Indexing Common Lisp With Kythe

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Agenda

- Introduction
- Motivation
- Overview of Kythe
- Output and Tools
- Challenges
- Future Work

About Me

Software Engineer at Google working on QPX

Maintainer of Lisp-Koans:
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TLDR

Kythe is a pluggable system for creating annotated code graphs.

We have developed a Common Lisp (SBCL) indexer plug-in for Kythe.

This will allow you to create UI’s with jump to definition.

We are working on open sourcing the plugin.

You may stop listening… Or I have 25 minutes so…

Motivation

- Code distributed across a code-base is hard to navigate.
- Take the function “verbose” from
  - https://github.com/qitab/bazelisp/blob/master/bazel/log.lisp
- Locally in your file system you have to grep, but this only works for the files you have locally.
- With Slime you still have to load all possible files and then M-. and that misses quite a few cross references.

```
;;;
;;; Simple logging utilities for the Bazel Lisp Compile utility.
;;;

(defpackage bazel.log
  (:use :cl)
  (:export #:info #:message
           #:verbose #:vv #:vvv
           #:fatal #:fatal-error #:non-fatal-error
           #:*verbose*))

(in-package #:bazel.log)

(declaim (fixnum *verbose*))
(defvar *verbose* 0)

(define-condition fatal-error (error)
  ((message :reader fatal-error-message :initarg :message :type (or null string)))
  (:documentation "An error caused by the log:fatal.")
  (:report (lambda (e s)
             (format s "~@[~A~]" (fatal-error-message e)))))

(deftype non-fatal-error () '(and error (not fatal-error)))

(defun message (severity level control &rest args)
  "Format and print a log message.
 The first argument is SEVERITY: :INFO, :WARNING, :ERROR.
 The second argument specifies log verbosity LEVEL.
 The ARGS are applied to the CONTROL string to produce the log output."
  (declare (fixnum level))
  (when (>= *verbose* level)
    (with-standard-io-syntax
      (let ((*print-readably* nil)
            (out (if (eq severity :info)
                     *standard-output*
                     *error-output*)))
        (format out "~&~A: ~?~%" severity control args)))))

(defun verbose (control &rest args)
  "Same as message with level 1. CONTROL is the format control string that operates on ARGS."
  (apply #'message :info 1 control args))
```

And then we don’t even get the right results...

- On Github we can’t find where it’s used without a textual search.
  - I can’t even provide a link to the function itself.
  - I can provide a link to the line number, but that may change.

6 code results in qitab/bazelisp or view all results on GitHub

bazel/log.lisp

```
5   (defpackage bazel.log
6     (:use :cl)
7     (:export #:info #:message
8              #:verbose #:vv #:vvv
9              #:fatal #:fatal-error #:non-fatal-error
10             #:*verbose*))
11
12  (in-package #:bazel.log)
13
14  (declaim (fixnum *verbose*))
```

Common Lisp Showing the top three matches Last indexed on Jul 2, 2018

bazel/main.lisp

```
191     "Add a WARNING to the failures list of the ACTION."
192     (verbose "Added failure: ~S '~A'" (type-of warning) warning)
…
271     (declare (string warning-file) (list warnings))
272     (verbose "Saving ~A warning~:P: ~S" (length warnings) warning-file)
```

Common Lisp Showing the top two matches Last indexed on Jul 2, 2018

bazel/rules.bzl

```
100           cfg="host",
101           default=Label(BAZEL_LISP)),
102       "verbose": attr.int(),
103       # Internal, for testing coverage.
…
169   def _default_flags(ctx, trans, verbose_level):
170     """Returns a list of default flags based on the context and trans provider.
```

Python Showing the top two matches Last indexed on Jul 2, 2018

Our tools should help us...

- We should be able to click on verbose and get every reference.
- We should be able right click on verbose and get a link directly to verbose.
- We should not get Python file references unless they are intra-language function calls.
- We should not have to compile all possible lisp code into a REPL.

What is Kythe?

- From https://kythe.io/:
  - *“A pluggable, (mostly) language-agnostic ecosystem for building tools that work with code.”*
- What does that mean?
  - Kythe is a database of code annotations and references across a possibly multi-language codebase.
  - Each language must have its own “indexer” to analyze that language’s code.
  - It provides an index for data at one snapshot in time.
  - It’s used at Google to get cross-references for data across a very large code base.
  - We’ve developed a Lisp indexer plugin for Kythe so we can add Lisp data to a Kythe database.
- Why is it useful:
  - Indexing a code base, serving cross-references, creating call graphs, all with a static codebase.

Kythe's Schema: How we encode the graph

- The Kythe schema is robust enough to incorporate facets of many languages.
- Kythe creates Nodes to identify aspects of an object, VNames to uniquely identify those nodes, and edges between nodes.
- Take bordeaux-threads:threadp for example:
  - bordeaux-threads/impl-sbcl.lisp at master · sionescu/bordeaux-threads · GitHub
- We will look at the "object" variable on line 25:

```
25 (defun threadp (object)
26  (typep object 'sb-thread:thread))
```

Node

- The kind is the type of node we have, in this case we have a variable.
- The name is the name of the object in the code, as we would expect it's "object".
- The ticket is a URI encoding of the VName.
- The corpus is the root of the code repository your working in.

Example Kythe Output:

{ ticket: "kythe://corpus??lang=lisp?path=PATH#BORDEAUX-THREADS%3A%3AOBJECT%20%3AVARIABLE%20loc%3D%2825%3A16-25%3A22%29", kind: "variable", language: "lisp", name: "object", qualified_name: "object", location: { corpus: "corpus", path: "PATH/TO/bordeaux-threads/src/impl-sbcl.lisp", line_number: 25, line_number_end: 25, column_number: 16, column_number_end: 22 }, v_name: { signature: "BORDEAUX-THREADS::OBJECT :VARIABLE loc=(25:16-25:22)", corpus: "corpus", path: "PATH/TO/bordeaux-threads/src/impl-sbcl.lisp", language: "lisp" } }

Node

Given the form:

```
25 (defun threadp (object)
26  (typep object 'sb-thread:thread))
```

The node for *object* on line 25 is shown to the right.

The main sub-objects are location and VName.

1. Location, the file name and location within the file.
2. VName is a name that uniquely identifies this node.
    a. Each language has to make its own VName which makes intra-language edges difficult.

Example Kythe Output:

{ ticket: "kythe://corpus??lang=lisp?path=PATH#BORDEAUX-THREADS%3A%3AOBJECT%20%3AVARIABLE%20loc%3D%2825%3A16-25%3A22%29", kind: "variable", language: "lisp", name: "object", qualified_name: "object", location: { corpus: "corpus", path: "PATH/TO/bordeaux-threads/src/impl-sbcl.lisp", line_number: 25, line_number_end: 25, column_number: 16, column_number_end: 22 }, v_name: { signature: "BORDEAUX-THREADS::OBJECT :VARIABLE loc=(25:16-25:22)", corpus: "corpus", path: "PATH/TO/bordeaux-threads/src/impl-sbcl.lisp", language: "lisp" } }

Edges

Edges look like:

{source: node1, target: node2, edge_kind: edge_kind}

There is a second variable node for object on line 26 with edge_kind “ref” telling us that the node one line 26 references the node on line 25.

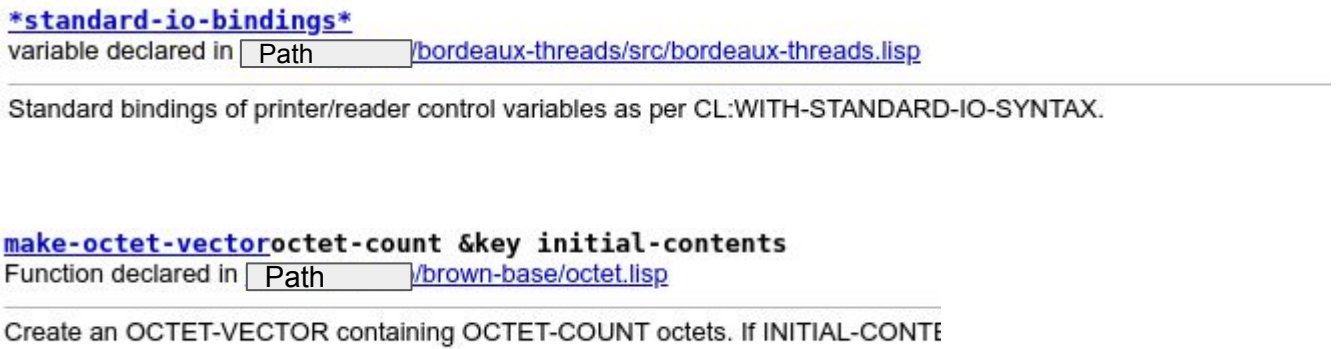
With proper IDE integration clicking on object on line 25 tells you there’s a cross reference on line 26 (as we see below):

```
25 (defun threadp (object)
26  (typep object 'sb-thread:thread))
```

For the full schema please reference: https://kythe.io/docs/schema/

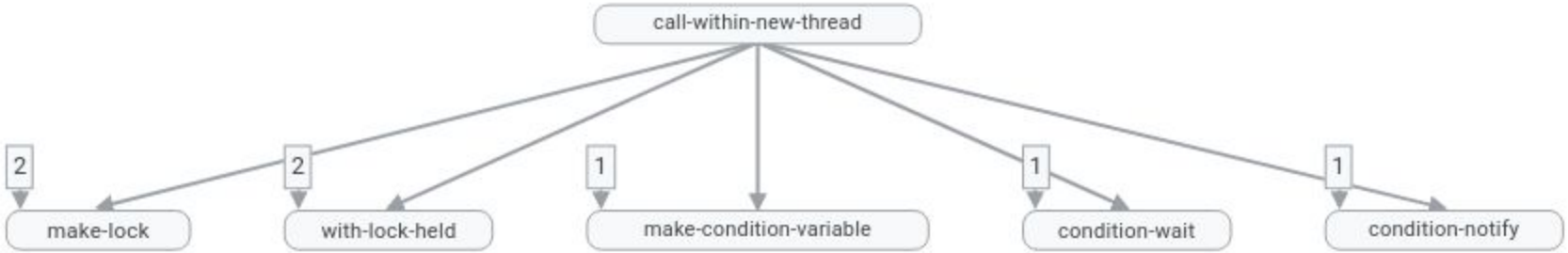
Web UI

Since docstring and lists of a functions variables are part of the schema we can display documentation:



More Web UI

We can also make call graphs



Taken from bordeaux-threads/src/impl-sbcl.lisp

Note the numbers are the numbers are the number of non-expanded places a function/macro is called in other files.

Running Kythe

Kythe is currently implemented to build and run with Bazel, the Google build system open sourced at: https://bazel.build/

There's a lisp plugin https://github.com/qitab/bazelisp

Kythe uses a dependency graph created by Bazel to know what files to compile.

It send the files to the language specific indexer in an analysis request.

How any language analyzes a file is up to the language itself.

In lisp, due to the nature of macros, we compile the file and use the cross-reference data, as well as the docstrings as we will discuss shortly.

Useful Tools

After running kythe the data can be sent into the Cayley Graph database:

> cayleygraph/cayley: An open-source graph database

for all of your querying and call-graph making wishes.

Kythe has its own command line tool:

https://kythe.io/docs/kythes-command-line-tool.html

Integration with LSP is simple, Kythe was designed with this partially in mind.

How do we Make the Nodes

- Call compile on a file with all of its dependencies.
- Built an AST of the file with source location info.
- Do a depth first search through the AST checking the who-calls database at each level.
  - This gives us non-inlined function references.
  - Macro and setf references for most things.
  - Docstrings
  - Global variable references.
- Since you compile the file, if the file is in the indexer binary you better hope no constants or structures have changed...

Basic Things We Miss

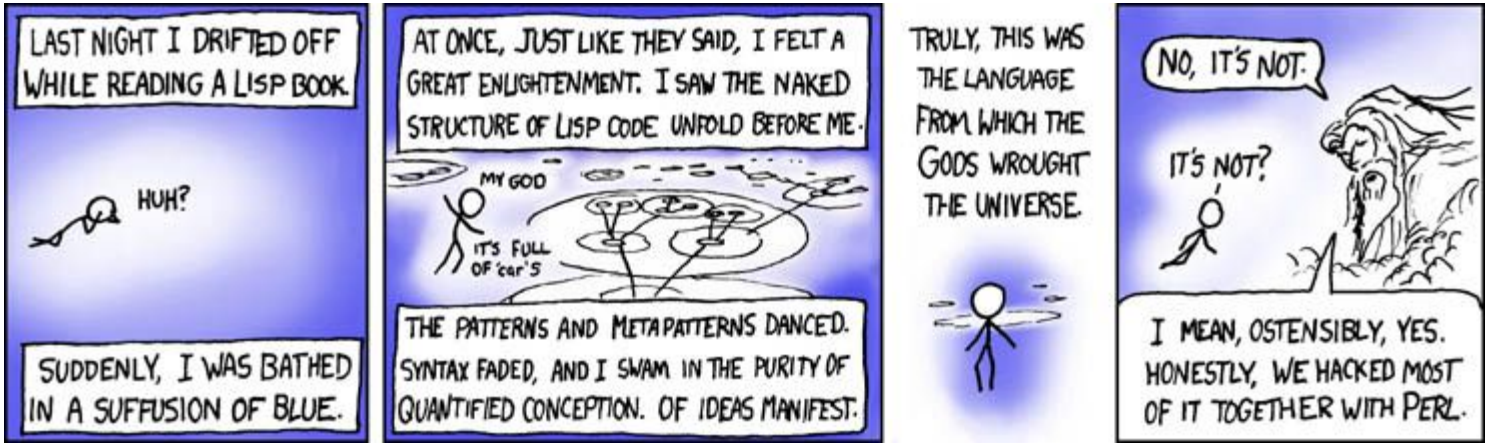
- Function argument bindings.
- Let, Flet and Labels bindings
- Loop binding
- These we can easily create parsers to figure out!
  - If you see (defun foo (bar baz) …) then ‘(bar baz) are the bound symbols
- Structure-object accessors
  - SBCL doesn’t use a traditional setf function for accessing structure fields
  - Thus the setf function is not in the who-calls database, so we can’t find it!
    - We iterate through the structure objects and add accessors to the who-calls database manually.

Lisp Difficulties: With great syntax...

- Lisp has no syntax, or it has all the syntax, you the dear listener make the syntax.
- In most languages, without Lisp macros, it's easier to tell what's being bound where.
- If I have the c++ function:

  ```
  int foo(int bar) {
      return ++bar;
  }
  ```

  I can say explicitly where bar is bound.
- Even with c++ macros I can say without to much trouble where each variable is bound.
- Lisp allows the user to define whatever syntax they want, whenever they want.



Basic Example

- How do I know what is bound in with-data-mutex?
- What's the difference between bindings and bodies?
- If &body is there our job's a little easier but it isn't always.
- What about anaphoric macros?

```
(defvar *process-data-mutex* (make-mutex))

(defmacro with-data-mutex ((mutex) &body body)
    `(let ((,mutex *process-data-mutex*))
        (sb-thread:get-mutex ,mutex)
         ,@body (sb-thread:release-mutex ,mutex)))

(defun process-data (data)
    (with-data-mutex (data-mutex)
        (format t "I have mutex ~a" data-mutex)
(print a)))
```

Inter-Language References

At Google we like to use protocol buffers

The message to the right defines a structure-object hello-world with an accessor proto2:hello-world-string.

We would like to know everywhere the lisp accessor proto2:hello-world-string is called.

If you know the VName of a node, you can make an edge from all of your accessors calls to the hello_world_string protobuf field.

The big issue is you have to know how to make your VNames.

hello_world.proto

```
syntax = "proto2";

package example;

message HelloWorld {

        optional string hello_world_string = 1;

}
```

Why Should I Use This?

- This lets you get cross-reference data for a many file, many language, repository.
  - Imagine having xrefs for all (open source) Lisp code world-wide.
- It can be used to produce call graphs.
- You have jump to definition outside an IDE.
- You can add the data to a graph store and query.

Future Work (my todo list)

- Open source the Lisp Kythe Indexer
  - This is on my roadmap, I promise.
  - While you're waiting try the C++ or Java indexers:
    - kythe/kythe: Kythe is a pluggable, (mostly) language-agnostic ecosystem for building tools that work with code.
- Have the Lisp Kythe Indexer index a CL other then SBCL.
  - SLIME uses the who-calls database for whatever common-lisp variant thats running, why can't we?
  - CCL will probably be nicer as its database is more robust.
- Make a generic macro parser
  - Code walker? Calling macrostep-expand a lot?
  - Ideas?

Acknowledgements

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My wife Wenwen and daughter Lyra

You, for listening.

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Citations:

Protocol buffers. https://developers.google.com/protocol-buffers. Accessed: 2020-02-10

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