13
Gathering Optimizer Statistics

This chapter explains how to use the DBMS_STATS.GATHER_*_STATS program units.

> **See Also:**
>
> - "Optimizer Statistics Concepts"
> - "Query Optimizer Concepts "
> - *Oracle Database PL/SQL Packages and Types Reference* to learn about DBMS_STATS.GATHER_TABLE_STATS

Configuring Automatic Optimizer Statistics Collection

Oracle Database can gather optimizer statistics automatically.

About Automatic Optimizer Statistics Collection

The automated maintenance tasks infrastructure (known as AutoTask) schedules tasks to run automatically in Oracle Scheduler windows known as maintenance windows.

Difference Between Automatic and Manual Statistics Collection

The principal difference is that automatic collection prioritizes database objects that need statistics. Before the maintenance window closes, automatic collection assesses all objects and prioritizes objects that have no statistics or very old statistics.

When gathering statistics manually, you can reproduce the object prioritization of automatic collection by using the DBMS_AUTO_TASK_IMMEDIATE package. This package runs the same statistics gathering job that is executed during the automatic nightly statistics gathering job.

How Automatic Statistics Collection Works

Automatic optimizer statistics collection runs as part of AutoTask. By default, the collection runs in all predefined maintenance windows. One window is scheduled for each day of the week.

To collect the optimizer statistics, the database calls an internal procedure that operates similarly to the GATHER_DATABASE_STATS procedure with the GATHER AUTO option. Automatic statistics collection honors all preferences set in the database.

When an automatic optimizer statistics collection task gathers data for a PDB, it stores this data in the PDB. This data is included if the PDB is unplugged. A common user whose current container is the CDB root can view optimizer statistics data for PDBs. A user whose current container is a PDB can view optimizer statistics data for the PDB only.

Configuring Automatic Optimizer Statistics Collection Using Cloud Control

You can enable and disable all automatic maintenance tasks, including automatic optimizer statistics collection, using Cloud Control.

The default window timing works well for most situations. However, you may have operations such as bulk loads that occur during the window. In such cases, to avoid potential conflicts that result from operations occurring at the same time as automatic statistics collection, Oracle recommends that you change the window accordingly.

Prerequisites

Access the Database Home page, as described in "Accessing the Database Home Page in Cloud Control."

To control automatic optimizer statistics collection using Cloud Control:

1. From the **Administration** menu, select **Oracle Scheduler**, then **Automated Maintenance Tasks**.

   The Automated Maintenance Tasks page appears.

   This page shows the predefined tasks. To retrieve information about each task, click the corresponding link for the task.

2. Click **Configure**.

   The Automated Maintenance Tasks Configuration page appears.

   By default, automatic optimizer statistics collection executes in all predefined maintenance windows in `MAINTENANCE_WINDOW_GROUP`.

3. Perform the following steps:

   a. In the Task Settings section for Optimizer Statistics Gathering, select either **Enabled** or **Disabled** to enable or disable an automated task.

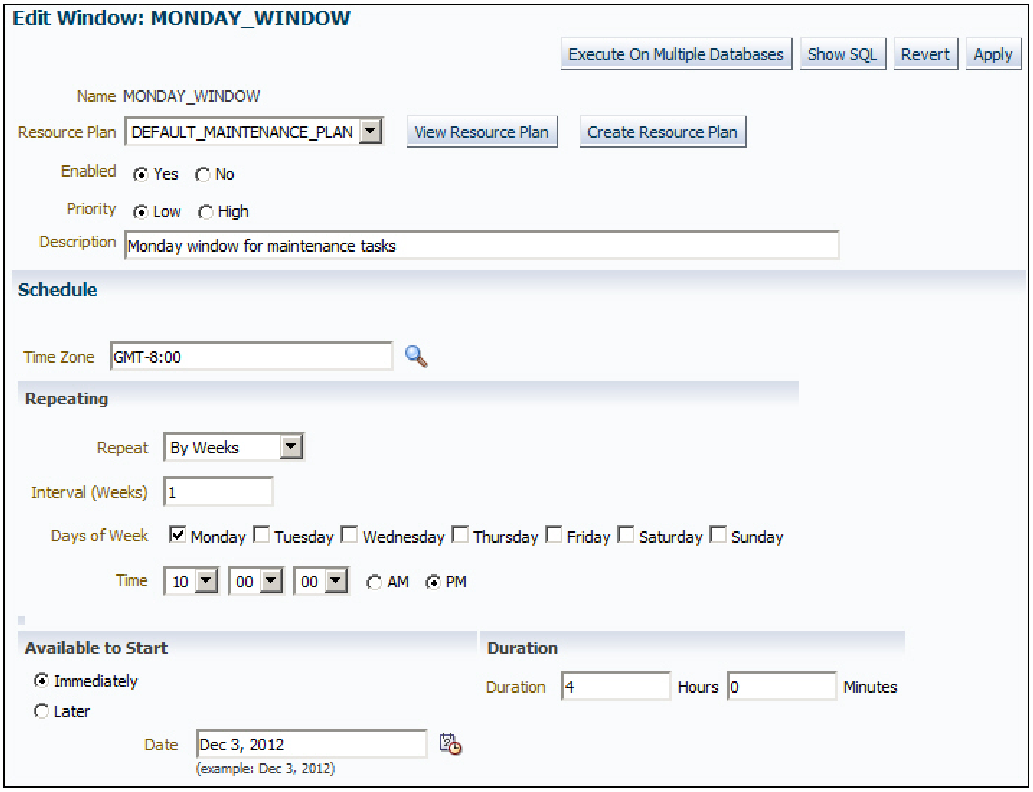
   > **Note:**
   >
   > Oracle strongly recommends that you not disable automatic statistics gathering because it is critical for the optimizer to generate optimal plans for queries against dictionary and user objects. If you disable automatic collection, ensure that you have a good manual statistics collection strategy for dictionary and user schemas.

   b. To disable statistics gathering for specific days in the week, check the appropriate box next to the window name.

   c. To change the characteristics of a window group, click **Edit Window Group**.

   d. To change the times for a window, click the name of the window (for example, **MONDAY_WINDOW**), and then in the Schedule section, click **Edit**.

   The Edit Window page appears.



Edit Window: MONDAY_WINDOW

Name MONDAY_WINDOW

Resource Plan DEFAULT_MAINTENANCE_PLAN

Enabled ● Yes ○ No

Priority ● Low ○ High

Description Monday window for maintenance tasks

Schedule

Time Zone GMT-8:00

Repeating

Repeat By Weeks

Interval (Weeks) 1

Days of Week ☑ Monday □ Tuesday □ Wednesday □ Thursday □ Friday □ Saturday □ Sunday

Time 10 00 00 ○ AM ● PM

Available to Start

● Immediately

○ Later

Date Dec 3, 2012
(example: Dec 3, 2012)

Duration

Duration 4 Hours 0 Minutes

In this page, you can change the parameters such as duration and start time for window execution.

e. Click **Apply**.

> **See Also:**
>
> Online Help for Oracle Enterprise Manager Cloud Control

Configuring Automatic Optimizer Statistics Collection from the Command Line

If you do not use Cloud Control to configure automatic optimizer statistics collection, then you must use the command line.

You have the following options:

- Run the `ENABLE` or `DISABLE` procedure in the `DBMS_AUTO_TASK_ADMIN` PL/SQL package.

  This package is the recommended command-line technique. For both the `ENABLE` and `DISABLE` procedures, you can specify a particular maintenance window with the `window_name` parameter.

- Set the `STATISTICS_LEVEL` initialization level to `BASIC` to disable collection of *all* advisories and statistics, including Automatic SQL Tuning Advisor.

Note:

Because monitoring and many automatic features are disabled, Oracle strongly recommends that you do not set `STATISTICS_LEVEL` to `BASIC`.

To control automatic statistics collection using DBMS_AUTO_TASK_ADMIN:

1. In SQL*Plus or SQL Developer, log in to the database as a user with administrative privileges.
2. Do one of the following:
   - To enable the automated task, execute the following PL/SQL block:

     ```
     BEGIN
       DBMS_AUTO_TASK_ADMIN.ENABLE (
         client_name  => 'auto optimizer stats collection'
     ,   operation    => NULL
     ,   window_name  => NULL
     );
     END;
     /
     ```

   - To disable the automated task, execute the following PL/SQL block:

     ```
     BEGIN
       DBMS_AUTO_TASK_ADMIN.DISABLE (
         client_name  => 'auto optimizer stats collection'
     ,   operation    => NULL
     ,   window_name  => NULL
     );
     END;
     /
     ```

3. Query the data dictionary to confirm the change.

   For example, query `DBA_AUTOTASK_CLIENT` as follows:

   ```
   COL CLIENT_NAME FORMAT a31

   SELECT CLIENT_NAME, STATUS
   FROM   DBA_AUTOTASK_CLIENT
   WHERE  CLIENT_NAME = 'auto optimizer stats collection';
   ```

   Sample output appears as follows:

   ```
   CLIENT_NAME                     STATUS
   ------------------------------- --------
   auto optimizer stats collection ENABLED
   ```

To change the window attributes for automatic statistics collection:

1. Connect SQL*Plus to the database with administrator privileges.
2. Change the attributes of the maintenance window as needed.

For example, to change the Monday maintenance window so that it starts at 5 a.m., execute the following PL/SQL program:

```
BEGIN
  DBMS_SCHEDULER.SET_ATTRIBUTE (
    'MONDAY_WINDOW'
,   'repeat_interval'
,   'freq=daily;byday=MON;byhour=05;byminute=0;bysecond=0'
);
END;
/
```

See Also:

- *Oracle Database PL/SQL Packages and Types Reference* to learn about the DBMS_AUTO_TASK_ADMIN package
- *Oracle Database Reference* to learn about the STATISTICS_LEVEL initialization parameter

Configuring High-Frequency Automatic Optimizer Statistics Collection

This lightweight task supplements standard automatic statistics collection.

About High-Frequency Automatic Optimizer Statistics Collection

You can configure automatic statistics collection to occur more frequently.

Purpose of High-Frequency Automatic Optimizer Statistics Collection

AutoTask schedules tasks to run automatically in maintenance windows. By default, one window is scheduled for each day of the week. Automatic optimizer statistics collection (DBMS_STATS) runs in all predefined maintenance windows.

Statistics can go stale between two consecutive statistics collection tasks. If data changes frequently, the stale statistics could cause performance problems. For example, a brokerage company might receive tremendous data during trading hours, leading the optimizer to use stale statistics for queries executed during this period.

High-frequency automatic optimizer statistics collection complements the standard statistics collection job. By default, the collection occurs every 15 minutes, meaning that statistics have less time in which to be stale.

How High-Frequency Automatic Optimizer Statistics Collection Works

To enable and disable the high-frequency task, set the execution interval, and set the maximum run time, use the DBMS_STATS.SET_GLOBAL_PREFS procedure. The high-frequency task is “lightweight” and only gathers stale statistics. It does not perform actions such as purging statistics for non-existent objects or invoking Optimizer Statistics Advisor. The standard automated job performs these additional tasks.

Automatic statistics collection jobs that run in the maintenance window are not affected by the high-frequency jobs. The high-frequency task may execute in maintenance windows, but it will not execute while the maintenance window auto stats gathering job is executing. You can monitor the tasks by querying DBA_AUTO_STAT_EXECUTIONS.

Setting Preferences for High-Frequency Automatic Optimizer Statistics Collection

To enable and disable the task, use DBMS_STATS.SET_GLOBAL_PREFS.

You can use DBMS_STATS.SET_GLOBAL_PREFS to set preferences to any of the following values:

- AUTO_TASK_STATUS

  Enables or disables the high-frequency automatic optimizer statistics collection. Values are:

  - ON — Enables high-frequency automatic optimizer statistics collection.
  - OFF — Disables high-frequency automatic optimizer statistics collection. This is the default.

- AUTO_TASK_MAX_RUN_TIME

  Configures the maximum run time in seconds of an execution of high-frequency automatic optimizer statistics collection. The maximum value is 3600 (equal to 1 hour), which is the default.

- AUTO_TASK_INTERVAL

  Specifies the interval in seconds between executions of high-frequency automatic optimizer statistics collection. The minimum value is 60. The default is 900 (equal to 15 minutes).

To configure the high-frequency task, you must have administrator privileges.

To configure the high-frequency task:

1. Log in to the database as a user with administrator privileges.
2. To enable the high-frequency task, set the AUTO_TASK_STATUS preference to ON.

   The following example enables the automatic task:

   ```
   EXEC DBMS_STATS.SET_GLOBAL_PREFS('AUTO_TASK_STATUS','ON');
   ```

3. To set the maximum run time, set the AUTO_TASK_MAX_RUN_TIME preference to the desired number of seconds.

   The following example sets the maximum run time to 10 minutes:

   ```
   EXEC DBMS_STATS.SET_GLOBAL_PREFS('AUTO_TASK_MAX_RUN_TIME','600');
   ```

4. To set the frequency, set the AUTO_TASK_INTERVAL preference to the desired number of seconds.

   The following example sets the frequency to 8 minutes:

   ```
   EXEC DBMS_STATS.SET_GLOBAL_PREFS('AUTO_TASK_INTERVAL','240');
   ```

High-Frequency Automatic Optimizer Statistics Collection: Example

In this example, you enable run DML statements, and then enable the high-frequency statistics collection job.

This example assumes the following:

- You are logged in to the database as an administrator.
- The statistics for the `sh` schema are fresh.
- High-frequency automatic optimizer statistics collection

  is not enabled.

1. Query the data dictionary for the statistics for the `sales` and `customers` tables (sample output included):

   ```
   SET LINESIZE 170
   SET PAGESIZE 5000
   COL TABLE_NAME FORMAT a20
   COL PARTITION_NAME FORMAT a20
   COL NUM_ROWS FORMAT 9999999
   COL STALE_STATS FORMAT a3

   SELECT TABLE_NAME, PARTITION_NAME, NUM_ROWS, STALE_STATS
   FROM   DBA_TAB_STATISTICS
   WHERE  OWNER = 'SH'
   AND    TABLE_NAME IN ('CUSTOMERS','SALES')
   ORDER BY TABLE_NAME, PARTITION_NAME;

   TABLE_NAME           PARTITION_NAME       NUM_ROWS STA
   -------------------- -------------------- -------- ---
   CUSTOMERS                                    55500 NO
   SALES                SALES_1995                  0 NO
   SALES                SALES_1996                  0 NO
   SALES                SALES_H1_1997               0 NO
   SALES                SALES_H2_1997               0 NO
   SALES                SALES_Q1_1998           43687 NO
   SALES                SALES_Q1_1999           64186 NO
   SALES                SALES_Q1_2000           62197 NO
   SALES                SALES_Q1_2001           60608 NO
   SALES                SALES_Q1_2002               0 NO
   SALES                SALES_Q1_2003               0 NO
   SALES                SALES_Q2_1998           35758 NO
   SALES                SALES_Q2_1999           54233 NO
   SALES                SALES_Q2_2000           55515 NO
   SALES                SALES_Q2_2001           63292 NO
   SALES                SALES_Q2_2002               0 NO
   SALES                SALES_Q2_2003               0 NO
   SALES                SALES_Q3_1998           50515 NO
   SALES                SALES_Q3_1999           67138 NO
   SALES                SALES_Q3_2000           58950 NO
   SALES                SALES_Q3_2001           65769 NO
   SALES                SALES_Q3_2002               0 NO
   SALES                SALES_Q3_2003               0 NO
   SALES                SALES_Q4_1998           48874 NO
   ```

```
SALES                SALES_Q4_1999           62388 NO
SALES                SALES_Q4_2000           55984 NO
SALES                SALES_Q4_2001           69749 NO
SALES                SALES_Q4_2002               0 NO
SALES                SALES_Q4_2003               0 NO
SALES                                       918843 NO
```

The preceding output shows that none of the statistics are stale.

2. Perform DML on `sales` and `customers`:

```
-- insert 918K rows in sales
INSERT INTO sh.sales SELECT * FROM sh.sales;
-- update around 15% of sales rows
UPDATE sh.sales SET amount_sold = amount_sold + 1 WHERE amount_sold > 100;
-- insert 1 row into customers
INSERT INTO sh.customers(cust_id, cust_first_name, cust_last_name,
    cust_gender, cust_year_of_birth, cust_main_phone_number,
    cust_street_address, cust_postal_code, cust_city_id,
    cust_city, cust_state_province_id, cust_state_province,
    country_id, cust_total, cust_total_id)
  VALUES(188710, 'Jenny', 'Smith', 'F', '1966', '555-111-2222',
    '400 oracle parkway','94065',51402, 'Redwood Shores',
    52564, 'CA', 52790, 'Customer total', '52772');
COMMIT;
```

The total number of `sales` rows increased by 100%, but only 1 row was added to `customers`.

3. Save the optimizer statistics to disk:

```
EXEC DBMS_STATS.FLUSH_DATABASE_MONITORING_INFO;
```

4. Query the table statistics again (sample output included):

```
SELECT TABLE_NAME, PARTITION_NAME, NUM_ROWS, STALE_STATS
FROM   DBA_TAB_STATISTICS
WHERE  OWNER = 'SH'
AND    TABLE_NAME IN ('CUSTOMERS','SALES')
ORDER BY TABLE_NAME, PARTITION_NAME;

TABLE_NAME           PARTITION_NAME       NUM_ROWS STA
-------------------- -------------------- -------- ---
CUSTOMERS                                    55500 NO
SALES                SALES_1995                  0 NO
SALES                SALES_1996                  0 NO
SALES                SALES_H1_1997               0 NO
SALES                SALES_H2_1997               0 NO
SALES                SALES_Q1_1998           43687 YES
SALES                SALES_Q1_1999           64186 YES
SALES                SALES_Q1_2000           62197 YES
SALES                SALES_Q1_2001           60608 YES
SALES                SALES_Q1_2002               0 NO
SALES                SALES_Q1_2003               0 NO
SALES                SALES_Q2_1998           35758 YES
SALES                SALES_Q2_1999           54233 YES
SALES                SALES_Q2_2000           55515 YES
SALES                SALES_Q2_2001           63292 YES
SALES                SALES_Q2_2002               0 NO
SALES                SALES_Q2_2003               0 NO
SALES                SALES_Q3_1998           50515 YES
SALES                SALES_Q3_1999           67138 YES
SALES                SALES_Q3_2000           58950 YES
SALES                SALES_Q3_2001           65769 YES
SALES                SALES_Q3_2002               0 NO
SALES                SALES_Q3_2003               0 NO
SALES                SALES_Q4_1998           48874 YES
SALES                SALES_Q4_1999           62388 YES
SALES                SALES_Q4_2000           55984 YES
SALES                SALES_Q4_2001           69749 YES
SALES                SALES_Q4_2002               0 NO
SALES                SALES_Q4_2003               0 NO
SALES                                      1837686
SALES                                       918843 YES

31 rows selected.
```

The preceding output shows that the statistics are not stale for `customers` but are stale for `sales`.

5. Configure high-frequency automatic optimizer statistics collection:

```
EXEC DBMS_STATS.SET_GLOBAL_PREFS('AUTO_TASK_STATUS','ON');
EXEC DBMS_STATS.SET_GLOBAL_PREFS('AUTO_TASK_MAX_RUN_TIME','180');
EXEC DBMS_STATS.SET_GLOBAL_PREFS('AUTO_TASK_INTERVAL','240');
```

The preceding PL/SQL programs enable high-frequency collection, set the maximum run time to 3 minutes, and set the task execution interval to 4 minutes.

6. Wait for a few minutes, and then query the data dictionary:

```
COL OPID FORMAT 9999
COL STATUS FORMAT a11
COL ORIGIN FORMAT a20
COL COMPLETED FORMAT 99999
COL FAILED FORMAT 99999
COL TIMEOUT FORMAT 99999
COL INPROG FORMAT 99999

SELECT OPID, ORIGIN, STATUS, TO_CHAR(START_TIME, 'DD/MM HH24:MI:SS' ) AS
BEGIN_TIME,
       TO_CHAR(END_TIME, 'DD/MM HH24:MI:SS') AS END_TIME, COMPLETED,
FAILED,
       TIMED_OUT AS TIMEOUT, IN_PROGRESS AS INPROG
FROM  DBA_AUTO_STAT_EXECUTIONS
ORDER BY OPID;
```

The output shows that the high-frequency job executed twice, and the standard automatic statistics collection job executed once:

```
ID  ORIGIN               STATUS   BEGIN_TIME     END_TIME       COMP FAIL TIMEO INPRO
--- -------------------- -------- -------------- -------------- ---- ---- ----- -----
790 HIGH_FREQ_AUTO_TASK  COMPLETE 03/10 14:54:02 03/10 14:54:35  338    3     0     0
793 HIGH_FREQ_AUTO_TASK  COMPLETE 03/10 14:58:11 03/10 14:58:45  193    3     0     0
794 AUTO_TASK            COMPLETE 03/10 15:00:02 03/10 15:00:20   52    3     0     0
```

Gathering Optimizer Statistics Manually

As an alternative or supplement to automatic statistics gathering, you can use the DBMS_STATS package to gather optimizer statistics manually.

> **See Also:**
>
> - "Configuring Automatic Optimizer Statistics Collection"
> - *Oracle Database PL/SQL Packages and Types Reference* to learn about the DBMS_STATS package

About Manual Statistics Collection with DBMS_STATS

Use the DBMS_STATS package to manipulate optimizer statistics. You can gather statistics on objects and columns at various levels of granularity: object, schema, and database. You can also gather statistics for the physical system.

The following table summarizes the DBMS_STATS procedures for gathering optimizer statistics. This package does not gather statistics for table clusters. However, you can gather statistics on individual tables in a table cluster.

Table 13-1 DBMS_STATS Procedures for Gathering Optimizer Statistics

Procedure	Purpose
GATHER_INDEX_STATS	Collects index statistics
GATHER_TABLE_STATS	Collects table, column, and index statistics
GATHER_SCHEMA_STATS	Collects statistics for all objects in a schema
GATHER_DICTIONARY_STATS	Collects statistics for all system schemas, including SYS and SYSTEM, and other optional schemas, such as CTXSYS and DRSYS
GATHER_DATABASE_STATS	Collects statistics for all objects in a database

When the OPTIONS parameter is set to GATHER STALE or GATHER AUTO, the GATHER_SCHEMA_STATS and GATHER_DATABASE_STATS procedures gather statistics for any table that has stale statistics and any table that is missing statistics. If a monitored table has been modified more than 10%, then the database considers these statistics stale and gathers them again.

Note:

As explained in "Configuring Automatic Optimizer Statistics Collection", you can configure a nightly job to gather statistics automatically.

See Also:

- "Gathering System Statistics Manually"
- *Oracle Database PL/SQL Packages and Types Reference* to learn more about the `DBMS_STATS` package

Guidelines for Gathering Optimizer Statistics Manually

In most cases, automatic statistics collection is sufficient for database objects modified at a moderate speed.

Automatic collection may sometimes be inadequate or unavailable, as shown in the following table.

Table 13-2 Reasons for Gathering Statistics Manually

Issue	To Learn More
You perform certain types of bulk load and cannot wait for the maintenance window to collect statistics because queries must be executed immediately.	"Online Statistics Gathering for Bulk Loads"
During a nonrepresentative workload, automatic statistics collection gathers statistics for fixed tables.	"Gathering Statistics for Fixed Objects"
Automatic statistics collection does not gather system statistics.	"Gathering System Statistics Manually"
Volatile tables are being deleted or truncated, and then rebuilt during the day.	"Gathering Statistics for Volatile Tables Using Dynamic Statistics"

Guideline for Setting the Sample Size

In the context of optimizer statistics, **sampling** is the gathering of statistics from a random subset of table rows. By enabling the database to avoid full table scans and sorts of entire tables, sampling minimizes the resources necessary to gather statistics.

The database gathers the most accurate statistics when it processes all rows in the table, which is a 100% sample. However, larger sample sizes increase the time of statistics gathering operations. The challenge is determining a sample size that provides accurate statistics in a reasonable time.

`DBMS_STATS` uses sampling when a user specifies the parameter `ESTIMATE_PERCENT`, which controls the percentage of the rows in the table to sample. To maximize performance gains while achieving necessary statistical accuracy, Oracle recommends that the `ESTIMATE_PERCENT` parameter use the default setting of DBMS_STATS.AUTO_SAMPLE_SIZE. In this case, Oracle Database chooses the sample size automatically. This setting enables the use of the following:

- A hash-based algorithm that is much faster than sampling

  This algorithm reads all rows and produces statistics that are nearly as accurate as statistics from a 100% sample. The statistics computed using this technique are deterministic.
- Incremental statistics
- Concurrent statistics
- New histogram types

The DBA_TABLES.SAMPLE_SIZE column indicates the actual sample size used to gather statistics.

> **See Also:**
>
> - "Hybrid Histograms"
> - *Oracle Database PL/SQL Packages and Types Reference* to learn more about DBMS_STATS.AUTO_SAMPLE_SIZE

Guideline for Gathering Statistics in Parallel

By default, the database gathers statistics with the parallelism degree specified at the table or index level.

You can override this setting with the degree argument to the DBMS_STATS gathering procedures. Oracle recommends setting degree to DBMS_STATS.AUTO_DEGREE. This setting enables the database to choose an appropriate degree of parallelism based on the object size and the settings for the parallelism-related initialization parameters.

The database can gather most statistics serially or in parallel. However, the database does not gather some index statistics in parallel, including cluster indexes, domain indexes, and bitmap join indexes. The database can use sampling when gathering parallel statistics.

> **Note:**
>
> Do not confuse gathering statistics in parallel with gathering statistics concurrently.

> **See Also:**
>
> - "About Concurrent Statistics Gathering"
> - *Oracle Database PL/SQL Packages and Types Reference* to learn more about DBMS_STATS.AUTO_DEGREE

Guideline for Partitioned Objects

For partitioned tables and indexes, DBMS_STATS can gather separate statistics for each partition and global statistics for the entire table or index.

Similarly, for composite partitioning, DBMS_STATS can gather separate statistics for subpartitions, partitions, and the entire table or index.

To determine the type of partitioning statistics to be gathered, specify the granularity argument to the DBMS_STATS procedures. Oracle recommends setting granularity to the default value of AUTO to gather subpartition, partition, or global statistics, depending on partition type. The ALL setting gathers statistics for all types.

> **See Also:**
>
> "Gathering Incremental Statistics on Partitioned Objects"

Guideline for Frequently Changing Objects

When tables are frequently modified, gather statistics often enough so that they do not go stale, but not so often that collection overhead degrades performance.

You may only need to gather new statistics every week or month. The best practice is to use a script or job scheduler to regularly run the DBMS_STATS.GATHER_SCHEMA_STATS and DBMS_STATS.GATHER_DATABASE_STATS procedures.

Guideline for External Tables

Because the database does not permit data manipulation against external tables, the database never marks statistics on external tables as stale. If new statistics are required for an external table, for example, because the underlying data files change, then regather the statistics.

For external tables, use the same DBMS_STATS procedures that you use for internal tables. Note that the scanrate parameter of DBMS_STATS.SET_TABLE_STATS and DBMS_STATS.GET_TABLE_STATS specifies the rate (in MB/s) at which Oracle Database scans data in tables, and is relevant only for external tables. The SCAN_RATE column appears in the DBA_TAB_STATISTICS and DBA_TAB_PENDING_STATS data dictionary views.

> **See Also:**
>
> - "Creating Artificial Optimizer Statistics for Testing"
> - *Oracle Database PL/SQL Packages and Types Reference* to learn about SET_TABLE_STATS and GET_TABLE_STATS
> - *Oracle Database Reference* to learn about the DBA_TAB_STATISTICS view

Determining When Optimizer Statistics Are Stale

Stale statistics on a table do not accurately reflect its data. To help you determine when a database object needs new statistics, the database provides a table monitoring facility.

Monitoring tracks the approximate number of DML operations on a table and whether the table has been truncated since the most recent statistics collection. To check whether statistics are stale, query the STALE_STATS column in DBA_TAB_STATISTICS and DBA_IND_STATISTICS. This column is based on data in the DBA_TAB_MODIFICATIONS view and the STALE_PERCENT preference for DBMS_STATS.

> **Note:**
>
> Starting in Oracle Database 12c Release 2 (12.2), you no longer need to use DBMS_STATS.FLUSH_DATABASE_MONITORING_INFO to ensure that view metadata is current. The statistics shown in the DBA_TAB_STATISTICS, DBA_IND_STATISTICS, and DBA_TAB_MODIFICATIONS views are obtained from both disk and memory.

The STALE_STATS column has the following possible values:

- YES

  The statistics are stale.
- NO

  The statistics are not stale.
- null

  The statistics are not collected.

Executing GATHER_SCHEMA_STATS or GATHER_DATABASE_STATS with the GATHER AUTO option collects statistics only for objects with no statistics or stale statistics.

To determine stale statistics:

1. Start SQL*Plus, and then log in to the database as a user with the necessary privileges.
2. Query the data dictionary for stale statistics.

   The following example queries stale statistics for the sh.sales table (partial output included):

   ```
   COL PARTITION_NAME FORMAT a15

   SELECT PARTITION_NAME, STALE_STATS
   FROM   DBA_TAB_STATISTICS
   WHERE  TABLE_NAME = 'SALES'
   AND    OWNER = 'SH'
   ORDER BY PARTITION_NAME;

   PARTITION_NAME  STA
   --------------- ---
   SALES_1995      NO
   SALES_1996      NO
   ```

```
SALES_H1_1997   NO
SALES_H2_1997   NO
SALES_Q1_1998   NO
SALES_Q1_1999   NO
.
.
.
```

See Also:

Oracle Database Reference to learn about the DBA_TAB_MODIFICATIONS view

Gathering Schema and Table Statistics

Use GATHER_TABLE_STATS to collect table statistics, and GATHER_SCHEMA_STATS to collect statistics for all objects in a schema.

To gather schema statistics using DBMS_STATS:

1. Start SQL*Plus, and connect to the database with the appropriate privileges for the procedure that you intend to run.
2. Run the GATHER_TABLE_STATS or GATHER_SCHEMA_STATS procedure, specifying the desired parameters.

   Typical parameters include:

   - Owner - ownname
   - Object name - tabname, indname, partname
   - Degree of parallelism - degree

Example 13-1 Gathering Statistics for a Table

This example uses the DBMS_STATS package to gather statistics on the sh.customers table with a parallelism setting of 2.

```
BEGIN
  DBMS_STATS.GATHER_TABLE_STATS (
    ownname => 'sh'
,   tabname => 'customers'
,   degree  => 2
);
END;
/
```

See Also:

Oracle Database PL/SQL Packages and Types Reference to learn about the GATHER_TABLE_STATS procedure

Gathering Statistics for Fixed Objects

Fixed objects are dynamic performance tables and their indexes. These objects record current database activity.

Unlike other database tables, the database does not automatically use dynamic statistics for SQL statement referencing X$ tables when optimizer statistics are missing. Instead, the optimizer uses predefined default values. These defaults may not be representative and could potentially lead to a suboptimal execution plan. Thus, it is important to keep fixed object statistics current.

Oracle Database automatically gathers fixed object statistics as part of automated statistics gathering if they have not been previously collected. You can also manually collect statistics on fixed objects by calling DBMS_STATS.GATHER_FIXED_OBJECTS_STATS. Oracle recommends that you gather statistics when the database has representative activity.

Prerequisites

You must have the SYSDBA or ANALYZE ANY DICTIONARY system privilege to execute this procedure.

To gather schema statistics using GATHER_FIXED_OBJECTS_STATS:

1. In SQL*Plus or SQL Developer, log in to the database as a user with the necessary privileges.
2. Run the DBMS_STATS.GATHER_FIXED_OBJECTS_STATS procedure, specifying the desired parameters.

   Typical parameters include:

   - Table identifier describing where to save the current statistics - stattab
   - Identifier to associate with these statistics within stattab (optional) - statid
   - Schema containing stattab (if different from current schema) - statown

Example 13-2   Gathering Statistics for a Table

This example uses the DBMS_STATS package to gather fixed object statistics.

```
BEGIN
  DBMS_STATS.GATHER_FIXED_OBJECTS_STATS;
END;
/
```

See Also:

- "Configuring Automatic Optimizer Statistics Collection"
- *Oracle Database PL/SQL Packages and Types Reference* to learn about the GATHER_TABLE_STATS procedure

Gathering Statistics for Volatile Tables Using Dynamic Statistics

Statistics for volatile tables, which are tables modified significantly during the day, go stale quickly. For example, a table may be deleted or truncated, and then rebuilt.

When you set the statistics of a volatile object to null, Oracle Database dynamically gathers the necessary statistics during optimization using dynamic statistics. The OPTIMIZER_DYNAMIC_SAMPLING initialization parameter controls this feature.

Assumptions

This tutorial assumes the following:

- The oe.orders table is extremely volatile.
- You want to delete and then lock the statistics on the orders table to prevent the database from gathering statistics on the table. In this way, the database can dynamically gather necessary statistics as part of query optimization.
- The oe user has the necessary privileges to query DBMS_XPLAN.DISPLAY_CURSOR.

To delete and the lock optimizer statistics:

1. Connect to the database as user oe, and then delete the statistics for the oe table.

   For example, execute the following procedure:

   ```
   BEGIN
     DBMS_STATS.DELETE_TABLE_STATS('OE','ORDERS');
   END;
   /
   ```

2. Lock the statistics for the oe table.

   For example, execute the following procedure:

   ```
   BEGIN
     DBMS_STATS.LOCK_TABLE_STATS('OE','ORDERS');
   END;
   /
   ```

3. You query the orders table.

   For example, use the following statement:

   ```
   SELECT COUNT(order_id) FROM orders;
   ```

4. You query the plan in the cursor.

   You run the following commands (partial output included):

   ```
   SET LINESIZE 150
   SET PAGESIZE 0

   SELECT * FROM TABLE(DBMS_XPLAN.DISPLAY_CURSOR);

   SQL_ID  aut9632fr3358, child number 0
   -------------------------------------
   ```

```
SELECT COUNT(order_id) FROM orders

Plan hash value: 425895392

---------------------------------------------------------------------
| Id  | Operation          | Name   | Rows  | Cost (%CPU)| Time     |
---------------------------------------------------------------------
|   0 | SELECT STATEMENT   |        |       |     2 (100)|          |
|   1 |  SORT AGGREGATE    |        |     1 |            |          |
|   2 |   TABLE ACCESS FULL| ORDERS |   105 |     2   (0)| 00:00:01 |
---------------------------------------------------------------------

Note
-----
   - dynamic statistics used for this statement (level=2)
```

The Note in the preceding execution plan shows that the database used dynamic statistics for the `SELECT` statement.

See Also:

- "Configuring Options for Dynamic Statistics"
- "Locking and Unlocking Optimizer Statistics" to learn how to gather representative statistics and then lock them, which is an alternative technique for preventing statistics for volatile tables from going stale

Gathering Optimizer Statistics Concurrently

Oracle Database can gather statistics on multiple tables or partitions concurrently.

About Concurrent Statistics Gathering

By default, each partition of a partition table is gathered sequentially.

When **concurrent statistics gathering mode** is enabled, the database can simultaneously gather optimizer statistics for multiple tables in a schema, or multiple partitions or subpartitions in a table. Concurrency can reduce the overall time required to gather statistics by enabling the database to fully use multiple processors.

Note:

Concurrent statistics gathering mode does not rely on parallel query processing, but is usable with it.

How DBMS_STATS Gathers Statistics Concurrently

Oracle Database employs multiple tools and technologies to create and manage multiple statistics gathering jobs concurrently.

The database uses the following:

- Oracle Scheduler
- Oracle Database Advanced Queuing (AQ)
- Oracle Database Resource Manager (the Resource Manager)

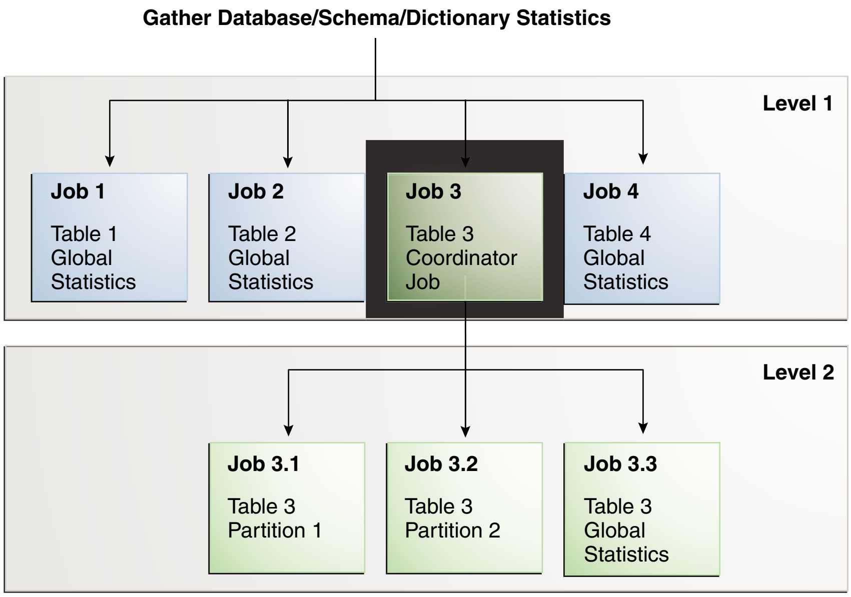
Enable concurrent statistics gathering by setting the CONCURRENT preference with DBMS_STATS.SET_GLOBAL_PREF.

The database runs as many concurrent jobs as possible. The Job Scheduler decides how many jobs to execute concurrently and how many to queue. As running jobs complete, the scheduler dequeues and runs more jobs until the database has gathered statistics on all tables, partitions, and subpartitions. The maximum number of jobs is bounded by the JOB_QUEUE_PROCESSES initialization parameter and available system resources.

In most cases, the DBMS_STATS procedures create a separate job for each table partition or subpartition. However, if the partition or subpartition is empty or very small, then the database may automatically batch the object with other small objects into a single job to reduce the overhead of job maintenance.

The following figure illustrates the creation of jobs at different levels, where Table 3 is a partitioned table, and the other tables are nonpartitioned. Job 3 acts as a coordinator job for Table 3, and creates a job for each partition in that table, and a separate job for the global statistics of Table 3. This example assumes that incremental statistics gathering is disabled; if enabled, then the database derives global statistics from partition-level statistics after jobs for partitions complete.

Figure 13-1 Concurrent Statistics Gathering Jobs


Gather Database/Schema/Dictionary Statistics
Level 1
Job 1
Table 1 Global Statistics
Job 2
Table 2 Global Statistics
Job 3
Table 3 Coordinator Job
Job 4
Table 4 Global Statistics
Level 2
Job 3.1
Table 3 Partition 1
Job 3.2
Table 3 Partition 2
Job 3.3
Table 3 Global Statistics

See Also:

- "Enabling Concurrent Statistics Gathering"
- *Oracle Database PL/SQL Packages and Types Reference* to learn about the `DBMS_STATS` package
- *Oracle Database Reference* to learn about the `JOB_QUEUE_PROCESSES` initialization parameter

Concurrent Statistics Gathering and Resource Management

The `DBMS_STATS` package does not explicitly manage resources used by concurrent statistics gathering jobs that are part of a user-initiated statistics gathering call.

Thus, the database may use system resources fully during concurrent statistics gathering. To address this situation, use the Resource Manager to cap resources consumed by concurrent statistics gathering jobs. The Resource Manager must be enabled to gather statistics concurrently.

The system-supplied consumer group `ORA$AUTOTASK` registers all statistics gathering jobs. You can create a resource plan with proper resource allocations for `ORA$AUTOTASK` to prevent concurrent statistics gathering from consuming all available resources. If you lack your own resource plan, and if choose not to create one, then consider activating the Resource Manager with the system-supplied `DEFAULT_PLAN`.

Note:

The `ORA$AUTOTASK` consumer group is shared with the maintenance tasks that automatically run during the maintenance windows. Thus, when concurrency is activated for automatic statistics gathering, the database automatically manages resources, with no extra steps required.

See Also:

Oracle Database Administrator’s Guide to learn about the Resource Manager

Enabling Concurrent Statistics Gathering

To enable concurrent statistics gathering, use the `DBMS_STATS.SET_GLOBAL_PREFS` procedure to set the `CONCURRENT` preference.

Possible values are as follows:

- `MANUAL`

  Concurrency is enabled only for manual statistics gathering.
- `AUTOMATIC`

  Concurrency is enabled only for automatic statistics gathering.

- `ALL`

  Concurrency is enabled for both manual and automatic statistics gathering.
- `OFF`

  Concurrency is disabled for both manual and automatic statistics gathering. This is the default value.

This tutorial in this section explains how to enable concurrent statistics gathering.

Prerequisites

This tutorial has the following prerequisites:

- In addition to the standard privileges for gathering statistics, you must have the following privileges:
  - `CREATE JOB`
  - `MANAGE SCHEDULER`
  - `MANAGE ANY QUEUE`
- The `SYSAUX` tablespace must be online because the scheduler stores its internal tables and views in this tablespace.
- The `JOB_QUEUE_PROCESSES` initialization parameter must be set to at least `4`.
- The Resource Manager must be enabled.

  By default, the Resource Manager is disabled. If you do not have a resource plan, then consider enabling the Resource Manager with the system-supplied `DEFAULT_PLAN`.

Assumptions

This tutorial assumes that you want to do the following:

- Enable concurrent statistics gathering
- Gather statistics for the `sh` schema
- Monitor the gathering of the `sh` statistics

To enable concurrent statistics gathering:

1. Connect SQL*Plus to the database with the appropriate privileges, and then enable the Resource Manager.

   The following example uses the default plan for the Resource Manager:

   ```
   ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = 'DEFAULT_PLAN';
   ```

2. Set the `JOB_QUEUE_PROCESSES` initialization parameter to at least twice the number of CPU cores.

   In Oracle Real Application Clusters, the `JOB_QUEUE_PROCESSES` setting applies to each node.

   Assume that the system has 4 CPU cores. The following example sets the parameter to `8` (twice the number of cores):

   ```
   ALTER SYSTEM SET JOB_QUEUE_PROCESSES=8;
   ```

3. Confirm that the parameter change took effect.

For example, enter the following command in SQL*Plus (sample output included):

```
SHOW PARAMETER PROCESSES;

NAME                             TYPE        VALUE
-------------------------------- ----------- -----
_high_priority_processes         string      VKTM
aq_tm_processes                  integer     1
db_writer_processes              integer     1
gcs_server_processes             integer     0
global_txn_processes             integer     1
job_queue_processes              integer     8
log_archive_max_processes        integer     4
processes                        integer     100
```

4. Enable concurrent statistics.

   For example, execute the following PL/SQL anonymous block:

   ```
   BEGIN
     DBMS_STATS.SET_GLOBAL_PREFS('CONCURRENT','ALL');
   END;
   /
   ```

5. Confirm that the statistics were enabled.

   For example, execute the following query (sample output included):

   ```
   SELECT DBMS_STATS.GET_PREFS('CONCURRENT') FROM DUAL;

   DBMS_STATS.GET_PREFS('CONCURRENT')
   ----------------------------------
   ALL
   ```

6. Gather the statistics for the `SH` schema.

   For example, execute the following procedure:

   ```
   EXEC DBMS_STATS.GATHER_SCHEMA_STATS('SH');
   ```

7. In a separate session, monitor the job progress by querying `DBA_OPTSTAT_OPERATION_TASKS`.

   For example, execute the following query (sample output included):

   ```
   SET LINESIZE 1000

   COLUMN TARGET FORMAT a8
   COLUMN TARGET_TYPE FORMAT a25
   COLUMN JOB_NAME FORMAT a14
   COLUMN START_TIME FORMAT a40

   SELECT TARGET, TARGET_TYPE, JOB_NAME,
          TO_CHAR(START_TIME, 'dd-mon-yyyy hh24:mi:ss')
   FROM   DBA_OPTSTAT_OPERATION_TASKS
   WHERE  STATUS = 'IN PROGRESS'
   AND    OPID = (SELECT MAX(ID)
   ```

```
               FROM   DBA_OPTSTAT_OPERATIONS
               WHERE  OPERATION = 'gather_schema_stats');

TARGET    TARGET_TYPE               JOB_NAME       TO_CHAR(START_TIME,'
--------- ------------------------- -------------- --------------------
SH.SALES  TABLE (GLOBAL STATS ONLY) ST$T292_1_B29  30-nov-2012 14:22:47
SH.SALES  TABLE (COORDINATOR JOB)   ST$SD290_1_B10 30-nov-2012 14:22:08
```

8. In the original session, disable concurrent statistics gathering.

   For example, execute the following query:

   ```
   EXEC DBMS_STATS.SET_GLOBAL_PREFS('CONCURRENT','OFF');
   ```

> **See Also:**
>
> - "Monitoring Statistics Gathering Operations"
> - *Oracle Database Administrator’s Guide*
> - *Oracle Database PL/SQL Packages and Types Reference* to learn how to use the DBMS_STATS.SET_GLOBAL_PREFS procedure

Monitoring Statistics Gathering Operations

You can monitor statistics gathering jobs using data dictionary views.

The following views are relevant:

- DBA_OPTSTAT_OPERATION_TASKS

  This view contains the history of tasks that are performed or currently in progress as part of statistics gathering operations (recorded in DBA_OPTSTAT_OPERATIONS). Each task represents a target object to be processed in the corresponding parent operation.
- DBA_OPTSTAT_OPERATIONS

  This view contains a history of statistics operations performed or currently in progress at the table, schema, and database level using the DBMS_STATS package.

The TARGET column in the preceding views shows the target object for that statistics gathering job in the following form:

```
OWNER.TABLE_NAME.PARTITION_OR_SUBPARTITION_NAME
```

All statistics gathering job names start with the string ST$.

To display currently running statistics tasks and jobs:

- To list statistics gathering currently running tasks from all user sessions, use the following SQL statement (sample output included):

  ```
  SELECT OPID, TARGET, JOB_NAME,
         (SYSTIMESTAMP - START_TIME) AS elapsed_time
  FROM   DBA_OPTSTAT_OPERATION_TASKS
  ```

```
WHERE  STATUS = 'IN PROGRESS';

OPID TARGET                    JOB_NAME      ELAPSED_TIME
---- ------------------------- ------------- --------------------------
 981 SH.SALES.SALES_Q4_1998    ST$T82_1_B29  +000000000 00:00:00.596321
 981 SH.SALES                  ST$SD80_1_B10 +000000000 00:00:27.972033
```

To display completed statistics tasks and jobs:

- To list only completed tasks and jobs from a particular operation, first identify the operation ID from the `DBA_OPTSTAT_OPERATIONS` view based on the statistics gathering operation name, target, and start time. After you identify the operation ID, you can query the `DBA_OPTSTAT_OPERATION_TASKS` view to find the corresponding tasks in that operation

  For example, to list operations with the ID 981, use the following commands in SQL*Plus (sample output included):

  ```
  VARIABLE id NUMBER
  EXEC :id := 981

  SELECT TARGET, JOB_NAME, (END_TIME - START_TIME) AS ELAPSED_TIME
  FROM   DBA_OPTSTAT_OPERATION_TASKS
  WHERE  STATUS <> 'IN PROGRESS'
  AND    OPID = :id;

  TARGET                    JOB_NAME      ELAPSED_TIME
  ------------------------- ------------- --------------------------
  SH.SALES_TRANSACTIONS_EXT               +000000000 00:00:45.479233
  SH.CAL_MONTH_SALES_MV     ST$SD88_1_B10 +000000000 00:00:45.382764
  SH.CHANNELS               ST$SD88_1_B10 +000000000 00:00:45.307397
  ```

To display statistics gathering tasks and jobs that have failed:

- Use the following SQL statement (partial sample output included):

  ```
  SET LONG 10000

  SELECT TARGET, JOB_NAME AS NM,
         (END_TIME - START_TIME) AS ELAPSED_TIME, NOTES
  FROM   DBA_OPTSTAT_OPERATION_TASKS
  WHERE  STATUS = 'FAILED';

  TARGET             NM ELAPSED_TIME               NOTES
  ------------------ -- -------------------------- -----------------
  SYS.OPATCH_XML_INV    +000000007 02:36:31.130314 <error>ORA-20011:
                                                   Approximate NDV
                                                   failed: ORA-29913:
                                                   error in
  ```

See Also:

Oracle Database Reference to learn about the `DBA_SCHEDULER_JOBS` view

Gathering Incremental Statistics on Partitioned Objects

Incremental statistics scan only changed partitions. When gathering statistics on large partitioned table by deriving global statistics from partition-level statistics, **incremental statistics maintenance** improves performance.

Purpose of Incremental Statistics

In a typical case, an application loads data into a new partition of a range-partitioned table. As applications add new partitions and load data, the database must gather statistics on the new partition and keep global statistics up to date.

Typically, data warehouse applications access large partitioned tables. Often these tables are partitioned on date columns, with only the recent partitions subject to frequent DML changes. Without incremental statistics, statistics collection typically uses a two-pass approach:

1. The database scans the table to gather the global statistics.

   The full scan of the table for global statistics collection can be very expensive, depending on the size of the table. As the table adds partitions, the longer the execution time for `GATHER_TABLE_STATS` because of the full table scan required for the global statistics. The database must perform the scan of the entire table even if only a small subset of partitions change.
2. The database scans the changed partitions to gather their partition-level statistics.

Incremental maintenance provides a huge performance benefit for data warehouse applications because of the following:

- The database must scan the table only once to gather partition statistics and to derive the global statistics by aggregating partition-level statistics. Thus, the database avoids the *two* full scans that are required when not using incremental statistics: one scan for the partition-level statistics, and one scan for the global-level statistics.
- In subsequent statistics gathering, the database only needs to scan the stale partitions and update their statistics (including synopses). The database can derive global statistics from the fresh partition statistics, which saves a full table scan.

When using incremental statistics, the database must still gather statistics on any partition that will change the global or table-level statistics. Incremental statistics maintenance yields the same statistics as gathering table statistics from scratch, but performs better.

How DBMS_STATS Derives Global Statistics for Partitioned tables

When incremental statistics maintenance is enabled, `DBMS_STATS` gathers statistics and creates synopses for changed partitions only. The database also automatically merges partition-level synopses into a global synopsis, and derives global statistics from the partition-level statistics and global synopses.

The database avoids a full table scan when computing global statistics by deriving some global statistics from the partition-level statistics. For example, the number of rows at the global level is the sum of number of rows of partitions. Even global histograms can be derived from partition histograms.

However, the database cannot derive *all* statistics from partition-level statistics, including the NDV of a column. The following example shows the NDV for two partitions in a table:

Table 13-3 NDV for Two Partitions

Object	Column Values	NDV
Partition 1	1,3,3,4,5	4
Partition 2	2,3,4,5,6	5

Calculating the NDV in the table by adding the NDV of the individual partitions produces an NDV of 9, which is incorrect. Thus, a more accurate technique is required: synopses.

Partition-Level Synopses

A **synopsis** is special type of statistic that tracks the number of distinct values (NDV) for each column in a partition. You can consider a synopsis as an internal management structure that samples distinct values.

The database can accurately derive the global-level NDV for each column by merging partition-level synopses. In the example shown in Table 13-3, the database can use synopses to calculate the NDV for the column as 6.

Each partition maintains a synopsis in incremental mode. When a new partition is added to the table you only need to gather statistics for the new partition. The database automatically updates the global statistics by aggregating the new partition synopsis with the synopses for existing partitions. Subsequent statistics gathering operations are faster than when synopses are not used.

The database stores synopses in data dictionary tables `WRI$_OPTSTAT_SYNOPSIS_HEAD$` and `WRI$_OPTSTAT_SYNOPSIS$` in the `SYSAUX` tablespace. The `DBA_PART_COL_STATISTICS` dictionary view contains information of the column statistics in partitions. If the `NOTES` column contains the keyword `INCREMENTAL`, then this column has synopses.

See Also:

Oracle Database Reference to learn more about `DBA_PART_COL_STATISTICS`

NDV Algorithms: Adaptive Sampling and HyperLogLog

Starting in Oracle Database 12c Release 2 (12.2), the HyperLogLog algorithm can improve NDV (number of distinct values) calculation performance, and also reduce the storage space required for synopses.

The legacy algorithm for calculating NDV uses **adaptive sampling**. A synopsis is a sample of the distinct values. When calculating the NDV, the database initially stores every distinct value in a hash table. Each distinct value occupies a distinct hash bucket, so a column with 5000 distinct values has 5000 hash buckets. The database then halves the number of hash buckets, and then continues to halve the result until a small number of buckets remain. The algorithm is “adaptive” because the sampling rate changes based on the number of hash table splits.

To calculate the NDV for the column, the database uses the following formula, where *B* is the number of hash buckets remaining after all the splits have been performed, and *S* is the number of splits:

```
NDV = B * 2^S
```

Adaptive sampling produces accurate NDV statistics, but has the following consequences:

- Synopses occupy significant disk space, especially when tables have many columns and partitions, and the NDV in each column is high.

  For example, a 60-column table might have 300,000 partitions, with an average per-column NDV of 5,000. In this example, each partition has 300,000 entries (60 x 5000). In total, the synopses tables have 90 billion entries (300,000 squared), which occupies at least 720 GB of storage space.

- Bulk processing of synopses can negatively affect performance.

  Before the database regathers statistics on the stale partitions, it must delete the associated synopses. Bulk deletion can be slow because it generates significant amounts of undo and redo data.

In contrast to dynamic sampling, the HyperLogLog algorithm uses a randomization technique. Although the algorithm is complex, the foundational insight is that in a stream of random values, *n* distinct values will be spaced on average 1/*n* apart. Therefore, if you know the smallest value in the stream, then you can roughly estimate the number of distinct values. For example, if the values range from 0 to 1, and if the smallest value observed is .2, then the numbers will on average be evenly spaced .2 apart, so the NDV estimate is 5.

The HyperLogLog algorithm expands on and corrects the original estimate. The database applies a hash function to every column value, resulting in a set of hash values with the same cardinality as the column. For the base estimate, the NDV equals 2^n, where *n* is the maximum number of trailing zeroes observed in the binary representation of the hash values. The database refines its NDV estimate by using part of the output to split values into different hash buckets.

The advantages of the HyperLogLog algorithm over adaptive sampling are:

- The accuracy of the new algorithm is similar to the original algorithm.
- The memory required is *significantly* lower, which typically leads to huge reductions in synopsis size.

  Synopses can become large when many partitions exist, and they have many columns with high NDV. Synopses that use the HyperLogLog algorithm are more compact. Creating and deleting synopses affects batch run times. Any operational procedures that manage partitions reduce run time.

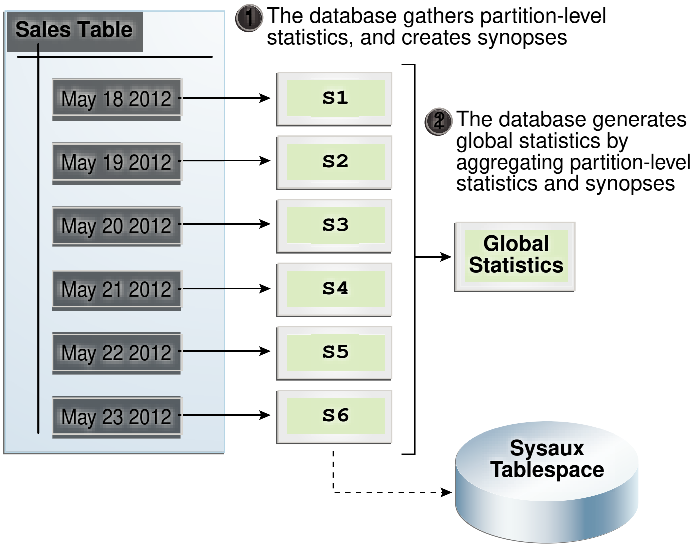
The `DBMS_STATS` preference `APPROXIMATE_NDV_ALGORITHM` determines which algorithm the database uses for NDV calculation.

> **See Also:**
>
> *Oracle Database PL/SQL Packages and Types Reference* to learn about the `APPROXIMATE_NDV_ALGORITHM` preference

Aggregation of Global Statistics Using Synopses: Example

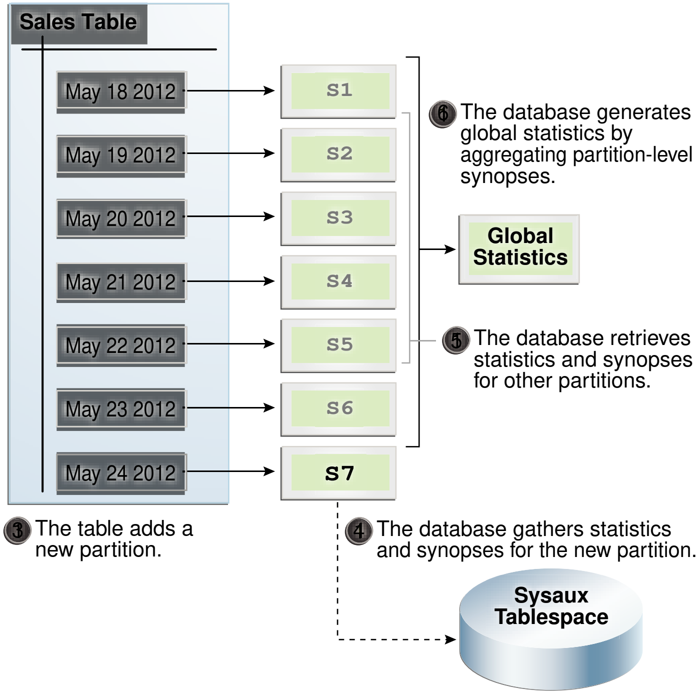
In this example, the database gathers statistics for the initial six partitions of the `sales` table, and then creates synopses for each partition (`S1`, `S2`, and so on). The database creates global statistics by aggregating the partition-level statistics and synopses.

Figure 13-2 Aggregating Statistics


Sales Table
May 18 2012
May 19 2012
May 20 2012
May 21 2012
May 22 2012
May 23 2012
S1
S2
S3
S4
S5
S6
1 The database gathers partition-level statistics, and creates synopses
2 The database generates global statistics by aggregating partition-level statistics and synopses
Global Statistics
Sysaux Tablespace

The following graphic shows a new partition, containing data for May 24, being added to the `sales` table. The database gathers statistics for the newly added partition, retrieves synopses for the other partitions, and then aggregates the synopses to create global statistics.

Figure 13-3 Aggregating Statistics after Adding a Partition


Sales Table
May 18 2012
May 19 2012
May 20 2012
May 21 2012
May 22 2012
May 23 2012
May 24 2012
S1
S2
S3
S4
S5
S6
S7
6 The database generates global statistics by aggregating partition-level synopses.
Global Statistics
5 The database retrieves statistics and synopses for other partitions.
3 The table adds a new partition.
4 The database gathers statistics and synopses for the new partition.
Sysaux Tablespace

Gathering Statistics for a Partitioned Table: Basic Steps

This section explains how to gather optimizer statistics for a partitioned table.

Considerations for Incremental Statistics Maintenance

Enabling incremental statistics maintenance has several consequences.

Specifically, note the following:

- If a table uses composite partitioning, then the database only gathers statistics for modified subpartitions. The database does not gather statistics at the subpartition level for unmodified subpartitions. In this way, the database reduces work by skipping unmodified partitions.
- If a table uses incremental statistics, and if this table has a locally partitioned index, then the database gathers index statistics at the global level and for modified (not unmodified) index partitions. The database does not generate global index statistics from the partition-level index statistics. Rather, the database gathers global index statistics by performing a full index scan.
- A hybrid partitioned table contains both internal and external partitions. For internal partitions only, DDL changes invoke incremental statistic maintenance on individual partitions and on the table itself. For example, if `june18` is an internal partition, then `ALTER TABLE ... MODIFY PARTITION jun18 ...` triggers incremental statistics maintenance during statistics collection; if `june18` is an external partition, however, then incremental maintenance does not occur.
- The `SYSAUX` tablespace consumes additional space to maintain global statistics for partitioned tables.

See Also:

- *Oracle Database VLDB and Partitioning Guide* to learn how to create hybrid partitioned tables
- *Oracle Database PL/SQL Packages and Types Reference* to learn more about `DBMS_STATS`

Enabling Incremental Statistics Using SET_TABLE_PREFS

To enable incremental statistics maintenance for a partitioned table, use `DBMS_STATS.SET_TABLE_PREFS` to set the `INCREMENTAL` value to `true`. When `INCREMENTAL` is set to `false`, which is the default, the database uses a full table scan to maintain global statistics.

For the database to update global statistics incrementally by scanning *only* the partitions that have changed, the following conditions must be met:

- The `PUBLISH` value for the partitioned table is `true`.
- The `INCREMENTAL` value for the partitioned table is `true`.
- The statistics gathering procedure must specify `AUTO_SAMPLE_SIZE` for `ESTIMATE_PERCENT` and `AUTO` for `GRANULARITY`.

Example 13-3 Enabling Incremental Statistics

Assume that the PUBLISH value for the partitioned table sh.sales is true. The following program enables incremental statistics for this table:

```
EXEC DBMS_STATS.SET_TABLE_PREFS('sh', 'sales', 'INCREMENTAL', 'TRUE');
```

About the APPROXIMATE_NDV_ALGORITHM Settings

The DBMS_STATS.APPROXIMATE_NDV_ALGORITHM preference specifies the synopsis generation algorithm, either HyperLogLog or adaptive sampling. The INCREMENTAL_STALENESS preference controls when the database reformats synopses that use the adaptive sampling format.

The APPROXIMATE_NDV_ALGORITHM preference has the following possible values:

- REPEAT OR HYPERLOGLOG

  This is the default. If INCREMENTAL is enabled on the table, then the database preserves the format of any existing synopses that use the adaptive sampling algorithm. However, the database creates any new synopses in HyperLogLog format. This approach is attractive when existing performance is acceptable, and you do not want to incur the performance cost of reformatting legacy content.

- ADAPTIVE SAMPLING

  The database uses the adaptive sampling algorithm for all synopses. This is the most conservative option.

- HYPERLOGLOG

  The database uses the HyperLogLog algorithm for all new and stale synopses.

The INCREMENTAL_STALENESS preference controls when a synopsis is considered stale. When the APPROXIMATE_NDV_ALGORITHM preference is set to HYPERLOGLOG, then the following INCREMENTAL_STALENESS settings apply:

- ALLOW_MIXED_FORMAT

  This is the default. If this value is specified, and if the following conditions are met, then the database does *not* consider existing adaptive sampling synopses as stale:

  - The synopses are fresh.
  - You gather statistics manually.

  Thus, synopses in both the legacy and HyperLogLog formats can co-exist. However, over time the automatic statistics gathering job regathers statistics on synopses that use the old format, and replaces them with synopses in HyperLogLog format. In this way, the automatic statistics gather job gradually phases out the old format. Manual statistics gathering jobs do not reformat synopses that use the adaptive sampling format.

- Null

  Any partitions with the synopses in the legacy format are considered stale, which *immediately* triggers the database to regather statistics for stale synopses. The advantage is that the performance cost occurs only once. The disadvantage is that regathering all statistics on large tables can be resource-intensive.

Configuring Synopsis Generation: Examples

These examples show different approaches, both conservative and aggressive, to switching synopses to the new HyperLogLog format.

Example 13-4 Taking a Conservative Approach to Reformatting Synopses

In this example, you allow synopses in mixed formats to coexist for the sh.sales table. Mixed formats yield less accurate statistics. However, you do *not* need to regather statistics for all partitions of the table.

To ensure that all new and stale synopses use the HyperLogLog algorithm, set the APPROXIMATE_NDV_ALGORITHM preference to HYPERLOGLOG. To ensure that the automatic statistics gathering job reformats stale synopses gradually over time, set the INCREMENTAL_STALENESS preference to ALLOW_MIXED_FORMAT.

```
BEGIN
  DBMS_STATS.SET_TABLE_PREFS
    (   ownname => 'sh'
    ,   tabname => 'sales'
    ,   pname   => 'approximate_ndv_algorithm'
    ,   pvalue  => 'hyperloglog' );

  DBMS_STATS.SET_TABLE_PREFS
    (  ownname  => 'sh'
    ,  tabname  => 'sales'
    ,  pname    => 'incremental_staleness'
    ,  pvalue   => 'allow_mixed_format' );
END;
```

Example 13-5 Taking an Aggressive Approach to Reformatting Synopses

In this example, you force all synopses to use the HyperLogLog algorithm for the sh.sales table. In this case, the database must regather statistics for all partitions of the table.

To ensure that all new and stale synopses use the HyperLogLog algorithm, set the APPROXIMATE_NDV_ALGORITHM preference to HYPERLOGLOG. To force the database to immediately regather statistics for all partitions in the table and store them in the new format, set the INCREMENTAL_STALENESS preference to null.

```
BEGIN
  DBMS_STATS.SET_TABLE_PREFS
    (   ownname => 'sh'
    ,   tabname => 'sales'
    ,   pname   => 'approximate_ndv_algorithm'
    ,   pvalue  => 'hyperloglog' );

  DBMS_STATS.SET_TABLE_PREFS
    (  ownname  => 'sh'
    ,  tabname  => 'sales'
    ,  pname    => 'incremental_staleness'
    ,  pvalue   => 'null' );
END;
```

Maintaining Incremental Statistics for Partition Maintenance Operations

A **partition maintenance operation** is a partition-related operation such as adding, exchanging, merging, or splitting table partitions.

Oracle Database provides the following support for incremental statistics maintenance:

- If a partition maintenance operation triggers statistics gathering, then the database can reuse synopses that would previously have been dropped with the old segments.
- DBMS_STATS can create a synopsis on a nonpartitioned table. The synopsis enables the database to maintain incremental statistics as part of a partition exchange operation without having to explicitly gather statistics on the partition after the exchange.

When the DBMS_STATS preference INCREMENTAL is set to true on a table, the INCREMENTAL_LEVEL preference controls which synopses are collected and when. This preference takes the following values:

- TABLE

  DBMS_STATS gathers table-level synopses on this table. You can only set INCREMENTAL_LEVEL to TABLE at the table level, not at the schema, database, or global level.
- PARTITION (default)

  DBMS_STATS only gathers synopsis at the partition level of partitioned tables.

When performing a partition exchange, to have synopses after the exchange for the partition being exchanged, set INCREMENTAL to true and INCREMENTAL_LEVEL to TABLE on the table to be exchanged with the partition.

Assumptions

This tutorial assumes the following:

- You want to load empty partition p_sales_01_2010 in a sales table.
- You create a staging table t_sales_01_2010, and then populate the table.
- You want the database to maintain incremental statistics as part of the partition exchange operation without having to explicitly gather statistics on the partition after the exchange.

To maintain incremental statistics as part of a partition exchange operation:

1. Set incremental statistics preferences for staging table t_sales_01_2010.

   For example, run the following statement:

   ```
   BEGIN
     DBMS_STATS.SET_TABLE_PREFS (
         ownname  =>  'sh'
   ,     tabname  =>  't_sales_01_2010'
   ,     pname    =>  'INCREMENTAL'
   ,     pvalue   =>  'true'
   );
     DBMS_STATS.SET_TABLE_PREFS (
         ownname  =>  'sh'
   ,     tabname  =>  't_sales_01_2010'
   ,     pname    =>  'INCREMENTAL_LEVEL'
   ,     pvalue   =>  'table'
   );
   END;
   ```

2. Gather statistics on staging table t_sales_01_2010.

For example, run the following PL/SQL code:

```
BEGIN
  DBMS_STATS.GATHER_TABLE_STATS (
      ownname  => 'SH'
,     tabname  => 'T_SALES_01_2010'
);
END;
/
```

`DBMS_STATS` gathers table-level synopses on `t_sales_01_2010`.

3. Ensure that the `INCREMENTAL` preference is `true` on the `sh.sales` table.

   For example, run the following PL/SQL code:

   ```
   BEGIN
     DBMS_STATS.SET_TABLE_PREFS (
         ownname  =>  'sh'
   ,     tabname  =>  'sales'
   ,     pname    =>  'INCREMENTAL'
   ,     pvalue   =>  'true'
   );
   END;
   /
   ```

4. If you have never gathered statistics on `sh.sales` before with `INCREMENTAL` set to `true`, then gather statistics on the partition to be exchanged.

   For example, run the following PL/SQL code:

   ```
   BEGIN
     DBMS_STATS.GATHER_TABLE_STATS (
         ownname  =>  'sh'
   ,     tabname  =>  'sales'
   ,     pname    =>  'p_sales_01_2010'
   ,     pvalue   =>  granularity=>'partition'
   );
   END;
   /
   ```

5. Perform the partition exchange.

   For example, use the following SQL statement:

   ```
   ALTER TABLE sales EXCHANGE PARTITION p_sales_01_2010 WITH TABLE
   t_sales_01_2010;
   ```

   After the exchange, the partitioned table has both statistics and a synopsis for partition `p_sales_01_2010`.

   In releases before Oracle Database 12c, the preceding statement swapped the segment data and statistics of `p_sales_01_2010` with `t_sales_01_2010`. The database did not maintain synopses for nonpartitioned tables such as `t_sales_01_2010`. To gather global statistics on the partitioned table, you needed to rescan the `p_sales_01_2010` partition to obtain its synopses.

See Also:

Oracle Database PL/SQL Packages and Types Reference to learn more about `DBMS_STATS.SET_TABLE_PREFS`

Maintaining Incremental Statistics for Tables with Stale or Locked Partition Statistics

Starting in Oracle Database 12c, incremental statistics can automatically calculate global statistics for a partitioned table even if the partition or subpartition statistics are stale and locked.

When incremental statistics are enabled in releases before Oracle Database 12c, if any DML occurs on a partition, then the optimizer considers statistics on this partition to be stale. Thus, `DBMS_STATS` must gather the statistics again to accurately aggregate the global statistics. Furthermore, if DML occurs on a partition whose statistics are locked, then `DBMS_STATS` cannot regather the statistics on the partition, so a full table scan is the only means of gathering global statistics. Regathering statistics creates performance overhead.

In Oracle Database 12c, the statistics preference `INCREMENTAL_STALENESS` controls how the database determines whether the statistics on a partition or subpartition are stale. This preference takes the following values:

- `USE_STALE_PERCENT`

  A partition or subpartition is not considered stale if DML changes are less than the `STALE_PERCENT` preference specified for the table. The default value of `STALE_PERCENT` is `10`, which means that if DML causes more than 10% of row changes, then the table is considered stale.

- `USE_LOCKED_STATS`

  Locked partition or subpartition statistics are not considered stale, regardless of DML changes.

- `NULL` (default)

  A partition or subpartition is considered stale if it has any DML changes. This behavior is identical to the Oracle Database 11g behavior. When the default value is used, statistics gathered in incremental mode are guaranteed to be the same as statistics gathered in nonincremental mode. When a nondefault value is used, statistics gathered in incremental mode might be less accurate than those gathered in nonincremental mode.

You can specify `USE_STALE_PERCENT` and `USE_LOCKED_STATS` together. For example, you can write the following anonymous block:

```
BEGIN
  DBMS_STATS.SET_TABLE_PREFS (
    ownname     => null
,   table_name  => 't'
,   pname       => 'incremental_staleness'
,   pvalue      => 'use_stale_percent,use_locked_stats'
);
END;
```

Assumptions

This tutorial assumes the following:

- The STALE_PERCENT for a partitioned table is set to 10.
- The INCREMENTAL value is set to true.
- The table has had statistics gathered in INCREMENTAL mode before.
- You want to discover how statistics gathering changes depending on the setting for INCREMENTAL_STALENESS, whether the statistics are locked, and the percentage of DML changes.

To test for tables with stale or locked partition statistics:

1. Set INCREMENTAL_STALENESS to NULL.

   Afterward, 5% of the rows in one partition change because of DML activity.

2. Use DBMS_STATS to gather statistics on the table.

   DBMS_STATS regathers statistics for the partition that had the 5% DML activity, and incrementally maintains the global statistics.

3. Set INCREMENTAL_STALENESS to USE_STALE_PERCENT.

   Afterward, 5% of the rows in one partition change because of DML activity.

4. Use DBMS_STATS to gather statistics on the table.

   DBMS_STATS does *not* regather statistics for the partition that had DML activity (because the changes are under the staleness threshold of 10%), and incrementally maintains the global statistics.

5. Lock the partition statistics.

   Afterward, 20% of the rows in one partition change because of DML activity.

6. Use DBMS_STATS to gather statistics on the table.

   DBMS_STATS does *not* regather statistics for the partition because the statistics are locked. The database gathers the global statistics with a full table scan.

   Afterward, 5% of the rows in one partition change because of DML activity.

7. Use DBMS_STATS to gather statistics on the table.

   When you gather statistics on this table, DBMS_STATS does not regather statistics for the partition because they are not considered stale. The database maintains global statistics incrementally using the existing statistics for this partition.

8. Set INCREMENTAL_STALENESS to USE_LOCKED_STATS and USE_STALE_PERCENT.

   Afterward, 20% of the rows in one partition change because of DML activity.

9. Use DBMS_STATS to gather statistics on the table.

   Because USE_LOCKED_STATS is set, DBMS_STATS ignores the fact that the statistics are stale and uses the locked statistics. The database maintains global statistics incrementally using the existing statistics for this partition.

See Also:

Oracle Database PL/SQL Packages and Types Reference to learn more about `DBMS_STATS.SET_TABLE_PREFS`

Gathering System Statistics Manually

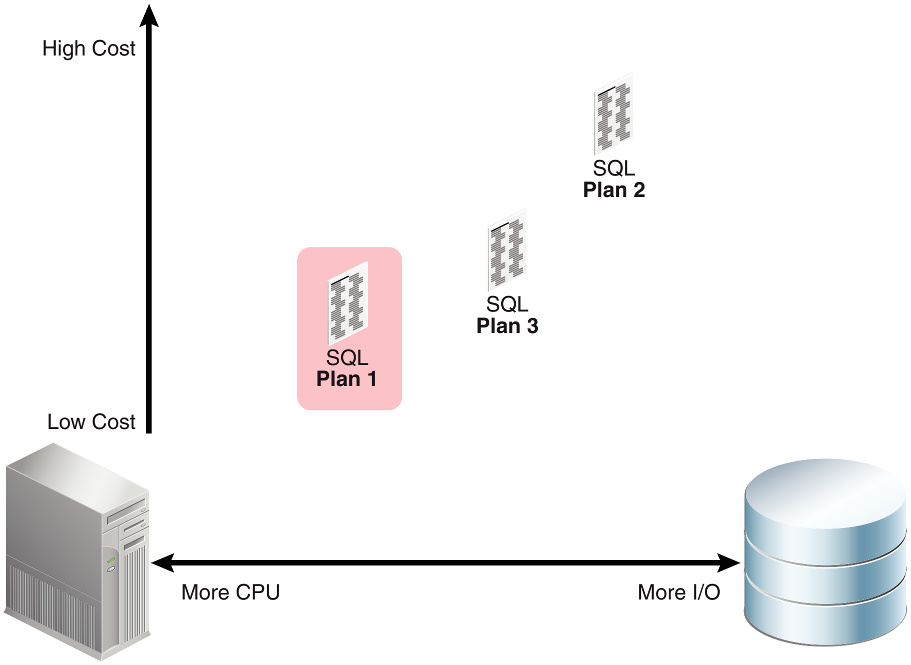
System statistics describe hardware characteristics, such as I/O and CPU performance and utilization, to the optimizer.

About System Statistics

System statistics measure the performance of CPU and storage so that the optimizer can use these inputs when evaluating plans.

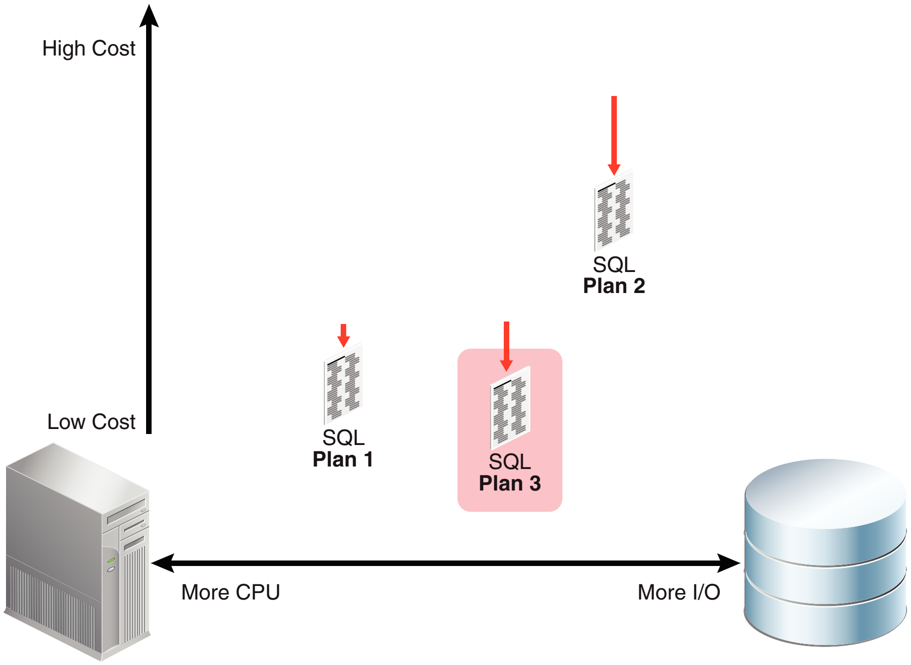
When a query executes, it consumes CPU. In many cases, a query also consumes storage subsystem resources. Each plan in a typical query may consume a different proportion of CPU and I/O. Using the cost metric, the optimizer chooses the plan that it estimates will execute most quickly. If the optimizer knows the speed of CPU and storage, then it can make finer judgments about the cost of each alternative plan.

The following figure shows a query that has three possible plans. Each plan uses different amounts of CPU and I/O. For the sake of this example, the optimizer has assigned Plan 1 the lowest cost.



The database automatically gathers essential system statistics, called noworkload statistics, at the first instance startup. Typically, these characteristics only change when some aspect of the hardware configuration is upgraded.

The following figure shows the same database after adding high-performance storage. Gathering system statistics enables the optimizer to take the storage performance into account. In this example, the high-performance storage lowers the relative cost of Plan 2 and Plan 3 significantly. Plan 1 shows only marginal improvement because it uses less I/O. Plan 3 has now been assigned the lowest cost.



On systems with fast I/O infrastructure, system statistics increase the probability that queries choose table scans over index access methods.

Guidelines for Gathering System Statistics

Unless there is a good reason to gather manually, Oracle recommends using the defaults for system statistics.

System statistics are important for performance because they affect *every* SQL statement executed in the database. Changing system statistics may change SQL execution plans, perhaps in unexpected or unwanted ways. For this reason, Oracle recommends considering the options carefully before changing system statistics.

When to Consider Gathering System Statistics Manually

If you are using Oracle Exadata, and if the database is running a pure data warehouse load, then gathering system statistics using the `EXADATA` option can help performance in some cases because table scans are more strongly favored. However, even on Exadata, the defaults are best for most workloads.

If you are not using Oracle Exadata, and if you choose to gather system statistics manually, then Oracle recommends the following:

- Gather system statistics when a physical change occurs in your environment, for example, the server gets faster CPUs, more memory, or different disk storage. Oracle recommends that you gather noworkload statistics after you create new tablespaces on storage that is not used by any other tablespace.
- Capture statistics when the system has the most common workload. Gathering workload statistics does not generate additional overhead.

When to Consider Using Default Statistics

Oracle recommends using the defaults for system statistics in most cases. To reset system statistics to their default values, execute `DBMS_STATS.DELETE_SYSTEM_STATS`, and then shut down and reopen the database. To ensure that appropriate defaults are used, this step is also recommended on a newly created database.

Gathering System Statistics with DBMS_STATS

To gather system statistics manually, use the `DBMS_STATS.GATHER_SYSTEM_STATS` procedure.

About the GATHER_SYSTEM_STATS Procedure

The `DBMS_STATS.GATHER_SYSTEM_STATS` procedure analyzes activity in a specified time period (**workload statistics**) or simulates a workload (**noworkload statistics**).

The input arguments to `DBMS_STATS.GATHER_SYSTEM_STATS` are:

- `NOWORKLOAD`

  The optimizer gathers statistics based on system characteristics only, without regard to the workload.

- `INTERVAL`

  After the specified number of minutes has passed, the optimizer updates system statistics either in the data dictionary, or in an alternative table (specified by `stattab`). Statistics are based on system activity during the specified interval.

- `START` and `STOP`

  `START` initiates gathering statistics. `STOP` calculates statistics for the elapsed period (since `START`) and refreshes the data dictionary or an alternative table (specified by `stattab`). The optimizer ignores `INTERVAL`.

- `EXADATA`

  The system statistics consider the unique capabilities provided by using Exadata, such as large I/O size and high I/O throughput. The optimizer sets the multiblock read count and I/O throughput statistics along with CPU speed.

The following table lists the optimizer system statistics gathered by `DBMS_STATS` and the options for gathering or manually setting specific system statistics.

Table 13-4 Optimizer System Statistics in the DBMS_STATS Package

Parameter Name	Description	Initialization	Options for Gathering or Setting Statistics	Unit
`cpuspeedNW`	Represents noworkload CPU speed. CPU speed is the average number of CPU cycles in each second.	At system startup	Set `gathering_mode` = `NOWORKLOAD` or set statistics manually.	millions/s

Table 13-4 (Cont.) Optimizer System Statistics in the DBMS_STATS Package

Parameter Name	Description	Initialization	Options for Gathering or Setting Statistics	Unit
`ioseektim`	Represents the time it takes to position the disk head to read data. I/O seek time equals seek time + latency time + operating system overhead time.	At system startup 10 (default)	Set `gathering_mode` = `NOWORKLOAD` or set statistics manually.	ms
`iotfrspeed`	Represents the rate at which an Oracle database can read data in the single read request.	At system startup 4096 (default)	Set `gathering_mode` = `NOWORKLOAD` or set statistics manually.	bytes/ms
`cpuspeed`	Represents workload CPU speed. CPU speed is the average number of CPU cycles in each second.	None	Set `gathering_mode` = `NOWORKLOAD`, `INTERVAL`, or `START|STOP`, or set statistics manually.	millions/s
`maxthr`	Maximum I/O throughput is the maximum throughput that the I/O subsystem can deliver.	None	Set `gathering_mode` = `NOWORKLOAD`, `INTERVAL`, or `START|STOP`, or set statistics manually.	bytes/s
`slavethr`	Secondary I/O throughput is the average parallel execution server I/O throughput.	None	Set `gathering_mode` = `INTERVAL` or `START|STOP`, or set statistics manually.	bytes/s
`sreadtim`	Single-block read time is the average time to read a single block randomly.	None	Set `gathering_mode` = `INTERVAL` or `START|STOP`, or set statistics manually.	ms
`mreadtim`	Multiblock read is the average time to read a multiblock sequentially.	None	Set `gathering_mode` = `INTERVAL` or `START|STOP`, or set statistics manually.	ms
`mbrc`	Multiblock count is the average multiblock read count sequentially.	None	Set `gathering_mode` = `INTERVAL` or `START|STOP`, or set statistics manually.	blocks

See Also:

Oracle Database PL/SQL Packages and Types Reference for detailed information on the procedures in the `DBMS_STATS` package for gathering and deleting system statistics

Gathering Workload Statistics

Oracle recommends that you use DBMS_STATS.GATHER_SYSTEM_STATS to capture statistics when the database has the most typical workload.

About Workload Statistics

Workload statistics analyze activity in a specified time period.

Workload statistics include the following statistics listed in Table 13-4:

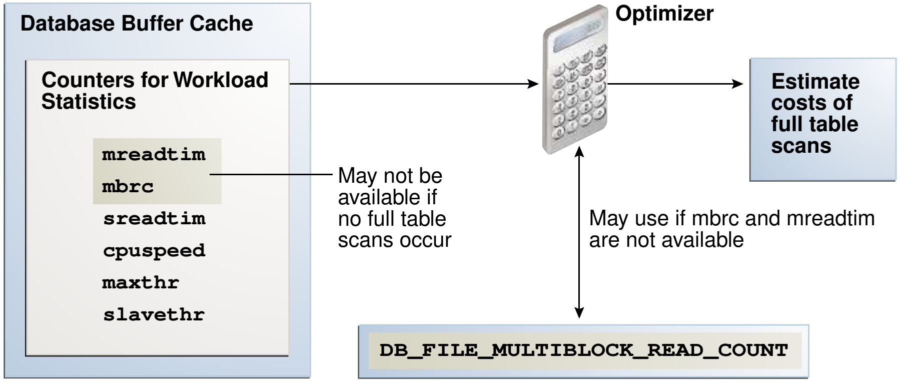
- Single block (sreadtim) and multiblock (mreadtim) read times
- Multiblock count (mbrc)
- CPU speed (cpuspeed)
- Maximum system throughput (maxthr)
- Average parallel execution throughput (slavethr)

The database computes sreadtim, mreadtim, and mbrc by comparing the number of physical sequential and random reads between two points in time from the beginning to the end of a workload. The database implements these values through counters that change when the buffer cache completes synchronous read requests.

Because the counters are in the buffer cache, they include not only I/O delays, but also waits related to latch contention and task switching. Thus, workload statistics depend on system activity during the workload window. If system is I/O bound (both latch contention and I/O throughput), then the statistics promote a less I/O-intensive plan after the database uses the statistics.

As shown in Figure 13-4, if you gather workload statistics, then the optimizer uses the mbrc value gathered for workload statistics to estimate the cost of a full table scan.

Figure 13-4 Workload Statistics Counters


Database Buffer Cache
Counters for Workload Statistics
mreadtim
mbrc
sreadtim
cpuspeed
maxthr
slavethr
May not be available if no full table scans occur
Optimizer
Estimate costs of full table scans
May use if mbrc and mreadtim are not available
DB_FILE_MULTIBLOCK_READ_COUNT

When gathering workload statistics, the database may not gather the mbrc and mreadtim values if no table scans occur during serial workloads, as is typical of OLTP systems. However, full table scans occur frequently on DSS systems. These scans may run parallel and bypass the buffer cache. In such cases, the database still gathers the sreadtim because index lookups use the buffer cache.

If the database cannot gather or validate gathered `mbrc` or `mreadtim` values, but has gathered `sreadtim` and `cpuspeed`, then the database uses only `sreadtim` and `cpuspeed` for costing. In this case, the optimizer uses the value of the initialization parameter `DB_FILE_MULTIBLOCK_READ_COUNT` to cost a full table scan. However, if `DB_FILE_MULTIBLOCK_READ_COUNT` is `0` or is not set, then the optimizer uses a value of `8` for calculating cost.

Use the `DBMS_STATS.GATHER_SYSTEM_STATS` procedure to gather workload statistics. The `GATHER_SYSTEM_STATS` procedure refreshes the data dictionary or a staging table with statistics for the elapsed period. To set the duration of the collection, use either of the following techniques:

- Specify `START` the beginning of the workload window, and then `STOP` at the end of the workload window.
- Specify `INTERVAL` and the number of minutes before statistics gathering automatically stops. If needed, you can use `GATHER_SYSTEM_STATS (gathering_mode=>'STOP')` to end gathering earlier than scheduled.

> **See Also:**
>
> *Oracle Database Reference* to learn about the `DB_FILE_MULTIBLOCK_READ_COUNT` initialization parameter

Starting and Stopping System Statistics Gathering

This tutorial explains how to set the workload interval with the `START` and `STOP` parameters of `GATHER_SYSTEM_STATS`.

Assumptions

This tutorial assumes the following:

- The hour between 10 a.m. and 11 a.m. is representative of the daily workload.
- You intend to collect system statistics directly in the data dictionary.

To gather workload statistics using START and STOP:

1. Start SQL*Plus and connect to the database with administrator privileges.
2. Start statistics collection.

   For example, at 10 a.m., execute the following procedure to start collection:

   ```
   EXECUTE DBMS_STATS.GATHER_SYSTEM_STATS( gathering_mode => 'START' );
   ```

3. Generate the workload.
4. End statistics collection.

   For example, at 11 a.m., execute the following procedure to end collection:

   ```
   EXECUTE DBMS_STATS.GATHER_SYSTEM_STATS( gathering_mode => 'STOP' );
   ```

The optimizer can now use the workload statistics to generate execution plans that are effective during the normal daily workload.

5. Optionally, query the system statistics.

   For example, run the following query:

   ```
   COL PNAME FORMAT a15
   SELECT PNAME, PVAL1
   FROM   SYS.AUX_STATS$
   WHERE  SNAME = 'SYSSTATS_MAIN';
   ```

> **See Also:**
>
> *Oracle Database PL/SQL Packages and Types Reference* to learn about the `DBMS_STATS.GATHER_SYSTEM_STATS` procedure

Gathering System Statistics During a Specified Interval

This tutorial explains how to set the workload interval with the `INTERVAL` parameter of `GATHER_SYSTEM_STATS`.

Assumptions

This tutorial assumes the following:

- The database application processes OLTP transactions. To gather representative statistics, you collect them during the day for two hours and then at night for two hours.
- You want to store statistics in a table named `workload_stats`.
- You intend to switch between the statistics gathered.

To gather workload statistics using INTERVAL:

1. Start SQL*Plus and connect to the production database as administrator `dba1`.
2. Create a table to hold the production statistics.

   For example, execute the following PL/SQL program to create user statistics table `workload_stats`:

   ```
   BEGIN
     DBMS_STATS.CREATE_STAT_TABLE (
         ownname  =>  'dba1'
   ,     stattab  =>  'workload_stats'
   );
   END;
   /
   ```

3. Ensure that `JOB_QUEUE_PROCESSES` is not `0` so that `DBMS_JOB` jobs and Oracle Scheduler jobs run.

   ```
   ALTER SYSTEM SET JOB_QUEUE_PROCESSES = 1;
   ```

4. Gather statistics.

For example, gather statistics for two hours with the following program:

```
BEGIN
  DBMS_STATS.GATHER_SYSTEM_STATS (
      interval  =>  120
,     stattab   => 'workload_stats'
,     statid    => 'OLTP'
);
END;
/
```

5. Import the appropriate statistics into the data dictionary.

   For example::

```
BEGIN
  DBMS_STATS.IMPORT_SYSTEM_STATS (
      stattab  =>  'workload_stats'
,     statid   =>  'OLTP'
);
END;
/
```

See Also:

Oracle Database PL/SQL Packages and Types Reference to learn about the DBMS_STATS.GATHER_SYSTEM_STATS procedure

Gathering Noworkload Statistics

Noworkload statistics capture characteristics of the I/O system.

By default, Oracle Database uses noworkload statistics and the CPU cost model. The values of noworkload statistics are initialized to defaults at the first instance startup. You can also use the DBMS_STATS.GATHER_SYSTEM_STATS procedure to gather noworkload statistics manually.

Noworkload statistics include the following system statistics listed in Table 13-4:

- I/O transfer speed (iotfrspeed)
- I/O seek time (ioseektim)
- CPU speed (cpuspeednw)

The major difference between workload statistics and noworkload statistics is in the gathering method. Noworkload statistics gather data by submitting random reads against all data files, whereas workload statistics uses counters updated when database activity occurs. If you gather workload statistics, then Oracle Database uses them instead of noworkload statistics.

To gather noworkload statistics, run DBMS_STATS.GATHER_SYSTEM_STATS with no arguments or with the gathering mode set to noworkload. There is an overhead on the I/O system during the gathering process of noworkload statistics. The gathering process may take from a few seconds to several minutes, depending on I/O performance and database size.

When you gather noworkload statistics, the database analyzes the information and verifies it for consistency. In some cases, the values of noworkload statistics may retain their default values. You can either gather the statistics again, or use `SET_SYSTEM_STATS` to set the values manually to the I/O system specifications.

Assumptions

This tutorial assumes that you want to gather noworkload statistics manually.

To gather noworkload statistics manually:

1. Start SQL*Plus and connect to the database with administrator privileges.
2. Gather the noworkload statistics.

   For example, run the following statement:

   ```
   BEGIN
     DBMS_STATS.GATHER_SYSTEM_STATS (
       gathering_mode => 'NOWORKLOAD'
   );
   END;
   ```

3. Optionally, query the system statistics.

   For example, run the following query:

   ```
   COL PNAME FORMAT a15

   SELECT PNAME, PVAL1
   FROM   SYS.AUX_STATS$
   WHERE  SNAME = 'SYSSTATS_MAIN';
   ```

> **See Also:**
>
> *Oracle Database PL/SQL Packages and Types Reference* to learn about the `DBMS_STATS.GATHER_SYSTEM_STATS` procedure

Deleting System Statistics

The `DBMS_STATS.DELETE_SYSTEM_STATS` procedure deletes system statistics.

This procedure deletes workload statistics collected using the `INTERVAL` or `START` and `STOP` options, and then resets the default to noworkload statistics. However, if the `stattab` parameter specifies a table for storing statistics, then the subprogram deletes all system statistics with the associated `statid` from the statistics table.

If the database is newly created, then Oracle recommends deleting system statistics, shutting down the database, and then reopening the database. This sequence of steps ensures that the database establishes appropriate defaults for system statistics.

Assumptions

This tutorial assumes the following:

- You gathered statistics for a specific intensive workload, but no longer want the optimizer to use these statistics.

- You stored workload statistics in the default location, not in a user-specified table.

To delete system statistics:

1. In SQL*Plus, log in to the database as a user with administrative privileges.
2. Delete the system statistics.

   For example, run the following statement:

   ```
   EXEC DBMS_STATS.DELETE_SYSTEM_STATS;
   ```

> **See Also:**
>
> *Oracle Database PL/SQL Packages and Types Reference* to learn about the DBMS_STATS.DELETE_SYSTEM_STATS procedure

Running Statistics Gathering Functions in Reporting Mode

You can run the DBMS_STATS statistics gathering procedures in reporting mode.

When you use the REPORT_* procedures, the optimizer does not actually gather statistics. Rather, the package reports objects that *would* be processed if you were to use a specified statistics gathering function.

The following table lists the DBMS_STATS.REPORT_GATHER_*_STATS functions. For all functions, the input parameters are the same as for the corresponding GATHER_*_STATS procedure, with the following additional parameters: detail_level and format. Supported formats are XML, HTML, and TEXT.

Table 13-5 DBMS_STATS Reporting Mode Functions

Function	Description
REPORT_GATHER_TABLE_STATS	Runs GATHER_TABLE_STATS in reporting mode. The procedure does not collect statistics, but reports all objects that would be affected by invoking GATHER_TABLE_STATS.
REPORT_GATHER_SCHEMA_STATS	Runs GATHER_SCHEMA_STATS in reporting mode. The procedure does not actually collect statistics, but reports all objects that would be affected by invoking GATHER_SCHEMA_STATS.
REPORT_GATHER_DICTIONARY_STATS	Runs GATHER_DICTIONARY_STATS in reporting mode. The procedure does not actually collect statistics, but reports all objects that would be affected by invoking GATHER_DICTIONARY_STATS.
REPORT_GATHER_DATABASE_STATS	Runs GATHER_DATABASE_STATS in reporting mode. The procedure does not actually collect statistics, but reports all objects that would be affected by invoking GATHER_DATABASE_STATS.

Table 13-5 (Cont.) DBMS_STATS Reporting Mode Functions

Function	Description
REPORT_GATHER_FIXED_OBJ_STATS	Runs GATHER_FIXED_OBJ_STATS in reporting mode. The procedure does not actually collect statistics, but reports all objects that would be affected by invoking GATHER_FIXED_OBJ_STATS.
REPORT_GATHER_AUTO_STATS	Runs the automatic statistics gather job in reporting mode. The procedure does not actually collect statistics, but reports all objects that would be affected by running the job.

Assumptions

This tutorial assumes that you want to generate an HTML report of the objects that would be affected by running GATHER_SCHEMA_STATS on the oe schema.

To report on objects affected by running GATHER_SCHEMA_STATS:

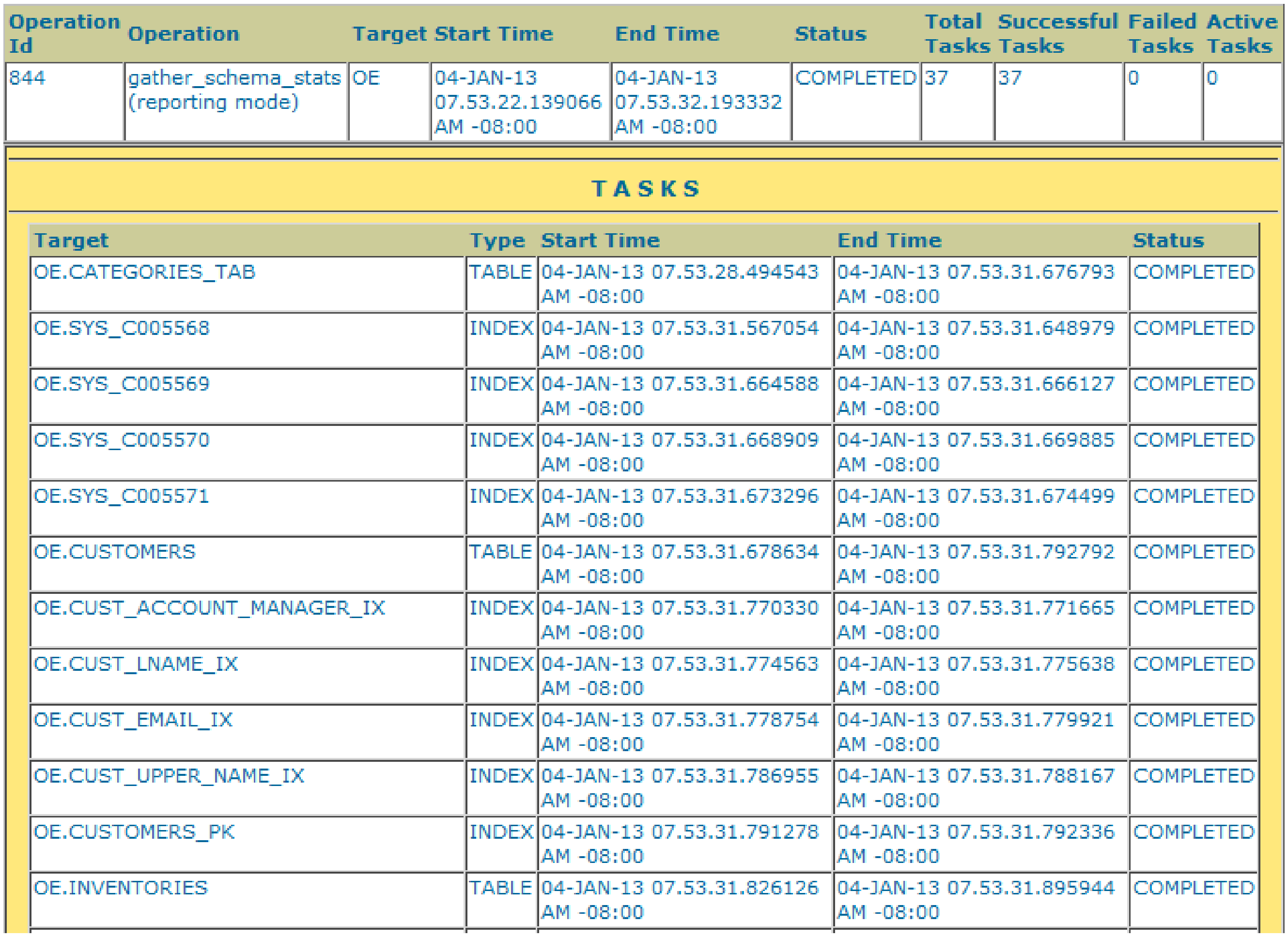
1. Start SQL*Plus and connect to the database with administrator privileges.
2. Run the DBMS_STATS.REPORT_GATHER_SCHEMA_STATS function.

   For example, run the following commands in SQL*Plus:

```
SET LINES 200 PAGES 0
SET LONG 100000
COLUMN REPORT FORMAT A200

VARIABLE my_report CLOB;
BEGIN
  :my_report :=DBMS_STATS.REPORT_GATHER_SCHEMA_STATS(
    ownname      => 'OE'       ,
    detail_level => 'TYPICAL'  ,
    format       => 'HTML'     );
END;
/
```

The following graphic shows a partial example report:



Operation Id	Operation	Target	Start Time	End Time	Status	Total Tasks	Successful Tasks	Failed Tasks	Active Tasks
844	gather_schema_stats (reporting mode)	OE	04-JAN-13 07.53.22.139066 AM -08:00	04-JAN-13 07.53.32.193332 AM -08:00	COMPLETED	37	37	0	0

TASKS

Target	Type	Start Time	End Time	Status
OE.CATEGORIES_TAB	TABLE	04-JAN-13 07.53.28.494543 AM -08:00	04-JAN-13 07.53.31.676793 AM -08:00	COMPLETED
OE.SYS_C005568	INDEX	04-JAN-13 07.53.31.567054 AM -08:00	04-JAN-13 07.53.31.648979 AM -08:00	COMPLETED
OE.SYS_C005569	INDEX	04-JAN-13 07.53.31.664588 AM -08:00	04-JAN-13 07.53.31.666127 AM -08:00	COMPLETED
OE.SYS_C005570	INDEX	04-JAN-13 07.53.31.668909 AM -08:00	04-JAN-13 07.53.31.669885 AM -08:00	COMPLETED
OE.SYS_C005571	INDEX	04-JAN-13 07.53.31.673296 AM -08:00	04-JAN-13 07.53.31.674499 AM -08:00	COMPLETED
OE.CUSTOMERS	TABLE	04-JAN-13 07.53.31.678634 AM -08:00	04-JAN-13 07.53.31.792792 AM -08:00	COMPLETED
OE.CUST_ACCOUNT_MANAGER_IX	INDEX	04-JAN-13 07.53.31.770330 AM -08:00	04-JAN-13 07.53.31.771665 AM -08:00	COMPLETED
OE.CUST_LNAME_IX	INDEX	04-JAN-13 07.53.31.774563 AM -08:00	04-JAN-13 07.53.31.775638 AM -08:00	COMPLETED
OE.CUST_EMAIL_IX	INDEX	04-JAN-13 07.53.31.778754 AM -08:00	04-JAN-13 07.53.31.779921 AM -08:00	COMPLETED
OE.CUST_UPPER_NAME_IX	INDEX	04-JAN-13 07.53.31.786955 AM -08:00	04-JAN-13 07.53.31.788167 AM -08:00	COMPLETED
OE.CUSTOMERS_PK	INDEX	04-JAN-13 07.53.31.791278 AM -08:00	04-JAN-13 07.53.31.792336 AM -08:00	COMPLETED
OE.INVENTORIES	TABLE	04-JAN-13 07.53.31.826126 AM -08:00	04-JAN-13 07.53.31.895944 AM -08:00	COMPLETED

See Also:

Oracle Database PL/SQL Packages and Types Reference to learn more about `DBMS_STATS`