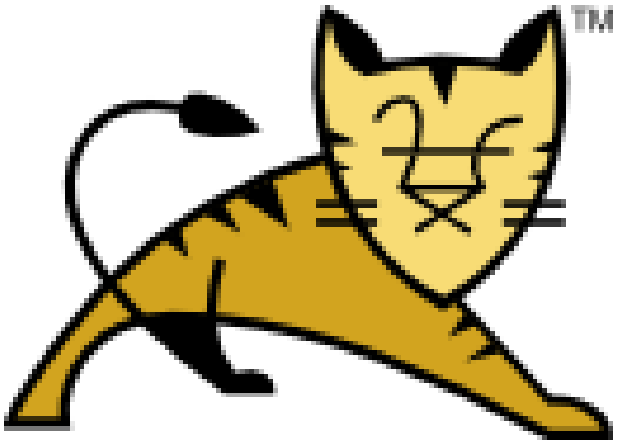


# Monitoring Tomcat with JMX


# Christopher Schultz

Chief Technology Officer

Total Child Health, Inc.


* Slides available on the Linux Foundation / ApacheCon2016 web site and at http://people.apache.org/~schultz/ApacheCon NA 2016/Monitoring Apache Tomcat with JMX.odp

# Java Management Extensions

- Protocol and API for managing and monitoring
  - Access data via JMX “Mbeans”
  - Read and write bean attributes
  - Invoke operations
  - Receive notifications
- JVM exposes certain status
- Tomcat exposes certain status

# Monitoring JVM

- Heap status
- Total, free, used memory
- Garbage collection
- GC pause times

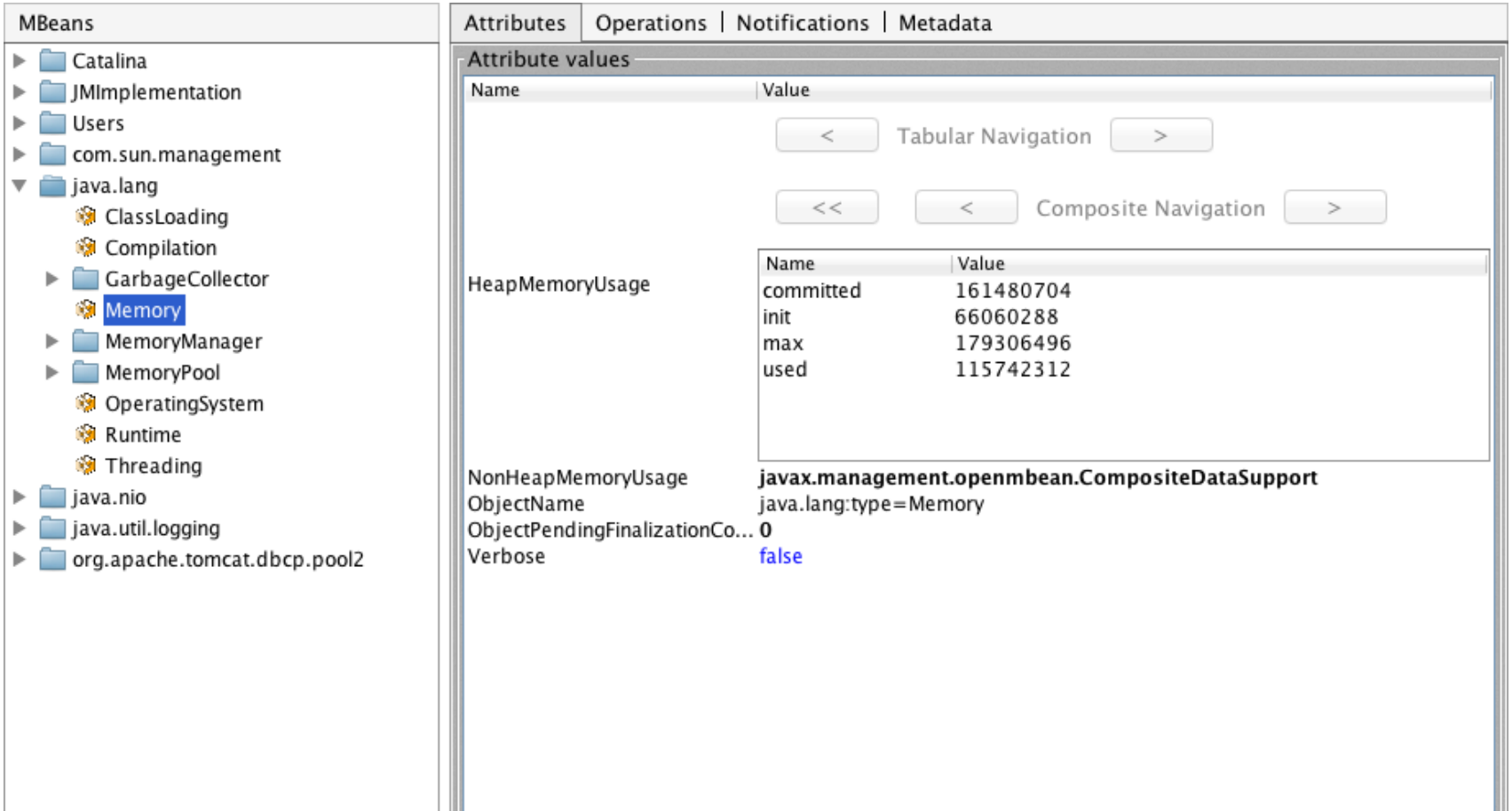
# Monitoring Tomcat

- Status of connector
- Status of request-processor thread pool
- Status of data sources
- Request performance

# JMX Tools

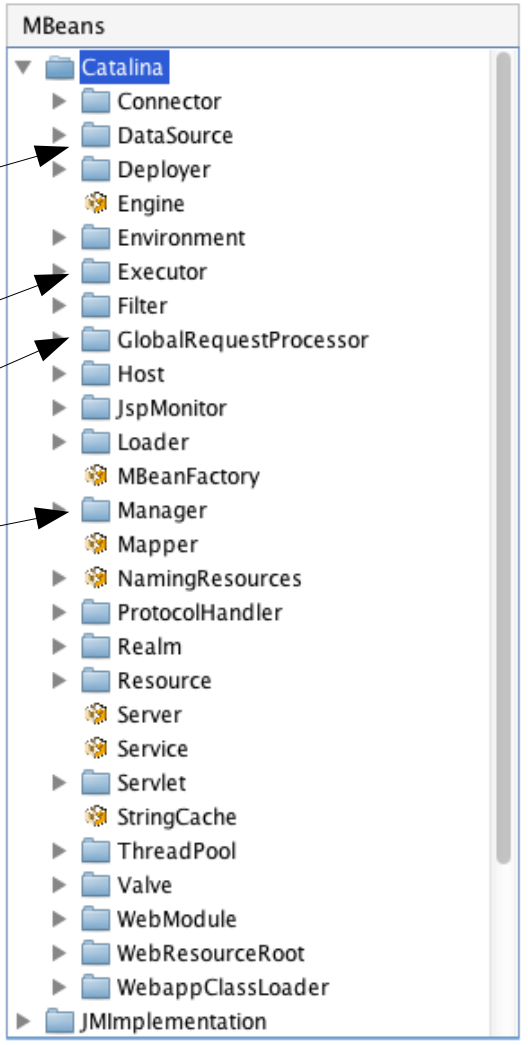
- jconsole (JDK)
- VisualVM (JDK, app bundle)
- Most profilers (e.g. YourKit, etc.)
- Custom tools using javax.management API

# Monitoring JVM: Heap



# Monitoring Tomcat

- Status of data sources
- Status of request-processor thread pool
- Request performance
- Session information



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- Status of request-processor thread pool
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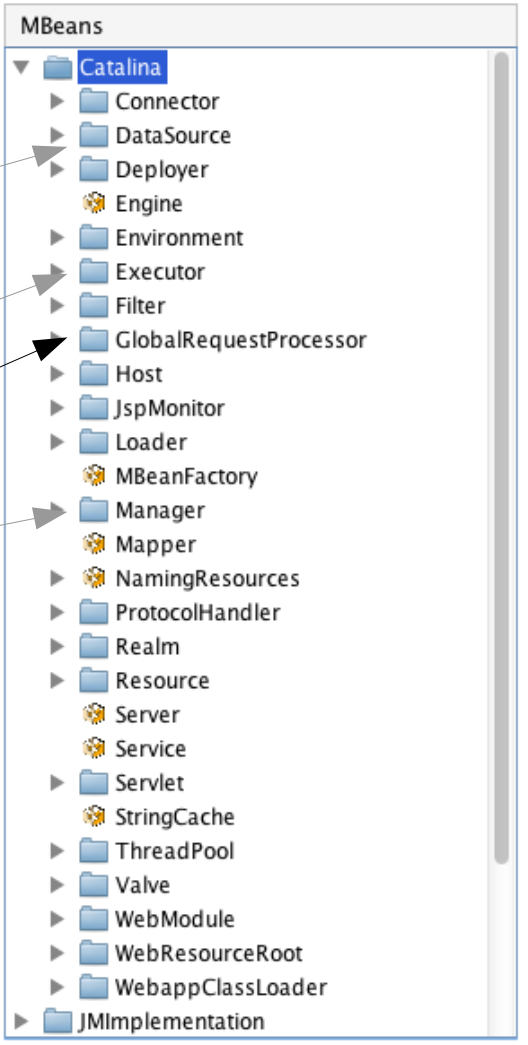
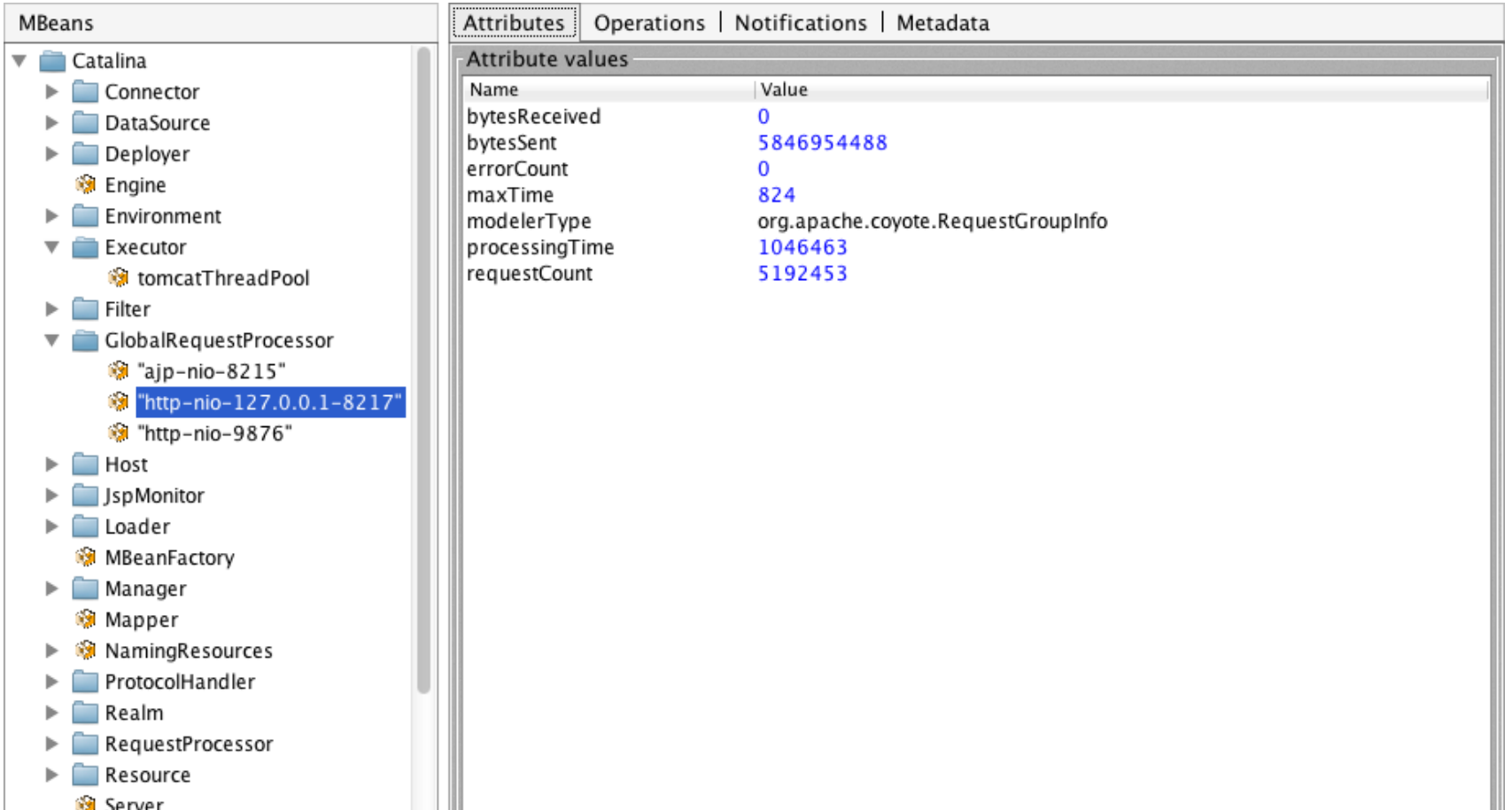
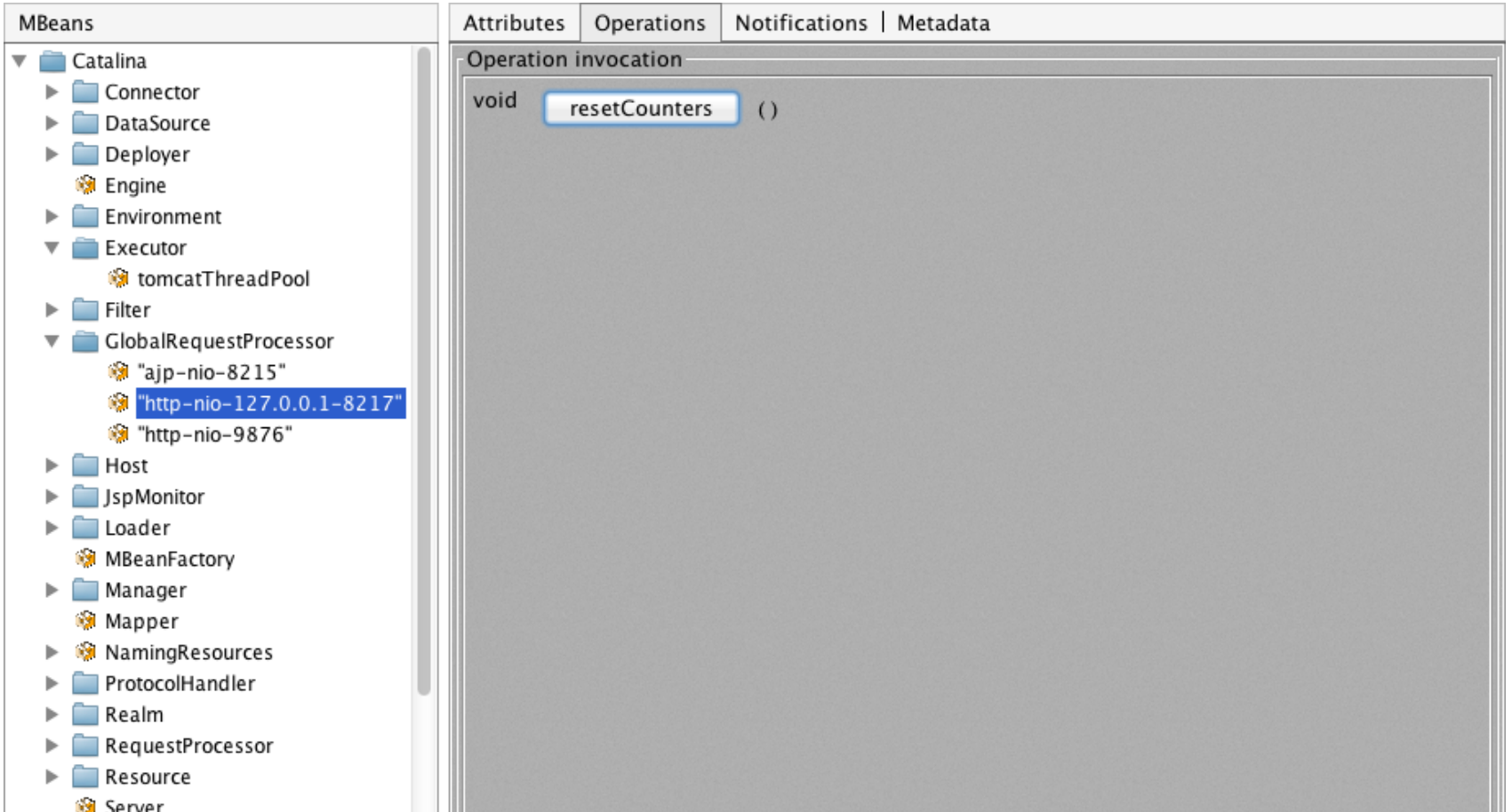


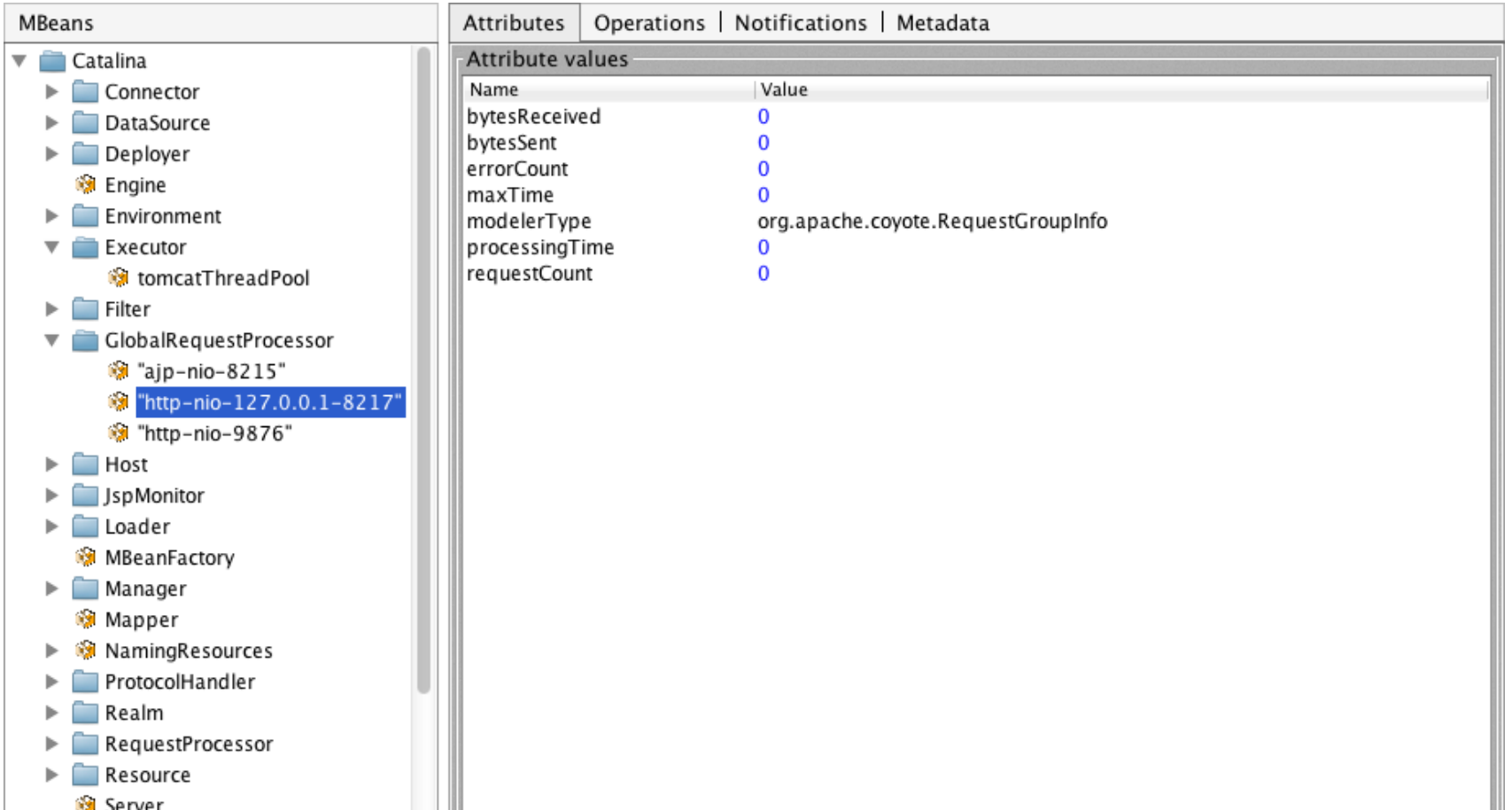
# Monitoring Tomcat: Requests



# Monitoring Tomcat: Requests

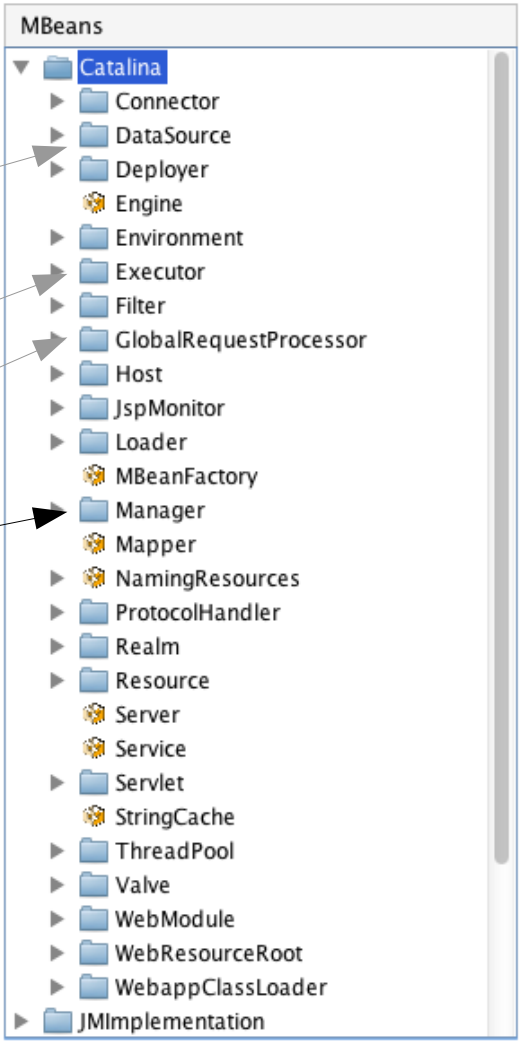


# Monitoring Tomcat: Requests

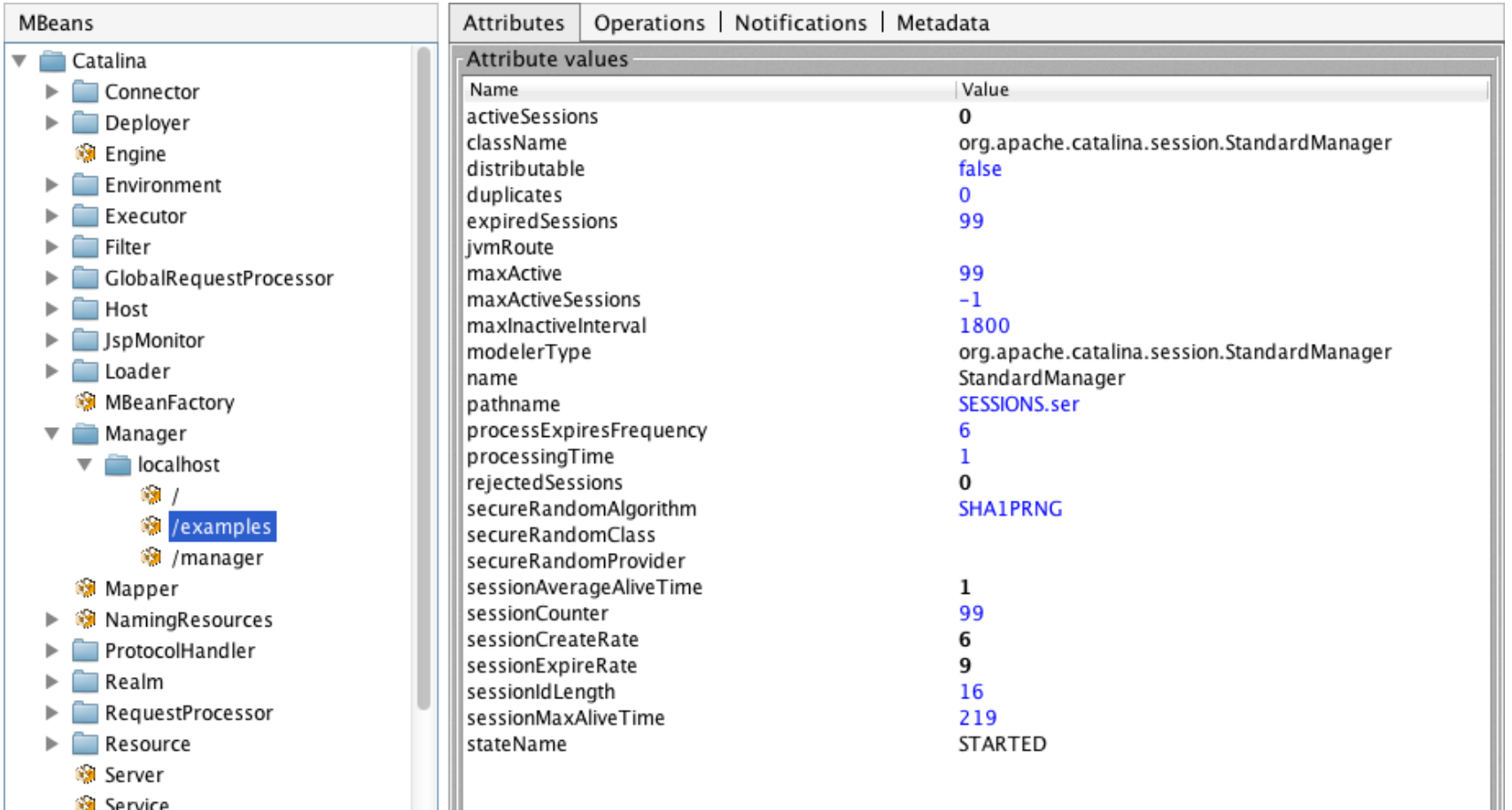


# Monitoring Tomcat

- Status of data sources
- Status of request-processor thread pool
- Request performance
- Session information

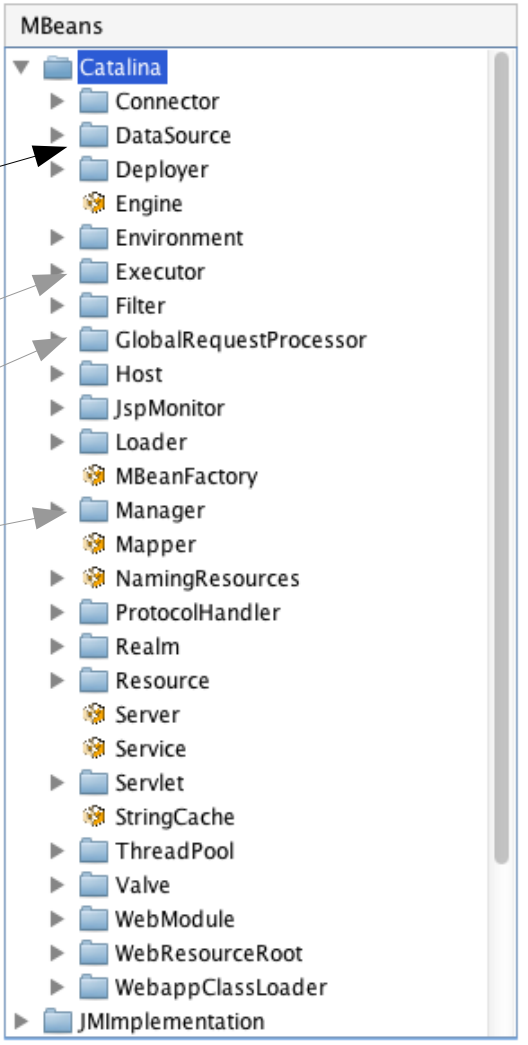


# Monitoring Tomcat: Sessions

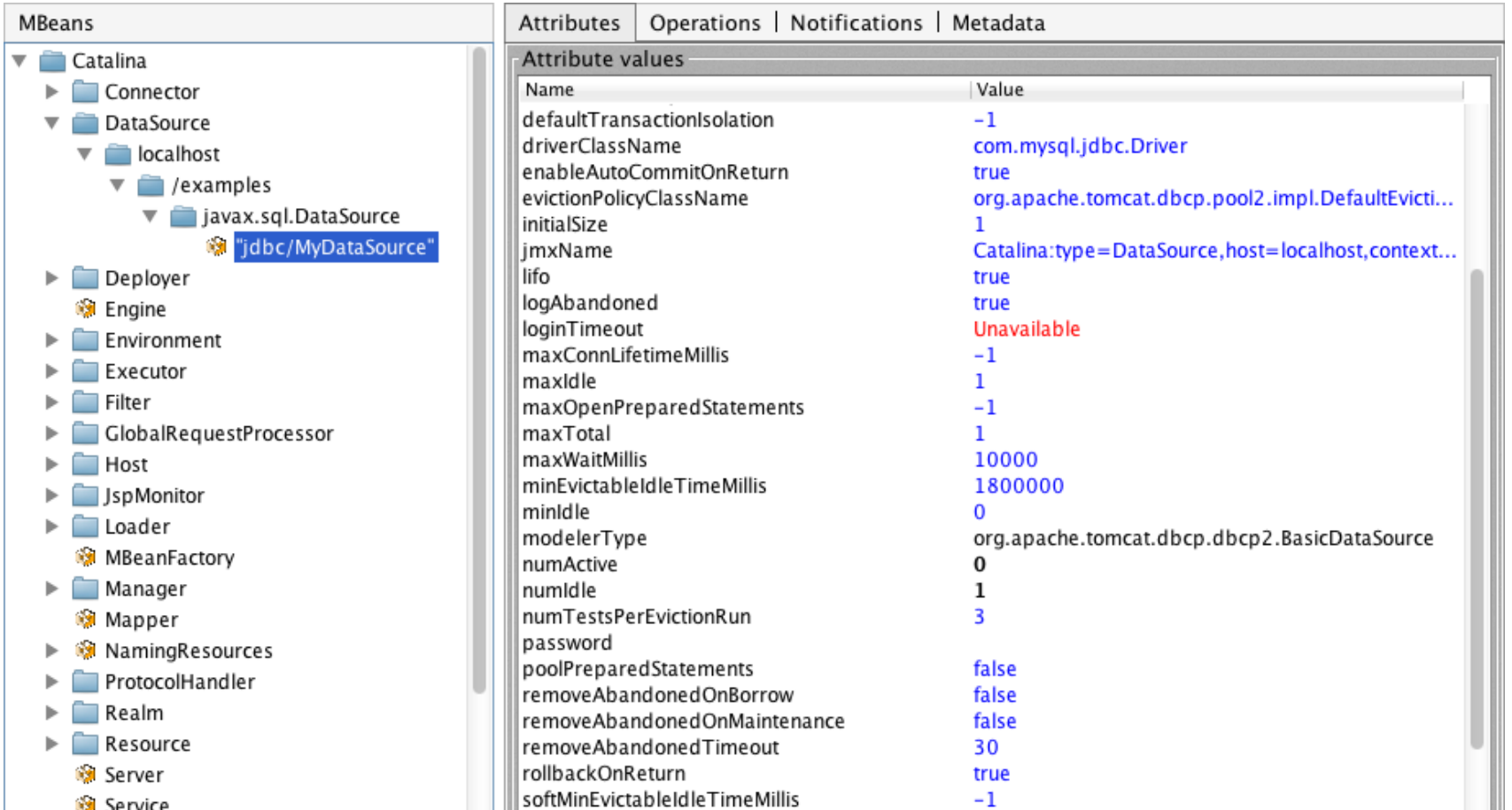


# Monitoring Tomcat

- Status of data sources
- Status of request-processor thread pool
- Request performance
- Session information

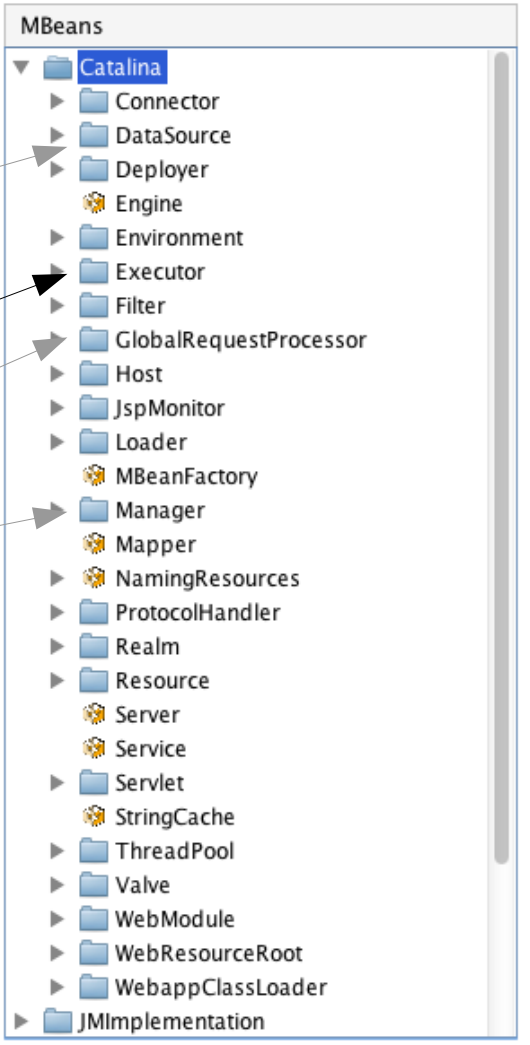


# Monitoring Tomcat: DataSources

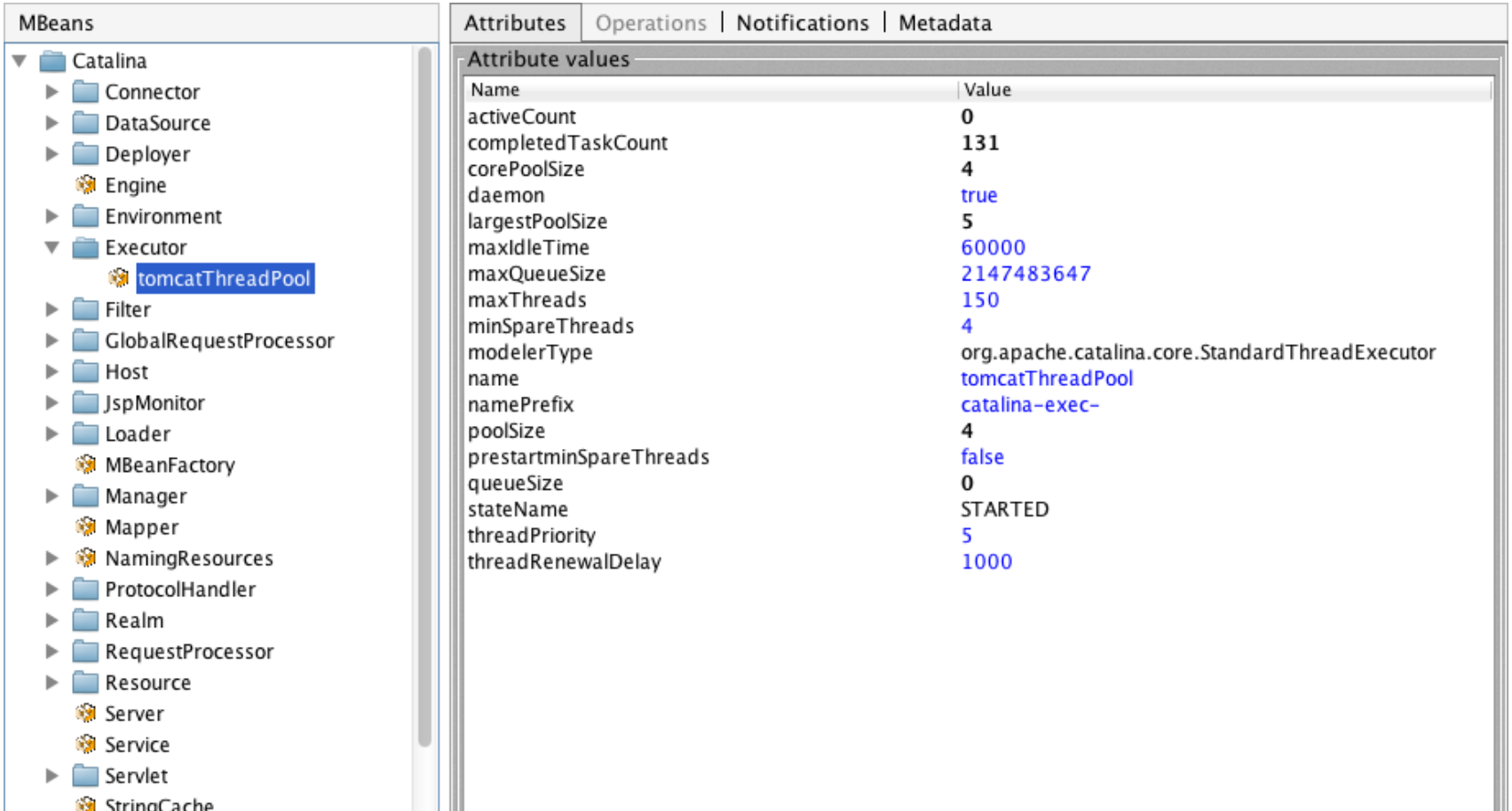


# Monitoring Tomcat

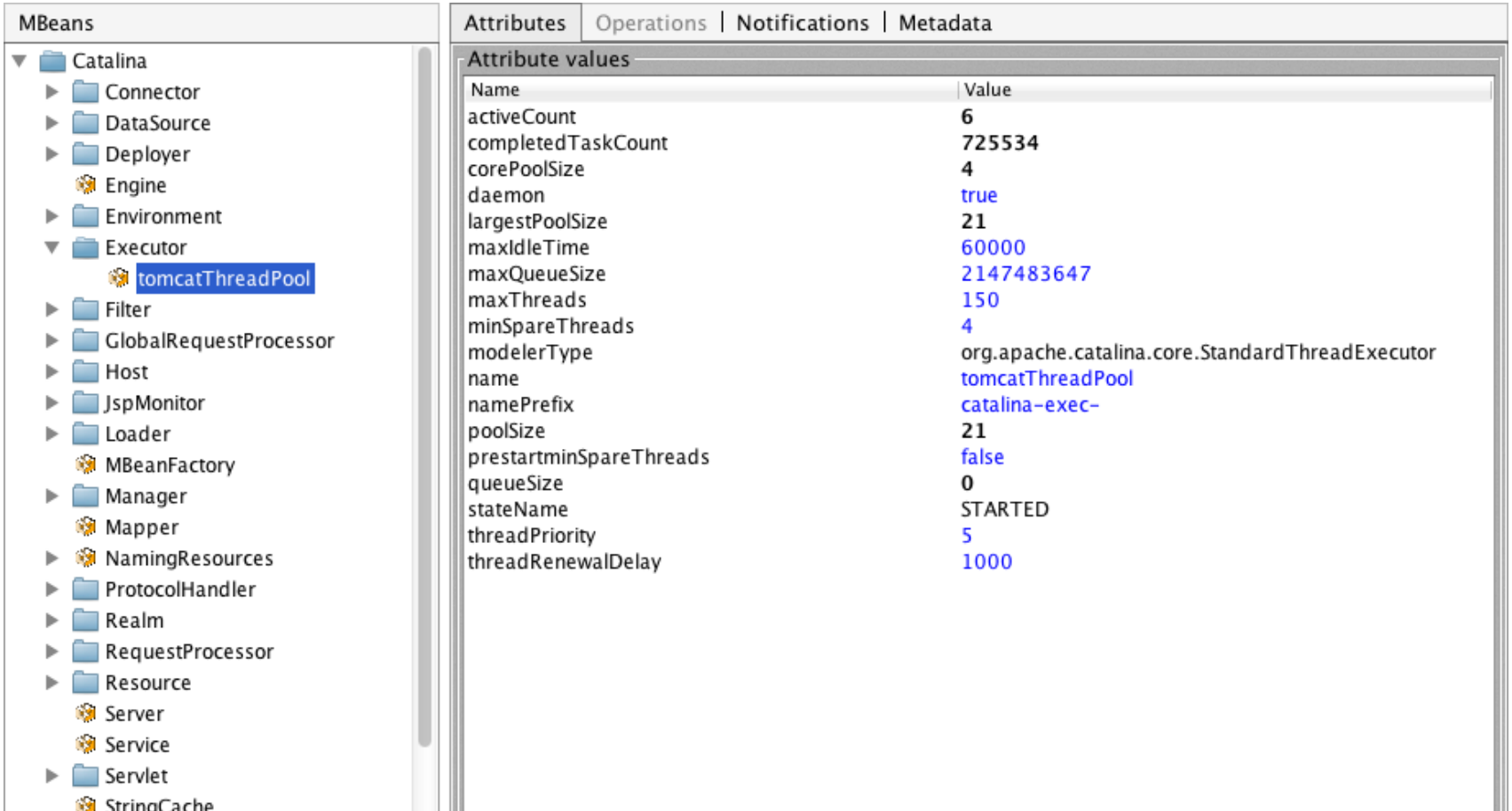
- Status of data sources
- Status of request-processor thread pool
- Request performance
- Session information



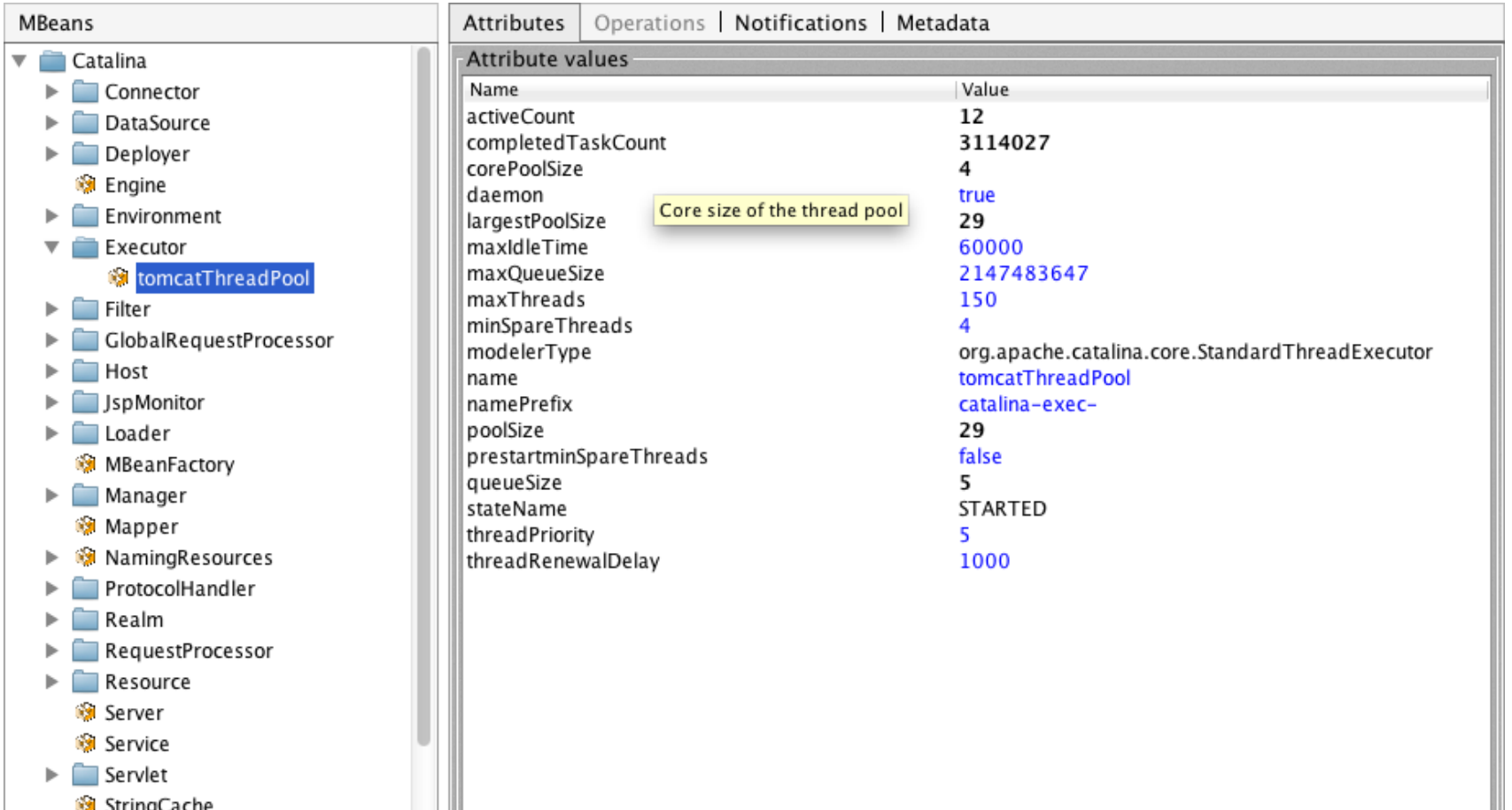
# Monitoring Tomcat: Threads



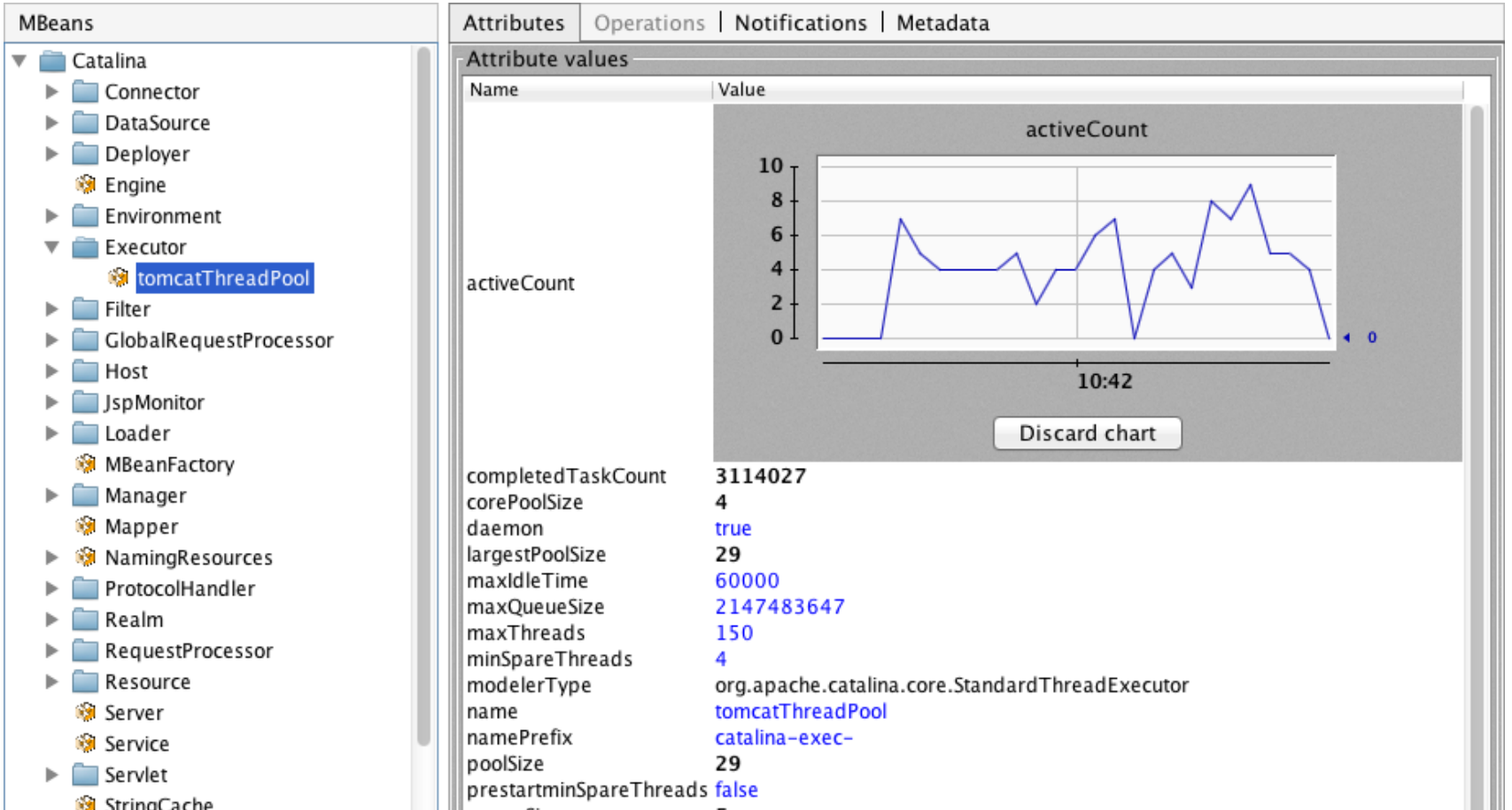
# Monitoring Tomcat: Threads



# Monitoring Tomcat: Threads



# Monitoring Tomcat: Threads



# Monitoring Your Application

- Monitor Application Processes
- Performance Metrics
- On-the-fly re-configuration

# Monitoring Your Application

- Write an MBean
  - Create an Interface: FooMBean
  - Create an Implementation: Foo
  - Create an XML MBean descriptor
- Deploy package to Tomcat
  - Publish the MBean to the MBean server
- Query / invoke as necessary

* Example code available at
http://people.apache.org/~schultz/ApacheCon NA 2016

# Example MBean

- Servlet Filter that captures total request processing time
  - Timestamp prior to request
  - Timestamp after request
  - Add the delta to a JMX-accessible counter: RequestStats

# RequestStats MBean

- Write an MBean

```
public interface RequestStatsMBean {
    public long getProcessingTime();
    public long getRequestCount();
    public void resetCounters();
}
public class RequestStats
    implements RequestStatsMBean {
    [...]
    public void updateStats(long timestamp,
ServletRequest request, long elapsed) {

_totalElapsedTime.addAndGet(elapsed);
        _requestCount.incrementAndGet();
    }
```

```
 public long getProcessingTime(){
   return _totalElapsedTime.get();
 }
 public long getRequestCount() {
   return _requestCount.get();
 }
 public void resetCounters() {
   _totalElapsedTime.set(0l);
   _requestCount.set(0l);
  }
}
```

# RequestStats MBean

- Write an MBean descriptor

```
<mbeans-descriptors>
  <mbean name="RequestStats" ...>
    <operation name="getProcessingTime"
        description="Gets the total number of
milliseconds spent processing requests."
             impact="INFO"
         returnType="long" />
    <operation name="getRequestCount"
        description="Gets the total number of
requests processed."
             impact="INFO"
         returnType="long" />
    <operation
          name="resetCounters"
   description="Resets all
counters."
         impact="ACTION"
    returnType="void" />
  </mbean>
</mbeans-descriptors>
```

# RequestStats MBean

- Create JAR
  - Java interface
  - Java implementation
  - mbeans-descriptors.xml
- Put JAR into $CATALINA_BASE/lib

# RequestStats MBean

- Write the Filter

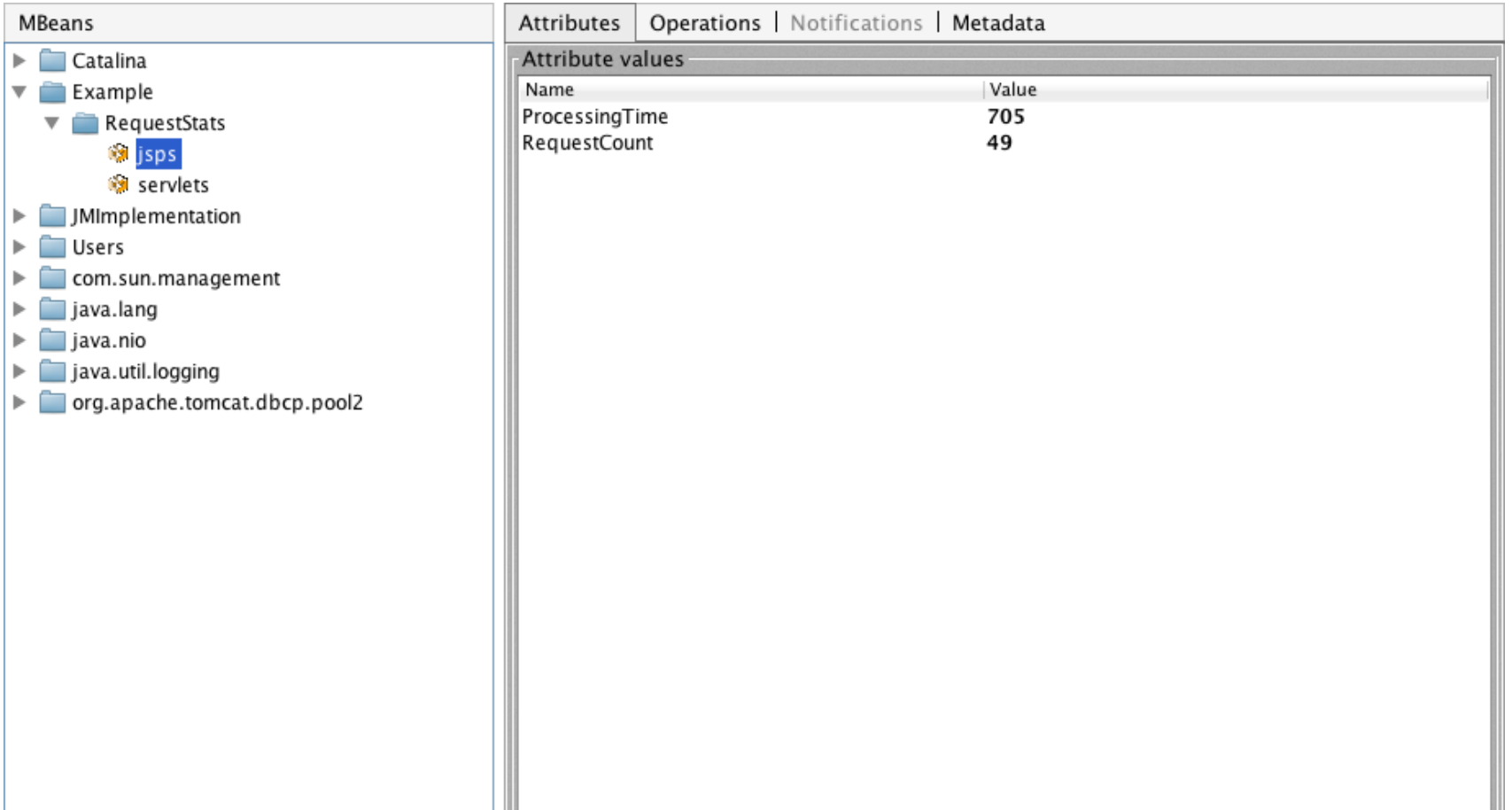
```
  public void init(FilterConfig config) {
     MBeanServer server = getServer();
     server.registerMBean(_stats, new
ObjectName("Example:RequestStats=RequestStats,name=" + filterName;));
  }
  public void doFilter(...) {
    timestamp = elapsed = System.currentTimeMillis();
    chain.doFilter(request, response);
    elapsed = System.currentTimeMillis() - elapsed;

    _stats.updateStats(timestamp, request, elapsed);
  }
```

# RequestStats MBean

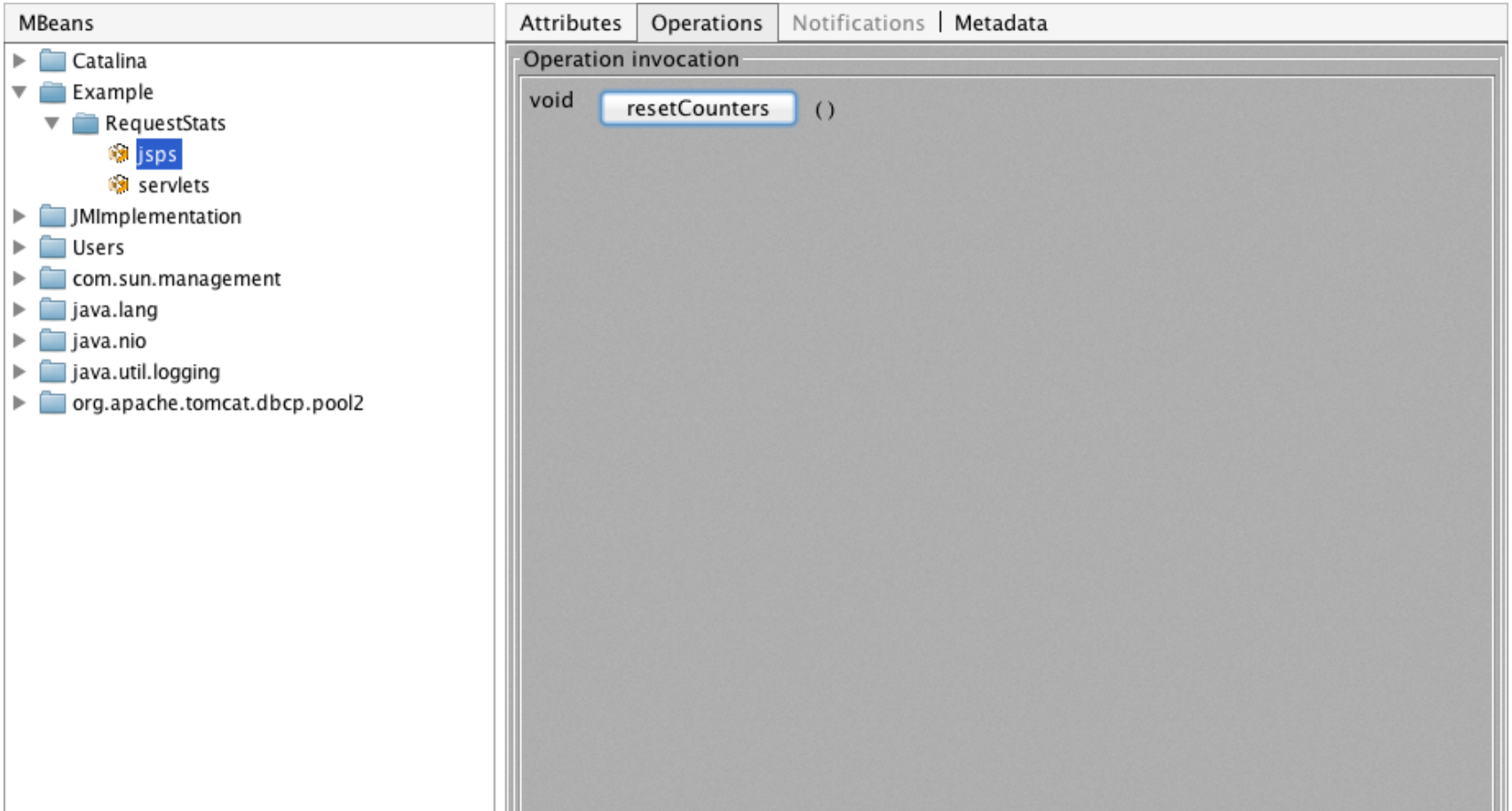
- Map the Filter

```
<filter>
  <filter-name>servlet-request-stats</filter-name>
  <filter-class>filters.RequestStatsFilter</filter-class>
  <init-param>
    <param-name>name</param-name>
    <param-value>servlets</param-value>
  </init-param>
</filter>
<filter-mapping>
  <filter-name>servlet-request-stats</filter-name>
  <url-pattern>/servlets/*</url-pattern>
</filter-mapping>
<filter><filter-name>jsp-request-stats</filter-name><filter-
class>filters.RequestStatsFilter</filter-class><init-param><param-name>name</param-name><param-
value>jsps</param-value></init-param></filter>
<filter-mapping><filter-name>jsp-request-stats</filter-name><url-pattern>/jsp/*</url-
pattern></filter-mapping>
```

# RequestStats MBean



# RequestStats MBean



# Automated Monitoring

- Remote Access
- Large Scale
- Constant

# Automated Monitoring

- Remote Access
- Large Scale
- Constant
- Need more tools!

# Automated Monitoring

- Nagios
  - Simple
  - Flexible
  - Well-deployed
  - No-cost community version available

# Automated Monitoring

| Host | Service | Status | Last Check | Duration | Attempt | Status Information |
|---|---|---|---|---|---|---|
| abi.apache.org | SSH | OK | 2014-03-18 15:12:04 | 1d 16h 22m 57s | 1/10 | SSH OK - OpenSSH_5.8p2_hpn13v11 FreeBSD-20110503 (protocol 2.0) |
| aegis.apache.org | HTTP - Buildbot | OK | 2014-03-18 15:13:43 | 9d 12h 56m 18s | 1/10 | HTTP OK HTTP/1.1 200 OK - 22230 bytes in 0.642 seconds |
| | HTTPS - Jenkins | OK | 2014-03-18 15:14:43 | 0d 23h 25m 18s | 1/10 | HTTP OK HTTP/1.1 200 OK - 22230 bytes in 0.830 seconds |
| | SSH | OK | 2014-03-18 15:14:14 | 9d 0h 25m 47s | 1/10 | SSH OK - OpenSSH_5.9p1 Debian-5ubuntu1.1 (protocol 2.0) |
| analysis-vm.apache.org | SSH | OK | 2014-03-18 15:12:43 | 4d 12h 32m 18s | 1/10 | SSH OK - OpenSSH_5.9p1 Debian-5ubuntu1.1 (protocol 2.0) |
| any.no-ip.com | DNS | OK | 2014-03-18 15:11:42 | 24d 19h 28m 22s | 1/10 | DNS OK: 0.023 seconds response time. www.apache.org returns 140.211.11.131,192.87.106.229 |
| arcas.apache.org | SSH | OK | 2014-03-18 15:14:48 | 19d 7h 40m 14s | 1/10 | SSH OK - OpenSSH_5.9p1 Debian-20120710asf3 (protocol 2.0) |
| athena.apache.org | DNS | OK | 2014-03-18 15:14:23 | 9d 0h 25m 38s | 1/10 | DNS OK: 0.172 seconds response time. svn.geo.apache.org returns 160.45.251.2 |
| | GEODNS | OK | 2014-03-18 15:14:14 | 12d 17h 10m 47s | 1/10 | OK DNS server 140.211.11.136 geo.apache.org is in sync with the zone file held in SVN (SERIAL in SVN: [2013101200] // SERIAL on 140.211.11.136 geo.apache.org [2013101200]) |
| | SMTP | OK | 2014-03-18 15:10:14 | 0d 13h 14m 47s | 1/10 | SMTP OK - 0.651 sec. response time |
| | SSH | OK | 2014-03-18 15:14:23 | 20d 15h 50m 38s | 1/10 | SSH OK - OpenSSH_5.8p2_hpn13v11 FreeBSD-20110503 (protocol 2.0) |
| aurora.apache.org | HTTP - WWW EU | OK | 2014-03-18 15:13:19 | 0d 23h 41m 42s | 1/10 | HTTP OK HTTP/1.1 200 OK - 40315 bytes in 0.418 seconds |

# Nagios Monitoring

- Plug-in architecture (i.e. arbitrary scripts)
- Freely-available JMX plug-in: check_jmx

```
$ ./check_jmx -U service:jmx:rmi:///jndi/rmi://localhost:1100/jmxrmi\
   -O java.lang:type=Memory -A NonHeapMemoryUsage -K used\
   -w 29000000 -c 30000000
JMX WARNING NonHeapMemoryUsage.used=29050880
```

# Nagios Monitoring

- Problems with check_jmx
  - Complex configuration for remote JMX
  - JVM launch for every check
  - Course-grained authentication options

# Nagios Monitoring

- Alternative Option: Tomcat's JMXProxyServlet
  - JMX data available via HTTP
  - Can use Tomcat's authentication tools

```
$ ./check_jmxproxy -U 'http://localhost/manager/jmxproxy?
get=java.lang:type=Memory&att=HeapMemoryUsage&key=used' \
   -w 29000000 -c 30000000
JMX CRITICAL: OK - Attribute get 'java.lang:type=Memory' - HeapMemoryUsage
- key 'used' = 100875248
```

* check_jmxproxy can be found at http://wiki.apache.org/tomcat/tools/check_jmxproxy.pl

# Nagios Monitoring

| | | | | | |
|---|---|---|---|---|---|
| JVM:Heap | OK | 03-18-2014 15:17:04 | 8d 9h 56m 14s | 1/4 | JMX OK: OK - Attribute get 'java.lang:type=Memory' - HeapMemoryUsage - key 'used' = 126743888 |
| JVM:Sessions | OK | 03-18-2014 15:15:05 | 8d 9h 53m 13s | 1/4 | JMX OK: OK - Attribute get 'Catalina:type=Manager,context=/ ,host=localhost' - activeSessions = 0 |
| JVM:Heap | OK | 03-18-2014 15:16:08 | 0d 0h 42m 10s | 1/4 | JMX OK: OK - Attribute get 'java.lang:type=Memory' - HeapMemoryUsage - key 'used' = 253538440 |
| JVM:Sessions | OK | 03-18-2014 15:15:08 | 8d 10h 13m 10s | 1/4 | JMX OK: OK - Attribute get 'Catalina:type=Manager,context=/ ,host=localhost' - activeSessions = 180 |
| JVM:Heap-OOME ? | OK | 03-06-2014 15:58:13 | 11d 23h 20m 5s | 1/1 | OK |

# JMX Command-line Tricks

- Show all logged-in usernames

```
for sessionid in `wget -O - 'http://user:pwd@host/manager/jmxproxy?
invoke=Catalina:type=Manager,context=/myapp,host=localhost&op=listSessionI
ds' \

    | sed -e "s/ /\n/g"

    | grep '^[0-9A-Za-z]\+\(\..*\)\?$' ;\

do wget -O – "http://user:pwd@host/manager/jmxproxy?
invoke=Catalina:type=Manager,context=/myapp,host=localhost&op=getSessionAt
tribute&ps=$sessionid,user" ; done 2>/dev/null \

    | grep User
```

# Tracking Values Over Time

- Some metrics are best observed as deltas
  - Session count
  - Request error count
- Requires that you have a history of data
- Requires that you consult the history of that data
- check_jmxproxy provides such capabilities

# Tracking Values Over Time

```
$ ./check_jmxproxy -U 'http://localhost/manager/jmxproxy?
get=java.lang:type=Memory&att=HeapMemoryUsage&key=used' -w 33554432 -c 50331648 --write number.out
--compare number.out

JMX OK: OK - Attribute get 'java.lang:type=Memory' - HeapMemoryUsage - key 'used' = 102278904,
delta=[...]

$ ./check_jmxproxy -U 'http://localhost/manager/jmxproxy?
get=java.lang:type=Memory&att=HeapMemoryUsage&key=used' -w 33554432 -c 50331648 --write number.out
--compare number.out

JMX OK: OK - Attribute get 'java.lang:type=Memory' - HeapMemoryUsage - key 'used' = 113806144,
delta=11527240

$ ./check_jmxproxy -U 'http://localhost/manager/jmxproxy?
get=java.lang:type=Memory&att=HeapMemoryUsage&key=used' -w 33554432 -c 50331648 --write number.out
--compare number.out

JMX OK: OK - Attribute get 'java.lang:type=Memory' - HeapMemoryUsage - key 'used' = 109264056,
delta=-4542088
```

# Tracking Values Over Time

- Session count
  - Tomcat actually provides this already via Manager's `sessionCreateRate` attribute
- Request errors

```
$ ./check_jmxproxy  -U 'http://localhost/manager/jmxproxy?
get=Catalina:type=RequestProcessor,worker="http-nio-127.0.0.1-
8217",name=HttpRequest1&att=errorCount' -w 1 -c 10 --write errors.txt
--compare errors.txt

JMX OK: OK - Attribute get 'Catalina:type=RequestProcessor,worker="http-
nio-127.0.0.1-8217",name=HttpRequest1' - errorCount = 0, delta=0
```

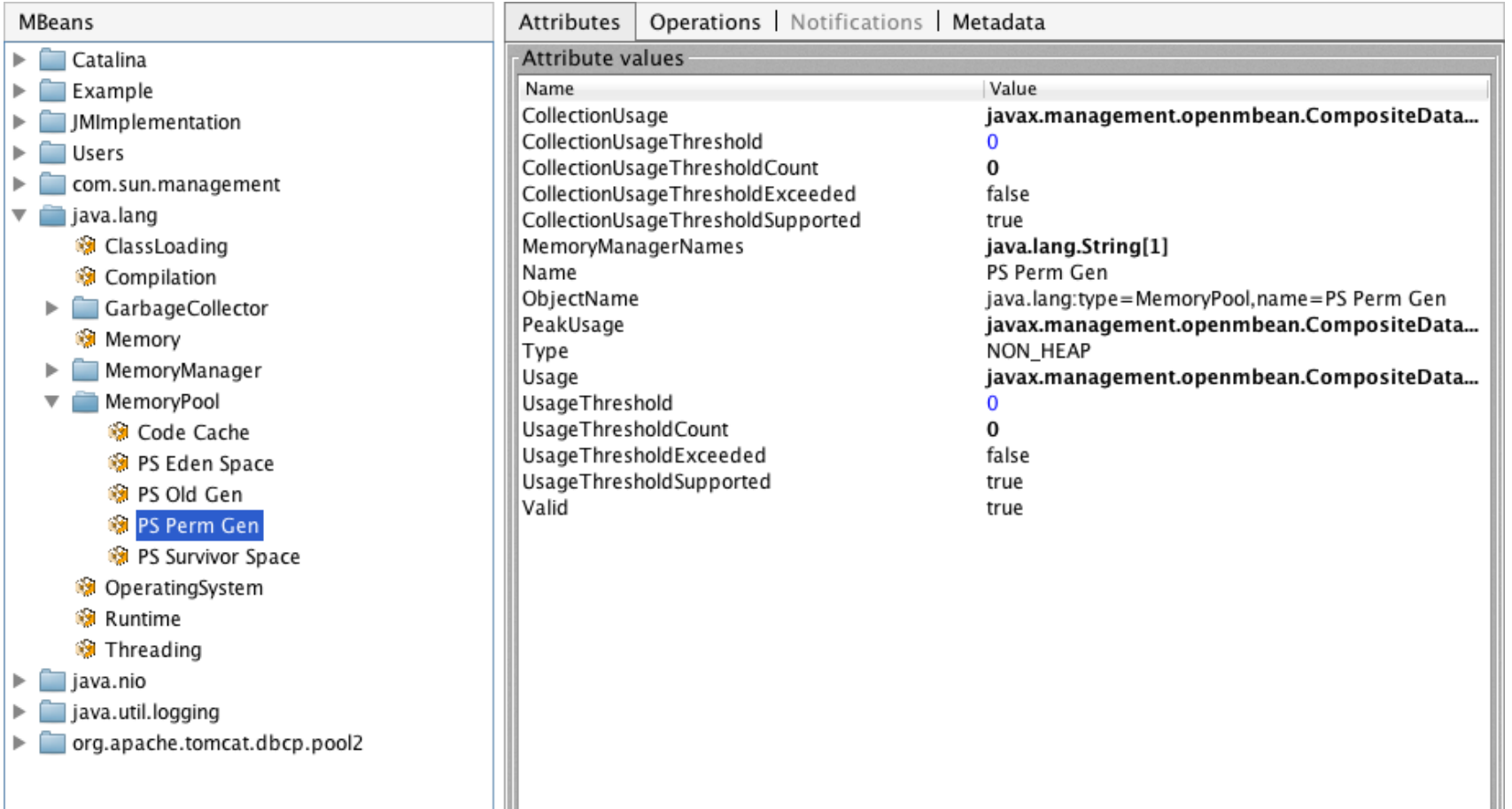
# Detecting OutOfMemory

- Many sources of OOME
  - Heap exhaustion
  - PermGen exhaustion
  - Hit thread limit
  - Hit file descriptor limit

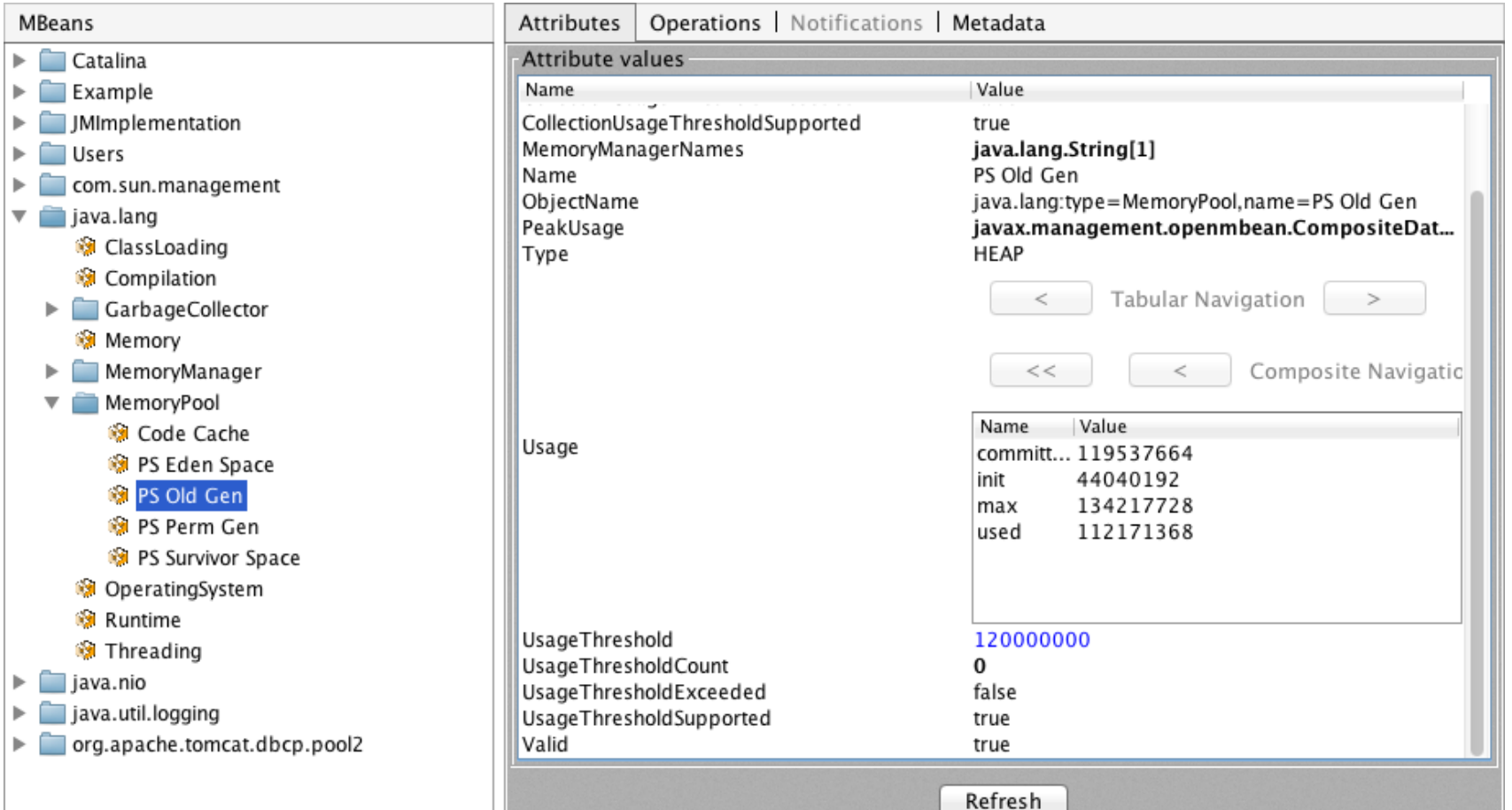
# Detecting OutOfMemory

- Two types of heap OOME
  - One thread generates lots of local references
  - All threads collaborate to generate globally-reachable objects (e.g. session data)
- Former is recoverable, latter is not
- You want to be notified in any case

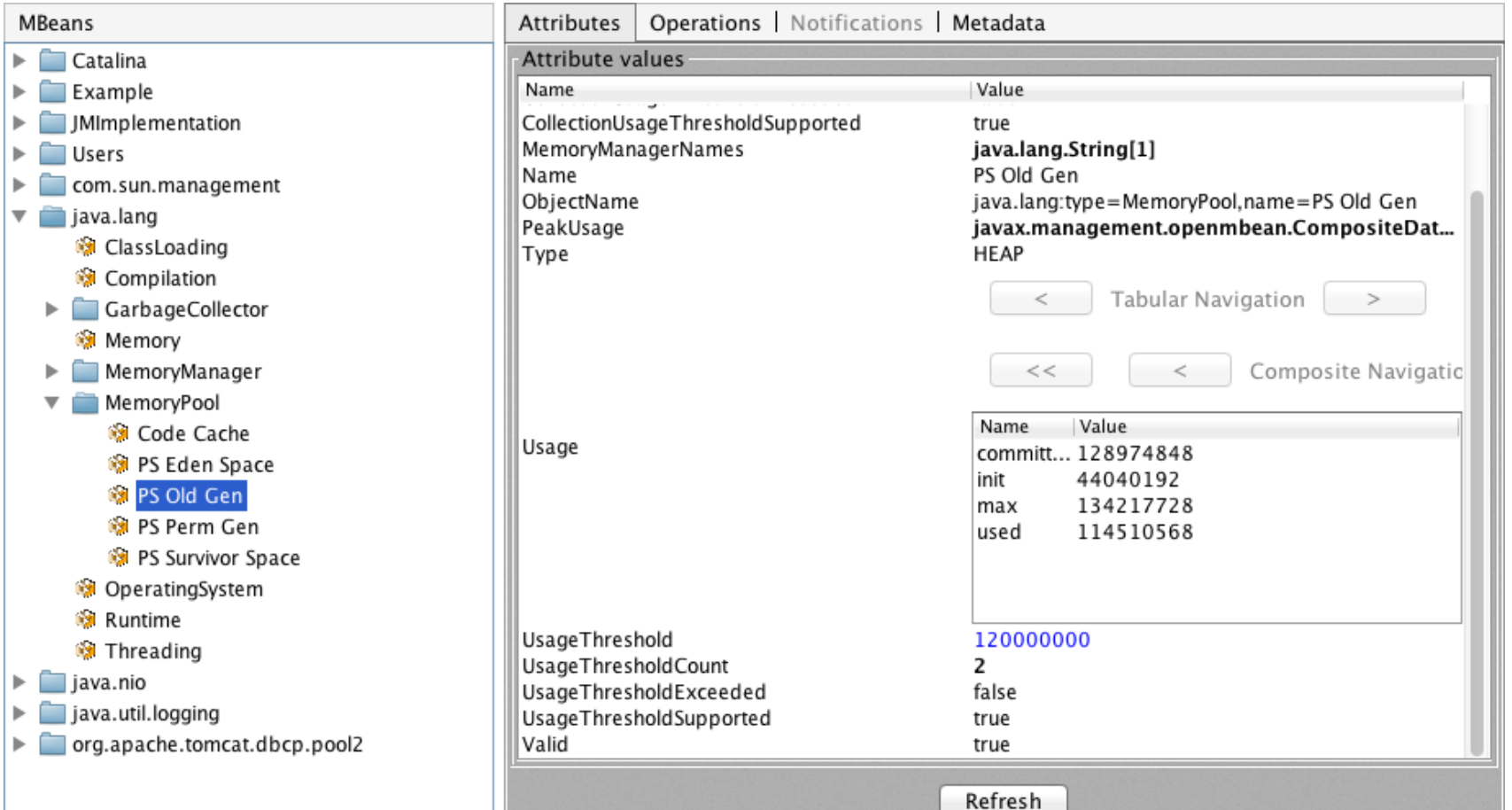
# Memory Pool Thresholds



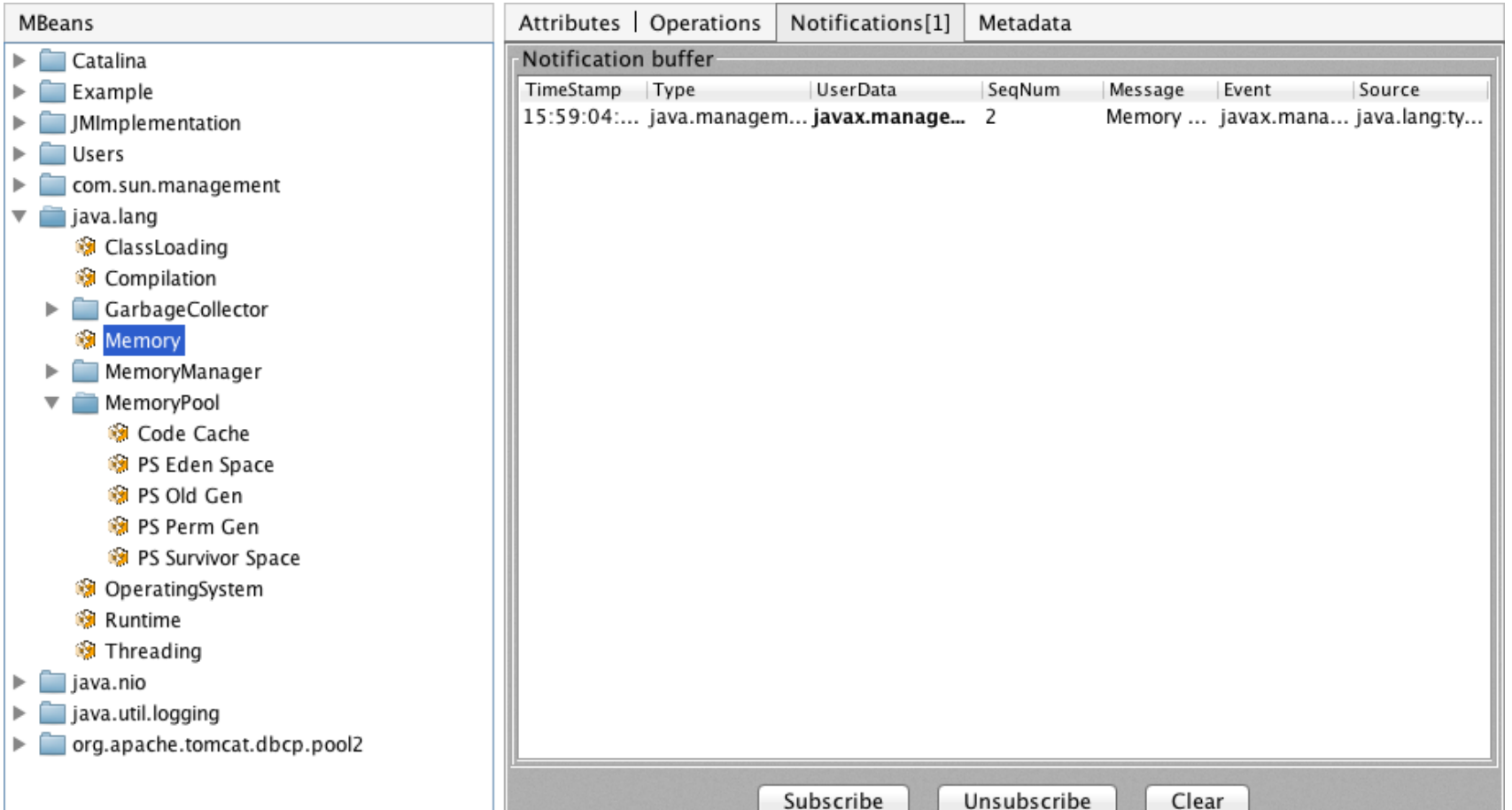
# Memory Pool Thresholds



# Memory Pool Thresholds



# Memory Pool Thresholds



# Memory Pool Thresholds

- Choice of how to detect exceeded-threshold conditions
  - Polling using check_jmxproxy
  - Register a notification listener from Java
    - Have that listener take some action

# Detect OutOfMemory

- Monitoring Memory Thresholds
  - Set threshold on startup
  - Register a notification listener (callback)
  - Watch “exceeded” count (poll)
  - Report to monitoring software (Nagios)
  - Repeat for each memory pool you want to watch
  - Hope the JVM does not fail during notification
  - This is getting ridiculous

# Detecting OutOfMemory

- JVM has an easier way
- Use -XX:OnOutOfMemoryError to run a command on *first* OOME detected by the JVM
- Need a command to notify Nagios

# Notify Nagios on OOME

- Script that wraps curl

```
$ curl -si \
     --data-urlencode 'cmd_typ=30' \
     --data-urlencode 'cmd_mod=2' \
     --data-urlencode "host=myhost" \
     --data-urlencode "service=JVM:Heap:OOME" \
     --data-urlencode "plugin_state=2" \
     --data-urlencode "plugin_output=OOME CRITICAL" \
     'https://monitoring-host/nagios/cgi-bin/cmd.cgi'
```

Script can be found at http://wiki.apache.org/tomcat/tools/nagios-send-passive-check.sh

# Monitoring Tomcat with JMX

- JMX Provides Monitoring and Management of JVMs
- Tomcat exposes a great amount of information via JMX
- Applications can expose anything to JMX via MBeans
- JRE ships with tools for light JMX interaction
- Practical use of JMX requires some additional tools

# Resources

- Presentation Slides

  `http://people.apache.org/~schultz/ApacheCon NA 2016/Monitoring Apache Tomcat with JMX.odp`

- Nagios passive-check script

  `http://wiki.apache.org/tomcat/tools/nagios-send-passive-check.sh`

- check_jmxproxy

  `http://wiki.apache.org/tomcat/tools/check_jmxproxy.pl`

- Special thanks to Christopher Blunck (MBeans info)

  `http://oss.wxnet.org/mbeans.html`