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# Oracle Database 12c: Real Application Testing Overview

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## Introduction

The Oracle database is the market-leader and the preferred database for hundreds of thousands of enterprises as well as application developers and database administrators worldwide. Over the years, enterprises have come to rely on the Oracle database to provide unparalleled performance and reliability. Oracle continues to raise the bar with Oracle Database 12c with extensive support for consolidation. Designed for data center environments that are rapidly evolving and changing to keep up with the demands of the business, Oracle Database 12c allows businesses to adopt new technologies quickly while minimizing risk.

## Real Application Testing

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

Oracle Database 12c Real Application Testing option addresses these issues head-on with two complementary solutions, SQL Performance Analyzer and Database Replay.

## SQL Performance Analyzer

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

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

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

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

- Database upgrade, patches, initialization parameter changes
- Configuration changes to the operating system, hardware, or database
- Schema changes such as adding new indexes, partitioning or materialized views
- Gathering optimizer statistics.
- SQL tuning actions, for example, creating SQL profiles
- Database consolidation testing using Oracle Multitenant Databases or schema consolidation methods

SQL Performance Analyzer functionality is available through DBMS\_SQLPA API and through Oracle Enterprise Manager interface. There are various custom workflows available through Enterprise Manager and the Guided Workflow encompasses all of them and provides complete control and flexibility at every step of the process. Using the SQL Performance Analyzer Guided Workflow involves the following 5 main steps:

1. Capture the SQL workload that you want to analyze with SPA. The Oracle database offers ways to capture SQL workload from several sources, such as cursor cache and Automatic

Workload Repository, into a SQL Tuning Set (STS). This would typically be done on a production system and the STS would then be transported to the test system where SPA analysis will take place.

2. Measure the performance of the workload before a change by executing SPA on the STS. Very short running queries are executed multiple times and their statistics are averaged to eliminate variations due to buffer cache state and other noise factors
3. Make the change, such as database upgrade or optimizer statistics refresh.
4. Measure performance of the workload after the change by executing SPA on the STS again, as in step 2.
5. Compare performance of the two executions of the SQL tuning set to identify the SQL statements that have regressed, improved, or were unchanged.

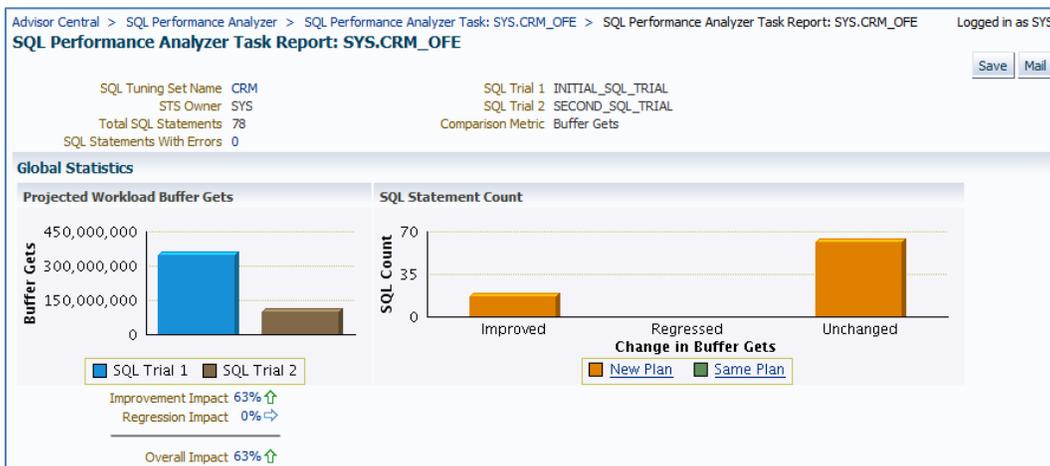


Figure 1. SQL Performance Analyzer report

The SPA comparison report in Figure 1 shows significant performance improvement of overall SQL workload after the proposed system change but with a few execution plan regressions. SQL Performance Analyzer takes into account the number of executions of a SQL statement when measuring its impact. A SQL statement that completes in seconds but is frequently executed may have a higher impact on the system than a long running statement executed only once. SPA takes these factors into account when predicting overall performance improvements and regressions. If any regressions are encountered, SPA allows the user to fix them using SQL Tuning Advisor or with SQL Plan Baselines, a plan stability feature introduced in Oracle Database 11g.

SPA Quick Check is an enhancement to SQL Performance Analyzer introduced in Enterprise Manager Cloud Control 12c Release 3, Plug-in Release 1 and can be used on Oracle database versions 11.2 and above.

SPA Quick Check enables verification of routine DBA operations that affect database performance on production databases with a single click of a button. SPA Quick Check runs SQL Performance Analyzer in an optimized mode that is suitable for running on production systems. In this mode, it uses minimal system resources by first identifying SQL with plan changes and then test-executing only those SQL, thereby consuming only a fraction of system resources. SPA Quick Check further limits unusual resource usage by placing run-time limits for each SQL and uses Resource Manager to ensure that only a limited amount of system resources are utilized by this task. All these optimizations make it possible to run SPA on production databases for routine DBA tasks such as optimizer statistics gathering, init.ora parameter changes, etc.

SPA Quick Check enables DBAs to run quick validations for any system change they are required to make to a database and helps improve quality of service of their mission critical databases.

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

1. SPA helps estimate the IO reduction that can be accomplished by migrating to Exadata server but without actually requiring you provision the hardware. This can be used to identify potential workloads/systems that are good candidates for Exadata migration.
2. SPA supports comparing the performance of two similar workloads or STSs – this functionality is useful when you have mechanisms such as load testing scripts or Oracle Application Testing Suite that can be used to test system changes. By capturing the workload in to two different STSs (for before and after change runs), one can use SPA to assess the impact of the system change.
3. With Oracle Enterprise Manager Cloud Control 12c, a “one-click” STS transport mechanism can be used to simplify the process of moving STS workloads and tuning artifacts such as SQL Profiles or Plan Baselines between production and test databases.
4. SPA supports testing of databases consolidated through Oracle Multitenant Databases or schema consolidation techniques.

## 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 traditional testing tools that rely on simulation can never duplicate. With Database Replay, DBAs and system administrators can test

- Database upgrades, patches, parameter, schema changes, etc.
- Configuration changes such as conversion from a single instance to RAC, ASM, etc.
- Storage, network, interconnect changes
- Operating system, hardware migrations, patches, upgrades, parameter changes
- Database consolidation testing projects using Oracle Multitenant Databases and schema consolidation
- Workload scale-up and custom load testing scenarios

### Lower test infrastructure cost

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

### Faster deployment

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

Database Replay consists of four main steps as illustrated in Figure 2 and described below:

#### 1. Workload capture

When workload capture is enabled, all external client requests directed to the Oracle Database are tracked and stored in binary files, called capture files, on the database server host file system. Oracle recommends taking a backup of the entire database prior to the workload capture. The user specifies the location of the capture files and the workload

capture start and end time. During this process, all information pertaining to external database calls is written to the capture files.

2. Workload processing

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

3. Workload replay

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

4. Analysis and Reporting

Extensive reports are provided to enable detailed analysis of the capture and replay. Any errors encountered during replay are reported. Any divergence in rows returned by DML or queries is shown. Basic performance comparisons between capture and replay are provided. For advanced analysis, Replay Compare Period and other AWR reports are available to allow detailed comparison of various statistics between capture and replays.

Both the workload capture and replay process support a filtering capability that is useful for targeting workload of interest, such as by service, action, module to name a few. Oracle Enterprise Manager Cloud Control 12c significantly enhances the value of Real Application Testing by supporting end-to-end Database Replay automation. This simplifies the process of saving and transferring the workload capture and performance data to test system, setting up the test system and replay clients correctly, and orchestrating the entire replay through the Cloud Control interface.

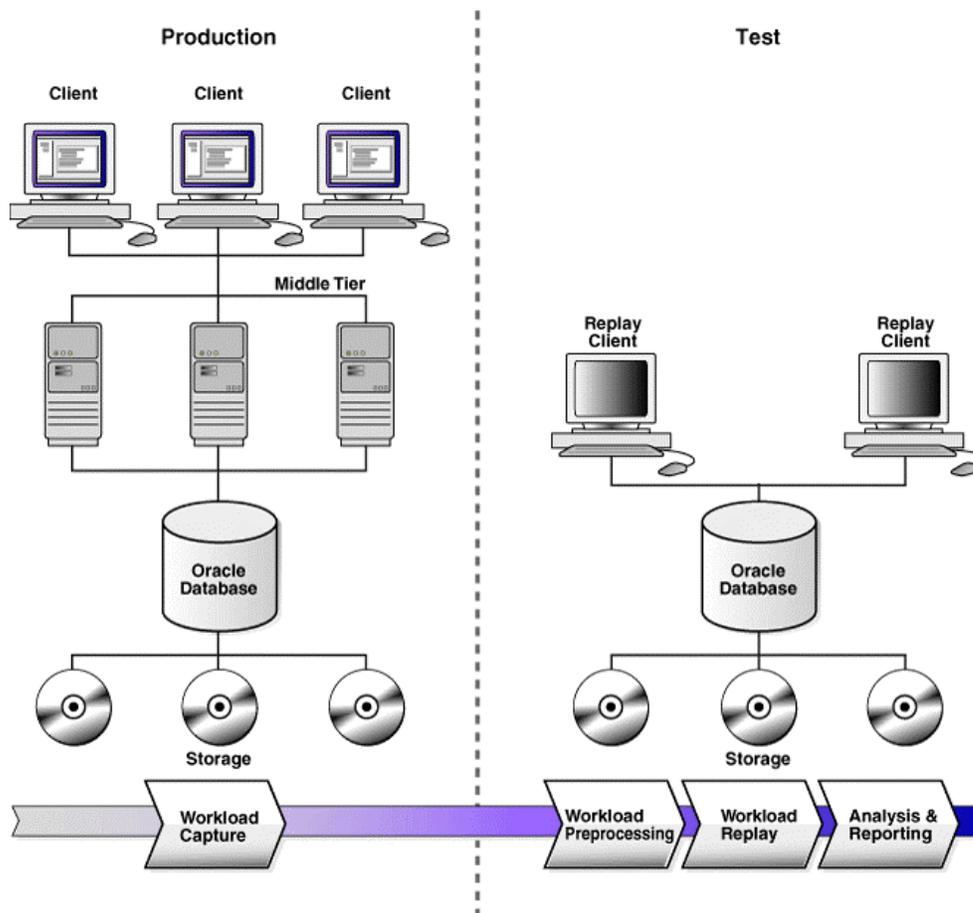


Figure 2. Database Replay Workflow

## 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 Multitenant database 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 any supported Oracle Database version. 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.

Figure 3 shows the result of a Consolidated Replay of two workloads.



Figure 3. Consolidated Replay of Two Workloads

## Database Replay Workload Scale-Up

Database Replay also supports creation of a 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. This 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.

Oracle Enterprise Manager Cloud Control 12c Release 3, Plug-in Release 1 provides a comprehensive and intuitive user interface for testing consolidation and capacity planning through support for workload subsetting, workload scheduling, and multitenant architecture. This enables businesses to future-proof their environment for growth and improve their SLAs.

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.

## Workload Intelligence

Workload Intelligence enables you to use the information stored in database capture files in additional ways, including the following:

- Analyze and model the workload
- Discover significant patterns and trends within the workload
- Visualize what was running on the production system during workload capture

Workload Intelligence enables you to better visualize what a captured workload looks like by exploring template patterns and the corresponding SQL statements. For each pattern, you can view important statistics, such as the number of executions of a given pattern and the database time consumed by the pattern during its execution. Some typical uses for Workload Intelligence are workload modeling and profiling. Workload Intelligence provides context for application optimization and performance tuning, identifies significant SQL statements, their patterns and workload impact.

### Which testing solution

Choosing the right testing solution helps DBAs absorb and manage change efficiently.

SPA helps DBAs improve SQL response time. SPA is the SQL unit test to validate that all of your individual SQL statements are performing optimally and should be used first in almost every testing environment.

Database Replay is designed to test and improve overall system performance. After SPA has validated the individual SQL performance, Database Replay should be used to ensure performance under full system load.

Consolidated Database Replay provides the ability to assure desired database performance for database consolidation projects, whether consolidating onto an Oracle Exadata machine, Oracle Database Appliance, Oracle Multitenant Databases or other consolidated infrastructure. Database Workload Scale-up and custom workload creation functionality enables you to future-proof your environment by making it possible to test the system under various what-if workload scenarios.

Real Application Testing makes it easy for database administrators to manage and execute changes that are critical to the business and do it all at lower risk.

## Conclusion

Change is relentless in today's rapidly evolving IT environments. But it doesn't have to be difficult for data center managers and administrators. Thanks to the Real Application Testing capabilities in Oracle Database 12c, database administrators can adapt to changes easily while eliminating any undesired side effects. . Numerous customers have already deployed Real Application Testing and benefited from greatly reduced cost and effort in testing target environments with enormous reductions in unplanned downtime. A Forrester research study determined that customers who have deployed Real Application Testing have a 224% risk adjusted ROI over a three year time frame with a payback period of 5.9 months.

Real Application Testing helps organizations lower their testing costs by giving DBAs and system administrators an easy-to-deploy solution for testing and rolling out data center changes with reduced hardware and software investments.



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