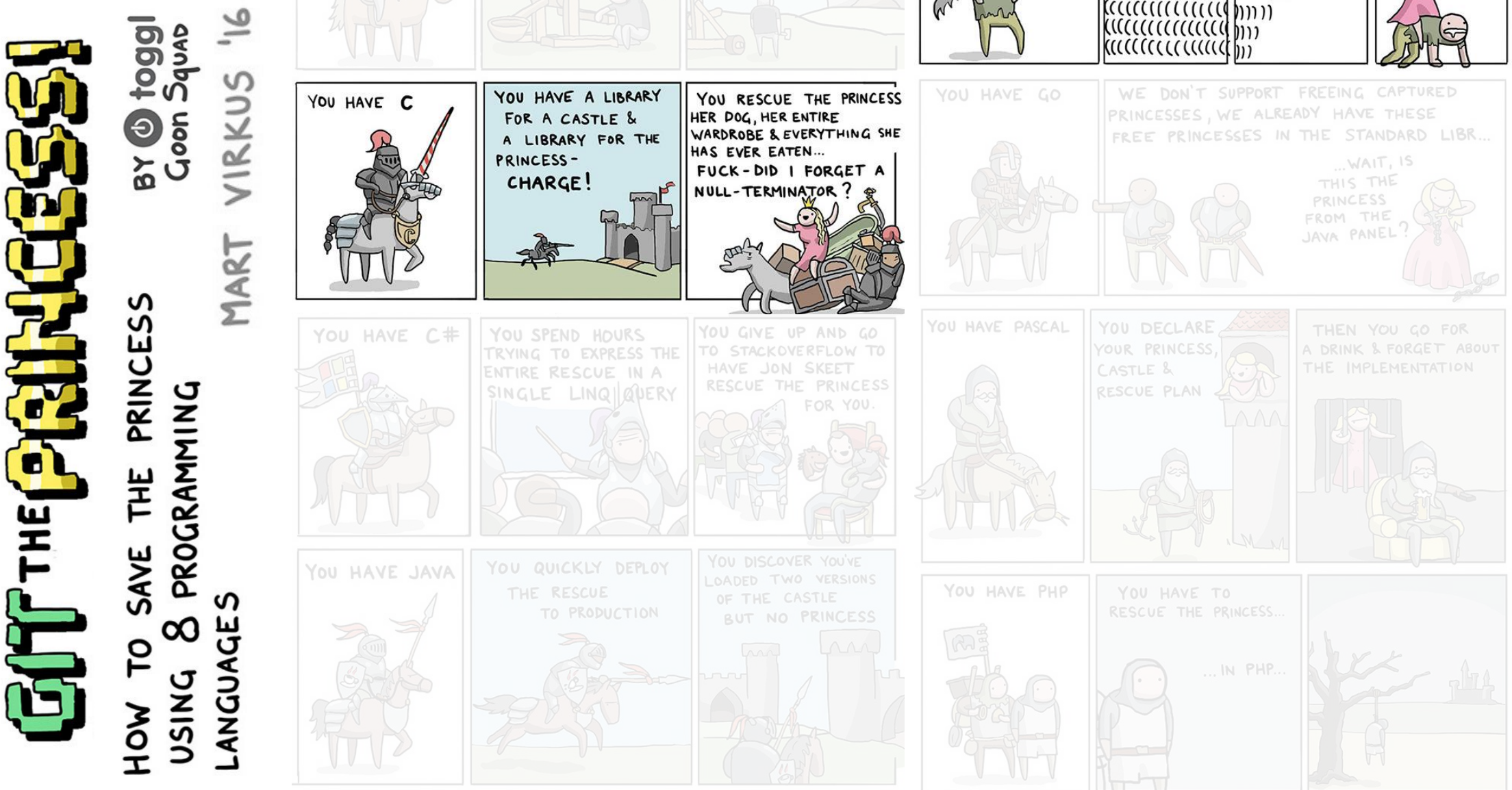
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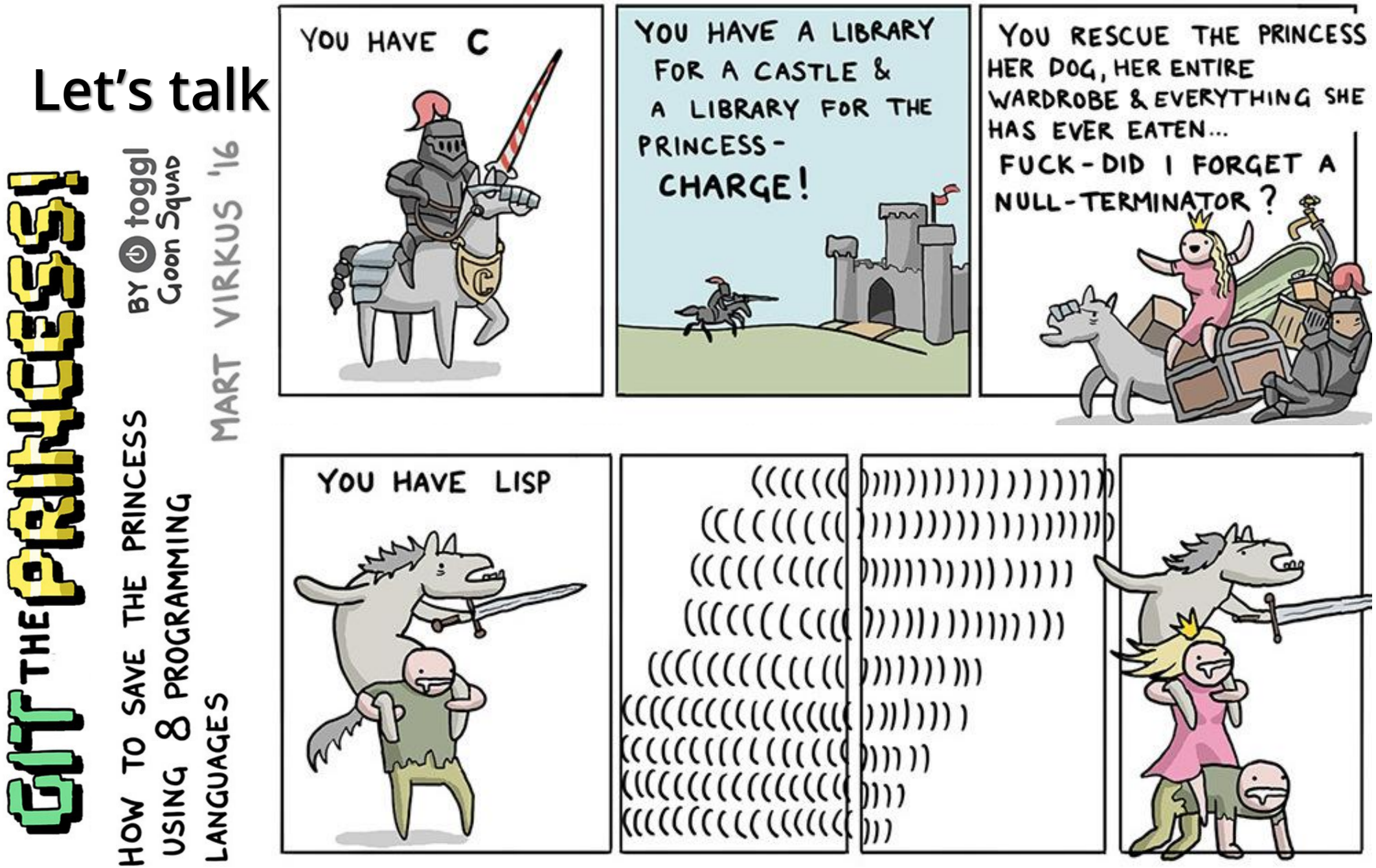
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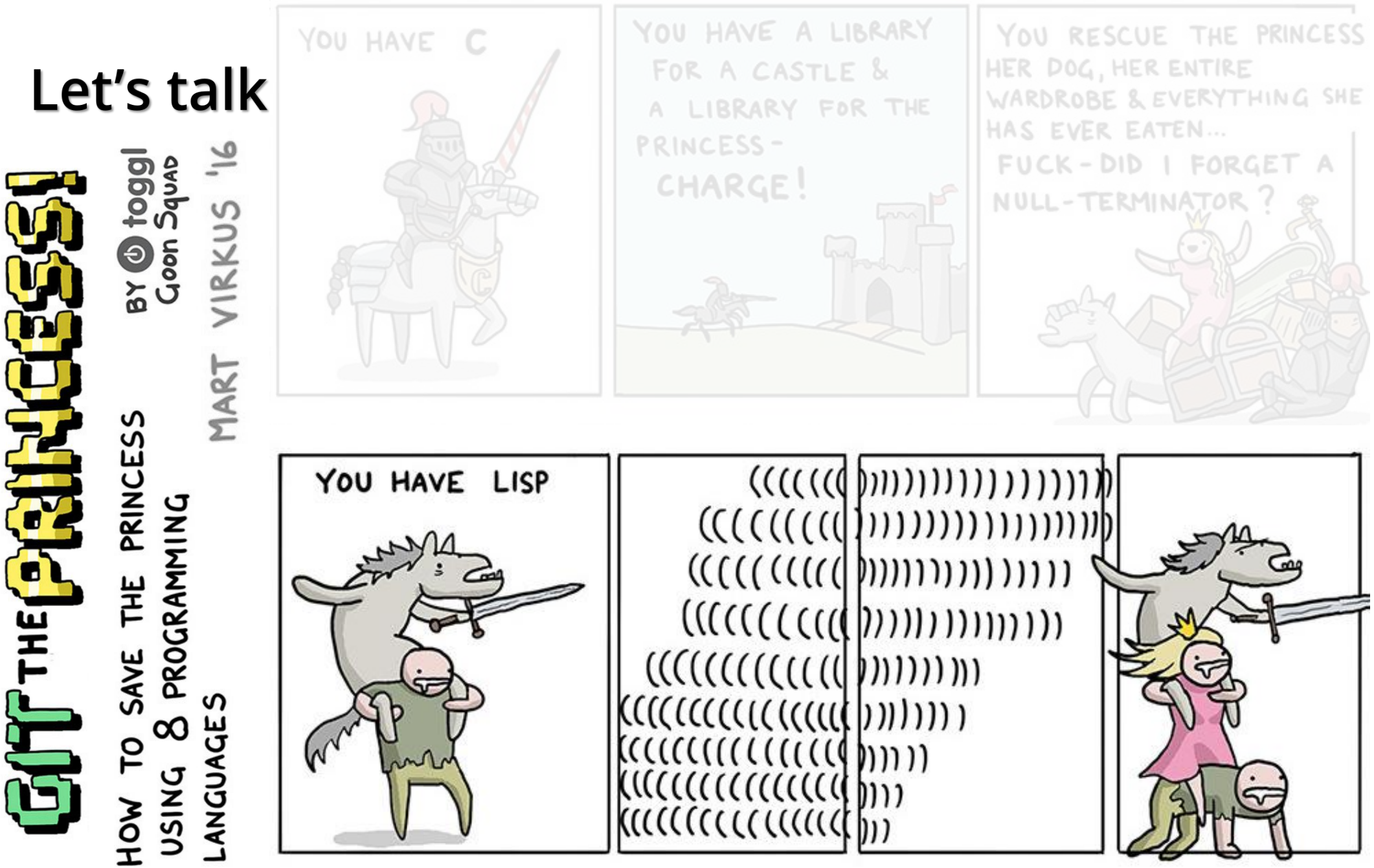
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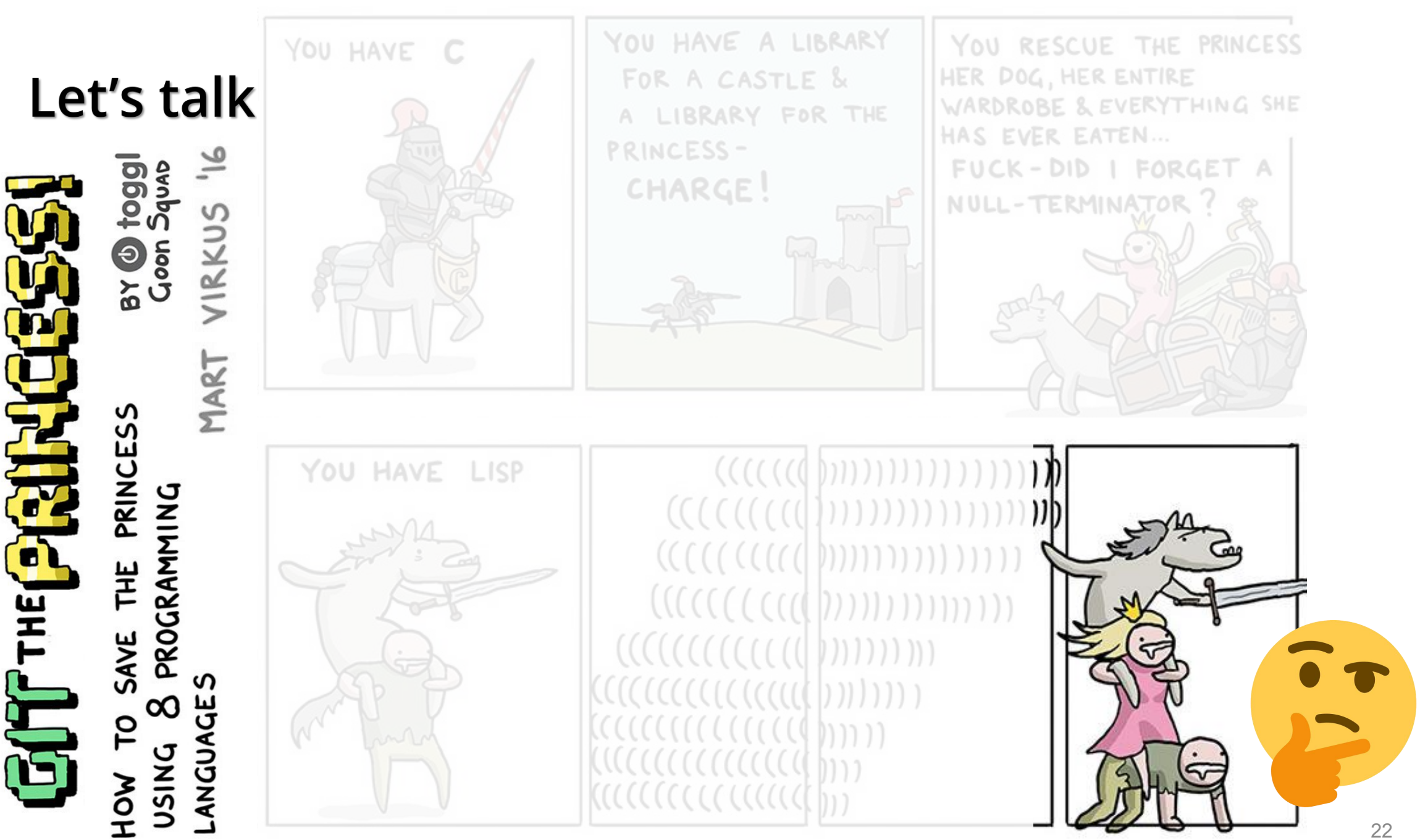
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- `if`

```
(if (foo)
    (bar)
    (baz))
```

Let’s talk about control flow in Common Lisp

- `if`
- `tagbody/go`

```
(tagbody
 10 (print “hello”)
 20 (go 10))
```

Let’s talk about control flow in Common Lisp

- `if`
- `tagbody/go`
- `block/return-from`

```
(block my-block
  (...)
  (... (return-from my-block 42))
  (...))
```

Let’s talk about control flow in Common Lisp

- `if`
- `tagbody/go`
- `block/return-from`
- `catch/throw`

```
(catch ‘quux
  (...)
  (... (foo))
  (...)))
```

```
(defun foo ()
  (throw ‘quux 42))
```

Let’s talk about control flow in Common Lisp

- `if`
- `tagbody/go`
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- `catch/throw`
- `unwind-protect`

```
(let ((thing (make-thing)))
  (unwind-protect (frob thing)
    (cleanup thing)))
```

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- `lambda/apply`

```
(let ((fn (lambda ...))
      (args ...))
  (apply fn 1 2 3 args))
```

Let's talk about control flow in Common Lisp

- `if`
- `tagbody/go`
- `block/return-from`
- `catch/throw`
- `unwind-protect`
- `lambda/apply ; and funcall`

```
(let ((fn (lambda ...))
      (args ...))
  (apply fn 1 2 3 args))
```

```
(let ((fn (lambda ...)))
  (funcall fn 1 2 3))
```

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```
(let ((x 42))
  (lambda () x))
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;; but we can close over more
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```

Let's talk about non-local control flow in Common Lisp

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(let ((x 42))
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```
(defun foo (x) (funcall x))
```

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```
(defun foo (x) (funcall x))

(defun bar () ; block bar
  ...)
```

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(defun foo (x) (funcall x))

(defun bar ()
  (let ((fn (lambda ()
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    ...))
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(defun foo (x) (funcall x))

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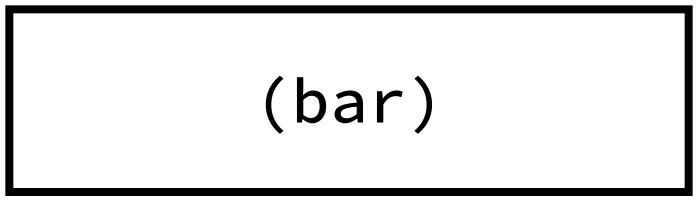

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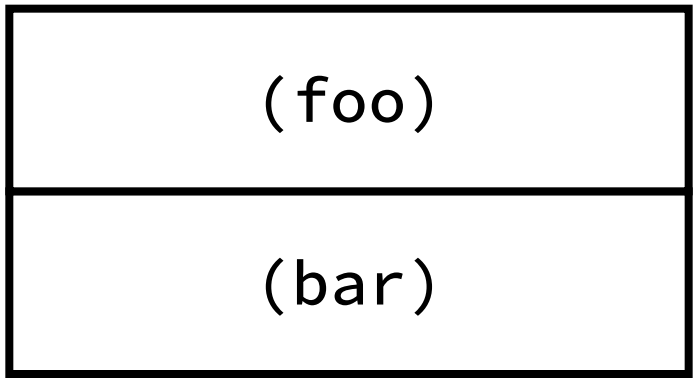

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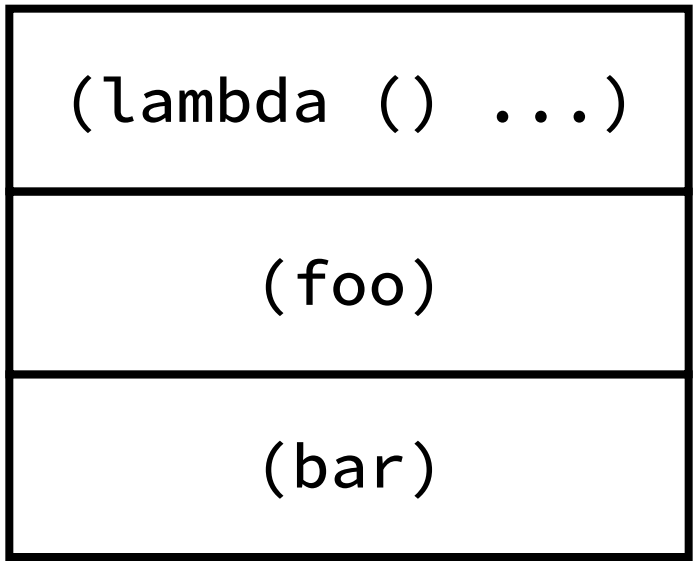

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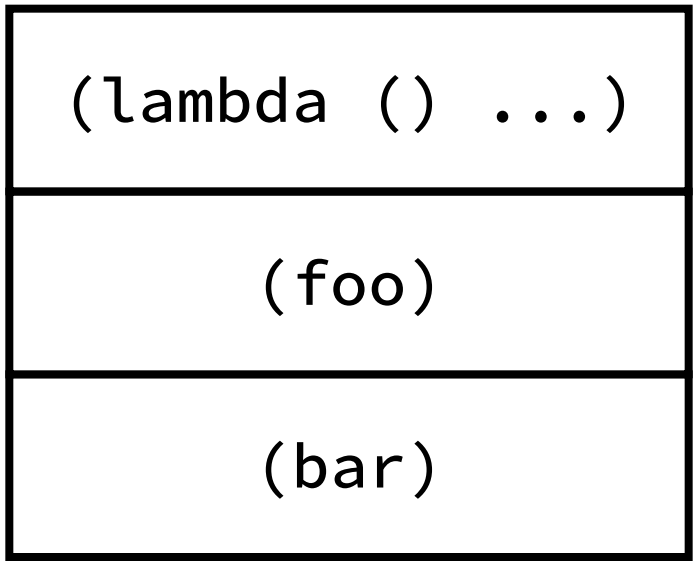


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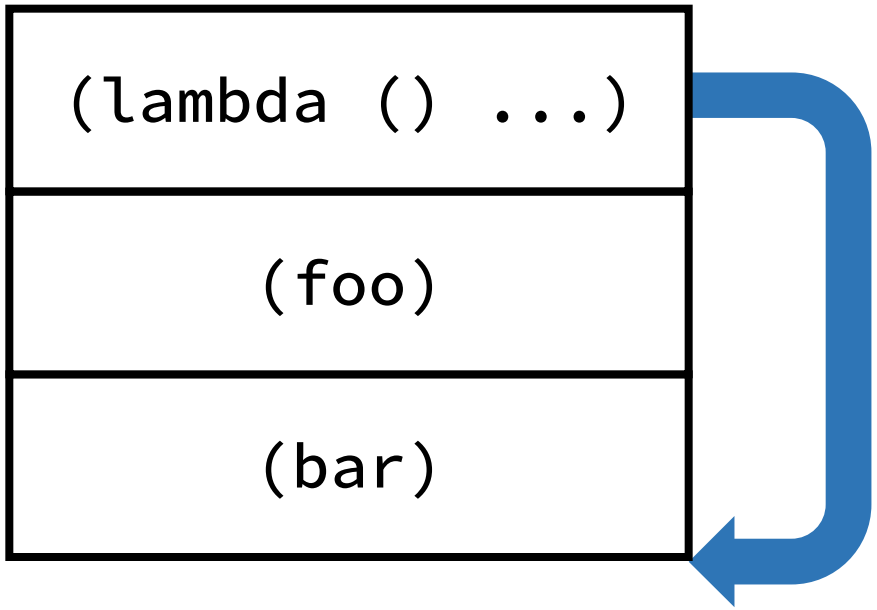


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- if
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- block/return-from
- catch/throw
- unwind-protect
- lambda/apply

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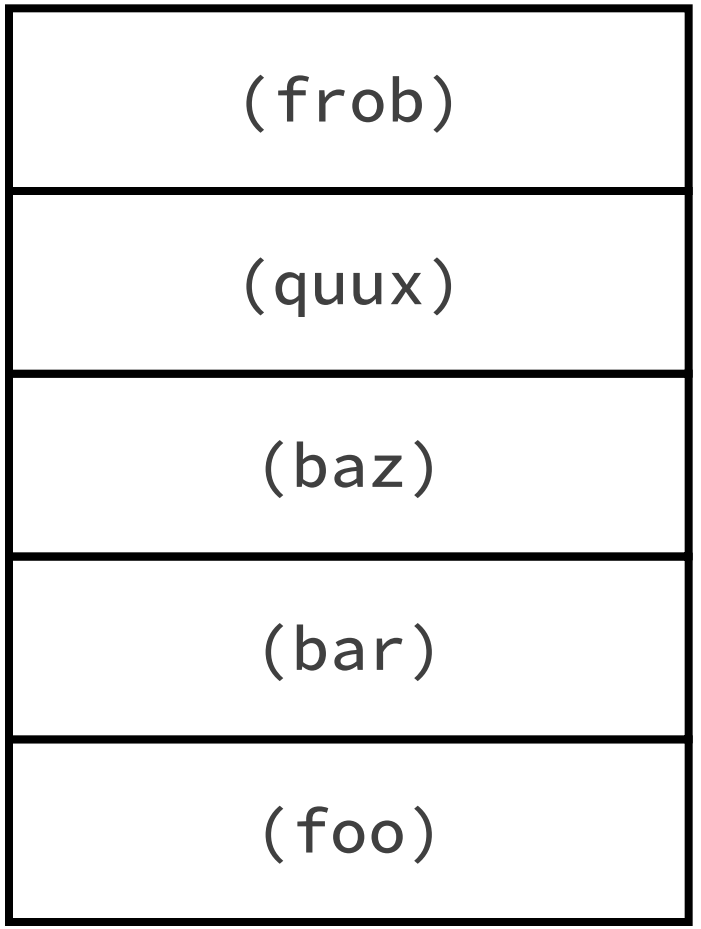

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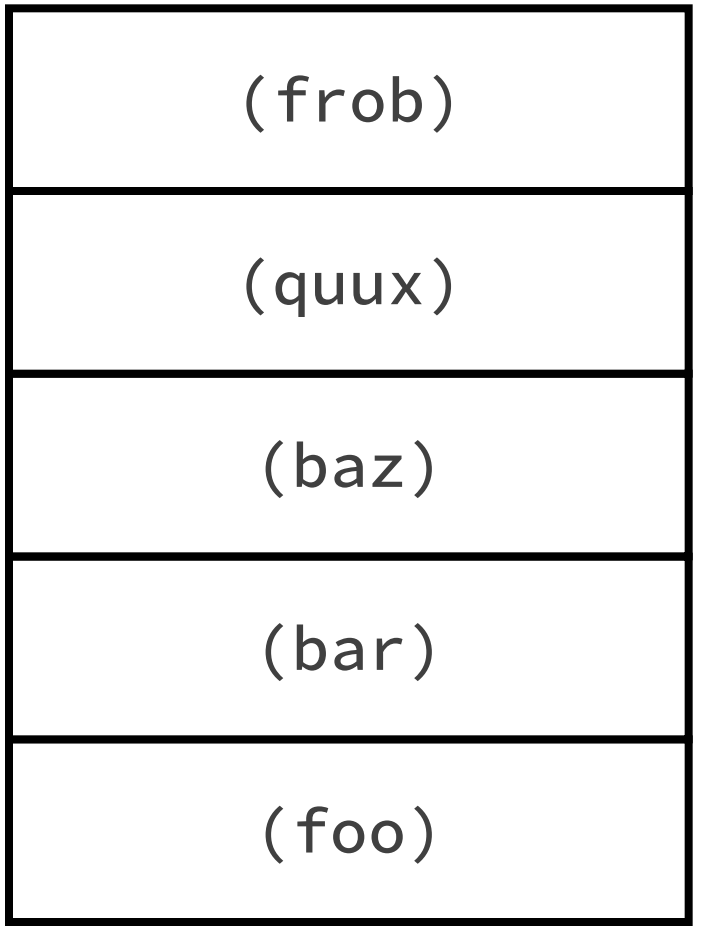

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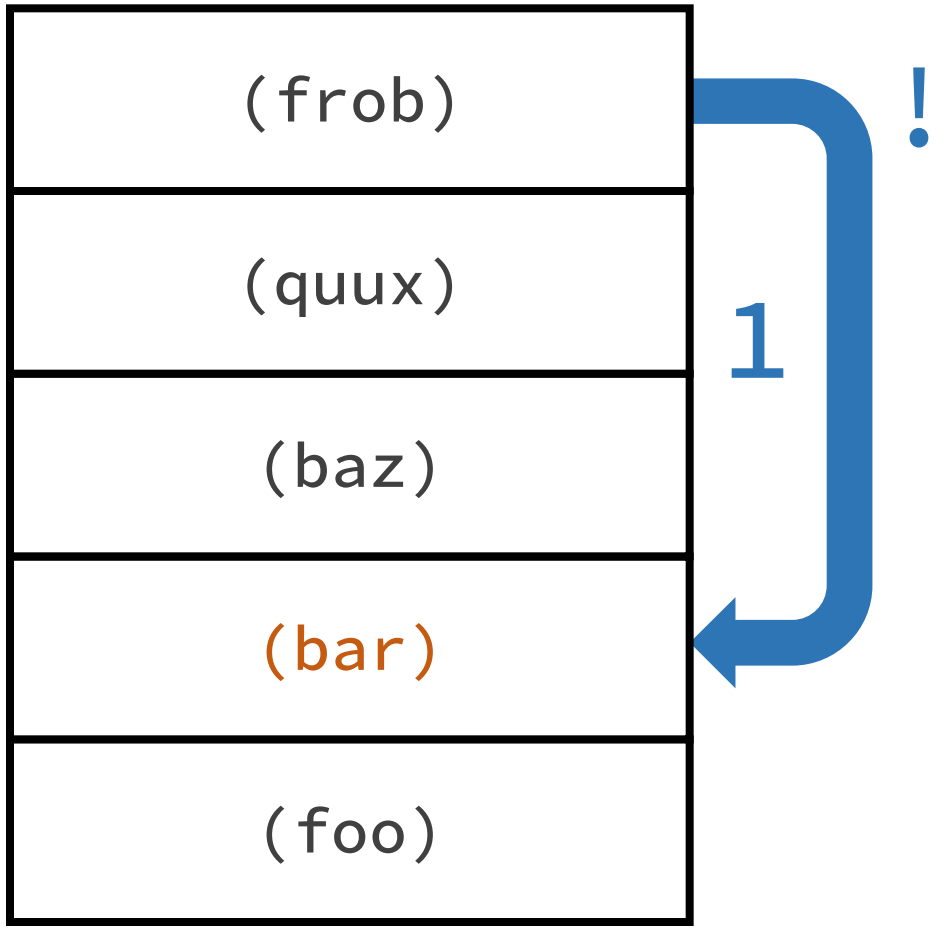

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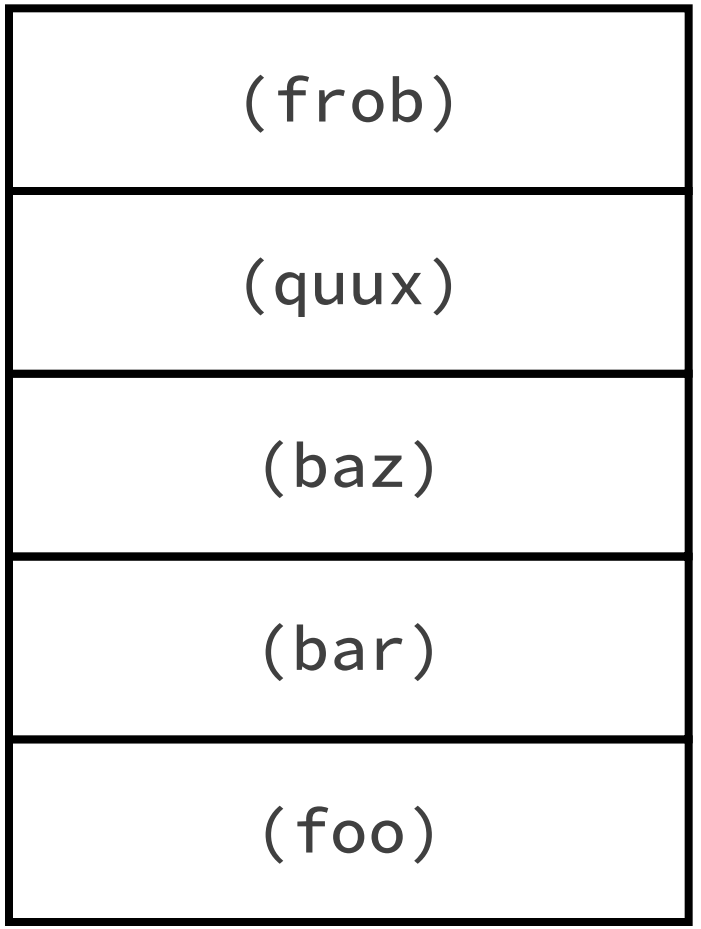

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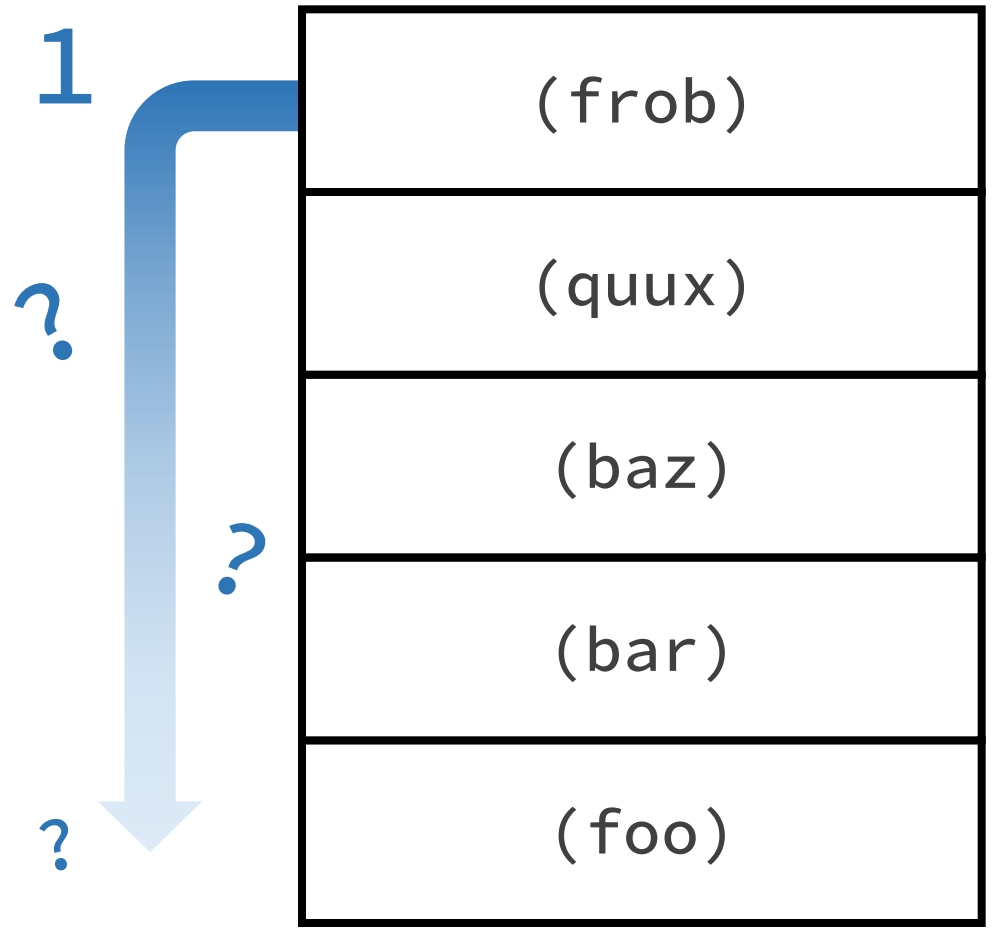

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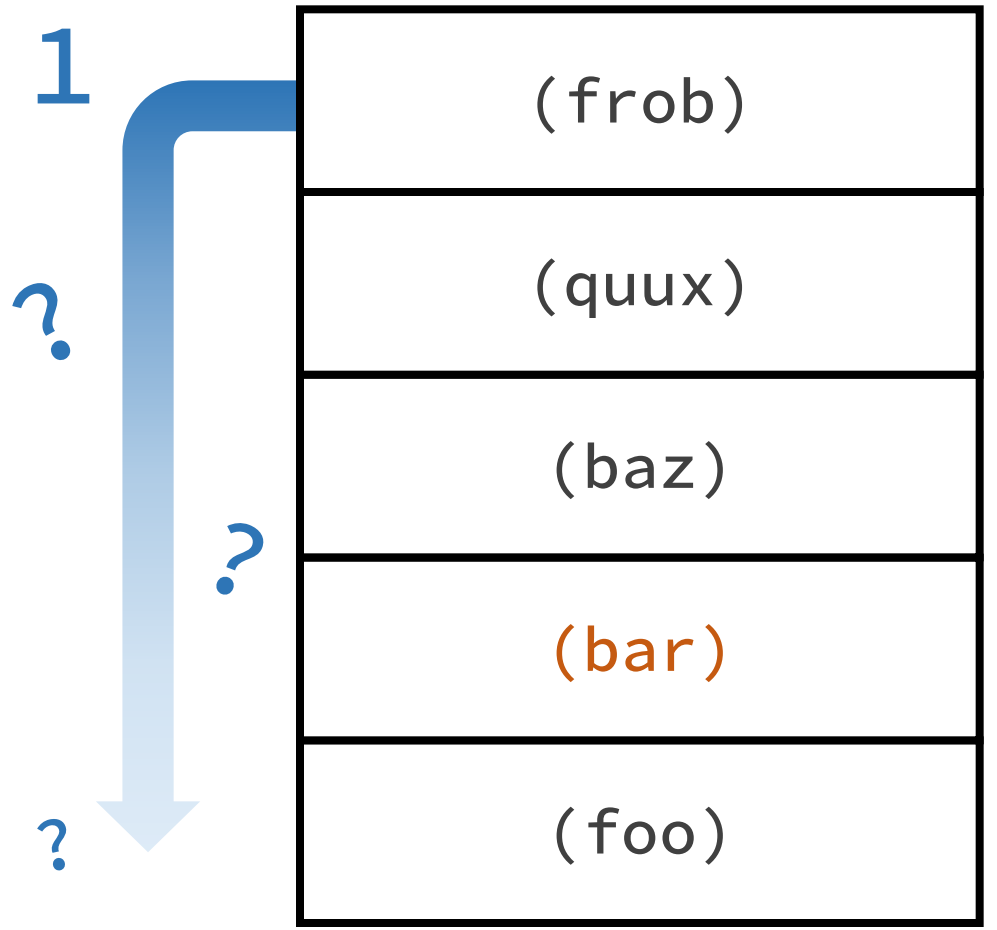

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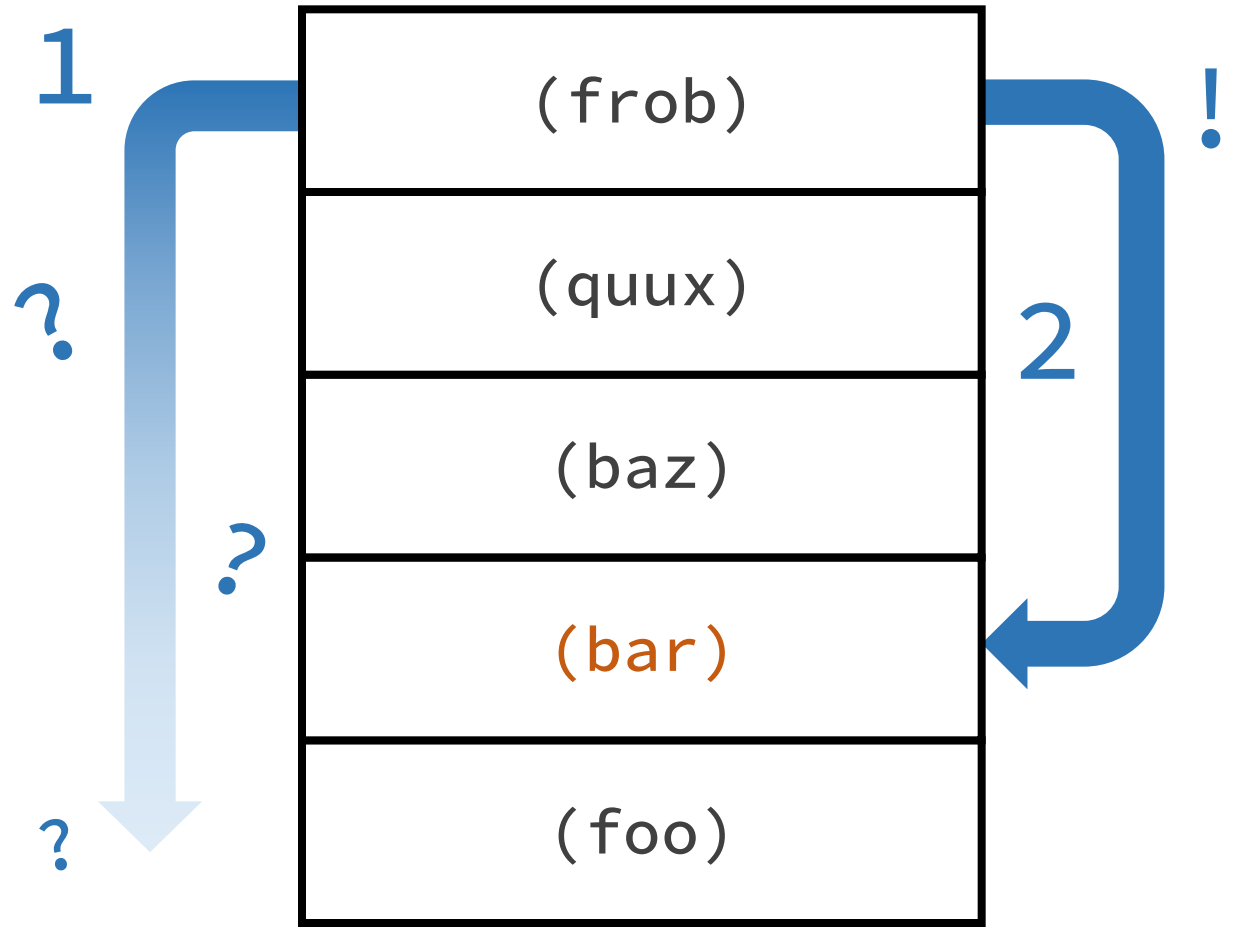

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- `if`
- `tagbody/go` ; 1-phase unwind (no search)
- `block/return-from` ; 1-phase unwind (no search)
- `catch/throw` ; 2-phase unwind (search)
- `unwind-protect`
- `lambda/apply`

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  - loops (`do`, `dolist`, `loop`, ...)

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Let’s talk about control flow in Common Lisp

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Let’s talk about control flow in WebAssembly

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  - Name the WASM operator `unwind` instead of `throw` perhaps?

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  - 2PEH → 2PU = two-phase unwinding (`stack-search` + `unwind`)
- Suggestion: support for dynamic (fluid) variables?
  - Basis for implementing a condition system
  - Otherwise, we will need some other stack-searching operator
  - …or we'll need to reimplement dynamic variables

- **Control flow ≠ exception handling**

Let’s talk about control flow in WebAssembly

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  Control Flow in Common Lisp - Online Lisp Meeting #11,
  a recording of material presented in this talk,
  including the differences between conditions and exceptions

<3

<3

but wait hold on for just one moment

Control Flow in Common Lisp

aka Why Lisp Doesn't Need To Throw Exceptions

Appendix A

Differences between conditions and exceptions

Let’s talk about control flow

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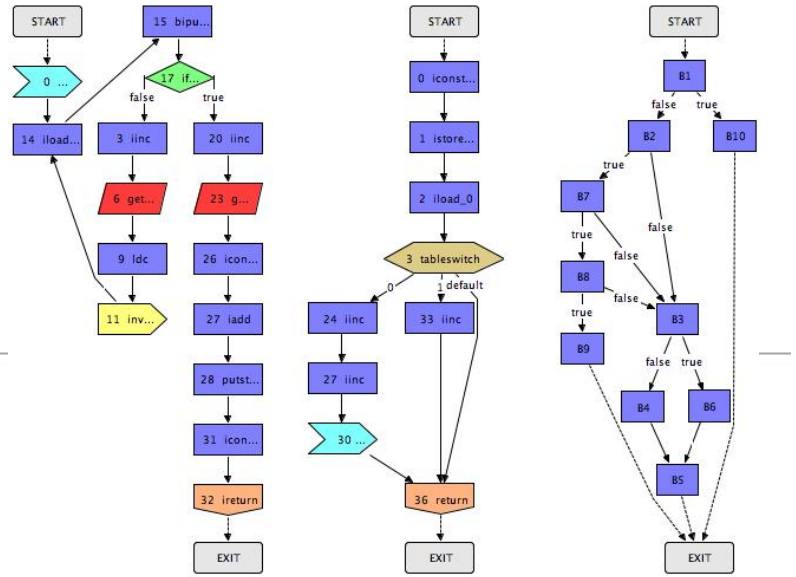
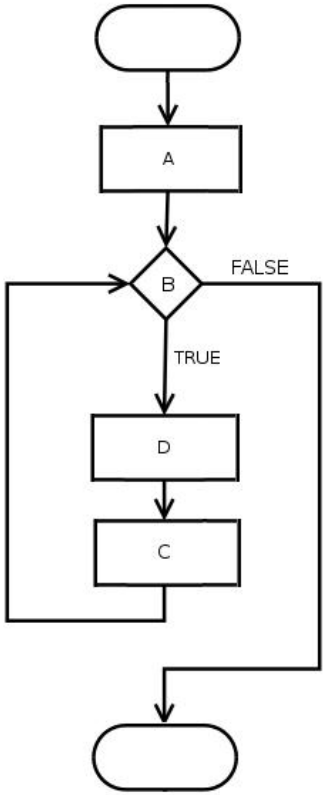


for(A;B;C)
D;



Control flow

From Wikipedia, the free encyclopedia

Not to be confused with Flow control (data).

In computer science, **control flow** (or **flow of control**) is the order in which individual statements, instructions or function calls of an imperative program are executed or evaluated. The emphasis on explicit control flow distinguishes an *imperative programming* language from a *declarative programming* language.

Let’s talk about non-local control flow

Structured non-local control flow [edit]

Many programming languages, especially those favoring more dynamic styles of programming, offer constructs for *non-local control flow*. These cause the flow of execution to jump out of a given context and resume at some predeclared point. *Conditions*, *exceptions* and *continuations* are three common sorts of non-local control constructs; more exotic ones also exist, such as generators, coroutines and the async keyword.

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Let’s talk about exceptions

Exception support in programming languages [edit]

See also: Exception handling syntax

Many computer languages have built-in support for exceptions and exception handling. This includes ActionScript, Ada, BlitzMax, C++, C#, Clojure, COBOL, D, ECMAScript, Eiffel, Java, ML, Next Generation Shell, Object Pascal (e.g. Delphi, Free Pascal, and the like), PowerBuilder, Objective-C, OCaml, PHP (as of version 5), PL/I, PL/SQL, Prolog, Python, REALbasic, Ruby, Scala, Seed7, Smalltalk, Tcl, Visual Prolog and most .NET languages. Exception handling is commonly not resumable in those languages, and when an exception is thrown, the program searches back through the stack of function calls until an exception handler is found.

Some languages call for unwinding the stack as this search progresses. That is, if function f, containing a handler H for exception E, calls function g, which in turn calls function h, and an exception E occurs in h, then functions h and g may be terminated, and H in f will handle E.

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`ArithmeticException`

```
1/0
baz()
bar()
foo()
```

Let’s talk about exceptions

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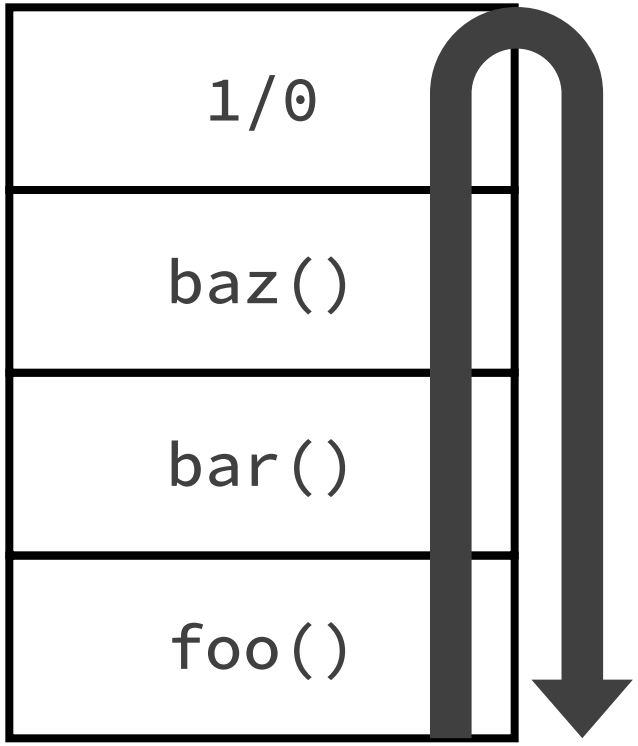

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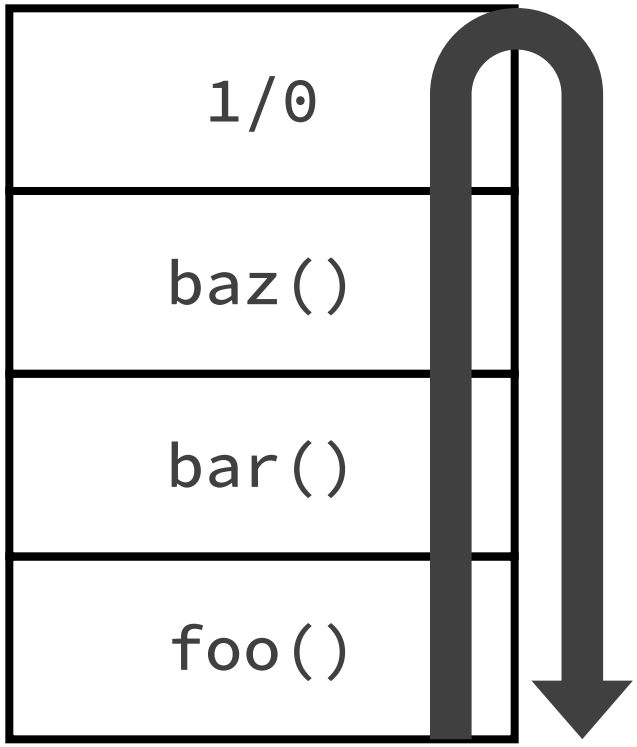

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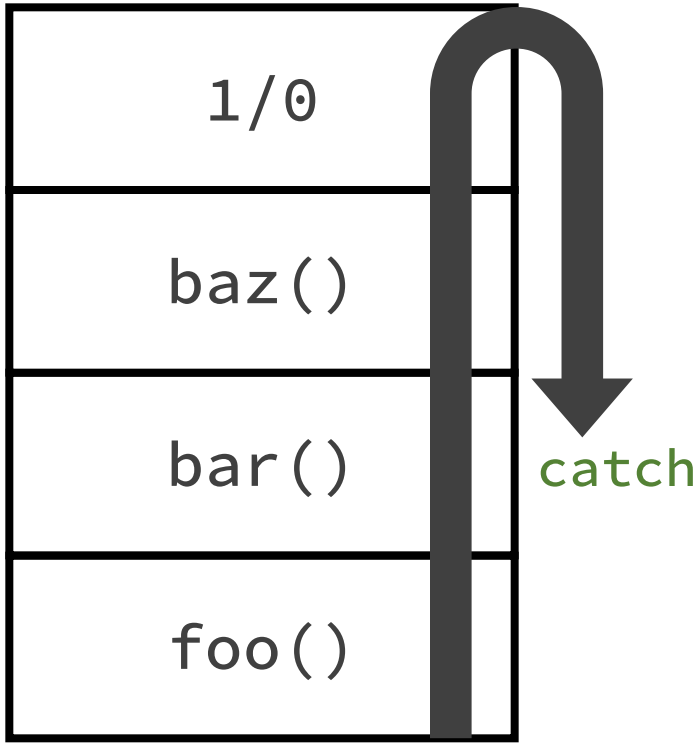

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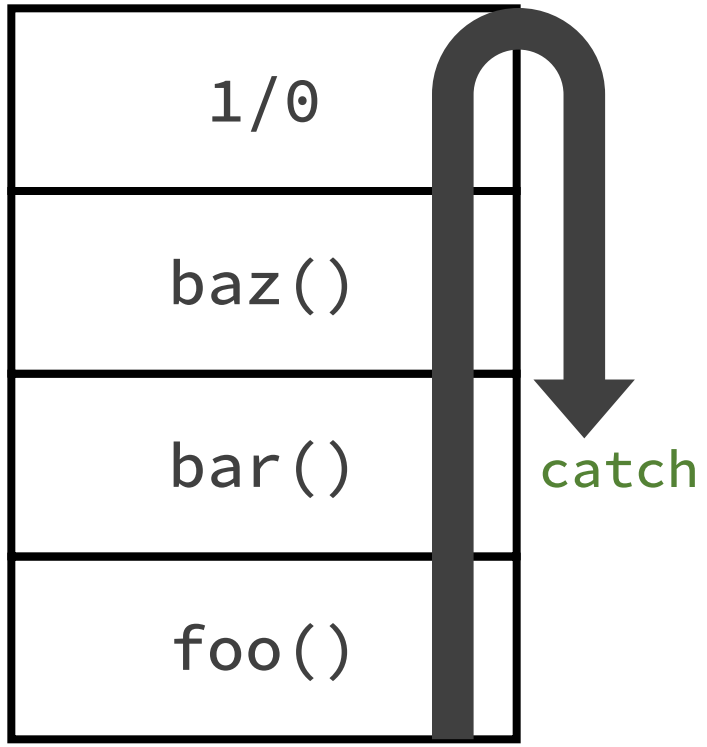

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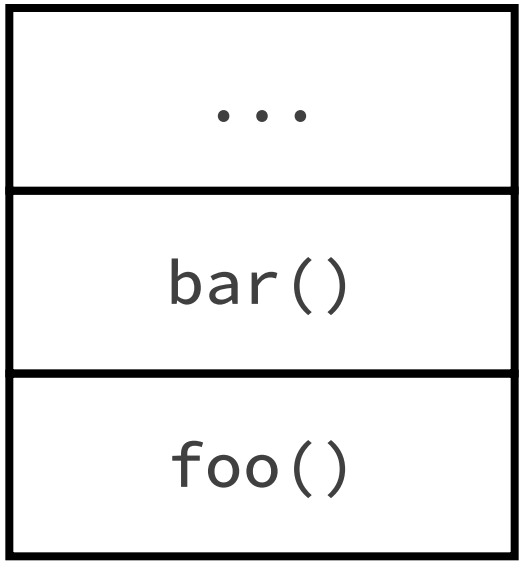


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Let’s talk about conditions

Condition systems [edit]

Common Lisp, Dylan and Smalltalk have a condition system[53] (see Common Lisp Condition System) that encompasses the aforementioned exception handling systems. In those languages or environments the advent of a condition (a "generalisation of an error" according to Kent Pitman) implies a function call, and only late in the exception handler the decision to unwind the stack may be taken.

Conditions are a generalization of exceptions. When a condition arises, an appropriate condition handler is searched for and selected, in stack order, to handle the condition. Conditions that do not represent errors may safely go unhandled entirely; their only purpose may be to propagate hints or warnings toward the user.[54]

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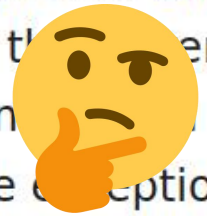

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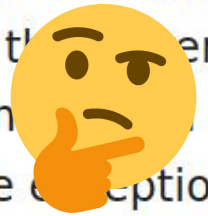

Let’s talk about signaling an error

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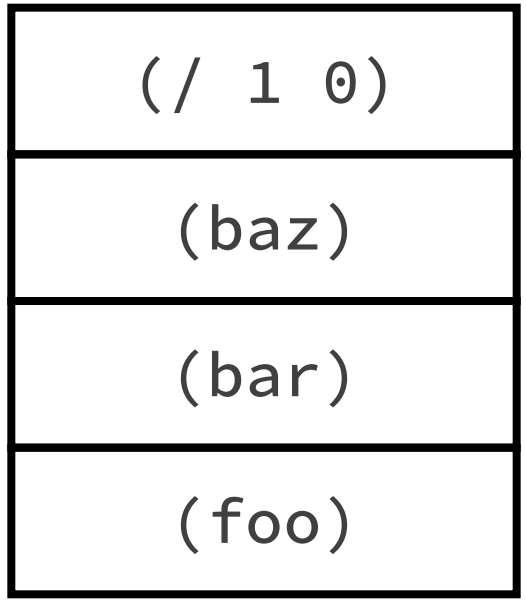
division-by-zero



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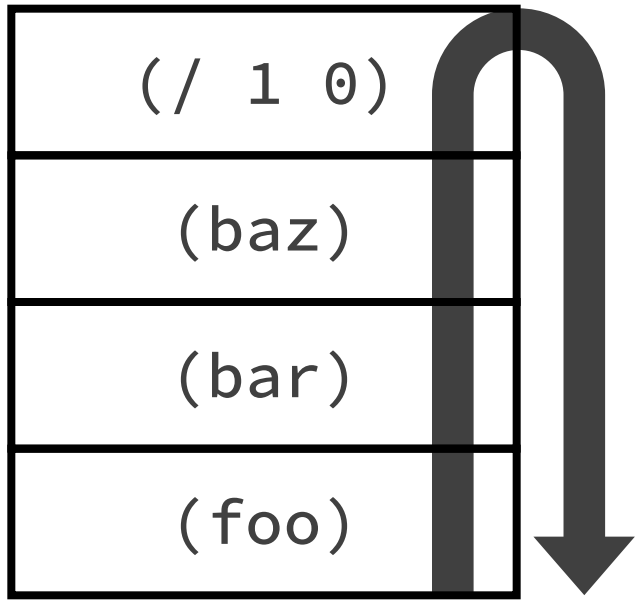

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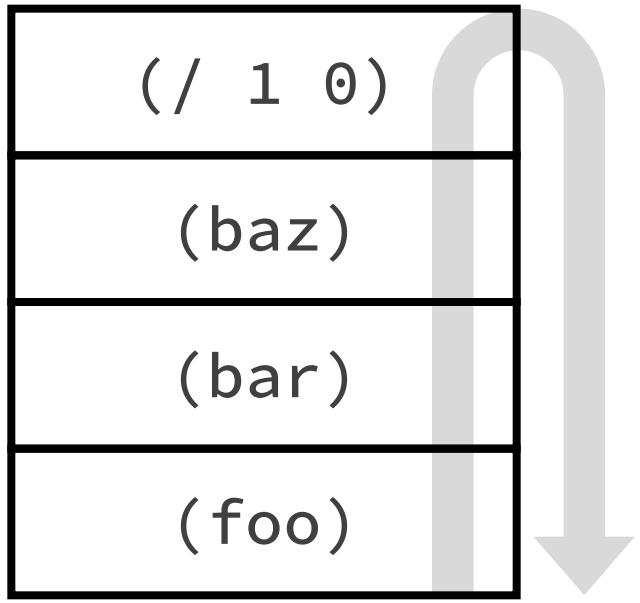

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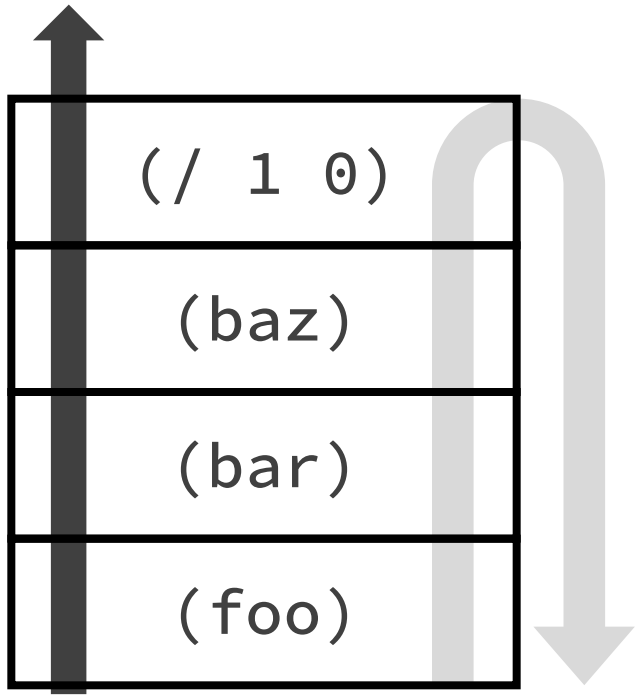

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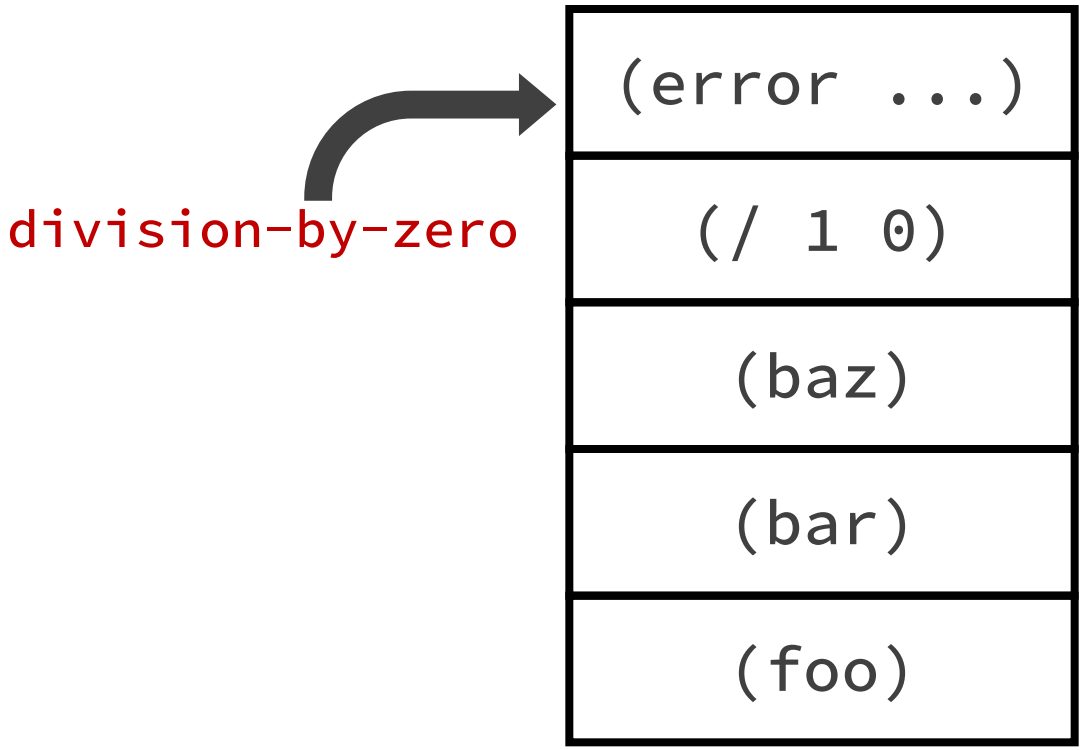

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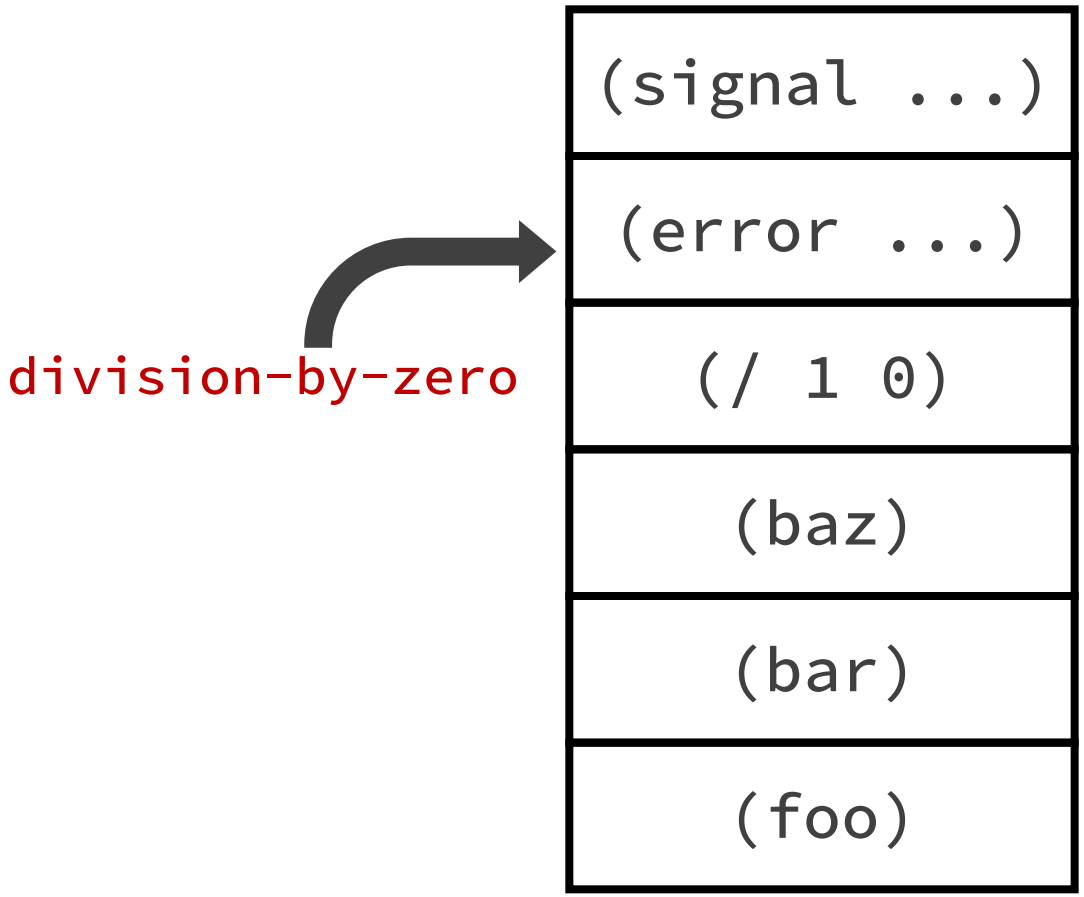

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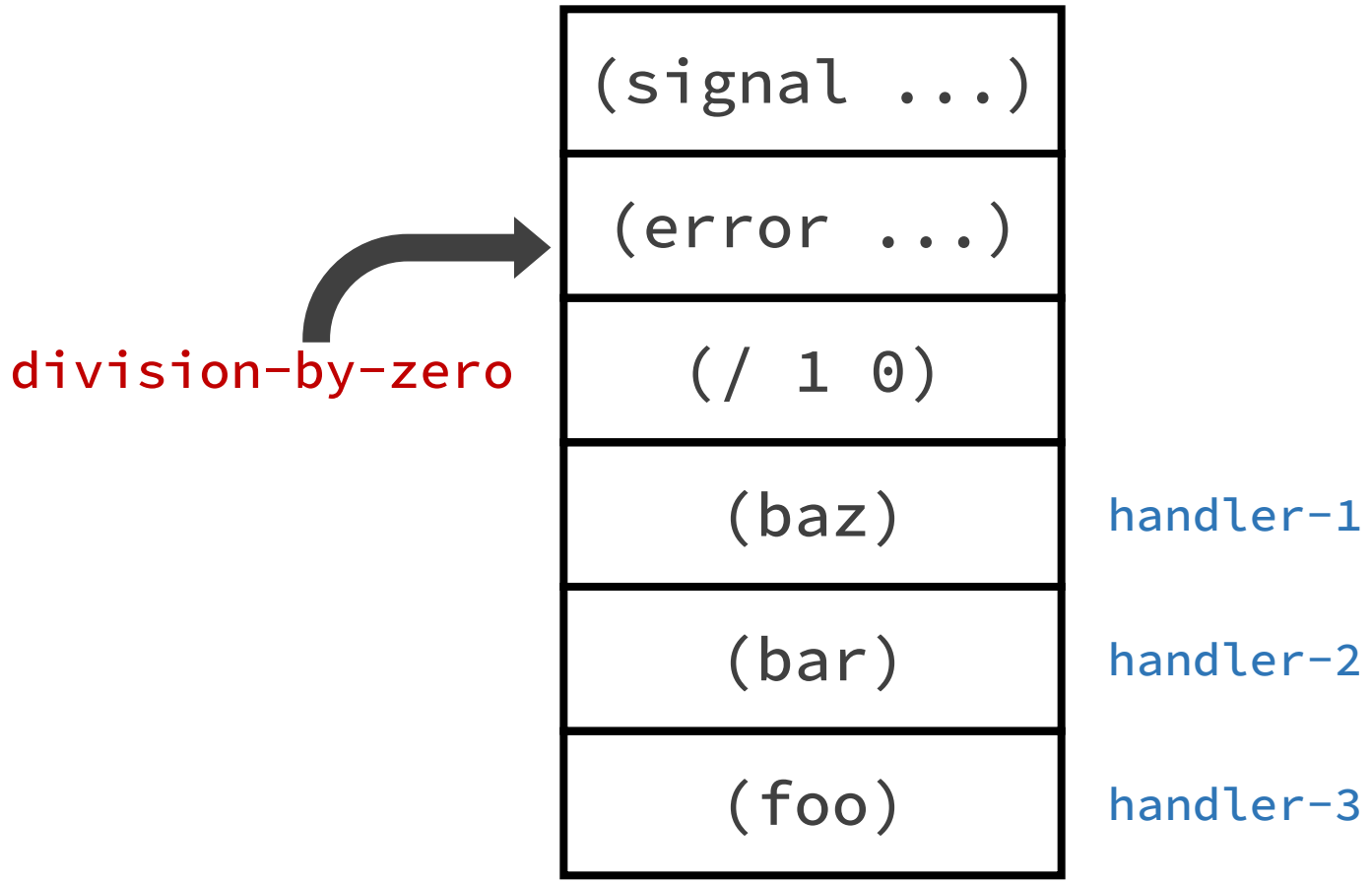

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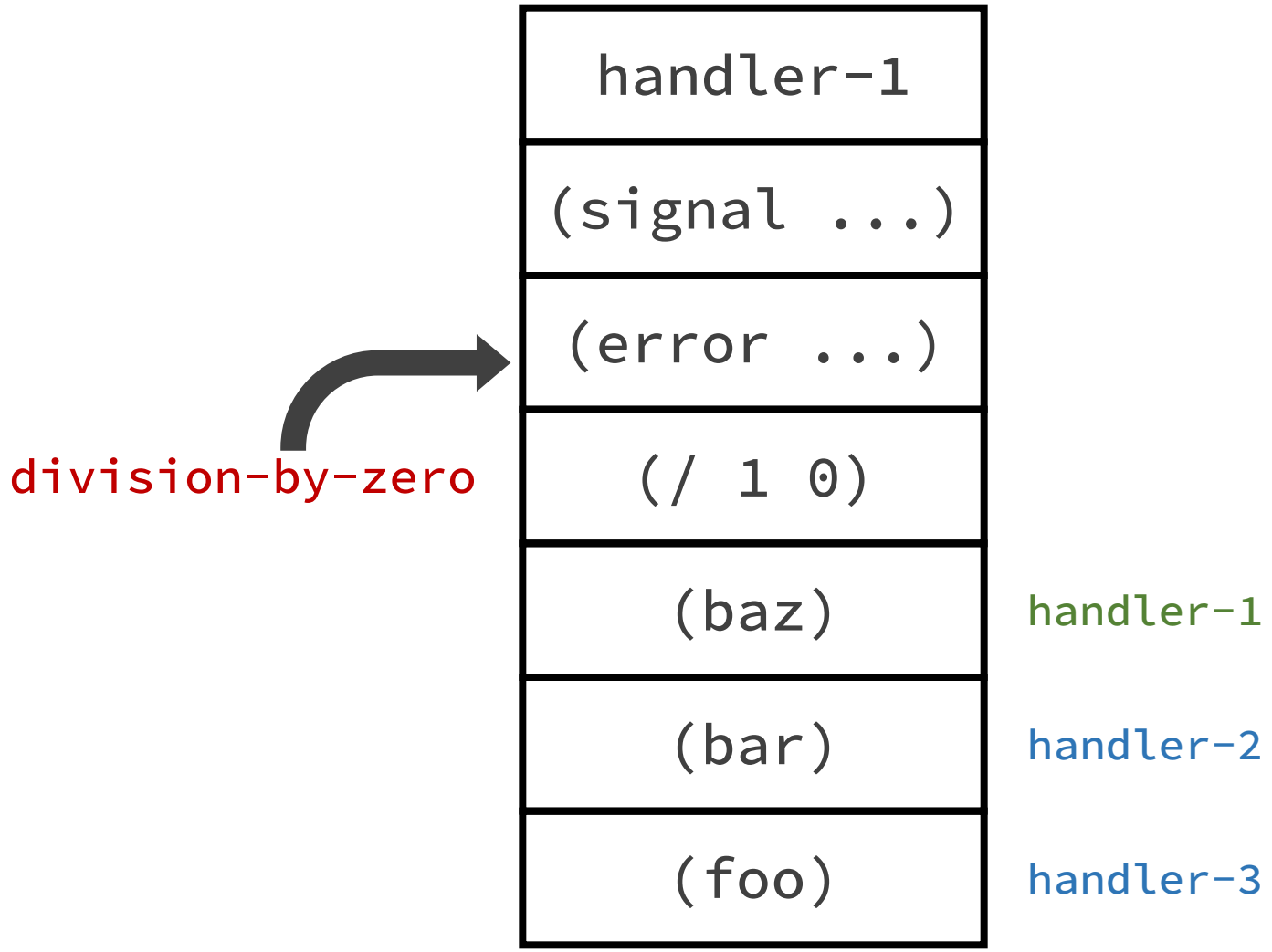

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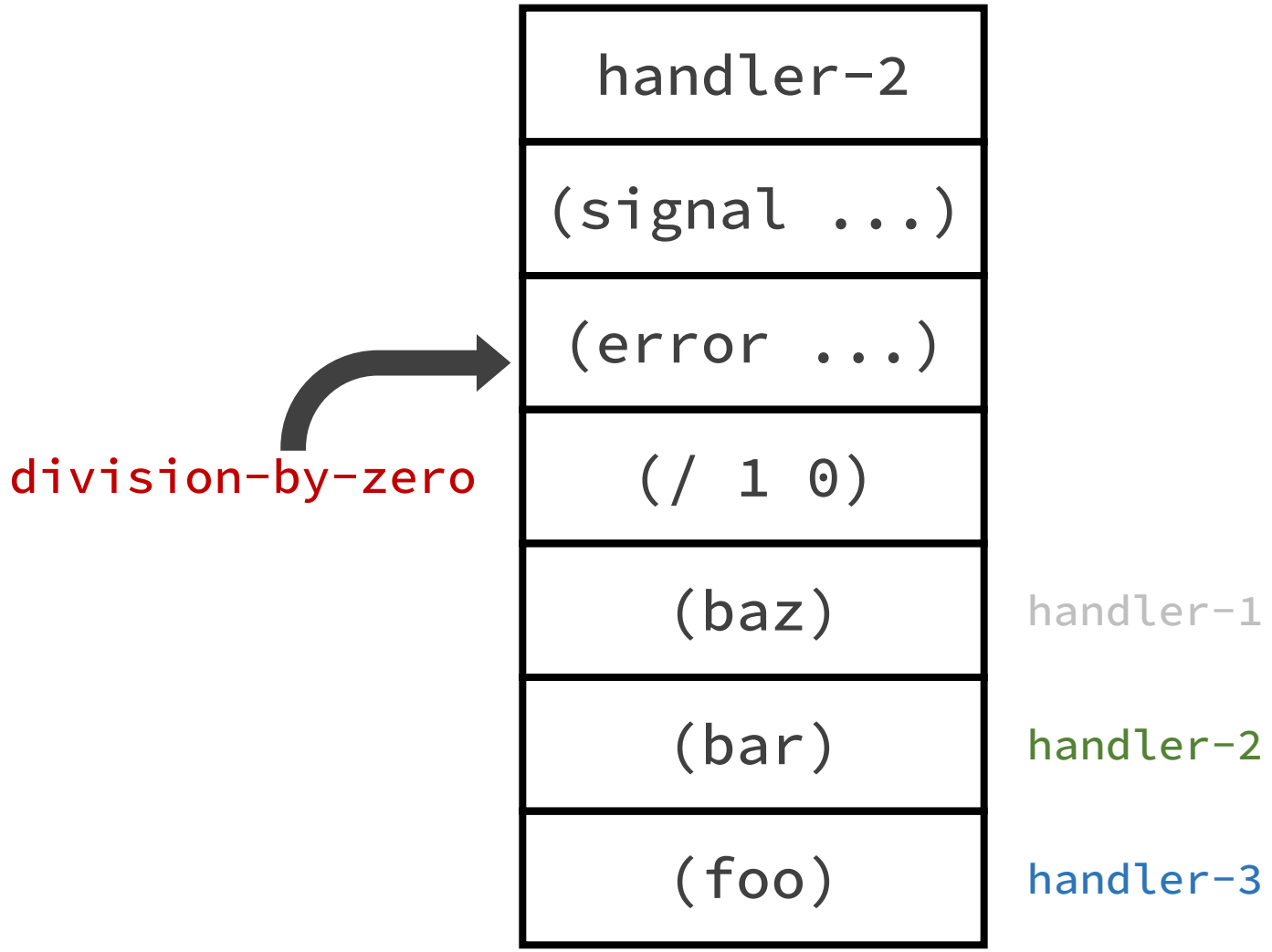

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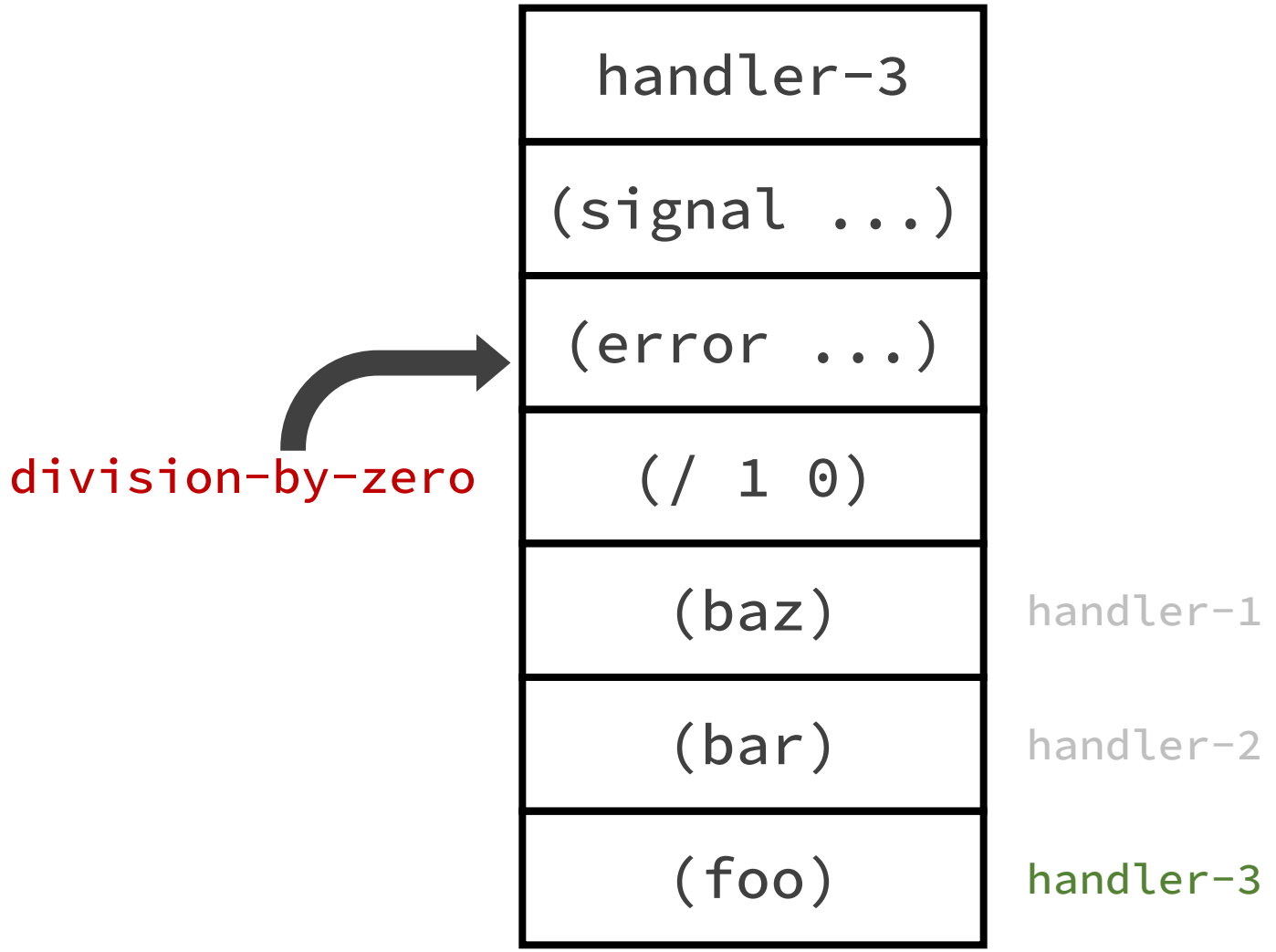

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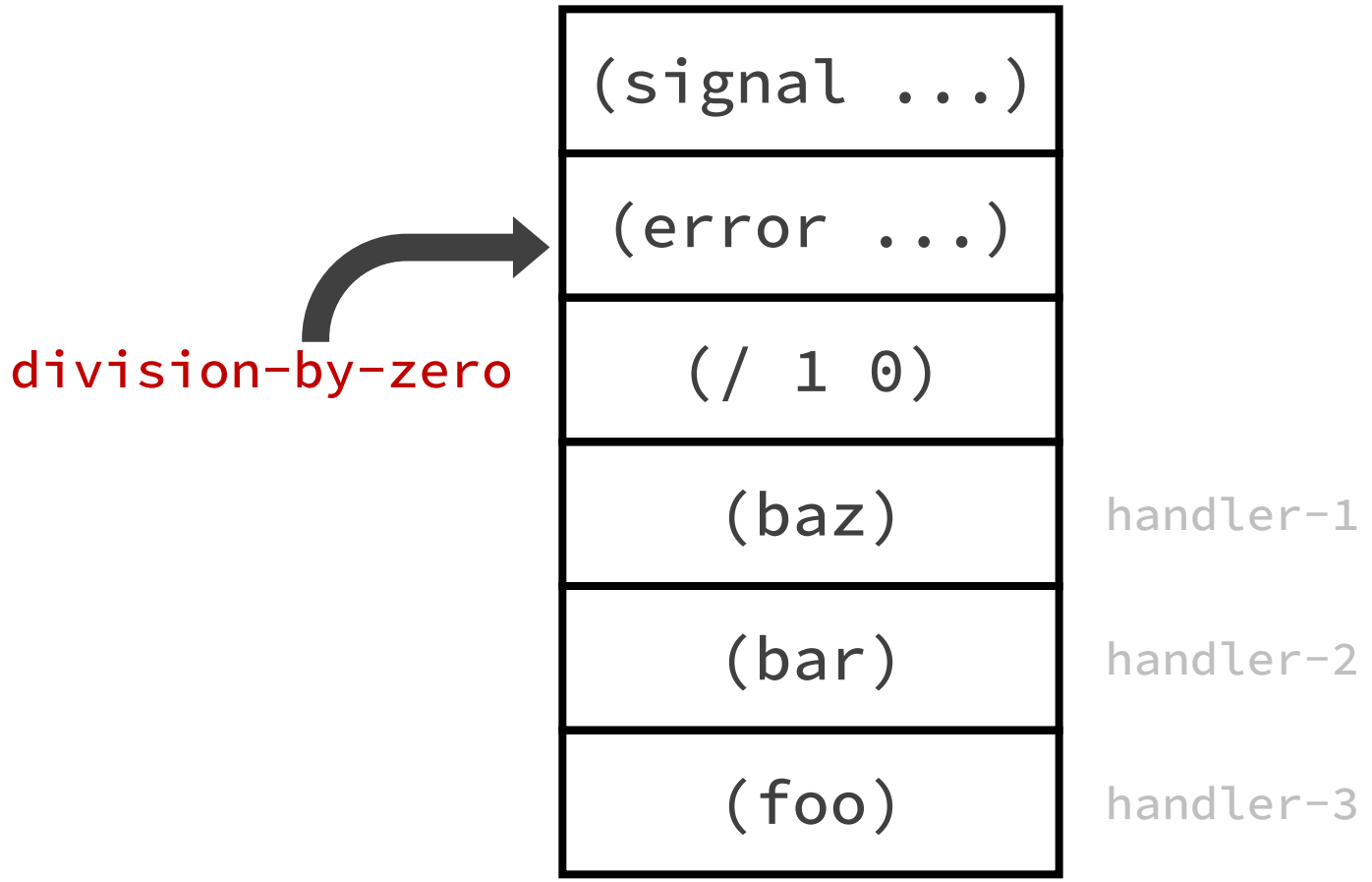

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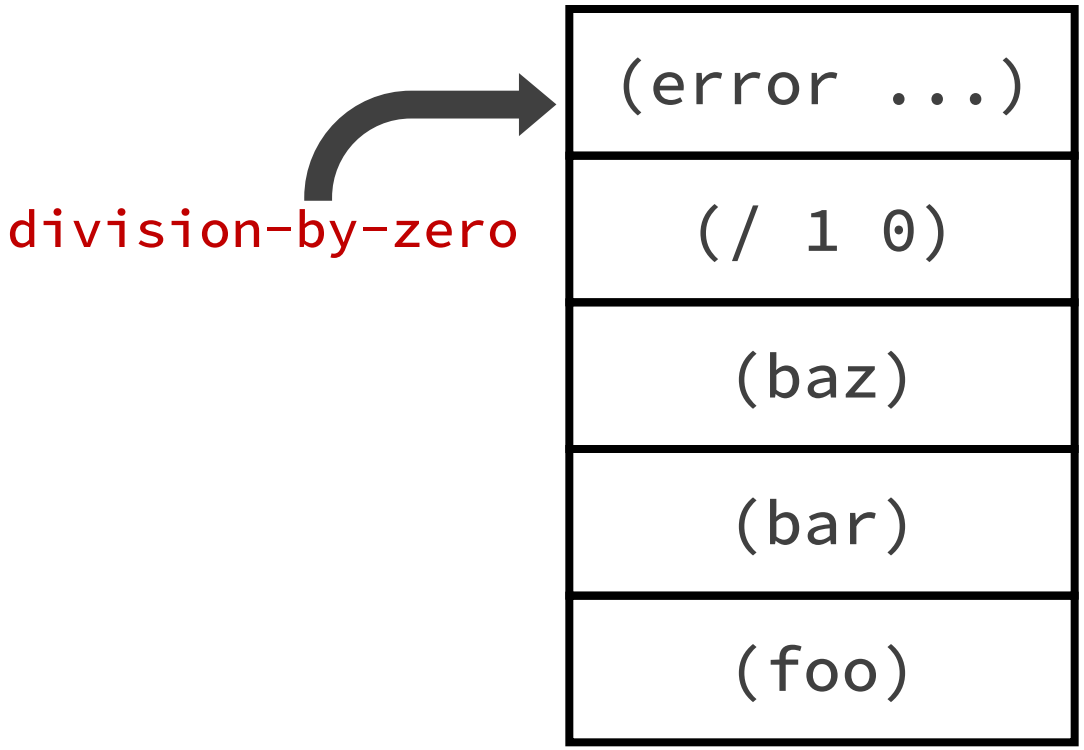

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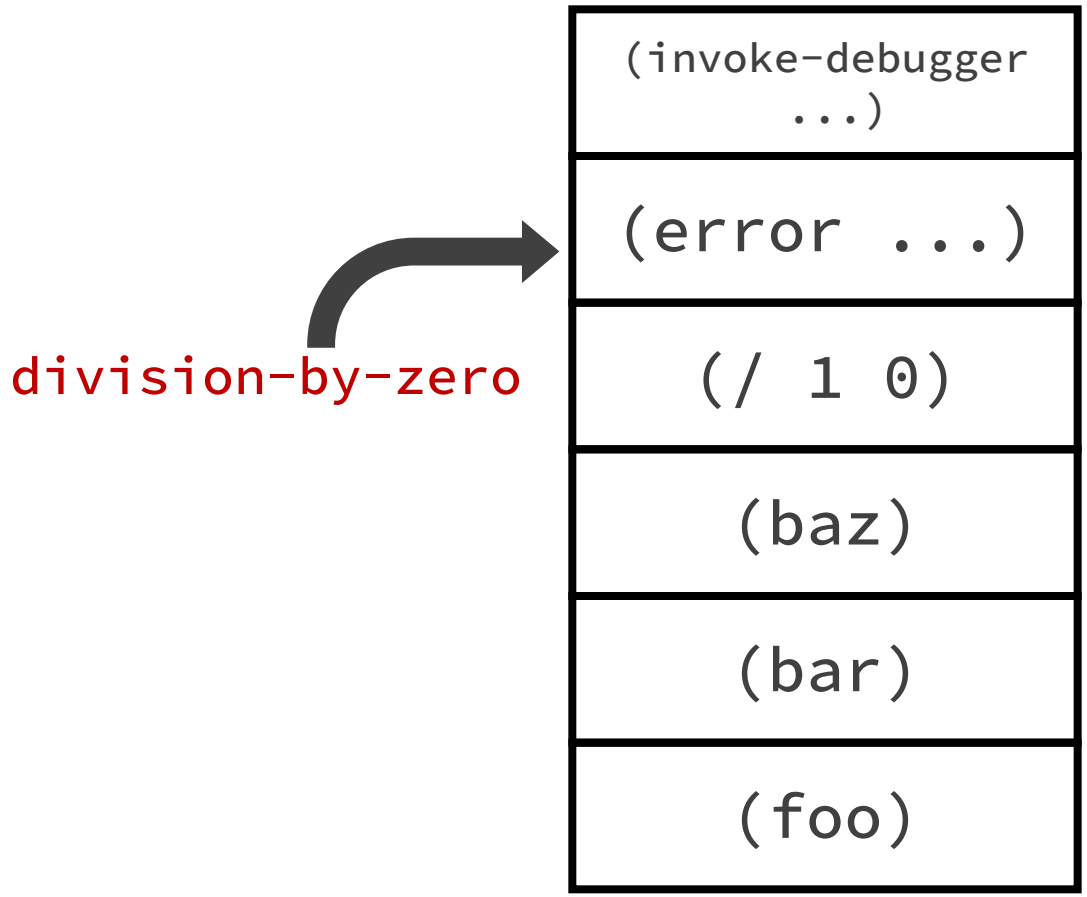

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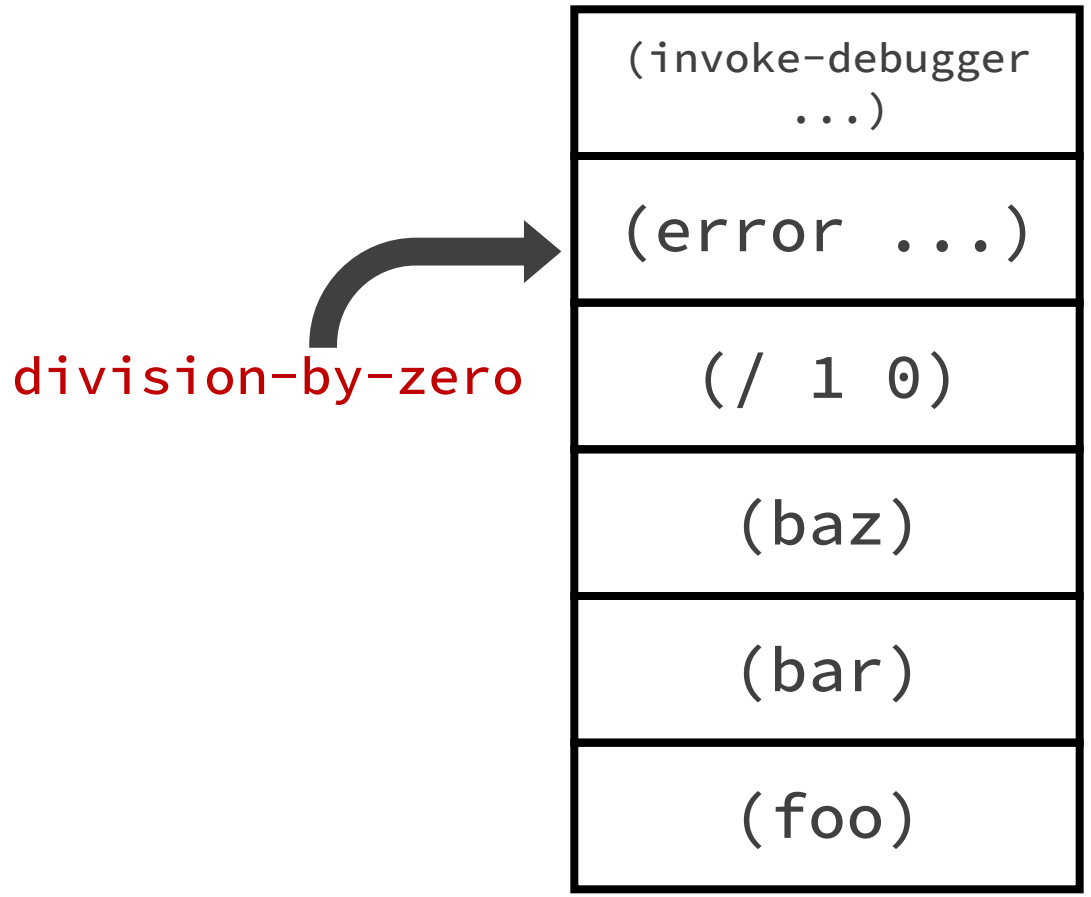

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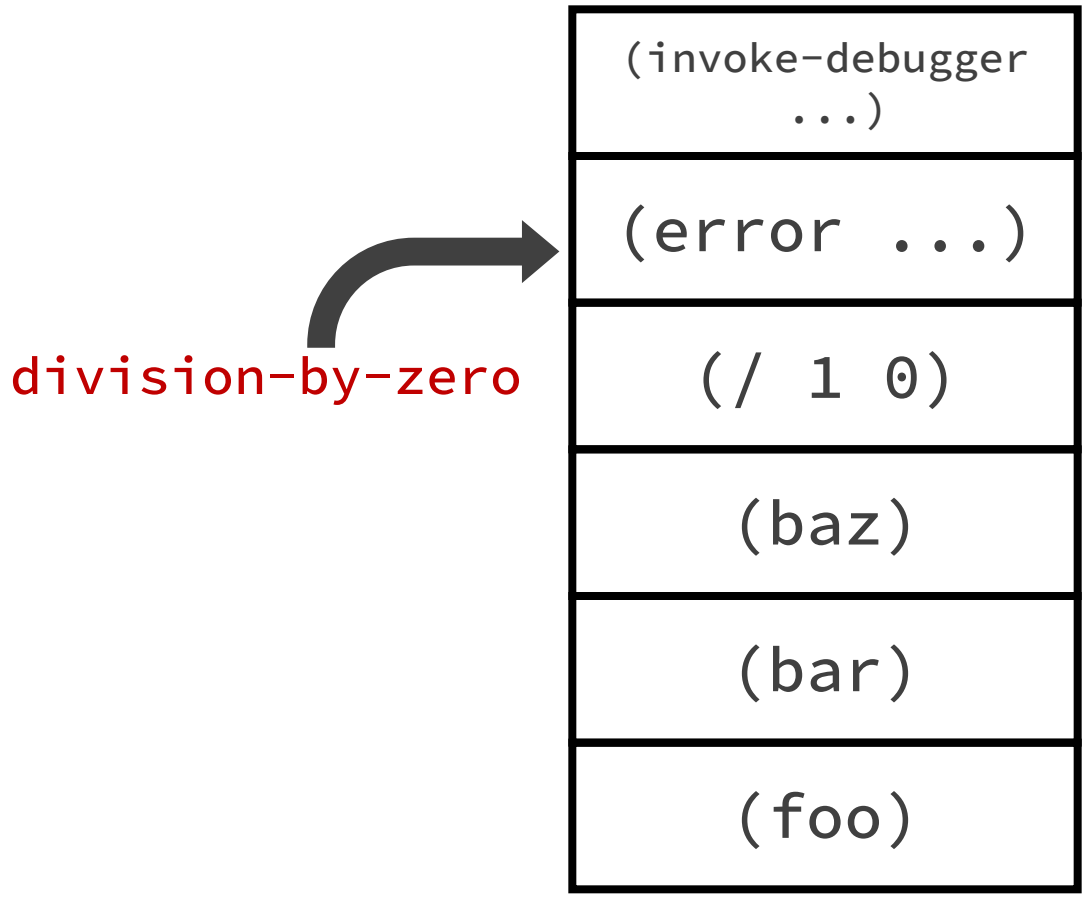

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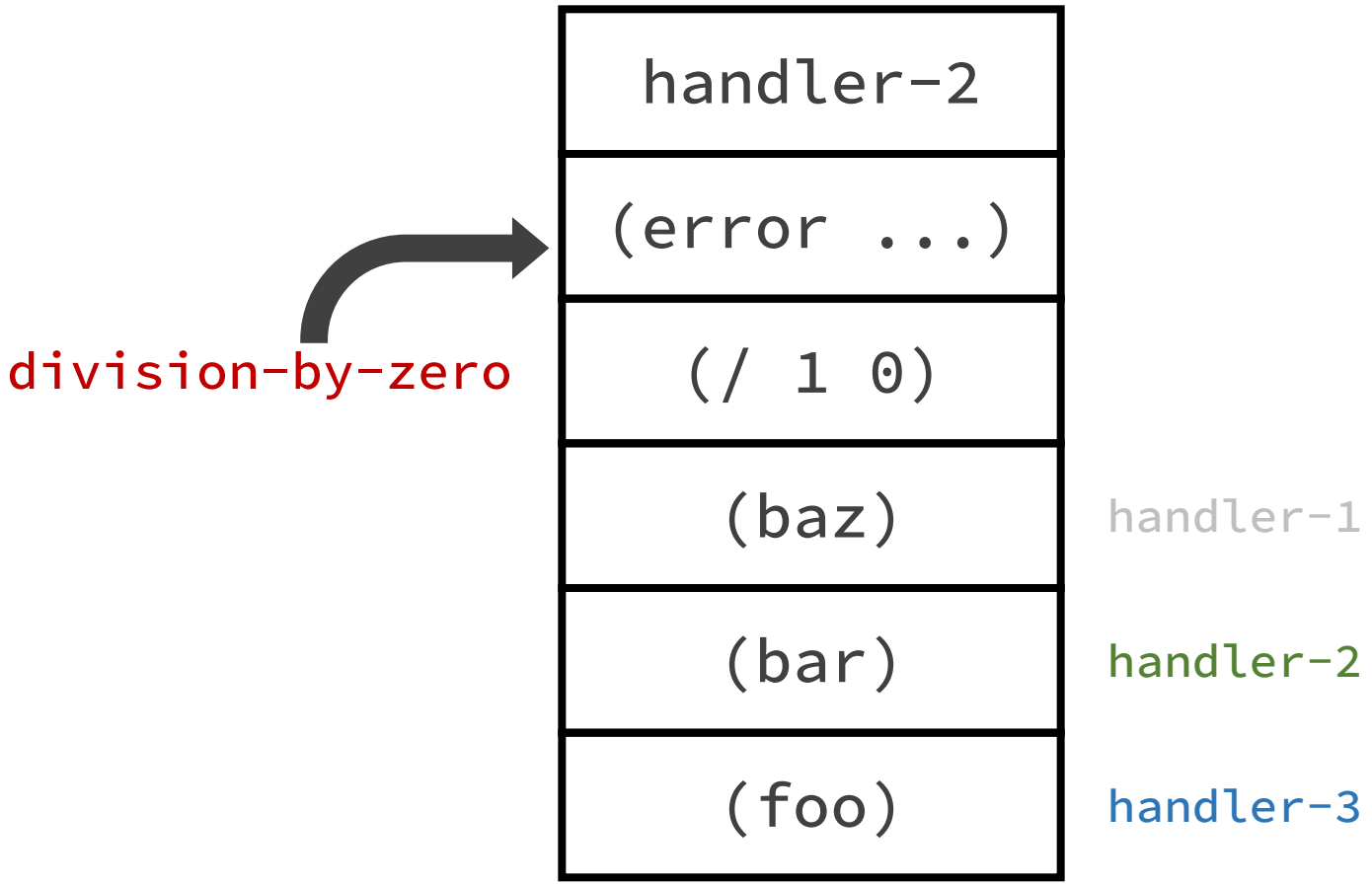

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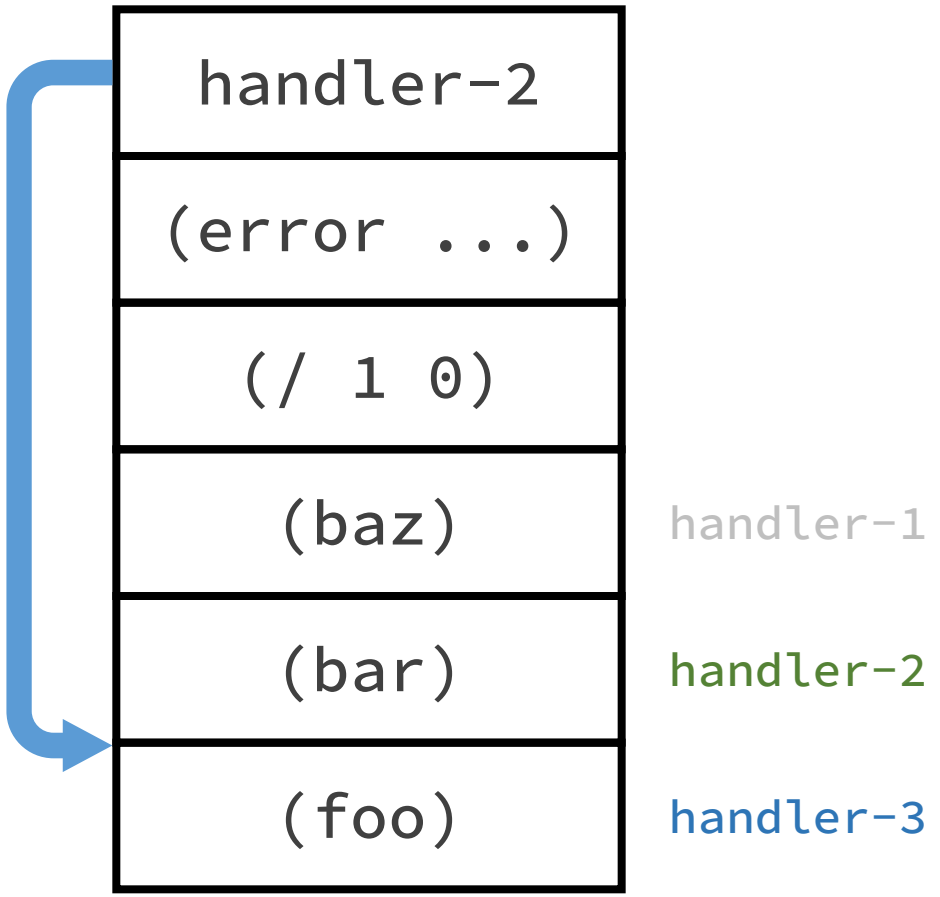

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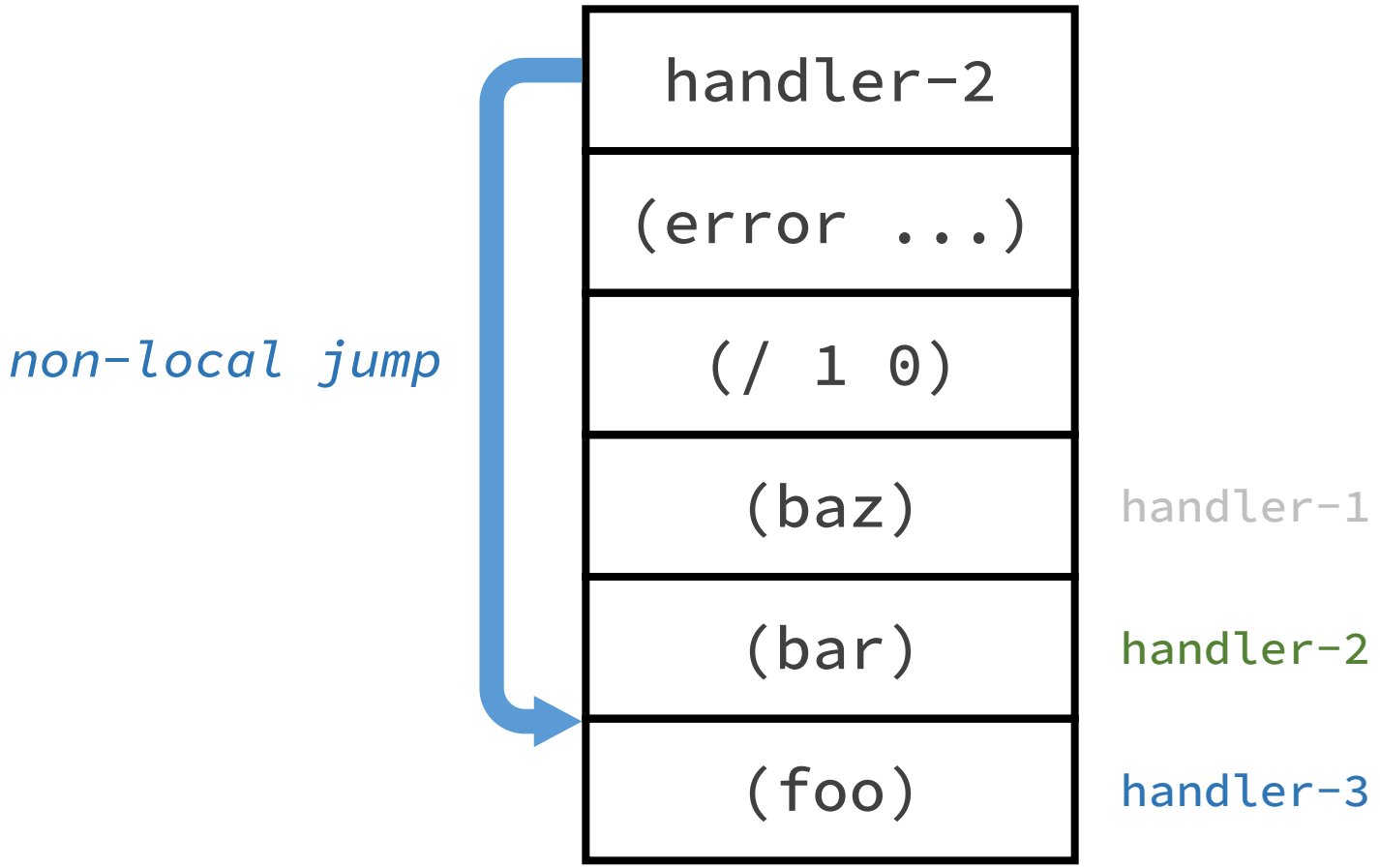

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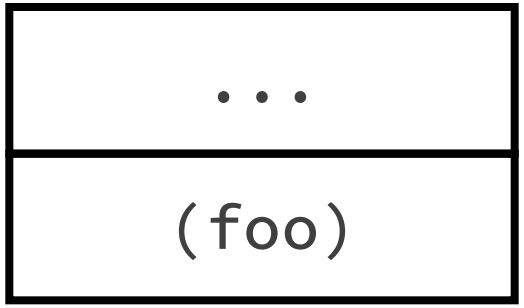
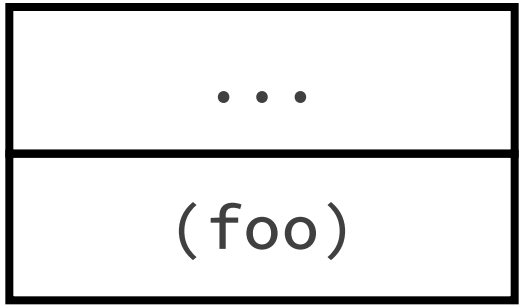



```
// execution continues
```

Let’s talk about restarts

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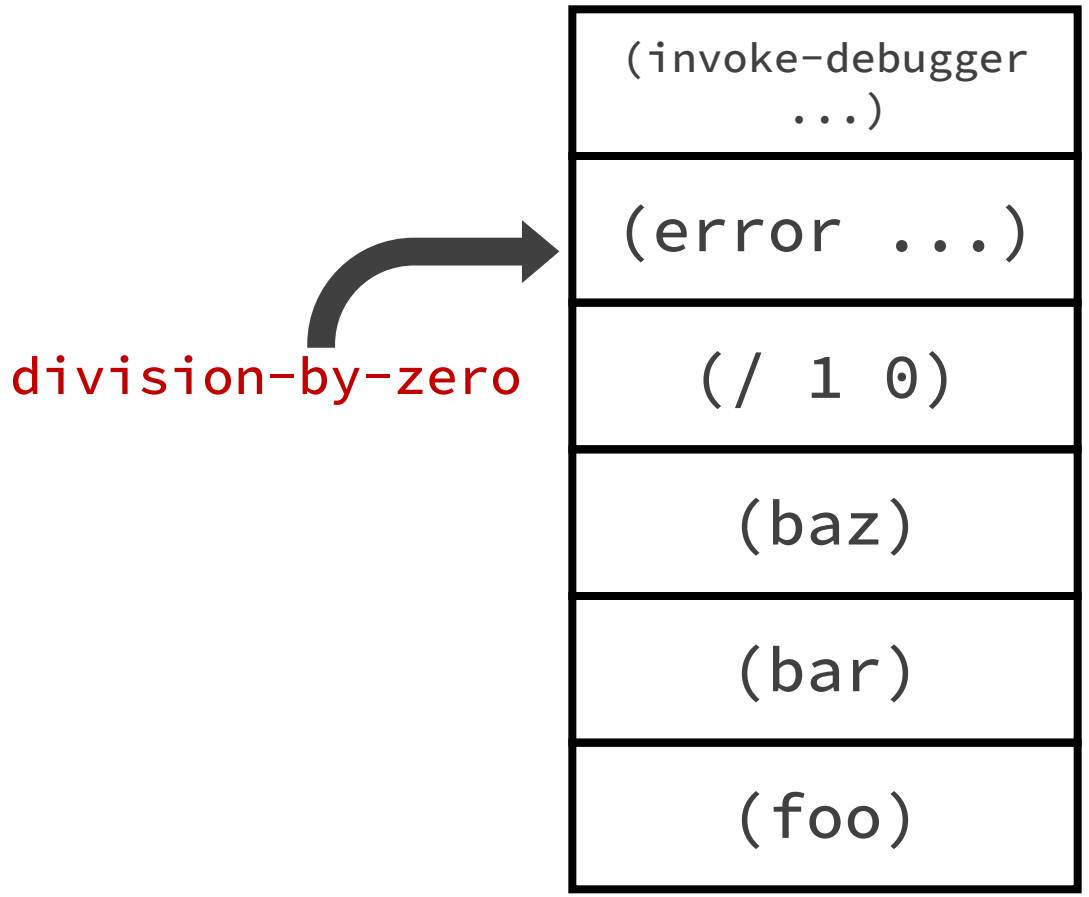
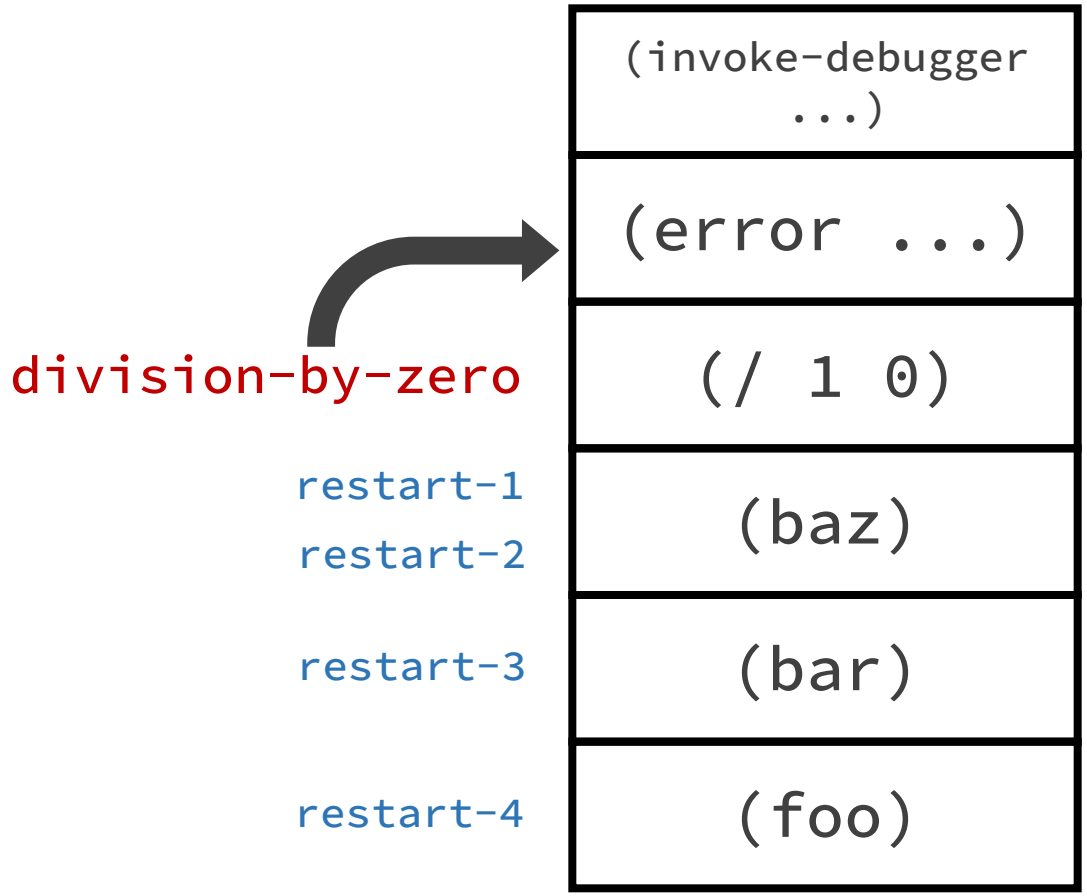
Let's talk about restarts



Let's talk about restarts



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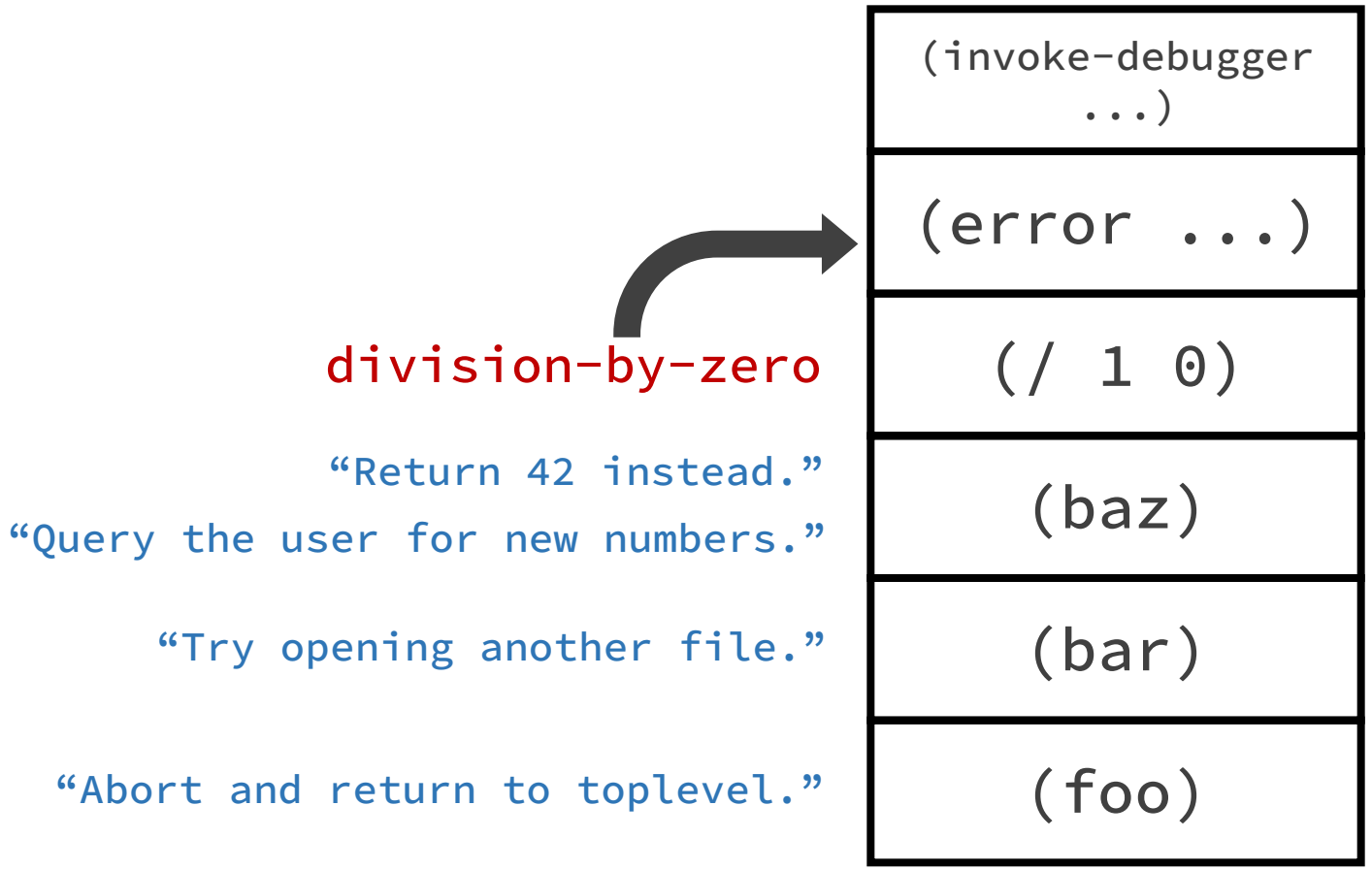

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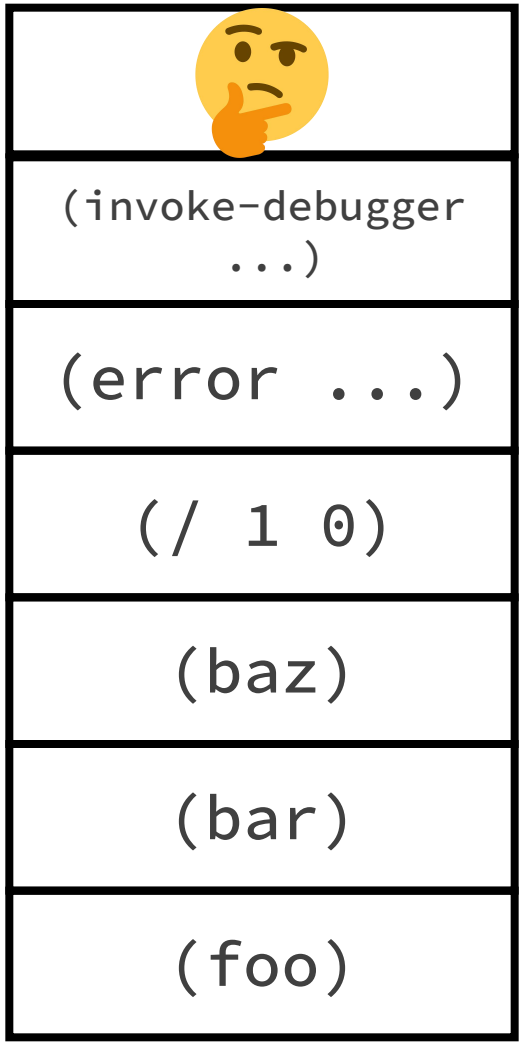


division-by-zero

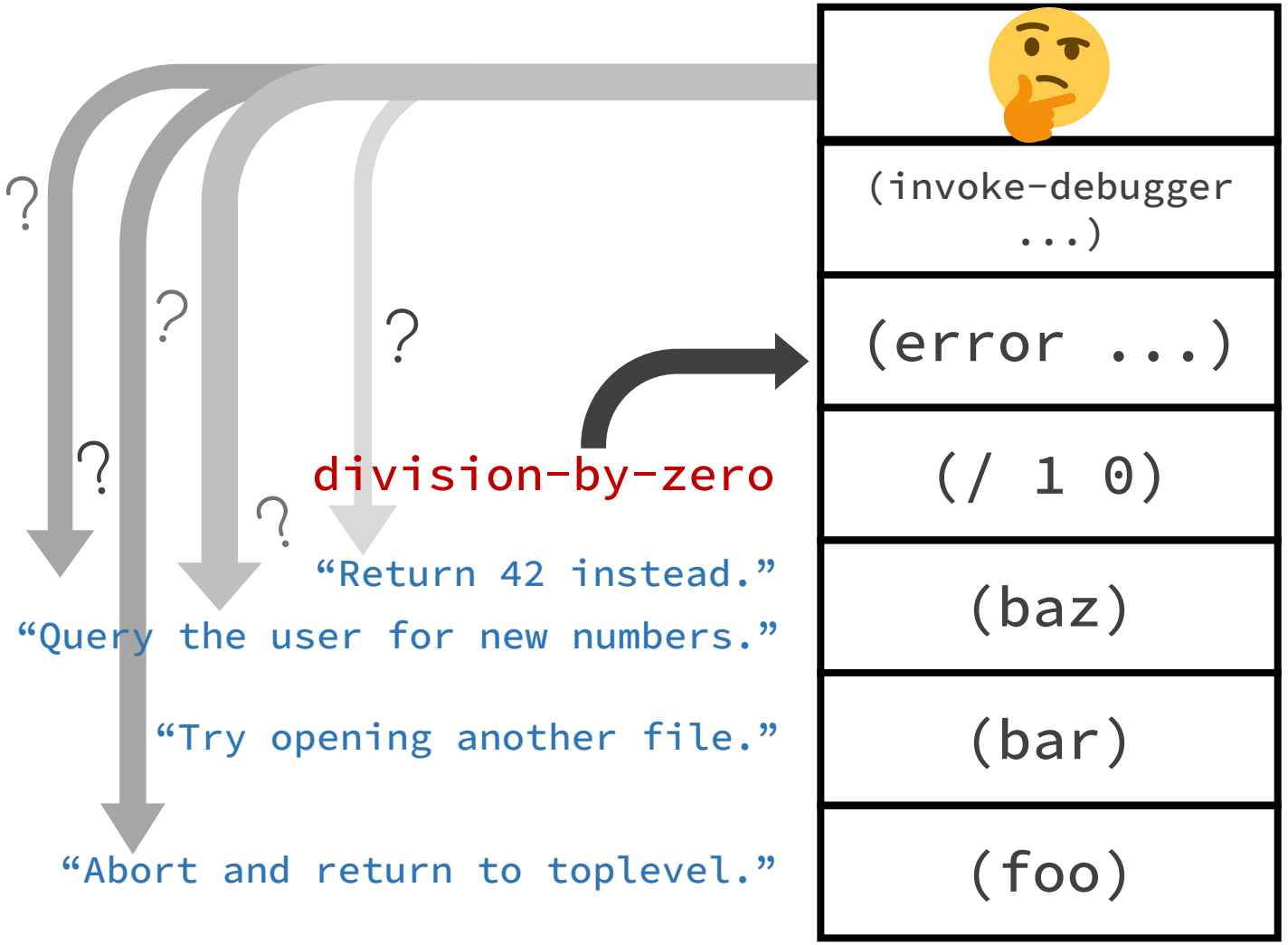
“Return 42 instead.”

“Query the user for new numbers.”

“Try opening another file.”

“Abort and return to toplevel.”

Let's talk about restarts



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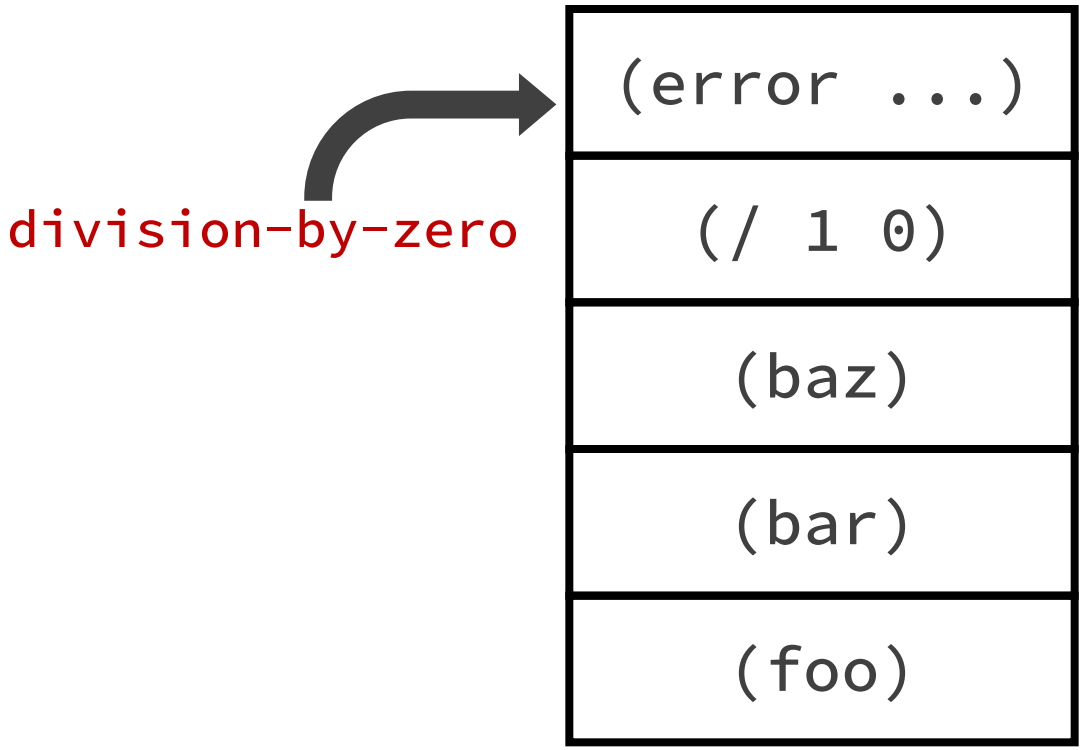

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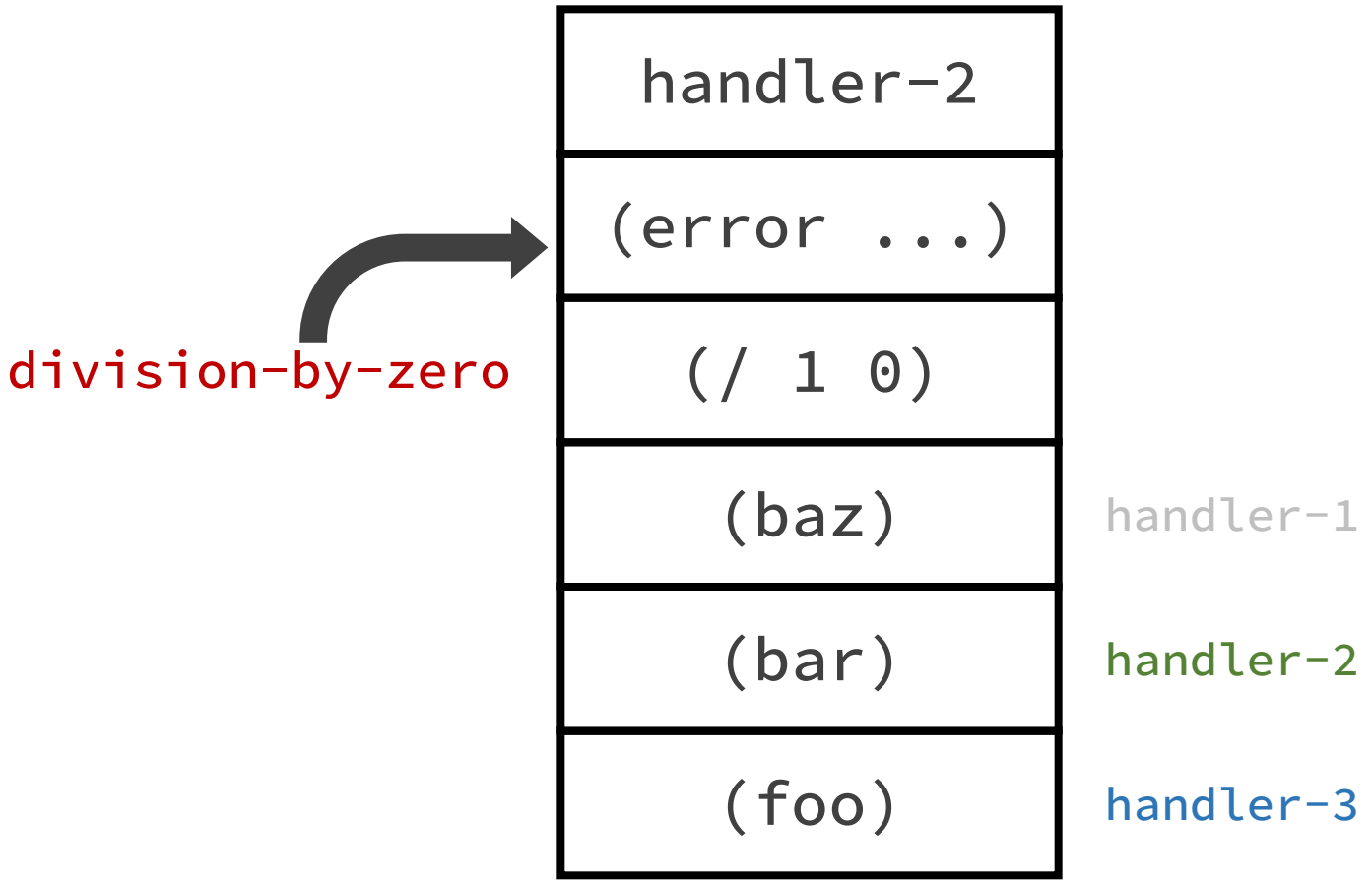

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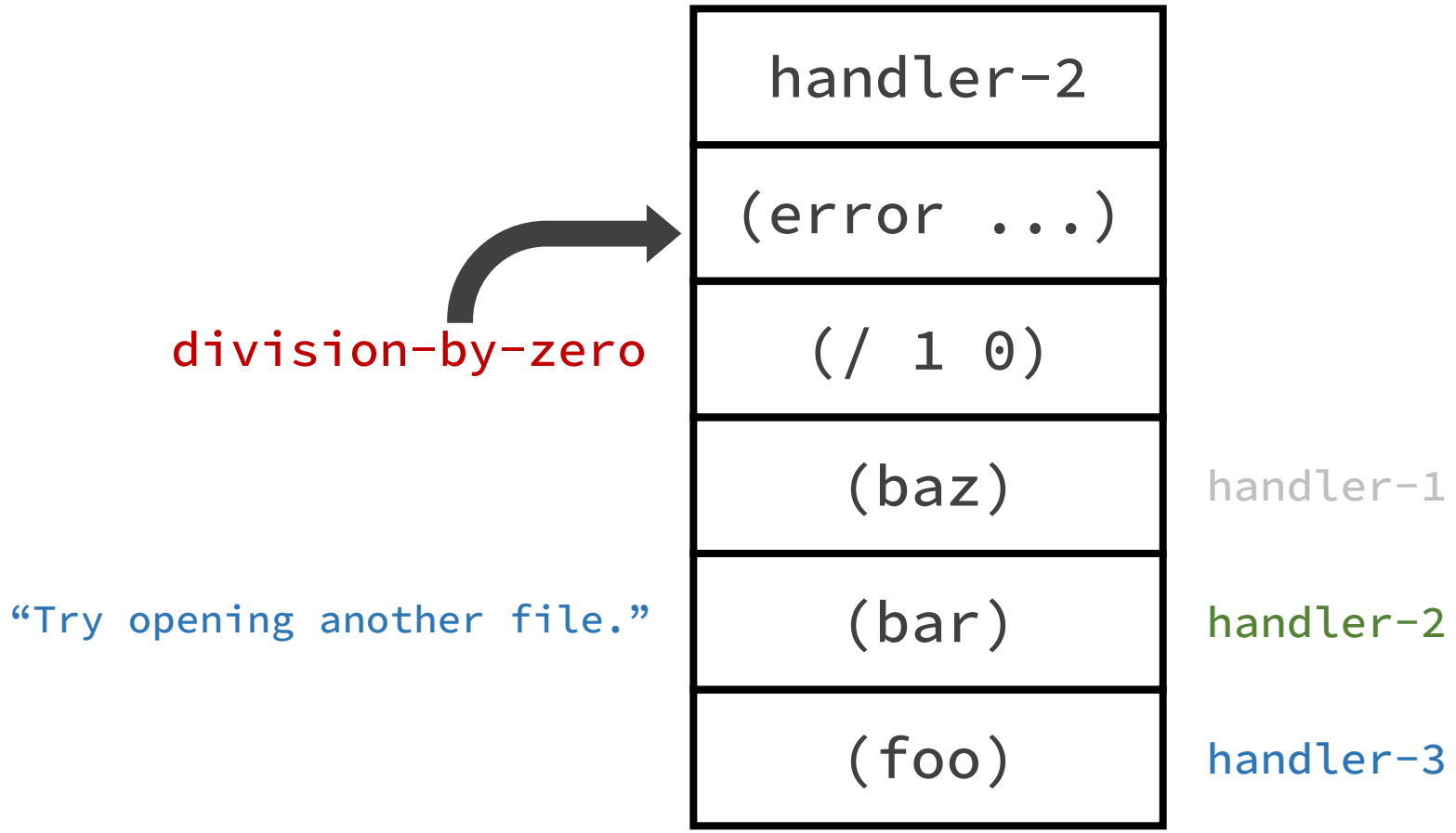

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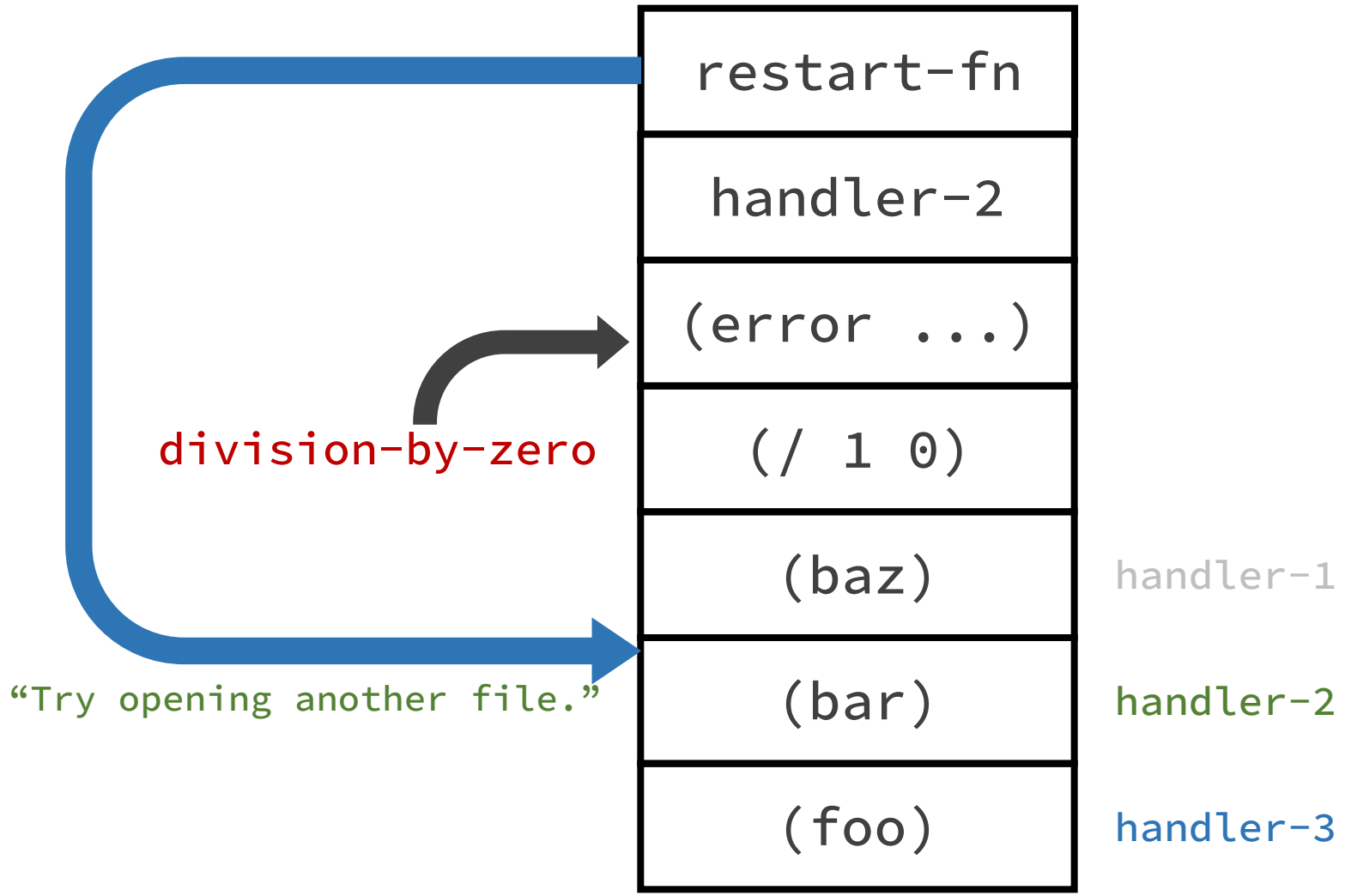

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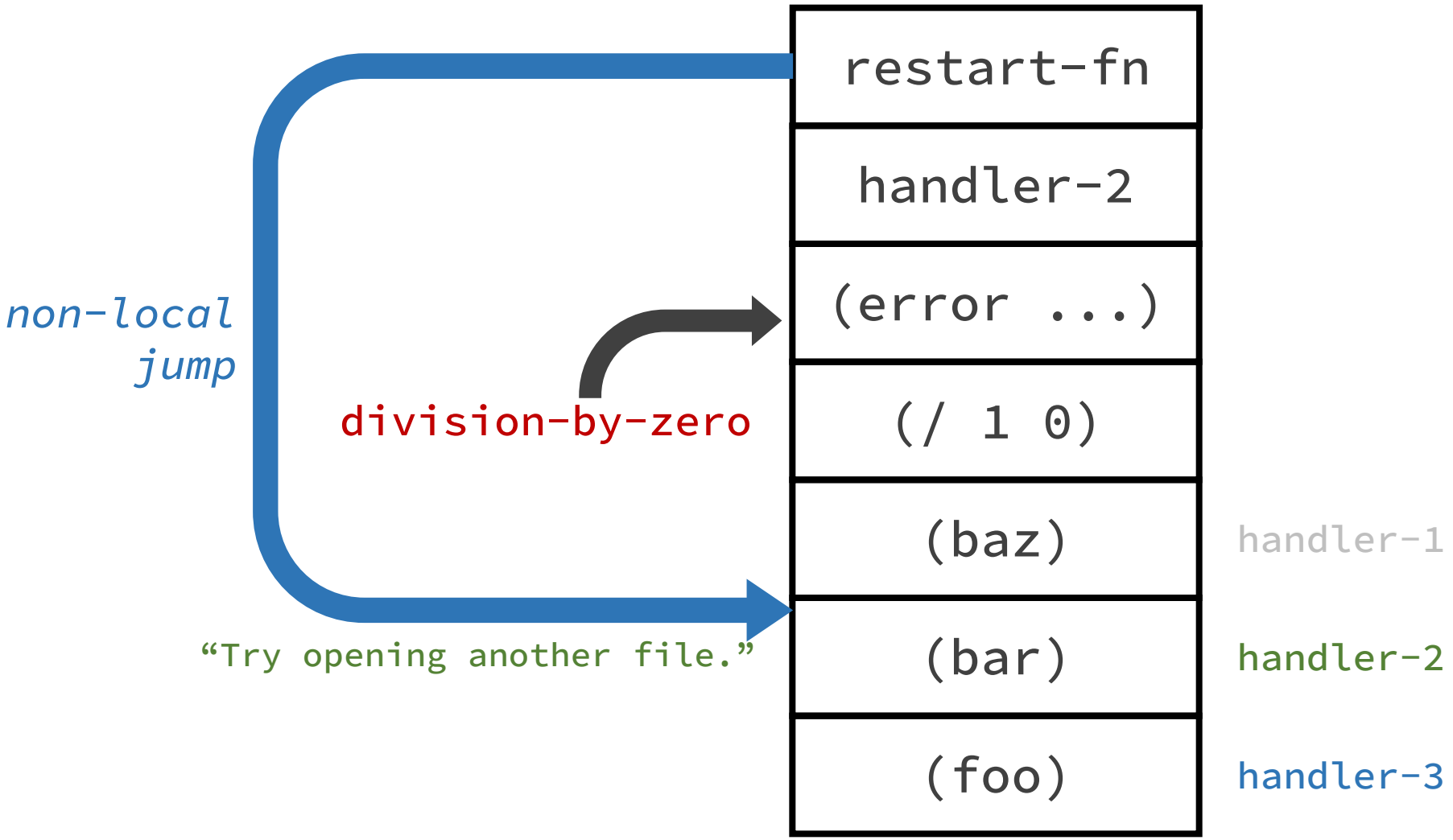

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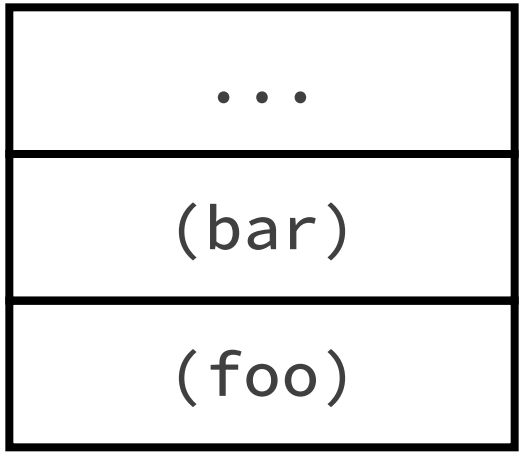


```
// execution continues
```

Let’s talk about signaling a non-error condition

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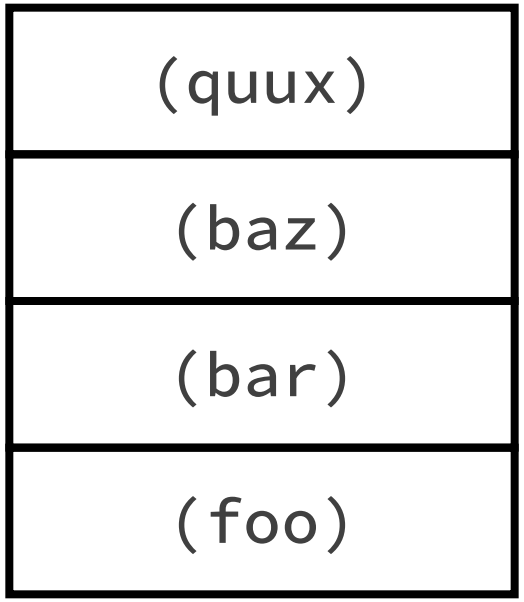
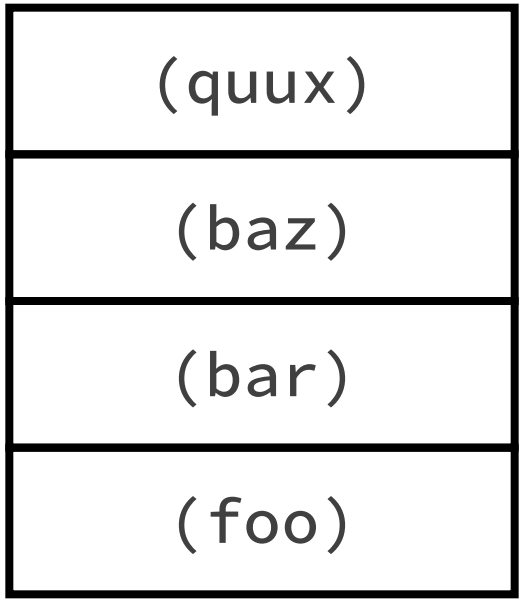


Let’s talk about signaling a non-error condition

some-condition



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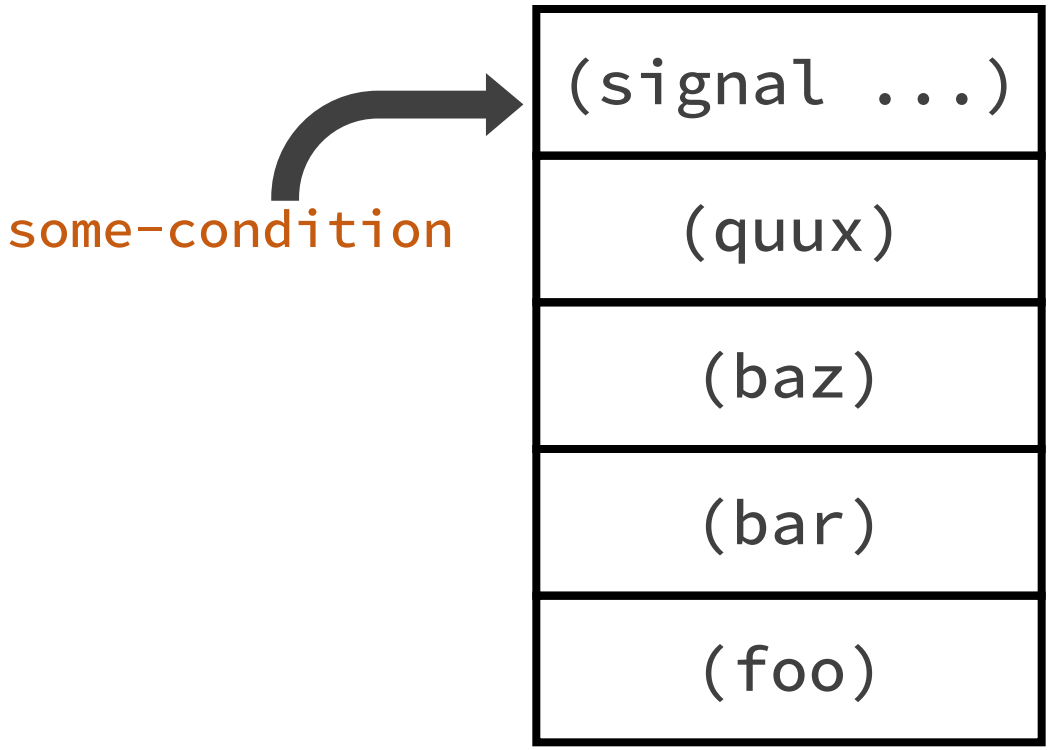

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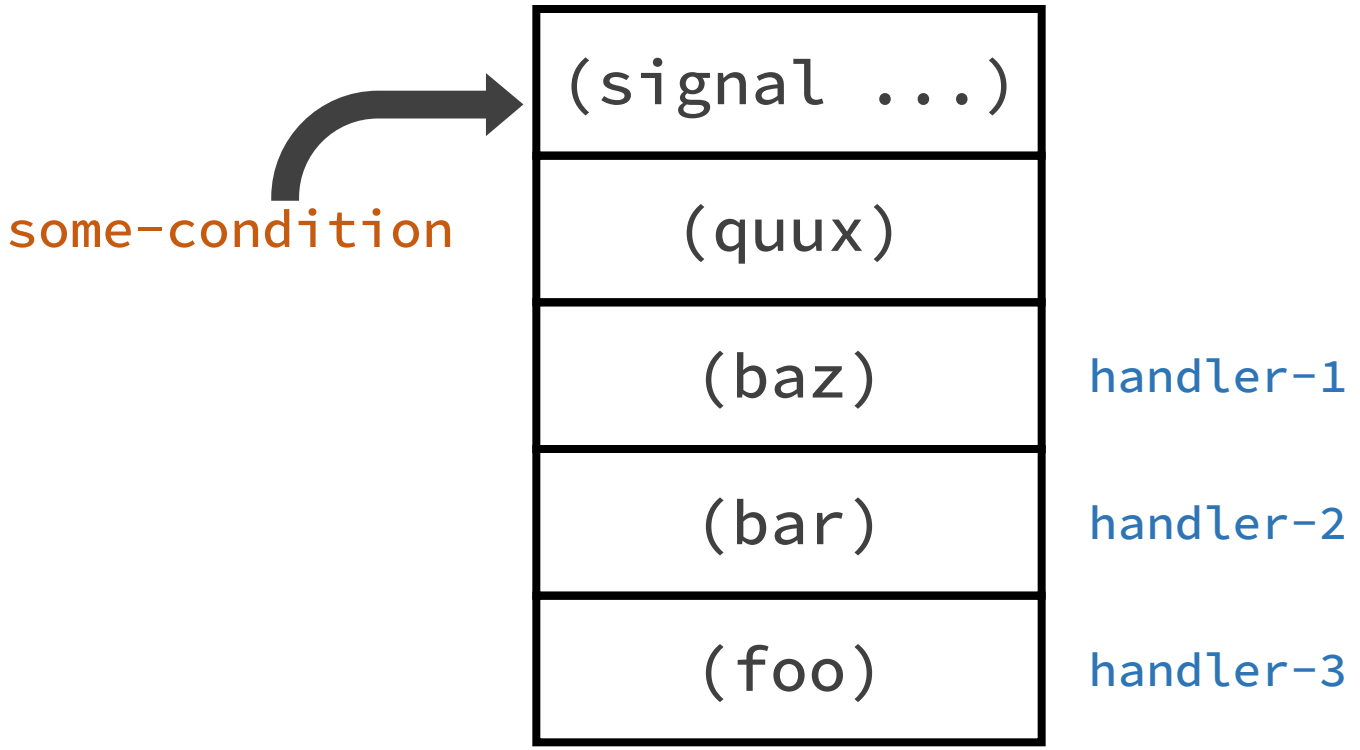

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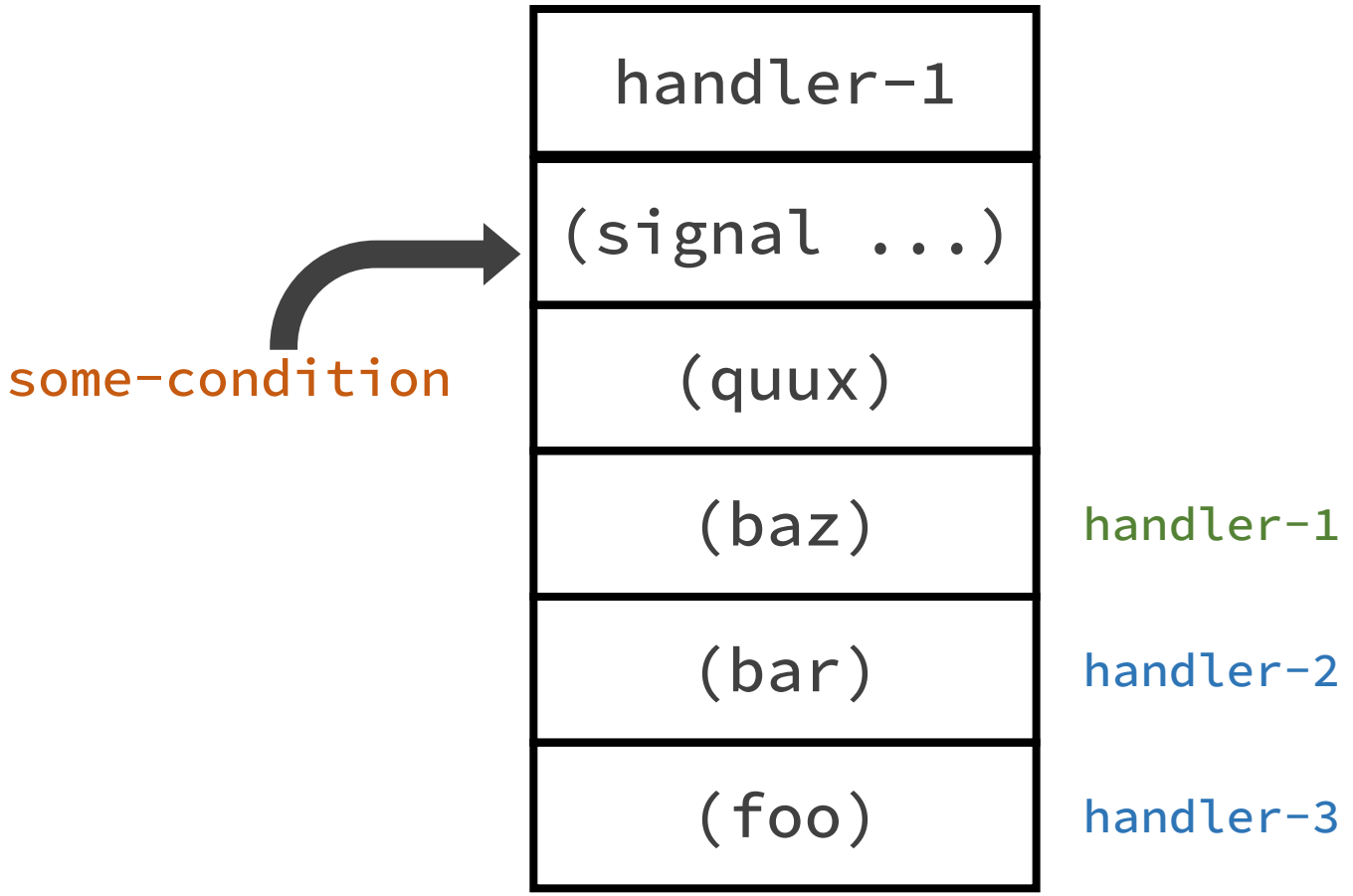

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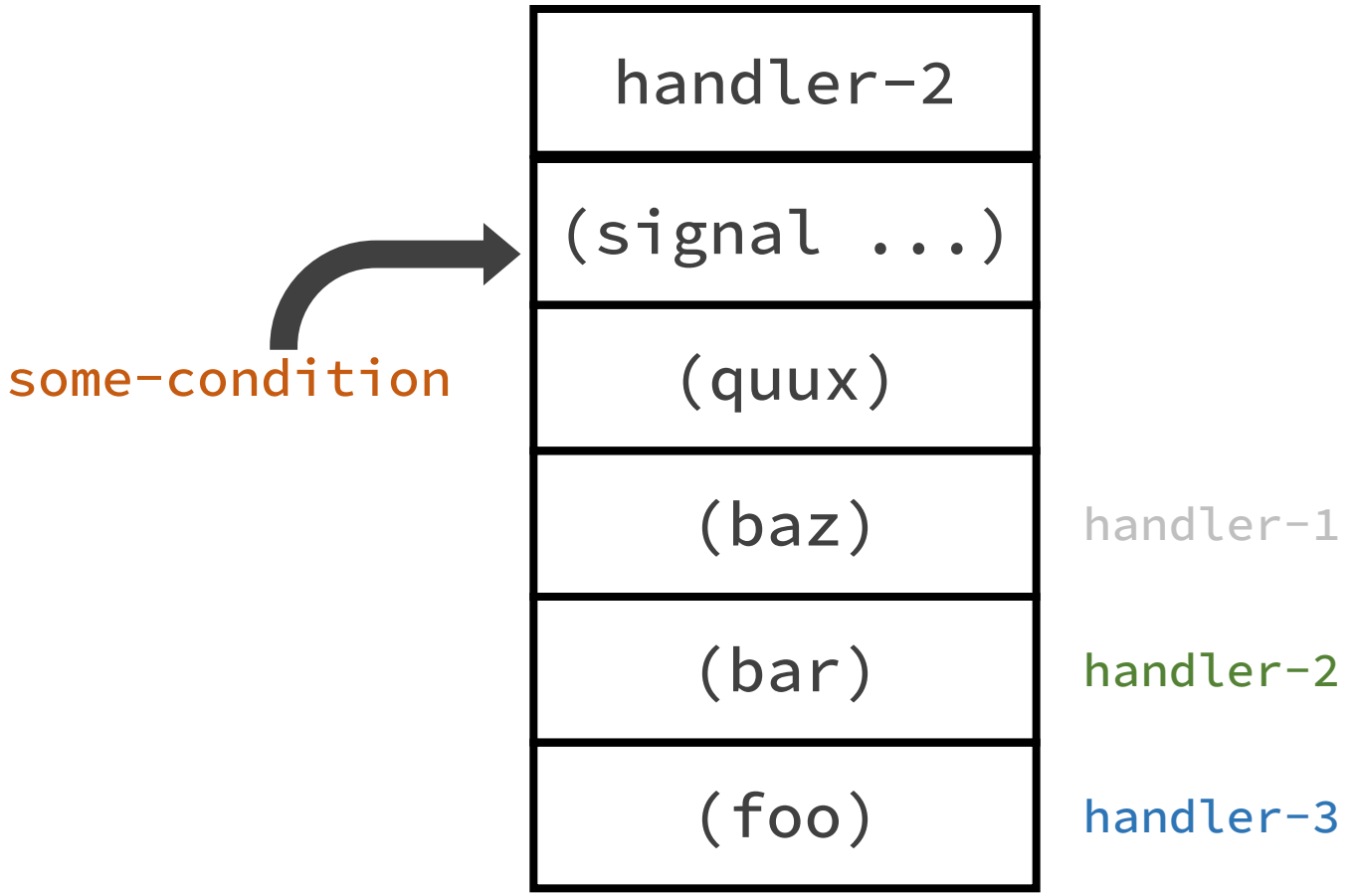

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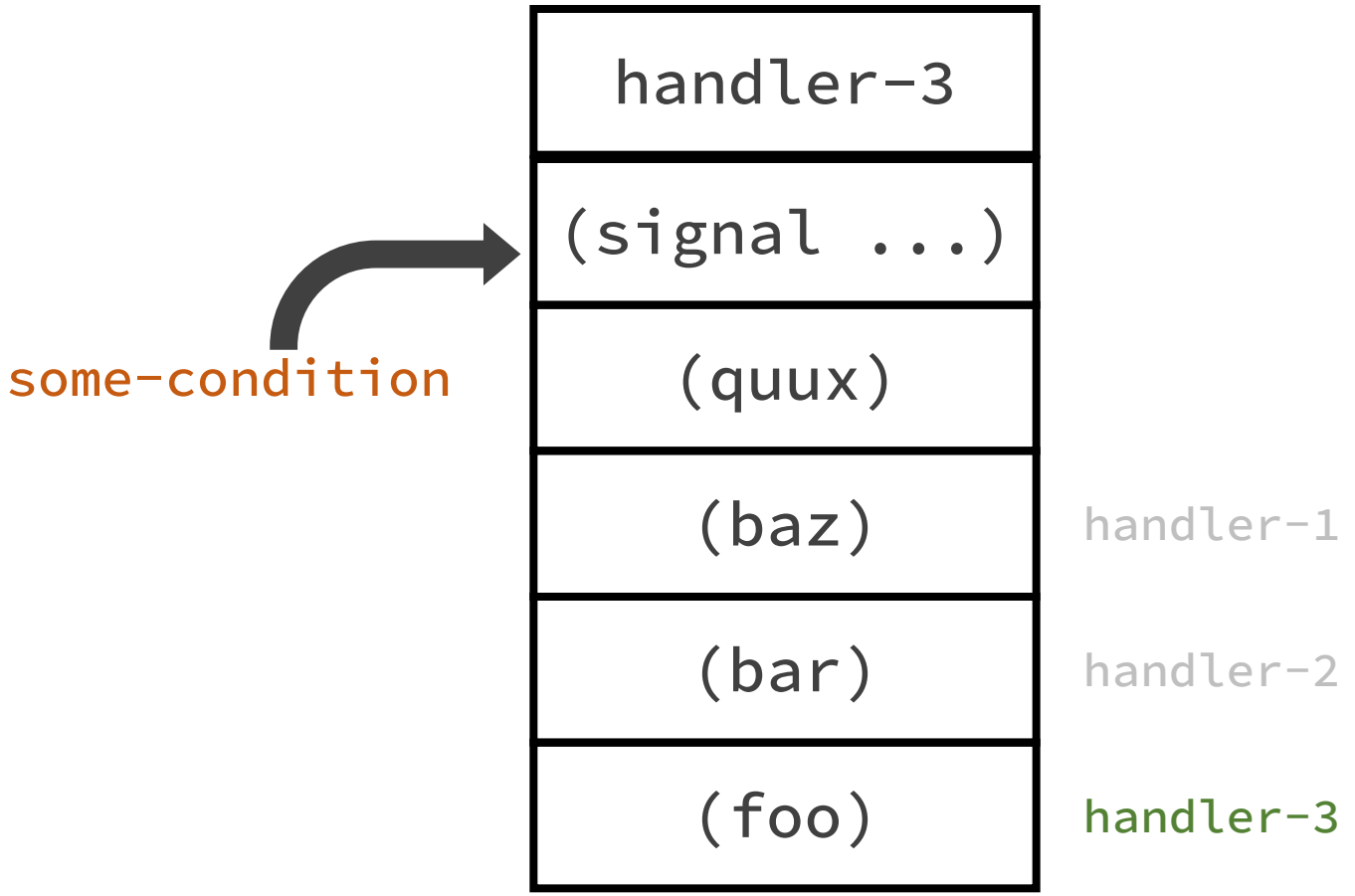

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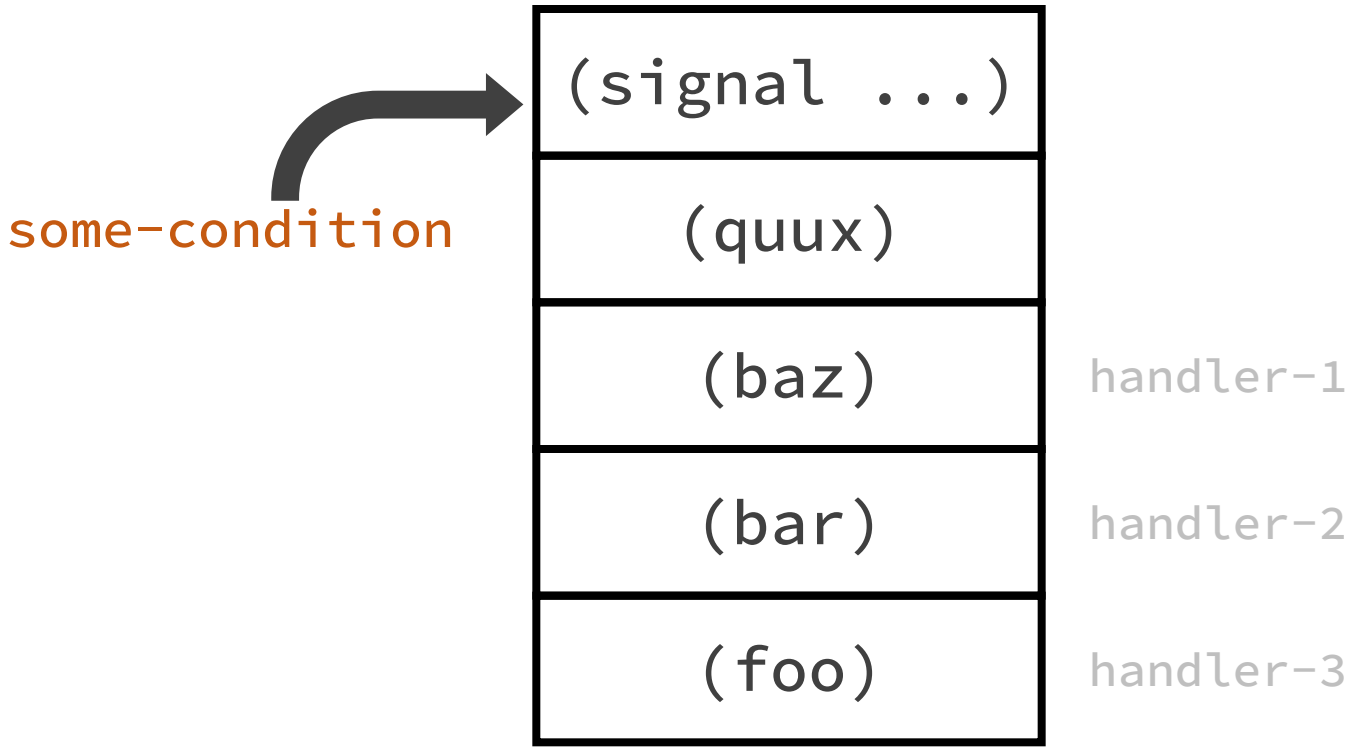

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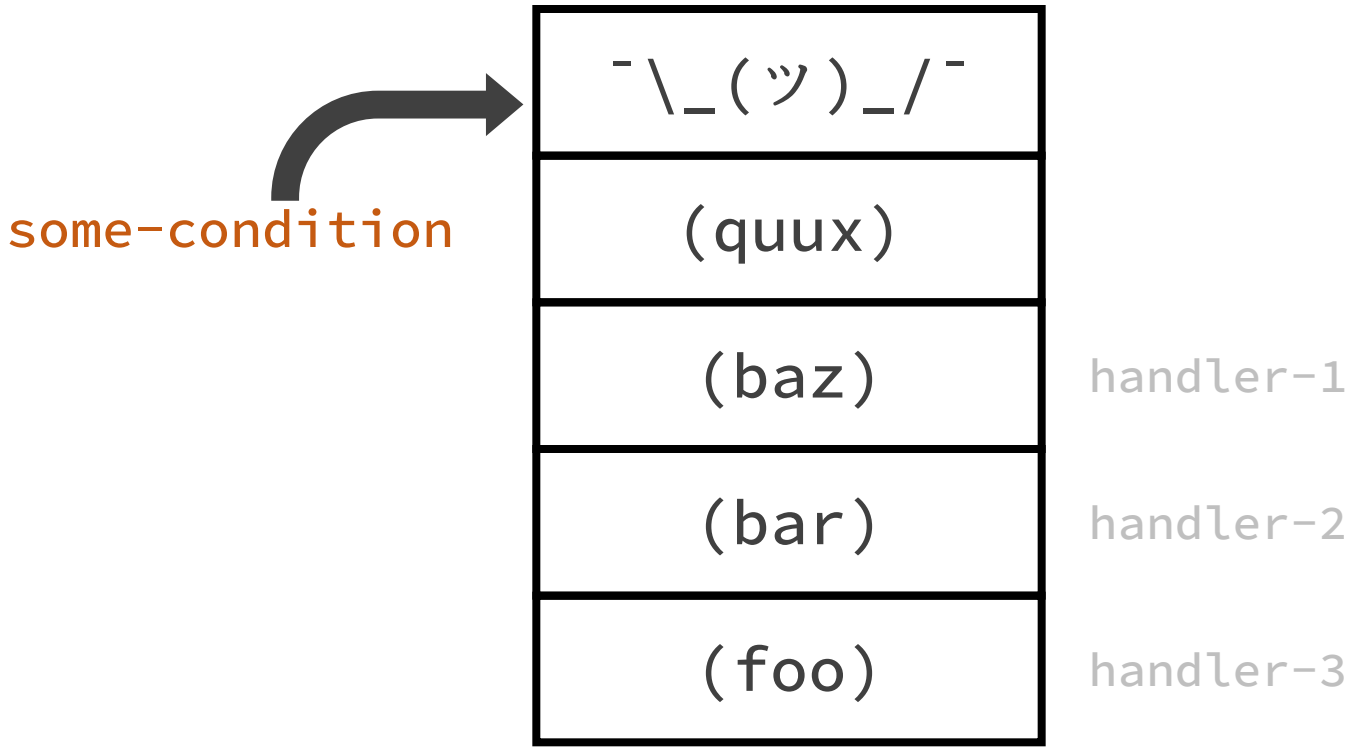

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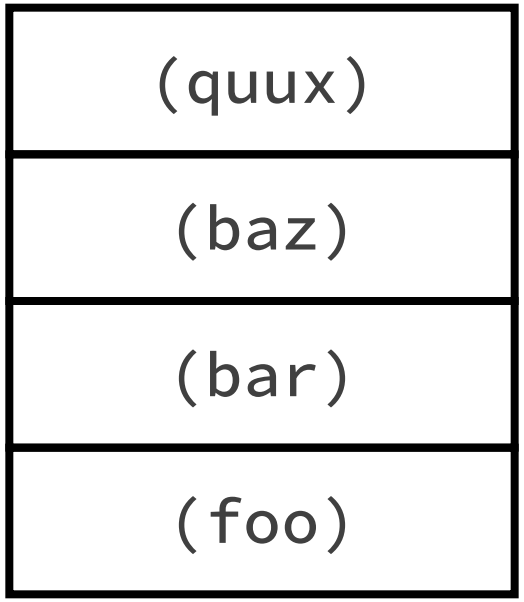

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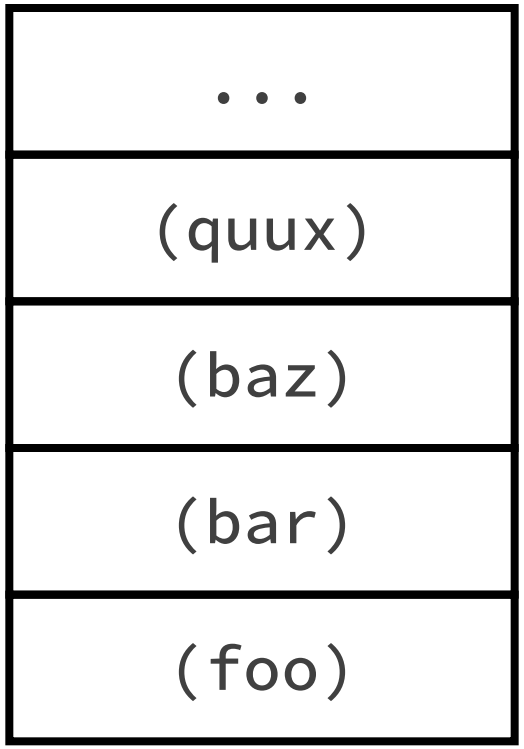


```
// execution continues
```

Let’s talk about throwing exceptions

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- Construct the exception object

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  - What do the handlers do?
    - Maybe execute some code

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    - Maybe invoke a restart

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    - Maybe invoke a restart
    - Maybe do nothing and return

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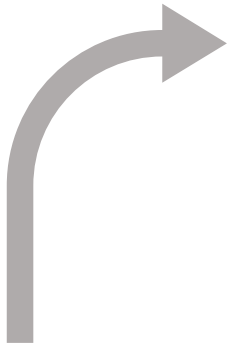

- signaling = a dynamically scoped hooking mechanism
  - progress bars
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  - etc..

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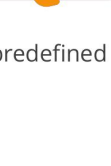

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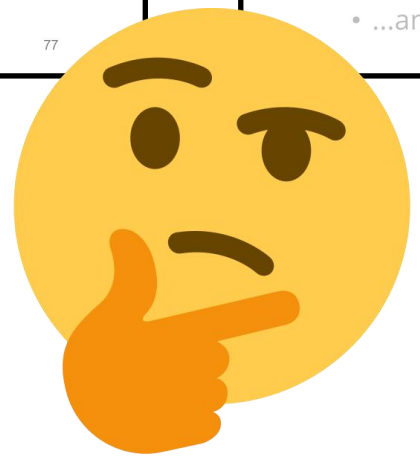

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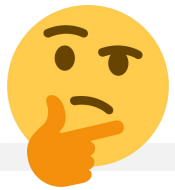

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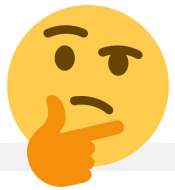

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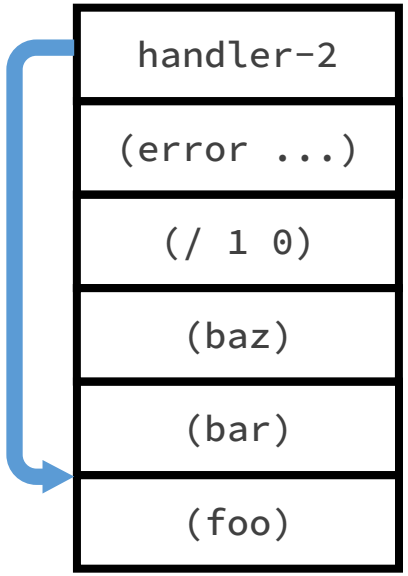

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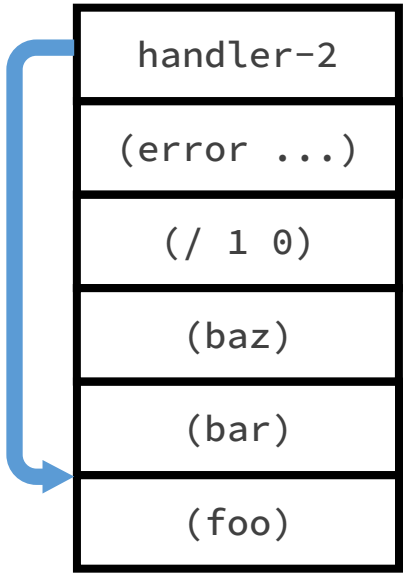

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Let’s talk about control flow in Common Lisp

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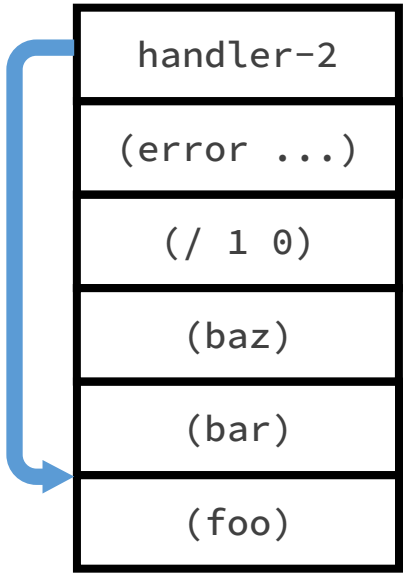

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Control Flow in Common Lisp

aka Why Lisp Doesn't Need To Throw Exceptions

Appendix B

Proving one-phase unwind in TAGBODY and BLOCK

Let’s talk about non-local control flow in Common Lisp

- `if`
- `tagbody/go` `; 1-phase unwind (no search)`
- `block/return-from` `; 1-phase unwind (no search)`
- `catch/throw` `; 2-phase unwind (search)`
- `unwind-protect`
- `lambda/apply`

Let’s talk about non-local control flow in Common Lisp

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Let’s talk about one-phase unwind in Common Lisp

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Let's talk about one-phase unwind in Common Lisp

- if
- tagbody/go
- block/return-from
- catch/throw
- unwind-protect
- lambda/apply

```
                    ; 1-phase unwind (no search)
                    ; 1-phase unwind (no search)
                    ; 2-phase unwind (search)
(block foo
  (lambda ()
    (return-from foo)))
```

Let's talk about one-phase unwind in Common Lisp

- if
- tagbody/go
- block/return-from
- catch/throw
- unwind-protect
- lambda/apply

```
                    ; 1-phase unwind (no search)
                    ; 1-phase unwind (no search)
                    ; 2-phase unwind (search)
(let ((fn (block foo
            (lambda ()
              (return-from foo)))))
  (funcall fn))
; ...?
```

Let's talk about one-phase unwind in Common Lisp

- if
- tagbody/go
- block/return-from
- catch/throw
- unwind-protect
- lambda/apply

```
                    ; 1-phase unwind (no search)
                    ; 1-phase unwind (no search)
                    ; 2-phase unwind (search)
```

```
(let ((fn (block foo
            (lambda ()
              (return-from foo)))))
  (funcall fn))
; ERROR: Condition CONTROL-ERROR
; was signaled.
```

Let's talk about one-phase unwind in Common Lisp

- if
- tagbody/go
- block/return-from
- catch/throw
- unwind-protect
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```
                                ; 1-phase unwind (no search)
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Let's talk about one-phase unwind in Common Lisp

- if
- tagbody/go
- block/return-from
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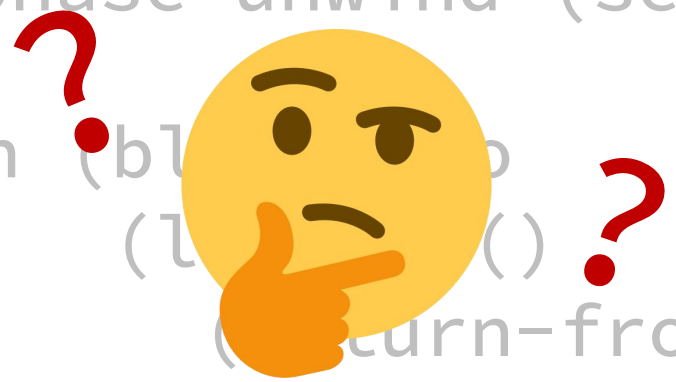
```
                                ; 1-phase unwind (no search)
                                ; 1-phase unwind (no search)
                                ; 2-phase unwind (search)
(let ((fn (bl                 p
            (l                ()
                                (return-from foo)))))
  (funcall fn))
; ERROR: Condition CONTROL-ERROR
; was signaled.
```



Let’s talk about one-phase unwind in Common Lisp

```
(block foo
  (lambda ()
    (return-from foo)))
```

Let’s talk about one-phase unwind in Common Lisp

```
(block foo
  ...)
```

Let’s talk about one-phase unwind in Common Lisp

```
(let ((return-valid-p t))
  (unwind-protect
      (%unwind-tag foo
        ...)
    (setf return-valid-p nil)))
```

Let’s talk about one-phase unwind in Common Lisp

```
(let ((return-valid-p t))
  (unwind-protect
      (%unwind-tag foo
        ...) ;; let’s expand the lambda!
    (setf return-valid-p nil)))
```

Let’s talk about one-phase unwind in Common Lisp

```
(let ((return-valid-p t))
  (unwind-protect
      (%unwind-tag foo
        (lambda ()
          (if return-valid-p
              (%1-phase-unwind-to-tag foo)
              (error ‘control-error))))
    (setf return-valid-p nil)))
```

Let’s talk about one-phase unwind in Common Lisp

```
(let ((return-valid-p t))
  (unwind-protect
      (%unwind-tag foo
        (lambda ()
          (if return-valid-p
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              (error ‘control-error))))
    (setf return-valid-p nil)))
```

Let’s talk about one-phase unwind in Common Lisp

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(let ((return-valid-p t))
  (unwind-protect
      (%unwind-tag foo
        (lambda ()
          (if return-valid-p
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              (error ‘control-error))))
    (setf return-valid-p nil)))
```

Let’s talk about one-phase unwind in Common Lisp

```
(let ((return-valid-p t))
  (unwind-protect
      (%unwind-tag foo
        (lambda ()
          (if return-valid-p
              (%1-phase-unwind-to-tag foo)
              (error ‘control-error))))
    (setf return-valid-p nil)))

;; similar validation scheme applies for TAGBODY/GO
```

Control Flow in Common Lisp

aka Why Lisp Doesn't Need To Throw Exceptions

Appendix C

Describing UNWIND-PROTECT

Let’s talk about non-local control flow in Common Lisp

- `if`
- `tagbody/go`
- `block/return-from`
- `catch/throw`
- `unwind-protect`
- `lambda/apply`

Let’s talk about non-local control flow in Common Lisp

- `if`
- `tagbody/go`
- `block/return-from`
- `catch/throw`
- `unwind-protect`
- `lambda/apply`

Let’s talk about unwinding in Common Lisp

- `if`
- `tagbody/go`
- `block/return-from`
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Let’s talk about unwinding in Common Lisp

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Let’s talk about unwinding in Common Lisp

- `if`
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Let's talk about unwinding in Common Lisp

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- tagbody/go
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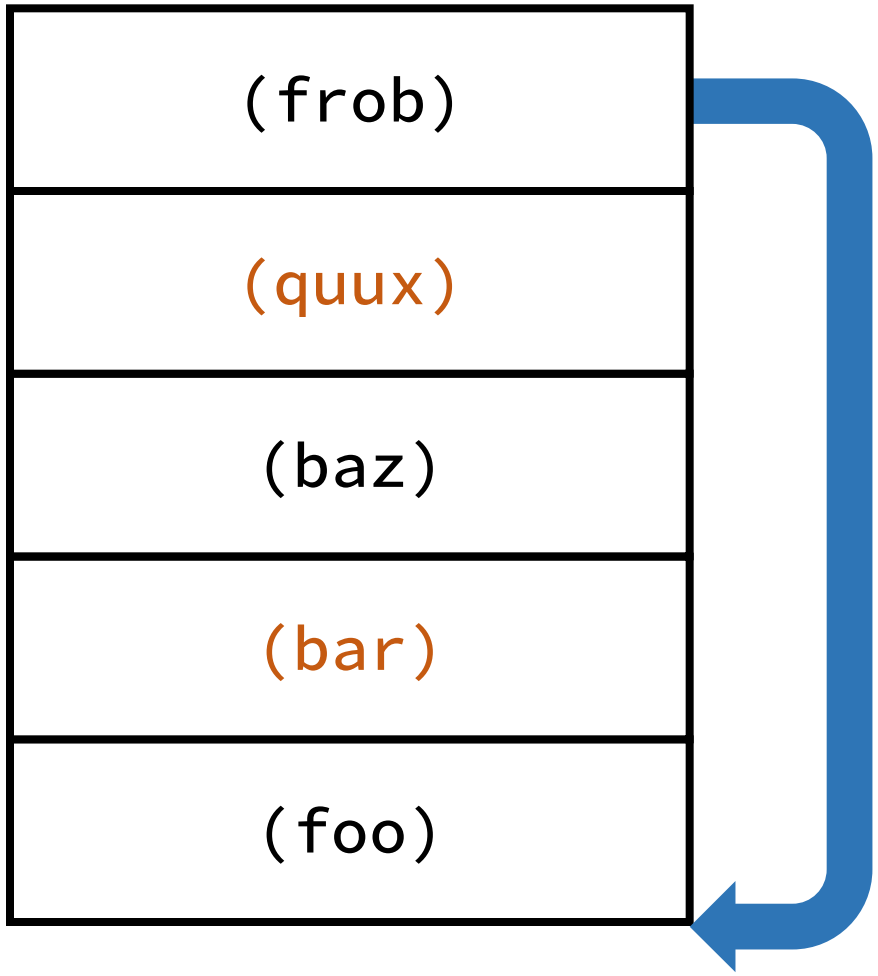

Let's talk about unwinding in Common Lisp

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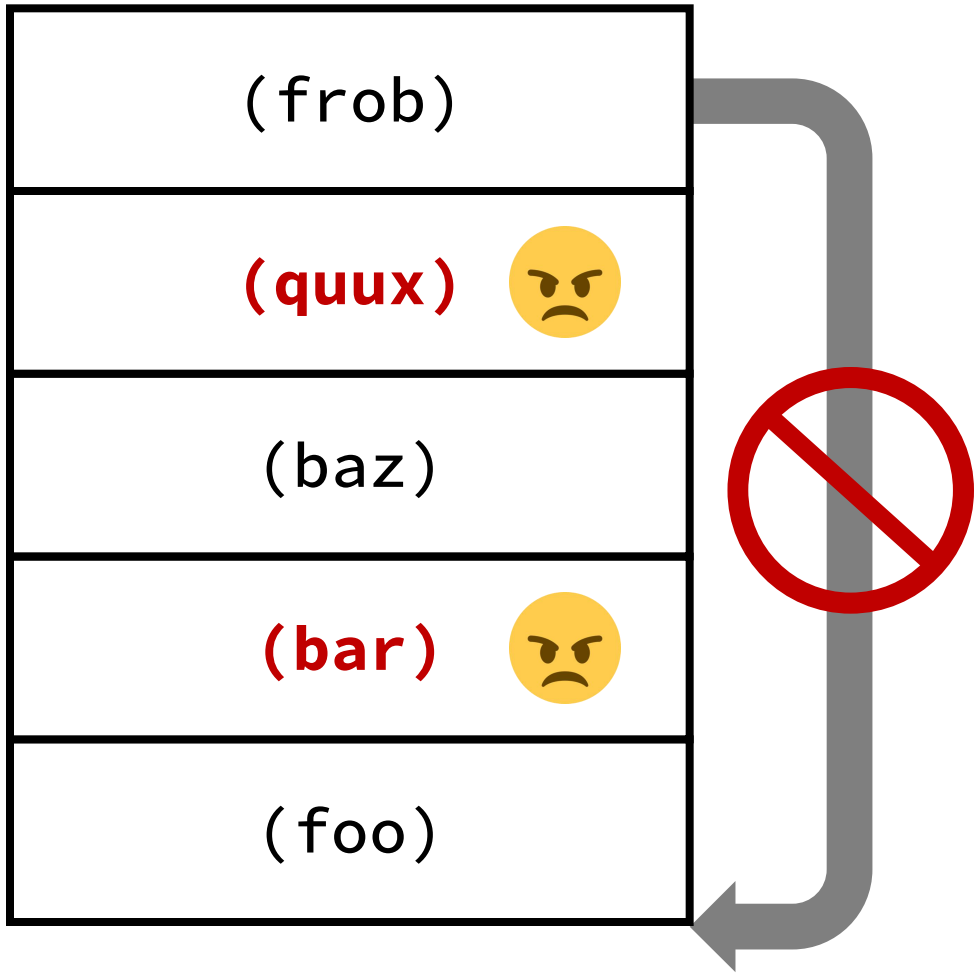

Let’s talk about unwinding in Common Lisp

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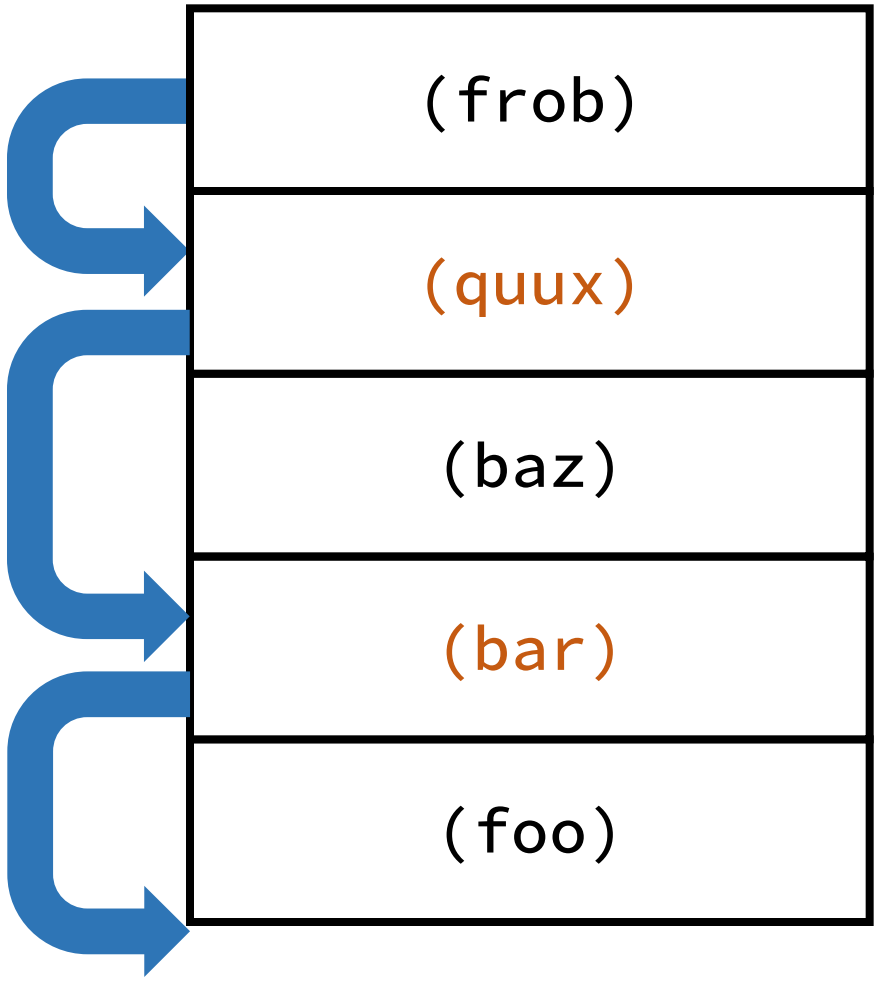

Let's talk about unwinding in Common Lisp

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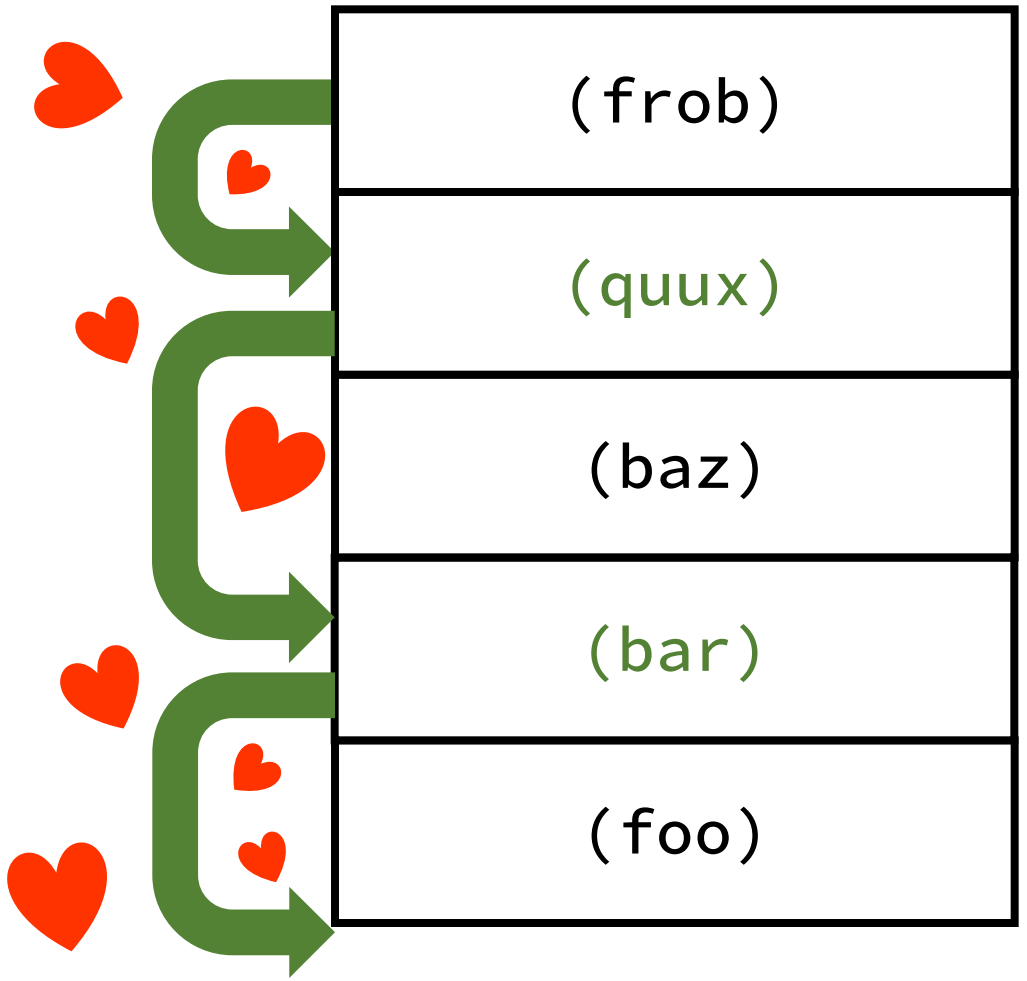

Control Flow in Common Lisp

aka Why Lisp Doesn't Need To Throw Exceptions

Appendix D

Common Lisp condition system without Common Lisp

(this is the last one I promise)

Let’s talk about control flow in Common Lisp

- `if`
- `tagbody/go`
- `block/return-from`
- `catch/throw`
- `unwind-protect`
- `lambda/apply`

Let’s talk about control flow in Common Lisp and Java

- `if`
- `tagbody/go`
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- `catch/throw`
- `unwind-protect`
- `lambda/apply`

- `if`
- `tagbody/go`
- `block/return-from`
- `catch/throw`
- `try/finally`
- `new/.apply()`
- `throw exception`

Let’s talk about control flow in Common Lisp and Java

Metacircular Semantics for Common Lisp Special Forms

Henry G. Baker
Nimble Computer Corporation, 16231 Meadow Ridge Way, Encino, CA 91436
(818) 986-1436 (818) 986-1360 (FAX)

McCarthy's metacircular interpreter for Lisp has been criticized by Reynolds and others for not providing precise semantics. Unfortunately, the alternative of English prose currently favored by the ANSI X3J13 and ISO committees for the definition of Common Lisp is even less precise than a metacircular interpreter. Thus, while a system of denotational semantics á la Scheme or ML could be developed for Common Lisp, we believe that a carefully fashioned system of metacircular definitions can achieve most of the precision of denotational semantics. Furthermore, a metacircular definition is also more readable and understandable by the average Common Lisp programmer, since it is written in terms he mostly understands. Finally, a metacircular definition for Common Lisp special forms enables us to transparently customize the representation of certain "built-in" mechanisms such as `function` closures, to enable sophisticated systems like "Portable Common Loops" to become truly portable.

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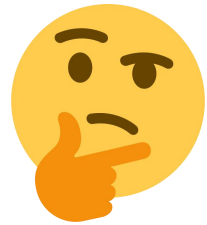

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- Can we port the condition system to Java?

Let’s talk about control flow in Common Lisp and Java

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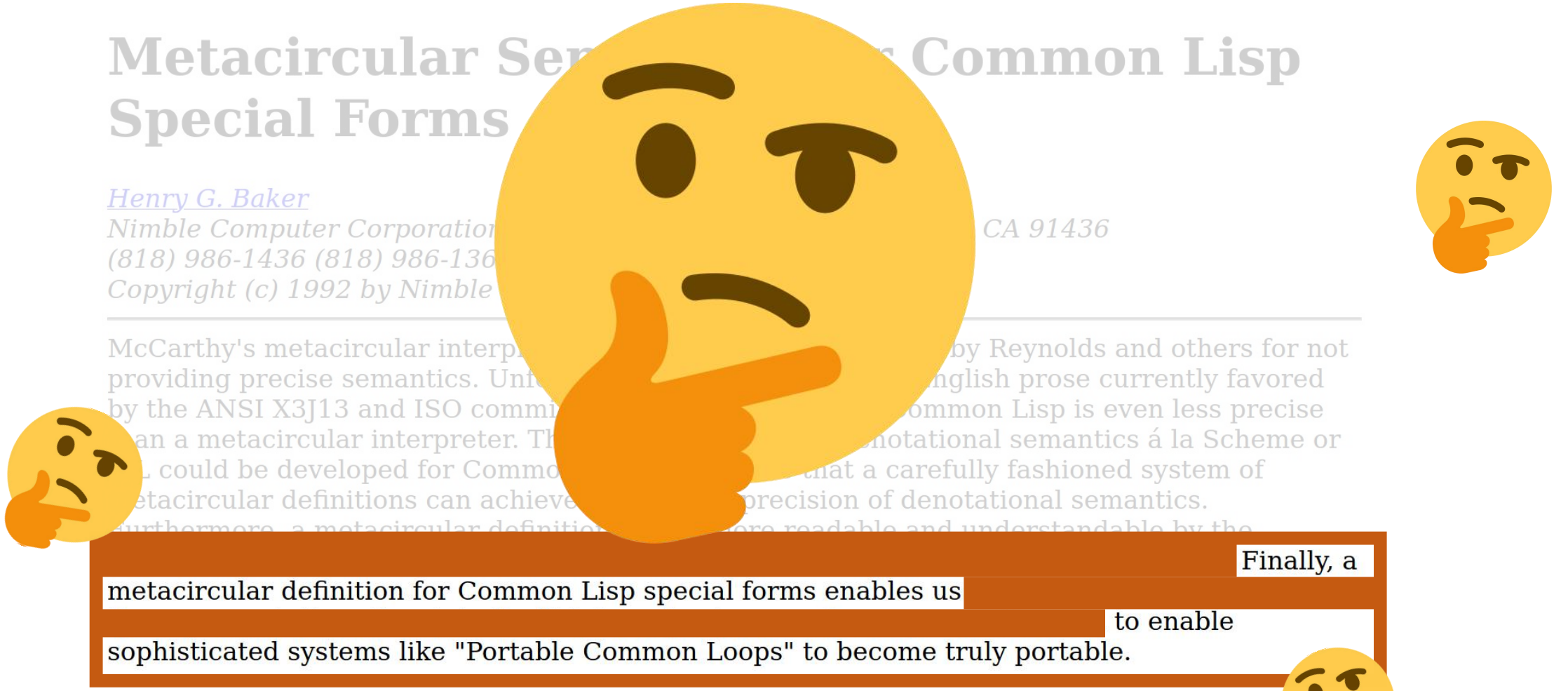
- Can we port CL control flow to Java?

Let’s talk about Common Lisp control flow in Java



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Let’s talk about Common Lisp control flow in Java

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- `block/return-from`
- `catch/throw`
- `unwind-protect`
- `lambda/apply`

- `if`
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- `catch/throw`
- `try/finally`
- `new/.apply()`
- `throw exception`

Let's talk about Common Lisp control flow in Java

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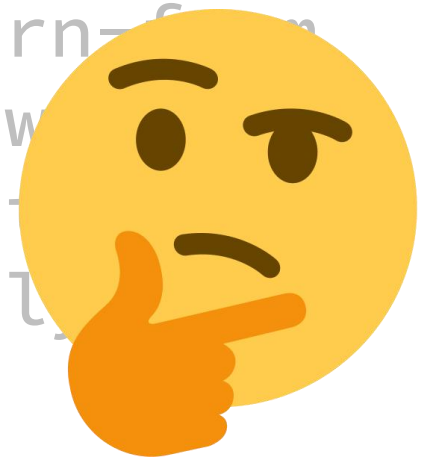

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Let's talk about Common Lisp control flow in Java

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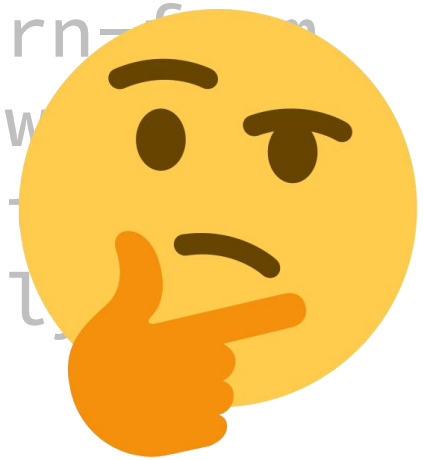

- `if`
- `tagbody/go`
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- `catch/throw`
- `try/finally`
- `new/.apply()`
- `throw exception`

"I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail."

--- Abraham H. Maslow

Let's talk about Common Lisp control flow in Java

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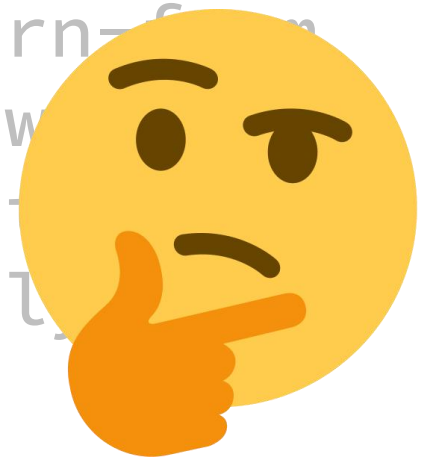

- if
- tagbody/go
- block/return-from
- catch/throw
- try/finally
- new/.apply()
- throw exception

https://github.com/phoe/cafe-latte

<3

<3

yes, it’s seriously the end this time