Design and Implementation of a Backward-In-Time Debugger

Christoph Hofer
Marcus Denker
Stephane Ducasse

Roadmap

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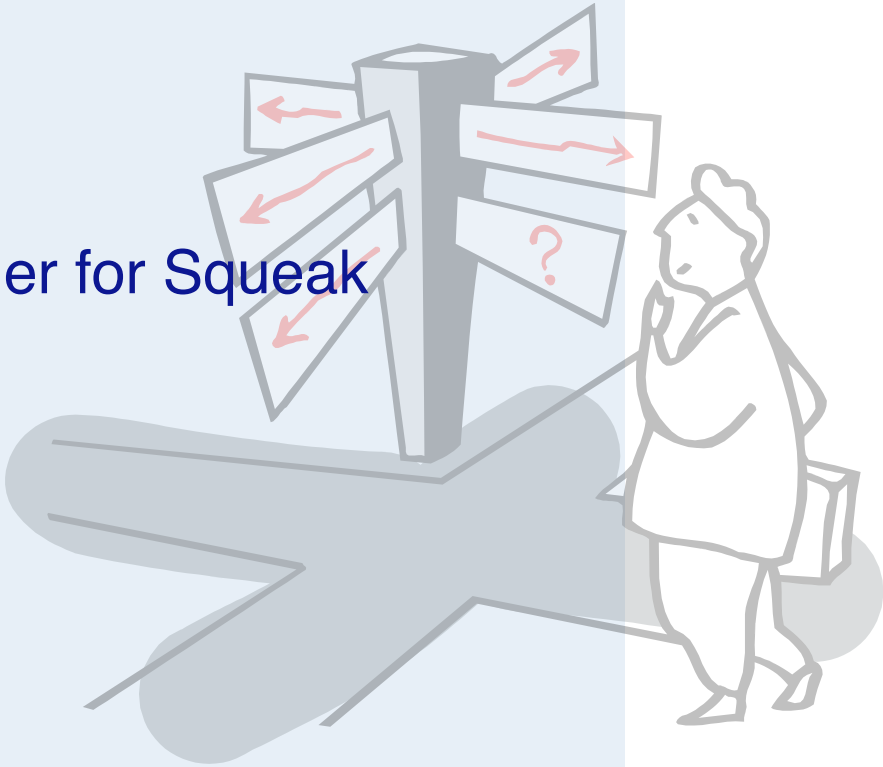
- Problem
- Unstuck: A new Debugger for Squeak
- Implementation
- Lessons Learned
- Future work



Problem

- Debugger: Snapshot of state at time of error
- Cause for errors is in the past
  - Who assigned *that* value?
- very incomplete history available
  - guess were to set breakpoint, rerun

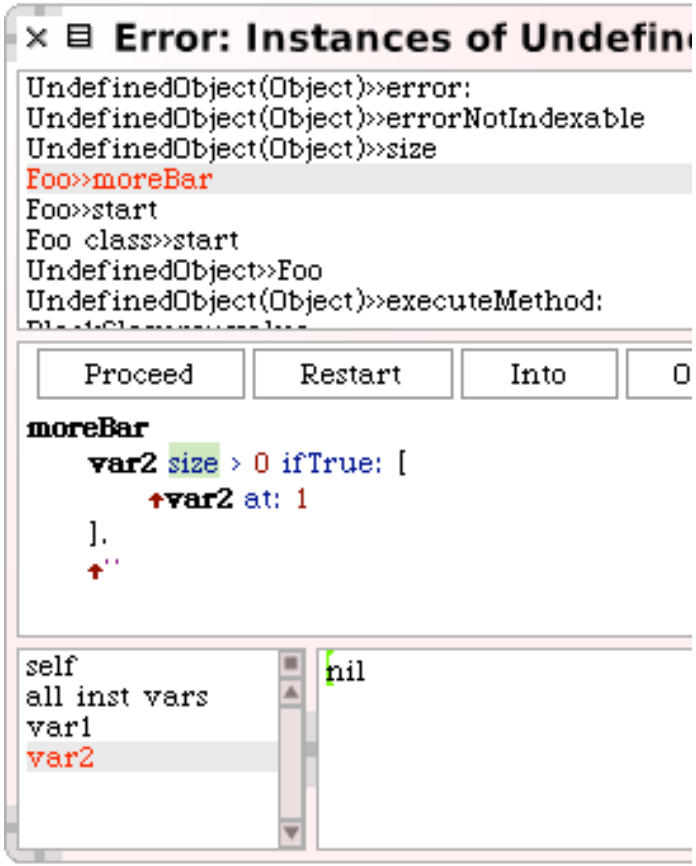
Example

```
Foo>>initialize
    var1 := 0.
    var2 := ''.

Foo>>start
    self beforeBar.
    self bar.
    self moreBar.

Foo>>beforeBar
    var1 = 0 ifTrue: [
        var2 := nil.]
```

```
Foo>>bar
    ......

Foo>>moreBar
    var2 size > 0 ifTrue:[
        ^var2 at: 1].
    ^''
```

Stack Trace

- Squeak Debugger
- Shows stack trace
  - methods not returned
  - old state lost



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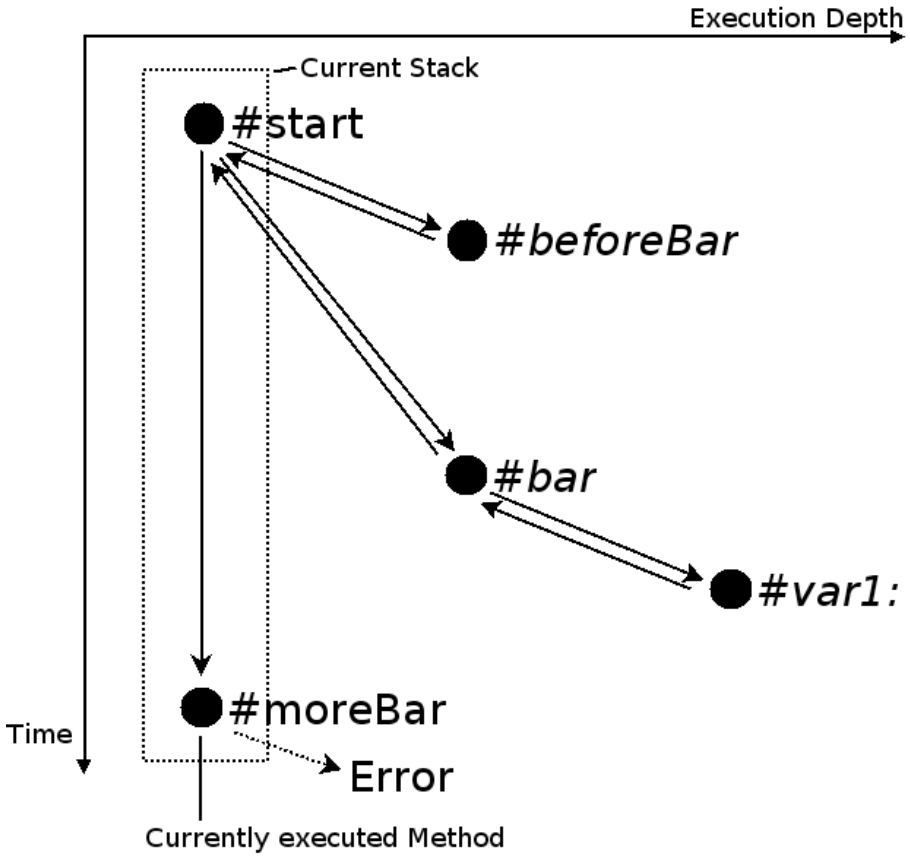


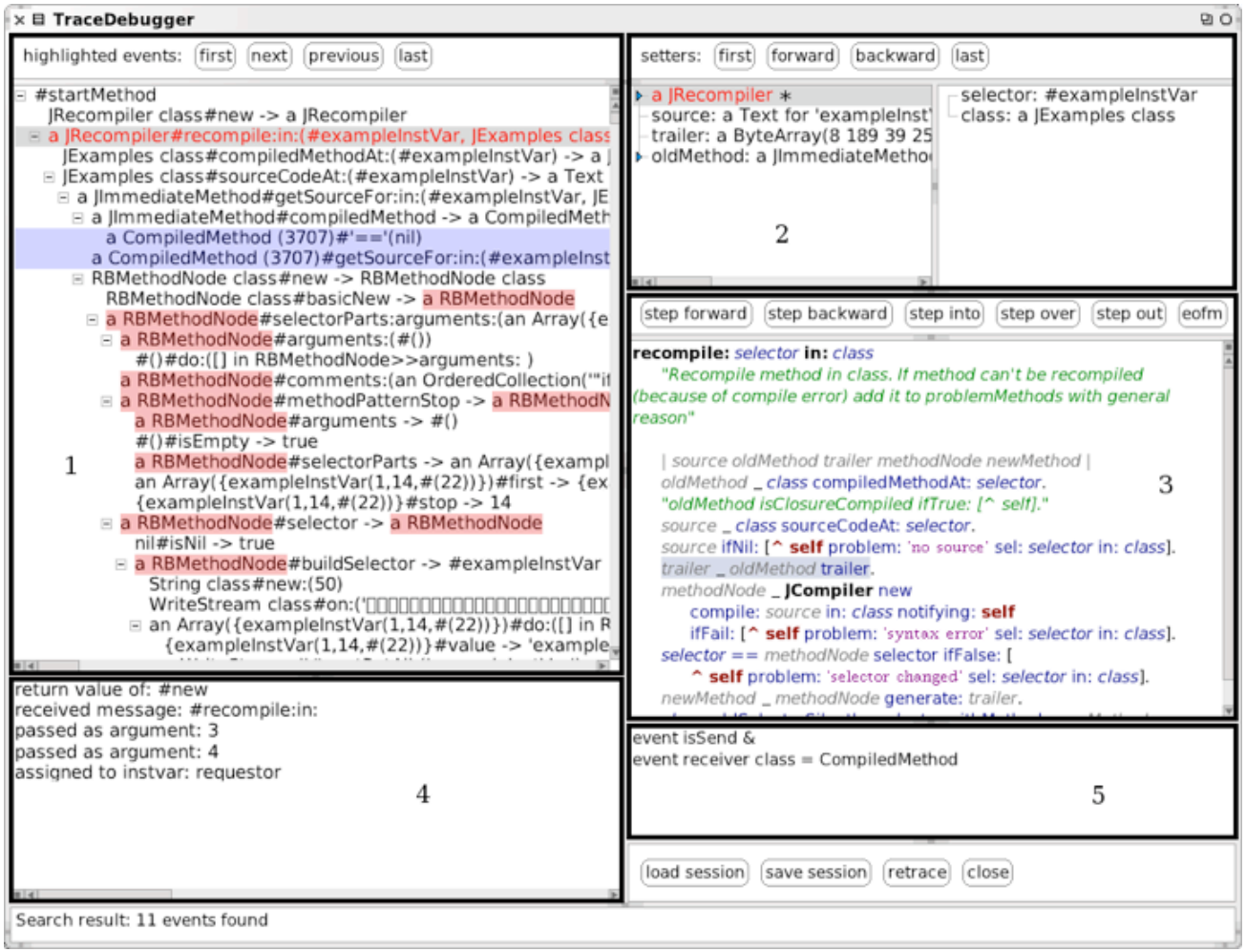
Methods in italic means their execution is finished

Solution

- We want:
  - Record the history of the program
  - View the state at any point in the past
- Unstuck
  - A new Debugger for Squeak
  - Provides full trace information

Unstuck UI

1. Trace
2. Object
3. Code
4. History
5. Query



Searching

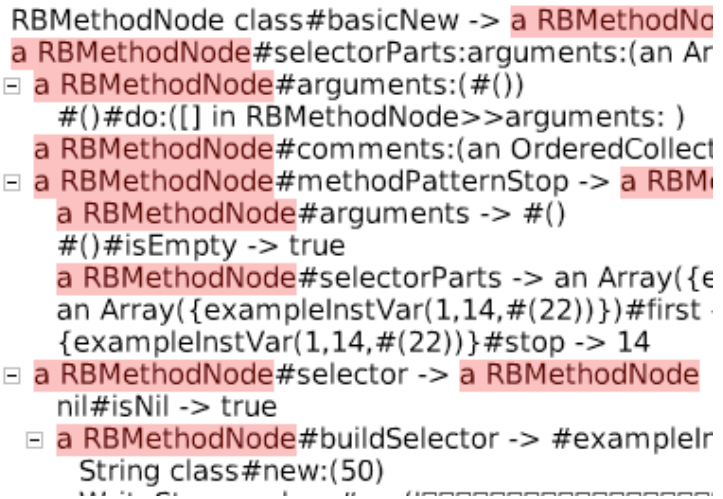
Variable	Search Domain
event	All events
send	all message sends
return	all method returns
varAccess	all variable accesses
instVarAccess	instance variable access
tempVarAccess	temporary variables

Searching: Example

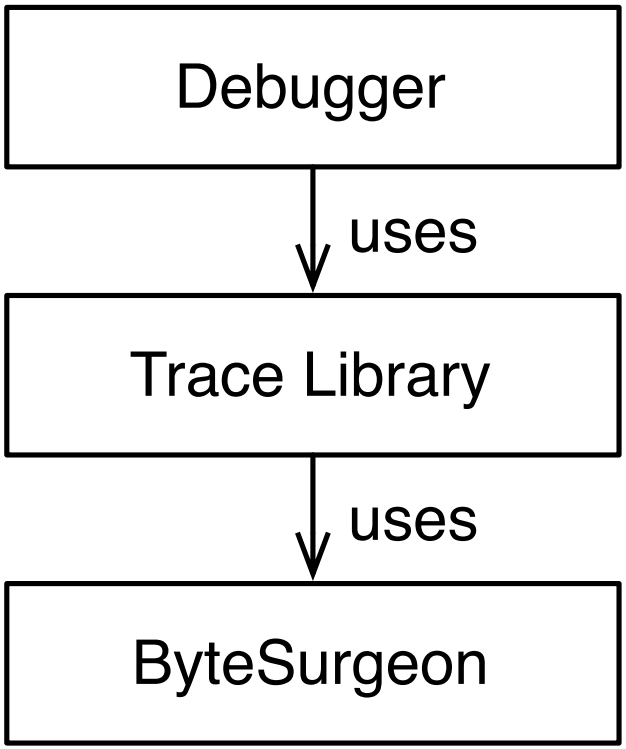
Query	Result
send selector = #foo	All the executed methods named ”foo”
return returnValue > 4	All returns with a return value greater than 4
events isSend & (even arguments size = 1)	Message sends with exactly one argument

Coloring

- We can assign a color to any object
- Easy tracking of objects
- Color is shown in all views of the UI



Implementation



ByteSurgeon

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- Framework for editing bytecode for Squeak
  - Like Javasist in Java, but:
- Uses structural reflection to transform at runtime
  - Simple model: Inline code before / after a bytecode
  - Inlined code is normal smalltalk code
  - Not much knowledge about bytecode needed

Trace Library

- Called from annotated code
- Builds up the trace

- Provides
  - Trace model
  - Event pre-processing (ordering)
  - State reconstruction

State reconstruction

- State not recorded for completely annotated classes
  - past state can be reconstructed from trace
- System never completely annotated
  - Tracer saves state of non-annotated objects

Debugging system classes

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- Annotate classes used by Bytesurgeon or Tracer
  - System classes (e.g. Collection or String)
  - Compiler (e.g. AST)
- Problems:
  - Classes used for annotation --> crash
  - Tracer records events generated by the tracer

Solution

- Retain both methods (original + annotated)
- Generate preamble
  - test for global
  - call original methods when inactive
- Common problem when using reflection!
  - General solution?
  - Future work!

Benchmarks

	Events	Slowdown	Memory (Kb)
Example	74	6	16
AST Bug	2725	3.8	800
Pier Trace	389689	248	88800

Future Work

- further analyze + improve
  - Memory Consumption (GC effects)
  - Performance
- Use behavioral reflection
  - fine grained selection
  - Scoping
  - Annotation of system classes

Conclusion

- Problem of current debugging tools
- Overview of Unstuck
  - UI
  - Implementation
- Having the history available helps
  - Possible for small programs
  - Work needed for bigger systems + continuous use

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Questions?