Indepth™ for J2EE v8
Technical Brief

Solving Performance Problems
Using Indepth for J2EE SmarTune™

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Abstract

Companies have a growing challenge to keep their business-critical applications running at peak performance, and when they fail, potentially incur millions of dollars in losses. These complex applications often include a J2EE tier. J2EE applications are complex systems and addressing performance problems consumes an increasing amount of IT staff time. Symantec Indepth for J2EE v8, a component of Symantec i3 for Web Applications, has improved the industry toolset by providing SmarTune, an automated solution that increases the productivity of IT staff by pinpointing J2EE performance problems, identifying their cause, and providing advice about options available for their resolution.

The challenge of Application Performance Management

Organizations are more reliant on complex multi-tier applications than ever before in order to conduct commerce, work with vendors and partners, and to communicate. Yet, serious application problems occur daily in 15% of enterprises, and every week in 53% of enterprises\(^1\). With the continuing evolution to online commerce, there will be more problems occurring as well as more at stake for organizations.

At the core of the problem is growing application complexity. According to Forrester, “Many new applications are actually the revamping or front-ending of old applications using J2EE application servers, for example. The introduction of these technologies and the trends toward using service-oriented architecture and Web services increase the complexity of applications, as the dependency of enterprises on these applications is at least the same or increased.”\(^2\)

The cost of application performance problems and outages is significant, and drives the need for Performance Management tools. Areas of cost include lost sales, lost customers, lost user productivity and increased IT spend, along with less tangible impacts such as low user satisfaction, inability to support new business, the business’s poor perception of IT and the customer’s poor perception of the organization. For large enterprises doing much of their critical business online and in real-time, such as Financial Services, Telecommunications and Online retailing, the cost of application downtime can reach a million dollars per hour. Based on Symantec sponsored research which estimates that 24% of IT time is spent troubleshooting, just this payroll expense alone for the typical Global 2000 company, will equal $30 million annually.
Symantec Application Performance Management solution architecture

Symantec Application Performance Management (APM) is an integrated offering that reduces the costs of IT troubleshooting, lost revenues and lost end-user productivity. Symantec i3 is the core component of the Symantec APM solution, which uses a real-user based performance management approach. Symantec APM also includes Symantec Insight Inquire which takes a synthetic approach for 24x7 active availability monitoring for business critical web applications, along with Symantec Application Service Dashboard which integrates all your monitoring and business performance metrics into user-relevant, consolidated portals.

![Figure 1](image)

Symantec APM suite is a comprehensive application management solution ensuring the performance and availability of your most business-critical applications.

<table>
<thead>
<tr>
<th>Symantec Insight Inquire</th>
<th>Symantec i3 Performance Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>for Databases</strong> - i3 for SQL Server, i3 for Oracle, i3 for Sybase, i3 for DB2</td>
<td><strong>for Databases</strong> - i3 for SQL Server, i3 for Oracle, i3 for Sybase, i3 for DB2</td>
</tr>
<tr>
<td><strong>for Web Applications</strong> - i3 for .NET, i3 for J2EE, i3 for Web Servers</td>
<td><strong>for ERP and CRM</strong> - i3 for SAP, i3 for Oracle Applications, i3 for PeopleSoft, i3 for Siebel</td>
</tr>
</tbody>
</table>

Symantec Storage Extensions – EMC, Hitachi, IBM, HP
Symantec i³ for Web Applications

Symantec Indepth for J2EE is an underlying component of Symantec i³ for Web Applications. i³ for Web Applications is our comprehensive application performance management solution for Web 2.0 and Service Oriented Architecture (SOA) applications that helps you detect, communicate, and correct performance problems in an application before your business is affected. Symantec i³ for Web Applications addresses the need to optimize application performance during the development, testing, and production phases of the application lifecycle and can be shared by all stakeholders involved. Whether your Web application is running on Java™ Enterprise Edition (Java EE) application servers or Microsoft® .NET, i³ uses optimized collectors to gather performance and availability data. In addition, it provides visibility into interactions between Web clients and Web servers.

Key features and benefits of i³ for Web Applications

- Review current and historical performance data from Web clients, Web servers, Microsoft .NET, or Java EE
- Correlate activity across Web servers, multiple application servers, and databases
- Take advantage of SmarTune technology, which automatically drills down, analyzes, and provides expert advice
- Use flexible instrumentation to automatically discover and instrument application components to maximize visibility and minimize overhead
- Understand response time contributions from various application components:
  - .NET: ASP.NET, ADO.NET, Web services, XML, Windows Forms, .NET Remoting
  - Java EE: JavaServer Pages (JSP), Java Servlets, Java Database Connectivity (JDBC), Enterprise JavaBeans (EJB), Java Message Service (JMS), XML, Web services
- Correlate statistics from the Web server and the operating system
- Visually manage the health of Web applications by monitoring memory, CPU, threads
- Quickly isolate SQL statements generated by Web applications that are causing problems, and then continue performance analysis in the database using Symantec i³ for Databases and Storage
- Build a dashboard view specific to administrator role (Java EE, .NET, or Web admin)
- Get an executive view of application health via the dashboard
- Visually manage Service Level Agreement (SLA) compliance per instance, service request, or business transaction
• Monitor and measure Web services in SOA environments
• Help ensure that the presentation and business logic layers of the application are performing to service level expectations
• Isolate and focus on business-critical transactions

Figure 2
Symantec i³ for Web Applications includes Indepth for J2EE with its web-based GUI dashboard that quickly and efficiently communicates performance problems within your J2EE environment.

Benefits of SmarTune within Indepth for J2EE

Indepth for J2EE boosts productivity with respect to identifying and solving J2EE application performance problems. The SmarTune feature within Indepth for J2EE helps automate performance analysis and focuses tuning efforts on the most significant performance contributors.

Indepth for J2EE has been developed to minimize monitoring overhead to the point that it may be used effectively within QA or production environments. Indepth for J2EE collects and stores performance data that SmarTune uses to automatically identify the bottlenecks affecting user service requests, other threads, individual methods, or application server runtime efficiency.
Measuring and Managing Performance with Indepth for J2EE

IT Organizations face a daunting challenge in maintaining the peak performance of complex, multi-tier applications, and a key link is the middleware-tier Java application server. Application administrators need specialized data collection and analysis capabilities to make sure that new J2EE applications scale properly and meet service level expectations. The following sections portray a performance scenario along with a step-by-step, best-practice approach to identifying and addressing performance bottlenecks, using Indepth for J2EE.

Measuring a Baseline of Performance

A good approach for performance management starts with a plan that includes proactive performance testing of J2EE application software at one or more stages of development prior to deployment, as well as on-going performance monitoring and testing throughout the application life cycle. A typical plan includes staff and their roles, machine resources, application transactions to be measured, and on-going performance goals. An example of a performance goal is that the dynamic content for a specific online catalog transaction should complete loading in less than 500 milliseconds with 20 concurrent users.

A good rule of thumb is to use a load test tool to execute performance tests that drive the application with a consistent and repeatable load. The repeatable load allows transaction performance to be compared from one test to the next. The test transaction mix should be representative of typical user behavior, transaction types, frequency and concurrency. If you measure a transaction one day, and the application environment doesn’t change, then the performance should be similar the next day. Useful and currently free tools that you can use to accomplish this include: JMeter, an HTTP load test tool from the Apache project (http://jakarta.apache.org/jmeter/) and JUnit, a unit test development tool (http://junit.org) and its extensions like HttpUnit and DBUnit, that allow you to build repeatable test scenarios for application functionality.
Collecting Performance Data

Indepth for J2EE monitors the performance of J2EE applications using in-memory byte-code instrumentation and collects Java method invocation counts, response time, CPU time, Lock wait time, and SQL statements, in real-time. Additionally, Indepth for J2EE collects other useful data like Java object and Array memory leaks, URL parameters, Java method arguments, Heap memory usage and JMX statistics.

Indepth for J2EE correlates the monitored Java methods into method invocation tree structures where the tree branches are unique call paths to one or more methods. The invocation tree allows Java method performance to be analyzed for each unique call path.

Figure 3, below, is an illustration of three Java invocation trees, with the trees showing Java methods calling other Java methods. Each level of an invocation tree viewed from left to right allows the caller response time to be decomposed by more detailed calls.

The top-level methods shown on the left of Figure 3 (e.g. worker threads or HTTP service request invocations) are the entry points into the application and are the coarsest measurement of the user experience. These are shown as the root of their invocation tree. As you follow the invocation tree, the branches emanating from the top-level method lead you to the underlying methods that account for the application time.
A method located within an invocation tree accounts for all the time required to execute the methods that it directly or indirectly invokes, and in Figure 3 the methods on the left account for all the time to invoke the connected nodes on the right. The ends of the call paths are leaves of the invocation trees and are the smallest invocation detail available. A method may be invoked from many locations in the call tree. For example, a JDBC method `executeQuery` may be invoked from several call paths in the application and Indepth for J2EE will monitor each `executeQuery` invocation and collect data for each call in the path. The call paths are very valuable, for example, to identify relatively few methods that are responsible for the majority of application time. Fortunately, Indepth for J2EE SmarTune automates the call path analysis and finds every occurrence of the methods that are significant performance contributors. You can even set the minimum contribution threshold to ignore methods that contribute less than your desired target (3% by default).

Many Application Servers provide a huge amount of information about server configuration and runtime status using Java Management Extensions (JMX). JMX technology provides a standard mechanism for the application server to store management information in objects called Mbeans and allow it to be remotely accessible. The JMX statistics are collected by Indepth for J2EE, correlated to the current time frame, and persisted to the database. The statistics are very valuable to compare with other performance metrics of the application. SmarTune Application Summary will automatically analyze 40 JMX Statistics and provide critical feedback if your statistics cross targeted thresholds.

**Identifying Java Method Performance Contributors**

To analyze Java application performance we typically look at Java method Response Time and CPU Time, call counts, Memory leaks and heap statistics, and Application Server JMX Statistics. Response time is the time it takes to execute a Java method and is comprised of time executing local calls, or time spent waiting for calls to other tiers or locks. CPU time is the processing time needed to execute the method’s tasks and does not include time spent waiting. Lock time is wait time to enter a critical (synchronized) section of code or acquire an exclusive access lock on a Java object. Lock access time is displayed like a separate call to a Java method that has a call path and response time.
Analysis of the application call paths is useful to find significant performance contributors to specific methods but it hides more pervasive application-wide performance contributors. To identify application-wide contributors, SmarTune aggregates the total contributions of all similarly named methods, ignoring recursion in certain cases, and compares the method aggregates to the total application time to identify the overall contributions of many calls spread throughout the application.

For example, consider an application where there are 10 top-level service requests and 2% of each service request response time is spent in XML parsing. When looking at a single service request, the `parse()` method at 2% would not appear to be a significant performance contributor. However, when considered over all 10 service requests, the `parse()` time is 20% of the application’s time, so it deserves closer scrutiny.

Indepth for J2EE SmarTune automates analysis of specific paths as well as overall application contributors. In the SmarTune Contributors by Category page it categorizes the application methods as one of 22 Java technologies and displays context specific descriptions and tuning advice about each technology category.

**Identifying Application Server Performance Contributors**

The application server provides many resources to the application such as thread pools, JDBC and JCA connection pools, and JMS implementations, to name a few. The Java methods that access those resources may be significant performance contributors. For example, `getConnection()` obtains a connection from a JCA connection pool. Let’s say `getConnection()` response time is not near zero, it may indicate a problem with the available capacity of the connection pool. Furthermore, the SmarTune Application Summary page displays the available capacity of each pool and shows severe alerts next to those pools with low available capacity. SmarTune allows you to correlate the status of application server resources with Java method performance.
Java memory leaks may become a significant performance contributor. The Java Garbage Collector typically allows unreferenced objects (garbage) to accumulate before reclaiming the objects in an operation called Garbage Collection. An accumulation of referenced objects, that are no-longer used, may become a leak. Leaks will eventually cause the application to fail when new memory requirements can no longer be met. The Leak Seeker feature of Indepth for J2EE analyzes the top accumulations of referenced Java Objects, Collections, StringBuffers, and Array allocations and records their stack trace. You can analyze the accumulated size and allocation trend of leaked objects and determine if they present a problem. However, if the free heap is shrinking and leaks are increasing then it will likely become a catastrophic problem when the free heap is exhausted. The SmarTune Application Summary page analyzes the Max Free Heap trend and will display a red alert icon if the free heap falls below 10%.

Inefficient memory usage may become a significant performance contributor when many objects are created, and discarded, and the cycling causes the garbage collector to analyze the fragmented heap with increased frequency. When the garbage is collected it may be incremental or a major collection. Incremental garbage collection takes very little time but major garbage collections pause the JVM’s threads during the garbage collection process. Your application may benefit from tuning the JVM heap size or garbage collection parameters to collect incremental garbage more frequently rather than rely on long running major garbage collections. Your application may benefit by investigating caching strategies that generate less garbage by caching frequently used objects. The SmarTune Application Summary page analyzes the Garbage Collection Time and will display a red alert icon if the total Garbage Collection Time is over 1%.

SmarTune automates analysis of application server resource statistics from today’s leading Application servers. The statistics are compared against recommended values and the analysis results are displayed with application server-specific tuning advice, as well as a red alert icon if the recommended threshold is exceeded.
Uncovering Method Details with Instrumentation Explorer and Adaptive Instrumentation

Indepth for J2EE instruments a default set of well-known method APIs in order to limit overhead incurred. The default methods typically allow a good view of performance details. In most cases, when the instrumented APIs show significant work time, an application has been constructed with user-defined code called from the instrumented APIs. When code is called that is not instrumented, its time is displayed as Work Time. SmarTune then automatically finds and displays the methods with significant work time in the Application Methods category of the Contributor by Category page. This custom code can then be instrumented to uncover the performance details of the work time. Indepth for J2EE contains two tools to discover and instrument more method details: Instrumentation Explorer and Adaptive Instrumentation.

Instrumentation Explorer may be used to instrument additional methods that are not part of the default set of instrumented APIs. If you locate a method with work time you may open Instrumentation Explorer to investigate and instrument that method’s calls. Instrumentation Explorer allows you to investigate all method’s calls and compare their response time and invocation counts. You can select additional calls to instrument, click Apply, and the instrumentation will be enabled and persisted for those calls that you selected.

Adaptive Instrumentation automates the Instrumentation Explorer’s manual processes by traversing the instrumentation call paths and automatically instrumenting all methods and calls with significant performance contributions. Adaptive Instrumentation requires you to execute application activity during a data collection period (i.e. running a load test on your application) while it measures the significant call paths. Then it uses sophisticated rules to instrument additional application entry methods and long response time paths, and removes instrumentation that exceeds the overhead budget. You select a response time overhead budget and data collection duration and Adaptive Instrumentation tracks as many methods as possible to stay within the overhead budget.
Making Sense of Performance Measurement Details

Indepth for J2EE has “workspaces” that allow you to select metrics to analyze. The metrics can include invocation frequency, time, availability, memory and JMX metrics.

The traditional examination of just selecting and monitoring a few performance indicators is no longer sufficient for modern complex application performance management. For example, ‘average response time’ is a metric that is often tracked, with the definition being the total method response time divided by the number of invocations. Though interesting, just looking at this one stat can hide the fact that short running methods may be called too often or that a few methods are taking a relatively long time to run (i.e. skewed distribution).

SmarTune focuses on Java method total time contributions. Total response time is the average time multiplied by the invocation frequency and includes two metrics, the response time and the number of invocations. The benefit of this more data-rich approach is that total response time and CPU time allows us to compare the total time for many short calls and fewer longer calls.

![Example method invocation tree with execution times (T).](image)
The invocation tree in the previous diagram, Figure 4, displays total response time metrics (T). Invocation trees are used to pinpoint the largest performance contributor to Servlet A, such as in this example. We can see 80% of Servlet A’s response time is inside the call to JSP C whose largest contributor is the call to XML F at 40% (actually two calls made to F). A cursory reading would put Servlet A’s largest contributor as JSP C, but actually C itself only contributes 10% of the work time to A. Most of the time comprised within C’s time is the result of call F. We have to be careful not to count F twice because total response time cannot be summed along the call path or else it becomes double counted. In order to automate this analysis, a lot of operations must occur to find the largest performance contributor.

<table>
<thead>
<tr>
<th>Contributors to Servlet A</th>
<th>Work Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>XML F (call 2)</td>
<td>300 ms</td>
</tr>
<tr>
<td>XML F (call 1)</td>
<td>100 ms</td>
</tr>
<tr>
<td>JDBC H</td>
<td>200 ms</td>
</tr>
<tr>
<td>Servlet A</td>
<td>100 ms</td>
</tr>
<tr>
<td>JSP C</td>
<td>100 ms</td>
</tr>
<tr>
<td>EJB G</td>
<td>100 ms</td>
</tr>
<tr>
<td>Custom D</td>
<td>50 ms</td>
</tr>
<tr>
<td>XML E</td>
<td>50 ms</td>
</tr>
<tr>
<td>JSP B</td>
<td>0 ms</td>
</tr>
<tr>
<td>TOTAL Time</td>
<td>1000 ms</td>
</tr>
</tbody>
</table>

Another way to make sense of performance measurement is to consider Work Time. Work time is the time unaccounted for by instrumentation and is derived by subtracting from a given method call, the execution time or times of the adjoining method call(s) further along that branch. The work time of the methods in Figure 4 are shown in Table 1. By calculating the total work time for each method, and sorting the values in descending order, we can see the call to XML F is at the top of Table 1 and the most significant contributor to Servlet A performance. This contribution is calculated as 40%, or (XML F 400ms) / (Servlet A 1000ms). Work time can be summed along the call path without regard to double counting. Notice the total of 1000 ms in Table 1 is the same as the Servlet A time in Figure 4.
Figures 3 and 5, which show invocation trees, are color coded. By incorporating the dimensions of performance time contribution as we just reviewed, these colors can be used to represent the percentages of the total application time. In this case, the red nodes contribute over 15% to the application, yellow nodes over 7.5%, green nodes over 1% and grey just over 0.9%. The effect enables an easy-to-comprehend visualization of method time contribution as the call paths progress from left to right. There is a key advantage to the work time approach, however.

Figure 5 shows the same application as Figure 3, but Figure 5 displays Work time percentages and indicates the highest response work time contributors to the application in red (i.e. as a root and leaf on the tree). This visualization similarly applies to the contributions of XML F in Figure 4 where F would be displayed as a red node on the right side of Servlet A’s invocation tree. The Work Time analysis, however, leads us directly to the significant consumers and avoids invocation complexities of the data inherent to using response time.

SmarTune allows you to easily select Response Time, Response Work Time, CPU time, or CPU Work Time to give the user flexibility in targeting and analyzing performance contributors.
Automated Analysis of Performance Contributors by Technology Category

The SmarTune Workspace default view is the Contributors by Category page, shown in Figure 6, below. This view automatically analyzes all the method invocations for the current context and for the selected time frame. Each monitored method is compared to a list of Java technologies and categorized by the technology matching the method’s name, class, and package as well as the JVM vendor. This categorization allows SmarTune to customize the display for specific methods while saving the user from the arduous task of mentally categorizing the methods. This page is very useful for analyzing a new application because the automatic categorization lets you quickly see the types of technology used by the application. If there are no matches for a category, the page displays “no contributors found”. This page displays only the categories that contribute more than the minimum contribution percentage in order to remove noise, and keep the focus on just the significant contributors. In the case of the output shown in Figure 6, the % Response Time contribution threshold is set to 3%.

Analyzed categories include: JDBC Connection Pool, SQL, JDBC, EJB, JNDI, HTTP Sessions, XML, JMS, Java Transactions, Java IO, Web Services, Synchronized/Lock, and custom code Application methods. Additionally, there are vendor-specific EJB lifecycle categories for WebLogic, WebSphere and Oracle application servers.

![Figure 6](image_url)  
Example of Contributors by Category page, showing significant Response Time contributors.
In Figure 6, on the previous page, the technology categories are listed by their total percentage contribution to performance and individual matched methods are listed by their contributions. The top entry shows that 33 JDBC Connection Pool contributors are responsible for 44.5% of the response time. We can see other significant contributors such as EJB, JNDI, and custom application methods work time. Without knowing much about the application we can easily see that JDBC Pool access is a large contributor. If we select the longest method, indicated by the hyperlink `com.ibm.eis.cm.JDBC1PhaseRF.getConnection()`, a more detailed page is then displayed, `Contributor by Category Details`, as shown in Figure 7 below.

The Contributor by Category Details page identifies the selected contributor and its technology details. In this illustrated case, the identified performance problem is that the DB Connection Pool is too small and this Contributor description is followed by related expert advice on improving application performance. The advice itself describes the technology and issue in detail, along with prescribed tuning activities. In this case the advice states that `getConnection()` time should be zero and if it is not zero then the application is waiting to get a database connection. If the concurrent load in the system causes more connections to be requested than the pool contains, then the application will wait for an idle connection, resulting in the performance problem.
Another useful aspect of the Contributor by Category Details page, shown in Figure 7 on the previous page, is that we can easily compare the calls and identify the top invocations using the graphic display on the top right-hand side of the page. The graph plots the performance of the top `getConnection()` contributors over time. In this example we can see that the top `getConnection()` call, which contributes 9.71 % to the application time, has markedly increased response time over the latter portion of the time range. This behavior may be a result of the advice provided, that the call is sensitive to concurrent load with regard to the small pool size, and that perhaps given the execution load, this method is allocating more connections than its similar peer invocations.

To get a further detailed view of this performance data, we can click the top `getConnection()` hyperlink, in order to see the Contributor by Category Location page, shown below in Figure 8.

![Figure 8](image.png)

**Figure 8**
Contributor by Category Location page, depicting Call Path average response time.
The Contributor by Category Location page displays the instrumented call path of the selected contributor. We previously learned that `getConnection()` is the longest total contributor at 9.71% of the application time. Now looking at this report, shown in Figure 8 on the previous page, we get the view “down the path” to the contributing callers. In this case, the graph on the top-right quickly shows that the largest contributor is an application specific method `product_jsp`. It’s also spelled out within the text, showing an average response time of 724.66 milliseconds. The remainder of the path is infrastructure. The description and advice confirm the connection pool is too small with respect to concurrent load and for comparison, the Concurrent Active Threads (CATs) page in the Activity workspace shows a large increase in concurrent load, Figure 9 below, correlating exactly with the increase in `getConnection()` response time.

The Activity charts in Figure 9 above confirm that the HTTP Response time increases as the Concurrent Active Threads (i.e. user request load) shown in the middle, increase. Throughput, the chart on the far right, is constant as more work arrives, so it appears response time increases only as load increases.

Now let’s switch to the DB Pool status reports found with the Indepth for J2EE Statistics Workspace, shown on the next page, in Figure 10. In this view, we see, on the left side, that the DB Pool is maxed for the same period that has long response times. And on the right-hand chart, the Pool Size is 3. In figure 9, we learned the Concurrent Load is 8 threads, so if `product_jsp` used 1 connection per user, then 5 threads may wait for a connection. In this case, following the advice to increase the Pool Size to 8 will allow more connections to service the load, and thus solves our problem.
Figure 10
DB Connection pool percent used and pool size.

The connection pool size may be easily changed by an operator without involving the development team.

Our findings also point to a programmatic solution to the problem. The Contributor by Category Location report, shown back in Figure 8, displayed `getConnection()` executions at 7,828 and `_product_jsp` executions at 523. You can derive that about 15 (7,828 ÷ 523) connections are used by each `_product_jsp` execution. So another solution is that the application developers could cache results or in some way improve the efficiency of database usage, in order to save the need for so many database connections to be allocated to the pool.

This scenario illustrated how SmarTune and its technology-specific categories are a valuable guide to solving performance problems. SmarTune categorization portrays complex data in a simple, yet effective way. It provides insight into significant method usage, and the related description and advice provides guidance on what to next. You may add SmarTune Contributors by Category results as a portlet in the Dashboard Workspace to help as a lookout for performance problems.
Graphically Identifying Impacts of Performance

The Method Call Graph view of the SmarTune Workspace allows us to visualize the invocation performance metrics as a color coded hierarchical graph. In essence, this is a heat matrix for application call paths. This view makes it easier to communicate about the instrumented application and the impacts of performance, because it analyzes all the significant method invocations for the current context within a selected time frame. The call graph, shown in Figure 11 below, is a response time graph for the same period analyzed in our just-completed performance scenario. By default, the red colored nodes contribute over 15% to the application, yellow nodes over 7.5%, and green nodes over 1% and grey over 0.9% (these percentages are adjustable in the Settings page). The methods whose percentage does not meet the grey setting threshold are hidden from view, with the exception being work time graphs where the call path to significant nodes may be all gray.

In figure 11, the large Focus View panel on the left allows you to see a full size area of the graph and displays method names and contribution statistics. The nodes are methods and the edges are invocation relationships between the methods. The Response time graph shows the percentage contribution of each call in the application along the lines.
The Work Time graph, Figure 12 below, displays the percentage of work time found in each method by annotating the nodes. You can pan the Focus View or click the Full View to move the focus. Clicking a node in the Focus View shows the Method Details, and you can search for methods in the graph using the Find panel on the bottom right.

This work time graph example identifies the top contributing method work time as the yellow filled `getConnection()` method, contributing 9%. The graph makes it easy to visually identify the same significant node as we discovered in the Contributors by Category page earlier in the paper. The Find tool sorts the nodes either by their measurement or name. In this case, the measurement values are sorted, with `getConnection()` shown at the top.
Advanced Analysis of Performance Using Packages and Methods Names

The SmarTune Workspace Method Hotspots view, shown below in Figure 13, is designed for users who wish to see all the methods executed in their application for the current context within a selected time frame. It displays the methods names and a variety of measurements.

![Image of Method HotSpots page]

You can see the getConnection() method has the top work time, with its low CPU Bound % measurement indicating it is mostly waiting and not executing. When you select the methods in the Method Hotspots page, you can drill down to the Contributor Details and Location pages discussed in the previous sections.

The column headers in this page may be clicked to sort the methods by that metric. This example shows results by Response Work Time %. Available HotSpot measurements are shown below.

<table>
<thead>
<tr>
<th>Method HotSpots measurements</th>
<th>Work Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total time %</td>
<td>Response Time, Response Work Time, CPU Time, and CPU Work Time</td>
</tr>
<tr>
<td>Total invocation count</td>
<td>Accumulated total number of invocations of this method for all call paths</td>
</tr>
<tr>
<td>Average response time</td>
<td>Mean response time for each invocation</td>
</tr>
<tr>
<td>Average CPU time</td>
<td>Mean CPU time for each invocation</td>
</tr>
<tr>
<td>CPU Bound %</td>
<td>Percentage of response time spent running on the CPU; higher number indicates more processing time and less wait time</td>
</tr>
<tr>
<td>Number of invocation contexts</td>
<td>Number of unique call paths of the invocation</td>
</tr>
</tbody>
</table>
Performance Contribution Categories of the Application Server

The SmarTune Workspace Application Summary View is the page designed to pinpoint Application Server resource constraints. The Application Summary page intelligently analyzes Concurrent Load, Memory and Garbage Collection time for all application servers. Depending on the application server version, there are additional pre-built categories for version specific JMX statistics. A sample of the WebLogic 9.1 metrics is shown in Figure 14.

![Figure 14 Example Application Summary page for WebLogic 9.1](image)

The Application Summary categories are listed with the most severe performance-impacting findings reported at the top of the page with red icons. A “severe” finding is one where the analyzed metric is out of range, which is to say the value is greater or less than the built-in recommended threshold value. Category statistics that are within the recommended range are listed with a green checkmark icon. Categories where the statistics are not collected are listed as “status unknown” in blue. In our severe example above, the report is showing that the percentage of Idle Threads in the `weblogic.socket.Muxer ExecuteQueue` is below 20% of the capacity (i.e. it is depleted to zero). Clicking the `ExecuteQueue Idle Threads Shortage` hyperlink allows us to see more technology specific details about the observation, shown in Application Summary Details on the following page.
The Application Summary Details page provides analytical information related to an Application Summary category. In Figure 15 below, the observation compares a recommended value, in this case 20%, to the percentage of idle threads in the pool. The graph on the right shows the metric values over time, plotting the total count of threads (blue line) at 2 and the current idle count (green line) at 0. Hypothetically, if the current idle count was 1 and the total count of threads is 2 then the percent idle threads would be 50% and this category would not be listed as a problem.

The Execute Thread capacity used or idle threads categories are very similar to the DB and JCA Connection Pool categories and both are available for most application servers. In general, most categories either compare a single statistic against a recommended value (e.g. some statistic greater than zero) or allow the comparison of a capacity value (e.g. capacity used greater than 80%). The default recommended values are general rules of thumb and can be reconfigured if desired for some implementations. The pre-built categories included by default are listed in Table 3, below.

Table 3  Application Summary Categories by Application Server version

<table>
<thead>
<tr>
<th>Application Summary Categories For All Servers</th>
<th>Application Summary WITH LOGIC: 9.0 Categories</th>
<th>Application Summary SAP 6.4 Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Fail Memory</td>
<td>Database Connection Availability</td>
<td>Application Thread Pool Availability</td>
</tr>
<tr>
<td>Peak Used Memory</td>
<td>Working For Database Connection</td>
<td>Application Thread Pool Waiting Tasks</td>
</tr>
<tr>
<td>Current Active Threads</td>
<td>Maximum Database Connections Pending</td>
<td>System Thread Pool Availability</td>
</tr>
<tr>
<td></td>
<td>Linked Database Connections</td>
<td>Managed Connection Pool Availability</td>
</tr>
<tr>
<td>Application Summary WEBSPHERE 5.0 Categories</td>
<td>Application Summary WITH LOGIC 9.1 Categories</td>
<td>Application Summary ORACLE 10.2 Categories</td>
</tr>
<tr>
<td>Database Connection Pool Maximum Connections In Use</td>
<td>Database Connection Availability</td>
<td>JDBC Connection Leaks</td>
</tr>
<tr>
<td></td>
<td>Working For Database Connection</td>
<td></td>
</tr>
<tr>
<td>Application Summary WEBSPHERE 5.1 Categories</td>
<td>Application Summary WITH LOGIC 9.1 Categories</td>
<td>Application Summary ORACLE 10.3 Categories</td>
</tr>
<tr>
<td>Thread Pool Maximum Threads In Use</td>
<td>Database Connection Availability</td>
<td>JCA Connections Leaks</td>
</tr>
<tr>
<td></td>
<td>Linked Database Connections</td>
<td></td>
</tr>
<tr>
<td>Application Summary WEBSPHERE 6.0 Categories</td>
<td>Application Summary WITH LOGIC 9.2 Categories</td>
<td>Application Summary WEBLOGIC 9.1 Categories</td>
</tr>
<tr>
<td>Thread Pool Maximum Threads In Use</td>
<td>Database Connection Availability</td>
<td>ExecuteQueue Idle Threads Shortage</td>
</tr>
<tr>
<td></td>
<td>Linked Database Connections</td>
<td></td>
</tr>
<tr>
<td>Application Summary WEBSPHERE 6.1 Categories</td>
<td>Application Summary WITH LOGIC 9.2 Categories</td>
<td></td>
</tr>
<tr>
<td>Thread Pool Maximum Connections In Use</td>
<td>Working For Database Connection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Linked Database Connections</td>
<td></td>
</tr>
<tr>
<td>Application Summary WEBSPHERE 6.0 Categories</td>
<td>Application Summary WITH LOGIC 9.2 Categories</td>
<td></td>
</tr>
<tr>
<td>Thread Pool Maximum Connections In Use</td>
<td>Database Connection Pool Maximum Connections In Use</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Linked Database Connections</td>
<td></td>
</tr>
</tbody>
</table>
Some categories are specialized. For example, the Garbage Collection time category computes the time spent collecting garbage and compares it to the elapsed time displayed. If Garbage Collections blocks the application more than 1% (default setting) of the elapsed time, then the Garbage Collection may be a severe problem. Figure 16 below, shows Garbage Collection details for an application with over 4% of its time spent collecting garbage.

![Image of Garbage Collection Details](image1)

**Figure 16**
Example Application Summary Details page for excessive Garbage Collection time

The Concurrent Active Threads category computes a trend line of the concurrent active threads count and compares the slope of the trend with a recommended slope of 0.1. If the load is flat or decreasing, then the severity is green, yet if the trend begins increasing by over 10%, the category will be denoted as a potentially severe problem. Figure 17 below shows the Concurrent Active Threads category details for the application scenario described in the previous Contributors By Category section of our performance scenario.

![Image of Concurrent Active Threads](image2)

**Figure 17**
Example Application Summary Details page for Concurrent Active Threads Increasing
Customizing SmarTune displays

The Indepth for J2EE user can add the SmarTune Application Summary results as a portlet in the Dashboard Workspace to help as a lookout for performance problems. You can also extend the Application Summary analysis by adding your own categories for other JMX statistics that interest you and by doing so allow the Application Summary analysis to become an indispensable part of your performance monitoring plan of action.

The SmarTune Workspace Contributors By Category and Application Summary pages allow you to add new categories to the analysis or customize the existing categories. The SmarTune settings page allows both pages' categories to be enabled or disabled as needed.

You may create custom statistics categories for the Application Summary page that specify: the server vendor and version, the JMX statistics to compare and display in the chart, the comparison operation (i.e. greater than or less than), as well as the recommended operation result. When the observed result fails to meet the recommendation, a red severity is displayed, otherwise it will show as green. The description and advice are completely customizable and accept Unicode characters for non-English locales. Advice can be highly customized to include such things as phone numbers and contact information.

The SmarTune settings page allows the minimum contribution percentage to be changed. Changing this threshold setting will expand or contract the number of methods displayed in the Contributors by Category page. The Method Call Graph percentages used to determine node colors may be customized to assist for easy identification of significant method contributors.
Iterative Analysis for Evolving Applications

The SmarTune Workspace provides a set of tools to analyze Java method and Application Server contributors. SmarTune is typically used either in a regression testing approach to compare performance of revisions of application code, or as an iterative troubleshooting tool to identify problematic application configurations.

To assist with regression analysis, you may label a time range with a descriptive name and save it to be loaded and referenced as needed for comparison with other time frames or against current performance. Regression analysis involves running a consistent and repeatable load against the application so you can compare the code performance consistently across revisions.

In troubleshooting mode, the easiest place to start is the Contributors By Category page and look for significant contributors during the time frame. Iterate though the list of categories and investigate the largest contributors first, so you spend your time focusing on the contributors with the largest performance impact. Visually correlate Statistics and Activity information to investigate complex scenarios to identify multiple factors involving concurrent load, memory usage, and application configuration statistics. Often, long running Java methods are identified that the application developers may not have anticipated taking so long. In many cases, performance problems occur because of simple configuration issues and doing something like increasing a pool size or available memory can have immediate and quantifiable results.
Infrastructure checklist

Indepth for J2EE manages the performance of the following Application servers, on the following operating system platforms:

**Application Servers**
- BEA WebLogic
- IBM WebSphere
- Oracle 9iAS, 10gAS
- JBoss
- Tomcat
- Macromedia JRun
- Sun iPlanet
- Sun Java Enterprise System (JES)
- ATG Dynamo
- Resin
- JEUS

**Operating Systems**
- Microsoft Windows
- Sun Solaris
- IBM AIX
- HP-UX
- Linux on Intel-based systems
Summary

J2EE represents a complex environment often found within business-critical, multi-tier applications. Symantec Indepth for J2EE v8 with SmarTune provides a valuable set of tools for IT staff to analyze Java method and Application Server performance contributors, in order to keep the J2EE tier up-and-running at peak performance. Indepth for J2EE isolates the root cause of performance problems in minutes rather than days or weeks, and SmarTune automates analysis that allows both Java gurus and non-developers to manage application performance by analyzing contributions of common Java technologies, custom code, and application server configurations.

Footnotes:

About the authors

Tim Isenhart is a Senior Principle Software Engineer at Symantec and one of the founders of the Indepth for J2EE software engineering team. He has gathered 15 years of performance monitoring and analysis experience and lives in Colorado.

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This document would not be possible without the technical review contributions provided by Steve Burton and Stan Gonsalves. Thank you!

Where to get more information

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