Ruby Tooling: State of the Art

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Goal

Demonstrate that full-fledged integrated development environments (IDEs) can significantly boost programmer productivity for dynamic languages such as Ruby.

Ruby Tooling: State of the Art

- Much of the work is not Ruby-specific
  - The techniques apply to most other dynamic languages
- Expect similar tooling elsewhere

Non-Goals

- Coverage of the latest type inference research in academia
  - This talk focuses on state of well-known Ruby tools
  - Rapidly moving target!
- Discuss all aspects of Ruby development: Rails…
- Fair and balanced IDE shoot-out
  - Editors: Textmate, Emacs, Vim
  - Commercial IDEs: IntelliJ, “Ruby In Steel”, Komodo IDE
  - Free IDEs: Eclipse RDT, RadRails/Aptana and DLTK, NetBeans™ IDE

Agenda

Editors vs. IDEs
Debugging
Code Templates
Code Completion and Type Attribution
Goto Declaration
Refactoring
Demo

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“We Don’t Need No Stinking IDEs”

- “You Java™ technology people need IDEs to help you with all that boiler plate code; my language is much cleaner than that”
  - DRY principle—don’t repeat yourself
  - Real programmers don’t use a crutch like an IDE
- I don’t need all that bloat—I have Emacs!
  - **E**ight **M**egabytes **A**nd **C**ontinually **S**wapping

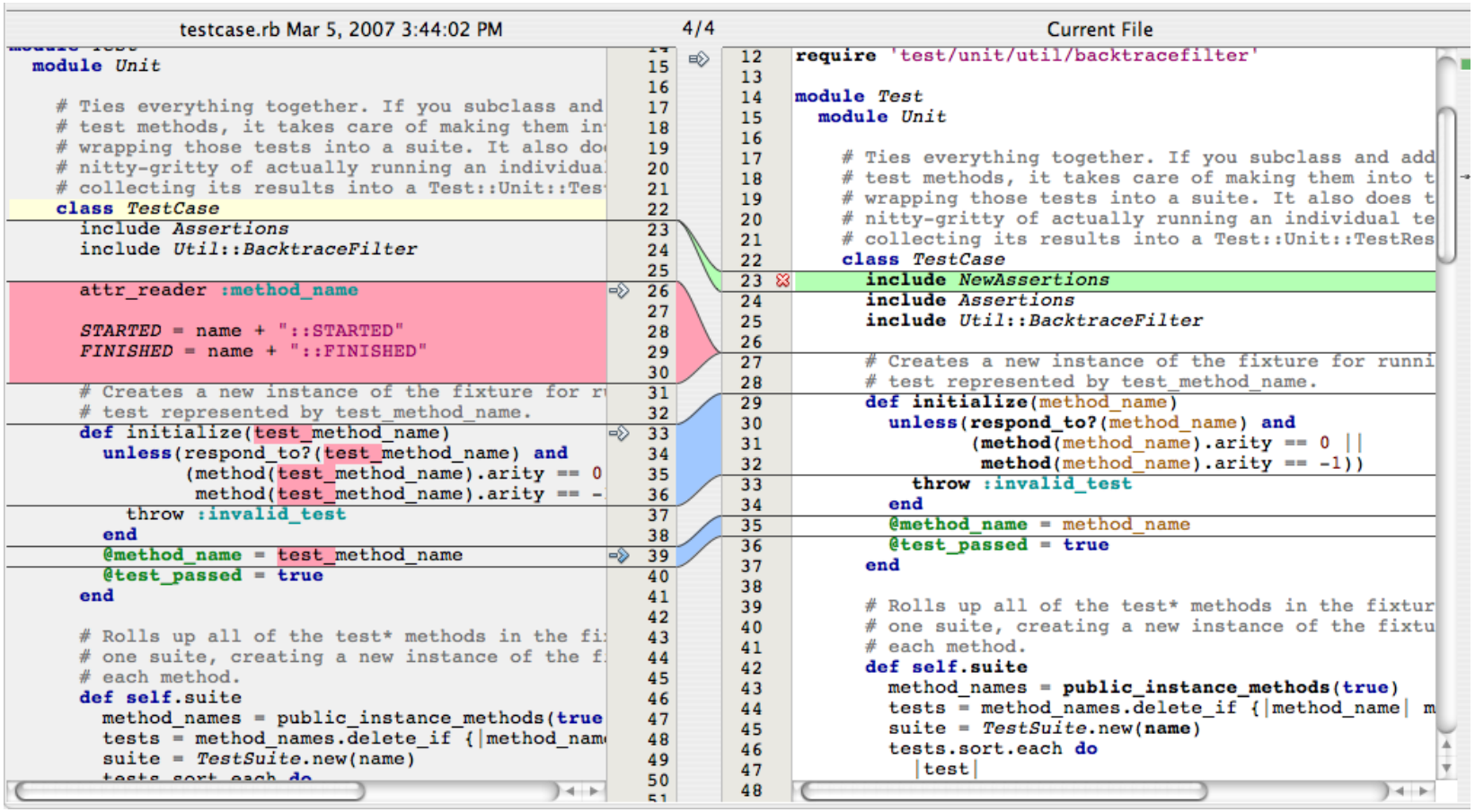
Don’t Forget Vim!

Source: http://eigenclass.org/hiki/rcodetools-screenshots

Editor vs. Full-Blown IDE

- Emacs is an IDE
  - For some, it's a login shell, a mail tool…
- IDE facilities
  - Support for all coding related tasks
  - Team collaboration: tight version control system integration, integrated chat and code sharing
  - Tasks/TODO management, project system
  - Debugging infrastructure: balloon eval, thread view…
  - Plug-in management

Local File Editing History Diff



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Tools Supporting Ruby Debugging

- **CLI tools**
  - debug.rb, ruby-debug-cli gem, breakpointer
- **Power editors**
  - Emacs, Textmate, (Vim?)
- **IDEs**
  - Arachno, DLTK, FreeRIDE, Komodo, Mr. Guid, Mondrian, NetBeans, RadRails, RDT, Ruby In Steel,...

CLI Tools

- debug.rb
  - `ruby -rdebug hello.rb`
- Breakpointer
  - `<rails_app>/script/server`
  - `<rails_app>/script/breakpointer`
  - `breakpoint call`
- ruby-debug-cli gem
  - `rdebug hello.rb`

Tools Supporting Ruby Rebugging

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Techniques

- Kernel#set_trace_func(event_handler)
- Kent Sibilev's **`ruby-debug-base`**
  - **`Handler: at_line, at_breakpoint at_catchpoint, at_tracing`**
  - Native C Ruby extension
- Others (hacking interpreter)

Techniques

- **Kernel#set_trace_func(event_handler)**
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- **Others (hacking interpreter)**

Implementing frontend

- From scratch
- Choose technique
  - ruby-debug-base for C Ruby
  - set_trace_func for JRuby
- Communication protocol
- etc.
- Reinventing the wheel
- Slow progress of Ruby debugging

Solution: Debug-Commons

- Open source rubyforge.org project
  - Common effort
  - RDT, NetBeans
  - Nice contribution from Markus Barchfeld (RDT)
  - DLTK and others?
- IDE-independent
- Language-independent

Future Works, Aims

- debug-commons
  - frontend entry point
  - Debugging standard in the future (as Java's JPDA)
  - A lot of work requires more people to get involved
  - Gain for community as well as for all frontend implementers
- jruby-debug (fast debugging for JRuby)
- Cross-language debugging

Summary

- Ruby debugging quickly becoming mature
  - Full-fledged and **fast** debuggers frontends **are** available
- Cooperation is working well
- Join the debug-commons project
- Still a lot of work to be done

For More Information

- Debug Commons
  - http://debug-commons.rubyforge.org/
  - http://debug-commons.rubyforge.org/misc/ruby-debugging.html
- Ruby-debug
  - http://www.datanoise.com/ruby-debug/
  - http://rubyforge.org/projects/ruby-debug/

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IDEs and Boilerplate

- Java IDE: add a private field `foo` and apply encapsulate field refactoring or quick fix
  - IDE generates getter and setter methods
  - IDE can collate these into a logical property in navigator
- Ruby: add `attr_accessor :foo` and the language/runtime provides getter and setter methods
- However, you still have to code…
  - Lots of common idioms
  - Rails has a large body of popular templates

Code Templates and Snippets

- Live code templates
  - Linked substitution of **related** and **logical** variables
  - With “DRY”, related variables not as common in Ruby
- Semantic information helps:
  - Choose variable names guaranteed to be unique: no accidental aliasing or side effects
  - Templates referring to existing variables can automatically use the right one
    - For example, a template referencing a hash can expand to using a hash present in the local scope

Live Template Example

```
hashkeys:
${name type="Hash"}.each_key { |${o new}| yield(${o}) }

def foo
  o = 50
  new_topic_values = { :title => "AnotherTopic" }
  new_array = [1,2,3]

  # Expand template hashkeys
  new_topic_values.each_key { |p| yield(p) }

end
```

Linked logical variable: o

Code Templates and Snippets

- `${param_name type="Fixnum"}`
  - Requires parameter type to be of a specific type
  - This may help the IDE match an existing variable with this parameter
- `${param_name new}`
  - The variable name will be a new, unique local variable
  - There are similar variables for fields, classes, constants, etc.
- `${param_name default="file"}`
  - Specify a default name to be used

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Static Typing vs. Dynamic Typing

Example 1:

```
public List javaUnmodifiableList(List list) {
    return new Ar<complete>   ==> ArrayList

def ruby_unmodifiableList(list)
    return Ar<complete>       ==> ?
```

Example 2:

```
public void javaTrim(String s) {
    return s.tr<complete>     ==> s.trim()

def ruby_chomp(s) {
    return s.ch<complete>     ==> ?
```

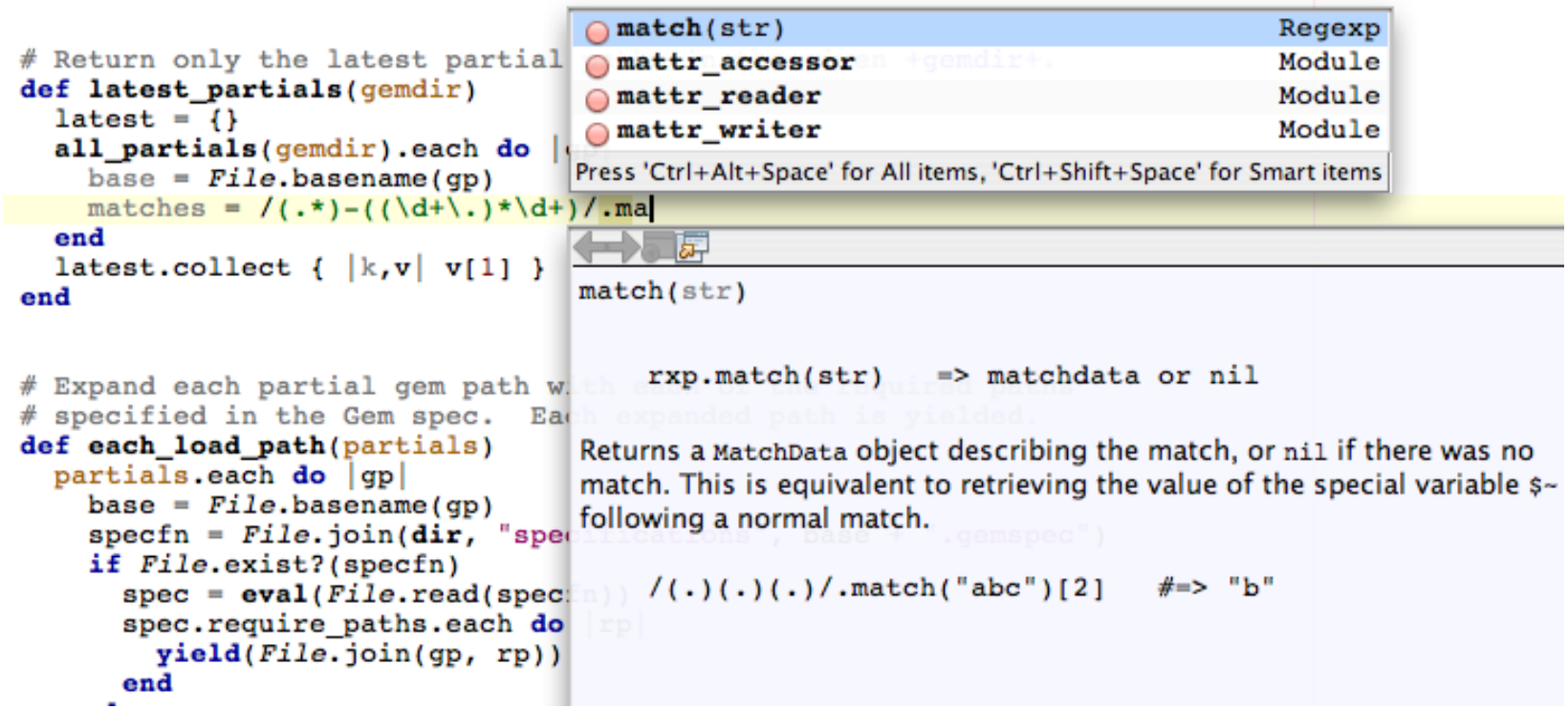
Code Completion

- **Not** the same as automatic { and } pair matching, inserting a matching “end” for a “begin”, etc.
- Goal: Determine the exact set of applicable methods, instance variables, class variables, classes, or modules under the cursor
- Many uses in the IDE—not about keystrokes
  - Completion pop-up, parameter help, documentation pop-up
  - Goto declaration
  - Rename refactoring, other refactorings

Completion Scenarios

- Exploring an unfamiliar class
- Exploring available modules and classes
- Learning or confirming method parameter usage
- Learning the language
  - Completion on %: show and describe %q, %Q, %r,…
  - Completion on $: describe globals - $*, $<,…
  - Completion in \ in regexps: describe \A, \S, \w,…
  - Completion on Ruby keywords: explain yield, unless…

Completion Usage Example



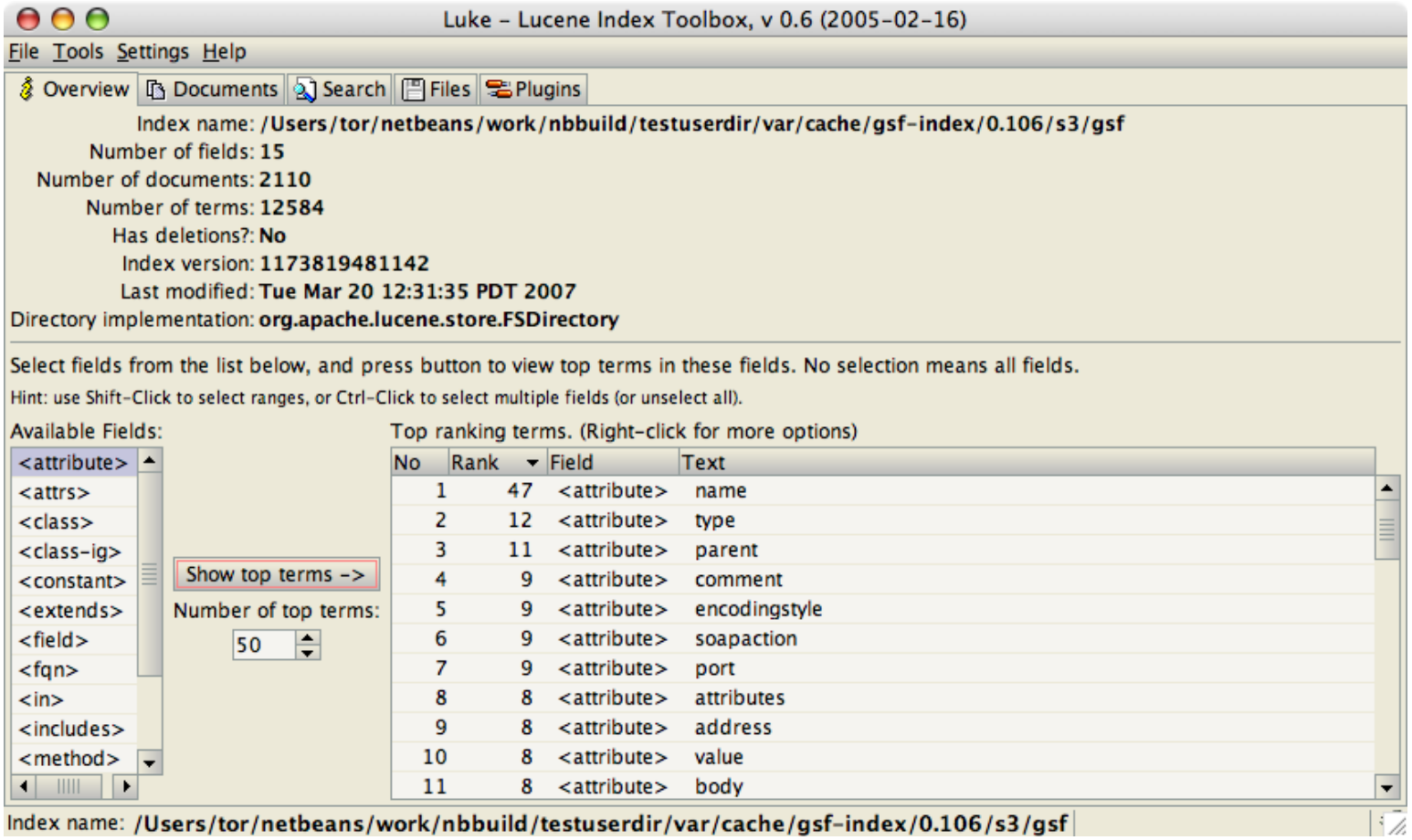

```
# Return only the latest partial
def latest_partials(gemdir)
  latest = {}
  all_partials(gemdir).each do |
    base = File.basename(gp)
    matches = /(.*)-((\d+\.)*\d+)/.ma
  end
  latest.collect { |k,v| v[1] }
end


# Expand each partial gem path w
# specified in the Gem spec.  Ea
def each_load_path(partials)
  partials.each do |gp|
    base = File.basename(gp)
    specfn = File.join(dir, "spe
    if File.exist?(specfn)
      spec = eval(File.read(spec
      spec.require_paths.each do
        yield(File.join(gp, rp))
      end
```

The Index

- Completion prerequisite: global knowledge
  - Know about user classes
  - Know about libraries: Ruby built-in libraries AND gems
  - This is typically what separates editors from IDEs
- Index allows fallback mechanism: prefix matching
- unknown.**`descr`** matches
  - OCI8:**`descr`**ibe(name)
  - Exception::**`descr`**ibe_blame
  - Generators::HtmlMethod::**`descr`**iption

The NetBeans IDE Ruby Lucene Index



Singleton Method Completion

- Singleton method completion
  - File.exi => File.exists, String.ne => String.new
- Algorithm
  - Index knows about singleton methods from parse trees
  - Determine the exact class on the left hand side
  - May involve looking at require statements transitively
  - Add all its methods known to be singleton methods
  - Iterate recursively up the chain to include inherited methods from superclasses and module mixins

Object Literal Completion

- Literal method completion
  - “foo”.gs => String.gsub, 5.ea => Fixnum.each,…
- Completion algorithm
  - Look at lexical tokens, determine corresponding type
  - Hashes, arrays, numbers, strings, regular expressions, symbols, nil/true/false,…
  - Use corresponding built-in type for literals (Hash, Array, String, Fixnum, Regexp, etc.) and apply same algorithm as for singleton method completion
  - This time, don’t exclude instance methods

Inherited Method Completion

- Inherited method completion
  - Within a class extending TestCase: as => assert_*
- Completion algorithm
  - Look at the enclosing class to determine supertype
  - Add methods from superclasses and mixins
  - This time, don’t filter out private or protected methods

Variable Completion

- Track variable types in local scope

```
def block_scanf(fstr,&b)
  fs = Scanf::FormatString.new(fstr)
  str = self.dup
  final = []
  begin
    current = str.scanf(fs)
    final.push(yield(current)) unless current.empty?
    str = fs.string_left
  end until current.empty? || str.empty?
  return final
end
```

Tracking Variable Types

- If we see an assignment where we know the expression type, record it
  - x = Foo::Bar.new => x is now of type Foo::Bar
    y = /whatever/ => y is now of type Regexp
    x = foobar() => x is now unknown again
- Completion algorithm
  - Track variables up to the completion point
  - For known types, apply normal instance completion

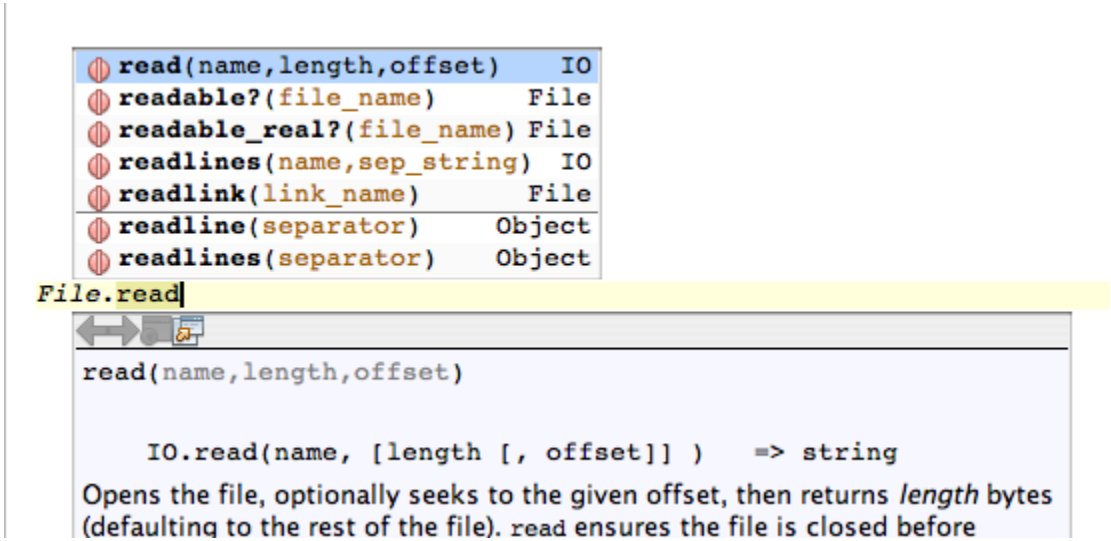
Dealing With Uncertainty

- Works for instance vars, class vars, globals too
  - **Unless intermediate calls have side effects**

```
def block_scanf(fstr,&b)
  @fs = Scanf::FormatString.new(fstr)
  @str = self.dup
  final = []
  begin
    current = str.scanf(@fs)
    final.push(yield(current)) unless current.empty?
    str = @fs.string_left
  end until current.empty? || str.empty?
  return final
end
```

Dealing With Uncertainty

- Let the user decide or interpret the results
  - For example, show best guesses first, then list all matches



Enhanced Variable Tracking

- Compute expression types: x = foo().bar()
- Store return types in the index and use these to compute expression types—when possible
  - Return type is frequently not known
- Suppose String#chomp always returns a String, and String#count always returns a Fixnum:
  x = “foo\n”.chomp().count()
  - We now know that x is of type Fixnum
  - Local variable tracking can proceed

Indexing Return Types

- When indexing code, look for return statements and last expressions
- If the type is known, record it
- This method returns AssertionMessage

```
def build_message(head, template=nil, *arguments)
  template &&= template.chomp
  return AssertionMessage.new(head, template, arguments)
end
```

Multiple Return Types

- A method can have multiple return types
- If the number is small—record all, and let completion include all possibilities
- This method returns {FalseClass,TrueClass}:

```
def has_expires?
  @hash.each do |k, v|
    v.each do |tuple|
      return true if tuple.expires
    end
  end
  false
end
```

Full Class Scope Type Tracking

- Track all assignments to class instance variables and class variables
- If there are no unknown type assignments
  - We can deduce the possible types of the symbol
  - More than one is okay—completion can use a union

```
class Foo
  def whatever(x)
    @state = 0
  end
  def whatever(x)
    @state = "Error:" + x.to_s
  end
  # @state is Fixnum or String
```

Call Site Tracking

- ```
  def make_sound(duck)
        duck.qu^
  end
  ```
- Usually think of "**`duck`**" as unknowable since there is no type information here—any **`duck`** will do
- We are already tracking method references (for refactoring purposes)
- What if we know that **`make_sound`** is called only once—with a known type?
  ```

Call Site Tracking (Cont.)

- More calls yields better accuracy
  - Each additional call type constrains parameter methods
  - Eventually, only “quack” may be present in all call types
  - ```
    def swap(a,b)
      return b,a
    end
    swap(5,10);swap("x","y");swap(/r/,/s/)
    ```
  - The only method available on **a** and **b** above is **to_s** (other than the methods on Object and Class)
  - This approach doesn’t work well when you write methods before calling them (which is common…)
    ```

Parameter Usage Analysis

- We can also look at the actual operations performed on the parameters
  - ```
    def rotate_log(age)
      age.downto(0) do |i|
      ...
    ```
  - Without looking at **any** uses of this method, we can deduce that the type of **`age`** is either **`Integer`** or **`Date`**, the only known classes which provide a **`downto`** method
  - (Unless the program is relying on **`method_missing`**)
    ```

Parameter Usage Analysis (Cont.)

- It's not as simple as it sounds
  - You have to know that the parameter value is still being used at the time of the method reference (back to local variable type tracking)
  - Control flow can introduce complications:

```
def combine(s)
if (foo())
  s.downto(0)
...
```

  - Here we can't conclude that **`s`** is an Integer because the call to foo() could have let other types legally bypass the downto call

Type Hints and Type Assertions

- Before annotations in Java™ code, JavaDoc™ tool markers were used to store metadata for tool use
- We can do the same with Ruby comments
- Record parameter types and return values in the RDoc

FXRuby

```
#
# Draw a circle centered at (_x_, _y_), with radius r.
#
# === Parameters:
#
# +x+:: x-coordinate of the circle's center [Integer]
# +y+:: y-coordinate of the circle's center [Integer]
# +r+:: radius of the circle, in pixels [Integer]
#
# See also #fillCircle.
#
def drawCircle(x, y, r)
  drawArc(x-r, y-r, 2*r, 2*r, 0, 360*64)
end
```

Source: FXRuby-1.6.5/lib/fox16/core.rb from http://www.fxruby.org

“Ruby In Steel” IDE

```
#:return:=>Array
#:arg:names=>Array
#:arg:aName=>String
def addName( names, aName  )
   return names << aName
end
```

Source: http://www.sapphiresteel.com/onlinehelp/Type%20Assertions.html

Type Hints

- We need an agreed upon convention
- Possibly one which allows multiple allowed types, multiple possible return values, or even specific required “quack” methods

Source: http://groups.google.com/group/comp.lang.ruby/browse_thread/thread/c5a19668a0963cb4/085debfba2fe6338

Flame War Alert!

- Type hinting is a highly controversial topic!
- Inserting actual type “constraints” into the source files defeats the purpose of dynamic languages
  - “Sorry, that’s not Ruby!”
- C Ruby relies on comment conventions to document the libraries
  - **/* call-seq:**
    *** Time.at(seconds [, microseconds]) => time**
    ***/ static VALUE time_s_at(argc, argv, klass)**

Source: http://groups.google.com/group/comp.lang.ruby/browse_thread/thread/c5a19668a0963cb4/085debfba2fe6338

Type Hints

- Comments can lie
  - So can type constraints expressed in comments
  - Like comments, type hints express intent, not reality
- IDEs can help detect violations of the type constraints, a la Java code's FindBugs tool
- Parameter hints are not just for type inference
  - Tooltip pop-ups on parameters
  - Improved description of current entry during parameter code completion

Source: http://groups.google.com/group/comp.lang.ruby/browse_thread/thread/c5a19668a0963cb4/085debfba2fe6338

Known Types

- JRuby bridges the Java technology and Ruby worlds
- In the following we know everything about **`frame`** and we can do accurate completion

```
require 'java'

JFrame = javax.swing.JFrame
frame = JFrame.new("Hello Swing")
button = javax.swing.JButton.new("Click Me!")
frame.getContentPane.add button
```

Source: http://groups.google.com/group/comp.lang.ruby/browse_thread/thread/c5a19668a0963cb4/085debfba2fe6338

Recorded Types

- Ruby encourages unit tests with a built-in testing framework (Test::Unit)
- Ruby on Rails takes this even further
- Tools may run unit tests automatically after edits
- With some hooks, unit test execution can record and attribute types for the user program
  - Similar to, and perhaps performed by, code coverage tools
- These are **some** of the parameter's types, not **all**
  - "Sampling"—types may depend on the input data

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Goto Declaration

- Quick navigation (ctrl-click hyperlinks in NetBeans IDE) to declaration point
- Relies on resolving types
- Tricky in Ruby because of “open classes”
  - The “Test::Unit::TestCase” class is defined in many places: test/unit/testcase.rb, active_record/fixtures.rb, action_controller/test_process.rb, action_web_service/test_invoke.rb,...
- “Goto the TestCase Declaration”—which one?

Heuristics

- If the reference includes the module qualifier, we're closer—if we know we're looking for Test::Unit::TestCase we can skip RUNIT::TestCase
- Prefer documented versions of the class over undocumented
  - TestCase in testcase.rb matches; fixtures.rb does not
  - Not enough: File is documented at length in both ftools.rb and the standard Ruby library

Heuristics (Cont.)

- Uses of the class near the reference helps disambiguate—match with methods in each file
  - File.makedirs implies we are looking for File in ftools.rb
- Prefer matches in files that are required
  - Require ‘ftools’
  - May have to look transitively: If resolving “Context”: require ‘irb’ will recursively require ‘irb/context’ which defines IRB::Context
  - May have to look at requires in parent classes as well

Heuristics (Cont.)

- Prefer “built-in” classes over other ones
  - Unless they are defined in the user’s own project files
  - e.g., prefer the built-in “File” over the ftools.rb File
  - Stdlib matching is based on C comment signatures…
- When going to method declarations, additional criteria are available
  - Arity (number of arguments) matching
  - Look in super classes and mixins for matching inherited methods

Arity Matching

- #1: def method(arg1, arg2)
  #2: def method(arg1, arg2, arg3=50)
  #3: def method(arg1, arg2, *arg3)
- **method(1)** matches none of these methods
- **method(x,y)** matches #1, #2 and #3
- **method(x,y,z)** matches #2 and #3
- **method(x,y,z,w)** matches #3
- Used for occurrences highlighting, Goto Decl,…

Other Semantic Editing Features

- Smart selection: select progressively larger surrounding logical code blocks: statement, block, method, class…
- Find usages
  - Including current class—can be split over multiple files
- Semantic highlighting
  - Highlight unused local variables
  - Highlight potentially accidental variable aliasing in blocks
  - Highlight other occurrences of current symbol

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Refactoring

- Rename
  - “Killer app”
  - Complicated by metaprogramming

```
def def_method(mod, methodname, fname='(ERB)')
  mod.module_eval("def #{methodname}\n" + self.src +
    "\nend\n", fname, 0)
end
```

Refactoring

- Local variable/parameter rename
  - Trivial (with a parse tree), and often quite handy
  - Not the same as Search/Replace
    - The third reference to `foo` below is a separate symbol

```
def parse_mode(m)
  result = 0
  (1..9).each do |foo|
    result = 2*result + ((m[foo]==?-) ? 0 : 1)
  end
  foo = count(result)
end
```

Example: Extract Method

- Move a selected chunk of text within a method into its own method
- The IDE looks for local variables used within the block, and converts these into parameters
- The IDE also replaces the selection with a call to the new method
- The IDE may look for other code fragments that can be converted to a call
- New variables created within the block and referenced outside are converted to return values

Ruby Specific Refactorings

- Merge class parts
  - Ruby classes are open and can span many files: this merges them all (or portions of the class) into one
- Extract mixin
  - Move features common to several classes into its own module and add include it as a mixin
- Remove unused scope
  - Remove unnecessary begin/end blocks
- Combine redundant exception handlers
  - Handlers that do the same can be shared

Other Refactorings

- The usual OO-language refactorings also apply
  - Extract Superclass, Convert local variable to a field, Pull Up, Encapsulate Field, Inline Class/Method, move Field/Method/Class, etc.
- Some of these refactorings can take advantage of Ruby techniques
  - Decorator pattern allows us to implement only the unique methods and use a single method_missing to dispatch everything else to the original decorated class
- Ruby-oriented refactoring books in the works

Multi-Language Editing

- Support “languages” like RDoc, Quoted Strings, Regular Expressions, Ruby Within Strings
  - Nested lexing, etc.
- Support RHTML/Eruby: Ruby within HTML markup
  - Full type attribution is necessary such that refactoring, code completion, goto declaration and friends all work
  - More complicated—not well supported anywhere yet*
    - *At the time of this writing, probably obsolete when this is read

DEMO

NetBeans IDE + Ruby Support

Future Directions

- New and better Refactoring operations
- "Smarter" code completion based on improved heuristics
- Static analysis incorporating runtime logs and statistics
  - Perhaps the other way around as well—during a run the debugger can poke the live object hierarchies and perform checks traditionally done by tools like Findbugs
- Incorporate research: "Success Typings" type inference algorithm, etc.

Summary

- Dynamic languages can benefit from features typically available in Java IDEs
- Full-fledged Ruby IDEs in particular are available now
- There is a lot of development in this area

For More Information

- http://wiki.netbeans.org/wiki/view/Ruby
- Ruby related sessions and BOFs:
  - TS-9370: JRuby on Rails: Agility for the Enterprise
  - TS-6503: JRuby; Rails; and Java™ Platform, Enterprise Edition (Java™ EE)
  - TS-9535: Comparing the Developer Experience of Java EE 5.0, Ruby on Rails, and Grails: Lessons Learned
  - TS-9294: Exploiting JRuby: Building Domain-Specific Languages for the Java™ Virtual Machine (JVM™)
  - BOF-9179: Java Platform Web Applications Versus Ruby on Rails: This Time with Tools
  - BOF-2958: Dynamic Scripting Languages BOF
  - BOF-5122: JRubME Is JRuby on Java™ Platform, Micro Edition (Java™ ME)

The terms “Java Virtual Machine” and “JVM” mean a Virtual Machine for the Java™ platform.

Q&A

Ruby Tooling: State of the Art

Tor Norbye and Martin Krauskopf

Senior Staff Engineer
Sun Microsystems
http://www.sun.com

Session TS-9972