Eclipse Test & Performance Tools Platform, Part 1: Test, profile, and monitor applications

Skill Level: Intermediate

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Learn how to use the Eclipse Test & Performance Tools Platform (TPTP) to profile a Java™ application, and discover how to quantify memory usage, identify memory leaks, and isolate performance bottlenecks.

Section 1. Before you start

About this tutorial

This tutorial introduces the Eclipse Test & Performance Tools Platform (TPTP), provides step-by-step instructions on how to install Eclipse and the TPTP tools, and demonstrates how to profile a running Java application.

Prerequisites

To benefit, you should have experience with Java software development and the entire software development life cycle, including testing and profiling. You should also have experience installing software from the command line, and setting and managing shell and system environment variables, such as the Java `CLASSPATH`. Acquaintance with Eclipse and the Standard Widget Toolkit (SWT) is also beneficial.

Before you start, you must install several software packages on your UNIX®, Linux®, Mac OS X, or Microsoft® Windows® system. You need a functioning Java Virtual Machine (JVM), a copy of the Eclipse platform, the Eclipse TPTP runtime, and several prerequisites and co-requisites on which TPTP depends. You also need TPTP's Agent Controller, which allows you to start and profile applications. Here's everything you need:

- Java 2 Platform, Standard Edition (J2SE) V1.4 Software Development Kit (SDK)
- J2SE V1.4 Java Runtime Environment (J2RE)
- Eclipse V3.1 SDK
- Eclipse Modeling Framework (EMF) SDK V2.1
- XML Schema Infoset Model (XSD) SDK V2.1
- Version 1.1.1 of UML2
- TPTP runtime
- Agent Controller runtime (appropriate to your system)
- The Eclipse Update Manager (optional)

System requirements

If you don't have a JVM and Eclipse installed on your system, make sure you have at least 300 MB of disk space free for all the software. You also need enough free physical memory to run the JVM. In general, 64 MB or more of free physical memory is recommended.

Section 2. Introducing TPTP

Writing the Java code for an application or servlet is just the first stage in the much longer process required to deliver robust production-quality programs. Code must be tested to vet its operation and accuracy. Code must often be profiled to remove bottlenecks that impede performance and to remove wasteful or inadvertent use of resources, especially memory. Code must also be monitored -- to pinpoint failures, of course, but also to identify usage patterns, opportunities for further enhancement and optimization, and attempted and actual intrusions.

What is the Eclipse TPTP?

While many tools exist to test, profile, and monitor code, few, if any, are integrated into a larger whole. Moreover, such tools are typically offered by separate vendors, leaving you to spend valuable time and effort learning and mastering many different user interfaces (UIs), compilers, and diagnostics. Measured in hours and dollars, proprietary development tools require a steep investment.

But what if the test harness, profiler, and monitor were open source? And what if the tools were extensible, so that any vendor or developer could create new tools or enhance existing tools? And what if the tools were well integrated into an existing, popular, familiar development environment? A daydream, perchance? Hardly.

The Eclipse TPTP is a software architecture and several realized components (so far) that extend the Eclipse platform to include test, performance, and monitoring tools. Some Java, C, and C++ developers use TPTP to build unique tools for other developers, while others combine TPTP-derived tools and the other features of Eclipse to build and deploy applications for users.

The TPTP deliverables

Briefly, TPTP is an Eclipse Foundation top-level project chartered to "build a generic, extensible, standards-based tool platform upon which software developers can create specialized, differentiated, and interoperable ... test and performance tools." In other words, TPTP, at its core, is a tool to build other tools that automate software quality control.

Indeed, the current release of TPTP includes that core and three core-derived tools:

TPTP
: The TPTP provides foundational code for UI development, data collection, rule-based data queries, and the control of applications. For instance, the TPTP provides many wizards that other tools can reuse and extend. It also provides programming interfaces and a daemon that facilitate data collection from a running, local, or remote process.

TPTP Testing Tools
: This project builds upon TPTP to provide additional services for automating application testing of all kinds. The current release supports JUnit automated testing, a point-and-click scriptable system to direct manual testing and record results, and an automated system to test Web applications, including a recorder that can record and play back Web browsing sessions and authenticate results. Eclipse V4.1 also includes an early release of a graphical user interface (GUI) recorder that can record and play back mouse and keyboard events in SWT-based interfaces.

TPTP Monitoring Tools
: This project collects, analyzes, and visualizes data, either from log files or from statistics that the application gathers.

TPTP Tracing and Profiling Tools
: This project also extends the TPTP to collect and analyze resource use, including CPU and memory, in running applications. The tracing tools also allow you to interact with a running process. For example, you can manually force garbage collection and examine the remaining object pool in efforts to find and fix a memory "leak."

In addition, the TPTP includes a daemon called the *Agent Controller*. The Agent Controller is a liaison between the Eclipse workbench and the application being tested. It can launch local or remote Java applications on behalf of Eclipse and forwards application metrics, including application log files, to the workbench.

The remainder of this tutorial demonstrates several of the TPTP profiling tools for Java technology.

Section 3. Installing the prerequisite software and components

Before you can begin this tutorial, you must install and set up the software and components included in the Prerequisites section.

Install J2SE and J2RE

Download and install the J2SE V1.4 SDK and the V1.4 J2RE. (If your system already has J2SE V1.4.2_10 or a higher version, you can skip this step.)

Typically, the J2SE SDK and Java Runtime Environment (JRE) are distributed as self-extracting binaries. Installation on Linux is typically as easy as this:

Listing 1. J2SE SDK and Java Runtime Environment installation

```
% cd ~
% mkdir ~/java
% cd ~/java
% mv ~/j2sdk-1_4_2_10-linux-i586.bin .
% mv ~/j2re-1_4_2_10-linux-i586.bin .
% chmod +x j2sdk-1_4_2_10-linux-i586.bin \
j2re-1_4_2_10-linux-i586.bin
% ./j2sdk-1_4_2_10-linux-i586.bin
.
% ./j2re-1_4_2_10-linux-i586.bin
.
% ls -F
j2re1.4.2_10/    j2sdk1.4.2_10/
```

Use the Eclipse Update Manager to install TPTP (optional)

If you have already installed Eclipse, you can use the Eclipse Update Manager to install TPTP. To do so:

1. Click **Help > Software Updates > Find and Install**.
2. Select the **Search for new features to install** option, then click **Next**.
3. Click **New Remote Site**, then type `TPTP Update Site` and

`http://eclipse.org/tptp/updates/site.xml` for the name and URL, respectively. Click **Finish**.

4. Select the features to install, then **Next**.
5. Accept the license agreement, click **Next**, then **Finish**.
6. At the confirmation prompt, click **Install All**. When the installation is complete, restart Eclipse.

You can now safely skip to the steps in the Install the Agent Controller section below that describe how to install the Agent Controller, which you must install manually. If you haven't installed Eclipse yet, continue reading.

Install the Eclipse V3.1 SDK

Download the Eclipse 3.1 SDK that's appropriate for your platform. You can find the SDK at the Eclipse Downloads. Typically, installation is as easy as unpacking the Eclipse .tar.gz file into the directory of your choice. For example, if you're using Linux, download the Eclipse V3.1 SDK tarball, then unpack it in a directory, such as ~/java/, using this code:

```
% cd ~/java
% mv ~/eclipse-SDK-3.1.1-linux-gtk.tar.gz .
% tar zxvf eclipse-SDK-3.1.1-linux-gtk.tar.gz
```

To verify that Eclipse was installed successfully, remain in the directory where you unpacked Eclipse, make sure that the `java` executable is in your `PATH`, and run `java -jar eclipse/startup.jar`. For example:

Listing 2. Verify that Eclipse was installed successfully

```
% export JAVA_DIR=$HOME/java
% export JAVA_HOME=$JAVA_DIR/j2sdk1.4.2_08/sdk
% export PATH=$JAVA_HOME/bin
% export CLASSPATH=$JAVA_HOME
% cd $JAVA_DIR
% java -jar eclipse/startup.jar
```

If you're prompted to choose a directory for your workspace, type `$HOME/java/workspace`. This directory will retain all the projects you create in Eclipse. (Of course, if you have many projects, you can choose other directories later, say, to contain one project per workspace.)

Install the EMF SDK V2.1

Quit Eclipse if it's running and download EMF SDK V2.1. (According to the EMF Web site, "EMF is a modeling framework and code generation facility for building tools and other applications based on a structured data model.") After you download the file, change to the directory that contains the Eclipse folder and run `unzip emf-sdo-SDK-2.1.0.zip`. For instance:

Listing 3. Run unzip emf-sdo-SDK-2.1.0.zip

```
% cd $JAVA_DIR
% ls
eclipse j2sdk1.4.2_08
% mv ~/emf-sdo-SDK-2.1.0.zip .
% unzip emf-sdo-SDK-2.1.0.zip
  creating: eclipse/features/
  creating: eclipse/features/org.eclipse.emf.ecore.sdo_2.1.0/
  creating: eclipse/features/org.eclipse.emf_2.1.0/
  inflating: ...
```

Install the XSD SDK V2.1

Download the XSD SDK V2.1. (According to the project Web site, "XSD is a library that provides an application programming interface (API) for manipulating the components of an XML schema as described by the World Wide Web Consortium (W3C) XML Schema specifications.") As with the previous file, change to the directory that contains the Eclipse directory, and run `unzip xsd-SDK-2.1.0.zip`. Here is an example:

```
% cd $JAVA_DIR
% mv ~/xsd-SDK-2.1.0.zip .
% unzip xsd-SDK-2.1.0.zip
```

If you're prompted to confirm the overwrite of any files, simply press **y** (lowercase) to answer Yes to each question.

Install the UML V2.0 Metamodel Implementation

To use the Unified Modeling Language (UML) features of TPTP, you need to install the UML V2.0 Metamodel Implementation. If you're using Eclipse V3.1.1, download V1.1.1 of UML2, then unpack its archive file in the same directory that contains Eclipse:

```
% cd $JAVA_DIR
% mv ~/uml2-1.1.1.zip .
% unzip uml2-1.1.1.zip
```

Install the TPTP runtime

For the next step, download the TPTP runtime, which contains all the TPTP features and Eclipse plug-ins needed to integrate the two systems. To install TPTP, change to the directory that contains Eclipse and run unzip tptp.runtime-TPTP-4.1.0.zip. Here is an example:

```
% cd $JAVA_DIR
% mv ~/tptp.runtime-TPTP-4.1.0.zip .
% unzip tptp.runtime-TPTP-4.1.0.zip
```

Install the Agent Controller

The Agent Controller is a vital component of TPTP that allows Eclipse to launch applications and interact with those applications to extract profiling data. Download the Agent Controller runtime appropriate for your operating system. Next, create a directory named tptpd in the same directory that contains Eclipse and unpack the Agent Controller archive into that directory. The commands to run are:

```
% mkdir $JAVA_DIR/tptpd
% cd $JAVA_DIR/tptpd
% mv ~/tptpdc.linux_ia32-TPTP-4.1.0.zip .
% unzip tptpdc.linux_ia32-TPTP-4.1.0.zip
```

If you see two errors like these:

```
linking: lib/libxerces-c.so
warning:  symbolic link (lib/libxerces-c.so) failed

linking: lib/libxerces-c.so.24
warning:  symbolic link (lib/libxerces-c.so.24) failed
```

you must recreate the two links manually by typing the following commands:

```
% cd $JAVA_DIR/tptpd/lib
% rm libxerces-c.so libxerces-c.so.24
% ln -s libxerces-c.so.24.0 libxerces-c.so
% ln -s libxerces-c.so.24.0 libxerces-c.so.24
```

Add the Agent Controller directory

To use the Agent Controller, you must add its lib directory to your `LD_LIBRARY_PATH`. For example, if you're running Linux and have adopted the same directory structure shown in the steps above, you'd add `$JAVA_DIR/tptpd/lib` as follows:

```
% export LD_LIBRARY_PATH=$JAVA_DIR/tptpd/lib:$LD_LIBRARY_PATH
```

You must also ensure that the contents of the Controller's lib and bin directories are executable. To do that, run:

```
% chmod +x $JAVA_DIR/tptpd/{bin,lib}/*
```

Now add the scripts that configure and start and stop the Agent Controller to your

`PATH`:

```
% export PATH=$JAVA_DIR/tptpd/bin:$PATH
```

Configure the Agent Controller for your environment

Finally, you configure the Agent Controller to match your environment. Change to the Agent Controller's bin directory, then run SetConfig.sh.

```
% cd $JAVA_DIR/tptpd/bin
% ./SetConfig.sh
```

When the configure script prompts you, accept the defaults. Running the configure script creates the file config/serviceconfig.xml in the Agent Controller's hierarchy of files.

Test the Agent Controller

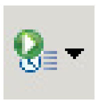
To test the Agent Controller, run `RAStart.sh`. To stop the Agent Controller, run `RAStop.sh`:

Listing 4. Stop the Agent Controller

```
db% RAStart.sh
Starting Agent Controller
RAServer started successfully
% RAStop.sh
RAServer stopped, pid = 5891
RAServer stopped, pid = 5892
RAServer stopped, pid = 5893
RAServer stopped, pid = 5894
RAServer stopped, pid = 5895
RAServer stopped, pid = 5896
RAServer stopped, pid = 5897
RAServer stopped, pid = 5898
RAServer stopped, pid = 5899
RAServer stopped, pid = 5900
RAServer stopped, pid = 5901
RAServer stopped, pid = 5902
RAServer stopped, pid = 5904
RAServer stopped, pid = 5905
RAServer stopped, pid = 5906
```

Finished! Restart Eclipse. You should now see a new button on the Eclipse toolbar that looks like Figure 1. That's the TPTP Profile button. TPTP is installed, and you're ready to continue with the tutorial.

Figure 1. TPTP Profile button



Section 4. Profiling a Java application

Now that you've installed the TPTP and underlying software, run Eclipse.

The sample application

The Java application to profile is shown in Listing 5.

Listing 5. A simple Java application that hordes a small number of objects

```
import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;

public class SpaceShipToy {
    /*
     * To build a spaceship, you need a
capsule, a booster,
     * three stages, and two monkeys
(borrowed
     *  from a Barrel of Monkeys).
     */
    public Capsule capsule = new Capsule();
    public Booster booster = new Booster();
    public Stage[] stage = new Stage[3];

    public SpaceShipToy()
    {
       for (int i = 0; i  < 3; i++)
        stage[i] = new Stage();
    }

    private void _killTime(int seconds)
    {
        if (seconds <= 0)
          return;

        for (int i = 0; i < seconds; i++);
    }

  static final int MINUTE = 60;
    static final int CAPSULE = 2 * MINUTE;
    static final int BOOSTER = 5 * MINUTE;
    static final int STAGE = 3 * MINUTE;
    static final int MONKEY = 10 * MINUTE;

    class Capsule {
        public Monkey chimp1 = new Monkey(),
\
        chimp2 = new Monkey();

        public Capsule() {
          System.out.println("Start building
the capsule...");
          _killTime(CAPSULE);
          chimp1.build();
          chimp2.build();
          System.out.println("Capsule
complete.");
        }
    }

    class Booster   {
      public Booster() {
        System.out.println("Start
booster...");
        _killTime(BOOSTER);
        System.out.println("Blast off.");
      }
    }

    class Stage {
      public Stage() {
        System.out.println("Start
stage...");
        _killTime(STAGE);
        System.out.println("Stage
complete.");
      }
    }

    class Monkey  {
      public void start() {
        System.out.println("Start the monkey
business...");
      }

      public void build() {
        start();
        _killTime(MONKEY);
        finish();
      }

      public void finish()  {
        System.out.println("Monkey business
complete.");
      }
    }


    public static void main(String[] args)
throws \
    java.io.IOException
    {
       final int NUMBERTOYS = 9;

       BufferedReader in = new
         BufferedReader(new
InputStreamReader(System.in));
       SpaceShipToy[] toys = new
SpaceShipToy[NUMBERTOYS];
       String input = in.readLine().trim();

       System.out.println("Toy factory is up
and running...");
       System.out.flush();

       for (int i = 0; i < NUMBERTOYS; i++)
         toys[i] = null;

       while (!input.equalsIgnoreCase("q"))
{
        if (input == null || input.length()
!= 1
          ||
!Character.isDigit(input.charAt(0))) {
          System.err.println ("Unknown
option. Try 0-9, q");
          input = in.readLine().trim();
          continue;
        }

        int number =
Integer.valueOf(input).intValue();
        if (number == 9) {
          new SpaceShipToy();
          System.out.println("Whoops... Lost
one...");
        }
        else {
          if (toys[number] != null) {
            System.out.println("Shipping toy
# " + number);
            toys[number] = null;
          }
          else {
            System.out.println("Building toy
# " + number);
            toys[number] = new
SpaceShipToy();
          }
        }

        input = in.readLine().trim();
     }
  }
}
```

The Java application is simple: It "builds" toy rocket ships and "ships" them to stores. Each toy is represented by a Java object that contains a handful of other objects, each representing a part of the toy. Each toy part takes a certain amount of time to build.

To use the application, press the **0** to **8** number keys to build a toy. If you press the same key again, the built toy is "shipped" and the associated object is de-referenced to be made available for garbage collection. Therefore, you can have up to nine toys in memory at any one time (if all nine toys are built but not yet shipped).

Press the **9** key to create an unreferenced object, simulating a memory leak. Press **q** (lowercase) to quit the application.

Run a profiling session

Use Eclipse and TPTP to run and profile the "toy factory." TPTP can show the number of active objects, execution time, and more. To use Eclipse and TPTP:

1. Launch the Agent Controller.
2. Change to the Agent Controller bin directory, and then run RAStart.sh:

```
% cd $JAVA_DIR/tptpd/bin
% ./RAStart.sh
```

3. In Eclipse, go to the workbench and create a new Java Project by clicking **File > New > Project**. Select **Java Project** from the list of options, then click **Next**.
4. In the following window, type `Toy Maker` for the Project Name, then click **Finish**. A new project titled "Toy Maker" should appear in the Package Explorer pane.

5. Create a new Java class within the project called `SpaceShipToy` in the `example` package. Click **File > New > Class**.

6. In the window that pops up, type `example` in the **Package** field and `SpaceShipToy` in the **Name** field. Leave the other settings in the window as is.

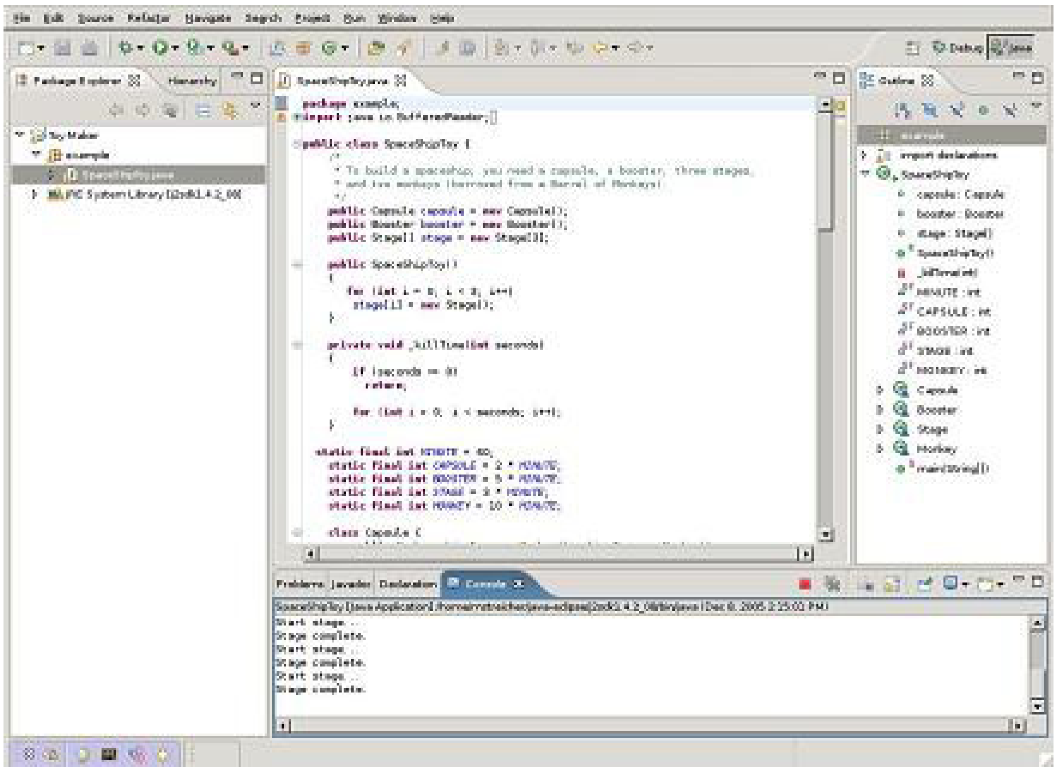
7. Click **Finish**. You should now see a skeleton for the new class.

8. Paste the code from Listing 1 into the Eclipse class editor, being sure to leave the `package example` declaration, but replacing the empty class definition. Save the code to persist your changes, which also causes Eclipse to automatically recompile the new version of your class.

9. If you want to run the application, click **Run > Run...**, double-click **Java Application**, select **SpaceShipToy**, then click **Run**. To interact with the application, click **Windows > Show View...**, then select **Console**.

10. Type a `1` (the numeral one) and press **Return**. Your screen should look something like Figure 2.

Figure 2. The toy factory running under Eclipse

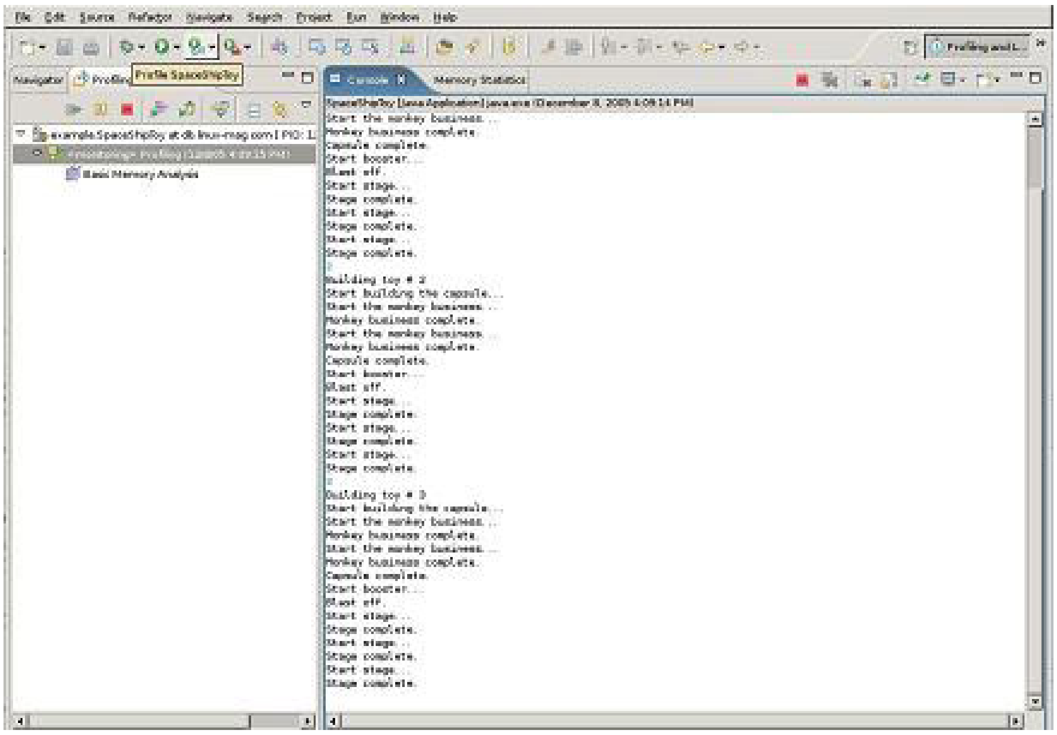


```
package example;
import java.io.BufferedReader;

public class SpaceShipToy {
    /*
     * To build a spaceship, you need a capsule, a booster, three stages,
     * and two monkeys (borrowed from a Barrel of Monkeys).
     */
    public Capsule capsule = new Capsule();
    public Booster booster = new Booster();
    public Stage[] stage = new Stage[3];

    public SpaceShipToy()
    {
      for (int i = 0; i < 3; i++)
        stage[i] = new Stage();
    }

    private void _killTime(int seconds)
    {
       if (seconds == 0)
         return;

       for (int i = 0; i < seconds; i++);
    }

  static final int MINUTE = 60;
    static final int CAPSULE = 2 * MINUTE;
    static final int BOOSTER = 5 * MINUTE;
    static final int STAGE = 3 * MINUTE;
    static final int MONKEY = 10 * MINUTE;

    class Capsule {
```

```
SpaceShipToy [Java Application] [illegible]/j2sdk1.4.2_08/bin/java (Dec 6, 2005 2:25:02 PM)
Start stage ...
Stage complete.
Start stage ...
Stage complete.
Start stage ...
Stage complete.
```

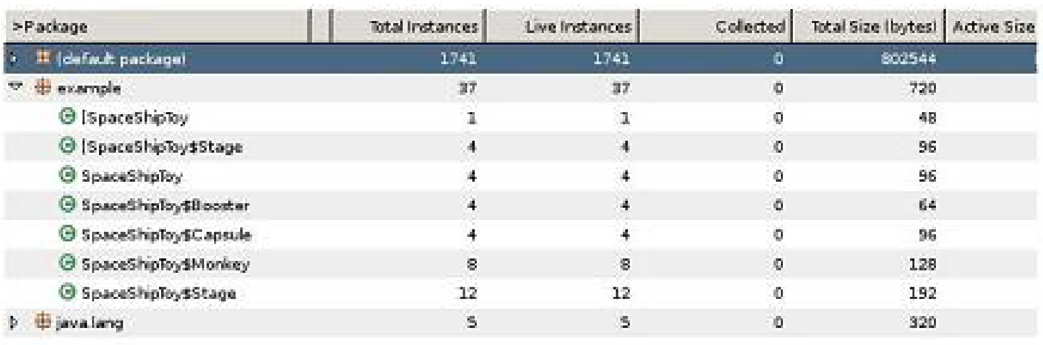
Profile the same application

To profile the same application:

1. Click TPTP Profile, then select **Profile...**.
2. Expand Java Application to reveal SpaceShipToy. Notice that the Profile window is similar to the Run window that appears when you click **Run**, but there's an additional tab called **Profile**.
3. Click **Profile** to launch the application under the profiler. If the perspective does not automatically change, click **Window > Open Perspective > Other...**, then select **Profiling and Logging**.
4. When the Profiling and Logging perspective appears, expand the contents of the Profiling Monitor view, then select the line that begins with `<monitoring>`. When you choose that line, a console view appears.
5. Type `0`, `1`, `2`, and `9`. Your screen should look something like Figure 3.
Figure 3. The Profiling and Logging perspective with the running application

File Edit Source Refactor Navigate Search Project Run Window Help
Profiling and L...
Navigator
Profiling
Profile SpaceShipToy
Console
Memory Statistics
example.SpaceShipToy at db.linux-mag.com [PID: 1
<monitoring> Profiling (12/8/05 4:07:15 PM)
Basic Memory Analysis

```
SpaceShipToy [Java Application] java.exe (December 8, 2005 4:08:14 PM)
Start the monkey business...
Monkey business complete.
Capsule complete.
Start booster...
Blast off.
Start stage...
Stage complete.
Start stage...
Stage complete.
Start stage...
Stage complete.
2
Building toy # 2
Start building the capsule...
Start the monkey business...
Monkey business complete.
Start the monkey business...
Monkey business complete.
Capsule complete.
Start booster...
Blast off.
Start stage...
Stage complete.
Start stage...
Stage complete.
Start stage...
Stage complete.
2
Building toy # 3
Start building the capsule...
Start the monkey business...
Monkey business complete.
Start the monkey business...
Monkey business complete.
Capsule complete.
Start booster...
Blast off.
Start stage...
Stage complete.
Start stage...
Stage complete.
Start stage...
Stage complete.
```

6. Click the Memory Statistics view, then expand the line associated with the `example` package. The view should look something like Figure 4. There are four instances of each object: three for the "built" toys and one for the unreferenced toy.
Figure 4. Memory consumption after building three toy objects and one unreferenced toy object



>Package	Total Instances	Live Instances	Collected	Total Size (bytes)	Active Size
(default package)	1741	1741	0	802544	
example	37	37	0	720	
[SpaceShipToy	1	1	0	48	
[SpaceShipToy$Stage	4	4	0	96	
SpaceShipToy	4	4	0	96	
SpaceShipToy$Booster	4	4	0	64	
SpaceShipToy$Capsule	4	4	0	96	
SpaceShipToy$Monkey	8	8	0	128	
SpaceShipToy$Stage	12	12	0	192	
java.lang	5	5	0	320	

The columns in the Memory Statistics view track instance and memory use statistics:

- **Total Instances** reflects the total number of instances of a class.
- **Live Instances** shows how many instances are still referenced and were not collected by the garbage collector.
- **Collected** counts how many class instances the garbage collector reaped.
- **Total Size (bytes)** and **Active Size (bytes)** show the total cumulative memory that all instances used (a kind of high-water mark) and the amount of memory in active use by the live instances, respectively.

Finish the trial run

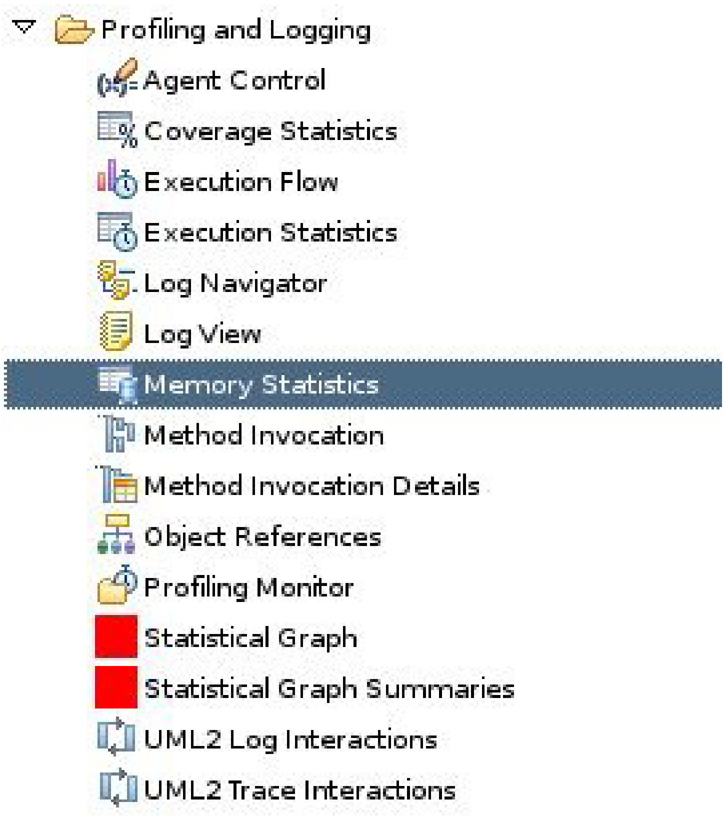
To finish this trial run, switch back to the console view, then press the **0**, **1**, and **2** number keys again. Click the trash can icon in the Monitoring view to force garbage collection. A good garbage collector will reap all the unreferenced objects. You can refresh all the views in the current perspective at any time by clicking **Refresh**, shown in Figure 5.

Figure 5. The Refresh button

Section 5. Finding the data you want

The Profiling and Logging perspective offers a large collection of views that reveal a great deal about the state of your application. To see the list, click **Window > Show View > Other...**, then expand the list under Profiling and Logging. The list should look like Figure 6.

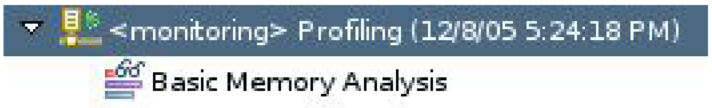
Figure 6. The list of Profiling and Logging views



Collect data to populate views

Depending on your goals and the problem at hand, you can collect data to populate one or all of those views. In the previous section, the only data collected was memory statistics to populate the Memory Statistics view. If you recall, the Monitoring view looked like Figure 7.

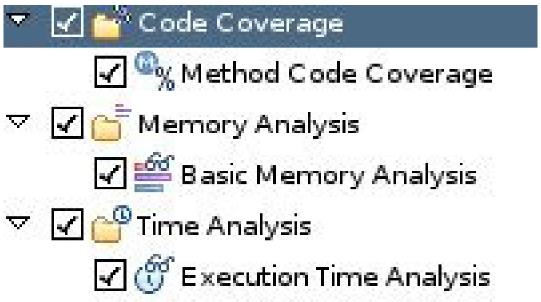
Figure 7. Basic statistics in the Monitoring view



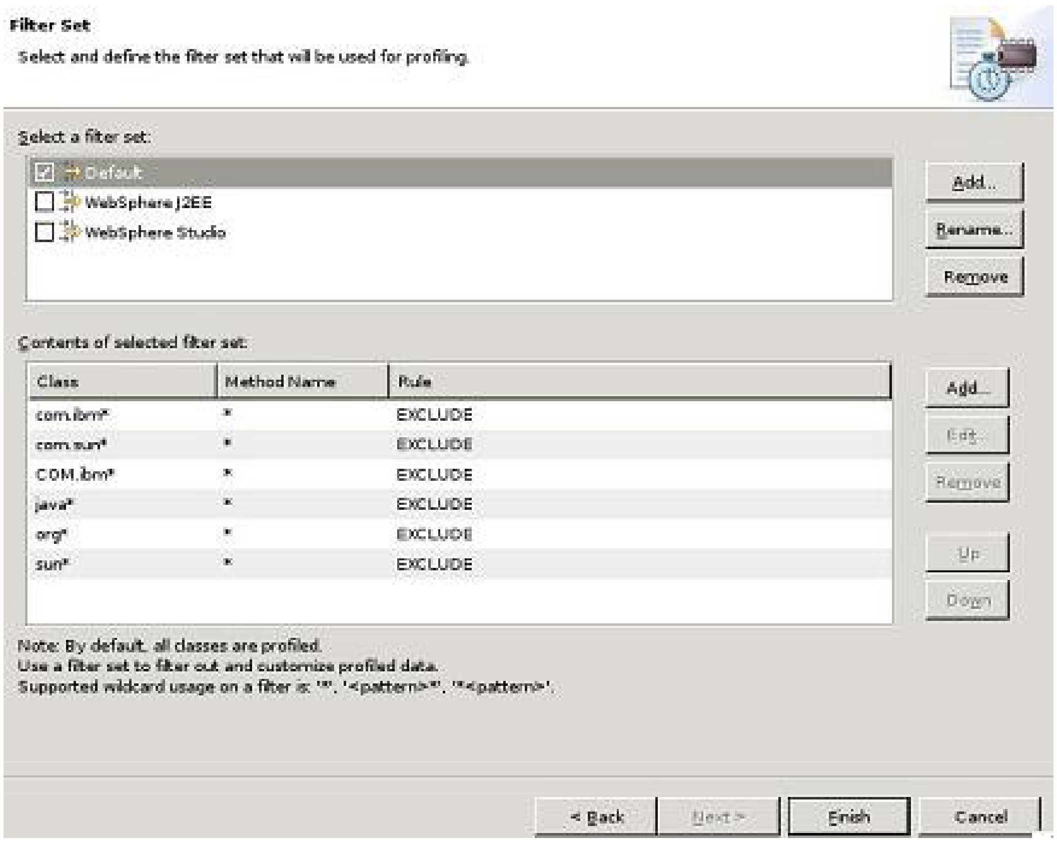
The bottom-most expanded list indicates that the current profile configuration includes statistics only for memory use. Let's create a new profile configuration that collects as much information as possible, so you can explore all the metrics and visualizations that the profiling and performance tools provide:

1. Click the little arrow in the TPTP Profile button, then select **Profile...**.
2. In the Profile window, select **SpaceShipToy**, then click **New** at the bottom left of the window.
3. At the top of the right-most pane, type `Lots of Data` in the **Name** field, then click **Apply**.
4. Click the Profiling tab, then click **Add...**.

5. In the next window, type `All` for the **Profile set name** and `All of the data that's available` in the **Description** field. Click **Next**.

6. The next pane allows you to choose the data you want to collect. Expand all the choices, then select all the check boxes shown in Figure 8.
Figure 8. Metrics to select

- ☑ Code Coverage
  - ☑ Method Code Coverage
- ☑ Memory Analysis
  - ☑ Basic Memory Analysis
- ☑ Time Analysis
  - ☑ Execution Time Analysis

7. Click **Execution Time Analysis**.

8. Select the **Collect method CPU time information** check box, then select the **Show execution flow graphical details** option. Click **Next** again. The next window, shown in Figure 9, allows you to filter out classes that don't interest you.
Figure 9. Excluding irrelevant classes from profiling

Filter Set
Select and define the filter set that will be used for profiling.

Select a filter set:
- ☑ Default
- ☐ WebSphere J2EE
- ☐ WebSphere Studio

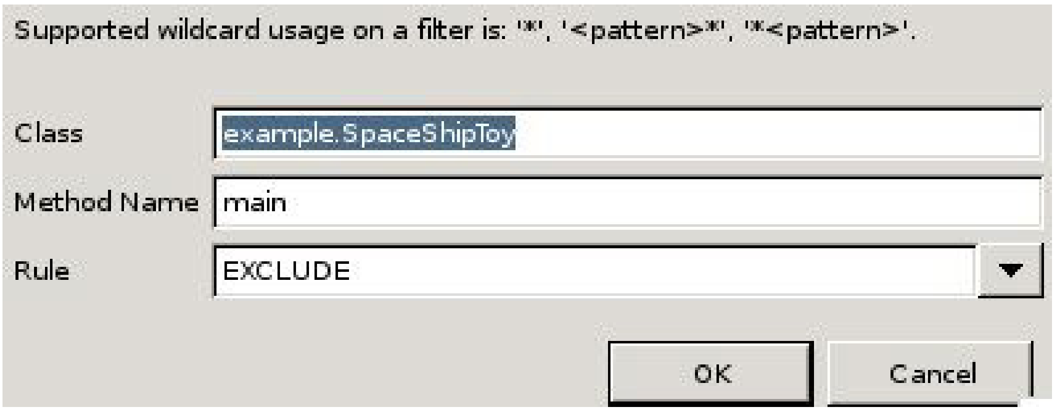
Contents of selected filter set:

Class	Method Name	Rule
com.ibm*	*	EXCLUDE
com.sun*	*	EXCLUDE
COM.ibm*	*	EXCLUDE
java*	*	EXCLUDE
org*	*	EXCLUDE
sun*	*	EXCLUDE

Note: By default, all classes are profiled.
Use a filter set to filter out and customize profiled data.
Supported wildcard usage on a filter is: '*', '<pattern>*', '*<pattern>'.

9. For the purposes of this example, click **Add...** at the top of the pane to

add a new filter set. Name the filter set `No Monkey Business` and click **OK**.

10. Click **Add...** to the right of the list of rules to add a new rule to the filter set. Type `example.SpaceShipToy` in the **Class name** field and `main` ("asterisk") in the **Method name** field, select **EXCLUDE** for the Rule (as shown in Figure 10), then click **OK**.
Figure 10. Edit a filter rule

Supported wildcard usage on a filter is: '*', '<pattern>*', '*<pattern>'.

Class: example.SpaceShipToy
Method Name: main
Rule: EXCLUDE

11. In the larger window, click **Apply**.

12. You've defined which application to profile and what metrics to collect. Now click **Profile**.

13. In the Profiling and Logging perspective, open the Memory Statistics view. You should see that execution metrics for the method `example.SpaceShipToy.main()` are missing, per the rule that you created.

Section 6. Tips and tricks

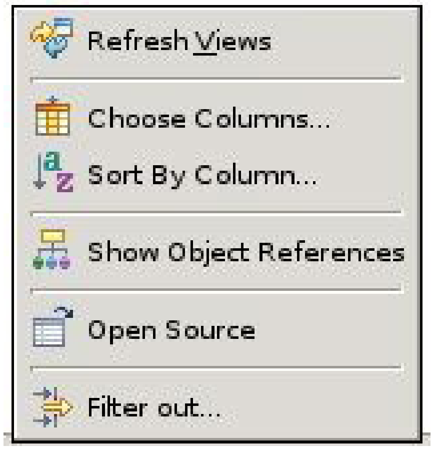
The TPTP tools are full of features to help you peer into your application. And because TPTP is well integrated with the rest of Eclipse, you'll find many conveniences that tie all of Eclipse's features together.

To get you started, here's a handful of tips and tricks you might find useful.

Quick data filters

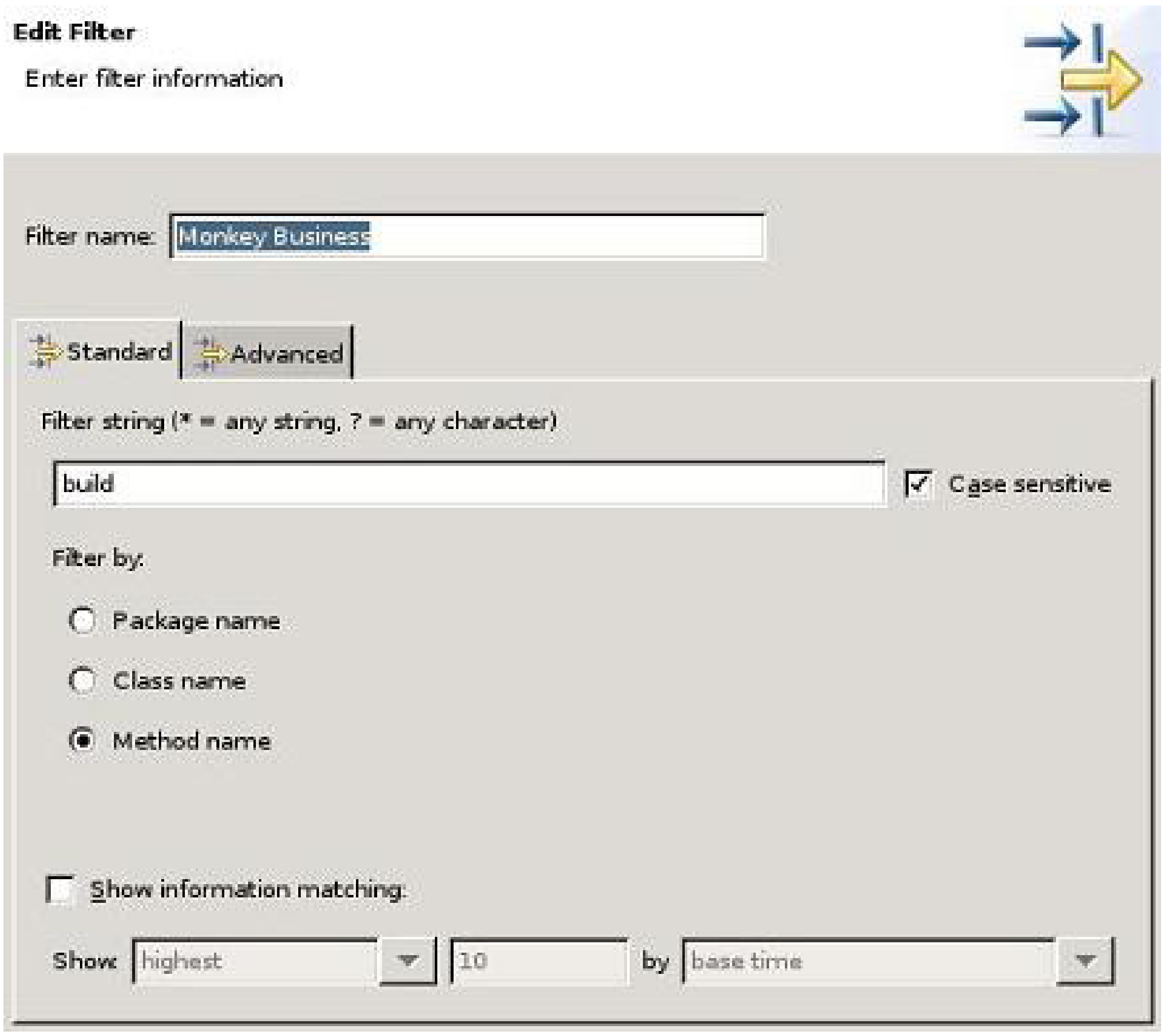
Start a profiling session and open the Execution Statistics view. The view shows all the classes and methods in the application (at least those that you did not filter out in the profile set). Right-click in the view to open a shortcut menu that looks like Figure 11.

Figure 11. Shortcut menu



Click **Filter out...**, select **Profiling**, then click **OK**. In the next window (shown in Figure 12), type `Monkey Business` as the filter name and `build` as the filter string, then select the **Method name** option beneath **Filter by**. Click **OK** and click **OK** again.

Figure 12. The Edit Filter window



Edit Filter

Enter filter information

Filter name: Monkey Business

Standard | Advanced

Filter string (* = any string, ? = any character)

build

[✓] Case sensitive

Filter by:

( ) Package name

( ) Class name

(●) Method name

[ ] Show information matching:

Show: highest ▾ 10 by base time ▾

Your view should change to show only the statistics for the `example.SpaceShipToy$Monkey.build()` method.

To revert the view so you can see all the methods again, click **Filter** (shown in Figure 13) and select **No filter**. To edit any filter, click the same button and select **Manage filters...**.

Figure 13. The Filter button

Jump to the source

Remain in the Execution Statistics view. Double-click the `SpaceShipToy$Booster` class. The perspective changes to Java and jumps immediately to the definition of the inner class `Booster`. This connection between the memory analysis view and the Eclipse code editor is invaluable.

Advanced, arbitrarily complex filters

You can build *arbitrarily complex filters* using the Advanced tab of the Edit Filter window. An *advanced filter* is a series of rules in which each rule lists a property, a condition (such as "equal," "not equal," and "like"), and a value. Care to know how much memory a single instance is consuming? You an express that in an advanced filter.

Organizing and sorting

Most data views can organize data by package, class, and method. You can quickly change how the data is organized by clicking one of the three buttons at the top of most data views, shown in Figure 14.

Figure 14. Three buttons for organizing data

From left to right, you see the organize by package, class, and method buttons, respectively.

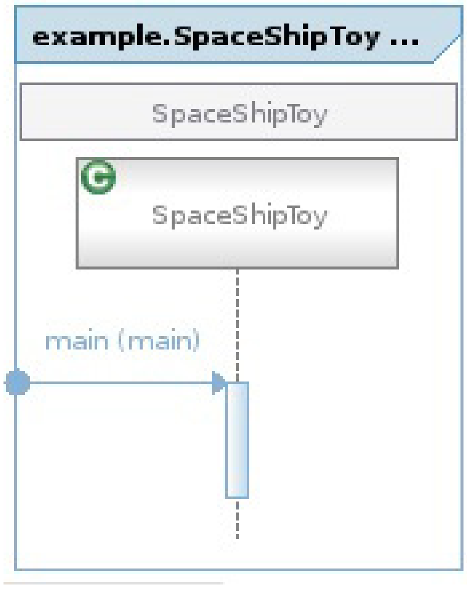
You can also sort all the data by clicking any of the column headers. Click a column header once to sort that column in ascending order; click the same column header again to show the data in descending order.

Section 7. Peering into code using UML2 sequence diagrams

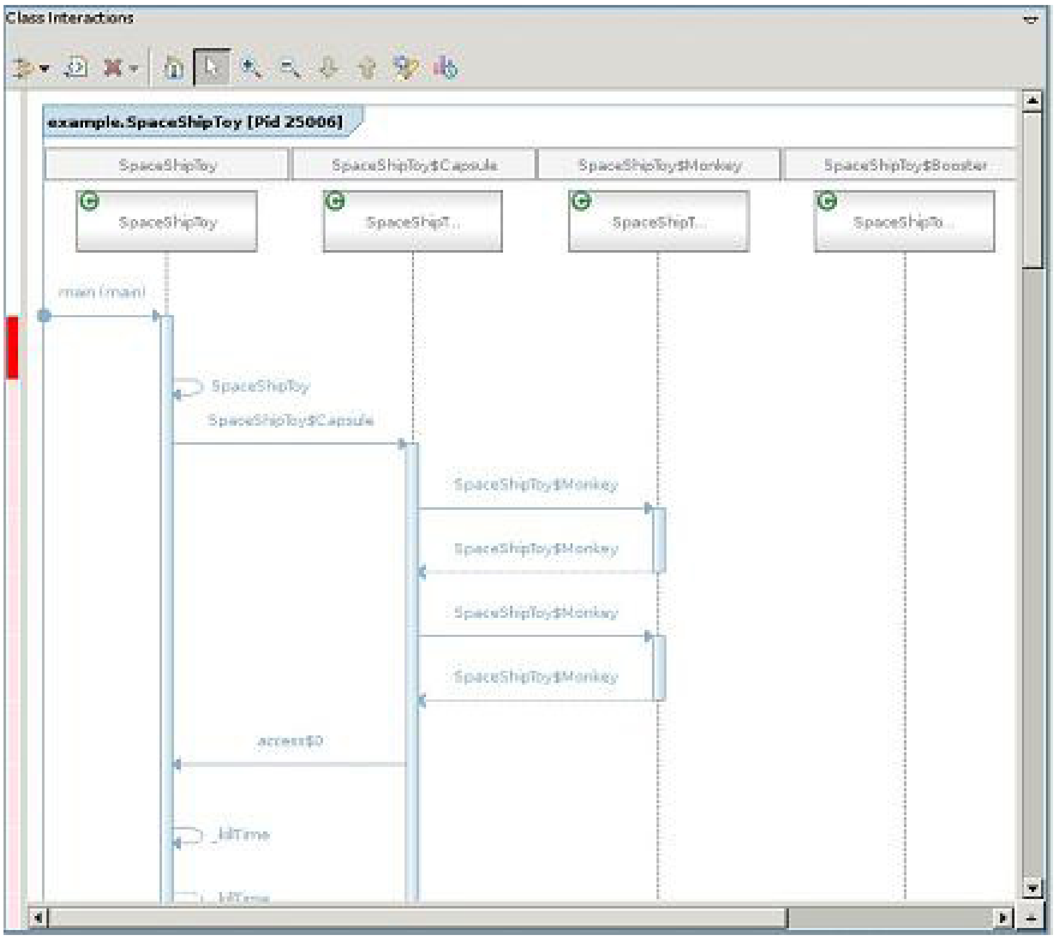
TPTP provides another helpful visualization of your running application: a UML2 sequence diagram. Not only does the diagram show the calling sequence between classes and methods but it can also highlight *hot spots*, areas of your code that consume the majority of application execution time.

View your code in sequence diagrams

To view your code using the UML2 sequence diagrams:

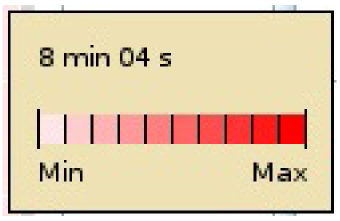
1. Quit all instances of the toy factory application you may be profiling.
2. Click the small arrow in the TPTP Profiling button. Select **Profile...**, select **SpaceShipToy**, click the Profiling tab, then select **All**.
3. Click **Apply** (if necessary), then click **Profile**.
4. When the application starts in the Profiling Monitor view, right-click the newly launched process and select **Open With... > UML2 Thread Interactions** to open the UML2 class interactions view. Because the application just started, the diagram only shows the call to `main()`, as Figure 15 shows.
Figure 15. Simple UML diagram of a call to main()


5. Switch to the console view, and interact with the application to generate more method calls. Then switch back to the UML2 Trace Interactions view. The UML diagram should have grown and may look like Figure 16.
Figure 16. The UML2 view of the sample application



6. Mouse over the red bar in the left margin to reveal a thermometer (see Figure 17) of CPU time consumption.

Figure 17. CPU consumption thermometer



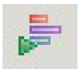
7. Bright red indicates maximum. In the context of the sample application, the construction of the `SpaceShipToy` class is clearly the bottleneck.

Section 8. Cataloging object references

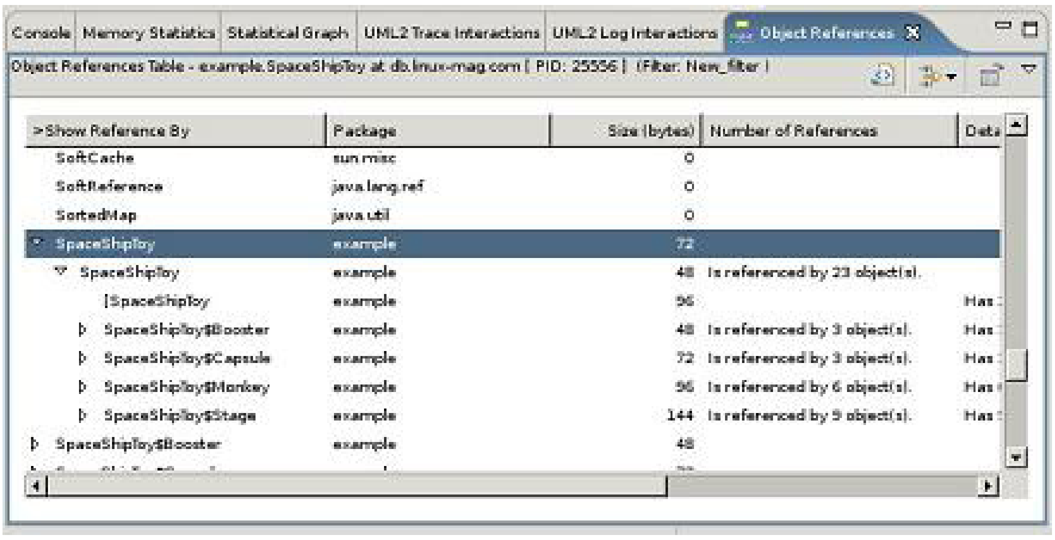
Another useful visualization of a running program is the Object References view, which shows the number of references to each type of object in your application. If your Java code is consuming what seems to be an exorbitant amount of memory, collecting and viewing the object references can help point to inadvertently greedy code.

Use the Object References view

Using the Object References view is as simple as any other TPTP view:

1. Terminate all the processes you may be profiling.
2. Right-click in the Profiling Monitor and select **Unload Profiling Data**. Follow the prompts to delete all the data collected so far.
3. Select all the processes you monitored previously and press **Delete**. When prompted with a window, select **Do not delete contents**, then click **Yes**.
4. Start a new profiling session with the toy factory. Switch to the Console view, then press **1 2 9** to create two toys and an unreferenced third "toy."
5. Collect the objects in use by clicking **Collect object references** in the Profiling Monitor view (see Figure 18).
   Figure 18. The Collect Object References button
   
6. On the Eclipse toolbar, click **Open Object References** (see Figure 19) to open the Object References view. The Object References view lists each object used in the application and the corresponding number of references.
   Figure 19. The Object References button

7. Expand SpaceShipToy. Your reference chart should look something like Figure 20. You created three toys, so the chart is accurate because each toy contains one booster, one capsule with two monkey astronauts, and three stages.
   Figure 20. The Object References of a snapshot of the sample application



Object References Table - example.SpaceShipToy at db.linux-mag.com [PID: 25556] (Filter: New_filter)

>Show Reference By	Package	Size (bytes)	Number of References	Deta
SoftCache	sun.misc	0		
SoftReference	java.lang.ref	0		
SortedMap	java.util	0		
SpaceShipToy	example	72		
SpaceShipToy	example	48	Is referenced by 23 object(s).	
[SpaceShipToy	example	56		Has
SpaceShipToy$Booster	example	48	Is referenced by 3 object(s).	Has
SpaceShipToy$Capsule	example	72	Is referenced by 3 object(s).	Has
SpaceShipToy$Monkey	example	56	Is referenced by 6 object(s).	Has
SpaceShipToy$Stage	example	144	Is referenced by 9 object(s).	Has
SpaceShipToy$Booster	example	48		

Section 9. Using TPTP with local Java applications

In addition to profiling Java applications built and launched through the Eclipse workbench, you can profile Java applications already running on the local machine (and on remote machines, although the process to profile remote applications isn't covered here). Through TPTP, you *attach* to the process. When attached, you can use all the tools you've learned so far to peek in and observe memory allocation.

Attach to a local Java application

To attach to a local Java application:

1. Quit and delete all the running processes you may have in the Profiling Monitor view.
2. Open a command window and verify that your `PATH` and `JAVA_HOME` environment variables point to the JRE.
3. Make sure that your `LD_LIBRARY_PATH` includes the TPTP libraries. On the test system, those variables looked like this (your path names and directory names may differ, depending on your system configuration):

```
% printenv
.
PATH=/bin:/usr/bin:/usr/X11R6/bin:/home/\
mstreicher/java/jdk/bin
JAVA_HOME=/home/mstreicher/java/jdk
JAVA_DIR=/home/mstreicher/java
LD_LIBRARY_PATH=/home/mstreicher/java/tptpd/lib:
```

4. Make sure that your TPTP Agent Controller is running. Change to the directory that contains the Agent Controller, then stop and start the daemon:

```
% cd $JAVA_DIR/tptpd/bin
% ./RAStop.sh
RAServer stopped, pid = 3163
RAServer stopped, pid = 3164
.
RAServer stopped, pid = 18108
% ./RAStart.sh
Starting Agent Controller
RAServer started successfully
```

5. Run the toy factory application as a separate, stand-alone Java application:

   - Change to the workspace directory that contains the sample application, perhaps $HOME/workspace/Toy Maker. Within that directory, you should see a directory named **example**, which contains the code for SpaceShipToy.java and the associated .class files.
   - Add the current working directory, `.` ("dot"), to your `CLASSPATH`:

```
% cd $HOME/workspace/Toy Maker
% ls -F
example
% export CLASSPATH=.:$CLASSPATH
```

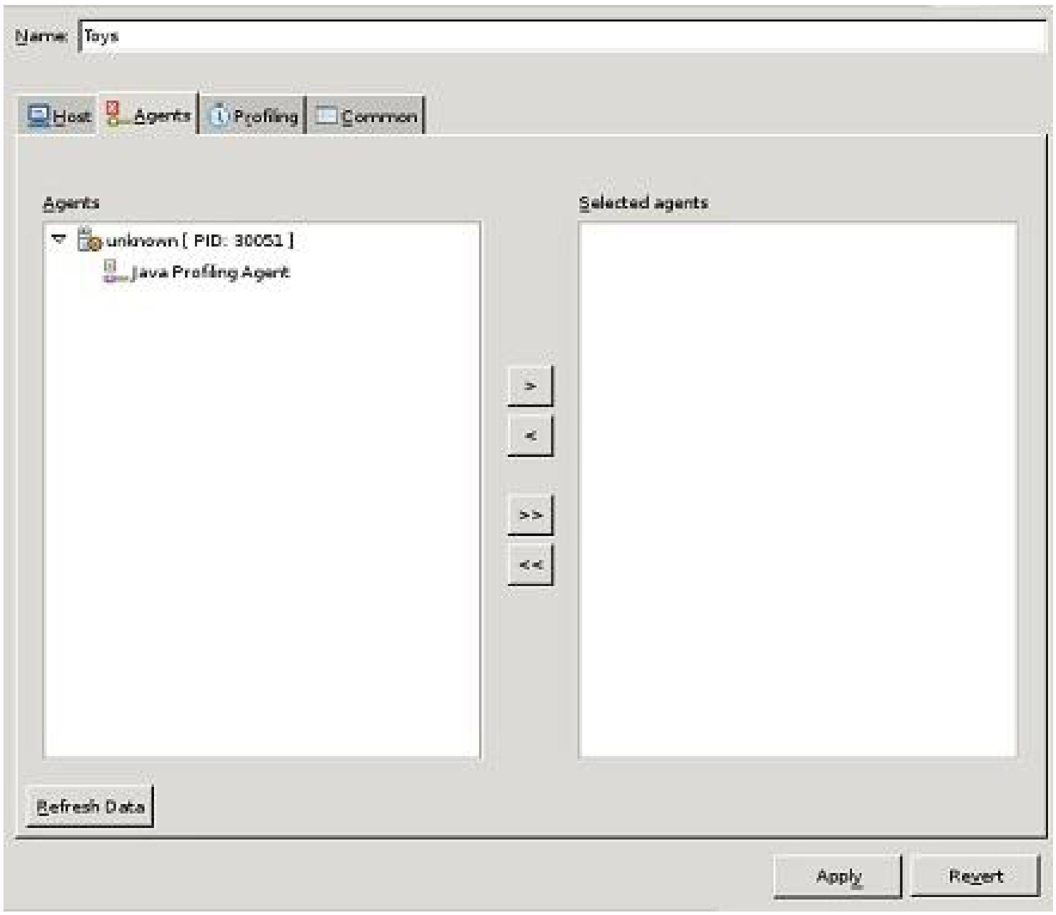
6. Launch the application through the TPTP Agent Controller with the `-XrunpiAgent:server=enabled` option. The `enabled` mode starts that Java application as normal and runs the controller in the background. (If you prefer to not execute the application until you attach to it, use the `controlled` mode.)

```
% java -XrunpiAgent:server=enabled example/SpaceShipToy
```

7. Return to Eclipse, then click the small arrow in the TPTP Profile button. Select **Profile...**. In the list on the left, double-click **Attach - Java Process**.

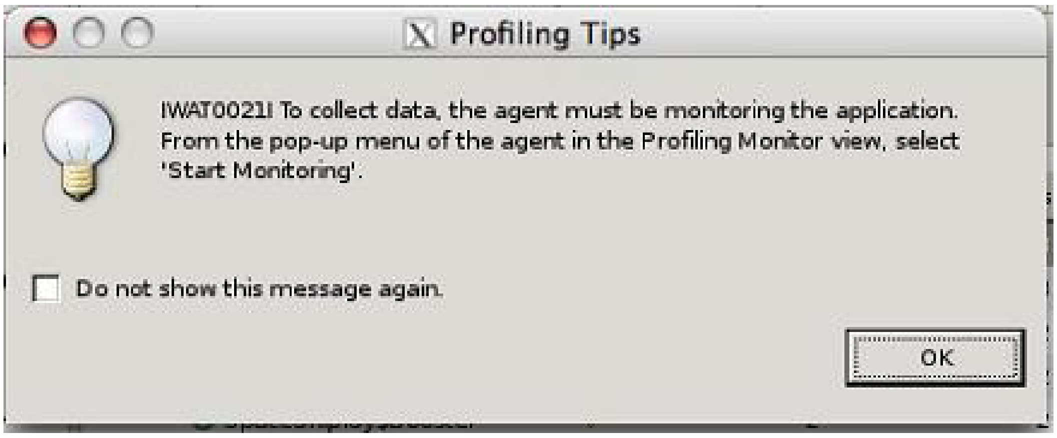
8. In the next window, type `Toys` in the **Name** field, then select **localhost** as the host. Click **Apply**.

9. Select an agent by clicking the Agents tab, which Figure 21 shows.
   Figure 21. Choosing an agent to attach to



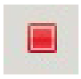
Click the agent displayed (there should be just one, at least for now, if no other application or process is actively being profiled), then click **>**. To save this change, click **Apply** again.

10. Select what data you would like to collect by clicking the Profiling tab and selecting a profiling set. You can choose **All**, the set you created earlier.
11. Click **Apply**, then **Profile**. Eclipse should switch to the Profiling and Logging perspective.
12. On most systems, you're then prompted with a window that looks like Figure 22.
    Figure 22. Profiling reminder


Profiling Tips

IWAT0021I To collect data, the agent must be monitoring the application. From the pop-up menu of the agent in the Profiling Monitor view, select 'Start Monitoring'.

This warning is normal and is provided to remind you that although you have attached to the process, you must always manually start monitoring. To start monitoring, right-click the newly launched profile process, and then select **Start monitoring**.

13. Switch back to the command window, and interact with the application. Return to Eclipse to explore the separate, running application. When you're finished, click the Terminate Process button (see Figure 23).
Figure 23. The Terminate Process button

The process will be killed in the command window:

```
% java -XrunpiAgent:server=enabled example/SpaceShipToy
.
Stage complete.
Start stage...
Stage complete.
Start stage...
Stage complete.
zsh: killed     java -XrunpiAgent:server=enabled example/SpaceShipToy
%
```

Section 10. Conclusion

This tutorial has demonstrated how you can refine and improve your Java application by profiling its code. Using the Eclipse TPTP, you can run your code and detect those segments that waste memory and ruin or slow performance. TPTP also offers other tools to comb through large log files and to automate and analyze test results.

Additional tools in the TPTP pipeline include a record-and-playback facility to test the GUIs of applications running under Eclipse and a special profiler called *XRay*, specially designed to profile applications derived from the Eclipse platform.

Resources

Learn

- Read Part 2 and Part 3 of this series for more information about the Eclipse Test & Performance Tools Platform.
- Learn more about the Eclipse Foundation and its many projects.
- Discover all the features of the Eclipse Test & Performance Tools Platform.
- Browse the extensive documentation, tutorials, presentations, and screen casts that further illuminate the Eclipse TPTP.
- Expand your Eclipse skills by visiting IBM developerWorks Eclipse project resources.
- Visit the developerWorks Open source zone for extensive how-to information, tools, and project updates to help you develop with open source technologies and use them with IBM's products.

Get products and technologies

- Visit Sun Microsystems to download the J2SE V1.4 SDK and the JRE.
- Download Eclipse, the open source, freely available, and extensible IDE.
- Download the Eclipse Test & Performance Tools Platform.
- The Eclipse TPTP depends on the EMF SDK V2.1 and the XSD SDK V2.1.
- If you want to visualize the behavior of your application as a UML2 diagram, download the UML2 plug-ins. If you're using Eclipse Version V3.1.1, download Version 1.1.1 of UML2 and unpack its archive file in the directory that contains Eclipse.
- Download the TPTP Agent Controller, a vital component if you want to profile your applications.
- Innovate your next open source development project with IBM trial software, available for download or on DVD.

Discuss

- Connect with Eclipse developers and other users in the Eclipse mailing lists and newsgroups. (You must register to read the newsgroups, but membership is free, and the registration process is easy.)
- Get involved in the developerWorks community by participating in developerWorks blogs.

About the author

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Martin Streicher is the Editor-in-Chief of *Linux Magazine*. He earned a master's degree in computer science from Purdue University and has been programming UNIX-like systems since 1982 in the Pascal, C, Perl, Java, and (most recently) Ruby programming languages.