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Manageability with Oracle Database 12*c*

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Introduction

Oracle Database is the market-leader and preferred database for hundreds of thousands of businesses as well as for 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. In Oracle Database 11g, Oracle added capabilities to perform database testing using production workloads as well as the ability to monitor database queries automatically. Oracle is ready to raise the bar once again with the release of Oracle Database 12*c*. The built-in features of Oracle Database 12*c* cater to data center environments that are rapidly evolving and continuously changing to keep up with the demands of continuous consolidation and cloud computing. In addition, building on its industry-leading self-managing capabilities, Oracle Database 12*c* has made significant advances in the areas of manageability, testing, and secure test data management and fault diagnostics that address many of the top challenges facing businesses today.

Oracle Enterprise Manager is Oracle's integrated enterprise IT management product line and provides the industry's first complete cloud lifecycle management solution. Oracle Database 12*c* along with Oracle Enterprise Manager Cloud Control 12*c* allows organizations to adopt new technologies quickly while minimizing risk. Oracle Enterprise Manager's business-driven IT management capabilities allow you to quickly set up, manage and support enterprise clouds and traditional IT environments from applications to disk.

Manageability Challenges

When managing a large number of databases in an enterprise, the areas that continue to pose the biggest management challenges to database administrators include:

- Performance diagnostics and tuning: How to maintain production databases at their peak performance to maintain committed service levels.
- Testing and test data management: How to reduce the risk of rolling out changes through testing and managing test data in Oracle database environments at lower costs.

- Ongoing administration: How to automate day-to-day repetitive tasks so that labor can be freed up to focus on more strategic requirements, such as security, data center consolidation and business continuity.
- Cloud consolidation and Exadata management: How to consolidate databases onto a common infrastructure to reduce data center costs and increase server efficiency.

To address these challenges, Oracle Database 12*c* has made significant advances in performance, change assurance and self-management to make Oracle Database 12*c* easier to manage than ever before.

Performance Management

Performance management has traditionally been a major challenge for database administrators. Oracle Database 12*c* continues to expand its self-managing capabilities in all areas, including the two key aspects of database performance management: performance diagnostics and application tuning.

Performance Diagnostics

Performance issues reported in a database can be broadly classified under the following four categories

i. Persistent performance problems

ii. Transient performance problems

iii. Comparative performance problems

iv. Real-Time performance problems

In the subsequent sections we will explore how the Oracle Database addresses these issues.

The steps to achieve good performance are to gather the right data, make a proper analysis, and derive an effective action plan. The Oracle Database 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. Oracle provides database administrators the option to either use Oracle Enterprise Manager Cloud Control for managing many databases from a single console or use Enterprise Manager Database Express that is integrated with the Oracle database for managing a specific target.

Oracle Enterprise Manager Database Express

Oracle Database 12*c* includes an out of the box web-based database management tool, Oracle Enterprise Manager Database Express, optimized for performance management. This tool is embedded inside the database and is auto-configured at the time of installation. With only a 20 MB disk footprint, there is no resource usage when it is not invoked or used. Oracle Enterprise Manager Database Express can manage both single instance and Oracle Real Application Clusters (Oracle RAC) databases. The tool also has built in support for container databases (CDBs). Along with in-depth support for performance management features Oracle Enterprise Manager Database Express can be

used for configuration management, storage management and security management. One of the significant additions is the performance hub, which is discussed below.

Automatic Workload Repository

The Automatic Workload Repository (AWR) is a built-in repository within every Oracle Database that contains operational statistics about that particular database and other configuration and usage information. At regular intervals, the Oracle database takes a snapshot of all its performance statistics and workload information and stores it 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.

AWR forms the foundation for most of the self-management functionality of Oracle Database. It is the source of information that gives the Oracle Database a historical perspective on how it is being used and enables it to make decisions, which are accurate and specifically tailored for the system's environment. Most of the self-managing features of the Oracle Database rely heavily on the information captured in AWR. The data in AWR is useful for diagnosing all types of performance issues ranging from persistent or comparative performance diagnosis.

AWR has been enhanced in Oracle Database 12*c* to include reports from Real-Time SQL Monitoring, Real-Time ADDM and Database Operations Monitoring.

AWR Warehouse

Beyond ongoing performance management, enterprises are also interested in analyzing their database performance data over a longer time periods for tasks such as capacity planning or identifying trends or patterns affecting performance in their mission critical databases. Oracle Enterprise Manager now provides the ability to transfer the performance data in from AWR across all enterprise databases into a central performance warehouse called AWR Warehouse.

AWR Warehouse allows DBAs and capacity planners to get answers to questions such as what was the performance of the database this quarter compared the same quarter last year or whether database servers in the next 6 months could support the growth in resource utilization of the databases running on the servers. Enterprise Manager completely automates the extraction, transfer and load of the performance data into the AWR warehouse so that the critical source databases can keep operating at optimal performance without incurring additional storage overhead. And, the DBAs now have all the performance data they need for analysis at their fingertips for all their critical databases for all time.

Diagnosing persistent performance problems with Automatic Database Diagnostics Monitor (ADDM)

Persistent performance issues generally last for hours or even days. Poorly written code, application design issues or over utilized system resources (e.g. I/O bandwidth fully utilized) etc. usually lead to persistent performance problems. Automatic Database Diagnostics Monitoring (ADDM), which is built as part of the self-managing framework of the Oracle Database, is best suited for diagnosing such problems.

ADDM builds upon the data captured in AWR. ADDM makes it possible for the Oracle Database 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 a proactive basis, recommends solutions and quantifies expected benefits. Some of the common problems detected by ADDM include: CPU bottlenecks, poor connection management, excessive parsing, lock contention, I/O capacity, under sizing of Oracle memory structures (such as PGA, buffer cache, log buffer, high load SQL statements), high PL/SQL and Java time, high checkpoint load and RAC-specific issues.

Besides reporting the potential performance issues, ADDM also documents the non-problem areas of the system. The sub-components, such as I/O, 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. For RAC environments, ADDM provides cluster-wide performance analyses 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. With the Oracle Database 12*c* and a CDB, ADDM recommendations include the associated pluggable database (PDB) where the issue has been detected to pinpoint the impacted database.

Diagnosing transient performance problems with Real-Time ADDM

Transient performance issues often last for a few seconds or minutes and result in inconsistencies in application performance. Extremely slow or unresponsive conditions often lead to unplanned outages, which eventually results in loss of revenue. It is extremely important to have the right set of tools to capture and analyze the root cause of these problems.

Real-Time ADDM is an innovative way to analyze problems in extremely slow or unresponsive databases, which would have traditionally required a database restart. Real-Time ADDM can help resolve issues such as deadlocks, hangs, and shared pool contentions, as well as many other exception situations, without resorting to a restart of the database.

In Oracle Database 12c, Real-Time ADDM has been enhanced to proactively detect and diagnose performance spikes. Built inside the database engine, Real-Time ADDM is triggered automatically when a "new" performance problem is detected in the server. The framework is built using a polling mechanism where a database background process (MMON) obtains performance statistics without lock or latch every 3 seconds. It then checks these statistics against past behavior and triggers a report if necessary, which is also stored in the AWR.

Comparing performance across periods with Compare Period ADDM

With comparative performance problems, database Administrators are often required to investigate why performance of one time period is slower than a similar time-period. This investigation is often very time consuming and usually leads to inconclusive results.

Comment – I think either the heading of this section or the first sentence should include the words "comparative performance problems" to tie it back to the list of 4 different types of problems described earlier in the paper.

Compare Period ADDM makes these investigations really simple. The administrator can choose from an AWR baseline, the older AWR snapshot period, or any calendar period of choice to determine why database performance during a particular period is slower than another period. Compare Period ADDM checks both the base period and the comparison period and lists out a set of findings pinpointing the root cause for the difference in performance. At the first step the causes behind the performance differences are detected and then measured to quantify the effect of these differences. In the final step the causes and effects are correlated to pinpoint a performance issue. Compare Period ADDM also indicates whether the two periods are comparable, i.e. have similar SQL running in the same period, by the use of the SQL Commonality index for the two periods.

AWR Baselines and Adaptive Thresholds

AWR baselines allow DBAs to capture and save system performance data over time periods with interesting or representative workloads. This data is very useful in running comparative analysis across multiple time periods or after introducing any configuration or parameter changes.

In addition, DBAs can use baselines to set 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. 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.

Real Time Performance Analysis with ASH Analytics

A key component of AWR is the Active Session History (ASH).

All active database sessions are automatically sampled once every second and stored in the ASH. The data is captured in a rolling buffer in database memory and once the buffer is filled or after 60 minutes, which ever happens first, the data is written to disk. But when the data is written to disk only 1 out of every 10 samples is written. The ASH data shows where the database is currently spending its time and highlights any performance bottlenecks.

As ASH captures the session state with many performance attributes, the in-memory ASH data can be very effectively used to understand the database workload profile and proactively diagnose any transient performance issue, such as a CPU spike or an I/O storm, that occurs for a very short duration. Oracle Enterprise Manager Cloud Control 12*c* includes ASH Analytics, a new tool to explore ASH data that allows the administrator to roll up, drill down, and slice or dice performance data across various performance dimensions. Using ASH Analytics, the database administrator can explore the different performance attributes of a database session at any point in time.

The ASH Analytics view is also available as an active report that can be used for offline analysis of any performance issues at a later point in time.

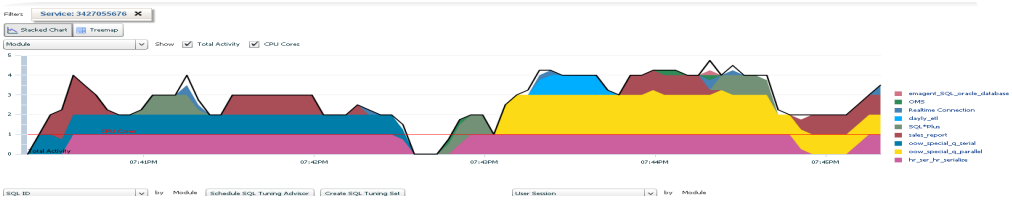

Figure 1: ASH Analytics

For Oracle Database 12*c* targets, ASH Analytics also captures a PDB as a dimension so that a CDB administrator can drill down into the performance activity of a particular PDB. The PDB administrators also have access to ASH Analytics that allows them to view the workload profile for their own PDBs.

Application Tuning

Application design issues are the most predominant cause of performance problems. The query optimizer makes crucial decisions that 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. While Oracle Database attempts to provide the best possible query optimization technology, which maximizes the application/query performance without any administrator intervention in the majority of cases, there may still be cases where the design of the application or a skew in data distribution may cause certain SQL statements to consume an unusually high percentage of total system resources.

SQL Tuning Advisor

ADDM identifies SQL statements that are consuming unusually high system resources and are therefore causing performance problems. 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 tuning framework and requires no intervention from the administrator.

After the top resource consuming SQL statements have been identified, Oracle Database can automatically analyze them and recommend solutions using the added automatic tuning capability of the query optimizer, called the automatic tuning optimizer. The automatic tuning optimizer is exposed to the database administrator 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 invoke the SQL Tuning Advisor to recommend the optimal tuning solution. It is important to bear in mind that the solution is coming right from the optimizer and not from external tools that use pre-defined heuristics.

The recommendation of the automatic tuning optimizer can fall into one of the following categories:

Category	Details
Statistics Analysis	Checks each query object for statistics and recommends to gather them if they are missing or stale.
SQL Profiling	The automatic tuning optimizer builds a SQL profile using auxiliary information, such as customized optimizer settings or past execution history, and generates a recommendation to create the SQL profile. The most powerful aspect of SQL profiles is that they enable transparent tuning of queries without requiring any application changes to allow Oracle administrators to tune SQL 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	Identifies poorly written SQL statements that lend themselves to bad plans, and makes relevant recommendations to restructure them.

The SQL Tuning Advisor also runs automatically during the system maintenance windows as a maintenance task. In each run, it automatically selects high-load SQL queries in the system and generates recommendations for tuning them.

To validate a recommendation, SQL Tuning Advisor in Oracle Database 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. The SQL Tuning Advisor can be configured to automatically implement SQL profile recommendations for SQL statements where the performance improvement would be at least three-fold.

The SQL Tuning Advisor in Oracle Database 12*c* has been enhanced to seamlessly support tuning at both the CDB and PDB level. Starting Oracle Database 12*c*, the SQL Tuning Advisor is also CDB aware. It can be successfully used in the root container to tune queries across PDBs. However PDB administrators can also use the SQL Tuning Advisor to tune queries for their PDBs.

SQL Access Advisor

The SQL Access Advisor is another major component of Oracle Database manageability. The SQL Access Advisor takes a database workload as its input and recommends adding various access structures. While generating recommendations, the SQL Access Advisor considers the impact of adding new indexes, materialized views or materialized view logs etc. on data manipulation activities, such as insert, update and delete, in addition to the performance improvement they are likely to provide for queries.

The partition advisor, which has been part of the SQL Access Advisor since Oracle Database 11*g*, has been enhanced in Oracle Database 12*c*. Along with advice on range, interval and hash based partitions, the partition advisor can now also recommend list based partition schemes.

Real Time SQL Monitoring

Part of Real-Time performance analysis involves examining the execution details of an in flight query determine why a query is taking a long time to run. Traditionally, this analysis has been done using reactive methods like SQL tracing, but the addition of Real Time SQL Monitoring enables you to monitor 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 initiated 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. SQL monitoring gives the DBA information on what steps long running SQL are executing and allows the DBA to decide if additional tuning is required.

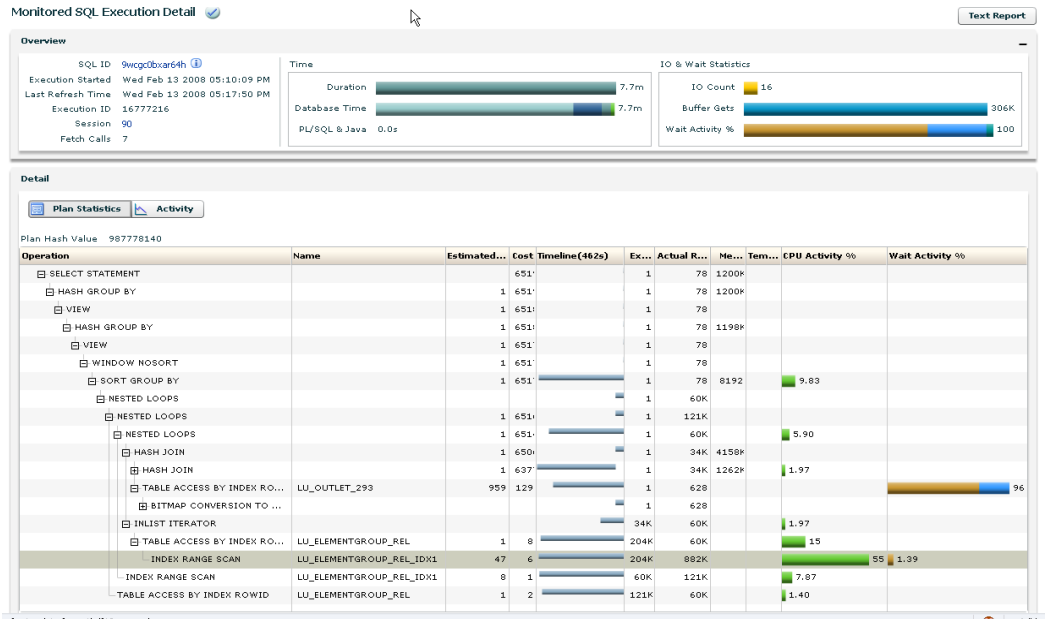

Figure 2: Real Time SQL Monitoring execution plan

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

Database Operations Monitoring

While Real-Time SQL monitoring allowed the DBA to monitor individual SQL and PL/SQL statements, there was no way to tie them to business operations. Real-Time Database Operations Monitoring, a new feature in Oracle Database 12*c*, combines the capability to monitor both SQL and PL/SQL with the ability to monitor long running database tasks such as batch jobs, ETLs etc. as a composite business operation. Live visual displays track the progress of SQL and PL/SQL queries associated with the business operation being monitored. Developers or DBAs can define business operations for monitoring by explicitly specifying the start and end of the operation or implicitly through the use of tags that identify the operation. With negligible overhead compared to SQL trace, Database Operations Monitoring can be used to proactively monitor critical business transactions automatically without any DBA intervention.

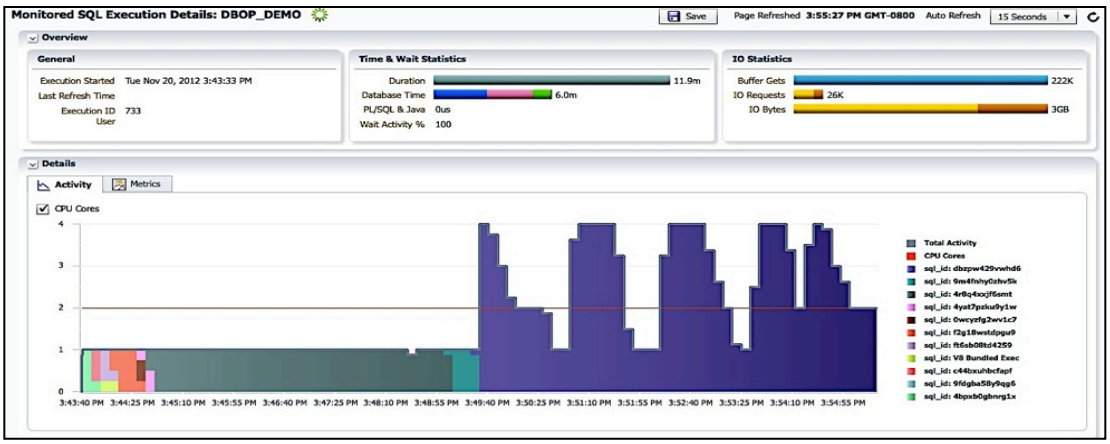

Figure 3: A Real-Time Database Operations Monitoring Report

Real-Time SQL Monitoring in Oracle Database works at the CDB as well as at the PDB level.

Performance Hub

Oracle Enterprise Manager Database Express includes Performance Hub, a completely new unified interface for performance monitoring. It is the single pane of glass view of database performance with access to ADDM, SQL Tuning, Real-Time SQL Monitoring and ASH Analytics (features discussed in detail below) under the same hood. A flexible time picker allows the administrator to seamlessly switch between Real-Time and Historical views of database performance. For Oracle RAC databases, there is an additional RAC tab that allows the database administrator to monitor cluster related performance problems.

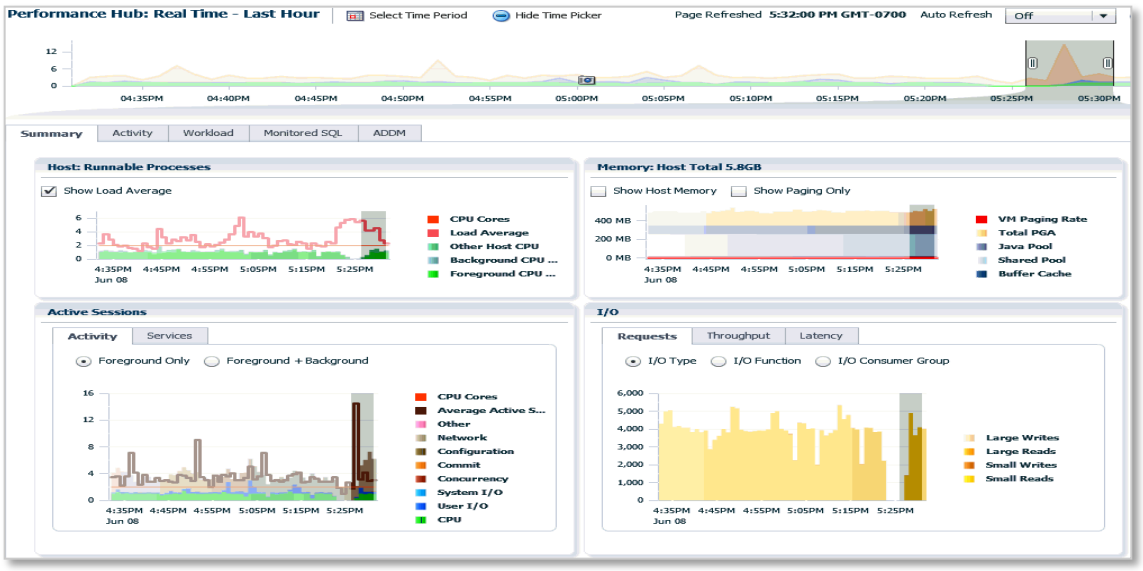

Figure 4: Performance Hub

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. Various changes can affect SQL performance, such as a 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.

SQL plan baselines evolve over time to produce better performance. During the SQL plan baseline evolution phase, Oracle Database 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.

Testing and Test Data Management

Oracle Enterprise Manager's Application Quality Management (AQM) solutions provide high quality testing for all tiers of the application stack. Thorough testing can help users identify application quality and performance issues prior to deployment. Testing is one of the most challenging and time consuming parts of successfully deploying an application, but it is also one of the most critical to the

project's success. The testing and secure test data management capabilities in Oracle Enterprise Manager provide a unique combination of test capabilities for Oracle Databases which enable users to:

- Test infrastructure changes: Real Application Testing is designed and optimized for testing database tier infrastructure changes using real application production workloads to validate database performance in your test environment.
- Manage your test data and enable secure production-class testing: Oracle Data Masking and Oracle Test Data Management solutions help enterprises achieve security and compliance objectives by obfuscating sensitive data in test databases and scaling down production data into right-sized databases so production data can be used securely in test and development environments.

Response Time Testing using 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.

SPA 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. SPA 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.

SPA is well integrated with existing SQL Tuning Set (STS), SQL Tuning Advisor and SQL plan management functionality. SPA 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 SPA, 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 SPA include:

- Database upgrade, patches, and 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

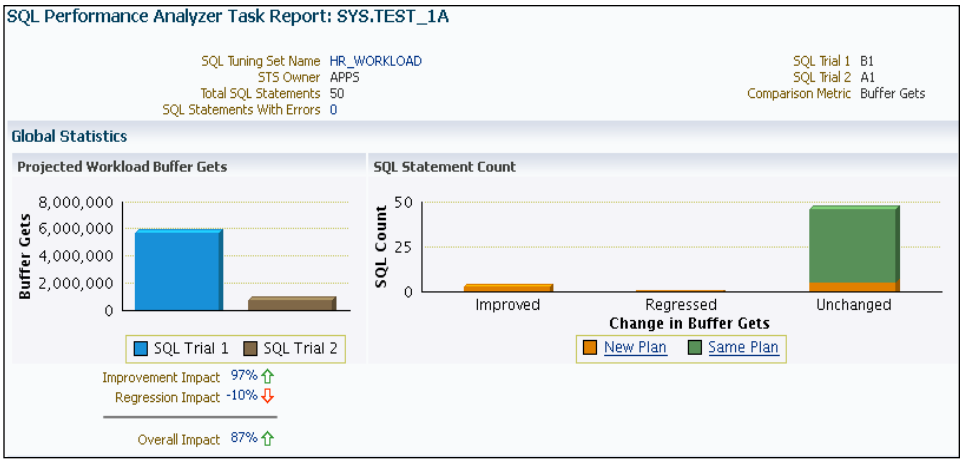

Figure 5: SQL Performance Analyzer Report

This SPA comparison report shows significant performance improvement of overall SQL workload after the proposed system change but with a few execution plan regressions. If any regressions are encountered, SPA allows the user to fix them using SQL Tuning Advisor or with SQL plan baselines.

Throughput Testing using 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, initialization parameter changes, schema changes, etc.
- Configuration changes such as conversion from a single instance to Oracle RAC, ASM, etc.
- Storage pool, network, and interconnect changes
- Operating system and hardware migrations, patches, upgrades, and 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.

Consolidation Testing using Consolidated Database Replay

New in Oracle Database 12*c*, Database Replay supports simultaneous execution of multiple database captures on a single consolidated database. The consolidated database can be a CDB with Oracle Pluggable Databases or a traditional database consolidated using schema consolidation methods. Replaying multiple workloads against a consolidated database gives assurance that the target platform can support the workload. Database Replay supports captures from Oracle Database 9.2.0.8 and above. Database Replay can be executed on Oracle Database 11.1 and above. Consolidated Database Replay can be executed on Oracle Database 11.2.0.2 and above. The captures for Database Replay are platform agnostic and can be replayed on any supported operating system.

In addition, Consolidated Database Replay supports scheduling of the individual replays enabling investigations of various workload scenarios.

Database Replay Workload Scale-Up

Database Replay also supports the creation of new workloads based on existing captured workloads. The new workloads can be used for capacity planning and validation of various what-if workload scenarios. Three techniques that can be used with Database Replay to validate consolidation include Workload Folding, Time Shifting and Schema Remapping.

The first of these techniques is Workload Folding. Workload subsetting can be used to compose new workloads. Existing captures can be divided into two smaller workloads by slicing an existing captured workload into subsets by specifying a point in time within the captured duration. Then you can double the workload by folding the workload along this specified point-in-time. This is done by submitting simultaneous replays of the subset workloads on the target database, which effectively doubles the workload without the need to use scripting or supplying binds. This technique is suitable for applications where individual transactions are mostly independent of each other.

Another scale-up technique is Time Shifting. You can schedule multiple database replays so that their peak database utilizations are aligned. This allows you to see if your target consolidated system can handle the maximum production workload from your current production systems.

Database Replay also supports testing with schema duplication. You can duplicate your target schema and run multiple replays of the same workload. Before running these multiple replays, you remap users so that each replay goes against its separate schema, avoiding workload collisions. Schema duplication allows you to test multiple scales of the current workload, maintaining the exact workload profile and concurrency. This is useful in scenarios such as schema as a service (SaaS) or where each line of business has its own schema.

Administrators can leverage the provisioning capabilities in Oracle Enterprise Manager to roll out pre-tested, standardized gold images of Oracle Database. This provides administrators with tremendous

labor savings instead of having to execute each step of the provisioning process manually. These gold images can be used to provision test systems from backups or live production databases.

When enterprises copy production data into test 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.

Real Application Testing and Data Masking integration enables businesses to perform secure testing. Typically testing is done in a non-production environment or by a different group or organization. Sharing production data and/or the captured workload that contains sensitive information can result in breach of data privacy regulations and poses significant business risk. Real Application Testing and Data Masking integration enables sharing of captured workload and data in the database in compliance with data privacy regulations.

At-Source Masking

Traditionally, sensitive and regulated information is obfuscated for non-production use outside of production environment. This technique required system administrators to isolate and fence off the cloned environment until all sensitive data had been scrubbed and then shared. As a consequence, setting up this environment took away limited key resources from productive use in addition to the added vulnerability. With the latest release of Oracle Enterprise Manager, customers can now take advantage of masking at the source without requiring a dedicated environment. Production data can be extracted and masked and kept in masked exported. These files can be shared directly with non-production environments without affecting production data. Hence sensitive production data never leaves production environments.

Reducing Storage Costs with Data Subsetting

With the growth in the number of database applications, enterprises are faced with the challenge of provisioning non-production environments that are used for application development and testing. They cannot afford to incur the storage expenses of provisioning the same production data in their non-production databases; nor do they have the tools or the application knowledge to shrink production data to a right-sized development environment. Oracle's test data management functionality helps enterprises shrink storage costs by creating reduced size copies of production data for application development and testing while maintaining the referential integrity of the data set. Through data discovery and application modeling, Oracle's test data management functionality automatically enforces complex business rules of enterprise applications resulting in accurate subsets of production data.

Integrated Data Masking and Data Subsetting

With rapidly growing data volumes and the frequency of refreshing non-production environments such as QA, test or development, implementing an efficient, highly performing data security solution becomes a paramount challenge.

The latest release of Data Masking Pack addresses this challenge by integrating the capabilities of Data Subsetting and Data Masking. This integration allows enterprises to provision a secure and reduced size test system directly from a production database without the need for a full production database copy. Enterprises may choose to execute the masking or subsetting operations (or both) to provision a non-production database in a single workflow from production without affecting production data.

These capabilities eliminate the need for a full copy of the production database that could incur significant storage costs and ensures that the sensitive data never leaves production.

Ongoing Administration

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

Resource Management

Automating resource management tasks, such as managing memory allocation and disk resources, has been another key achievement of the self-managing database. Let's examine these tasks in more detail.

Automatic Memory Management

One of the key self-management enhancements in Oracle Database 11*g* has been automatic memory management. This functionality automates the management of shared memory used by an Oracle instance and liberates administrators from manually configuring the shared memory components. The automatic memory management feature is based on sophisticated heuristics internal to Oracle Database that monitors the memory distribution and changes it according to the demands of the workload.

All memory, PGA and SGA, is now managed centrally with the automatic memory management feature. DBAs specify a single parameter, MEMORY_TARGET, and Oracle Database automatically sizes the PGA and SGA based on the workload. Using indirect memory transfer, Oracle Database transfers memory from SGA to PGA and vice versa to respond to the load.

Space Management

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

Proactive Space Management

Starting with version 11*g*, the Oracle Database does non-intrusive and timely monitoring checks for space utilization in the database server. Oracle Database'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 in the database server, space usage information is guaranteed to be available whenever the user needs it.

Transparent Space Reclamation

Oracle Database can perform an in-place reorganization of data for optimal space utilization by shrinking segments. Shrinking of a segment makes 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 de-allocate it from the segment. The de-allocated space is returned to the tablespace and is available to other objects in the tablespace. 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. In order to easily identify candidate segments for shrinking, Oracle Database also includes an automatic segment advisor that runs every night in a predetermined maintenance window to proactively identify segments that should be shrunk.

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 the Oracle Database, when creating non-partitioned 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

Oracle Database 11*g* table compression is completely transparent to applications. A compression advisor built into the Oracle Database facilitates choosing the correct compression level for your data. As part of the existing advisor framework in Oracle Database 11*g*, the compression advisor analyzes the objects in the database, discovers the possible compression ratios that could be achieved, and recommends optimal compression settings.

Exadata Management and Cloud Consolidation

As enterprises increasingly look to consolidate their disparate databases onto the Oracle Exadata infrastructure, Oracle Enterprise Manager Cloud Control 12*c* can help administrators manage the Exadata Database Machine using a holistic approach and can provide comprehensive lifecycle management from monitoring to management and ongoing maintenance for the entire engineered system.

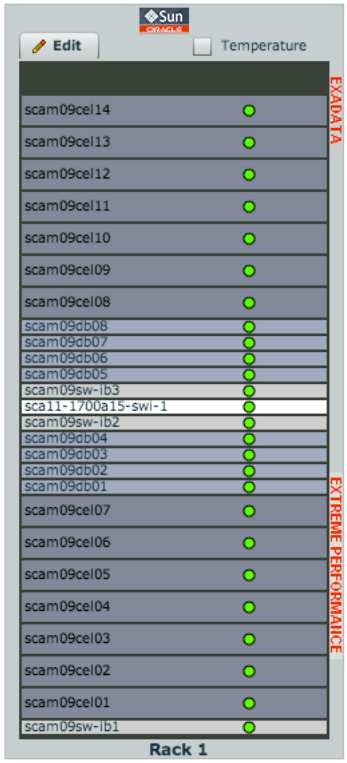

Figure 6: Exadata Schematic

Integrated System Monitoring

Oracle Enterprise Manager provides comprehensive monitoring and notifications to enable administrators to proactively detect and respond to problems with Oracle Exadata Database Machine and its software and hardware components. Administrators can easily adjust these monitoring settings to suit the needs of their datacenter environment. When notified of these alerts, administrators can easily view the history of alerts and associated performance metrics of the problem component, such as the network performance of an Infiniband port or the disk activity of an Exadata storage cell, to identify the root cause of the problem. Oracle Enterprise Manager Cloud Control 12*c* allows complete management and monitoring of the Exadata Storage Server, Infiniband Switches, Cisco Switch, KVM, PDU and ILOMs.

With direct connectivity into the hardware components of Exadata, Oracle Enterprise Manager can alert administrators to hardware-related faults and log service requests automatically through integration with Oracle Automatic Service Requests (ASR) for immediate review by Oracle Support.

Problems that would have required a combination of database, system and storage administrators to detect in traditional systems can now be diagnosed in minutes because of integrated systems monitoring for the entire Exadata Database Machine.

Fault Diagnostics

Oracle Database 11*g* 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 11*g* aims to provide the following benefits:

- Responding proactively to problems and prevent catastrophic system failure by alerting DBAs using health checks.
- Limiting damage and repair and interruptions after a problem is detected using the Data Recovery and SQL Repair Advisor.
- Reducing problem diagnostic time through ADR and Test Case Builder.
- Simplifying customer interaction with Oracle Support using the Incident Packaging Service (IPS) and Oracle Configuration Support Manager.

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

Automated Health Checks

A health checker framework exists in the Oracle Database 11*g* for the purposes of performing proactive checks on system health.

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

The Automatic Diagnostic Repository (ADR) is a file-based repository for database diagnostic data such as traces, dumps, the alert log, health monitor reports, and more. The diagnostic data in the 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. The V$DIAG_CRITICAL_ERROR view lists all of the non-internal errors designated as critical errors for the current Oracle Database release. In Oracle Database 12*c* there is a separate debug log, which is a file that records these warnings. The debug log has the same format and basic behavior as the alert log, but it only contains information about possible problems that might need to be corrected. The debug log reduces the amount of information in the alert log and trace files. It also improves the visibility of debug information. The debug log is included in IPS incident packages, and its contents are intended for Oracle Support. The alert log and the trace files are streamlined. They now contain fewer warnings of the type that are recorded in the debug log. In Oracle Database 12*c*, a separate DDL log is now created only for the RDBMS component if the ENABLE_DDL_LOGGING initialization parameter is set to TRUE. The DDL log contains one log record for each DDL statement issued by the database. The DDL log is included in IPS incident packages.

Incident Packaging Service

The Incident Packaging Service automates the process of collecting all necessary diagnostic data related to one or more problems.

Support Workbench

The Support Workbench is a facility in Oracle Enterprise Manager that enables you to interact with the fault diagnostic infrastructure of the Oracle Database. 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.

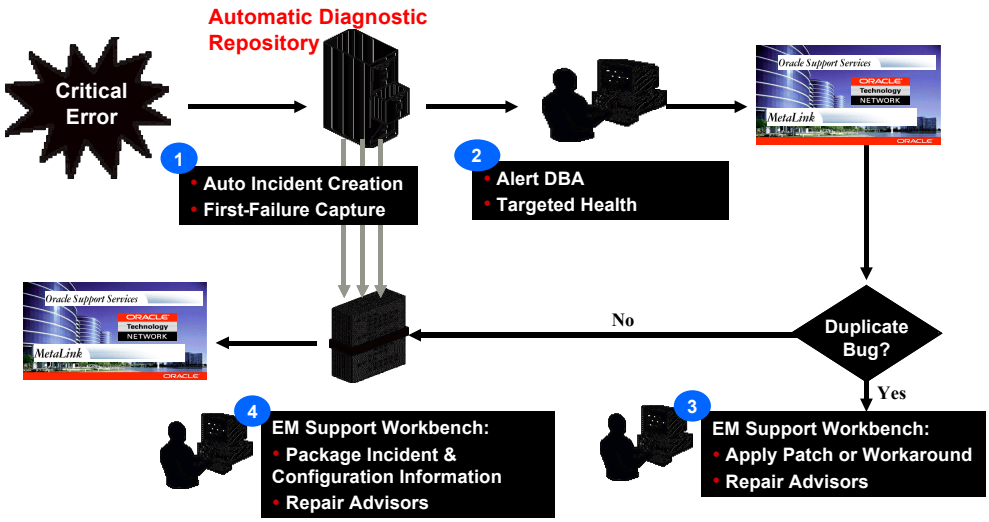

Figure 7: Support Workbench Workflow

What does it mean to you?

Change and consolidation are 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 manageability features in Oracle Database 12*c* managed using Oracle Enterprise Manager Cloud Control 12*c*, database administrators can keep their systems performing well and available while providing a higher quality of service to their users through testing and consolidation.

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 12*c* 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 12*c* managed by Oracle Enterprise Manager Cloud Control 12*c* offers next-generation database management for the next-generation DBA.

Manageability with Oracle Database 12c
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