OMR

A JVM's Journey Into Polyglot Runtimes

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Who am I?

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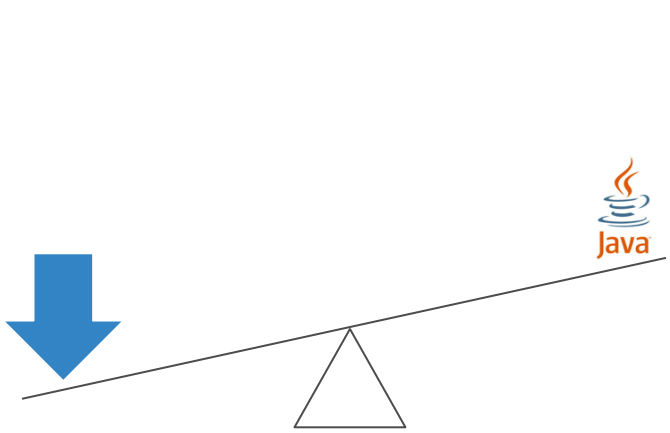
- Garbage Collection Architect for IBM J9 JVM
- Current focus on developing technologies for the OMR project

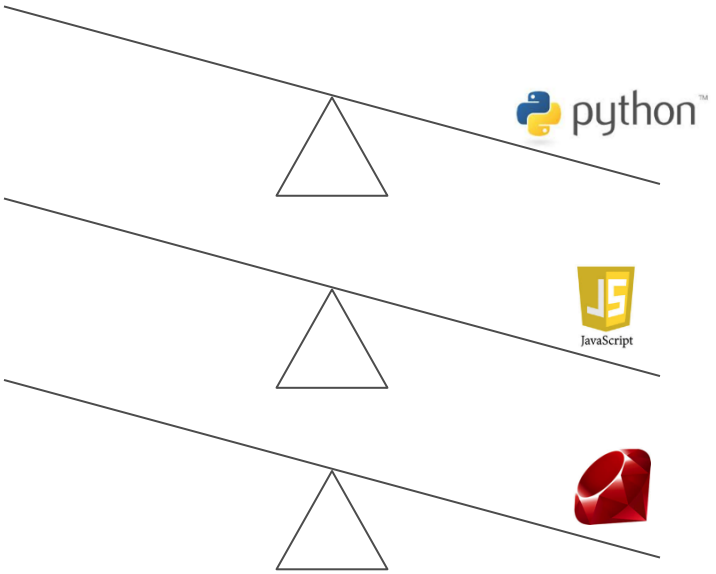
Java and the JVM

It’s a Polyglot World

No Shared Technology

- Effort in one runtime has no leverage in other runtimes





- …looking very costly to support many language runtimes

Languages on The JVM

- Leverage the investment in JVM
  - Cross platform support
  - High performance runtime
  - Production quality
  - Tooling / monitoring support
  - Interoperability with Java

Languages on The JVM

- Works great for new languages like Scala and Groovy
- Existing languages have vibrant communities
  - Not all languages map nicely to Java semantics
  - We decided to experiment with a different approach that would allow new and existing language communities to leverage JVM capabilities

OMR

An open source toolkit for language runtime technologies.

Open Source Toolkit for Building Runtimes

- Eclipse OMR project proposal
  - https://goo.gl/ZTBoeu
- Will be open sourced under EPL
- Derived from the source code of IBM's production runtimes

Open Source Toolkit for Building Runtimes

- Implements language-agnostic parts of a managed runtime
- Bootstraps development of new runtimes

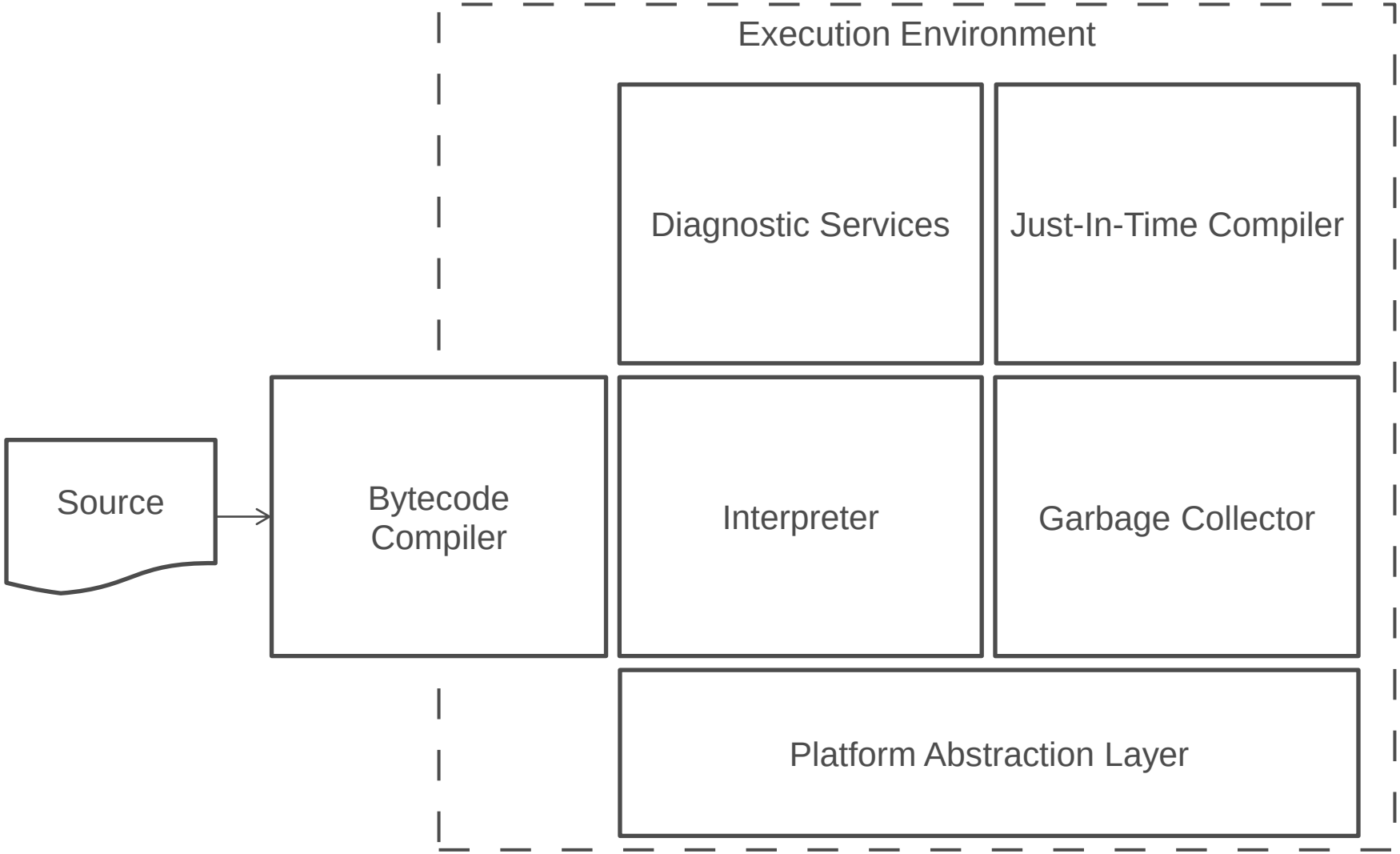
Open Source Toolkit for Building Runtimes

- Allows incremental enablement of advanced functionality
- Easily leverage new hardware features
  - GPU
  - FPGA

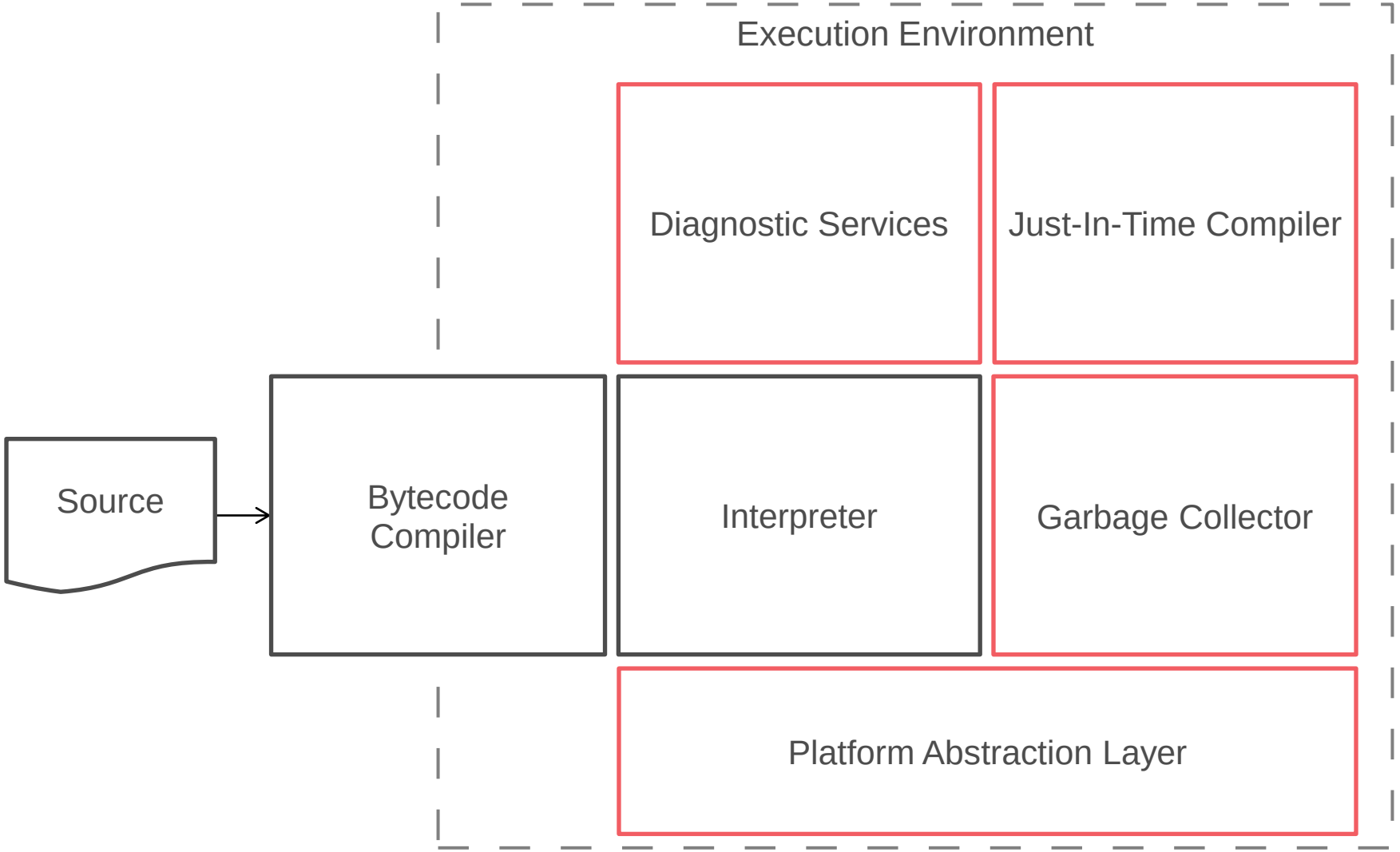
Open Source Toolkit for Building Runtimes

- Shipped as part of IBM SDK for Java 8
- Development of IBM SDK for Java 9 consuming OMR daily
- Proof-of-concept integration with Ruby MRI, CPython, SOM++

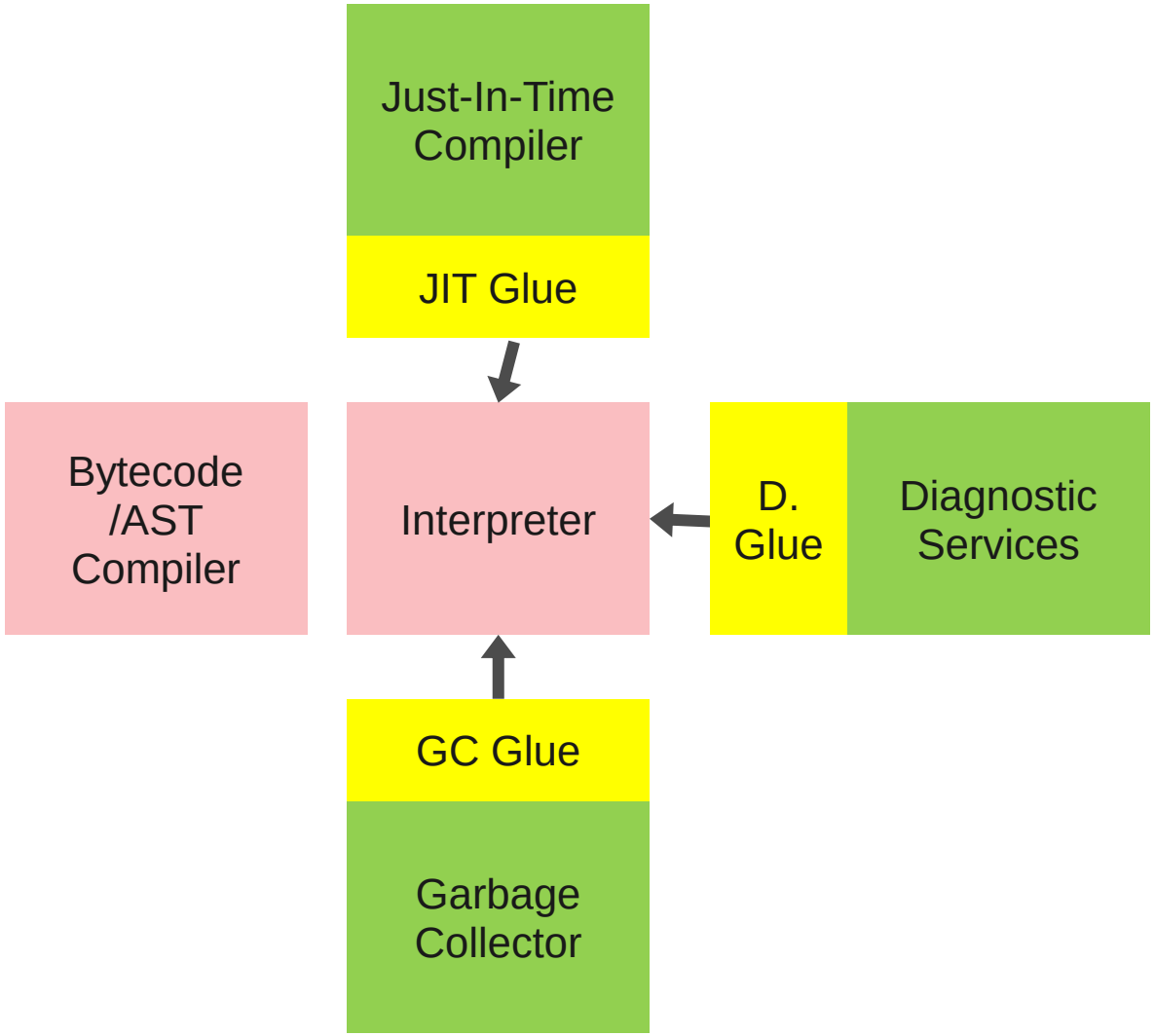
Language Runtime Components



Language-Agnostic Components



Gluing it Together



Ruby + OMR Preview

Ruby + OMR Preview

- GitHub location for the preview
  - https://goo.gl/P3yXuy
- Available as Docker images

Ruby + OMR Preview

- Based on Ruby 2.2.3
  - Working to merge with the master branch
- Successfully passes “make test”
- Runs rails apps

Ruby + OMR Preview

- Integrated OMR components include
  - Platform Abstraction Layer
  - Garbage Collection
  - Just In Time Compilation
  - Diagnostic Tooling

Garbage Collection

Our Strategy:

- Be 100% compatible

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- Be 100% compatible
- Decrease pause times
- Increase allocation speed
- Improve object locality

100% Compatible

- Do not break C extensions
- Pass all tests that ship with MRI
- Test 3rd party applications

Decrease Pause Times

- Complete the following in parallel
  - Root Marking
  - Object tracing
  - Object finalization
  - Sweep

Increase Allocation Speed

- Use TLH mechanism from OMR
  - Threads reserve blocks of heap memory for exclusive allocation
  - Threads bump allocate out of these blocks

```
alloc(rbthread_t thread, int size)
        if (thread->tlhAlloc < thread->tlhTop - size)
                object = thread->tlhAlloc
                thread->tlhAlloc = object + size
        else
                object = OMR_GC_Allocate(thread, size);
```


Improve Object Locality

- Create new OMRBuffer object type
- Allocate OMRBuffers on heap
- Data is regularly adjacent to object in heap
- OMRBuffers are automatically reclaimed during collection

Decrease Pause Times

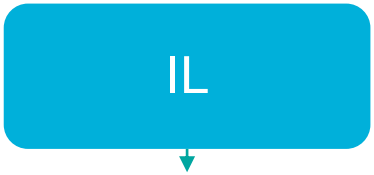
- OMRBuffers do not require calls to obj_free
- Significant reduction in pause times

Future Work

- Improve heap fragmentation
- Add support for concurrent marking

Just In Time Compilation

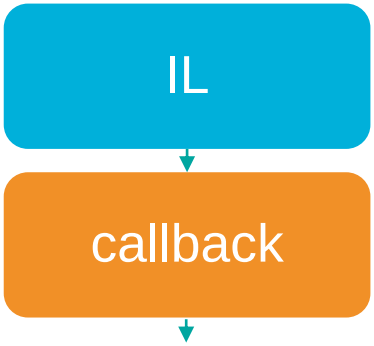
Our Strategy:



- Mimic interpreter for maximum compatibility.
- Implement simple opcodes directly in IL

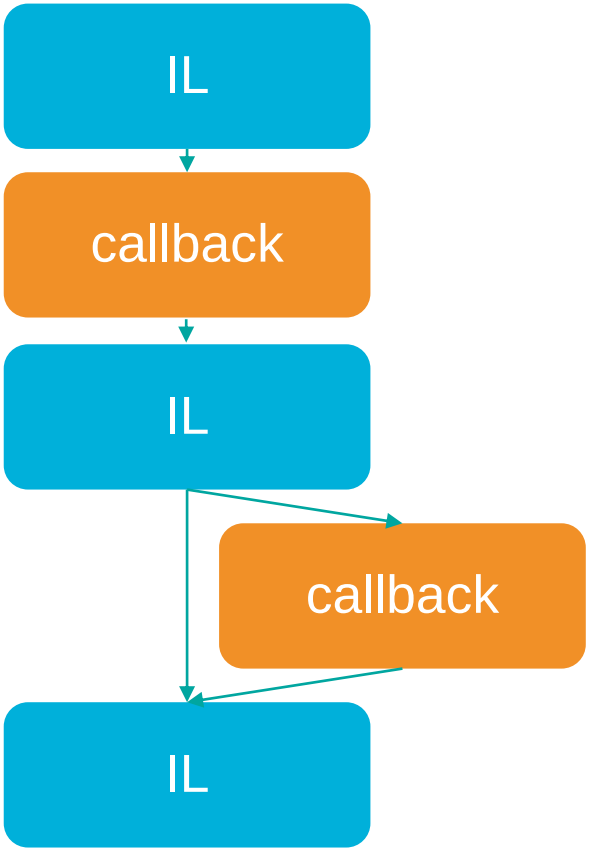
Our Strategy:

- Build callbacks to VM for complex opcodes.
  - Automatically generate callbacks from the instruction definition file.



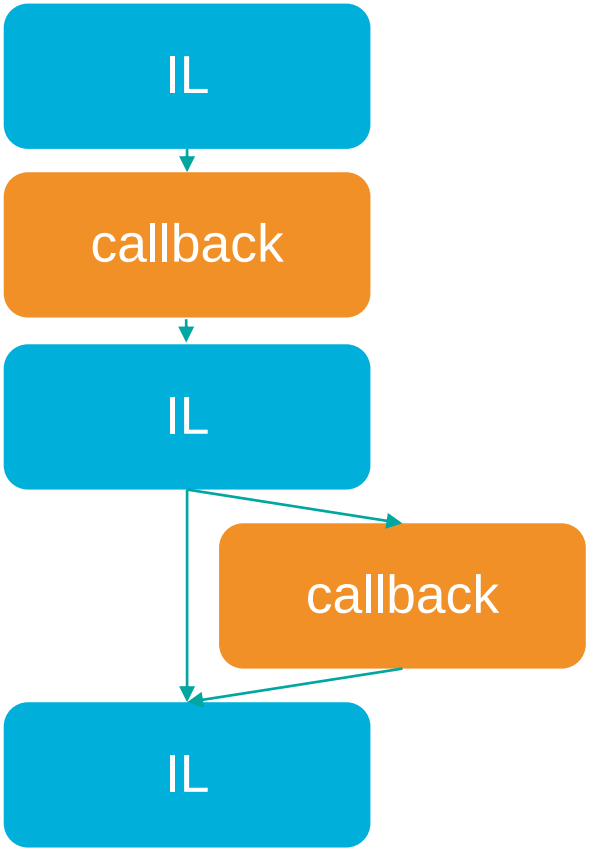
Our Strategy:

- Fast-path particular patterns
  - e.g `trace`



Our Strategy:

- Don’t try to handle everything – let interpreter handle hard cases!



Current Status

- Supports almost all opcodes
- Compile iseq after they are executed N times
- Dispatch to JIT code if the iseq has been compiled

Future Work

- Speculative optimizations powered by decompilation and code-patching
  - Class Hierarchy Based Optimization
  - Guarded inlining
  - Type Specialization
- Recompilation
- Interpreter and JIT Profiling
- Asynchronous Compilation
- More optimization!
  - OMR's Ruby JIT uses only **10 / 100+** optimizations.

Diagnostic Tooling

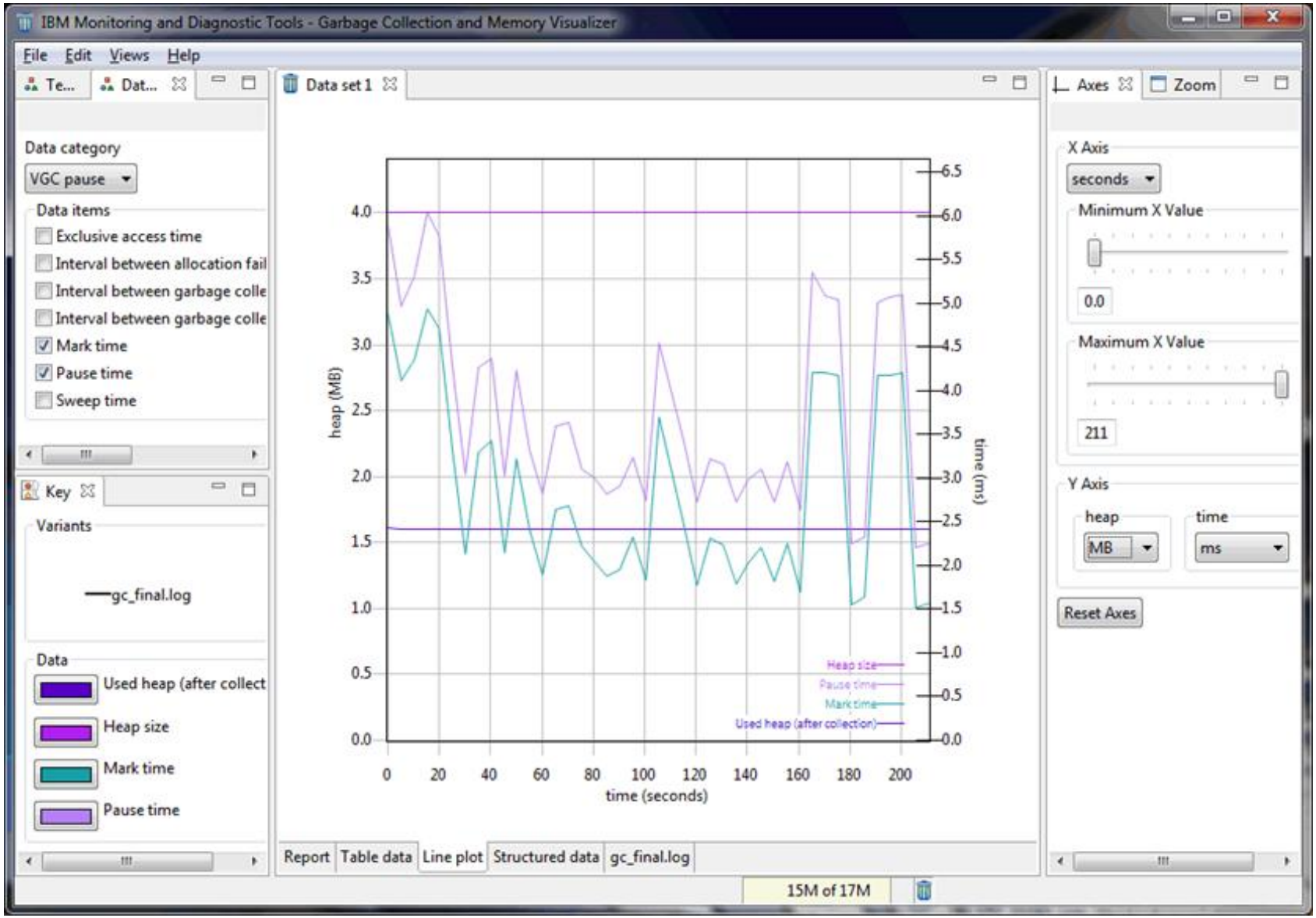
Verbose:gc Output

```
<af-start id="17" threadId="00007F2F3137CFD0" totalBytesRequested="8208" timestamp="2015-12-17T02:16:21.412" intervalms="23.538" />
<cycle-start id="18" type="global" contextid="0" timestamp="2015-12-17T02:16:21.413" intervalms="23.541" />
<gc-start id="19" type="global" contextid="18" timestamp="2015-12-17T02:16:21.413">
  <mem-info id="20" free="201320" total="4194304" percent="4">
    <mem type="tenure" free="201320" total="4194304" percent="4" />
  </mem-info>
</gc-start>
<allocation-stats totalBytes="2009264" >
  <allocated-bytes non-tlh="46328" tlh="1962936" />
  <largest-consumer threadName="OMR_VMThread [" threadId="00007F2F313786E0" bytes="2009264" />
</allocation-stats>
<gc-op id="21" type="mark" timems="3.660" contextid="18" timestamp="2015-12-17T02:16:21.417">
  <trace-info objectcount="27053" scancount="23093" scanbytes="926304" />
</gc-op>
<gc-op id="24" type="sweep" timems="0.232" contextid="18" timestamp="2015-12-17T02:16:21.417" />
<gc-end id="25" type="global" contextid="18" durationms="4.967" usertimems="4.256" systemtimems="0.000" timestamp="2015-12-17T02:16:21.418" activeThreads="1">
  <mem-info id="26" free="1467848" total="4194304" percent="34">
    <mem type="tenure" free="1467848" total="4194304" percent="34" />
  </mem-info>
</gc-end>
<cycle-end id="27" type="global" contextid="18" timestamp="2015-12-17T02:16:21.418" />
<allocation-satisfied id="28" threadId="00007F2F313786E0" bytesRequested="8208" />
<af-end id="29" timestamp="2015-12-17T02:16:21.418" threadId="00007F2F3137CFD0" success="true" />
```

Garbage Collection and Memory Visualizer

- Provides a graphical details on GC events post mortem from verbose:gc logs
- Works with IBM JDK, IBM Node.js and all of our proof-of-concepts
- https://goo.gl/YwNrmI

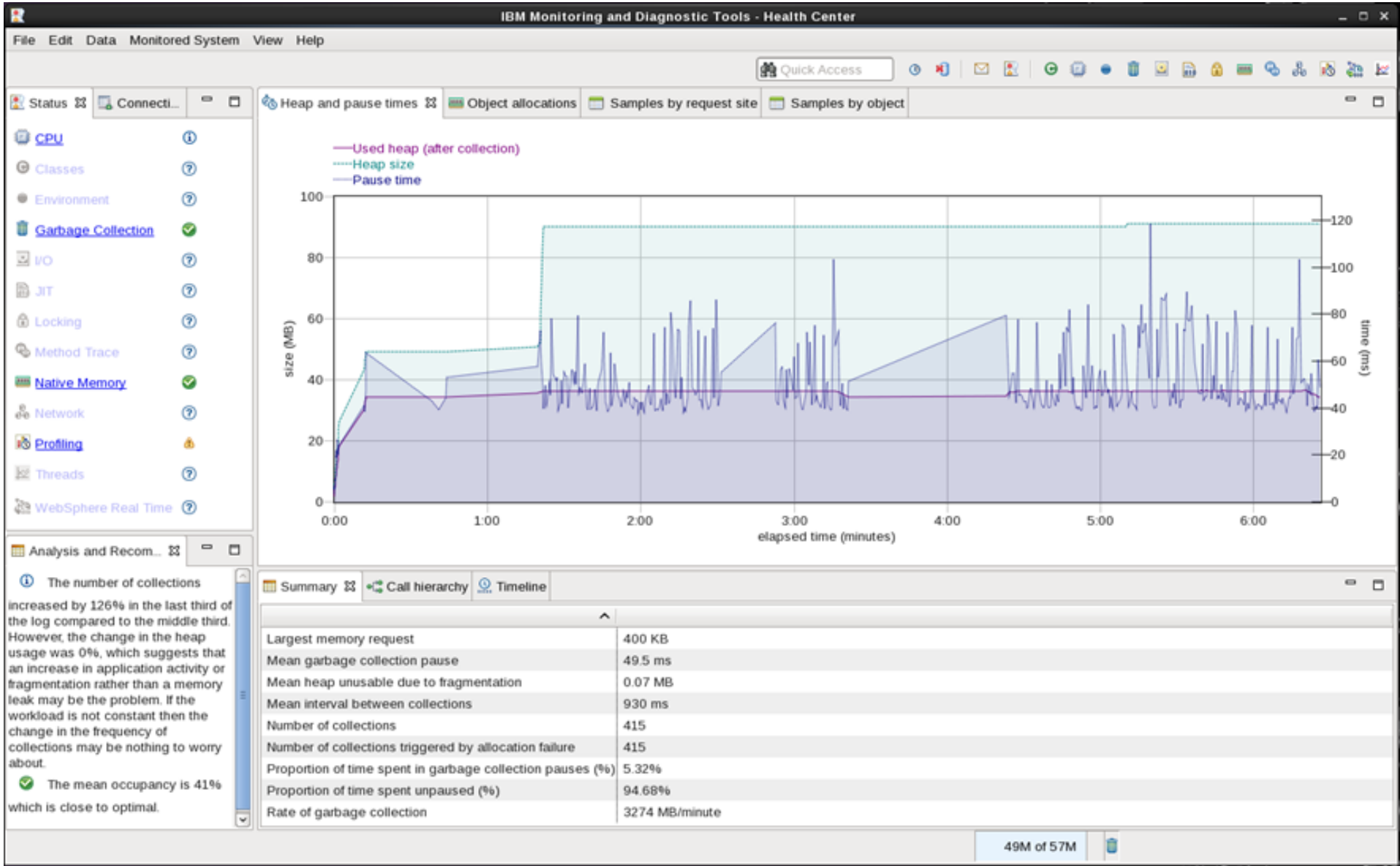
Garbage Collection and Memory Visualizer



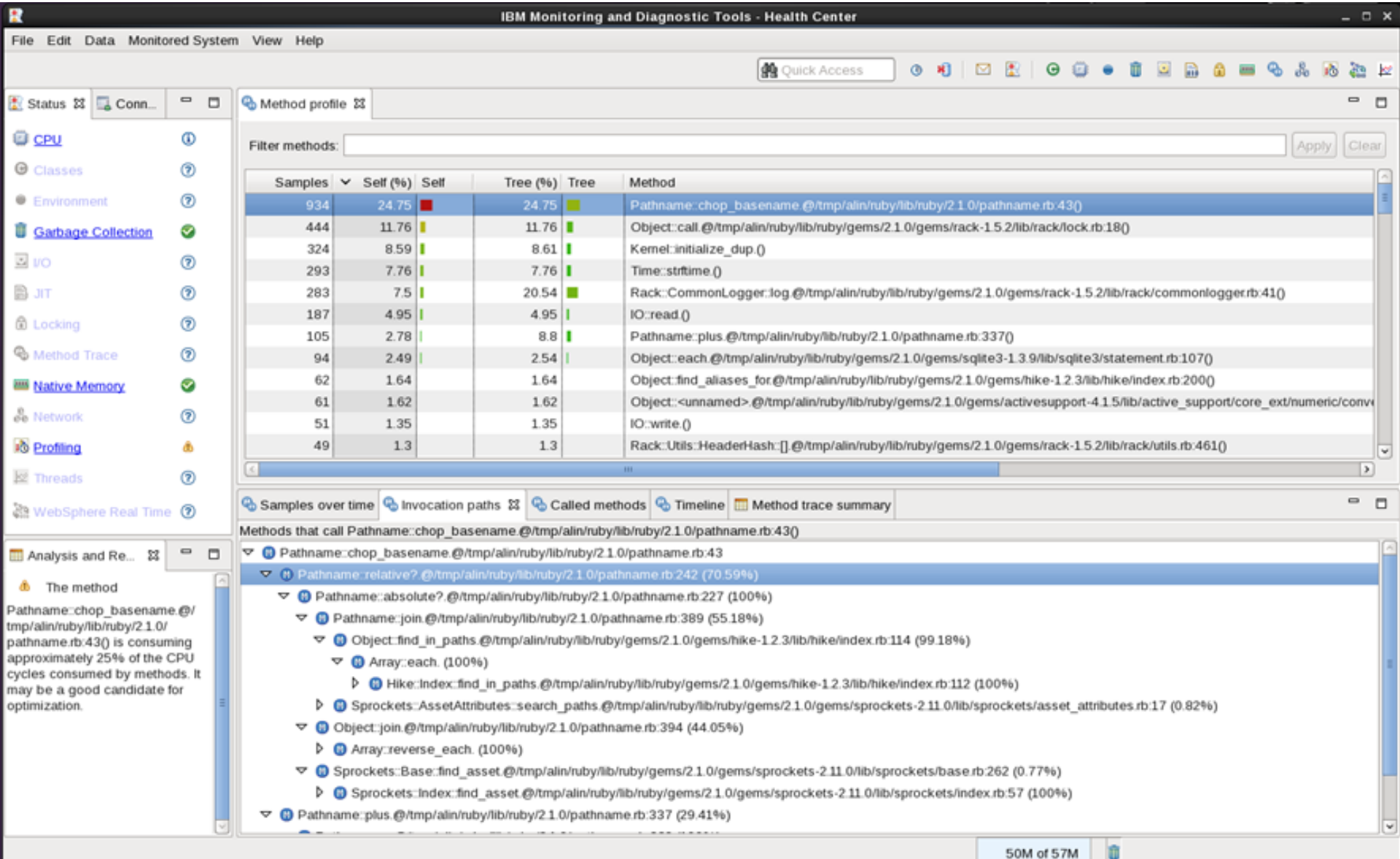
Health Center

- Provides a live view of runtime details
- Works with IBM JDK, IBM Node.js and all of our proof-of-concepts
- http://goo.gl/u3VITI

Health Center – GC Statistics

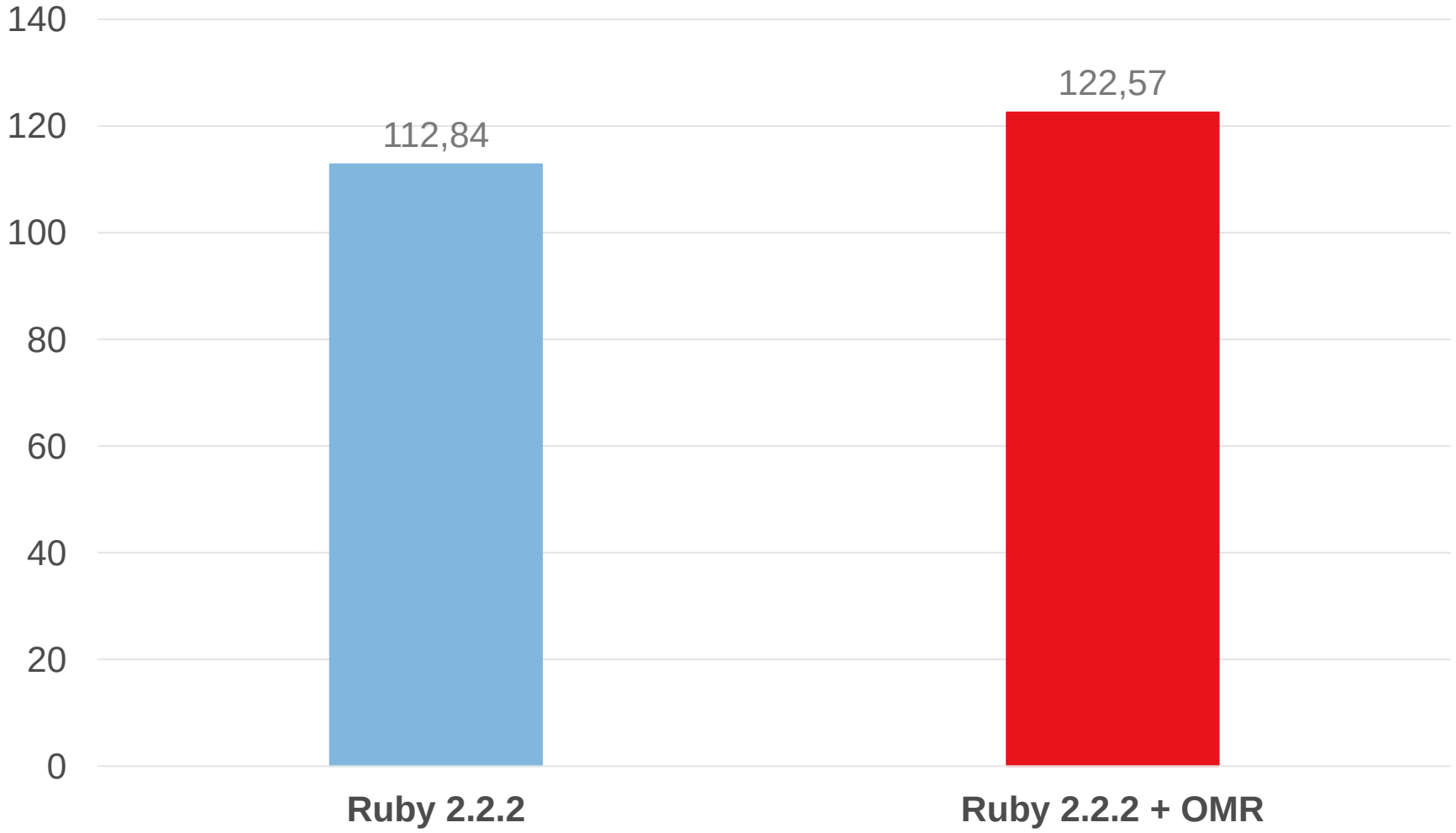


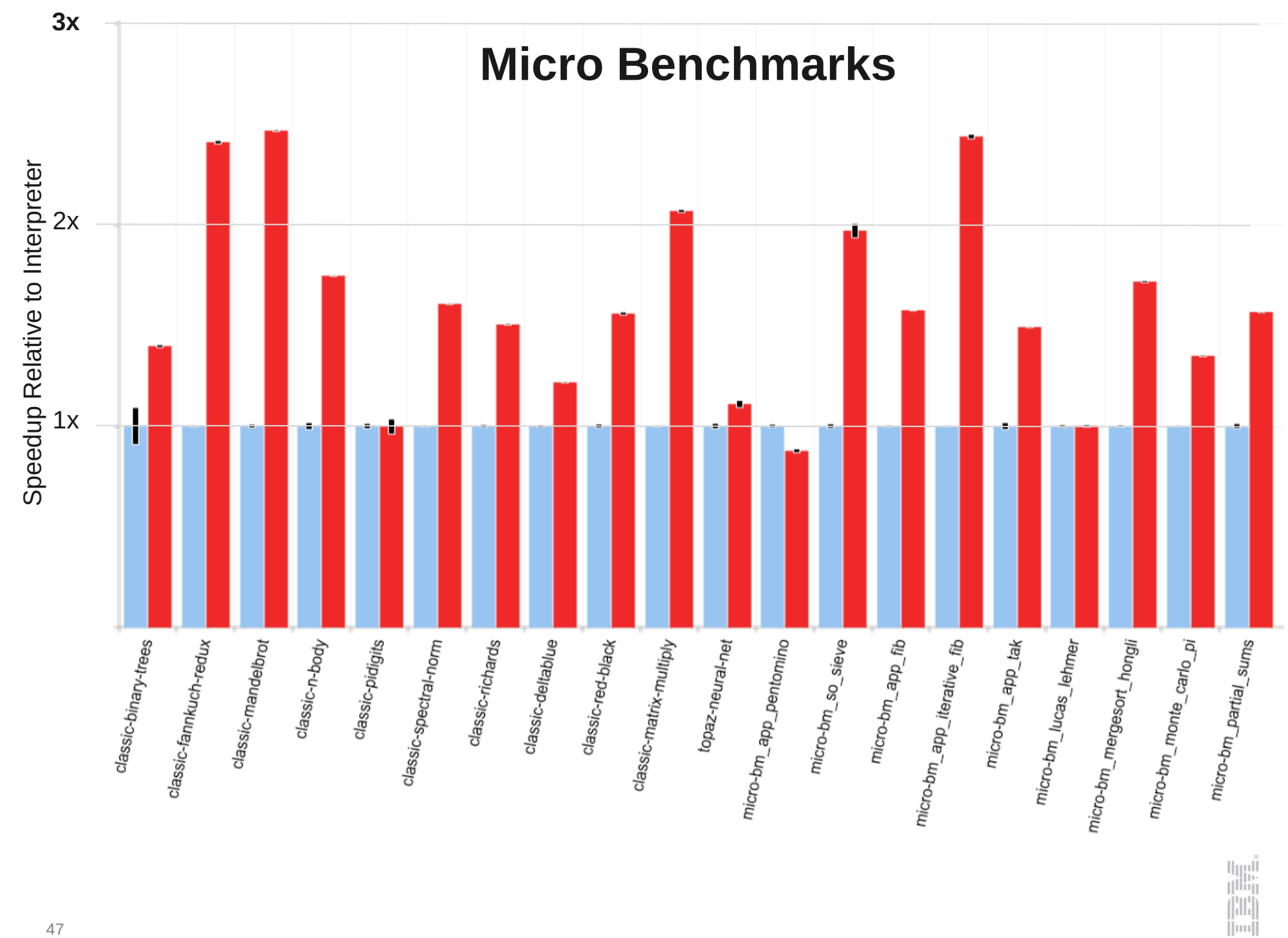
Health Center – Ruby Method Profiling



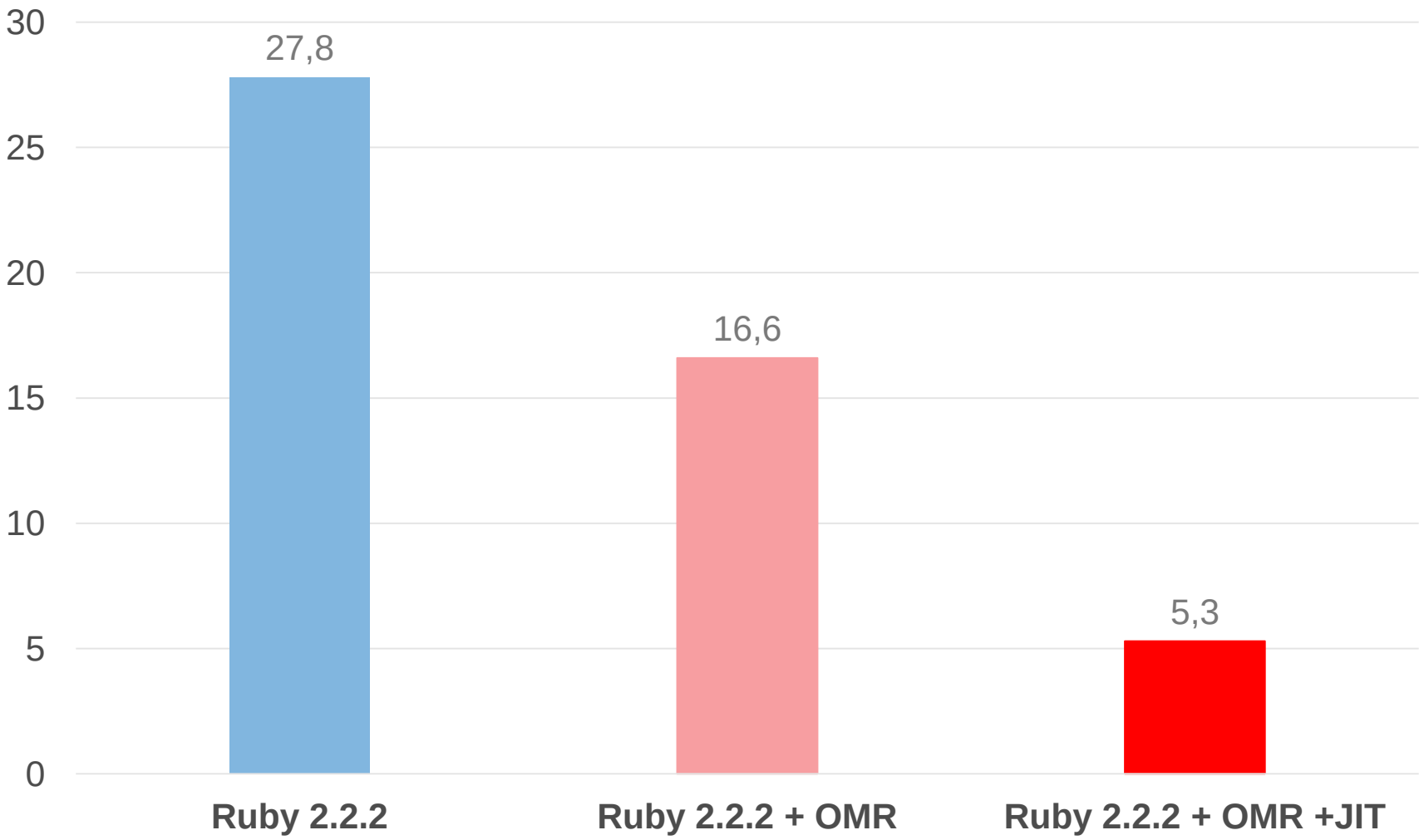
Performance Results

Is Ruby Fast Yet?




Micro Benchmarks
Speedup Relative to Interpreter
3x
2x
1x
classic-binary-trees
classic-fannkuch-redux
classic-mandelbrot
classic-n-body
classic-pidigits
classic-spectral-norm
classic-richards
classic-deltablue
classic-red-black
classic-matrix-multiply
topaz-neural-net
micro-bm_app_pentomino
micro-bm_so_sieve
micro-bm_app_fib
micro-bm_app_iterative_fib
micro-bm_app_tak
micro-bm_lucas_lehmer
micro-bm_mergesort_hongli
micro-bm_monte_carlo_pi
micro-bm_partial_sums

pow(2,n)


30
25
20
15
10
5
0
27,8
16,6
5,3
Ruby 2.2.2
Ruby 2.2.2 + OMR
Ruby 2.2.2 + OMR +JIT

Parting Thoughts

- Almost no one starts a new project saying:

Parting Thoughts

- Almost no one starts a new project saying:
  - First, I'll write the firmware from scratch…

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- Almost no one starts a new project saying:
  - First, I'll write the firmware from scratch…
  - First, I'll write the file system from scratch…

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- Almost no one starts a new project saying:
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  - First, I'll write the file system from scratch …
  - First, I'll write the display drivers from scratch …

Parting Thoughts

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  - First, I'll write the firmware from scratch …
  - First, I'll write the file system from scratch …
  - First, I'll write the display drivers from scratch …

- We would like to make these statements just as unlikely:
  - First, I'll write the cross platform port library from scratch …
  - First, I'll write a garbage collector from scratch …
  - First, I'll write the JIT compiler from scratch …

Thank you!


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Contact Info

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Questions?

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