18c ORACLE Database

Database Manageability

With Oracle Database 18*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 18*c*. The built-in features of Oracle Database 18*c* cater to data center environments that are rapidly evolving and continuously changing to keep up with the demands of consolidation and cloud computing. In addition, building on its industry-leading self-managing capabilities, Oracle Database 18*c* has made significant advances in the areas of manageability, testing, and fault diagnostics that address many of the top challenges facing businesses today. Oracle Database is now also available in the Oracle Database Cloud Service and it is 100% compatible with those deployed on-premise, while supporting an efficient Hybrid Cloud strategy for a smooth transition to the Cloud.

Oracle Enterprise Manager 13c streamlines and automates complex management tasks across the complete cloud lifecycle. On-premise administrators can monitor and manage public cloud services, and vice versa through a single pane of glass. Oracle Database Cloud services are managed by the same Oracle Enterprise Manager tools that customers use for on-premise to monitor, provision, and maintain the entire Oracle eco-system including a variety of third-party systems. These include Oracle Databases, Engineered Systems, Oracle Applications, Oracle Middleware, and a variety of third-party plug-ins and connectors. This strategy eliminates the costly consequences of purchasing and learning numerous new tools to manage enterprise hybrid clouds.

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:

- Database 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. How to use existing tools to monitor, manage, and tune database services on the Cloud.
- Cloud consolidation and Exadata management: How to consolidate databases onto a common infrastructure to reduce data center costs and increase server efficiency. How to estimate required compute resources when consolidating on-premise or to Cloud.

To address these challenges, Oracle Database 18c has been significantly enhanced in the areas of performance, change assurance, and Cloud support to make it easier to manage than ever before.

Performance Management and Application Tuning

Performance management has traditionally been a major challenge for database administrators. Oracle Database 18c 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

1. Persistent performance problems
2. Transient performance problems
3. Comparative performance problems
4. Real-Time performance problems

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.

Manageability Solutions

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 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, be it on-premise or cloud.

Enterprise Manager Cloud Control now provides you with a single pane of glass for monitoring and managing on-premise, Oracle Cloud, and Oracle Cloud Machine deployments, all from the same management console.

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 12c Release 2 to better support Multitenant architecture by allowing per PDB snapshot control and reporting. Additionally, the ability to monitor Active Data Guard (standby) database workload, and persisting reports such as for Real-Time SQL Monitoring, Real-Time ADDM and Database Operations Monitoring automatically makes the task of performance diagnostics significantly easier for the DBA.

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 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. As a result, the DBAs now have all the performance data they need for analysis at their fingertips for all their critical databases for all time.

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 Oracle Database 18c and Multitenant architecture, ADDM recommendations include the associated pluggable database (PDB) where the issue has been detected to pinpoint the impacted database.

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 can potentially result 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 contention, 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.

Compare Period ADDM

Database administrators are often required to investigate why performance of one time period is slower than a similar time-period. Such comparative performance problem investigation is often very time consuming and usually leads to inconclusive results.

Compare Period ADDM makes these investigations very 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 second 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.

Adaptive Thresholds can be used in two ways to help administrators set threshold values for metrics. The first method involves fully employing Adaptive Thresholds and letting Enterprise Manager set thresholds automatically based on settings within the tool. The second method allows end users to see the values Enterprise Manager recommends in a manual mode without automatically updating the thresholds.

Setting threshold values for Key Performance Indicators for an Exadata system can be time consuming and difficult. This is especially true in situations where administrators have new system types or are responsible for setting up monitoring for systems for which they are not directly responsible. By using the adaptive thresholds methodology, administrators can determine thresholds in a quick, easy and accurate manner

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 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. When the data is written to disk 1 out of every 10 samples is written to minimize the footprint on disk. 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 13c includes ASH Analytics, a 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. The ASH Analytics pages are also available in Oracle Enterprise Manager Database Express and are accessible from the Performance Hub, which provides a consolidated view of all performance data for a given time range.

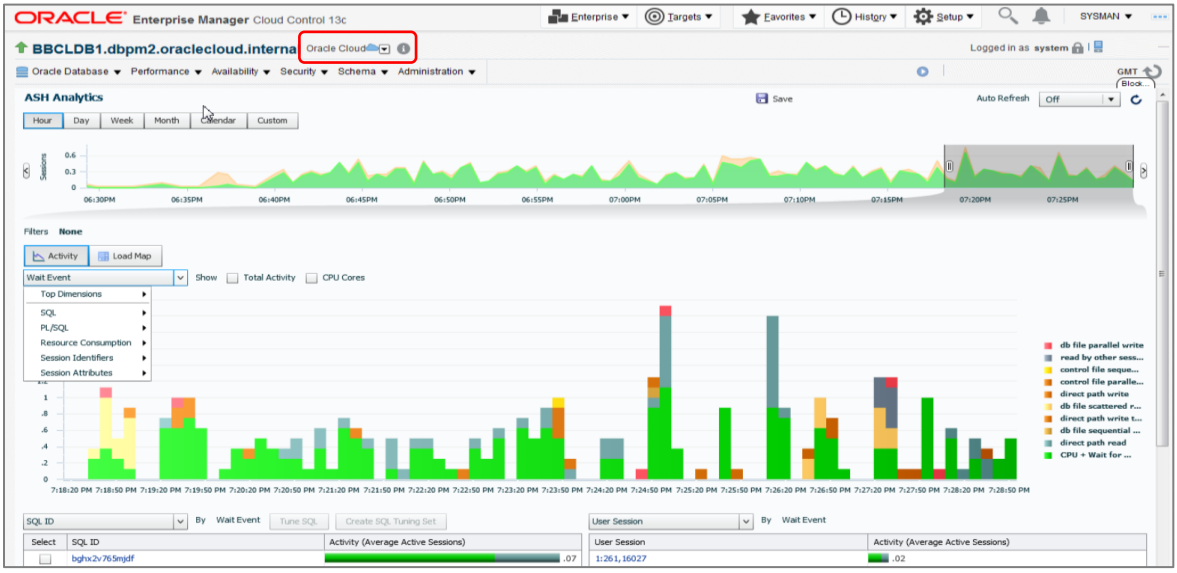

Figure 1: ASH Analytics

For Oracle Database 12c 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.

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.
Alternative Plan Analysis	While tuning a SQL statement, SQL Tuning Advisor searches real-time and historical performance data for better alternative execution plans for the statement. If plans other than the original plan exist, then SQL Tuning Advisor reports an alternative plan finding.

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.

SQL Tuning Advisor functionality in Oracle Database 18c has been enhanced to seamlessly support tuning at both the CDB and PDB level. SQL Tuning Advisor is CDB-aware, it can be successfully used in the root container to tune queries across PDBs. At a same time, PDB administrators can also use the SQL Tuning Advisor to tune queries for their individual PDBs. Oracle Database 12c Release 2 introduces the ability to tune SQL workload running on Active Data Guard (standby) databases.

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 11g, has been enhanced in Oracle Database 12c. 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 to 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.

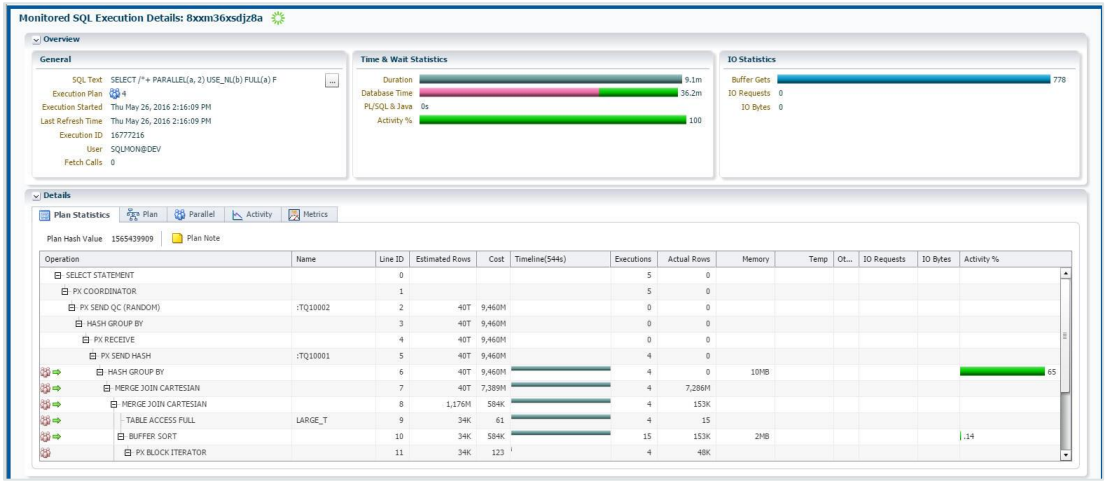

Figure 2: Real Time SQL Monitoring execution plan

In addition to being able to monitor SQL and PL/SQL statements in real time in Oracle Database 18c 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. Real-Time SQL Monitoring in Oracle Database works at the CDB as well as at the PDB level.

Database Operations Monitoring

While Real-Time SQL monitoring allows the DBA to monitor individual SQL and PL/SQL statements, there previously was no way to tie them to business operations. Real-Time Database Operations Monitoring, a new feature in Oracle Database 12c, 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.

Oracle Database 18c supports enabling Database Operations Monitoring for already running sessions, this helps avoid restarting sessions to get performance diagnostic information for trouble shooting purposes.

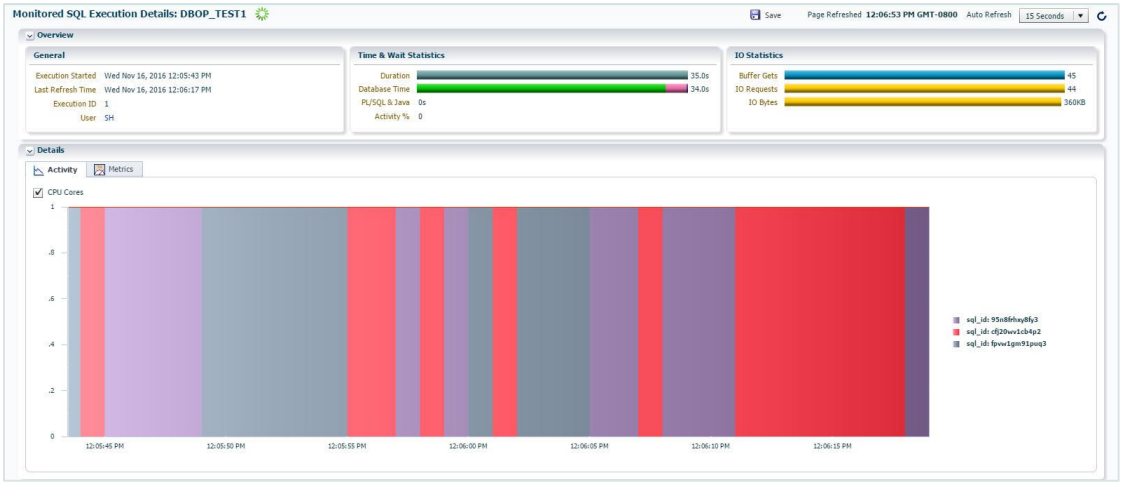

Figure 3: A Real-Time Database Operations Monitoring Report

Performance Hub

Database Performance Hub, a completely new unified interface for performance monitoring is available through Oracle Enterprise Manager Database Express (discussed below) and Database server API. 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 above) 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 Exadata Cloud databases, there is an additional Exadata tab that allows the database administrator to monitor the related performance problems.

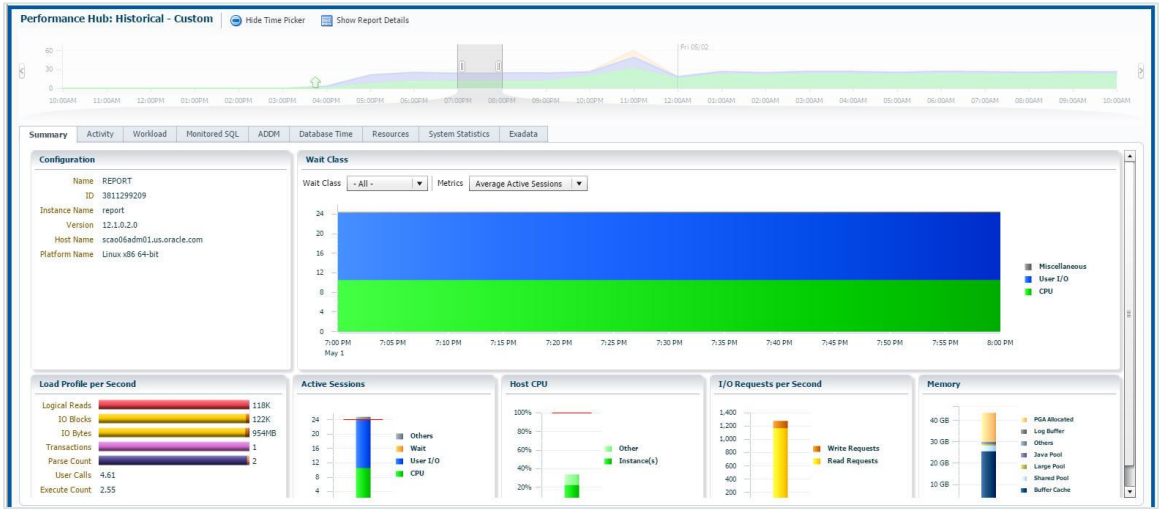

Figure 4: Performance Hub

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.

Oracle Enterprise Manager Database Express

Oracle Database 18c 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) and Oracle Database Cloud Services. 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.

Oracle Enterprise Manager Database Express has been enhanced in Oracle Database 12c Release 2 to include extensive support for resource manager and SQL Performance Analyzer. The support for Database Resource Manager includes the ability to easily create, manage and monitor resource plans over time in the database. Support for SQL Performance Analyzer includes support for both SPA Quick Check and standard SPA.

Real Application Testing

Real Application Testing offers an extremely cost-effective and easy-to-use risk free administration tool that enables businesses to fully assess the outcome of a system change in a production or a test environment, take any corrective action if necessary, and then to introduce the change safely to production systems, minimizing the undesirable impact on them. This approach reduces risk. Real Application Testing offers SQL Performance Analyzer (SPA), SPA Quick Check, Database Replay and Consolidated Database Replay. These features together provide customers a comprehensive and flexible risk free administration solution that significantly mitigates business risk, reduces testing costs and future-proofs database infrastructure.

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 as SQL Plan 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:

- Cloud and Exadata migration
- 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

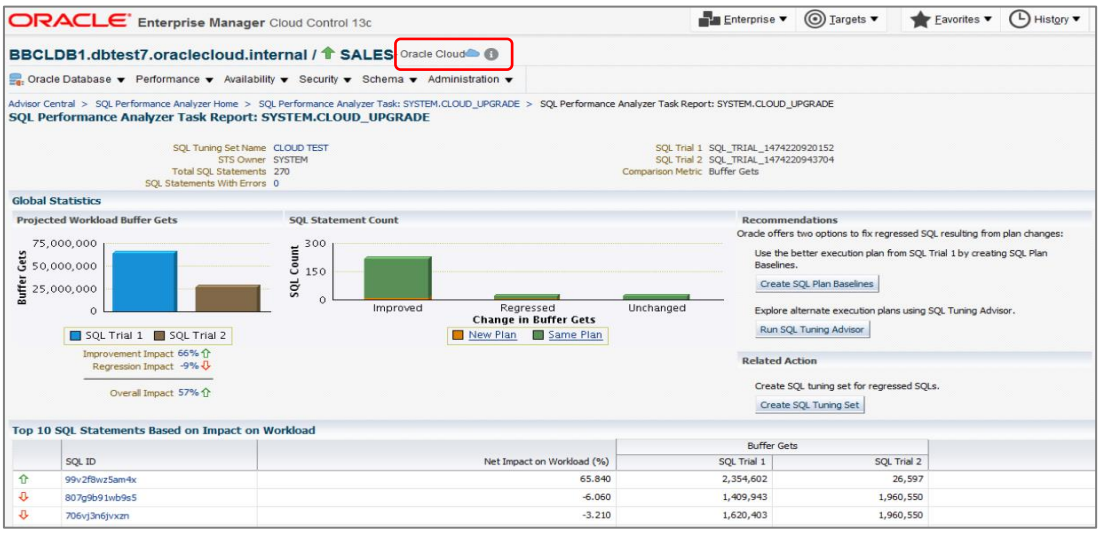

Figure 5: SQL Performance Analyzer Report

This SPA comparison report shows significant performance improvement of overall SQL workload after the proposed migration to the Oracle Database Cloud Services, 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.

SPA Quick Check: Optimized for use on production systems

SPA Quick Check feature, a new enhancement to Real Application Testing, allows customers to easily and quickly validate system changes directly on production databases. It is available starting from Oracle Enterprise Manager 12c Database Plug-in (12.1.0.5) and supports all Oracle Databases Releases 11.2 and above. SPA Quick Check supports scoped and change-aware intelligent workflows allowing administrators to verify routine DBA tasks like optimizer statistics gathering and init.ora parameter changes with a single click of a button. It is highly optimized and resource controlled making it viable to test directly on production.

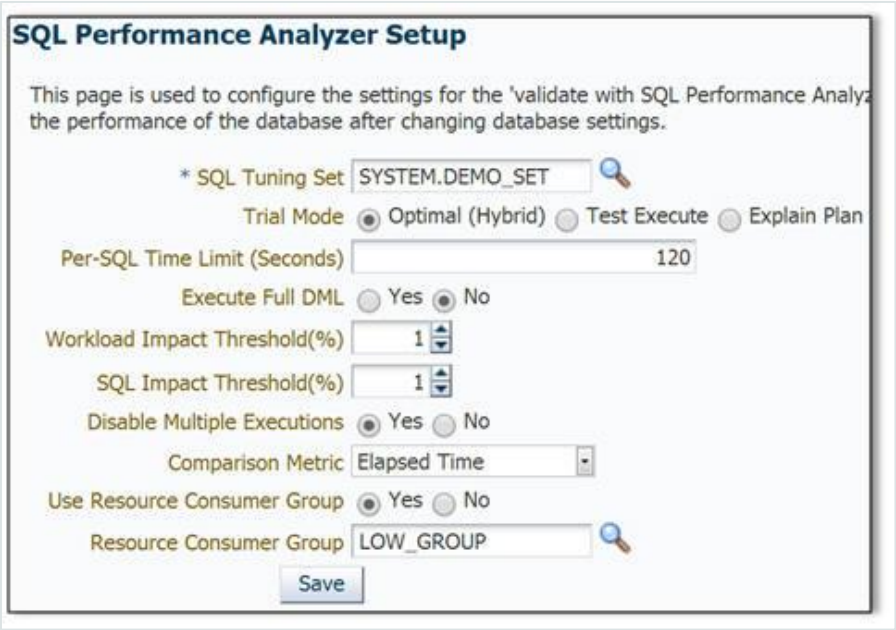

Figure 6: SPA Quick Check Setup

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.

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 12c, 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 works with supports all supported Oracle Database versions. 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.

Test Database Provisioning

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.

Enhanced PL/SQL Support

In Oracle Database 12c Release 2, Database Replay has enhanced support for long running PL/SQL packages. Database Replay always captured and replayed top-level PL/SQL calls, which results in accurate and complete replays in almost all cases. In Oracle Database 12c Release 2, the option has been added to either capture and replay the top level PL/SQL calls, or to capture and replay the individual SQL issued within those PL/SQL blocks. In some special cases, capturing and replaying the recursive SQL can produce a more correct and higher quality replay.

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 11g 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 11g, 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 18c table compression feature 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 18c, 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 either on-premise or Oracle Exadata cloud, Oracle Enterprise Manager Cloud Control 13c 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. Enterprise Manager 13c offers out of the box integration to provide single pane of management across on-premise and cloud services.

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 13c allows complete management and monitoring of the Exadata Storage Server, Infiniband Switches, Cisco Switch, KVM, PDU and ILOMs. In Oracle Enterprise Manager 13c, some of the important hardware management features have been tightly integrated and thus enables to have a more sophisticated management like monitoring open incidents, resource utilization and metrics for a specific component by making them available in a dashboard. The information appears in graphs, tables, charts, schematic, and photo-realistic views to help you to quickly understand the status and relationships between components. Exacheck configuration audit check feature is now integrated into the Compliance framework of Enterprise Manager 13c and can be helpful to generate automated notifications and reports for any violation in Exadata configurations.

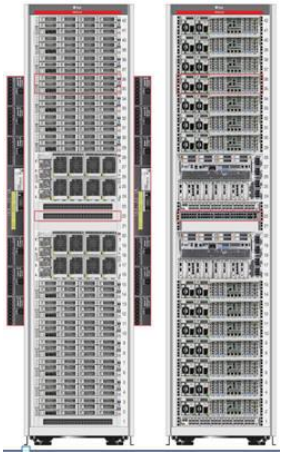

Figure 7: Enhanced Exadata schematic with a photorealistic view

Fault Diagnostics

Oracle Database includes an advanced fault diagnosability infrastructure for collecting and managing diagnostic data. Diagnostic data includes the trace files, dumps, and core files that are also present in previous releases, plus new types of diagnostic data that enable customers and Oracle Support to identify, investigate, track, and resolve problems quickly and effectively.

The goals of the fault diagnosability infrastructure are the following:

- First-failure diagnosis
- Problem prevention
- Limiting damage and interruptions after a problem is detected
- Reducing problem diagnostic time
- Reducing problem resolution time
- Simplifying customer interaction with Oracle Support

The keys to achieving these goals are the following technologies:

- Automatic capture of diagnostic data upon first failure—for critical errors, the ability to capture error information at first-failure greatly increases the chance of a quick problem resolution and reduced downtime. An always-on memory-based tracing system proactively collects diagnostic data from many database components, and can help isolate root causes of problems. Such proactive diagnostic data is similar to the data collected by airplane "black box" flight recorders. When a problem is detected, alerts are generated and the fault diagnosability infrastructure is activated to capture and store diagnostic data. The data is stored in a repository that is outside the database (and therefore available when the database is down), and is easily accessible with command line utilities and Oracle Enterprise Manager Cloud Control (Cloud Control).

- Standardized trace formats—Standardizing trace formats across all database components enables DBAs and Oracle Support personnel to use a single set of tools for problem analysis. Problems are more easily diagnosed, and downtime is reduced.
- Health checks—Upon detecting a critical error, the fault diagnosability infrastructure can run one or more health checks to perform deeper analysis of a critical error. Health check results are then added to the other diagnostic data collected for the error. Individual health checks look for data block corruptions, undo and redo corruption, data dictionary corruption, and more. As a DBA, you can manually invoke these health checks, either on a regular basis or as required.
- Incident packaging service (IPS) and incident packages—The IPS enables you to automatically and easily gather the diagnostic data—traces, dumps, health check reports, and more—pertaining to a critical error and package the data into a zip file for transmission to Oracle Support. Because all diagnostic data relating to a critical error are tagged with that error's incident number, you do not have to search through trace files and other files to determine the files that are required for analysis; the incident packaging service identifies the required files automatically and adds them to the zip file. Before creating the zip file, the IPS first collects diagnostic data into an intermediate logical structure called an incident package (package). Packages are stored in the Automatic Diagnostic Repository. If you choose to, you can access this intermediate logical structure, view and modify its contents, add or remove additional diagnostic data at any time, and when you are ready, create the zip file from the package. After these steps are completed, the zip file is ready to be uploaded to Oracle Support.
- Data Recovery Advisor—The Data Recovery Advisor integrates with database health checks and RMAN to display data corruption problems, assess the extent of each problem (critical, high priority, low priority), describe the impact of a problem, recommend repair options, conduct a feasibility check of the customer-chosen option, and automate the repair process.
- SQL Test Case Builder—For many SQL-related problems, obtaining a reproducible test case is an important factor in problem resolution speed. The SQL Test Case Builder automates the sometimes difficult and time-consuming process of gathering as much information as possible about the problem and the environment in which it occurred. After quickly gathering this information, you can upload it to Oracle Support to enable support personnel to easily and accurately reproduce the problem.

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.

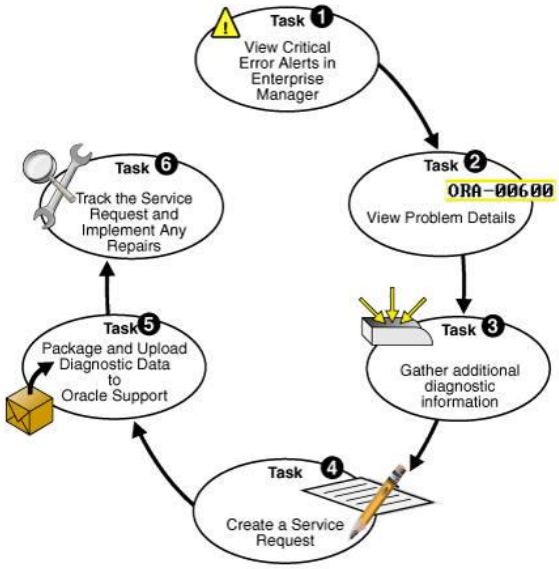

Figure 8: Workflow for Investigating, Reporting, and Resolving a Problem

What does it mean to you?

Change, consolidation and migration to Cloud are relentless in today's rapidly evolving IT environments, but it does not have to be difficult for data center managers and cloud administrators. Thanks to the manageability features in Oracle Database 18c managed using Oracle Enterprise Manager Cloud Control 13c, 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 18c 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 18c managed by Oracle Enterprise Manager Cloud Control 13c offers next-generation database management for the next-generation DBA.

Oracle Corporation, World Headquarters
500 Oracle Parkway
Redwood Shores, CA 94065, USA

Worldwide Inquiries
Phone: +1.650.506.7000
Fax: +1.650.506.7200

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