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Oracle Database 11g Release 2: Manageability and Real Application Testing Overview

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Introduction

Oracle Database is the market-leader and preferred database for hundreds of thousands of businesses as well as application developers and database administrators worldwide. Over the years, enterprises have come to rely on the Oracle Database to provide unparalleled performance and reliability. In Oracle Database 10g, Oracle delivered a self-managing database with breakthrough manageability that dramatically increased IT productivity and reduced management costs.

Oracle is ready to raise the bar once again with the release of Oracle Database 11g. Designed for data center environments that are rapidly evolving and changing to keep up with the demands of the business, Oracle Database 11g allows organizations to adopt new technologies quickly while minimizing risk. In addition, building on its industry-leading self-managing capabilities, Oracle Database 11g has made significant advances in the areas of manageability and fault diagnostics that address many of the top challenges facing businesses today.

Manageability Challenges

Three areas that continue to pose the biggest management challenges to database administrators include;

- Performance: How to maintain production databases at their peak performance to maintain committed service levels.
- Managing change: How to reduce the risk of rolling out changes, such as new technology innovations as well as routine changes, in Oracle database environments at lower costs.
- Ongoing administration: How to automate the day-to-day repetitive tasks so that labor can be freed up to focus on more strategic requirements, such as security and high availability.

To address these challenges, Oracle Database 11g has made significant advances in performance, change assurance and self-management to make Oracle Database 11g easier to manage than ever before.

Performance Management

Performance management has traditionally been a major challenge for database administrators. With the self-managing database, Oracle Database 11g, managing database performance is easier than ever. Oracle Database 11g continues to expand its self-managing capabilities in all areas, including the two main areas of database performance management: performance diagnostics and application tuning.

Performance Diagnostics

The steps to achieve good performance are to gather the right data, make a proper analysis and to then derive an effective action plan.

The Oracle Database 11g self management framework performs these tasks for the DBA, making performance diagnostics simple and routine. The Automatic Workload Repository gathers the required data and the Automatic Database Diagnostics Monitor analyzes the data and makes targeted, concrete and actionable recommendations. Let us look at them in more detail.

Automatic Workload Repository

The Automatic Workload Repository (AWR) is a built-in repository within every Oracle Database 11g database that contains operational statistics about that particular database and other such information. At regular intervals, the Oracle Database 11g makes a snapshot of all its vital statistics and workload information and stores them in AWR. By default, the snapshots are made every 60 minutes and are stored in the AWR for an 8 day period after which they are automatically purged. The administrator can easily change these defaults. AWR is designed to be lightweight and manage itself completely in order to ensure that it does not impose any additional management burden on administrators.

The data captured allows both system level and user level analysis to be performed, again reducing the requirement to repeat the workload in order to diagnose problems. Optimizations have been performed to ensure that the capture of data is performed efficiently to minimize overhead.

AWR forms the foundation for all self-management functionality of Oracle Database 11g. It is the source of information that gives the Oracle Database 11g an historical perspective on how it is being used and enables it to make decisions, which are accurate and specifically tailored for the environment that system is operating in.

Automatic Database Diagnostics Monitor

Building upon the data captured in AWR, Oracle Database 11g includes a self-diagnostic engine called the Automatic Database Diagnostic Monitor (ADDM). ADDM makes it possible for the Oracle Database 11g to diagnose its own performance and determine how any identified

problems could be resolved. ADDM runs automatically after each AWR statistics capture and makes the performance diagnostic data available immediately.

ADDM examines data captured in AWR and performs analysis to determine the major issues on the system on a proactive basis, recommends solutions and quantifies expected benefits. ADDM takes a holistic approach to the performance of the system, using time as a common currency between components. The goal of ADDM is to identify those areas of the system that are consuming the most 'DB time'. ADDM drills down to identify the root cause of problems rather than just the symptoms and reports the impact that the problem is having on the system overall. If a recommendation is made it reports the benefits that can be expected, again in terms of time.

The use of time throughout allows the impact of several problems or recommendations to be compared. Previously many problems have been identified based on value judgments and experience rather than quantifiable impacts. A good example of this is a system that is experiencing a high logon rate. A rule of thumb might have said that a logon rate of greater than 10 per seconds was a problem and should be fixed. However many systems can run significantly higher logon rates without it noticeably affecting performance. Using the time distribution data in AWR, ADDM can report quantitatively that logons are taking 20% of time spent in the database. This quantified value can make it much easier to convince whoever needs to do the work to fix the problem or arrange for it to be fixed, rather than just making a statement such as 'I think that you are doing too many logons'.

ADDM starts its analysis by focusing on the activities that the database is spending most time on and then drills down through a sophisticated problem classification tree. The problem classification tree used by ADDM encapsulates decades of performance tuning experience in the Server Technologies Performance Group at Oracle and other performance experts.

In developing the classification tree, the prime intent was to handle the most frequently seen problems and to drill down to the root causes of problems rather than just reporting symptoms. Some of the common problems detected by ADDM include:

- CPU bottlenecks
- Poor connection management
- Excessive parsing
- Lock contention
- IO capacity
- Under sizing of Oracle memory structures e.g. PGA, buffer cache, log buffer
- High load SQL statements
- High PL/SQL and Java time
- High checkpoint load and cause e.g., small log files

- RAC specific issues

Besides reporting the potential performance issues, ADDM also documents the non-problem areas of the system. The sub-components, such as IO, memory, etc, that are not significantly impacting the performance of the system are pruned from the classification tree at an early stage and are listed so that the DBA can quickly see that there is little to be gained by performing actions in those areas. Again this saves time and wasted effort (both human and hardware) fixing things that will not impact the system performance overall.

Oracle Database 11g extends ADDM by greatly enhancing cluster-wide performance analysis for Real Application Clusters (RAC) databases. For RAC environments ADDM analyses the RAC cluster and reports on issues that are affecting the entire database as well as its individual instances. DBAs can now use ADDM to perform database-wide analysis of global resources, such as high-load SQL, global cache interconnect traffic, network latency issues, skew in instance response times, and I/O capacity.

The Oracle Database was the first database product to introduce such a revolutionary self-diagnostic capability and has completely redefined the database administration landscape. Administrators no longer need to first collect huge volume of diagnostic data and spend endless hours analyzing them in order to find out answers to performance issues. With the Oracle Database 11g, they can simply ask the database what are the performance issues and ADDM does the rest. They can sit back, relax, follow the recommendation made by ADDM using just a few mouse clicks and forget about the rest.

AWR Baselines and Adaptive Thresholds

The usefulness and value of AWR continues to expand in Oracle Database 11g. Newly introduced AWR Baselines allow DBAs to capture and save system performance data over time periods with interesting or representative workloads.

The AWR Compare Periods report is provided to easily make comparisons of problem time periods against saved Baselines to identify potential sources of performance deviations. In addition to performance metrics, the report also captures the configuration information, such as the total memory, and number of CPUs, which can identify external sources of problems that may have caused the reduction in performance. In case there were out-of-band changes made to critical parameters, such as COMPATIBLE, which may affect SQL performance, the report also captures database system information, such as the initialization parameters.

In addition, Baselines can also be used in setting alert thresholds on system performance metrics. Most metrics can be viewed in Oracle Enterprise Manager against statistical aggregates of those same metrics observed over the Baseline period. This helps users set Baseline-informed thresholds rather than selecting thresholds without the context of actual data. In addition, Adaptive Thresholds are available for certain key performance metrics. Adaptive Thresholds are

performance alert thresholds that are automatically set and periodically adjusted by the system using the System Moving Window Baseline data as the basis for threshold determination. For customers who want to get started with Adaptive Thresholds immediately, the new “Quick Configure” option can setup a starter kit of thresholds based on common workload profiles using a few mouse clicks.

AWR baselines provide powerful capabilities for defining dynamic and future baselines and considerably simplify the process of creating and managing performance data for comparison purposes.

Application Tuning

Application design issues are the most predominant cause of performance problems. All the tuning wisdom of developers, DBAs and system administrators cannot make up for the slowdown caused by architectural and design deficiencies of the application. One important part of database system performance tuning is, therefore, the tuning of SQL statements.

Since the query optimizer takes crucial decisions which have a tremendous impact on the performance of a query such as, whether to use an index or not, which join techniques to use if the query involves joining multiple tables, etc., Oracle has invested considerable development effort in making the Cost Based Optimizer the industry's most sophisticated, mature, and thoroughly-tested query optimizer. The cost-based optimizer is also used extensively by the major packaged applications such as Oracle eBusiness Suite, SAP, PeopleSoft, etc. Since the Oracle database is the platform for the vast majority of customers using these applications, this demonstrates the success of the Oracle optimizer in a huge number of real application settings. Consequently, starting with Oracle Database 10g, the Rule Based Optimizer (RBO) is no longer available and the cost-based optimizer is the only supported optimizer mode.

While the Oracle Database provides best possible query optimization technology, which maximizes the application/query performance without any administrator intervention in majority of the cases, there may still be a few cases where the nature of the application or uniqueness of data distribution may cause certain SQL statements to consume unusually high percentage of total system resources. In such situation, the SQL tuning process involves three basic steps:

- Identify high load or top SQL statements that are responsible for a large share of the application workload and system resources, by looking at the past SQL execution history available in the system (e.g., the cursor cache statistics stored in the V\$SQL dynamic view),
- Verify that the execution plans produced by the query optimizer for these statements perform reasonably well,

- Take possible corrective actions to generate better execution plans for poorly performing SQL statements.

The three steps are repeated until the system performance reaches a satisfactory level or no more statements can be tuned. Besides being extremely time consuming, the SQL tuning process outlined above also requires a high degree of expertise. Only a person with a deep knowledge of the application and database system can undertake this task.

SQL Tuning and Access Advisors

Starting with Oracle Database 10g the SQL tuning process has been completely automated. ADDM identifies SQL statements that are consuming unusually high system resources and are therefore causing performance problem. In addition, the top SQL statements in terms of CPU and shared memory consumption are automatically captured in AWR. Thus, the identification of high load SQL statements happens automatically in the new tuning framework and requires no intervention from the administrator.

After the top resource consuming SQL statements have been identified, the Oracle Database can automatically analyze them and recommend solutions using newly added automatic tuning capability of the query optimizer, called the Automatic Tuning Optimizer. The Automatic SQL Tuning is exposed via an advisor called the SQL Tuning Advisor. The SQL Tuning Advisor takes one or more SQL statements, and produces well-tuned plans along with tuning advice. The administrator does not need to do anything other than just invoking the SQL tuning advisor so that it can recommend a solution. It is important to bear in mind here that the solution is coming right from the optimizer and not from any external tools using some pre-defined heuristics. This provides several advantages: a) the tuning is done by the system component that is ultimately responsible for the execution plans, b) the tuning process is fully cost-based and it naturally accounts for any changes and enhancements done to the query optimizer, c) the tuning process takes into account the past execution statistics of a SQL statement and customizes the optimizer settings for that statement, and d) it collects auxiliary information in conjunction with the regular statistics based on what is considered useful by the query optimizer.

The recommendation of the Automatic Tuning Optimizer can fall into one of the following categories:

Statistics Analysis: The Automatic Tuning Optimizer checks each query object for missing or stale statistics, and makes recommendation to gather relevant statistics. It also collects auxiliary information to supply missing statistics or correct stale statistics in case recommendations are not implemented.

SQL Profiling: The Automatic Tuning Optimizer verifies its own estimates and collects auxiliary information to remove estimation errors. It also collects auxiliary information in the form of customized optimizer settings (e.g., first rows vs. all rows) based on past execution history of the SQL statement. It builds a SQL Profile using the auxiliary information and makes a

recommendation to create it. When a SQL Profile is created it enables the query optimizer (under normal mode) to generate a well-tuned plan. The most powerful aspect of SQL profiles is that they enable tuning of queries without requiring any syntactical changes and thereby proving Oracle administrators with a solution to tune the SQL statements embedded in packaged applications.

Access Path Analysis: The Automatic Tuning Optimizer explores whether a new index can be used to significantly improve access to each table in the query, and when appropriate makes recommendations to create such indexes.

SQL Structure Analysis: Here the Automatic Tuning Optimizer tries to identify SQL statements that lend themselves to bad plans, and makes relevant suggestions to restructure them. The suggested restructurings can be syntactic as well as semantic changes to the SQL code.

Both Access Path and SQL structure analysis can be immensely useful in tuning the performance of an application under development or a homegrown production application where the administrators/developers have access to application code.

SQL Access Advisor is yet another major component of Oracle Database manageability. It can automatically analyze the schema design for a given workload and recommend indexes, materialized views, and materialized view logs to create, retain or drop as appropriate for the workload. While generating recommendations, the SQL Access Advisor considers the impact of adding new access structures on data manipulation activities, such as insert, update and delete, in addition to the performance improvement they are likely to provide for queries. The SQL Access Advisor provides a very easy to use interface and requires very little system knowledge. It can also be run without affecting production systems since the data can be gathered from the production system and taken to another machine where the SQL Access Advisor can be run.

SQL Access Advisor has been enhanced in Oracle Database 11g to provide partition advice as a part of SQL access structure recommendations.

Automatic SQL Tuning

In Oracle Database 11g, the SQL tuning process has been further enhanced and automated to keep databases running at their peak performance. The SQL Tuning Advisor now runs automatically during the system maintenance windows as a maintenance task. In each run, it auto-selects high-load SQL queries in the system, and generates recommendations on how to tune them.

To validate the recommendation, SQL Tuning Advisor in Oracle Database 11g performs a test-execute of the SQL statements with the new execution plan for which a SQL Profile is recommended. This dramatically increases the accuracy and reliability of SQL Profile recommendations.

Automatic SQL Tuning Advisor can be configured to auto-implement SQL Profile recommendations. If you enable automatic implementation, the advisor will create SQL Profiles for only those SQL statements, where the performance improvement would be at least three-fold. Other types of recommendations, such as the ones to create new indexes or refresh optimizer statistics or the ones that restructure SQL, can only be implemented manually. DML statements are not considered for tuning by Automatic SQL Tuning Advisor. By default, the Automatic SQL Tuning Advisor is configured to run nightly and only report recommendations but not auto implement them.

You can view a summary of the results of automatic SQL tuning over a specified period (such as the previous seven days), as well as view a detailed report on recommendations made for all SQL statements processed. The recommendations can then be selectively implemented through a manual process. You can also view the recommendations that were automatically implemented. The Automatic SQL Tuning Advisor can be configured to run in any maintenance window or can be disabled altogether if desired.

Real Time SQL Monitoring

The Real Time SQL Monitoring feature of Oracle Database 11g enables monitoring of the performance of SQL statements while they are executing. Live execution plans of long running SQL are automatically displayed on the SQL Monitor page in Oracle Enterprise Manager using new, fine-grained SQL statistics that are tracked out-of-the-box.

By default, SQL Monitoring is automatically started when a SQL statement runs in parallel, or when it has consumed at least 5 seconds of CPU or I/O time in a single execution. The DBA can observe the SQL statement step through the execution plan, displaying statistics for each step as it executes. Row source information at each step of the execution plan is tracked by means of key performance metrics, including elapsed time, CPU time, number of reads and writes, I/O waits and other wait time. SQL Monitoring gives the DBA information on what steps long running SQL are executing and allows the DBA to decide if additional tuning action needs to be taken.

Real Time SQL Monitoring has been enhanced in Oracle Database 11g Release 2 to support execution plans that are being executed in part by the Oracle Database machine, Exadata.

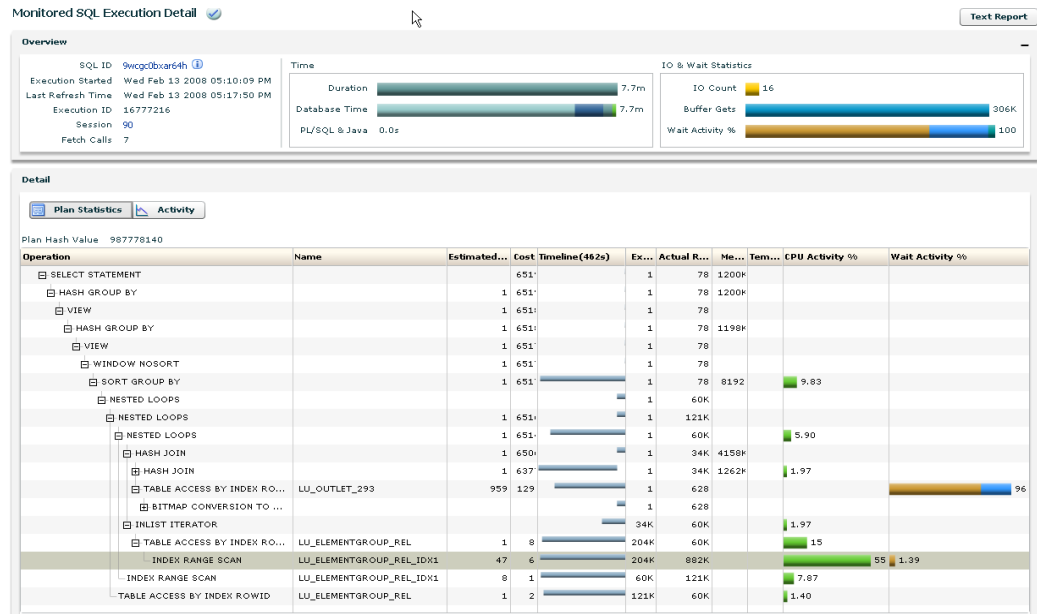


Figure 1. Real Time SQL Monitoring Execution plan

In addition to being able to monitor SQL statements in real time, in Oracle Database 11g Release 2 the DBA can also save all the execution details in an active report - an interactive report that can be used for off-line analysis. It offers the same level of interactivity as the live screens, with drill-downs to various levels of detail.

SQL Plan Management

SQL plan management prevents performance regressions resulting from sudden changes to the execution plan of a SQL statement by providing components for capturing, selecting, and evolving SQL executions plans. SQL performance can be affected by various changes, such as new optimizer version, changes to optimizer statistics and/or parameters, or creation of SQL profiles. SQL plan management is a preventative mechanism that records and evaluates the execution plans of SQL statements over time, and builds SQL plan baselines composed of a set of existing plans known to be efficient. The SQL plan baselines are then used to preserve performance of the corresponding SQL statements, regardless of changes occurring in the system.

Common usage scenarios where SQL plan management can improve or preserve SQL performance include:

- A database upgrade that installs a new optimizer version usually results in plan changes for a small percentage of SQL statements, with most of the plan changes resulting in either improvement or no performance changes. However, certain plan changes may

cause performance regressions. The use of SQL plan baselines significantly minimizes potential performance regressions resulting from a database upgrade.

- Ongoing system and data changes can impact plans for some SQL statements, potentially causing performance regressions. The use of SQL plan baselines can also help to minimize performance regressions and stabilize SQL performance.
- Deployment of new application modules means introducing new SQL statements into the system. The application software may use appropriate SQL execution plans developed under a standard test configuration for the new SQL statements.

SQL plan baselines evolve over time to produce better performance. During the SQL plan baseline evolution phase, Oracle Database 11g routinely evaluates the performance of new plans and integrates plans with better performance into SQL plan baselines. A successful verification of a new plan consists of comparing its performance to that of a plan selected from the SQL plan baseline and ensuring that it delivers better performance.

Migration of Stored Outlines to SQL Plan Baselines

Before SQL plan baselines were introduced as part of SQL Plan Management, stored outlines served a similar function. However, stored outlines lack the flexibility and adaptability of SQL Plan Management.

- Stored outlines cannot automatically evolve over time. Consequently, a stored outline may be good when it is created, but become a bad plan after a database change, leading to performance degradation.
- Hints in a stored outline can become invalid, for example, an index hint on a dropped index. In such cases, the database still uses the outlines but excludes the invalid hints, producing a plan that is often worse than the original plan or the current best-cost plan generated by the optimizer.
- For a SQL statement, the optimizer can only choose the plan defined in the stored outline in the currently specified category. The optimizer cannot choose from other stored outlines in different categories or the current cost-based plan even if they improve performance.

Oracle Database 11g release 2 provides the capability of migrating stored outlines to SQL Plan Baselines. The benefits of migrating to SQL Plan Baselines include:

- SQL plan baselines enable the optimizer to use the same good plan and allow this plan to evolve over time. For a specified SQL statement, you can add new plans as SQL plan baselines after they are verified not to cause performance regressions.
- SQL plan baselines prevent plans from going bad because of invalid hints. If hints stored in a plan baseline become invalid, the plan may not be reproducible by the

optimizer. In this case, the optimizer selects an alternative reproducible plan baseline or the current best-cost plan generated by optimizer.

- For a specific SQL statement, the database can maintain multiple plan baselines. The optimizer can choose from a set of good plans for a specific SQL statement instead of being restricted to a single plan per category, as required by stored outlines.

By utilizing the migration path in Oracle Database 11g release 2, old applications using stored outlines can be transparently migrated and can instantaneously take advantage of the enhanced functionality of SQL Plan Management.

Change Management

There are three components to managing changes in Oracle database environments. They are:

- **Change Detection:** Detecting unplanned changes or improperly configured database environments.
- **Change Testing:** Testing planned changes in test environments and remediating regressions prior to rolling them out in production.
- **Change Automation:** Automating the task of rolling out changes across multiple environments.

Change Detection

Using Oracle Enterprise Manager, administrators can view all their Oracle database assets across the enterprise. Using real-time and period data collection, administrators can get all the details needed to manage their databases, including version number, location of Oracle home, patch levels etc. Oracle Enterprise Manager also automatically provides a compliance score by evaluating each database against the 300+ out-of-the-box policies allowing administrators to take action to close security loopholes proactively.

With application changes being the #1 cause of downtime, enterprises are confronted with the problem of identifying unplanned changes made to production environments. By capturing the optimal state of the production database schema in a baseline, DBAs can easily pinpoint ad hoc changes made to production databases, whether they are changes to initialization parameters, new indexes or even malicious changes in business logic, by comparing the current production environment with the established gold baseline. In Oracle Database 11g, DBAs can track schema changes in real time by setting the `ENABLE_DDL_LOGGING` initialization parameter to `TRUE`.

Change Testing

Real Application Testing

Today, enterprises have to make sizeable investments in hardware and software to roll out infrastructure changes. For example, a data center may have an initiative to move databases to a low cost computing platform, such as Oracle Enterprise Linux. This would, traditionally, require the enterprise to invest in duplicate hardware for the entire application stack, including web server, application server and database, to test their production applications. Organizations therefore find it very expensive to evaluate and implement changes to their data center infrastructure. In spite of the extensive testing performed, unexpected problems are frequently encountered when a change is finally made in the production system. This is because test workloads are typically simulated and are not accurate or complete representations of true production workloads. Data center managers are therefore reluctant to adopt new technologies and adapt their businesses to the rapidly changing competitive pressures.

Oracle Database 11g's Real Application Testing addresses these issues head-on with the introduction of two new solutions, Database Replay and SQL Performance Analyzer.

Database Replay

Database Replay provides DBAs and system administrators with the ability to faithfully, accurately and realistically rerun actual production workloads, including online user and batch workloads, in test environments. By capturing the full database workload from production systems, including all concurrency, dependencies and timing, Database Replay enables you to realistically test system changes by essentially recreating production workloads on the test system – something that a set of scripts can never duplicate. With Database Replay, DBAs and system administrators can test

- Database upgrades, patches, parameter, schema changes, etc.
- Configuration changes such as conversion from a single instance to RAC, ASM, etc.
- Storage, network, interconnect changes
- Operating system, hardware migrations, patches, upgrades, parameter changes

Lower test infrastructure cost

DBAs now have a test infrastructure at their disposal to test their changes without the overhead of having to duplicate an entire application infrastructure. Database Replay does not require the set up overhead of having to recreate a middle-tier or a web server tier. Thus, DBAs and system administrators can rapidly test and upgrade data center infrastructure components with the utmost confidence, knowing that the changes have truly been tested and validated using production scenarios.

Faster deployment

Another major advantage of Database Replay is that it does not require the DBA to spend months getting a functional knowledge of the application and developing test scripts. With a few point and clicks, DBAs have a full production workload available at their fingertips to test and rollout any change. This cuts down testing cycles from many months to days or weeks and brings significant cost savings to businesses as a result.

Database Replay consists of four main steps:

1. Workload capture

When workload capture is enabled, all external client requests directed to the Oracle Database are tracked and stored in binary files, called capture files, on the file system. Oracle recommends taking a backup of the entire database prior to the workload capture. The user specifies the location of the capture files and the workload capture start and end time. During this process, all information pertaining to external database calls is written to the capture files.

2. Workload processing

Once the workload has been captured, the information in the capture files has to be processed. This processing transforms the captured data into replay files and creates all necessary metadata needed for replaying the workload. The capture files would typically be copied to another system for processing. This must be done once for every captured workload before they can be replayed. After the captured workload is processed, it can be replayed repeatedly on a replay system. As workload processing can be time consuming and resource intensive, it is generally recommended that this step be performed on the test system where the workload will be replayed.

3. Workload replay

After the captured workload has been processed, it is now ready for replay. A client program, called Replay Client, then processes the replay files and submits calls to the database with the exact same timing and concurrency as in the capture system. Depending on the captured workload, you may need one or more replay clients to properly replay the workload. A calibration tool is provided to help determine the number of replay clients needed for a workload. It should be noted that since the entire workload is replayed including DML and SQL queries, it is important that the data in the replay system be identical to that in the production system, whose workload was captured, to enable reliable analysis for reporting purposes.

4. Analysis and Reporting

Extensive reports are provided to enable detailed analysis of the capture and replay. Any errors encountered during replay are reported. Any divergence in rows returned by DML or queries is shown. Basic performance comparisons between capture and replay

are provided. For advanced analysis, Replay Compare Period and other AWR reports are available to allow detailed comparison of various statistics between capture and replays.

Both the workload capture and replay process support a filtering capability that is useful for targeting workload of interest, such as by service, action, module to name a few. Oracle Enterprise Manager significantly enhances the value of Real Application Testing by supporting end-to-end Database Replay automation. This simplifies the process of saving and transferring the workload capture and performance data to test system, setting up the test system and replay clients correctly, and orchestrating the entire replay through Oracle Enterprise Manager Grid Control (Grid Control) interface.

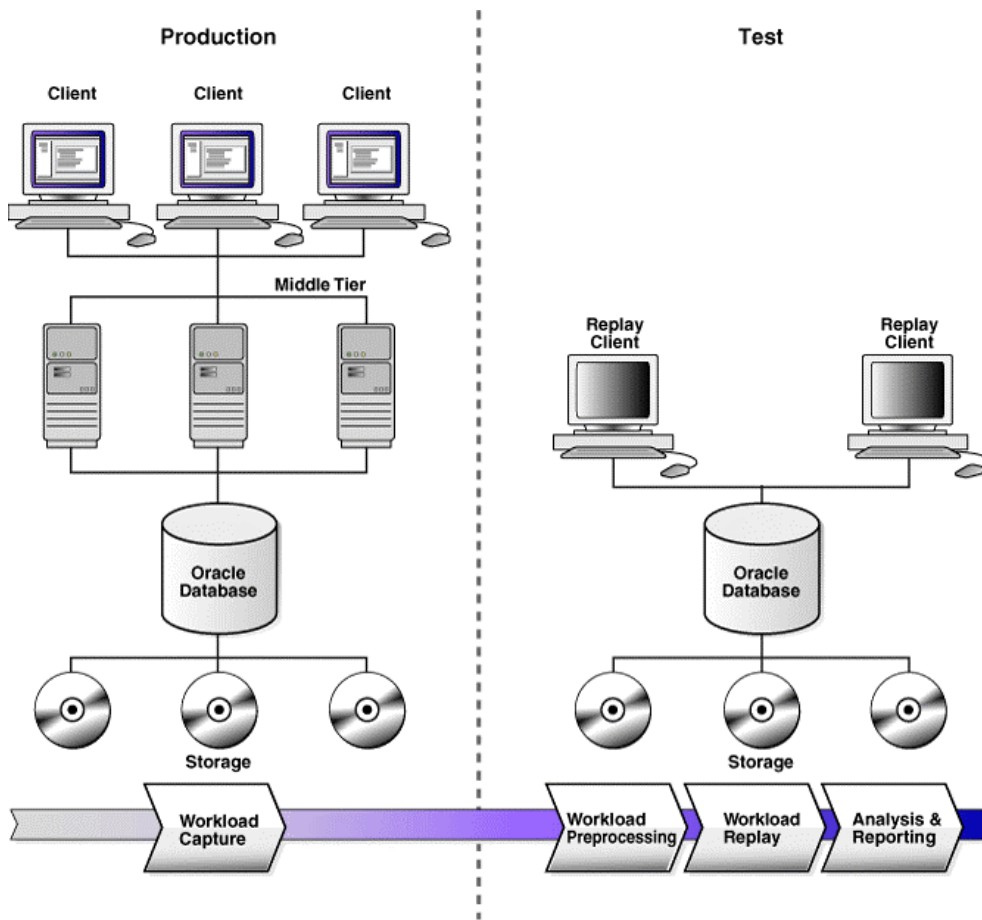


Figure 2. Database Replay Workflow

SQL Performance Analyzer

Changes that affect SQL execution plans can severely impact application performance and availability. As a result, DBAs spend enormous amounts of time identifying and fixing SQL statements that have regressed due to the system changes. SQL Performance Analyzer (SPA) can predict and prevent SQL execution performance problems caused by environment changes.

SQL Performance Analyzer provides a granular view of the impact of environment changes on SQL execution plans and statistics by running the SQL statements serially before and after the changes. SQL Performance Analyzer generates a report outlining the net benefit on the workload due to the system change as well as the set of regressed SQL statements. For regressed SQL statements, appropriate execution plan details along with recommendations to tune them are provided.

SQL Performance Analyzer is well integrated with existing SQL Tuning Set (STS), SQL Tuning Advisor and SQL Plan Management functionality. SQL Performance Analyzer completely automates and simplifies the manual and time-consuming process of assessing the impact of change on extremely large SQL workloads (thousands of SQL statements). DBAs can use SQL Tuning Advisor to fix the regressed SQL statements in test environments and generate new plans. These plans are then seeded in SQL Plan Management baselines and exported back into production. Thus, using SQL Performance Analyzer, businesses can validate with a high degree of confidence that a system change to a production environment in fact results in net positive improvement at a significantly lower cost.

Examples of common system changes for which you can use the SQL Performance Analyzer include:

- Database upgrade, patches, initialization parameter changes
- Configuration changes to the operating system, hardware, or database
- Schema changes such as adding new indexes, partitioning or materialized views
- Gathering optimizer statistics
- SQL tuning actions, for example, creating SQL profiles

Using SQL Performance Analyzer involves the following 5 main steps:

1. Capture the SQL workload that you want to analyze with SPA. The Oracle database offers ways to capture SQL workload from several sources, such as cursor cache and Automatic Workload Repository, into a SQL tuning set (STS). This would typically be done on a production system and the STS would then be transported to the test system where SPA analysis will take place.
2. Measure the performance of the workload before a change by executing SPA on the SQL tuning set. Very short running queries are executed multiple times and their

statistics are averaged to eliminate variations due to buffer cache state and other noise factors

3. Make the change, such as database upgrade or optimizer statistics refresh.
4. Measure performance of the workload after the change by executing SPA on the SQL tuning set again, as in step 2.
5. Compare performance of the two executions of the SQL tuning set to identify the SQL statements that have regressed, improved, or were unchanged.

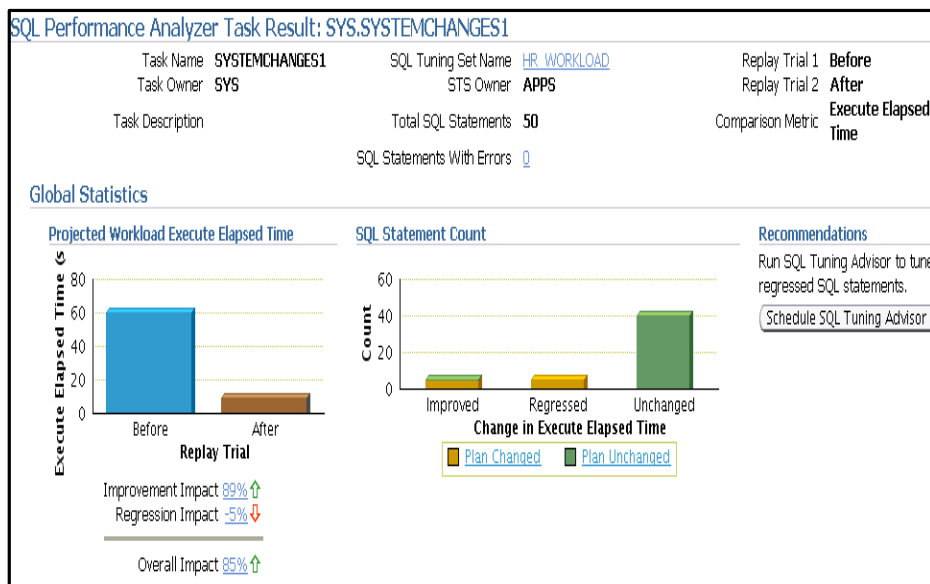


Figure 3. SQL Performance Analyzer report

This SPA comparison report shows significant performance improvement of overall SQL workload after the proposed system change but with a few execution plan regressions. SQL Performance Analyzer takes into account the number of executions of a SQL statement when measuring its impact. A SQL statement that completes in seconds but is frequently executed may have a higher impact on the system than a long running statement executed only once. SPA takes these factors into account when predicting overall performance improvements and regressions. If any regressions are encountered, SPA allows the user to fix them using SQL Tuning Advisor or with SQL Plan Baselines, a new plan stability feature introduced in Oracle Database 11g.

SPA supports numerous other features that help assess system changes, these are briefly described below:

1. SPA helps estimate the IO reduction that can be accomplished by migrating to Exadata server but without actually requiring you provision the hardware. This can be used to identify potential workloads/systems that are good candidates for Exadata migration.
2. SPA supports comparing two STSs – this functionality is useful when you have mechanisms such as load testing scripts or Oracle Application Testing Suite that can be used to test the changes. By capturing the workload in to two different STSs (for before and after change runs), one can use SPA to assess the impact of the system change.
3. With Oracle Enterprise Manager, a “one-click” STS transport mechanism can be used to simplify the process of moving STS workloads between production and test databases.

Choosing the right solution helps DBAs absorb and manage change efficiently. Database Replay is designed to test and improve system performance and SQL Performance Analyzer helps DBAs improve SQL response time. Oracle 11g Real Application Testing makes it easy for database administrators to manage and execute changes that are critical to the business and do it all at lower risk.

Change Automation

Oracle Enterprise Manager also provides comprehensive provisioning and patch automation capabilities for Oracle Databases. DBAs can deploy patches for Oracle database or Oracle Enterprise Linux. Through the integration with Oracle MetaLink, administrators can download patches directly from Oracle Support, stage them, test them and upon successful testing, roll them out to multiple database environments in one click. Compare this to having run `opatch` manually on each Oracle database one at a time.

DBAs can also automate the deployment of schema changes by capturing the definitions of the application schema objects in the form of a gold definition called a dictionary baseline. When all development changes have been applied to a development or staging database, DBAs can save them in these baselines and propagate the changes to any target database environment with a few simple clicks. Unlike SQL scripts, the schema change automation intelligently validates the changes against the target database to identify any discrepancies or conflicts, such as data type mismatches or duplicate objects. This allows DBAs to proactively correct them prior to apply the changes.

Securely provisioned database environments

Administrators can leverage the provisioning capabilities in Oracle Enterprise Manager to roll out pre-tested standardized gold images of Oracle database software or server operating system software. This provides administrators with tremendous labor savings instead of having to monitor each installation manually and then applying the relevant patches in the right order.

These gold images can be used to provision test systems or additional nodes in a Real Application Cluster database.

When enterprises copy production data into non-production environments for the purposes of application development or testing, they risk falling out of compliance with regulations or incurring fines and penalties that accompany violations of these data privacy laws. The data masking capabilities available to administrators helps organizations comply with privacy and confidentiality laws by masking sensitive or confidential data in development, test or staging environments. By using an irreversible process to replace sensitive data with realistic-looking but scrubbed data based on masking rules, security administrators can ensure that the original data cannot be retrieved, recovered or restored while maintaining the integrity of the application.

Ongoing Administration

Resource Management

Automating the day to day repetitive tasks that in the past have taken too much of an administrators time is a key achievement of the self managing database, Oracle 11g. By relieving the administrator s of the tedious management tasks, such as managing memory allocations and disk resources, they can be freed up to focus on more strategic requirements, such as security and high availability.

Automatic Memory Management

Memory is a precious system resource and administrators historically have spent a significant amount of their time optimizing its use. One of the key self-management enhancements in the Oracle Database 11g is Automatic Memory Management. This functionality automates the management of shared memory used by an Oracle Database instance and liberates administrators from having to configure the shared memory components manually. The Automatic Memory Management feature is based on sophisticated heuristics internal to the database that monitors the memory distribution and changes it according to the demands of the workload.

Oracle Database memory structures basically consist of shared memory or System Global Area (SGA) and private memory or Program Global Area (PGA). In Oracle Database 9i, Automatic SQL Execution Memory Management feature was introduced to automate management of PGA. In Oracle Database 10g, the same was done for SGA by the introduction of Automatic Shared Memory Management. This meant all the different SQL areas in PGA were auto-sized for the system workload to give best performance and all the memory pools in shared memory were similarly adjusted for size for optimal performance. The user was only required to specify the PGA and SGA target sizes and Oracle would appropriately allocate memory within these targets to give the best possible performance. PGA and SGA Advisors were also provided to help the user properly set the targets for SGA and PGA in Oracle Database 10g.

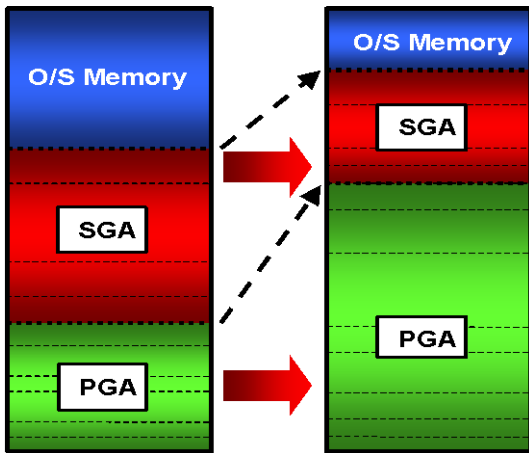


Figure 4. Automatic Memory Management

In Oracle Database 11g, memory management has been automated even further. All memory, PGA and SGA, is now managed centrally with the Automatic Memory Management feature. DBAs need to specify a single parameter, `MEMORY_TARGET`, and Oracle will automatically size the Program Global Area (PGA) and System Global Area (SGA) based on the workload. Using indirect memory transfer, the database transfers memory from SGA to PGA and vice versa to respond to the load. The indirect transfer uses the operating system mechanism to free up shared memory and allocating memory to other components requesting memory, e.g., from PGA to SGA. Dynamic allocation of memory is adjusted at frequent intervals to optimize memory usage in line with workload requirements to maximize memory utilization and avoid out-of-memory errors. Users can optionally set SGA and PGA targets when using the Automatic Memory Management feature. This ensures that SGA and PGA sizes will not be shrunk below the values specified by their respective parameter targets in auto-tuning mode. This feature is currently available in Linux, Solaris, HP-UX, AIX and Windows platforms.

First introduced in Oracle Database 10g, Memory Advisors provide graphical analyses of total memory target settings, SGA and PGA target settings, or SGA component size settings. DBAs can use these analyses to tune database performance and to perform what-if planning scenarios. Different memory advisors become available depending on the memory management mode used with the database.

For instance, if Automatic Memory Management is enabled, you can get advice for setting the target amount of memory to allocate to the entire database. This advisor provides advice for the total memory target for the instance. If Automatic Shared Memory Management is enabled, you can gain advice on configuring the target sizes of the SGA and instance PGA. If Manual Shared Memory Management is enabled, you can get advice on sizing the shared pool, buffer cache, and instance PGA.

Space Management

Space management can be one of the most time consuming tasks for database administrators. Fortunately, the Oracle Database 11g automatically manages its space consumption, alerts administrators on potential space problems, and recommends possible solutions.

Proactive Space Management

Oracle Database 11g does non-intrusive and timely monitoring checks for space utilization in the database server. The Oracle Database 11g automatically monitors its space utilization during its normal space allocation and de-allocation operations and alerts administrators if the free space availability falls below the pre-defined thresholds. Oracle Database 11g's space monitoring functionality is set up out-of-box, causes no measurable performance impact, and is uniformly available across all tablespace types. Since the monitoring is performed at the same time as space is allocated and freed up in the database server, this guarantees immediate availability of space usage information whenever the user needs it.

Notification is performed using server generated alerts mechanism. The alerts are triggered when certain space related events occur in the database. For example when the space usage threshold of a tablespace is crossed, an alert is raised. Another example of an alert is when a Resumable session encounters out of space situation. An alert is sent instantaneously to the DBA to take corrective measures. The DBA may choose to get paged with the alert information and add space to the tablespace to allow the suspended operation to continue from where it left off.

The database comes with a default set of alert thresholds. The DBA may override the default for a given tablespace or set a new default for the entire database through EM.

Transparent space reclamation

The Oracle Database 11g provides the ability of performing an in-place reorganization of data for optimal space utilization by shrinking it. Shrinking of a segment will make unused space available to other segments in the tablespace and may improve the performance of queries and DML operations.

The Segment Shrink functionality provides the ability to both compact the space used in a segment and then deallocate it from the segment. The deallocated space is returned to the tablespace and is available to other objects in the tablespace. Sparsely populated tables may cause a performance problem for full table scans. By performing shrink, data in the table is compacted and the high water mark of the segment is pushed down. This makes full table scans read less blocks and hence, run faster.

Segment Shrink is an online operation – the table being shrunk is open to queries and DML while the segment is being shrunk. Additionally, segment shrink is performed in-place. This is a key advantage over performing Online Table Redefinition for compaction and reclaiming space.

The DBA may schedule segment shrink for one or all the objects in the database as nightly jobs without requiring any additional space to be provided to the database.

In order to easily identify candidate segments for shrinking, the Oracle Database 11g also includes an Automatic Segment Advisor. The Automatic Segment Advisor runs every night in a predetermined maintenance window to proactively identify segments that need shrinking. The advisor, whether invoked manually or automatically, performs growth trend analysis on individual objects to determine if there will be any additional space left in the object in 7 days. It then uses the reclaim space target to select candidate objects to shrink.

Segment Creation On Demand

Installation of a packaged application can often create thousands of database tables and indexes. The creation of these tables and indexes can be time consuming and use a significant amount of disk space. Many of these tables and indexes may never be used if you have not licensed all the modules of the packaged application. In Oracle Database 11g Release 2, when creating nonpartitioned tables and indexes, the database by default uses delayed segment creation to update only database metadata and avoids the initial creation of user segments, saving disk space and greatly speeding up installation time. When a user inserts the first row into a table, the database creates segments for the table, its LOB columns, and its indexes.

Segment creation on demand saves time, space and computing resources.

Compression Advisor

In Oracle Database 11g, compression of your data saves disk space, reduces memory use in the database buffer cache, and can significantly speed query execution. Compression does have a cost in CPU overhead for data loading and DML. However, this cost is easily offset by greatly reduced I/O requirements.

Oracle Database 11g table compression is completely transparent to applications. It is especially useful in decision support systems, where there are lengthy read-only operations and large amounts of data, but it can also be used in online transaction processing systems. You can specify compression for a tablespace, a table, or a partition.

A Compression Advisor has been added in Oracle Database 11g Release 2 to facilitate choosing the correct compression level for your data. As part of the existing Advisor framework in Oracle Database 11g, the compression advisor analyzes the objects in the database, discovers the possible compression ratios that could be achieved, and recommends optimal compression settings.

Fault Diagnostics

Beginning with Release 11g, Oracle Database includes an advanced fault diagnostic infrastructure for preventing, detecting, diagnosing, and resolving problems. The problems that are targeted in

particular are critical errors that can affect the health of the database. When a critical error occurs, it is assigned an incident number, and diagnostic data for the error (traces, dumps, and more) are immediately captured and tagged with this number. The data is then stored in the Automatic Diagnostic Repository (ADR)—a file based repository outside the database—where it can later be retrieved by incident number and analyzed. The extensive improvement of the fault diagnostics infrastructure in Oracle Database 11g aims to provide the following benefits:

- Respond proactively to small problems and prevent catastrophic system failure by alerting DBAs using Health Checks.
- Limiting damage and repair and interruptions after a problem is detected using Data Recovery and SQL Repair Advisor.
- Reducing problem diagnostic time through ADR and Test Case Builder.
- Simplifying customer interaction with Oracle Support using IPS and Oracle Configuration Support Manager.

The following are the key components of the fault diagnostic infrastructure:

Automated Health Checks

Health checker framework has been added in Oracle Database 11g for the purposes of performing proactive checks on system health. Upon detecting a critical error, the fault diagnostic infrastructure can run one or more health checks to perform deeper analysis of a critical error. The results of a health check are stored in a report that can be viewed as a text file or as formatted HTML in a browser. The report can be added to the other diagnostic data collected for the error. Separate individual health checks look for data corruptions, undo and redo corruptions, data dictionary corruption, and more.

SQL Test Case Builder

For many application problems, obtaining a reproducible test case is an important factor in problem resolution speed. The SQL Test Case Builder allows a user to automatically gather all the necessary information needed to reproduce the problem such as SQL text, PL/SQL, DDL, execution environment information, etc. The information gathered can then be transmitted to Oracle Support to help reproduce the problem.

Automatic Diagnostic Repository (ADR)

The ADR is a file-based repository for database diagnostic data such as traces, dumps, the alert log, health monitor reports, and more. It has a unified directory structure across multiple instances and components of the Oracle Database and it replaces the `USER_DUMP_DEST`, `BACKGROUND_DUMP_DEST`, and `CORE_DUMP_DEST` of previous releases. The diagnostic data in ADR is self-managing and is purged automatically based on predefined data

retention setting. ADR also maintains meta-data for all critical errors on the database such that a user can run queries against ADR to determine what and how many critical problems occurred on the system over the last few days, months or even years.

Incident packaging service (IPS)

Incident Packaging Service automates the process of collecting all necessary diagnostic data related to one or more problems. Users no longer have to search in different directory locations trying to gather all the relevant trace files and dump files needed for problem diagnosis by Oracle Support. By invoking IPS, all diagnostic data (traces, dumps, health check reports, SQL test cases, and more) pertaining to a critical error is automatically packaged into a zip file which can then be shipped to Oracle Support.

Support Workbench

The Support Workbench is a facility in Oracle Enterprise Manager that enables you to interact with the new fault diagnostic infrastructure of Oracle Database 11g. With it you can investigate, report, and where appropriate, repair problems, all with an easy-to-use graphical interface. The Support Workbench provides a self-service means for you to package diagnostic data using IPS, obtain a support request number, and upload the IPS package to Oracle Support with a minimum of effort and in a very short time, thereby reducing time-to-resolution for problems.

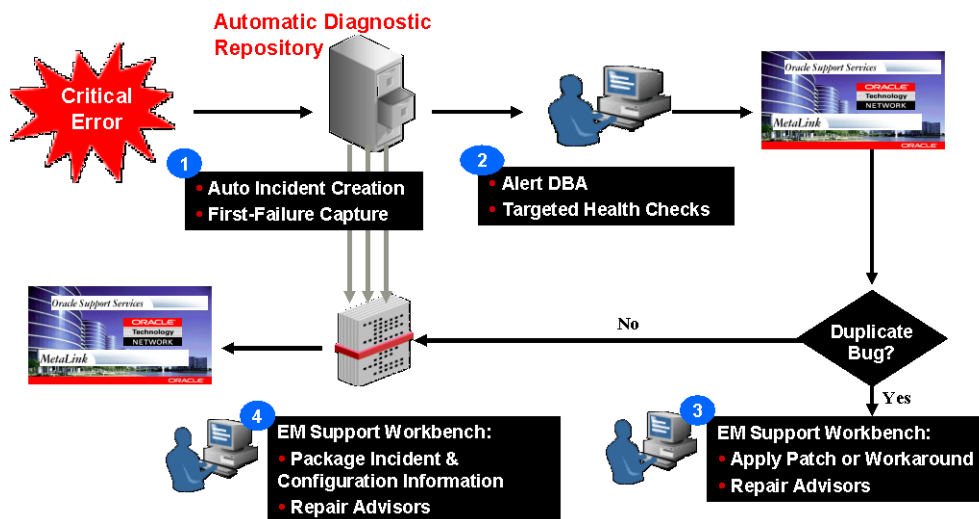


Figure 5. Support workbench workflow

The Support Workbench workflow consists of the following steps:

1. Create an incident in the database automatically based on the first occurrence of a failure.

2. Alert the DBA of the failure and run health checks in the areas where the failure was reported.
3. If it is a known issue, then recommend and apply patch to solve the problem.
4. Otherwise, package up incidents and relevant configuration information and upload to Oracle Support and run repair advisors to recover from failure.

There are many different kinds of problems that can occur in an Oracle Database and the right remedy for each problem may be different. The Support Workbench has extensive workflows that guide the user to take action that is appropriate for the problem encountered.

What does it mean to you?

Change is relentless in today's rapidly evolving IT environments but it does not have to be difficult for data center managers and administrators. Thanks to the Real Application Testing capabilities, database administrators can adapt to changes easily while keeping their undesired effects to a minimum. Real Application Testing helps organizations lower their testing costs by giving DBAs and system administrators an easy-to-deploy solution for testing and rolling out data center changes with reduced hardware and software investments. At the same time, the manageability enhancements in Oracle Database 11g allows database administrators to keep their systems performant and available, while providing higher quality of service to their users.

Conclusion

Modern enterprises are aggressively adopting new technology solutions to enhance their competitiveness and profitability. As a result, management challenges continue to rise. Oracle Database 11g addresses these critical challenges by enabling database administrators to maintain database performance at peak levels, adopt new technology rapidly and without risk, and increase DBA productivity and system availability by automating routine administrative tasks. Oracle Database 11g offers next-generation database management for the next-generation DBA.



Oracle Database 11g Release 2: Manageability
and Real Application Testing Overview

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