Monitoring Java Applications

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Monitoring a Java Application

Java applications are predominantly used in enterprises today owing to their multi-platform nature. Once written, a Java application can be run on heterogeneous platforms with no additional configuration. This is why, the Java technology is widely used in the design and delivery of many critical web and non-web-based applications.

The prime concern of the administrators of these applications is knowing how well the application is functioning, and how to troubleshoot issues (if any) in the performance of these applications. Most web application server vendors prescribe custom APIs for monitoring – for instance, WebSphere and WebLogic allow administrators to use their built-in APIs for performance monitoring and problem detection. The details of these APIs and how eG Enterprise uses them to monitor the application server in question is discussed elaborately in the previous chapters of this document.

Besides such applications, you might have stand-alone Java applications that do not provide any APIs for monitoring. To enable users to monitor the overall health of such stand-alone Java applications, eG Enterprise offers a generic monitoring model called the *Java Application*.

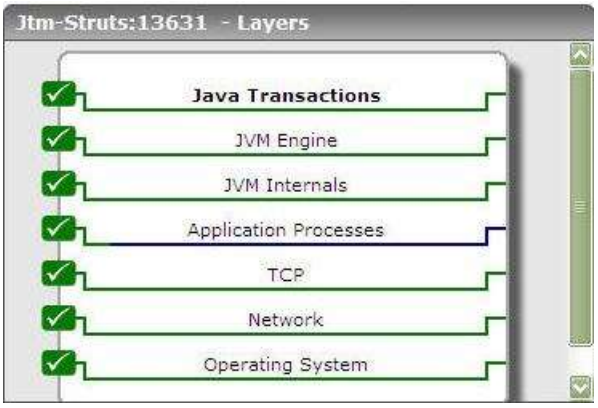


Figure 1: Layer model of the Java Application

Each layer of Figure 1 above is mapped to a series of tests that report critical statistics pertaining to the Java application being monitored. Using these statistics, administrators can figure out the following:

a. Has the Java heap been sized properly?

b. How effective is garbage collection? Is it impacting application performance?

c. Often, Java programs use threads. A single program may involve multiple concurrent threads running in parallel. Is there excessive blocking between threads due to synchronization issues during application design?

d. Are there runaway threads, which are taking too many CPU cycles? If such threads exist, which portions of code are responsible for spawning such threads?

e. Is the JVM managing its memory resources efficiently or is the free memory on the JVM very less? Which type of memory is being utilized by the JVM increasingly?

f. Has a scheduled JVM restart occurred? If so, when?

1.1 How does eG Enterprise Monitor Java Applications?

The *Java Application* model that eG Enterprise prescribes provides both *agentless* and *agent-based* monitoring support to Java applications. The eG agent, deployed either on the application host or on a remote Windows host in the environment (depending upon the monitoring approach – whether agent-based or agentless), can be configured to connect to the JRE used by the application and pull out metrics of interest, using either of the following methodologies:

- JMX (Java Management Extensions)
- SNMP (Simple Network Management Protocol)

The eG agent uses the specifications prescribed by JSR 174 to perform JVM monitoring.

This is why, each test mapped to the top 2 layers of Figure 1 provides administrators with the option to pick a monitoring **MODE** - i.e., either **JMX** or **SNMP**. The remaining test configuration depends upon the mode chosen.

Since both JMX and SNMP support are available for JRE 1.5 and above only, the *Java Application* model can be used to monitor **only those applications that are running JRE 1.5 and above**.

The sections to come discuss how to enable JMX and SNMP for JRE.

1.1.1 Enabling JMX Support for JRE

In older versions of Java (i.e., JDK/JRE 1.1, 1.2, and 1.3), very little instrumentation was built in, and custom-developed byte-code instrumentation had to be used to perform monitoring. From JRE/JDK 1.5 and above however, support for Java Management Extensions (JMX) were pre-built into JRE/JDK. JMX enables external programs like the eG agent to connect to the JRE of an application and pull out metrics in real-time.

This section discusses the procedure for enabling JMX support for the JRE of any generic Java application that may be monitored using eG Enterprise. To know how to enable JMX support for the JRE of key application servers monitored out-of-the-box by eG Eterprise, refer to the relevant chapters of the *Configuring and Monitoring Application Servers* document.

By default, JMX requires no authentication or security (SSL). In this case therefore, to use JMX for pulling out metrics from a target application, the following will have to be done:

1. Login to the application host.
2. The **<JAVA_HOME>\jre\lib\management** folder used by the target application will typically contain the following files:
    - *management.properties*
    - *jmxremote.access*
    - *jmxremote.password.template*
    - *snmp.acl.template*
3. Edit the *managerment.properties* file, and append the following lines to it:

```
com.sun.management.jmxremote.port=<Port No>
com.sun.management.jmxremote.ssl=false
com.sun.management.jmxremote.authenticate=false
```

For instance, if the JMX listens on port 9005, then the first line of the above specification would be:

```
com.sun.management.jmxremote.port=9005
```

4. Then, save the file.
5. Next, edit the start-up script of the target application, and add the following line to it:

```
-Dcom.sun.management.config.file=<management.properties_file_path>
-Djava.rmi.server.hostname=<IP Address>
```

6. For instance, on a Windows host, the *<management.properties_file_path>* can be expressed as: **D:\bea\jrockit_150_11\jre\lib\management\management.properties**
7. On other hand, on a Unix/Linux/Solaris host, a sample *<management.properties_file_path>* specification will be as follows: **/usr/jdk1.5.0_05/jre/lib/management/management.properties**
8. In the second line, set the **<IP Address>** to the IP address using which the Java application has been managed in the eG Enterprise system. Alternatively, you can add the following line to the startup script: *-Djava.rmi.server.hostname=localhost*
9. Save this script file too.
10. Next, during test configuration, do the following:
    - Set **JMX** as the mode;
    - Set the port that you defined in step 3 above (in the *management.properties* file) as the jmx remote port;
    - Set the user and password parameters to *none*.

- Update the test configuration.

On the other hand, if JMX requires **only authentication** (and no security), then the following steps will apply:

1. Login to the application host. If the application is executing on a Windows host, then, login to the host as a local/domain administrator.
2. As stated earlier, the **<JAVA_HOME>\jre\lib\management** folder used by the target application will typically contain the following files:
    - *management.properties*
    - *jmxremote.access*
    - *jmxremote.password.template*
    - *snmp.acl.template*
3. First, copy the *jmxremote.password.template* file to any other location on the host, rename it as as *jmxremote.password*, and then, copy it back to the **<JAVA_HOME>\jre\lib\management** folder.
4. Next, edit the *jmxremote.password* file and the *jmxremote.access* file to create a user with *read-write* access to the JMX. To know how to create such a user, refer to Section 1.1.1.2 of this document.
5. Then, proceed to make the *jmxremote.password* file secure by granting a single user "full access" to that file. For monitoring applications executing on Windows in particular, only the *Owner* of the *jmxremote.password* file should have full control of that file. To know how to grant this privilege to the *Owner* of the file, refer to Section 1.1.1.1.
6. In case of applications executing on Solaris / Linux hosts on the other hand, any user can be granted full access to the *jmxremote.password* file, by following the steps below:
    - Login to the host as the user who is to be granted full control of the *jmxremote.password* file.
    - Issue the following command:
    - **chmod 600 jmxremote.password**
    - This will automatically grant the login user full access to the *jmxremote.password* file.
7. Next, edit the *management.properties* file, and append the following lines to it:

```
com.sun.management.jmxremote.port=<Port No>
com.sun.management.jmxremote.ssl=false
com.sun.management.jmxremote.authenticate=true
com.sun.management.jmxremote.access.file=<Path of jmxremote.access>
com.sun.management.jmxremote.password.file=<Path of jmxremote.password>
```

For instance, assume that the JMX remote port is 9005, and the *jmxremote.access* and *jmxremote.password* files exist in the following directory on a Windows host: **D:\bea\jrockit_150_11\jre\lib\management**. The specification above will then read as follows:

```
com.sun.management.jmxremote.port=9005
com.sun.management.jmxremote.access.file=D:\\bea\\jrockit_150_11\\jre\\lib\\managem
ent\\jmxremote.access
com.sun.management.jmxremote.password.file=D:\\bea\\jrockit_150_11\\jre\\lib\\manag
ement\\jmxremote.password
```

8. If the application in question is executing on a Unix/Solaris/Linux host, and the *jmxremote.access* and *jmxremote.password* files reside in the **/usr/jdk1.5.0_05/jre/lib/management** folder of the host, then the last 2 lines of the specification will be:

```
com.sun.management.jmxremote.access.file=/usr/jdk1.5.0_05/jre/lib/management/jmxremote.access
com.sun.management.jmxremote.password.file=/usr/jdk1.5.0_05/jre/lib/management/jmxremote.password
```

9. Finally, save the file.

10. Then, edit the start-up script of the target web application server, include the following line in it, and save the file:

```
-Dcom.sun.management.config.file=<management.properties_file_path>
-Djava.rmi.server.hostname=<IP Address>
```

11. For instance, on a Windows host, the *<management.properties_file_path>* can be expressed as: **D:\bea\jrockit_150_11\jre\lib\management\management.properties**

12. On other hand, on a Linux/Solaris host, a sample *<management.properties_file_path>* specification will be as follows: **/usr/jdk1.5.0_05/jre/lib/management/management.properties**

13. In the second line, set the **<IP Address>** to the IP address using which the Java application has been managed in the eG Enterprise system. Alternatively, you can add the following line to the startup script of the target web application server: *-Djava.rmi.server.hostname=localhost*

14. Next, during test configuration, do the following:

    - Set **JMX** as the mode;
    - Ensure that the port number configured in the *management.properties* file at step 5 above is set as the jmx remote port;
    - Make sure that the user and password parameters of the test are that of a user with *readwrite* rights to JMX. To know how to create a new user and assign the required rights to him/her, refer to Section 1.1.1.2.

eG Enterprise cannot use JMX that requires both authentication and security (SSL), for monitoring the target Java application.

1.1.1.1 Securing the 'jmxremote.password' file

To enable the eG agent to use JMX (that requires **authentication only**) for monitoring a Windows-based Java application, you need to ensure that the *jmxremote.password* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application is accessible **only by the Owner of that file**. To achieve this, do the following:

1. Login to the Windows host as a local/domain administrator.
2. Browse to the location of the *jmxremote.password* file using Windows Explorer.
3. Next, right-click on the *jmxremote.password* file and select the **Properties** option (see Figure 2).

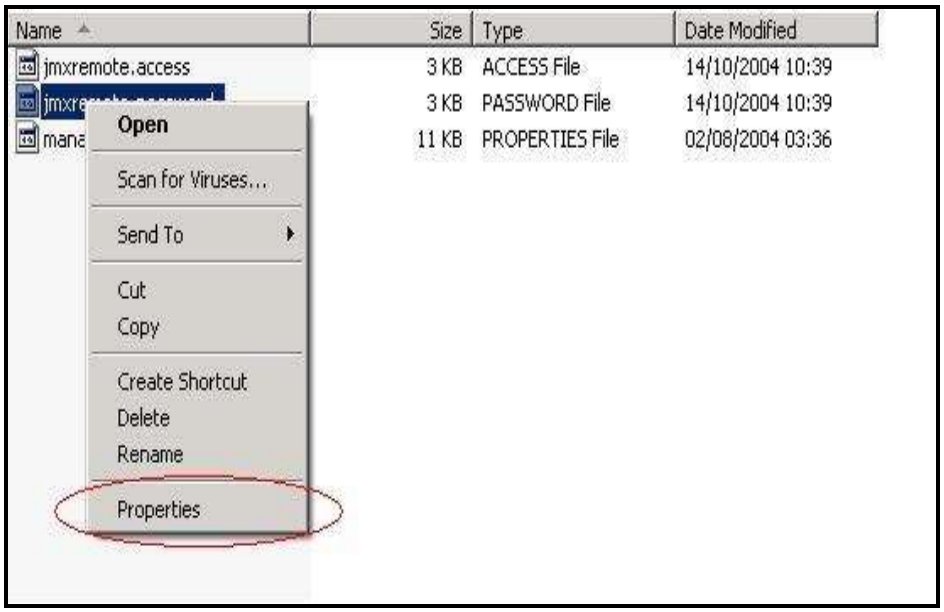


Figure 2: Selecting the Properties option

4. From Figure 3 that appears next, select the **Security** tab.

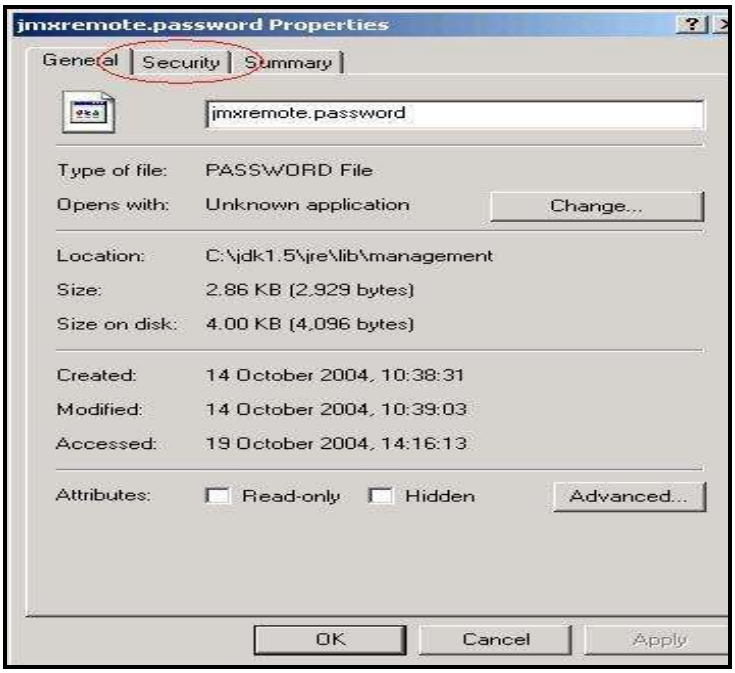


Figure 3: The Properties dialog box

However, if you are on Windows XP and the computer is not part of a domain, then the **Security** tab may be missing. To reveal the **Security** tab, do the following:

- Open Windows Explorer, and choose **Folder Options** from the **Tools** menu.
- Select the **View** tab, scroll to the bottom of the **Advanced Settings** section, and clear the check box next to **Use Simple File Sharing**.

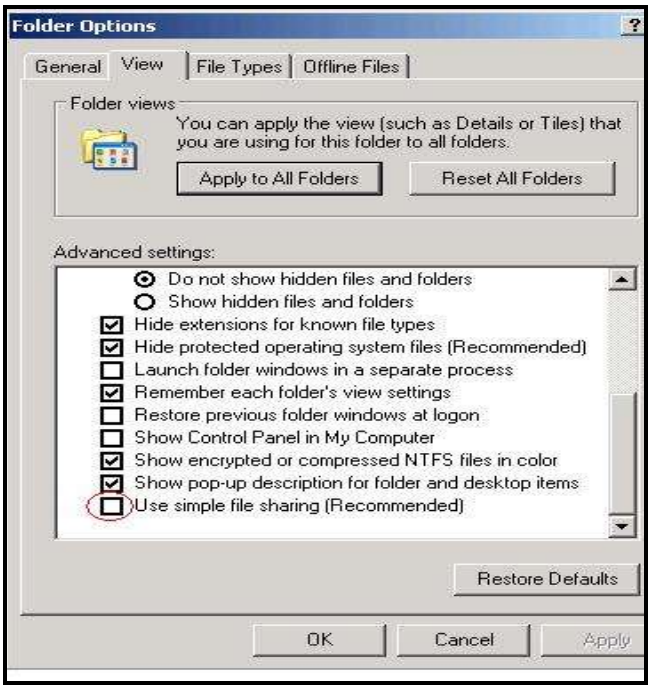


Figure 4: Deselecting the 'Use simple file sharing' option

- Click **OK** to apply the change
- When you restart Windows Explorer, the **Security** tab would be visible.

5. Next, select the **Advanced** button in the **Security** tab of Figure 5.

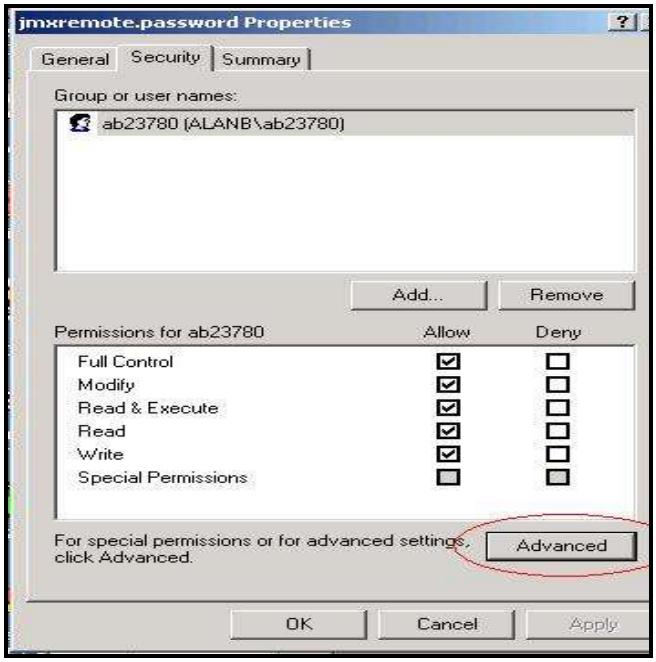


Figure 5: Clicking the Advanced button

6. Select the **Owner** tab to see who the owner of the file is.

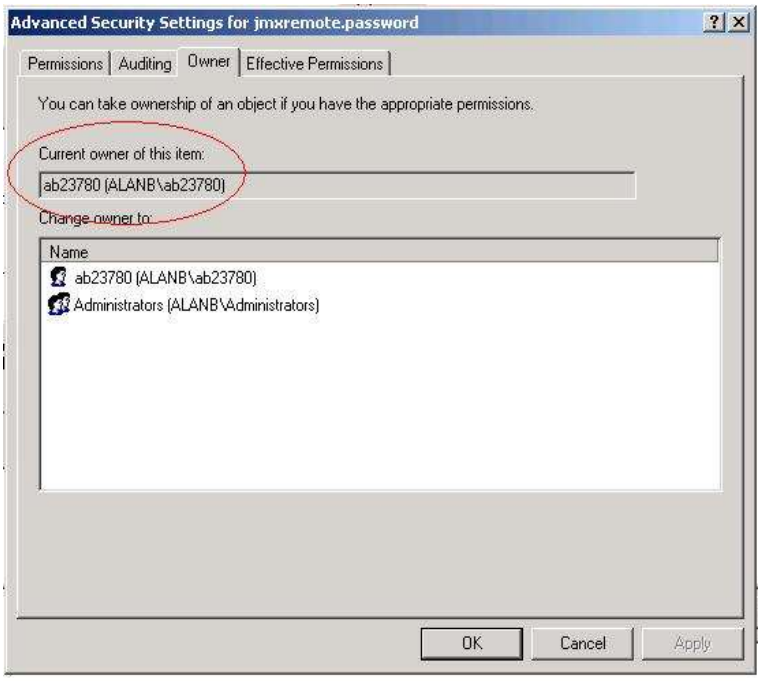


Figure 6: Verfying whether the Owner of the file is the same as the application Owner

7. Then, proceed to select the **Permissions** tab in Figure 6 to set the permissions. If the *jmxremote.password* file has inherited its permissions from a parent directory that allows users or groups other than the **Owner** to access the file, then clear the **Inherit from parent the permission entries that apply to child objects** check box in Figure 7.

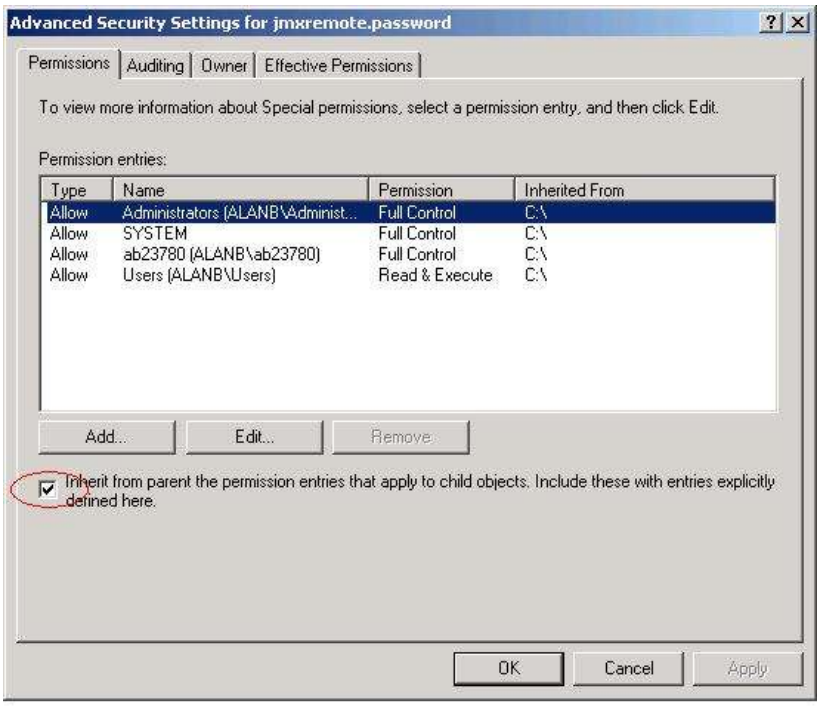


Figure 7: Disinheriting permissions borrowed from a parent directory

8. At this point, you will be prompted to confirm whether the inherited permissions should be copied from the parent or removed. Press the **Copy** button in Figure 8.

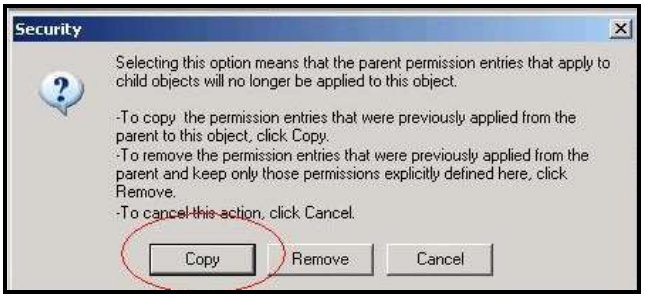


Figure 8: Copying the inherited permissions

9. Next, remove all permission entries that allow the *jmxremote.password* file to be accessed by users or groups other than the file **Owner**. For this, click the user or group and press the **Remove** button in Figure 9. At the end of this exercise, only a single permission entry granting **Full Control** to the owner should remain in Figure 9.

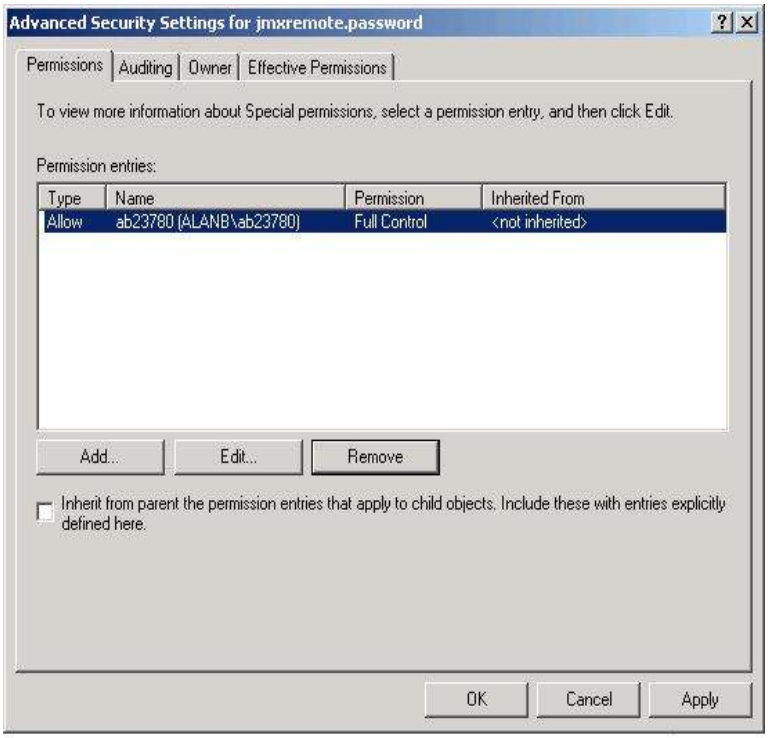


Figure 9: Granting full control to the file owner

10. Finally, click the **Apply** and **OK** buttons to register the changes. The password file is now secure, and can only be accessed by the file owner.

If you are trying to enable JMX on a Linux host, you might encounter issues with the way hostnames are resolved.

To solve it you might have to set the **-Djava.rmi.server.hostname=<hostname or localhost or ip>** property in the startup script of the target web application server.

If you are in local, simply try with **-Djava.rmi.server.hostname=localhost** or **-Djava.rmi.server.hostname=127.0.0.1**.

1.1.1.2 Configuring the eG Agent to Support JMX Authentication

If the eG agent needs to use JMX for monitoring a Java application, and this JMX requires **authentication only** (and not security), then every test to be executed by such an eG agent should be configured with the credentials of a valid user to JMX, with *read-write rights*. The steps for creating such a user are detailed below:

1. Login to the application host. If the application being monitored is on a Windows host, then login as a local/domain administrator to the host.
2. Go to the **<JAVA_HOME>\jre\lib\management** folder used by the target application to view the following files:
   - *management.properties*
   - *jmxremote.access*
   - *jmxremote.password.template*
   - *snmp.acl.template*
3. Copy the *jmxremote.password.template* file to a different location, rename it as *jmxremote.password*, and copy it back to the **<JAVA_HOME>\jre\lib\management** folder.
4. Open the *jmxremote.password* file and scroll down to the end of the file. By default, you will find the commented entries indicated by Figure 10 below:

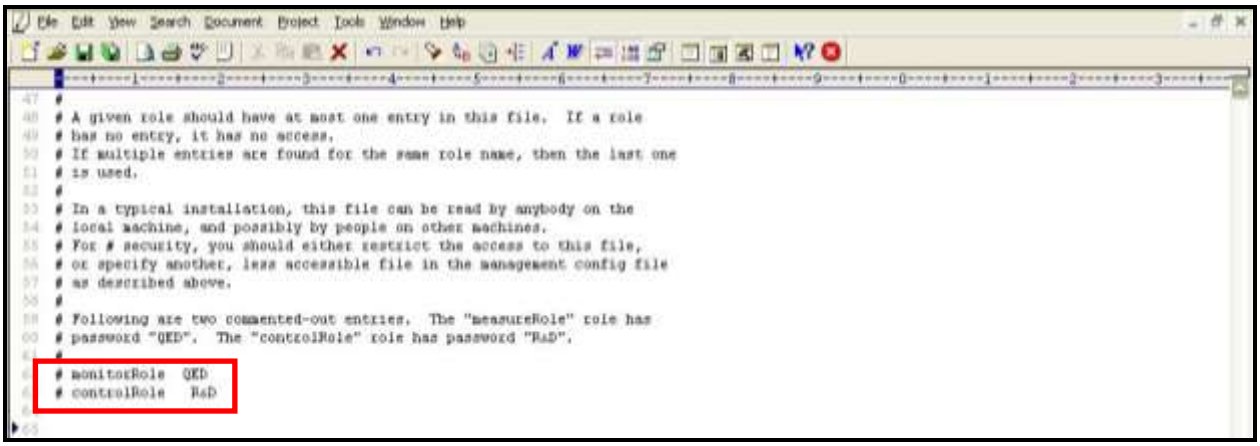


Figure 10: Scrolling down the jmxremote.password file to view 2 commented entries

5. The two entries indicated by Figure 10 are sample *username password* pairs with access to JMX. For instance, in the first sample entry of Figure 10, *monitorRole* is the *username* and *QED* is the *password* corresponding to *monitorRole*. Likewise, in the second line, the *controlRole* user takes the password *R&D*.
6. If you want to use one of these pre-defined *username password* pairs during test configuration, then simply uncomment the corresponding entry by removing the *#* symbol preceding that entry. However, prior to that, you need to determine what privileges have been granted to both these users. For that, open the *jmxremote.access* file in the editor.

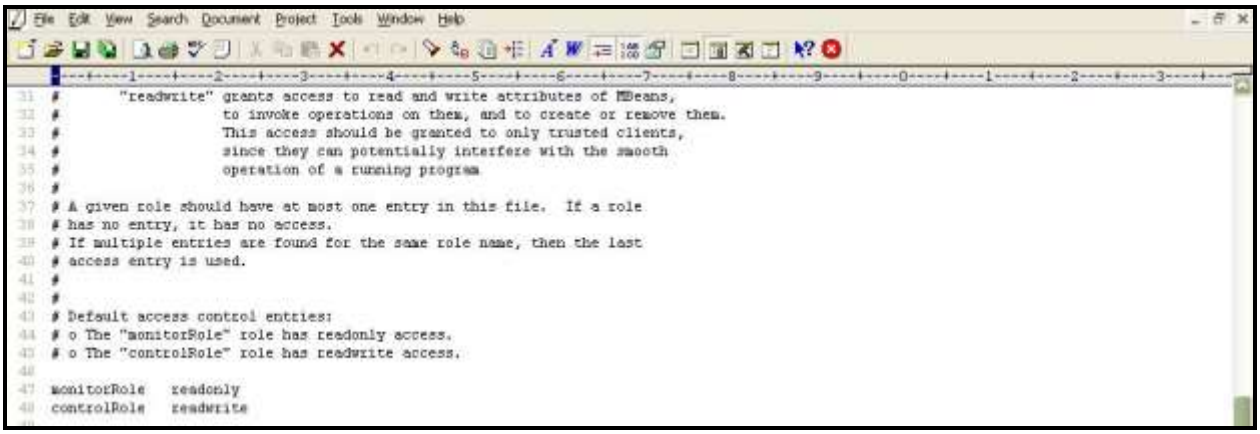


Figure 11: The jmxremote.access file

7. Scrolling down the file (as indicated by Figure 11) will reveal 2 lines, each corresponding to the sample *username* available in the *jmxremote.password* file. Each line denotes the access rights of the corresponding user. As is evident from Figure 11, the user *monitorRole* has only *readonly* rights, while user *controlRole* has *readwrite* rights. Since the eG agent requires *readwrite* rights to be able to pull out key JVM-related statistics using JMX, we will have to configure the test with the credentials of the user *controlRole*.

8. For that, first, edit the *jmxremote.password* file and uncomment the *controlRole <password>* line as depicted by Figure 12.

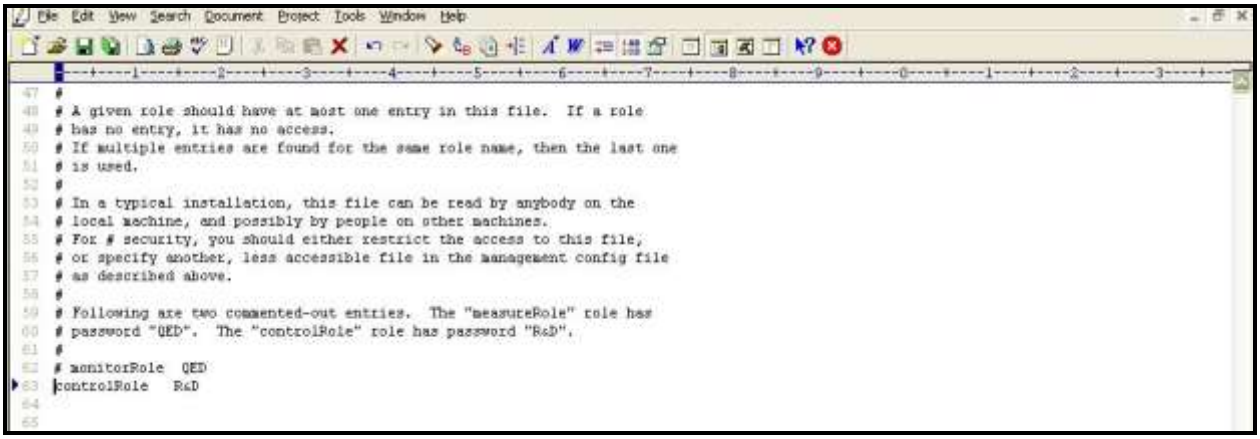


Figure 12: Uncommending the 'controlRole' line

9. Then, save the file. You can now proceed to configure the tests with the user name *controlRole*and password *R&D*.

10. Alternatively, instead of going with these default credentials, you can create a new *username password* pair in the *jmxremote.password* file, assign *readwrite* rights to this user in the *jmxremote.access* file, and then configure the eG tests with the credentials of this new user. For instance, let us create a user *john* with password *john* and assign *readwrite* rights to *john*.

11. For this purpose, first, edit the *jmxremote.password* file, and append the following line (see Figure 13) to it:

    john john

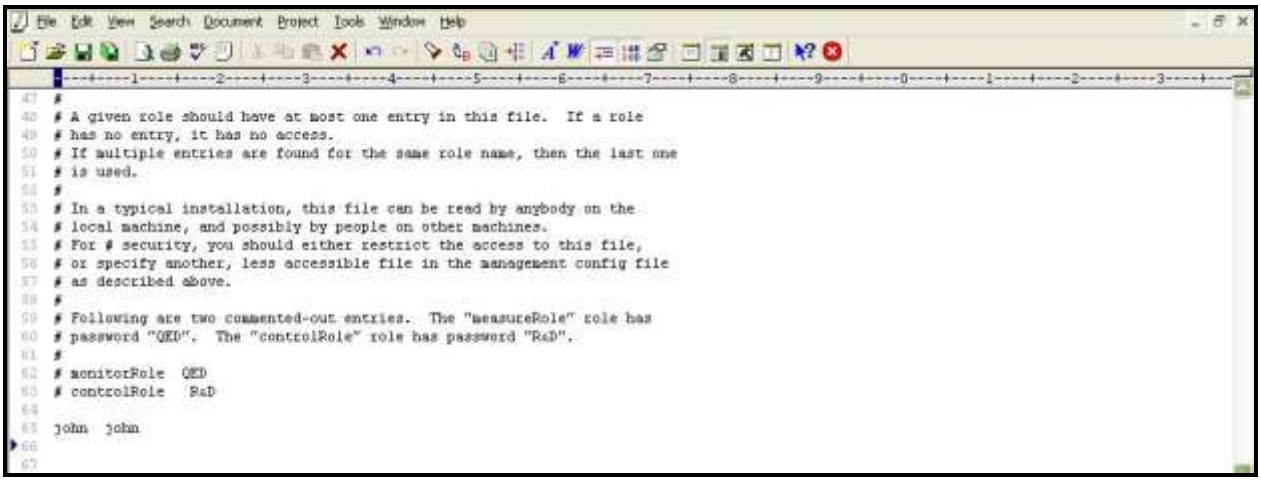


Figure 13: Appending a new username password pair

12. Save the *jmxremote.password* file.
13. Then, edit the *jmxremote.access* file, and append the following line (see Figure 14) to it:

    john readwrite

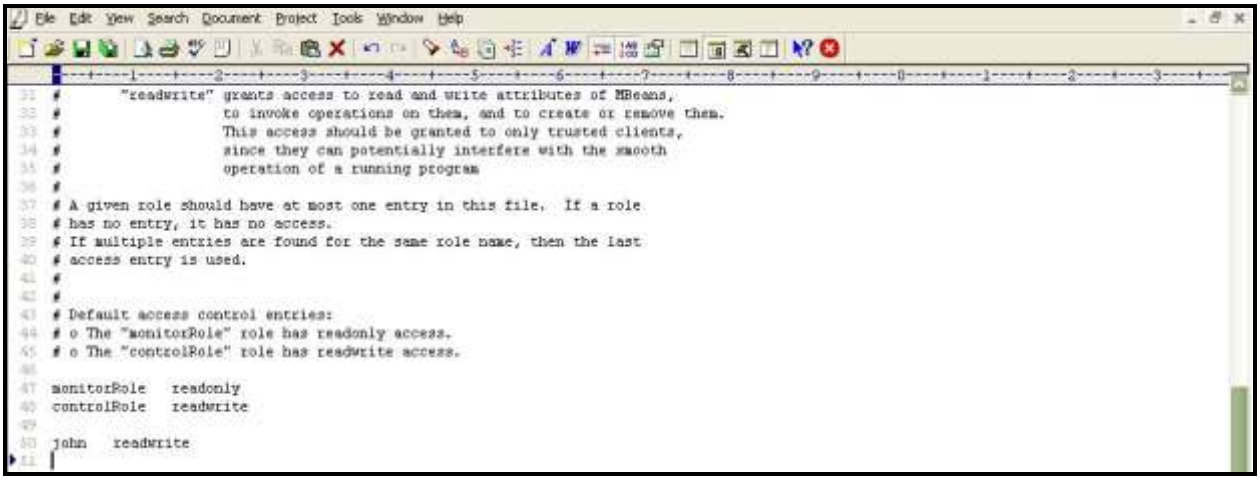


Figure 14: Assigning rights to the new user in the jmxremote.access file

14. Then, save the *jmxremote.access* file.
15. Finally, proceed to configure the tests with the user name and password, *john* and *john*, respectively.

1.1.2 Enabling SNMP Support for JRE

Instead of JMX, you can configure the eG agent to monitor a Java application using SNMP-based access to the Java runtime MIB statistics.

In some environments, SNMP access might have to be authenticated by an ACL (Access Control List), and in some other cases, it might not require an ACL.

If SNMP access **does not require ACL authentication**, then follow the steps below to enable SNMP support:

1. Login to the application host.

2. Ensure that the SNMP service and the SNMP Trap Service are running on the host.
3. Next, edit the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application.
4. Append the following lines to the file:

```
com.sun.management.snmp.port=<Port No>
com.sun.management.snmp.interface=0.0.0.0
com.sun.management.snmp.acl=false
```

For instance, if the SNMP port is 1166, then the first line of the above specification will be:

```
com.sun.management.snmp.port=1166
```

If the second line of the specification is set to *0.0.0.0*, then, it indicates that the JRE will accept SNMP requests from any host in the environment. To ensure that the JRE services only those SNMP requests that are received from the eG agent, set the second line of the specification to the IP address of the agent host. For instance, if the eG agent to monitor the Java application is executing on *192.168.10.152*, then the second line of the specification will be:

```
com.sun.management.snmp.interface=192.168.10.152
```

5. Next, edit the start-up script of the target application, include the following line it, and save the script file.

```
-Dcom.sun.management.config.file=<management.properties_file_path>
```

6. For instance, on a Windows host, the *<management.properties_file_path>* can be expressed as: **D:\bea\jrockit_150_11\jre\lib\management\management.properties**.
7. On other hand, on a Unix/Linux/Solaris host, a sample *<management.properties_file_path>* specification will be as follows: **/usr/jdk1.5.0_05/jre/lib/management/management.properties**.

On the contrary, if SNMP access requires **ACL authentication**, then follow the steps below to enable SNMP support for the JRE:

1. Login to the application host. If the target application is executing on a Windows host, login as a local/domain administrator.
2. Ensure that the SNMP service and SNMP Trap Service are running on the host.
3. Copy the *snmp.acl.template* file in the **<JAVA_HOME>\jre\lib\management** folder to another location on the local host. Rename the *snmap.acl.template* file as *snmp.acl*, and copy the *snmp.acl* file back to the **<JAVA_HOME>\jre\lib\management** folder.
4. Next, edit the *snmp.acl* file, and set rules for SNMP access in the file.

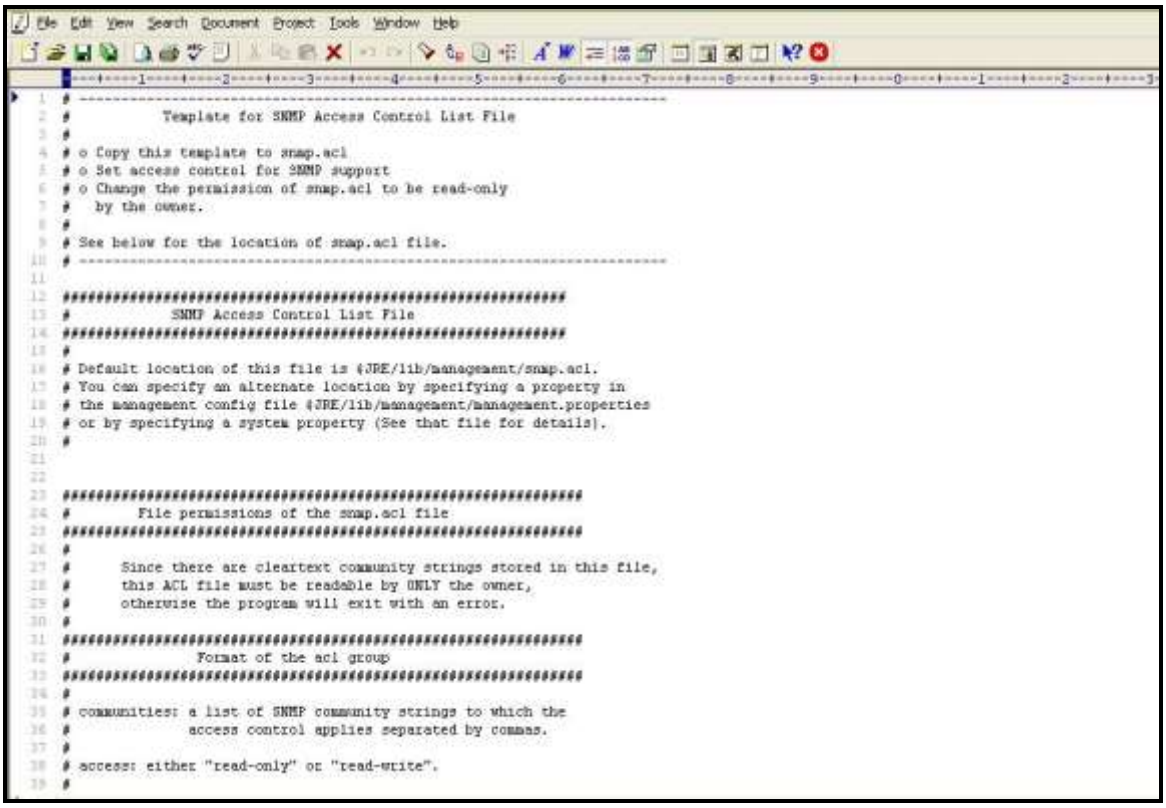


Figure 15: The snmp.acl file

5. For that, first scroll down the file to view the sample code block revealed by Figure 16.

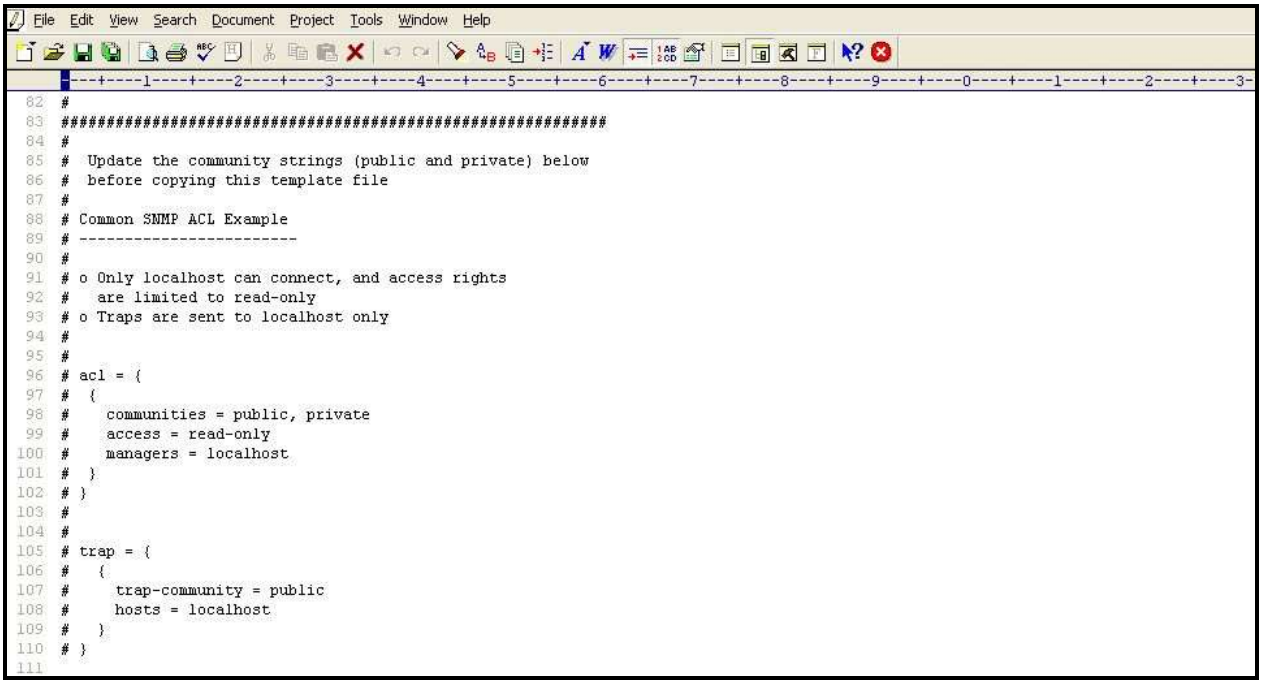


Figure 16: The snmp.acl file revealing the SNMP ACL example

6. Uncomment the code block by removing the # symbol preceding each line of the block as indicated by Figure

17.

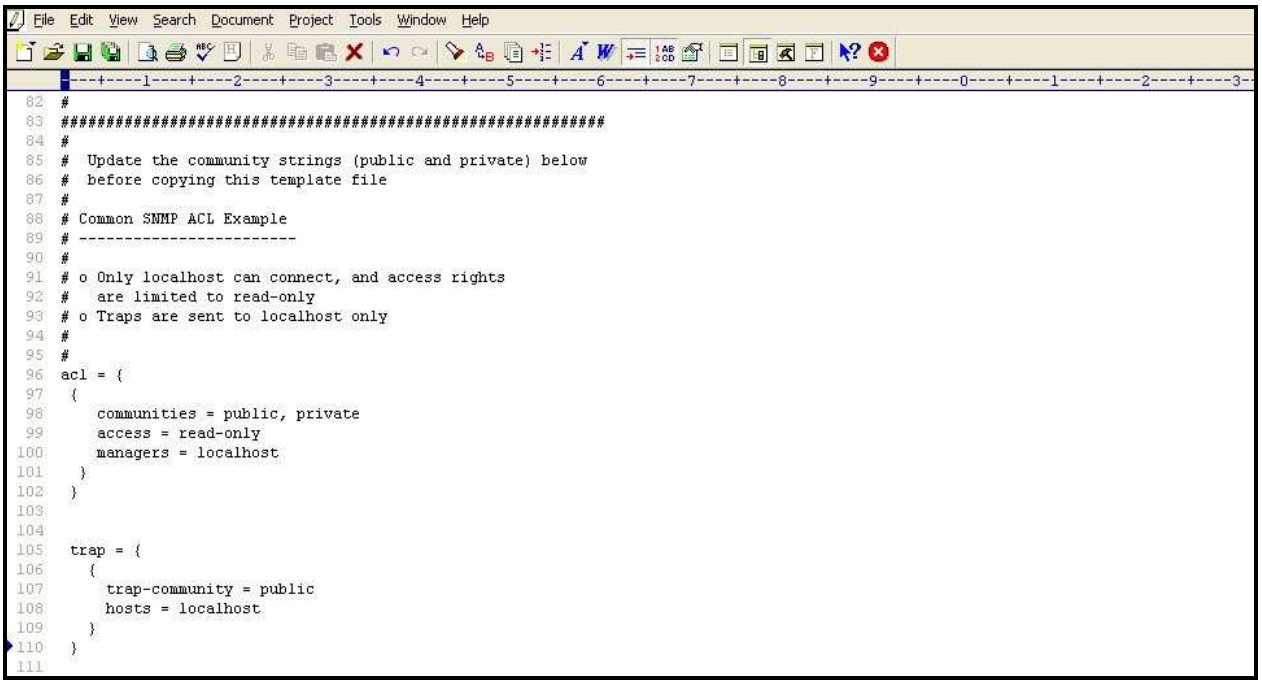


Figure 17: Uncommenting the code block

7. Next, edit the code block to suit your environment.

8. The *acl* block expects the following parameters:

   - *communities* : Provide a comma-separated list of community strings, which an SNMP request should carry for it to be serviced by this JRE; in the example illustrated by Figure 17, the community strings recognized by this JRE are *public* and *private*. You can add more to this list, or remove a *community string* from this list, if need be.

   - *access* : Indicate the access rights that SNMP requests containing the defined *communities* will have; in Figure 17, SNMP requests containing the community string *public* or *private*, will have only *read-only* access to the MIB statistics. To grant full access, you can specify *rea-write* instead.

   - *managers :* Specify a comma-separated list of SNMP managers or hosts from which SNMP requests will be accepted by this JRE; in the example illustrated by Figure 17, all SNMP requests from the *localhost* will be serviced by this JRE. Typically, since the SNMP requests originate from an eG agent, the IP of the eG agent should be configured against the *managers* parameter. For instance, if the IP address of the agent host is *192.16.10.160*, then, to ensure that the JRE accepts requests from the eG agent alone, set *managers* to *192.168.10.160*, instead of *localhost*.

9. Every *acl* block in the *snmp.acl* file should have a corresponding *trap* block. This *trap* block should be configured with the following values:

   - *trap-community*: Provide a comma-separated list of community strings that can be used by SNMP traps sent by the Java application to the *managers* specified in the *acl* block. In the example of Figure 17, all SNMP traps sent by the Java application being monitored should use the community string *public* only.

- *hosts*: Specify a comma-separated list of IP addresses / host names of hosts from which SNMP traps can be sent. In the case of Figure 17, traps can be sent by the *localhost* only. If a single *snmp.acl* file is being centrally used by multiple applications/devices executing on multiple hosts, then to ensure that all such applications are able to send traps to the configured SNMP *managers* (in the *acl* block), you can provide the IP address/hostname of these applications as a comma-separated list against *hosts*.

10. Figure 18 depicts how the *acl* and *trap* blocks can be slightly changed to suit the monitoring needs of an application.

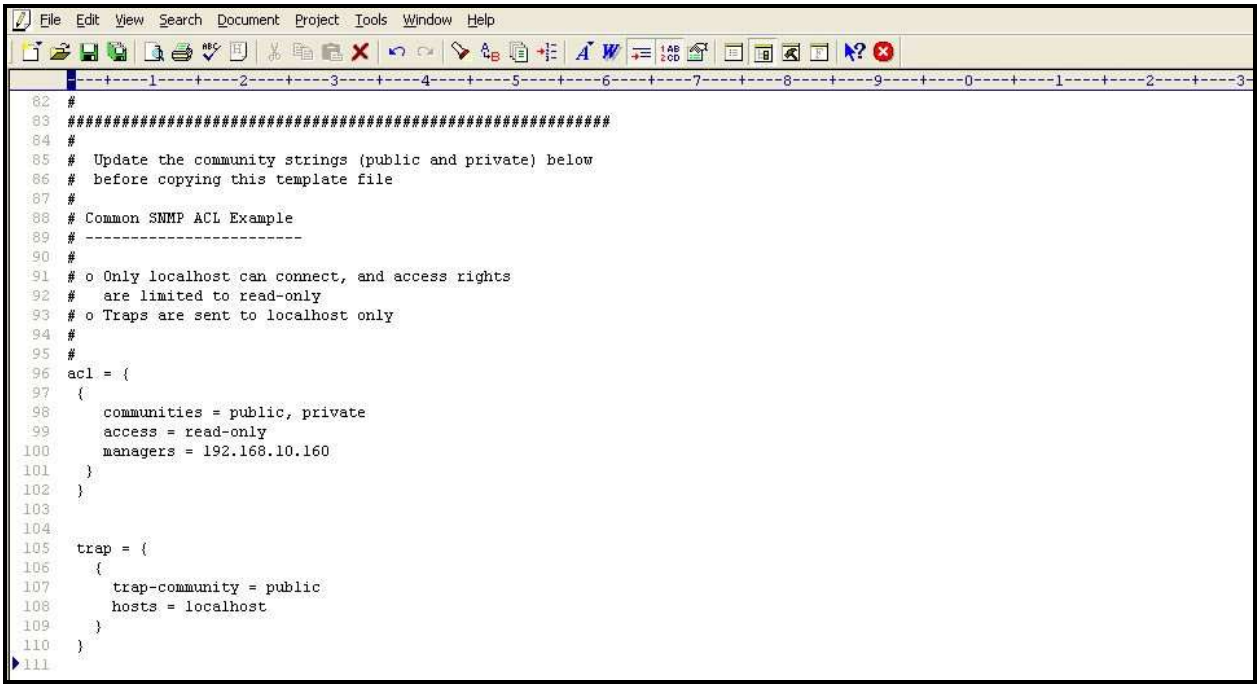


Figure 18: The edited block

11. Then, proceed to make the *snmp.acl* file secure by granting a single user "full access" to that file. For monitoring applications executing on Windows in particular, only the *Owner* of the *snmp,.acl* file should have full control of that file. To know how to grant this privilege to the *Owner* of a file, refer to Section 1.1.1.1. This section actually details the procedure for making the *jmxremote.password* file on Windows, secure. Use the same procedure for making the *snmp.acl* file on Windows secure, but make sure that you select the *snmp.acl* file and not the *jmxremote.password* file.

12. In case of applications executing on Solaris / Linux hosts on the other hand, any user can be granted full access to the *snmp.acl* file, by following the steps below:

    - Login to the host as the user who is to be granted full control of the *snmp.acl* file.
    - Issue the following command:

      chmod 600 snmp.acl

    - This will automatically grant the login user full access to the *jmxremote.password* file.

13. Next, edit the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application.

14. Append the following lines to the file:

```
com.sun.management.snmp.port=<PortNo>
com.sun.management.snmp.interface=0.0.0.0
com.sun.management.snmp.acl=true
com.sun.management.snmp.acl.file=<Path_of_snmp.acl>
```

If the second line of the specification is set to *0.0.0.0*, then, it indicates that the JRE will accept SNMP requests from any host in the environment. To ensure that the JRE services only those SNMP requests that are received from the eG agent, set the second line of the specification to the IP address of the agent host.

For example, if the Java application being monitored listens for SNMP requests at port number 1166, the eG agent monitoring the Java application is deployed on *192.168.10.152*, and these SNMP requests need to be authenticated using the *snmp.acl* file in the **D:\bea\jrockit_150_11\jre\lib** directory, then the above specification will read as follows:

```
com.sun.management.snmp.port=1166
com.sun.management.snmp.interface=192.168.10.152
com.sun.management.snmp.acl=true
com.sun.management.snmp.acl.file=D:\\bea\\jrockit_150_11\\jre\\lib\\management\\sn
mp.acl
```

15. However, if the application in question is executing on a Unix/Solaris/Linux host, and the *snmp.acl* file is in the **/usr/jdk1.5.0_05/jre/lib/management** folder of the host, then the last line of the specification will be:

```
com.sun.management.snmp.acl.file =/usr/jdk1.5.0_05/jre/lib/management/snmp.acl
```

16. Next, edit the start-up script of the target application, include the following line in it, and save the script file.

```
-Dcom.sun.management.config.file=<management.properties_file_path>
```

17. For instance, on a Windows host, the *<management.properties_file_path>* can be expressed as: **D:\bea\jrockit_150_11\jre\lib\management\management.properties**.

18. On other hand, on a Unix/Linux/Solaris host, a sample *<management.properties_file_path>* specification will be as follows: **/usr/jdk1.5.0_05/jre/lib/management/management.properties**.

The sections to come discuss the top 2 layers of Figure 1, as the remaining layers have already been discussed at length in the *Monitoring Unix and Windows Servers* document.

1.2 The Java Transactions Layer

By default, this layer will not be available for any monitored **Java Application**. This is because, the **Java Transactions** test mapped to this layer is disabled by default. To enable the test, follow the *Agents -> Tests -> Enable/Disable*

menu sequence, select *Java Application* as the **Component type**, *Performance* as the **Test type**, and then select **Java Transactions** from the **DISABLED TESTS** list. Click the **Enable** button to enable the selected test, and click the **Update** button to save the changes.

The **Java Transactions** test, once enabled, will allow you to monitor configured patterns of transactions to the target Java application, and report their response times, so that slow transactions and transaction exceptions are isolated and the reasons for the same analyzed. For the **Java Transactions** test to execute, you need to enable the **Java Transaction Monitoring (JTM)** capability of the eG agent. The procedure for the same has been discussed in Section 1.2.1.1 of this document.

Java Transaction Monitoring (JTM) can be enabled only for those Java applications that use **JDK 1.5 or higher**.

Figure 19: The test mapped to the Java Transactions layer

1.2.1 Java Transactions Test

When a user initiates a transaction to a J2EE application, the transaction typically travels via many sub-components before completing execution and sending out a response to the user.

Figure 20 reveals some of the sub-components that a web transaction/web request visits during its journey.

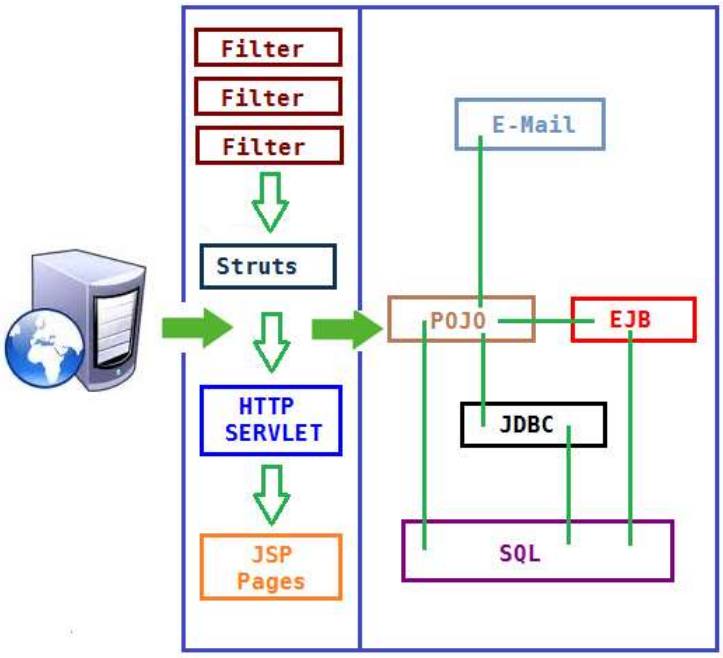


Figure 20: The layers through which a Java transaction passes

The key sub-components depicted by Figure 20 have been briefly described below:

- **Filter:** A filter is a program that runs on the server before the servlet or JSP page with which it is associated. All filters must implement **javax.servlet.Filter**. This interface comprises three methods: **init, doFilter, and destroy.**

- **Servlet:** A servlet acts as an intermediary between the client and the server. As servlet modules run on the server, they can receive and respond to requests made by the client. If a servlet is designed to handle HTTP requests, it is called an **HTTP Servlet**.

- **JSP:** Java Server Pages are an extension to the Java servlet technology. A JSP is translated into Java servlet before being run, and it processes HTTP requests and generates responses like any servlet. Translation occurs the first time the application is run.

- **Struts:** The Struts Framework is a standard for developing well-architected Web applications. Based on the Model-View-Controller (MVC) design paradigm, it distinctly separates all three levels (Model, View, and Control).

A delay experienced by any of the aforesaid sub-components can adversely impact the total response time of the transaction, thereby scarring the user experience with the web application. In addition, delays in JDBC connectivity and slowdowns in SQL query executions (if the application interacts with a database), bottlenecks in delivery of mails via the Java Mail API (if used), and any slow method calls, can also cause insufferable damage to the 'user-perceived' health of a web application.

The challenge here for administrators is to not just isolate the slow transactions, but to also accurately identify where the transaction slowed down and why - is it owing to inefficent JSPs? poorly written servlets or struts? poor or the lack of any JDBC connectivity to the database? long running queries? inefficient API calls? or delays in accessing the POJO methods? The **eG JTM Monitor** provides administrators with answers to these questions!

With the help of the **Java Transactions** test, the **eG JTM Monitor** traces the route a configured web transaction takes, and captures live the total responsiveness of the transaction and the response time of each Java component it visits en route. This way, the solution proactively detects transaction slowdowns, and also precisely points you to the sub-

components causing it - is it the Filters? JSPs? Servlets? Struts? JDBC? SQL query? Java Mail API? or the POJO? In addition to revealing where (i.e., at which Java component) a transaction slowed down, the solution also provides the following intelligent insights, on demand, making root-cause identification and resolution easier:

- A look at the methods that took too long to execute, thus leading you to those methods that may have contributed to the slowdown;
- Single-click access to each invocation of a chosen method, which provides pointers to when and where a method spent longer than desired;
- A quick glance at SQL queries and Java errors that may have impacted the responsiveness of the transaction;

Using these interesting pointers provided by the **eG JTM Monitor**, administrators can diagnose the root-cause of transaction slowdowns within minutes, rapidly plug the holes, and thus ensure that their critical web applications perform at peak capacity at all times!

1.2.1.1 How does eG Perform Java Transaction Monitoring?

Figure 21 depicts how eG monitors Java transactions.

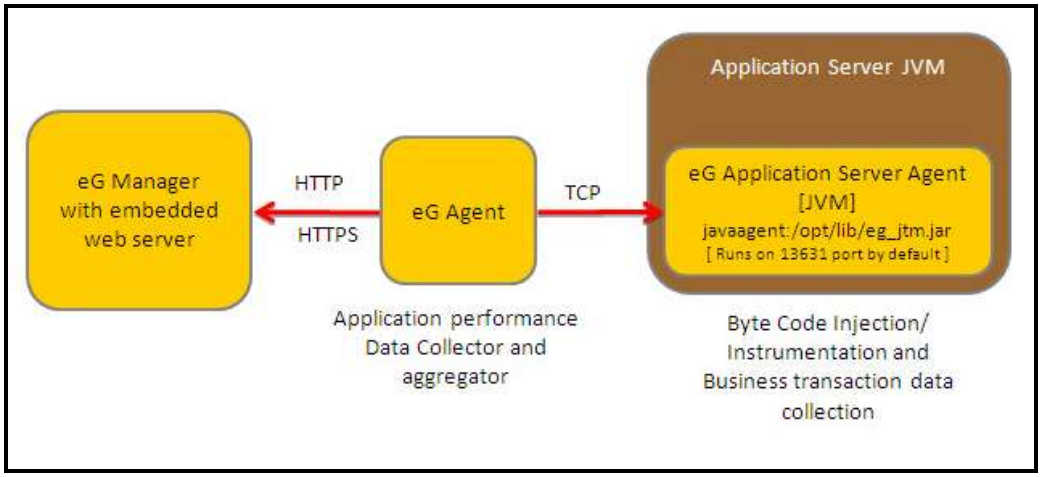


Figure 21: How eG monitors Java transactions

To track the live transactions to a J2EE application, eG Enterprise requires that a special **eG Application Server Agent** be deployed on the target application. The **eG Application Server Agent** is available as a file named **eg_jtm.jar** on the eG agent host, which has to be copied to the system hosting the application being monitored. The detailed steps for deployment have been discussed hereunder:

In the **<EG_INTALL_DIR>\lib\jtm** directory (on Windows; on Unix, this will be **/opt/egurkha/lib/jtm**) of the eG agent, you will find the following files:

- **eg_jtm.jar**
- **aspectjrt.jar**
- **aspectjweaver.jar**
- **jtmConn.props**
- **jtmLogging.props**
- **jtmOther.props**

Login to the system hosting the Java application to be monitored.

If the eG agent will be 'remotely monitoring' the target Java application (i.e., if the Java application is to be monitored in an 'agentless manner'), then, copy all the files mentioned above from the **<EG_INSTALL_DIR>\lib\jtm** directory (on Windows; on Unix, this will be **/opt/egurkha/lib/jtm**) of the eG agent to any location on the Java application host.

Then, proceed to edit the start-up script of the Java application being monitored, and append the following lines to it:

```
set JTM_HOME=<<PATH OF THE LOCAL FOLDER CONTAINING THE JAR FILES AND PROPERTY FILES
LISTED ABOVE>>
"-javaagent:%JTM_HOME%\aspectjweaver.jar"
"-DEG_JTM_HOME=%JTM_HOME%"
```

Note that the above lines will change based on the operating system and the web/web application server being monitored.

Then, add the **eg_jtm.jar**, **aspectjrt.jar**, and **aspectjweaver.jar** files to the **CLASSPATH** of the Java application being monitored.

Finally, save the file.

Next, edit the **jtmConn.props** file. You will find the following lines in the file:

```
#Contains the connection properties of eGurkha Java Transaction Monitor
JTM_Port=13631
Designated_Agent=
```

By default, the **JTM_Port** parameter is set to 13631. If the Java application being monitored listens on a different JTM port, then specify the same here. In this case, when managing a **Java Application** using the eG administrative interface, specify the **JTM_Port** that you set in the **jtmConn.props** file as the **Port** of the Java application.

Also, against the **Designated_Agent** parameter, specify the IP address of the eG agent which will poll the **eG JTM Monitor** for metrics. If no IP address is provided here, then the **eG JTM Monitor** will treat the host from which the very first 'measure request' comes in as the **Designated_Agent**.

In case a specific **Designated_Agent** is not provided, and the **eG JTM Monitor** treats the host from which the very first 'measure request' comes in as the **Designated_Agent**, then if such a **Designated_Agent** is stopped or uninstalled for any reason, the **eG JTM Monitor** will wait for a maximum of 10 measure periods for that 'deemed' **Designated_Agent** to request for metrics. If no requests come in for 10 consecutive measure periods, then the **eG JTM Monitor** will begin responding to 'measure requests' coming in from any other eG agent.

Finally, save the **jtmConn.props** file.

Restart the Java application.

Each request in the J2EE architecture is handled by a thread. Once the Java application is restarted therefore, the **eG Application Sever Agent** uses the thread ID and thread local data to keep track of requests to configured URL patterns (see Figure 22).

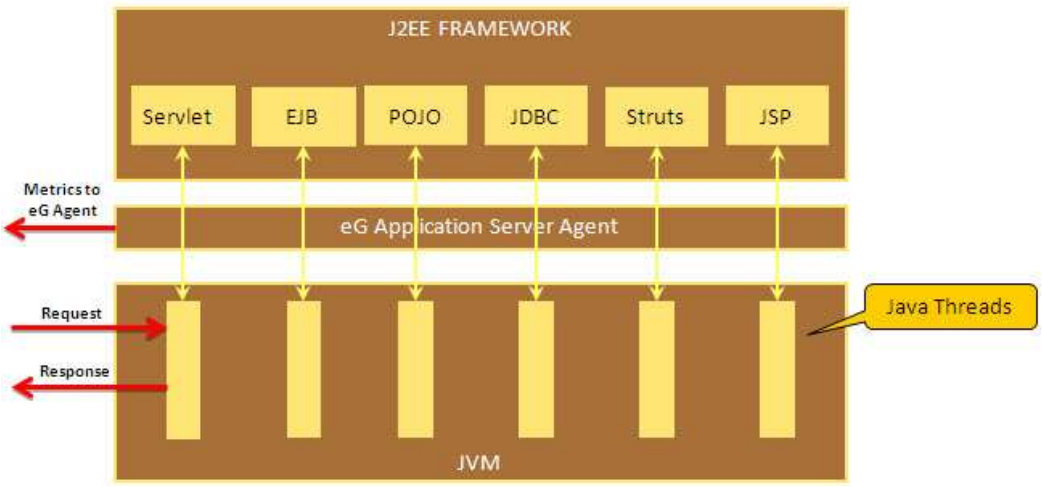


Figure 22: The eG Application Server Agent tracking requests using Java threads

In the process, the **eG Application Sever Agent** collects metrics for each URL pattern and stores them in memory. Then, every time the **Java Transactions** test runs, the eG agent will poll the **eG Application Server Agent** for the required metrics, extract the same from the memory, and report them to the eG manager.

The table below explains how to configure the **Java Transactions** test and what measures it reports.

- If the value of any of the parameters of the **Java Transactions** test is changed at a later point in time, then the test will not report any metrics for the measurement cycle that immediately follows the change. For instance, say that the **Java Transactions** test has been configured to run every 10 minutes, and the last time the test executed was as at 10.30 AM. This means that the test will execute next at 10.40 AM. Now, if you make changes to the test parameters at say, 10.35 AM, no metrics will be reported by the test when it executes at 10.40 AM. However, subsequently, when the test executes again at 10.50 AM, it will report all metrics.
- If multiple instances of a Java application are running on a single host, then, you can monitor the Java transactions of all instances using the **eg_jtm.jar** file available in the **<EG_INSTALL_DIR>\lib\jtm** folder (on Windows; this will be the **/opt/egurkha/lib/jtm** folder) of that host.

Purpose	Traces the route a configured web transaction takes, and captures live the total responsiveness of the transaction and the response time of each component it visits en route. This way, the solution proactively detects transaction slowdowns, and also precisely points you to the Java component causing it - is it the Filters? JSPs? Servlets? Struts? JDBC? SQL query? Java Mail API? or the POJO?
Target of the test	A Java application
Agent deploying the test	An internal/remote agent

Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens; if **Java Transaction Monitoring** is enabled for the target Java application, then the **JTM PORT** has to be specified here 4. **JTM PORT** – Specify the port number configured as the **JTM_Port** in the **jtmConn.props** file described in the procedure outlined above. 5. **URL PATTERNS** - Provide a comma-separated list of the URL patterns of web requests/transactions to be monitored. The format of your specification should be as follows: *<DisplayName_of_Pattern>:<Transaction_Pattern>*. For instance, your specification can be: *login:*log*,ALL:*,pay:*pay** 6. **FILTERED URL PATTERNS** - Provide a comma-separated list of the URL patterns of transactions/web requests to be excluded from the monitoring scope of this test. For example, **blog*,*paycheque** 7. **SLOW URL THRESHOLD** - The *Slow transactions* measure of this test will report the number of transactions (of the configured patterns) for which the response time is higher than the value (in seconds) specified here. 8. **METHOD EXEC CUTOFF** - The detailed diagnosis of the *Slow transactions* measure allows you to drill down to a **URL tree**, where the methods invoked by a chosen transaction are listed in the descending order of their execution time. By configuring an execution duration (in seconds) here, you can have the **URL Tree** list only those methods that have been executing for a duration greater the specified value. For instance, if you specify *5* here, the URL tree for a transaction will list only those methods that have been executing for over 5 seconds, thus shedding light on the slow method calls alone. 9. **MAX SLOW URLS PER TEST PERIOD** - Specify the number of top-n transactions (of a configured pattern) that should be listed in the detailed diagnosis of the *Slow transactions* measure, every time the test runs. By default, this is set to *10*, indicating that the detailed diagnosis of the *Slow transactions* measure will by default list the top-10 transactions, arranged in the descending order of their response times. 10. **MAX ERROR URLS PER TEST PERIOD** - Specify the number of top-n transactions (of a configured pattern) that should be listed in the detailed diagnosis of the *Error transactions* measure, every time the test runs. By default, this is set to *10*, indicating that the detailed diagnosis of the *Error transactions* measure will by default list the top-10 transactions, in terms of the number of errors they encountered.

	11. **DD FREQUENCY** - Refers to the frequency with which detailed diagnosis measures are to be generated for this test. The default is *1:1*. This indicates that, by default, detailed measures will be generated every time this test runs, and also every time the test detects a problem. You can modify this frequency, if you so desire. Also, if you intend to disable the detailed diagnosis capability for this test, you can do so by specifying *none* against **DD FREQUENCY**. 12. **DETAILED DIAGNOSIS** - To make diagnosis more efficient and accurate, the eG Enterprise suite embeds an optional detailed diagnostic capability. With this capability, the eG agents can be configured to run detailed, more elaborate tests as and when specific problems are detected. To enable the detailed diagnosis capability of this test for a particular server, choose the **On** option. To disable the capability, click on the **Off** option. The option to selectively enable/disable the detailed diagnosis capability will be available only if the following conditions are fulfilled: • The eG manager license should allow the detailed diagnosis capability • Both the normal and abnormal frequencies configured for the detailed diagnosis measures should not be 0.		
Outputs of the test	One set of results for each configured URL pattern		
Measurements made by the test	**Measurement**	**Measurement Unit**	**Interpretation**
	Total transactions: Indicates the total number of transactions of this pattern that the target application handled during the last measurement period.	Number	
	Avg. response time: Indicates the average time taken by the transactions of this pattern to complete execution.	Secs	Compare the value of this measure across patterns to isolate the type of transactions that were taking too long to execute. You can then take a look at the values of the other measures to figure out where the transaction is spending too much time.
	Slow transactions: Indicates the number of transactions of this pattern that were slow during the last measurement period.	Number	This measure will report the number of transactions with a response time higher than the configured **SLOW URL THRESHOLD**. A high value is a cause for concern, as too many slow transactions to an application can significantly damage the user experience with that application. Use the detailed diagnosis of this measure to know which transactions are slow.

	Slow transactions response time: Indicates the average time taken by the slow transactions of this pattern to execute.	Secs	
	Error transactions: Indicates the number of transactions of this pattern that experienced errors during the last measurement period.	Number	A high value is a cause for concern, as too many error-prone transactions to an application can significantly damage the user experience with that application. Use the detailed diagnosis of this measure to isolate the error transactions.
	Error transactions response time: Indicates the average duration for which the transactions of this pattern were processed before an error condition was detected.	Secs	
	Filters: Indicates the number of filters that were accessed by the transactions of this pattern during the last measurement period.	Number	A filter is a program that runs on the server before the servlet or JSP page with which it is associated.
	Filters response time: Indicates the average time spent by the transactions of this pattern at the **Filters** layer.	Secs	Typically, the **init, doFilter, and destroy** methods are called at the **Filters** layer. Issues in these method invocations can increase the time spent by a transaction in the **Filters** Java component. Compare the value of this measure across patterns to identify the transaction pattern that spent the maximum time with the **Filters** component. If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - in the filters, in JSPs, in servlets, in struts, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs.
	JSPs accessed: Indicates the number of JSPs accessed by the transactions of this pattern during the last measurement period.	Number	

	JSPs response time: Indicates the average time spent by the transactions of this pattern at the **JSP** layer.	Secs	Compare the value of this measure across patterns to identify the transaction pattern that spent the maximum time in **JSPs**. If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - in the filters, in JSPs, in servlets, in struts, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs..
	HTTP Servlets Accessed: Indicates the number of HTTP servlets that were accessed by the transactions of this pattern during the last measurement period.	Number	
	HTTP servlets response time: Indicates the average time taken by the HTTP servlets for processing the HTTP requests of this pattern.	Secs	Badly written servlets can take too long to execute, and can hence obstruct the smooth execution of the dependent transactions. By comparing the value of this measure across patterns, you can figure out which transaction pattern is spending the maximum time in **Servlets**. If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - in the filters, in JSPs, in servlets, in struts, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs.
	Generic servlets accessed: Indicates the number of generic (non-HTTP) servlets that were accessed by the transactions of this pattern during the last measurement period.	Number	

	Generic servlets response time: Indicates the average time taken by the generic (non-HTTP) servlets for processing transactions of this pattern.	Secs	Badly written servlets can take too long to execute, and can hence obstruct the smooth execution of the dependent transactions. By comparing the value of this measure across patterns, you can figure out which transaction pattern is spending the maximum time in **Servlets**. If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - in the filters, in JSPs, in servlets, in struts, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs.
	JDBC queries: Indicates the number of JDBC statements that were executed by the transactions of this pattern during the last measurement period.	Number	The methods captured by the **eG JTM Monitor** from the Java class for the JDBC sub-component include: `Commit()`, `rollback(..)`, `close()`,`GetResultSet()`, `executeBatch()`, `cancel()`, `connect(String, Properties)`, `getConnection(..)`,`getPooledConnection(..)`
	JDBC response time: Indicates the average time taken by the transactions of this pattern to execute JDBC statements.	Secs	By comparing the value of this measure across patterns, you can figure out which transaction pattern is taking the most time to execute JDBC queries. If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - in the filters, in JSPs, in servlets, in struts, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs.
	SQL statements executed: Indicates the number of SQL queries executed by the transactions of this pattern during the last measurement period.	Number	

	SQL statement time avg.: Indicates the average time taken by the transactions of this pattern to execute SQL queries.	Secs	Inefficient queries can take too long to execute on the database, thereby significantly delaying the responsiveness of the dependent transactions. To know which transactions have been most impacted by such queries, compare the value of this measure across the transaction patterns. If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - at the filters layer, JSPs layer, servlets layer, struts layer, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs.
	Exceptions seen: Indicates the number of exceptions encountered by the transactions of this pattern during the last measurement period.	Number	Ideally, the value of this measure should be 0.
	Exceptions response time: Indicates the average time which the transactions of this pattern spent in handling exceptions.	Secs	If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - at the filters layer, JSPs layer, servlets layer, struts layer, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs.
	Struts accessed: Indicates the number of struts accessed by the transactions of this pattern during the last meaurement period.	Number	The **Struts** framework is a standard for developing well-architected Web applications.

	Struts response time: Indicates the average time spent by the transactions of this pattern at the **Struts** layer.	Secs	If you compare the value of this measure across patterns, you can figure out which transaction pattern spent the maximum time in **Struts**. If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - in the filters, in JSPs, in servlets, in struts, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs.
	Java mails: Indicates the number of mails sent by the transactions of this pattern during the last measurement period, using the Java mail API.	Number	The **eG JTM Monitor** captures any mail that has been sent from the monitored application using Java Mail API. Mails sent using other APIs are ignored by the **eG JTM Monitor**.
	Java mail API time: Indicates the average time taken by the transactions of this pattern to send mails using the Java mail API.	Secs	If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - in the filters, in JSPs, in servlets, in struts, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs.
	POJOs: Indicates the number of transactions of this pattern that accessed POJOs during the last measurement period.	Number	Plain Old Java Object (POJO) refers to a 'generic' method in JAVA Language. All methods that are not covered by any of the Java components (eg., JSPs, Struts, Servlets, Filters, Exceptions, Queries, etc.) discussed above will be automatically included under POJO. When reporting the number of POJO methods, the eG agent will consider only those methods with a response time value that is higher than the threshold limit configured against the **METHOD EXEC CUTOFF** parameter.

	POJO avg. access time: Indicates the average time taken by the transactions of this pattern to access POJOs.	Secs	If one/more transactions of a pattern are found to be slow, then, you can compare the value of this measure with the other response time values reported by this test to determine where the slowdown actually occurred - in the filters, in JSPs, in servlets, in struts, in exception handling, when executing JDBC/SQL queries, when sending Java mails, or when accessing POJOs.
	HTTP calls: Indicates the number of HTTP calls made by transactions of this pattern.	Number	
	Web service calls: Indicates the number of calls made by the transactions of this pattern to web services.	Number	
	HTTP avg. call time: Indicates the average time taken by the transactions of this pattern to make the HTTP calls.	Secs	In the event of a transaction slowdown, you can compare the value of this measure with the other response time values reported for this transaction pattern to know whether the HTTP calls could have delayed transaction execution.
	Web service avg. call time: Indicates the average time taken by the transactions of this pattern to make web service calls.	Secs	In the event of a transaction slowdown, you can compare the value of this measure with the other response time values reported for this transaction pattern to know whether the web service calls could have delayed transaction execution.

The detailed diagnosis of the *Slow transactions* measure lists the top-10 (by default) transactions of a configured pattern that have violated the response time threshold set using the **SLOW URL THRESHOLD** parameter of this test. Against each transaction, the date/time at which the transaction was initiated/requested will be displayed. Besides the request date/time, the remote host from which the transaction request was received and the total response time of the transaction will also be reported. This response time is the sum total of the response times of each of the top methods (in terms of time taken for execution) invoked by that transaction. To compute this sum total, the test considers only those methods with a response time value that is higher than the threshold limit configured against the **METHOD EXEC CUTOFF** parameter.

In the detailed diagnosis, the transactions will typically be arranged in the descending order of the total response time; this way, you would be able to easily spot the slowest transaction. To know what caused the transaction to be slow, you can take a look at the **SUBCOMPONENT DETAILS** column of the detailed diagnosis. Here, the time spent by the transaction in each of the Java components (**FILTER**, **STRUTS**, **SERVLETS**, **JSPS**, **POJOS**, **SQL**, **JDBC**, etc.) will be listed, thus leading you to the exact Java component where the slowdown occurred.

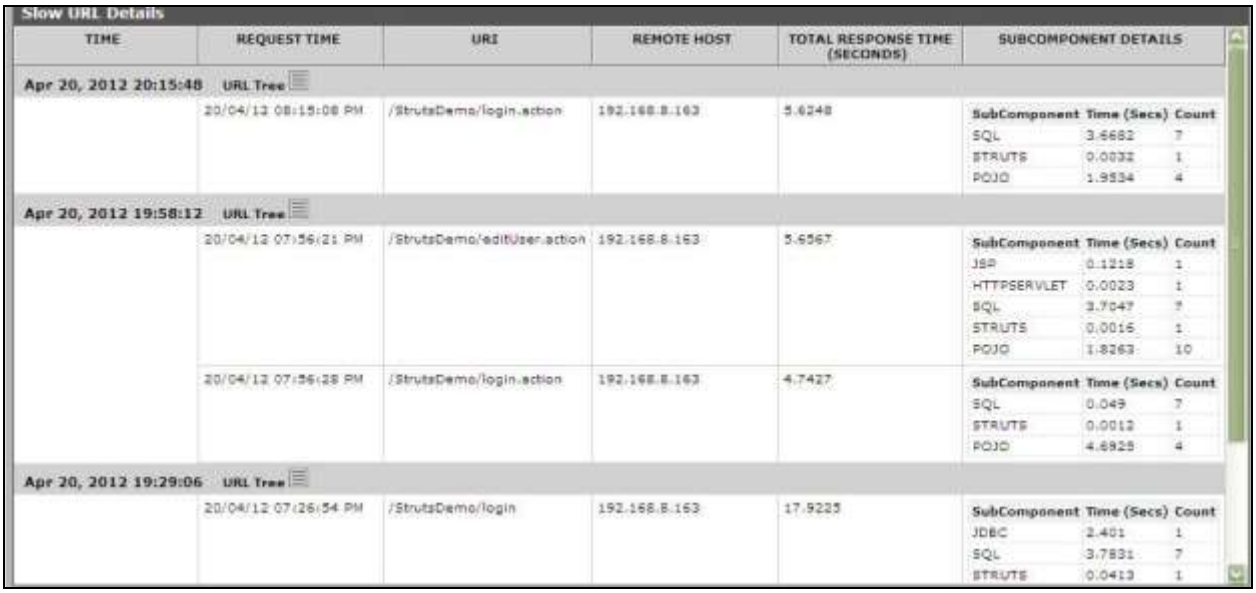


Figure 23: The detailed diagnosis of the Slow transactions measure

Note

If the target server is running in a time zone different from the time zone preference of the user who is currently logged into the eG management console, then you are sure to notice significant discrepancies in the **REQUEST TIME** of the transactions displayed in the **Detailed Diagnosis** and the time at which the eG agent collected the detailed measures – i.e, the **TIME** display in the **Detailed Diagnosis** page of Figure 23.

You can even perform detailed method-level analysis to isolate the methods taking too long to execute. For this, click on the **URL Tree** link. Figure 24 will then appear. In the left panel of Figure 24, you will find the list of transactions that match a configured pattern; these transactions will be sorted in the descending order of their *Total Response Time* (by default). This is indicated by the **Total Response Time** option chosen by default from the **Sort by** list in Figure 24. If you select a transaction from the left panel, an **At-A-Glance** tab page will open by default in the right panel, providing quick, yet deep insights into the performance of the chosen transaction and the reasons for its slowness. This tab page begins by displaying the **URL** of the chosen transaction, the total **Response time** of the transaction, the time at which the transaction was last requested, and the **Remote Host** from which the request was received.

If the **Response time** appears to be very high, then you can take a look at the **Method Level Breakup** section to figure out which method called by which Java component (such as **FILTER**, **STRUTS**, **SERVLETS**, **JSPS**, **POJOS**, **SQL**, **JDBC**, etc.) could have caused the slowdown. This section provides a horizontal bar graph, which reveals the percentage of time for which the chosen transaction spent executing each of the top methods (in terms of execution time) invoked by it. The legend below clearly indicates the top methods and the layer/sub-component that invoked each method. Against every method, the number of times that method was invoked in the **Measurement Time**, the **Duration** (in Secs) for which the method executed, and the percentage of the total execution time of the transaction for which the method was in execution will be displayed, thus quickly pointing you to those methods that may have contributed to the slowdown. The methods displayed here and featured in the bar graph depend upon the **METHOD EXEC CUTOFF** configuration of this test - in other words, only those methods with an execution duration that exceeds the threshold limit configured against **METHOD EXEC CUTOFF** will be displayed in the **Method Level Breakup** section.

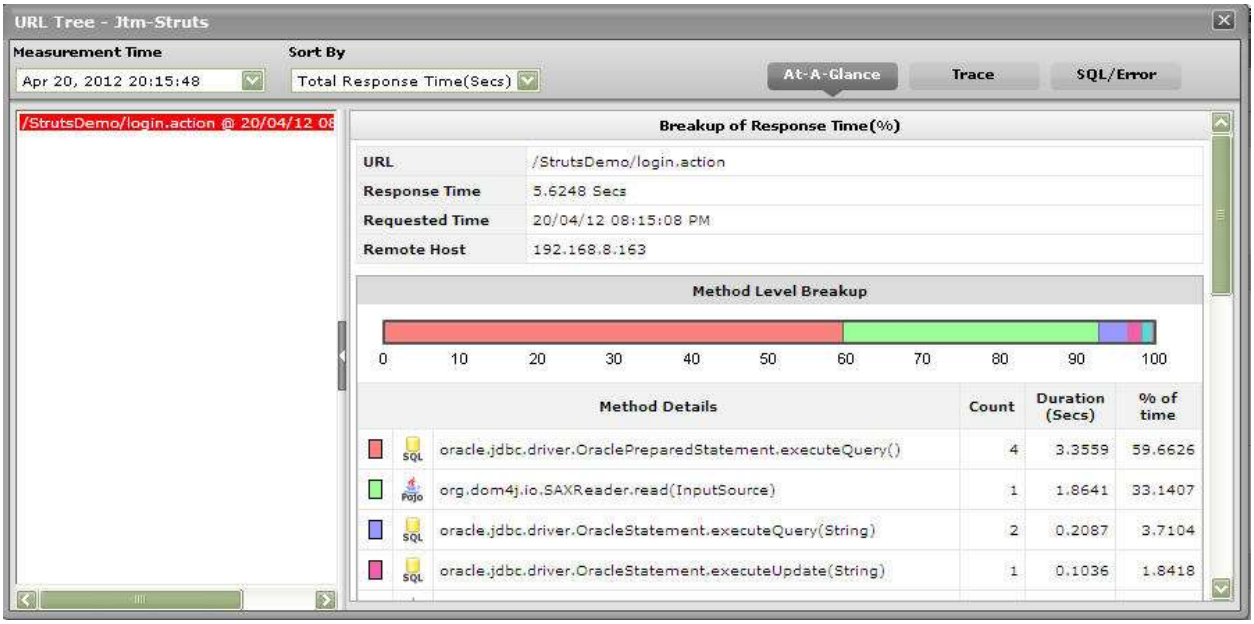


Figure 24: The Method Level Breakup section in the At-A-Glance tab page

While the **Method Level Breakup** section provides method-level insights into responsiveness, for a sub-component or layer level breakup of responsiveness scroll down the **At-A-Glance** tab to view the **Component Level Breakup** section (see Figure 25). Using this horizontal bar graph, you can quickly tell where - i.e., in which Java component - the transaction spent the maximum time. A quick glance at the graph's legend will reveal the Java components the transaction visited, the number of methods invoked by Java component, the **Duration (Secs)** for which the transaction was processed by the Java component, and what **Percentage** of the total transaction response time was spent in the Java component.

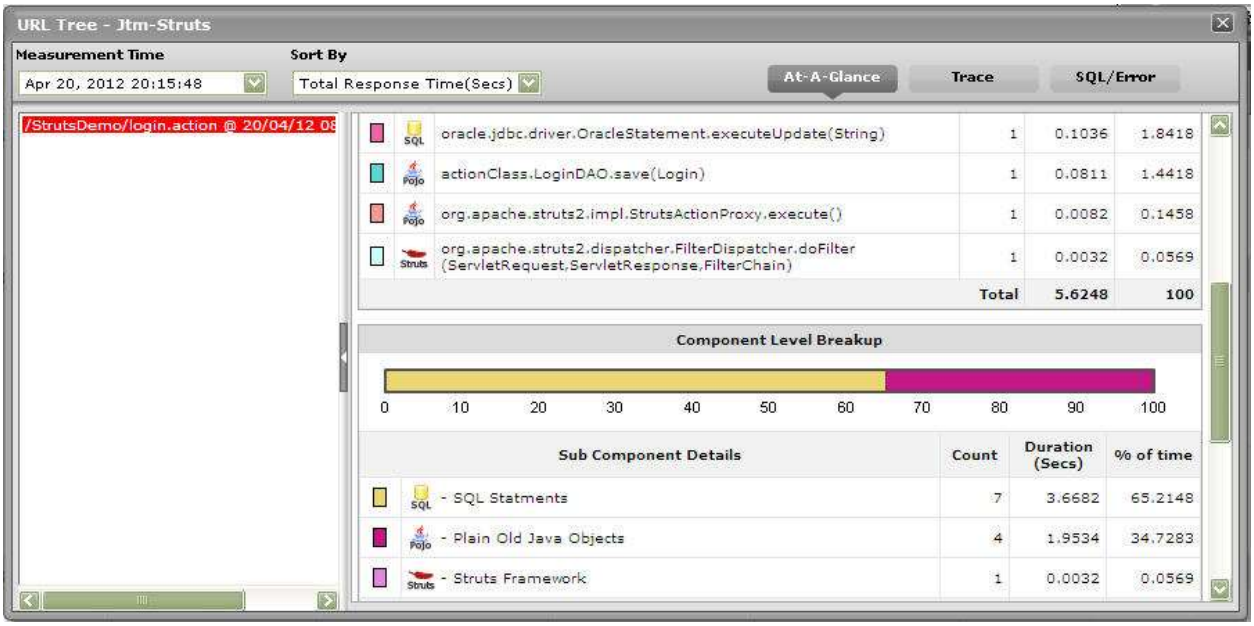


Figure 25: The Component Level Breakup section in the At-A-Glance tab page

Besides Java methods, where the target Java application interacts with the database, long-running SQL queries can also contribute to the poor responsiveness of a transaction. You can use the **At-A-Glance** tab page to determine

whether the transaction interacts with the database or not, and if so, how healthy that interaction is. For this, scroll down the **At-A-Glance** tab page.

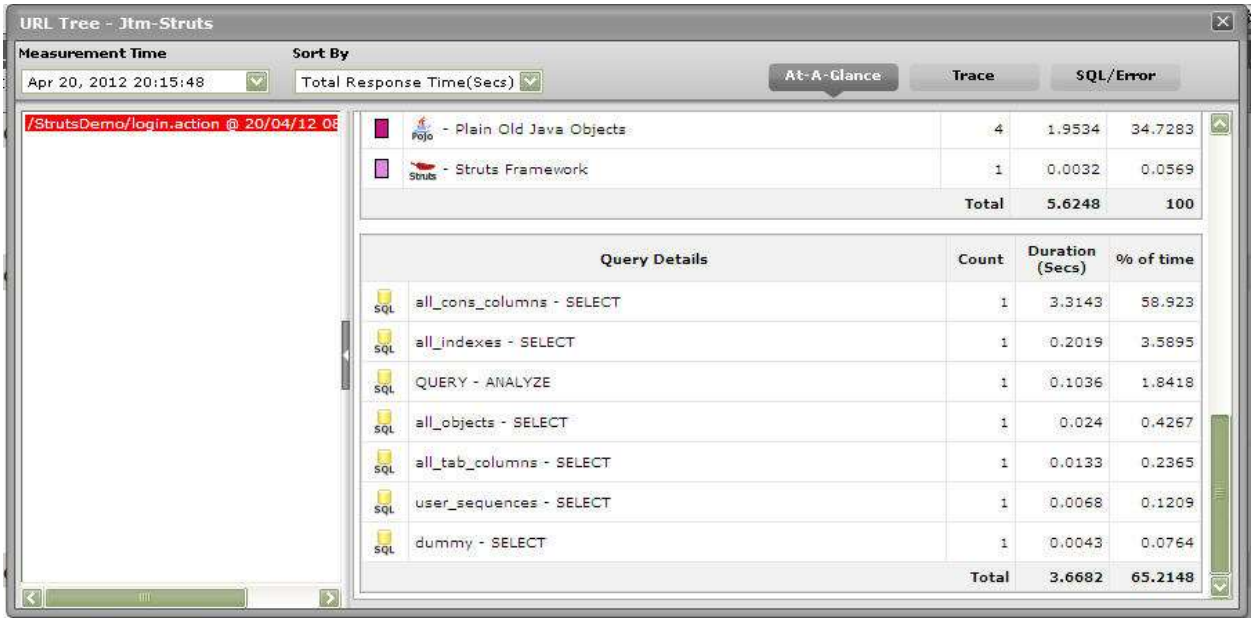


Figure 26: Query Details in the At-A-Glance tab page

Upon scrolling, you will find query details below the **Component Level Breakup** section. All the SQL queries that the chosen transaction executes on the backend database will be listed here in the descending order of their **Duration**. Corresponding to each query, you will be able to view the number of times that query was executed, the **Duration** for which it executed, and what percentage of the total transaction response time was spent in executing that query. A quick look at this tabulation would suffice to identify the query which executed for an abnormally long time on the database, causing the transaction's responsiveness to suffer. For a detailed query description, click on the query. Figure 27 will then pop up displaying the complete query and its execution duration.

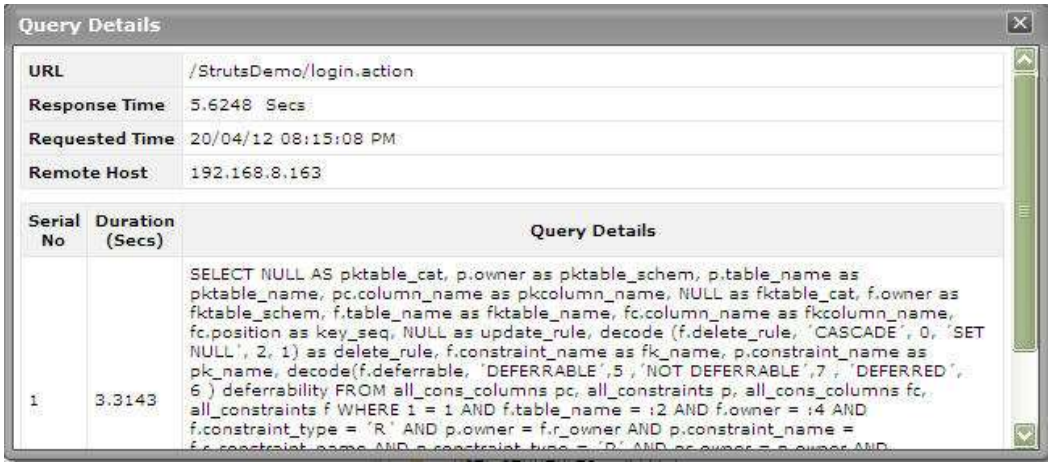


Figure 27: Detailed description of the query clicked on

This way, the **At-A-Glance** tab page allows you to analyze, at-a-glance, all the factors that can influence transaction response time - be it Java methods, Java components, and SQL queries - and enables you to quickly diagnose the source of a transaction slowdown. If, for instance, you figure out that a particular Java method is responsible for the slowdown, you can zoom into the performance of the 'suspect method' by clicking on that method in the **Method**

Level Breakup section of the **At-A-Glance** tab page. This will automatically lead you to the **Trace** tab page, where all invocations of the chosen method will be highlighted (see Figure 28).

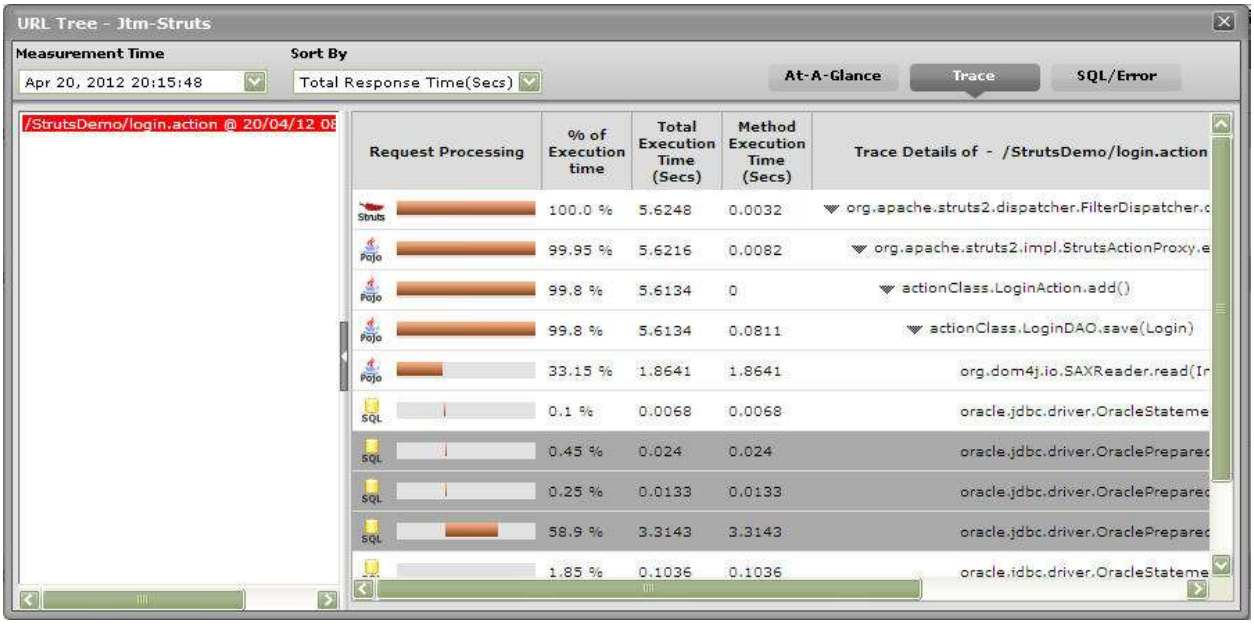


Figure 28: The Trace tab page displaying all invocations of the method chosen from the Method Level Breakup section

Typically, clicking on the **Trace** tab page will list all the methods invoked by the chosen transaction, starting with the very first method. Methods and sub-methods (a method invoked within a method) are arranged in a tree-structure, which can be expanded or collapsed at will. To view the sub-methods within a method, click on the **arrow icon** that precedes that method in the **Trace** tab page. Likewise, to collapse a tree, click once again on the **arrow icon**. Using the tree-structure, you can easily trace the sequence in which methods are invoked by a transaction.

If a method is chosen for analysis from the **Method Level Breakup** section of the **At-A-Glance** tab page, the **Trace** tab page will automatically bring your attention to all invocations of that method by highlighting them (as shown by Figure 28). Likewise, if a Java component is clicked in the **Component Level Breakup** section of the **At-A-Glance** section, the **Trace** tab page will automatically appear, displaying all the methods invoked from the chosen Java component (as shown by Figure 29).

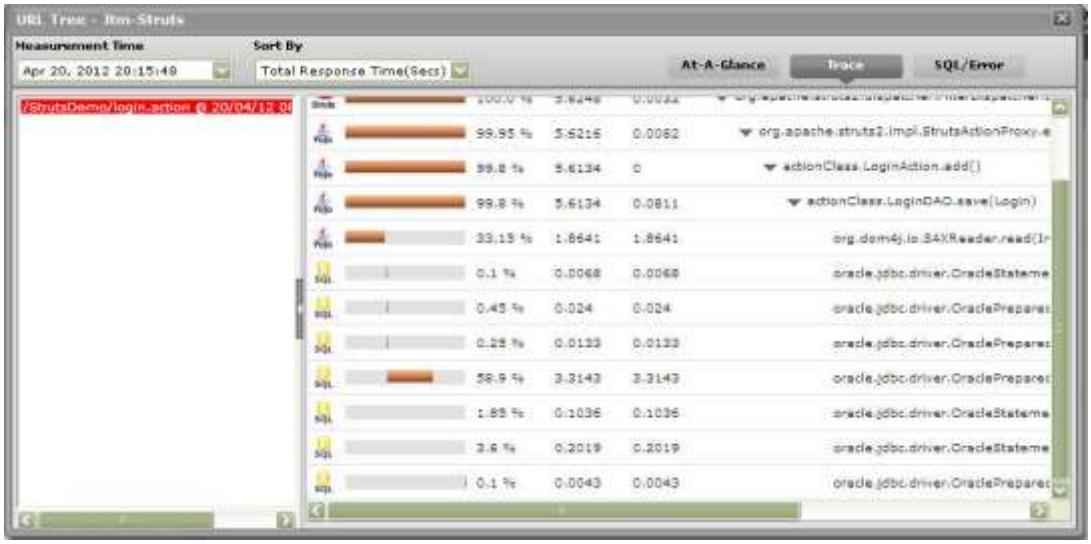


Figure 29: The Trace tab page displaying all methods invoked at the Java layer/sub-component chosen from the Component Level Breakup section

For every method, the **Trace** tab page displays a **Request Processing** bar, which will accurately indicate when, in the sequence of method invocations, the said method began execution and when it ended; with the help of this progress bar, you will be able to fairly judge the duration of the method, and also quickly tell whether any methods were called prior to the method in question. In addition, the **Trace** tab page will also display the time taken for a method to execute (**Method Execution Time**) and the percentage of the time the transaction spent in executing that method. The most time-consuming methods can thus be instantly isolated.

The **Trace** tab page also displays the **Total Execution Time** for each method - this value will be the same as the **Method Execution Time** for 'stand-alone' methods - i.e., methods without any sub-methods. In the case of methods with sub-methods however, the **Total Execution Time** will be the sum total of the **Method Execution Time** of each sub-method invoked within. This is because, a 'parent' method completes execution only when all its child/sub-methods finish executing.

With the help of the **Trace** tab page therefore, you can accurately trace the method that takes the longest to execute, when that method began execution, and which 'parent method' (if any) invoked the method.

Next, click on the **SQL/Errors** tab page. This tab page lists all the SQL queries the transaction executes on its backend database, and/or all the errors detected in the transaction's Java code. The query list (see Figure 30) is typically arranged in the descending order of the query execution **Duration**, and thus leads you to the long-running queries right away! You can even scrutinize the time-consuming query on-the-fly, and suggest improvements to your administrator instantly.

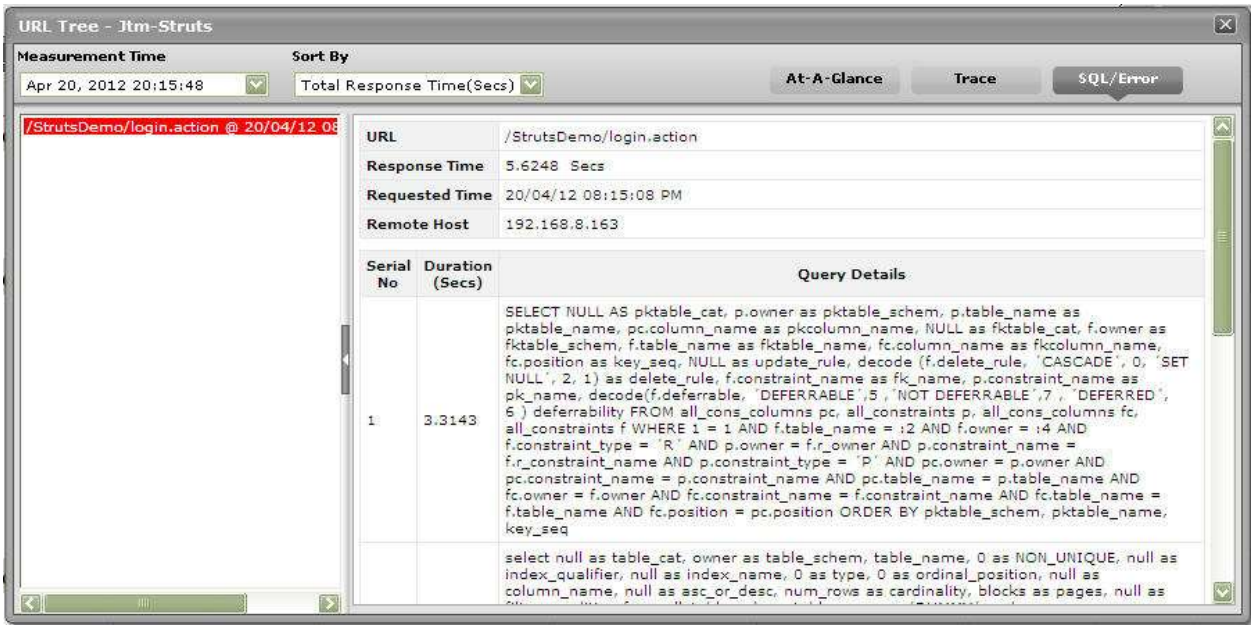


Figure 30: Queries displayed in the SQL/Error tab page

When displaying errors, the **SQL/Error** tab page does not display the error message alone, but displays the complete code block that could have caused the error to occur. By carefully scrutinizing the block, you can easily zero-in on the 'exact line of code' that could have forced the error - this means that besides pointing you to bugs in your code, the **SQL/Error** tab page also helps you initiate measures to fix the same.

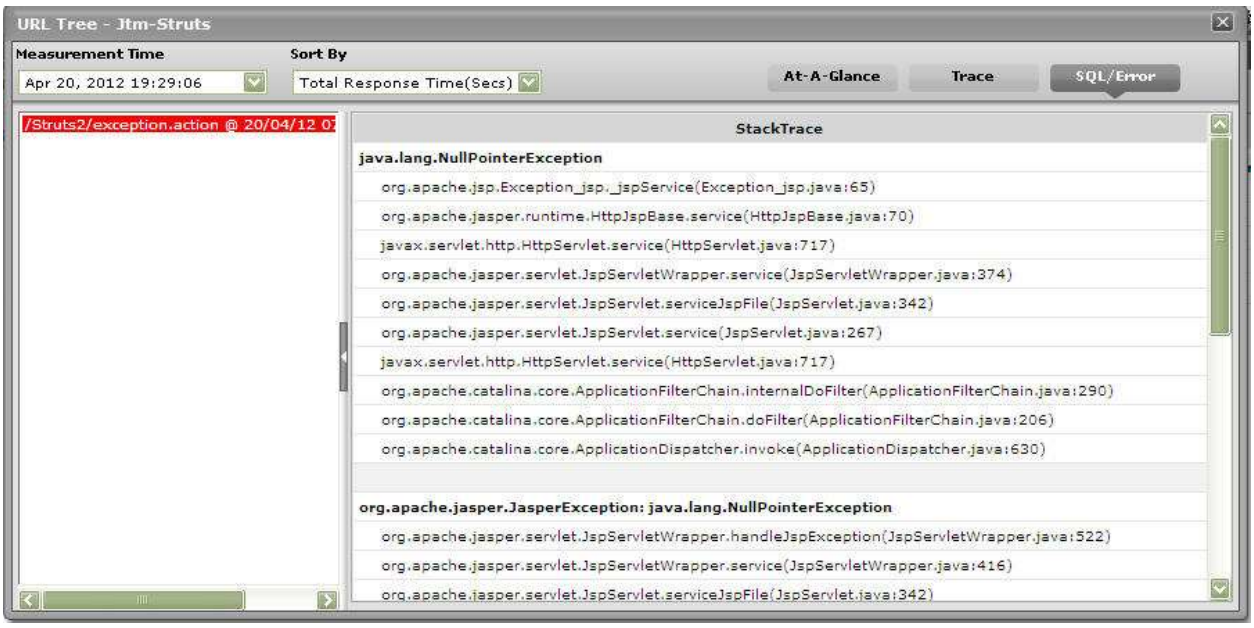


Figure 31: Errors displayed in the SQL/Error tab page

This way, with the help of the three tab pages - **At-A-Glance**, **Trace**, and **SQL/Error** - you can effectively analyze and accurately diagnose the root-cause of slowdowns in transactions to your Java applications.

The detailed diagnosis of the *Error transactions* measure reveals the top-10 (by default) transactions, in terms of **TOTAL RESPONSE TIME**, that have encountered errors. To know the nature of the errors that occurred, click on the **URL Tree** icon in Figure 32. This will lead you to the **URL Tree** window, which has already been elaborately discussed.

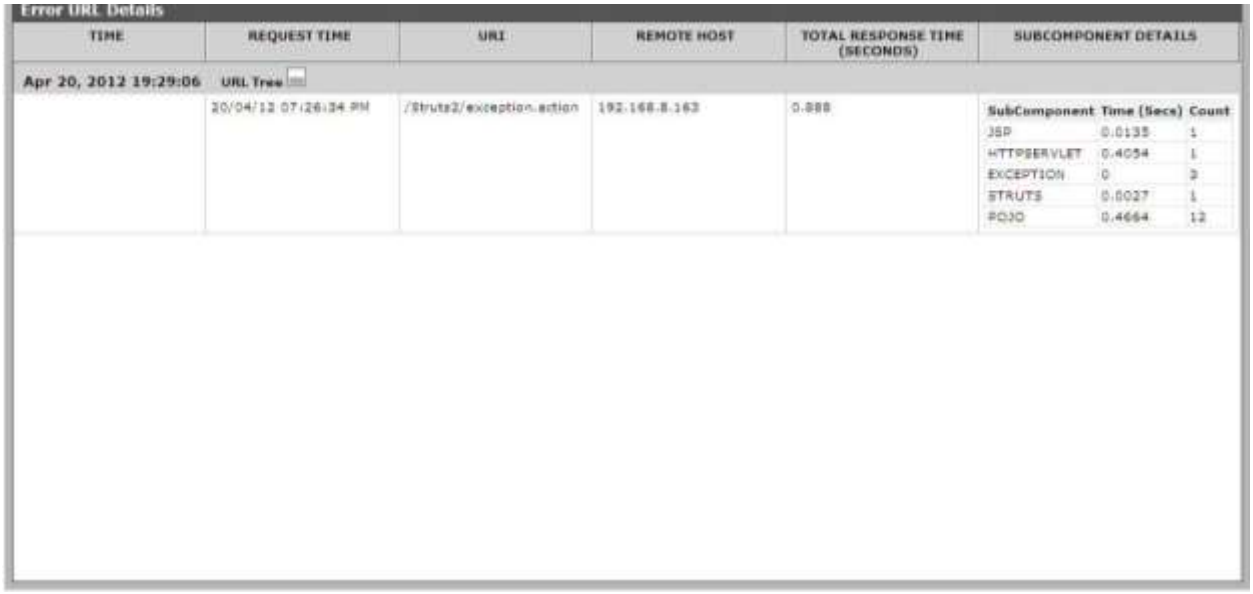


Figure 32: The detailed diagnosis of the Error transactions measure

1.3 The JVM Internals Layer

The tests associated with this layer measure the internal health of the Java Virtual Machine (JVM), and enables administrators to find accurate answers to the following performance queries:

- How many classes have been loaded/unloaded from memory?
- Did garbage collection take too long to complete? If so, which memory pools spent too much time in garbage collection?
- Are too many threads in waiting state in the JVM?
- Which threads are consuming CPU?

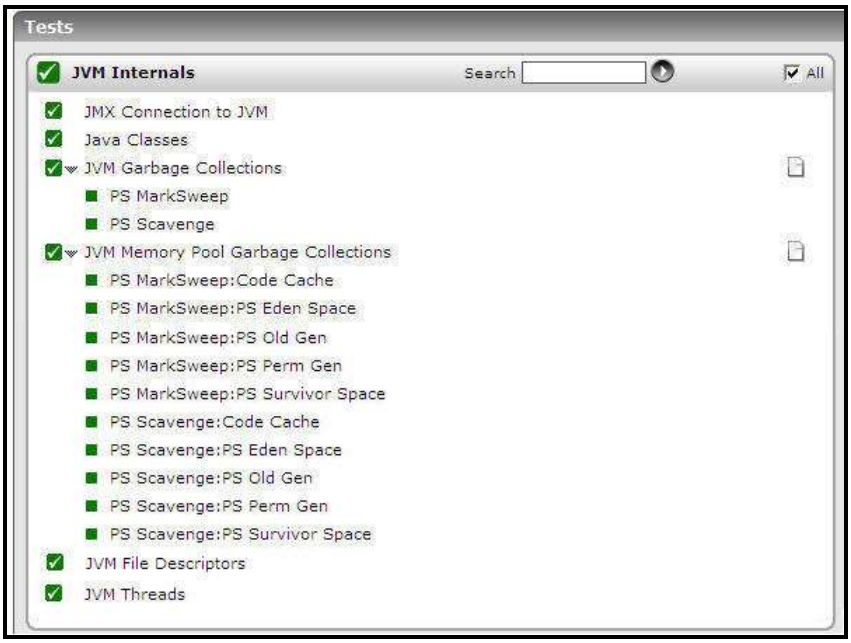


Figure 33: The tests associated with the JVM Internals layer

1.3.1 JMX Connection to JVM

This test reports the availability of the target Java application, and also indicates whether JMX is enabled on the application or not. In addition, the test promptly alerts you to slowdowns experienced by the application, and also reveals whether the application was recently restarted or not.

Purpose	Reports the availability of the target Java application, and also indicates whether JMX is enabled on the application or not. In addition, the test promptly alerts you to slowdowns experienced by the application, and also reveals whether the application was recently restarted or not
Target of the test	A Java application
Agent deploying the test	An internal/remote agent

<table>
<tr><td>Configurable parameters for the test</td><td colspan="3">1. TEST PERIOD - How often should the test be executed
2. HOST - The host for which the test is to be configured
3. PORT - The port number at which the specified HOST listens
4. JMX REMOTE PORT – Here, specify the port at which the JMX listens for requests from remote hosts. Ensure that you specify the same port that you configured in the management.properties file in the <JAVA_HOME>\jre\lib\management folder used by the target application (see page 3).
5. USER, PASSWORD, and CONFIRM PASSWORD – If JMX requires authentication only (but no security), then ensure that the USER and PASSWORD parameters are configured with the credentials of a user with read-write access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the CONFIRM PASSWORD text box.
6. JNDINAME – The JNDINAME is a lookup name for connecting to the JMX connector. By default, this is jmxrmi. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same.
7. PROVIDER – This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to com.sun.jmx.remote.protocol.
8. TIMEOUT – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to 240 seconds.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for the Java application being monitored</td></tr>
<tr><td rowspan="3">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>JMX availability:
Indicates whether the target application is available or not and whether JMX is enabled or not on the application.</td><td>Percent</td><td>If the value of this measure is 100%, it indicates that the Java application is available with JMX enabled. The value 0 on the other hand, could indicate one/both the following:
g. The Java application is unavailable;
h. The Java application is available, but JMX is not enabled;</td></tr>
<tr><td>JMX response time:
Indicates the time taken to connect to the JMX agent of the Java application.</td><td>Secs</td><td>A high value could indicate a connection bottleneck.</td></tr>
<tr><td></td><td>Has the PID changed?
Indicates whether/not the process ID that corresponds to the Java application has changed.</td><td></td><td>This measure will report the value Yes if the PID of the target application has changed; such a change is indicative of an application restart. If the application has not restarted - i.e., if the PID has not changed - then this measure will return the value No.</td></tr>
</table>

1.3.2 JVM File Descriptors Test

This test reports useful statistics pertaining to file descriptors.

This test will work only if the target Java application uses the JDK/JRE offered by one of the following vendors only: Oracle, Sun, OpenJDK. **IBM JDK/JRE is not supported**.

Purpose	Reports useful statistics pertaining to file descriptors
Target of the test	A Java application
Agent deploying the test	An internal/remote agent
Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens 4. **JMX REMOTE PORT** – Here, specify the port at which the **JMX** listens for requests from remote hosts. Ensure that you specify the same port that you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 3). 5. **USER**, **PASSWORD**, and **CONFIRM PASSWORD** – If JMX requires **authentication only** (but no security), then ensure that the **USER** and **PASSWORD** parameters are configured with the credentials of a user with *read-write* access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the **CONFIRM PASSWORD** text box. 6. **JNDINAME** – The **JNDINAME** is a lookup name for connecting to the JMX connector. By default, this is *jmxrmi*. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same. 7. **PROVIDER** – This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to *com.sun.jmx.remote.protocol*. 8. **TIMEOUT** – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to *240* seconds.
Outputs of the test	One set of results for the Java application being monitored

Measurements made by the test	Measurement	Measurement Unit	Interpretation
	Open file descriptors in JVM: Indicates the number of file descriptors currently open for the application.	Number	
	Maximum file descriptors in JVM: Indicates the maximum number of file descriptors allowed for the application.	Number	
	File descriptor usage by JVM: Indicates the file descriptor usage in percentage.	Percent	

1.3.3 Java Classes Test

This test reports the number of classes loaded/unloaded from the memory.

Purpose	Reports the number of classes loaded/unloaded from the memory
Target of the test	A Java application
Agent deploying the test	An internal/remote agent

Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens 4. **MODE** – This test can extract metrics from the Java application using either of the following mechanisms: • Using SNMP-based access to the Java runtime MIB statistics; • By contacting the Java runtime (JRE) of the application via JMX To configure the test to use SNMP, select the **SNMP** option. On the other hand, choose the **JMX** option to configure the test to use JMX instead. By default, the **JMX** option is chosen here. 5. **JMX REMOTE PORT** – This parameter appers only if the **MODE** is set to **JMX**. Here, specify the port at which the **JMX** listens for requests from remote hosts. Ensure that you specify the same port that you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 3). 6. **USER**, **PASSWORD**, and **CONFIRM PASSWORD** – These parameters appear only if the **MODE** is set to **JMX**. If JMX requires **authentication only** (but no security), then ensure that the **USER** and **PASSWORD** parameters are configured with the credentials of a user with *read-write* access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the **CONFIRM PASSWORD** text box. 7. **JNDINAME** – This parameter appears only if the **MODE** is set to **JMX**. The **JNDINAME** is a lookup name for connecting to the JMX connector. By default, this is *jmxrmi*. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same. 8. **PROVIDER** – This parameter appears only if the **MODE** is set to **JMX**. This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to *com.sun.jmx.remote.protocol*. 9. **TIMEOUT** – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to *240* seconds if the **MODE** is **JMX**, and *10* seconds if the **MODE** is **SNMP**. 10. **SNMPPORT** – This parameter appears only if the **MODE** is set to **SNMP**. Here specify the port number through which the server exposes its SNMP MIB. Ensure that you specify the same port you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 15). 11. **SNMPVERSION** – This parameter appears only if the **MODE** is set to **SNMP**. The default selection in the **SNMPVERSION** list is **v1**. However, for this test to work, you have to select SNMP **v2** or **v3** from this list, depending upon which version of SNMP is in use in the target environment. 12. **SNMPCOMMUNITY** – This parameter appears only if the **MODE** is set to **SNMP**. Here, specify the SNMP community name that the test uses to communicate with the mail server. The default is public. This parameter is specific to SNMP **v1** and **v2** only. Therefore, if the **SNMPVERSION** chosen is **v3**, then this parameter will not appear.

13. **USERNAME** – This parameter appears only when **v3** is selected as the **SNMPVERSION**. SNMP version 3 (SNMPv3) is an extensible SNMP Framework which supplements the SNMPv2 Framework, by additionally supporting message security, access control, and remote SNMP configuration capabilities. To extract performance statistics from the MIB using the highly secure SNMP v3 protocol, the eG agent has to be configured with the required access privileges – in other words, the eG agent should connect to the MIB using the credentials of a user with access permissions to be MIB. Therefore, specify the name of such a user against the **USERNAME** parameter.
14. **AUTHPASS** – Specify the password that corresponds to the above-mentioned **USERNAME**. This parameter once again appears only if the **SNMPVERSION** selected is **v3**.
15. **CONFIRM PASSWORD** – Confirm the **AUTHPASS** by retyping it here.
16. **AUTHTYPE** – This parameter too appears only if **v3** is selected as the **SNMPVERSION**. From the **AUTHTYPE** list box, choose the authentication algorithm using which SNMP v3 converts the specified **USERNAME** and **PASSWORD** into a 32-bit format to ensure security of SNMP transactions. You can choose between the following options:
    - **MD5** – Message Digest Algorithm
    - **SHA** – Secure Hash Algorithm
17. **ENCRYPTFLAG** – This flag appears only when **v3** is selected as the **SNMPVERSION**. By default, the eG agent does not encrypt SNMP requests. Accordingly, the **ENCRYPTFLAG** is set to **NO** by default. To ensure that SNMP requests sent by the eG agent are encrypted, select the **YES** option.
18. **ENCRYPTTYPE** – If the **ENCRYPTFLAG** is set to **YES**, then you will have to mention the encryption type by selecting an option from the **ENCRYPTTYPE** list. SNMP v3 supports the following encryption types:
    - **DES** – Data Encryption Standard
    - **AES** – Advanced Encryption Standard
19. **ENCRYPTPASSWORD** – Specify the encryption password here.
20. **CONFIRM PASSWORD** – Confirm the encryption password by retyping it here.
21. **DATA OVER TCP – This parameter is applicable only if MODE is set to SNMP.** By default, in an IT environment, all data transmission occurs over UDP. Some environments however, may be specifically configured to offload a fraction of the data traffic – for instance, certain types of data traffic or traffic pertaining to specific components – to other protocols like TCP, so as to prevent UDP overloads. In such environments, you can instruct the eG agent to conduct the SNMP data traffic related to the equalizer over TCP (and not UDP). For this, set the **DATA OVER TCP** flag to **Yes**. By default, this flag is set to **No**.
22. **CONTEXT** - This parameter appears only when **v3** is selected as the **SNMPVERSION**. An SNMP context is a collection of management information accessible by an SNMP entity. An item of management information may exist in more than one context and an SNMP entity potentially has access to many contexts. A context is identified by the *SNMPEngineID* value of the entity hosting the management information (also called a contextEngineID) and a context name that identifies the specific context (also called a contextName). If the **USERNAME** provided is associated with a context name, then the eG agent will be able to poll the MIB and collect metrics only if it is configured with the context name as well. In such cases therefore, specify the context name of the **USERNAME** in the **CONTEXT** text box. By default, this parameter is set to *none*.

Outputs of the test	One set of results for the Java application being monitored		
Measurements made by the test	**Measurement**	**Measurement Unit**	**Interpretation**
	Classes loaded: Indicates the number of classes currently loaded into memory.	Number	Classes are fundamental to the design of Java programming language. Typically, Java applications install a variety of class loaders (that is, classes that implement java.lang.ClassLoader) to allow different portions of the container, and the applications running on the container, to have access to different repositories of available classes and resources. A consistent decrease in the number of classes loaded and unloaded could indicate a road-block in the loading/unloading of classes by the class loader. If left unchecked, critical resources/classes could be rendered inaccessible to the application, thereby severely affecting its performance.
	Classes unloaded: Indicates the number of classes currently unloaded from memory.	Number	
	Total classes loaded: Indicates the total number of classes loaded into memory since the JVM started, including those subsequently unloaded.	Number	

1.3.4 JVM Garbage Collections Test

Manual memory management is time consuming, and error prone. Most programs still contain leaks. This is all doubly true with programs using exception-handling and/or threads. Garbage collection (GC) is a part of a Java application's JVM that automatically determines what memory a program is no longer using, and recycles it for other use. It is also known as "automatic storage (or memory) reclamation". The JVM Garbage Collections test reports the performance statistics pertaining to the JVM's garbage collection.

Purpose	Reports the performance statistics pertaining to the JVM's garbage collection
Target of the test	A Java application
Agent deploying the test	An internal/remote agent

Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens 4. **MODE** – This test can extract metrics from the Java application using either of the following mechanisms: • Using SNMP-based access to the Java runtime MIB statistics; • By contacting the Java runtime (JRE) of the application via JMX To configure the test to use SNMP, select the **SNMP** option. On the other hand, choose the **JMX** option to configure the test to use JMX instead. By default, the **JMX** option is chosen here. 5. **JMX REMOTE PORT** – This parameter appers only if the **MODE** is set to **JMX**. Here, specify the port at which the **JMX** listens for requests from remote hosts. Ensure that you specify the same port that you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 3). 6. **USER**, **PASSWORD**, and **CONFIRM PASSWORD** – These parameters appear only if the **MODE** is set to **JMX**. If JMX requires **authentication only** (but no security), then ensure that the **USER** and **PASSWORD** parameters are configured with the credentials of a user with *read-write* access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the **CONFIRM PASSWORD** text box. 7. **JNDINAME** – This parameter appears only if the **MODE** is set to **JMX**. The **JNDINAME** is a lookup name for connecting to the JMX connector. By default, this is *jmxrmi*. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same. 8. **PROVIDER** – This parameter appears only if the **MODE** is set to **JMX**. This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to *com.sun.jmx.remote.protocol*. 9. **TIMEOUT** – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to *240* seconds if the **MODE** is **JMX**, and *10* seconds if the **MODE** is **SNMP**. 10. **SNMPPORT** – This parameter appears only if the **MODE** is set to **SNMP**. Here specify the port number through which the server exposes its SNMP MIB. Ensure that you specify the same port you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 15). 11. **SNMPVERSION** – This parameter appears only if the **MODE** is set to **SNMP**. The default selection in the **SNMPVERSION** list is **v1**. However, for this test to work, you have to select SNMP **v2** or **v3** from this list, depending upon which version of SNMP is in use in the target environment. 12. **SNMPCOMMUNITY** – This parameter appears only if the **MODE** is set to **SNMP**. Here, specify the SNMP community name that the test uses to communicate with the mail server. The default is public. This parameter is specific to SNMP **v1** and **v2** only. Therefore, if the **SNMPVERSION** chosen is **v3**, then this parameter will not appear.

13. **USERNAME** – This parameter appears only when **v3** is selected as the **SNMPVERSION**. SNMP version 3 (SNMPv3) is an extensible SNMP Framework which supplements the SNMPv2 Framework, by additionally supporting message security, access control, and remote SNMP configuration capabilities. To extract performance statistics from the MIB using the highly secure SNMP v3 protocol, the eG agent has to be configured with the required access privileges – in other words, the eG agent should connect to the MIB using the credentials of a user with access permissions to be MIB. Therefore, specify the name of such a user against the **USERNAME** parameter.
14. **AUTHPASS** – Specify the password that corresponds to the above-mentioned **USERNAME**. This parameter once again appears only if the **SNMPVERSION** selected is **v3**.
15. **CONFIRM PASSWORD** – Confirm the **AUTHPASS** by retyping it here.
16. **AUTHTYPE** – This parameter too appears only if **v3** is selected as the **SNMPVERSION**. From the **AUTHTYPE** list box, choose the authentication algorithm using which SNMP v3 converts the specified **USERNAME** and **PASSWORD** into a 32-bit format to ensure security of SNMP transactions. You can choose between the following options:
    - **MD5** – Message Digest Algorithm
    - **SHA** – Secure Hash Algorithm
17. **ENCRYPTFLAG** – This flag appears only when **v3** is selected as the **SNMPVERSION**. By default, the eG agent does not encrypt SNMP requests. Accordingly, the **ENCRYPTFLAG** is set to **NO** by default. To ensure that SNMP requests sent by the eG agent are encrypted, select the **YES** option.
18. **ENCRYPTTYPE** – If the **ENCRYPTFLAG** is set to **YES**, then you will have to mention the encryption type by selecting an option from the **ENCRYPTTYPE** list. SNMP v3 supports the following encryption types:
    - **DES** – Data Encryption Standard
    - **AES** – Advanced Encryption Standard
19. **ENCRYPTPASSWORD** – Specify the encryption password here.
20. **CONFIRM PASSWORD** – Confirm the encryption password by retyping it here.
21. **DATA OVER TCP – This parameter is applicable only if MODE is set to SNMP**. By default, in an IT environment, all data transmission occurs over UDP. Some environments however, may be specifically configured to offload a fraction of the data traffic – for instance, certain types of data traffic or traffic pertaining to specific components – to other protocols like TCP, so as to prevent UDP overloads. In such environments, you can instruct the eG agent to conduct the SNMP data traffic related to the equalizer over TCP (and not UDP). For this, set the **DATA OVER TCP** flag to **Yes**. By default, this flag is set to **No**.
22. **CONTEXT** - This parameter appears only when **v3** is selected as the **SNMPVERSION**. An SNMP context is a collection of management information accessible by an SNMP entity. An item of management information may exist in more than one context and an SNMP entity potentially has access to many contexts. A context is identified by the *SNMPEngineID* value of the entity hosting the management information (also called a contextEngineID) and a context name that identifies the specific context (also called a contextName). If the **USERNAME** provided is associated with a context name, then the eG agent will be able to poll the MIB and collect metrics only if it is configured with the context name as well. In such cases therefore, specify the context name of the **USERNAME** in the **CONTEXT** text box. By default, this parameter is set to *none*.

Outputs of the test	One set of results for each garbage collector that is reclaiming the unused memory on the JVM of the Java application being monitored		
Measurements made by the test	**Measurement**	**Measurement Unit**	**Interpretation**
	No of garbage collections started: Indicates the number of times this garbage collector was started to release dead objects from memory during the last measurement period.	Number	
	Time taken for garbage collection: Indicates the time taken to by this garbage collector to perform the current garbage collection operation.	Secs	Ideally, the value of both these measures should be low. This is because, the garbage collection (GC) activity tends to suspend the operations of the application until such time that GC ends. Longer the GC time, longer it would take for the application to resume its functions. To minimize the impact of GC on application performance, it is best to ensure that GC activity does not take too long to complete.
	Percent of time spent by JVM for garbage collection: Indicates the percentage of time spent by this garbage collector on garbage collection during the last measurement period.	Percent	

1.3.5 JVM Memory Pool Garbage Collections Test

While the **JVM Garbage Collections** test reports statistics indicating how well each collector on the JVM performs garbage collection, the measures reported by the **JVM Memory Pool Garbage Collections** test help assess the impact of the garbage collection activity on the availability and usage of memory in each memory pool of the JVM. Besides revealing the count of garbage collections per collector and the time taken by each collector to perform garbage collection on the individual memory pools, the test also compares the amount of memory used and available for use pre and post garbage collection in each of the memory pools. This way, the test enables administrators to guage the effectiveness of the garbage collection activity on the memory pools, and helps them accurately identify those memory pools where enough memory could not reclaimed or where the garbage collectors spent too much time.

This test will work only if the target Java application uses the JDK/JRE offered by one of the following vendors: Oracle, Sun, OpenJDK. **IBM JDK/JRE is not supported.**

Purpose	Helps assess the impact of the garbage collection activity on the availability and usage of memory in each memory pool of the JVM

Target of the test	A Java application
Agent deploying the test	An internal/remote agent
Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens 4. **MEASURE MODE** - This test allows you the option to collect the desired metrics using one of the following methodologies: • By contacting the Java runtime (JRE) of the application via JMX • Using GC logs To use JMX for metrics collections, set the measure mode to **JMX**. On the other hand, if you intend to use the GC log files for collecting the required metrics, set the **MEASURE MODE** to **Log File**. In this case, you would be required to enable GC logging. The procedure for this has been detailed in Section 1.3.5.1 of this document. 5. **JMX REMOTE PORT** – This parameter will be available only if the **MEASURE MODE** is set to **JMX**. Here, specify the port at which the **JMX** listens for requests from remote hosts. Ensure that you specify the same port that you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 3). 6. **JNDINAME** – This parameter will be available only if the **MEASURE MODE** is set to **JMX**. The **JNDINAME** is a lookup name for connecting to the JMX connector. By default, this is *jmxrmi*. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same. 7. **USER**, **PASSWORD**, and **CONFIRM PASSWORD** – This parameter will be available only if the **MEASURE MODE** is set to **JMX**. If JMX requires **authentication only** (but no security), then ensure that the **USER** and **PASSWORD** parameters are configured with the credentials of a user with *read-write* access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the **CONFIRM PASSWORD** text box. 8. **JREHOME** - This parameter will be available only if the **MEASURE MODE** is set to **Log File**. Specify the full path to the Java Runtime Environment (JRE) used by the target application. 9. **LOGFILENAME** - This parameter will be available only if the **MEASURE MODE** is set to **Log File**. Specify the full path to the GC log file to be used for metrics collection. 10. **PROVIDER** – This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to *com.sun.jmx.remote.protocol*. 11. **TIMEOUT** – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to *240* seconds.
Outputs of the test	One set of results for every *GarbageCollector:MemoryPool* pair on the JVM of the Java application being monitored

<table>
<tr><th>Measurements made by the test</th><th>Measurement</th><th>Measurement Unit</th><th>Interpretation</th></tr>
<tr><td></td><td>Has garbage collection happened:
Indicates whether garbage collection occurred on this memory pool in the last measurement period.</td><td></td><td>This measure reports the value Yes if garbage collection took place or No if it did not take place on the memory pool.
The numeric values that correspond to the measure values of Yes and No are listed below:</td></tr>
<tr><td></td><td></td><td></td><td><table><tr><th>State</th><th>Value</th></tr><tr><td>Yes</td><td>1</td></tr><tr><td>No</td><td>0</td></tr></table>
Note:
By default, this measure reports the value Yes or No to indicate whether a GC occurred on a memory pool or not. The graph of this measure however, represents the same using the numeric equivalents – 0 or 1.</td></tr>
<tr><td></td><td>Collection count:
Indicates the number of time in the last measurement pool garbage collection was started on this memory pool.</td><td>Number</td><td></td></tr>
<tr><td></td><td>Initial memory before GC:
Indicates the initial amount of memory (in MB) that this memory pool requests from the operating system for memory management during startup, before GC process.</td><td>MB</td><td rowspan="2">Comparing the value of these two measures for a memory pool will give you a fair idea of the effectiveness of the garbage collection activity.
If garbage collection reclaims a large amount of memory from the memory pool, then the Initial memory after GC will drop. On the other hand, if the garbage collector does not reclaim much memory from a memory pool, or if the Java application suddenly runs a memory-intensive process when GC is being performed, then the Initial memory after GC may be higher than the Initial memory before GC.</td></tr>
<tr><td></td><td>Initial memory after GC:
Indicates the initial amount of memory (in MB) that this memory pool requests from the operating system for memory management during startup, after GC process</td><td>MB</td></tr>
</table>

	Max memory before GC: Indicates the maximum amount of memory that can be used for memory management by this memory pool, before GC process.	MB	Comparing the value of these two measures for a memory pool will provide you with insights into the effectiveness of the garbage collection activity. If garbage collection reclaims a large amount of memory from the memory pool, then the *Max memory after GC* will drop. On the other hand, if the garbage collector does not reclaim much memory from a memory pool, or if the Java application suddenly runs a memory-intensive process when GC is being performed, then the *Max memory after GC* value may exceed the *Max memory before GC*.
	Max memory after GC: Indicates the maximum amount of memory (in MB) that can be used for memory management by this pool, after the GC process.	MB	
	Committed memory before GC: Indicates the amount of memory that is guaranteed to be available for use by this memory pool, before the GC process.	MB	
	Committed memory after GC: Indicates the amount of memory that is guaranteed to be available for use by this memory pool, after the GC process.	MB	
	Used memory before GC: Indicates the amount of memory used by this memory pool before GC.	MB	Comparing the value of these two measures for a memory pool will provide you with insights into the effectiveness of the garbage collection activity. If garbage collection reclaims a large amount of memory from the memory pool, then the *Used memory after GC* may drop lower than the *Used memory before GC*. On the other hand, if the garbage collector does not reclaim much memory from a memory pool, or if the Java application suddenly runs a memory-intensive process when GC is being performed, then the *Used memory after GC* value may exceed the *Used memory before GC*.
	Used memory after GC: Indicates the amount of memory used by this memory pool after GC.	MB	

	Percentage of memory collected: Indicates the percentage of memory collected from this pool by the GC activity.	Percent	A high value for this measure is indicative of a large amount of unused memory in the pool. A low value on the other hand indicates that the memory pool has been over-utilized. Compare the value of this measure across pools to identify the pools that have very little free memory. If too many pools appear to be running short of memory, it could indicate that the target application is consuming too much memory, which in the long run, can slow down the application significantly.
	Collection duration: Indicates the time taken by this garbage collector for collecting unused memory from this pool.	Mins	Ideally, the value of this measure should be low. This is because, the garbage collection (GC) activity tends to suspend the operations of the application until such time that GC ends. Longer the GC time, longer it would take for the application to resume its functions. To minimize the impact of GC on application performance, it is best to ensure that GC activity does not take too long to complete.

1.3.5.1 Enabling GC Logging

If you want the **JVM Memory Pools Garbage Collections** test to use the GC log file to report metrics, then, you first need to enable GC logging. For this, follow the steps below:

1. Edit the startup script file of the Java application being monitored. Figure 20 depicts the startup script file of a sample application.

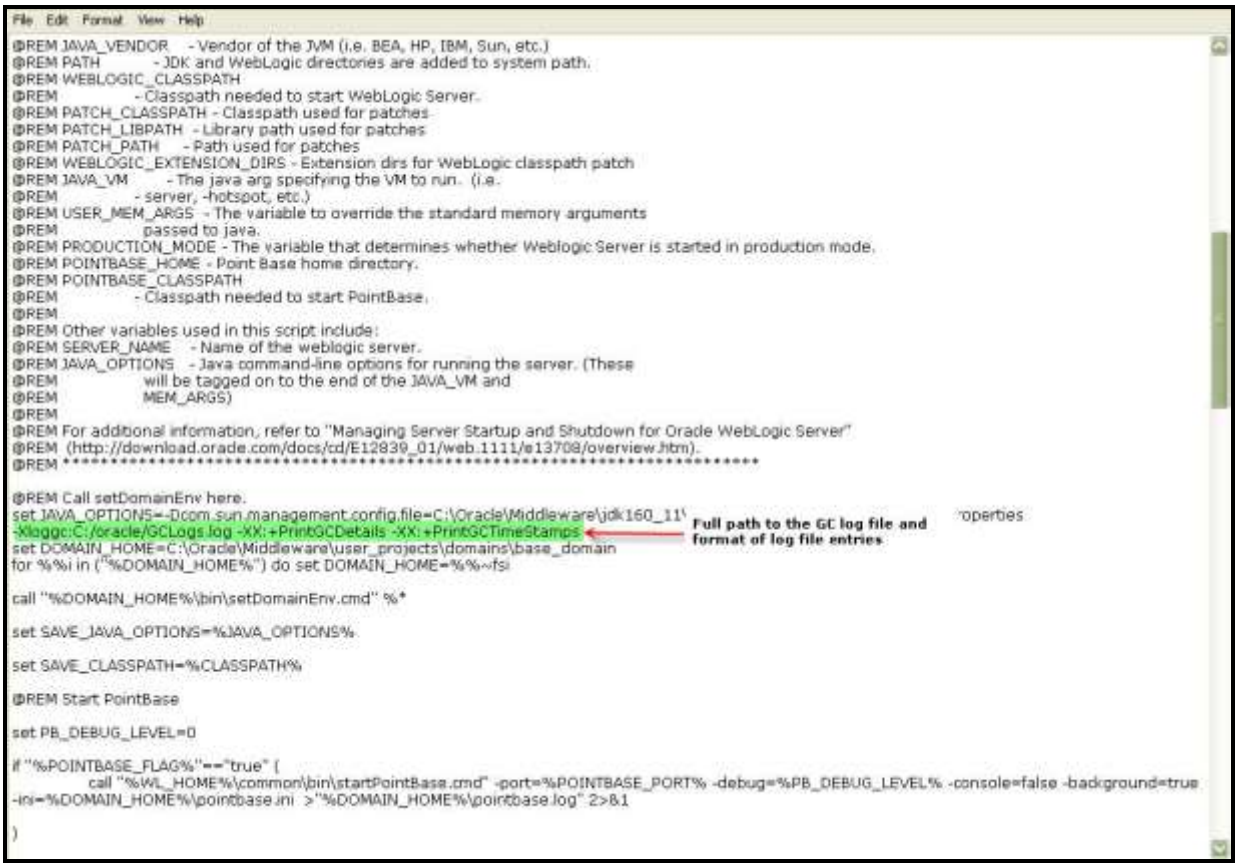


Figure 34: Editing the startup script file of a sample Java application

2. Add the line indicated by Figure 20 to the startup script file. This line should be of the following format:

   -Xloggc:<Full path to the GC log file to which GC details are to be logged> -XX:+PrintGCDetails -XX:+PrintGCTimeStamps

   Here, the entry, **-XX:+PrintGCDetails -XX:+PrintGCTimeStamps**, refers to the format in which GC details are to be logged in the specified log file. **Note that this test can monitor only those GC log files which contain log entries of this format.**

3. Finally, save the file and restart the application.

1.3.6 JVM Threads Test

This test reports the status of threads running in the JVM. Details of this test can be used to identify resource-hungry threads.

Purpose	Reports the status of threads running in the JVM
Target of the test	A Java application
Agent deploying the test	An internal/remote agent

Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens 4. **MODE** – This test can extract metrics from the Java application using either of the following mechanisms: • Using SNMP-based access to the Java runtime MIB statistics; • By contacting the Java runtime (JRE) of the application via JMX To configure the test to use SNMP, select the **SNMP** option. On the other hand, choose the **JMX** option to configure the test to use JMX instead. By default, the **JMX** option is chosen here. 5. **JMX REMOTE PORT** – This parameter appears only if the **MODE** is set to **JMX**. Here, specify the port at which the **JMX** listens for requests from remote hosts. Ensure that you specify the same port that you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 3). 6. **USER**, **PASSWORD**, and **CONFIRM PASSWORD** – These parameters appear only if the **MODE** is set to **JMX**. If JMX requires **authentication only** (but no security), then ensure that the **USER** and **PASSWORD** parameters are configured with the credentials of a user with *read-write* access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the **CONFIRM PASSWORD** text box. 7. **JNDINAME** – This parameter appears only if the **MODE** is set to **JMX**. The **JNDINAME** is a lookup name for connecting to the JMX connector. By default, this is *jmxrmi*. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same. 8. **PROVIDER** – This parameter appears only if the **MODE** is set to **JMX**. This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to *com.sun.jmx.remote.protocol*. 9. **TIMEOUT** – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to *240* seconds if the **MODE** is **JMX**, and *10* seconds if the **MODE** is **SNMP**. 10. **SNMPPORT** – This parameter appears only if the **MODE** is set to **SNMP**. Here specify the port number through which the server exposes its SNMP MIB. Ensure that you specify the same port you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 15). 11. **SNMPVERSION** – This parameter appears only if the **MODE** is set to **SNMP**. The default selection in the **SNMPVERSION** list is **v1**. However, for this test to work, you have to select SNMP **v2** or **v3** from this list, depending upon which version of SNMP is in use in the target environment. 12. **SNMPCOMMUNITY** – This parameter appears only if the **MODE** is set to **SNMP**. Here, specify the SNMP community name that the test uses to communicate with the mail server. The default is public. This parameter is specific to SNMP **v1** and **v2** only. Therefore, if the **SNMPVERSION** chosen is **v3**, then this parameter will not appear.

13. **USERNAME** – This parameter appears only when **v3** is selected as the **SNMPVERSION**. SNMP version 3 (SNMPv3) is an extensible SNMP Framework which supplements the SNMPv2 Framework, by additionally supporting message security, access control, and remote SNMP configuration capabilities. To extract performance statistics from the MIB using the highly secure SNMP v3 protocol, the eG agent has to be configured with the required access privileges – in other words, the eG agent should connect to the MIB using the credentials of a user with access permissions to be MIB. Therefore, specify the name of such a user against the **USERNAME** parameter.
14. **AUTHPASS** – Specify the password that corresponds to the above-mentioned **USERNAME**. This parameter once again appears only if the **SNMPVERSION** selected is **v3**.
15. **CONFIRM PASSWORD** – Confirm the **AUTHPASS** by retyping it here.
16. **PCT MEDIUM CPU UTIL THREADS** - By default, the **PCT MEDIUM CPU UTIL THREADS** parameter is set to 50. This implies that, by default, the threads for which the current CPU consumption is between 50% and 70% (the default value of the **PCT HIGH CPU UTIL THREADS** parameter) willl be counted as medium CPU-consuming threads. The count of such threads will be reported as the value of the **Medium CPU threads** measure.

    This default setting also denotes that threads that consume less than 50% CPU will, by default, be counted as **Low CPU threads**. If need be, you can modify the value of this **PCT MEDIUM CPU UTIL THREADS** parameter to change how much CPU should be used by a thread for it to qualify as a medium CPU-consuming thread. This will consequently alter the count of low CPU-consuming threads as well.
17. **PCT HIGH CPU UTIL THREADS** - By default, the **PCT HIGH CPU UTIL THREADS** parameter is set to 70. This implies that, by default, the threads that are currently consuming over 70% of CPU time are counted as high CPU consumers. The count of such threads will be reported as the value of the **High CPU threads** measure. If need be, you can modify the value of this parameter to change how much CPU should be used by a thread for it to qualify as a high CPU-consuming thread.
18. **MAX THREAD COUNT** –By default, this parameter is set to 20. This implies that the detailed diagnosis of the *Runnable threads*, *Waiting threads*, and *Timed waiting threads* measures will by default display only the top-20 JVM threads in terms of CPU consumption. To view more threads as part of detailed diagnostics, increase the value of this parameter. To view all threads that are in the said state (eg., runnable, waiting, and timed waiting), specify *All* or *** against this parameter.
19. **AUTHTYPE** – This parameter too appears only if **v3** is selected as the **SNMPVERSION**. From the **AUTHTYPE** list box, choose the authentication algorithm using which SNMP v3 converts the specified **USERNAME** and **PASSWORD** into a 32-bit format to ensure security of SNMP transactions. You can choose between the following options:

    - **MD5** – Message Digest Algorithm
    - **SHA** – Secure Hash Algorithm

20. **ENCRYPTFLAG** – This flag appears only when **v3** is selected as the **SNMPVERSION**. By default, the eG agent does not encrypt SNMP requests. Accordingly, the **ENCRYPTFLAG** is set to **NO** by default. To ensure that SNMP requests sent by the eG agent are encrypted, select the **YES** option.
21. **ENCRYPTTYPE** – If the **ENCRYPTFLAG** is set to **YES**, then you will have to mention the encryption type by selecting an option from the **ENCRYPTTYPE** list. SNMP v3 supports the following encryption types:
    - **DES** – Data Encryption Standard
    - **AES** – Advanced Encryption Standard
22. **ENCRYPTPASSWORD** – Specify the encryption password here.
23. **CONFIRM PASSWORD** – Confirm the encryption password by retyping it here.
24. **TIMEOUT** - This parameter appears only if the **MODE** is set to **SNMP**. Here, specify the duration (in seconds) within which the SNMP query executed by this test should time out in the **TIMEOUT** text box. The default is 10 seconds.
25. **USEPS** - **This flag is applicable only for AIX LPARs.** By default, on AIX LPARs, this test uses the **tprof** command to compute CPU usage. Accordingly, the **USEPS** flag is set to **No** by default. On some AIX LPARs however, the **tprof** command may not function properly (this is an AIX issue). While monitoring such AIX LPARs therefore, you can configure the test to use the **ps** command instead for metrics collection. To do so, set the **USEPS** flag to **Yes**.

    Note:

    Alternatively, you can set the **AIXusePS** flag in the **[AGENT_SETTINGS]** section of the **eg_tests.ini** file (in the **<EG_INSTALL_DIR>\manager\config** directory) to **yes** (default: **no**) to enable the eG agent to use the **ps** command for CPU usage computations on AIX LPARs. If this global flag and the **USEPS** flag for a specific component are both set to **no**, then the test will use the default **tprof** command to compute CPU usage for AIX LPARs. If either of these flags is set to **yes**, then the **ps** command will perform the CPU usage computations for monitored AIX LPARs.

    In some high-security environments, the **tprof** command may require some special privileges to execute on an AIX LPAR (eg., *sudo* may need to be used to run **tprof**). In such cases, you can prefix the **tprof** command with another command (like *sudo*) or the full path to a script that grants the required privileges to **tprof**. To achieve this, edit the **eg_tests.ini** file (in the **<EG_INSTALL_DIR>\manager\config** directory), and provide the prefix of your choice against the **AixTprofPrefix** parameter in the **[AGENT_SETTINGS]** section. Finally, save the file. For instance, if you set the **AixTprofPrefix** parameter to *sudo*, then the eG agent will call the **tprof** command as *sudo tprof*.

<table>
<tr><td></td><td colspan="3">
26. DATA OVER TCP – This parameter is applicable only if MODE is set to SNMP. By default, in an IT environment, all data transmission occurs over UDP. Some environments however, may be specifically configured to offload a fraction of the data traffic – for instance, certain types of data traffic or traffic pertaining to specific components – to other protocols like TCP, so as to prevent UDP overloads. In such environments, you can instruct the eG agent to conduct the SNMP data traffic related to the equalizer over TCP (and not UDP). For this, set the DATA OVER TCP flag to Yes. By default, this flag is set to No.
27. CONTEXT - This parameter appears only when v3 is selected as the SNMPVERSION. An SNMP context is a collection of management information accessible by an SNMP entity. An item of management information may exist in more than one context and an SNMP entity potentially has access to many contexts. A context is identified by the SNMPEngineID value of the entity hosting the management information (also called a contextEngineID) and a context name that identifies the specific context (also called a contextName). If the USERNAME provided is associated with a context name, then the eG agent will be able to poll the MIB and collect metrics only if it is configured with the context name as well. In such cases therefore, specify the context name of the USERNAME in the CONTEXT text box. By default, this parameter is set to none.
28. DD FREQUENCY - Refers to the frequency with which detailed diagnosis measures are to be generated for this test. The default is 1:1. This indicates that, by default, detailed measures will be generated every time this test runs, and also every time the test detects a problem. You can modify this frequency, if you so desire. Also, if you intend to disable the detailed diagnosis capability for this test, you can do so by specifying none against DD FREQUENCY.
29. DETAILED DIAGNOSIS - To make diagnosis more efficient and accurate, the eG Enterprise suite embeds an optional detailed diagnostic capability. With this capability, the eG agents can be configured to run detailed, more elaborate tests as and when specific problems are detected. To enable the detailed diagnosis capability of this test for a particular server, choose the On option. To disable the capability, click on the Off option.
The option to selectively enable/disable the detailed diagnosis capability will be available only if the following conditions are fulfilled:
• The eG manager license should allow the detailed diagnosis capability
• Both the normal and abnormal frequencies configured for the detailed diagnosis measures should not be 0.
</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for the Java application being monitored</td></tr>
<tr><td rowspan="2">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>Total threads:
Indicates the total number of threads (including daemon and non-daemon threads).</td><td>Number</td><td></td></tr>
</table>

	Runnable threads: Indicates the current number of threads in a runnable state.	Number	The detailed diagnosis of this measure, if enabled, lists the names of the top-20 (default) runnable threads in terms of their CPU usage. The time for which the thread was in a blocked state, waiting state, etc., are provided as part of the detailed diagnostics. You can change the sort order to view threads by waiting time, blocked time, etc.
	Blocked threads: Indicates the number of threads that are currently in a blocked state.	Number	If a thread is trying to take a lock (to enter a synchronized block), but the lock is already held by another thread, then such a thread is called a blocked thread. The detailed diagnosis of this measure, if enabled, provides in-depth information related to all the blocked threads.

	Waiting threads: Indicates the number of threads that are currently in a waiting state.	Number	A thread is said to be in a Waiting state if the thread enters a synchronized block, tries to take a lock that is already held by another thread, and hence, waits till the other thread notifies that it has released the lock. Ideally, the value of this measure should be low. A very high value could be indicative of excessive waiting activity on the JVM. You can use the detailed diagnosis of this measure, if enabled, to figure out which threads are currently in the waiting state. By default, the top-20 waiting threads in terms of CPU usage will be listed. You can change the sort order to view threads by waiting time, blocked time, etc. While waiting, the Java application program does no productive work and its ability to complete the task-at-hand is degraded. A certain amount of waiting may be acceptable for Java application programs. However, when the amount of time spent waiting becomes excessive or if the number of times that waits occur exceeds a reasonable amount, the Java application program may not be programmed correctly to take advantage of the available resources. When this happens, the delay caused by the waiting Java application programs elongates the response time experienced by an end user. An enterprise may use Java application programs to perform various functions. Delays based on abnormal degradation consume employee time and may be costly to corporations.

	Timed waiting threads: Indicates the number of threads in a TIMED_WAITING state.	Number	When a thread is in the TIMED_WAITING state, it implies that the thread is waiting for another thread to do something, but will give up after a specified time out period. To view the details of threads in the TIMED_WAITING state, use the detailed diagnosis of this measure, if enabled. By default, the top-20 timed waiting threads in terms of CPU usage will be listed. You can change the sort order to view threads by waiting time, blocked time, etc.
	Low CPU threads: Indicates the number of threads that are currently consuming CPU lower than the value configured in the **PCT MEDIUM CPU UTIL THREADS** text box.	Number	To know which threads are consuming low CPU, use the detailed diagnosis of this measure.
	Medium CPU threads: Indicates the number of threads that are currently consuming CPU that is higher than the value configured in the **PCT MEDIMUM CPU UTIL THREADS** text box and is lower than or equal to the value specified in the **PCT HIGH CPU UTIL THREADS** text box.	Number	To know which threads are consuming medium CPU, use the detailed diagnosis of this measure.
	High CPU threads: Indicates the number of threads that are currently consuming CPU that is greater than the percentage configured in the **PCT HIGH CPU UTIL THREADS** text box.	Number	Ideally, the value of this measure should be very low. A high value is indicative of a resource contention at the JVM. Under such circumstances, you might want to identify the resource-hungry threads. To know which threads are consuming excessive CPU, use the detailed diagnosis of this measure.
`	**Peak threads:** Indicates the highest number of live threads since JVM started.	Number	
	Total threads: Indicates the the total number of threads started (including daemon, non-daemon, and terminated) since JVM started.	Number	
	Daemon threads: Indicates the current number of live daemon threads.	Number	

	Deadlock threads: Indicates the current number of deadlocked threads.	Number	Ideally, this value should be 0. A high value is a cause for concern, as it indicates that many threads are blocking one another causing the application performance to suffer. The detailed diagnosis of this measure, if enabled, lists the deadlocked threads and their resource usage.

If the mode for the **JVM Threads** test is set to **SNMP**, then the detailed diagnosis of this test will not display the **Blocked Time** and **Waited Time** for the threads. To make sure that detailed diagnosis reports these details also, do the following:

- Login to the application host.
- Go to the **<JAVA_HOME>\jre\lib\management** folder used by the target application, and edit the *management.properties* file in that folder.
- Append the following line to the file:

```
com.sun.management.enableThreadContentionMonitoring
```

- Finally, save the file.

1.3.6.1 Accessing Stack Trace using the STACK TRACE link in the Measurements Panel

While viewing the measures reported by the **JVM Thread** test, you can also view the resource usage details and the **stack trace** information for all the threads, by clicking on the **STACK TRACE** link in the **Measurements** panel.

If the mode set for the **JVM Thread** test is **SNMP**, the stack trace details may not be available.

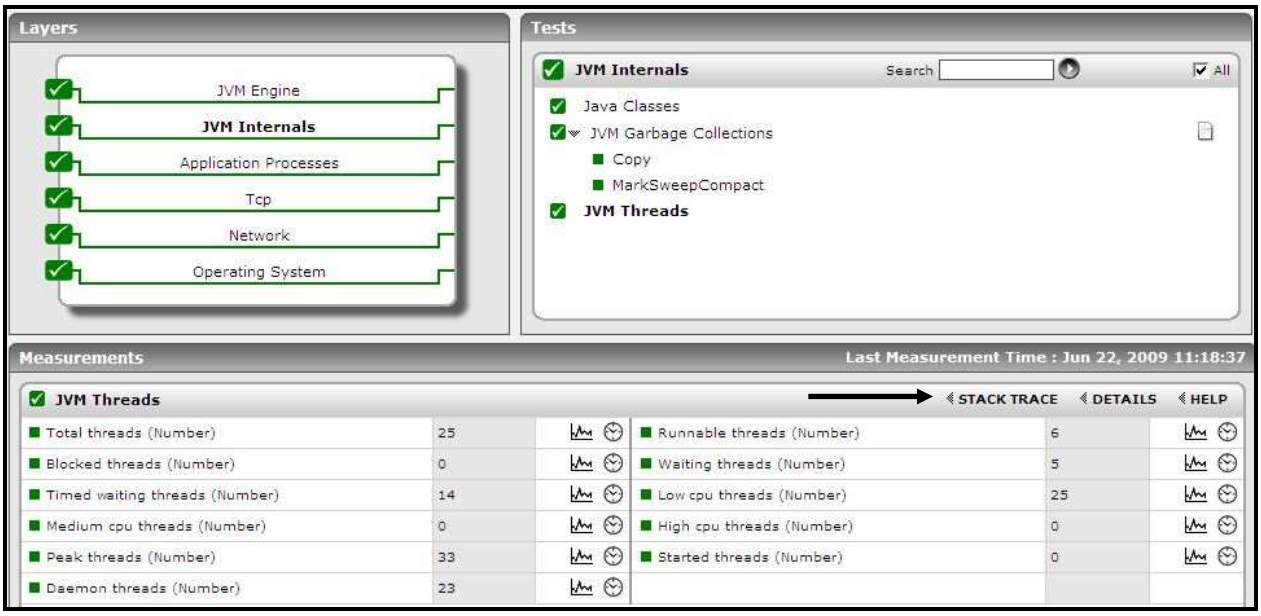


Figure 35: The STACK TRACE link

A **stack trace** (also called **stack backtrace** or **stack traceback**) is a report of the active stack frames instantiated by the execution of a program. It is commonly used to determine what threads are currently active in the JVM, and which threads are in each of the different states – i.e., alive, blocked, waiting, timed waiting, etc.

Typically, when a Java application begins exhibiting erratic resource usage patterns, it often takes administrators hours, even days to figure out what is causing this anomaly – could it be owing to one/more resource-intensive threads being executed by the application? If so, what is causing the thread to erode resources? Is it an inefficient piece of code? In which case, which line of code could be the most likely cause for the spike in resource usage? To be able to answer these questions accurately, administrators need to know the complete list of threads that the application executes, view the **stack trace** of each thread, analyze each stack trace in a top-down manner, and trace where the problem originated.

eG Enterprise simplifies this seemingly laborious procedure by not only alerting administrators instantly to excessive resource usage by a target application, but also by automatically identifying the problematic thread(s), and providing the administrator with quick and easy access to the **stack trace** information of that thread; with the help of stack trace, administrators can effortlessly drill down to the exact line of code that requires optimization.

To access the stack trace information of a thread, click on the **STACK TRACE** link in the **Measurements** panel of Figure 35.

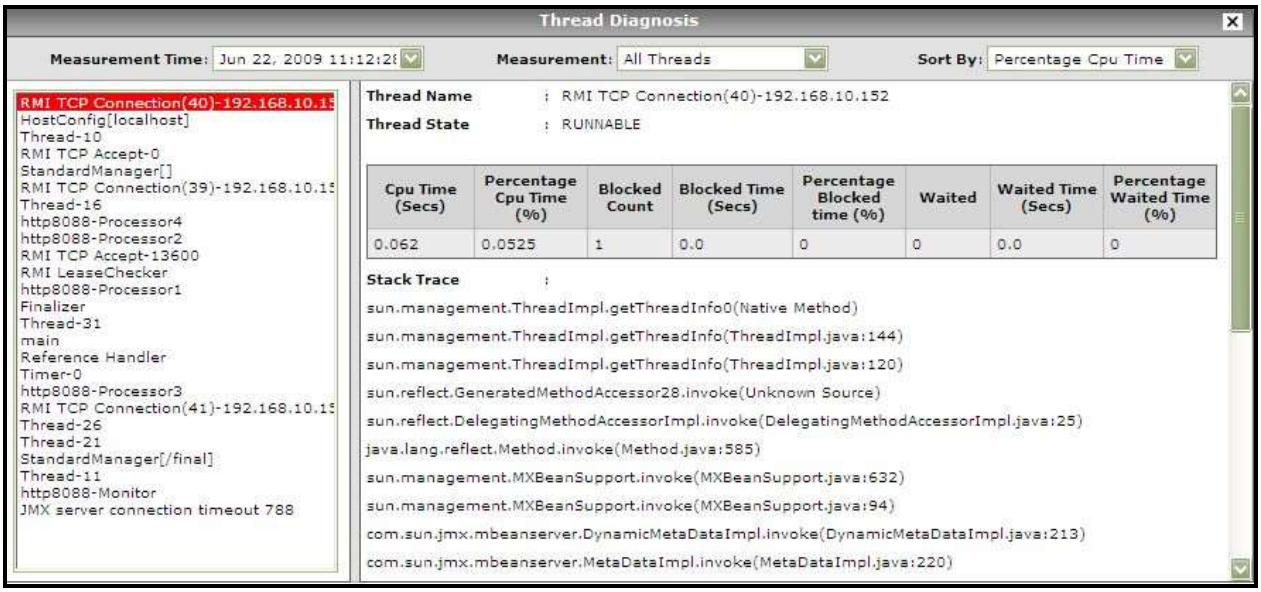


Figure 36: Stack trace of a resource-intensive thread

Figure 36 that appears comprises of two panels. The left panel, by default, lists all the threads that the target application executes, starting with the threads that are currently live. Accordingly, the **All Threads** option is chosen by default from the **Measurement** list. If need be, you can override the default setting by choosing a different option from the **Measurement** list – in other words, instead of viewing the complete list of threads, you can choose to view threads of a particular type or which are in a particular state alone in Figure 36, by selecting a different **Measurement** from Figure 36. For instance, to ensure that the left panel displays only those threads that are currently in a runnable state, select the **Live threads** option from the **Measurement** list. The contents of the left panel will change as depicted by Figure 37.

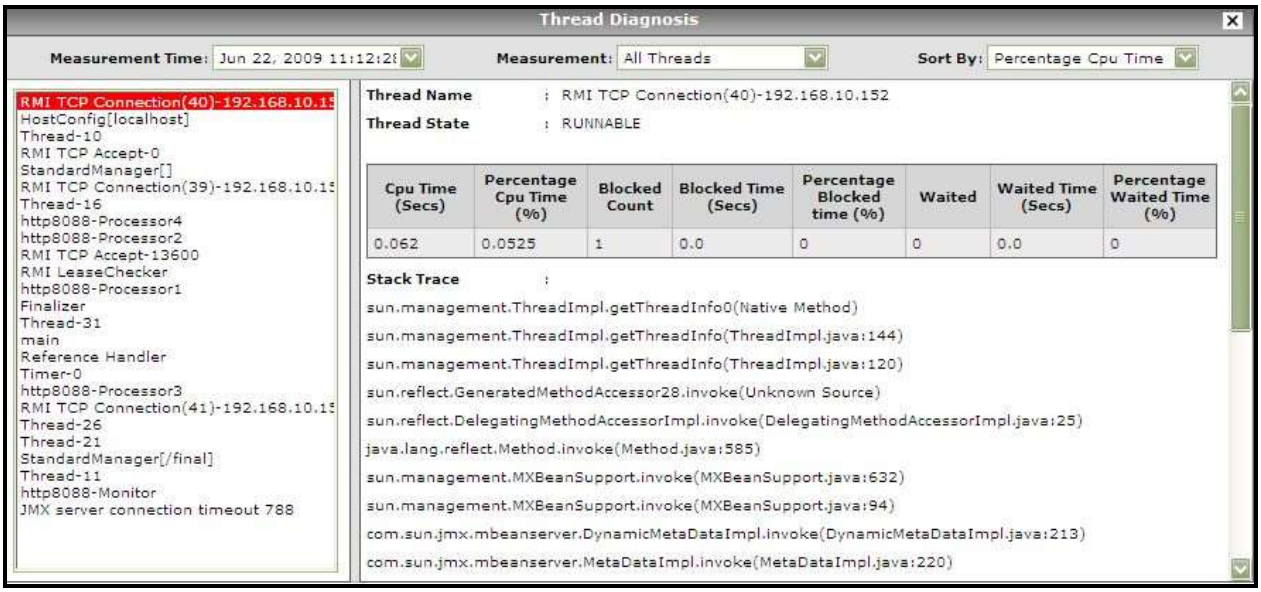


Figure 37: Thread diagnosis of live threads

Also, the thread list in the left panel is by default sorted in the descending order of the **Percent Cpu Time** of the threads. This implies that, by default, the first thread in the list will be the thread that is currently active and consuming the maximum CPU. You can change the sort order by selecting a different option from the **Sort by** list in Figure 37.

Typically, the contents of the right panel change according to the thread chosen from the left. Since the first thread is the default selection in the left panel, and this thread by default consumes the maximum CPU, we can conclude that the right panel will by default display the details of the leading CPU consumer. Besides the name and state of the chosen thread, the right panel will provide the following information:

- **Cpu Time** : The amount of CPU processing time (in seconds) consumed by the thread during the last measurement period;
- **Percent Cpu Time**: The percentage of time the thread was using the CPU during the last measurement period;
- **Blocked Count**: The number of the times during the last measurement period the thread was blocked waiting for another thread;
- **Blocked Time**: The total duration for which the thread was blocked during the last measurement period;
- **Percentage Blocked Time**: The percentage of time (in seconds) for which the thread was blocked during the last measurement period;
- **Waited**: The number of times during the last measurement period the thread was waiting for some event to happen (eg., wait for a thread to finish, wait for a timing event to finish, etc.);
- **Waited Time**: The total duration (in seconds) for which the thread was waiting during the last measurement period;
- **Percentage Waited Time**: The percentage of time for which the thread was waiting during the last measurement period.

In addition to the above details, the right panel provides the **Stack Trace** of the thread.

In the event of a sudden surge in the CPU usage of the target Java application, the **Thread Diagnosis** window of Figure 37 will lead you to the CPU-intensive thread, and will also provide you with the **Stack Trace** of that thread. By analyzing the stack trace in a top-down manner, you can figure out which method/routine called which, and thus locate the exact line of code that could have contributed to the sudden CPU spike.

If the CPU usage has been increasing over a period of time, then, you might have to analyze the stack trace for one/more prior periods, so as to perform accurate root-cause diagnosis. By default, the **Thread Diagnosis** window of Figure 37 provides the stack trace for the current measurement period only. If you want to view the stack trace for a previous measurement period, you will just have to select a different option from the **Measurement Time** list. By reviewing the code executed by a thread for different measurement periods, you can figure out out if the same line of code is responsible for the increase in CPU usage.

1.4 The JVM Engine Layer

The JVM Engine layer measures the overall health of the JVM engine by reporting statistics related to the following:

- The CPU usage by the engine
- How the JVM engine manages memory
- The uptime of the engine

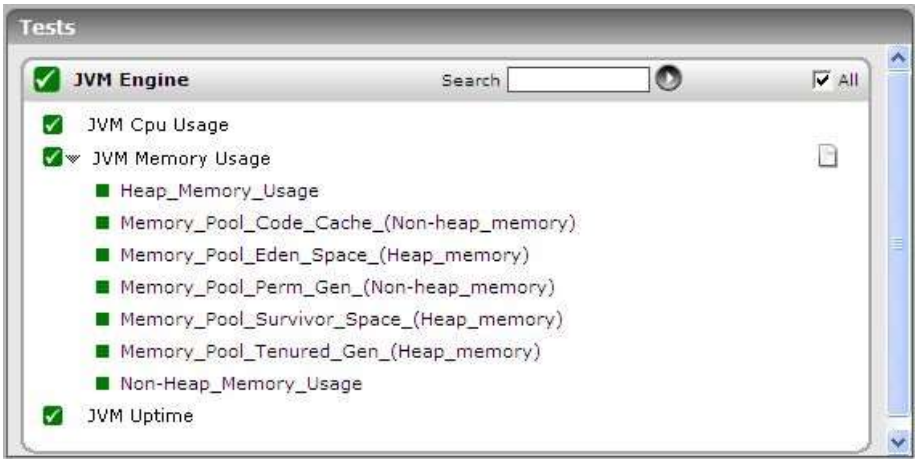


Figure 38: The tests associated with the JVM Engine layer

1.4.1 JVM Cpu Usage Test

This test measures the CPU utilization of the JVM. If the JVM experiences abnormal CPU usage levels, you can use this test to instantly drill down to the threads that are contributing to the CPU spike. Detailed stack trace information provides insights to code level information that can highlight problems with the design of the Java application.

Note

- If you want to collect metrics for this test from the JRE MIB – i.e, if the mode parameter of this test is set to **SNMP** – then ensure that the **SNMP** and **SNMP Trap** services are up and running on the application host.
- While monitoring a Java application executing on a Windows 2003 server using SNMP, ensure that the *community string* to be used during SNMP access is explicitly added when starting the SNMP service.

Purpose	Measures the CPU utilization of the JVM
Target of the test	A Java application
Agent deploying the test	An internal/remote agent

Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens 4. **MODE** – This test can extract metrics from the Java application using either of the following mechanisms: • Using SNMP-based access to the Java runtime MIB statistics; • By contacting the Java runtime (JRE) of the application via JMX To configure the test to use SNMP, select the **SNMP** option. On the other hand, choose the **JMX** option to configure the test to use JMX instead. By default, the **JMX** option is chosen here. 5. **JMX REMOTE PORT** – This parameter appers only if the **MODE** is set to **JMX**. Here, specify the port at which the **JMX** listens for requests from remote hosts. Ensure that you specify the same port that you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 3). 6. **JNDINAME** – This parameter appears only if the **MODE** is set to **JMX**. The **JNDINAME** is a lookup name for connecting to the JMX connector. By default, this is *jmxrmi*. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same. 7. **USER**, **PASSWORD**, and **CONFIRM PASSWORD** – These parameters appear only if the **MODE** is set to **JMX**. If JMX requires **authentication only** (but no security), then ensure that the **USER** and **PASSWORD** parameters are configured with the credentials of a user with *read-write* access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the **CONFIRM PASSWORD** text box. 8. **PROVIDER** – This parameter appears only if the **MODE** is set to **JMX**. This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to *com.sun.jmx.remote.protocol*. 9. **TIMEOUT** – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to *240* seconds if the **MODE** is **JMX**, and *10* seconds if the **MODE** is **SNMP**. 10. **SNMPPORT** – This parameter appears only if the **MODE** is set to **SNMP**. Here specify the port number through which the server exposes its SNMP MIB. Ensure that you specify the same port you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 15). 11. **SNMPVERSION** – This parameter appears only if the **MODE** is set to **SNMP**. The default selection in the **SNMPVERSION** list is **v1**. However, for this test to work, you have to select SNMP **v2** or **v3** from this list, depending upon which version of SNMP is in use in the target environment. 12. **SNMPCOMMUNITY** – This parameter appears only if the **MODE** is set to **SNMP**. Here, specify the SNMP community name that the test uses to communicate with the mail server. The default is public. This parameter is specific to SNMP **v1** and **v2** only. Therefore, if the **SNMPVERSION** chosen is **v3**, then this parameter will not appear.

13. **USERNAME** – This parameter appears only when **v3** is selected as the **SNMPVERSION**. SNMP version 3 (SNMPv3) is an extensible SNMP Framework which supplements the SNMPv2 Framework, by additionally supporting message security, access control, and remote SNMP configuration capabilities. To extract performance statistics from the MIB using the highly secure SNMP v3 protocol, the eG agent has to be configured with the required access privileges – in other words, the eG agent should connect to the MIB using the credentials of a user with access permissions to be MIB. Therefore, specify the name of such a user against the **USERNAME** parameter.
14. **AUTHPASS** – Specify the password that corresponds to the above-mentioned **USERNAME**. This parameter once again appears only if the **SNMPVERSION** selected is **v3**.
15. **CONFIRM PASSWORD** – Confirm the **AUTHPASS** by retyping it here.
16. **AUTHTYPE** – This parameter too appears only if **v3** is selected as the **SNMPVERSION**. From the **AUTHTYPE** list box, choose the authentication algorithm using which SNMP v3 converts the specified **USERNAME** and **PASSWORD** into a 32-bit format to ensure security of SNMP transactions. You can choose between the following options:
    - **MD5** – Message Digest Algorithm
    - **SHA** – Secure Hash Algorithm
17. **ENCRYPTFLAG** – This flag appears only when **v3** is selected as the **SNMPVERSION**. By default, the eG agent does not encrypt SNMP requests. Accordingly, the **ENCRYPTFLAG** is set to **NO** by default. To ensure that SNMP requests sent by the eG agent are encrypted, select the **YES** option.
18. **ENCRYPTTYPE** – If the **ENCRYPTFLAG** is set to **YES**, then you will have to mention the encryption type by selecting an option from the **ENCRYPTTYPE** list. SNMP v3 supports the following encryption types:
    - **DES** – Data Encryption Standard
    - **AES** – Advanced Encryption Standard
19. **ENCRYPTPASSWORD** – Specify the encryption password here.
20. **CONFIRM PASSWORD** – Confirm the encryption password by retyping it here.

21. **USEPS** - **This flag is applicable only for AIX LPARs.** By default, on AIX LPARs, this test uses the **tprof** command to compute CPU usage. Accordingly, the **USEPS** flag is set to **No** by default. On some AIX LPARs however, the **tprof** command may not function properly (this is an AIX issue). While monitoring such AIX LPARs therefore, you can configure the test to use the **ps** command instead for metrics collection. To do so, set the **USEPS** flag to **Yes**.

    Note:

    Alternatively, you can set the **AIXusePS** flag in the **[AGENT_SETTINGS]** section of the **eg_tests.ini** file (in the **<EG_INSTALL_DIR>\manager\config** directory) to **yes** (default: **no**) to enable the eG agent to use the **ps** command for CPU usage computations on AIX LPARs. If this global flag and the **USEPS** flag for a specific component are both set to **no**, then the test will use the default **tprof** command to compute CPU usage for AIX LPARs. If either of these flags is set to **yes**, then the **ps** command will perform the CPU usage computations for monitored AIX LPARs.

    In some high-security environments, the **tprof** command may require some special privileges to execute on an AIX LPAR (eg., *sudo* may need to be used to run **tprof**). In such cases, you can prefix the **tprof** command with another command (like *sudo*) or the full path to a script that grants the required privileges to **tprof**. To achieve this, edit the **eg_tests.ini** file (in the **<EG_INSTALL_DIR>\manager\config** directory), and provide the prefix of your choice against the **AixTprofPrefix** parameter in the **[AGENT_SETTINGS]** section. Finally, save the file. For instance, if you set the **AixTprofPrefix** parameter to *sudo*, then the eG agent will call the **tprof** command as *sudo tprof*.

22. **DATA OVER TCP – This parameter is applicable only if MODE is set to SNMP.** By default, in an IT environment, all data transmission occurs over UDP. Some environments however, may be specifically configured to offload a fraction of the data traffic – for instance, certain types of data traffic or traffic pertaining to specific components – to other protocols like TCP, so as to prevent UDP overloads. In such environments, you can instruct the eG agent to conduct the SNMP data traffic related to the equalizer over TCP (and not UDP). For this, set the **DATA OVER TCP** flag to **Yes**. By default, this flag is set to **No**.

23. **CONTEXT** - This parameter appears only when **v3** is selected as the **SNMPVERSION**. An SNMP context is a collection of management information accessible by an SNMP entity. An item of management information may exist in more than one context and an SNMP entity potentially has access to many contexts. A context is identified by the *SNMPEngineID* value of the entity hosting the management information (also called a contextEngineID) and a context name that identifies the specific context (also called a contextName). If the **USERNAME** provided is associated with a context name, then the eG agent will be able to poll the MIB and collect metrics only if it is configured with the context name as well. In such cases therefore, specify the context name of the **USERNAME** in the **CONTEXT** text box. By default, this parameter is set to *none*.

24. **DD FREQUENCY** - Refers to the frequency with which detailed diagnosis measures are to be generated for this test. The default is *1:1*. This indicates that, by default, detailed measures will be generated every time this test runs, and also every time the test detects a problem. You can modify this frequency, if you so desire. Also, if you intend to disable the detailed diagnosis capability for this test, you can do so by specifying *none* against **DD FREQUENCY**.

25. **DETAILED DIAGNOSIS** - To make diagnosis more efficient and accurate, the eG Enterprise suite embeds an optional detailed diagnostic capability. With this capability, the eG agents can be configured to run detailed, more elaborate tests as and when specific problems are detected. To enable the detailed diagnosis capability of this test for a particular server, choose the **On** option. To disable the capability, click on the **Off** option.

<table>
<tr><td></td><td colspan="3">The option to selectively enable/disable the detailed diagnosis capability will be available only if the following conditions are fulfilled:
The eG manager license should allow the detailed diagnosis capability
Both the normal and abnormal frequencies configured for the detailed diagnosis measures should not be 0.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for the Java application being monitored</td></tr>
<tr><td rowspan="2">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>CPU utilization of JVM:
Indicates the percentage of total available CPU time taken up by the JVM.</td><td>Percent</td><td>If a system has multiple processors, this value is the total CPU time used by the JVM divided by the number of processors on the system.

Ideally, this value should be low. An unusually high value or a consistent increase in this value is indicative of abnormal CPU usage, and could warrant further investigation.

In such a situation, you can use the detailed diagnosis of this measure, if enabled, to determine which runnable threads are currently utilizing excessive CPU.</td></tr>
</table>

The detailed diagnosis of the *CPU utilization of JVM* measure lists all the CPU-consuming threads currently executing in the JVM, in the descending order of the **Percentage Cpu Time** of the threads; this way, you can quickly and accurately identify CPU-intensive threads in the JVM. In addition to CPU usage information, the detailed diagnosis also reveals the following information for every thread:

- The number of times the thread was blocked during the last measurement period, the total duration of the blocks, and the percentage of time for which the thread was blocked;
- The number of times the thread was in wating during the last measurement period, the total duration waited, and the percentage of time for which the thread waited;
- The **Stacktrace** of the thread, using which you can nail the exact line of code causing the CPU consumption of the thread to soar;

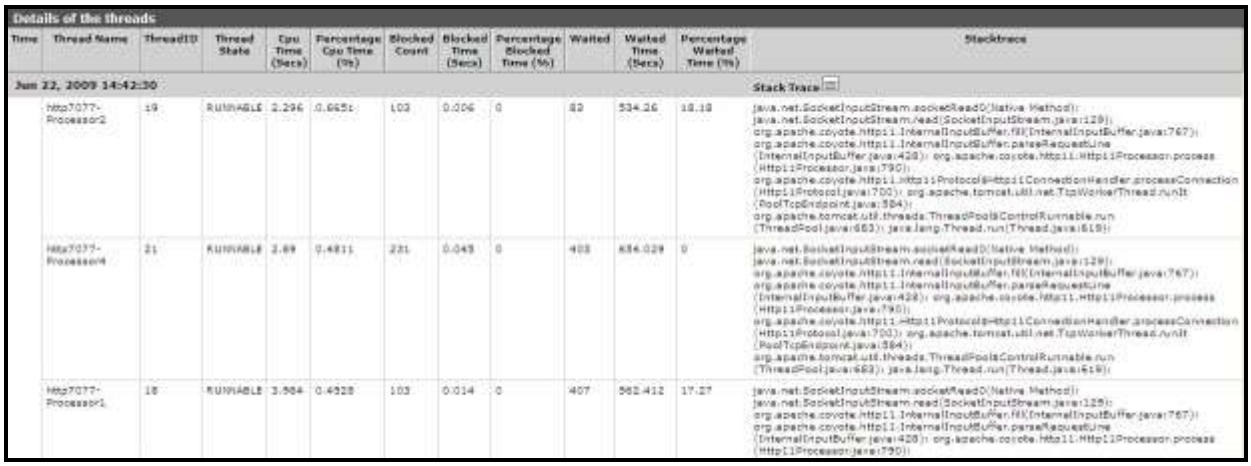


Figure 39: The detailed diagnosis of the CPU utilization of JVM measure

1.4.2 JVM Memory Usage Test

This test monitors every memory type on the JVM and reports how efficiently the JVM utilizes the memory resources of each type.

Note

- This test works only on Windows platforms.
- This test can provide detailed diagnosis information for only those monitored Java applications that use **JRE 1.6 or higher**.

Purpose	Monitors every memory type on the JVM and reports how efficiently the JVM utilizes the memory resources of each type
Target of the test	A Java application
Agent deploying the test	An internal/remote agent

Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens 4. **MODE** – This test can extract metrics from the Java application using either of the following mechanisms: • Using SNMP-based access to the Java runtime MIB statistics; • By contacting the Java runtime (JRE) of the application via JMX To configure the test to use SNMP, select the **SNMP** option. On the other hand, choose the **JMX** option to configure the test to use JMX instead. By default, the **JMX** option is chosen here. 5. **JMX REMOTE PORT** – This parameter appers only if the **MODE** is set to **JMX**. Here, specify the port at which the **JMX** listens for requests from remote hosts. Ensure that you specify the same port that you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 3). 6. **USER**, **PASSWORD**, and **CONFIRM PASSWORD** – These parameters appear only if the **MODE** is set to **JMX**. If JMX requires **authentication only** (but no security), then ensure that the **USER** and **PASSWORD** parameters are configured with the credentials of a user with *read-write* access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the **CONFIRM PASSWORD** text box. 7. **JNDINAME** – This parameter appears only if the **MODE** is set to **JMX**. The **JNDINAME** is a lookup name for connecting to the JMX connector. By default, this is *jmxrmi*. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same. 8. **PROVIDER** – This parameter appears only if the **MODE** is set to **JMX**. This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to *com.sun.jmx.remote.protocol*. 9. **TIMEOUT** – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to *240* seconds if the **MODE** is **JMX**, and *10* seconds if the **MODE** is **SNMP**. 10. **SNMPPORT** – This parameter appears only if the **MODE** is set to **SNMP**. Here specify the port number through which the server exposes its SNMP MIB. Ensure that you specify the same port you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 15). 11. **SNMPVERSION** – This parameter appears only if the **MODE** is set to **SNMP**. The default selection in the **SNMPVERSION** list is **v1**. However, for this test to work, you have to select SNMP **v2** or **v3** from this list, depending upon which version of SNMP is in use in the target environment. 12. **SNMPCOMMUNITY** – This parameter appears only if the **MODE** is set to **SNMP**. Here, specify the SNMP community name that the test uses to communicate with the mail server. The default is public. This parameter is specific to SNMP **v1** and **v2** only. Therefore, if the **SNMPVERSION** chosen is **v3**, then this parameter will not appear.

13. **USERNAME** – This parameter appears only when **v3** is selected as the **SNMPVERSION**. SNMP version 3 (SNMPv3) is an extensible SNMP Framework which supplements the SNMPv2 Framework, by additionally supporting message security, access control, and remote SNMP configuration capabilities. To extract performance statistics from the MIB using the highly secure SNMP v3 protocol, the eG agent has to be configured with the required access privileges – in other words, the eG agent should connect to the MIB using the credentials of a user with access permissions to be MIB. Therefore, specify the name of such a user against the **USERNAME** parameter.
14. **AUTHPASS** – Specify the password that corresponds to the above-mentioned **USERNAME**. This parameter once again appears only if the **SNMPVERSION** selected is **v3**.
15. **CONFIRM PASSWORD** – Confirm the **AUTHPASS** by retyping it here.
16. **AUTHTYPE** – This parameter too appears only if **v3** is selected as the **SNMPVERSION**. From the **AUTHTYPE** list box, choose the authentication algorithm using which SNMP v3 converts the specified **USERNAME** and **PASSWORD** into a 32-bit format to ensure security of SNMP transactions. You can choose between the following options:
    - **MD5** – Message Digest Algorithm
    - **SHA** – Secure Hash Algorithm
17. **ENCRYPTFLAG** – This flag appears only when **v3** is selected as the **SNMPVERSION**. By default, the eG agent does not encrypt SNMP requests. Accordingly, the **ENCRYPTFLAG** is set to **NO** by default. To ensure that SNMP requests sent by the eG agent are encrypted, select the **YES** option.
18. **ENCRYPTTYPE** – If the **ENCRYPTFLAG** is set to **YES**, then you will have to mention the encryption type by selecting an option from the **ENCRYPTTYPE** list. SNMP v3 supports the following encryption types:
    - **DES** – Data Encryption Standard
    - **AES** – Advanced Encryption Standard
19. **ENCRYPTPASSWORD** – Specify the encryption password here.
20. **CONFIRM PASSWORD** – Confirm the encryption password by retyping it here.
21. **DATA OVER TCP – This parameter is applicable only if MODE is set to SNMP.** By default, in an IT environment, all data transmission occurs over UDP. Some environments however, may be specifically configured to offload a fraction of the data traffic – for instance, certain types of data traffic or traffic pertaining to specific components – to other protocols like TCP, so as to prevent UDP overloads. In such environments, you can instruct the eG agent to conduct the SNMP data traffic related to the equalizer over TCP (and not UDP). For this, set the **DATA OVER TCP** flag to **Yes**. By default, this flag is set to **No**.

22. **HEAP ANALYSIS** – By default, this flag is set to **off**. This implies that the test will not provide detailed diagnosis information for memory usage, by default. To trigger the collection of detailed measures, set this flag to **On**.

    Note:

    - If heap analysis is switched **On**, then the eG agent will be able to collect detailed measures only if the Java application being monitored uses **JDK 1.6 OR HIGHER**.
    - Heap analytics / detailed diagnostics will be provided only if the Java application being monitored supports Oracle Hotspot.

23. **JAVA HOME** – This parameter appears only when the **HEAP ANALYSIS** flag is switched **On**. Here, provide the full path to the install directory of **JDK 1.6 or higher** on the application host. For example, *c:\JDK1.6.0*.

24. **EXCLUDE PACKAGES** - The detailed diagnosis of this test, if enabled, lists the Java classes/packages that are using the pool memory and the amount of memory used by each class/package. To enable administrators to focus on the memory consumed by those classes/packages that are specific to their application, without being distracted by the memory consumption of basic Java classes/packages, the test, by default, excludes some common Java packages from the detailed diagnosis. The packages excluded by default are as follows:

    - All packages that start with the string *java* or *javax* - in other words, *java.** and *javax.**.
    - Arrays of primitive data types - eg., *[Z*, which is a one-dimensional array of type boolean, *[[B*, which is a 2-dimensional array of type byte, etc.
    - A few class loaders - eg., *<symbolKlass>, <constantPoolKlass>, <instanceKlassKlass>, <constantPoolCacheKlass>*, etc.

    This is why, the **EXCLUDE PACKAGES** parameter is by default configured with the packages mentioned above. You can, if required, append more packages or patterns of packages to this comma-separated list. This will ensure that such packages also are excluded from the detailed diagnosis of the test. **Note that the EXCLUDE PACKAGES parameter is of relevance only if the HEAP ANALSIS flag is set to 'Yes'**.

25. **INCLUDE PACKAGES** - By default, this is set to *all*. This indicates that, by default, the detailed diagnosis of the test (if enabled) includes all classes/packages associated with the monitored Java application, regardless of whether they are basic Java packages or those that are crucial to the functioning of the application. However, if you want the detailed diagnosis to provide the details of memory consumed by a specific set of classes/packages alone, then, provide a comma-separated list of classes/packages to be included in the detailed diagnosis in the **INCLUDE PACKAGES** text box. **Note that the INCLUDE PACKAGES parameter is of relevance only if the HEAP ANALSIS flag is set to 'Yes'**.

<table>
<tr><td></td><td colspan="3">26. DD FREQUENCY - Refers to the frequency with which detailed diagnosis measures are to be generated for this test. The default is 1:1. This indicates that, by default, detailed measures will be generated every time this test runs, and also every time the test detects a problem. You can modify this frequency, if you so desire. Also, if you intend to disable the detailed diagnosis capability for this test, you can do so by specifying none against DD FREQUENCY.
27. DETAILED DIAGNOSIS - To make diagnosis more efficient and accurate, the eG Enterprise suite embeds an optional detailed diagnostic capability. With this capability, the eG agents can be configured to run detailed, more elaborate tests as and when specific problems are detected. To enable the detailed diagnosis capability of this test for a particular server, choose the On option. To disable the capability, click on the Off option.
The option to selectively enable/disable the detailed diagnosis capability will be available only if the following conditions are fulfilled:
• The eG manager license should allow the detailed diagnosis capability
• Both the normal and abnormal frequencies configured for the detailed diagnosis measures should not be 0.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for every memory type on the JVM being monitored</td></tr>
<tr><td rowspan="3">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>Initial memory:
Indicates the amount of memory initially allocated at startup.</td><td>MB</td><td></td></tr>
<tr><td>Used memory:
Indicates the amount of memory currently used.</td><td>MB</td><td>It includes the memory occupied by all objects, including both reachable and unreachable objects.
Ideally, the value of this measure should be low. A high value or a consistent increase in the value could indicate gradual erosion of memory resources. In such a situation, you can take the help of the detailed diagnosis of this measure (if enabled), to figure out which class is using up memory excessively.</td></tr>
<tr><td></td><td>Available memory:
Indicates the amount of memory guaranteed to be available for use by the JVM.</td><td>MB</td><td>The amount of Available memory may change over time. The Java virtual machine may release memory to the system and committed memory could be less than the amount of memory initially allocated at startup. Committed will always be greater than or equal to used memory.</td></tr>
</table>

	Free memory: Indicates the amount of memory currently available for use by the JVM.	MB	This is the difference between **Available memory** and **Used memory**. Ideally, the value of this measure should be high.
	Max free memory: Indicates the maximum amount of memory allocated for the JVM.	MB	
	Used percentage: Indicates the percentage of used memory.	Percent	Ideally, the value of this measure should be low. A very high value of this measure could indicate excessive memory consumption by the JVM, which in turn, could warrant further investigation. In such a situation, you can take the help of the detailed diagnosis of this measure (if enabled), to figure out which class is using up memory excessively.

The detailed diagnosis of the *Used memory* measure, if enabled, lists all the classes that are using the pool memory, the amount and percentage of memory used by each class, the number of instances of each class that is currently operational, and also the percentage of currently running instances of each class. Since this list is by default sorted in the descending order of the percentage memory usage, the first class in the list will obviously be the leading memory consumer.

Details of JVM Heap Usage

Time	Class Name	Instance Count	Instance Percentage	Memory used(MB)	Percentage memory used
Jun 17, 2009 12:11:01					
	com.ibc.object.SapBusinessObject	104003	11.5774	12.629	22.5521
	[Ljava.lang.Object;	23586	2.6255	7.4904	13.3759
	<constMethodKlas>	41243	4.5911	5.8357	10.4211
	java.lang.String	174044	19.3742	3.9836	7.1136
	[C	240000	26.7163	3.6621	6.5396
	[B	7336	0.8166	3.5868	6.4051
	<methodKlas>	41243	4.5911	3.1514	5.6275
	<symbolKlas>	69152	7.6979	2.8014	5.0025
	[I	26240	2.921	2.3018	4.1105
	<constantPoolKlas>	3097	0.3448	2.0491	3.6591
	<instanceKlassKlas>	3097	0.3448	1.296	2.3144
	<constantPoolCacheKlas>	2663	0.2964	1.2536	2.2386
	[S	5546	0.6174	0.4283	0.7649
	java.util.Hashtable$Entry	15908	1.7708	0.3641	0.6502
	<methodDataKlas>	870	0.0968	0.3594	0.6418
	java.lang.reflect.Method	4269	0.4752	0.3257	0.5816
	java.lang.Class	3383	0.3766	0.3097	0.5531
	java.util.Vector	13266	1.4767	0.3036	0.5422

Figure 40: The detailed diagnosis of the Used memory measure

1.4.3 JVM Uptime Test

This test tracks the uptime of a JVM. Using information provided by this test, administrators can determine whether the JVM was restarted. Comparing uptime across Java applications, an admin can determine the JVMs that have been running without any restarts for the longest time.

Purpose	Tracks the uptime of a JVM
Target of the test	A Java application
Agent deploying the test	An internal/remote agent

Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens 4. **MODE** – This test can extract metrics from the Java application using either of the following mechanisms: • Using SNMP-based access to the Java runtime MIB statistics; • By contacting the Java runtime (JRE) of the application via JMX To configure the test to use SNMP, select the **SNMP** option. On the other hand, choose the **JMX** option to configure the test to use JMX instead. By default, the **JMX** option is chosen here. 5. **JMX REMOTE PORT** – This parameter appears only if the **MODE** is set to **JMX**. Here, specify the port at which the **JMX** listens for requests from remote hosts. Ensure that you specify the same port that you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 3). 6. **USER**, **PASSWORD**, and **CONFIRM PASSWORD** – These parameters appear only if the **MODE** is set to **JMX**. If JMX requires **authentication only** (but no security), then ensure that the **USER** and **PASSWORD** parameters are configured with the credentials of a user with *read-write* access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the **CONFIRM PASSWORD** text box. 7. **JNDINAME** – This parameter appears only if the **MODE** is set to **JMX**. The **JNDINAME** is a lookup name for connecting to the JMX connector. By default, this is *jmxrmi*. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same. 8. **PROVIDER** – This parameter appears only if the **MODE** is set to **JMX**. This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to *com.sun.jmx.remote.protocol*. 9. **TIMEOUT** – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to *240* seconds if the **MODE** is **JMX**, and *10* seconds if the **MODE** is **SNMP**. 10. **SNMPPORT** – This parameter appears only if the **MODE** is set to **SNMP**. Here specify the port number through which the server exposes its SNMP MIB. Ensure that you specify the same port you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 15). 11. **SNMPVERSION** – This parameter appears only if the **MODE** is set to **SNMP**. The default selection in the **SNMPVERSION** list is **v1**. However, for this test to work, you have to select SNMP **v2** or **v3** from this list, depending upon which version of SNMP is in use in the target environment. 12. **SNMPCOMMUNITY** – This parameter appears only if the **MODE** is set to **SNMP**. Here, specify the SNMP community name that the test uses to communicate with the mail server. The default is public. This parameter is specific to SNMP **v1** and **v2** only. Therefore, if the **SNMPVERSION** chosen is **v3**, then this parameter will not appear.

13. **USERNAME** – This parameter appears only when **v3** is selected as the **SNMPVERSION**. SNMP version 3 (SNMPv3) is an extensible SNMP Framework which supplements the SNMPv2 Framework, by additionally supporting message security, access control, and remote SNMP configuration capabilities. To extract performance statistics from the MIB using the highly secure SNMP v3 protocol, the eG agent has to be configured with the required access privileges – in other words, the eG agent should connect to the MIB using the credentials of a user with access permissions to be MIB. Therefore, specify the name of such a user against the **USERNAME** parameter.
14. **AUTHPASS** – Specify the password that corresponds to the above-mentioned **USERNAME**. This parameter once again appears only if the **SNMPVERSION** selected is **v3**.
15. **CONFIRM PASSWORD** – Confirm the **AUTHPASS** by retyping it here.
16. **AUTHTYPE** – This parameter too appears only if **v3** is selected as the **SNMPVERSION**. From the **AUTHTYPE** list box, choose the authentication algorithm using which SNMP v3 converts the specified **USERNAME** and **PASSWORD** into a 32-bit format to ensure security of SNMP transactions. You can choose between the following options:
    - **MD5** – Message Digest Algorithm
    - **SHA** – Secure Hash Algorithm
17. **ENCRYPTFLAG** – This flag appears only when **v3** is selected as the **SNMPVERSION**. By default, the eG agent does not encrypt SNMP requests. Accordingly, the **ENCRYPTFLAG** is set to **NO** by default. To ensure that SNMP requests sent by the eG agent are encrypted, select the **YES** option.
18. **ENCRYPTTYPE** – If the **ENCRYPTFLAG** is set to **YES**, then you will have to mention the encryption type by selecting an option from the **ENCRYPTTYPE** list. SNMP v3 supports the following encryption types:
    - **DES** – Data Encryption Standard
    - **AES** – Advanced Encryption Standard
19. **ENCRYPTPASSWORD** – Specify the encryption password here.
20. **CONFIRM PASSWORD** – Confirm the encryption password by retyping it here.
21. **TIMEOUT** - This parameter appears only if the **MODE** is set to **SNMP**. Here, specify the duration (in seconds) within which the SNMP query executed by this test should time out in the **TIMEOUT** text box. The default is 10 seconds.

<table>
<tr><td></td><td colspan="3">22. DATA OVER TCP – This parameter is applicable only if MODE is set to SNMP. By default, in an IT environment, all data transmission occurs over UDP. Some environments however, may be specifically configured to offload a fraction of the data traffic – for instance, certain types of data traffic or traffic pertaining to specific components – to other protocols like TCP, so as to prevent UDP overloads. In such environments, you can instruct the eG agent to conduct the SNMP data traffic related to the equalizer over TCP (and not UDP). For this, set the DATA OVER TCP flag to Yes. By default, this flag is set to No.
23. DD FREQUENCY - Refers to the frequency with which detailed diagnosis measures are to be generated for this test. The default is 1:1. This indicates that, by default, detailed measures will be generated every time this test runs, and also every time the test detects a problem. You can modify this frequency, if you so desire. Also, if you intend to disable the detailed diagnosis capability for this test, you can do so by specifying none against DD FREQUENCY.
24. DETAILED DIAGNOSIS - To make diagnosis more efficient and accurate, the eG Enterprise suite embeds an optional detailed diagnostic capability. With this capability, the eG agents can be configured to run detailed, more elaborate tests as and when specific problems are detected. To enable the detailed diagnosis capability of this test for a particular server, choose the On option. To disable the capability, click on the Off option.
The option to selectively enable/disable the detailed diagnosis capability will be available only if the following conditions are fulfilled:
• The eG manager license should allow the detailed diagnosis capability
• Both the normal and abnormal frequencies configured for the detailed diagnosis measures should not be 0.</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for every Java application monitored</td></tr>
<tr><td>Measurements made by the</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
</table>

<table>
<tr>
<td>test</td>
<td>Has JVM been restarted?:
Indicates whether or not the JVM has restarted during the last measurement period.</td>
<td></td>
<td>If the value of this measure is No, it indicates that the JVM has not restarted. The value Yes on the other hand implies that the JVM has indeed restarted.
The numeric values that correspond to the restart states discussed above are listed in the table below:
<table>
<tr><th>State</th><th>Value</th></tr>
<tr><td>Yes</td><td>1</td></tr>
<tr><td>No</td><td>0</td></tr>
</table>
Note:
By default, this measure reports the value Yes or No to indicate whether a JVM has restarted. The graph of this measure however, represents the same using the numeric equivalents – 0 or 1.</td>
</tr>
<tr>
<td></td>
<td>Uptime during the last measure period:
Indicates the time period that the JVM has been up since the last time this test ran.</td>
<td>Secs</td>
<td>If the JVM has not been restarted during the last measurement period and the agent has been running continuously, this value will be equal to the measurement period. If the JVM was restarted during the last measurement period, this value will be less than the measurement period of the test. For example, if the measurement period is 300 secs, and if the JVM was restarted 120 secs back, this metric will report a value of 120 seconds. The accuracy of this metric is dependent on the measurement period – the smaller the measurement period, greater the accuracy.</td>
</tr>
<tr>
<td></td>
<td>Total uptime of the JVM:
Indicates the total time that the JVM has been up since its last reboot.</td>
<td>Secs</td>
<td>Administrators may wish to be alerted if a JVM has been running without a reboot for a very long period. Setting a threshold for this metric allows administrators to determine such conditions.</td>
</tr>
</table>

1.4.4 JVM Leak Suspects Test

This test is **CPU & Memory intensive** and can cause slowness to the underlying application**.** It is hence **NOT advisable** to enable this test on production environments. It is ideally suited for Development and Staging environments.

Java implements automatic garbage collection (GC); once you stop using an object, you can depend on the garbage collector to collect it. To stop using an object, you need to eliminate all references to it. However, when a program never stops using an object by keeping a permanent reference to it, memory leaks occur. For example, let's consider the piece of code below:

```
1 import java.util.ArrayList;
2 import java.util.List;
3
4 class MemoryLeakDemo {
5     private static List<Integer> memoryLeakArea = new ArrayList<Integer>();
6
7     public static void main(String [] args) {
8
9         int iteration = 0;
10
11        // This infinite loop would eventually run out of memory
12        while (true) {
13            // Add number of the current iteration to the list.
14            Integer payload = new Integer(iteration);
15            memoryLeakArea.add(payload);
16            iteration++;
17        }
18    }
19 }
```

Figure 41: A sample code

In the example above, we continue adding new elements to the list *memoryLeakArea* without ever removing them. In addition, we keep references to the *memoryLeakArea*, thereby preventing GC from collecting the list itself. So although there is GC available, it cannot help because we are still using memory. The more time passes the more memory we use, which in effect requires an infinite amount memory for this program to continue running. When no more memory is remaining, an OutOfMemoryError alert will be thrown and generate an exception like this:

Exception in thread "main" java.lang.OutOfMemoryError: Java heap space at MemoryLeakDemo.main(MemoryLeakDemo.java:14)

Typically, such alerts signal a potential memory leak!

A memory leak can diminish the performance of your mission-critical Java applications by reducing the amount of available memory. Eventually, in the worst case, it may cause the application to crash due to thrashing. To avert such unwarranted application failures, it is imperative that memory leaks are detected at the earliest and the objects responsible for them accurately isolated. This is where, the **JVM Leak Suspects** test helps! This test continuously monitors the JVM heap usage and promptly alerts administrators when memory usage crosses a configured limit. The detailed diagnostics of the test will then lead you to the classes that are consuming memory excessively, thereby pointing you to those classes that may have caused the leak.

This test will work only if the following pre-requisites are fulfilled:

- The test should be executed in an agent-based manner only.
- The target Java application should use the JDK/JRE offered by one of the following vendors only: Oracle, Sun, OpenJDK. **IBM JDK/JRE is not supported**.
- The monitored Java application should use **JDK/JRE 1.6 or higher**.
- For this test to run and report metrics, the *eG agent install user* should be the same as the *Java application* (or) *Java web/application server install user*.
- By default , this test programmatically dumps a heap dump (*.hprof* files) in the folder **<EG_AGENT_INSTALL_DIR>\agent\logs** folder. To enable the eG agent to read/analyse such files, you need to add the *eG agent install user* to the *Java application* (or) *Java web/application server install user group*. If this is not done, then the dump files will be created, but will not be processed by the eG agent, thus ending up unnecessarily occupying disk space (note that *.hprof* files are normally 1-5 GB in size).

This test is disabled by default. To enable the test, follow the Agents -> Tests -> Enable/Disable menu sequence. Select *Java application* as the **Component type** and *Performance* as the **Test type**. From the **DISABLED TESTS** list, pick this test and click the **Enable** button to enable it.

Purpose	Continuously monitors the JVM heap usage and promptly alerts administrators when memory usage crosses a configured limit
Target of the test	A Java application
Agent deploying the test	An internal/remote agent

Configurable parameters for the test	1. **TEST PERIOD** - How often should the test be executed 2. **HOST -** The host for which the test is to be configured 3. **PORT -** The port number at which the specified **HOST** listens 4. **MODE** – This test can extract metrics from the Java application using either of the following mechanisms: • Using SNMP-based access to the Java runtime MIB statistics; • By contacting the Java runtime (JRE) of the application via JMX To configure the test to use SNMP, select the **SNMP** option. On the other hand, choose the **JMX** option to configure the test to use JMX instead. By default, the **JMX** option is chosen here. 5. **JMX REMOTE PORT** – This parameter appears only if the **MODE** is set to **JMX**. Here, specify the port at which the **JMX** listens for requests from remote hosts. Ensure that you specify the same port that you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 3). 6. **USER**, **PASSWORD**, and **CONFIRM PASSWORD** – These parameters appear only if the **MODE** is set to **JMX**. If JMX requires **authentication only** (but no security), then ensure that the **USER** and **PASSWORD** parameters are configured with the credentials of a user with *read-write* access to JMX. To know how to create this user, refer to Section 1.1.1.2. Confirm the password by retyping it in the **CONFIRM PASSWORD** text box. 7. **JNDINAME** – This parameter appears only if the **MODE** is set to **JMX**. The **JNDINAME** is a lookup name for connecting to the JMX connector. By default, this is *jmxrmi*. If you have resgistered the JMX connector in the RMI registery using a different lookup name, then you can change this default value to reflect the same. 8. **PROVIDER** – This parameter appears only if the **MODE** is set to **JMX**. This test uses a JMX Provider to access the MBean attributes of the target Java application and collect metrics. Specify the package name of this JMX Provider here. By default, this is set to *com.sun.jmx.remote.protocol*. 9. **TIMEOUT** – Specify the duration (in seconds) for which this test should wait for a response from the target Java application. If there is no response from the target beyond the configured duration, the test will timeout. By default, this is set to *240* seconds if the monitoring mode is **JMX**, and *10* seconds if the monitoring mode is **SNMP**. 10. **SNMPPORT** – This parameter appears only if the **MODE** is set to **SNMP**. Here specify the port number through which the server exposes its SNMP MIB. Ensure that you specify the same port you configured in the *management.properties* file in the **<JAVA_HOME>\jre\lib\management** folder used by the target application (see page 15). 11. **SNMPVERSION** – This parameter appears only if the **MODE** is set to **SNMP**. The default selection in the **SNMPVERSION** list is **v1**. However, for this test to work, you have to select SNMP **v2** or **v3** from this list, depending upon which version of SNMP is in use in the target environment. 12. **SNMPCOMMUNITY** – This parameter appears only if the **MODE** is set to **SNMP**. Here, specify the SNMP community name that the test uses to communicate with the mail server. The default is public. This parameter is specific to SNMP **v1** and **v2** only. Therefore, if the **SNMPVERSION** chosen is **v3**, then this parameter will not appear.

13. **USERNAME** – This parameter appears only when **v3** is selected as the **SNMPVERSION**. SNMP version 3 (SNMPv3) is an extensible SNMP Framework which supplements the SNMPv2 Framework, by additionally supporting message security, access control, and remote SNMP configuration capabilities. To extract performance statistics from the MIB using the highly secure SNMP v3 protocol, the eG agent has to be configured with the required access privileges – in other words, the eG agent should connect to the MIB using the credentials of a user with access permissions to be MIB. Therefore, specify the name of such a user against the **USERNAME** parameter.
14. **AUTHPASS** – Specify the password that corresponds to the above-mentioned **USERNAME**. This parameter once again appears only if the **SNMPVERSION** selected is **v3**.
15. **CONFIRM PASSWORD** – Confirm the **AUTHPASS** by retyping it here.
16. **AUTHTYPE** – This parameter too appears only if **v3** is selected as the **SNMPVERSION**. From the **AUTHTYPE** list box, choose the authentication algorithm using which SNMP v3 converts the specified **USERNAME** and **PASSWORD** into a 32-bit format to ensure security of SNMP transactions. You can choose between the following options:
    - **MD5** – Message Digest Algorithm
    - **SHA** – Secure Hash Algorithm
17. **ENCRYPTFLAG** – This flag appears only when **v3** is selected as the **SNMPVERSION**. By default, the eG agent does not encrypt SNMP requests. Accordingly, the **ENCRYPTFLAG** is set to **NO** by default. To ensure that SNMP requests sent by the eG agent are encrypted, select the **YES** option.
18. **ENCRYPTTYPE** – If the **ENCRYPTFLAG** is set to **YES**, then you will have to mention the encryption type by selecting an option from the **ENCRYPTTYPE** list. SNMP v3 supports the following encryption types:
    - **DES** – Data Encryption Standard
    - **AES** – Advanced Encryption Standard
19. **ENCRYPTPASSWORD** – Specify the encryption password here.
20. **CONFIRM PASSWORD** – Confirm the encryption password by retyping it here.

<table>
<tr><td></td><td colspan="3">
21. PCT HEAP LIMIT - This test counts all those classes that are consuming memory beyond the limit (in percentage) specified against PCT HEAP LIMIT as 'memory leak suspects'. This count is reported as the value of the Leak suspect classes measure. By default, 30 (%) is the PCT HEAP LIMIT. This implies that the test, by default, reports each class that consumes over 30% of the Allocated heap memory as a Leak suspect class. Such classes are listed as part of detailed diagnostics.
22. DATA OVER TCP – This parameter is applicable only if MODE is set to SNMP. By default, in an IT environment, all data transmission occurs over UDP. Some environments however, may be specifically configured to offload a fraction of the data traffic – for instance, certain types of data traffic or traffic pertaining to specific components – to other protocols like TCP, so as to prevent UDP overloads. In such environments, you can instruct the eG agent to conduct the SNMP data traffic related to the equalizer over TCP (and not UDP). For this, set the DATA OVER TCP flag to Yes. By default, this flag is set to No.
23. DD FREQUENCY - Refers to the frequency with which detailed diagnosis measures are to be generated for this test. The default is 1:1. This indicates that, by default, detailed measures will be generated every time this test runs, and also every time the test detects a problem. You can modify this frequency, if you so desire. Also, if you intend to disable the detailed diagnosis capability for this test, you can do so by specifying none against DD FREQUENCY.
24. DETAILED DIAGNOSIS - To make diagnosis more efficient and accurate, the eG Enterprise suite embeds an optional detailed diagnostic capability. With this capability, the eG agents can be configured to run detailed, more elaborate tests as and when specific problems are detected. To enable the detailed diagnosis capability of this test for a particular server, choose the On option. To disable the capability, click on the Off option.
The option to selectively enable/disable the detailed diagnosis capability will be available only if the following conditions are fulfilled:
• The eG manager license should allow the detailed diagnosis capability
• Both the normal and abnormal frequencies configured for the detailed diagnosis measures should not be 0.
</td></tr>
<tr><td>Outputs of the test</td><td colspan="3">One set of results for every Java application monitored</td></tr>
<tr><td rowspan="2">Measurements made by the test</td><td>Measurement</td><td>Measurement Unit</td><td>Interpretation</td></tr>
<tr><td>Allocated Heap Memory:
Indicates the total amount of memory space occupied by the objects that are currently loaded on to the JVM.</td><td>MB</td><td></td></tr>
</table>

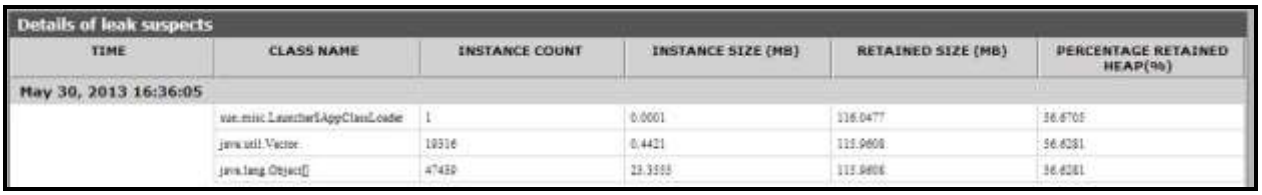
	Leak suspected classes: Indicates the number of classes that are memory leak suspects.	Number	Use the detailed diagnosis of this measure to know which classes are using more memory than the configured **PCT HEAP LIMIT**. Remember that all applications/classes that throw *OutofMemory* exceptions need not be guilty of leaking memory. Such an exception can occur even if a class requires more memory for normal functioning. To distinguish between a memory leak and an application that simply needs more memory, we need to look at the "peak load" concept. When program has just started no users have yet used it, and as a result it typically needs much less memory then when thousands of users are interacting with it. Thus, measuring memory usage immediately after a program starts is not the best way to gauge how much memory it needs! To measure how much memory an application needs, memory size measurements should be taken at the time of peak load—when it is most heavily used. Therefore, it is good practice to check the memory usage of the 'suspected classes' at the time of peak load to determine whether they are indeed leaking memory or not.
	Number of objects: Indicates the number of objects present in the JVM.	Number	Use the detailed diagnosis of this measure to view the top-20 classes in the JVM in terms of memory usage.
	Number of classes: Indicates the number of classes currently present in the JVM.	Number	
	Number of class loaders: Indicates the number of class loaders currently present in the JVM.	Number	

<table>
<tr>
<td></td>
<td>Number of GC roots:
Indicate the number of GC roots currently present in the JVM.</td>
<td>Number</td>
<td>A garbage collection root is an object that is accessible from outside the heap. The following reasons make an object a GC root:
<table>
<tr><th>Reason</th><th>Description</th></tr>
<tr><td>System Class</td><td>Class loaded by bootstrap/system class loader. For example, everything from the rt.jar like java.util.</td></tr>
<tr><td>JNI Local</td><td>Local variable in native code, such as user defined JNI code or JVM internal code</td></tr>
<tr><td>JNI Global</td><td>Global variable in native code, such as user defined JNI code or JVM internal code</td></tr>
<tr><td>Thread Block</td><td>Object referred to from a currently active thread block</td></tr>
<tr><td>Thread</td><td>A started, but not stopped, thread</td></tr>
</table>
</td>
</tr>
</table>

			Busy Monitor	Everything that has called wait() or notify() or that is synchronized. For example, by calling synchronized(Object) or by entering a synchronized method. Static method means class, non-static method means object
			Java Local	Local variable. For example, input parameters or locally created objects of methods that are still in the stack of a thread.
			Native Stack	In or out parameters in native code, such as user defined JNI code or JVM internal code. or reflection.

			Finalizer	An object which is in a queue awaiting its finalizer to be run.
			Unfinalized	An object which has a finalize method, but has not been finalized and is not yet on the finalizer queue.
			Unreachable	An object which is unreachable from any other root, but has been marked as a root by MAT to retain objects which otherwise would not be included in the analysis.
			Unknown	An object of unknown root type.
	Objects pending for finalization: Indicates the number of objects that are pending for finalization.	Number	Sometimes an object will need to perform some action when it is destroyed. For example, if an object is holding some non-java resource such as a file handle or window character font, then you might want to make sure these resources are freed before an object is destroyed. To handle such situations, Java provides a mechanism called finalization. By using finalization, you can define specific actions that will occur when an object is just about to be reclaimed by the garbage collector. A high value for this measure indicates the existence of many objects that are still occupying the JVM memory space and are unable to be reclaimed by GC. A consistent rise in this value is also a sign of a memory leak.		

The detailed diagnosis of the *Leak suspected classes* measure lists the names of all classes for which the memory usage is over the configured **PCT HEAP LIMIT.** In addition, the detailed diagnosis also reveals the **PERCENTAGE RETAINED HEAP** of each class - this is the percentage of the total *Allocated heap size* that is used by every class. From this, you can easily infer which class is consuming the maximum memory, and is hence, the key memory leak suspect. By observing the memory usage of this class during times of peak load, you can corroborate eG's findings - i.e., you can know for sure whether that class is indeed leaking memory or not!


Details of leak suspects

TIME	CLASS NAME	INSTANCE COUNT	INSTANCE SIZE (MB)	RETAINED SIZE (MB)	PERCENTAGE RETAINED HEAP(%)
May 30, 2013 16:36:05					
	sun.misc.Launcher$AppClassLoader	1	0.0001	116.0477	56.6703
	java.util.Vector	19316	0.4421	115.9808	56.6281
	java.lang.Object[]	47489	23.3393	115.9808	56.6281

Figure 42: The detailed diagnosis of the Leak suspect classes measure

The detailed diagnosis of the *Number of objects* measure lists the names of the top-20 classes in the JVM, in terms of memory usage. In addition, the detailed diagnosis also reveals the **PERCENTAGE RETAINED HEAP** of each class - this is the percentage of the total *Allocated heap size* that is used by every class. From this, you can easily infer which class is consuming the maximum memory, and is hence, the key memory leak suspect. By observing the memory usage of this class during times of peak load, you can corroborate eG's findings - i.e., you can know for sure whether that class is indeed leaking memory or not!

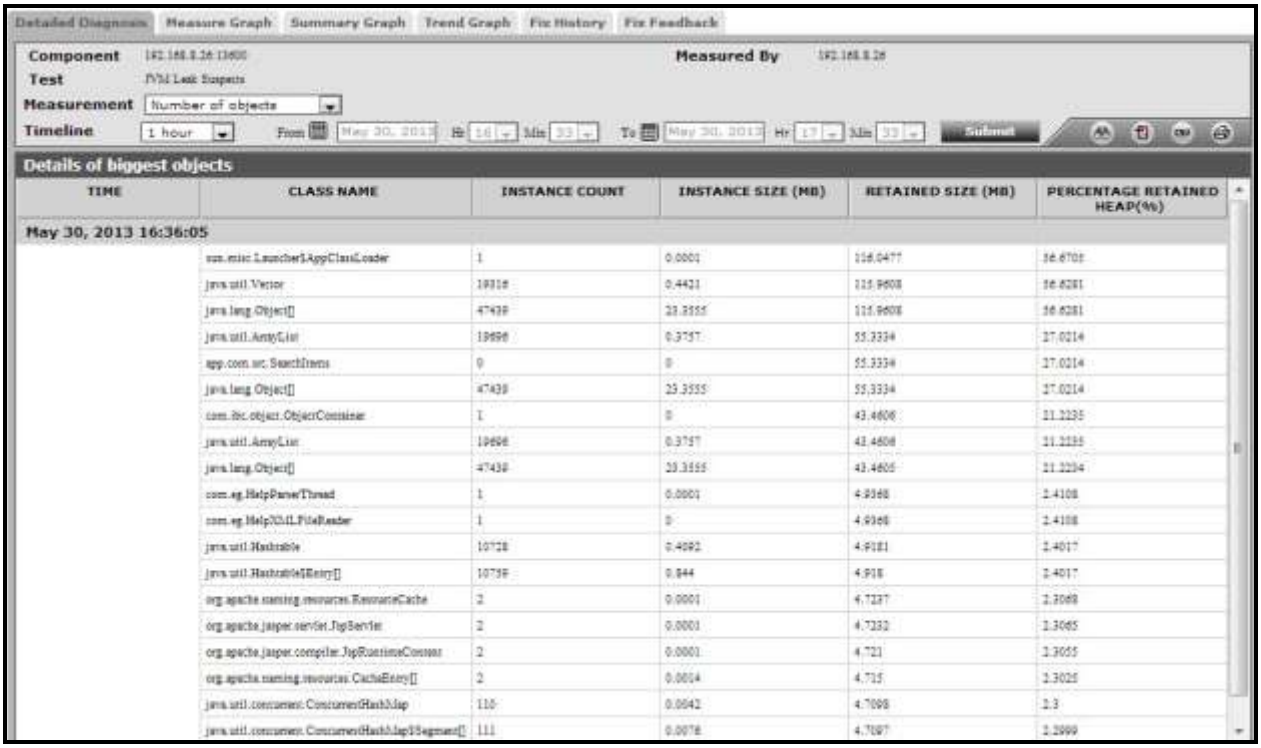


Figure 43: The detailed diagnosis of the Number of objects measure

1.5 What the eG Enterprise Java Monitor Reveals?

This section discusses how administrators can effortlessly and accurately diagnose the root-cause of issues experienced by Java applications, using thclasse eG JVM Monitor. Each of the sub-sections that follow take the case of a sample application problem, and illustrates the steps to be followed to troubleshoot the problem in the eG monitoring console.

1.5.1 Identifying and Diagnosing a CPU Issue in the JVM

In this section, let us consider the case of the Java application, *sapbusiness-152:123*, which is being monitored by eG Enterprise. Assume that this application is running on a Tomcat server.

Initially, the application was functioning normally, as indicated by Figure 44. There are no high CPU threads.

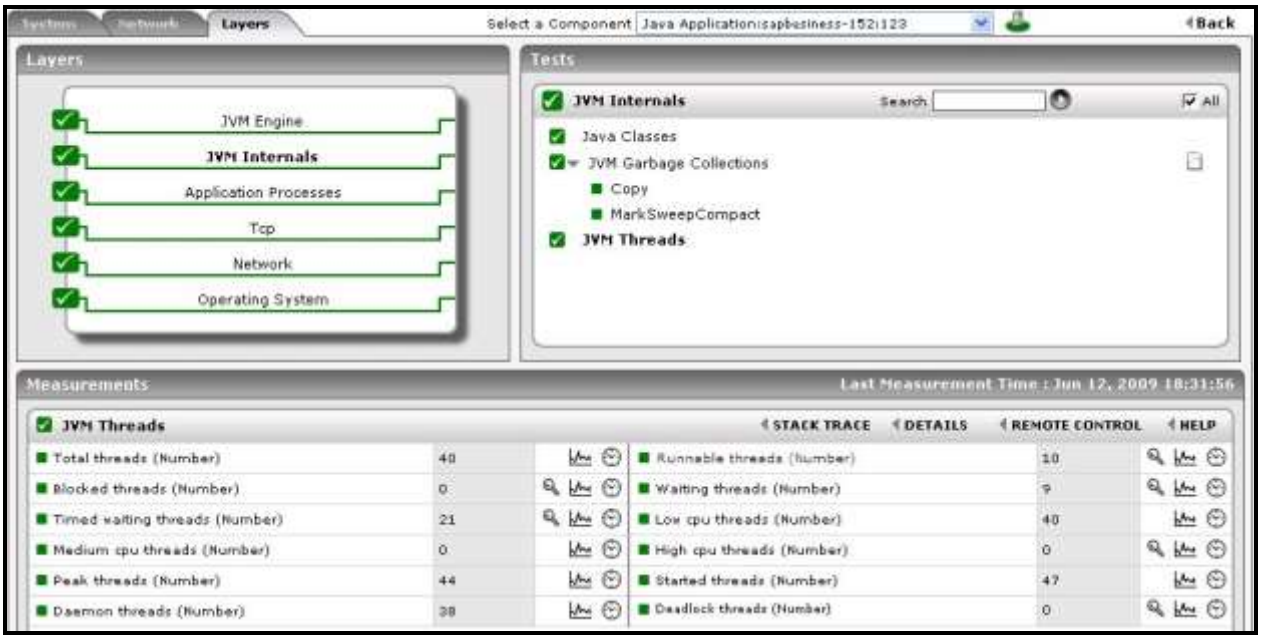


Figure 44: The Java application being monitored functioning normally

Now, assume that suddenly, one of the threads executed by the application starts to run abnormally, consuming excessive CPU resources. This is indicated by a change in the value of the *High cpu threads* measure reported by the **JVM Threads** test mapped to the **JVM Internals** layer of the *Java Application* monitoring model (see Figure 44). As you can see, as long as the *sapbusiness* application was performing well, the value of the *High cpu threads* measure was 0 (see Figure 44). However, as soon as a thread began exhibiting abnormal CPU usage trends, the value changed to 1 (see Figure 45).

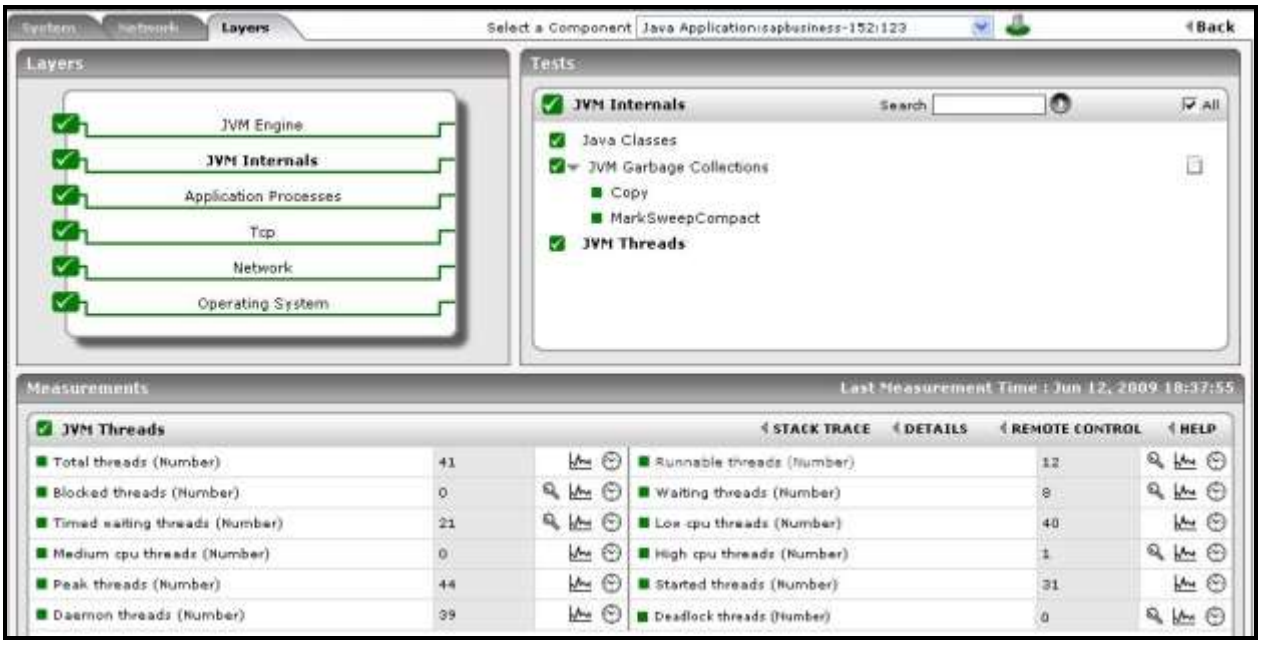


Figure 45: The High cpu threads measure indicating that a single thread is consuming CPU excessively

To know which thread is consuming too much CPU, click on the **DIAGNOSIS** icon (i.e., the magnifying glass icon) corresponding to the *High cpu threads* measure in Figure 45. Figure 46 then appears revealing the name of the CPU-

intensive thread (*SapBusinessConnectorThread*) and the percentage of CPU used by the thread during the last measurement period. In addition, Figure 46 also reveals the number of times the thread was blocked, the total duration of the blocks, the number of times the thread was in waiting, and the percentage of time waited, thereby revealing how resource-intensive the thread has been during the last measurement period.

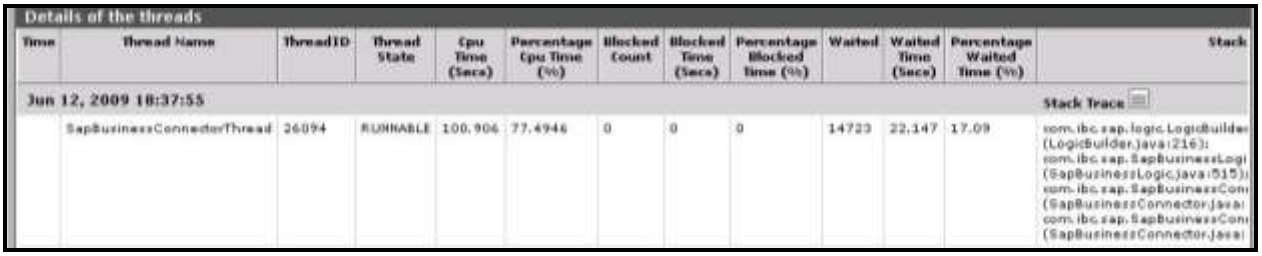


Figure 46: The detailed diagnosis of the High cpu threads measure

Let us now get back to the CPU usage issue. Now that we know which thread is causing the CPU usage spike, we next need to determine what is causing this thread to erode the CPU resources. To facilitate this analysis, the detailed diagnosis page of Figure 46 also provides the **Stack Trace** for the thread. You might have to scroll left to view the complete **Stack Trace** of the thread (see Figure 47).

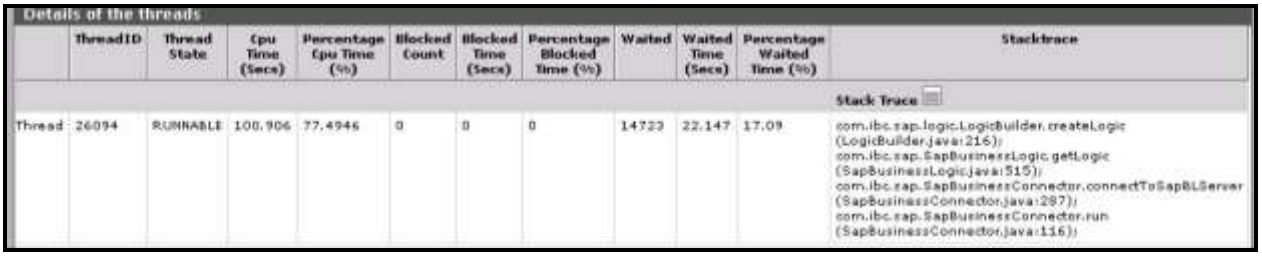


Figure 47: Viewing the stack trace as part of the detailed diagnosis of the High cpu threads measure

The stack trace is useful in determining exactly which line of code the thread was executing when we took the last diagnosis snapshot and what was the code execution path that the thread had taken.

To view the stack trace of the CPU-intensive thread more clearly and to analyze it closely, click on the icon in Figure 47 or the **Stack Trace** label adjacent to the icon. Figure 48 then appears.

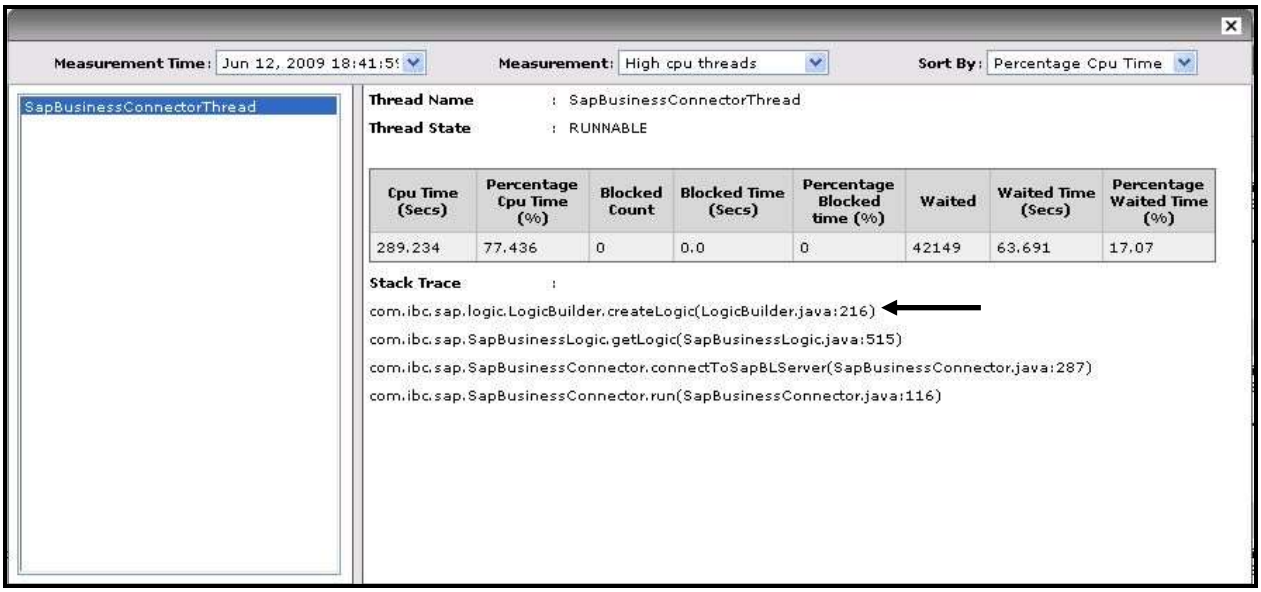


Figure 48: Stack trace of the CPU-intensive thread

As you can see, Figure 48 provides two panels. The left panel of Figure 48, by default, displays all the high CPU-consuming threads sorted in the descending order of their CPU usage. Accordingly, the **High cpu threads** measure is chosen by default from the **Measurement** list, and the **Percentage Cpu Time** is the default selection in the **Sort By** list in Figure 48. These default selections can however be changed by picking a different option from the **Measurement** and **Sort By** lists.

The right panel on the other hand, typically displays the current state, overall resource usage, and the **Stack Trace** for the thread chosen from the left panel. By default however, the right panel provides the stack trace for the leading CPU consumer.

In the case of our example, since only a single thread is currently utilizing CPU excessively, the name of that thread (i.e, *SapBusinessConnectorThread*) alone will appear in the left panel of Figure 48. The right panel too therefore, will display the details of the *SapBusinessConnectorThread* only. Let us begin to analyze the **Stack Trace** of this thread carefully.

Stack trace information should always be viewed in a top-down manner. The method most likely to be the cause of the problem is the one on top. In the example of Figure 48, this is *com.ibc.sap.logic.LogicBuilder.createLogic*. The line of code that was executed last when the snapshot was taken is within the *createLogic* method of the *com.ibc.sap.logic.LogicBuilder* class. This is line number 216 of the *LogicBuilder.java* source file. The subsequent lines of the stack trace indicate the sequence of method calls that resulted in *com.ibc.sap.logic.LogicBuilder.createLogic* being invoked. In this example, *com.ibc.sap.logic.LogicBuilder.createLogic* has been invoked from the method *com.ibc.sap.SapBusinessLogic.getLogic.* This invocation has been done by line 515 of *SapBusinessLogic.java* source file.

To verify if the stack trace is correct in identifying the exact line of the source code that is responsible for the sudden increase in CPU consumption by the *SapBusinessConnectorThread*, let us review the **LogicBuilder.java** file in an editor (see Figure 49).

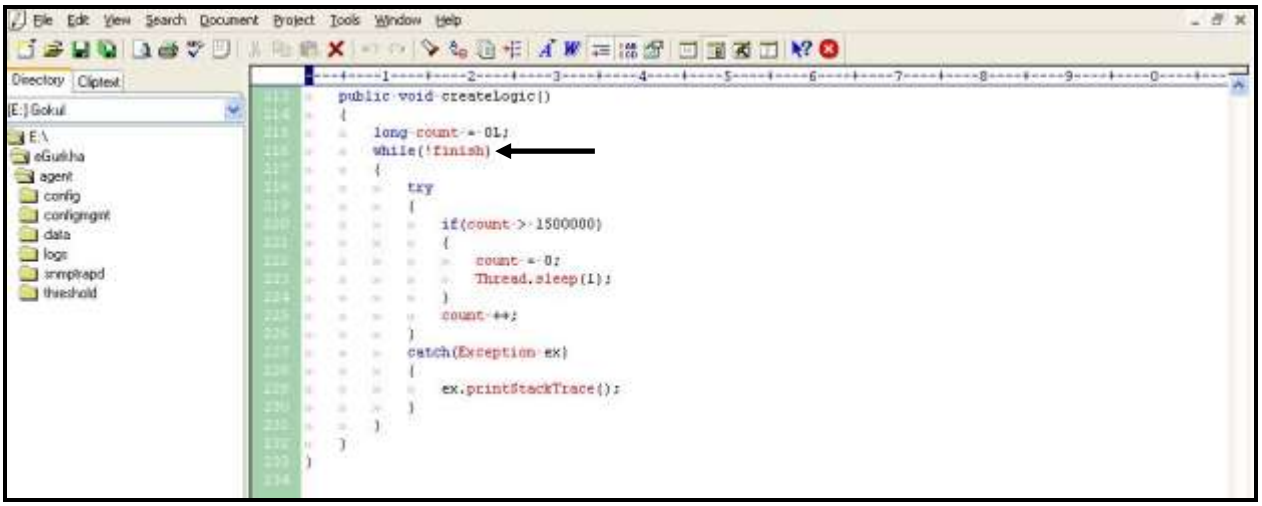


Figure 49: The LogicBuilder.java file

Figure 49 indicates line 216 of the **LogicBuilder.java** file. At this line, a *while* loop seems to have been initiated. This code is supposed to loop 1,500,000 times and then sleep waiting for count to decrease. Instead, a problem in the code – the value of count being reset to 0 at line 222 - is causing the while loop to execute forever, thereby resulting in one of the threads in the JVM taking a lot of CPU. Deleting the code at line 222 would solve this problem. Once this is done, then the *SapConnectorThread* will no longer consume too much CPU; this in turn will decrement the value of the *High Cpu threads* measure by 1 (see Figure 50).

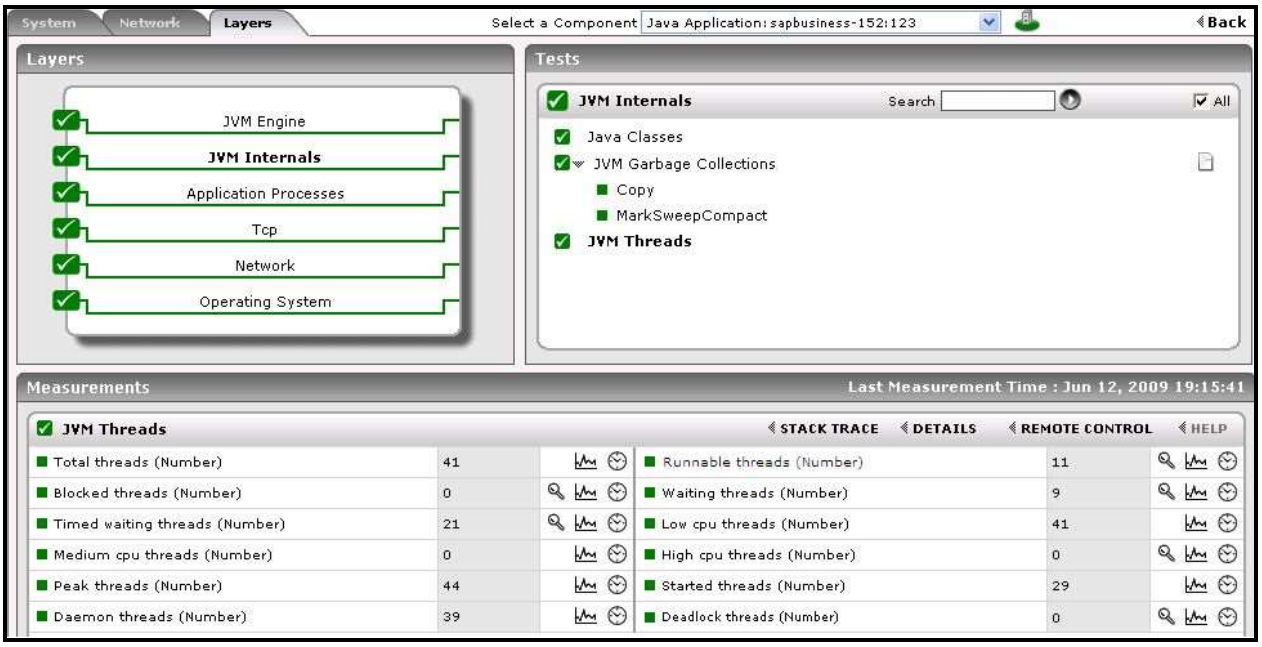


Figure 50: The High cpu threads measure reporting a 0 value

With that, we have seen how a simple sequence of steps bundled into the eG JVM Monitor, help an administrator in identifying not only a CPU-intensive thread, but also the exact line of code executed by that thread that could be triggering the spike in usage.

1.5.2 Identifying and Diagnosing a Thread Blocking Issue in the JVM

This section once again takes the example of the *sapbusiness* application used by Section 1.4.1. Here, we will see how the eG JVM Monitor instantly identifies blocked threads, and intelligently diagnoses the reason for the blockage.

If a thread executing within the *sapbusiness* application gets blocked, the value of the *Blocked threads* measure reported by the **JVM Threads** test mapped to the **JVM Internals** layer, gets incremented by 1. When this happens, eG Enterprise automatically raises this as a problem condition and changes the state of the *Blocked threads* measure (see Figure 51).

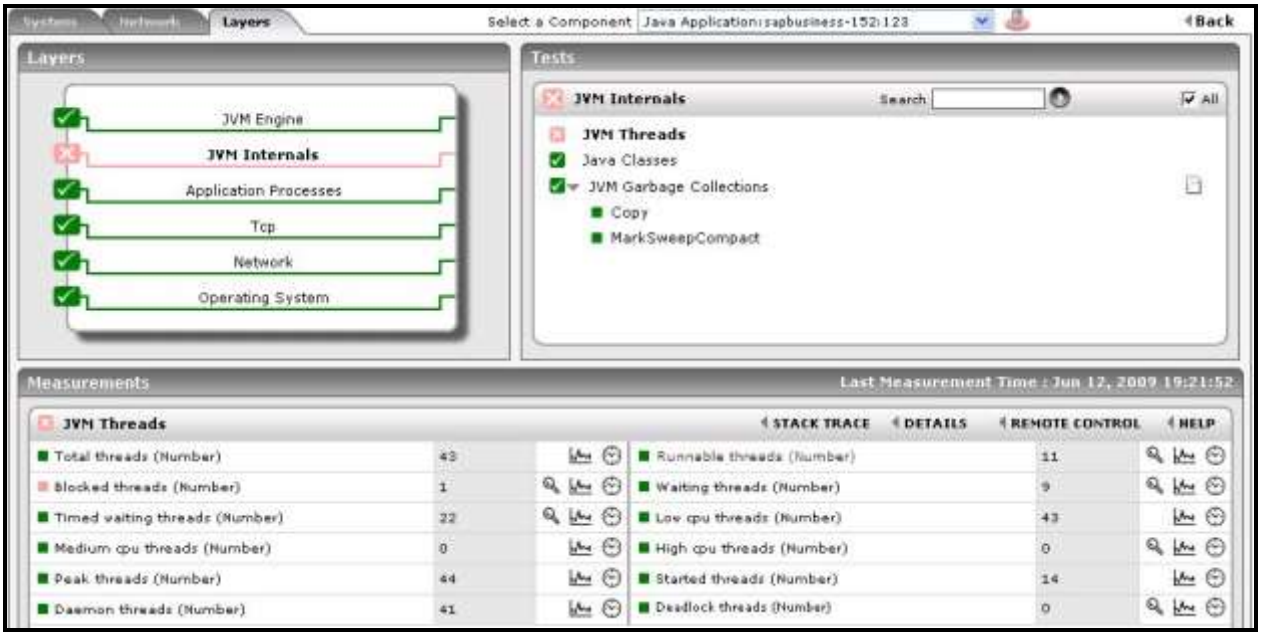


Figure 51: The value of the Blocked threads measure being incremented by 1

According to Figure 51, the eG JVM Monitor has detected that a thread running in the *sapclient* application has been blocked. To know which thread this is and for how long it has been blocked, click on the **DIAGNOSIS** icon corresponding to the *Blocked threads* measure. Figure 52 will then appear revealing the name of the blocked thread, how long it was blocked, the CPU usage of the thread, and the time for which the thread was in waiting.

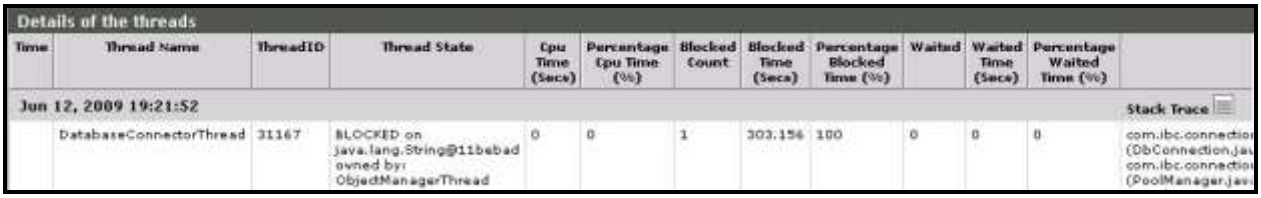


Figure 52: The detailed diagnosis of the Blocked threads measure revealing the details of the blocked thread

Figure 52 clearly indicates that the *DatabaseConnectorThread* running in the *sapbusiness* application was blocked *100%* of the time. The next step is to figure out who or what is blocking the thread, and why. To achieve this, we need to analyze the stack trace information of the blocked thread. To access the stack trace of the *DatabaseConnectorThread*, click on the icon in Figure 52 or the **Stack Trace** label adjacent to the icon. Figure 53 then appears.

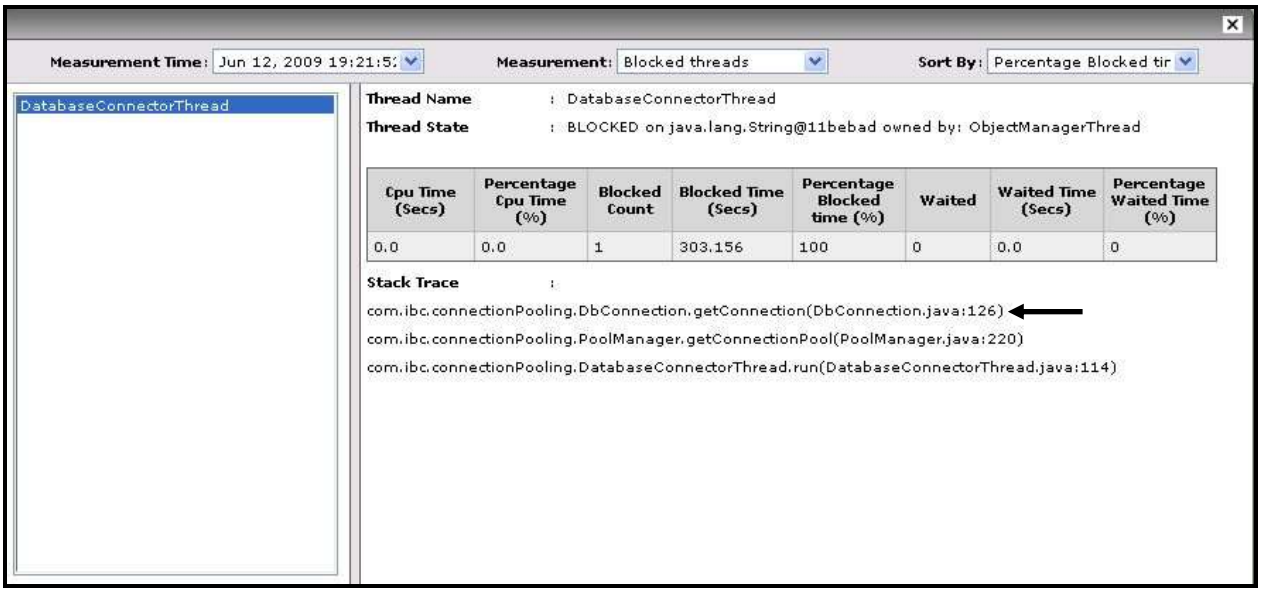


Figure 53: The Stack Trace of the blocked thread

While the left panel of Figure 53 displays the *DatabaseConnectorThread*, the right panel provides the following information about the *DatabaseConnectorThread*:

- The **Thread State** indicating the thread that is blocking the *DatabaseConnectorThread*, and the object on which the block occurred; from the right panel of Figure 53, we can infer that the *DatabaseConnectorThread* has been blocked on the *java.lang.Strin@11bebad* object owned by the *ObjectManagerThread*.

- The CPU usage of the *DatabaseConnectorThread*, and the number of times and duration for which this thread has been blocked and has been in waiting;

- The **Stack Trace** of the *DatabaseConnectorThread*.

Now that we have identified the blocked thread, let us proceed to determine the root-cause for this block. For this purpose, the **Stack Trace** of the *DatabaseConnectorThread* needs to be analyzed. As stated earlier, the stack trace needs to be analyzed in the top-down manner to identify the method that could have caused the block. Accordingly, we can conclude that the first method in the **Stack Trace** in Figure 53 is most likely to have introduced the block. This method, as can be seen from Figure 21, executes the lines of code starting from line **126** contained within the Java program file named **DbConnection.java**. In all probability, the problem should exist in this code block only. Reviewing this code block can therefore shed more light on the reasons for the *DatabaseConnectorThread* getting blocked. Hence, let us first open the **DbConnection.java** file in an editor (see Figure 54).

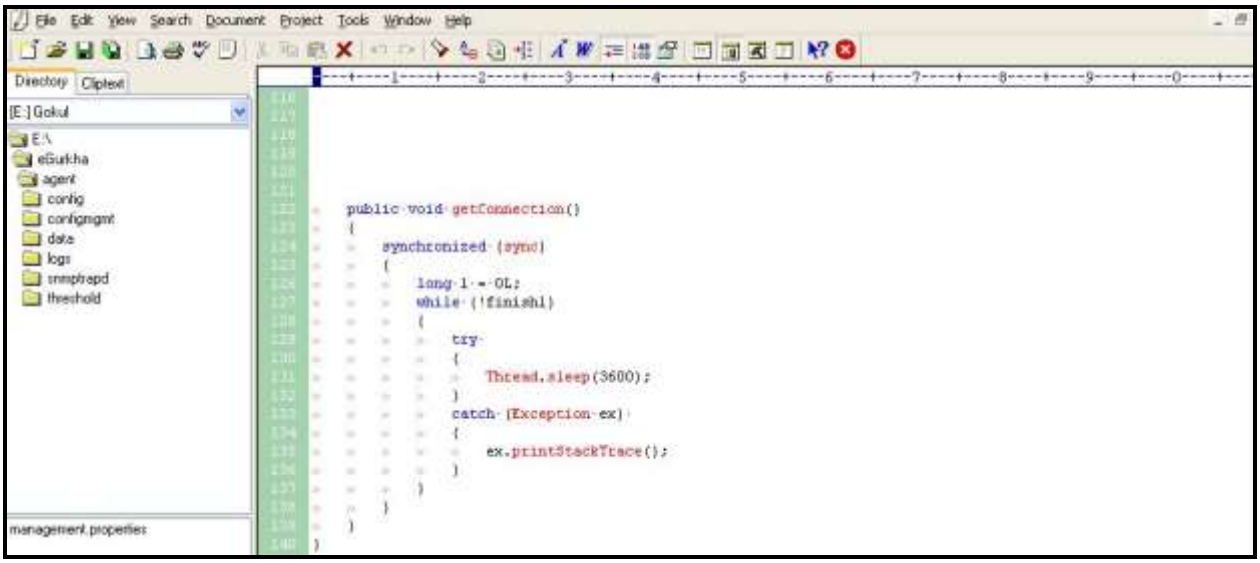


Figure 54: The DbConnection.java program file

Line 126 of Figure 54 is within a *synchronized* block. The object used to synchronize the accesses to this block is a variable named "sync". Looking at the variable declarations at the top of the source code, we can see that the "sync" variable refers to the static string "test" (see Figure 37).

Figure 55: The lines of code preceding line 126 of the DbConnection.java program file

By comparing information form stack trace and the source we can see that the *DatabaseConnectorThread* is stuck entering the synchronized block. Access to the synchronized block is exclusive – so some other thead is blocking this *DatabaseConnectorThread* from entering the synchronized block. Looking at the stack trace again (see Figure 35), we can see the name of the blocking thread. The blocking thread is the thread named "ObjectManagerThread".

We can now use the stack trace tool again to see the stack trace of the blocking *ObjectManagerThread*.

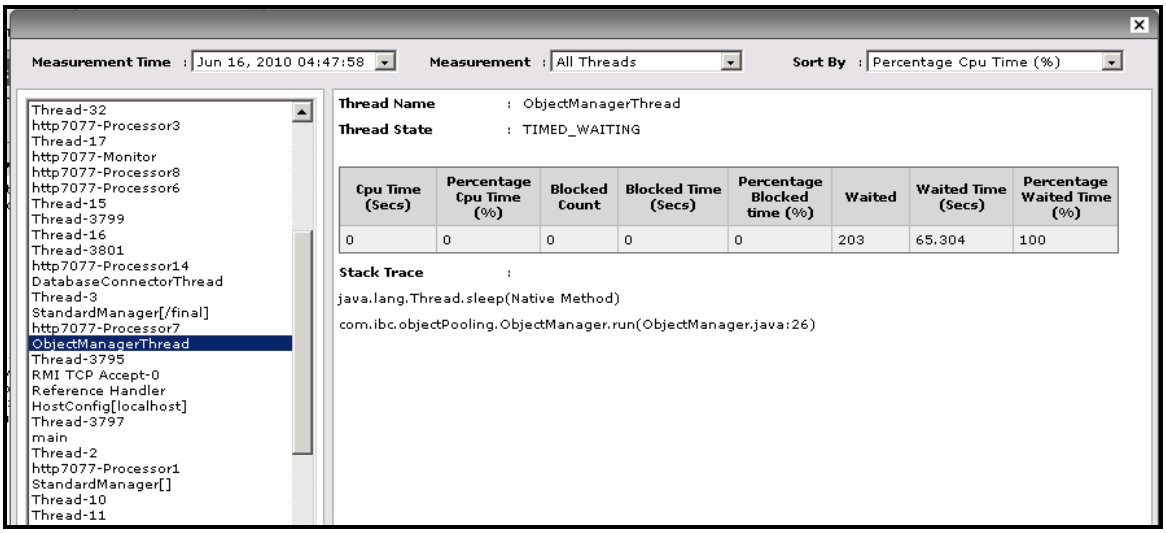


Figure 56: Viewing the stack trace of the ObjectManagerThread

From here, we can see that the *ObjectManagerThread* went into a timed waiting state at line number 26 of the **ObjectManager.java** source code.

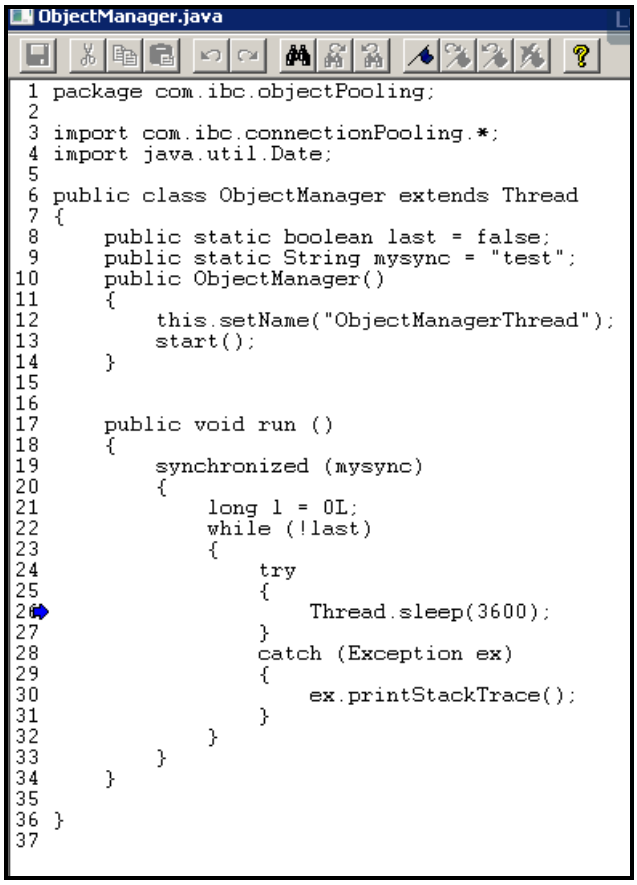


Figure 57: The lines of code in the ObjectManager.java source file

Again, using a text editor, we can see that the *ObjectManager* thread enters a 3600 second timed wait at line 26. This sleep call is inside a synchronized block with the local variable "mysync" being used as the object to synchronize on.

The key to troubleshooting this problem is to look at the variable declarations at the top of each source code file.

On the surface, it is not clear why the *ObjectManager* thread, which synchronizes a block using a variable called "mysync" which is local to this class would be blocked by the *DbConnection* thread, which synchronizes on a variable called "sync" that is local to the *DbConnection* class.

An astute java programmer, however, would know to look at the variable declarations at the top of each source code file. In that way, one will quickly observe that both the "mysync" variable of the *ObjectManager* class and the "sync" variable of the *DbConnection* class in fact refer to the same static string: "test".

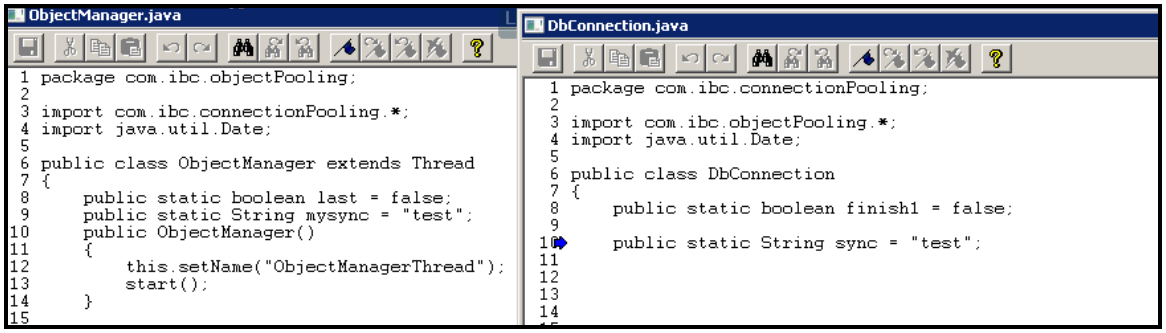


Figure 58: Comparing the ObjectManager and DbConnection classes

So, even though the programmer has given two different variable names in the two classes, the two classes refer to and are synchronizing on the same static string object "test". This is why two unrelated threads are interfering with each other's execution.

Modifying the two classes – *ObjectManager* and *DbConnection* – so that the variables "mysync" and "sync" point to two different strings by using the new object creator resolves the problem in this case.

We have demonstrated here a real-world example, where because of the careless use of variables, one could end up in a scenario where one thread blocks another. The solution in this case to avoid this problem is to define non-static variables that the two classes can use for synchronization. This example has demonstrated how the eG Java Monitor can help diagnose and resolve a complex multi-thread synchronization problem in a Java application.

1.5.3 Identifying and Diagnosing a Thread Waiting Situation in the JVM

This section takes the help of the *sapbusiness* application yet again to demonstrate how the eG JVM Monitor quickly isolates waiting threads and identifies the root-cause for the thread waits.

Whenever a thread goes into waiting, the value of the *Waiting threads* measure reported by the **JVM Threads** test mapped to the **JVM Internals** layer gets incremented by 1 (see Figure 59).

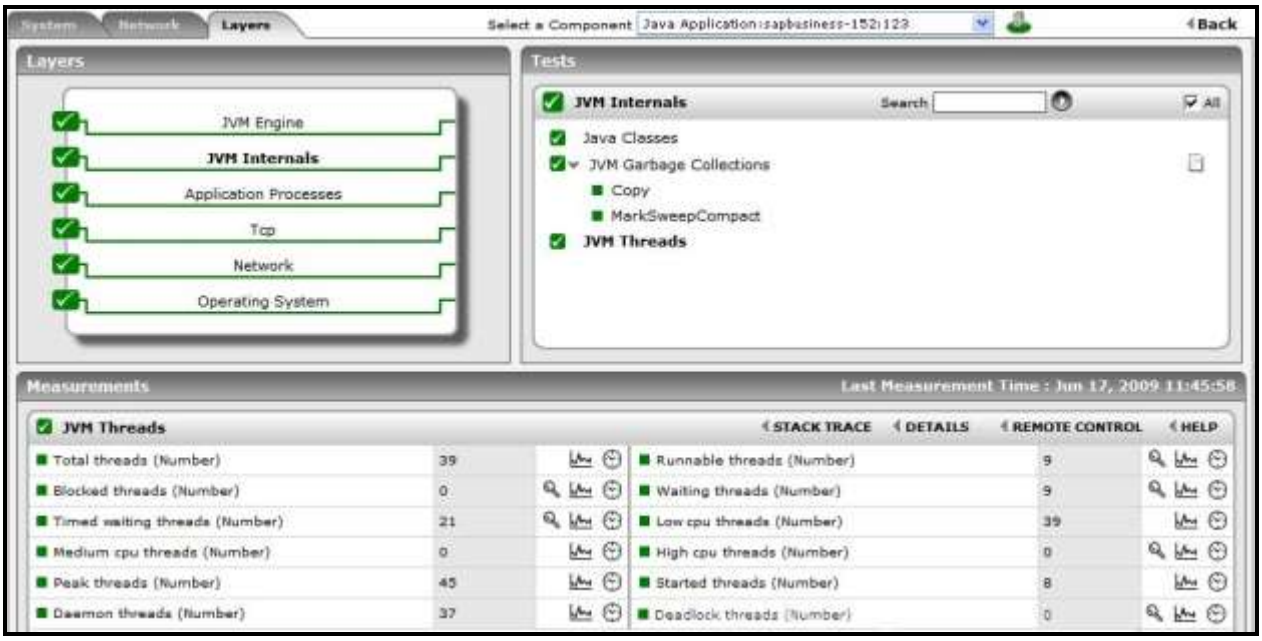


Figure 59: The Waiting threads

To know which threads are in waiting, click on the **DIAGNOSIS** icon corresponding to the *Waiting threads* measure in Figure 59. Figure 60 then appears listing all the threads that are currently in waiting.

Details of the threads

Time	Thread Name	ThreadID	Thread State	Cpu Time (Secs)	Percentage Cpu Time (%)	Blocked Count	Blocked Time (Secs)	Percentage Blocked Time (%)	Waited	W
Jun 17, 2009 11:45:58										
	http7077-Processor7	36	WAITING on org.apache.tomcat.util.threads.ThreadPool$ControlRunnable@166faac	2.125	0.0888	17	0.001	0	198	66
	http7077-Processor1	18	WAITING on org.apache.tomcat.util.threads.ThreadPool$ControlRunnable@5ac5f	1.671	0.038	21	0.004	0	124	87
	http7077-Processor8	37	WAITING on org.apache.tomcat.util.threads.ThreadPool$ControlRunnable@fbfb30	1.437	0.0253	13	0	0	75	14
	SessionController	78	WAITING on com.ibc.session.UserSession@9036e	0	0	0	0	0	2	18
	http7077-Processor6	35	WAITING on org.apache.tomcat.util.threads.ThreadPool$ControlRunnable@4683c2	0	0	0	0	0	1	0

Figure 60: The detailed diagnosis of the Waiting threads measure

Of the threads listed in Figure 60, those that begin with *http** are Tomcat's java threads. For these threads to be in a waiting state is normal, and hence, these threads can be ignored. Only the **SessionController** thread indicated by Figure 60 is an application-specific thread. To know why this thread has been in waiting, you need to study the stack trace of the thread; for this, first scroll to the left of Figure 60. You will then be able to view the stack trace of the thread.

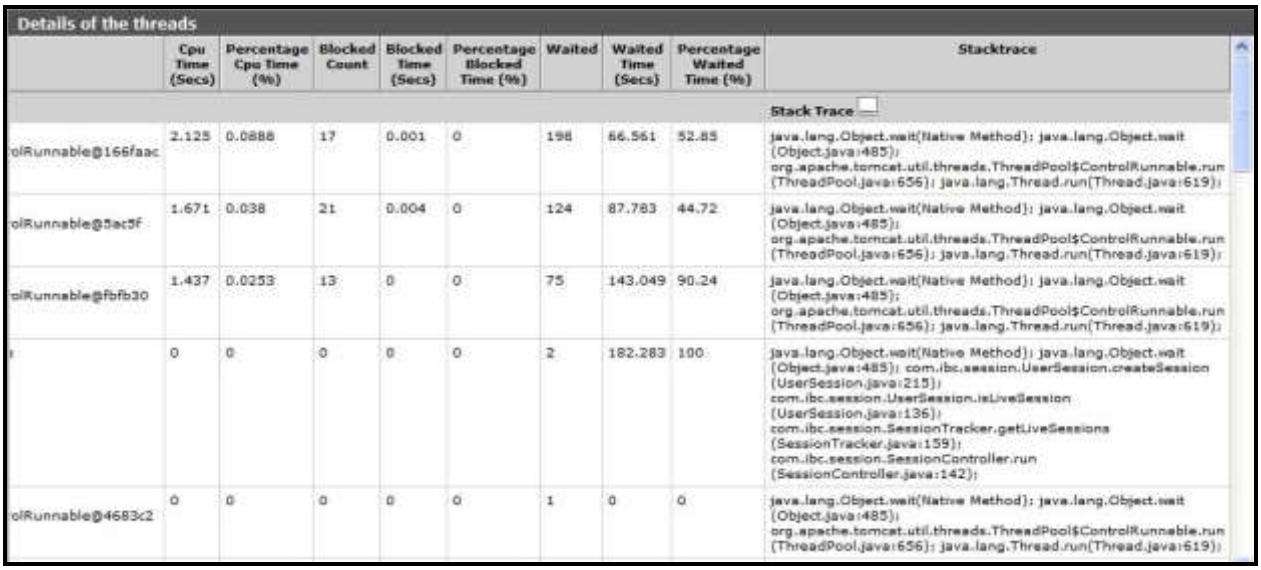


Figure 61: Viewing the stack trace of the waiting thread

If you want to view the stack trace more clearly, click on the icon in Figure 61 or the **Stack Trace** label adjacent to the icon. Figure 62 then appears.

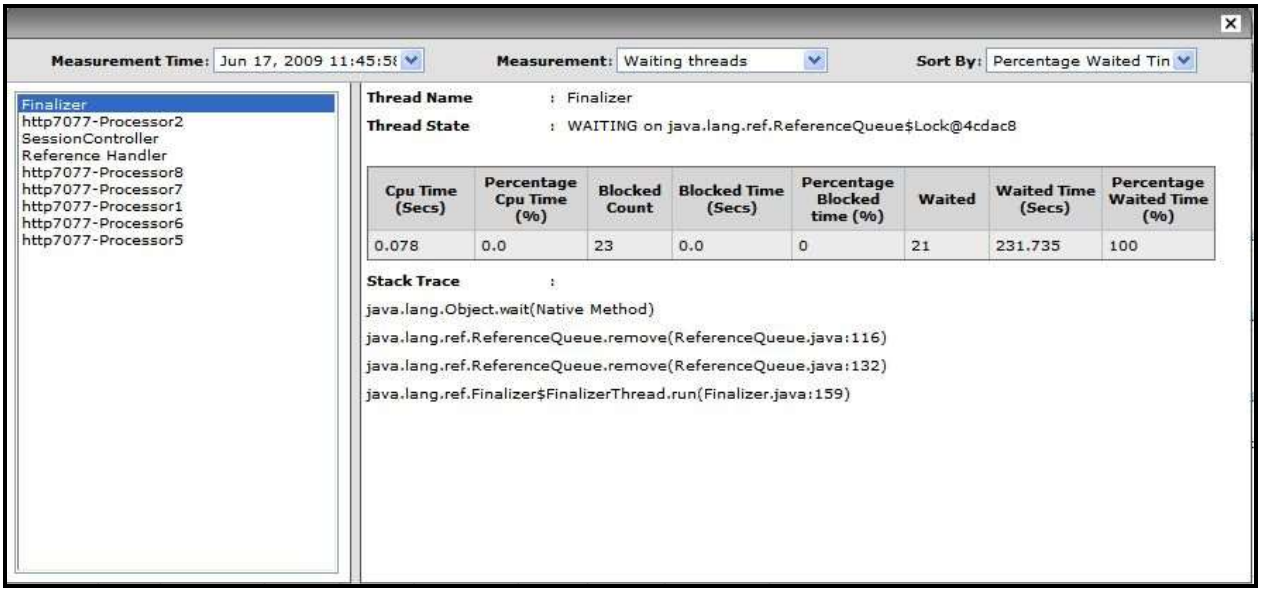


Figure 62: The Thread Diagnosis window for Waiting threads

The left panel of Figure 62 lists all the waiting threads, with the thread that registered the highest waiting time being selected by default. Since we are interested in the user-defined **SessionController** thread, select it from the left panel. The right panel will then change as depicted by Figure 63 below.

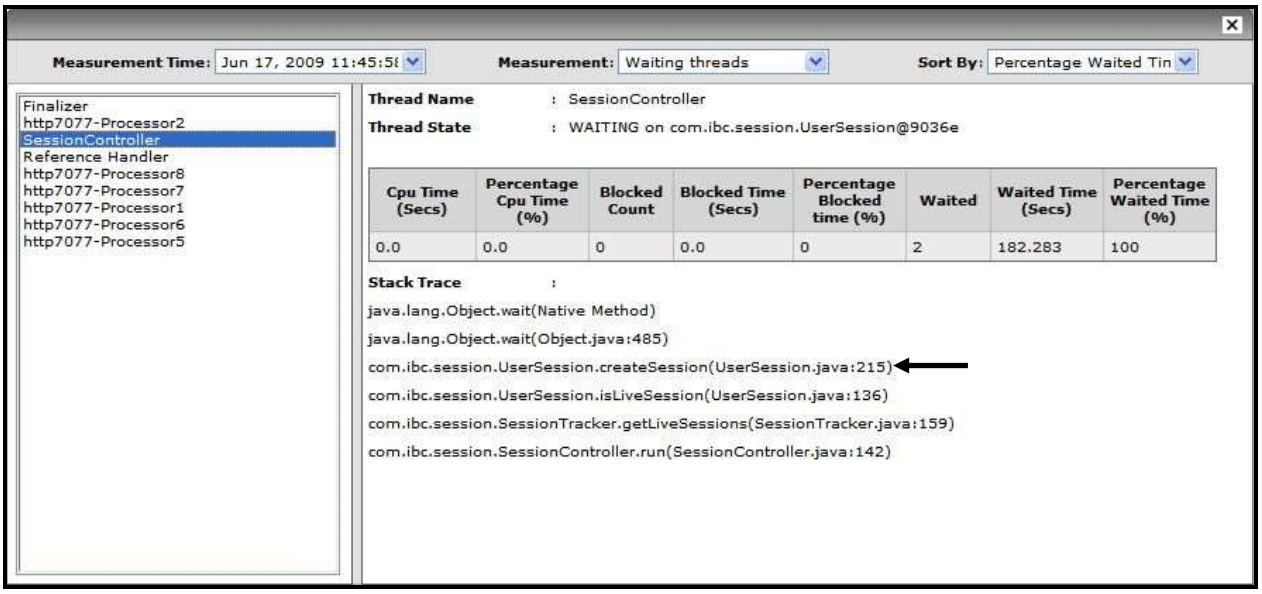


Figure 63 : The stack trace for the SessionController thread

A close look at the stack trace reveals that the thread could have gone into the waiting mode while executing the code block starting at line **215** of the **UserSession.java** program file. To zero-in on the precise code that could have caused the thread to wait, open the **UserSession.java** file in an editor, and locate line **215** in it.

```
210    public synchronized void createSession()
211    {
212        try
213        {
214            //System.out.println("Started to wait ... @ "+new java.util.Date());
215            wait();
216        }
217        catch (InterruptedException e)
218        {
219            System.out.println("Exiting MainThread...");
220        }
221    }
222
223    public synchronized void notifyThread()
224    {
225        try
226        {
227            notify();
228        }
229        catch (Exception e)
230        {
231            e.printStackTrace();
232        }
233    }
234 }
235
```

Figure 64: The UserSession.java file

The code block starting at line 215 of Figure 64 explicitly puts the thread in the wait state until such time that the *notify()* method is called to change the wait state to a runnable state. This piece of code will have to be optimized to reduce or even completely eliminate the waiting period of the **SessionController** thread.

With that, we have demonstrated the eG JVM Monitor's ability to detect waiting threads and lead you to the precise line of code that could have put the threads in a wait state.

1.5.4 Identifying and Diagnosing a Thread Deadlock Situation in the JVM

In this section, the *sapclient* application is used one more time to explain how the eG JVM Monitor can be used to report on deadlock situations in your JVM, and to diagnose the root-cause of the deadlock.

Until a deadlock situation arises, the **Deadlock threads** measure reported by the **JVM Threads** test will report only *0* as its value (see Figure 65).

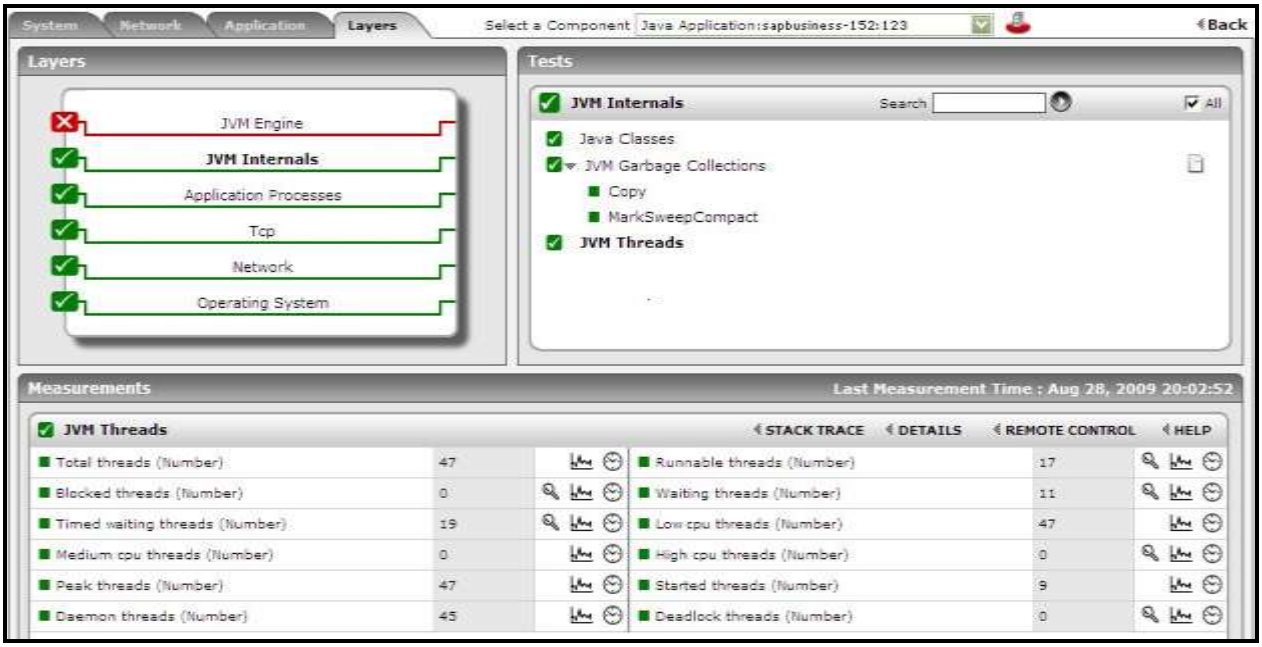


Figure 65: The JVM Threads test reporting 0 Deadlock threads

When, say 2 threads are deadlocked for a particular resource/object, then the **Deadlock threads** measure will report the value *2*, as depicted by Figure 66. Since a deadlock situation arises when two/more threads try to **block** each other from accessing a memory object or a resource, the value of the **Blocked threads** measure too will increase in the event of a deadlock; in the case of our example therefore, you will find that the **Blocked threads** measure too reports the value *2*.

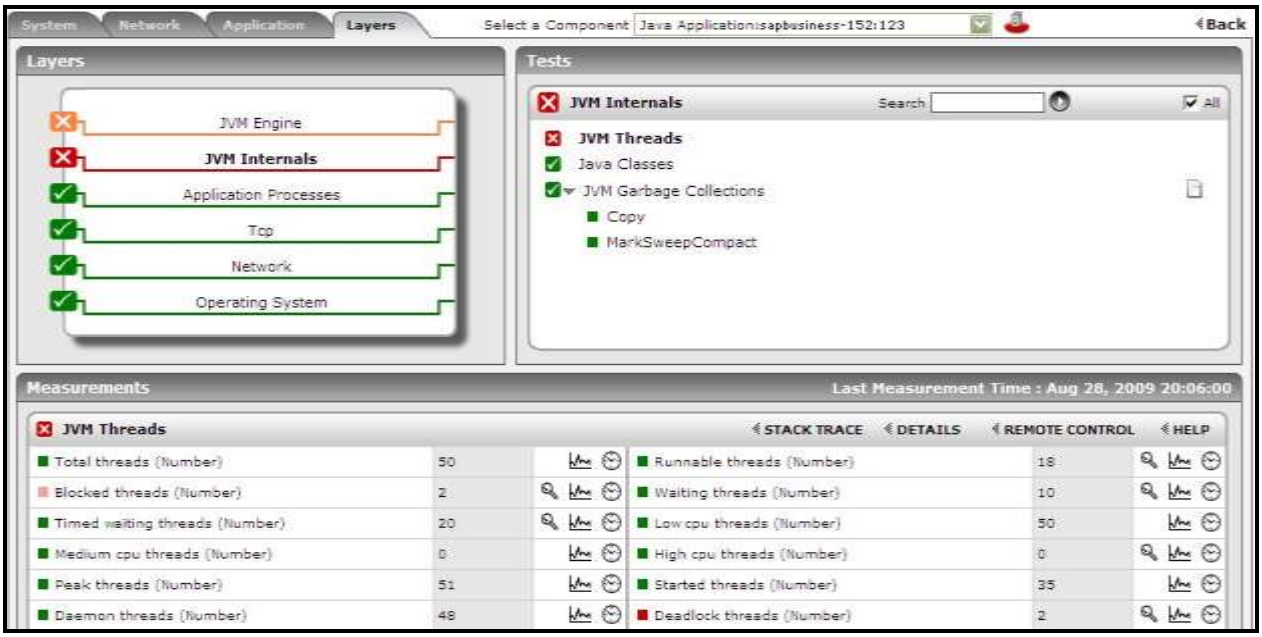


Figure 66: The Deadlock threads measure value increasing in the event of a deadlock situation

To know which threads are in a deadlock, click on the **DIAGNOSIS** icon corresponding to the **Deadlock threads** measure. Figure 67 then appears.

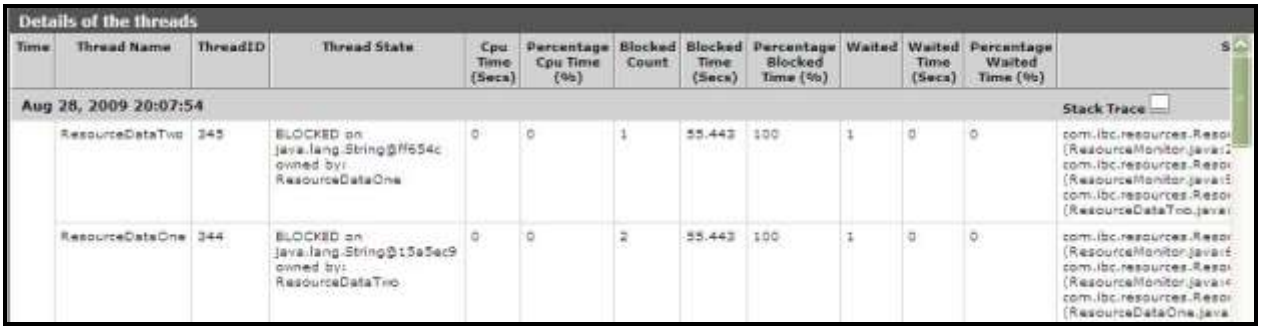


Figure 67: The detailed diagnosis page revealing the deadlocked threads

Figure 67 clearly reveals that 2 threads, namely – the *ResourceDataTwo* and the *ResourceDataOne* thread- are in a deadlock currently. To figure out why these two threads are deadlocked, you would have to carefully review the stack trace of both these threads. For this purpose, scroll to the left of Figure 67 to view the stack trace clearly.

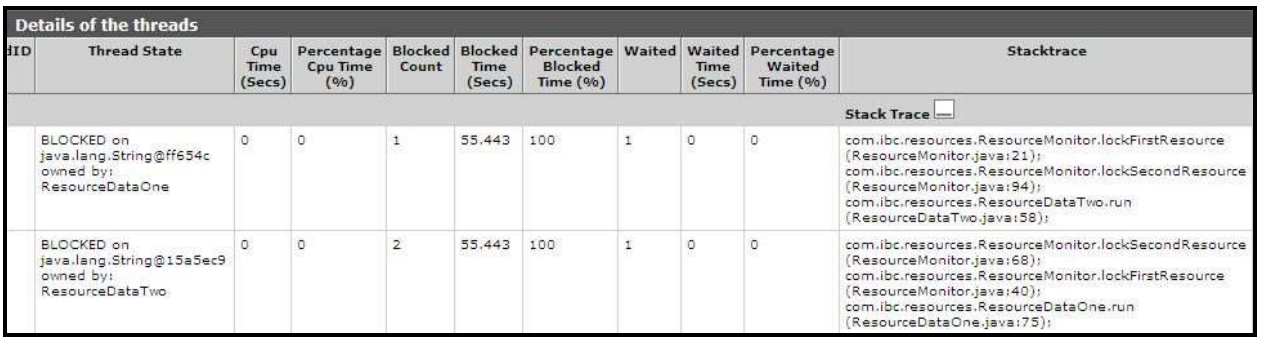


Figure 68: Viewing the stack trace of the dadlocked threads in the detailed diagnosis page

To keenly focus on the stack trace, without being distracted by the other columns in Figure 67 and Figure 68, click on the icon in Figure 68 or the **Stack Trace** label adjacent to the icon. Figure 69 then appears.

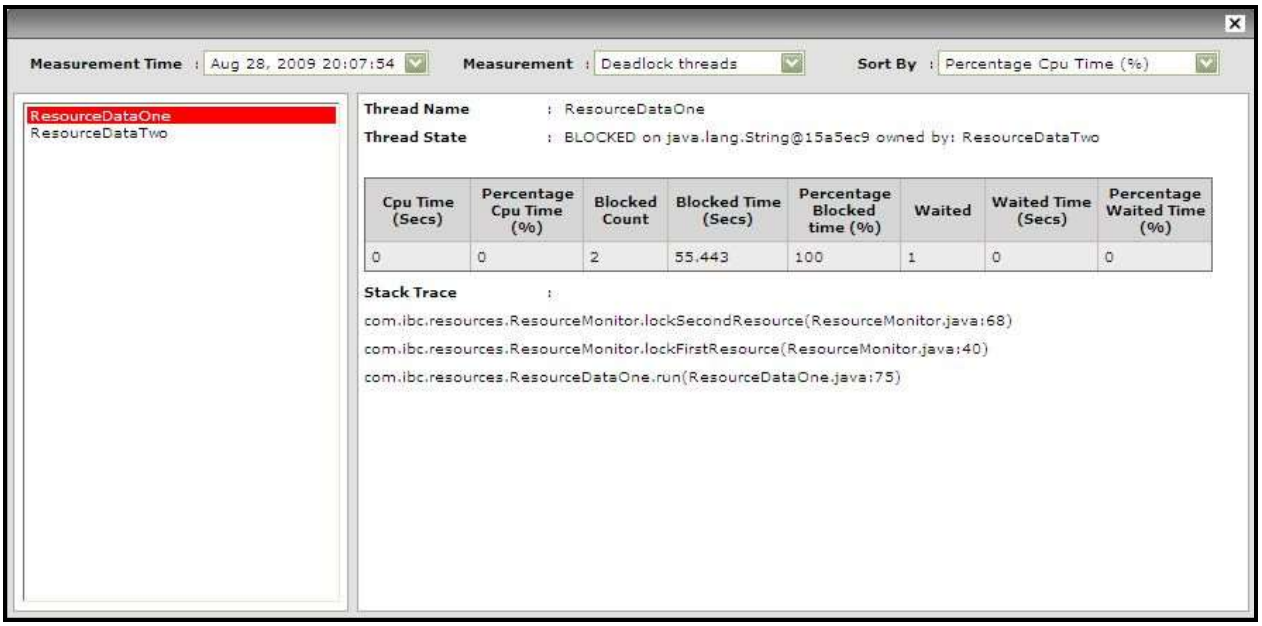


Figure 69: The stack trace for the ResourceDataOne thread

The left panel of Figure 69 lists the 2 deadlocked threads, with the thread that is the leading CPU consumer being selected by default – in the case of our example, this is the *ResourceDataOne* thread. For this default selection, the contents of the right panel will be as depicted by Figure 69 above. From the **Thread State**, it is evident that the *ResourceDataOne* thread has been blocked on an object that is owned by the *ResourceDataTwo* thread.

If you closely scrutinize the stack trace of *ResourceDataOne*, you will uncover that once the thread started running, it executed line 40 of the *ResourceMonitor.java* program file, which in turn invoked line 68 of the same file; the deadlock appears to have occurred at line 68 only.

Let us now shift our focus to the *ResourceDataTwo* thread. To view the stack trace of this thread, click on the thread name in the left panel of Figure 69. As you can see, the **Thread State** clearly indicates that the *ResouceDataTwo* thread has been blocked by the *ResourceDataOne* thread. With that, we can conclude that both threads are blocking each other, thus making for an ideal deadlock situation.

Analysis of the stack trace of the *ResourceDataTwo* thread (see Figure 70) reveals that once started, the thread executed line 94 of the *ResourceMonitor.java* file, which in turn invoked line 21 of the same file; since no lines of code have been executed subsequently, we can conclude that the deadlock occurred at line 21 only.

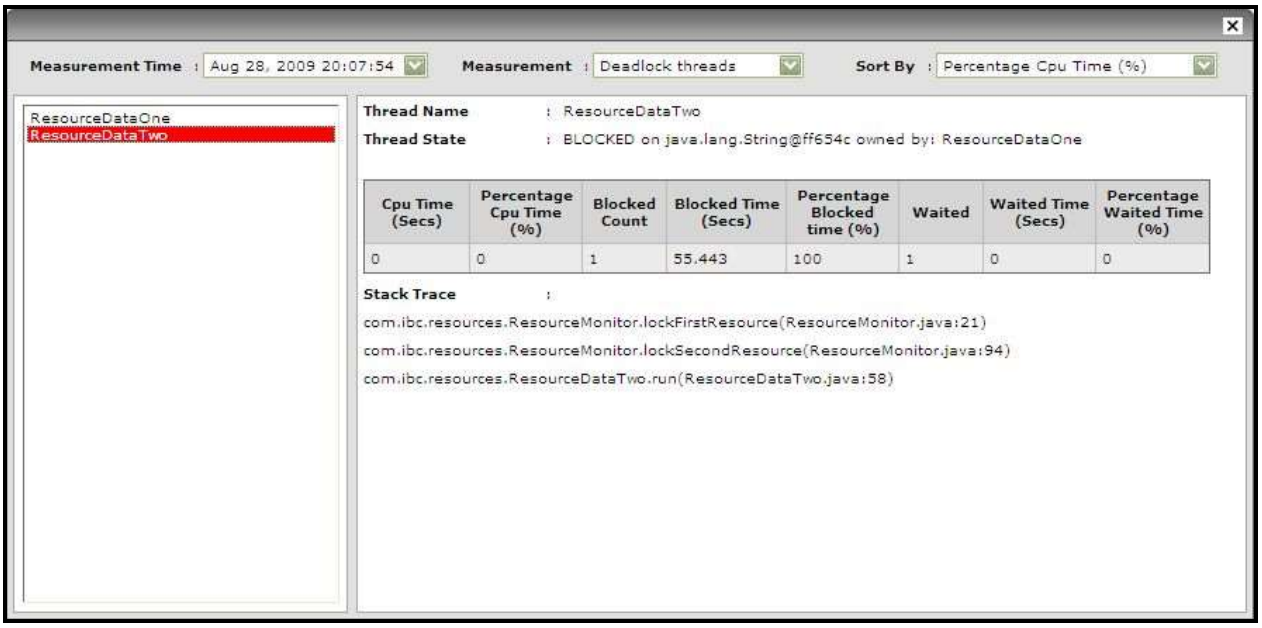


Figure 70 : The stack trace for the ResourceDataTwo thread

From the above discussion, we can infer both the threads deadlocked while attempting to execute code contained within the *ResourceMonitor.java* file. We now need to examine the code in this file to figure out why the deadlock occurred. Let us therefore open the *ResourceMonitor.java* file.

```
61
62      public void lockSecondResource()
63      {
64          synchronized (resource2)
65          {
66              try
67              {
68                  Thread.sleep(500);
69              }
70              catch (InterruptedException e)
71              {
72                  e.printStackTrace();
73              }
74              lockFirstResource();
75          }
76      }
77  }
```

Figure 71: The lines of code executed by the ResourceDataOne thread

If you can recall, the stack trace of the *ResourceDataOne* thread indicated a problem while executing the code around line number 68 (see Figure 69) of the *ResourceMonitor.java* file. Figure 71 depicts this piece of code. According to this code, the *ResourceDataOne* thread calls a *lockSecondResource()* method, which in turn invokes a *synchronized* block that puts the thread to sleep for 500 milliseconds; **a synchronized method, when called by a thread, cannot be invoked by any other thread until its original caller releases the method**.

Going back to Figure 71, at the end of the sleep duration of 500 milliseconds, the *synchronized* block will invoke another method named *lockFirstResource()*. However, note that this method and the *lockSecondResource()* method are also called by the *ResourceDataTwo* thread. To verify this, let us proceed to review the lines of code executed by the *ResourceDataTwo* thread (see Figure 72).

```
13
14
15      public void lockFirstResource()
16      {
17          synchronized (resource1)
18          {
19              try
20              {
21                  Thread.sleep(500);
22              }
23              catch (InterruptedException e)
24              {
25                  e.printStackTrace();
26              }
27              lockSecondResource();
28          }
29      }
```

Figure 72: The lines of code executed by the ResourceDataTwo thread

As per the stack trace corresponding to the *ResourceDataTwo* thread (see Figure 70), the deadlock creeps in at line 21 of the *ResourceMonitor.java* file. Figure 72 depicts the code around line 21 of the *ResourceMonitor.java* file. This code reveals that the *ResourceDataTwo* thread executes a *lockFirstResource()*method, which in turn invokes a *synchronized* block; within this block, the thread is put to sleep for 500 milliseconds. Once the sleep ends, the block will invoke the *lockSecondResource()* method; both this method and the *lockFirstResource()* method are also executed by the *ResourceDataOne* thread.

From the discussion above, the following are evident:

- The *ResourceDataOne* thread will not be able to execute the *lockSecondResource*() method, since the *ResourceDataTwo* thread calls this method within a *synchronized* block – this implies that the *ResourceDataTwo* thread will 'block' the *ResourceDataOne* thread from executing the *lockSecondResource*() method until such time that *ResourceDataTwo* executes the method.

- The *ResourceDataTwo* thread on the other hand, will not be able to execute the *lockFirstResource()* method, since the *ResourceDataOne* thread calls this method within a *synchronized* block – this implies that the *ResourceDataOne* thread will 'block' the *ResourceDataTwo* thread from executing the *lockFirstResource*() method until such time that *ResourceDataOne* executes the method.

Since both threads keep blocking each other, a deadlock situation occurs.

With that, we have demonstrated the eG JVM Monitor's ability to detect deadlock threads and lead you to the precise line of code that could have caused the deadlock.

1.5.5 Identifying and Diagnosing Memory Issues in the JVM

This section takes the example of the *sapclient* application again to demonstrate the effectiveness of the eG JVM Monitor in proactively detecting and alerting administrators to memory contentions experienced by Java applications.

If the usage of a memory pool increases, the eG JVM Monitor indicates the same using the *Used memory* measure for that pool reported by the **JVM Memory Usage** test mapped to the **JVM Engine** layer.

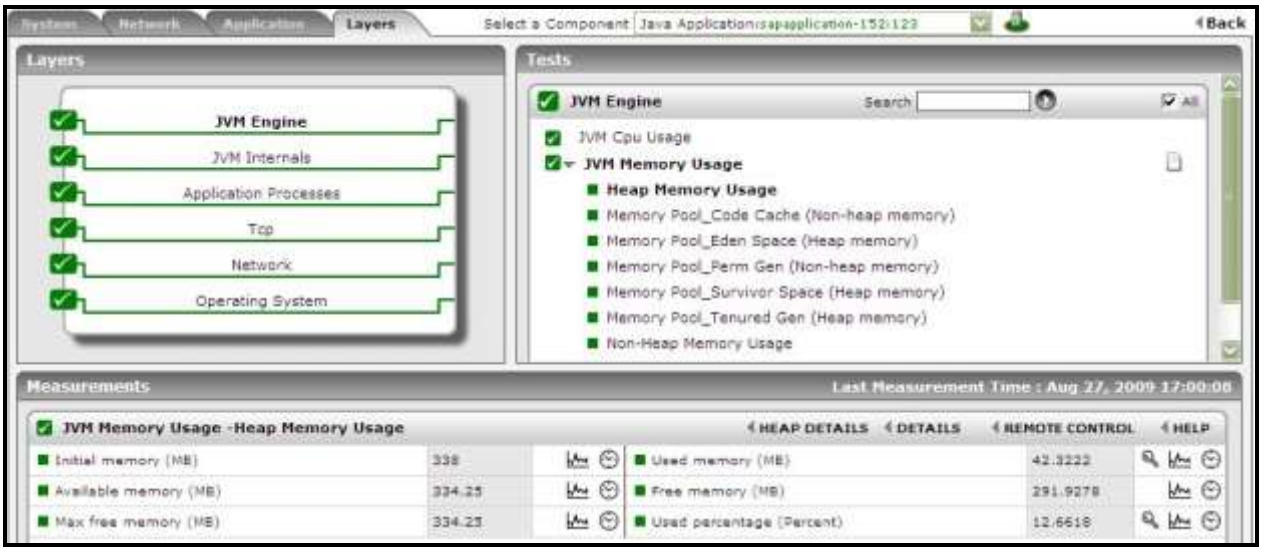
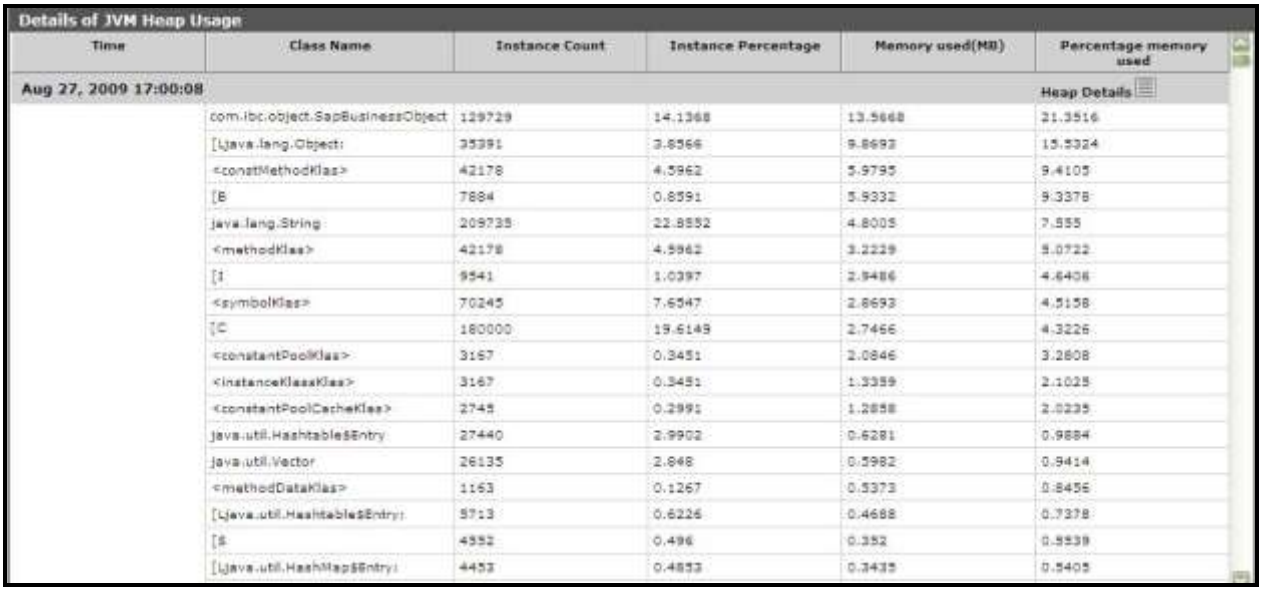


Figure 73: The Used memory measure indicating the amount of pool memory being utilized

To know which class is consuming memory excessively, click on the **DIAGNOSIS** icon corresponding to the *Used memory* measure in Figure 73. Figure 74 then appears listing all the classes that are using the pool memory, the amount and percentage of memory used by each class, the number of instances of each class that is currently operational, and also the percentage of currently running instances of each class. Since this list is by default sorted in the descending order of the percentage memory usage, the first class in the list will obviously be the leading memory consumer. In the case of our example, the memory contention in the *sapbusiness* application has been caused by the 22% heap memory usage of the *com.ibc.object.SapBusinessObject* class.

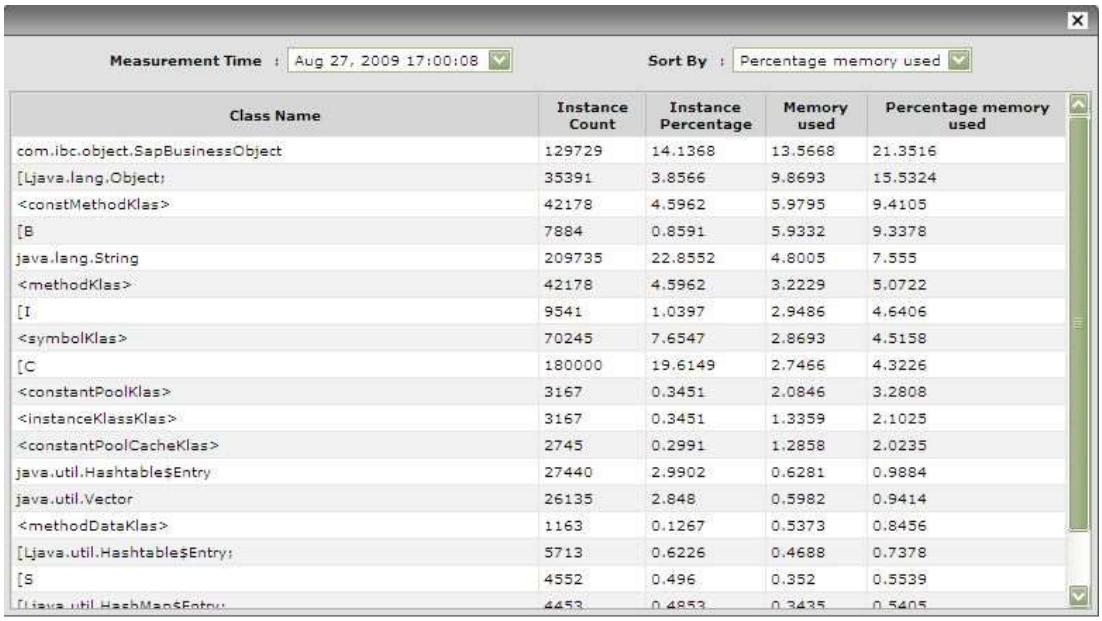


Details of JVM Heap Usage

Time	Class Name	Instance Count	Instance Percentage	Memory used(MB)	Percentage memory used
Aug 27, 2009 17:00:08					Heap Details
	com.ibc.object.SapBusinessObject	129729	14.1368	13.5668	21.3516
	[Ljava.lang.Object;	35391	3.8566	9.8693	15.5324
	<constMethodKlass>	42178	4.5962	5.9795	9.4105
	[B	7884	0.8591	5.9332	9.3378
	java.lang.String	209735	22.8552	4.8005	7.555
	<methodKlass>	42178	4.5962	3.2229	5.0722
	[I	9541	1.0397	2.9486	4.6406
	<symbolKlass>	70245	7.6547	2.8693	4.5158
	[C	180000	19.6149	2.7466	4.3226
	<constantPoolKlass>	3167	0.3451	2.0846	3.2808
	<instanceKlassKlass>	3167	0.3451	1.3359	2.1025
	<constantPoolCacheKlass>	2745	0.2991	1.2858	2.0235
	java.util.Hashtable$Entry	27440	2.9902	0.6281	0.9884
	java.util.Vector	26135	2.848	0.5982	0.9414
	<methodDataKlass>	1163	0.1267	0.5373	0.8456
	[Ljava.util.Hashtable$Entry;	5713	0.6226	0.4688	0.7378
	[S	4552	0.496	0.352	0.5539
	[Ljava.util.HashMap$Entry;	4453	0.4853	0.3435	0.5405

Figure 74: The detailed diagnosis of the Used memory measure

Sometimes, you might want to sort the classes by another column or quickly switch to another measurement period to analyze the memory usage during that time frame. To achieve this, click on the **Heap Details** link or the button next to it. Figure 53 then appears, allowing you the flexibility to view memory-consuming classes based on a **Sort by** option and a **Measurement Time** of your choice.



Measurement Time : Aug 27, 2009 17:00:08 Sort By : Percentage memory used

Class Name	Instance Count	Instance Percentage	Memory used	Percentage memory used
com.ibc.object.SapBusinessObject	129729	14.1368	13.5668	21.3516
[Ljava.lang.Object;	35391	3.8566	9.8693	15.5324
<constMethodKlas>	42178	4.5962	5.9795	9.4105
[B	7884	0.8591	5.9332	9.3378
java.lang.String	209735	22.8552	4.8005	7.555
<methodKlas>	42178	4.5962	3.2229	5.0722
[I	9541	1.0397	2.9486	4.6406
<symbolKlas>	70245	7.6547	2.8693	4.5158
[C	180000	19.6149	2.7466	4.3226
<constantPoolKlas>	3167	0.3451	2.0846	3.2808
<instanceKlassKlas>	3167	0.3451	1.3359	2.1025
<constantPoolCacheKlas>	2745	0.2991	1.2858	2.0235
java.util.Hashtable$Entry	27440	2.9902	0.6281	0.9884
java.util.Vector	26135	2.848	0.5982	0.9414
<methodDataKlas>	1163	0.1267	0.5373	0.8456
[Ljava.util.Hashtable$Entry;	5713	0.6226	0.4688	0.7378
[S	4552	0.496	0.352	0.5539
[Ljava.util.HashMap$Entry;	4453	0.4853	0.3435	0.5405

Figure 75: Choosing a different Sory By option and Measurement Time

Careful examination of the method that calls the *SapBusinessObject* (see Figure 76) reveals that an *endless while loop* is causing an array list named *a* to be populated with 20,000 instances of the *SapBusinessObject*, every 10 seconds! The continuous addition of objects is quiet obviously depleting the memory available to the JVM.

```
115
116     public void getClonedObject()
117     {
118         while (!finish2)
119         {
120             ArrayList a = new ArrayList();
121             for(int i=0;i<20000;i++)
122             {
123                 SapBusinessObject sbo = new SapBusinessObject("java",i);
124                 a.add(sbo);
125             }
126             try
127             {
128                 Thread.currentThread().sleep(10000);
129             }
130             catch (Exception ex)
131             {
132                 ex.printStackTrace();
133             }
134         }
135     }
136
137 }
```

Figure 76: The method that is invoking the SapBusinessObject

This is how the eG JVM Monitor greatly simplifies the process of identifying the source of memory bottlenecks in a Java application.

1.5.6 Identifying and Diagnosing the Root-Cause of Slowdowns in Java Transactions

This section takes the example of a Java application to demonstrate how effectively the **eG JTM Monitor** identifies transactions that are responding slowly and isolates the root-cause of the slowdown.

If one/more transactions executing on a Java application experience a slowdown, the *Slow Transactions* measure of the **Java Transactions** test captures the delay and reports the count of transactions that have been affected. From Figure 77, it is evident that 11 transactions executiing on the sample Java application in our example are slowing down. Too many slow transactions to an application can significantly damage the user experience with that application - this is why, this problem has been flagged as a **Critical** problem by the eG Enterprise system, and the state of the **Slow Transactions** measure has been set as **Critical**. The *Slow transactions response time* measure reported by the same test indicates how slowly these transactions are responding. To know which transactions are slow, click on the 'magnifying glass' icon adjacent to the *Slow transactions response time* measure.

Figure 77: The layer model of a sample Java application indicating too many slow transactions

This will lead you to Figure 78, where you can view the **URL** of the top-10 (by default) slow transactions. These transactions will be arranged in the descending order of the **TOTAL RESPONSE TIME**. We can thus conclude that the transaction with the URL, "**/StrutsDemo/login;jsessionid=...**", with the highest response time of over *1.5 seconds*, is the slowest transaction on the target application. But, what is causing this slowdown and where did it originate? The **SUBCOMPONENT DETAILS** column of Figure 78 answers these questions.

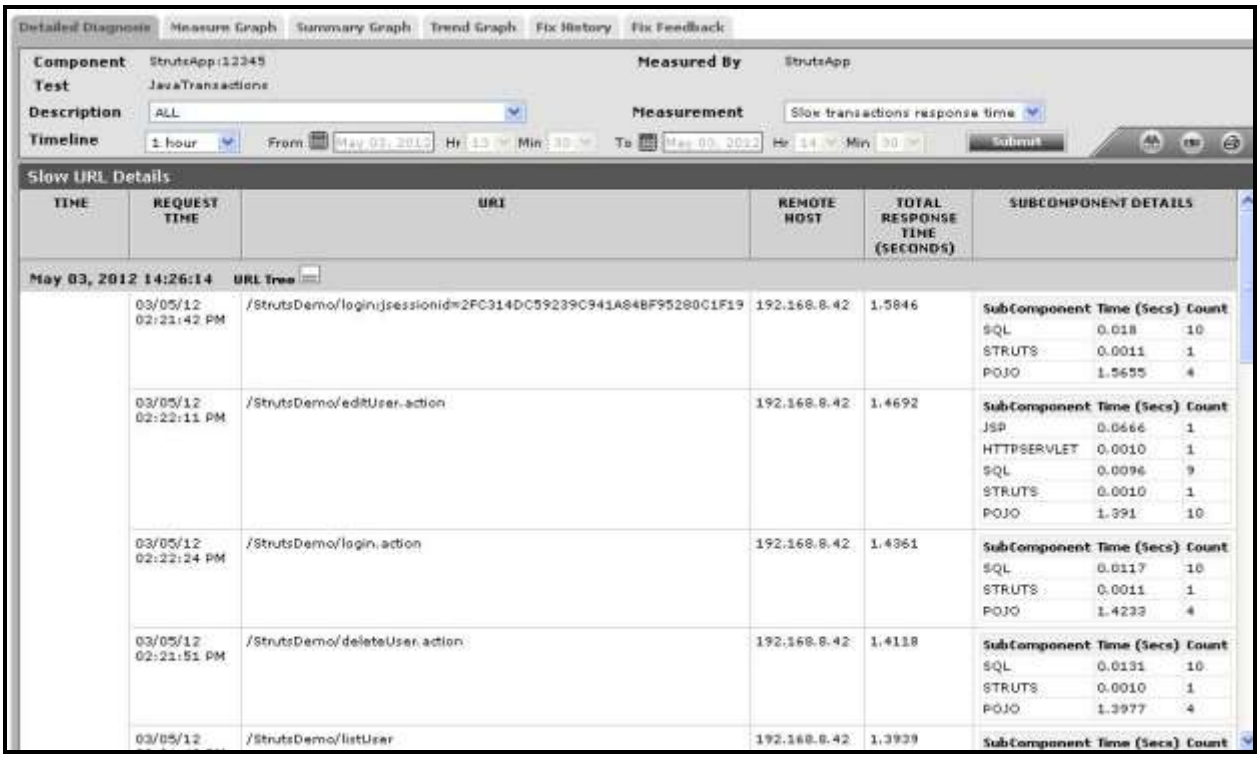


Figure 78: The detailed diagnosis of the Slow transactions response time measure

When a user initiates a transaction to a Java-based web application, the transaction typically travels many layers/sub-components (in Java) before completing execution and sending out a response to the user. These layers/sub-components can be **FILTERS**, **STRUTS**, **JSPs**, **SERVLETS**, **POJOs**, **JAVA MAIL APIs**, **JDBC QUERIES**, or **SQL STATEMENTS**. A variety of methods are typically invoked at each layer/sub-component. A delay in the execution of any of these methods/queries can impact the execution of the transaction. The **SUBCOMPONENT DETAILS** column of Figure 78 will reveal the layers/sub-components that the corresponding transaction visited during its journey, and the time the transaction spent at each layer/sub-component. Using this information, you can quickly identify the layer/sub-component at which the slowdown might have occurred. In the case of our example, the **POJO** sub-component, with a total response time of over *1.3 seconds*, is guilty of consuming too much time. We can thus conclude that the slowdown may have originated at the **POJO** layer. But, which method is causing the slowdown? To figure this out, click on the **URL Tree** icon in Figure 78. This will invoke Figure 79.

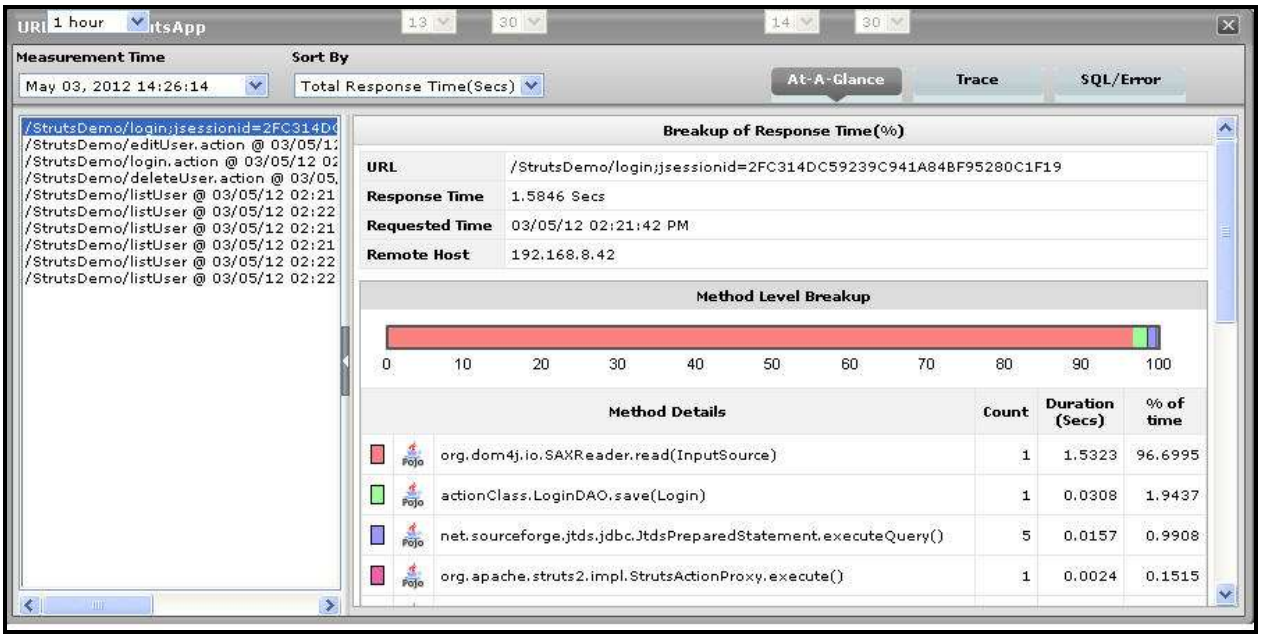


Figure 79: The At-A-Glance tab page of the URL tree

In the left panel of Figure 79, you will find the list of slow transactions sorted in the descending order of their *Total Response Time*. By default, the slowest transaction in our example, the "**/StrutsDemo/login;jsessionid=...**", will be chosen from the left panel. The **At-A-Glance** tab page, which will be open by default in the right panel, will provide quick, yet deep insights into the performance of the chosen transaction and the reasons for its slowness.

You can take a look at the **Method Level Breakup** section in the **At-A-Glance** tab page to figure out which method called by which layer/sub-component (such as **FILTER**, **STRUTS**, **SERVLETS**, **JSPS**, **POJOS**, **SQL**, **JDBC**, etc.) could have caused the slowdown. This section provides a horizontal bar graph, which reveals the percentage of time the chosen transaction spent executing each of the top methods (in terms of execution time) invoked by it. The legend below clearly indicates the top methods and the layer/sub-component that invoked each method. Previously, we had deduced that one/more methods invoked at the **POJO** layer could have hampered transaction execution. The bar graph and the legend in the **Method Level Breakup** section corroborate this finding, as the most time-consuming method, as inferred from Figure 79, is the **org.dom5j.io.SAXReaer.read(InputSource)**, which is invoked by the **POJO** component (indicated by the **POJO** icon). The legend also reveals that this method has been running for over 1.5 seconds, and is hogging nearly 97% of the total execution time (i.e., response time) of the transaction. The question now which invocation of the **org.dom5j.io.SAXReaer.read(InputSource)** method could have contributed to the slowdown. Thankfully, the **Count** column of the legend reveals that this **POJO** method has been invoked only once! To know when and how the method was called, click on the **org.dom5j.io.SAXReaer.read(InputSource)** method in the **Method Level Breakup** section of Figure 80. Doing so automatically switches control to the **Trace** tab page in the right panel (see Figure 80).

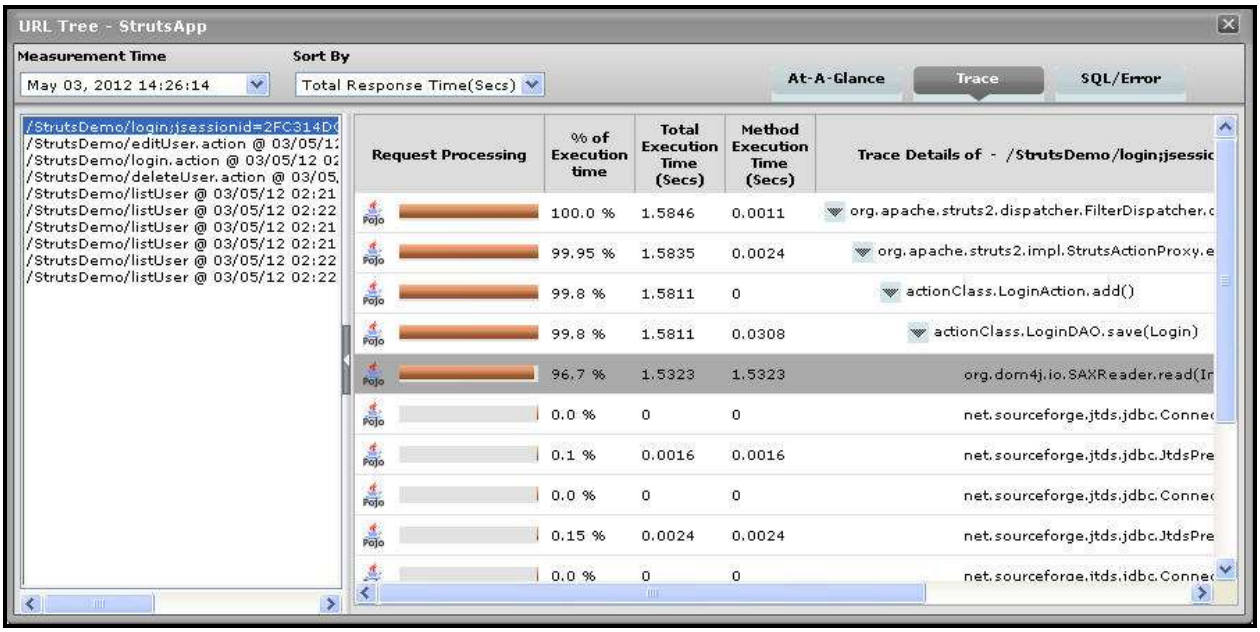


Figure 80: The Trace tab page highlighting the single instance of the org.dom5j.io.SAXReaer.read(InputSource) method in our example

Typically, the **Trace** tab page lists all the methods invoked by the chosen transaction, starting with the very first method. Methods and sub-methods (a method invoked within a method) are arranged in a tree-structure, which can be expanded or collapsed at will. To view the sub-methods within a method, click on the **arrow icon** that precedes that method in the **Trace** tab page. Likewise, to collapse a tree, click once again on the **arrow icon**. Using the tree-structure, you can easily trace the sequence in which methods are invoked by a transaction.

If a method is chosen for analysis from the **Method Level Breakup** section of the **At-A-Glance** tab page, the **Trace** tab page will automatically bring your attention to all invocations of that method by highlighting them (as shown by Figure 80). Since the **org.dom5j.io.SAXReaer.read(InputSource)** method was invoked only once, Figure 80 highlights it. From the invocation sequence indicated by the **Trace Details** column of Figure 76, it is clear that the delay in the execution of the **org.dom5j.io.SAXReaer.read(InputSource)** method has rippled and affected the execution of all its 'parent methods', thus significantly affecting transaction performance. We can thus conclude that the **org.dom5j.io.SAXReaer.read(InputSource)** method, with a response time of over 1.5 seconds, is the source of the slowdown experienced by the transaction. To confirm these findings, you can use the **Component Level Breakup** section that appears when scrolling down the the **At-A-Glance** tab page (see Figure 81).

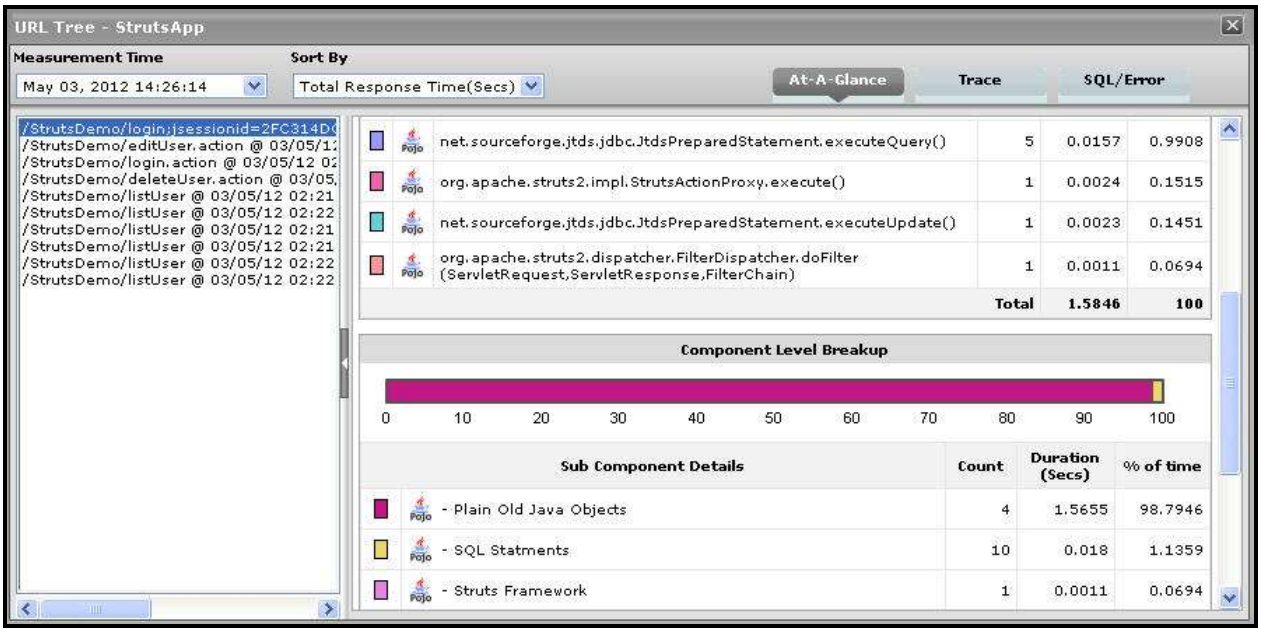


Figure 81: The Component Level Breakup

Using the horizontal bar graph in this section, you can quickly tell where - i.e., at which Java layer/sub-component - the transaction spent the maximum time. A quick glance at the graph's legend will reveal the layers/sub-components the transaction visited, the number of methods invoked by each layer/sub-component, the **Duration (Secs)** for which the transaction was processed at the layer/sub-component, and what **Percentage** of the total transaction response time was spent at the layer/sub-component. From Figure 81 in our example, it is evident that the transaction has spent considerable time at the **POJO** layer. To know the exact duration, take a look at the **Duration** and **% of time** column. The transaction has apparently pent nearly 98% of its time at the POJO layer - this amounts of over *1.5 seconds*.

To know which methods are causing it, click on the top layer in the legend of the **Component Level Breakup** section. Doing so will invoke the **Trace** tab page yet again (see Figure 79), but this time displaying all the methods invoked by the **POJO** layer alone. A quick look at Figure 79 reveals that the **org.dom5j.io.SAXReaer.read(InputSource)** method invoked by the parent method has been executing for over *1.5* seconds, and could hence be causing the slowdown.

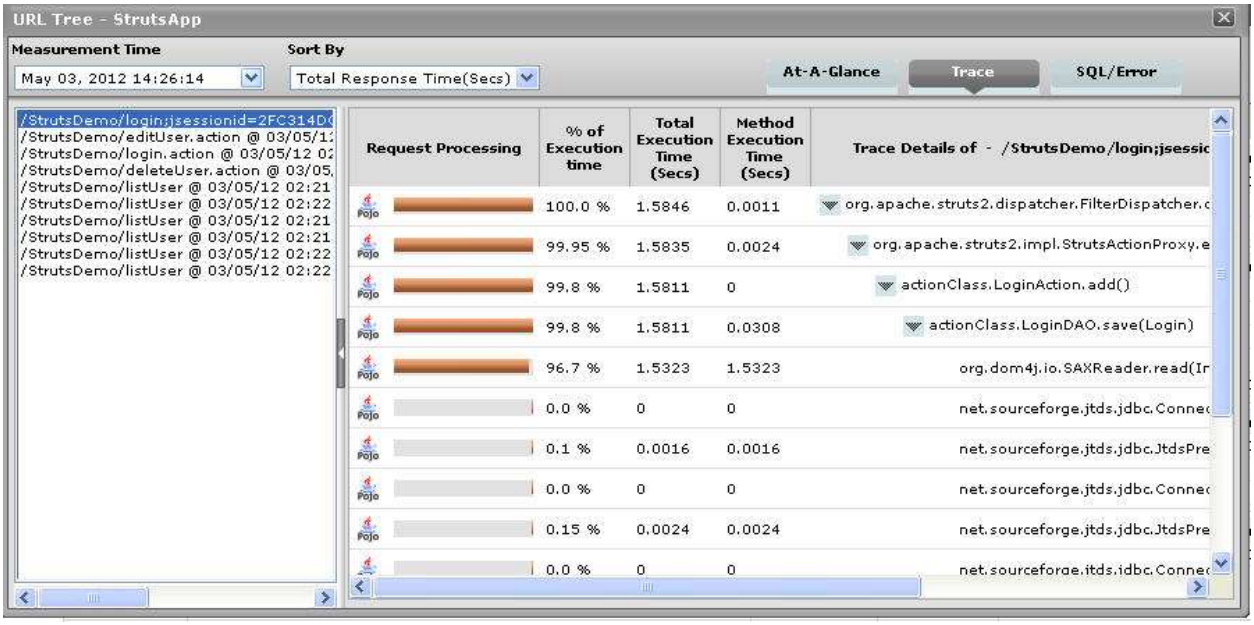


Figure 82: The Trace tab page displaying all the methods invoked by the POJO layer

By closely scrutinizing the parent method's code and that of the **org.dom5j.io.SAXReaer.read(InputSource)** method, you will be able to detect coding inconsistencies, which when removed, can make the code more efficient and faster!

2

Conclusion

This document has clearly explained how eG Enterprise monitors **Java Applications**. For more information on eG Enterprise, please visit our web site at www.eginnovations.com or write to us at sales@eginnovations.com.