Oracle® Database

2 Day + Performance Tuning Guide

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Oracle Database 2 Day + Performance Tuning Guide, 21c

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Preface

This preface contains the following topics:

- Audience
- Documentation Accessibility
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Audience

This guide is intended for Oracle database administrators (DBAs) who want to tune and optimize the performance of Oracle Database. Before using this document, you should be familiar with Oracle Database administration.

In particular, this guide is targeted toward the following groups of users:

- Oracle DBAs who want to acquire database performance tuning skills
- DBAs who are new to Oracle Database

> **See Also:**
>
> - *Oracle Database Administrator's Guide* for more information about database administration

Documentation Accessibility

For information about Oracle's commitment to accessibility, visit the Oracle Accessibility Program website at http://www.oracle.com/pls/topic/lookup?ctx=acc&id=docacc.

Access to Oracle Support

Oracle customers that have purchased support have access to electronic support through My Oracle Support. For information, visit http://www.oracle.com/pls/topic/lookup?ctx=acc&id=info or visit http://www.oracle.com/pls/topic/lookup?ctx=acc&id=trs if you are hearing impaired.

Related Documents

For more information about the topics covered in this document, see the following documents:

- *Oracle Database Administrator's Guide*
- *Oracle Database Concepts*
- *Oracle Database Performance Tuning Guide*
- *Oracle Database SQL Tuning Guide*

Conventions

The following conventions are used in this document:

Convention	Meaning
boldface	Boldface type indicates graphical user interface elements associated with an action, or terms defined in text or the glossary.
italic	Italic type indicates book titles, emphasis, or placeholder variables for which you supply particular values.
`monospace`	Monospace type indicates commands within a paragraph, URLs, code in examples, text that appears on the screen, or text that you enter.

Changes in This Release for Oracle Database 2 Day + Performance Tuning Guide

This preface contains:

Changes in Oracle Database Release 19c, Version 19.1

The following are the changes in *Oracle Database 2 Day + Performance Tuning Guide* for Oracle Database release 19c, version 19.1.

New Features

The following features are new in this release:

- Automatic Database Diagnostic Monitor (ADDM) support for pluggable databases (PDBs)

  You can now use ADDM to analyze AWR data in PDBs for identifying and resolving performance related issues.

  See "ADDM for a Multitenant Environment" for more information.

- Real-time SQL monitoring functionality enabled for non-administrative database users

  The database users without the administrative privileges can also now view the execution plans and performance metrics of their SQL statements by navigating to the Monitored SQL Executions page of Oracle Enterprise Manager Cloud Control (Cloud Control).

  See the section "Monitoring Database Operations in Cloud Control" for more information.

Desupported Features

The following feature is desupported in this release.

- Oracle Streams

  Starting in Oracle Database 19c, the Oracle Streams feature is desupported. Use Oracle GoldenGate to replace all replication features of Oracle Streams.

Changes in Oracle Database Release 18c, Version 18.1

There are no changes in *Oracle Database 2 Day + Performance Tuning Guide* for Oracle Database release 18c, version 18.1. For the Oracle Database performance related features that are new in this release, see *Oracle Database Performance Tuning Guide* and *Oracle Database SQL Tuning Guide*.

Changes in Oracle Database 12*c* Release 2 (12.2)

There are no changes in *Oracle Database 2 Day + Performance Tuning Guide* for Oracle Database 12*c* Release 2 (12.2). For the Oracle Database performance related features that are new in this release, see *Oracle Database Performance Tuning Guide*.

Changes in Oracle Database 12*c* Release 1 (12.1.0.2)

The following are changes in *Oracle Database 2 Day + Performance Tuning Guide* for Oracle Database 12*c* Release 1 (12.1.0.2).

New Features

The following features are new in this release:

- Manageability support for In-Memory Column Store

  The new Oracle Database In-Memory Column Store (IM column store) feature accelerates database performance of analytics, data warehousing, and online transaction processing (OLTP) applications.

  SQL Monitor report, ASH report, and AWR report now show statistics for various in-memory operations.

  - In-memory statistics in SQL Monitor report: Activity % in Time and Wait Statistics panel, Activity column in Plan Statistics table, and Activity tab in SQL Monitor report show CPU consumed by SQL commands while executing in-memory query operations. SQL Monitor report now supports Adaptive plans. The Execution plan shows Resolving or Resolved icon depending upon the current status of that plan. The Plan Statistics tab contains a drop down list to show current plan, final plan, and full plan. It also contains Plan Note button, which when clicked, shows the notes that are generated in the explain plan for the SQL statement.

  - In-memory statistics in ASH report: ASH report header table shows the size of in-memory pool under In Memory Area column. Top Events, Top SQL, and Activity Over Time sections show CPU consumption by various in-memory operations.

  - In-memory statistics in AWR report: AWR report contains a new section - In-Memory Segments Statistics - that shows in-memory segment consumption based on various attributes, such as, scans, DB block changes, populate CUs, and repopulate CUs. Time Model Statistics section shows statistics related to in-memory CPU usage and Instance Activity Statistics section shows statistics related to in-memory activities.

Other Changes

The following are additional changes in the release:

- Changes in ASH Analytics page

  In the Average Active Sessions chart on ASH analytics page, you can now click on CPU wait class to see its breakdown by CPU usage based on various in-memory operations as well as total CPU used for operations other than in-memory operations.

  See "Determining the Cause of Spikes in Database Activity" for more information.

Changes in Oracle Database 12*c* Release 1 (12.1.0.1)

The following are changes in *Oracle Database 2 Day + Performance Tuning Guide* for Oracle Database 12*c* Release 1 (12.1.0.1).

New Features

The following features are new in this release:

- Real-time database operations monitoring

  Real-Time database operations monitoring tracks and reports on active and recently completed database operations. You can monitor details of the execution of a single SQL or PL/SQL statement. You can also monitor the progress of long-running operations such as a batch job, or extract, transform, and load (ETL) processing.

  See "Monitoring Real-Time Database Operations " for information on this feature.

Desupported Features

Oracle Enterprise Manager Database Control is no longer supported by Oracle.

Other Changes

The following are additional changes in the release:

- Oracle Enterprise Manager Cloud Control

  In previous releases of Oracle Database, you used Oracle Enterprise Manager Database Control (Database Control) to manage database performance tuning from a graphical user interface. In this release, you can use the Oracle Enterprise Manager Cloud Control (Cloud Control) graphical user interface. Cloud Control provides more functionality than Database Control. The procedures in this guide use Cloud Control.

  You must install Cloud Control separately from Oracle Database.

  > ✎ **See Also:**
  >
  > *Oracle Enterprise Manager Cloud Control Basic Installation Guide*

- ASH Analytics page

Cloud Control has the ASH Analytics page, which graphically displays recent Active Session History information.

See "Determining the Cause of Spikes in Database Activity" for more information.

- Real-Time ADDM

Cloud Control has the Real-Time ADDM page, from which you can run automatic database diagnostic monitoring in real time to diagnose problems with a slow or hung database.

See "Diagnosing Serious Performance Problems in Real Time" for more information.

Part I

Getting Started

Part I provides an introduction to this guide and explains the Oracle Database performance method. This part contains the following chapters:

- Introduction
- Oracle Database Performance Method

1

Introduction

As an Oracle database administrator (DBA), you are responsible for the performance of your Oracle database. Tuning a database to reach a desirable performance level may be a daunting task, especially for DBAs who are new to Oracle Database. *Oracle Database 2 Day + Performance Tuning Guide* is a quick start guide that describes how to perform day-to-day database performance tuning tasks using features provided by Oracle Diagnostics Pack, Oracle Tuning Pack, and Oracle Enterprise Manager Cloud Control (Cloud Control).

This chapter contains the following sections:

- About This Guide
- Common Oracle DBA Tasks
- Tools for Tuning the Database
- Accessing the Database Home Page

About This Guide

Before using this guide, you must do the following:

- Be familiar with Oracle Database administration. See *Oracle Database Administrator's Guide* for more information.
- Obtain the necessary products and tools described in "Tools for Tuning the Database".

Oracle Database 2 Day + Performance Tuning Guide is task-oriented. The objective is to describe why and when tuning tasks need to be performed.

This guide is not an exhaustive discussion of all Oracle Database concepts. For that type of information, see *Oracle Database Concepts*.

This guide does not describe basic Oracle Database administrative tasks. For that type of information, see *Oracle Database Administrator's Guide.*

The primary interface used in this guide is the Enterprise Manager Cloud Control console. This guide is not an exhaustive discussion of all Oracle Database performance tuning features. It does not cover available application programming interfaces (APIs) that provide comparable tuning options to those presented in this guide. For this type of information, see *Oracle Database Performance Tuning Guide* and *Oracle Database SQL Tuning Guide*.

Common Oracle DBA Tasks

As an Oracle DBA, you can expect to be involved in the following tasks:

- Installing Oracle software
- Creating Oracle databases
- Upgrading the database software to new releases
- Starting up and shutting down the database

- Managing the storage structures of the database

- Managing user accounts and security

- Managing schema objects, such as tables, indexes, and views

- Making database backups and performing database recovery, when necessary

- Monitoring proactively the condition of the database and taking preventive or corrective actions, as required

- Monitoring and tuning database performance

This guide describes how to accomplish the last two tasks in the preceding list.

Tools for Tuning the Database

The intent of this guide is to allow you to quickly and efficiently tune and optimize the performance of Oracle Database.

To achieve the goals of this guide, you must acquire the following products, tools, features, and utilities:

- **Oracle Database 19c, Version 19.1 (Enterprise Edition)**

  Oracle Database offers enterprise-class performance, scalability and reliability on clustered and single-server configurations. It includes many performance features that are used in this guide.

- **Oracle Enterprise Manager Cloud Control**

  The primary tool to manage the database is Enterprise Manager Cloud Control (Cloud Control), a web-based interface. After you install the Oracle software, create or upgrade a database, and configure the network, you can use Cloud Control to manage the database. In addition, Cloud Control provides an interface for performance advisors and for database utilities, such as SQL*Loader and Recovery Manager (RMAN).

- **Oracle Diagnostics Pack**

  Oracle Diagnostics Pack offers a complete, cost-effective, and easy-to-use solution to manage the performance of Oracle Database environments by providing unique features, such as automatic identification of performance bottlenecks, guided problem resolution, and comprehensive system monitoring. Key features of Oracle Diagnostics Pack used in this guide include Automatic Workload Repository (AWR), Automatic Database Diagnostic Monitor (ADDM), and Active Session History (ASH).

- **Oracle Tuning Pack**

  Oracle Tuning Pack automates the database application tuning process, thereby significantly lowering database management costs while enhancing performance and reliability. Key features of Oracle Tuning Pack that are used in this guide include the following:

  – SQL Tuning Advisor

    This feature enables you to submit one or more SQL statements as input and receive output in the form of specific advice or recommendations for how to tune statements, along with a rationale for each recommendation and its expected benefit. A recommendation relates to collection of statistics on

objects, creation of new indexes, restructuring of the SQL statements, or creation of SQL profiles.

– SQL Access Advisor

This feature enables you to optimize data access paths of SQL queries by recommending the proper set of materialized views and view logs, indexes, and partitions for a given SQL workload.

- **Oracle Real Application Testing**

Oracle Real Application Testing consists of the following key features:

– Database Replay

This feature enables you to capture the database workload on a production system, and replay it on a test system with the exact same timing and concurrency as the production system on the same or later release of Oracle Database.

– SQL Performance Analyzer

This feature enables you to assess the effect of system changes on SQL performance by identifying SQL statements that have regressed, improved, or remained unchanged.

> **See Also:**
>
> *Oracle Database Testing Guide* for information about how to use the features Database Replay and SQL Performance Analyzer

> **Note:**
>
> Some of the products and tools in the preceding list, including Oracle Diagnostics Pack and Oracle Tuning Pack, require separate licenses. For more information, see *Oracle Database Licensing Information*.

Accessing the Database Home Page

The Database Home page is the main database management page in Oracle Enterprise Manager Cloud Control (Cloud Control). After you log in to Cloud Control, you navigate to the Database Home page for the target database you want to manage in Cloud Control.

To access the Database Home page in Cloud Control:

1. Start Cloud Control.

   The URL for accessing Cloud Control has the following syntax:

   ```
   http://hostname.domain:portnumber/em
   ```

2. In the Welcome page, enter your Cloud Control user name and password, and then click **Login**.

3. From the **Targets** drop-down menu, select **Databases**.

   The Databases page appears with a list of the available target databases.

4. Select the database that you want to observe or modify from the Databases page.

   If the list of databases is long, use the **Search** functionality.

   The home page for the target database appears. The first time that you select an option from some of the menus, such as the Performance menu, the Database Login page appears.

5. In the login page for the target database, log in as a user with the appropriate privileges. For example, to log in as user `SYS` with the `SYSDBA` privilege:

   • User Name: Enter `SYS`.

   • Password: Enter the password for the `SYS` user.

   • Connect As: From the Role list, select **SYSDBA**.

2
Oracle Database Performance Method

Performance improvement is an iterative process. Removing the first **bottleneck** (a point where resource contention is highest) may not lead to performance improvement immediately because another bottleneck might be revealed that has an even greater performance impact on the system. Accurately diagnosing the performance problem is the first step toward ensuring that your changes improve performance.

Typically, performance problems result from a lack of **throughput** (the amount of work that can be completed in a specified time), unacceptable user or job **response time** (the time to complete a specified workload), or both. The problem might be localized to specific application modules or it might span the system.

Before looking at database or operating system statistics, it is crucial to get feedback from the system users and the people in charge of the application. This feedback makes it easier to set performance goals. Improved performance can be measured in terms of business goals rather than system statistics.

The Oracle performance method can be applied until performance goals are met or deemed impractical. Because this process is iterative, some investigations may have little impact on system performance. It takes time and experience to accurately pinpoint critical bottlenecks quickly. Automatic Database Diagnostic Monitor (ADDM) implements the Oracle performance method and analyzes statistics to provide automatic diagnosis of major performance problems. Because ADDM can significantly shorten the time required to improve the performance of a system, it is the method used in this guide.

This chapter discusses the Oracle Database performance method and contains the following sections:

- Gathering Database Statistics Using the Automatic Workload Repository
- Using the Oracle Performance Method
- Common Performance Problems Found in Databases

Gathering Database Statistics Using the Automatic Workload Repository

Database statistics provide information about the type of load on the database and the internal and external resources used by the database. To accurately diagnose performance problems with the database using ADDM, statistics must be available.

A **cumulative statistic** is a count such as the number of block reads. Oracle Database generates many types of cumulative statistics for the system, sessions, and individual SQL statements. Oracle Database also tracks cumulative statistics about segments and services. Automatic Workload Repository (AWR) automates database statistics gathering by collecting, processing, and maintaining performance statistics for database problem detection and self-tuning purposes.

By default, the database gathers statistics every hour and creates an **AWR snapshot**, which is a set of data for a specific time that is used for performance comparisons. The delta values

captured by the snapshot represent the changes for each statistic over the time period. Statistics gathered by AWR are queried from memory. The gathered data can be displayed in both reports and views.

The following initialization parameters are relevant for AWR:

- `STATISTICS_LEVEL`

  Set this parameter to `TYPICAL` (default) or `ALL` to enable statistics gathering by AWR. Setting `STATISTICS_LEVEL` to `BASIC` disables many database features, including AWR, and is not recommended.

- `CONTROL_MANAGEMENT_PACK_ACCESS`

  Set to `DIAGNOSTIC+TUNING` (default) or `DIAGNOSTIC` to enable automatic database diagnostic monitoring. Setting `CONTROL_MANAGEMENT_PACK_ACCESS` to `NONE` disables many database features, including ADDM, and is strongly discouraged.

> ✎ **See Also:**
>
> - *Oracle Database Reference* for more information about the `STATISTICS_LEVEL` initialization parameter
>
> - *Oracle Database Reference* for more information about the `CONTROL_MANAGEMENT_PACK_ACCESS` initialization parameter

The database statistics collected and processed by AWR include:

- Time Model Statistics
- Wait Event Statistics
- Session and System Statistics
- Active Session History Statistics
- High-Load SQL Statistics

Time Model Statistics

Time model statistics measure the time spent in the database by operation type. The most important time model statistic is **database time (DB time)**. DB time represents the total time spent in database calls by foreground sessions, and is an indicator of the total instance workload. As shown in Figure 2-1, database time makes up a portion of an application's overall user response time.

Figure 2-1   DB Time in Overall User Response Time
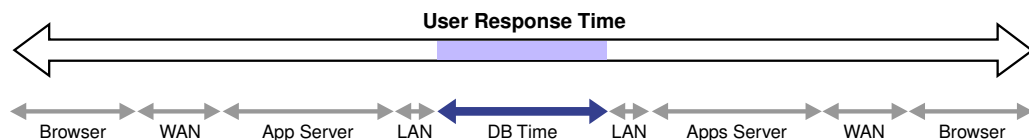
A **session** is a logical entity in the database instance memory that represents the state of a current user login to a database. Database time is calculated by aggregating the

CPU time and wait time of all **active sessions** (sessions that are not idle). For any database request, the CPU time is the sum of the time spent working on the request, while the wait time is the sum of all the waits for various database instance resources. DB time includes only time spent on client processes and does not include time spent on background processes such as PMON.

For example, a user session may involve an online transaction made at an online bookseller consisting of the actions shown in Figure 2-2.

Figure 2-2   DB Time in User Transaction
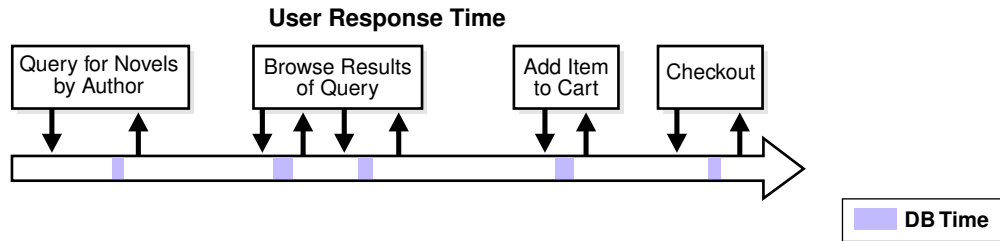
1. Query for novels by author

   The user performs a search for novels by a particular author. This action causes the application to perform a database query for novels by the author.

2. Browse results of query

   The user browses the returned list of novels by the author and accesses additional details, such as user reviews and inventory status. This action causes the application to perform additional database queries.

3. Add item to cart

   After browsing details about the novels, the user decides to add one novel to the shopping cart. This action causes the application to make a database call to update the shopping cart.

4. Checkout

   The user completes the transaction by checking out, using the address and payment information previously saved at the bookseller's website from a previous purchase. This action causes the application to perform various database operations to retrieve the user's information, add a new order, update the inventory, and generate an email confirmation.

For each of the preceding actions, the user makes a request to the database, as represented by the down arrow in Figure 2-2. The CPU time spent by the database processing the request and the wait time spent waiting for the database are considered DB time, as represented by the shaded areas. After the request is completed, the results are returned to the user, as represented by the up arrow. The space between the up and down arrows represents the total user response time for processing the request, which contains other components besides DB time, as illustrated in Figure 2-1.

> **✏ Note:**
>
> DB time is measured cumulatively from when the instance started. Because DB time combines times from all non-idle user sessions, DB time can exceed the time elapsed since the instance started. For example, an instance that has run 5 minutes could have four active sessions whose cumulative DB time is 20 minutes.

The objective of database tuning is to reduce DB time. In this way, you can improve the overall response time of user transactions in the application.

Wait Event Statistics

Wait events are incremented by a session to indicate that the session had to wait for an event to complete before being able to continue processing. When a session has to wait while processing a user request, the database records the wait by using one of a set of predefined wait events. The events are then grouped into wait classes, such as User I/O and Network. Wait event data reveals symptoms of problems that might be affecting performance, such as latch, buffer, or I/O contention.

> **✏ See Also:**
>
> - *Oracle Database Performance Tuning Guide*
> - *Oracle Database Reference*

Session and System Statistics

A large number of cumulative database statistics are available on a system and session level. Some of these statistics are collected by AWR.

Active Session History Statistics

The Active Session History (ASH) statistics are samples of session activity in the database. The database samples active sessions every second and stores them in a circular buffer in the System Global Area (SGA). Any session that is connected to the database and using CPU, or is waiting for an event that does not belong to the idle wait class, is considered an active session. By capturing only active sessions, a manageable set of data is represented. The size of the data is directly related to the work being performed, rather than the number of sessions allowed on the database.

Using the DB time example described in "Time Model Statistics", samples of session activity are collected from the online transaction made at the bookseller's website, represented as vertical lines below the horizontal arrow in Figure 2-3.

Figure 2-3   Active Session History
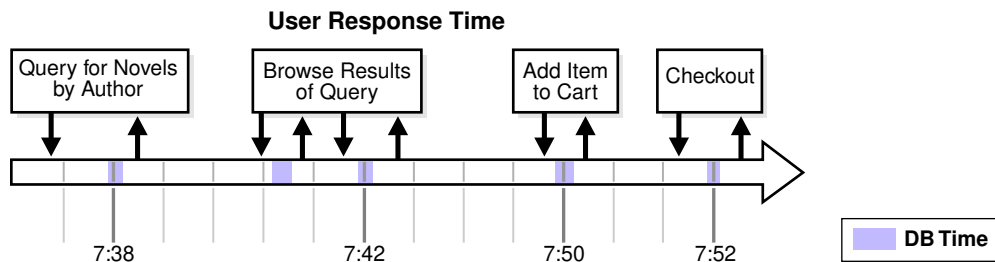
The light vertical lines represent samples of inactive session activity that are not captured in the ASH statistics. The bold vertical lines represent samples of active sessions that are captured at:

- 7:38, while novels by the author are being queried

- 7:42, while the user is browsing the query results

- 7:50, when one novel is added to the shopping cart

- 7:52, during the checkout process

Table 2-1 lists ASH statistics collected for the active sessions, along with examples of the session ID (SID), module, SQL ID, session state, and wait events that are sampled.

Table 2-1   Active Session History

Time	SID	Module	SQL ID	State	Event
7:38	213	Book by author	qa324jffritcf	Waiting	db file sequential read
7:42	213	Get review ID	aferv5desfzs5	CPU	n/a
7:50	213	Add item to cart	hk32pekfcbdfr	Waiting	buffer busy wait
7:52	213	Checkout	abngldf95f4de	Waiting	log file sync

High-Load SQL Statistics

SQL statements that are consuming the most resources produce the highest load on the system, based on criteria such as elapsed time and CPU time.

Using the Oracle Performance Method

Performance tuning using the Oracle performance method is driven by identifying and eliminating bottlenecks in the database, and by developing efficient SQL statements. Database tuning is performed in two phases: proactively and reactively.

In the proactive tuning phase, you must perform tuning tasks as part of your daily database maintenance routine, such as reviewing ADDM analysis and findings, monitoring the real-time performance of the database, and responding to alerts.

In the reactive tuning phase, you must respond to issues reported by users, such as performance problems that may occur for only a short duration of time, or performance degradation to the database over a period of time.

SQL tuning is an iterative process to identify, tune, and improve the efficiency of high-load SQL statements.

Applying the Oracle performance method involves the following:

- Performing pre-tuning preparations, as described in "Preparing the Database for Tuning"

- Tuning the database proactively on a regular basis, as described in "Tuning the Database Proactively"

- Tuning the database reactively when performance problems are reported by the users, as described in "Tuning the Database Reactively"

- Identifying, tuning, and optimizing high-load SQL statements, as described in "Tuning SQL Statements"

To improve database performance, you must apply these principles iteratively.

Preparing the Database for Tuning

This section lists and describes the steps that must be performed before the database can be properly tuned.

To prepare the database for tuning:

1. Get feedback from users.

   Determine the scope of the performance project and subsequent performance goals, and determine performance goals for the future. This process is key for future capacity planning.

2. Check the operating systems of all systems involved with user performance.

   Check for hardware or operating system resources that are fully utilized. List any overused resources for possible later analysis. In addition, ensure that all hardware is functioning properly.

3. Ensure that the `STATISTICS_LEVEL` initialization parameter is set to `TYPICAL` (default) or `ALL` to enable the automatic performance tuning features of Oracle Database, including AWR and ADDM.

4. Ensure that the `CONTROL_MANAGEMENT_PACK_ACCESS` initialization parameter is set to `DIAGNOSTIC+TUNING` (default) or `DIAGNOSTIC` to enable ADDM.

> **✎ See Also:**
>
> - "Gathering Database Statistics Using the Automatic Workload Repository" for information about configuring AWR
> - "Configuring Automatic Database Diagnostic Monitor"

Tuning the Database Proactively

This section lists and describes the proactive steps required to keep the database properly tuned on a regular basis. Perform these steps as part of your daily

maintenance of Oracle Database. Repeat the tuning process until your performance goals are met or become impossible to achieve because of other constraints.

To tune the database proactively:

1. Review the ADDM findings, as described in Automatic Database Performance Monitoring.

    ADDM automatically detects and reports on performance problems with the database, including most of the "Common Performance Problems Found in Databases". The results are displayed as ADDM findings on the Database Home page in Oracle Enterprise Manager Cloud Control (Cloud Control). Reviewing these findings enables you to quickly identify the performance problems that require your attention.

2. Implement the ADDM recommendations, as described in Automatic Database Performance Monitoring.

    With each ADDM finding, ADDM automatically provides a list of recommendations for reducing the impact of the performance problem. Implementing a recommendation applies the suggested changes to improve the database performance.

3. Monitor performance problems with the database in real time, as described in Monitoring Real-Time Database Performance.

    The Performance page in Cloud Control enables you to identify and respond to real-time performance problems. By drilling down to the appropriate pages, you can identify and resolve performance problems with the database in real time, without having to wait until the next ADDM analysis.

4. Respond to performance-related alerts, as described in Monitoring Performance Alerts.

    The Database Home page in Cloud Control displays performance-related alerts generated by the database. Typically, resolving the problems indicated by these alerts improves database performance.

5. Validate that any changes have produced the desired effect, and verify that the users experience performance improvements.

Tuning the Database Reactively

This section lists and describes the steps required to tune the database based on user feedback. This tuning procedure is considered reactive. Perform this procedure periodically when performance problems are reported by the users.

To tune the database reactively:

1. Run ADDM manually to diagnose current and historical database performance when performance problems are reported by the users, as described in Manual Database Performance Monitoring.

    In this way you can analyze current database performance before the next ADDM analysis, or analyze historical database performance when you were not proactively monitoring the system.

2. Resolve transient performance problems, as described in Resolving Transient Performance Problems.

    The Active Session History (ASH) reports enable you to analyze transient performance problems with the database that are short-lived and do not appear in the ADDM analysis.

3. Resolve performance degradation over time, as described in Resolving Performance Degradation Over Time.

   The Automatic Workload Repository (AWR) Compare Periods report enables you to compare database performance between two periods of time, and resolve performance degradation that may happen from one time period to another.

4. Validate that the changes made have produced the desired effect, and verify that the users experience performance improvements.

5. Repeat these steps until your performance goals are met or become impossible to achieve due to other constraints.

Tuning SQL Statements

This section lists and describes the steps required to identify, tune, and optimize high-load SQL statements.

To tune SQL statements:

1. Identify high-load SQL statements, as described in Identifying High-Load SQL Statements.

   Use the ADDM findings and the Top SQL section to identify high-load SQL statements that are causing the greatest contention.

2. Tune high-load SQL statements, as described in Tuning SQL Statements.

   You can improve the efficiency of high-load SQL statements by tuning them using SQL Tuning Advisor.

3. Optimize data access paths, as described in Optimizing Data Access Paths.

   You can optimize the performance of data access paths by creating the proper set of materialized views, materialized view logs, and indexes for a given workload by using SQL Access Advisor.

4. Analyze the SQL performance impact of SQL tuning and other system changes by using SQL Performance Analyzer.

   To learn how to use SQL Performance Analyzer, see *Oracle Database Testing Guide*.

5. Repeat these steps until all high-load SQL statements are tuned for greatest efficiency.

Common Performance Problems Found in Databases

This section lists and describes common performance problems found in databases. By following the Oracle performance method, you should be able to avoid these problems in an Oracle Database instance. If you experience these problems, then repeat the steps in the Oracle performance method, as described in "Using the Oracle Performance Method", or consult the appropriate section that addresses these problems:

* CPU bottlenecks

  Is the application performing poorly because the system is CPU-bound? Performance problems caused by CPU bottlenecks are diagnosed by ADDM, as described in Automatic Database Performance Monitoring. You can also identify

CPU bottlenecks by using the Performance page in Cloud Control, as described in "Monitoring CPU Utilization".

- Undersized memory structures

  Are the Oracle memory structures such as the System Global Area (SGA), Program Global Area (PGA), and buffer cache adequately sized? Performance problems caused by undersized memory structures are diagnosed by ADDM, as described in Automatic Database Performance Monitoring. You can also identify memory usage issues by using the Performance page in Cloud Control, as described in "Monitoring Memory Utilization".

- I/O capacity issues

  Is the I/O subsystem performing as expected? Performance problems caused by I/O capacity issues are diagnosed by ADDM, as described in Automatic Database Performance Monitoring. You can also identify disk I/O issues by using the Performance page in Cloud Control, as described in "Monitoring Disk I/O Utilization".

- Suboptimal use of Oracle Database by the application

  Is the application making suboptimal use of Oracle Database? Problems such as establishing new database connections repeatedly, excessive SQL parsing, and high levels of contention for a small amount of data (also known as application-level block contention) can degrade the application performance significantly. Performance problems caused by suboptimal use of Oracle Database by the application are diagnosed by ADDM, as described in Automatic Database Performance Monitoring. You can also monitor top activity in various dimensions—including SQL, session, services, modules, and actions—by using the Performance page in Cloud Control, as described in "Monitoring User Activity".

- Concurrency issues

  Is the database performing suboptimally due to a high degree of concurrent activities in the database? A high degree of concurrent activities might result in contention for shared resources that can manifest in the form of locks or waits for buffer cache. Performance problems caused by concurrency issues are diagnosed by ADDM, as described in Automatic Database Performance Monitoring. You can also identify concurrency issues by using Top Sessions in Cloud Control, as described in "Monitoring Top Sessions".

- Database configuration issues

  Is the database configured optimally to provide desired performance levels? For example, is there evidence of incorrect sizing of log files, archiving issues, too many checkpoints, or suboptimal parameter settings? Performance problems caused by database configuration issues are diagnosed by ADDM, as described in Automatic Database Performance Monitoring.

- Short-lived performance problems

  Are users complaining about short-lived or intermittent performance problems? Depending on the interval between snapshots taken by AWR, performance problems that have a short duration may not be captured by ADDM. You can identify short-lived performance problems by using the Active Session History report, as described in Resolving Transient Performance Problems.

- Degradation of database performance over time

  Is there evidence that the database performance has degraded over time? For example, are you or your users noticing that the database is not performing as well as it was 6 months ago? You can generate an AWR Compare Periods report to compare the period when the performance was poor to a period when the performance is stable to identify configuration settings, workload profile, and statistics that are different between these two

time periods. This technique helps you identify the cause of the performance degradation, as described in Resolving Performance Degradation Over Time.

- Inefficient or high-load SQL statements

  Are any SQL statements using excessive system resources that impact the system? Performance problems caused by high-load SQL statements are diagnosed by ADDM, as described in Automatic Database Performance Monitoring and "Identification of High-Load SQL Statements Using ADDM Findings". You can also identify high-load SQL statements by using Top SQL in Cloud Control, as described in "Identifying High-Load SQL Statements Using Top SQL". After they have been identified, you can tune the high-load SQL statements using SQL Tuning Advisor, as described in Tuning SQL Statements.

- Object contention

  Are any database objects the source of bottlenecks because they are continuously accessed? Performance problems caused by object contention are diagnosed by ADDM, as described in Automatic Database Performance Monitoring. You can also optimize the data access path to these objects using SQL Access Advisor, as described in Optimizing Data Access Paths.

- Unexpected performance regression after tuning SQL statements

  Is the performance of SQL statements degrading after they have been tuned? Tuning SQL statements may cause changes to their execution plans, resulting in a significant impact on SQL performance. In some cases, the changes may result in the improvement of SQL performance. In other cases, the changes may cause SQL statements to regress, resulting in a degradation of SQL performance.

  Before making changes on a production system, you can analyze the impact of SQL tuning on a test system by using SQL Performance Analyzer. This feature enables you to forecast the impact of system changes on a SQL workload by:

  – Measuring the performance before and after the change

  – Generating a report that describes the change in performance

  – Identifying the SQL statements that regressed or improved

  – Providing tuning recommendations for each SQL statement that regressed

  – Enabling you to implement the tuning recommendations when appropriate

  > **✎ See Also:**
  >
  > *Oracle Database Testing Guide* to know more about how to use SQL Performance Analyzer

Part II

Proactive Database Tuning

Part II describes how to tune Oracle Database proactively on a regular basis and contains the following chapters:

- Automatic Database Performance Monitoring
- Monitoring Real-Time Database Performance
- Monitoring Real-Time Database Operations
- Monitoring Performance Alerts

3

Automatic Database Performance Monitoring

Automatic Database Diagnostic Monitor (ADDM) automatically detects and reports performance problems with the database. The results are displayed as ADDM findings on the Database Home page in Oracle Enterprise Manager Cloud Control (Cloud Control). Reviewing the ADDM findings enables you to quickly identify the performance problems that require your attention. Before using another performance tuning method described in this guide, first review the results of the ADDM analysis.

Each ADDM finding provides a list of recommendations for reducing the impact of the performance problem. You should review ADDM findings and implement the recommendations every day as part of regular database maintenance. Even when the database is operating at an optimal performance level, you should continue to use ADDM to monitor database performance on an ongoing basis.

This chapter contains the following sections:

- Overview of Automatic Database Diagnostic Monitor
- Configuring Automatic Database Diagnostic Monitor
- Reviewing the Automatic Database Diagnostic Monitor Analysis
- Interpretation of Automatic Database Diagnostic Monitor Findings
- Implementing Automatic Database Diagnostic Monitor Recommendations
- Viewing Snapshot Statistics

> ✎ **See Also:**
>
> - *Oracle Database Performance Tuning Guide* for information about using the `DBMS_ADVISOR` package to diagnose and tune the database with the Automatic Database Diagnostic Monitor

Overview of Automatic Database Diagnostic Monitor

ADDM is diagnostic software built into Oracle Database. ADDM examines and analyzes data captured in Automatic Workload Repository (AWR) to determine possible database performance problems. ADDM then does the following:

- Locates the root causes of the performance problems
- Provides recommendations for correcting them
- Quantifies the expected benefits
- Identifies areas where no action is necessary.

This section contains the following topics:

- ADDM Analysis

- [ADDM Recommendations](#)
- [ADDM for Oracle Real Application Clusters](#)
- [ADDM for a Multitenant Environment](#)

ADDM Analysis

An ADDM analysis is performed after each AWR snapshot (every hour by default), and the results are saved in the database. You can then view the results using Cloud Control.

The ADDM analysis is performed from the top down, first identifying symptoms and then refining the analysis to reach the root causes of performance problems. ADDM uses the DB time statistic to identify performance problems. Database time (DB) time is the cumulative time spent by the database in processing user requests, including both the wait time and CPU time of all user sessions that are not idle.

The goal of database performance tuning is to reduce the DB time of the system for a given workload. By reducing DB time, the database can support more user requests by using the same or fewer resources. ADDM reports system resources that are using a significant portion of DB time as problem areas and sorts them in descending order by the amount of related DB time spent.

> ✎ **See Also:**
>
> "[Time Model Statistics](#)" for more information about the DB time statistic

ADDM Recommendations

In addition to diagnosing performance problems, ADDM recommends possible solutions. When appropriate, ADDM recommends multiple solutions from which you can choose. ADDM recommendations include the following:

- Hardware changes

  Adding CPUs or changing the I/O subsystem configuration

- Database configuration

  Changing initialization parameter settings

- Schema changes

  Hash partitioning a table or index, or using automatic segment space management (ASSM)

- Application changes

  Using the cache option for sequences or using bind variables

- Using other advisors

  Running SQL Tuning Advisor on high-load SQL statements or running the Segment Advisor on hot objects

ADDM benefits apply beyond production systems. Even on development and test systems, ADDM can provide an early warning of potential performance problems.

Performance tuning is an iterative process. Fixing one problem can cause a bottleneck to shift to another part of the system. Even with the benefit of the ADDM analysis, it can take multiple tuning cycles to reach a desirable level of performance.

ADDM for Oracle Real Application Clusters

In an Oracle Real Application Clusters (Oracle RAC) environment, you can use ADDM to analyze the throughput performance of a database cluster. ADDM for Oracle RAC considers DB time as the sum of database times for all database instances and reports findings that are significant at the cluster level. For example, the DB time of each cluster node may be insignificant when considered individually, but the aggregate DB time may be a significant problem for the cluster as a whole.

> **See Also:**
>
> - *Oracle Real Application Clusters Administration and Deployment Guide* for information about using ADDM for Oracle RAC

ADDM for a Multitenant Environment

Starting with Oracle Database 12c, ADDM is enabled by default in the root container of a multitenant container database (CDB). Starting with Oracle Database 19c, you can also use ADDM in a pluggable database (PDB).

> **Note:**
>
> A multitenant container database is the only supported architecture in Oracle Database 21c. While the documentation is being revised, legacy terminology may persist. In most cases, "database" and "non-CDB" refer to a CDB or PDB, depending on context. In some contexts, such as upgrades, "non-CDB" refers to a non-CDB from a previous release.

To use ADDM in a PDB, you must enable automatic snapshots in the PDB by setting the `AWR_PDB_AUTOFLUSH_ENABLED` initialization parameter to `TRUE` and AWR snapshot interval greater than 0.

> **See Also:**
>
> *Oracle Database Performance Tuning Guide* for more information about using ADDM in a multitenant environment

Configuring Automatic Database Diagnostic Monitor

This section contains the following topics:

- Setting Initialization Parameters to Enable ADDM
- Setting the DBIO_EXPECTED Parameter
- Managing AWR Snapshots

Setting Initialization Parameters to Enable ADDM

Automatic database diagnostic monitoring is enabled by default and is controlled by the `CONTROL_MANAGEMENT_PACK_ACCESS` and the `STATISTICS_LEVEL` initialization parameters.

Set `CONTROL_MANAGEMENT_PACK_ACCESS` to `DIAGNOSTIC+TUNING` (default) or `DIAGNOSTIC` to enable automatic database diagnostic monitoring. Setting `CONTROL_MANAGEMENT_PACK_ACCESS` to `NONE` disables many Oracle Database features, including ADDM, and is strongly discouraged.

Set `STATISTICS_LEVEL` to `TYPICAL` (default) or `ALL` to enable automatic database diagnostic monitoring. Setting `STATISTICS_LEVEL` to `BASIC` disables many Oracle Database features, including ADDM, and is strongly discouraged.

To determine whether ADDM is enabled:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Administration** menu, select **Initialization Parameters**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Initialization Parameters page appears.

3. In the **Name** field, enter `statistics_level` and then click **Go**.

   The Initialization Parameters table shows the setting of this initialization parameter.

Name ▲	Help	Revisions	Value	Comments	Type	Basic	Modified	Dynamic	Category
statistics_level	ⓘ		TYPICAL ▾		String			✓	Diagnostics and Statistics

4. Do one of the following:

   - If the Value list shows **ALL** or **TYPICAL**, then do nothing.

   - If the Value list shows **BASIC**, then select **ALL** or **TYPICAL**, and then click **Apply**.

5. In the **Name** field, enter `control_management_pack_access`, and then click **Go**.

   The table shows the setting of this initialization parameter.

6. Do one of the following:

   - If the Value column shows **DIAGNOSTIC** or **DIAGNOSTIC+TUNING**, then do nothing.

   - If the Value column shows **NONE**, then select **DIAGNOSTIC** or **DIAGNOSTIC+TUNING** and click **Apply**.

> ✏ **See Also:**
>
> - *Oracle Database Reference* for information about the `STATISTICS_LEVEL` initialization parameter
> - *Oracle Database Reference* for information about the `CONTROL_MANAGEMENT_PACK_ACCESS` initialization parameter

Setting the DBIO_EXPECTED Parameter

ADDM analysis of I/O performance partially depends on a single argument, `DBIO_EXPECTED`, that describes the expected performance of the I/O subsystem. The value of `DBIO_EXPECTED` is the average time it takes to read a single database block, in microseconds. Oracle Database uses the default value of 10 milliseconds, which is an appropriate value for most hard drives. You can choose a different value based on the characteristics of your hardware.

To determine the correct setting for the `DBIO_EXPECTED` initialization parameter:

1. Measure the average read time of a single database block for your hardware.

   This measurement must be taken for random I/O, which includes seek time if you use standard hard drives. Typical values for hard drives are between 5000 and 20000 microseconds.

   > ✏ **See Also:**
   >
   > *Oracle Database Performance Tuning Guide* to learn how to assess the I/O capability of the storage subsystem

2. Set the value one time for all subsequent ADDM executions.

   For example, if the measured value is 8000 microseconds, then execute the following PL/SQL code as the `SYS` user:

   ```
   EXECUTE DBMS_ADVISOR.SET_DEFAULT_TASK_PARAMETER(
                        'ADDM', 'DBIO_EXPECTED', 8000);
   ```

Managing AWR Snapshots

By default, the Automatic Workload Repository (AWR) generates snapshots of performance data once every hour, and retains the statistics in the workload repository for 8 days. You can change the default values for both the snapshot interval and the retention period.

Oracle recommends that you adjust the AWR retention period to at least one month. You can also extend the period to one business cycle so you can compare data across time frames such as the close of the fiscal quarter. You can also create AWR baselines to retain snapshots indefinitely for important time periods.

The data in the snapshot interval is analyzed by ADDM. ADDM compares the differences between snapshots to determine which SQL statements to capture, based on the effect on the system load. The ADDM analysis shows the number of SQL statements that need to be captured over time.

This section contains the following topics:

- Creating Snapshots
- Modifying Snapshot Settings

Creating Snapshots

Manually creating snapshots is usually not necessary because AWR generates snapshots of the performance data once every hour by default. In some cases, however, it may be necessary to manually create snapshots to capture different durations of activity, such as when you want to compare performance data over a shorter period than the snapshot interval.

To create snapshots:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **AWR** and then select **AWR Administration**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Automatic Workload Repository page appears.

3. Under Manage Snapshots and Baselines, click the number next to Snapshots.

   The Snapshots page appears with a list of the most recent snapshots.

4. Click **Create**.

   The Confirmation page appears.

5. Click **Yes**.

   The Processing: Create Snapshot page is displayed while the snapshot is being taken.

   After the snapshot is taken, the Snapshots page reappears with a Confirmation message.

   The following screenshot of the list of snapshots shows that a snapshot was created at 9:24:25 a.m. The ID of the snapshot is 383.

Select	ID	Capture Time	Collection Level	Within A Baseline
○	378	Jan 12, 2012 7:00:57 AM	TYPICAL	
○	379	Jan 12, 2012 7:30:02 AM	TYPICAL	
○	380	Jan 12, 2012 8:00:12 AM	TYPICAL	
○	381	Jan 12, 2012 8:30:18 AM	TYPICAL	
○	382	Jan 12, 2012 9:00:24 AM	TYPICAL	
◉	383	Jan 12, 2012 9:24:25 AM	TYPICAL	

Modifying Snapshot Settings

By default, AWR generates snapshots of performance data once every hour. You can modify the default values of both the interval between snapshots and their retention period.
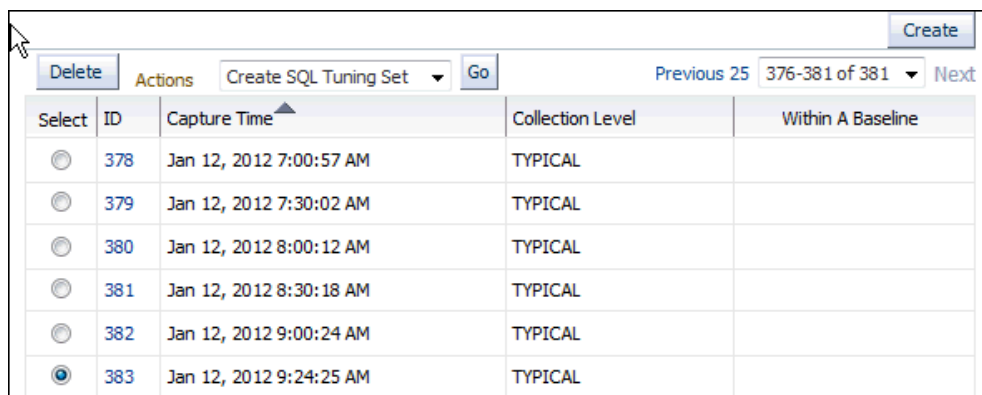
To modify the snapshot settings:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **AWR**, then select **AWR Administration**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Automatic Workload Repository page appears.

   In the following screenshot of the General section of the page, the snapshot retention is set to 8 days and the snapshot interval is set to 60 minutes.
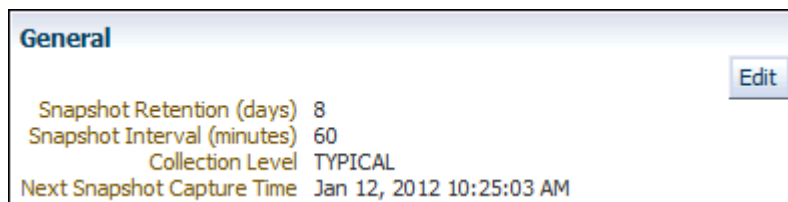
3. Click **Edit**.

   The Edit Settings page appears.
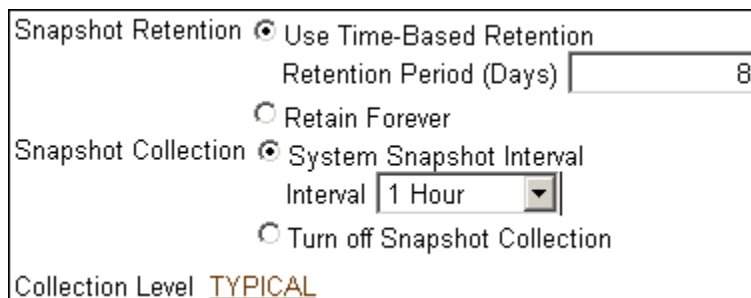
4. For **Snapshot Retention**, do one of the following:

   • Select **Use Time-Based Retention Period (Days)**, and in the associated field enter the number of days to retain the snapshots.

   • Select **Retain Forever** to retain snapshots indefinitely.

   It is recommended that you increase the snapshot retention period to the maximum allowed by the available disk space.

   In the following screenshot of the Snapshot Retention group, the snapshot retention period is changed to 30 days.
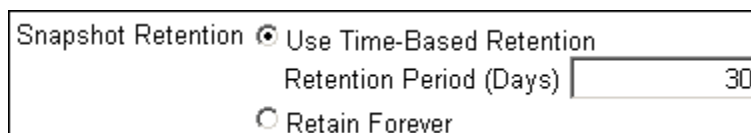
5. For **Snapshot Collection**, do one of the following:

    •   Select **System Snapshot Interval**, and in the **Interval** list, select the desired interval to change the interval between snapshots.

    •   Select **Turn off Snapshot Collection** to disable snapshot collection.

    In the following screenshot of the Snapshot Collection group, the snapshot collection interval is changed to 30 minutes.
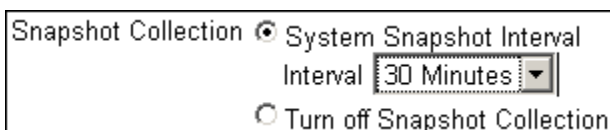
6. Click the link next to **Collection Level**.

    The Initialization Parameters page appears.

    To change the statistics level, select `TYPICAL` or `ALL` in the Value list for the `statistics_level` parameter. Click **Save to File** to set the value in the server parameter file.

    In the following screenshot of the Initialization Parameters table, the default value of Typical is used.

7. Click **OK** to apply the changes.

    The Automatic Workload Repository page appears and displays the new settings.

Reviewing the Automatic Database Diagnostic Monitor Analysis

By default, ADDM runs every hour to analyze snapshots taken by AWR during that period. If the database finds performance problems, then it displays the results of the analysis under Diagnostics in the Summary section on the Database Home page.

The ADDM Findings link shows how many ADDM findings were found in the most recent ADDM analysis.

To view ADDM findings:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Advisors Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Advisor Central page appears.

3. In the Results section of Advisor Tasks, select the most recent ADDM result, and then click **View Result**.

   The Automatic Database Diagnostic Monitor (ADDM) page appears. The results of the ADDM run are displayed.

Figure 3-1   The Automatic Database Diagnostic Monitor Page
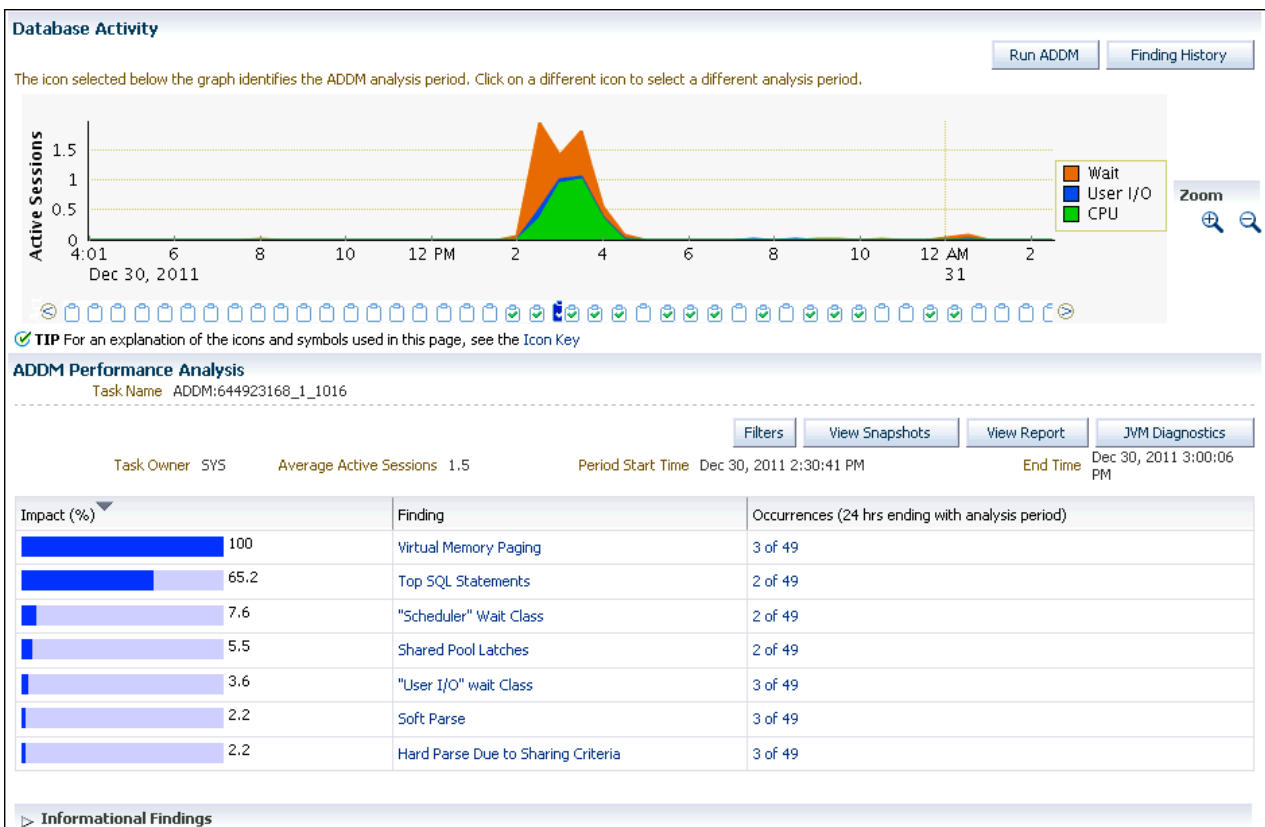
On the Automatic Database Diagnostic Monitor (ADDM) page, the Database Activity chart shows the database activity during the ADDM analysis period. Database activity types are defined in the legend based on their corresponding colors in the chart. Each icon below the chart represents a different ADDM task, which in turn corresponds to a pair of snapshots saved in AWR.

In Figure 3-1, stacked area chart in the Database Activity section shows that the most database activity was between 2:00 p.m. to 4:30 p.m. on December 30. During that time, the activity was dominated by CPU and wait classes, with very little I/O happening.

In the ADDM Performance Analysis section, ADDM findings are listed in descending order, from highest to least impact. The Informational Findings section lists areas that have no performance impact and are for information only.

4. Optionally, click the Zoom icons to shorten or lengthen the analysis period displayed on the chart.

5. To view the ADDM findings in a report, click **View Report**.

   The View Report page appears.

   You can click **Save to File** to save the report for later access.

Interpretation of Automatic Database Diagnostic Monitor Findings

The ADDM analysis results are represented as a set of findings. Each ADDM finding belongs to one of three types:

- Problem

  Findings that describe the root cause of a database performance issue

- Symptom

  Findings that contain information that often leads to one or more problem findings

- Information

  Findings that are used to report areas of the system that do not have a performance impact

Each problem finding is quantified with an estimate of the portion of DB time that resulted from the performance problem.

When a specific problem has multiple causes, ADDM may report multiple findings. In this case, the impacts of these multiple findings can contain the same portion of DB time. Because performance problems can overlap, summing the impacts of the reported findings can yield a number higher than 100% of DB time. For example, if a system performs many read I/O operations, ADDM may report a SQL statement responsible for 50% of DB time due to I/O activity as one finding, and an undersized buffer cache responsible for 75% of DB time as another finding.

A problem finding can be associated with a list of recommendations for reducing the impact of a performance problem. Each recommendation has a benefit that is an estimate of the portion of DB time that can be saved if the recommendation is

implemented. When multiple recommendations are associated with an ADDM finding, the recommendations may contain alternatives for solving the same problem. In this case, the sum of the benefits may be higher than the impact of the finding. You do not need to apply all the recommendations to solve the same problem.

Recommendations are composed of actions and rationales. You must apply all the actions of a recommendation to gain its estimated benefit. The rationales explain why the set of actions are recommended, and provide additional information for implementing them. An ADDM action may present multiple solutions. If this is the case, then choose the easiest solution to implement.

Implementing Automatic Database Diagnostic Monitor Recommendations

This section describes how to implement ADDM recommendations. ADDM findings are displayed in the Automatic Database Diagnostic Monitor (ADDM) page under ADDM Performance Analysis.

To implement ADDM recommendations:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Advisors Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Advisor Central page appears.

3. In the Results section of Advisor Tasks, select the most recent ADDM result, then click **View Result**.

   The Automatic Database Diagnostic Monitor (ADDM) page appears.

4. In the Database Activity section, click the chart icon for the ADDM run to investigate.

   The data in the ADDM Performance Analysis section changes based on the ADDM run that you selected.

5. In the ADDM Performance Analysis table, click the ADDM finding that has the greatest impact.

   In the following screenshot of the ADDM Performance Analysis table, the finding with the greatest impact is Top SQL Statements.

Impact (%) ▽		Finding	Occurrences (24 hrs ending with analysis period)
	83.7	Top SQL Statements	5 of 29
	23.4	"Scheduler" Wait Class	5 of 29
	3.5	Log File Switches	1 of 29
	2.1	Undersized Buffer Cache	1 of 29

   The Performance Finding Details page appears.

   In the following screen shot of the Performance Finding Details page, five recommendations are shown. The first is estimated to have a maximum benefit of up to 26.7% of DB time in the analysis period. The second recommendation is estimated to

have a maximum benefit of up to 10.9% of DB time, the third also has a maximum of 10.9%, the fourth has a maximum of 9.9%, and the fifth has a maximum of 5%.
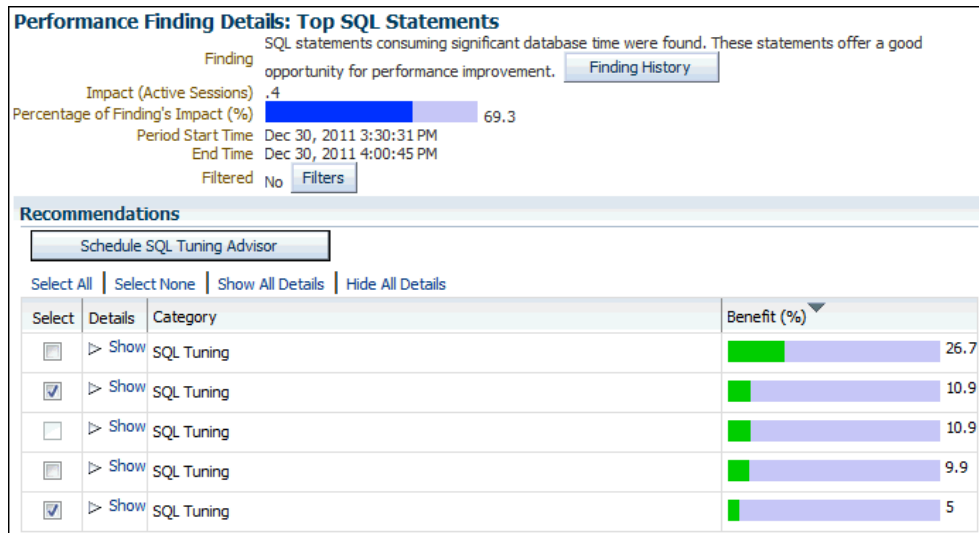
6. Under Recommendations, click **Show** to review the recommendations and required actions for each recommendation.

   The Category column displays the category of the recommendation. The Benefit (%) column displays the estimated benefit of implementing the recommendation.

   Figure 3-2 shows the recommendations for the first item in the Recommendations table.

Figure 3-2   Recommendations on the Performance Finding Details Page
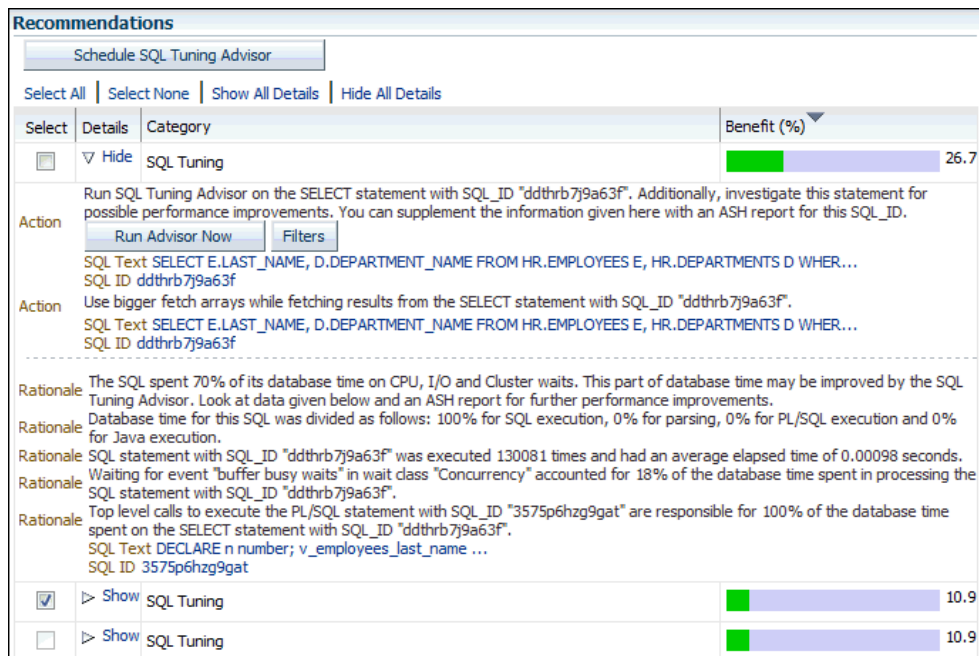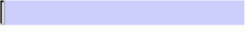
7. If additional information is available about why the set of actions was recommended, then click **Additional Information**, or review the content displayed under Additional Information.

   For example, the following screenshot shows an Undersized Buffer Cache finding that contains additional information that indicates the recommended value of the `DB_CACHE_SIZE` initialization parameter.

8. To view the history of a finding, click **Finding History**.

   The Finding History page appears. The following screenshot shows the Finding History page for the top SQL statements.
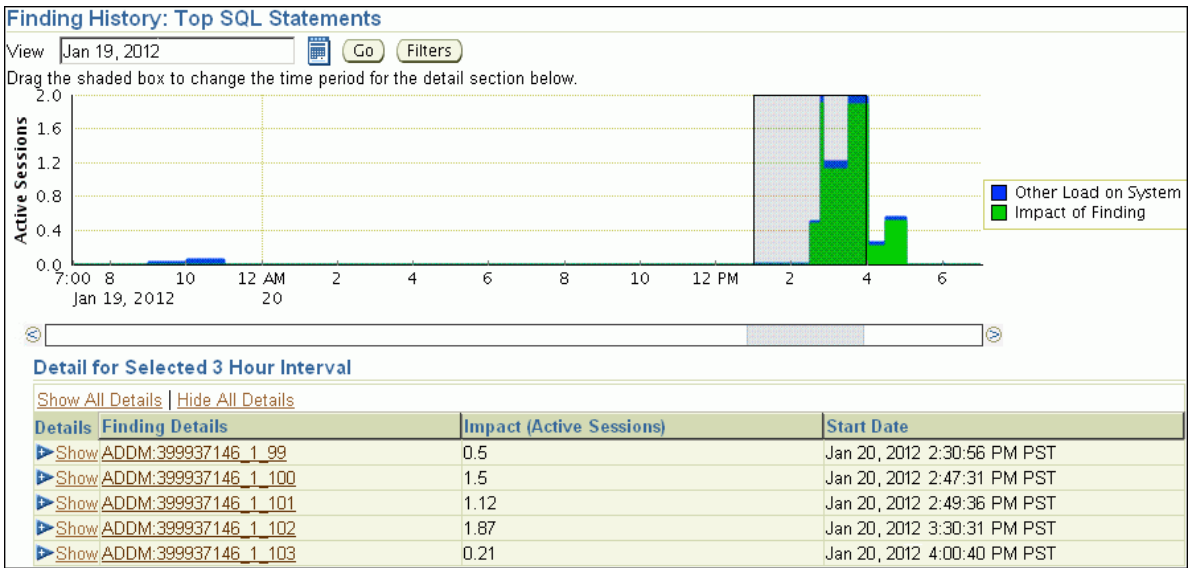
The Finding History page shows how often a particular finding has occurred in a selected 3-hour interval. You can use this information to determine whether the finding was a transient or a persistent problem in the system. Based on this information, you can determine whether the actions associated with the finding should be implemented.

The Active Sessions stacked area chart shows the impact of the finding and of the other loads on the system. You can change the display as follows:

a. To move the 3-hour interval, click and drag the shaded box in the Active Sessions chart.

b. To change dates, enter the desired date in the **View** field, and then click **Go**.

c. To view details about a finding, under Detail for Selected 3 Hour Interval, click the link in the **Finding Details** column to display the Performance Finding Details page for the corresponding ADDM finding.

9. Optionally, create a filter to suppress known findings that have been tuned or cannot be tuned further. To create filters for a selected ADDM finding:

a. Click **Filters**.

The Filters for Finding page appears.

b. Click **Create**.

The Create Filter for Finding page appears.

c. In the **Name** field, enter a name for the ADDM filter.

d. In the **Active Sessions** field, specify the filter criteria in terms of the number of active sessions.

The database filters the ADDM finding for future ADDM runs if the number of active sessions for the finding is less than the specified filter criteria.

e. In the **% Active Sessions** field, specify the filter criteria in terms of percentage of active sessions.

The database filters the ADDM finding for future ADDM runs if the number of active sessions for the finding is less than the specified filter criteria.

      f. Click **OK**.

10. Perform the required action of a chosen recommendation.

    Depending on the type of action you choose to perform, various options may be available, such as **Implement** or **Run Advisor Now**. These options enable you to implement the recommendation immediately with a single mouse click.

    In the example shown in Figure 3-2, the simplest solution is to click **Run Advisor Now** to immediately run a SQL Tuning Advisor task on the SQL statement.

> ✎ **See Also:**
>
> • "Tuning SQL Statements "

Viewing Snapshot Statistics

You can view the data contained in snapshots taken by AWR using Cloud Control. Typically, it is not necessary to review snapshot data because it primarily contains raw statistics. Instead, rely on ADDM, which analyzes statistics to identify performance problems. Snapshot statistics are intended primarily for advanced users, such as DBAs accustomed to using Statspack for performance analysis.

To view snapshot statistics:

1. Access the Database Home page.

    See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **AWR** and then select **AWR Administration**.

    If the Database Login page appears, then log in as a user with administrator privileges. The Performance page appears.

3. Under Manage Snapshots and Baselines, click the number next to Snapshots.

    The Snapshots page appears with a list of the most recent snapshots.

4. To view the statistics gathered in a snapshot, click the **ID** link of the snapshot you want to view.

    The Snapshot Details appears, showing the Details subpage.

    The following screenshot of a Details subpage shows statistics gathered from the previous snapshot (snapshot 386) to the selected snapshot (snapshot 387).

Details	Report			

| Beginning Snapshot ID | 386 | | Ending Snapshot ID | 387 |
| Beginning Snapshot Capture Time | Jan 12, 2012 11:00:49 AM | | Ending Snapshot Capture Time | Jan 12, 2012 11:30:56 AM |

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Name	Value	Per Second	Per Transaction
DB cpu (seconds)	0.00	0.00	0.00
DB time (seconds)	64.25	0.04	3.78
db block changes	7,150.00	3.96	420.59
execute count	4,384.00	2.43	257.88
global cache cr block receive time (seconds)	0.00	0.00	0.00
global cache cr blocks received	0.00	0.00	0.00
global cache current block receive time (seconds)	0.00	0.00	0.00
global cache current blocks received	0.00	0.00	0.00
global cache get time (seconds)	0.00	0.00	0.00
global cache gets	0.00	0.00	0.00
opened cursors cumulative	2,162.00	1.20	127.18
parse count (total)	782.00	0.43	46.00
parse time cpu (seconds)	0.07	0.00	0.00
parse time elapsed (seconds)	4.42	0.00	0.26
physical reads	58.00	0.03	3.41
physical writes	786.00	0.44	46.24
redo size (KB)	2,452.19	1.36	144.25
session cursor cache hits	2,589.00	1.43	152.29
session logical reads	197,072.00	109.12	11,592.47
sql execute cpu time (seconds)	0.00	0.00	0.00
sql execute elapsed time (seconds)	0.00	0.00	0.00
user calls	828.00	0.46	48.71
user commits	17.00	0.01	1.00
user rollbacks	0.00	0.00	0.00

5. To view a Workload Repository report of the statistics, click **Report**.

   The Workload Repository report appears.

6. Optionally, click **Save to File** to save the report for later access.

> **See Also:**
>
> • " Resolving Performance Degradation Over Time "

4

Monitoring Real-Time Database Performance

The Automatic Database Diagnostic Monitor (ADDM) automatically identifies performance problems with the database, as described in Automatic Database Performance Monitoring. Information on performance appears on the Performance page in Oracle Enterprise Manager Cloud Control (Cloud Control).

By drilling down to other pages from the Performance page, you can identify database performance problems in real time. If you find a problem, then you can run ADDM manually to analyze it immediately without having to wait until the next ADDM analysis. To learn how to run ADDM manually, see "Manually Running ADDM to Analyze Current Database Performance".

This chapter describes how to monitor some aspects of database activity. It contains the following sections:

- Monitoring User Activity
- Monitoring Instance Activity
- Monitoring Host Activity
- Determining the Cause of Spikes in Database Activity
- Customizing the Database Performance page

Monitoring User Activity

As described in Oracle Database Performance Method , database time (DB time) is an indicator of the total database instance workload. The **average active sessions** for a time period equals the total database time of all user sessions during the period divided by the elapsed time (wall-clock time) for the period.

The **Average Active Sessions** graph on the **Performance Hub** page shows the average active sessions for CPU usage and wait classes in the time period. You can drill down by clicking on the graph to identify the causes of instance-related performance issues and resolve them.

To monitor user activity:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Hub** and **ASH Analytics**.

   If the Database Login page appears, then log in as a user with administrator privileges. The **Performance Hub** page appears.

3. Locate any spikes or other areas of interest in the **Average Active Sessions** stacked area chart.

   Figure 4-1 shows an example of one dimension of the **Average Active Sessions** chart on the **Performance Hub** page.

Figure 4-1   Average Active Sessions by Wait Class
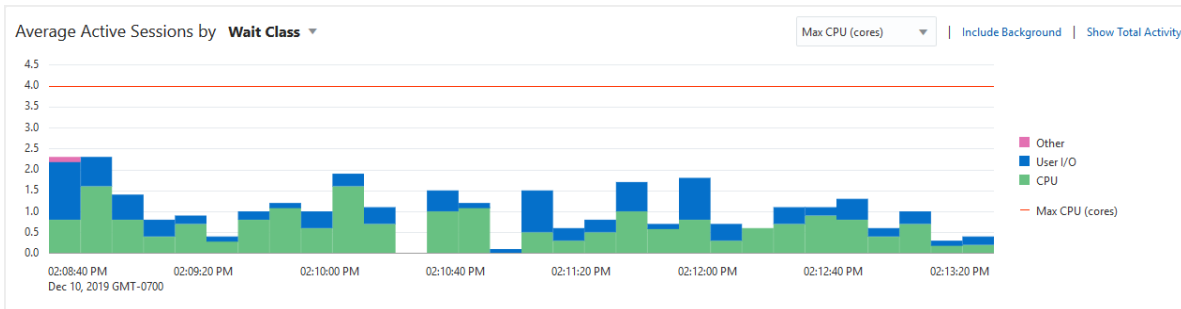
Each color-filled area on the stacked area chart shows the average active sessions for the specified event at the specified time. In the chart, the average active sessions amount for each event is stacked upon the one below it. The events appear on the chart in the order shown in the legend, with CPU starting at zero on the y-axis and the other events stacked in ascending order, from CPU Wait to Other. The wait classes show how much database activity is consumed by waiting for a resource such as disk I/O.

The CPU Cores line at 2 on the y-axis indicates the number of CPUs on the host system. When the CPU value reaches the CPU Cores line, the database instance is consuming 100 percent of CPU time on the system.

The last item in the graph title **Average Active Sessions by *Wait Class*** is a drop-down menu for other dimensions to view the performance. **Wait Class** is the default.

The main dimensions are:

- Wait Class
- Wait Event
- Instance
- Service
- Module
- Action
- User Session
- SQL ID

The Active Sessions Working page shows a 1-hour timeline. Details for each wait class are shown in 5-minute intervals.

You can view the details of wait classes in different dimensions by proceeding to one of the following sections:

- Monitoring Top Dimensions
- Monitoring SQL
- Monitoring PL/SQL
- Monitoring Resource Consumption
- Monitoring Session Identifiers

- • Monitoring Session Attributes

4. To change the selected time interval, use the **Performance Hub** view and drag start and end times to a different interval.

Figure 4-2   Average Active Sessions by "Wait Class"
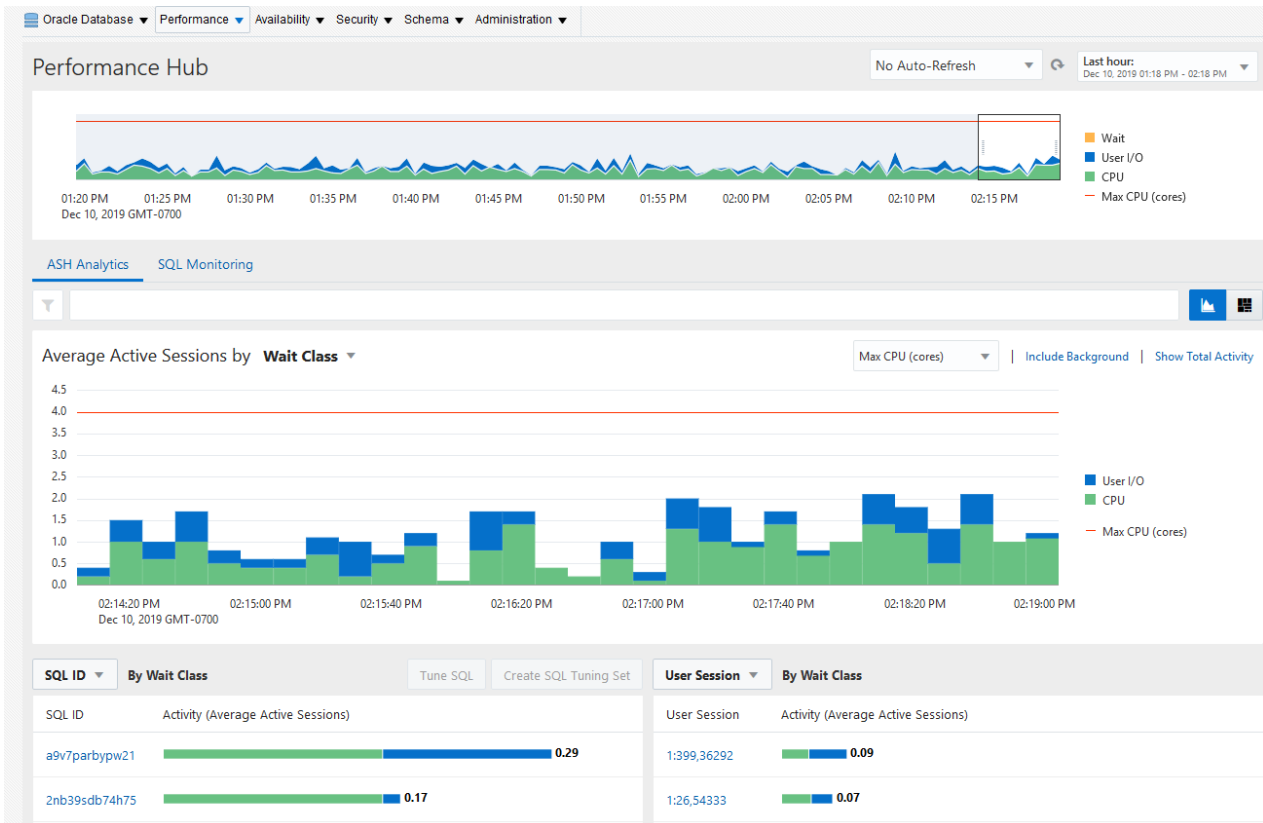
The information contained in the **Average Active Sessions** is automatically updated to display the selected time period.

If you discover a performance problem, then you can attempt to resolve it in real time. On the **Performance** page, do one of the following:

- • Below the Average Active Sessions chart, click the snapshot corresponding to the time when the performance problem occurred to run ADDM for this time period.

  For information about ADDM analysis, see "Reviewing the Automatic Database Diagnostic Monitor Analysis".

- • Click **Run ADDM Now** to create a snapshot manually.

  For information about creating snapshots manually, see "Creating Snapshots". For information about running ADDM manually, see "Manually Running ADDM to Analyze Current Database Performance".

- • Click **Run ASH Report** to create an Active Session History (ASH) report to analyze transient, short-lived performance problems.

  For information about ASH reports, see "Active Session History Reports".

Monitoring Top Dimensions

The **Average Active Sessions by** drop-down contains a **Top Dimensions** fly-out with the following common views:

- **Wait Class**
- **Wait Event**
- **Instance**
- **Service**
- **Module**
- **Action**
- **User Session**
- **SQL ID**

To monitor a Top Dimension:

1. Access the **Performance Hub** page, as explained in "Monitoring User Activity".
2. Click on the drop-down in **Average Active Sessions by**, mouse onto **Top Dimensions**, and select the desired view.

    - **Wait Class**
    - **Wait Event**
    - **Instance**
    - **Service**
    - **Module**
    - **Action**
    - **User Session**
    - **SQL ID**

    Graphs, tables, and information on the page are updated to reflect the selected criteria.

Monitoring SQL

The **Average Active Sessions by** drop-down contains a **SQL** fly-out with the following common views:

- **SQL ID**
- **Top Level SQL ID**
- **SQL Force Matching Signature**
- **SQL Plan Hash Value**
- **SQL Full Plan Hash Value**

- **SQL Plan Operation**
- **SQL Plan Operation Line**
- **SQL Opcode**
- **Top Level SQL Opcode**

To monitor SQL:

1. Access the **Performance Hub** page, as explained in "Monitoring User Activity".
2. Click on the drop-down in **Average Active Sessions by**, mouse onto **SQL**, and select the desired view from the fly-out.

   - **SQL ID**
   - **Top Level SQL ID**
   - **SQL Force Matching Signature**
   - **SQL Plan Hash Value**
   - **SQL Full Plan Hash Value**
   - **SQL Plan Operation**
   - **SQL Plan Operation Line**
   - **SQL Opcode**
   - **Top Level SQL Opcode**

   Graphs, tables, and information on the page are updated to reflect the selected criteria.

> ✎ **See Also:**
>
> - "Viewing Details of SQL Statements"
> - "Tuning SQL Statements "
> - "Tuning SQL Statements Using SQL Tuning Advisor"

Monitoring PL/SQL

The **Average Active Sessions by** drop-down contains a **PL/SQL** fly-out with the following common views:

- **PL/SQL**
- **Top Level PL/SQL**

To monitor PL/SQL:

1. Access the **Performance Hub** page, as explained in "Monitoring User Activity".
2. Click on the drop-down in **Average Active Sessions by**, mouse onto **PL/SQL**, and select the desired view from the fly-out.

   - **PL/SQL**

- **Top Level PL/SQL**

Graphs, tables, and information on the page are updated to reflect the selected criteria.

Monitoring Resource Consumption

The **Average Active Sessions by** drop-down contains a **Resource Consumption** fly-out with the following common views:

- **Wait Class**
- **Wait Event**
- **Object**
- **Blocking Session**

A **session** is a logical entity in the database instance memory that represents the state of a current user login to the database. A session lasts from the time a user logs in to the database until the user disconnects. For example, when a user starts SQL*Plus, the user must provide a valid database user name and password to establish a session. If a single session is consuming the majority of database activity, then you should investigate it.

To monitor resource consumption:

1. Access the **Performance Hub** page, as explained in "Monitoring User Activity".

2. Click on the drop-down in **Average Active Sessions by**, mouse onto **Resource Consumption**, and select the desired view from the fly-out.

   - **Wait Class**
   - **Wait Event**
   - **Object**
   - **Blocking Session**

   Graphs, tables, and information on the page are updated to reflect the selected criteria.

Monitoring Session Identifiers

The **Average Active Sessions by** drop-down contains a **Sessions Identifiers** fly-out with the following common views:

- **Instance**
- **Service**
- **User Session**
- **Parallel Process**
- **User Name**
- **Program**

- **Session Type**

A **service** is a group of applications with common attributes, service-level thresholds, and priorities. For example, the SYS$USERS service is the default service name used when a user session is established without explicitly identifying a service name. The SYS$BACKGROUND service consists of all database background processes. If a service is using the majority of the wait time, then you should investigate it.

A **session** is a logical entity in the database instance memory that represents the state of a current user login to the database. A session lasts from the time a user logs in to the database until the user disconnects. For example, when a user starts SQL*Plus, the user must provide a valid database user name and password to establish a session. If a single session is consuming the majority of database activity, then you should investigate it.

To monitor session identifiers:

1. Access the **Performance Hub** page, as explained in "Monitoring User Activity".

2. Click on the drop-down in **Average Active Sessions by**, mouse onto **Session Identifiers**, and select the desired view from the fly-out.

    - **Instance**
    - **Service**
    - **User Session**
    - **Parallel Process**
    - **User Name**
    - **Program**
    - **Session Type**

    Graphs, tables, and information on the page are updated to reflect the selected criteria.

Monitoring Session Attributes

The **Average Active Sessions by** drop-down contains a **Sessions Attributes** fly-out with the following common views:

- **Consumer Group**
- **Module**
- **Action**
- **Client**
- **Client Host Name**
- **Client Host Port**
- **Transaction ID**
- **Execution Context ID**
- **Database Operation**

A client can be a web browser or any client process that initiates a request for the database to perform an operation. If a single client is using the majority of the wait time, then you should investigate it.

Modules represent the applications that set the service name as part of the workload definition. For example, the `DBMS_SCHEDULER` module may assign jobs that run within the `SYS$BACKGROUND` service. If a single module is using the majority of the wait time, then it should be investigated.

To monitor session attributes:

1. Access the **Performance Hub** page, as explained in "Monitoring User Activity".

2. Click on the drop-down in **Average Active Sessions by**, mouse onto **Sessions Attributes**, and select the desired view from the fly-out.

   - **Consumer Group**

   - **Module**

   - **Action**

   - **Client**

   - **Client Host Name**

   - **Client Host Port**

   - **Transaction ID**

   - **Execution Context ID**

   - **Database Operation**

   Graphs, tables, and information on the page are updated to reflect the selected criteria.

Monitoring Instance Activity

Below the Average Active Sessions chart on the Performance page are other charts that you can use to monitor database instance activity. As explained in "Customizing the Database Performance page", you can also customize the Performance page so that the most useful instance activity charts are displayed by default.

You can use the instance activity charts to perform the following tasks:

- Monitoring Throughput

- Monitoring I/O

- Monitoring Parallel Execution

- Monitoring Services

Monitoring Throughput

Database **throughput** measures the amount of work the database performs in a unit of time. The Throughput charts show any contention that appears in the Average Active Sessions chart.

Compare the peaks on the Throughput charts with the peaks on the Average Active Sessions chart. If the Average Active Sessions chart displays a large number of sessions waiting, indicating internal contention, but throughput is high, then the situation may be acceptable. The database is probably also performing efficiently if internal contention is low but throughput is high. However, if internal contention is high but throughput is low, then consider tuning the database.

To monitor throughput:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Performance page appears.

3. Click the **Throughput** tab.

4. Select one of the following Instance Throughput Rate options.

   • **Per Second**

   Two charts appear. One shows the number of logons and transactions per second and the other shows the physical reads and redo size per second.

   Figure 4-3 shows the Throughput charts with the Instance Throughput Rate of Per Second selected. The bar in the middle of the figure indicates a portion of the charts (from approximately 1:37 to 1:52) that has been removed for space considerations. In Figure 4-3, the most transactions occurred from 1:15 to 1:27 p.m. and from 2:08 to 2:12 p.m.

   • **Per Transaction**

   One chart appears that shows the number of physical reads and redo size per transaction.

Figure 4-3   Monitoring Throughput
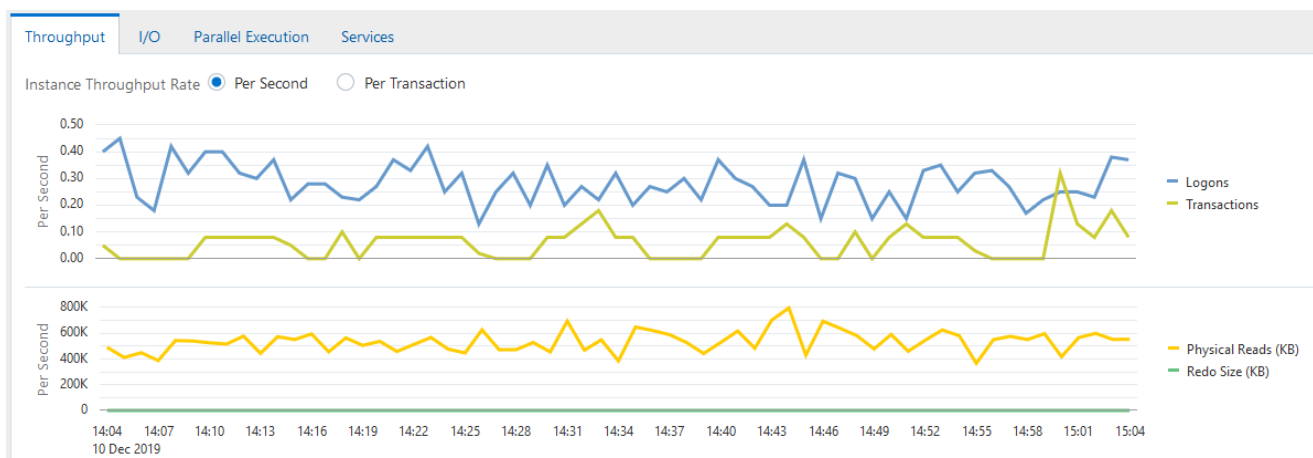
Monitoring I/O

The I/O charts show I/O statistics collected from all database clients. The I/O wait time for a database process represents the amount of time that the process could have been doing useful work if a pending I/O had completed. Oracle Database captures the I/O wait times for all important I/O components in a uniform fashion so that every I/O wait by any Oracle process can be derived from the I/O statistics.

Figure 4-4   Monitoring I/O

The Latency for Synchronous Single Block Reads chart shows the total perceived **I/O latency** for a block read, which is the time difference between when an I/O request is submitted and when the first byte of the transfer arrives. Most systems are performing satisfactorily if latency is fewer than 10 milliseconds. This type of I/O request is the best indicator of I/O performance for the following reasons:

- Write operations may exhibit good performance because of write caches in storage.

- Because multiblock I/O requests have varying sizes, they can take different amounts of time.

- The latency of asynchronous I/O requests does not represent the full I/O wait time.

The other charts shown depend on your selection for **I/O Breakdown**, as described in the following sections:

- Monitoring I/O by Function

- Monitoring I/O by Type

- Monitoring I/O by Consumer Group

Monitoring I/O by Function

The I/O Function charts determine I/O usage level by application or job. The component-level statistics give a detailed view of the I/O bandwidth usage, which you can then use in scheduling jobs and I/O provisioning. The component-level statistics fall in the following categories:

- Background type

  This category includes ARCH, LGWR, and DBWR.

- Activity

This category includes XDB, Advanced Queuing (AQ), Data Pump, Recovery, and RMAN.

- I/O type

  The category includes the following:

  - Direct Writes

    This write is made by a foreground process and is not from the buffer cache.

  - Direct Reads

    This read is physical I/O from a data file that bypasses the buffer cache and reads the data block directly into process-private memory.

  - Buffer Cache Reads

- Others

  This category includes I/Os such as control file I/Os.

To monitor I/O by function:

1. Access the Performance page, as explained in "Monitoring User Activity".

2. In the instance activity chart, click **I/O**.

   The Latency for Synchronous Single Block Reads, I/O Megabytes per Second, and I/O Requests per Second charts appear.

3. For **I/O Breakdown**, select **I/O Function**.

   The I/O Megabytes per Second by I/O Function and I/O Requests per Second by I/O Function charts appear.

   The example in Figure 4-4 shows that a significant amount of I/O is being performed by the log writer. The log writer activity peaked at approximately 600 I/O requests per second.

4. Click the largest colored area on the chart or the corresponding function in the legend to drill down to the function with the highest I/O rate.

   An I/O Throughput by I/O Function page appears with details about the selected category.

   You can view real-time or historical data for details on I/O megabytes or I/O requests.

> **See Also:**
>
> - *Oracle Database Concepts* to learn about database background processes such as ARCH, LGWR, and DBWR

Monitoring I/O by Type

The I/O Type charts enable you to monitor I/O by the types of read and write operations. Small I/Os are requests smaller than 128 KB and are typically single database block I/O operations. Large I/Os are requests greater than or equal to 128 KB. Large I/Os are generated by database operations such as table/index scans, direct data loads, backups, restores, and archiving.

Figure 4-5   Performance Monitoring I/O by Type
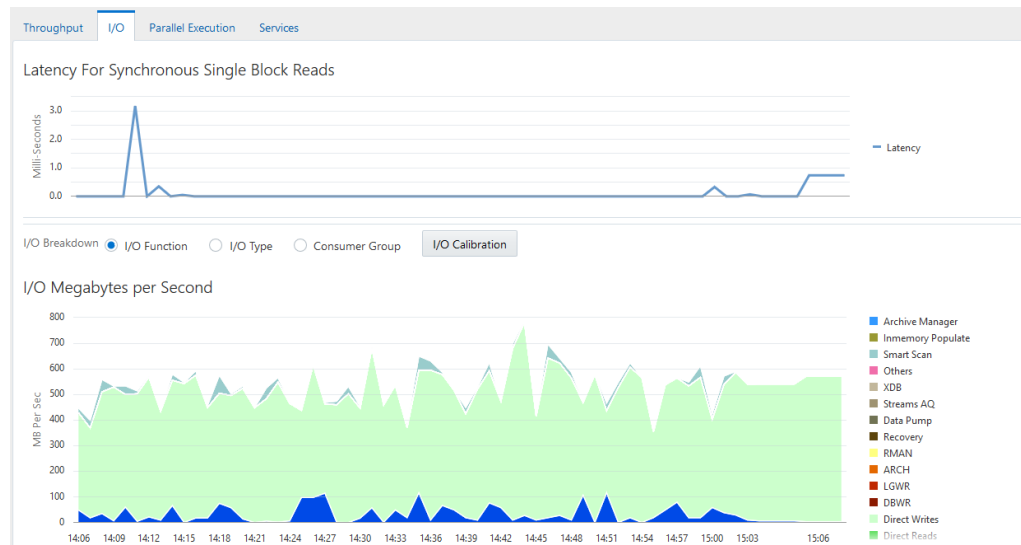
When optimizing for short transaction times, such as in an OLTP environment, monitor latency for small I/Os. High latencies typically indicate that the storage system is a bottleneck.

When optimizing for large queries, such as in a data warehouse, performance depends on the maximum throughput the storage system can achieve rather than the latency of the I/O requests. In this case, monitor the I/O megabytes per second rather than the synchronous single-block I/O latencies.

To monitor I/O by type:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Performance page appears.

3. In the instance activity area, click **I/O** tab.

   The I/O Megabytes per Second and I/O Requests per Second graphs appear.

4. For **I/O Breakdown**, select **I/O Type**.

   The I/O Megabytes per Second by I/O Type and I/O Requests per Second by I/O Type charts appear.

5. Click the largest colored area on the chart or the corresponding function in the legend to drill down to the function with the highest I/O rate.

   The I/O Details page appears.

   You can view real-time or historical data for details on I/O megabytes or I/O requests.

Monitoring I/O by Consumer Group

When Oracle Database Resource Manager is enabled, the database collects I/O statistics for all consumer groups that are part of the currently enabled resource plan. The Consumer Group charts enable you to monitor I/O by consumer group.

A resource plan specifies how the resources are to be distributed among various users (resource consumer groups). Resource consumer groups enable you to organize user sessions by resource requirements. Note that the _ORACLE_BACKGROUND_GROUP_ consumer group contains I/O requests issued by background processes.

To monitor I/O requests by consumer group:
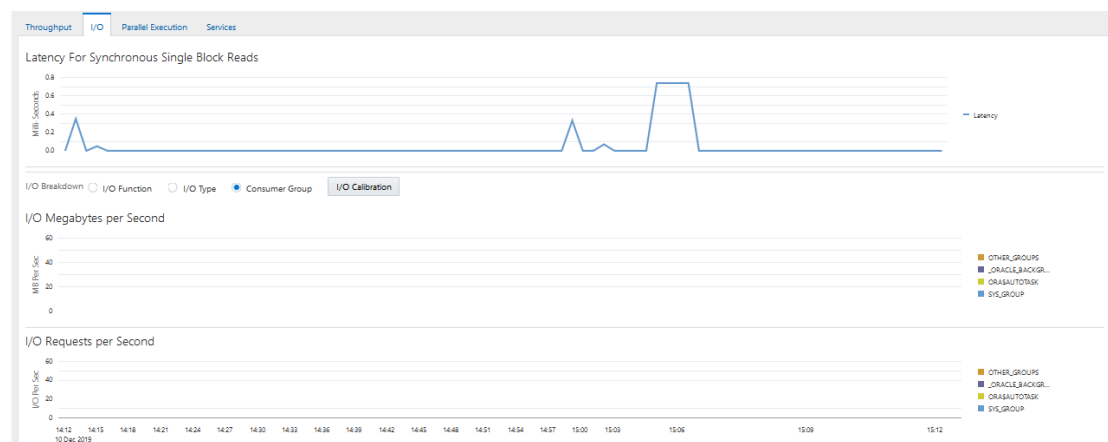
1. Access the Database Home page.

    See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Home**.

    If the Database Login page appears, then log in as a user with administrator privileges. The Performance page appears.

3. In the instance activity area, click **I/O** tab.

    The I/O Megabytes per Second and I/O Requests per Second graphs appear.

4. For **I/O Breakdown**, select **Consumer Group**.

    The I/O Megabytes per Second by Consumer Group and I/O Requests per Second by Consumer Group graphs appear.

Monitoring Parallel Execution

The Parallel Execution charts show system metrics related to parallel queries. **Metrics** are statistical counts per unit. The unit could be a time measure, such as seconds, or per transaction, or session.

A parallel query divides the work of executing a SQL statement across multiple processes. The charts show parallel queries that were waiting for a particular wait event that accounted for the highest percentages of sampled session activity.

Figure 4-6   Monitoring Parallel Execution
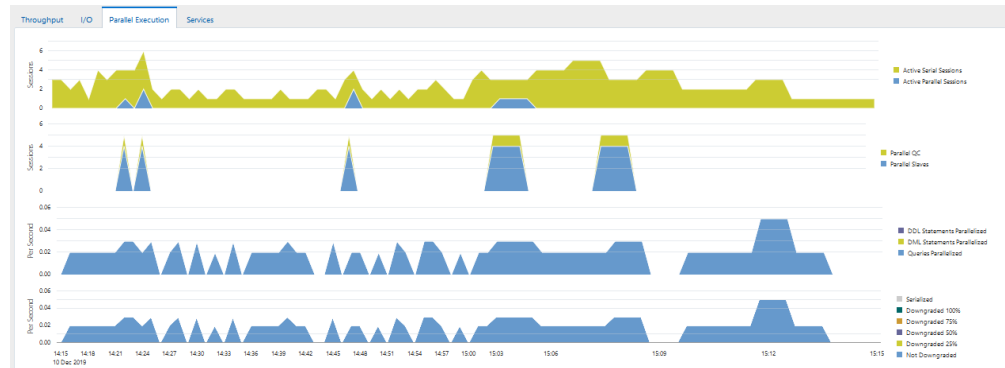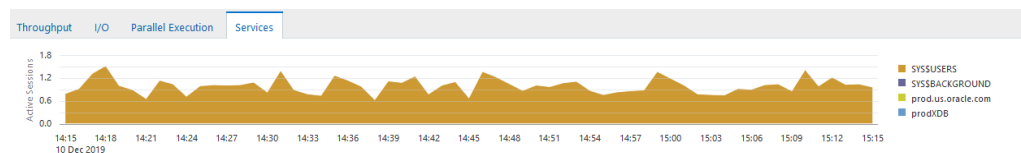

To monitor parallel execution:

1. Access the Database Home page.

    See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Home**.

    If the Database Login page appears, then log in as a user with administrator privileges. The Performance page appears.

3. In the instance activity chart, click **Parallel Execution** tab.

    The Parallel Execution charts appear.

    Two pairs of charts are shown. The first pair shows the number of sessions on the y-axis, whereas the second pair shows the per second rate on the y-axis.

Monitoring Services

Services represent groups of applications with common attributes, service-level thresholds, and priorities. For example, the SYS$USERS service is the default service name used when a user session is established without explicitly identifying a service name.

Figure 4-7   Monitoring Services

To monitor services:

1. Access the Database Home page.

    See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Home**.

    If the Database Login page appears, then log in as a user with administrator privileges. The Performance page appears.

3. In the instance activity chart, click **Services**.

    The Services chart appears. The Services chart shows services waiting for the corresponding wait event during the time period shown. Only active services are shown.

    In Figure 4-7, the `SYS$USERS` service has the greatest number of active sessions.

4. Click the largest colored area on the chart or the corresponding service in the legend to drill down to the service with the highest number of active sessions.

    The Service page appears, showing the Activity subpage.

    You can view real-time data showing the session load for all wait classes associated with the service.

Monitoring Host Activity

The Host chart on the Performance page displays utilization information about the system hosting the database.

To determine if the host system has enough resources available to run the database, establish appropriate expectations for the amount of CPU, memory, and disk resources that your system should be using. You can then verify that the database is not consuming too many of these resources.

To view details about CPU, memory, and disk utilization:

1. From the **Targets** menu, select **Hosts**.

    The Hosts page appears.

2. In the list of hosts, click the name of the host on which your database resides.

    The *hostname* page appears, where *hostname* is the name of the host.

3. Determine whether sufficient resources are available and whether your system is using too many resources.

    For example, determine the amount of CPU, memory, and disk resources the database uses in the following scenarios:

    •   When your system is idle, or when little database and nondatabase activity exists

    •   At average workloads

    •   At peak workloads

    Workload is an important factor when evaluating the level of resource utilization for your system. During peak workload hours, 90 percent utilization of a resource, such as a CPU with 10 percent idle and waiting time, can be acceptable. However, if your system shows high utilization at normal workload, then there is no room for additional workload.

    Perform the following tasks to monitor the host activity for your database:

    •   Monitoring CPU Utilization

    •   Monitoring Memory Utilization

    •   Monitoring Disk I/O Utilization

4. Set the appropriate threshold values for the performance metrics so the system can automatically generate alerts when these thresholds are exceeded.

    For information about setting metric thresholds, see "Setting Metric Thresholds for Performance Alerts".

Monitoring CPU Utilization

To address CPU problems, first establish appropriate expectations for the amount of CPU resources your system should be using. You can then determine whether sufficient CPU resources are available and recognize when your system is consuming too many resources. This section describes how to monitor CPU utilization.

To monitor CPU utilization:

1. Access the *hostname* page as explained in "Monitoring Host Activity".

2. From the **Host** drop-down menu, select **Monitoring**, and then **CPU Details**.

   The CPU Details page appears.

   This page contains statistics about CPU utilization, I/O wait times, and load gathered over the last hour. The top 10 processes are listed based on CPU utilization.

3. Verify the current CPU utilization using the CPU Utilization chart.

   The CPU Utilization chart shows CPU utilization over the last hour and a half. The current value is displayed below the chart. During standard workload hours, the value should not exceed the critical threshold.

4. Under the graph for **CPU Utilization**, click the link **CPU Utilization**.

   This page contains CPU utilization statistics and related alerts generated over the last 24 hours.

   If you notice an unexpected spike in this value that is sustained through normal workload hours, then the CPU performance problem should be investigated.

5. Return to the **CPU Details** page. From the **Host** menu, select **Monitoring**, and then **CPU Details**.

6. Verify the current CPU I/O wait time using the CPU I/O Wait chart.

   The CPU I/O Wait chart shows CPU I/O wait time over the last hour and a half. The current value is displayed below the chart. During normal workload hours, the value of CPU I/O wait should not exceed the warning threshold.

   CPU I/O wait represents the average number of jobs waiting for I/O during an interval.

7. Under the graph for **CPU I/O Wait**, click the link **CPU I/O Wait**.

   The CPU in I/O Wait page appears.

   This page contains CPU I/O wait statistics and related alerts generated over the last 24 hours.

   If you notice an unexpected increase in this value that is sustained through standard workload hours, then a CPU performance problem may exist.

8. Return to the **CPU Details** page. From the **Host** menu, select **Monitoring**, and then **CPU Details**.

9. Verify the current CPU load using the **CPU Load** chart.

   The **CPU Load** chart shows the CPU load over the last hour and a half. The current value is displayed below the chart. During standard workload hours, the value of CPU load should not exceed the warning threshold.

CPU load represents the average number of processes waiting to be scheduled for CPU resources in the previous minute, or the level of CPU contention time over time.

10. Under the graph for **CPU Load**, click the link **CPU Load**.

    The **Run Queue Length (5 minute average) page** appears.

    This page contains CPU load statistics and related alerts generated over the last 24 hours.

    If you notice an unexpected spike in this value that is sustained through normal workload hours, then a CPU performance problem might exist.

11. Return to the **CPU Details** page. From the **Host** menu, select **Monitoring**, and then **CPU Details**.

12. Review the **Top 10 Processes (ordered by CPU)** table.

    If a process is consuming too much of the CPU utilization percentage, then investigate that process.

13. If a CPU performance problem is identified, then you can try to resolve the issue by doing the following:

    • Use Oracle Database Resource Manager to reduce the impact of peak-load-use patterns by prioritizing CPU resource allocation

    • Avoid running too many processes that use a large amount of CPU

    • Increase hardware capacity, including changing the system architecture

> **See Also:**
>
> • *Oracle Database Performance Tuning Guide* for information about resolving CPU issues
>
> • *Oracle Database Administrator's Guide* for information about Oracle Database Resource Manager

Monitoring Memory Utilization

Operating system performance issues commonly involve process management, memory management, and scheduling. This section describes how to monitor memory utilization and identify problems such as paging and swapping.

To monitor memory utilization:

1. Access the *hostname* page as explained in "Monitoring Host Activity".

2. From the **Host** drop-down menu, select **Monitoring**, and then **Memory Details**.

    The **Memory Details** page appears.

    This page contains statistics about memory utilization, page scan rates, and swap utilization gathered over the last hour. The top 10 processes are also listed ordered by memory utilization. Figure 4-8 shows a portion of the Memory Details page. The Top 10 Processes (ordered by Memory) section is not shown.

Figure 4-8   Memory Details Page
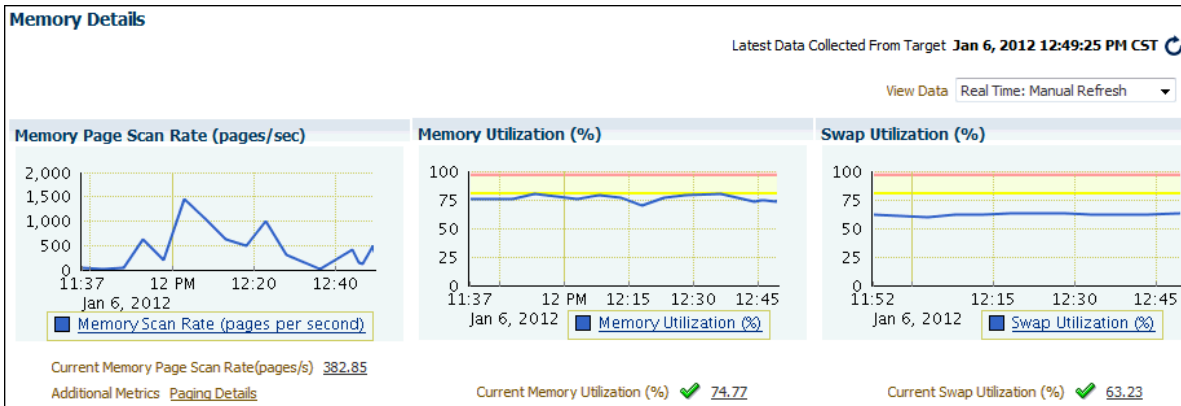
3. Verify the current memory page scan rate using the **Memory Page Scan Rate** chart.

    The current value of the memory page scan rate is displayed below the chart. On UNIX and Linux, this value represents the number of pages scanned per second. On Microsoft Windows, this value represents the rate at which pages are read from or written to disk to resolve hard page faults. This value is a primary indicator of the types of faults that may be causing system-wide delays.

4. Click **Memory Scan Rate (pages per second)**.

    The Memory Page Scan Rate page appears.

    This page contains memory page scan rate statistics and related alerts over the last 24 hours.

    If you notice an unexpected increase in this value that is sustained through standard workload hours, then a memory performance problem might exist.

5. Return to the **Memory Details** page. From the **Host** drop-down menu, select **Monitoring**, and then **Memory Details**.

6. Using the Memory Utilization chart, verify the current memory utilization.

    The Memory Utilization chart shows how much memory is being used. The current value of memory utilization is displayed below the chart. During standard workload hours, the value should not exceed the warning threshold (shown in yellow).

7. Click **Memory Utilization (%)**.

    The **Memory Utilization** page appears.

    This page contains memory utilization statistics and related alerts generated over the last 24 hours.

In this example, memory utilization has exceeded 80%, so warnings appear in the Metric Alert History table.

If you notice an unexpected spike in this value that is sustained through normal workload hours, then a memory performance problem might exist.

8. Return to the **Memory Details** page. From the **Host** drop-down menu, select **Monitoring**, and then **Memory Details**.

9. Using the Swap Utilization chart, verify current swap utilization.

The Swap Utilization chart shows how much swap space is being used. The current value of swap utilization is displayed below the chart. During normal workload hours, the value should not exceed the warning threshold.

10. Click **Swap Utilization (%)**.

The **Swap Utilization** page appears.

This page contains swap utilization statistics and related alerts generated over the last 24 hours.

If you notice an unexpected spike in this value that is sustained through normal workload hours, then a memory performance problem might exist.

11. Return to the **Memory Details** page. From the **Host** drop-down menu, select **Monitoring**, and then **Memory Details**.

12. Review the top processes in the Top 10 Processes (ordered by Memory) table.

If a process is taking up too much memory, then this process should be investigated.

13. If a memory performance problem is identified, then you can attempt to resolve the issue by doing the following:

- Use Automatic Memory Management to automatically manage and distribute memory between the System Global Area (SGA) and the aggregate program global area (PGA aggregate).

- Use the Memory Advisor to set SGA and PGA memory target values.

- Use Automatic PGA Management to manage SQL memory execution.

- Avoid running too many processes that consume large amounts of memory.

- Reduce paging or swapping.

- Reduce the number of open cursors and hard parsing with cursor sharing.

> **✎ See Also:**
>
> - *Oracle Database Administrator's Guide* for information about using Automatic Memory Management
> - *Oracle Database Performance Tuning Guide* for information about resolving memory issues

Monitoring Disk I/O Utilization

Because the database resides on a set of disks, the performance of the I/O subsystem is very important to database performance. Important disk statistics include the disk I/Os per second and the length of the service times. These statistics show if the disk is performing optimally or if the storage system is being overworked. This section describes how to monitor disk I/O utilization.
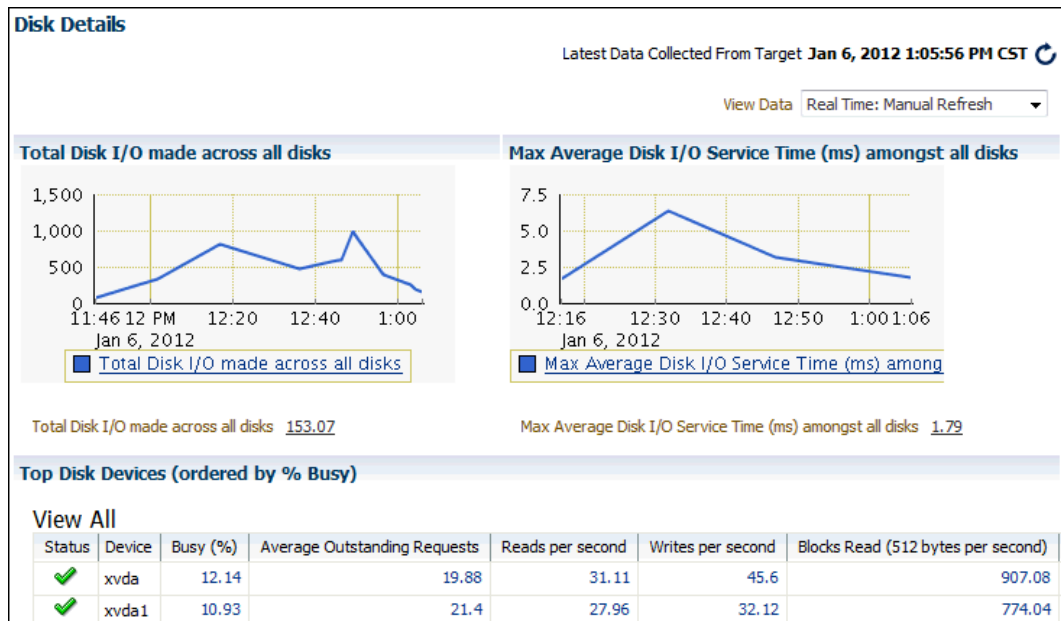
To monitor disk I/O utilization:

1. Access the *hostname* page as explained in "Monitoring Host Activity".

2. From the **Host** drop-down menu, select **Monitoring**, and then **Disk Details**.

   The **Disk Details** page appears.

   This page contains disk I/O utilization and service time statistics, and the top disk devices ordered by the percentage of time that they were in use.

Figure 4-9   Disk Details

3. Verify the current disk I/O utilization using the Total Disk I/O Made Across All Disks chart.

   The Total Disk I/O Made Across All Disks chart shows how many disk I/Os are being performed per second. The current value for total disk I/O per second is displayed below the chart. In Figure 4-9 the value is 153.07.

4. Click **Total Disk I/O made across all disks (per second)**.

   The **Total Disk I/O Made Across All Disks (Per Second)** page appears.

   This page contains disk utilization statistics and related alerts generated over the last 24 hours.

   If you notice an unexpected spike in this value that is sustained through standard workload hours, then a disk I/O performance problem might exist and should be investigated.

5. Verify the current I/O service time using the **Max Average Disk I/O Service Time (ms) Among All Disks** chart.

   The **Max Average Disk I/O Service Time (ms) Among All Disks** chart shows the longest service time for disk I/Os in milliseconds. The current value for longest I/O service time is displayed below the chart. In Figure 4-9 the value is 1.79.

6. Return to the **Disk Details** page. From the **Host** drop-down menu, select **Monitoring**, and then **Disk Details**.

7. Click **Max Average Disk I/O (ms) Service Time Among All Disks**.

   This page contains I/O service time statistics and related alerts generated over the last 24 hours.

   If you notice an unexpected spike in this value that is sustained through normal workload hours, then a disk I/O performance problem might exist and should be investigated.

8. Return to the **Disk Details** page. From the **Host** drop-down menu, select **Monitoring**, and then **Disk Details**.

9. On the **Disk Details** page, verify the disk devices in the **Top Disk Devices (ordered by % Busy)** table.

   If a particular disk is busy a high percentage of the time, then this disk should be investigated.

10. If a disk I/O performance problem is identified, you can attempt to resolve the problem by doing the following:

    - Use Oracle Automatic Storage Management (Oracle ASM) to manage database storage.

    - Stripe everything across every disk to distribute I/O.

    - Move files such as archived redo logs and online redo logs to separate disks.

    - Store required data in memory to reduce the number of physical I/Os.

> ✏️ **See Also:**
>
> - *Oracle Database Performance Tuning Guide* for information about resolving disk I/O issues

Determining the Cause of Spikes in Database Activity

If you see a spike in database activity in the Performance page, then you can access the ASH Analytics page to find out which sessions are consuming the most database time. This page provides stacked area charts to help you visualize the active session activity from various dimensions, such as Wait Class, Module, Actions, SQL ID, Instance, User Session, Consumer Group, and others. You can drill down into specific members of a dimension (vertical zooming), and zoom in and out of any time period (horizontal zooming).

To view active session activity on the ASH Analytics page:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Hub** and then **ASH Analytics**.

   If the Database Login page appears, then log in as a user with administrator privileges. The ASH Analytics page appears.

   Figure 4-10 shows an example of the ASH Analytics page.

Figure 4-10   ASH Analytics Page
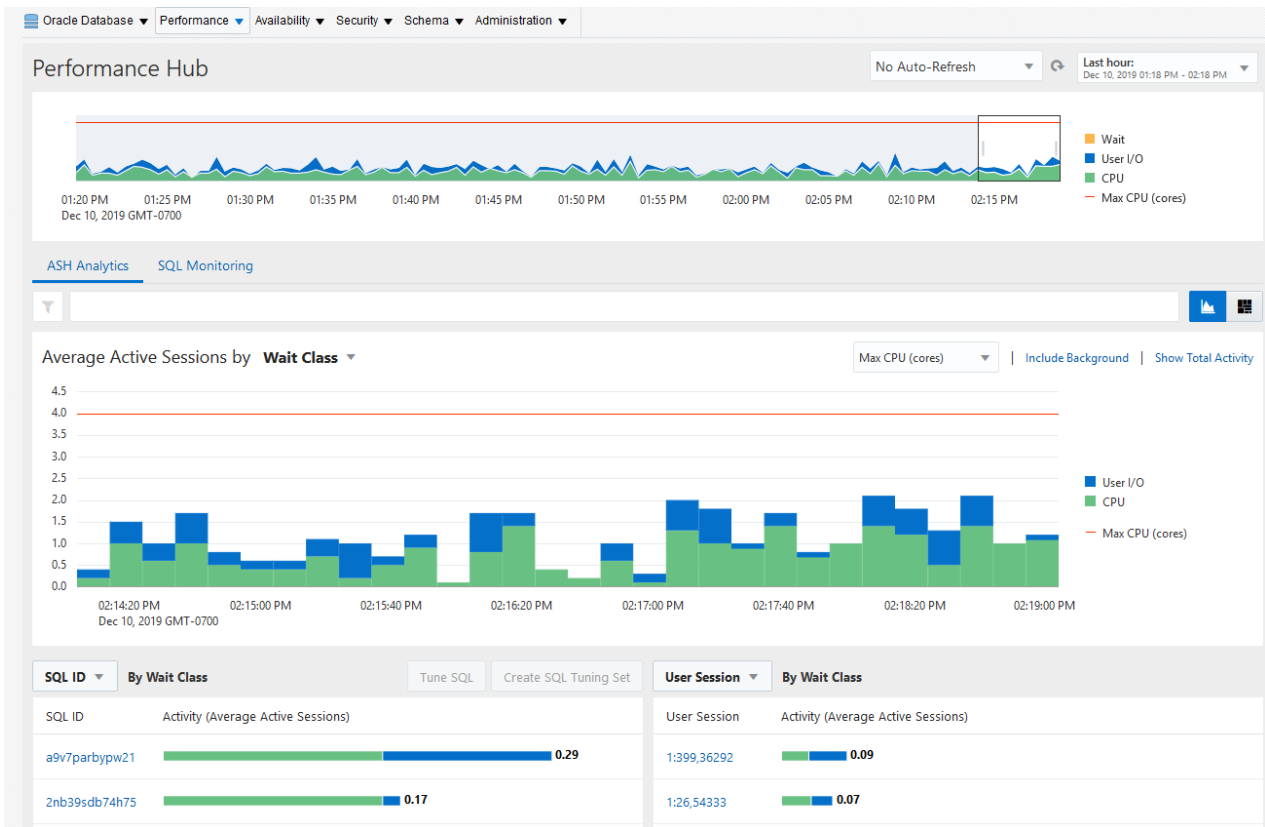
3. To view a high-level perspective of top activity during a selected time period, drag the entire shaded slider area in the top chart to the desired time period.

> ### ◯ Tip:
>
> You can change the amount of time selected in the shaded slider area by selecting the control at either edge of the slider and dragging it to the left or right.
>
> You can select a time period within the default setting of one hour or you can use the selector buttons above the chart to display time periods of one day, one week, or one month. You can also use the Calendar and Custom buttons to display a time period other than one of the preset choices.

4. To view a more detailed perspective of your selected time period, use the Activity chart on the page. By default, the chart shows a breakdown of workload activity by wait classes.

5. Investigate the impact by viewing detailed statistics for the top activity sessions that are adversely affecting the system.

   To view detailed statistics for a session:

   a. Select the largest spike in the chart or the corresponding wait class in the legend beside the chart. The viewer now filters out everything in the chart except for the wait class of interest.

For example, if the chart shows that the Concurrency wait class has the biggest spike, select the chart area of the legend for Concurrency. The viewer refreshes the chart and now only shows the Concurrency value and displays a Wait Class: Concurrency icon in the Filters bar.

> 💡 **Tip:**
>
> You can create an unlimited number of filters.

b. In the Activity section, select **Top Dimensions** from the dimensions list. The chart refreshes in response to your selection, displaying values for the particular category you selected.

For instance, if you create a filter for Concurrency as described above, then select **Top Dimensions** from the list, and then select **User Session**, the chart shows user sessions only for Concurrency.

Figure 4-11 shows the list of activities with Top Dimensions selected.

Figure 4-11   List of Activities

6. Optionally, use the Load Map for a graphical view of system activity.

The Load Map is useful for viewing activity in a single- or multi-dimensional layout when you are not interested in seeing how activity has changed over time during the selected period.

Figure 4-12 shows the load map for activity by wait class and wait events.

Figure 4-12   Load Map on the ASH Analytics Page

5
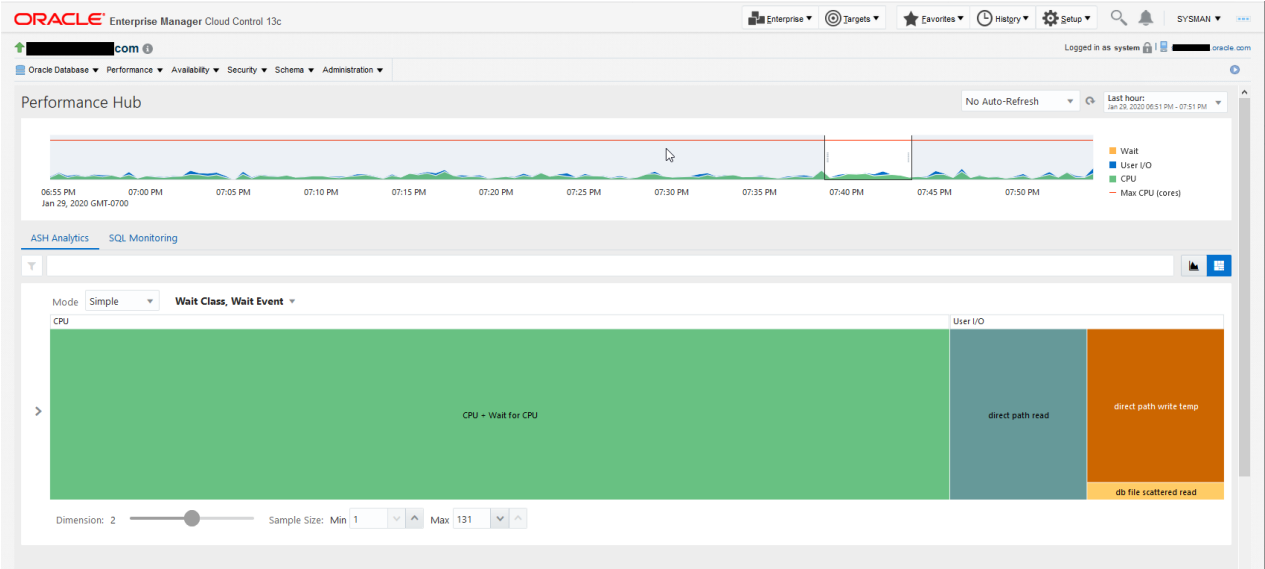
Monitoring Real-Time Database Operations

This chapter describes how to monitor current and recent database operations in Oracle Enterprise Manager Cloud Control (Cloud Control). This chapter contains the following topics:

- About Monitoring Database Operations
- Creating a Database Operation
- Monitoring Database Operations in Cloud Control

> **See Also:**
>
> - *Oracle Database SQL Tuning Guide* for information on monitoring database operations using an API

About Monitoring Database Operations

The SQL Monitoring pages in Cloud Control display information that you can use to monitor the performance of database operations while they are executing, view details about the time and resources used for recently completed operations, and track and report on database operations. A **database operation** is a set of database tasks defined by end users or application code such as a SQL statement or PL/SQL function, a batch job, or extract, transform, and load (ETL) processing. You can define, monitor, and report on database operations.

This section contains the following topics:

- Types of Database Operations
- Purposes of Monitoring Database Operations
- Enabling Monitoring of Database Operations
- Attributes of Database Operations

> **See Also:**
>
> - *Oracle Database SQL Tuning Guide* for more information about monitoring database operations

Types of Database Operations

Database operations are either simple or composite. A **simple database operation** is a single SQL statement or PL/SQL procedure or function. Monitoring of a simple operation

starts automatically 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.

A **composite database operation** is activity between two defined points in time in a database session. You begin and end a composite operation by using PL/SQL procedures, as shown in "Creating a Database Operation". Only one composite database operation at a time can run in a database session.

Purposes of Monitoring Database Operations

In general, database operation monitoring is useful for the following users:

- DBAs whose responsibilities include identifying expensive (high response time) SQL statements and PL/SQL functions

- DBAs who manage batch jobs in a data warehouse or OLTP system

- Application or database developers who need to monitor the activities related to particular operations, for example, Data Pump operations

Monitoring database operations is useful for performing the following tasks:

- Tracking and reporting

  Tracking requires first defining a composite database operation. When the operation begins, the database infrastructure determines what to track on behalf of the operation. For example, your tuning task may involve determining which SQL statements run on behalf of a specific batch job, what their execution statistics were, what was occurring in the database when the operation was executing, and so on. In Cloud Control, you can view the reports for the composite database operation and for the simple database operations that comprise the composite database operation. You can save the reports to disk.

- Monitoring execution progress

  This task involves monitoring a currently executing database operation. The information is particularly useful when you are investigating why an operation is taking a long time to complete.

- Monitoring resource usage

  You may want to detect when a SQL execution uses excessive CPU, issues an excessive amount of I/O, or takes a long time to complete. With the Oracle Database Resource Manager (Resource Manager), you can configure thresholds for each consumer group that specify the maximum resource usage for all SQL executions in the group. When a SQL operation reaches a specified threshold, Resource Manager can switch the operation into a lower-priority consumer group, terminate the session, or cancel and quarantine the SQL operation. In Cloud Control, you can examine these SQL operations.

  > **See Also:**
  >
  > *Oracle Database Administrator's Guide* for more information about consumer group switching by setting resource limits using the Resource Manager

- Tuning for response time

When tuning a database operation, you typically want to improve the response time. Often the database operation performance issues are mainly SQL performance issues.

Enabling Monitoring of Database Operations

Real-time database operations monitoring is enabled by default when the `STATISTICS_LEVEL` initialization parameter is either set to `TYPICAL` (the default value) or `ALL`. Because database operations monitoring is a feature of the Oracle Tuning Pack, the `CONTROL_MANAGEMENT_PACK_ACCESS` parameter must be set to `DIAGNOSTIC+TUNING` (the default value).

> ✎ **See Also:**
>
> *Oracle Database SQL Tuning Guide* for more information about how to disable real-time database operations monitoring

Attributes of Database Operations

A database operation has attributes that uniquely identify it. These attributes are the following:

- Database operation name

  This is a user-created name such as `daily_sales_report`. For an example of naming a database operation, see "Creating a Database Operation".

- Database operation execution ID

  Two or more occurrences of the same database operation can run at the same time, each in a different database session, with the same name but with different execution IDs. This numeric ID uniquely identifies different executions of the same database operation.

  The database automatically creates an execution ID when you begin a database operation. You can also specify your own execution ID.

Creating a Database Operation

You can create a composite database operation using the `DBMS_SQL_MONITOR` package subprograms.

The following example creates a database operation named `DBOP_EXAMPLE`. The example begins the database operation. It has a PL/SQL procedure that selects the maximum sales amount by customer by city. It then has a SQL statement that selects the maximum sales amount of all customers from cities that have at least two customers. Finally, it ends the database operation.

Example 5-1   Creating a Database Operation

```
VAR eid NUMBER
EXEC :eid := DBMS_SQL_MONITOR.BEGIN_OPERATION('DBOP_EXAMPLE');
declare
--
v1 number;
```

```
--
CURSOR c1 IS
SELECT cust_city
  FROM (SELECT COUNT(*) cnt, cust_city
        FROM sh.customers GROUP BY cust_city
        ORDER BY 1 desc);
--
BEGIN
FOR i IN c1
LOOP
--
v1 := 0;
--
SELECT MAX(amount_sold)
INTO v1
FROM sh.sales
WHERE cust_id IN (select cust_id FROM sh.customers WHERE cust_city=i.cust_city);
--
DBMS_OUTPUT.PUT_LINE('Amount: '||v1);
--
END LOOP;
--
END;
/
SELECT MAX(asld) FROM
(SELECT MAX(amount_sold) asld, cust_id FROM sh.sales WHERE cust_id IN
  (SELECT cust_id FROM sh.customers WHERE cust_city IN
    (SELECT cust_city FROM
     (SELECT count(*) cnt, cust_city FROM sh.customers
      GROUP BY cust_city HAVING COUNT(*) > 1)
    ))
GROUP BY cust_id)
/

EXEC DBMS_SQL_MONITOR.END_OPERATION('DBOP_EXAMPLE',:eid);
```

> **Note:**
>
> Starting with Oracle Database 19c, database users without the administrative privileges can also create composite database operations using the `DBMS_SQL_MONITOR` package subprograms and view the SQL execution details of those operations, including the execution plans and performance metrics, by navigating to the Monitored SQL Executions page of Cloud Control.

> **See Also:**
>
> - *Oracle Database SQL Tuning Guide* for information on monitoring database operations using an API
>
> - *Oracle Database PL/SQL Packages and Types Reference* for information on the `DBMS_SQL_MONITOR` package

Monitoring Database Operations in Cloud Control

The Monitored SQL Executions page of Cloud Control displays a table of database operations that are currently running or have completed.

With a selection from the Top 100 By list, you can order the rows of the table by aspects of the operations such as Last Active Time, Duration, or CPU Time. With a selection from the Type list, you can show all of the operations or filter the rows to show only the SQL, PL/SQL, or database operations.

The table contains data about the operations, such as the status and type of the operation, the operation ID, the database time consumed, the SQL text, if appropriate, and so on. The values in some columns are links to other pages or display information when the cursor points to them. For example, the value in the ID column is a link to the Monitored SQL Execution Details page. Another example is that when the cursor points to the bar in the Database Time column, a context message appears that displays information such as the wait class, the amount of time, and the percentage of database time. For example, pointing to the bar in the Database Time column displays a message such as `CPU: 2.8m (92%).` The Execution Detail, SQL Detail, and Session Detail controls above the table become active when you select a row from the table.

> **Note:**
>
> Starting with Oracle Database 19c, database users without the administrative privileges can also view the execution plans and performance metrics of their SQL statements by navigating to the Monitored SQL Executions page of Cloud Control.

This section contains the following topics:

- Viewing SQL Execution Details for a Composite Database Operation
- Viewing SQL Execution Details for a SQL Statement
- Viewing SQL Execution Details for a PL/SQL Statement

> **See Also:**
>
> - Cloud Control Online Help for descriptions of the elements on the Monitored SQL Executions Details page

Viewing SQL Execution Details for a Composite Database Operation

This topic describes how to view the execution details for a composite database operation.

To view execution details for a composite database operation:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Hub** and then **SQL Monitoring**.

If the Database Login page appears, then log in as a user with administrator privileges. The Monitored SQL Execution page appears.
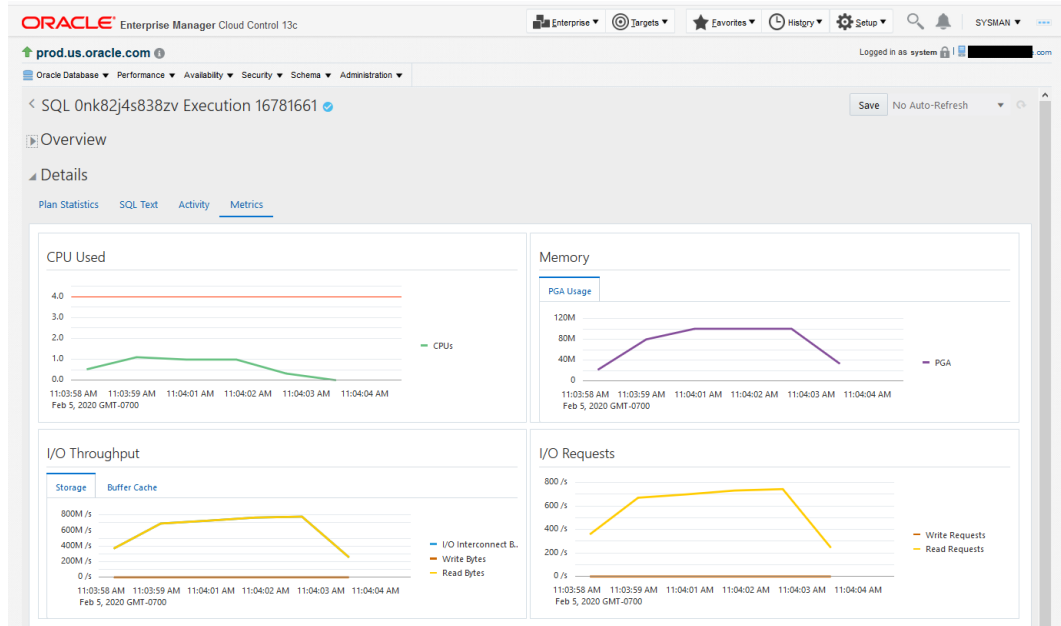
Figure 5-1   Monitored SQL Executions Page
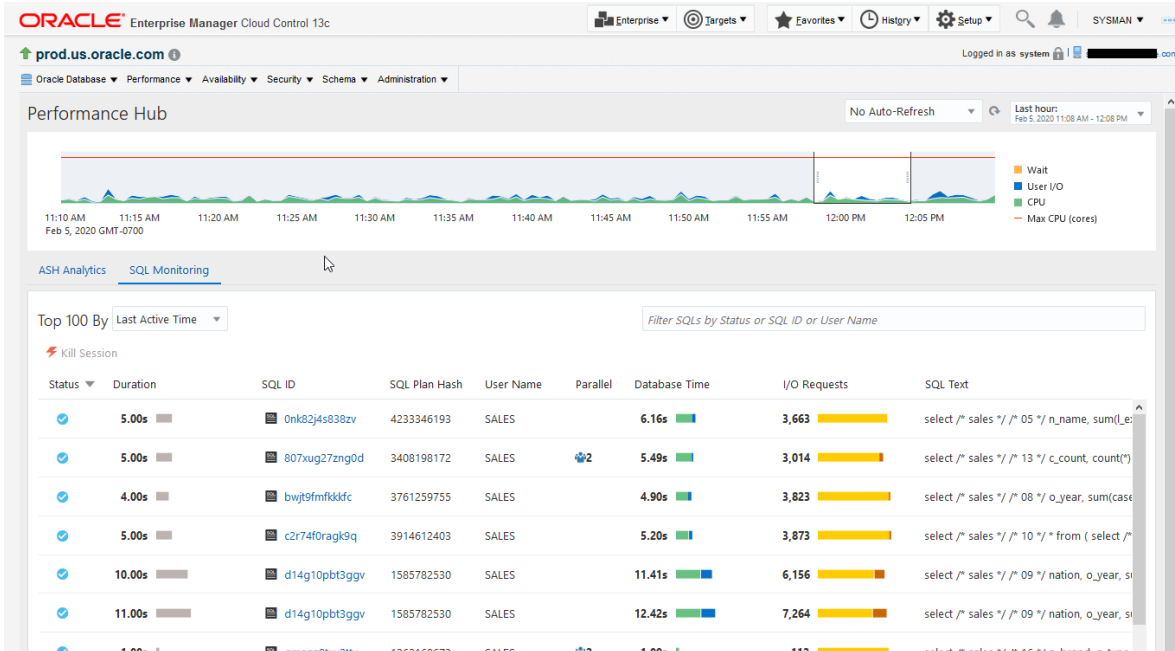
3. Click the ID of a composite database operation in the table.

The Monitored SQL Execution Details page for the operation appears. In the Details section, the Activity subpage is selected by default. Selecting an area in the Activity chart or selecting the corresponding SQL ID value in the legend displays the SQL Details page for that statement.
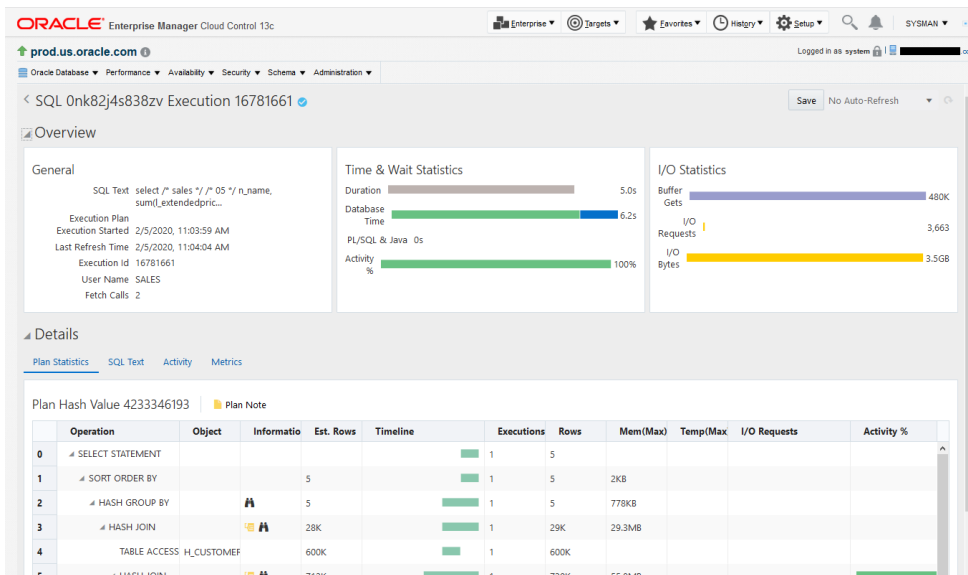
4. To view metrics of the operation, click the **Metrics** tab.

Viewing SQL Execution Details for a SQL Statement

This topic describes how to view the execution details for a SQL statement.

To view execution details for a SQL statement:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Hub** and then **SQL Monitoring**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Monitored SQL Execution page appears.

3. Click the ID of a SQL statement in the table.

   The Monitored SQL Execution Details page for the operation appears. In the Details section, the Plan Statistics subpage is selected by default.

Viewing SQL Execution Details for a PL/SQL Statement

This topic describes viewing the execution details for a PL/SQL statement.

To view execution details for a PL/SQL statement:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Hub** and then **SQL Monitoring**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Monitored SQL Execution page appears.

3. Click the ID of a PL/SQL statement in the table.

   The Monitored SQL Execution Details page for the operation appears. In the Details section, the Activity subpage is selected by default.

6

Monitoring Performance Alerts

Oracle Database includes a built-in alerts infrastructure to notify you of impending problems with the database. Alerts are a type of event and events comprise incidents. A problem is a special type of incident.

By default, Oracle Database enables some alerts, including the following:

- Archive Area Used
- Current Open Cursors Count
- Recovery Area Free Space
- Tablespace Space Used

In addition to these default alerts, you can set metric thresholds so that Oracle Database generates alerts to notify you about the database performance conditions that you specify.

This chapter contains the following sections:

- Setting Metric Thresholds for Performance Alerts
- Responding to Alerts
- Clearing Alerts

> ✏ **See Also:**
>
> - *Oracle Database Administrator's Guide* for information about incidents and how to monitor and manage them

Setting Metric Thresholds for Performance Alerts

A **metric** is the rate of change in a cumulative statistic. This rate can be measured against a variety of units, including time, transactions, or database calls. For example, the number of database calls per second is a metric. You can set thresholds on a metric so that an alert is generated when the threshold is passed.

Performance alerts are based on metrics that are performance-related. These alerts are either environment-dependent or application-dependent.

Environment-dependent performance alerts may not be relevant on all systems. For example, the `AVERAGE_FILE_READ_TIME` metric generates an alert when the average time to read a file exceeds the metric threshold. This alert may be useful on a system with only one disk. On a system with multiple disks, however, the alert may not be relevant because I/O processing is spread across the entire subsystem.

Application-dependent performance alerts are typically relevant on all systems. For example, the `BLOCKED_USERS` metric generates a performance alert when the number of users blocked

by a particular session exceeds the metric threshold. This alert is relevant regardless of how the environment is configured.

To obtain the most relevant information from performance alerts, set the threshold values of performance metrics to values that represent desirable boundaries for your system. You can then fine-tune these values over time until your system meets or exceeds your performance goals.

To set thresholds for performance metrics:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Oracle Database** menu, select **Monitoring**, and then **Metric and Collection Settings**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Metric Settings page appears.

3. For each performance metric relevant for your system, click the **Edit** icon.

   The Edit Advanced Settings page appears.

4. Follow the steps of the wizard to set the threshold value.
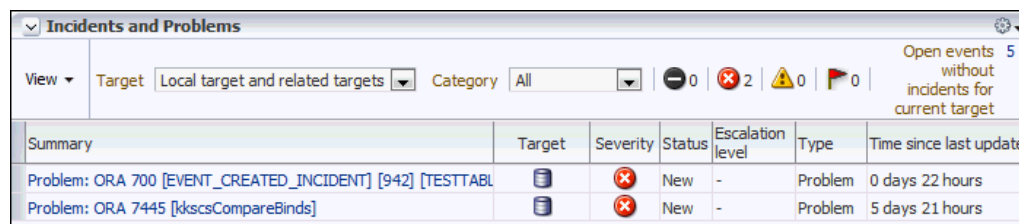
> ✎ **See Also:**
>
> • "Setting Metric Thresholds for Baselines"

Responding to Alerts

When an alert is generated by Oracle Database, it appears in the Incidents and Problems section of the Database Home page.

Figure 6-1 shows the Incidents and Problems section of the Database Home page. The section is below the SQL Monitor - Last Hour section in the default layout of the page.

Figure 6-1   Incidents and Problems Section of the Database Home Page

Oracle Enterprise Manager Cloud Control (Cloud Control) enables you to configure alerts to be sent by email, pager, or text messaging.

To respond to an alert:

1. Access the Database Home page.

    See "Accessing the Database Home Page" for more information.

2. In the table in the Incidents and Problems section, find the alert that you want to investigate and click the link in the Summary column.

    If the Database Login page appears, then log in as a user with administrator privileges. An Incident Manager page appears that contains further information about the alert. For example, clicking the value in the first row of the Summary column in Figure 6-1 causes the Incident Manager Problem Details page shown in Figure 6-2 to appear. The General sub-page is selected.

Figure 6-2   Incident Manager Problem Details Page

3. Do one or more of the following:

    •   Click the other tabs to see information on the subpages.

    •   Perform one or more of the actions in the Tracking section on the General subpage.

    •   In the Guided Resolution section, view diagnostic information by clicking **Support Workbench: Problem Details**. To package and upload diagnostic data to Oracle Support, click **Support Workbench: Package Diagnostic**.

    •   Run Automatic Database Diagnostic Monitor (ADDM) or another advisor to get more detailed diagnostics of the system or object behavior.

Clearing Alerts

Most alerts, such as the CPU Utilization alert, are cleared automatically when the cause of the problem disappears. However, other alerts, such as the Generic Alert Log Error or Generic Incident alert, must be acknowledged.

After taking the necessary corrective measures, you can clear an alert.

To clear alerts:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. In the Incidents and Problems section, click the link in the Summary column of the table. See Figure 6-1 for a screenshot of the section.

   The Incident Manager Problem Details page appears. If the incident or problem can be manually cleared, the **Clear** button appears in the Tracking section.

   What happens if the Clear button does not appear. How is the problem cleared?

3. In the Tracking section, click **Clear**.

Part III

Reactive Database Tuning

Part III describes how to tune Oracle Database in response to a reported problem, such as when the user reports a performance problem with the database that must be tuned immediately.

This part contains the following chapters:

- Manual Database Performance Monitoring
- Resolving Transient Performance Problems
- Resolving Performance Degradation Over Time
- Using Automatic Workload Repository Warehouse for Generating Performance Reports

7

Manual Database Performance Monitoring

You can run the Automatic Database Diagnostic Monitor (ADDM) manually to monitor current and historical database performance. Typically, you use the automatic diagnostic feature of ADDM to identify performance problems with the database. As described in Automatic Database Performance Monitoring, ADDM runs once every hour by default. You can configure ADDM to run at a different time interval. However, in some cases you may want to run ADDM manually.

You can run ADDM manually to analyze a time period that is longer than one ADDM analysis period. For example, you may want to analyze database performance in a workday by analyzing 8 consecutive hours. You could analyze each of the individual ADDM periods within the workday, but this approach may become complicated if performance problems appear in only some ADDM periods. Alternatively, you can run ADDM manually with a pair of Automatic Workload Repository (AWR) snapshots that encompass the 8-hour period. In this case, ADDM identifies the most critical performance problems in the entire time period.

This chapter contains the following sections:

- Manually Running ADDM to Analyze Current Database Performance
- Manually Running ADDM to Analyze Historical Database Performance
- Accessing Previous ADDM Results

Manually Running ADDM to Analyze Current Database Performance

By default, ADDM runs every hour to analyze snapshots taken by AWR during this period. In some cases you may notice performance degradation that did not exist in the previous ADDM analysis period, or a sudden spike in database activity on the Performance page, as described in Monitoring Real-Time Database Performance . If the next ADDM analysis is not scheduled to run for 30 minutes, then you can run ADDM manually to identify and resolve the performance problem.

When you run ADDM manually, a manual AWR snapshot is created automatically. This manual run may affect the ADDM run cycle. For example, if you scheduled ADDM to run hourly at the start of each hour and the last ADDM run was at 8:00 p.m., running ADDM manually at 8:30 p.m. causes the next scheduled run to start at 9:30 p.m., not 9:00 p.m. Subsequent ADDM runs continue on the new run cycle, occurring hourly at the half-hour instead of the start of each hour.

To analyze current database performance by manually running ADDM:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Advisors Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Advisor Central page appears.

3. Under Advisors, select **ADDM**. The Run ADDM page appears.
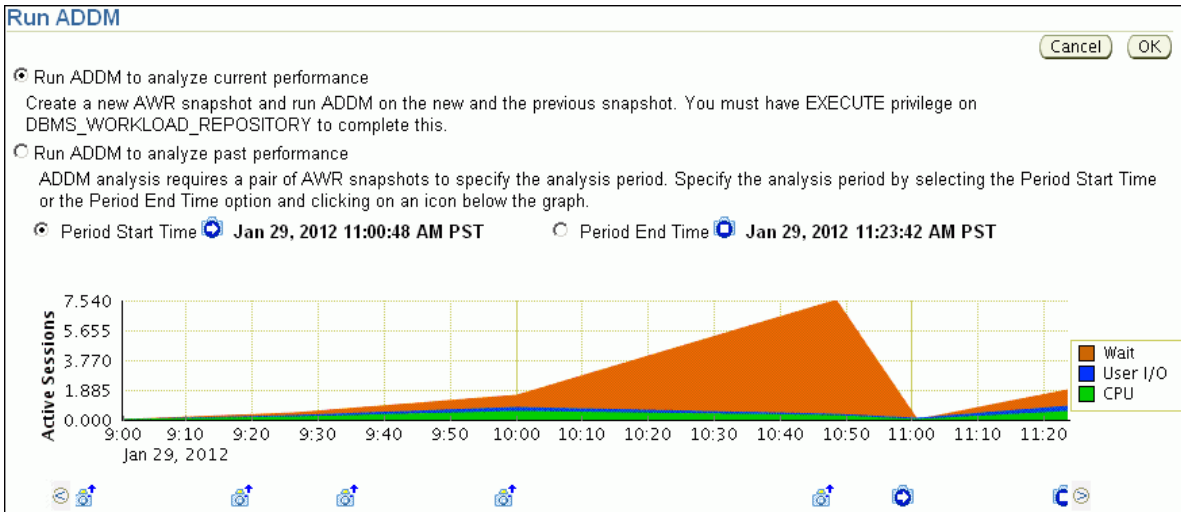
In this example, the average active sessions with wait events rose at 10:00 a.m., peaking at 10:50 a.m. The number dipped at 11:00 a.m. and then started to rise again at 11:10 a.m.

4. Select **Run ADDM to analyze current performance** and click **OK**.

The Confirmation page appears.

5. Click **Yes**.

The Processing: Run ADDM Now page appears while the database takes a new AWR snapshot.

An ADDM run occurs for the time period between the new and the previous snapshot. After ADDM completes the analysis, the Automatic Database Diagnostic Monitor (ADDM) page appears with the results.
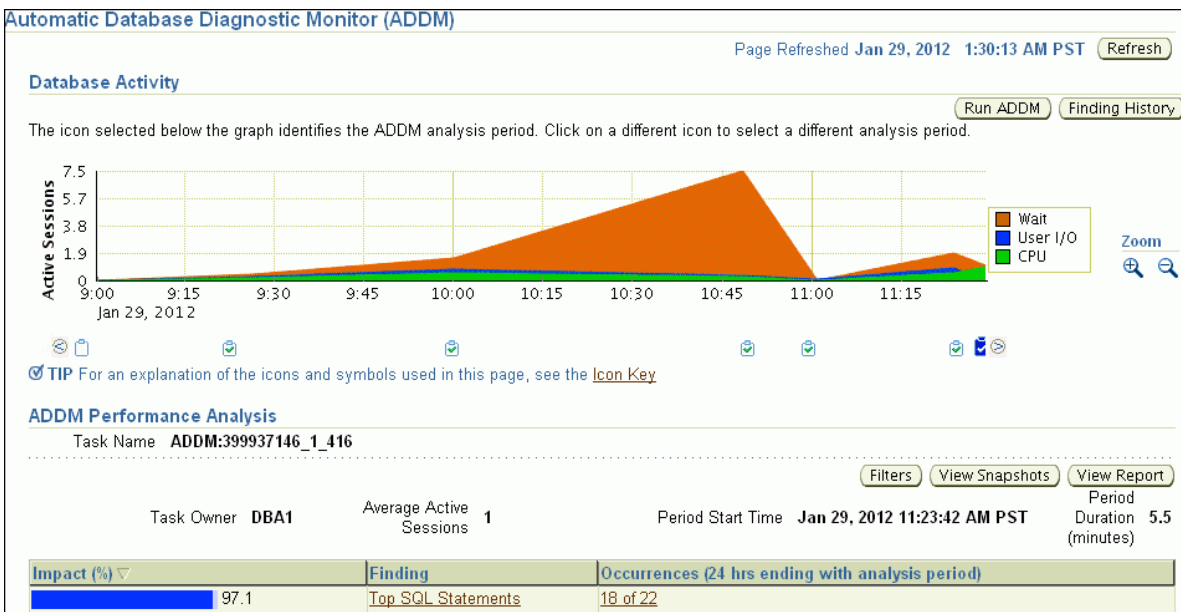
6. Click **View Report**.

   The View Report page appears.

7. Optionally, click **Save to File** to save the results of the ADDM task in a report for later access.

> ✎ **See Also:**
>
> • "Reviewing the Automatic Database Diagnostic Monitor Analysis"

Manually Running ADDM to Analyze Historical Database Performance

You can run ADDM manually to analyze historical database performance by selecting a pair or range of AWR snapshots as the analysis period. This technique is useful when you have identified a previous time period when database performance was poor.

In the Performance page, you can monitor historical performance by selecting **Historical** from the View Data list. In the Historical view, you can monitor database performance in the past, up to the duration defined by the AWR retention period. If you notice performance degradation, then you can drill down from the Performance page to identify historical performance problems with the database, as described in Monitoring Real-Time Database Performance . If you identify a problem, then you can run ADDM manually to analyze a particular time period.

To analyze historical database performance by manually running ADDM:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Advisors Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Advisor Central page appears.

3. Under Advisors, select **ADDM**. The Run ADDM page appears.

4. Select **Run ADDM to analyze past performance**.

5. Specify a time period for analysis by selecting a pair of AWR snapshots. Complete the following steps:

   a. Select **Period Start Time**.

   b. Below the chart for the starting snapshot, click the snapshot you want to use for the start time.

      A play icon (displayed as an arrow) appears over the snapshot icon.

      In this example, database activity peaked from 10 a.m. to 11 a.m., so the snapshot taken at 10 a.m. is selected for the start time.

   c. Select **Period End Time**.

   d. Below the chart for the ending snapshot, click the snapshot you want to use for the end time.

A stop icon (displayed as a square) appears over the snapshot icon.

In this example, the ending snapshot is at 11:00 a.m.
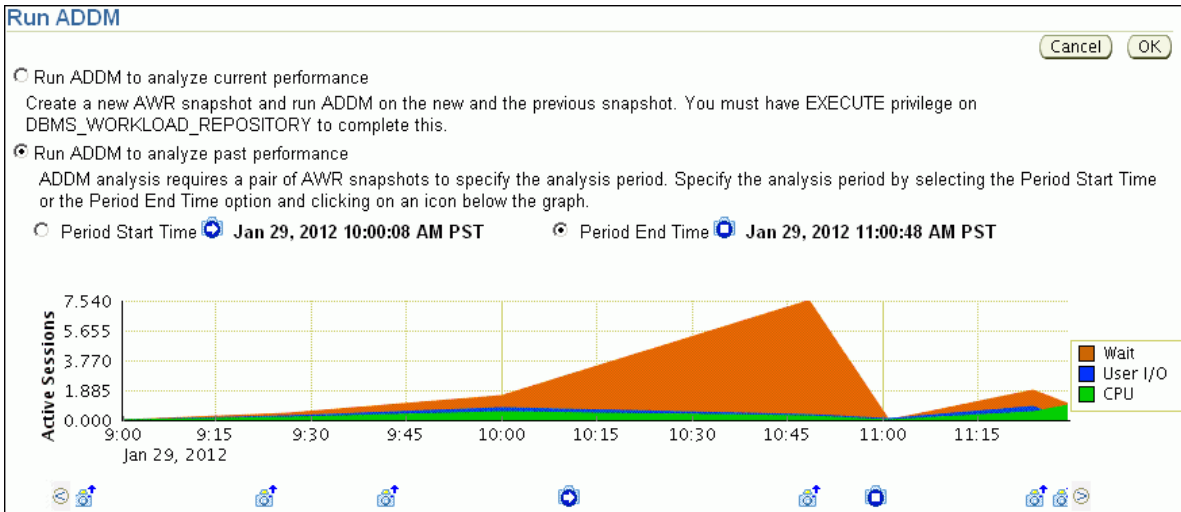
6. Click **OK**.

   After ADDM completes the analysis, the Automatic Database Diagnostic Monitor (ADDM) page appears with the results of the ADDM run.

Figure 7-1   Analyzing Historical Database Performance
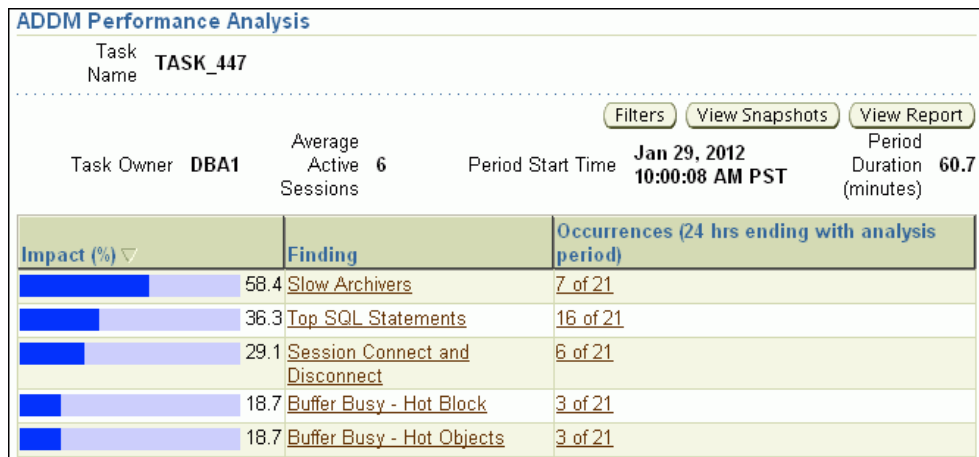
7. Click **View Report**.

   The View Report page appears.

8. Optionally, click **Save to File**.

> ✎ **See Also:**
>
> • "Reviewing the Automatic Database Diagnostic Monitor Analysis"

Accessing Previous ADDM Results

If you ran ADDM manually to analyze current or historical database performance, the results are displayed on the Automatic Database Diagnostic Monitor (ADDM) page after the ADDM run has completed.

You can access the ADDM results at a later time, or access the ADDM results from previous run cycles.

To access the ADDM results:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Advisors Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Advisor Central page appears.

3. Complete the following steps:

   a. Under Advisor Tasks, select **ADDM** from the Advisory Type list.

   b. Select the appropriate search criteria.

   For example, you can select **All** in the Advisor Runs list to view all ADDM tasks.

   c. Click **Go**.

The ADDM tasks are displayed under Results.

4. To view an ADDM result, select the desired ADDM task and click **View Result**.

The results from the selected ADDM task are shown in the Automatic Database
Diagnostic Monitor (ADDM) page.

> ✎ **See Also:**
>
>   • "Reviewing the Automatic Database Diagnostic Monitor Analysis"

8

Resolving Transient Performance Problems

Transient performance problems are short-lived and typically do not appear in the Automatic Database Diagnostic Monitor (ADDM) analysis. ADDM tries to report the most significant performance problems during an analysis period in terms of their effect on database time (DB time). If a problem lasts for a brief time, then its severity might be averaged out or minimized by other performance problems in the entire analysis period. Therefore, the problem may not appear in the ADDM findings. Whether or not a performance problem is captured by ADDM depends on its duration compared to the interval between the Automatic Workload Repository (AWR) snapshots.

If a performance problem lasts for a significant portion of the time between snapshots, then it is captured by ADDM. For example, if the snapshot interval is one hour, then a performance problem that lasts 30 minutes should not be considered a transient performance problem because its duration represents a significant portion of the snapshot interval and is likely to be captured by ADDM.

On the other hand, a performance problem that lasts 2 minutes could be transient because its duration is a small portion of the snapshot interval and probably does not appear in the ADDM findings. For example, if the system was slow between 10:00 p.m. and 10:10 p.m., and if the ADDM analysis for the time period between 10:00 p.m. and 11:00 p.m. does not show a problem, then a transient problem may have occurred for only a few minutes of the 10-minute interval.

This chapter contains the following sections:

- Overview of Active Session History
- Running Active Session History Reports
- Active Session History Reports
- Diagnosing Serious Performance Problems in Real Time

Overview of Active Session History

To capture a detailed history of database activity, Oracle Database samples active sessions each second with the Active Session History (ASH) sampler. AWR snapshot processing collects the sampled data into memory and writes it to persistent storage. ASH is an integral part of the Oracle Database self-management framework and is extremely useful for diagnosing performance problems.

ASH gathers sampled data at the session level rather than at the instance level. By capturing statistics for only active sessions, ASH collects a manageable set of data. The size of this data is directly related to the work being performed, rather than to the size of the entire database instance.

Sampled data captured by ASH can be aggregated based on the dimensions in the data, including the following:

- SQL identifier of a SQL statement
- Object number, file number, and block number

- Wait event identifier and parameters

- Session identifier and session serial number

- Module and action name

- Client identifier of the session

- Service hash identifier

You can run ASH reports to analyze transient performance problems with the database that only occur during specific times. This technique is especially useful when you are trying to do either of the following:

- Resolve transient performance problems that may last for only a short period of time, such as why a particular job or session is not responding when the rest of the instance is performing as usual

- Perform scoped or targeted performance analysis by various dimensions or their combinations, such as time, session, module, action, or SQL identifier

> ✏️ **See Also:**
>
> - "Active Session History Statistics"
> - *Oracle Database Performance Tuning Guide* for more detailed information about ASH reports

Running Active Session History Reports

This section describes how to generate ASH reports using Oracle Enterprise Manager Cloud Control (Cloud Control).

To run ASH reports:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Performance Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Performance page appears.

3. Under Average Active Sessions, click **Run ASH Report**.

   The Run ASH Report page appears.

4. Enter the date and time for the start and end of the time period when the transient performance problem occurred.

   In this example, database activity increased between 9:15 p.m. and 9:20 p.m., so an ASH report should be created for that time period.

8-3

5. Click **Generate Report**.

    The Processing: View Report page appears while the report is being generated.

    After the report is generated, the ASH report appears under Report Results on the Run ASH Report page.

6. Optionally, click **Save to File** to save the report in HTML format for future analysis.

Active Session History Reports

You can use an ASH report to identify the source of transient performance problems. The report is divided into titled sections. The following sections of the ASH report are useful places to begin the investigation:

• Top Events

• Load Profile

• Top SQL

- Top Sessions
- Top DB Objects/Files/Latches
- Activity Over Time

> **See Also:**
>
> - *Oracle Database Performance Tuning Guide* for more detailed information about ASH reports

Top Events

The Top Events section of the report describes the top wait events of the sampled session activity categorized by user, background, and priority. Use this information to identify the wait events that may be the cause of the transient performance problem.

The Top Events section of the report contains the following subsections:

- Top User Events
- Top Background Events

Top User Events

The Top User Events subsection of the report lists the top wait events from client processes that accounted for the highest percentages of sampled session activity.

Figure 8-1 shows that most database activity is consumed by the `CPU + Wait for CPU` event. The Wait for CPU is the time the process spent in the operating system run queue. The `%Event` column shows the percentage of DB time consumed by this event. In this example, over 30 percent of DB time was spent either on the CPU or waiting to get on it. The Load Profile section should be examined next to determine the type of activity that is causing this CPU consumption.

Figure 8-1   Top User Events

Top User Events

Event	Event Class	% Event	Avg Active Sessions
CPU + Wait for CPU	CPU	30.56	1.10
db file sequential read	User I/O	23.64	0.85
CPU - IM Query	CPU	3.32	0.12
latch: shared pool	Concurrency	1.02	0.04

Top Background Events

The Top Background Events subsection lists the top wait events from the background events that accounted for the highest percentages of sampled session activity.

The example in Figure 8-2 shows that 22.81 percent of sampled session activity is consumed by the `CPU + Wait for CPU` event.

Figure 8-2   Top Background Events

Top Background Events

Event	Event Class	% Activity	Avg Active Sessions
CPU + Wait for CPU	CPU	22.81	0.82
log file parallel write	System I/O	8.22	0.30
control file parallel write	System I/O	3.05	0.11
control file sequential read	System I/O	1.11	0.04
db file sequential read	User I/O	1.11	0.04

Load Profile

The Load Profile section of the report describes the load analyzed in the sampled session activity. Use the information in this section to identify the service, client, or SQL command type that may be the cause of the transient performance problem.

The Top Service/Module subsection lists the services and modules that accounted for the highest percentages of sampled session activity. A **service** is a group of related database tasks that share common functionality, quality expectations, and priority. Services are a convenient way to monitor multiple applications. The `SYS$USERS` and `SYS$BACKGROUND` services are always defined.

Figure 8-3 shows that over half of the database activity is consumed by the `SYS$USERS` service running the SQL*Plus module. In this example, it appears that the user is running high-load SQL that is causing the performance problem indicated in Figure 8-1. The Top SQL section of the report should be analyzed next to determine whether a particular type of SQL statement makes up the load.

Figure 8-3   Top Service/Module

Top Service/Module

Service	Module	% Activity	Action	% Action
SYS$USERS	SQL*Plus	54.66	EMP_DML	27.33
			SALES_INFO	27.33
SYS$BACKGROUND	UNNAMED	35.83	UNNAMED	35.83
	MMON_SLAVE	4.16	Auto-Flush Slave Action	2.86
			Auto ADDM Slave Action	1.29
SYS$USERS	UNNAMED	2.31	UNNAMED	2.31
	emagent@dbhost (TNS V1-V3)	1.57	UNNAMED	1.57

> **See Also:**
>
> - "Monitoring Top Services"
> - "Monitoring Top Modules"

Top SQL

The Top SQL section of the report describes the top SQL statements of the sampled session activity. Use this information to identify high-load SQL statements that may be the cause of the transient performance problem. The Top SQL with Top Events subsection lists the SQL statements that accounted for the highest percentages of sampled session activity. The Sampled # of Executions column shows how many distinct executions of a particular SQL statement were sampled. To view the text of the SQL statements, click the **SQL ID** link.

Figure 8-4 shows that over half of DB time is consumed by three DML statements. These statements were run in the SQL*Plus module shown in Figure 8-3. The Top Sessions section should be analyzed to identify the sessions running these statements.

Figure 8-4   Top SQL with Top Events

SQL ID	Planhash	Sampled # of Executions	% Activity	Event	% Event	Top Row Source	% RwSrc	SQL Text
31h2wmu3q47u6	4090065844	277	26.22	CPU + Wait for CPU	26.13	TABLE ACCESS - FULL	19.94	SELECT /*+ ORDERED USE_NL(c) F...
				CPU - In-memory Query	1.90	TABLE ACCESS - FULL	1.89	
				flashback buf free by RVWR	1.39	** Row Source Not Available **	1.39	
7u628xsamhgka	781635435	127	11.82	db file sequential read	9.70	DELETE	9.70	DELETE FROM EMPLOYEES WHERE EM...
				flashback buf free by RVWR	1.75	DELETE	1.75	

> **See Also:**
>
> - "Monitoring Top SQL"

Top Sessions

The Top Sessions section lists the sessions that were waiting for the wait event that accounted for the highest percentages of sampled session activity. Use this information to identify the sessions that may be the cause of the performance problem.

The `# Samples Active` column shows the number of ASH samples in which the session was found waiting for that particular event. The percentage is calculated based on wall-clock time.

In Figure 8-5, the `# Samples Active` column shows that of the 300 times that ASH sampled database activity, the `HR` session (SID 123) performed a sequential read 243 times and a flashback operation 36 times. So, `HR` was active at least 93% of the time. The session consumed 27% of the total activity (much less than 93%) because other sessions, including the `SH` session, were also active.

It appears that the `HR` and `SH` sessions were running the high-load SQL statement in Figure 8-4. You should investigate this session to determine whether it is performing a legitimate operation and tune the SQL statement if possible. If tuning the SQL is not possible, and if a session is causing an unacceptable performance impact on the system, then consider terminating the session.

Figure 8-5   Top Sessions

Sid, Serial#	% Activity	Event	% Event	User	Program	# Samples Active	XIDs
123, 275	27.33	db file sequential read	22.44	HR	sqlplus -L@dbh...1 (TNS V1-V3)	243/300 [81%]	16
		flashback buf free by RVWR	3.32			36/300 [12%]	4
126,28313	27.33	CPU + Wait for CPU	26.78	SH	sqlplus -L@dbh...1 (TNS V1-V3)	290/300 [97%]	0
154, 5	15.24	CPU + Wait for CPU	11.54	SYS	oracle@dbhost (RVWR)	125/300 [42%]	0
		control file parallel write	2.12			23/300 [8%]	0
161, 1	8.31	log file parallel write	8.22	SYS	oracle@dbhost (LGWR)	89/300 [30%]	0
110,36790	2.86	CPU + Wait for CPU	1.11	SYS	oracle@dbhost (M000)	12/300 [4%]	0

> **✎ See Also:**
>
> - "Monitoring Top Sessions"
> - "Tuning SQL Statements "

Top DB Objects/Files/Latches

The Top Objects/Files/Latches section provides additional information about the most commonly-used database resources and contains the following subsections:

- Top DB Objects
- Top DB Files
- Top Latches

Top DB Objects

The Top DB Objects subsection lists the database objects (such as tables and indexes) that accounted for the highest percentages of sampled session activity.

The example in Figure 8-6 shows that the `hr.departments` and `hr.employees` tables account for a high percentage of activity. Enqueue waits are waits for locks. In this example, the wait is for the TM (table) lock. Sometimes these waits indicate unindexed foreign key constraints. The `buffer busy waits` event records waits for a buffer to become available. These waits indicate that multiple processes are attempting to concurrently access the same buffers in the buffer cache.

Figure 8-6   Top DB Objects

Top DB Files

The Top DB Files subsection lists the database files that accounted for the highest percentages of sampled session activity. Only cluster and I/O events are considered. The `%` `Event` column breaks down the activity by event, so if multiple rows exist in this table, then the sampled activity is divided among multiple events.

Figure 8-7 shows that about 11 percent of DB time involves waits for the `UNDOTBS` tablespace. This information is consistent with Figure 8-4, which shows significant DML activity from multiple sessions.

Figure 8-7   Top DB Files

Top Latches

The Top Latches subsection lists the latches that accounted for the highest percentages of sampled session activity. Latches are simple, low-level serialization mechanisms to protect shared data structures in the System Global Area (SGA).

Activity Over Time

The Activity Over Time section of the ASH report is particularly useful for longer time periods because it provides in-depth details about activities and workload profiles during the analysis period. The Activity Over Time section is divided into **time slots**. The ASH report time span is divided into 10 time slots unless the time period is short or the data is sparse.

Figure 8-8 shows an activity report for the period between 2:10 p.m. and 2:40 p.m. The report indicates that the number of sampled sessions rose sharply in the sixth inner slot (2:24 p.m.) and stayed up. During this period CPU activity and lock enqueue waits increased dramatically.

Figure 8-8 Activity Over Time

Slot Time (Duration)	Slot Count	Event	Event Count	% Event
14:10:50 (1.2 min)	5	control file sequential read	4	0.11
		CPU + Wait for CPU	1	0.03
14:12:00 (3.0 min)	9	CPU + Wait for CPU	5	0.14
		CPU - In-memory Query	2	0.05
		null event	1	0.03
14:15:00 (3.0 min)	8	control file parallel write	4	0.11
		control file sequential read	4	0.11
14:18:00 (3.0 min)	10	control file sequential read	6	0.16
		control file parallel write	3	0.08
		SQL*Net break/reset to client	1	0.03
14:21:00 (3.0 min)	14	CPU + Wait for CPU	5	0.14
		control file parallel write	5	0.14
		control file sequential read	3	0.08
14:24:00 (3.0 min)	275	CPU + Wait for CPU	95	2.60
		enq: TM - contention	60	1.64
		control file sequential read	36	0.99
14:27:00 (3.0 min)	703	enq: TM - contention	187	5.12
		CPU + Wait for CPU	175	4.79
		CPU - In-memory Query	81	2.22
14:30:00 (3.0 min)	737	enq: TM - contention	210	5.75
		CPU + Wait for CPU	199	5.45
		CPU - In-memory Query	95	2.60
14:33:00 (3.0 min)	713	enq: TM - contention	181	4.96
		CPU + Wait for CPU	176	4.82
		enq: CF - contention	84	2.30
14:36:00 (3.0 min)	740	enq: TM - contention	222	6.08
		CPU + Wait for CPU	212	5.81
		CPU - In-memory Query	80	2.19
14:39:00 (1.8 min)	437	enq: TM - contention	126	3.45
		CPU + Wait for CPU	114	3.12
		enq: CF - contention	52	1.42

Each time slot contains session and wait event activity, as described in Table 8-1.

Table 8-1 Activity Over Time

Column	Description
Slot Time (Duration)	Duration of the slot
Slot Count	Number of sampled sessions in the slot
Event	Top three wait events in the slot

Table 8-1   (Cont.) Activity Over Time

Column	Description
Event Count	Number of ASH samples waiting for the wait event
% Event	Percentage of ASH samples waiting for wait events in the entire analysis period

All inner slots are the same number of minutes each for easy comparison. The first and last slots, called **outer slots**, are odd-sized because they do not have a fixed slot time.

When comparing the inner slots, perform a skew analysis by identifying spikes. A spike in the Slot Count column indicates an increase in active sessions and a relative increase in database workload. A spike in the Event Count column indicates an increase in the number of sampled sessions waiting for an event. Typically, when the number of active session samples and the number of sessions associated with a wait event increase, the slot may be the cause of the transient performance problem.

9

Resolving Performance Degradation Over Time

Performance degradation of the database occurs when your database was performing optimally in the past, such as 6 months ago, but has gradually degraded to a point where it becomes noticeable to the users. The Automatic Workload Repository (AWR) Compare Periods report enables you to compare database performance between two periods of time.

While an AWR report shows AWR data between two snapshots (or two points in time), the AWR Compare Periods report shows the difference between two periods (or two AWR reports with a total of four snapshots). Using the AWR Compare Periods report helps you to identify detailed performance attributes and configuration settings that differ between two time periods. The two time periods selected for the AWR Compare Periods report can be of different durations. The report normalizes the statistics by the amount of time spent on the database for each time period and presents statistical data ordered by the largest difference between the periods.

For example, a batch workload that historically completed in the maintenance window between 10:00 p.m. and midnight is currently showing poor performance and completing at 2 a.m. You can generate an AWR Compare Periods report from 10:00 p.m. to midnight on a day when performance was good and from 10:00 a.m. to 2 a.m. on a day when performance was poor. The comparison of these reports should identify configuration settings, workload profile, and statistics that were different in these two time periods. Based on the differences identified, you can diagnose the cause of the performance degradation.

This chapter contains the following sections:

- Managing Baselines
- Running the AWR Compare Periods Reports
- Using the AWR Compare Periods Reports

> ✏️ **See Also:**
>
> - "Gathering Database Statistics Using the Automatic Workload Repository"

Managing Baselines

Baselines are an effective way to diagnose performance problems. AWR supports the capture of baseline data by enabling you to specify and preserve a pair or a range of snapshots as a baseline. The snapshots contained in a baseline are excluded from the automatic AWR purging process and are retained indefinitely.

A moving window baseline corresponds to all AWR data that exists within the AWR retention period. Oracle Database automatically maintains a system-defined moving window baseline.

The default size of the window is the current AWR retention period, which by default is 8 days.

This section contains the following topics:

- Creating a Baseline
- Deleting a Baseline
- Computing Threshold Statistics for Baselines
- Setting Metric Thresholds for Baselines

Creating a Baseline

Before creating a baseline, carefully consider the time period you choose as a baseline because it should represent the database operating at an optimal level. In the future, you can compare these baselines with other baselines or snapshots captured during periods of poor performance to analyze performance degradation over time.

You can create the following types of baseline:

- Creating a Single Baseline
- Creating a Repeating Baseline

Creating a Single Baseline

A single baseline is captured at a single, fixed time interval. For example, a single baseline may be captured on February 5, 2020 from 5:00 p.m. to 8:00 p.m.

You can choose future start and end times to create a baseline that captures future database activity. If both the start time and the end time are in the future, then a baseline template with the same name as the baseline is also created. A baseline template is a specification that enables Oracle Database to automatically generate a baseline for a future time period.

To create a single baseline:

1. Access the **Database Home** page for the target database.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **AWR** and then **AWR Administration**.

   If the **Database Login** page appears, then log in as a user with administrator privileges. The **Performance** page appears.

3. Under **Manage Snapshots and Baselines**, click the number next to Baselines.

   The AWR Baselines page appears with a list of existing baselines displayed.

4. Click **Create**.

   The **Create Baseline: Baseline Interval Type** page appears.

5. Select **Single** and then **Continue**.

   The **Create Baseline: Single Baseline** page appears.

6. In the **Baseline Name** field, enter a name for the baseline.

7. Under **Baseline Interval**, select whether to use a snapshot range or a time range for the baseline. Do one of the following:

   • To use a range, select **Snapshot Range**. Complete the following steps:

   – Under **Select Time Period**, specify a start time for the baseline by selecting **Period Start Time** radio button and then a snapshot icon below the **Active Sessions** chart that corresponds to the desired start time.

   – Specify an end time for the baseline by selecting **Period End Time** radio button and then a snapshot icon below the **Active Sessions** chart that corresponds to the desired end time.

– **Optionally**, to view older snapshots that are not displayed below the **Active Sessions** chart, expand **Change Chart Time Period**. Enter the desired start date in the **Chart Start Date** field and the desired end date in the **Chart End Date** field, and click **Go**.

In this example, a snapshot range of February 7, 2012 from 10:50 a.m. to 11:20 a.m. is selected.
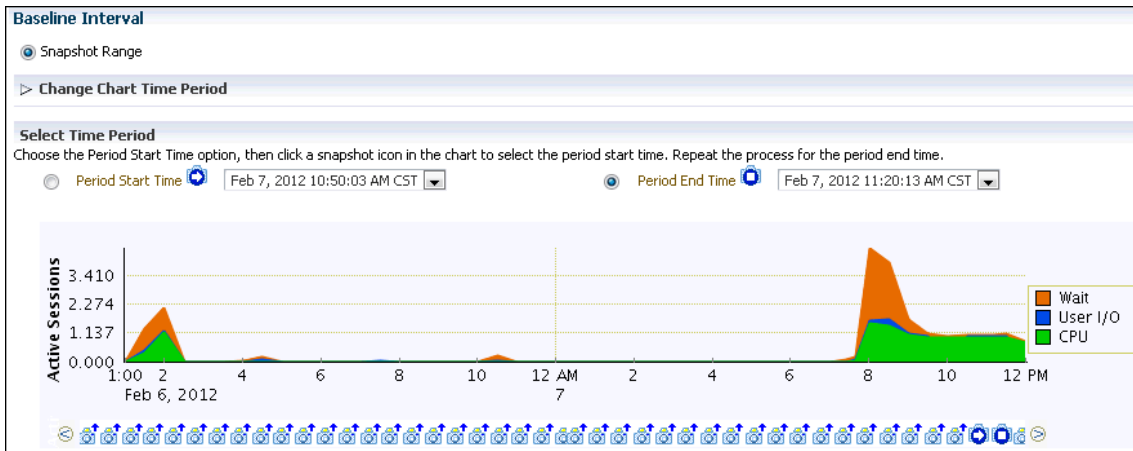
- To use a time range, select **Time Range**. Complete the following steps:
  – In the **Start Time** fields, select a start time for the baseline.
  – In the **End Time** fields, select an end time for the baseline.

In the following example, a time range from 12:20 p.m. to 12:35 p.m. on February 7, 2012 is selected.

8. Click **Finish**.

The **AWR Baselines** page returns and has a new item for just created baseline.

Creating a Repeating Baseline

A repeating baseline is a baseline that repeats during a time interval over a specific period. For example, a repeating baseline may repeat every Monday from 1:00 p.m. to 3:00 p.m. from February 7, 2012 to February 7, 2013.

To create a repeating baseline:

1. Access the AWR Baselines page, as explained in "Creating a Single Baseline".

2. Click **Create**.

The **Create Baseline: Baseline Interval Type** page appears.

3. Select **Repeating** and then click **Continue**.

The **Create Baseline: Repeating Baseline Template** page appears.

4. In the **Baseline Name Prefix** field, enter a name prefix for the baseline.

5. Under **Baseline Time Period**, specify the time of the day that you want the baseline to begin collecting AWR data and the duration of the baseline collection.

6. Under **Frequency**, do one of the following:

   • Select **Daily** if you want the baseline to repeat on a daily basis.

   • Select **Weekly** if you want the baseline to repeat on a weekly basis, and then select the day of the week on which the baseline repeats.

7. Under **Interval of Baseline Creation**, complete the following steps:

   a. In the **Start Time** fields, select a date and time in the future when the data collection should begin.

   b. In the **End Time** fields, select a date and time in the future when the data collection should end.

8. Under **Purge Policy**, enter the number of days to retain captured baselines.

9. Click **Finish**.

   A baseline template with the same name as the baseline name prefix is created. A baseline template is a specification that enables Oracle Database to automatically generate a baseline for a future time period.

   This example creates a baseline that repeats weekly on Mondays from 8:00 a.m. to 10:00 a.m. from February 6, 2009 to February 6, 2010. Every captured baseline expires after 30 days.

Deleting a Baseline

To conserve storage space, you may want to periodically delete unused baselines stored in the database.

Removing a source from AWR dashboard presents two options:

1. **Hard Delete: Remove source from AWR Warehouse and purge all collected AWR data**

- All the extract/transfer jobs scheduled for the source are removed.
- The source databases are removed from AWR dashboard
- Already collected AWR data for the source from the warehouse is purged.

2. **Soft Delete: Stop all upload on source but retain collected data in AWR Warehouse**

- Source database remain in the dashboard, but in a disabled (greyed out) state.
- The extract/transfer jobs scheduled for the source are removed.
- Diagnosis,edit,enable/disable snapshots user actions are disabled.
- Retention period for the collected snapshots is still applicable. For example , all snapshots older than the retention period are deleted.
- AWR data collected in the Warehouse are *not* purged, and AWR reports can be generated from the data.

To delete a baseline:

1. Access the AWR Baselines page, as explained in "Creating a Single Baseline".
2. Select a baseline and click **Delete**.

   The **Confirmation** page appears.
3. Select whether to purge the underlying data associated with the baseline.

   The underlying data includes the individual snapshots preserved in the baseline and any statistics that are computed for the baseline. Do one of the following:

   - To delete the underlying data, select **Purge the underlying data associated with the baseline**.
   - To preserve the underlying data, select **Do not purge the underlying data associated with the baseline**.
4. Click **Yes**.

   The AWR Baselines page reappears. A message informs you that the baseline was deleted successfully.

Computing Threshold Statistics for Baselines

Computing threshold statistics for baselines enables you to graphically display the computed statistics in the charts on the Performance page.

To compute threshold statistics for baselines:

1. Access the AWR Baselines page, as explained in "Creating a Single Baseline".
2. Select the baseline for which you want to compute statistics.

   Select a baseline that does not already have computed statistics. These baselines are identified by **No** in the **Statistics Computed** column.
3. From the **Actions** list, select **Schedule Statistics Computation**, and then click **Go**.

   The **Compute Threshold Statistics** page appears.

   This example computes statistics for the baseline `BASELINE_TUE_1120`.

4. In the **Name** field, enter a name for the task.

   Alternatively, you can choose to use the system-generated name.

5. In the **Description** field, enter a description for the task.

   Alternatively, you can choose to use the system-generated description.

6. Under **Start**, do one of the following:

   • Select **Immediately** to run the task immediately after it has been submitted.

   • Select **Later** to run the task at a later time as specified using the Date and Time fields.

   This computation is resource-intensive, so you may want to schedule it to run during off-peak hours.

7. Click **Submit**.

   The AWR Baselines page appears. A message informs you that statistics computation has been scheduled for the selected baseline.

> **See Also:**
>
> "Customizing the Database Performance page" for information about displaying computed statistics on the Performance page

Setting Metric Thresholds for Baselines

As explained in "Setting Metric Thresholds for Performance Alerts", a metric is the rate of change in a cumulative statistic. Alerts notify you when particular metric thresholds are

crossed. When the metric thresholds are crossed, the system is in an undesirable state. You can edit the threshold settings for baseline metrics.

You can create the following types of baseline:

- Setting Metric Thresholds for the Default Moving Baseline
- Setting Metric Thresholds for Selected Baselines

Setting Metric Thresholds for the Default Moving Baseline

This section describes the easiest technique for setting the metric thresholds for the default moving baseline. You can choose a group of basic metric threshold settings based on common database workload profiles such as OLTP, data warehousing, and OLTP with nighttime batch jobs. After choosing a workload profile, you can expand or change the threshold values as needed.

To set metric thresholds for the default moving baseline:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Adaptive Thresholds**.

   If the Database Login page appears, then log in as a user with administrator privileges.

   The Threshold Configuration tab of the Baseline Metric Thresholds page appears.

3. Click **Quick Configuration**.

   The Quick Configuration: Baseline Metric Thresholds page appears.

4. In **Workload Profile**, select one of the following options, depending on how you are using the database:

   - **Primarily OLTP (pure transaction processing 24 hours a day)**
   - **Primarily Data Warehousing (query and load intensive)**
   - **Alternating (OLTP during the daytime and batch during the nighttime)**

   In this example, **Primarily OLTP** was selected.

5. Click **Continue**.

   The Quick Configuration: Review OLTP Threshold Settings page appears.

6. Review the metric threshold settings and then click **Finish**.

You are returned to the Baseline Metric Thresholds page, with the Threshold Configuration tab selected. The metric threshold settings are displayed.

Setting Metric Thresholds for Selected Baselines

This section explains how to select a baseline and edit its thresholds. You can configure the type of threshold, for example, whether it is based on significance levels, percentage of maximum values, or fixed values. You can also configure the threshold levels that determine when the database generates critical alerts and warnings.

You can edit thresholds for the default moving baseline or a baseline that you created in the AWR Baselines page. You can select a baseline in the Edit Thresholds page after you have scheduled statistics computation from the AWR Baselines page and the statistics have finished computing on the static baseline.

To set a metric threshold for a selected moving baseline:

1. Access the Baseline Metric Thresholds page, as explained in "Setting Metric Thresholds for the Default Moving Baseline".

2. In the View list, select **Basic Metrics**.

   The Baseline Metric Thresholds page appears.

3. In the **Category/Name** column, click the link for the metric whose threshold you want to set or change.

   For example, click **Number of Transactions (per second)**.

   The Edit Thresholds: Number of Transactions (per second) appears.
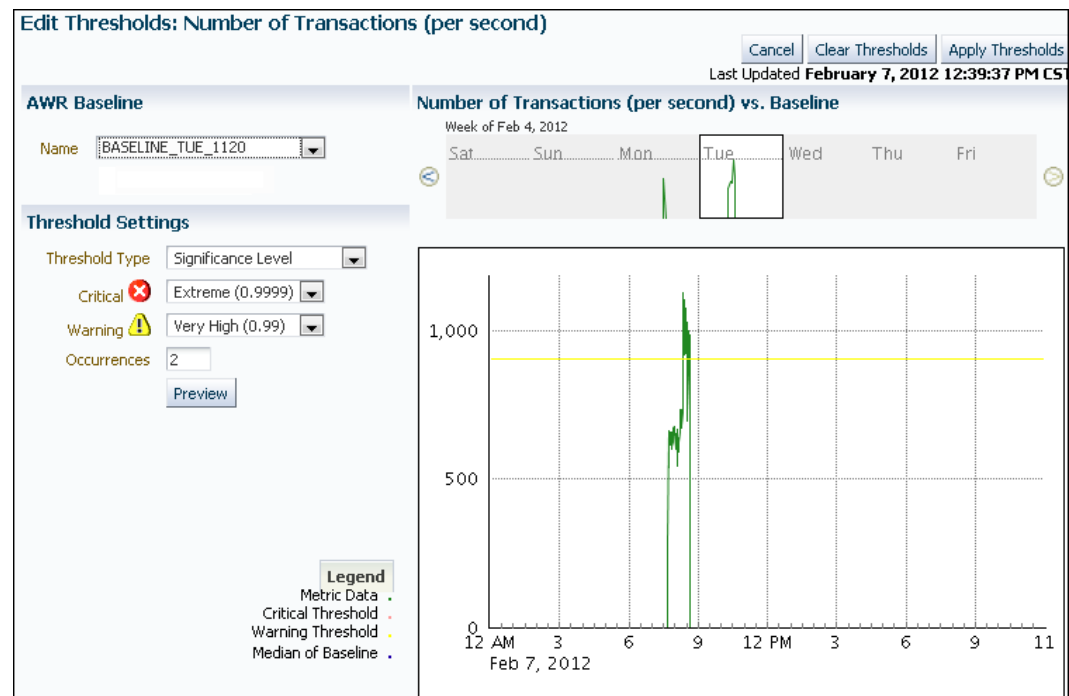
The charts on this page provide simple and detailed views of metric activity for a 24-hour period. In the top simple chart, click a day to view the value of the metric plotted against a 24-hour period.

4. Under **AWR Baseline**, in the Name list, select either the default **SYSTEM_MOVING_WINDOW** or the name of a baseline created in the AWR Baselines page.

   A baseline appears in the AWR Baseline list after you have scheduled statistics computation from the AWR Baselines page and the statistics have finished computing on the static baseline.

   In this example, `BASELINE_TUE_1120` is selected.

   The page refreshes to show the charts for the baseline that you selected.

5. In the Threshold Settings section, complete the following steps to change the settings:

   a. In the **Threshold Type** list, select a type.

   b. In the **Critical** list, select a level.

   c. In the **Warning** list, select a value.

   d. In the **Occurrences** list, select a value.

6. Click **Apply Thresholds**.

   The Baseline Metric Thresholds page reappears. The page shows the altered metric threshold settings.

Running the AWR Compare Periods Reports

This section describes how to run the AWR Compare Periods reports using Enterprise Manager Cloud Control (Cloud Control).

You can use AWR Compare Periods reports to compare the database performance between two time periods by:

- Comparing a Baseline to Another Baseline or Pair of Snapshots
- Comparing Current System Performance to a Baseline Period
- Comparing Two Pairs of Snapshots

Comparing a Baseline to Another Baseline or Pair of Snapshots

When performance degradation occurs over time, you can run the AWR Compare Periods report to compare the degraded performance, captured as a new baseline or a pair of snapshots, to an existing baseline. You must have a baseline that represents the system operating at an optimal level. If an existing baseline is unavailable, then compare database performance between two periods of time using two arbitrary pairs of snapshots, as described in "Comparing Two Pairs of Snapshots".

To compare a baseline to another baseline:

1. Access the **Database Home** page for the target database.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **AWR**, then **AWR Administration**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Automatic Workload Repository page appears.

3. Under **Manage Snapshots and Baselines**, click the link next to **Baselines**.

   The AWR Baselines page appears.

4. Complete the following steps:

   a. Select the baseline to use for the report.

      At least one existing baseline must be available.

   b. From the Actions list, select **Compare Periods** and then click **Go**.

   The Compare Periods: Second Period Start page appears. Under First Period, the selected baseline is displayed.

   In this example, the baseline named `BASELINE_TUE_1120` is selected.

5. Compare the baseline selected in the first period to another baseline or a pair of snapshots. Do one of the following:

   • To compare to another baseline, select **Select a Baseline** and the baseline you want to use in the second period, and then click **Next**.

     The **Compare Periods: Review** page appears.

   • To compare to a pair of snapshots, select **Select Beginning Snapshot** and the beginning snapshot to use in the second period, and then click **Next**.

     This example selects snapshot 18, taken on February 7, 2012 at 1:00 p.m.

The **Compare Periods: Second Period End** appears. Proceed to the next step.

6. Select the ending snapshot for the snapshot period to include in the report and then click **Next**.

   In this example, snapshot 1500, taken on February 7, 2009 at 12:50 p.m., is selected.

The **Compare Periods: Review** page appears.

7. Review the periods to be included in the report and then click **Finish**.

   The **Compare Periods: Results** page appears.

   Data from the selected periods appears under the **General** subpage. You can view data per second or per transaction by selecting an option from the View Data list.

> **Note:**
>
> If the time periods have different lengths, then the data is normalized over database time before calculating the difference so that periods of different lengths can be compared.

In this example, almost every metric shows that more resources were consumed in the first period. The bar graphs indicate the proportions of the values in the two periods. The absence of bars indicates equivalent values. The report for this example shows significantly more database block changes per second and parse time in the first period than in the second.

Name ▲	First Period Metric Ratio	Second Period Metric Ratio	First Period Value	Second Period Value	First Period Rate Per Second	Second Period Rate Per Second
DB cpu (seconds)			0.00	0.00	0.00	0.00
DB time (seconds)			7,341.60	60.83	4.06	0.10
db block changes			68,185.00	6,558.00	37.69	10.91
execute count			42,907.00	1,941.00	23.72	3.23
global cache cr block receive time (seconds)			0.00	0.00	0.00	0.00
global cache cr blocks received			0.00	0.00	0.00	0.00
global cache current block receive time (seconds)			0.00	0.00	0.00	0.00
global cache current blocks received			0.00	0.00	0.00	0.00
global cache get time (seconds)			0.00	0.00	0.00	0.00
global cache gets			0.00	0.00	0.00	0.00
opened cursors cumulative			41,062.00	1,157.00	22.70	1.93
parse count (total)			4,053.00	402.00	2.24	0.67
parse time cpu (seconds)			0.89	0.03	0.00	0.00
parse time elapsed (seconds)			7.71	0.05	0.00	0.00
physical reads			2,478,815.00	85.00	1,370.27	0.14
physical writes			13,086.00	681.00	7.23	1.13
redo size (KB)			7,050.67	2,198.98	3.90	3.66
session cursor cache hits			-27,137.00	1,213.00	-15.00	2.02

8. Click **Report** to view the report.

   The Processing: View Report page appears while the report is being generated. After it completes, the report appears.

9. Optionally, do the following:

   • To change periods, click **Change Periods**.

   • To save the report as an HTML file, click **Save to File**.

> **See Also:**
>
> • "Creating a Baseline"
>
> • "Using the AWR Compare Periods Reports"

Comparing Current System Performance to a Baseline Period

You may have noticed a performance change on a production system and would like to know why, or you may have implemented a change to a production system and want to know the effect of the change, such as increased concurrency waits.

The Compare Period ADDM compares the performance of the database server in two time periods, and returns a report describing the performance changes and the root origin of the changes. The Advisor can analyze any Oracle RDBMS version 10.2.0.4 or later monitored by Cloud Control. The following procedure explains how to initiate a report from the Compare Period ADDM.

1. From the Performance menu, select **AWR**, then **Compare Period ADDM**.

2. From the **Run Compare Period ADDM** page, specify the desired comparison and base periods:

   • **Comparison Period** — Generally represents an improperly functioning time period. However, you could also use the advisor to understand why performance has improved now when compared with an earlier time period.

   • **Base Period** — Represents a known (baseline or reference) period in which the database is functioning properly. You should select a base period in which the performance was acceptable, and the workload was as similar or identical as possible.

3. Click **Run** to display the **Database Compare Period Report**.

4. Examine the sections of the report to understand the performance change between the two periods and the cause of the change:

   • **Overview**

     This portion of the report shows SQL commonality, which is the comparability between the base and comparison periods based on the average resource consumption of the SQL statements common to both periods.

     A commonality value of 100% means that the workload "signature" in both time periods is identical. A value of 0% means that the two time periods have no items in common for the specific workload dimension.

     Commonality is based on the type of input (that is, which SQL is executing) as well as the load of the executing SQL statements. Consequently, SQL statements running in only one time period, but not consuming significant time, do not affect commonality. Therefore, two workloads could have a commonality of 100% even if some SQL statements are running only in one of the two periods, provided that these SQL statements do not consume significant resources.

   • **Configuration**

     The information displayed shows base period and comparison period values for various parameters categorized by instance, host, and database.

   • **Findings**

     The findings can show performance improvements and identify the major performance differences caused by system changes. For negative outcomes, if you understand and remove the cause, the negative outcome can be eliminated.

     The values shown for the Base Period and Comparison Period represent performance with regard to database time.

     The Change Impact value represents a measurement of the scale of a change in performance from one time period to another. It is applicable to issues or items measured by the total database time they consumed in each time period. The absolute values are sorted in descending order.

If the value is positive, an improvement has occurred, and if the value is negative, a regression has occurred. For instance, a change impact of -200% means that period 2 is three times as slow as period 1.

You can run performance tuning tools, such as ADDM and the SQL Tuning Advisor, to fix issues in the comparison period to improve general system performance.

- **Resources**

    The information shown here provides a summary of the division of database time for both time periods, and shows the resource usage for CPU, memory, I/O, and interconnect (Oracle RAC only).

5. Based on your observations, decide how to proceed to resolve performance regressions, then implement your action plan.

Comparing Two Pairs of Snapshots

If an existing baseline is unavailable, then you can compare database performance by using two arbitrary pairs of snapshots. Use one pair taken when the database is performing optimally, and another pair when the database is performing poorly. At least four snapshots must be available.

To compare performance using two pairs of snapshots:

1. Access the Database Home page.

    See "Accessing the Database Home Page" for more information.

2. From the **Performance** drop-down menu, select **AWR** and then **Compare Periods Reports**.

    If the Database Login page appears, then log in as a user with administrator privileges. The Run Compare Periods Report page appears.

3. In First Period, select **By Snapshot**.

4. In Begin Snapshot, click the magnifying glass icon.

    The Search and Select: Snapshots page appears.

5. Select the starting point for the first snapshot period to be included in the report, and then click **Select**.

    You are returned to the Run Compare Periods Report page.

6. In End Snapshot, click the magnifying glass icon.

    The Search and Select: Snapshots page appears.

7. Select the ending point for the first snapshot period to be included in the report, and then click **Select**.

    You are returned to the Run Compare Periods Report page.

8. Under Second Period, repeat Step 3 through Step 7.

9. Click **Generate Report**.

    The Report Results section appears on the Run Compare Periods Report page. The section contains the Workload Repository Compare Period Report.

10. Optionally, do the following:

    - To change periods, repeat Step 3 through Step 9.

- To save the report as an HTML file, click **Save to File**.

Using the AWR Compare Periods Reports

After an AWR Compare Periods report is generated for the time periods you want to compare, you can use it to analyze performance degradation. To learn how to create the report, see "Running the AWR Compare Periods Reports".

Figure 9-1 shows a portion of an AWR Compare Periods report.

Figure 9-1   AWR Compare Periods Report

The AWR Compare Periods report is divided into the following sections:

- Summary of the AWR Compare Periods Report
- Details of the AWR Compare Periods Report
- Supplemental Information in the AWR Compare Periods Report

Summary of the AWR Compare Periods Report

The report summary is at the beginning of the AWR Compare Periods report, and summarizes information about the snapshot sets and loads used in the report. The report summary contains the following sections:

- Snapshot Sets
- Host Configuration Comparison
- Cache Sizes
- Load Profile
- Top Timed Events

Snapshot Sets

The Snapshot Sets section displays information about the snapshot sets used for this report, such as instance, host, and snapshot information.

In the example shown in Figure 9-1, the first snapshot period corresponds to the time when performance was stable on February 7 from 10:50 to 11:20. The second snapshot period corresponds to the time when performance degradation occurred on the same day from 12:50 to 13:00.

Host Configuration Comparison

The Host Configuration Comparison section compares the host configurations used in the two snapshot sets. For example, the report compares physical memory and number of CPUs. Differences in the configurations are quantified as percentages in the %Diff column.

Cache Sizes

The Cache Sizes section compares the database configurations used in the two snapshot sets. For example, the report compares the SGA and log buffer size. Differences in the configurations are quantified as percentages in the %Diff column.

Load Profile

The Load Profile section compares the loads used in the two snapshot sets. Differences in the loads are quantified as percentages in the %Diff column.

Load Profile

	1st per sec	2nd per sec	%Diff	1st per txn	2nd per txn	%Diff
DB time:	1.1	0.0	-100.0	18.5	0.1	-99.7
CPU time:	1.0	0.0	-100.0	16.6	0.1	-99.7
Redo size:	3,990.2	3,740.6	-6.3	67,475.6	173,212.3	156.7
Logical reads:	12,987.5	34.7	-99.7	219,620.6	1,606.2	-99.3
Block changes:	37.7	10.9	-71.1	637.2	504.5	-20.8
Physical reads:	1,370.0	0.1	-100.0	23,166.5	6.5	-100.0
Physical writes:	7.2	1.1	-84.4	122.3	52.4	-57.2
User calls:	5.9	0.5	-91.8	99.4	22.2	-77.7
Parses:	2.2	0.7	-70.1	37.9	30.9	-18.4
Hard parses:	0.0	0.0	0.0	0.0	0.1	166.7
W/A MB processed:	1,703,507.8	120,606.6	-92.9	28,806,651.2	5,584,817.2	-92.9
Logons:	1.1	0.0	-97.3	18.8	1.3	-93.0
Executes:	23.7	3.2	-86.4	401.0	149.3	-62.8
Transactions:	0.1	0.0	-66.7			

	1st	2nd	Diff
% Blocks changed per Read:	0.3	31.4	31.1
Recursive Call %:	96.8	97.7	1.0
Rollback per transaction %:	0.0	0.0	0.0
Rows per Sort:	9,435.6	15.9	-9,419.7
Avg DB time per Call (sec):	0.2	0.0	-0.2

In this example, the DB time per second was 100% higher in the first period. CPU time per second was 100% higher.

Top Timed Events

The Top Timed Events section is one of the most useful sections in the report. This section displays the five timed events or operations that consumed the highest percentage of total DB time in each of the snapshot sets.

Top Timed Events

- Events with a "-" did not make the Top list in this set of snapshots, but are displayed for comparison purposes

	1st					2nd				
Event	Wait Class	Waits	Time(s)	Avg Time(ms)	%DB time	Event	Wait Class	Waits	Time(s)	Avg Time(ms)	%DB time
CPU time			1,772.85		89.54	oracle thread bootstrap	Other	15	2.07	137.74	250.26
resmgr:cpu quantum	Scheduler	14,105	108.51	7.69	5.48	CPU time			0.68		82.37
db file sequential read	User I/O	2,470,197	65.48	0.03	3.31	db file sequential read	User I/O	103	0.64	6.25	77.93
db file async I/O submit	System I/O	831	10.10	12.15	0.51	LGWR slave barrier	Other	231	0.31	1.32	36.97
oracle thread bootstrap	Other	51	6.64	130.28	0.34	log file parallel write	System I/O	97	0.27	2.80	32.96
-LGWR slave barrier	Other	1,518	4.20	2.77	0.21	-db file async I/O submit	System I/O	445	0.09	0.19	10.32
-log file parallel write	System I/O	659	3.20	4.86	0.16	-					

In this example, CPU time and the number of waits for database file sequential reads are significantly higher in the first period than in the second.

Details of the AWR Compare Periods Report

The Report Details section follows the summary of the AWR Compare Periods report, and provides statistics about the snapshot sets and loads used in the report. For example, the section includes statistics for time model statistics, wait events, SQL execution time, and instance activity.

Supplemental Information in the AWR Compare Periods Report

The supplemental information is at the end of the AWR Compare Periods report, and provides additional information about initialization parameters and SQL statements. The init.ora Parameters section lists all the initialization parameter values for the first snapshot set. The Complete List of SQL Text section lists each statement by SQL ID and shows the text of the SQL statement.

10

Using Automatic Workload Repository Warehouse for Generating Performance Reports

The Enterprise Manager AWR Warehouse enables you to consolidate and store detailed performance data from the Automatic Workload Repository of your important Oracle databases. This consolidated AWR Warehouse allows DBAs and developers to view and analyze historical performance data beyond the AWR retention period of the source database. Enterprise Manager extracts Automatic Workload Repository (AWR) data from one or more source database targets and transfers it into the AWR Warehouse, which is maintained independent of the source databases. The AWR Warehouse lets you keep a long-term history of AWR data, forever, if so configured, from the selected Enterprise Manager database targets. This enables long-term analysis of AWR data across databases without performance or storage impact on the source database targets.

Therefore, by uploading AWR data to a centralized AWR Warehouse, you free up space and improve performance on your production systems.

Starting in version 19c, AWR supports pluggable databases (PDB) as source databases that upload their AWR data to the warehouse. Also PDBs can be the AWR warehouse repository. This feature requires Oracle Database 12.2 and higher as the source or repository.

To configure an AWR warehouse, an Enterprise Manager administrator needs to designate an existing Enterprise Manager database target as the AWR Warehouse.

The warehouse target database must be version 12.1.0.2 or higher or version 11.2.0.4 with the appropriate patch. It also must be an equal or higher database version of the source databases it accommodates.

The warehouse is built in the `SYS` schema, using the `SYSAUX` tablespace by default. Starting Database 19c, it is possible to specify another tablespace to store the AWR data collected from all the source databases. This tablespace must exist on the Warehouse database.

To use the feature, you first need to set up an Oracle database that Enterprise Manager can use as the AWR Warehouse. After you set up the warehouse database, you can identify source databases whose repositories you want to extract and upload to the warehouse.

In Oracle Enterprise Manager 13c Platform Release 4 Update 2 (13.4.0.2). Active Data Guard (ADG) supports the switch over when the warehouse database or source database is configured with ADG and the primary database goes down and the standby database becomes the primary. After the switchover, the databases are automatically switched in the AWR warehouse.

Setting Up the AWR Warehouse

Ensure that these prerequisites are satisfied before designating a database as the AWR Warehouse:

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Setting Up the AWR Warehouse

- The target database must be an existing version 12.1.0.2 or higher or 11.2.0.4 with the appropriate patch level managed target in Enterprise Manager Cloud Control. Oracle recommends that the selected database not be used by any other application and that the Enterprise Manager Cloud Control repository not be used as the warehouse.

- There is sufficient space available to accommodate the data to be uploaded, as a factor of per source database per day. Rule of thumb is a range of 4-10MB per database per day.

- You must have Super Administrator privileges to configure the AWR Warehouse.

1. From the **Targets** drop-down menu, select **Databases**.

   The Databases page appears with a list of the available target databases.

2. Access the **Database Home** page for the target database.

   See "Accessing the Database Home Page" for more information.

3. On the **Databases** page, click **Performance** drop-down, then select **AWR Warehouse**.

   If it has not previously been configured, a workflow diagram appears with a**Configure** button in the right-hand pane. If it has been configured, the tool icon takes you to the configuration page.

   Prior to warehouse setup, the page displays a feature workflow on the left and configuration access on the right.

> **Note:**
>
> When adding a new AWR source database, you can specify dump locations for extract. The location should be a valid directory inside the source database host (or a shared location in case of a cluster) and accessible by the host credential specified. By default, the field is empty and means the dump file location is the default agent directory.

After setup, the right side of the page summarizes the warehouse configuration and graphically depicts space used as a percentage of space available.
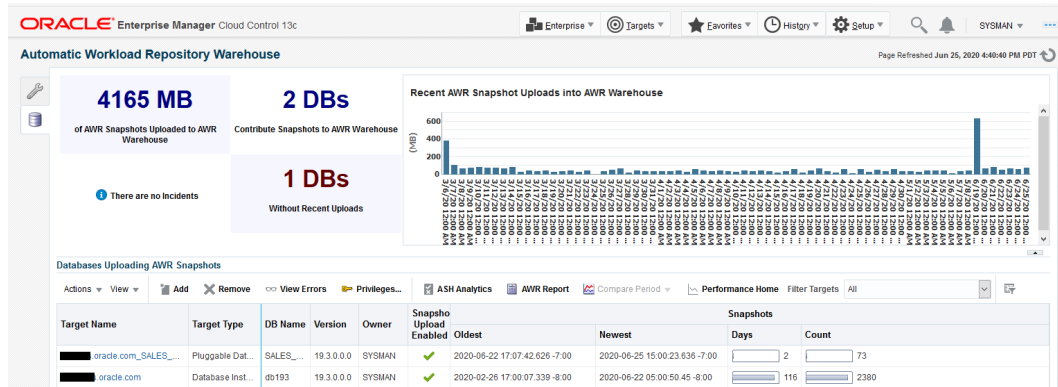
4. Click **Configure** in the pane to the right of the workflow diagram. The first configuration page (Repository) appears.

5. Click the search icon to select the database to serve as the AWR Warehouse.

6. Select the preferred or named credentials established for the target database. You can also provide new credentials.

   You can specify a password compliant with password policy for staging schema during warehouse configuration. If none specified, a complex random password is used by default.

7. Select the preferred or named credentials established for the target database host. You can also provide new credentials.

8. Click **Next**. The second configuration page (AWR Snapshot Management) appears.

9. Set the retention period to a number of years. Optionally, you can choose to retain the data indefinitely.

10. Set the snapshot upload interval. The default is 24 hours The minimum interval is one hour. You can also upload snapshots on-demand.

11. Select where on the warehouse database host to save exported dump files. For a single instance database, the location defaults to the agent state directory. For a cluster database, you have to specify a location that is accessible to all nodes.

12. Click **Submit**. This submits a job with the prefix `CAW_LOAD_SETUP_`.

After initial setup, the AWR Warehouse page becomes a dashboard where you can perform the following tasks:

• Add and remove source databases.

• Enable and disable snapshot uploads.

• Upload snapshots on-demand.

• Give administrators access to AWR data stored in the warehouse.

• Monitor and research incidents and errors.

• Run performance reports and analytics on the warehouse the same as you would on local AWRs.

• Edit Warehouse properties after the configuration is done with the **Edit** button. Properties that can be changed are:

1. Database Credential

2. Host Credential

3. Retention period

4. Upload Interval

5. Staging Schema Password

> **Note:**
>
> Modifying Warehouse properties affects all the sources and overrides source level custom properties, if any.

- Edit the properties of a source database.

  1. Host Credential

  2. Database Credential

  3. Upload Interval

  4. Retention period

> **Note:**
>
> If you modify **Host Credential**, **Database Credential**, or **Upload Interval**, a `Reconfigure Job` is triggered and re-schedules the extract and transfer jobs with the new values.

- Specify dump locations for extract when adding a new AWR source database.

> **Note:**
>
> The location should be a valid directory inside the source database host (shared location in case of a cluster) and accessible by the host credential specified. By default, the field is empty and uses the default agent directory.

Working with Source Databases

Use the **AWR Warehouse** dashboard to manage the source databases that comprise the AWR warehouse, including the following activities:

- Add and remove source databases.

- Enable and disable snapshot uploads.

- Upload snapshots on-demand

- Grant view access to centrally stored AWR data.

Adding and Removing Source Databases

A source database whose AWR data you want to upload to the warehouse must be the same or earlier (to 10.2.0.4) as the version of the warehouse database. You can add and remove source databases provided you have access to the database target and to database credentials with execute privileges on the `sys.dbms_swrf_internal` package and the DBA role.

Click the **Add** button on the toolbar and select the source to add to the AWR Warehouse. The source can be a database or an **Autonomous Data Warehouse (ADW)**.

- If the provided user does not have the DBA role, the message appears **User does not have DBA privileges.**

- The **Required privileges** link is displayed under the **Override DBA role** check box in the **Add Source** dialog box accessed from the AWR Warehouse dashboard. On clicking the **Required privileges** link, you can view the database privileges that the database user must have to add a source database to the AWR Warehouse.

- To skip checking for the DBA role to allow a non-DBA database user to add a source database to AWR Warehouse, click on the checkbox for **Override DBA role**. When selected, the action happens without errors. However, the user has to ensure that the DB user provided has all required privileges in place of the DBA role. The **Required privileges** link is replaced with a **Missing privileges** link. On clicking the **Missing privileges** link, you can view the database privileges that the non-DBA database user must be granted to add a source database.

If you are adding an ADW to the AWR Warehouse, the following are additional items required.

- An OCI credential, which is created in the Enterprise Manager.

- OCI storage URL.

- Bucket Name

To remove a source from the AWR Warehouse, select a source database or ADW on the dashboard and click the **Remove** button. When you remove a database, its data remains for a time until a job runs to clear the data. If you want to retain the data, disable the snapshot upload instead of removing the database.

Enabling and Disabling Snapshot Uploads

When you add a source database, its snapshot upload is enabled by default. You must be the owner or a proxy to disable (and re-enable) a source database's snapshot upload. When you disable an upload, any in-process job is allowed to complete prior to the cessation of an upload. When re-enabled, the upload resumes with the next scheduled upload.

Uploading Snapshots On-Demand

You can also upload a snapshot on-demand. Select a source database on the dashboard and then select **Upload Snapshots Now** from the **Actions** menu.

Granting View Access to AWR Snapshots

The source database owner can grant other Enterprise Manager Administrators view access to AWR snapshots stored in the AWR Warehouse.

1. Select a source database in the dashboard table and click the **Privileges** button in the toolbar.

2. In the dialog that opens, move administrator names from the Available list to the Selected list.

3. Click **OK** to grant view access to the selected names.

Uploading Snapshots to the AWR Warehouse

Upload of AWR snapshot data from source databases occurs as an ETL process, which is a series of jobs that perform ETL—Extract, Transfer, Load—processing.

Extract AWR Data

As part of the collection process, a DBMS job runs at regular intervals to collect AWR snapshots and create dumps in a staging area on the target host. Initially, this job collects existing AWR data and subsequently collects the latest snapshot in incremental fashion. If there is too much data to collect initially, the job staggers the collection process to avoid placing a burden on the source database.

Transfer AWR Data

An Enterprise Manager job runs at regular intervals on the respective host to transfer the source database AWR data to a staging area on the warehouse host for further processing. This job copies the dump files using an agent-to-agent file transfer mechanism. Upon successful upload to the warehouse, the dump file is removed from the host staging area.

Loading Transferred Data into the AWR Warehouse

A DBMS job runs at regular intervals to process multiple source database dump files and import them into the warehouse schema. This occurs incrementally to ensure snapshots were not already imported. As part of the import process, the job maps DB IDs to ensure uniqueness. This information is maintained in a separate table to handle duplicate DB IDs and to support multitenant scenarios; for example, multiple customers' data stored in a single AWR database, where there might be duplicate database names. AWR data remains in the warehouse up to the configurable retention period, after which it is purged.

> **✎ Note:**
>
> You can also upload snapshots on-demand. Select a source database on the dashboard and then select **Upload Snapshots Now** from the **Actions** menu.

Using Performance Pages with the AWR Warehouse

You can view historical data, charts, and reports from a configured AWR Warehouse, by switching the **View Data** mode to **AWR Warehouse** on the respective performance pages for a source database.

Performance Home Page

Use the **Performance Home** page with the **AWR Warehouse** as follows:

1. If you are already in the **AWR Warehouse**, skip to 5.

2. From the **Targets** drop-down menu, select **Databases**.

3. Select a database on the Enterprise Manager dashboard.

4. From the **Performance** drop-down menu, select **AWR** and then **AWR Warehouse**.

5. From **AWR Warehouse** dashboard, highlight a database.

6. Click the **Performance Home** button on the AWR toolbar.

   The **Performance Home** page displays in **Historical - AWR Warehouse** mode.

> **Note:**
>
> You do not have to log in to the source database to view this page.
>
> The AWR Warehouse selection is available only for databases that have been added as source databases and only to users who have been granted access.

> **See Also:**
>
> "Monitoring User Activity" for more information about the Performance Home page.

ASH Analytics Page

Use the **ASH Analytics** page with the AWR Warehouse as follows:

1. If you are already in the **AWR Warehouse**, skip to 5.

2. From the **Targets** drop-down menu, select **Databases**.

3. Select a database on the Enterprise Manager dashboard.

4. From the **Performance** drop-down menu, select **AWR** and then **AWR Warehouse**.

5. From **AWR Warehouse** dashboard, highlight a database.

6. Click the **ASH Analytics** button on the toolbar.

   The **ASH Analytics** page displays in **Historical - AWR Warehouse** mode.

> **Note:**
>
> You do not have to log in to the source database to view this page.

> **See Also:**
>
> "Determining the Cause of Spikes in Database Activity" for more information about ASH Analytics.

AWR Report Page

Use the AWR Report page with the AWR Warehouse as follows:

1. If you are already in the **AWR Warehouse**, skip to 5.
2. From the **Targets** drop-down menu, select **Databases**.
3. Select a database on the Enterprise Manager dashboard.
4. From the **Performance** drop-down menu, select **AWR** and then **AWR Warehouse**.
5. From **AWR Warehouse** dashboard, highlight a database.
6. Click the **AWR Report** button on the toolbar.

   The AWR Report page displays in Historical - AWR Warehouse mode. Note that you do not have to log in to the source database to view this page.
7. Click **Generate Report**.

> **See Also:**
>
> " Resolving Performance Degradation Over Time " for more information about AWR Report.

Compare Period ADDM Page

Use the **Compare Period ADDM** page with the AWR Warehouse as follows:

1. If you are already in the **AWR Warehouse**, skip to 5.
2. From the **Targets** drop-down menu, select **Databases**.
3. Select a database on the Enterprise Manager dashboard.
4. From the **Performance** drop-down menu, select **AWR** and then **AWR Warehouse**.
5. From **AWR Warehouse** dashboard, highlight a database.
6. Select **Compare Period ADDM** from the **Compare Period** drop-down menu.

   The Compare Period ADDM page displays in Historical - AWR Warehouse mode. Note that you do not have to log in to the source database to view this page.
7. Complete Steps 1 and 2. Note that database selection in Step 2 lists all databases with AWR data in the warehouse to which you have access.
8. Click Run to run the comparison.

> **See Also:**
>
> "Comparing Current System Performance to a Baseline Period" for more information about Compare Period ADDM.

Compare Periods Report

Use the **Compare Periods Report** page with the AWR Warehouse as follows:

1. If you are already in the **AWR Warehouse**, skip to 5.

2. From the **Targets** drop-down menu, select **Databases**.

3. Select a database on the Enterprise Manager dashboard.

4. From the **Performance** drop-down menu, select **AWR** and then **AWR Warehouse**.

5. From **AWR Warehouse** dashboard, highlight a database.

6. Select **Compare Periods Report** from the **Compare Period** drop-down menu.

   The **Compare Periods Report** page displays in **Historical - AWR Warehouse** mode. Note that you do not have to log in to the source database to view this page.

7. Complete First and Second Periods.

> **Note:**
>
> The selections for the two periods are derived from data in the warehouse. For the second period, you can select any database in the warehouse to which you have access.

8. Click **Generate Report**.

> **See Also:**
>
> "Running the AWR Compare Periods Reports" for more information about Compare Periods Report.

AWR Warehouse Best Practices

Oracle makes best practices recommendations from both a warehouse database perspective and an Enterprise Manager perspective.

Database Best Practices

Best practices from the warehouse database perspective involve the following areas:

- Memory Management

- • Storage Requirements
- • Backup
- • Redo Log Size
- • Stats Collection
- • The job_queue_processes Parameter
- • Access Control

Memory Management

Oracle recommends that you use Automatic Memory Management on the warehouse database to manage and tune it as required. To do this, set the target memory size initialization parameter (MEMORY_TARGET) and optionally a maximum memory size initialization parameter (MEMORY_MAX_TARGET). The amount of target memory depends on the number of users of the warehouse. Set it to at least 2GB and modify it as needed depending on the load and other requirements.

When using manual memory management, set the sizes of SGA and instance PGA to sufficiently high enough values, minimally, 2GB. And if using manual shared memory management, set the sizes of individual SGA components, especially buffer cache size and shared pool size, to sufficiently high enough values.

Storage Requirements

By default, Oracle Database captures snapshots once every hour; the snapshot size varies depending on the database load. A typical system with an average of 10 concurrent active sessions may take anywhere from 1MB to 2MB per snapshot. Thus, the one hour default snapshot interval requires approximately 24MB to 48MB a day.

AWR data is stored in SYSAUX tablespace. The tablespace space required depends on the number of source databases. Using default settings with a typical load on source databases requires approximately 24MB to 48MB a day per source database.

To get a more accurate read on space requirements, run the `awrinfo.sql` script located in the `ORACLE_HOME/rdbms/admin` directory. In particular, see the "Size estimates for AWR snapshots" section, which contains "AWR size/day" and "AWR size/wk" values. On source databases, these values represent the average size of AWR data being generated on that database. On the AWR Warehouse database, these values represent the average size of AWR data imported from all the source databases. Use these values to estimate the warehouse space requirements. Naturally, as more source databases are added to the warehouse, the space required to store their AWR data increases.

Use Automatic Storage Management (ASM) with redundant disk groups and "Average Synchronous Single-Block Read Latency" of less than 40 milliseconds. The DBA_HIST_SYSMETRIC_SUMMARY view contains this and other metrics related to storage and I/O.

Additionally, ensure that there is enough free disk space (approximately 50GB) on the warehouse host to store the dump files containing incoming AWR data from source databases until the data can be loaded into the warehouse database.

Backup

Oracle recommends that you back up the AWR Warehouse on a regular basis as a safeguard against any data loss. Using Data Guard along with RMAN ensures high availability and data protection.

Redo Log Size

It is important to size the redo logs correctly. A small redo results in frequent log switches affecting database performance. The amount of redo generated in AWR Warehouse varies based on the number of source databases moving their AWR data into the warehouse. Oracle recommends a minimum of 1GB redo log sizing.

Stats Collection

Gather statistics periodically, once a day at a minimum, for SYS and DBSNMP schemas to ensure that the stats are accurate.

The job_queue_processes Parameter

Set JOB_QUEUE_PROCESSES to a value greater than 0. Oracle scheduler jobs are responsible for importing AWR data. Setting the parameter ensures that job slaves are created to run the scheduler jobs.

Access Control

Ensure that users do not have direct access to the warehouse database as this will bypass the Enterprise Manager security model. The AWR Warehouse console in Enterprise Manager has an access control mechanism to control who can view data in the AWR Warehouse and for which source databases.

Enterprise Manager Best Practices

Best practices from the Enterprise Manager perspective involve the following areas:

- AWR Warehouse Credentials
- Source Database Credentials
- Staging Location on AWR Warehouse
- Network Latency

AWR Warehouse Credentials

When configuring an Enterprise Manager target as the AWR Warehouse Repository, select two credentials:

- Database credentials–AWR Warehouse requires SYSDBA credentials.
- Database host credentials–select credentials that have write permission on the dump file staging location. The default staging location is the agent state directory to which the agent user has the necessary permissions.

Source Database Credentials

Before adding source database targets to the AWR Warehouse Repository, set Preferred Credentials (Normal Credentials should be sufficient) for each of the source databases and their hosts. This facilitates adding multiple source databases at once (select multiple databases in the Search and Select: Database dialog).

- Database credentials–the database user requires the following:

    - DBA role

    - Execute privileges on `SYS.DBMS_SWRF_INTERNAL` package

- Database host credentials–the user should be the same as the agent user.

Staging Location on AWR Warehouse

AWR data from source databases moves as dump files to a staging location on the warehouse database host. You can configure the staging location when setting up the AWR Warehouse. For a single instance database, the location defaults to the agent state directory. For a cluster database, you have to specify a location that is accessible to all nodes.

Network Latency

AWR Warehouse uses the Agent-to-Agent file transfer method to move dump files from source databases to the warehouse database host. The connection between the source agent host and the warehouse agent host should have low network latency to avoid delays and problems during the transfer.

Monitoring and Researching Incidents and Errors

With the constant movement of data, problems can occur at various stages of the upload process. The dashboard reports on incidents and errors so that you can trace and resolve issues. Consistent with Enterprise Manager best practices, you can use the existing frameworks to manage incidents, configure notifications, and so forth.

The graphical region of the dashboard provides an at-a-glance view of issues encountered overall during warehouse upload activity. When an incident is raised, a **View Incidents** link appears; click it to link directly to Incident Manager where you can drill down to research the details. The Guided Resolution section provides links to view any warehouse errors reported and to return to the AWR Warehouse dashboard.

You can proactively identify the points of failure after the AWR warehouse is configured and the ETL process started running between the source database and warehouse, by running a number of tests on the AWR warehouse or a select set of sources and determine the health of the AWR warehouse configuration.

To view errors related to a specific database source, select the database row in the dashboard and click **View Errors** on the toolbar.

Errors typically break down by activity—AWR Warehouse load, source database extract, transfer. Some of the more common errors and suggested resolutions are described below.

AWR Warehouse Load Errors

When SYSAUX tablespace on the AWR Warehouse is insufficient to accommodate the import of AWR snapshots, the import fails with the following errors:

```
ORA-20115: Data Pump import encountered error:
ORA-31626: job does not exist
ORA-31633: unable to create master table "SYS.SYS_IMPORT_FULL_27"
ORA-06512: at "SYS.DBMS_SYS_ERROR", line 95
ORA-06512: at "SYS.KUPV$FT", line 1048
ORA-01658: unable to create INITIAL extent for segment in tablespace SYSAUX
ORA-31626: job does not exist
```

Increase the SYSAUX tablespace to resolve the issue.

Load jobs use Data Pump to import AWR snapshot dumps. Data Pump jobs use a master table to track a job's progress. If an error occurs during import, the master table remains. As errors accumulate so too do master tables, eventually resulting in the following errors:

```
ORA-20115: Data Pump import encountered error:
ORA-31634: job already exists
ORA-31664: unable to construct unique job name when defaulted
ORA-31634: job already exists
```

The solution is to drop the master tables from the previous failed jobs. Query the `dba_datapump_jobs` view for jobs in the NOT RUNNING state, as follows:

```
SELECT job_name
FROM dba_datapump_jobs
WHERE owner_name='SYS'
 AND operation='IMPORT'
 AND job_mode='FULL'
 AND job_name like 'SYS_IMPORT_%'
 AND state='NOT RUNNING';
```

> ⚠️ **Caution:**
>
> There may be cases where a job name the query returns is in use by an active Data Pump job. Ensure that there are no active Data Pump jobs to avoid mistakenly deleting their master tables.

The patch that enables the AWR Warehouse feature includes a fix for the legacy master tables, so you should not encounter this problem after applying the patch.

When an active Data Pump job exits ungracefully (it aborts or the database shuts down, for example), subsequent jobs fail with the following errors:

```
ORA-39097: Data Pump job encountered unexpected error -56935
ORA-39065: unexpected master process exception in DISPATCH
ORA-56935: existing datapump jobs are using a different version of time zone
data file
```

To resolve the issue, check database properties for certain values on database startup and take appropriate action, as follows:

```
SELECT property_name, property_value
FROM sys.database_properties
WHERE property_name in ('DST_UPGRADE_STATE', 'DST_SECONDARY_TT_VERSION');
```

If the query returns `'DATAPUMP'` and `'<> 0'`, respectively, for the named properties, run the following:

```
exec dbms_dst.unload_secondary();
```

> **✎ Note:**
>
> This Data Pump error can also happen during source database extraction.

When the source database time zone is ahead of the AWR Warehouse time zone, the following error occurs when importing the latest snapshot dumps:

```
ORA-20105: Unable to move AWR data to SYS
ORA-06512: at "SYS.DBMS_SWRF_INTERNAL", line 4773
ORA-13555: Message 13555 not found;  product=RDBMS; facility=ORA;
arguments: [end_time is greater than SYSDATE]
```

No action is necessary. The issue self-corrects when the SYSDATE of the AWR Warehouse advances past the date of the dump file.

Source Database Extract Errors

When SYSAUX tablespace on the source database is insufficient to accommodate the extract of AWR snapshots, the extract fails with the following errors:

```
ORA-20115: Data Pump export encountered error:
ORA-31626: job does not exist
ORA-31633: unable to create master table "SYS.SYS_EXPORT_TABLE_08"
ORA-06512: at "SYS.DBMS_SYS_ERROR", line 95
ORA-06512: at "SYS.KUPV$FT", line 1048
ORA-01658: unable to create INITIAL extent for segment in tablespace SYSAUX
ORA-06512: at "SYS.DBMS_SWRF_INTERNAL", line 2159
ORA-31626: job does not exist
```

Increase the SYSAUX tablespace to resolve the issue.

Extract jobs use Data Pump to export AWR snapshot dumps. Data Pump jobs use a master table to track a job's progress. If an error occurs during export, the master table remains. As errors accumulate so too do master tables, eventually resulting in the following errors:

```
ORA-20115: Data Pump import encountered error:
ORA-31634: job already exists
ORA-31664: unable to construct unique job name when defaulted
ORA-31634: job already exists
```

The solution is to drop the master tables from the previous failed jobs. Query the dba_datapump_jobs view for jobs in the NOT RUNNING state, as follows:

```
SELECT job_name
FROM dba_datapump_jobs
WHERE owner_name='SYS'
 AND operation='EXPORT'
 AND job_mode='TABLE'
```

```
AND job_name like 'SYS_EXPORT_%'
AND state='NOT RUNNING';
```

> ⚠ **Caution:**
>
> There may be cases where a job name the query returns is in use by an active Data Pump job. Ensure that there are no active Data Pump jobs to avoid mistakenly deleting their master tables.

The patch that enables the AWR Warehouse feature includes a fix for the legacy master tables, so you should not encounter this problem after applying the patch.

See also the Data Pump error under AWR Warehouse Load errors for another potential error during source database extraction.

Transfer Errors

If many dump files from a single source database are waiting to be loaded into the AWR Warehouse and their total size exceeds a threshold value (1 GB), the following error results:

```
The total size of dump files from the source database exceeds threshold value
(size: xxx MB, threshold: xxx MB)
```

There appears to be an underlying problem loading dump files into the AWR Warehouse, resulting in a backlog of dump files. Check for and resolve any outstanding load errors to enable importing to resume.

If the total size of dump files from all source databases waiting to be loaded into the AWR Warehouse exceeds a threshold value (30 GB), the following error results:

```
The total size of dump files on AWR Warehouse exceeds threshold value (size: xxx
MB, threshold: xxx MB)
```

Determine why there is a backlog of pending dump files in the load queue. Resolving the backlog issue will enable the load to resume.

Using Autonomous Database Warehouse in Automatic Workload Repository

Autonomous Data Warehouse (ADW) is supported in AWR Warehouse. The ADW must be discovered as an Enterprise Manager (EM) target. In addition to other AWR information, the user needs to provide for ADW:

- A Named OCI Credential to access Object Store. This is created in EM.
- Object Store base URI.
- Bucket Name.

When the warehouse is ADW, these features are disabled in the AWR dashboard in EM:

- `Edit Warehouse`
- `Restore Warehouse` if the warehouse is on error state

If the EM does not detect when ADG switch-over has occurred for a database, you can manually restore the source database to the new ADG primary.

Part IV
SQL Tuning

Part IV describes how to effectively tune SQL statements and contains the following chapters:

- Identifying High-Load SQL Statements
- Tuning SQL Statements
- Optimizing Data Access Paths

11
Identifying High-Load SQL Statements

High-load SQL statements may consume a disproportionate amount of system resources. These SQL statements often greatly affect database performance and must be tuned to optimize their performance and resource consumption. Even when a database is properly tuned, inefficient SQL can significantly degrade performance.

Identifying high-load SQL statements is an important SQL tuning activity that must be performed regularly. Automatic Database Diagnostic Monitor (ADDM) automates this task by proactively identifying potential high-load SQL statements. Additionally, you can use Oracle Enterprise Manager Cloud Control (Cloud Control) to identify high-load SQL statements that require further investigation. After you have identified the high-load SQL statements, you can tune them with SQL Tuning Advisor and SQL Access Advisor.

This chapter describes how to identify high-load SQL statements and contains the following sections:

- Identification of High-Load SQL Statements Using ADDM Findings
- Identifying High-Load SQL Statements Using Top SQL

Identification of High-Load SQL Statements Using ADDM Findings

By default, ADDM runs proactively once every hour. It analyzes key statistics gathered by the Automatic Workload Repository (AWR) over the last hour to identify any performance problems, including high-load SQL statements. When the system finds performance problems, it displays them as ADDM findings in the Automatic Database Diagnostic Monitor (ADDM) page.

ADDM provides recommendations with each ADDM finding. When a high-load SQL statement is identified, ADDM gives recommendations, such as running SQL Tuning Advisor on the SQL statement. You can begin tuning SQL statements as described in Tuning SQL Statements .

> ✎ **See Also:**
>
> - "Overview of Automatic Database Diagnostic Monitor"
> - "Interpretation of Automatic Database Diagnostic Monitor Findings"
> - "Implementing Automatic Database Diagnostic Monitor Recommendations"

Identifying High-Load SQL Statements Using Top SQL

ADDM automatically identifies high-load SQL statements that may be causing system-wide performance degradation. Under normal circumstances, manual identification of high-load

SQL statements is not necessary. In some cases, however, you may want to monitor SQL statements at a more granular level.

The Top SQL section of the Top Activity page in Cloud Control enables you to identify high-load SQL statements for any 5-minute interval.

Figure 11-1 shows an example of the Top Activity page. The page shows a 1-hour time line of the top activity running on the database. SQL statements that are using the highest percentage of database activity are listed under the Top SQL section, and are displayed in 5-minute intervals.

Figure 11-1   Top Activity Page
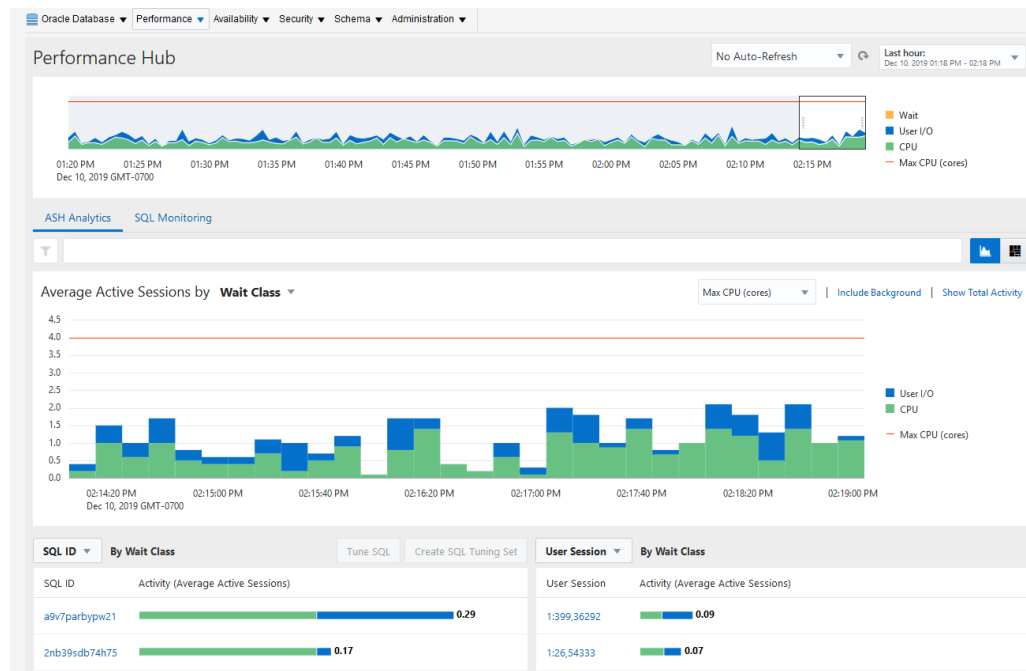
To access the SQL Monitoring:

1. From the **Targets** drop-down menu, select **Databases**.

    See "Accessing the Database Home Page" for more information.

2. From the **Performance** drop-down menu, select **Performance Hub** and **ASH Analytics**.

3. Using the drop-down menu on the right of **Average Active Sessions by**, select **SQL** and one of its fly-out options.

    •   **SQL ID**

    •   **Top Level SQL ID**

    •   **SQL Force Matching Signature**

    •   **SQL Plan Hash Value**

    •   **SQL Full Plan Hash Value**

    •   **SQL Plan Operation**

- **SQL Plan Operation Line**
- **SQL Opcode**
- **Top Level SQL Opcode**

4. To move the 5-minute interval, drag the shaded box to the desired time.

   The information contained in the Top SQL section is automatically updated to reflect the selected time period.

12
Tuning SQL Statements

A SQL statement specifies the data you want Oracle Database to retrieve. For example, a SQL statement can retrieve the names of employees in a department. When Oracle Database executes the SQL statement, the **query optimizer** (also called the **optimizer**) first determines the best and most efficient way to retrieve the results.

The optimizer determines whether it is more efficient to read all data in the table, called a full table scan, or use an index. It compares the cost of all possible approaches and chooses the approach with the least cost. The access method for physically executing a SQL statement is called an **execution plan**, which the optimizer is responsible for generating. The determination of an execution plan is an important step in the processing of any SQL statement, and can greatly affect execution time.

The query optimizer can also help you tune SQL statements. By using SQL Tuning Advisor and SQL Access Advisor, you can run the query optimizer in advisory mode to examine a SQL statement or set of statements and determine how to improve their efficiency. SQL Tuning Advisor and SQL Access Advisor can make various recommendations, such as the following:

- Creating SQL profiles
- Restructuring SQL statements
- Creating additional indexes or materialized views
- Refreshing optimizer statistics

Additionally, Oracle Enterprise Manager Cloud Control (Cloud Control) enables you to accept and implement many of these recommendations easily.

SQL Access Advisor is primarily responsible for making schema modification recommendations, such as adding or dropping indexes and materialized views. SQL Tuning Advisor makes other types of recommendations, such as creating SQL profiles and restructuring SQL statements. If significant performance improvements can be gained by creating a new index, then SQL Tuning Advisor may recommend it. However, such recommendations should be verified by running SQL Access Advisor using a SQL workload that contains a set of representative SQL statements.

This chapter describes how to tune SQL statements using SQL Tuning Advisor and contains the following sections:

> ✎ **See Also:**
>
> - "Identifying High-Load SQL Statements "
> - " Optimizing Data Access Paths " for information about SQL Access Advisor

Tuning SQL Statements Using SQL Tuning Advisor

You can use SQL Tuning Advisor to tune one or more SQL statements. When tuning multiple statements, SQL Tuning Advisor does not recognize interdependencies between the SQL statements. Instead, SQL Tuning Advisor provides a convenient way to obtain tuning advice for a large number of SQL statements.

Oracle Database can generate SQL tuning reports automatically. Automatic SQL Tuning runs during system **maintenance windows** as an automated maintenance task, searching for ways to improve the execution plans of high-load SQL statements. A maintenance window is a contiguous time interval during which automated maintenance tasks are run.

Tuning SQL Manually Using SQL Tuning Advisor

As described in Identifying High-Load SQL Statements , Automatic Database Diagnostic Monitor (ADDM) automatically identifies high-load SQL statements. If ADDM identifies such statements, then click **Schedule/Run SQL Tuning Advisor** on the Recommendation Detail page to run SQL Tuning Advisor.

To tune SQL statements manually using SQL Tuning Advisor:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Advisors Home**

   If the Database Login page appears, then log in as a user with administrator privileges. The Advisor Central page appears.

3. In the Advisors section, click **SQL Advisors**. The SQL Advisors page appears.

4. In the SQL Tuning Advisor section, click **SQL Tuning Advisor**.

   The Schedule SQL Tuning Advisor page appears.

5. In the **Name** field, enter a name for the SQL tuning task.

   If unspecified, then SQL Tuning Advisor uses a system-generated name.

6. Do one of the following:

   • To run a SQL tuning task for one or more high-load SQL statements, under Overview click **Top Activity**.

     The Top Activity page appears.

     Under Top SQL, select the SQL statement that you want to tune.

     In the Actions list, select **Schedule SQL Tuning Advisor** and click **Go**.

   > ✎ **See Also:**
   >
   > "Identifying High-Load SQL Statements Using Top SQL" to learn how to identify high-load SQL statements using the Top Activity page

   • To run a SQL tuning task for historical SQL statements from the Automatic Workload Repository (AWR), under Overview click **Historical SQL (AWR)**.

     The Historical SQL (AWR) page appears.

     Under Historical SQL (AWR), click the band below the chart, and select the 24-hour interval for which you want to view SQL statements that ran on the database. Under Detail for Selected 24 Hour Interval, select the SQL statement you want to tune, and click **Schedule SQL Tuning Advisor**.

   • To run a SQL tuning task for a SQL tuning set, under Overview click **SQL Tuning Sets**.

     The SQL Tuning Sets page appears.

     Select the SQL tuning set that contains the SQL statements you want to tune and then click **Schedule SQL Tuning Advisor**.

> ✏ **See Also:**
>
> "Creating a SQL Tuning Set" to learn how to create SQL tuning sets

The Schedule SQL Tuning Advisor page reappears.

7. To display the SQL text of the selected statement, expand **SQL Statements**.

8. Under Scope, select the scope of tuning to perform. Do one of the following:

   • Select **Limited**.

     A limited scope takes approximately 1 second to tune each SQL statement but does not recommend a SQL profile.

   • Select **Comprehensive**, and then set a time limit (in minutes) for each SQL statement in the **Time Limit per Statement** field, and a total time limit (in minutes) in the **Total Time Limit** field. Note that setting the time limit too small may affect the quality of the recommendations.

     Comprehensive mode may take several minutes to tune a single SQL statement. This mode is both time and resource intensive because each query must be hard-parsed. You should only use comprehensive scope for high-load SQL statements that have a significant impact on the entire system.

> ✏ **See Also:**
>
> "Managing SQL Profiles" to learn more about SQL profiles

9. Under Schedule, do one of the following:

   • Select **Immediately** and then click **Submit** to run the SQL tuning task immediately.

     The Processing: SQL Tuning Advisor Task page appears.

   • Select **Later** to schedule a specific time in the future, and then click **OK**.

10. From the Performance menu, select **Advisors Home**.

    The Advisor Central page appears.

    Under Advisor Tasks, the Results sections lists the result of advisors.

11. Select a SQL Tuning Advisor type result from the table and then click **View Result**.

The Recommendations for SQL ID page appears.

If you used a SQL tuning set, then multiple recommendations may be shown. To help you decide whether to implement a recommendation, an estimated benefit of implementing the recommendation is displayed in the Benefit (%) column. The Rationale column displays an explanation of why the recommendation is made.

12. To implement the recommendation, do one of the following:

- If an automated solution is recommended, then click **Implement**.

  A confirmation page appears. Click **Yes** to confirm the change.

- If a manual solution is recommended, then consider implementing the recommendation.

Viewing Automatic SQL Tuning Results

By analyzing data in the Automatic Workload Repository (AWR), the database can identify routine maintenance tasks. The automated maintenance tasks infrastructure (known as **AutoTask**) schedules these tasks to run in maintenance windows.

Maintenance windows are Oracle Scheduler time intervals that belong to the window group named `MAINTENANCE_WINDOW_GROUP`. By default, one window is scheduled for each day of the week. You can customize attributes of these maintenance windows, including start and end times, frequency, and days of the week.

By default, AutoTask runs the following automated maintenance tasks in all maintenance windows:

- Optimizer Statistics Collection
- Segment Advisor
- SQL Tuning Advisor

You can view the results of automated execution of SQL Tuning Advisor on observed high-load SQL statements.

To view automatic SQL tuning results:

1. Access the Database Home page.

See "Accessing the Database Home Page" for more information.

2. From the **Performance** page, select **Advisors Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Advisor Central page appears.

3. Under Advisors, click **SQL Advisors**.

   The SQL Advisors page appears.

4. Under SQL Tuning Advisor, click **Automatic SQL Tuning Results**.

   The Automatic SQL Tuning Result Summary page appears.

   The top half of the page includes sections for the status and activity summary of the SQL Tuning task.

5. In the Time Period list, select **All** and then click **Go**.

   The Overall Task Statistics and Profile Effect Statistics sections are refreshed.
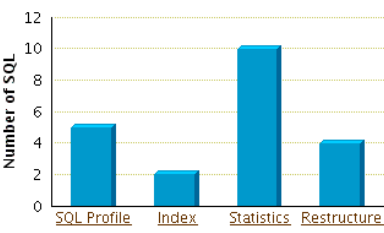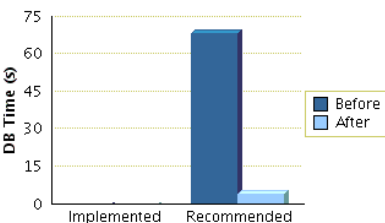
6. Optionally, in the Task Status section, click **Configure** to change the attributes of the Automatic SQL Tuning task.

The Automated Maintenance Tasks Configuration page appears.

In this page, you can enable or disable the Automatic SQL Tuning task and specify which days it should run. Click **Apply** or **Revert** to return to the previous page.

7. In the Task Activity Summary section, leave **All** selected for the **Time Period** and then click **View Report**.

The Automatic SQL Tuning Result Details page appears.

The page lists SQL statements that have been automatically selected by the database as candidates for SQL tuning.

8. Under Recommendations, select a SQL statement and then click **View Recommendations**.

The Recommendations for SQL ID page appears.

This page can include recommendations for SQL profiles and indexes.

> ✎ **See Also:**
>
> "Tuning SQL Manually Using SQL Tuning Advisor" to learn how to implement recommendations made by SQL Tuning Advisor

Managing SQL Tuning Sets

A **SQL tuning set** is a database object that includes one or more SQL statements and their execution statistics and context. You can use the set as an input for advisors such as SQL Tuning Advisor, SQL Access Advisor, and SQL Performance Analyzer. You can load SQL statements into a SQL tuning set from different SQL sources, such as AWR, the cursor cache, or high-load SQL statements that you identify.

A SQL tuning set includes the following:

- A set of SQL statements
- Associated execution context such as:
  - User schema
  - Application module name and action
  - List of bind values
  - Cursor compilation environment
- Associated basic execution statistics such as:
  - Elapsed time and CPU time
  - Buffer gets
  - Disk reads
  - Rows processed
  - Cursor fetches
  - Number of executions and number of complete executions
  - Optimizer cost
  - Command type
- Associated execution plans and row source statistics for each SQL statement (optional)

SQL statements can be filtered using the application module name and action, or any of the execution statistics. In addition, SQL statements can be ranked based on any combination of execution statistics.

SQL tuning sets are transportable, enabling SQL workloads to be transferred between databases for remote performance diagnostics and tuning. When high-load SQL statements are identified on a production system, it may not be desirable to perform investigation and tuning activities directly on this system. This feature enables you to transport the high-load SQL statements to a test system, where they can be safely analyzed and tuned.

> **See Also:**
>
> *Oracle Database SQL Tuning Guide* for more information about transporting SQL tuning sets between databases

Using Cloud Control, you can manage SQL tuning sets by doing the following:

- Creating a SQL Tuning Set
- Dropping a SQL Tuning Set
- Transporting SQL Tuning Sets

Creating a SQL Tuning Set

This section describes how to create a SQL tuning set with Cloud Control.

To create a SQL tuning set:

1. Specify the initial options for the SQL tuning set, as described in "Creating a SQL Tuning Set: Options".
2. Select the load method to use for collecting and loading SQL statements into the SQL tuning set, as described in "Creating a SQL Tuning Set: Load Methods".
3. Specify the filter options for the SQL tuning set, as described in "Creating a SQL Tuning Set: Filter Options".
4. Schedule and submit a job to collect the SQL statements and load them into the SQL tuning set, as described in "Creating a SQL Tuning Set: Schedule".

Creating a SQL Tuning Set: Options

The first step in creating a SQL tuning set is to specify options for the set such as name, owner, and description.

To specify options for creating a SQL tuning set:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.
2. From the **Performance** menu, select **SQL**, and then **SQL Tuning Sets**.

   If the Database Login page appears, then log in as a user with administrator privileges. The SQL Tuning Sets page appears.
3. Click **Create**.

   The Create SQL Tuning Set: Options page appears.
4. Enter the following details:
   - In **SQL Tuning Set Name**, enter a name for the SQL tuning set.
   - In **Owner**, enter the owner of the SQL tuning set.
   - In **Description**, enter a description of the SQL tuning set.

5. Optionally, to create an empty SQL tuning set and add SQL statements to it at a later time, complete the following steps:

   a. Select **Create an empty SQL tuning set**.

   b. Click **Next**.

      The Create SQL Tuning Set: Review page appears.

   c. Review your SQL tuning set options and click **Submit**.

      The empty SQL tuning set is created. You can add SQL statements to it later.

6. Click **Next**.

   The Create SQL Tuning Set: Load Methods page appears.

7. Proceed to the next step, as described in "Creating a SQL Tuning Set: Load Methods".

Creating a SQL Tuning Set: Load Methods

After options are specified for the SQL tuning set, select the load method to use for collecting and loading SQL statements into the SQL tuning set, as described in the following sections:

- Loading Active SQL Statements Incrementally from the Cursor Cache
- Loading SQL Statements from the Cursor Cache
- Loading SQL Statements from AWR Snapshots
- Loading SQL Statements from AWR Baselines
- Loading SQL Statements from a User-Defined Workload

Loading Active SQL Statements Incrementally from the Cursor Cache

You can load active SQL statements from the cursor cache into the SQL tuning set incrementally over a specified period of time. This technique enables you to not only collect current and recent SQL statements stored in the SQL cache, but also SQL statements that run during a specified time period in the future.

To load active SQL statements incrementally from the cursor cache:

1. Access the Create SQL Tuning Set: Load Methods page, as explained in "Creating a SQL Tuning Set: Options".

2. Select **Incrementally capture active SQL statements over a period of time from the cursor cache**.

3. In the **Duration** field, specify how long to capture active SQL statements.

4. In the **Frequency** field, specify how often to capture active SQL statements during the specified duration.

5. Click **Next**.

   The Create SQL Tuning Set: Filter Options page appears.

6. Proceed to the next step, as described in "Creating a SQL Tuning Set: Filter Options".

Loading SQL Statements from the Cursor Cache

You can load SQL statements from the cursor cache into the SQL tuning set. However, because only current and recent SQL statements are in the SQL cache, collecting these statements only once may result in a SQL tuning set this is not representative of the entire database workload.

To load SQL statements from the cursor cache:

1. Access the Create SQL Tuning Set: Load Methods page, as explained in "Creating a SQL Tuning Set: Options".

2. Select **Load SQL statements one time only**.

3. From the Data Source list, select **Cursor Cache**.

4. Click **Next**.

   The Create SQL Tuning Set: Filter Options page is shown.

5. Proceed to the next step, as described in "Creating a SQL Tuning Set: Filter Options".

Loading SQL Statements from AWR Snapshots

You can load SQL statements captured in AWR snapshots. This is useful when you want to collect SQL statements for specific snapshot periods of interest that can be used for later comparison or tuning purposes.

To load SQL statements from AWR snapshots:

1. Access the Create SQL Tuning Set: Load Methods page, as explained in "Creating a SQL Tuning Set: Options".

2. Select **Load statements one time only**.

3. In the **Data Source** list, select **AWR Snapshots**.

4. In the **AWR Snapshots** field, select the snapshots to include. Do one of the following:

   • Select either **ALL** or a time period such as **Last 24 hours** and then go to Step 6.

     Only snapshots that are captured and stored in AWR in the specified time are included.

- Select **Customize** and then go to Step 5.

  Only snapshots that are captured and stored in AWR during a customized time period that you specify are included.

5. To select a customized time period of snapshots, complete the following steps:

   a. Select **Customize** and then click **Go**.

      The Select Time Period window opens.

   b. For the starting snapshot, select **Period Start Time** and then click the snapshot icon below the Active Session graph that corresponds to the desired start time.

   c. For the ending snapshot, select **Period End Time** and then click the snapshot icon below the Active Session graph that corresponds to the desired end time.

   d. Click **Select**.

   In this example, the snapshot taken on December 27, 2011 at 9:00 a.m. is selected as the start time, and the snapshot taken on December 27, 2011 at 11:00 a.m. is selected as the end time.
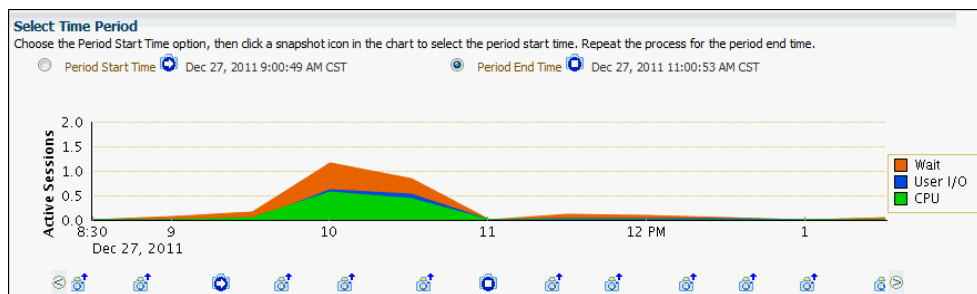
6. Click **Next**.

   The Create SQL Tuning Set: Filter Options page is shown.

7. Proceed to the next step, as described in "Creating a SQL Tuning Set: Filter Options".

Loading SQL Statements from AWR Baselines

You can load SQL statements captured in AWR baselines. This technique is useful when you want to collect SQL statements that are representative of a time period during known performance levels that can be used for later comparison or tuning purposes.

To load SQL statements from AWR baselines:

1. Access the Create SQL Tuning Set: Load Methods page, as explained in "Creating a SQL Tuning Set: Options".

2. Select **Load SQL statements one time only**.

3. In the **Data Source** field, select **AWR Baseline**.

4. In the **AWR Baseline** field, select the baseline to include.

5. Click **Next**.

    The Create SQL Tuning Set: Filter Options page is shown.

6. Proceed to the next step, as described in "Creating a SQL Tuning Set: Filter Options".

Loading SQL Statements from a User-Defined Workload

You can load SQL statements by importing from a table or view. This technique is useful if the workload you want to analyze is not currently running on the database or captured in an existing AWR snapshot or AWR baseline.

There are no restrictions on which schema the workload resides in, the name of the table, or the number of tables that you can define. The only requirement is that the format of the table must match format of the `USER_WORKLOAD` table.

To load SQL statements from a user-defined workload:

1. Access the Create SQL Tuning Set: Load Methods page, as explained in "Creating a SQL Tuning Set: Options".

2. Select **Load statements one time only**.

3. In the **Data Source** field, select **User-Defined Workload**.

4. In the **User-Defined Workload** field, select the table or view to include.

5. Click **Next**.

    The Create SQL Tuning Set: Filter Options page appears.

6. Proceed to the next step, as described in "Creating a SQL Tuning Set: Filter Options".

Creating a SQL Tuning Set: Filter Options

After the load method is selected, you can apply filters to reduce the scope of the SQL statements found in the SQL tuning set. While using filters is optional, it can be very beneficial due to the following:

•   Using filters directs the various advisors that use the SQL tuning set as a workload source, such as SQL Tuning Advisor, SQL Access Advisor, and SQL Performance Analyzer, to make recommendations based on a specific subset of SQL statements, which may lead to better recommendations.

•   Using filters removes extraneous SQL statements from the SQL tuning set, which may greatly reduce processing time when it is used as a workload source for the various advisors.

To specify filter options for a SQL tuning set:

1. Create a SQL tuning set and specify the initial options, as described in "Creating a SQL Tuning Set: Options".

2. Select the load method, as described in "Creating a SQL Tuning Set: Load Methods".

3. On the Create SQL Tuning Set: Filter Options page, specify the values of filter conditions that you want use in the search in the **Value** column, and an operator or a condition in the **Operator** column.

   Only the SQL statements that meet all of the specified filter conditions are added to the SQL tuning set. Unspecified filter values are not included as filter conditions in the search.

   By default, the following filter conditions are displayed:

   • Parsing Schema Name

   • SQL Text

   • SQL ID

   • Elapsed Time (sec)

4. To add filter conditions, under Filter Conditions, select the filter condition you want to add and click **Add a Filter or Column**.

   After the desired filter conditions have been added, specify their values in the **Value** column, and an operator or a condition in the **Operator** column.

5. To remove any unused filter conditions, click the icon in the **Remove** column for the corresponding filter condition you want to remove.

6. Click **Next**.

   The Create SQL Tuning Set: Schedule page appears.

7. Proceed to the next step, as described in "Creating a SQL Tuning Set: Schedule".

Creating a SQL Tuning Set: Schedule

After the filter options are specified for the SQL tuning set, you can schedule and submit a job to collect the SQL statements and load them into the SQL tuning set.

To schedule and submit a job to create a SQL tuning set:

1. Create a SQL Tuning Set and specify the initial options, as described in "Creating a SQL Tuning Set: Options".

2. Select the load method, as described in "Creating a SQL Tuning Set: Load Methods".

3. Specify the filter options, as described in "Creating a SQL Tuning Set: Filter Options".

4. On the Create SQL Tuning Set: Schedule page, under Job Parameters, enter a name in the **Job Name** field if you do not want to use the system-generated job name.

5. In the **Description** field, enter a description of the job.

6. Under Schedule, do one of the following:

- • **Immediately** to run the job immediately after it has been submitted
- • **Later** to run the job at a later time as specified using the Time Zone, Date, and Time fields

7. Click **Next**.

   The Create SQL Tuning Set: Review page appears.

8. Review the SQL Tuning Set options that you have selected.

   To view the SQL statements used by the job, expand **Show SQL**.

9. Click **Submit**.

   The SQL Tuning Sets page appears.

   If the job was scheduled to run immediately, then a message is displayed to inform you that the job and the SQL tuning set were created successfully. If the job was scheduled to run at a later time, a message is displayed to inform you that the job was created successfully.

10. To view details about the job, such as operation status, click **View Job Details**.

   The View Job page appears to display details about the job.

Dropping a SQL Tuning Set

This section describes how to drop a SQL tuning set. To conserve storage space, you may want to periodically drop unused SQL tuning sets stored in the database.

To drop a SQL tuning set:

1. Access the Database Home page.

    See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **SQL**, and then **SQL Tuning Sets**.

    If the Database Login page appears, then log in as a user with administrator privileges. The SQL Tuning Sets page appears.

3. Select the SQL tuning set you want to drop and then click **Drop**.

    The Confirmation page appears to verify that you want to drop the selected SQL tuning set.

4. Click **Yes**.

    The SQL Tuning Sets page appears.

    A confirmation message is displayed to indicate that the SQL tuning set was successfully dropped.

Transporting SQL Tuning Sets

You can transport SQL tuning sets from one system to another by first exporting a SQL tuning set from one database, and then importing it into another database.

This section contains the following topics:

*   Exporting a SQL Tuning Set
*   Importing a SQL Tuning Set

Exporting a SQL Tuning Set

This section describes how to export a SQL tuning set, enabling it to be transported to another system.

To export a SQL tuning set:

1. Access the Database Home page.

    See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **SQL**, then **SQL Tuning Sets**.

    If the Database Login page appears, then log in as a user with administrator privileges. The SQL Tuning Sets page appears.

3. Select the SQL tuning set that you want to export and then click **Export To A File**.

    The Export SQL Tuning Set page appears.

4. In the **Directory Object** field, select a directory in which to create the export file.

   For example, to use the Oracle Data Pump directory, select DATA_PUMP_DIR. The Directory Name field refreshes automatically to indicate the selected directory.

5. In the **Export File** field, enter a name for the file.

   Alternatively, you can accept the name generated by the database.

6. In the **Log File** field, enter a name for the log file for the export operation.

   Alternatively, you can accept the name generated by the database.

7. Select a tablespace to temporarily store the data for the export operation.

   By default, SYSAUX is used.

8. Under Job Parameters, in the **Job Name** field, enter a name for the job.

   Alternatively, you can accept the name generated by the database.

   Optionally, in the **Description** field, enter a description of the tuning set.

9. Under Schedule, do one of the following:

- Select **Immediately** to run the job immediately after it has been submitted.

- Select **Later** to run the job at a later time as specified by selecting or entering values in the **Time Zone**, **Date**, and **Time** fields.

10. Click **OK**.

The SQL Tuning Sets page appears.

A confirmation message indicates that the job was created successfully.

11. Transport the export file to another system using the mechanism of choice, such as Oracle Data Pump or a database link.

Importing a SQL Tuning Set

Before a SQL tuning set can be imported, you must first export a SQL tuning set from another system and transport it to your current system.

> ✎ **See Also:**
>
> "Exporting a SQL Tuning Set" for more information

To import a SQL tuning set:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **SQL**, then **SQL Tuning Sets**.

   If the Database Login page appears, then log in as a user with administrator privileges. The SQL Tuning Sets page appears.

3. Click **Import From A File**.

   The Import SQL Tuning Set page appears.

4. In **Directory Object**, select the directory containing the file to be imported.

   The directory should contain the export file that was transported to your current system. For example, if the file resides in the Data Pump directory, then select `DATA_PUMP_DIR`. The Directory Name field refreshes automatically to indicate the selected directory.

5. In the **Import File** field, enter the name of the dump file to import.

6. In the **Log File** field, enter a name for the log file for the import operation.

7. To replace an existing SQL tuning set with the one that you are importing, select **Replace the existing SQL tuning set if one exists**.

8. Select a tablespace to temporarily store the data for the import operation.

   By default, `SYSAUX` is used.

9. Under Job Parameters, in the **Job Name** field, enter a name for the job.

   Alternatively, you can accept the name generated by the system.

   Optionally, in the **Description** field, enter a description of the tuning set.

10. Under Schedule, do one of the following:

- Select **Immediately** to run the job immediately after it has been submitted.

- Select **Later** to run the job at a later time as specified by selecting or entering values in the **Time Zone**, **Date**, and **Time** fields.

11. Click **OK**.

    The SQL Tuning Sets page appears.

    A confirmation message appears that indicates that the job was successfully created. If the job is scheduled to run immediately, then the imported SQL tuning set is shown on this page. You may need to refresh to see the SQL tuning set.

Managing SQL Profiles

A **SQL profile** is a set of auxiliary information that is built during automatic tuning of a SQL statement. A SQL profile is to a SQL statement what statistics are to a table.

When running a SQL Tuning Advisor task with a limited scope, the optimizer makes estimates about cardinality, selectivity, and cost that are sometimes significantly off, resulting in poor execution plans. To address this problem, consider running a SQL Tuning Advisor task with a comprehensive scope to collect additional information using sampling and partial execution techniques into a SQL profile. The database can use the profile to verify and, if necessary, adjust optimizer estimates.

During SQL profiling, the optimizer uses the execution history of the SQL statement to create appropriate settings for optimizer parameters. After SQL profiling completes, the optimizer uses the information in the SQL profile and regular database statistics to generate execution plans. The additional information enables the database to produce well-tuned plans for corresponding SQL statements.

After running a SQL Tuning Advisor task with a comprehensive scope, a SQL profile may be recommended. If you accept the recommendation, then the database creates the SQL profile and enables it for the SQL statement.

In some cases, you may want to disable a SQL profile. For example, you may want to test the performance of a SQL statement without using a SQL profile to determine if the SQL profile is actually beneficial. If the SQL statement is performing poorly after the SQL profile is disabled, then you should enable it again to avoid performance degradation. If the SQL statement is performing optimally after you have disabled the SQL profile, then you may want to remove the SQL profile from your database.

To enable, disable, or delete a SQL profile:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Top Activity**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Top Activity page appears.

3. Under Top SQL, click the **SQL ID** link of the SQL statement that is using a SQL profile.

   The SQL Details page appears.

4. Click the **Plan Control** tab.

   A list of SQL profiles is displayed under SQL Profiles and Outlines.

5. Select the SQL profile you want to manage. Do one of the following:

- To enable a SQL profile that is disabled, click **Disable/Enable**.

- To disable a SQL profile that is enabled, click **Disable/Enable**.

- To remove a SQL profile, click **Delete**.

A confirmation page appears.

6. Click **Yes** to continue, or **No** to cancel the action.

> ✎ **See Also:**
>
> *Oracle Database SQL Tuning Guide* to learn how to manage SQL profiles using an API

Managing SQL Plan Baselines

SQL plan management is a preventative mechanism that enables the optimizer to automatically manage execution plans, ensuring that the database uses only known or verified plans. In this context, a plan includes all plan-related information that the optimizer needs to reproduce an execution plan.

SQL plan management uses SQL plan baselines. A **SQL plan baseline** is a set of accepted plans that the optimizer is allowed to use for a SQL statement. In the typical use case, a plan is accepted into the SQL plan baseline only after the database verifies that the plan performs well.

SQL plan management avoids SQL performance regression caused by plan changes. Events such as new optimizer statistics, changes to initialization parameters, database upgrades, and so on can cause changes to execution plans. These changes can cause SQL performance regressions that are difficult and time-consuming to fix manually. SQL plan baselines preserve performance of SQL statements, regardless of changes in the database. SQL plan management adapts to such changes by verifying and accepting only plan changes that improve performance.

Capturing a SQL plan automatically or loading a plan manually makes SQL plan management aware of the plan. Evolving a plan is the process by which the optimizer verifies new plans and adds them to an existing SQL plan baseline. This section contains the following topics:

- Capturing SQL Plan Baselines Automatically
- Loading SQL Plan Baselines Manually
- Evolving SQL Plans

> ✎ **See Also:**
>
> - *Oracle Database SQL Tuning Guide* for more information on SQL plan management and on controlling it with APIs

Capturing SQL Plan Baselines Automatically

You can specify that Oracle Database captures SQL plan baselines automatically.

To capture SQL plan baselines automatically:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. Select **Performance**, then **SQL**, and then **SQL Plan Control**.

   If the Database Login page appears, then log in as a user with administrator privileges. The SQL Profile subpage of the SQL Plan Control page appears.

3. Click **SQL Plan Baseline**.

   The SQL Plan Baseline subpage appears.
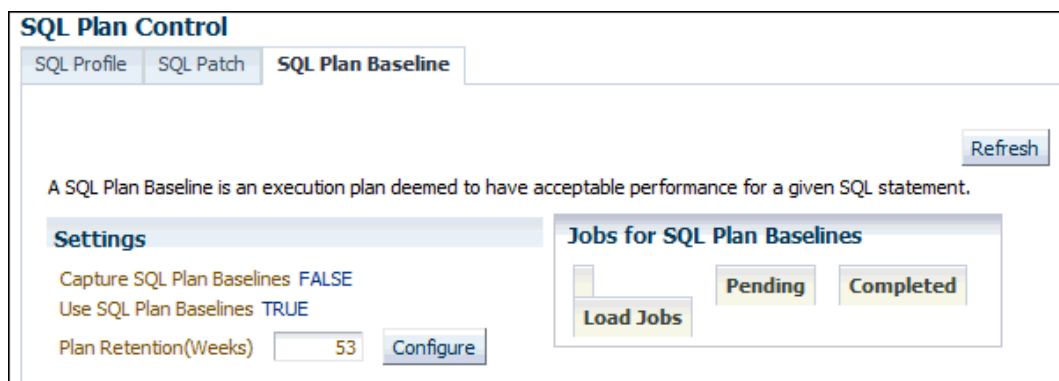
4. Under Settings, click the link next to **Capture SQL Plan Baselines**.

   The Initialization Parameters page appears.

5. In the **Value** column of the table, select **TRUE** and then click **OK**.

   You are returned to the SQL Plan Baseline subpage, which now shows **Capture SQL Baselines** set to `TRUE`.

   Because you configured baselines to be automatically captured, the database will create a SQL plan baseline for all SQL statements executed more than once and adds the current execution plan for the statement to the SQL plan baseline as the first accepted plan.

Loading SQL Plan Baselines Manually
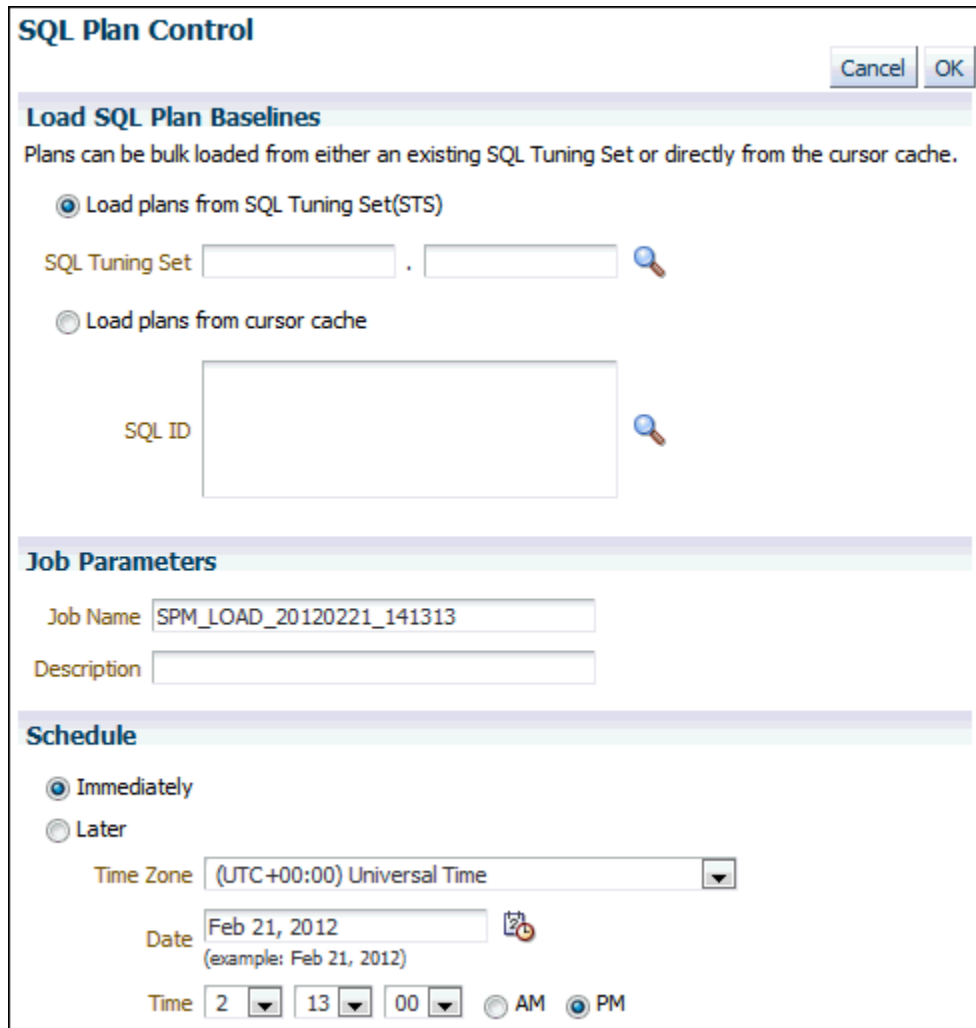
You can manually load existing plans into a SQL plan baseline. You can load plans from a SQL tuning set (STS) or you can load selected plans from the cursor cache.

To load SQL execution plans manually, the Capture SQL Baselines setting must be FALSE.

To manually load SQL execution plans:

1. Access the Database Home page.

2. Select **Performance**, then **SQL**, and then **SQL Plan Control**.

   The SQL Profile subpage of the SQL Plan Control page appears.

3. Click **SQL Plan Baseline**.

The SQL Plan Baseline subpage appears.

4. Click **Load**.

The SQL Plan Control page appears.

5. Select the SQL plan baselines to be loaded by completing the following steps:

a. Under Load SQL Plan Baselines, select **Load plans from SQL Tuning Set (STS)**.

In this example, load plans from the SQL tuning set that you created in "Creating a SQL Tuning Set".

b. In **Job Name**, enter a name for the job. For example, enter `SPM_LOAD_TEST`.

c. Under Schedule, select **Immediately**.

d. Click **OK**.

The SQL Plan Control page reappears.

The table displays a list of SQL plans that are stored as SQL plan baselines.

6. Optionally, fix the execution plan of a baseline to prevent the database from using an alternative SQL plan baseline. Complete the following steps:

   a. Select a SQL plan baseline that is not fixed.

   b. Select **Fixed - Yes** from the list preceding the baseline table.

   c. Click **Go**.

   The table is refreshed to show the SQL execution plan with the value `YES` in the Fixed column of the table.

> ✏ **See Also:**
>
> • Cloud Control context-sensitive online help to learn about the other options on the SQL Plan Baseline subpage

Evolving SQL Plans

A SQL plan baseline for a SQL statement usually starts with a single accepted plan. However, some SQL statements perform well when executed with different plans under different conditions. For example, a SQL statement with bind variables whose values result in different selectivities may have several good plans. Creating a materialized view or an index or repartitioning a table may make current plans more expensive than other plans.

If new plans were never added to SQL plan baselines, then the performance of some SQL statements might degrade. Thus, it is sometimes necessary to evolve newly found plans to see if they should be added to SQL plan baselines. Plan evolution prevents performance regressions by verifying the performance of a new plan before including it in a SQL plan baseline.

Plan evolution consists of the following distinct steps:

1. Verifying that unaccepted plans perform at least as well as accepted plans in a SQL plan baseline.

2. Adding unaccepted plans in the plan history to the plan baseline as accepted plans when they have been proven to perform as well as previously accepted plans.

You can evolve a plan manually or you can use the SQL Plan Management (SPM) Evolve Advisor.

By default, the SPM Evolve Advisor runs daily in the scheduled maintenance window. It ranks all unaccepted plans, and then performs test executions of as many plans as possible during the window. The evolve advisor selects the lowest-cost accepted plan in the SQL plan

baseline to compare against each unaccepted plan. If a plan performs sufficiently better than the existing accepted plan, then the database automatically accepts it.

> ✎ **See Also:**
>
> • *Oracle Database SQL Tuning Guide* for more information on configuring SPM Evolve Advisor and on running it manually by using APIs

To evolve plans manually:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. Select **Performance**, then **SQL**, and then **SQL Plan Control**.

   If the Database Login page appears, then log in as a user with administrator privileges. The SQL Profile subpage of the SQL Plan Control page appears.

3. Click **SQL Plan Baseline**.

   The SQL Plan Baseline subpage appears.

4. In the table, select one or more SQL plans that have No in the Accepted column and then click **Evolve**.

   The Evolve SQL Plan Baselines page appears.

5. Specify the options to perform.

   • For Verify Performance, select one of the following:

      – Select **Yes** to have the database verify that the plan performs as good as or better than the current baseline plan.

      – Select **No** to automatically evolve the plan regardless of how it performs.

   • For Time Limit, select one of the following:

      – **Auto** to have the database determine how long to spend verifying the performance of the unaccepted plan.

      – **Unlimited** to run the verification to completion regardless of how long it takes.

      – **Specify** to specify a time limit for the verification process. Enter a value in minutes in the associated field.

   • For Action, select one of the following:

      – **Report and Accept** to have the database accept the plan and create a report.

      – **Report Only** to have the database create a report but not accept the plan.

   Click **OK** to implement the options.

   A report appears. After viewing the report, click **Return** to return to the SQL Plan Baseline subpage.

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Optimizing Data Access Paths

To achieve optimal performance for data-intensive queries, materialized views and indexes are essential for SQL statements. However, implementing these objects does not come without cost. Creation and maintenance of these objects can be time-consuming. Space requirements can be significant. SQL Access Advisor enables you to optimize query access paths by recommending materialized views and view logs, indexes, SQL profiles, and partitions for a specific workload.

A **materialized view** provides access to table data by storing query results in a separate schema object. Unlike an ordinary view, which does not take up storage space or contain data, a materialized view contains the rows from a query of one or more base tables or views. A **materialized view log** is a schema object that records changes to a master table's data, so that a materialized view defined on the master table can be refreshed incrementally. SQL Access Advisor recommends how to optimize materialized views so that they can be rapidly refreshed and make use of the query rewrite feature.

SQL Access Advisor also recommends bitmap, function-based, and B-tree indexes. A **bitmap index** reduces response time for many types of ad hoc queries and can also reduce storage space compared to other indexes. A **function-based index** computes the value of a function or expression involving one or more columns and stores it in the index. **B-tree indexes** are commonly used to index unique or near-unique keys.

Using SQL Access Advisor involves the following tasks:

- Running SQL Access Advisor
- Reviewing the SQL Access Advisor Recommendations
- Implementing the SQL Access Advisor Recommendations

> ✎ **See Also:**
>
> - "Identifying High-Load SQL Statements "
> - "Tuning SQL Statements " for information about SQL Tuning Advisor
> - *Oracle Database Concepts* to learn about materialized views
> - *Oracle Database Concepts* to learn about indexes

Running SQL Access Advisor

This section describes how to run SQL Access Advisor to make recommendations for a SQL workload.

To run SQL Access Advisor:

1. Select the initial options, as described in "Selecting the Initial Options".

2. Select the workload source you want to use for the analysis, as described in "Selecting the Workload Source".

3. Define the filters options, as described in "Applying Filter Options".

4. Choose the types of recommendations, as described in "Specifying Recommendation Options".

5. Schedule the SQL Access Advisor task, as described in "Specifying Task and Scheduling Options".

Selecting the Initial Options

The first step in running SQL Access Advisor is to select the initial options on the SQL Access Advisor: Initial Options page.

To select initial options:

1. Access the Database Home page.

   See "Accessing the Database Home Page" for more information.

2. From the **Performance** menu, select **Advisors Home**.

   If the Database Login page appears, then log in as a user with administrator privileges. The Advisor Central page appears.

3. Click **SQL Advisors**.

   The SQL Advisors page appears.

4. Click **SQL Access Advisor**.

   The SQL Access Advisor: Initial Options page appears.

5. Do one of the following:

   • Select **Verify use of access structures (indexes, materialized views, partitioning, and so on) only** to verify existing structures.

   • Select **Recommend new access structures** to use the recommended options defined in the Oracle Enterprise Manager Cloud Control (Cloud Control) default template.

     If you select this option, then you can optionally complete the following steps:

     – Select **Inherit Options from a previously saved Task or Template** to use the options defined in an existing SQL Access Advisor task or another template.

     – In Tasks and Templates, select the task or template that you want to use.

   In this example, **Recommend new access structures** is selected.

6. Click **Continue**.

   The SQL Access Advisor: Workload Source page appears.

7. Proceed to the next step, as described in "Selecting the Workload Source".

Selecting the Workload Source

After initial options are specified for SQL Access Advisor, select the workload source that you want to use for the analysis, as described in the following sections:

- Using SQL Statements from the Cache
- Using an Existing SQL Tuning Set
- Using a Hypothetical Workload

Using SQL Statements from the Cache

You can use SQL statements from the cache as the workload source. However, only current and recent SQL statements are stored in the SQL cache, so this workload source may not be representative of the entire workload on your database.

To use SQL statements from the cache as the workload source:

1. Select the initial options, as described in "Selecting the Initial Options".

2. On the SQL Access Advisor: Workload Source page, select **Current and Recent SQL Activity**.

3. Proceed to the next step, as described in "Applying Filter Options".

Using an Existing SQL Tuning Set

You can use an existing SQL tuning set as the workload source. This option is useful because SQL tuning sets can be used repeatedly as the workload source for SQL Access Advisor and SQL Tuning Advisor.

To use a SQL tuning set as the workload source:

1. Select the initial options, as described in "Selecting the Initial Options".

2. On the SQL Access Advisor: Workload Source page, select **Use an existing SQL Tuning Set**.

3. Click the **SQL Tuning Set** search icon to use an existing SQL tuning set.

   The Search and Select: SQL Tuning Set dialog box appears.

4. In the **Schema** field, enter the name of the schema containing the SQL tuning set you want to use and then click **Go**.

   A list of SQL tuning sets contained in the selected schema appears.

5. Select the SQL tuning set to be used for the workload source and click **Select**.

   The Search and Select: SQL Tuning Set dialog box closes and the selected SQL Tuning Set now appears in the **SQL Tuning Set** field.

6. Proceed to the next step, as described in "Applying Filter Options".

> ✎ **See Also:**
>
> • "Managing SQL Tuning Sets"

Using a Hypothetical Workload

A **dimension table** stores all or part of the values for a logical dimension in a star or snowflake schema. You can create a hypothetical workload from dimension tables containing primary or foreign key constraints. This option is useful if the workload to be analyzed does not exist. In this case, SQL Access Advisor examines the current

logical schema design, and provides recommendations based on the defined relationships between tables.

To use a hypothetical workload as the workload source:

1. Select the initial options, as described in "Selecting the Initial Options".

2. On the SQL Access Advisor: Workload Source page, select **Create a Hypothetical Workload from the Following Schemas and Tables**.

3. Leave **Schemas and Tables** empty and then click **Add** to search for tables.

   The Workload Source: Search and Select Schemas and Tables page appears.

4. In the Tables section, enter a schema name in the **Schema** field and then click **Search**.

   A list of tables in the selected schema is displayed.

5. Select the tables to be used in creating the hypothetical workload and then click **Add Tables**.

   The selected tables now appear in the **Schemas and Tables** field.

6. Click **OK**.

   The SQL Access Advisor: Workload Source page appears with the selected tables now added.

7. Proceed to the next step, as described in "Applying Filter Options".

> **See Also:**
>
> • *Oracle Database Concepts* for an overview of materialized views

Applying Filter Options

After the workload source is selected, you can optionally apply filters to reduce the scope of the SQL statements found in the workload. Filters are beneficial for the following reasons:

• Using filters directs SQL Access Advisor to make recommendations based on a specific subset of SQL statements from the workload, which may lead to better recommendations.

• Using filters removes extraneous SQL statements from the workload, which may greatly reduce processing time.

To apply filters to the workload source:

1. Select initial options, as described in "Selecting the Initial Options".

2. Select the workload source, as described in "Selecting the Workload Source".

3. On the SQL Access Advisor: Workload Source page, click **Filter Options**.

   The Filter Options section expands.

4. Select **Filter Workload Based on these Options**.

   The Filter Options section is enabled.

5. Define the filters you want to apply, as described in the following sections:

- • Defining Filters for Resource Consumption
- • Defining Filters for Users
- • Defining Filters for Tables
- • Defining Filters for SQL Text
- • Defining Filters for Modules
- • Defining Filters for Actions

6. Click **Next**.

   The Recommendation Options page appears.

7. Proceed to the next step, as described in "Specifying Recommendation Options".

Defining Filters for Resource Consumption

The resource consumption filter restricts the workload to include only the number of high-load SQL statements that you specify.

To define a filter for resource consumption:

1. On the SQL Access Advisor: Workload Source page, under User Resource Consumption, enter the number of high-load SQL statements in the **Number of Statements** field.

2. From the Order by list, select one of the methods by which the SQL statements are to be ordered.

Defining Filters for Users

The users filter restricts the workload to include or exclude SQL statements executed by users that you specify.

To define a filter for users:

1. On the SQL Access Advisor: Workload Source page, under Users, select **Include only SQL statements executed by these users** or **Exclude all SQL statements executed by these users**.
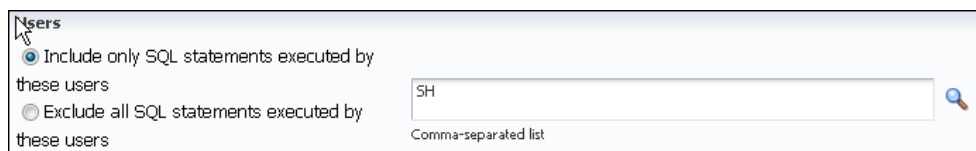
2. To search for available users, click the Users search icon.

   The Search and Select: Users dialog box appears.

3. Select the users whose SQL statements you want to include or exclude and then click **Select**.

   The Search and Select: Users dialog box closes and the selected tables now appear in the **Users** field.

   In this example, a filter is defined to include only SQL statements executed by the user SH.

Defining Filters for Tables

The tables filter restricts the workload to include or exclude SQL statements that access a list of tables that you specify. Table filters are not permitted if you selected the **Create a Hypothetical Workload from the Following Schemas and Tables** option, as described in "Using a Hypothetical Workload".

To define a filter for tables:

1. To include only SQL statements that access a specific list of tables, enter the table names in the **Include only SQL statements that access any of these tables** field.

2. To exclude all SQL statements that access a specific list of tables, enter the table names in the **Exclude all SQL statements that access any of these tables** field.

3. To search for available tables, click the Tables search icon.

   The Search and Select: Schema and Table dialog box appears.

4. Select the tables for which you want to include or exclude SQL statements and click **Select**.

   The Search and Select: Schema and Table dialog box closes and the selected tables now appear in the corresponding Tables field.

Defining Filters for SQL Text

The SQL text filter restricts the workload to include or exclude SQL statements that contains SQL text substrings that you specify.

To define a filter for SQL text:

1. To include only SQL statements that contains specific SQL text, enter the SQL text to be included in the **Include only SQL statements containing these SQL text substrings** field.

2. To exclude all SQL statements that contain specific SQL text, enter the SQL text to be excluded in the **Exclude all SQL statements containing these SQL text substrings** field.

Defining Filters for Modules

The module filter restricts the workload to include or exclude SQL statements that are associated with modules that you specify.

To define a filter for module ID:

1. Do one of the following:

   - To include only SQL statements associated with a specific module ID in the workload, select **Include only SQL statements associated with these modules**.

   - To exclude all SQL statements associated to a specific module ID from the workload, select **Exclude all SQL statements associated with these modules**.

2. In the Modules field, enter the names of the modules for which associated SQL statements are included or excluded.

Defining Filters for Actions

The actions filter restricts the workload to include or exclude SQL statements that are associated with actions that you specify.

To define a filter for actions:

1. Do one of the following:

   - To include only SQL statements associated with a specific action in the workload, select **Include only SQL statements associated with these actions**.

   - To exclude all SQL statements associated with a specific action from the workload, select **Exclude all SQL statements associated with these actions**.

2. In the Actions field, enter the actions for which associated SQL statements are included or excluded.

Specifying Recommendation Options

To improve the underlying data access methods chosen by the optimizer for the workload, SQL Access Advisor provides recommendations for indexes, materialized views, and partitioning. Using these access structures can significantly improve the performance of the workload by reducing the time required to read data from the database. However, you must balance the benefits of using these access structures against the cost to maintain them.

To specify recommendation options:

1. Select initial options, as described in "Selecting the Initial Options".

2. Select the workload source, as described in "Selecting the Workload Source".

3. Define the filter options, as described in "Applying Filter Options".

4. On the SQL Access Advisor: Recommendation Options page, under Access Structures to Recommend, select the type of access structures to be recommended by SQL Access Advisor:

   - Indexes

   - Materialized Views

   - Partitioning

   In this example, all of the preceding access types are selected.

5. Under Scope, select the mode in which SQL Access Advisor runs. Do one of the following:

- Select **Limited**.

    In limited mode, SQL Access Advisor focuses on SQL statements with the highest cost in the workload. The analysis is quicker, but the recommendations may be limited.

- Select **Comprehensive**.

    In comprehensive mode, SQL Access Advisor analyzes all SQL statements in the workload. The analysis can take much longer, but the recommendations are exhaustive.

    In this example, **Limited Mode** is selected.
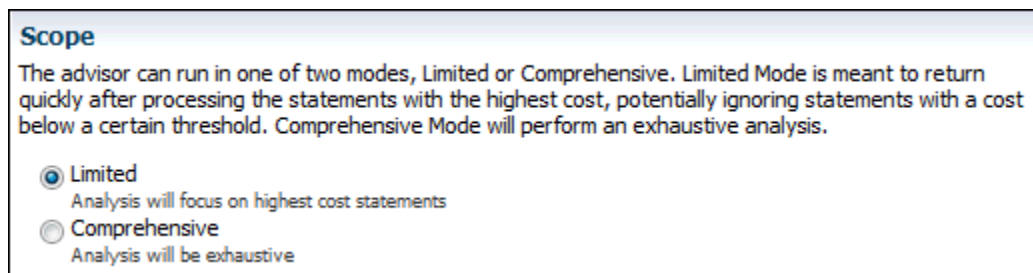
6. Optionally, click **Advanced Options**.

    The Advanced Options section expands. This section contains the following subsections:

    - Workload Categorization

        In this section, you can specify the type of workload for which you want a recommendation. The following categories are available:

        – Workload Volatility

            Select **Consider only queries** if the workload primarily contains read-only operations, as in data warehouses. Volatility data is useful for online transaction processing (OLTP) systems, where the performance of `INSERT`, `UPDATE`, and `DELETE` operations is critical.

        – Workload Scope

            Select **Recommend dropping unused access structures** if the workload represents all access structure use cases.

    - Space Restrictions

        Indexes and materialized views increase performance at the cost of space. Do one of the following:

        – Select **No, show me all recommendations (unlimited space)** to specify no space limits. When SQL Access Advisor is invoked with no space limits, it makes the best possible performance recommendations.

        – Select **Yes, limit additional space to** and then enter the space limit in megabytes, gigabytes, or terabytes. When SQL Access Advisor is invoked with a space limit, it produces only recommendations with space requirements that do not exceed the specified limit.

    - Tuning Prioritization

        This section enables you to specify how SQL statements are tuned. Complete the following steps:

- From the Prioritize tuning of SQL statements by list, select a method by which SQL statements are to be tuned and then click **Add**.

- Optionally, select **Consider access structures creation costs recommendations** to weigh the cost of creating access structures against the frequency and potential improvement of SQL statement execution time. Otherwise, creation cost is ignored. You should select this option if you want specific recommendations generated for SQL statements that are executed frequently.

- Default Storage Locations

  Use this section to override the defaults defined for schema and tablespace locations. By default, indexes are in the schema and tablespace of the table they reference. Materialized views are in the schema and tablespace of the first table referenced in the query. Materialized view logs are in the default tablespace of the schema of the table that they reference.

7. Click **Next**.

   The SQL Access Advisor: Schedule page appears.

8. Proceed to the next step, as described in "Specifying Task and Scheduling Options".

Specifying Task and Scheduling Options

Use the SQL Access Advisor Schedule page to set or modify the schedule parameters for the SQL Access Advisor task.

Figure 13-1   Scheduling a SQL Access Advisor Task

To schedule a SQL Access Advisor task:

1. Select initial options, as described in "Selecting the Initial Options".

2. Select the workload source, as described in "Selecting the Workload Source".

3. Define the filter options, as described in "Applying Filter Options".

4. Specify the recommendation options, as described in "Specifying Recommendation Options".

5. On the SQL Access Advisor: Schedule page, under Advisor Task Information, enter a name in the **Task Name** field if you do not want to use the system-generated task name.

    In the example in Figure 13-1, SQLACCESS8895797 is entered.

6. In the **Task Description** field, enter a description of the task.

In the example in Figure 13-1, `SQL Access Advisor` is entered.

7. From the Journaling Level list, select the level of journaling for the task.

   Journaling level controls the amount of information that is logged to the SQL Access Advisor journal during task execution. This information appears on the Details subpage when viewing task results.

   In the example in Figure 13-1, `Basic` is selected.

8. In the **Task Expiration (days)** field, enter the number of days to retain the task in the database before it is purged.

   In the example in Figure 13-1, `30` is entered.

9. In the **Total Time Limit (minutes)** field, enter the maximum number of minutes that the job is permitted to run.

   You must enter a time in this field rather than use the default.

10. Under Scheduling Options, in the Schedule Type list, select a schedule type for the task and a maintenance window in which the task should run. Do one of the following:

    • Click **Standard**.

      This schedule type enables you to select a repeating interval and start time for the task. Complete the following steps:

      – Enter your time zone code in the **Time Zone** field or click the search icon to locate the code for your area.

      – In the Repeat list, select **Do Not Repeat** to perform the task only once, or select a unit of time and enter the number of units in the **Interval** field.

      – Under Start, select **Immediately** to start the task now, or **Later** to schedule the task to start at a time specified using the **Date** and **Time** fields.

    • Click **Use Predefined Schedule**.

      This schedule type enables you to select an existing schedule. Do one of the following:

      – In the **Schedule** field, enter the name of the schedule to be used for the task.

      – To search for a schedule, click the search icon.

        The Search and Select: Schedule dialog box appears.

        Select the desired schedule and click **Select**. The selected schedule now appears in the **Schedule** field.

    • Click **Standard Using PL/SQL for Repeated Interval**.

      This schedule type enables you to select a repeating interval and an execution time period (window) for the task. Complete the following steps:

      – Enter your time zone code in the **Time Zone** field or click the search icon to locate the code for your area.

      – Under Available to Start, select **Immediately** to start the task now, or **Later** to schedule the task to start at a time specified using the **Date** and **Time** fields.

- – In the **Repeated Interval** field, enter a PL/SQL schedule expression, such as `SYSDATE+1`.

  – Under Not Available After, select **No End Date** to indicate that there is no end date for the execution window, or **Specified End Date** to specify an end date using the **Date** and **Time** fields.

- • Click **Use Predefined Window**.

  This schedule type enables you to select an existing window. Select **Stop on Window Close** to stop the job when the window closes. Do one of the following:

  – In the **Window** field, enter the name of the window to be used for the task.

  – To search for a window, click the search icon.

  The Search and Select: Window and Window Groups dialog box appears.

  Select the desired window and click **Select**. The selected window now appears in the **Schedule** field.

- • Click **Event**.

  Complete the following steps:

  – Enter your time zone code in the **Time Zone** field or click the search icon to locate the code for your area.

  – Under Event Parameters, enter values in the **Queue Name** and **Condition** fields.

  – Under Start, select **Immediately** to start the task now, or **Later** to schedule the task to start at a time specified using the **Date** and **Time** fields.

  – Under Not Available After, select **No End Date** to indicate that there is no end date for the execution window, or **Specified End Date** to specify an end date using the **Date** and **Time** fields.

- • Click **Calendar**.

  Complete the following steps:

  – Enter your time zone code in the **Time Zone** field or click the search icon to locate the code for your area.

  – Under Calendar Expression, enter a calendar expression.

  – Under Start, select **Immediately** to start the task now, or **Later** to schedule the task to start at a time specified using the **Date** and **Time** fields.

  – Under Not Available After, select **No End Date** to indicate that there is no end date for the execution window, or **Specified End Date** to specify an end date using the **Date** and **Time** fields.

  In the example in Figure 13-1, **Standard** is selected for schedule type. The task does not repeat and is scheduled to start immediately.

11. Click **Next**.

    The SQL Access Advisor: Review page appears.

Under Options is a list of modified options for the SQL Access Advisor task. To display both modified and unmodified options, click **Show All Options**. To view the SQL text for the task, click **Show SQL**.

12. Click **Submit**.

The Advisor Central page appears. A message informs you that the task was created successfully.

Reviewing the SQL Access Advisor Recommendations

SQL Access Advisor graphically displays the recommendations and provides links so that you can quickly see which SQL statements benefit from a recommendation. Each recommendation produced by the SQL Access Advisor is linked to the SQL statement it benefits.

To review the SQL Access Advisor recommendations:

1. Run SQL Access Advisor to make the recommendations, as described in "Running SQL Access Advisor".

2. Access the Database Home page.

See "Accessing the Database Home Page" for more information.

3. From the **Performance** menu, select **Advisors Home**.

If the Database Login page appears, then log in as a user with administrator privileges. The Advisor Central page appears.

4. Select the SQL Access Advisor task for review and click **View Result**.

If the task is not displayed, then you may need to refresh the screen. The Results for Task page appears.

5. Review the Summary subpage, which provides an overview of the SQL Access Advisor analysis, as described in "Reviewing the SQL Access Advisor Recommendations: Summary".

6. Review the Recommendations subpage, which enables you to view the recommendations ranked by cost improvement, as described in "Reviewing the SQL Access Advisor Recommendations: Recommendations".

7. Review the SQL statements analyzed in the workload, as described in "Reviewing the SQL Access Advisor Recommendations: SQL Statements".

8. Review the details of the workload, task options, and the SQL Access Advisor task, as described in "Reviewing the SQL Access Advisor Recommendations: Details".

Reviewing the SQL Access Advisor Recommendations: Summary

The Summary subpage displays an overview of the SQL Access Advisor analysis.

To review the recommendations summary:

1. Access the Results for Task page, as described in "Reviewing the SQL Access Advisor Recommendations".

2. Click **Summary**.

   The Summary subpage of the Results for Tasks page appears.

   In this example, **Limited Mode** is selected so that SQL Access Advisor analyzes the highest cost statements rather than all statements.

Results for Task: SQLACCESS8895797

Task Name	SQLACCESS8895797	Started	Feb 22, 2012 2:22:11 PM CST
Status	COMPLETED	Ended	Feb 22, 2012 2:22:36 PM CST
Advisor Mode	LIMITED	Running Time (seconds)	25
Scheduler Job	ADV_SQLACCESS8895797	Total Time Limit (minutes)	10000
Publish Point	1		

Summary | Recommendations | SQL Statements | Details

Overall Workload Performance

ⓘ **Potential for Improvement**

Workload I/O Cost

Query Execution Time Improvement

Original Cost (323818)
New Cost (298034)

No Performance Improvement
Potential Performance Improvement

Recommendations

Recommendations	4
Space Requirements (MB)	3.522
User Specified Space Adjustment	Unlimited

▷ Show Recommendation Action Counts

SQL Statements

SQL Statements	6

Statements remaining after filters were applied
▷ Show Statement Counts

3. Under Overall Workload Performance, assess the potential for improvement in implementing the recommendations.

4. Use the Workload I/O Cost chart to compare the original workload I/O cost with the new cost.

In this example, the workload I/O cost decreases from 107.1 million to 43.1 million by implementing the recommendations.

5. Use the Query Execution Time Improvement chart to compare the improvement in query execution time.

This chart shows the percentage of SQL statements in the workload whose execution time improves by accepting the recommendations. The SQL statements are grouped by the projected improvement factor along the horizontal axis on the chart (1x to >10x). The percentage of SQL statements that improve by the projected improvement factor are along the vertical axis (0% to 100%).

In this example, approximately 62 percent of SQL statements in the workload do not improve execution time, but about 25 percent have the potential for improvement of over 4x or more.

6. Under Recommendations, click **Show Recommendation Action Counts**.

In the following example, creating 2 indexes, 4 materialized views, and 4 materialized view logs is recommended.

7. Under SQL Statements, click **Show Statement Counts** to display the type of SQL statement.

   In the following example, 25 `SELECT` statements are analyzed.

Reviewing the SQL Access Advisor Recommendations: Recommendations

The Recommendations subpage ranks the SQL Access Advisor recommendations by cost improvement. You can also view details about each recommendation.

To review recommendation details:

1. Access the Results for Task page, as described in "Reviewing the SQL Access Advisor Recommendations".

2. Click **Recommendations**.

   The Recommendations subpage appears.

3. Use the Recommendations by Cost Improvement chart to view recommendations ordered by the cost improvement.

Under Select Recommendations for Implementation, each recommendation is listed with its implementation status, recommendation ID, cost improvement, space consumption, and the number of affected SQL statements for each recommendation. Implementing the top recommendation has the biggest benefit to the total performance of the workload.

4. To view details for a particular recommendation, select the recommendation and click **Recommendation Details**.

The Recommendation Details page appears. For space reasons, the following screenshot does not show the rightmost columns of the Actions table. The columns not shown are Tablespace and Estimated Space Used (MB).

Recommendation Details

SQL Access Advisor generates default object names and uses the default schemas and tablespaces specified during task creation, but you can change them. If you edit any name, dependent names, which are shown as readonly, will be updated accordingly. If the Tablespace field is left blank the default tablespace of the schema will be used. When you click OK, the SQL script is modified, but it is not actually executed until you select 'Schedule Implementation' on the Recommendations or SQL Statements pages.

Cancel   OK

Actions

Set Schema for All Actions [_____] 🔍 Go

Set Tablespace for All Actions [_____] 🔍 Go

Implementation Status	Recommendation IDs	Action	Object Name	Object Attributes	Indexed Columns	Base Table	Schema ▼
▣	3	ALTER_MATERIALIZED_VIEW_LOG				SH.SALES	SH
▣	3	ALTER_MATERIALIZED_VIEW_LOG				SH.PRODUCTS	SH
▣	1	CREATE_INDEX	SALES_IDX$$_01680000	BITMAP, LOCAL	QUANTITY_SOLD	SH.SALES	SH 🔍
▣	2	CREATE_INDEX	SALES_IDX$$_01680001	BITMAP, LOCAL	AMOUNT_SOLD	SH.SALES	SH 🔍
▣	3	CREATE_MATERIALIZED_VIEW	MV$$_01680000	General Match			DBA1 🔍
▣	3	GATHER_TABLE_STATISTICS	MV$$_01680000				DBA1

SQL Affected by Recommendations

Statement ID	Statement	Recommendation ID	Original Cost	New Cost	Cost Improvement ▼	Cost Improvement (%)	Execution Count
497	select * from sales where quantity_sold < 5 union select * from sales where quantity_sold > 500	1	307676	297784	9892	3.22	4
1479	select * from sales where amount_sold = 4	2	9964	204	9760	97.95	4
803	select sum(quantity_sold) from sales s, products p where s.prod_id = p.prod_id and s.amount_sold > 20000 and p.prod_name = 'Linen Big Shirt'	3	6144	12	6132	99.80	4

The Recommendation Details page displays all actions for the specified recommendation.

Under Actions, you can choose to specify the schema or the tablespace for all actions. For some actions you can modify the object name, tablespace, and schema. To view the SQL text of an action, click the link in the Action column for the specified action.

Under SQL Affected by Recommendation, the SQL text of the SQL statement and cost improvement information are displayed.

5. Click **OK**.

The Recommendations subpage appears.

6. To view the SQL text of a recommendation, select the recommendation and click **Show SQL**.

The Show SQL page for the selected recommendation appears.

```
Show SQL
                                                                    Done

Rem SQL Access Advisor: Version 12.1.0.0.2 - Production
Rem
Rem Username: DBA1
Rem Task: SQLACCESS8895797
Rem Execution date:
Rem

ALTER MATERIALIZED VIEW LOG FORCE ON
"SH"."SALES"
ADD ROWID, SEQUENCE("PROD_ID","QUANTITY_SOLD","AMOUNT_SOLD")
INCLUDING NEW VALUES;

ALTER MATERIALIZED VIEW LOG FORCE ON
"SH"."PRODUCTS"
ADD ROWID, SEQUENCE("PROD_ID","PROD_NAME")
INCLUDING NEW VALUES;

CREATE MATERIALIZED VIEW "DBA1"."MV$$_01680000"
REFRESH FAST WITH ROWID
ENABLE QUERY REWRITE
AS SELECT SH.PRODUCTS.PROD_NAME C1, SH.SALES.AMOUNT_SOLD C2,
SUM("SH"."SALES"."QUANTITY_SOLD")
M1, COUNT("SH"."SALES"."QUANTITY_SOLD") M2, COUNT(*) M3 FROM SH.SALES,
SH.PRODUCTS WHERE SH.SALES.PROD_ID = SH.PRODUCTS.PROD_ID AND (SH.SALES.AMOUNT_SOLD
> 20000) AND (SH.PRODUCTS.PROD_NAME = 'Linen Big Shirt') GROUP BY SH.PRODUCTS.PROD_NAME,
SH.SALES.AMOUNT_SOLD;

begin
dbms_stats.gather_table_stats('"DBA1"','"MV$$_01680000"',NULL,dbms_stats.auto_sample_size);
end;
/

CREATE BITMAP INDEX "SH"."SALES_IDX$$_01680000"
ON "SH"."SALES"
("QUANTITY_SOLD")
COMPUTE STATISTICS
LOCAL;
```

Reviewing the SQL Access Advisor Recommendations: SQL Statements

The SQL Statements subpage ranks SQL statements in the workload by cost improvement. You can use this page to view details about the SQL statements analyzed in the workload.

To review SQL statements:

1. Access the Results for Task page, as described in "Reviewing the SQL Access Advisor Recommendations".

2. Click **SQL Statements**.

    The SQL Statements subpage appears.
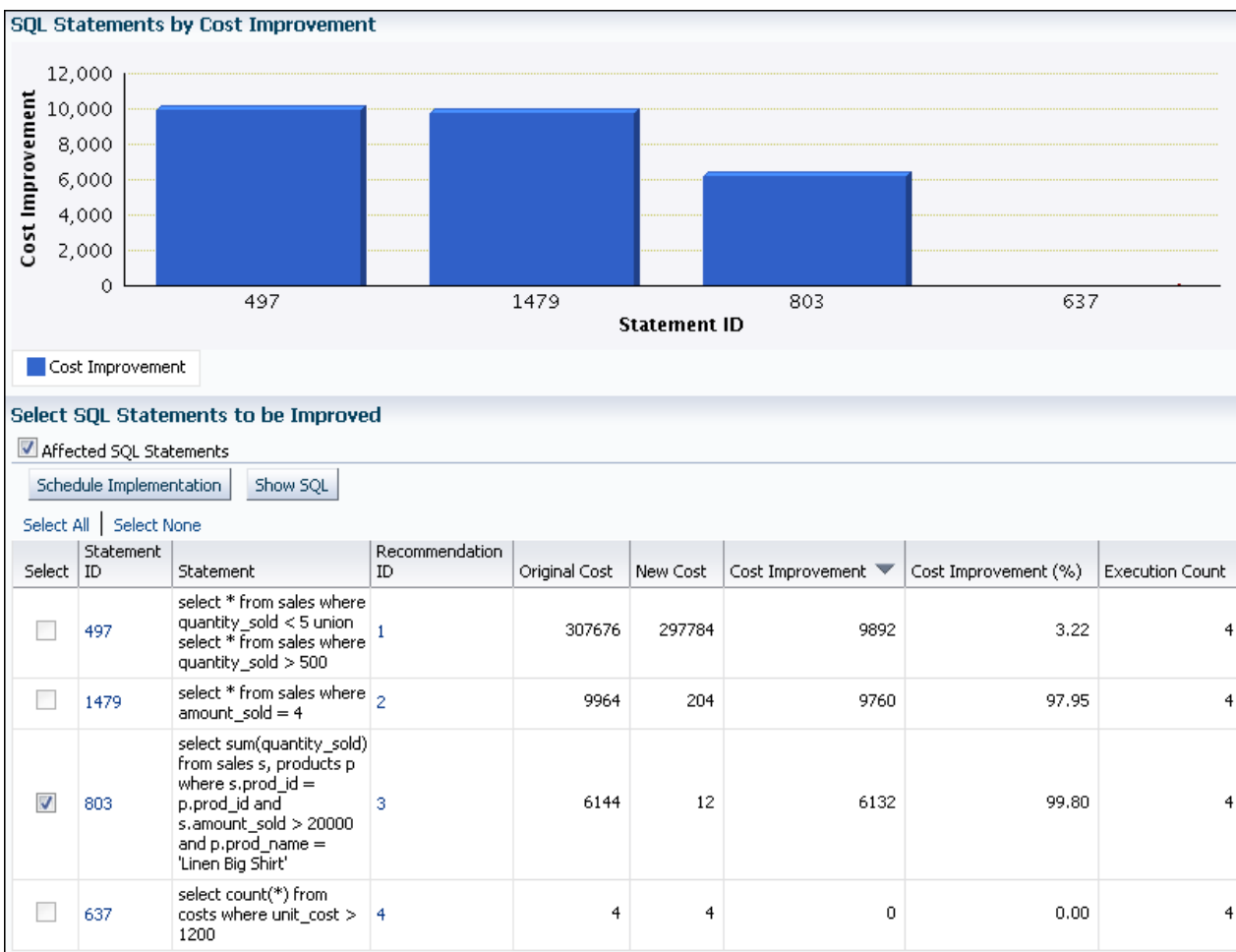
3. Use the SQL Statements by Cost Improvement chart to view SQL statements in the workload ordered by the cost improvement.

   Under Select SQL Statements to be Improved, each SQL statement is listed with its statement ID, SQL text, associated recommendation, cost improvement, and execution count.

   Implementing the recommendation associated with the top SQL statement has the biggest benefit to the total performance of the workload. In this example, implementing the recommendation with ID 3 produces the biggest benefit, a cost improvement of 99.80%, for the SQL statement with ID 803.

4. To view the SQL text of a recommendation, select the recommendation and click **Show SQL**.

   The Show SQL page for the selected recommendation appears.

Reviewing the SQL Access Advisor Recommendations: Details

The Details subpage displays a list of all the workload and task options used in the analysis. You can also use this page to view a list of journal entries for the task, based on the journaling level used when the task was created.

To review workload and task details:

1. Access the Results for Task page, as described in "Reviewing the SQL Access Advisor Recommendations".

2. Click **Details**.

   The Details subpage appears.

   Workload and Task Options
   These are the options that were selected when the advisor task was created.

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Option	Value	Description
Advisor Mode	Limited	Specifies the mode in which SQL Access Advisor will operate during an analysis, either limited (quicker results) or comprehensive (higher quality recommendations)
Analysis Scope	All Tuning Artifacts	The type of recommendations that are allowed
Creation Cost	Consider creation cost	When specified, the SQL Access Advisor will weigh the cost of creation of access structures against the frequency of the queries and potential improvement in query execution time
Default Index Schema	None	Specifies the default owner for new index recommendations
Default Index Tablespace	None	Specifies the default tablespace for new index recommendations
Default MVLog Tablespace	None	Specifies the default tablespace for new materialized view log recommendations
Default MView Schema	None	Specifies the default owner for new materialized view recommendations
Default MView Tablespace	None	Specifies the default tablespace for new materialized view recommendations
Default Partitioning Tablespaces	None	Specifies the default tablespaces for new Partitioning recommendations
Excluded Actions	None	Contains a list of application actions that are NOT eligible for tuning

   Previous | 1-10 of 29 | Next 10

   Journal Entries
   These are the messages that were logged to the advisor journal while the task was executing. The amount of information logged is controlled by the "Journaling Level" option shown in the table above.

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Severity	Entry	Order ▲
ℹ	Preparing workload for analysis	1
⚠	Missing statistics: Table: "SH"."PROMOTIONS"	2
ℹ	Filter Summary: Valid username: Statements discarded: 1519	3
ℹ	Filter Summary: Invalid username: Unused	4
ℹ	Filter Summary: Valid module: Unused	5
ℹ	Filter Summary: Invalid module: Unused	6
ℹ	Filter Summary: Valid action: Unused	7
ℹ	Filter Summary: Invalid action: Unused	8
ℹ	Filter Summary: Valid SQL String: Unused	9
ℹ	Filter Summary: Invalid SQL String: Statements discarded: 0	10

   Previous | 1-10 of 19 | Next 9

   Under Workload and Task Options, a list of options that were selected when the advisor task was created is displayed.

   Under Journal Entries, a list of messages that were logged to the SQL Access Advisor journal while the task was executing is displayed.

Implementing the SQL Access Advisor Recommendations

A SQL Access Advisor recommendation can range from a simple suggestion to a complex solution that requires partitioning a set of existing base tables and

implementing a set of database objects such as indexes, materialized views, and materialized view logs. You can select the recommendations for implementation and schedule when the job should be executed.

To implement the SQL Access Advisor recommendations:

1. Review the SQL Access Advisor recommendations for cost benefits to determine which ones, if any, should be implemented.

   See "Reviewing the SQL Access Advisor Recommendations" for more information.

2. Access the Results for Task page, as described in "Reviewing the SQL Access Advisor Recommendations".

3. Click **Recommendations**.

   The Recommendations subpage appears.

4. Under Select Recommendations for Implementation, select the recommendation you want to implement and then click **Schedule Implementation**.

   In the following example, the recommendation with ID value 1 is selected.

   The Schedule Implementation page appears.

5. In the **Job Name** field, enter a name for the job if you do not want to use the system-generated job name.

6. Determine whether the implementation job should stop if an error is encountered. Do one of the following:

   • To stop processing if an error occurs, select **Stop on Error**.

   • To continue processing even if an error occurs, deselect **Stop on Error**.

7. Under Scheduling Options, in the Schedule Type list, select a schedule type for the task and a maintenance window in which the task should run. Do one of the following:

   • Click **Standard**.

     This schedule type enables you to select a repeating interval and start time for the task. Complete the following steps:

     – Enter your time zone code in the **Time Zone** field or click the search icon to locate the code for your area.

     – In the Repeat list, select **Do Not Repeat** to perform the task only once, or select a unit of time and enter the number of units in the **Interval** field.

– Under Start, select **Immediately** to start the task now, or **Later** to schedule the task to start at a time specified using the **Date** and **Time** fields.

• Click **Use predefined schedule**.

This schedule type enables you to select an existing schedule. Do one of the following:

– In the **Schedule** field, enter the name of the schedule to be used for the task.

– To search for a schedule, click the search icon.

The Search and Select: Schedule dialog box appears.

Select the desired schedule and click **Select**. The selected schedule now appears in the **Schedule** field.

• Click **Standard using PL/SQL for repeated interval**.

This schedule type enables you to select a repeating interval and an execution window for the task. Complete the following steps:

– Enter your time zone code in the **Time Zone** field or click the search icon to locate the code for your area.

– Under Available to Start, select **Immediately** to start the task now, or **Later** to schedule the task to start at a time specified using the **Date** and **Time** fields.

– In the **Repeated Interval** field, enter a PL/SQL schedule expression, such as `SYSDATE+1`.

– Under Not Available After, select **No End Date** to indicate that there is no end date for the execution window, or **Specified End Date** to specify an end date using the **Date** and **Time** fields.

• Click **Use predefined window**.

This schedule type enables you to select an existing window. Select **Stop on Window Close** to stop the job when the window closes. Do one of the following:

– In the **Window** field, enter the name of the window to be used for the task.

– To search for a window, click the search icon.

The Search and Select: Window and Window Groups dialog box appears.

Select the desired window and click **Select**. The selected window now appears in the **Schedule** field.

• Click **Event**.

Complete the following steps:

– Enter your time zone code in the **Time Zone** field or click the search icon to locate the code for your area.

– Under Event Parameters, enter values in the **Queue Name** and **Condition** fields.

– Under Start, select **Immediately** to start the task now, or **Later** to schedule the task to start at a time specified using the **Date** and **Time** fields.

- – Under Not Available After, select **No End Date** to indicate that there is no end date for the execution window, or **Specified End Date** to specify an end date using the **Date** and **Time** fields.

- Click **Calendar**.

  Complete the following steps:

  - – Enter your time zone code in the **Time Zone** field or click the search icon to locate the code for your area.

  - – Under Calendar Expression, enter a calendar expression.

  - – Under Start, select **Immediately** to start the task now, or **Later** to schedule the task to start at a time specified using the **Date** and **Time** fields.

  - – Under Not Available After, select **No End Date** to indicate that there is no end date for the execution window, or **Specified End Date** to specify an end date using the **Date** and **Time** fields.

In this example, **Standard** is selected for schedule type. The job does not repeat and is scheduled to start immediately.

8. Optionally, click **Show SQL** to view the SQL text for the job.

9. Click **Submit** to submit the job.

10. Do one of the following, depending on whether the job is scheduled to start immediately or later:

- If you submitted the job immediately, and if the Results for Task page appears, then click the link in the **Scheduler Job** field to display the View Job page. Go to Step 12.

- If the job is scheduled to start at a later time, then proceed to Step 11.

11. Complete the following steps:

   a. From the Administration menu, select **Oracle Scheduler**, then **Jobs**.

      The Scheduler Jobs page appears.

   b. Select the implementation job and click **View Job Definition**.

      The View Job page for the selected job appears.

12. On the View Job page, under Operation Detail, check the status of the operation.

Operation Detail			
View			
Select	Log ID	Log Date ▼	Operation	Status
◉	2592	Feb 22, 2012 2:22:36 PM -06:00	RUN	SUCCEEDED

13. Optionally, select the operation and click **View**.

   The Operation Detail page appears.

   This page contains information (such as start date and time, run duration, CPU time used, and session ID) that you can use when troubleshooting.

14. Optionally, from the Database Home page, select **Schema**, then the page of the object that was created.

   Depending on the type of access structure that is created, you can display the access structure using the Indexes page, Materialized Views page, or the Materialized View Logs page.

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