OPERATIONS VIEW OF THE JAVA VM

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Presentation available at
https://github.com/bilsch/columbus_devops_presentations

Rough overview

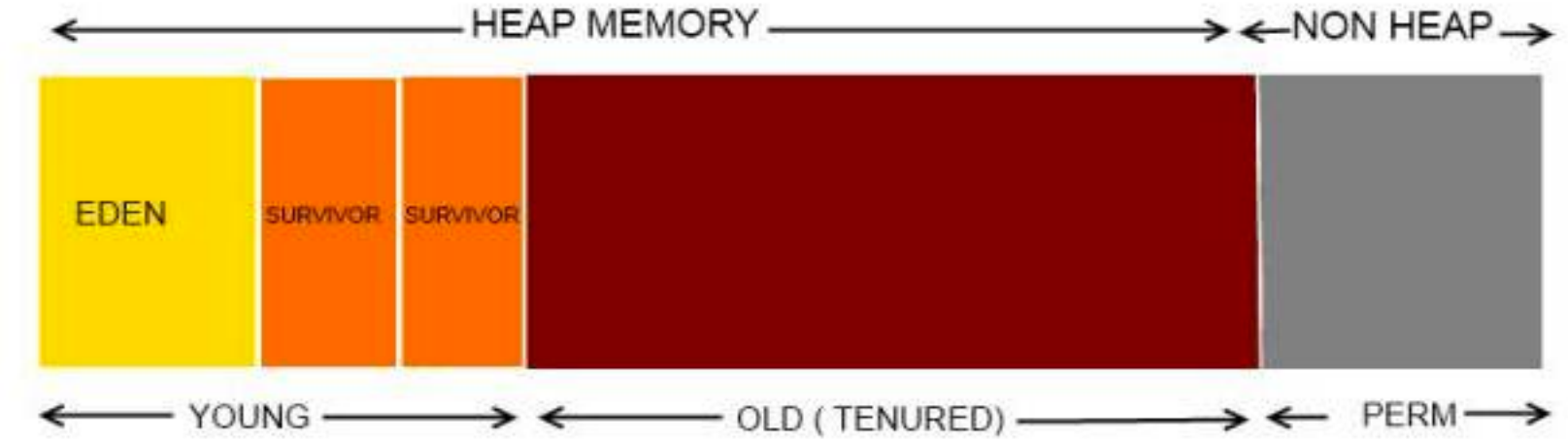
- Quick overview of java
- Crash course introduction to the Java heap
- Crash course on garbage collection (I'll keep this very simple)
- Common simple tunable/run-time tweaks
- Helpful tools
- Common exceptions
  - OutOfMemory
  - How to read/decrypt an exception
- "Just give me more heap!"
  - Developers like to punt and just ask for more heap. I'll give you compelling arguments to not give in too quickly

Quick overview of Java

- Object-oriented programming language developed by Sun Microsystems
  - First released in 1995
- Inspired/based on c and c++
- Original idea was to have a cross-platform just-in-time compiled language.
  - Write to the Java spec, it should run anywhere
  - The nasty stuff supposedly gets handled by the Java Virtual Machine
- Automatic memory management
  - At the expense of Garbage Collection

Crash course on Java Heap

- Broken out in to sections or generations
  - Eden, or New/Young generation
    - Further sub-divided to survivors
  - Old, or Tenured generation
  - Perm, or Permanent generation
    - Disappears in Java 8
- Generations have a default size
  - Based on runtime type, client or server



Crash course on Garbage collection

- non-referenced objects are marked for deletion
- Depending on java version, generation and vm type **may** be run in parallel
- Garbage collection event types
  - Minor GC – happens often and only in Eden
  - Major GC – happens very infrequently and this Eden, Old and Perm
- In Eden
  - Objects bounce between Survivor 0 and Survivor 1
  - After surviving for so many minor garbage collections, promotion to Old generation occurs
- In Old
  - Objects are usually only removed in major (aka stop the world) garbage collection events
- In Perm
  - Objects **never** removed unless a full/major gc occurs
  - Should never see memory shrink!

Common simple tunable/run-time tweaks

Java arg	Action	Value/example	When to change
-Xmx	Sets max heap size	2g	If you really need to!
-Xms	Sets min heap size	2g	Any time
-XX:MaxPermSize	Increase permgen size	256m	If you really need to
-XX:+PrintGCDetails	Turns up logging to stdout of garbage collector	n/a	Debugging mainly but can be used full time with Xloggc
-XX:+PrintGCTimeSTamps	Enhanced output of PrintGCDetails	n/a	^^
-Xloggc:<file>	Logs gc to alternate log file	/foo/bar	^^

http://www.oracle.com/technetwork/articles/java/vmoptions-jsp-140102.html

Helpful tools

Tool Name	URL
VisualVM	https://visualvm.java.net/
Samurai	http://samuraism.jp/samurai/en/index.html
jmap	included in jdk
jstat	^^
gcviz	https://github.com/Netflix/gcviz
GCViewer	https://github.com/chewiebug/GCViewer
MAT	https://eclipse.org/mat/

Common exceptions

- java.lang.OutOfMemoryError: Java heap space
- java.lang.OutOfMemoryError: PermGen space
- java.lang.OutOfMemoryError: GC overhead limit exceeded
- java.lang.NullPointerException

How to read an exception

- When a failure occurs in java, unless the developer catches it you get a nasty backtrace
- Presented from latest to oldest
  - Eg most relevant information is on top

```
15/05/25 16:35:11 INFO DAGScheduler: Job 0 failed: count at <console>:23, took 3.016429 s
15/05/25 16:35:11 INFO TaskSetManager: Lost task 4.3 in stage 0.0 (TID 19) on executor cdm.home.bilsch.org: java.io.FileNotFoundException (/home/
vagrant/jdk-8u45-linux-x64.rpm (Permission denied)) [duplicate 19]
15/05/25 16:35:11 INFO TaskSchedulerImpl: Removed TaskSet 0.0, whose tasks have all completed, from pool
org.apache.spark.SparkException: Job aborted due to stage failure: Task 0 in stage 0.0 failed 4 times, most recent failure: Lost task 0.3 in stag
e 0.0 (TID 15, cdm.home.bilsch.org): java.io.FileNotFoundException: /home/vagrant/jdk-8u45-linux-x64.rpm (Permission denied)
        at java.io.FileInputStream.open(Native Method)
        at java.io.FileInputStream.<init>(FileInputStream.java:146)
        at org.apache.hadoop.fs.RawLocalFileSystem$LocalFSFileInputStream.<init>(RawLocalFileSystem.java:104)
        at org.apache.hadoop.fs.RawLocalFileSystem.open(RawLocalFileSystem.java:200)
        at org.apache.hadoop.fs.ChecksumFileSystem$ChecksumFSInputChecker.<init>(ChecksumFileSystem.java:141)
        at org.apache.hadoop.fs.ChecksumFileSystem.open(ChecksumFileSystem.java:341)
        at org.apache.hadoop.fs.FileSystem.open(FileSystem.java:766)
        at org.apache.hadoop.mapred.LineRecordReader.<init>(LineRecordReader.java:108)
        at org.apache.hadoop.mapred.TextInputFormat.getRecordReader(TextInputFormat.java:67)
        at org.apache.spark.rdd.HadoopRDD$$anon$1.<init>(HadoopRDD.scala:236)
        at org.apache.spark.rdd.HadoopRDD.compute(HadoopRDD.scala:212)
        at org.apache.spark.rdd.HadoopRDD.compute(HadoopRDD.scala:101)
        at org.apache.spark.rdd.RDD.computeOrReadCheckpoint(RDD.scala:277)
        at org.apache.spark.rdd.RDD.iterator(RDD.scala:244)
        at org.apache.spark.rdd.MapPartitionsRDD.compute(MapPartitionsRDD.scala:35)
        at org.apache.spark.rdd.RDD.computeOrReadCheckpoint(RDD.scala:277)
        at org.apache.spark.rdd.RDD.iterator(RDD.scala:244)
        at org.apache.spark.scheduler.ResultTask.runTask(ResultTask.scala:61)
        at org.apache.spark.scheduler.Task.run(Task.scala:64)
        at org.apache.spark.executor.Executor$TaskRunner.run(Executor.scala:203)
        at java.util.concurrent.ThreadPoolExecutor.runWorker(ThreadPoolExecutor.java:1145)
        at java.util.concurrent.ThreadPoolExecutor$Worker.run(ThreadPoolExecutor.java:615)
        at java.lang.Thread.run(Thread.java:745)
```

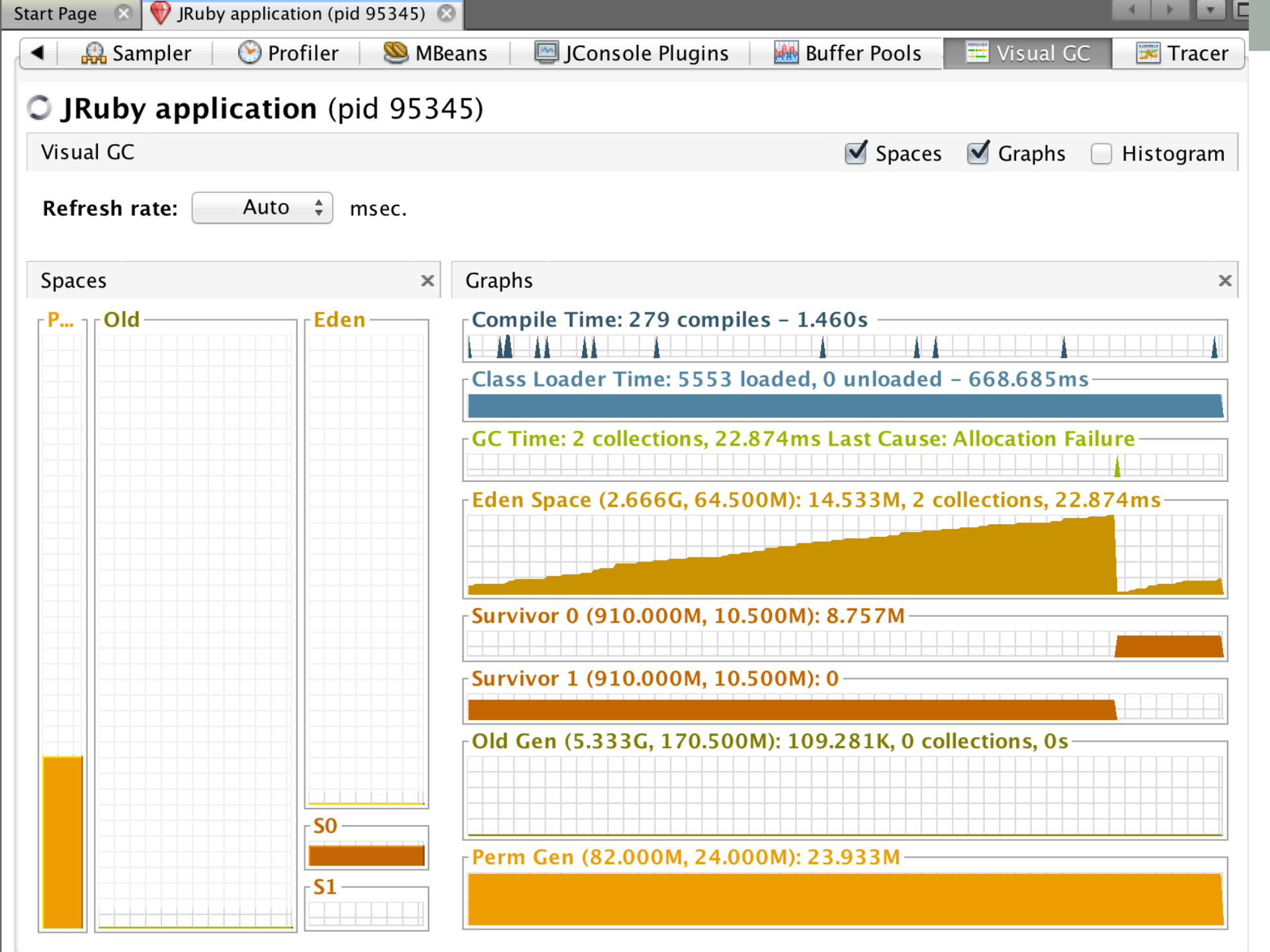
- Simple example, permission denied trying to read a file
- Simple version of what is going on
  - Within a java thread in org.apache.spark
  - Scheduled task trying to iterate over the contents of a file
  - Bunch of hadoop classes
  - Top most is java.io.FileInputStream in the open method

Just give me more heap!

- I used to get this request a lot!
- Keep in mind garbage collection
  - Bigger heaps mean longer garbage collections
  - But could also really just be the right answer!
- Remember other applications need memory too
  - Especially the kernel and caches!
- Having a bunch of JVMs on a single machine can be problematic when saturating host
  - Research garbage collector thread allocation!
  - http://architects.dzone.com/articles/how-tune-java-garbage

jstat

```
/usr/bin/jstat
bilsch@Euclid:~ $ jstat -gcutil 53988 5s
  S0     S1     E      O      P     YGC     YGCT    FGC    FGCT     GCT
  0.00   0.00  85.71  85.63  59.39     13    0.764     8    4.180    4.944
  0.00   0.00  85.79  85.63  59.48     13    0.764     8    4.180    4.944
  0.00   0.00  87.50  87.84  59.48     13    0.764     8    4.180    4.944
  0.00   0.00  87.50  87.84  59.48     13    0.764     8    4.180    4.944
  0.00   0.00  87.50  87.84  59.48     13    0.764     8    4.180    4.944
  0.00   0.00  87.50  87.84  59.48     13    0.764     8    4.180    4.944
  0.00   0.00  30.50  90.17  62.61     14    1.205     9    4.832    6.037
  0.00   0.00  30.50  90.17  62.61     14    1.205     9    4.832    6.037
  0.00   0.00  82.95  90.17  62.61     14    1.205     9    4.832    6.037
  0.00   0.00  30.38  89.63  66.09     15    2.438    10    6.329    8.767
  0.00   0.00  30.38  89.63  66.09     15    2.438    10    6.329    8.767
  0.00   0.00  30.55  89.63  66.09     15    2.438    10    6.329    8.767
  0.00   0.00  30.55  89.63  66.09     15    2.438    10    6.329    8.767
  0.00   0.00  75.90  89.63  66.09     15    2.438    10    6.329    8.767
  0.00   0.00  75.90  89.63  66.09     15    2.438    10    6.329    8.767
  0.00   0.00  76.70  97.22  66.09     15    2.438    10    6.329    8.767
```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JRuby application (pid 95345)
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Buffer Pools
Visual GC
Tracer
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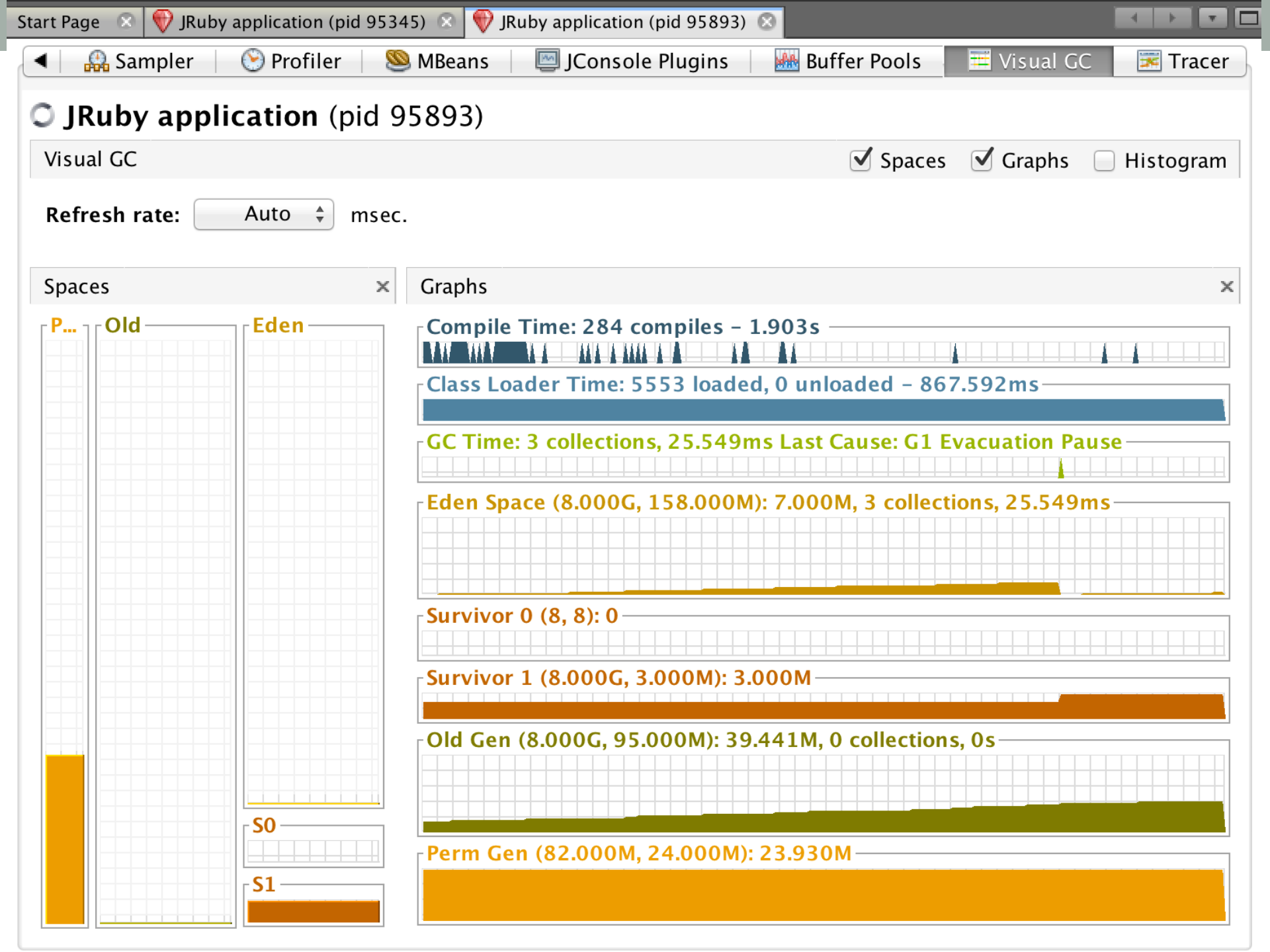
Visual GC
Spaces
Graphs
Histogram
Refresh rate:
Auto
msec.
Spaces
Graphs
P...
Old
Eden
S0
S1
Compile Time: 279 compiles - 1.460s
Class Loader Time: 5553 loaded, 0 unloaded - 668.685ms
GC Time: 2 collections, 22.874ms Last Cause: Allocation Failure
Eden Space (2.666G, 64.500M): 14.533M, 2 collections, 22.874ms
Survivor 0 (910.000M, 10.500M): 8.757M
Survivor 1 (910.000M, 10.500M): 0
Old Gen (5.333G, 170.500M): 109.281K, 0 collections, 0s
Perm Gen (82.000M, 24.000M): 23.933M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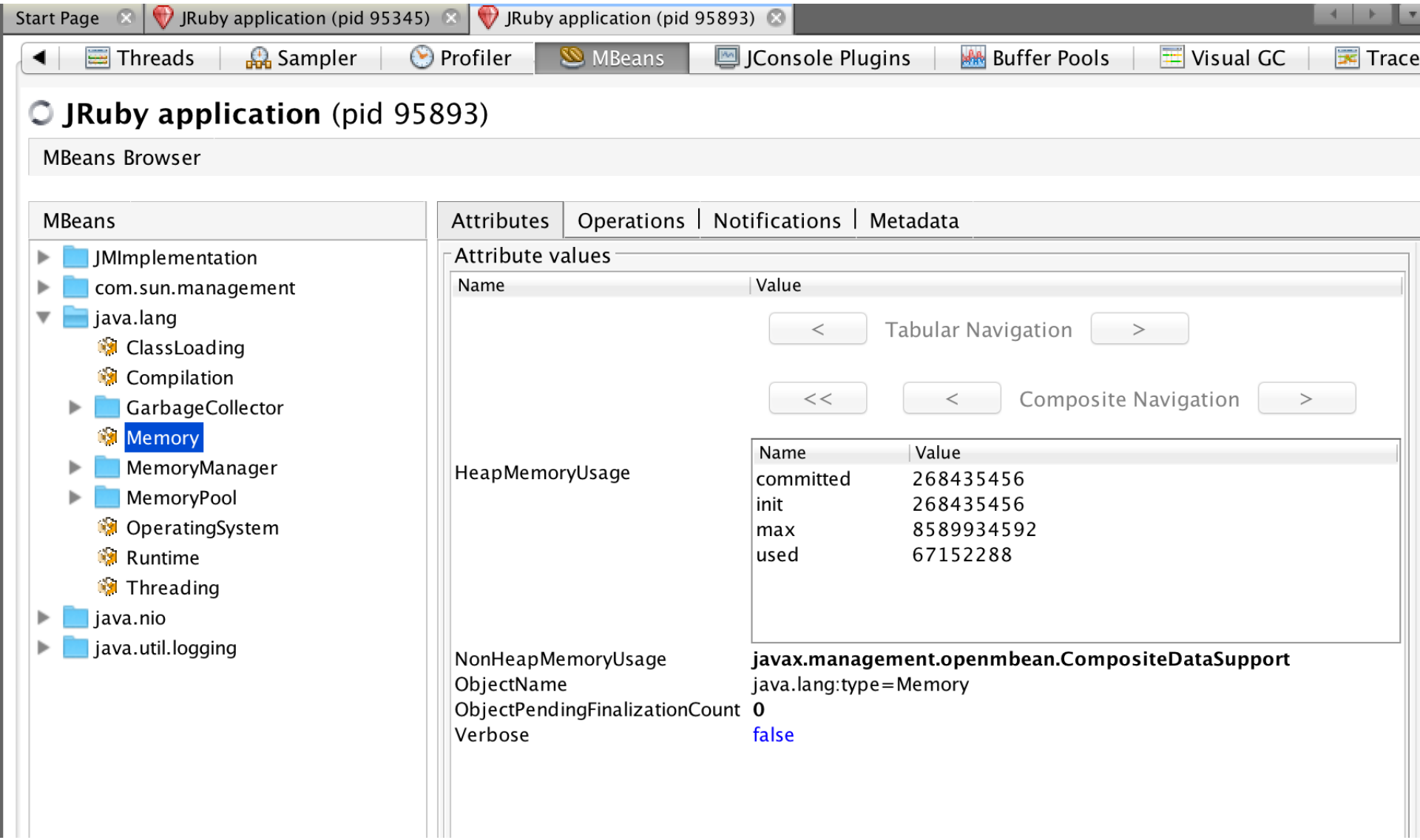
P...
Old
Eden
S0
S1
Compile Time: 284 compiles - 1.903s
Class Loader Time: 5553 loaded, 0 unloaded - 867.592ms
GC Time: 3 collections, 25.549ms Last Cause: G1 Evacuation Pause
Eden Space (8.000G, 158.000M): 7.000M, 3 collections, 25.549ms
Survivor 0 (8, 8): 0
Survivor 1 (8.000G, 3.000M): 3.000M
Old Gen (8.000G, 95.000M): 39.441M, 0 collections, 0s
Perm Gen (82.000M, 24.000M): 23.930M

JMX

- Java Management Extensions
- Provides access to all kinds of neat stuff
  - Access to counters/gauges on individual MBeans
  - Ability to interrogate certain components of the MBean
    - Toggle runtime
    - Invoke methods
      - Trigger a garbage collection
      - Turn a jdbc pool on/off
      - Temporarily bump log levels
      - …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java.util.logging
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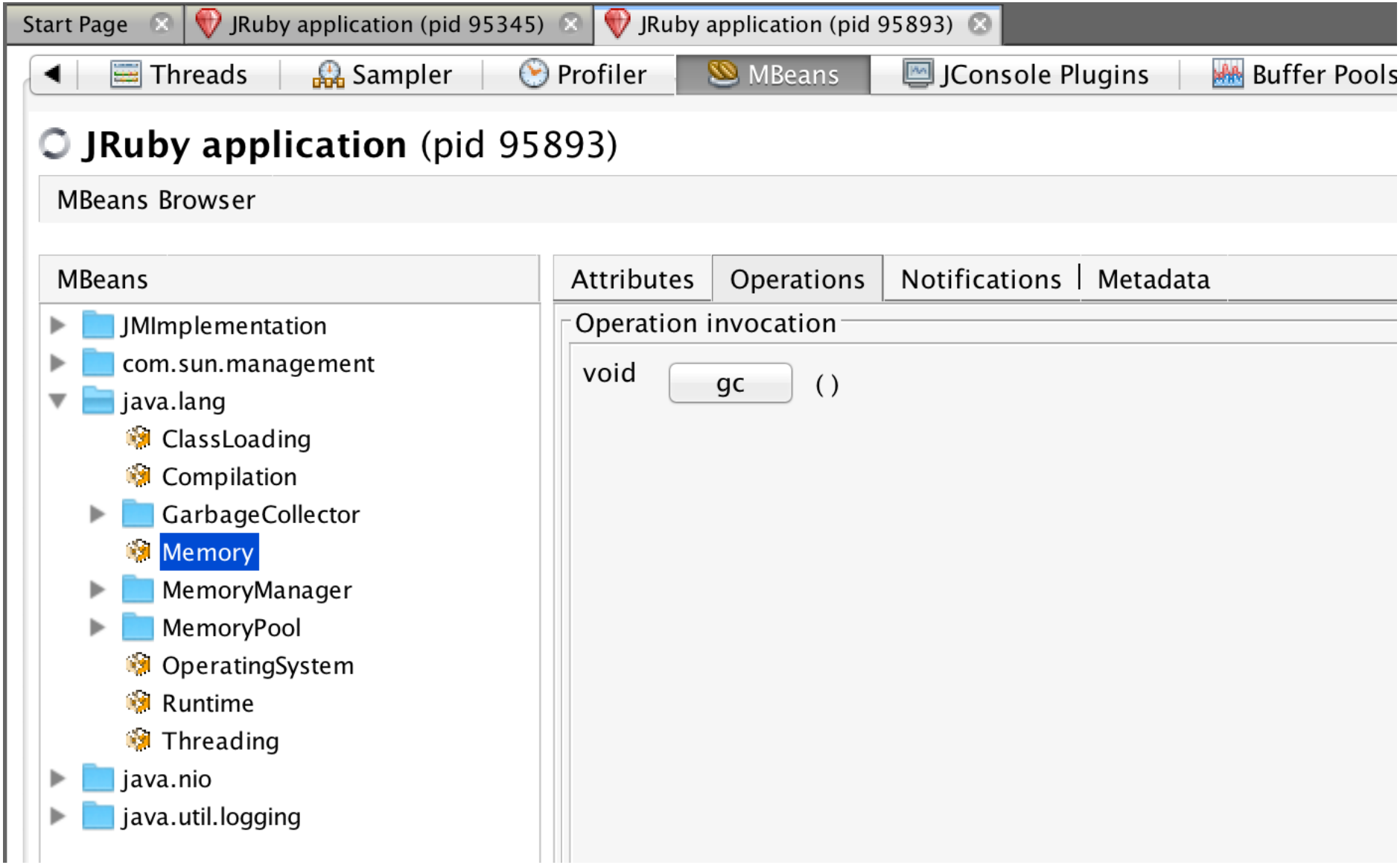
Name
Value
<
Tabular Navigation
>
<<
<
Composite Navigation
>
HeapMemoryUsage
Name
Value
committed
268435456
init
268435456
max
8589934592
used
67152288
NonHeapMemoryUsage
javax.management.openmbean.CompositeDataSupport
ObjectName
java.lang:type=Memory
ObjectPendingFinalizationCount
0
Verbose
false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Operation invocation
void
gc
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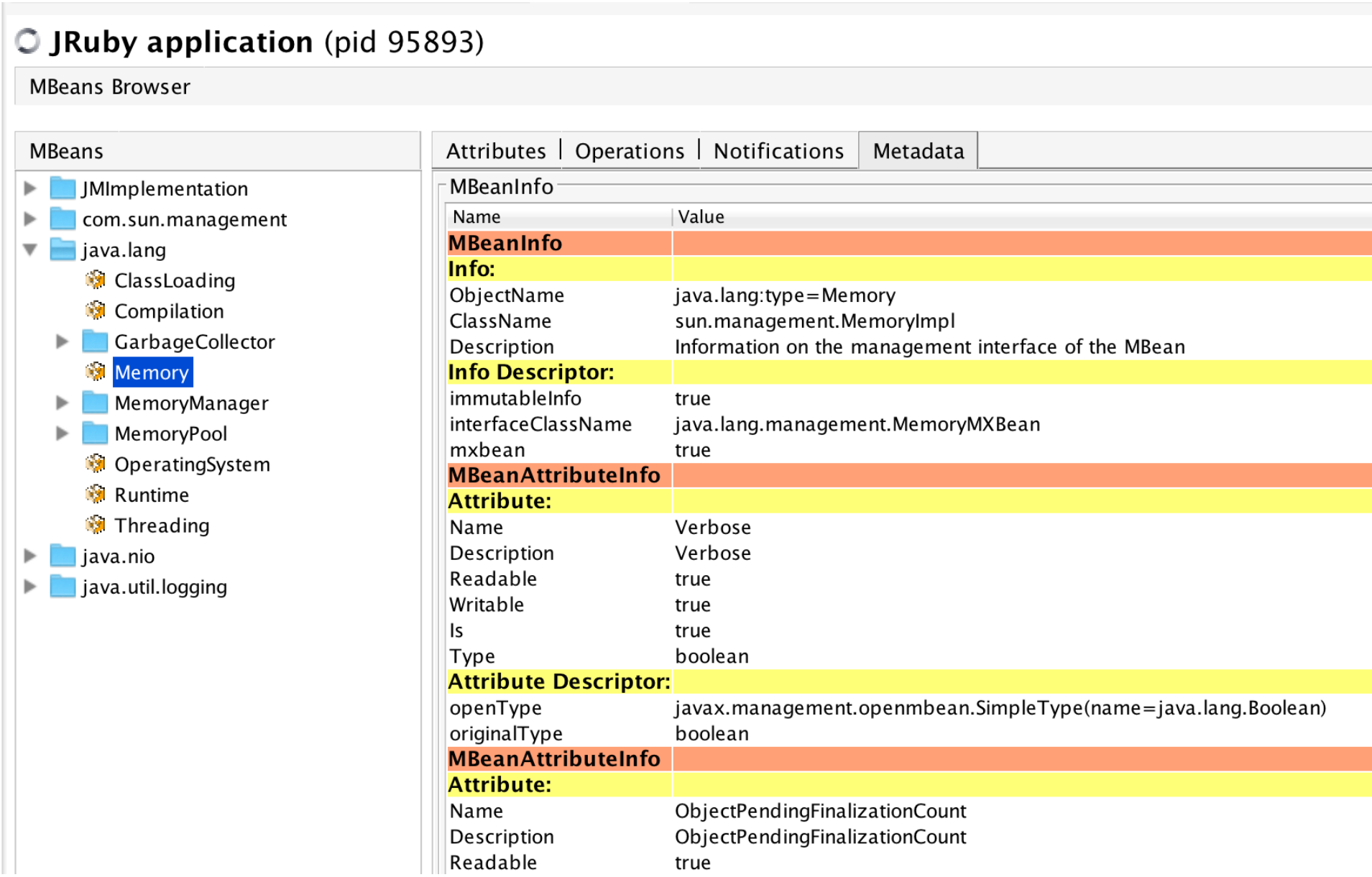
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java.nio
java.util.logging
Attributes
Operations
Notifications
Metadata
MBeanInfo
Name
Value
MBeanInfo
Info:
ObjectName
java.lang:type=Memory
ClassName
sun.management.MemoryImpl
Description
Information on the management interface of the MBean
Info Descriptor:
immutableInfo
true
interfaceClassName
java.lang.management.MemoryMXBean
mxbean
true
MBeanAttributeInfo
Attribute:
Name
Verbose
Description
Verbose
Readable
true
Writable
true
Is
true
Type
boolean
Attribute Descriptor:
openType
javax.management.openmbean.SimpleType(name=java.lang.Boolean)
originalType
boolean
MBeanAttributeInfo
Attribute:
Name
ObjectPendingFinalizationCount
Description
ObjectPendingFinalizationCount
Readable
true

Final thoughts, monitoring

- Last thought on JMX. Collectd and others can pull jmx metric data
  - https://collectd.org/wiki/index.php/Plugin:GenericJMX
    - Embeds a jvm in to collectd
    - I found upstream builds do **not** compile jmx support in
  - https://exchange.nagios.org/directory/Plugins/Java-Applications-and-Servers/check_jmx/details
  - https://jolokia.org/index.html
    - Requires altering the class path and may or may not be liked by vendors
    - Much lighter weight than the check_jmx as you can get at things with curl vs. invoking a small jvm