Oracle Real Application Testing:

Testing the SQL Performance Impact of an Oracle Database Release 10.2.0.x to 10.2.0.y upgrade using SQL Performance Analyzer

prabhaker.gongloor@oracle.com
pete.belknap@oracle.com
mark.rivkin@oracle.com

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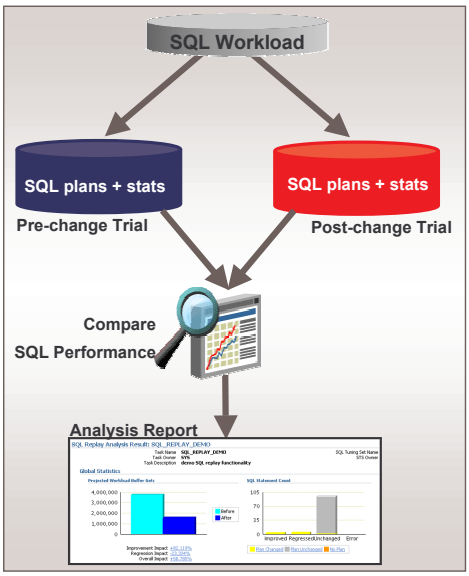
SQL Performance Analyzer: Concepts

- Helps users predict the impact of system changes on SQL workload response time
- Builds different trials (experiment) of SQL workload performance (i.e., SQL execution plans and statistics)
- Analyzes performance differences
- Offers fine-grained performance analysis on individual SQL
- Integrated with SQL tuning set, SQL plan baselines, and SQL tuning advisor to form an End-to-end solution



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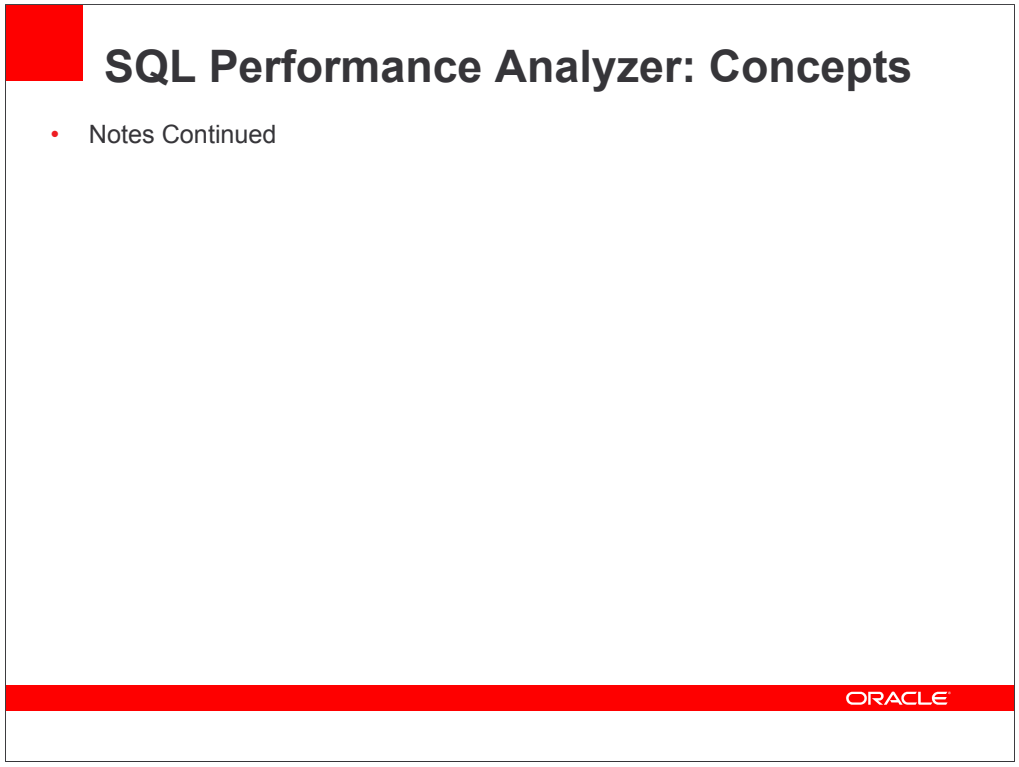
The SQL Performance Analyzer (SPA) introduces the following key concepts:

- **SQL Tuning Set (STS): the STS is a database object representing a SQL workload. Oracle contains facilities for populating and manage the STS making it easy to capture your SQL workload and provide it as input to different operations.**
- **SPA task: the analysis task is a container that encapsulates an entire experiment. In the case of an upgrade, we will create a single task to cover the entire upgrade experiment. SPA tasks are stored in the SYSAUX tablespace and available for inspection in the DBA_ADVISOR_XXX views. The primary input of a task is the STS that the experiment will operate upon.**
- **SPA trial: a SPA task contains multiple SPA trials, where each trial is a single version of the workload performance data. SPA can execute SQLs (using test-execute technology to avoid side-effects) and gather execution stats and execution plans or get execution plans only by simply performing an EXPLAIN PLAN on each SQL statement.**



- **SPA comparison: SPA allows you to compare two trials to see what has changed; this is the performance analysis step when SPA examines each SQL and sees if, and how much, its performance has improved or regressed due to the change. You can perform an analysis using the performance metric of your choice. SPA will recommend running SQL Tuning Advisor or using SQL Plan Baselines to fix regressed SQL statements.**
- **SPA report: The user-consumable output of a SPA comparison is a SPA report, which shows all of the discoveries from the SPA analysis.**

An experiment starts off with two SPA trials, one for before the change and one for after the change, followed by a SPA comparison to analyze the change. Further SPA trials and comparisons will be performed as you make additional changes to tune your performance.

Database Upgrade: 10.2.0.x → 10.2.0.y

Scenario:

One of the database I'm managing is on 10.2.0.2. How can I use 11g SQL Performance Analyzer (SPA) functionality to accomplish an 10.2.0.4 patchset upgrade?

Goal:

Assess impact of upgrade on SQL workload performance using SPA so that there are no surprises after upgrade.

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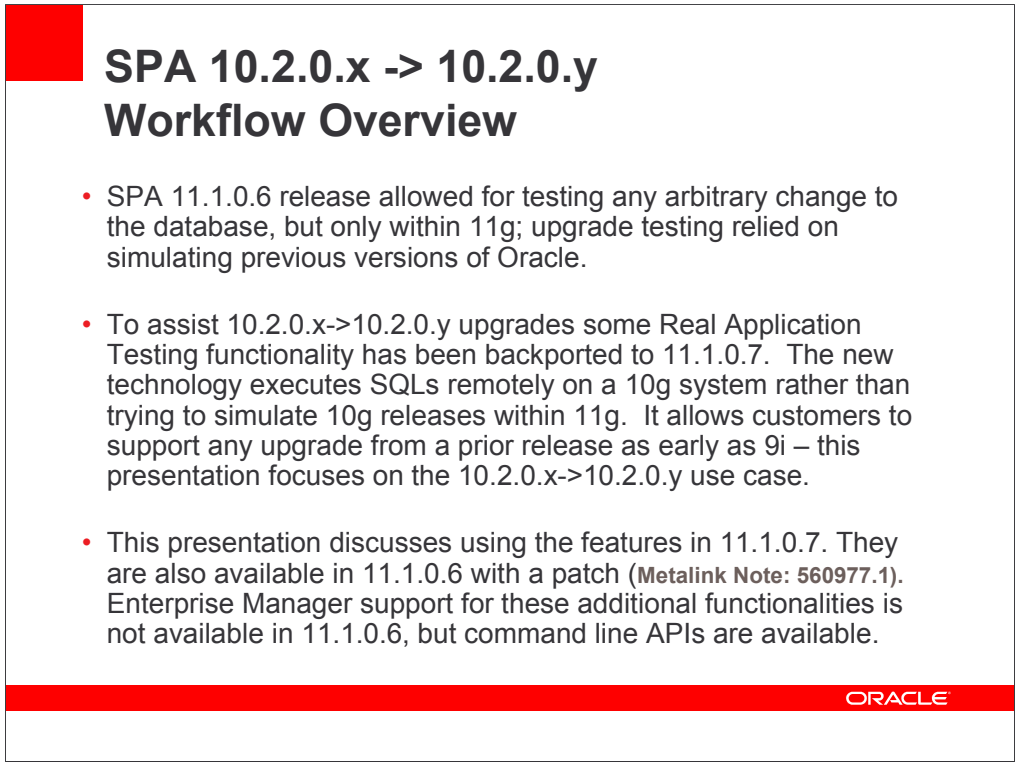
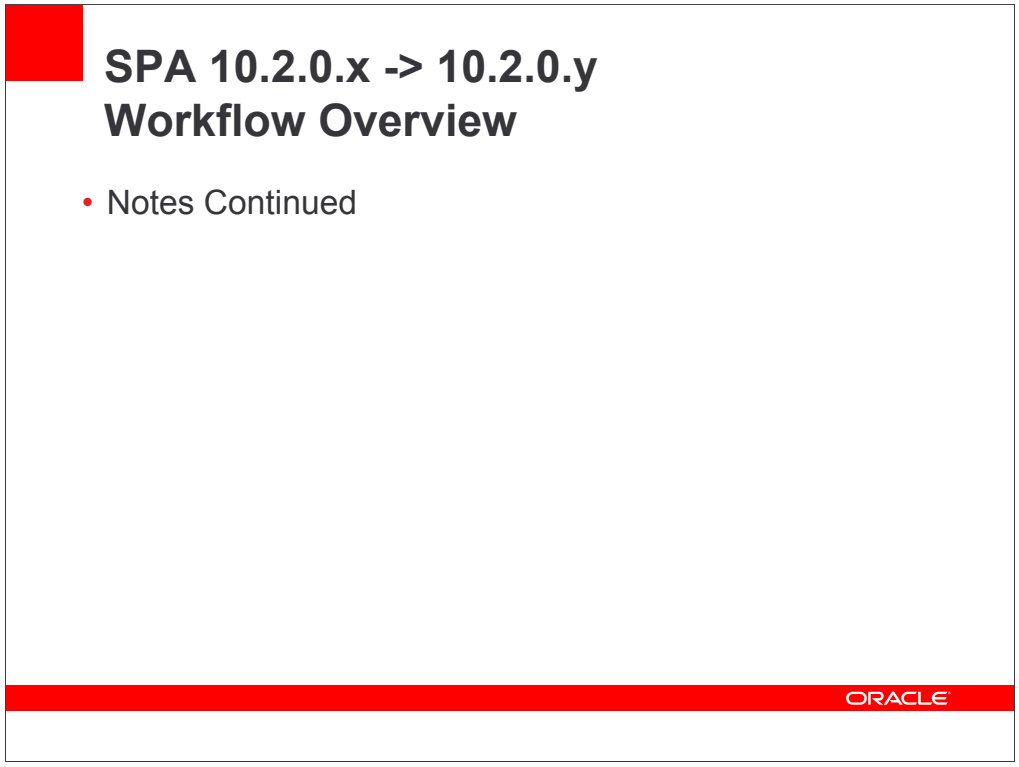
Note that the content of this presentation applies to all upgrades with the prior release >= 10.2.0.2



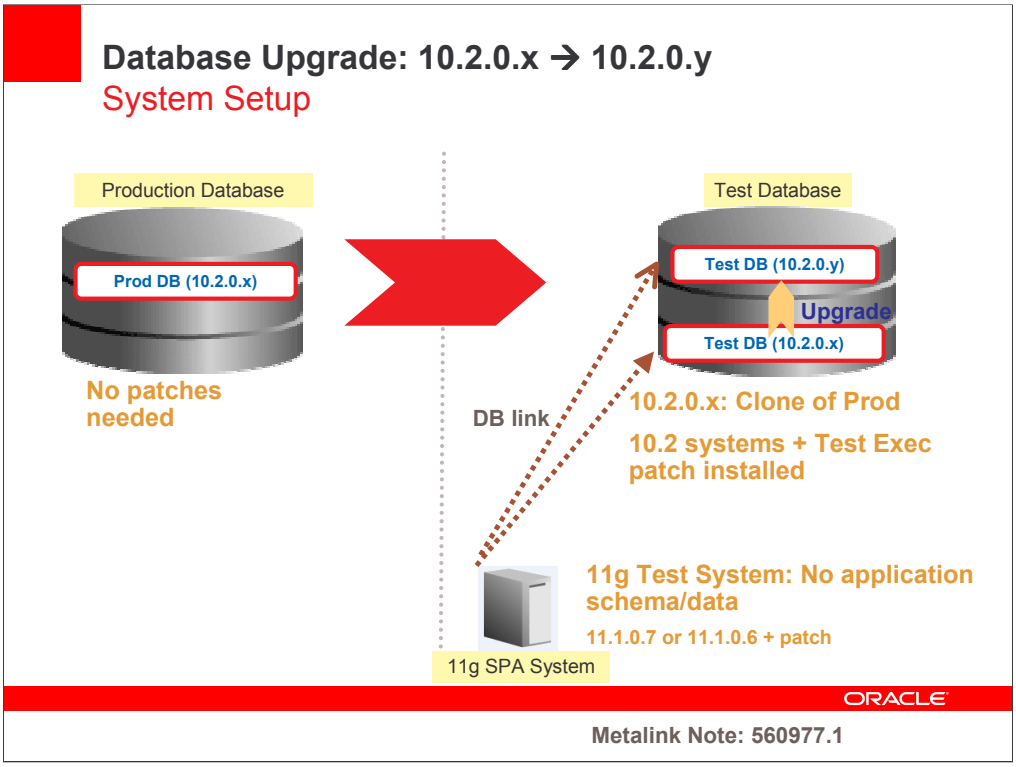
The first release of SQL Performance Analyzer (SPA) was created for Oracle Database 11.1.0.6. It allowed you to take a set of SQL statements, called a SQL Tuning Set (STS), run it before and after making your desired changes and compare the results with a detailed report. This SPA allowed us to evaluate how any database changes will impact SQL performance. SPA suggests using SQL Tuning Advisor or SQL Plan Management to tune any regressed SQL. In the Oracle Database 11.1.0.7 release (and in a one-off patch atop 11.1.0.6, see metalink note 560977.1) we have added to the SPA upgrade testing scenario, allowing you to set up a small "SPA System" with just a SQL Tuning Set but no application schema nor data and use it to drive a test, connecting to a test system running the database release you will be upgrading from/to, executing the SQLs there, and sending the results back to the SPA system where they can be used for analysis. In particular, this enhancement is especially useful because it opens the door to testing upgrades to Oracle Database 10.2 releases.

***In this presentation we will discuss only the upgrade from Oracle 10.2.0.x to Oracle 10.2.0.y*. You can also use SQL Performance Analyzer to test upgrades from Oracle 9i/10.1 to Oracle 10.2 – these are discussed in our Oracle White Paper, titled "Oracle Real Application Testing: Testing the SQL Performance Impact of an Oracle 9i to Oracle Database 10g Release 2 using SQL Performance Analyzer", available on OTN and linked at the end of this presentation.**



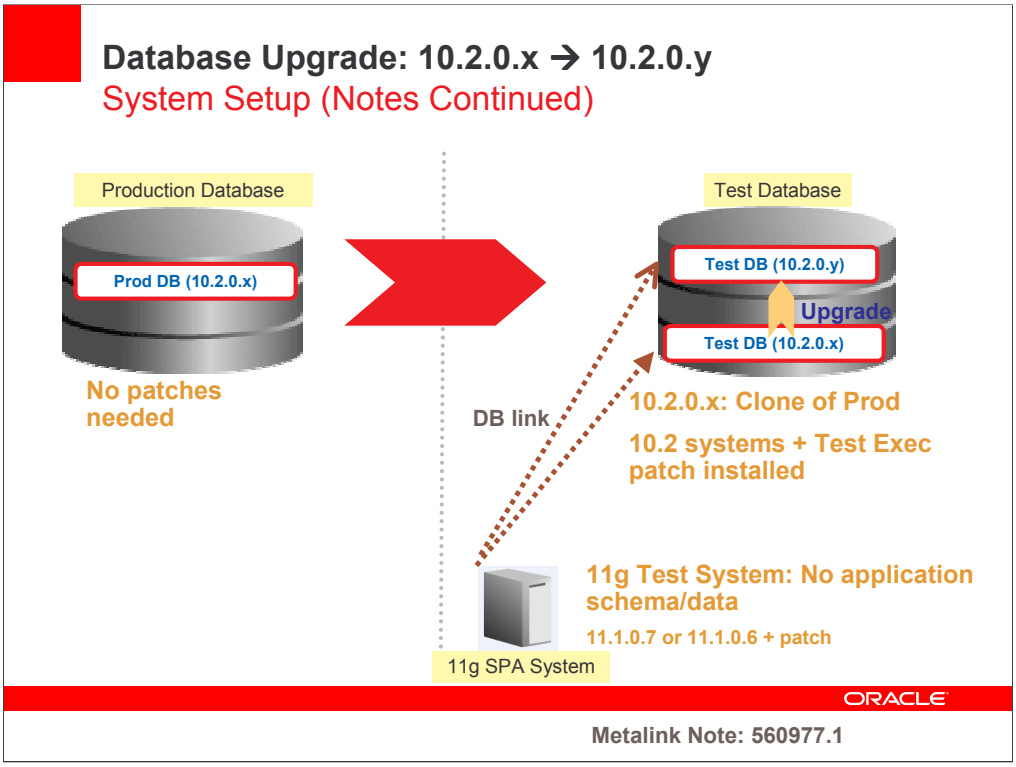
We do recommend reading over the white paper while noting the differences in the 10.2.0.x->10.2.0.y workflow described in this presentation – this workflow is much simpler than the 9i/10.1->10.2 workflow because of the additional manageability infrastructure available in the 10.2 database release to build on top of. Testing an upgrade from 10.2 to 11g can be done with the same flow as described in this presentation.

This presentation assumes testing using the 11.1.0.7 database release, as it contains Enterprise Manager support to simplify the workflow. Testing with the 11.1.0.6 one-off patch can be done with the identical workflow, but only from the command line APIs. Here we show only examples using enterprise manager, but the command-line APIs are described in the White Paper (linked at the end of the presentation) and made easier to use by some SQL*Plus scripts we have provided (linked from Metalink note 560977.1).



The basic components of this experiment will be:

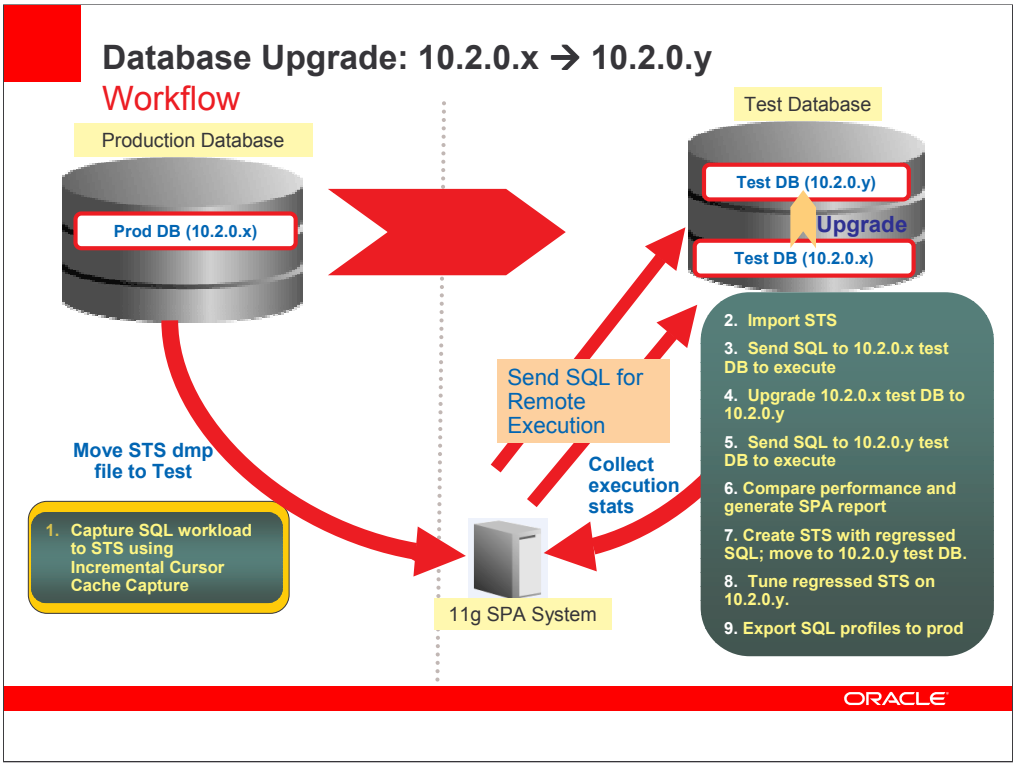
- **The production system, on release 10.2.0.x: no patch is needed. Here we will capture the SQL workload into a SQL Tuning Set. No actual testing will be run on the production system.**
- **A test system with a full clone of production schema+data (or as similar as possible) on 10.2.0.x: we will use SPA to test-execute the workload here once on 10.2.0.x, then upgrade the system to 10.2.0.y, and perform a second test-execution of the workload.**
- **A second test system, which we call the SPA system, on 11.1.0.7; this can be a small system as no application schema nor data is required. This can even be on the same host as the test system with the schema and data where test-execution is performed. The SPA system will store the results of the experiment. It can be convenient to keep these results in a different system than the one we are upgrading as part of the experiment.**



Both the test system and the SPA system should license Real Application Testing, while the Production system needs to license the Tuning Pack.

To prepare for the experiment, you will need to complete the following steps:

1. **Clone 10.2.0.x production to 10.2.0.x test environment. If a full clone is not available you should create a system that is as similar as possible to production.**
2. **Apply test execution patch to 10.2.0.x test system (see metalink note #560977.1).**
3. **Create the 11.1.0.7 SPA system, which does not need any application schema or data and can even be on the same host as the test system.**
4. **Create a PUBLIC database link from the SPA system to the test system. This will allow the SPA system to connect to the test system in order to drive the experiment.**



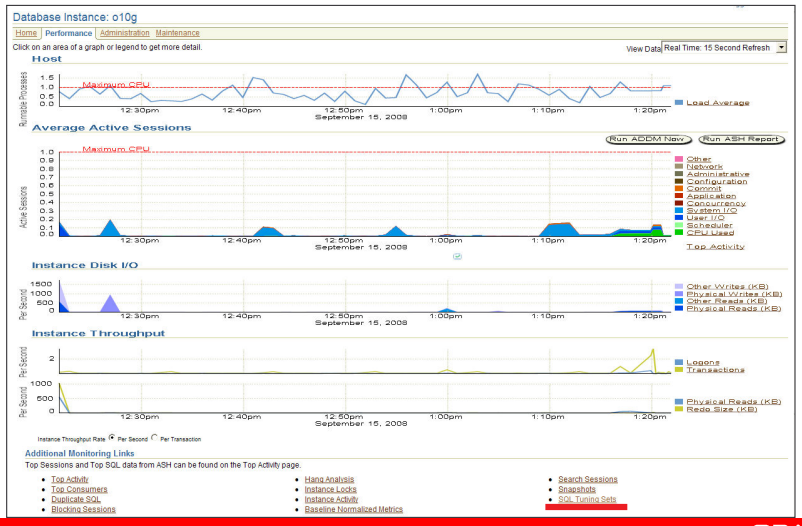
The experiment will have the following major steps:

1. **Capture SQL workload into an STS using the Incremental Cursor Cache Capture facility.**
2. **Move this STS on 11g SPA system.**
3. **Create a SPA task on the 11g SPA system, and execute the task to send SQL for remote execution to 10.2.0.x to build a pre-change trial**
4. **Upgrade 10.2.0.x database to 10.2.0.y database**
5. **Send SQL for remote execution to 10.2.0.y DB and build post-change trial**
6. **Compare performance and generate SPA report**
7. **Create STS with regressed SQL from 11g SPA System; move to test 10.2.0.y database**
8. **Tune regressed SQLs**
9. **Export SQL Profiles to the production system after upgrading it to 10.2.0.y**

Database Upgrade: 10.2.0.x -> 10.2.0.y

1. Create STS in test database 10.2

- Use Performance page on 10.2 to create STS

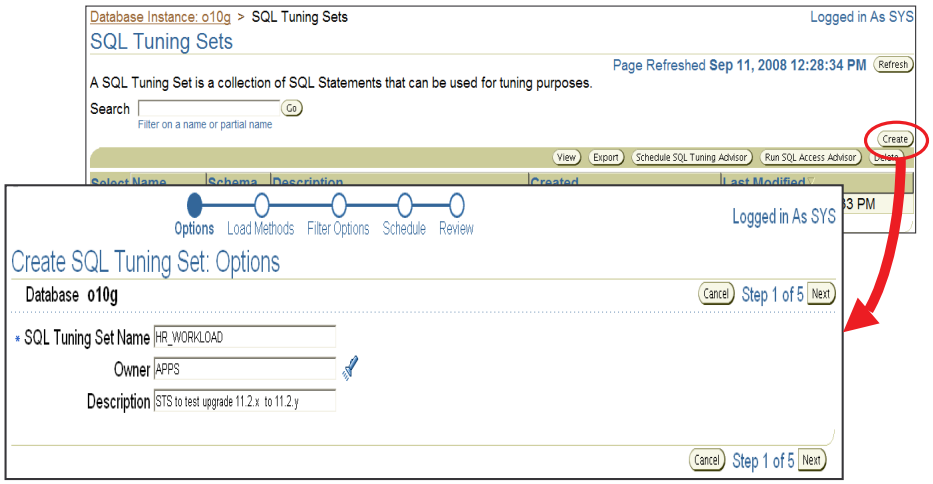


Our first step is to create in the production database a SQL Tuning Set (STS) and capture SQL statements in this STS. To create STS in 10.2 Enterprise Manager use the link “SQL Tuning Sets” in the bottom right-hand corner of the performance page.

Database Upgrade: 10.2.0.x -> 10.2.0.y

1. Create STS in test database 10.2

- Create STS and load SQL statements from cursor cache.



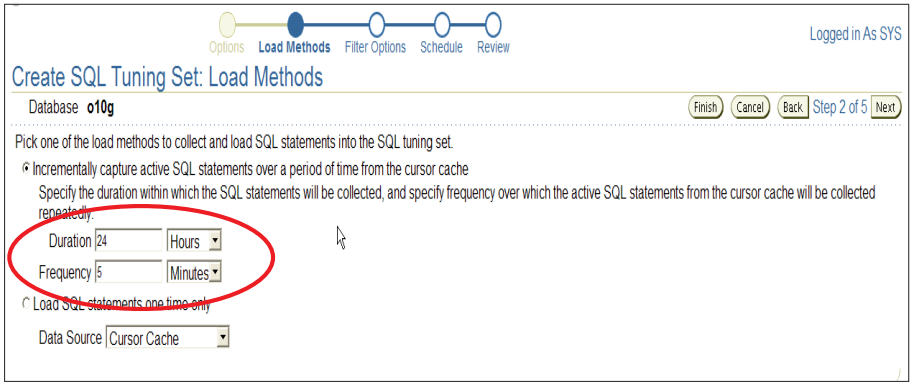
On the STS page push the Create button.

Enter the STS name, STS owner name and STS description.

Database Upgrade: 10.2.0.x -> 10.2.0.y

1. Create STS in test database 10.2

- Use incremental capture to load all active SQLs from cursor cache during peak time



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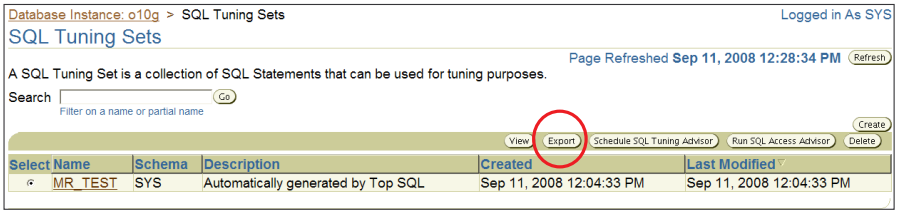
You can capture SQL statements from many sources – cursor cache, AWR, exported STS file etc. Since SPA needs to capture your entire workload, we will use the incremental capture facility to capture all SQL active over a period of time from the cursor cache. This example shows a capture job that will run for 24 hours and scan the cursor cache every 5 minutes. Note that the performance overhead for capturing a SQL Tuning Set is very low (<2%) and will not impact system throughput. You can capture all SQL or create filters to capture SQL from concrete modules, for example.

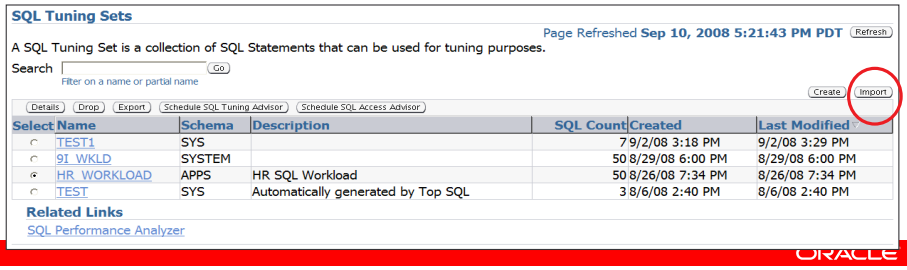
Database Upgrade: 10.2.0.x -> 10.2.0.y

2. Export/Import STS (10.2 –> 11.1) with OEM

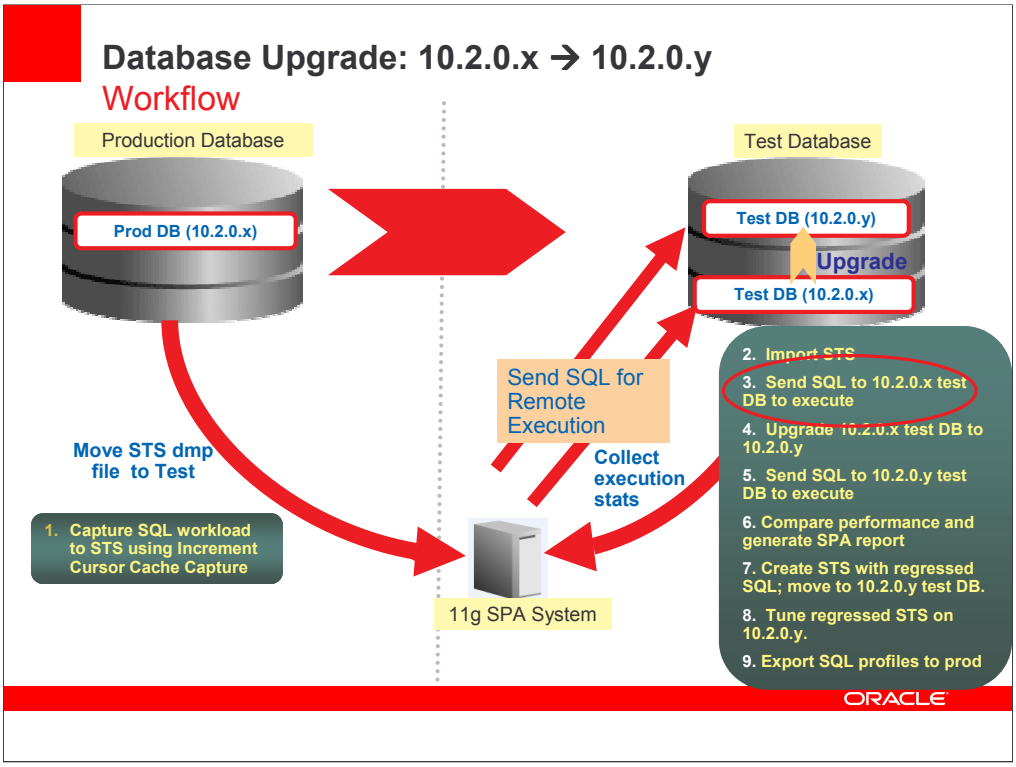
- Use SQL Tuning Sets page of OEM to move STS from prod 10.2…



- ……To 11g SPA system



Once the capture completes, you can move the STS to the Oracle 11g SPA system using Oracle Enterprise Manager.

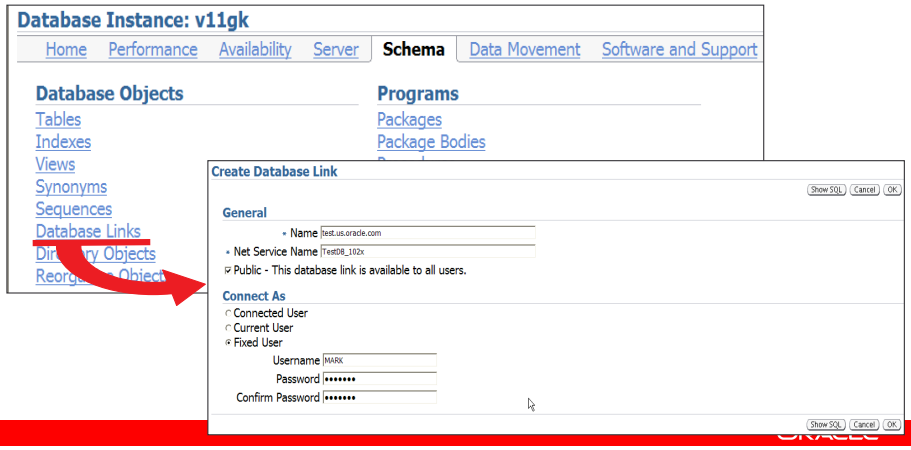


Next step – remotely execute this STS in test 10.2.0.x test database, using the database link, and collect execution statistics into the SQL Analysis task. In this step SPA will send the SQL statements in the STS over the database link to the 10.2.0.x test database, where they will be executed using SPA test-execute technology.

Database Upgrade: 10.2.0.x -> 10.2.0.y

Create Database link on test database 10.2.0.x

- Use Database Link page of OEM to create Database Link on test database
- User that will remote test execute from 11g db needs
  - Grant execute on dbms_sqlpa
  - Grant advisor privileges

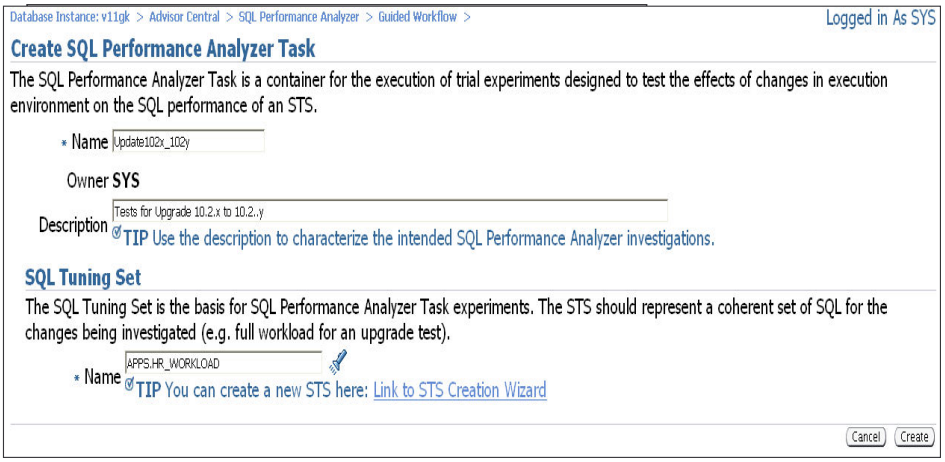


To run SQL statements from your STS on remote test database 10.2.0.x you have to create a public database link from the 11g SPA database to the test database. For this goal you can use the OEM GUI or the CREATE PUBLIC DATABASE LINK DDL.

The user that the link connects to on the test database needs the following privileges:

- EXECUTE on dbms_sqlpa
- ADVISOR privilege

Create SQL Performance task in 11g SPA



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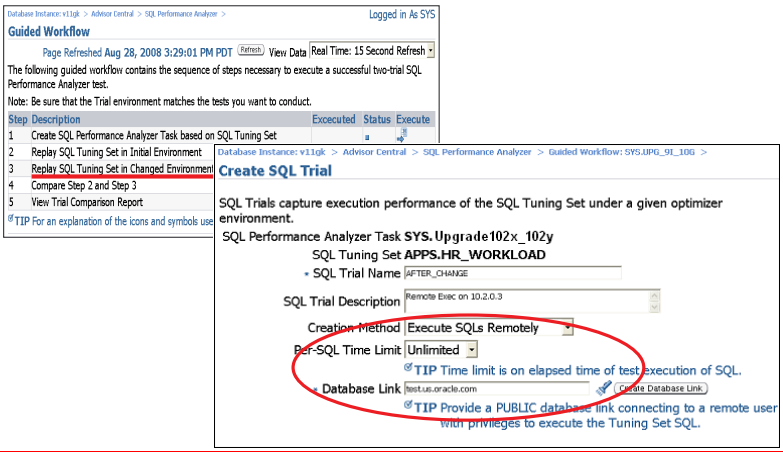
Next step – create SQL performance task in 11g SPA system using the STS captured on the production database. EM provides step-by-step control over the SPA experiment using the Guided workflow UI. The Guided Workflow will take us through the following steps:

1. **Create SPA Task – container to store results of STS executions (pre/post-change trials) and results of trial's comparison**
2. **Replay STS in initial environment**
3. **Replay STS in changed environment**
4. **Compare the two trials**
5. **View trial comparison reports**

Database Upgrade: 10.2.0.x -> 10.2.0.y

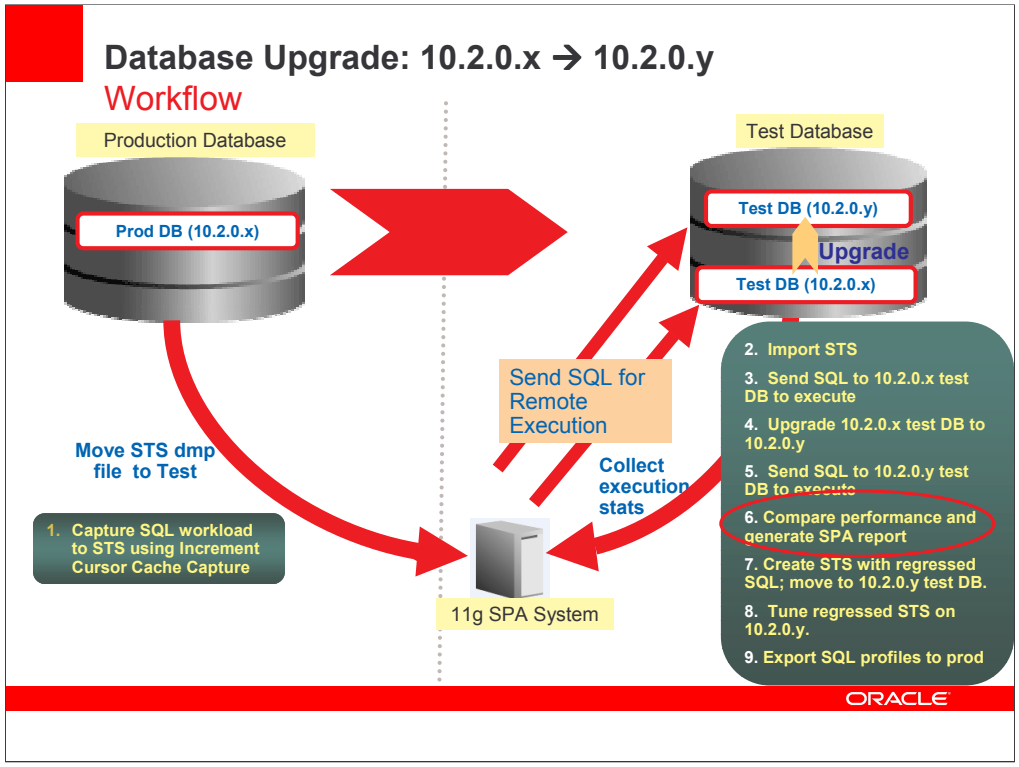
Remote STS execution

- Use Remote Test Execution on 10.2 over database link



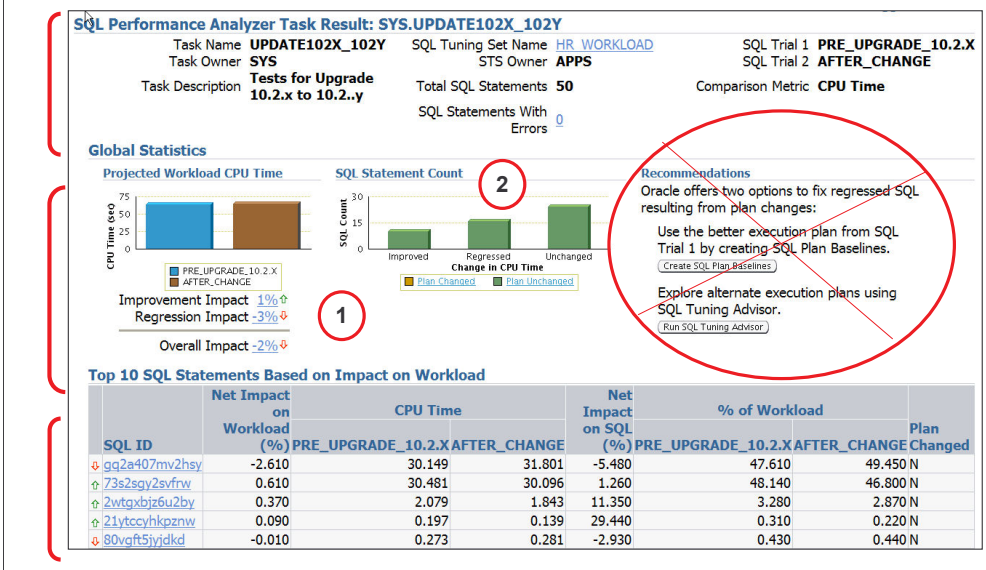
We will test our SQL in the old version of our database (10.2.0.x) and then in the upgraded version of our database (10.2.0.y). To do this we will run SPA from the Oracle 11g SPA system and build pre/post-upgrade trials. The trials will execute using the DB Link, so we call them remote trials. In the Create SQL Trial form we will choose Creation Method = Execute SQLs Remotely and select the DB link name to the test database.

After the trial completes, we can upgrade the test database from release 10.2.0.x to release 10.2.0.y. Then perform the second trial, just as we have here, to execute the SQLs in version 10.2.0.y. All of the performance data for both trials will be stored in the 11g SPA system.



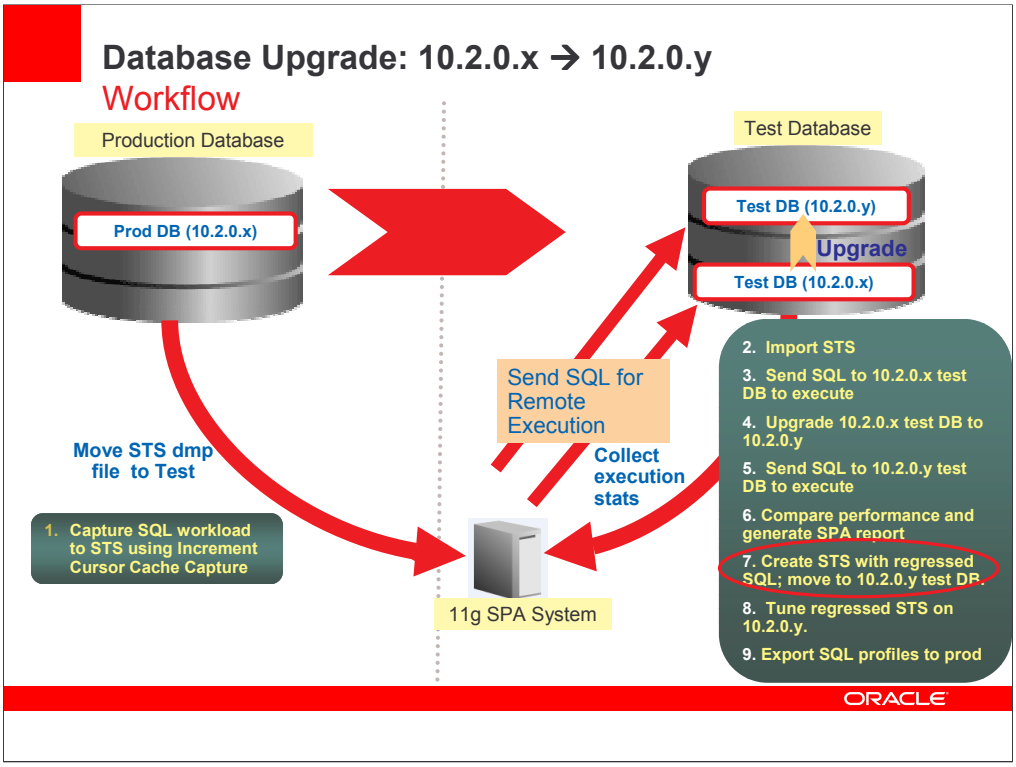
Next step – compare pre- and post-upgrade trials and build a comparison report.

SPA Report

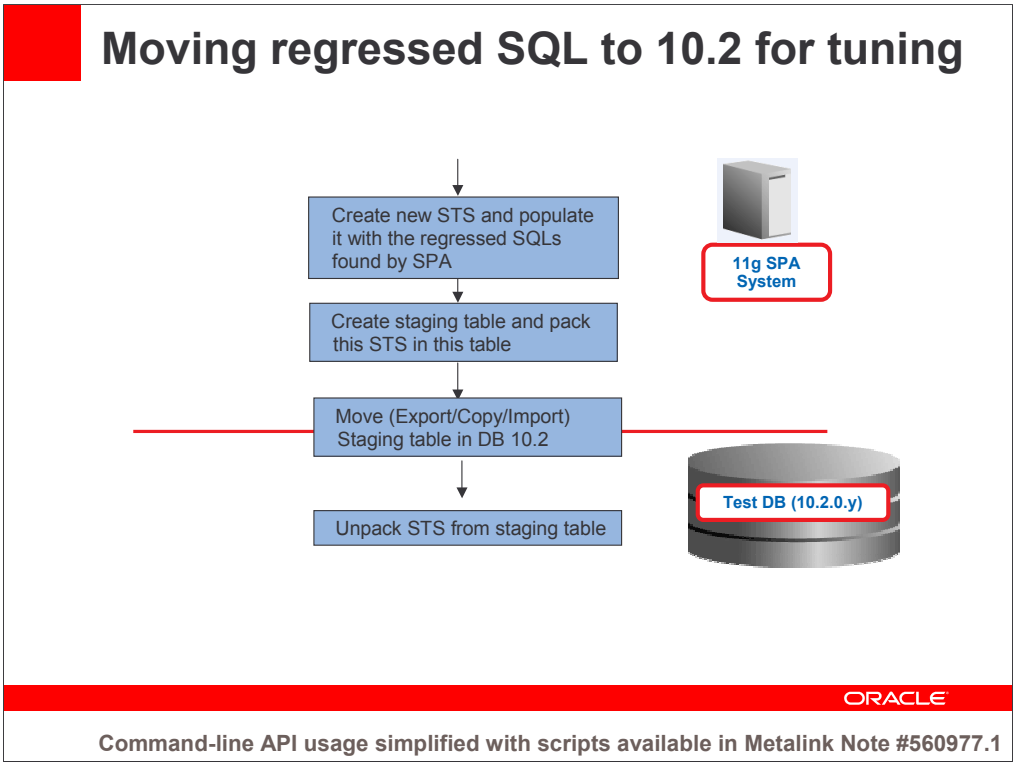


In the SPA report we can see the upgrade's impact on SQL performance (1) and the number and list of regressed SQL (2). From the summary screen you can drill down to all of the details for each SQL statement, including execution plans and statistics from before and after the change. Look over the report to decide which SQL statements seem to be experiencing significant regressions that you would like to tune.

Our next step will be to tune the regressed SQLs on the 10.2 system. We cannot tune them directly from the SPA UI as as tuning needs to happen on the 10.2.0.y test DB, where the SPA trials are executed and the application schema and data will be available to the SQL Tuning Adivsor. Also note that SQL Plan Baselines are a new 11g feature and cannot therefore be used for a 10.2 upgrade.



After reviewing the SPA reports, our next step will be to create a SQL Tuning Set containing only the regressed SQLs we wish to tune using the SQL Tuning Advisor and move it to the test system.

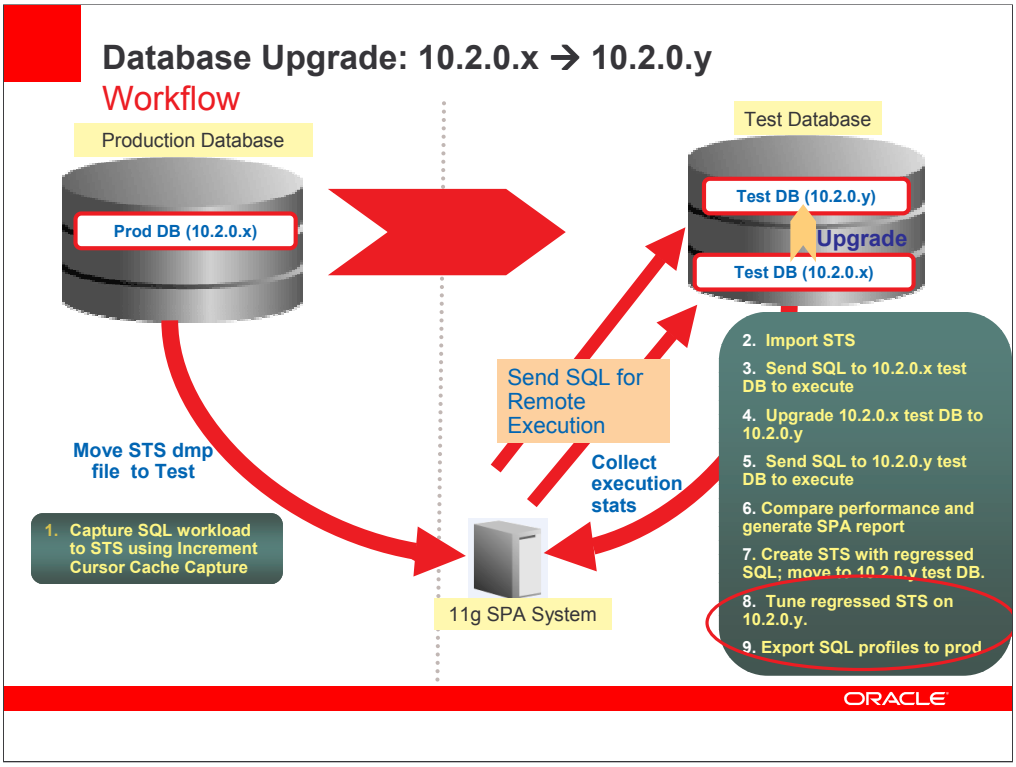


The next step will be to materialize just the subset of SQLs we wish to tune into a new SQL Tuning Set, move that STS to the test system, and tune the SQLs there.

As we have already shown, Oracle Enterprise Manager supports moving an STS between Oracle Databases using the STS export/import facilities. In this case, however, since we are moving the STS to an older release, we need to complete the steps manually as the APIs do not support moving an STS to an older release. To simplify this for you we have provided some SQL*Plus scripts (see Metalink note #560977.1).

We will do the following:

1. **Subset our production STS to contain only regressed SQLs identified by SPA (run script 6_regressions2sts.sql)**
2. **Create a staging table and pack the STS into the table (run script 7_sts2stgtab.sql)**
3. **Move the staging table to the 10.2.0.y test system (using the standard export/import or datapump facilities)**
4. **Import the dump file and unpack the staging table using the DBMS_SQLTUNE.UNPACK_STGTAB_SQLSET API.**



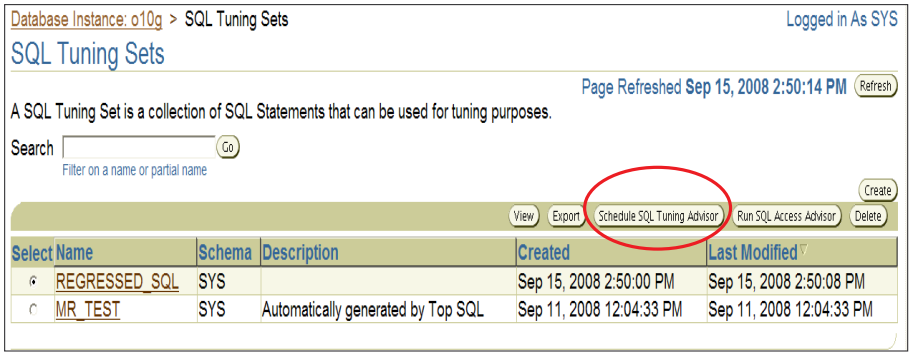
In the next step we will use the SQL Tuning Advisor on the 10.2 test system to tune the regressed SQLs. You can create SQL profiles as recommended by the advisor and perform any other tuning actions you deem necessary to fix the SQL regressions detected by SPA. After tuning the system we recommend performing another SPA trial and comparing it to your first trial to make sure the regressions have disappeared prior to upgrading the production system.

Also you should keep track of whatever tuning actions you have taken, as these will need to be re-issued after upgrading the production DB. Any SQL profiles created can be exported from the test DB to the production DB using the SQL Profile export/import facility (described in the following slides).

Database Upgrade: 10.2.0.x -> 10.2.0.y

Tuning regressed SQL in test database 10.2.0.y

- Use STS page in Oracle 10.2.0.y to run SQL Tuning Advisor or SQL Access Advisor and tune STS with regressed SQL



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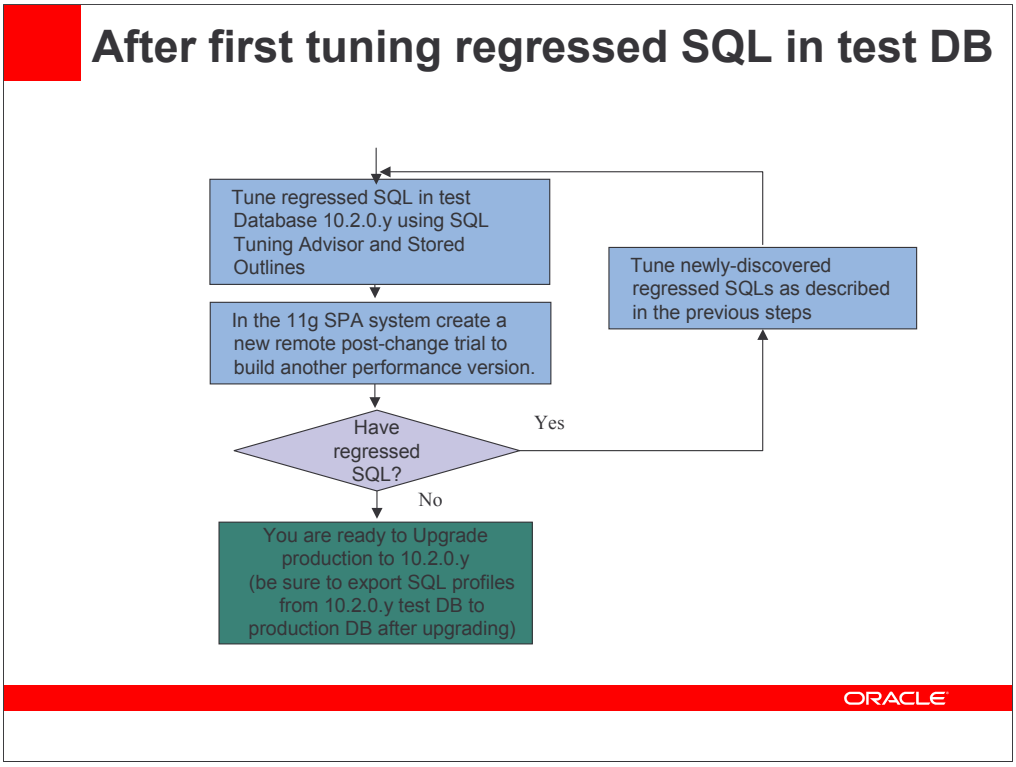
To run the SQL Tuning Advisor on the test system use the "Schedule SQL Tuning Advisor" button on STS page in your test database. You can then review the SQL Tuning results and implement changes as you deem necessary.



To tune regressed SQL in test database we can use many features – SQL profiles, indexes, MV, refresh statistics, stored outlines, change database parameters etc. These actions can improve SQL performance but at the same time they may impact some SQL negatively. For this reason we recommend running further SPA trials after performing any tuning action and comparing the performance to the first trial in order to make sure the changes had their desired effect.

After tuning regressed SQLs in 10.2.0.y return to the 11g SPA system and build a new post-upgrade trial in SPA using remote STS execution as in previous cases. Compare this new trial with pre-upgrade trial and analyze the report. Enterprise Manager contains support for performing all of these steps. If you have new regressed SQLs in this report, you should repeat the process iteratively until all performance issues are resolved.

When all issues are resolved, you are ready to upgrade the production system. Don't forget to implement the same tuning actions after upgrading production that you made on the test system. In the case of SQL profiles created on test, we describe an easy way to move them to the production system (similar to how we have moved STSes already) in the following slides.

Database Upgrade: 10.2.0.x -> 10.2.0.y

Export SQL profiles for future production system

- If you create SQL profiles in the 10.2 test system, export them and later import in production system after upgrade
- Use Expdp/Impdp for export/import stage table
- Unpack SQL profiles, imported in new production 10.2.0.y database, using CLI, to re-create them.

```
begin
  dbms_sqltune.create_stgtab_sqlprof(
    table_name => 'SQLPROF_TAB');

  -- pack all sql profiles, for export
  dbms_sqltune.pack_stgtab_sqlprof(
    profile_name => '%',
    staging_table_name => 'SQLPROF_TAB');
end;
/
```

```
begin
  -- pack all sql profiles, for export
  dbms_sqltune.unpack_stgtab_sqlprof(
    replace => TRUE,
    staging_table_name => 'SQLPROF_TAB');
end;
/
```

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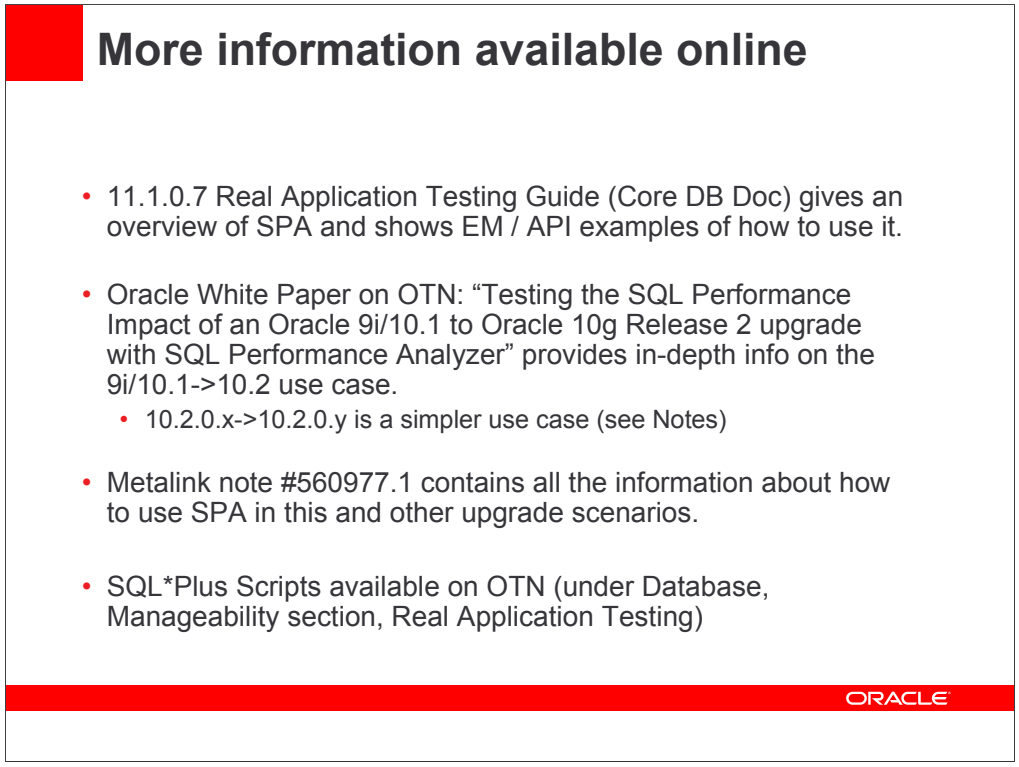
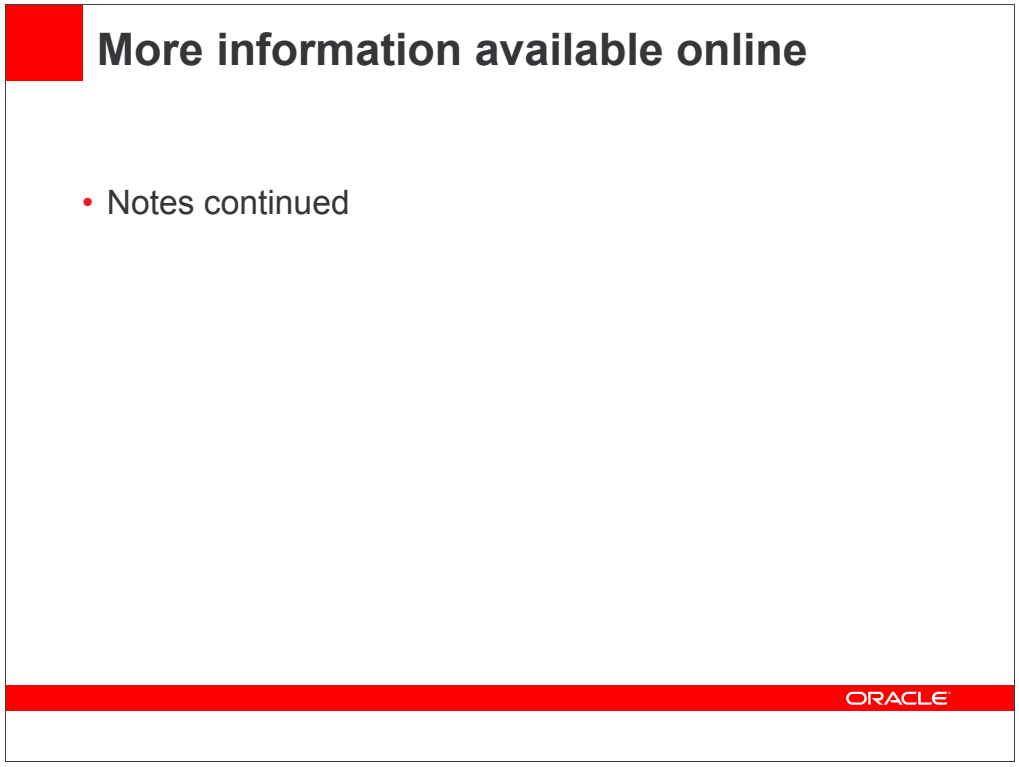
To export/import SQL profiles in Oracle 10.2 you can use the command line dbms_sqltune API as described here.



We have written a technical white paper about the 9i/10.1 use case, available at http://www.oracle.com/technology/products/manageability/database/pdf/owp_spa_9i.pdf. When you are reviewing the white paper, please note that the 9i/10.1 case has several key differences from the 10.2.0.x->10.2.0.y case, especially the following:

- **For the 10.2.0.x->10.2.0.y flow we capture the production workload into a SQL Tuning Set rather than enabling SQL trace. This has several implications on the workflow:**
  - No need to capture SQL trace / mapping table; you can just directly capture an STS
  - Execution Frequency will be captured into the STS, so you can depend on SPA to weigh improvements and regressions accordingly without needing your own knowledge of the application. In particular, this means you should not set the WORKLOAD_IMPACT_THRESHOLD / SQL_IMPACT_THRESHOLD task parameters as described in the white paper, since those values are only appropriate when the execution frequency is not captured.
  - Because capture STS has a negligible performance overhead, you do not need to worry about impacting the performance of the production system when capturing the workload as with sql trace



- **For the 10.2.0.x->10.2.0.y flow we do one remote test-execute on version 10.2.0.x and a second on 10.2.0.y, while the 9i->10.2 scenario built an STS from production stats and did only a single test execute, in 10.2.**
  - This makes for a more scientific test as both sides of the comparison are stats generated by SPA on the test system
  - In the 9i->10.2 case we had to account for the overhead of SQL trace when comparing SQL trace stats to SPA test-execute stats. This is no longer necessary.
  - Because SQL trace so greatly impacts the response time of SQL statements, we could not use the ELAPSED_TIME metric and instead had to count on BUFFER_GETS and CPU_TIME; In the 10.2.0.x->10.2.0.y case ELAPSED_TIME is a sensible performance metric since the sql trace overhead is no longer in effect.
  - The 10.2.0.x -> 10.2.0.y case requires upgrading your test system between running the before and after trials; the alternative is to have two test systems, one on 10.2.0.x and the second on 10.2.0.y. If the hardware resources are available this can be convenient as it keeps both releases available for diagnosing issues after getting the SPA report. But it does require extra diligence to make sure that the 10.2.0.x and 10.2.0.y systems are in fact identical in terms of data, optimizer stats, and configuration.