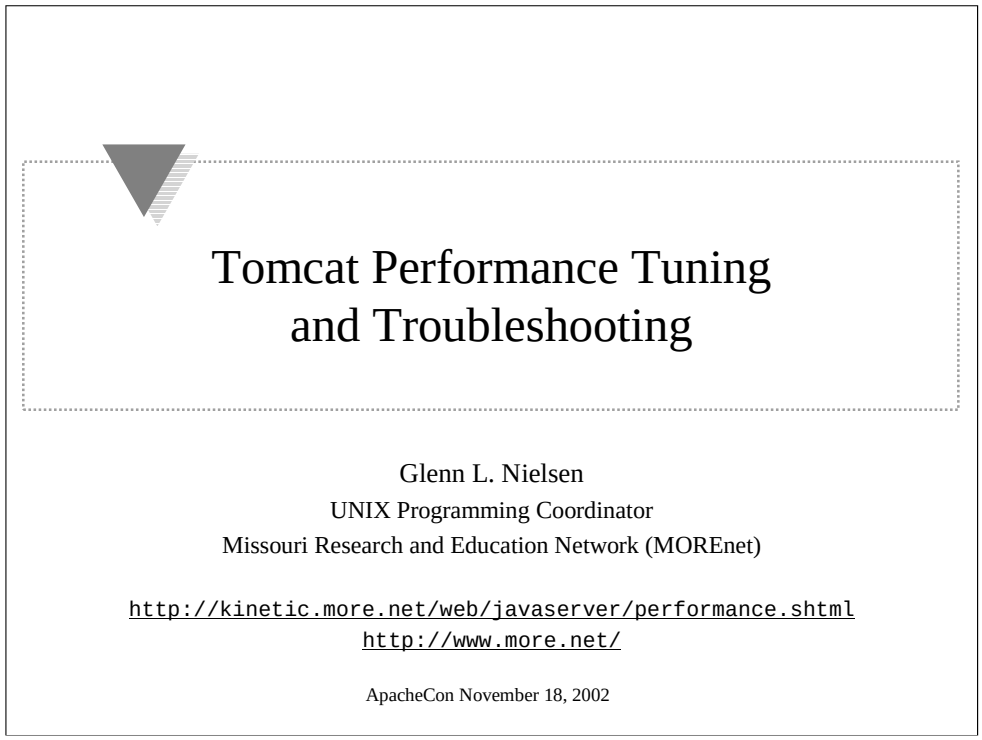
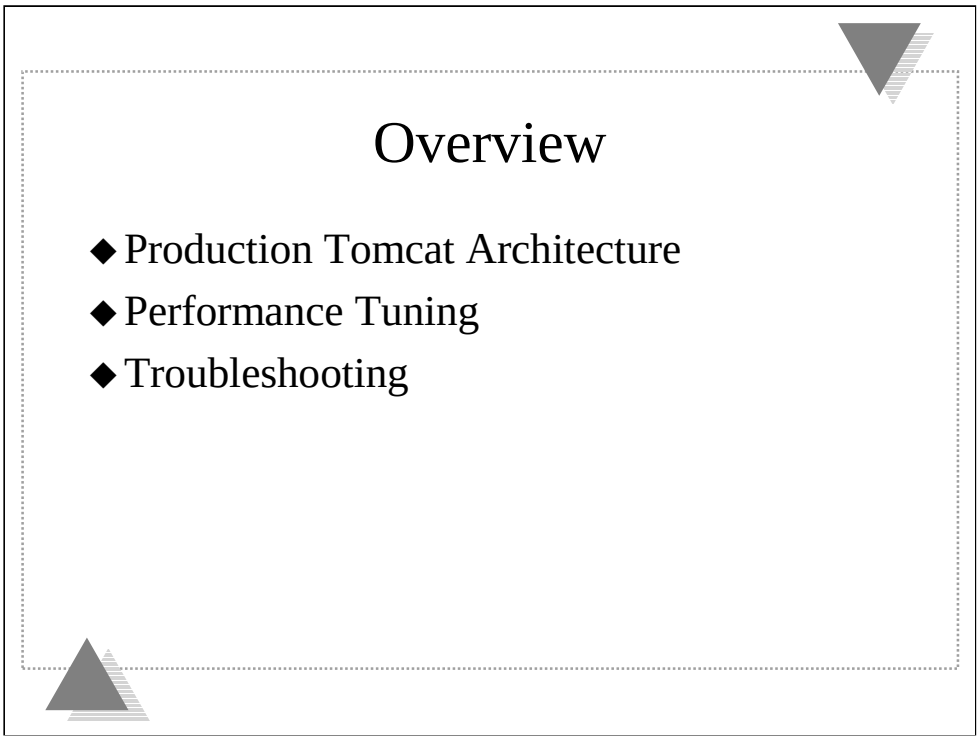


Notes

Tuning Tomcat for performance and resolving problems which affect availability are critical for a production instance of Tomcat. This session addresses how to collect and analyze data to trouble shoot problems and configure Tomcat for performance.



Notes

Production Tomcat Architecture

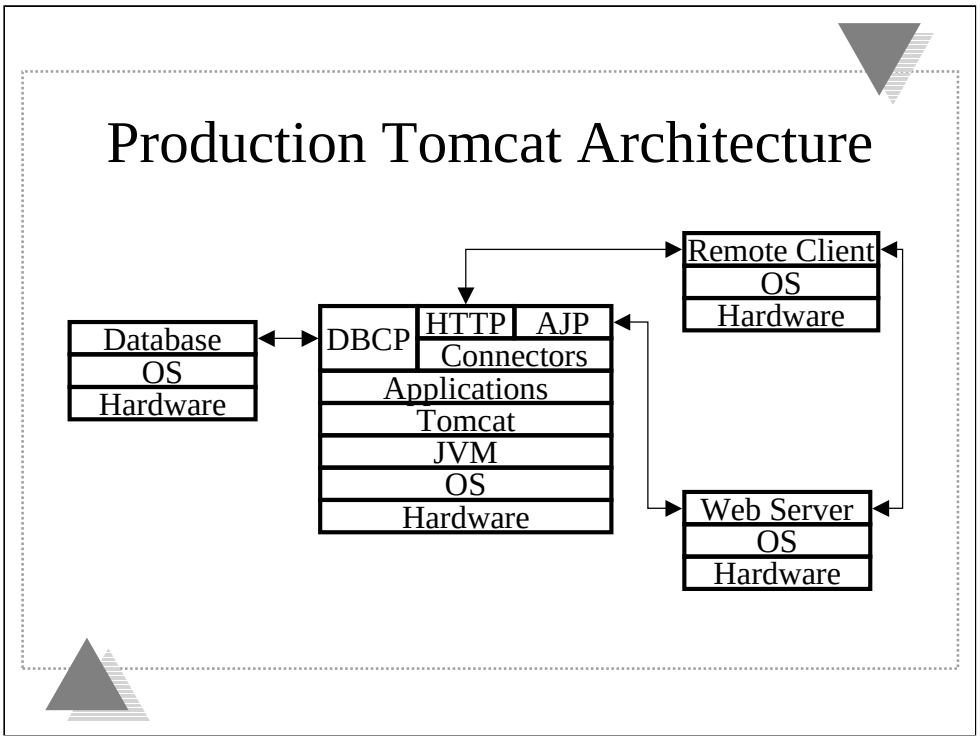
In production Tomcat relies on a number of resources which can all impact its overall performance. Understanding the overall system architecture is key to tuning performance and troubleshooting problems.

Performance Tuning

- How to measure and test performance
- JVM version, memory usage, and garbage collection
- Tomcat version and configuration
- Database connection pools
- Application Design and Profiling

Troubleshooting

- Collecting and analyzing log data
- Common problems



Notes

Hardware. CPU(s), memory, network IO, and file IO

Operating System. SMP and thread support

Database. Conncurrent db connections allowed, db connection pooling, and object caching.

JVM. Version, tuning memory usage, and tuning garbage collection are important.

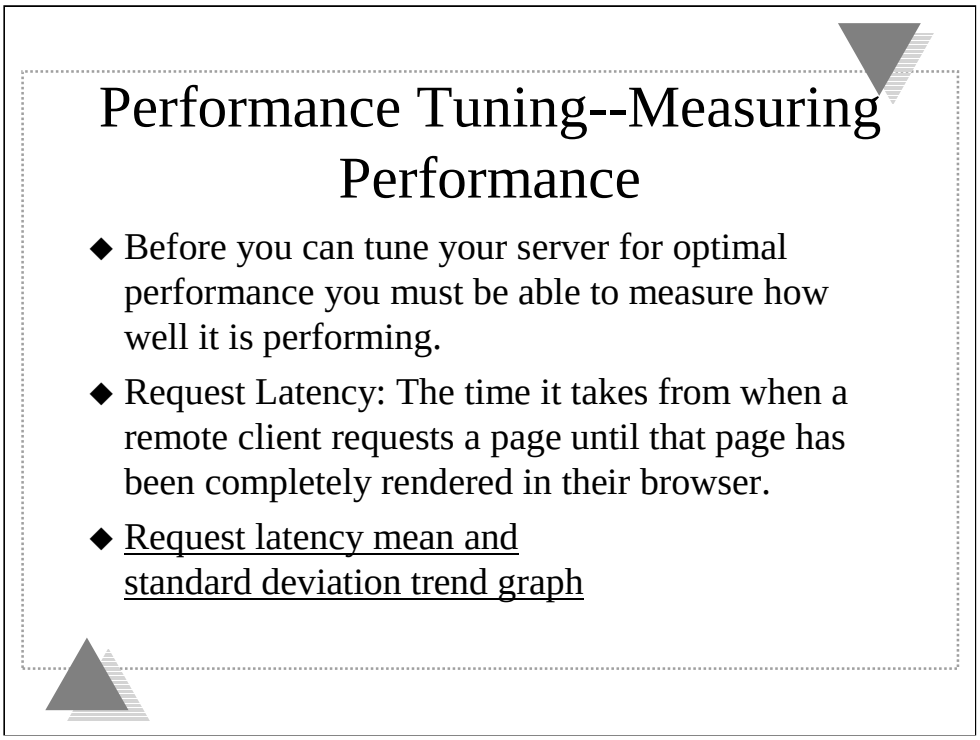
Tomcat. Later releases are more optimized for performance. If you use JavaServer Pages, Jasper 2 available in Tomcat 4.1 significantly boosts performance.

Application. Application design can have the largest impact on overall performance.

Web Server. Can be used in front of Tomcat to serve static content removing this load from Tomcat. This allows Tomcat to do what it does best, dynamic web application content.

Network. Network delays. Nothing we can do about this.

Remote Client. Speed of remote client network connection. Nothing we can do about this except compress the content using Apache mod_gzip or Tomcat compression filter.



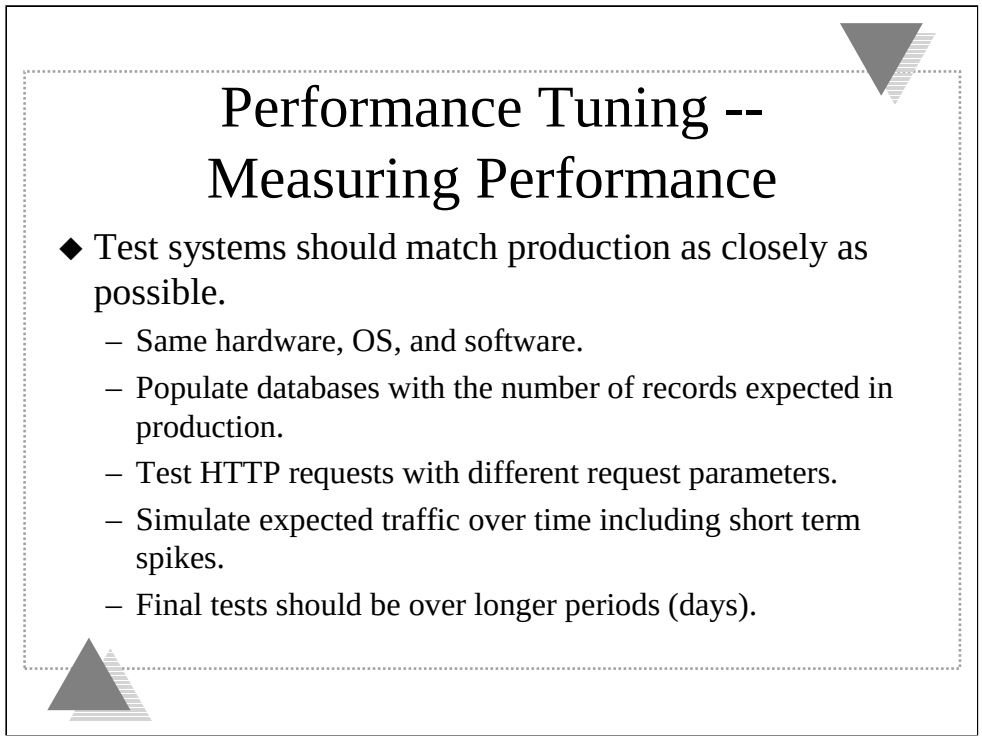
Notes

Without testing and measuring performance how can you know if any changes made have improved performance?

Request latency is the most important performance measurement.

You can only control the portion of the overall request latency which occurs while processing the request on your servers.

There is nothing you can do about the speed of the remote clients network connection or any network delays between your servers and the remote client.



Notes

Databases

An application may perform well with a small number of records in the database. Performance could degrade a great deal as the number of records in the table(s) increases.

Request parameters

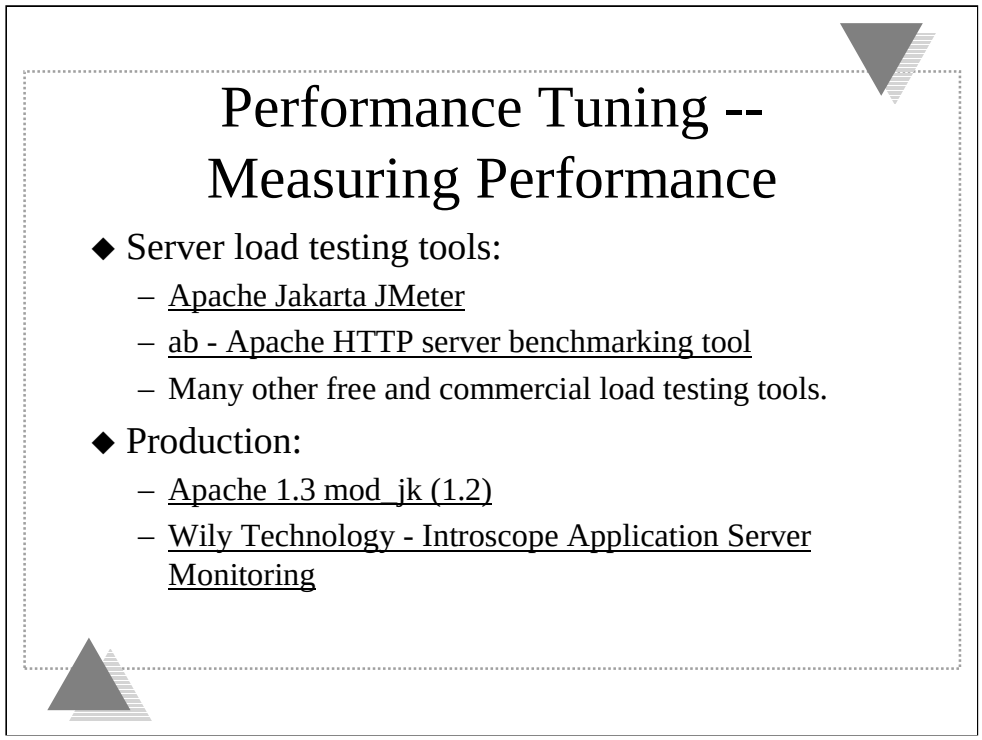
Test with the extremes. A page which performs a search may perform well when the search criteria returns a small result set, but perform poorly when the search criteria returns a large result set.

Simulated request traffic

A page which performs well with low request volume can cause the server to fail under higher request volume.

Longer tests

The JVM performance changes over time and can actually improve if using HotSpot. Memory leaks, db temporarily unavailable, etc. can only be found when running longer tests.



Notes

Apache Jakarta JMeter

http://jakarta.apache.org/jmeter

Apache HTTP server benchmarking tool

http://httpd.apache.org/docs/programs/ab.html

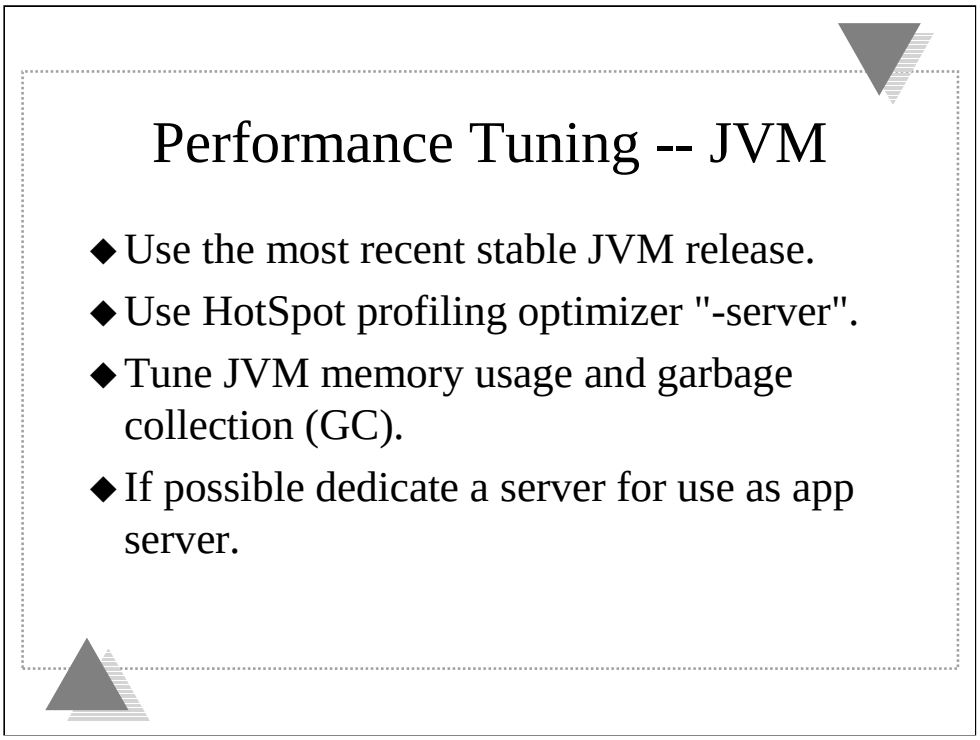
mod_jk

If you are using Apache 1.3 and mod_jk 1.2 you can use JkRequestLogFormat to log individual Tomcat request latency in nanoseconds.

http://jakarta.apache.org/tomcat/tomcat-4.1-doc/jk2/jk/aphowto.html

Production Runtime Monitoring

http://www.wilytech.com/

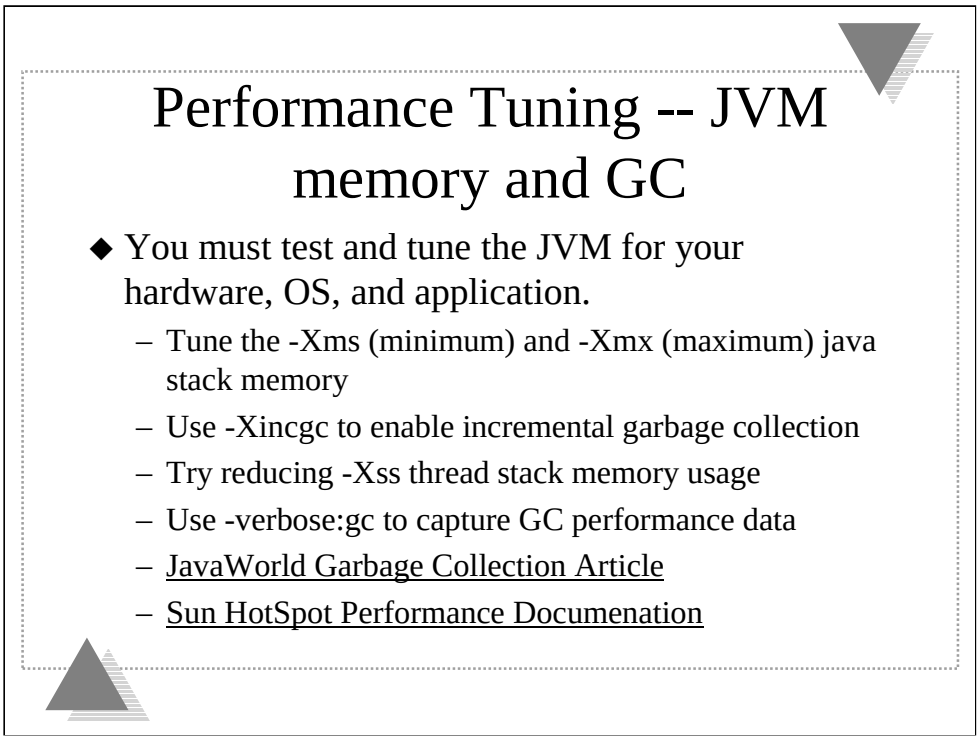


Notes

Sun Java 1.3 and later releases include the HotSpot profiling optimizer customized for long running server applications.

Sun Java 1.4 improves performance for servlet containers by approximately 35%.

Tomcat will freeze processing of all requests while the JVM is performing GC. On a poorly tuned JVM this can last 10's of seconds. Most GC's should take < 1 second and never exceed 10 seconds.



Notes

Setting the minimum and maximum java stack memory to the same value can improve GC performance.

Make sure the java process always keeps the memory it uses resident in physical memory and not swapped out to virtual memory.

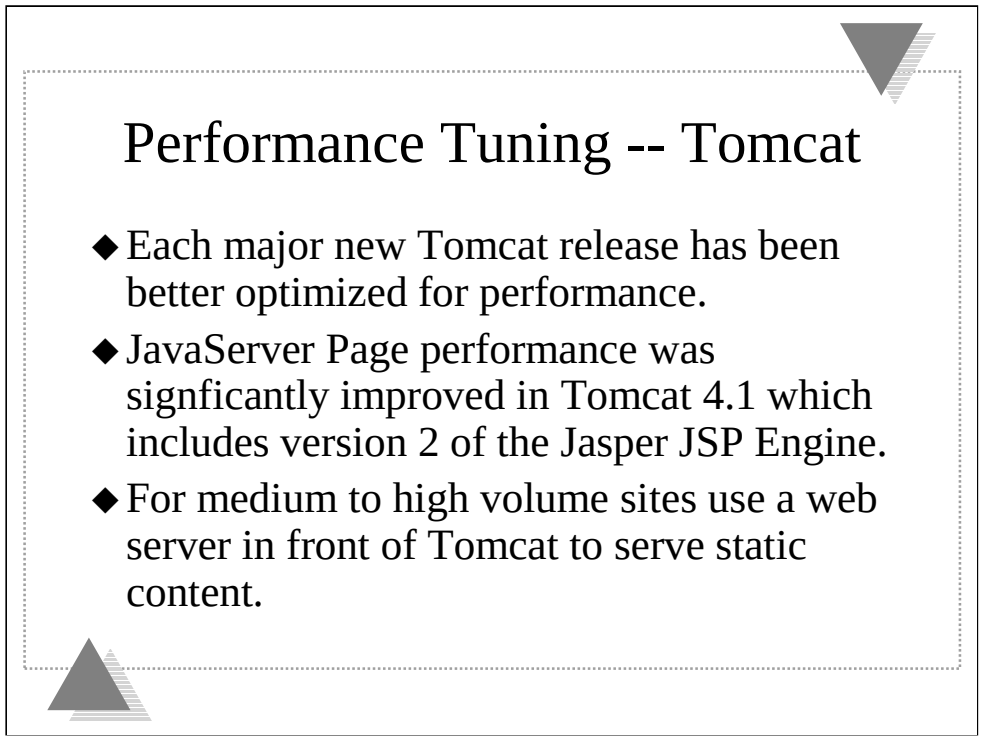
JVM garbage collection performance can degrade significantly if the JVM stack gets swapped out to disk as virtual memory.

JavaWorld Garbage Collection Article

http://www.javaworld.com/javaworld/jw-01-2002/jw-0111-hotspotgc.html

Sun HotSpot Performance Documenation

http://java.sun.com/docs/hotspot/index.html



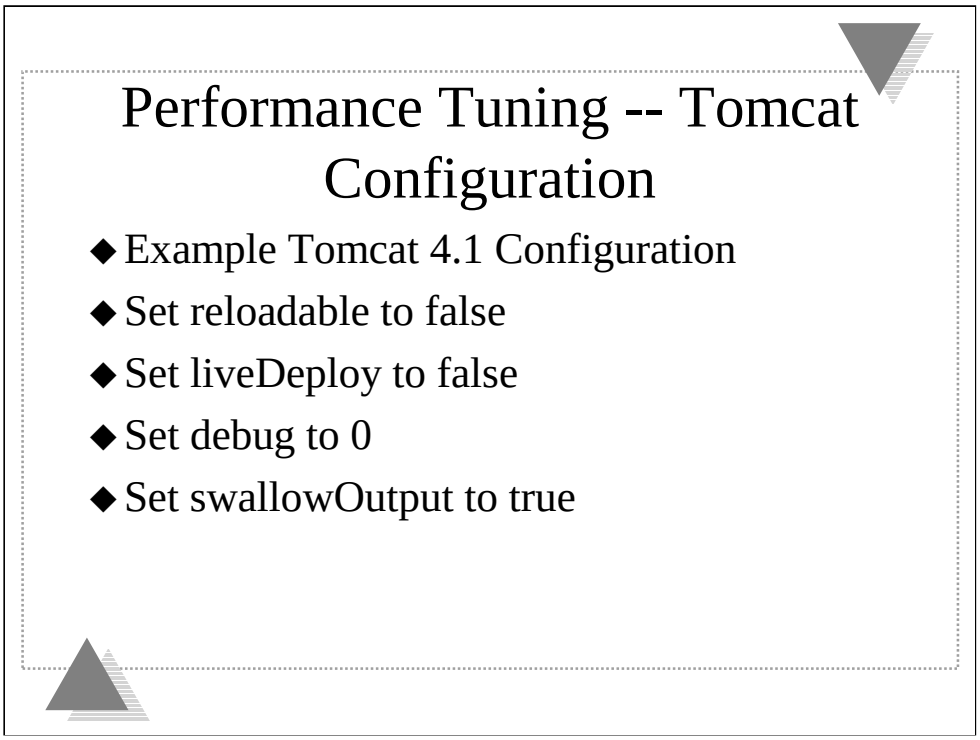
Notes

Jasper 2

Can perform JSP page recompile in the background. Implements JSP custom tag pooling.

Web server

Let the web server do what it does best, serve static content. And let Tomcat do what it does best, generate dynamic content.



Notes

See Appendix A -- Example Tomcat 4.1 Configuration

reloadable false

When reloadable is true Tomcat tries to detect web application class changes and automatically reload any classes which change. Setting this to false removes a lot of unnecessary overhead in production.

liveDeploy false

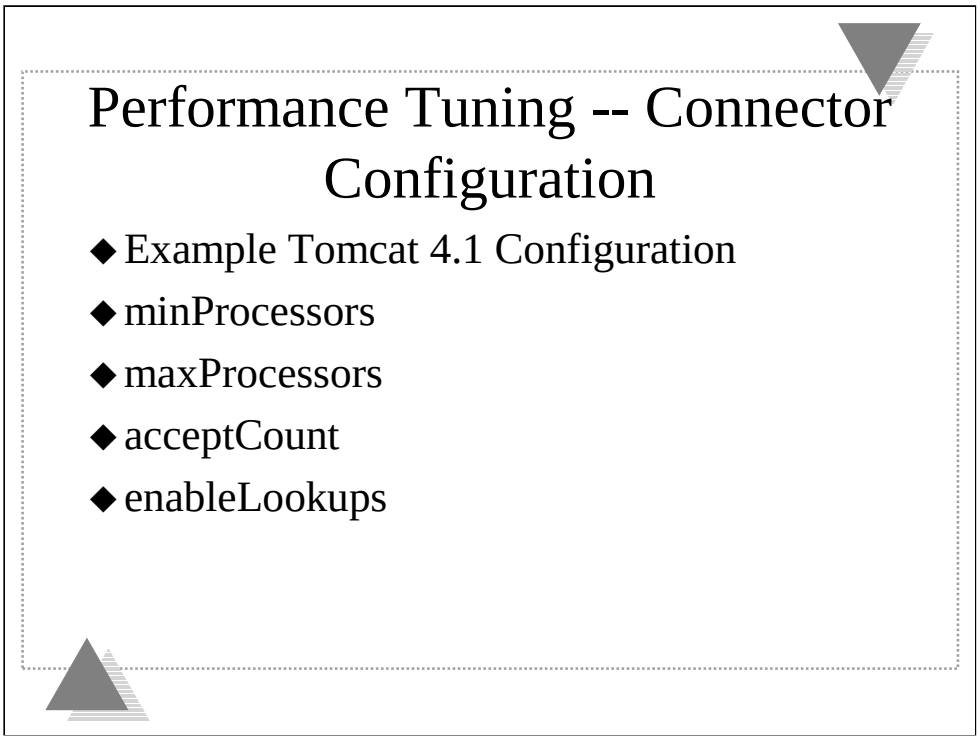
liveDeploy controls whether your webapps directory is periodically checked for new web application directories and war files. This is done using a background thread. Set this to false and use the manager application or ant deploy tasks instead.

debug 0

Disable all debug output, unnecessary logging just adds overhead.

swallowOutput true

This makes sure all output to stdout or stderr for a web application gets directed to the web application log rather than the console or catalina.out. This makes it easier to troubleshoot web application problems.



Notes

See Appendix A -- Example Tomcat 4.1 Configuration

minProcessors

Set to number of processors required for normal request volume.

maxProcessors

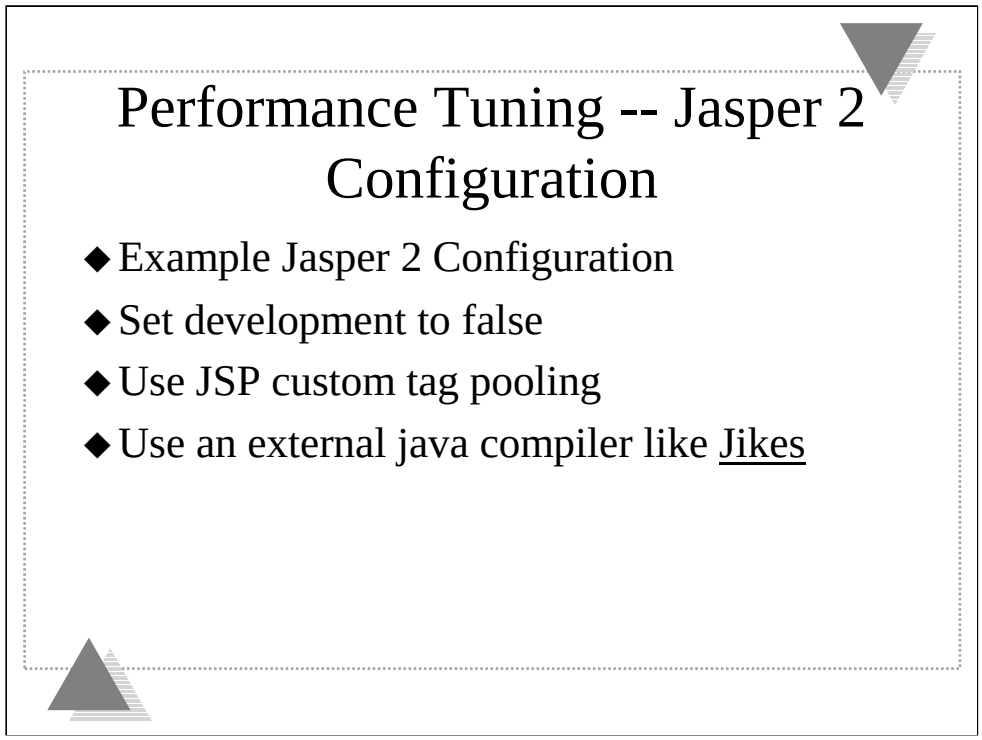
Set to twice the max number of concurrent requests expected.

acceptCount

Don't set too high, this sets the number of pending requests awaiting processing. In my opinion it is better to deny a few requests than overload Tomcat and cause problems for all requests.

enableLookups

DNS lookups can add significant delays.



Notes

See Appendix B -- Example Jasper 2 Configuration

development false

Disables JSP page out of date checks on each request and enables JSP background recompiles. development is set to true by default.

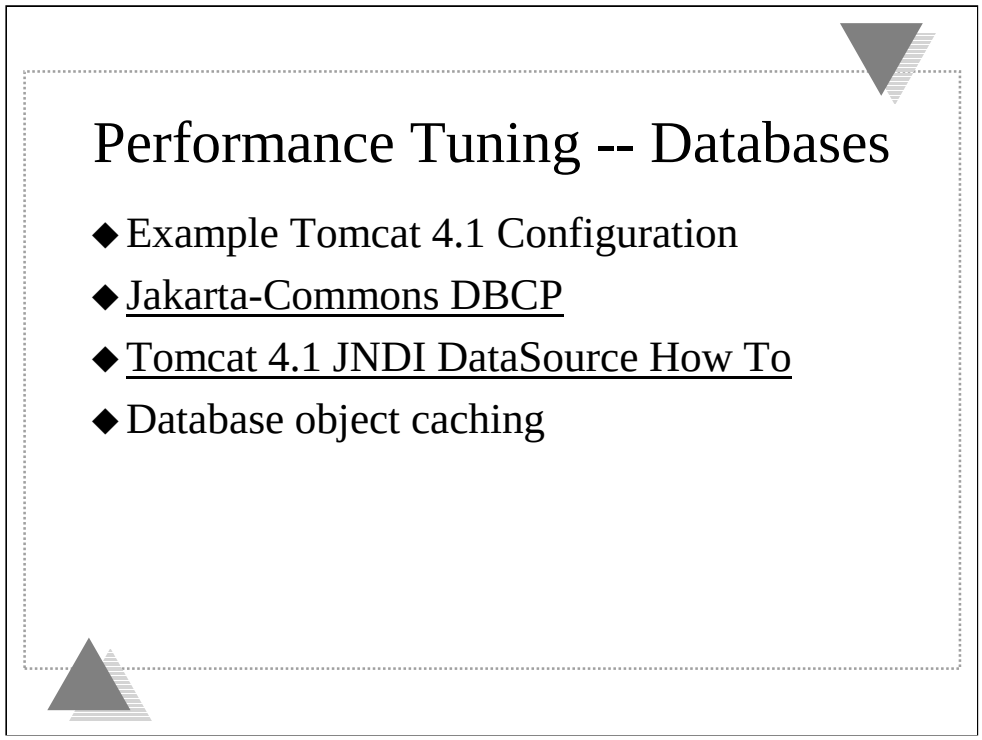
JSP custom tag pooling

Object pooling of classes which implement custom tags significantly improves performance of JSP pages which use custom tag libraries. JSP custom tag pooling is enabled by default.

External compiler - Jikes

The JVM compiler javac has known memory leaks. Eliminates JVM memory usage and GC overhead of javac.

http://oss.software.ibm.com/developerworks/opensource/jikes/



Notes

See Appendix A -- Example Tomcat 4.1 Configuration

Jakarta-Commons DBCP

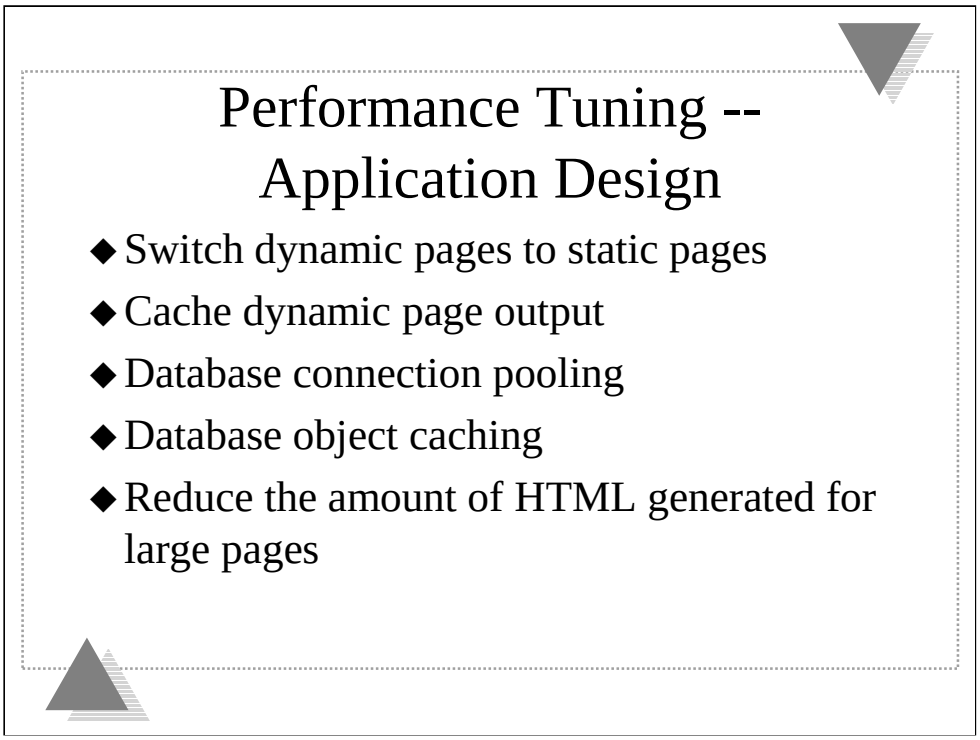
http://jakarta.apache.org/commons/dbcp.html

Tomcat 4.1 JNDI DataSource How To

http://jakarta.apache.org/tomcat/tomcat-4.1-doc/jndi-datasource-examples-howto.html

Database object caching

- •Using middleware to persist and cache objects from your database can significantly improve performance.
- •Fewer delays due to db query latency.
- •Less thrashing of the JVM for creation and subsequent GC of objects created for result sets.
- •Object Relational Bridge http://jakarta.apache.org/ojb/



Notes

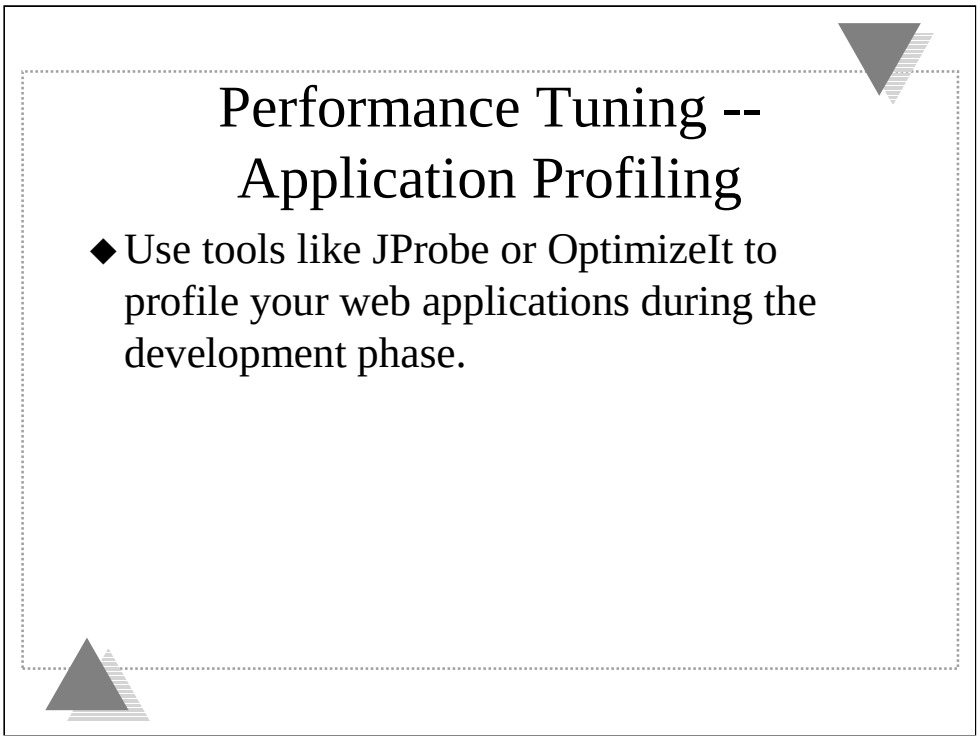
Switch dynamic pages to static pages

If the data used to generate a dynamic page rarely changes change to a static page which you regenerate periodically.

Cache dynamic page output

If each request for a page doesn't generate unique output but changes too frequently to make it static, consider temporary caching of the generated output.

- Servlet 2.3 Cache Filter
  http://www.servletsuite.com/servlets/cacheflt.htm
- Jakarta-Taglibs Cache JSP tag library
  http://jakarta.apache.org/taglibs/doc/cache-doc/intro.html



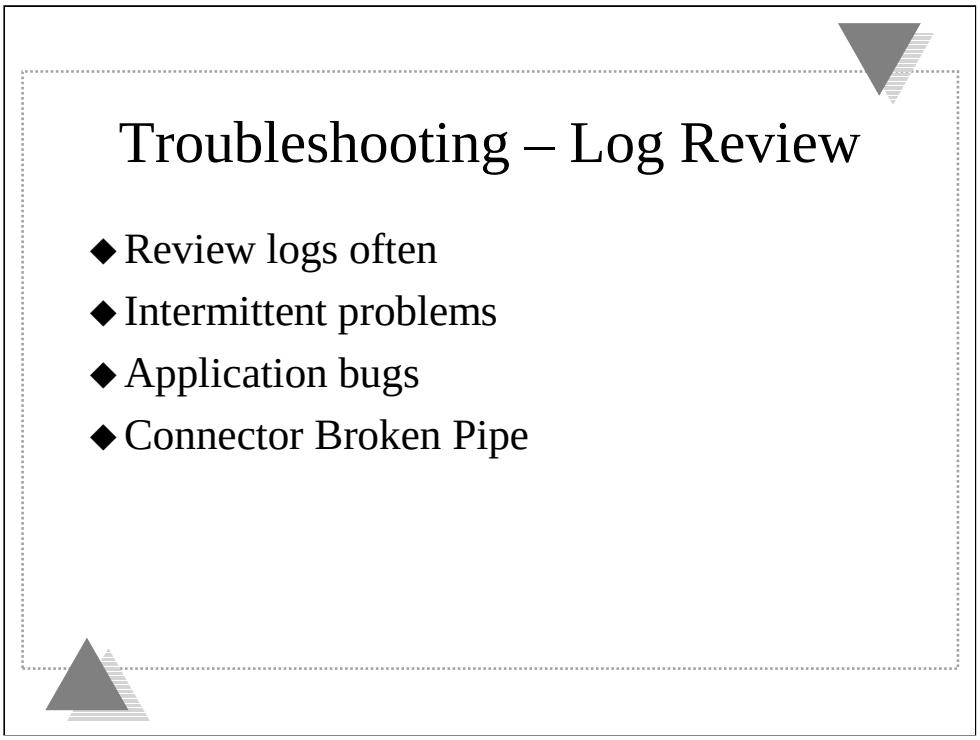
Notes

JProbe

http://www.sitraka.com/software/jprobe/

OptimizeIt

http://www.borland.com/optimizeit/



Notes

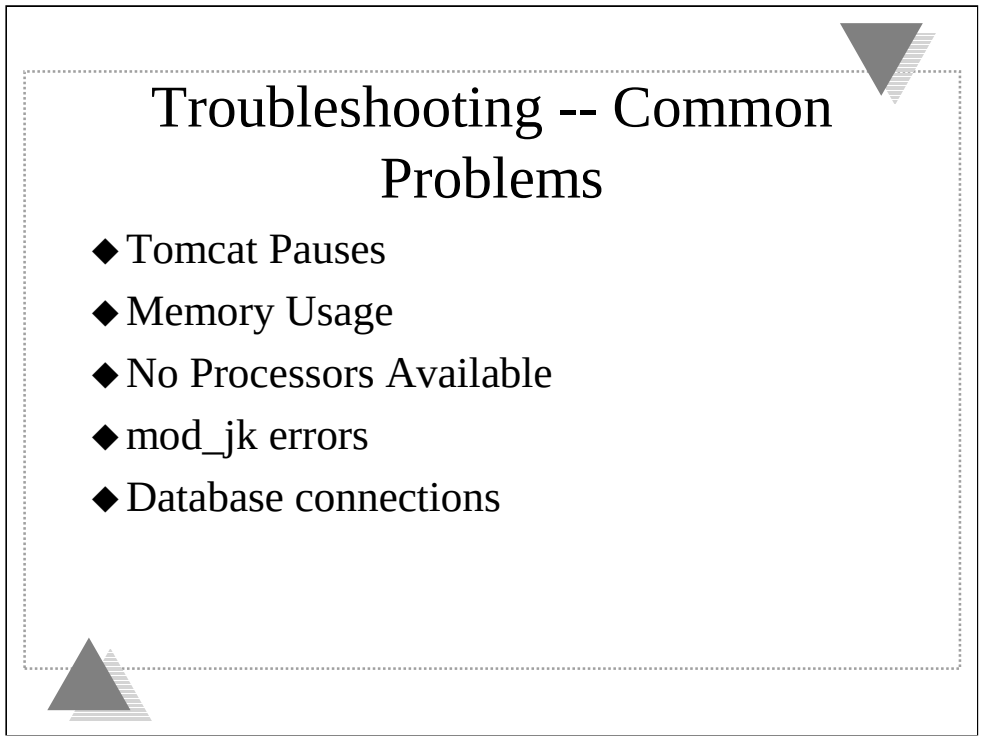
Review logs often, daily if possible.

Can help identify intermittent problems.

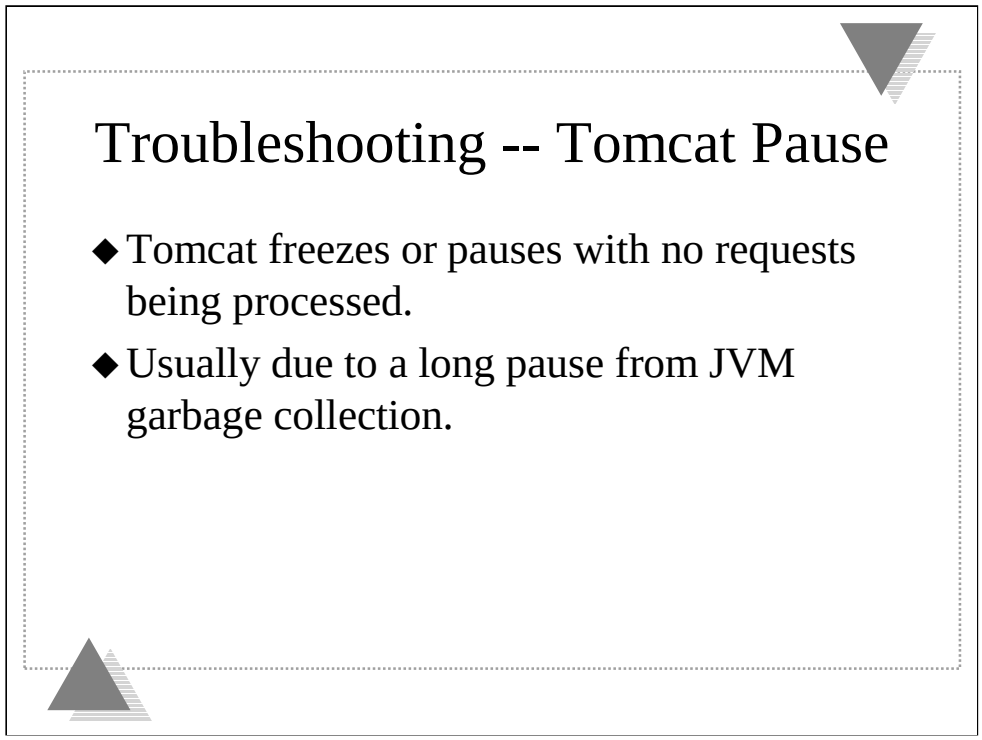
Application bugs can be found and fixed.

Connector Broken Pipe

- For HTTP Connector indicates that the remote client aborted the request.
- For a web server JK Connector indicates that the web server process or thread was terminated.
- These are normal and rarely due to a problem with Tomcat.


Troubleshooting -- Common Problems
Tomcat Pauses
Memory Usage
No Processors Available
mod_jk errors
Database connections

Notes

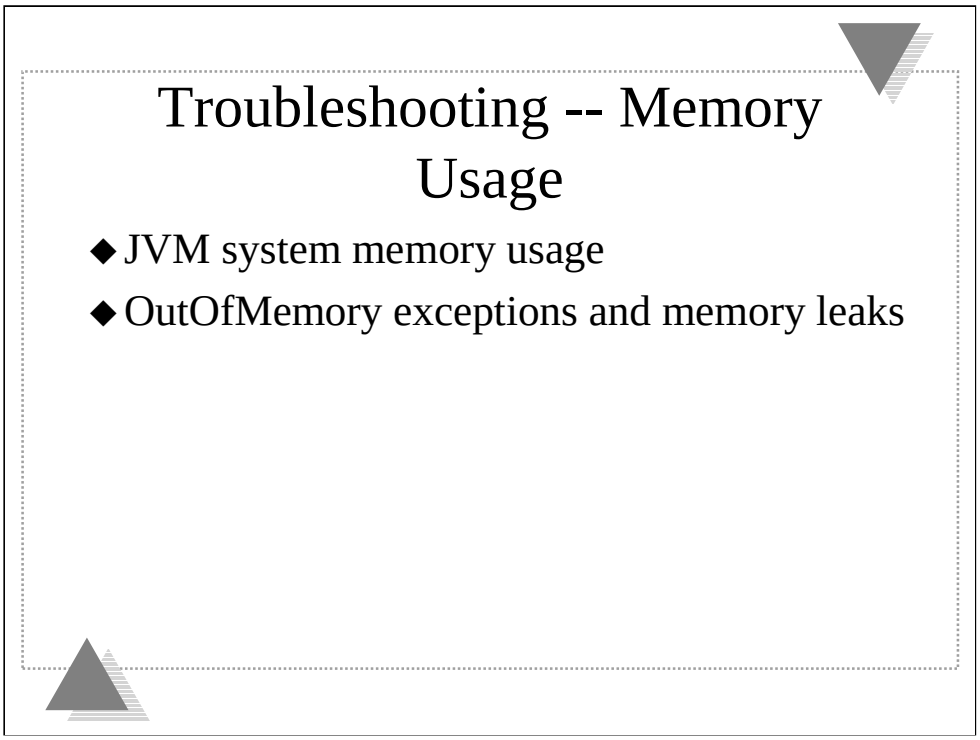


Notes

Use java -verbose;gc startup argument to collect GC data.

A long pause can cause a cascading effect and high load once Tomcat starts handling requests again.

Don't set the Connector acceptCount to high.



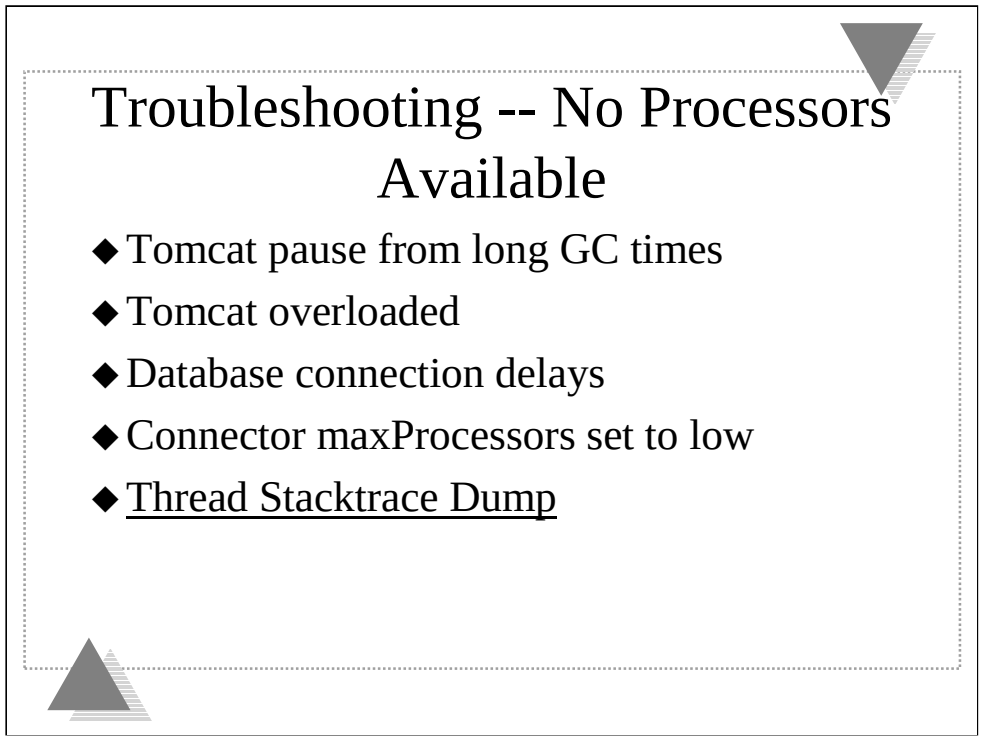
Notes

JVM system memory usage

- JVM memory usage will increase over time to your -Xmx maximum memory config.
- The JVM will never release that memory back to the OS.
- The JVM manages its memory usage internally.
- Use the java -verbose:gc option to collect data on JVM memory usage.

OutOfMemory exceptions and memory leaks

- These are almost always caused by your application code.
- Try increasing -Xmx if you have available memory on the system.
- Stop and restart Tomcat
- Profile your web application to determine where and why it is using excessive amounts of memory or leaking memory.



Notes

Tomcat overloaded

- •Review request volume
- •Review Tomcat CPU usage
- •Review request latency

Database connection delays

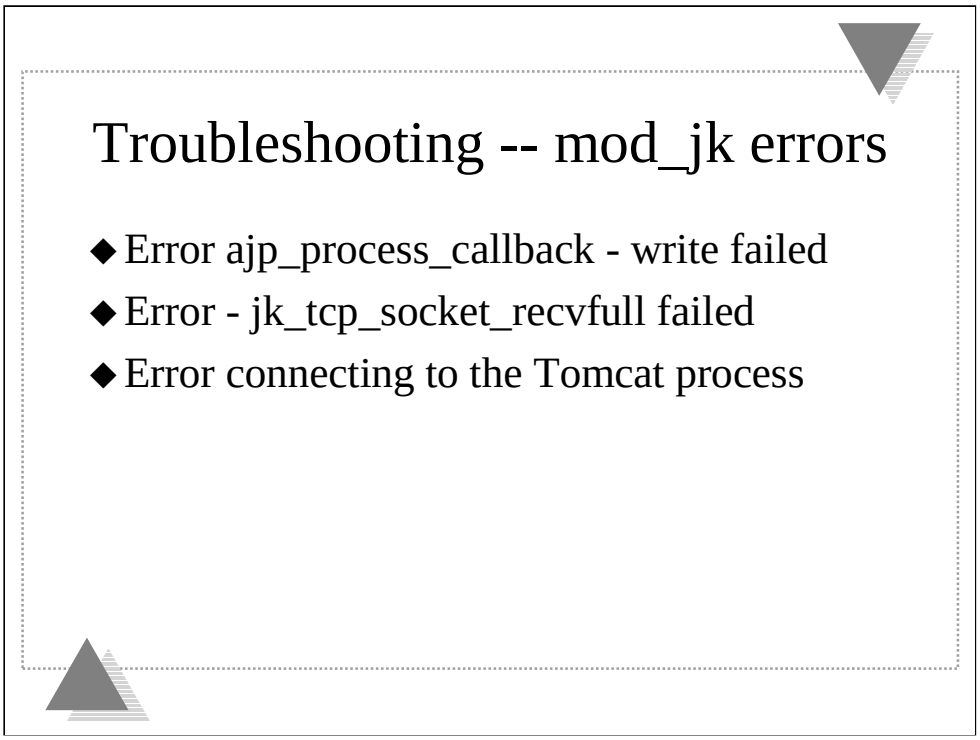
If there are database connection problems each request which uses the database could pause for as long as your db connection timeout. This puts processing for requests which use the db into a long wait. More and more Processors get used because too many requests are waiting for the db.

Connector maxProcessors set to low

If there is no other problem causing the Connector to run out of Processors, your maxProcessor setting may be to low. I recommend setting it to twice the number of concurrent requests you expect Tomcat to process.

Thread Stacktrace Dump

http://developer.java.sun.com/developer/technicalArticles/Programming/Stacktrace/



Notes

Error ajp_process_callback - write failed

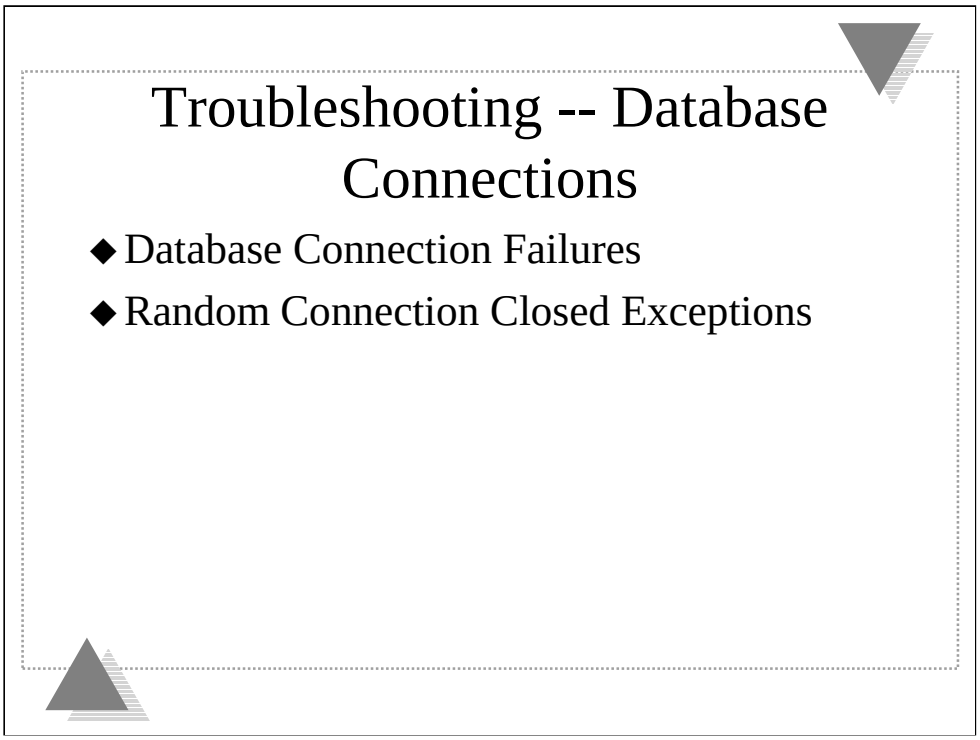
The remote browser client aborted the HTTP request. It is normal to see this error once in a while. This error occurs more frequently when request latency has increased due to Tomcat being overloaded.

Error - jk_tcp_socket_recvfull failed

All of Tomcats AjpProcessor's are in use and Tomcat rejected the connection. Tomcat is overloaded or the Connector maxProcessors needs to be increased.

Error connecting to the Tomcat process

Either Tomcat isn't running or Tomcat and mod_jk are configured to use different ports.



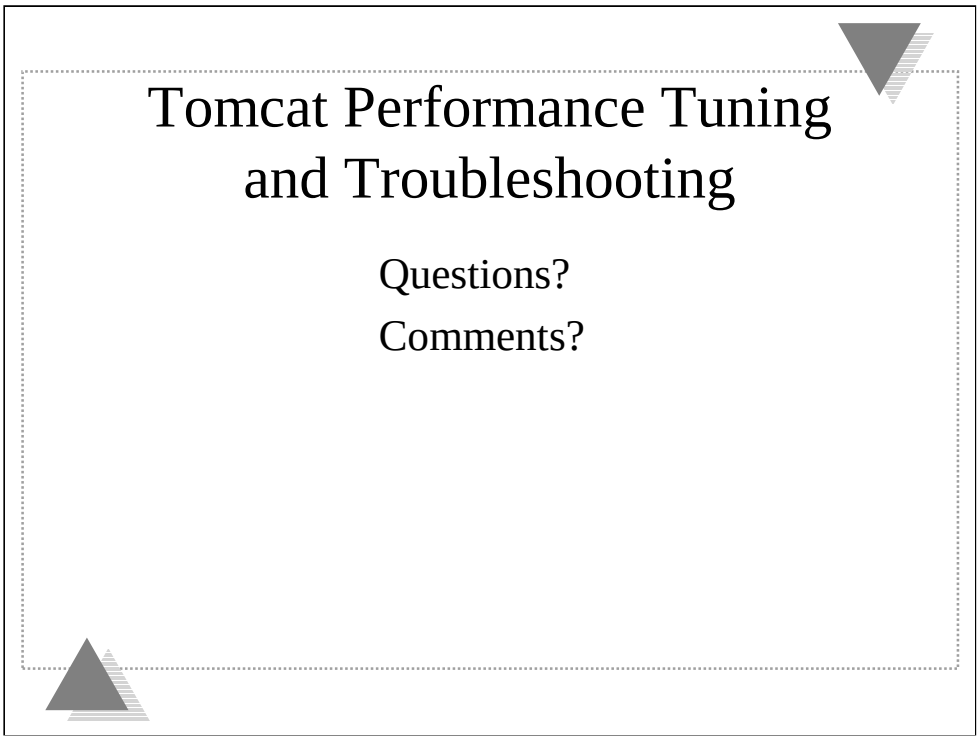
Notes

Database connection failures

- Long JVM GC times greater than db connection timeout can cause intermittent db connection failures.
- Database connection pool out of connections due to abandoned db pooled connections which are never recycled.
- Spike in traffic to site using up all available db connections. This can either be in your db connection pool configuration or in your database server configuration.

Random Connection Closed Exceptions

- Usually caused by a bug in the web application usage of the db.
- See Appendix C -- Random Connection Closed Exceptions


Tomcat Performance Tuning
and Troubleshooting
Questions?
Comments?

Notes

Appendix A -- conf/server.xml Tomcat 4.1 configuration

```
<Server port="8005" shutdown="SHUTDOWN" debug="0">

  <Service name="Tomcat-Apache">

    <Connector className="org.apache.ajp.tomcat4.Ajp13Connector"
               port="8009" minProcessors="50" maxProcessors="375"
               acceptCount="10" connectionTimeout="0" debug="0"/>

    <Engine name="Tomcat-Apache" defaultHost="www.myhost.com" debug="0">

      <Logger className="org.apache.catalina.logger.FileLogger"
              prefix="catalina_log." suffix=".txt"
              timestamp="true"/>

      <Host name="www.myhost.com" debug="0"
            appBase="webapps" swallowOutput="true"
            unpackWARs="true" autoDeploy="true" liveDeploy="false">

        <Realm  className="org.apache.catalina.realm.JDBCRealm" debug="0"
                driverName="org.gjt.mm.mysql.Driver"
                connectionURL="jdbc:mysql://localhost/realm?autoReconnect=true"
                connectionName="admin" connectionPassword="password"
                userTable="users" userNameCol="user_name" userCredCol="user_pass"
                userRoleTable="user_roles" roleNameCol="role_name" digest="MD5" />

        <Logger className="org.apache.catalina.logger.FileLogger"
                prefix="myhost_log-" suffix=".txt" timestamp="true"/>

        <DefaultContext debug="0" reloadable="false" swallowOutput="true">
          <!-- JNDI JDBC DataSource Resource for using MySQL dB -->
          <Resource name="jdbc/data" auth="CONTAINER"
                    type="javax.sql.DataSource"/>
          <ResourceParams name="jdbc/data">
            <parameter>
              <name>factory</name>
              <value>org.apache.commons.dbcp.BasicDataSourceFactory</value>
            </parameter>
            <parameter><name>username</name><value>username</value></parameter>
            <parameter><name>password</name><value>password</value></parameter>
            <parameter>
              <name>driverClassName</name>
              <value>org.gjt.mm.mysql.Driver</value></parameter>
            <parameter>
              <name>url</name>
              <value>jdbc:mysql://localhost/myhost?autoReconnect=true</value>
            </parameter>
            <parameter>
              <name>maxIdle</name>
              <value>50</value>
            </parameter>
            <parameter>
              <name>maxActive</name>
              <value>200</value>
            </parameter>
```

```
            <parameter>
              <name>maxWait</name>
              <value>10000</value>
            </parameter>
            <parameter>
              <name>logAbandoned</name>
              <value>true</value>
            </parameter>
            <parameter>
              <name>removeAbandoned</name>
              <value>true</value>
            </parameter>
            <parameter>
              <name>removeAbandonedTimeout</name>
              <value>300</value>
            </parameter>
          </ResourceParams>
        </DefaultContext>

        <Context path="/manager"
                 docBase="/usr/local/kinetic/tomcat4/server/webapps/manager"
                 debug="0" privileged="true">
          <Valve className="org.apache.catalina.valves.RemoteAddrValve"
                 allow="127.0.0.1"/>
        </Context>

      </Host>

    </Engine>

  </Service>

</Server>
```

Appendix B -- conf/web.xml Jasper 2 configuration

```
<!-- The JSP page compiler and execution servlet, which is the mechanism  -->
<!-- used by Tomcat to support JSP pages.  Traditionally, this servlet    -->
<!-- is mapped to URL patterh "*.jsp".  This servlet supports the         -->
<!-- following initialization parameters (default values are in square    -->
<!-- brackets):                                                           -->
<!--                                                                      -->
<!--   checkInterval       If development is false and relaoding is true, -->
<!--                       background compiles are enabled. checkInterval -->
<!--                       is the time in seconds between checks to see   -->
<!--                       if a JSP page needs to be recompiled. [300]    -->
<!--                                                                      -->
<!--   compiler            Which compiler Ant should use to compile JSP   -->
<!--                       pages.  See the Ant documenation for more      -->
<!--                       information. [javac]                           -->
<!--                                                                      -->
<!--   classdebuginfo      Should the class file be compiled with         -->
<!--                       debugging information?  [true]                 -->
<!--                                                                      -->
<!--   classpath           What class path should I use while compiling   -->
<!--                       generated servlets?  [Created dynamically      -->
<!--                       based on the current web application]          -->
<!--                                                                      -->
<!--   development         Is Jasper used in development mode (will check -->
<!--                       for JSP modification on every access)?  [true] -->
<!--                                                                      -->
<!--   enablePooling       Determines whether tag handler pooling is      -->
<!--                       enabled  [true]                                -->
<!--                                                                      -->
<!--   ieClassId           The class-id value to be sent to Internet      -->
<!--                       Explorer when using <jsp:plugin> tags.         -->
<!--                       [clsid:8AD9C840-044E-11D1-B3E9-00805F499D93]   -->
<!--                                                                      -->
<!--   javaEncoding        Java file encoding to use for generating java  -->
<!--                       source files. [UTF8]                           -->
<!--                                                                      -->
<!--   keepgenerated       Should we keep the generated Java source code  -->
<!--                       for each page instead of deleting it? [true]   -->
<!--                                                                      -->
<!--   largefile           Should we store the static content of JSP      -->
<!--                       pages in external data files, to reduce the    -->
<!--                       size of the generated servlets?  [false]       -->
<!--                                                                      -->
<!--   logVerbosityLevel   The level of detailed messages to be produced  -->
<!--                       by this servlet.  Increasing levels cause the  -->
<!--                       generation of more messages.  Valid values are -->
<!--                       FATAL, ERROR, WARNING, INFORMATION, and DEBUG. -->
<!--                       [WARNING]                                      -->
<!--                                                                      -->
<!--   mappedfile          Should we generate static content with one     -->
<!--                       print statement per input line, to ease        -->
<!--                       debugging?  [false]                            -->
<!--                                                                      -->
<!--   reloading           Should Jasper check for modified JSPs?  [true] -->
```

```
<!--                                                                    -->
<!--   scratchdir          What scratch directory should we use when     -->
<!--                       compiling JSP pages?  [default work directory -->
<!--                       for the current web application]              -->
<!--                                                                     -->
<!-- If you wish to use Jikes to compile JSP pages:                      -->
<!--   Set the init parameter "compiler" to "jikes".  Define             -->
<!--   the property "-Dbuild.compiler.emacs=true" when starting Tomcat.  -->
<!--   If you get an error reporting that jikes can't use UTF8 encoding, -->
<!--   try setting the init parameter "javaEncoding" to "ISO-8859-1".    -->

  <servlet>
      <servlet-name>jsp</servlet-name>
      <servlet-class>org.apache.jasper.servlet.JspServlet</servlet-class>
      <init-param>
          <param-name>logVerbosityLevel</param-name>
          <param-value>ERROR</param-value>
      </init-param>

      <!-- Uncomment the following two parameters to use jikes as the
           java compiler for generated java code from JSP pages. -->
      <init-param>
          <param-name>compiler</param-name>
          <param-value>jikes</param-value>
      </init-param>
      <init-param>
          <param-name>javaEncoding</param-name>
          <param-value>ISO-8859-1</param-value>
      </init-param>

      <!-- Set the following two parameters to false for production -->
      <init-param>
          <param-name>development</param-name>
          <param-value>false</param-value>
      </init-param>
      <init-param>
          <param-name>mappedfile</param-name>
          <param-value>false</param-value>
      </init-param>
      <load-on-startup>3</load-on-startup>
  </servlet>
```

Appendix C - Random Database Connection Closed Exceptions

These can occur when one request gets a db connection from the connection pool and closes it twice. When using a connection pool, closing the connection just returns it to the pool for reuse by another request, it doesn't close the connection. And Tomcat uses multiple threads to handle concurrent requests. Here is an example of the sequence of events which could cause this error in Tomcat:

1. Request 1 running in Thread 1 gets a db connection.
2. Request 1 closes the db connection.
3. The JVM switches the running thread to Thread 2
4. Request 2 running in Thread 2 gets a db connection(the same db connection just closed by Request 1).
5. The JVM switches the running thread back to Thread 1
6. Request 1 closes the db connection a second time in a finally block.
7. The JVM switches the running thread back to Thread 2
8. Request 2 Thread 2 tries to use the db connection but fails because Request 1 closed it.

Here is an example of properly written code to use a db connection obtained from a connection pool:

```
Connection conn = null;
Statement stmt = null;  // Or PreparedStatement if needed
ResultSet rs = null;
try {
  conn = ... get connection from connection pool ...
  stmt = conn.createStatement("select ...");
  rs = stmt.executeQuery();
  ... iterate through the result set ...
  rs.close();
  rs = null;
  stmt.close();
  stmt = null;
  conn.close(); // Return to connection pool
  conn = null;  // Make sure we don't close it twice
} catch (SQLException e) {
  ... deal with errors ...
} finally {
  // Always make sure result sets and statements are closed,
  // and the connection is returned to the pool
  if (rs != null) {
    try { rs.close(); } catch (SQLException e) { ; }
    rs = null;
  }
  if (stmt != null) {
    try { stmt.close(); } catch (SQLException e) { ; }
    stmt = null;
  }
  if (conn != null) {
    try { conn.close(); } catch (SQLException e) { ; }
    conn = null;
  }
}
```