



Integrated Cloud Applications & Platform Services

## Oracle Database 12c R2: SQL Tuning for Developers

Activity Guide

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## **Practices for Lesson 1: Course Introduction**

## Practices for Lesson 1

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There are no practices for lesson 1.

## **Practices for Lesson 2: Introduction to SQL Tuning**

## Practices for Lesson 2: Overview

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### Practices Overview

This practice covers using SQL Developer.

## Practice 2: Using SQL Developer

### Overview

In this practice, you get acquainted with SQL Developer functions.

### Tasks

1. Start Oracle SQL Developer.

Double-click the Oracle SQL Developer icon on your desktop.



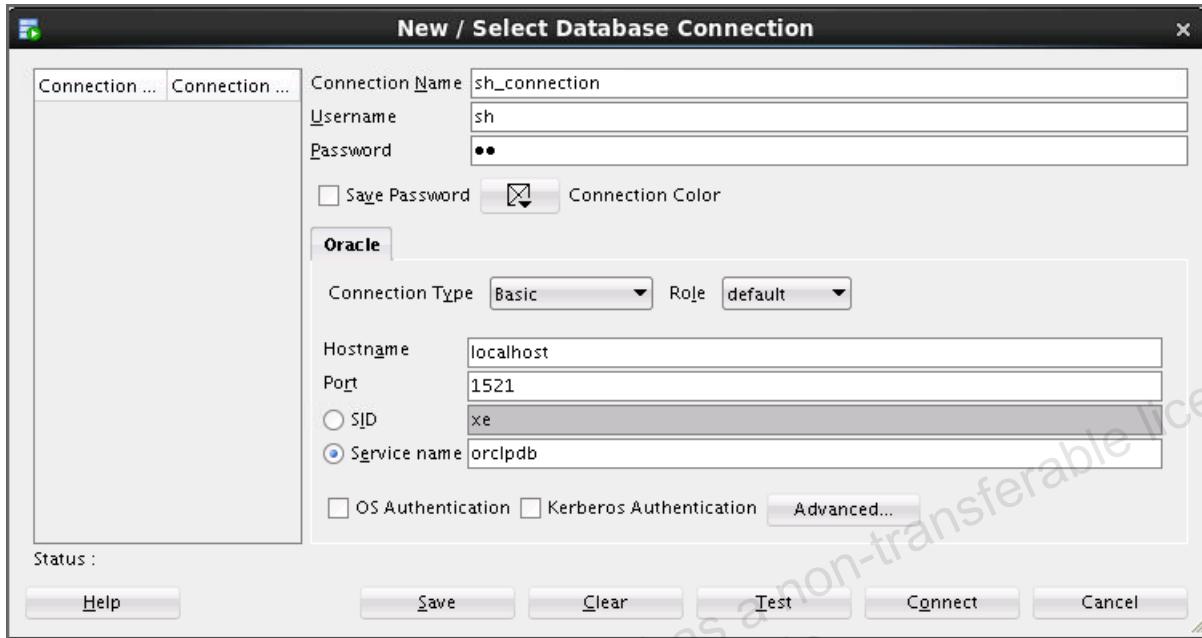
2. Create a database connection to the SH schema by using the following information:

a. Connection Name	b. sh_connection
c. Username	d. sh
e. Password	f. sh
g. Hostname	h. localhost
i. Port	j. 1521
k. SID	l. orclpdb

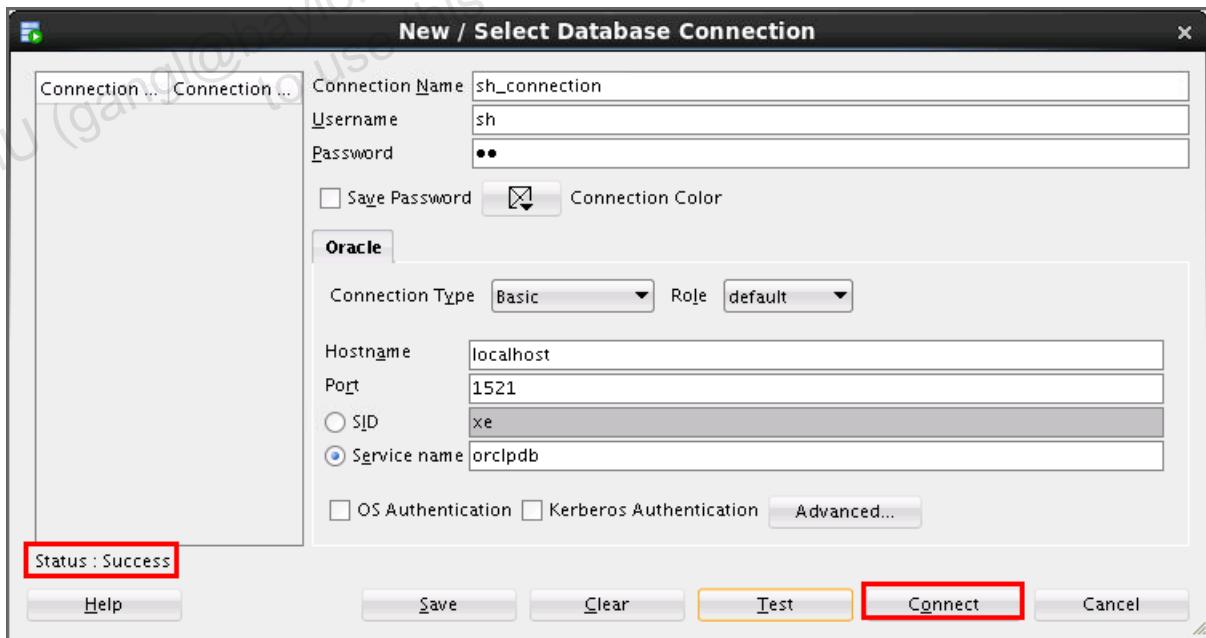
Right-click the Connections icon on the Connections tabbed page, and then select **New Connection** from the shortcut menu. The **New / Select Database Connection Window** appears. Use the preceding information to create the new database connection.

**Note:** To display the properties of the newly created connection, right-click the connection name, and then select Properties from the shortcut menu. Enter the username, password, host name, and service name with the appropriate information, as provided in the table. Select the “**Save Password**” check box.

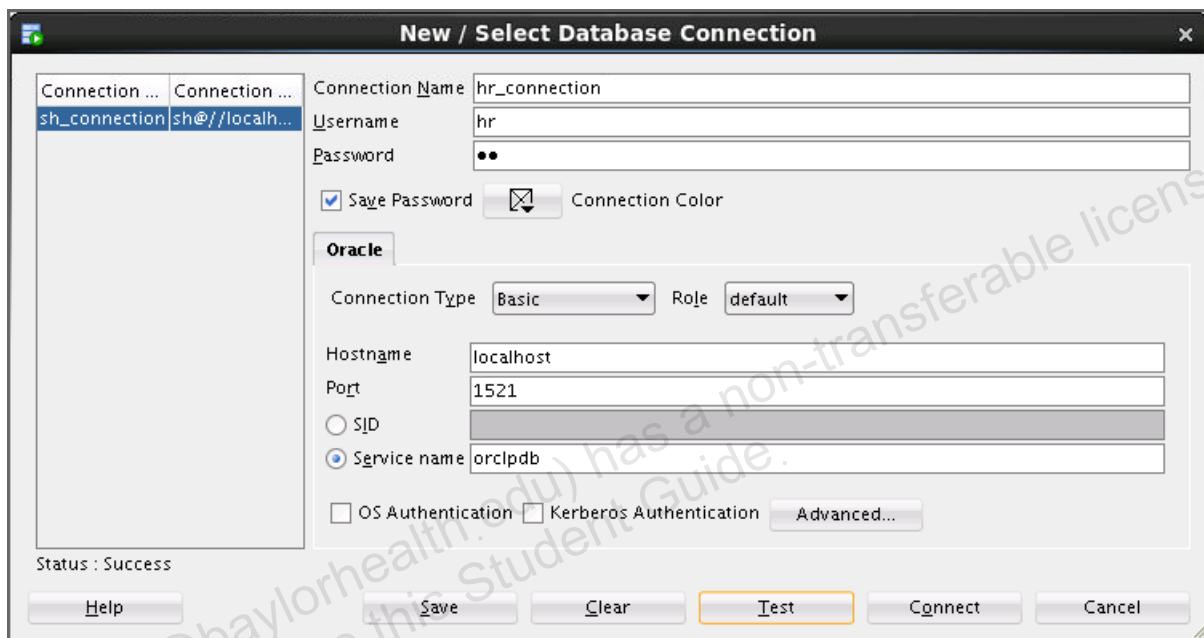
The following is a sample of the newly created database connection for the SH schema using a local connection:



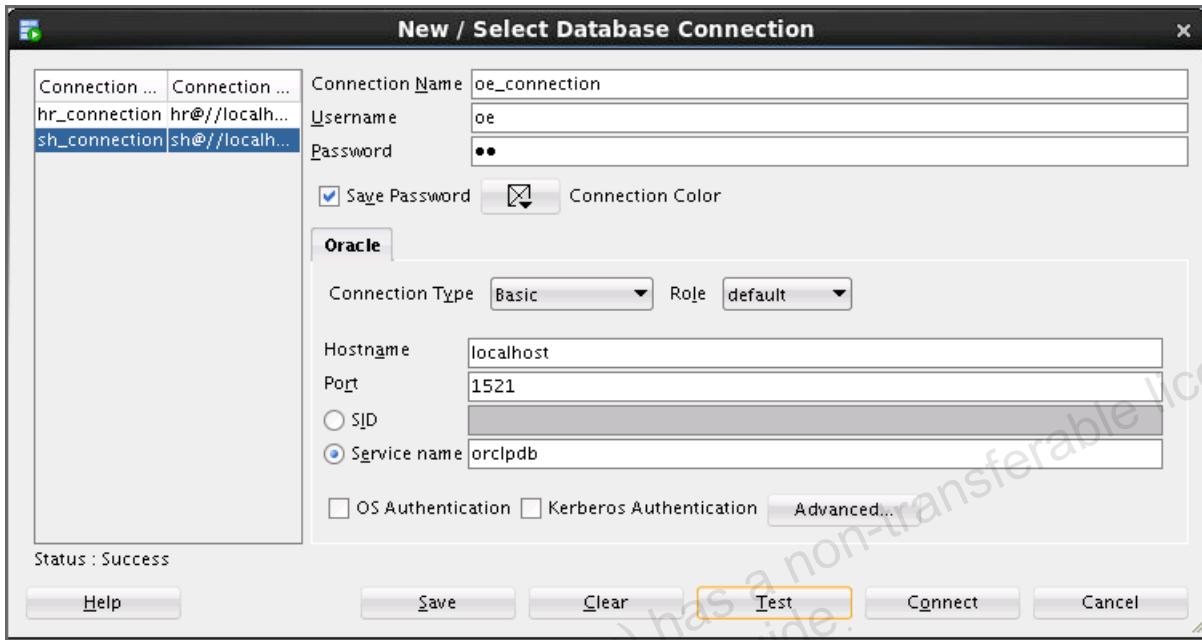
3. Test the new connection. If the Status is Success, save the connection and then connect to the database by using this new connection.



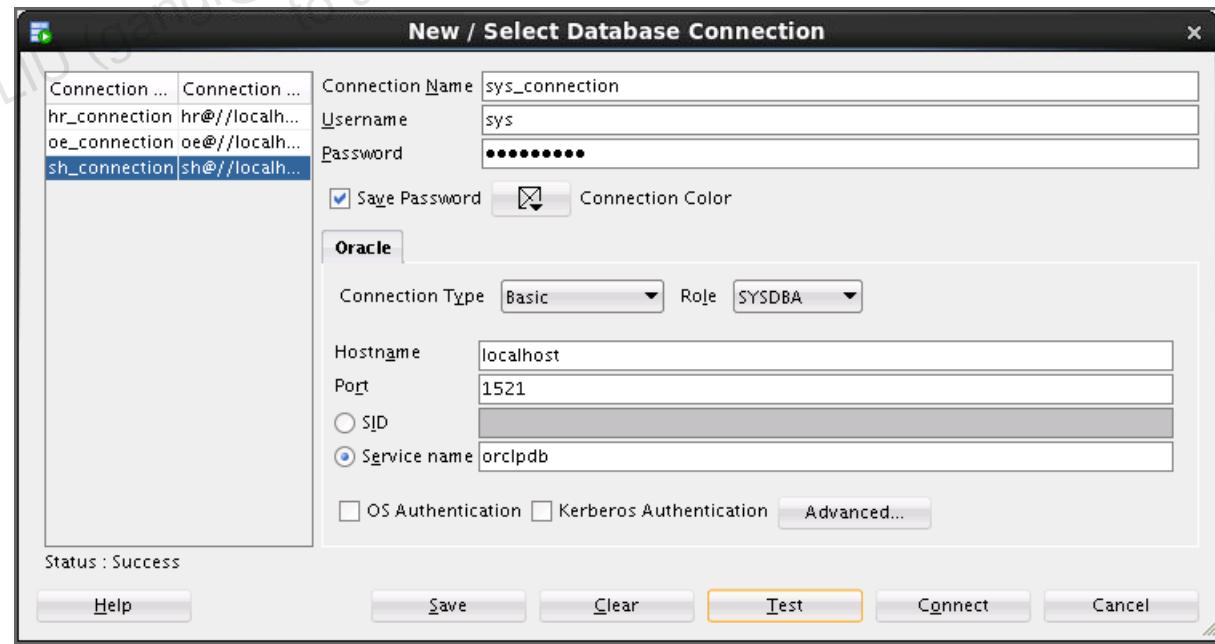
4. Create a new database connection named `hr_connection`.
  - a. Right-click `sh_connection` in the Object Navigation tree, and select the Properties menu option.
  - b. Enter `hr_connection` as the connection name and `hr` as the username and password, select Save Password, and then click Test to test the new connection.
  - c. Click Connect to connect to the database.



5. Repeat steps 2 and 3 to create and test a new database connection named oe\_connection. Enter oe as the database connection username and password.



6. Repeat steps 2 and 3 to create and test a new database connection named sys\_connection. Enter sys in the Username field and oracle\_4U in the Password field. From the Role drop-down menu, select SYSDBA as the role.



## Browsing the HR, SH, and OE Schema Tables

7. Browse the structure of the EMPLOYEES table in the HR schema.
  - a. Expand the hr\_connection connection by clicking the plus sign.
  - b. Expand Tables by clicking the plus sign.
  - c. Display the structure of the EMPLOYEES table. Click the EMPLOYEES table. The Columns tab displays the columns in the EMPLOYEES table as follows:

COLUMN_NAME	DATA_TYPE	NULLABLE	DATA_DEFAULT	COLUMN_ID	COMMENTS
1 EMPLOYEE_ID	NUMBER(6,0)	No	(null)	1	Primary key of employees table.
2 FIRST_NAME	VARCHAR2(20 BYTE)	Yes	(null)	2	First name of the employee. A not
3 LAST_NAME	VARCHAR2(25 BYTE)	No	(null)	3	Last name of the employee. A not
4 EMAIL	VARCHAR2(25 BYTE)	No	(null)	4	Email id of the employee
5 PHONE_NUMBER	VARCHAR2(20 BYTE)	Yes	(null)	5	Phone number of the employee; inc
6 HIRE_DATE	DATE	No	(null)	6	Date when the employee started on
7 JOB_ID	VARCHAR2(10 BYTE)	No	(null)	7	Current job of the employee; fore
8 SALARY	NUMBER(8,2)	Yes	(null)	8	Monthly salary of the employee. M
9 COMMISSION_PCT	NUMBER(2,2)	Yes	(null)	9	Commission percentage of the empl
10 MANAGER_ID	NUMBER(6,0)	Yes	(null)	10	Manager id of the employee; has s
11 DEPARTMENT_ID	NUMBER(4,0)	Yes	(null)	11	Department id where employee work

8. Browse the EMPLOYEES table and display its data.
  - a. To display the employee data, click the Data tab. The EMPLOYEES table data is displayed as follows:

EMPLOYEE_ID	FIRST_NAME	LAST_NAME	EMAIL	PHONE_NUMBER	HIRE_DATE	JOB_ID	SALARY	COMMISSION
1	100 Steven	King	SKING	515.123.4567	17-JUN-03	AD_PRES	24000	(
2	101 Neena	Kochhar	NKOCHHAR	515.123.4568	21-SEP-05	AD_VP	17000	(
3	102 Lex	De Haan	LDEHAAN	515.123.4569	13-JAN-01	AD_VP	17000	(
4	103 Alexander	Hunold	AHUNOLD	590.423.4567	03-JAN-06	IT_PROG	9000	(
5	104 Bruce	Ernst	BERNST	590.423.4568	21-MAY-07	IT_PROG	6000	(
6	105 David	Austin	DAUSTIN	590.423.4569	25-JUN-05	IT_PROG	4800	(
7	106 Valli	Pataballa	VPATABAL	590.423.4560	05-FEB-06	IT_PROG	4800	(
8	107 Diana	Lorentz	DLORENTZ	590.423.5567	07-FEB-07	IT_PROG	4200	(
9	108 Nancy	Greenberg	NGREENBE	515.124.4569	17-AUG-02	FI_MGR	12008	(
10	109 Daniel	Faviet	DFAVIET	515.124.4169	16-AUG-02	FI_ACCOUNT	9000	(
11	110 John	Chen	JCHEN	515.124.4269	28-SEP-05	FI_ACCOUNT	8200	(
12	111 Ismael	Sciarra	ISCIARRA	515.124.4369	30-SEP-05	FI_ACCOUNT	7700	(
13	112 Jose Manuel	Urman	JMURMAN	515.124.4469	07-MAR-06	FI_ACCOUNT	7800	(
14	113 Luis	Popp	LPOPP	515.124.4567	07-DEC-07	FI_ACCOUNT	6900	(

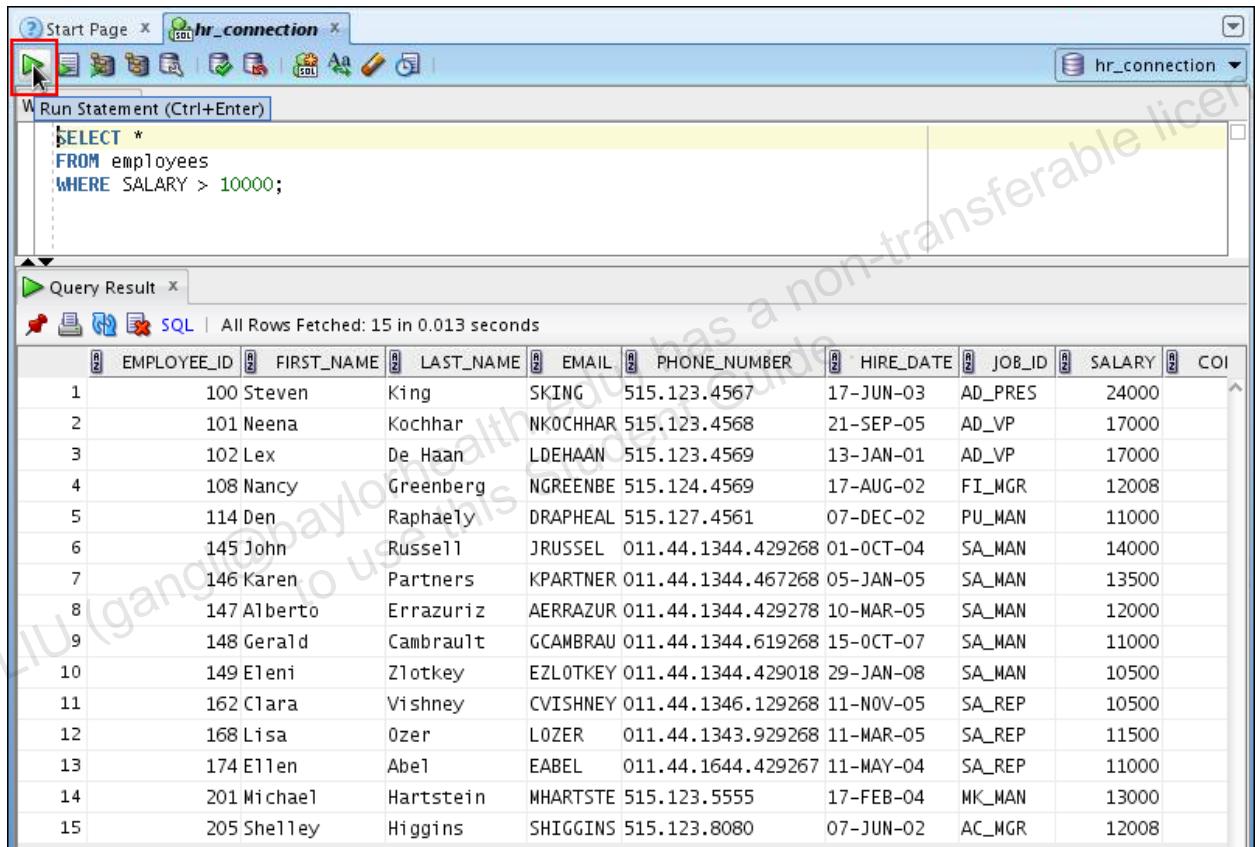
...

9. Use the SQL Worksheet to select the last names and salaries of all employees whose annual salary is greater than \$10,000. Use both the Execute Statement (F9) and the Run Script (F5) icons to execute the SELECT statement. Review the results of both methods of executing the SELECT statements on the appropriate tabs.

Display the SQL Worksheet by using any of the following two methods: Select Tools > SQL Worksheet, or click the Open SQL Worksheet icon. The Select Connection window appears. Select hr\_connection. Enter the following statement in the SQL Worksheet:

```
SELECT *
FROM employees
WHERE SALARY > 10000;
```

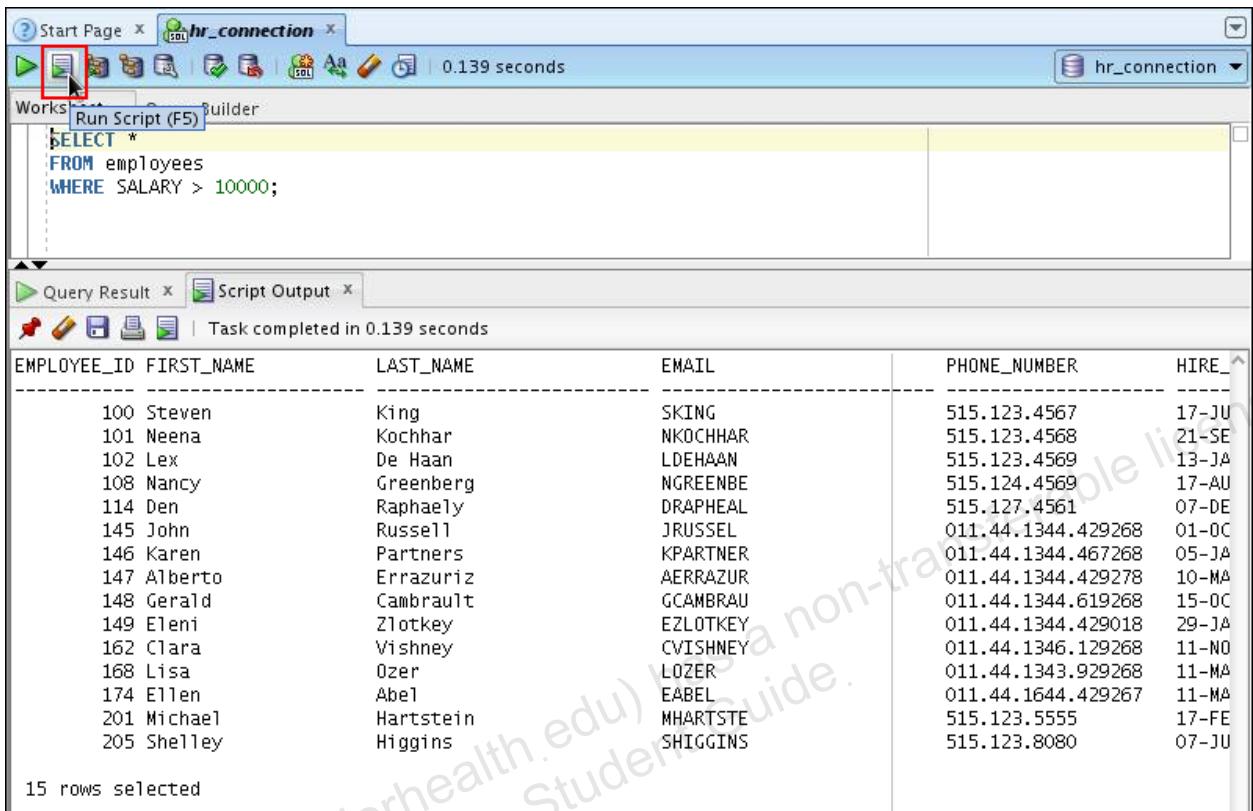
- 1) Execute by pressing Ctrl + Enter or by clicking the Run Statement icon .



The screenshot shows the Oracle SQL Worksheet interface. At the top, there's a toolbar with various icons. Below it is a connection dropdown set to 'hr\_connection'. A red box highlights the 'Run Statement (Ctrl+Enter)' button, which is located next to the connection name. The main area has two tabs: 'SQL' (selected) and 'Query Result'. The SQL tab contains the query: 'SELECT \* FROM employees WHERE SALARY > 10000;'. The Query Result tab shows the results of the query, which is a table of employee data. The table has 15 rows and columns for Employee ID, First Name, Last Name, Email, Phone Number, Hire Date, Job ID, Salary, and Commission Percentage (CO). The data includes names like Steven King, Neena Kochhar, and others, along with their respective job roles and salaries.

	EMPLOYEE_ID	FIRST_NAME	LAST_NAME	EMAIL	PHONE_NUMBER	HIRE_DATE	JOB_ID	SALARY	CO
1	100	Steven	King	SKING	515.123.4567	17-JUN-03	AD_PRES	24000	
2	101	Neena	Kochhar	NKOCHHAR	515.123.4568	21-SEP-05	AD_VP	17000	
3	102	Lex	De Haan	LDEHAAN	515.123.4569	13-JAN-01	AD_VP	17000	
4	108	Nancy	Greenberg	NGREENBE	515.124.4569	17-AUG-02	FI_MGR	12008	
5	114	Den	Raphaely	DRAPEHAL	515.127.4561	07-DEC-02	PU_MAN	11000	
6	145	John	Russell	JRUSSEL	011.44.1344.429268	01-OCT-04	SA_MAN	14000	
7	146	Karen	Partners	KPARTNER	011.44.1344.467268	05-JAN-05	SA_MAN	13500	
8	147	Alberto	Errazuriz	AERRAZUR	011.44.1344.429278	10-MAR-05	SA_MAN	12000	
9	148	Gerald	Cambrault	GCAMBRAU	011.44.1344.619268	15-OCT-07	SA_MAN	11000	
10	149	Eleni	Zlotkey	EZLOTKEY	011.44.1344.429018	29-JAN-08	SA_MAN	10500	
11	162	Clara	Vishney	CVISHNEY	011.44.1346.129268	11-NOV-05	SA REP	10500	
12	168	Lisa	Ozer	LOZER	011.44.1343.929268	11-MAR-05	SA REP	11500	
13	174	Ellen	Abel	EABEL	011.44.1644.429267	11-MAY-04	SA REP	11000	
14	201	Michael	Hartstein	MHARTSTE	515.123.5555	17-FEB-04	MK_MAN	13000	
15	205	Shelley	Higgins	SHIGGINS	515.123.8080	07-JUN-02	AC_MGR	12008	

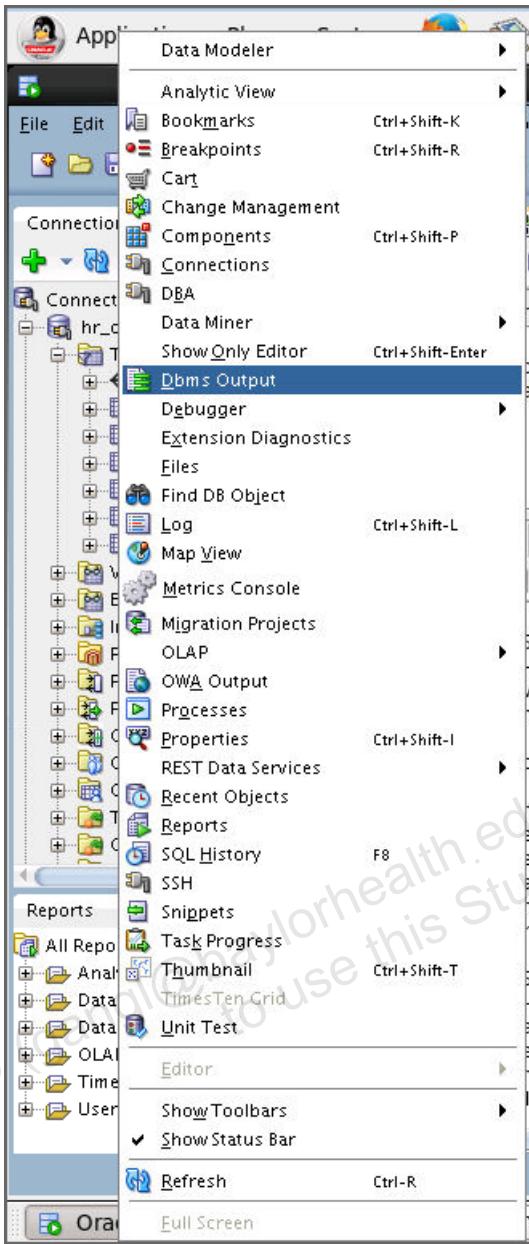
- 2) Execute by pressing the F5 key or by clicking the Execute Script icon .



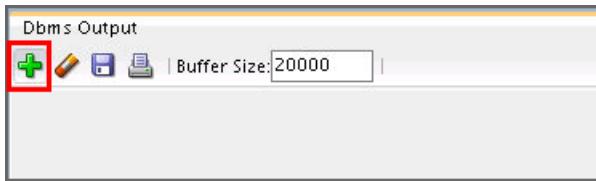
EMPLOYEE_ID	FIRST_NAME	LAST_NAME	EMAIL	PHONE_NUMBER	HIRE_DATE
100	Steven	King	SKING	515.123.4567	17-JU
101	Neena	Kochhar	NKOCHHAR	515.123.4568	21-SE
102	Lex	De Haan	LDEHAAN	515.123.4569	13-JA
108	Nancy	Greenberg	NGREENBE	515.124.4569	17-AU
114	Den	Raphaely	DRAPHEAL	515.127.4561	07-DE
145	John	Russell	JRUSSEL	011.44.1344.429268	01-OC
146	Karen	Partners	KPARTNER	011.44.1344.467268	05-JA
147	Alberto	Errazuriz	AERRAZUR	011.44.1344.429278	10-MA
148	Gerald	Cambrault	GCAMBRAU	011.44.1344.619268	15-OC
149	Eleni	Zlotkey	EZLOTKEY	011.44.1344.429018	29-JA
162	Clara	Vishney	CVISHNEY	011.44.1346.129268	11-NO
168	Lisa	Ozer	LOZER	011.44.1343.929268	11-MA
174	Ellen	Abel	EABEL	011.44.1644.429267	11-MA
201	Michael	Hartstein	MHARTSTE	515.123.5555	17-FE
205	Shelley	Higgins	SHIGGINS	515.123.8080	07-JU

15 rows selected

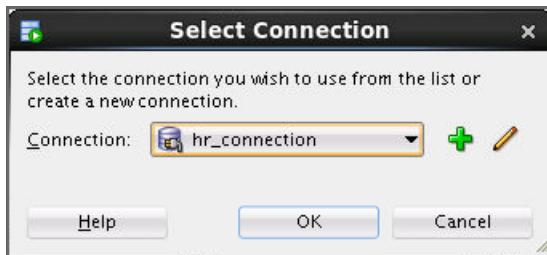
10. In the same SQL Worksheet, create and execute a simple anonymous block that outputs "Hello World."
- Enable `SET SERVEROUTPUT ON` to display the output of the `DBMS_OUTPUT` package statements. Select **View > Dbms Output**.



- b. Click the green plus sign, as shown below, to enable DBMS\_OUTPUT.

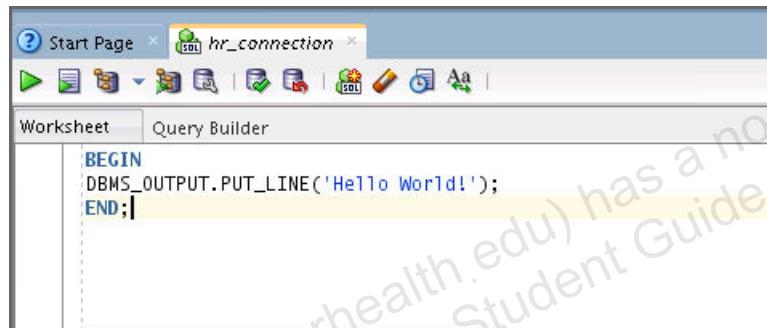


- c. In the dialog box that appears, select hr\_connection and click OK.



- d. Use the SQL Worksheet area to enter the code for your anonymous block.

```
BEGIN  
DBMS_OUTPUT.PUT_LINE('Hello World!');  
END;
```



- e. Click the Execute icon (Ctrl + Enter) to run the anonymous block.

The Script Output tab displays the output of the anonymous block as follows:

A screenshot of the Oracle SQL Developer interface. The top menu bar shows 'Start Page' and 'hr\_connection'. The toolbar includes icons for New, Open, Save, Copy, Paste, Find, and others. A red box highlights the green 'Execute' icon (a play button). The main workspace is titled 'Worksheet' and contains the following PL/SQL code:

```
BEGIN  
DBMS_OUTPUT.PUT_LINE('Hello World!');  
END;|
```

Below the worksheet is a status bar with 'Query Result' and 'Script Output' tabs, both of which are currently selected. It shows the message 'Task completed in 0.03 seconds' and 'PL/SQL procedure successfully completed.' In the bottom right corner of the status bar, there is a watermark: 'GANG LIU (gangli@baylorhealth.edu) has a non-transferable license to use this Student Guide.'

The bottom panel is titled 'Dbms Output' and shows the output 'hr\_connection x' followed by 'Hello World!'.

## **Practices for Lesson 3: Using Application Tracing Tools**

## Practices for Lesson 3: Overview

---

### Practices Overview

This practice covers the following topics:

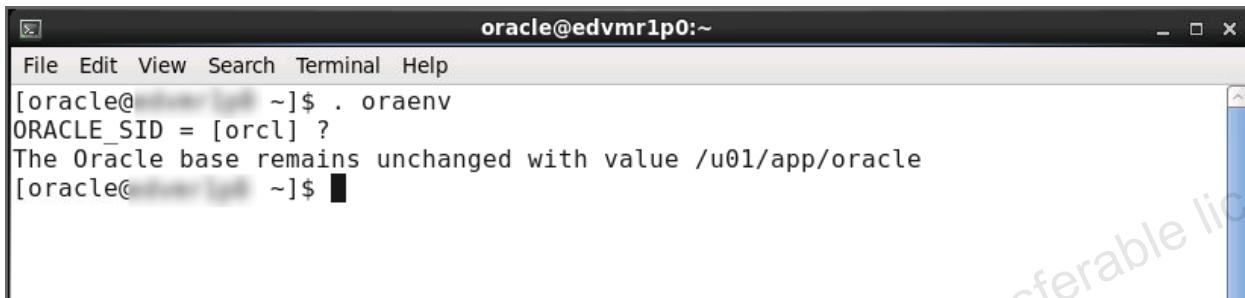
- Creating a service
- Tracing your application by using services
- Interpreting trace information by using `trcsess` and `TKPROF`

## Practice 3: Tracing Applications

### Overview

In this practice, you define a service and use it to generate traces. You then interpret the generated trace files. You can find all needed script files for this practice in your home/oracle/labs/solutions/Application\_Tracing directory.

**Note:** Before executing the scripts, set your environment by using the following code:



A screenshot of a terminal window titled "oracle@edvmr1p0:~". The window shows the command ". oraenv" being run, followed by the output "ORACLE\_SID = [orcl] ?" and "The Oracle base remains unchanged with value /u01/app/oracle". The terminal window has a standard Linux-style interface with a menu bar and a scroll bar.

### Tasks

1. Your environment has been initialized with the `at_setup.sql` script before the class began. The script is listed below:

```
set echo on

drop user trace cascade;

create user trace identified by trace default tablespace users
temporary tablespace temp;

grant connect, resource, dba to trace;

drop tablespace tracetbs including contents and datafiles;

drop tablespace tracetbs3 including contents and datafiles;

create tablespace tracetbs
datafile '/u01/app/oracle/oradata/orcl/tracetbs.dbf' size 100m
extent management local uniform size 40k;

create tablespace tracetbs3
datafile '/u01/app/oracle/oradata/orcl/tracetbs3.dbf' size 100m
extent management local uniform size 10m;

connect trace/trace@orclpdb
```

```
drop table sales purge;

create table sales as select * from sh.sales;

drop table sales2 purge;

create table sales2 tablespace tracetbs as select * from sh.sales
where 1=2;

drop table sales3 purge;

create table sales3 tablespace tracetbs3 as select * from sh.sales
where 1=2;

exit;
```

2. Connect to your database instance as the **SYS** user by using a SQL\*Plus session.

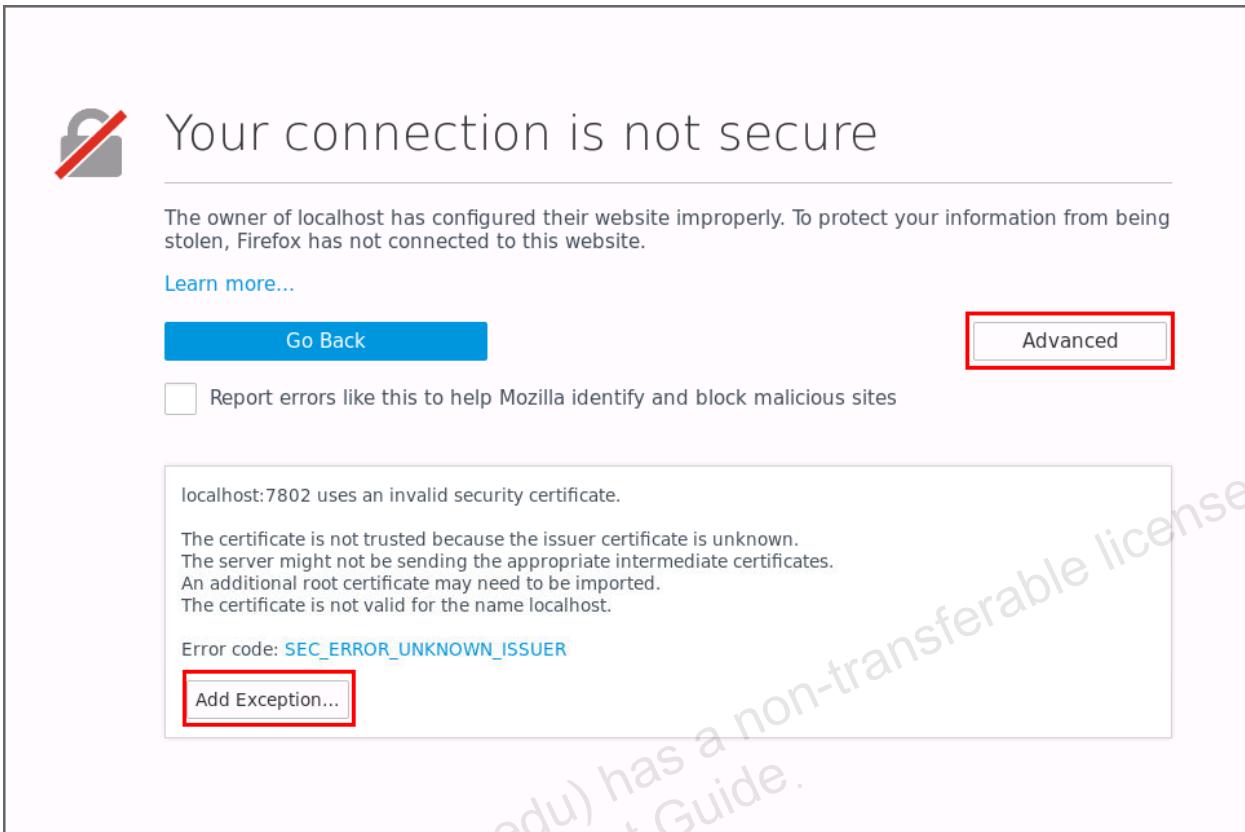
```
$ sqlplus / as sysdba

...
SQL>
```

3. Open a browser window and connect to Enterprise Manager Cloud Control as the **SYSMAN** user. Navigate to the Top Services page. The URL is <https://localhost:7802/em>.

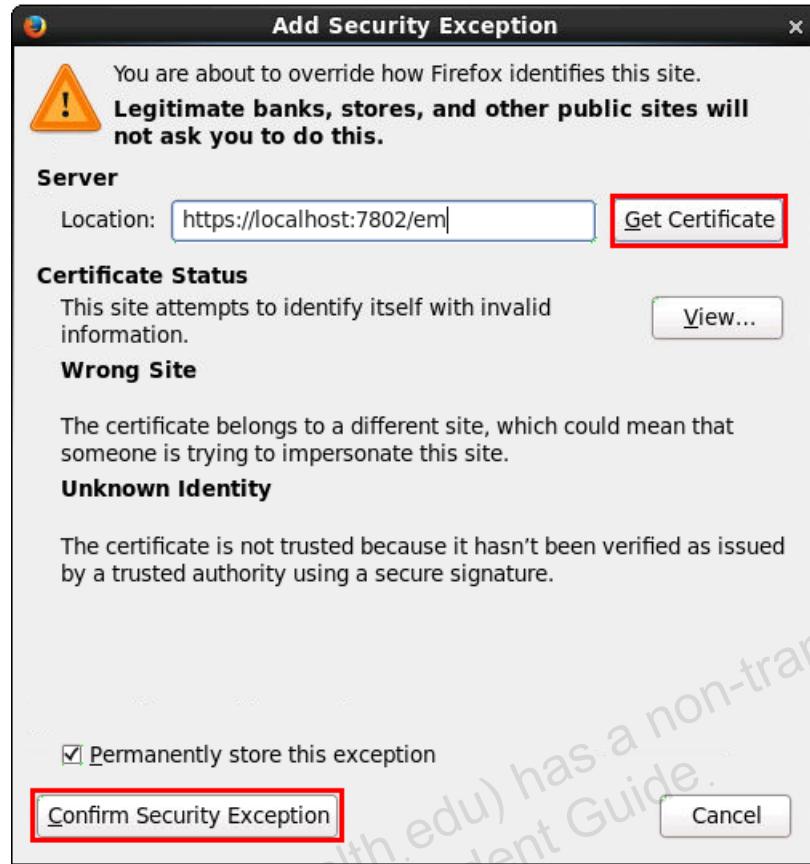
**Note:** If you get an alert box saying “Your Connection is not secure,” then perform the following steps:

Click the **Advanced** button.



Click the “**Add Exception**” button.

Click the “**Get Certificate**” button.

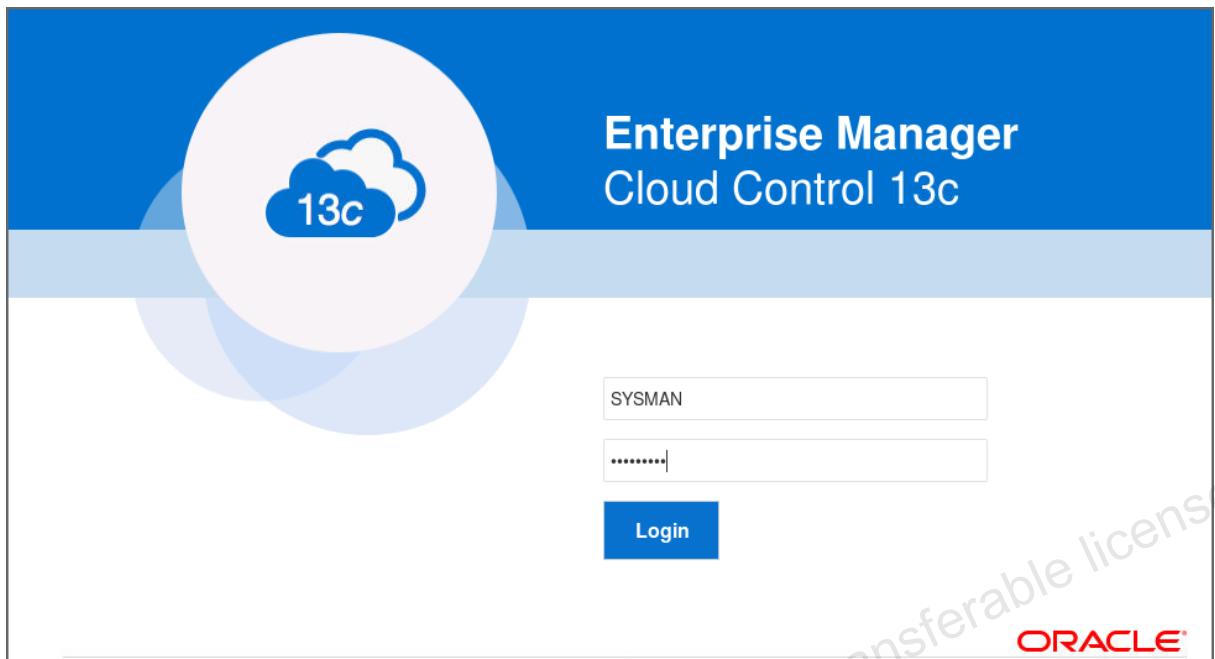


Confirm by clicking the “**Confirm Security Exception**” button.

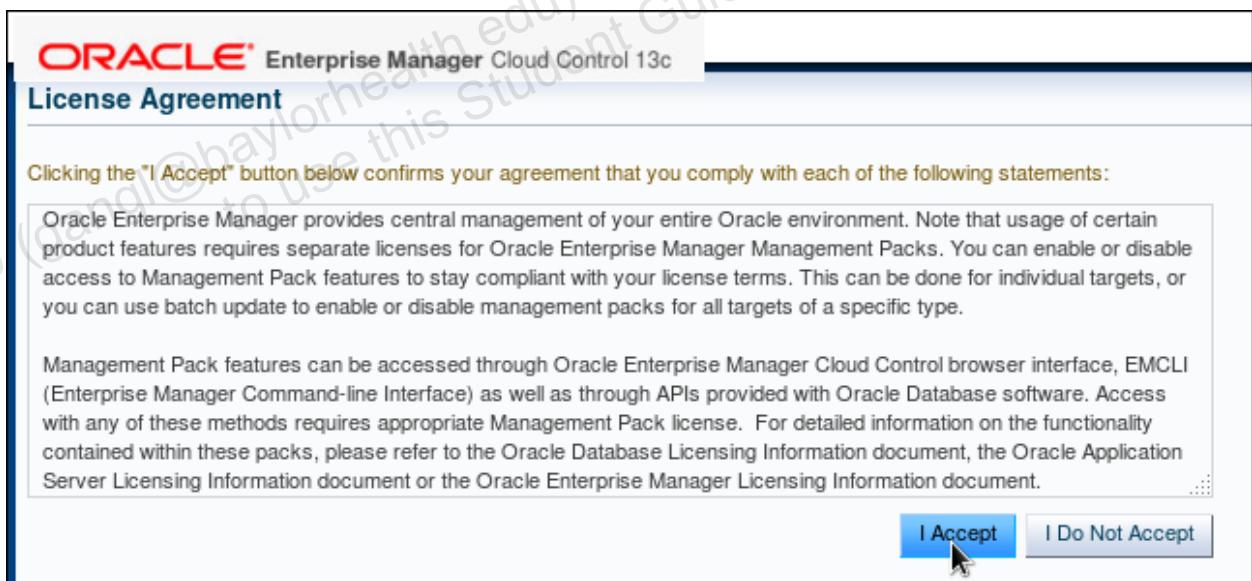
- a. Log in to Enterprise Manager as the sysman user.

Username: sysman

Password: oracle\_4U



- b. Click **I Accept** button.



- c. Go to the **Targets** tab and select **Databases**.  
d. For the **View** field, select the **Search List** radio button.  
e. Click **orcl**.

The screenshot shows the 'Databases' section of the Oracle Enterprise Manager interface. At the top, there are navigation links for Performance, Availability, Security, Schema, and Administration. Below these are buttons for View, Database Load Map, and Search List. A search bar with a 'Find Name' input field and a magnifying glass icon is present. Under the search bar are buttons for View, Add, Remove, and Configure. The main table lists databases with columns for Name, Type, Status, Target Version, Incidents, Average Compliance Score, and Member Summary. The 'orcl' database is highlighted with a red box in the 'Name' column.

- f. On the Database Home page, select **Performance Home**.

The screenshot shows the 'orcl (Container Database)' Performance Home page. The top navigation bar has tabs for Oracle Database, Performance (which is selected and highlighted in blue), Availability, Security, and Schema. The main content area includes sections for Load and Capacity (showing 12.2.0.1 Version, 0.03 Average Active Sessions, and 14.46 Used Space (GB)), Incidents and Compliance (showing 0 Critical, 0 Major, 0 Minor, and 0 Pending incidents, and a note about Compliance Not Configured), and Recommendations (showing 0 ADDM Findings). To the right, there is a performance monitoring chart with a legend for CPU (orange), Memory (green), and Disk (blue). A dropdown menu is open over the Performance tab, listing options: Performance Home (selected and highlighted in red), Top Activity, ASH Analytics, SQL Monitoring, PL/SQL, AWR, Advisors Home, Emergency Monitoring, Real-Time ADDM, Adaptive Thresholds, Search Sessions, Blocking Sessions, and Database Replay.

- g. Log in to the Performance page as following:

Username: SYS

Password: oracle\_4U

Role: SYSDBA

The screenshot shows the 'Database Login' dialog box for the 'orcl (Container Database)'. The 'Database' dropdown is set to 'orcl (Container Database)'. The 'Username' field contains 'sys'. The 'Password' field is redacted. The 'Role' dropdown is set to 'SYSDBA'. There is a 'Save As' checkbox and two buttons at the bottom: 'Login' and 'Cancel'.

- h. On the Performance page, click the **Top Consumers** link in the Additional Monitoring links section of the page.

The screenshot shows the 'Additional Monitoring Links' section of the Performance page. It includes a note about Top Sessions and Top SQL data from ASH. A red box highlights the 'Top Consumers' link in the list of links.

Links	Description
• <a href="#">Top Consumers</a>	Top Sessions and Top SQL data from ASH can be found on the Top Activity page.
• <a href="#">Duplicate SQL</a>	
• <a href="#">Instance Locks</a>	
• <a href="#">Instance Activity</a>	

- i. On the Top Consumers page, click the **Top Services** tab. This takes you to the Top Services page.

**Note:** If you get a message to activate Adobe Flash, click **Activate Adobe Flash** and continue.

The screenshot shows the Oracle Enterprise Manager Cloud Control interface for the 'orcl (Container Database)' target. The 'Top Consumers' page is displayed, with the 'Top Services' tab highlighted by a red box. The page includes two pie charts: one for 'Top Services' showing SYSSUSERS (69%), orclpdb (17%), and SYSSBACKGROUND (14.3%); and another for 'Top Modules (by Service)' showing various modules like EM Realtime Connection, Unnamed, JDBC Thin Client, MGMT\_COLLECTION.COLLECTION\_SUBSYSTEM, and DBMS\_SCHEDULER. Below the charts is a table of service activity over the last 5 minutes, with SYSSUSERS at 89.5% activity and 54464 seconds of delta elapsed time.

Select	Service	Activity (% for the last 5 minutes)	SQL Trace Enabled	Delta Elapsed Time (seconds)	Cumulative Elapsed Time (seconds)	Delta CPU Time (seconds)
<input type="checkbox"/>	SYSSUSERS	89.5	FALSE	3	54464	
<input type="checkbox"/>	SYSSBACKGROUND	7.9	FALSE	0	32	
<input type="checkbox"/>	orclpdb	2.6	FALSE	0	10087	

**Additional Monitoring Links**  
Top Sessions and Top SQL data from ASH can be found on the Top Activity page.

- Duplicate SQL
- Instance Activity

- You now execute seven workload scripts that are traced. All workload scripts run under the ORCLPDB service. Your goal is to analyze the generated trace files to interpret what happens in the seven cases. From your terminal session, execute the `run_tracep0.sh` script. This script is used to trigger the generation of statistics for your ORCLPDB service so

it can be viewed from within Enterprise Manager. As soon as you start the execution of the `run_tracep0.sh` script, move to the next step of this practice.

```
$ cd /home/oracle/labs/solutions/Application_Tracing
$ ./run_tracep0.sh

...
Connected to:...

SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set tracefile_identifier='mytraceP0';

Session altered.

SQL>
SQL> set termout off
SQL>
SQL> exit;

...
$
```

5. Go back to the Top Consumers page in your Enterprise Manager session. Under the Active Services table, enable tracing for ORCLPDB service.
  - a. When you see ORCLPDB in the Active Services table on the Top Services page, select it, and click the Enable SQL Trace button.

Select	Service	Activity (% for the last 5 minutes)	SQL Trace Enabled	Delta Elapsed Time (seconds)	Cumulative Elapsed Time (seconds)	Delta CPU Time (seconds)	Cumulative CPU Time (seconds)	Delta Physical I/O (blocks)	C
<input type="checkbox"/>	SYS\$USERS	42.7	FALSE	3	364	3	93	1	
<input type="checkbox"/>	SYS\$BACKGROUND	34.1	FALSE	0	6	0	4	118	
<input checked="" type="checkbox"/>	orclpdb	23.2	FALSE	0	729	0	170	0	

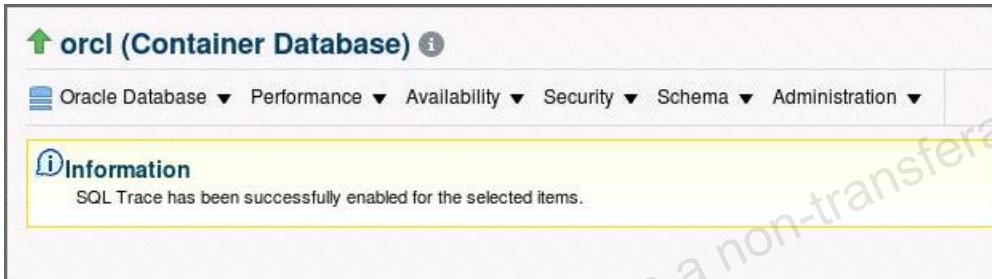
**Additional Monitoring Links**  
Top Sessions and Top SQL data from ASH can be found on the Top Activity page.

- Duplicate SQL
- Instance Locks
- Instance Activity

- b. On the Enable SQL Trace page, make sure that Waits is set to TRUE, and Binds is set to FALSE. Click **OK**.



- c. Back on the Top Services page, you should see a confirmation message near the top of the Top Consumers page.



6. When tracing for ORCLPDB is enabled and `run_tracep0.sh` has finished, execute the `run_tracep1.sh` script from your terminal session. Observe the Enterprise Manager Top Consumers/Top Services page.

```
$ ./run_tracep1.sh
...
SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set workarea_size_policy=manual;

Session altered.

SQL>
SQL> alter session set sort_area_size=50000;

Session altered.

SQL>
SQL> alter session set hash_area_size=5000;

Session altered.
```

```
SQL>
SQL>
SQL> alter session set tracefile_identifier='mytraceP1';

Session altered.

SQL> EXEC DBMS_MONITOR.session_trace_enable;
PL/SQL procedure successfully completed.

SQL>
SQL>
SQL> set timing on
SQL>
SQL> select /*+ ORDERED USE_HASH(s2) */ count(*) from sales s1, sales
      s2 where s1.cust_id=s2.cust_id;

          COUNT(*)
-----
172878975

Elapsed: 00:00:44.35
SQL>
SQL>
SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set tracefile_identifier='mytraceS1';

Session altered.

Elapsed: 00:00:00.00
SQL> EXEC DBMS_MONITOR.session_trace_enable;
PL/SQL procedure successfully completed.
Elapsed: 00:00:00.01

SQL>
SQL> set timing on
SQL>
SQL> select /*+ ORDERED USE_HASH(s2) S1 */ count(*) from sales s1,
      sales s2 where s1.cust_id=s2.cust_id;

          COUNT(*)
-----
172878975
```

```
Elapsed: 00:00:13.72
SQL>
SQL> exit;

...
$
```

7. Execute the `run_tracep2.sh` script from your terminal session. Observe the output.

```
$ ./run_tracep2.sh
...
SQL*Plus: Release 12.2.0.1.0 Production on Tue Jan 23 22:23:59 2018

Copyright (c) 1982, 2016, Oracle. All rights reserved.

Connected to:
Oracle Database 12c Enterprise Edition Release 12.2.0.1.0- 64bit
Production
SQL> alter session set container = orclpdb;
Session altered.
SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set tracefile_identifier='mytraceP2';

Session altered.
SQL> EXEC DBMS_MONITOR.session_trace_enable;
PL/SQL procedure successfully completed.
SQL>
SQL> set timing on
SQL>
SQL> declare
 2      c      number := dbms_sql.open_cursor;
 3      oname  varchar2(50);
 4      ignore integer;
 5  begin
 6      for i in 1 .. 5000 loop
 7          dbms_sql.parse(c,'select object_name from dba_objects where
object_id = ''||i , dbms_sql.native); -- use literal
 8          dbms_sql.define_column(c, 1, oname, 50);
 9          ignore := dbms_sql.execute(c);
```

```
10      if dbms_sql.fetch_rows(c)>0 then
11          dbms_sql.column_value(c, 1, oname);
12      end if;
13  end loop;
14  dbms_sql.close_cursor(c);
15 end;
16 /
```

PL/SQL procedure successfully completed.

Elapsed: 00:02:24.36

```
SQL>
SQL>
SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set tracefile_identifier='mytrace$2';

Session altered.
```

Elapsed: 00:00:00.00

```
SQL>
SQL> declare
2      c number := dbms_sql.open_cursor;
3      oname varchar2(50);
4      ignore integer;
5  begin
6      dbms_sql.parse(c,'select object_name from dba_objects where
object_id = :y' , dbms_sql.native); -- use bind var
7      for i in 1 .. 5000 loop
8          dbms_sql.bind_variable(c,:y',i);
9          dbms_sql.define_column(c, 1, oname, 50);
10         ignore := dbms_sql.execute(c);
11         if dbms_sql.fetch_rows(c)>0 then
12             dbms_sql.column_value(c, 1, oname);
13         end if;
14     end loop;
15     dbms_sql.close_cursor(c);
16 end;
17 /
```

PL/SQL procedure successfully completed.

Elapsed: 00:00:00.86

```
SQL>
```

```
SQL> exit; Disconnected ...  
$
```

8. Execute the `run_tracep3.sh` script from your terminal session. Observe the output.

```
$ ./run_tracep3.sh  
...  
  
SQL>  
SQL> connect trace/trace@orclpdb  
Connected.  
SQL>  
SQL> alter session set tracefile_identifier='mytraceP3';  
  
Session altered.  
  
SQL> EXEC DBMS_MONITOR.session_trace_enable;  
PL/SQL procedure successfully completed.  
  
SQL>  
SQL> update sales set amount_sold=20000 where prod_id=13 and  
cust_id=987;  
  
2 rows updated.  
  
SQL>  
SQL> commit;  
  
Commit complete.  
  
SQL>  
SQL>  
SQL> connect trace/trace@orclpdb  
Connected.  
SQL>  
SQL> create index sales_prod_cust_indx on sales(prod_id,cust_id);  
  
Index created.  
  
SQL>  
SQL> connect trace/trace@orclpdb  
Connected.  
SQL>
```

```
SQL> alter session set tracefile_identifier='mytraces3';
Session altered.

SQL> EXEC DBMS_MONITOR.session_trace_enable;
PL/SQL procedure successfully completed.

SQL>
SQL> update sales set amount_sold=30000 where prod_id=13 and
cust_id=987;

2 rows updated.

SQL>
SQL> commit;

Commit complete.

SQL>
SQL> connect trace/trace
Connected.
SQL>
SQL> drop index sales_prod_cust_indx;

Index dropped.

SQL>
SQL>
SQL> exit;
Disconnected ...
$
```

9. Execute the `run_tracep4.sh` script from your terminal session. Observe the output.

```
$ ./run_tracep4.sh
...
SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set tracefile_identifier='mytraceP4';

Session altered.
SQL> EXEC DBMS_MONITOR.session_trace_enable;
```

```
PL/SQL procedure successfully completed.

SQL>
SQL> set timing on
SQL>
SQL> DECLARE
  2      TYPE SalesCurTyp  IS REF CURSOR;
  3      v_sales_cursor      SalesCurTyp;
  4      sales_record        sh.sales%ROWTYPE;
  5      v_stmt_str          VARCHAR2(200);
  6  BEGIN
  7      -- Dynamic SQL statement with placeholder:
  8      v_stmt_str := 'select * from sh.sales where amount_sold>0';
  9
 10     -- Open cursor and specify bind argument in USING clause:
 11     OPEN v_sales_cursor FOR v_stmt_str;
 12
 13     -- Fetch rows from result set one at a time:
 14     LOOP
 15         FETCH v_sales_cursor INTO sales_record;
 16         EXIT WHEN v_sales_cursor%NOTFOUND;
 17     END LOOP;
 18
 19     -- Close cursor:
 20     CLOSE v_sales_cursor;
 21 END;
 22 /
```

PL/SQL procedure successfully completed.

Elapsed: 00:00:21.27

```
SQL>
SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set tracefile_identifier='mytraceS4';

Session altered.

Elapsed: 00:00:00.01
SQL> EXEC DBMS_MONITOR.session_trace_enable;
PL/SQL procedure successfully completed.
Elapsed: 00:00:00.01

SQL>
```

```
SQL> set timing on
SQL>
SQL> DECLARE
  2      TYPE SalesCurTyp  IS REF CURSOR;
  3      TYPE SalesList IS TABLE OF sh.sales%ROWTYPE;
  4      v_sales_cursor      SalesCurTyp;
  5      sales_List          SalesList;
  6      v_stmt_str          VARCHAR2(200);
  7  BEGIN
  8      -- Dynamic SQL statement with placeholder:
  9      v_stmt_str := 'select /* S4 */ * from sh.sales where
amount_sold>0';
10
11      -- Open cursor:
12      OPEN v_sales_cursor FOR v_stmt_str;
13
14      -- Fetch rows from result set one at a time:
15      LOOP
16          FETCH v_sales_cursor BULK COLLECT INTO Sales_List LIMIT
10000;
17          EXIT WHEN v_sales_cursor%NOTFOUND;
18      END LOOP;
19
20      -- Close cursor:
21      CLOSE v_sales_cursor;
22  END;
23  /
PL/SQL procedure successfully completed.

Elapsed: 00:00:00.87
SQL>
SQL>
SQL> exit;
Disconnected ...
$
```

10. Execute the `run_tracep5.sh` script from your terminal session. Observe the output.

```
$ ./run_tracep5.sh
...
Connected to: ...

SQL>
```

```
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set tracefile_identifier='mytraceP5';

Session altered.
SQL>
SQL> EXEC DBMS_MONITOR.session_trace_enable;
PL/SQL procedure successfully completed.

SQL> delete from sales2;
0 rows deleted;

SQL>
SQL> insert into sales2 select * from sh.sales union all select * from
sales;

1837686 rows created.

SQL> commit;

Commit complete.

SQL>
SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set tracefile_identifier='mytraceS5';

Session altered.
SQL> EXEC DBMS_MONITOR.session_trace_enable;
PL/SQL procedure successfully completed.

SQL>
SQL> insert into sales3 select * from sh.sales union all select * from
sales;

1837686 rows created.

SQL> commit;

Commit complete.

SQL>
SQL> exit;
```

```
Disconnected ...
$
```

11. Execute the `run_tracep6.sh` script from your terminal session. Observe the output. Wait until you see the message `run_tracep6 finished` before proceeding to the next step.

```
$ ./run_tracep6.sh
...
SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> alter session set tracefile_identifier='mytraceP6';

Session altered.
SQL> EXEC DBMS_MONITOR.session_trace_enable;
PL/SQL procedure successfully completed.
SQL>
SQL> exec dbms_lock.sleep(30);
Connected.
SQL> update sales set amount_sold=amount_sold+1;

918843 rows updated.

SQL>
SQL> exec dbms_lock.sleep(60);

SQL> exit;
Disconnected from Oracle Database 12c Enterprise Edition Release
12.2.0.1.0 - 64bit Production
[oracle@EDT3R13P1 Application_Tracing]$
PL/SQL procedure successfully completed.

SQL>
SQL> rollback;

Rollback complete.

SQL>
SQL> -- Run_tracep6 Finished
SQL> exit;
Disconnected ...

$
```

**Note:** `run_tracep6.sh` takes a while to execute completely. Wait for some time to finish execution and then continue.

12. Execute the `run_tracep7.sh` script from your terminal session. Observe the output.

```
$ ./run_tracep7.sh
...
SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL> drop index SALES_CUST_INDX;
Index dropped.
SQL> alter session set tracefile_identifier='mytraceP7';

Session altered.

SQL> EXEC dbms_monitor.session_trace_enable;
PL/SQL procedure successfully completed.

SQL>
SQL> declare
 2      c number := dbms_sql.open_cursor;
 3      custid number;
 4      amount number;
 5      ignore integer;
 6  begin
 7      dbms_sql.parse(c,'select cust_id, sum(amount_sold) from sales
where cust_id=2 group by cust_id order by cust_id' , dbms_sql.native);
-- use bind var
 8      dbms_sql.define_column(c, 1, custid);
 9      dbms_sql.define_column(c, 2, amount);
10      ignore := dbms_sql.execute(c);
11      if dbms_sql.fetch_rows(c)>0 then
12          dbms_sql.column_value(c, 1, custid);
13          dbms_sql.column_value(c, 2, amount);
14      end if;
15  end;
16 /
PL/SQL procedure successfully completed.

SQL>
SQL> connect trace/trace@orclpdb
Connected.
SQL>
SQL> create index sales_cust_indx on sales(cust_id);
```

```
Index created.
```

```
SQL>
SQL> exit;
Disconnected ...
$
```

13. Disable tracing for your database.

- Go back to the Top Services page in your Enterprise Manager session.
- Select the **Services with Aggregation enable** from the drop-down box of the View field.
- Ensure that ORCLPDB is selected, and click the **Disable SQL trace** button.
- Back on the Top Consumers page, you should see a confirmation message near the top of the page.



**Information**

SQL Trace has already been disabled for the selected items.

14. Try to find out all the trace files that were generated to handle the previous seven cases.

**Note:** Your output may differ based on your environment.

```
$ ./show_mytraces.sh
orcl_ora_19313_mytraceP1.trc
orcl_ora_19313_mytraceP1.trm
orcl_ora_19355_mytraceS1.trc
orcl_ora_19355_mytraces1.trm
orcl_ora_19382_mytraceP2.trc
orcl_ora_19382_mytraceP2.trm
orcl_ora_19467_mytraces2.trc
orcl_ora_19467_mytraces2.trm
orcl_ora_19474_mytraceP3.trc
orcl_ora_19474_mytraceP3.trm
orcl_ora_19503_mytraces3.trc
orcl_ora_19503_mytraces3.trm
orcl_ora_19534_mytraceP4.trm
orcl_ora_19549_mytraces4.trc
orcl_ora_19549_mytraces4.trm
orcl_ora_19558_mytraceP5.trc
orcl_ora_19558_mytraceP5.trm
orcl_ora_19568_mytraces5.trc
orcl_ora_19568_mytraces5.trm
orcl_ora_19583_mytraceP6.trc
```

```
orcl _ora_19583_mytraceP6.trm  
orcl _ora_19634_mytraceP7.trc  
orcl _ora_19634_mytraceP7.trm  
$
```

15. After you identify the location of those trace files, merge their content into one file called mytrace.trc located in your \$HOME/labs/solutions/Application\_Tracing directory.

```
$ ./merge_traces.sh  
$
```

16. Use tkprof over the mytrace.trc file to generate a compiled trace output called myreport.txt located in your \$HOME/labs/solutions/Application\_Tracing directory.

```
$ ./tkprof_traces.sh  
  
TKPROF: Release 12.2.0.1.0- Development on Tue Jan 23 02:00:00 2018  
  
Copyright (c) 1982, 2017, Oracle and/or its affiliates. All rights reserved.  
$
```

17. In addition, run TKPROF over the trace file that was generated for case 7 (step 12) with the EXPLAIN option set to your TRACE account.

```
$ tkprof /u01/app/oracle/diag/rdbms/orcl/orcl/trace/*mytraceP7.trc  
myreport2.txt explain=trace@orclpdb  
  
TKPROF: Release 12.2.0.1.0- Development on Tue Jan 23 02:00:48 2018  
  
Copyright (c) 1982, 2017, Oracle and/or its affiliates. All rights reserved.  
$
```

18. After this is done, interpret the trace generated for case 1 (step 6). Case 1 appears near the beginning of the myreport.txt file.

**Suggestion:** Use a text editor or pager that has a search capability. gedit, vi, and less are available on the Oracle University classroom machines. gedit provides a GUI.

**Hint:** Search for the first occurrence of the string ‘ORDERED USE\_HASH(s2)’ and examine the trace. Then find the second occurrence and compare the trace to the first occurrence. What do you observe, and what are your conclusions?

Case 1 illustrates the consequences of using manually sized SQL area parameters, such as HASH\_AREA\_SIZE. The first statement was executed by using a very small HASH\_AREA\_SIZE value. The immediate consequence was the number of temporary segments needed to execute the statement. Later, the same statement was executed, but this time by using the default SQL area parameters, which were sized automatically by the system to handle the needs. You can see a high disk value as well as a high number of waits for temporary segments for the first execution, compared to the second one. Compare the statistics direct path read temp and direct path write temp in the two statement traces. These indicate activity from SQL work areas to temporary segments.

**Note:** The actual statistics will vary from the example shown.

```

SQL ID: 5h4bydz30hvf7
Plan Hash: 2354142265
select /*+ ORDERED USE_HASH(s2) */ count(*)
from
  sales s1, sales s2 where s1.cust_id=s2.cust_id

call      count        cpu   elapsed         disk    query   current      rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse        1        0.00     0.00          0        0        0          0
Execute      1        0.00     0.00          0        0        0          0
Fetch        2     105.91    118.33    806501      8874        0          1
-----  -----  -----  -----  -----  -----  -----  -----
total       4     105.92    118.34    806501      8874        0          1
Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95

Rows      Row Source Operation
-----
1  SORT AGGREGATE (cr=8874 pr=806501 pw=2524 time=0 us)
172878975  HASH JOIN (cr=8874 pr=806501 pw=2524 time=244058880 us
cost=463845 size=1196022750 card=119602275)
918843    TABLE ACCESS FULL SALES (cr=4437 pr=4434 pw=0 time=770629
us cost=1230 size=4594215 card=918843)
918843    TABLE ACCESS FULL SALES (cr=4437 pr=4433 pw=0 time=775236
us cost=1230 size=4594215 card=918843)

Elapsed times include waiting on following events:
Event waited on                      Times   Max. Wait  Total Waited
-----  -----  -----  -----
Waited

```

```

SQL*Net message to client                      2      0.00      0.00
Disk file operations I/O                       2      0.00      0.00
db file sequential read                      1      0.01      0.01
direct path read                           88      0.08     1.16
direct path write temp                     2524      0.02     0.77
direct path read temp                   797634      0.14     8.46
SQL*Net message from client                  2      0.00      0.00
*****
...
SQL ID: 3a5334n3vuu8y
Plan Hash: 2354142265
select /*+ ORDERED USE_HASH(s2) S1 */ count(*)
from
  sales s1, sales s2 where s1.cust_id=s2.cust_id

call      count      cpu    elapsed      disk      query      current      rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse        1      0.00      0.00          0          0          0          0
Execute      1      0.00      0.00          0          0          0          0
Fetch        2     61.66     67.70    8866     8874          0          1
-----  -----  -----  -----  -----  -----  -----  -----
total       4     61.66     67.71    8866     8874          0          1

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95

Rows      Row Source Operation
-----
1   SORT AGGREGATE (cr=8882 pr=2 pw=0 time=0 us)
172878975   HASH JOIN (cr=8882 pr=2 pw=0 time=188874752 us cost=4314
size=1196022750 card=119602275)
918843      TABLE ACCESS FULL SALES (cr=4441 pr=2 pw=0 time=791235 us
cost=1230 size=4594215 card=918843)
918843      TABLE ACCESS FULL SALES (cr=4441 pr=0 pw=0 time=938296 us
cost=1230 size=4594215 card=918843)

Elapsed times include waiting on following events:
Event waited on          Times      Max. Wait      Total Waited
-----  -----  -----  -----
SQL*Net message to client          2      0.00      0.00
SQL*Net message from client        2      0.00      0.00
*****

```

19. Interpret the trace generated for case 2 (step 7). In this trace, the first statement of interest has the string “use literal.”

**Note:** This trace is very long. What do you observe, and what are your conclusions?

- a. For this case, an almost identical statement was run 5000 times, but each time a different literal was used to execute the query. This caused the system to parse almost the same statement 5000 times, which is extremely inefficient, although the time precision is too low to give accurate information about the parse time of each statement. But the `elapsed` time and the `CPU` for the PL/SQL block include the time that these 5000 statements took to execute.

**Note:** Confirm that these 5000 executions are at “recursive depth: 1”.

The actual statistics you see will vary from the example shown. The first two recursive SQL statements are shown and then the last statement where `object_id = 5000` is shown.

```
...
declare
  c      number := dbms_sql.open_cursor;
  oname  varchar2(50);
  ignore integer;
begin
  for i in 1 .. 5000 loop
    dbms_sql.parse(c, 'select object_name from dba_objects where
object_id = ''||i , dbms_sql.native); -- use literal
    dbms_sql.define_column(c, 1, oname, 50);
    ignore := dbms_sql.execute(c);
    if dbms_sql.fetch_rows(c)>0 then
      dbms_sql.column_value(c, 1, oname);
    end if;
  end loop;
  dbms_sql.close_cursor(c);
end;

call  count      cpu   elapsed      disk  query   current      rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse     1      0.00      0.00       0      0      0          0
Execute   1      4.27      5.77       0      0      0          1
Fetch     0      0.00      0.00       0      0      0          0
-----
total     2      4.27      5.77       0      0      0          1

Misses in library cache during parse: 0
Optimizer mode: ALL_ROWS
Parsing user id: 95

Elapsed times include waiting on following events:
```

Event waited on	Times Waited	Max. Wait	Total Waited
SQL*Net message to client	1	0.00	0.00
SQL*Net message from client	1	0.00	0.00
*****			
SQL ID: 04qmn5w5qg1j3			
Plan Hash: 2729849777			
select object_name			
from			
dba_objects where object_id = 1			
call count	cpu elapsed	disk query	current rows
Parse 1 0.02 0.03 0 0 0 0			
Execute 1 0.00 0.00 0 0 0 0			
Fetch 1 0.00 0.00 1 3 0 0			
total 3 0.02 0.03 1 3 0 0			
Misses in library cache during parse: 1			
Optimizer mode: ALL_ROWS			
Parsing user id: 95 (recursive depth: 1)			
Rows Row Source Operation			
0 VIEW DBA_OBJECTS (cr=3 pr=1 pw=0 time=0 us cost=5 size=158 card=2)			
0 UNION-ALL (cr=3 pr=1 pw=0 time=0 us)			
0 FILTER (cr=3 pr=1 pw=0 time=0 us)			
0 NESTED LOOPS (cr=3 pr=1 pw=0 time=0 us cost=5 size=108 card=1)			
0 NESTED LOOPS (cr=3 pr=1 pw=0 time=0 us cost=4 size=104 card=1)			
0 TABLE ACCESS BY INDEX ROWID OBJ\$ (cr=3 pr=1 pw=0 time=0 us cost=3 size=82 card=1)			
1 INDEX RANGE SCAN I_OBJ1 (cr=2 pr=0 pw=0 time=0 us cost=2 size=0 card=1) (object id 36)			
0 INDEX RANGE SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1 size=22 card=1) (object id 47)			
0 INDEX RANGE SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1 size=4 card=1) (object id 47)			
0 TABLE ACCESS BY INDEX ROWID IND\$ (cr=0 pr=0 pw=0 time=0 us cost=2 size=8 card=1)			
0 INDEX UNIQUE SCAN I_IND1 (cr=0 pr=0 pw=0 time=0 us cost=1 size=0 card=1) (object id 41)			

```

          0      NESTED LOOPS  (cr=0 pr=0 pw=0 time=0 us cost=2 size=29
card=1)
          0      INDEX FULL SCAN I_USER2  (cr=0 pr=0 pw=0 time=0 us cost=1
size=20 card=1) (object id 47)
          0      INDEX RANGE SCAN I_OBJ4  (cr=0 pr=0 pw=0 time=0 us cost=1
size=9 card=1) (object id 39)
          0      FILTER  (cr=0 pr=0 pw=0 time=0 us)
          0      NESTED LOOPS  (cr=0 pr=0 pw=0 time=0 us cost=1 size=83
card=1)
          0      INDEX FULL SCAN I_LINK1  (cr=0 pr=0 pw=0 time=0 us cost=0
size=79 card=1) (object id 137)
          0      INDEX RANGE SCAN I_USER2  (cr=0 pr=0 pw=0 time=0 us cost=1
size=4 card=1) (object id 47)

Elapsed times include waiting on following events:
Event waited                      Times     Max. Wait  Total Waited
-----  Waited
db file sequential read           1          0.00        0.00
*****
SQL ID: 28m8r9uth07db
Plan Hash: 2729849777
select object_name
from
  dba_objects where object_id = 2

call    count      cpu  elapsed       disk      query     current         rows
-----  -----  -----
Parse      1      0.01      0.02          0          0          0            0
Execute    1      0.00      0.00          0          0          0            0
Fetch      1      0.00      0.00          0          5          0            1
-----
total     3      0.01      0.02          0          5          0            1

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95      (recursive depth: 1)

Rows      Row Source Operation
-----
1      VIEW   DBA_OBJECTS  (cr=5 pr=0 pw=0 time=0 us cost=5 size=158
card=2)
1      UNION-ALL  (cr=5 pr=0 pw=0 time=0 us)
1      FILTER  (cr=5 pr=0 pw=0 time=0 us)
1      NESTED LOOPS  (cr=5 pr=0 pw=0 time=0 us cost=5 size=108
card=1)

```

```

      1      NESTED LOOPS  (cr=4 pr=0 pw=0 time=0 us cost=4 size=104
card=1)
      1          TABLE ACCESS BY INDEX ROWID OBJ$ (cr=3 pr=0 pw=0 time=0
us cost=3 size=82 card=1)
      1              INDEX RANGE SCAN I_OBJ1 (cr=2 pr=0 pw=0 time=0 us
cost=2 size=0 card=1) (object id 36)
      1              INDEX RANGE SCAN I_USER2 (cr=1 pr=0 pw=0 time=0 us
cost=1 size=22 card=1) (object id 47)
      1              INDEX RANGE SCAN I_USER2 (cr=1 pr=0 pw=0 time=0 us cost=1
size=4 card=1) (object id 47)
      0      TABLE ACCESS BY INDEX ROWID IND$ (cr=0 pr=0 pw=0 time=0 us
cost=2 size=8 card=1)
      0          INDEX UNIQUE SCAN I_IND1 (cr=0 pr=0 pw=0 time=0 us cost=1
size=0 card=1) (object id 41)
      0      NESTED LOOPS  (cr=0 pr=0 pw=0 time=0 us cost=2 size=29
card=1)
      0          INDEX FULL SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1
size=20 card=1) (object id 47)
      0          INDEX RANGE SCAN I_OBJ4 (cr=0 pr=0 pw=0 time=0 us cost=1
size=9 card=1) (object id 39)
      0          FILTER   (cr=0 pr=0 pw=0 time=0 us)
      0      NESTED LOOPS  (cr=0 pr=0 pw=0 time=0 us cost=1 size=83
card=1)
      0          INDEX FULL SCAN I_LINK1 (cr=0 pr=0 pw=0 time=0 us cost=0
size=79 card=1) (object id 137)
      0          INDEX RANGE SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1
size=4 card=1) (object id 47)

*****
...
SQL ID: 2d2078j2pucd5
Plan Hash: 2729849777
select object_name
from
  dba_objects where object_id = 5000

call     count        cpu  elapsed       disk    query     current         rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse      1      0.01      0.01        0        0        0            0
Execute    1      0.00      0.00        0        0        0            0
Fetch      1      0.00      0.00        0        5        0            1
-----
total      3      0.01      0.01        0        5        0            1

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS

```

```

Parsing user id: 95      (recursive depth: 1)

Rows      Row Source Operation
-----
   1  VIEW    DBA_OBJECTS (cr=5 pr=0 pw=0 time=0 us cost=5 size=158
card=2)
   1  UNION-ALL (cr=5 pr=0 pw=0 time=0 us)
   1  FILTER   (cr=5 pr=0 pw=0 time=0 us)
   1  NESTED LOOPS (cr=5 pr=0 pw=0 time=0 us cost=5 size=108
card=1)
   1  NESTED LOOPS (cr=4 pr=0 pw=0 time=0 us cost=4 size=104
card=1)
   1      TABLE ACCESS BY INDEX ROWID OBJ$ (cr=3 pr=0 pw=0 time=0
us cost=3 size=82 card=1)
   1      INDEX RANGE SCAN I_OBJ1 (cr=2 pr=0 pw=0 time=0 us
cost=2 size=0 card=1) (object id 36)
   1      INDEX RANGE SCAN I_USER2 (cr=1 pr=0 pw=0 time=0 us
cost=1 size=22 card=1) (object id 47)
   1      INDEX RANGE SCAN I_USER2 (cr=1 pr=0 pw=0 time=0 us cost=1
size=4 card=1) (object id 47)
   0      TABLE ACCESS BY INDEX ROWID IND$ (cr=0 pr=0 pw=0 time=0 us
cost=2 size=8 card=1)
   0      INDEX UNIQUE SCAN I_IND1 (cr=0 pr=0 pw=0 time=0 us cost=1
size=0 card=1) (object id 41)
   0      NESTED LOOPS (cr=0 pr=0 pw=0 time=0 us cost=2 size=29
card=1)
   0      INDEX FULL SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1
size=20 card=1) (object id 47)
   0      INDEX RANGE SCAN I_OBJ4 (cr=0 pr=0 pw=0 time=0 us cost=1
size=9 card=1) (object id 39)
   0      FILTER  (cr=0 pr=0 pw=0 time=0 us)
   0      NESTED LOOPS (cr=0 pr=0 pw=0 time=0 us cost=1 size=83
card=1)
   0      INDEX FULL SCAN I_LINK1 (cr=0 pr=0 pw=0 time=0 us cost=0
size=79 card=1) (object id 137)
   0      INDEX RANGE SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1
size=4 card=1) (object id 47)

*****

```

- b. Another statement was also executed 5000 times but, this time, using a bind variable. The statement of interest has the string “use bind var.” The statement was parsed only once, and executed 5000 times. This behavior is much more efficient than the previous one.

**Note:** The CPU and elapsed columns for the PL/SQL block include the time spent on all the SQL statements executed inside the block.

```

...
*****
```

```

declare
  c number := dbms_sql.open_cursor;
  oname varchar2(50);
  ignore integer;
begin
  dbms_sql.parse(c,'select object_name from dba_objects where
object_id = :y' , dbms_sql.native); -- use bind var
  for i in 1 .. 5000 loop
    dbms_sql.bind_variable(c,:y',i);
    dbms_sql.define_column(c, 1, oname, 50);
    ignore := dbms_sql.execute(c);
    if dbms_sql.fetch_rows(c)>0 then
      dbms_sql.column_value(c, 1, oname);
    end if;
  end loop;
  dbms_sql.close_cursor(c);
end;

call      count      cpu  elapsed      disk  query     current      rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse        1      0.01      0.01      0          0          0          0
Execute      1      0.55      0.55      0          0          0          1
Fetch        0      0.00      0.00      0          0          0          0
-----  -----  -----  -----  -----  -----  -----  -----
total       2      0.56      0.56      0          0          0          1

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95

Elapsed times include waiting on following events:
Event waited on                      Times     Max. Wait  Total Waited
-----  -----  -----  -----
Waited
SQL*Net message to client            1          0.00      0.00
SQL*Net message from client          1          0.00      0.00
*****
SQL ID: 25t3qdy59b8tk
Plan Hash: 2729849777
select object_name
from
  dba_objects where object_id = :y

call      count      cpu  elapsed      disk  query     current      rows
-----  -----  -----  -----  -----  -----  -----  -----

```

Parse	1	0.00	0.00	0	0	0	0
Execute	5000	0.23	0.22	0	0	0	0
Fetch	5000	0.27	0.29	0	26810	0	4931
total	10001	0.50	0.51	0	26810	0	4931

Misses in library cache during parse: 1  
 Misses in library cache during execute: 1  
 Optimizer mode: ALL\_ROWS  
 Parsing user id: 95      (**recursive depth: 1**)

Rows	Row Source Operation
0	VIEW DBA_OBJECTS (cr=3 pr=0 pw=0 time=0 us cost=5 size=158 card=2)
0	UNION-ALL (cr=3 pr=0 pw=0 time=0 us)
0	FILTER (cr=3 pr=0 pw=0 time=0 us)
0	NESTED LOOPS (cr=3 pr=0 pw=0 time=0 us cost=5 size=108 card=1)
0	NESTED LOOPS (cr=3 pr=0 pw=0 time=0 us cost=4 size=104 card=1)
0	TABLE ACCESS BY INDEX ROWID OBJ\$ (cr=3 pr=0 pw=0 time=0 us cost=3 size=82 card=1)
1	INDEX RANGE SCAN I_OBJ1 (cr=2 pr=0 pw=0 time=0 us cost=2 size=0 card=1) (object id 36)
0	INDEX RANGE SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1 size=22 card=1) (object id 47)
0	INDEX RANGE SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1 size=4 card=1) (object id 47)
0	TABLE ACCESS BY INDEX ROWID IND\$ (cr=0 pr=0 pw=0 time=0 us cost=2 size=8 card=1)
0	INDEX UNIQUE SCAN I_IND1 (cr=0 pr=0 pw=0 time=0 us cost=1 size=0 card=1) (object id 41)
0	NESTED LOOPS (cr=0 pr=0 pw=0 time=0 us cost=2 size=29 card=1)
0	INDEX FULL SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1 size=20 card=1) (object id 47)
0	INDEX RANGE SCAN I_OBJ4 (cr=0 pr=0 pw=0 time=0 us cost=1 size=9 card=1) (object id 39)
0	FILTER (cr=0 pr=0 pw=0 time=0 us)
0	NESTED LOOPS (cr=0 pr=0 pw=0 time=0 us cost=1 size=83 card=1)
0	INDEX FULL SCAN I_LINK1 (cr=0 pr=0 pw=0 time=0 us cost=0 size=79 card=1) (object id 137)
0	INDEX RANGE SCAN I_USER2 (cr=0 pr=0 pw=0 time=0 us cost=1 size=4 card=1) (object id 47)

\*\*\*\*\*

20. Interpret the trace generated for case 3 (step 8). This trace starts at the string “update sales set amount\_sold=20000”. What do you observe, and what are your conclusions?

If you look closely at this case, you see that you access the complete table to update only two rows. This is very inefficient. The alternative case is much better because it uses an index to speed up the retrieval of the rows that need to be updated.

```
SQL ID: 8mt8gqs6btkb6
Plan Hash: 3654535892
update sales set amount_sold=20000
where
  prod_id=13 and cust_id=987

call      count        cpu   elapsed         disk    query     current          rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse       1        0.00     0.00          0        1        0          0
Execute     1        0.09     0.10      228    4441        3          2
Fetch       0        0.00     0.00          0        0        0          0
-----  -----  -----  -----  -----  -----  -----  -----
total      2        0.10     0.11      228    4442        3          2

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95

Rows Row Source Operation
-----
 0 UPDATE  SALES (cr=4441 pr=228 pw=0 time=0 us)
 2 TABLE ACCESS FULL SALES (cr=4441 pr=228 pw=0 time=19 us
cost=1231 size=3549 card=91)

Elapsed times include waiting on following events:
Event waited on                                Times     Max. Wait  Total Waited
-----  -----  -----  -----
db file scattered read                      20        0.00        0.00
db file sequential read                   184        0.00        0.00
SQL*Net message to client                  1        0.00        0.00
SQL*Net message from client                 1        0.00        0.00
*****
...
SQL ID: c9ffzgn5fv6gk
Plan Hash: 1889391443
```

```

update sales set amount_sold=30000
where
  prod_id=13 and cust_id=987

call      count      cpu    elapsed      disk      query      current          rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse        1      0.00      0.00        0          2          0          0
Execute      1      0.00      0.00        0          3          3          2
Fetch         0      0.00      0.00        0          0          0          0
-----  -----  -----  -----  -----  -----  -----  -----
total        2      0.00      0.00        0          5          3          2

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95

Rows      Row Source Operation
-----
0   UPDATE  SALES (cr=3 pr=0 pw=0 time=0 us)
    2   INDEX RANGE SCAN SALES_PROD_CUST_INDX (cr=3 pr=0 pw=0 time=2
us cost=3 size=78 card=2) (object id 78771)

Elapsed times include waiting on following events:
Event waited on                      Times     Max. Wait  Total Waited
-----  -----  -----  -----
SQL*Net message to client            1          0.00      0.00
SQL*Net message from client         1          0.01      0.01
*****
```

21. Interpret the trace generated for case 4 (step 9). This trace can be found below the string 'sh.sales where amount\_sold>0'. What do you observe, and what are your conclusions?

In this case, the first statement does not use the fetching mechanism appropriately. One fetch operation is done for every single row retrieved. This is also very inefficient. The alternative case is doing 92 fetches to retrieve the same amount of rows. This technique is called array fetch.

```

SQL ID: 1j17cdqu55s6k
Plan Hash: 0
alter session set tracefile_identifier='mytraceP4'
...
SQL ID: fh0354r530g32
Plan Hash: 1550251865
select *
```

```

from
sh.sales where amount_sold>0


call      count      cpu    elapsed      disk      query      current      rows
-----  -----
Parse        1      0.05      0.05          0          0          0          0
Execute      1      0.00      0.00          0          0          0          0
Fetch  918844     8.98     10.80       879  918942          0  918843
-----
total   918846     9.04     10.86       879  918942          0  918843

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95      (recursive depth: 1)

Rows      Row Source Operation
-----
918843  PARTITION RANGE ALL PARTITION: 1 28 (cr=918942 pr=879 pw=0
time=7298636 us cost=490 size=26646447 card=918843)
918843  TABLE ACCESS FULL SALES PARTITION: 1 28 (cr=918942 pr=879
pw=0 time=4239558 us cost=490 size=26646447 card=918843)

Elapsed times include waiting on following events:
Event waited on                      Times      Max. Wait  Total Waited
-----  -----
Disk file operations I/O                  1          0.00      0.00
db file sequential read                 52          0.05      0.32
db file scattered read                122          0.07      1.33
*****
...
*****
```

SQL ID: ftygqy235kbwv  
Plan Hash: 1550251865  
select /\* S4 \*/ \*  
from  
sh.sales where amount\_sold>0

call	count	cpu	elapsed	disk	query	current	rows
Parse	1	0.00	0.00	0	0	0	0
Execute	1	0.00	0.00	0	0	0	0

Fetch	92	2.47	2.52	0	1809	0	918843
-----	-----	-----	-----	-----	-----	-----	-----
total	94	2.48	2.52	0	1809	0	918843

Misses in library cache during parse: 1  
 Optimizer mode: ALL\_ROWS  
 Parsing user id: 95 (recursive depth: 1)

Rows	Row Source Operation
918843	PARTITION RANGE ALL PARTITION: 1 28 (cr=1809 pr=0 pw=0 time=2810666 us cost=490 size=26646447 card=918843)
918843	TABLE ACCESS FULL SALES PARTITION: 1 28 (cr=1809 pr=0 pw=0 time=1190617 us cost=490 size=26646447 card=918843)

Elapsed times include waiting on following events:

Event waited on	Times Waited	Max. Wait	Total Waited
Disk file operations I/O	1	0.00	0.00

22. Interpret the trace generated for case 5 (step 10). This trace can be found using the string union all. What do you observe, and what are your conclusions?

In this statement, notice the large values associated with the Execute phase. Here, the first statement incurs too many recursive calls to allocate extents to the table. This is because the tablespace in which it is stored is not correctly set up for extent allocations. The symptoms can be seen in the number of statements that follow this statement that have the message “recursive depth: 1.” These recursive statements are not seen if SYS=NO in the tkprof command.

The alternative case, which starts with the next statement containing the string union all, is much better, as you can see. The times for the execute phase are much lower compared to the first case. Also, the number of recursive statements in the second case should be much lower than the first one.

SQL ID: 4u687pw6m3kst
Plan Hash: 3659198364
insert into sales2 select * from sh.sales <b>union all</b> select * from sales
call count cpu elapsed disk query current rows
----- ----- ----- ----- ----- ----- ----- -----
Parse 1 0.01 0.03 1 3 0 0
Execute 1 3.04 4.09 13 9871 66966 782730
Fetch 0 0.00 0.00 0 0 0 0

total	2	3.06	4.13	14	9874	66966	782730	
 Misses in library cache during parse: 1								
Optimizer mode: ALL_ROWS								
Parsing user id: 95								
Rows	Row	Source	Operation					
0	LOAD TABLE CONVENTIONAL	(cr=0 pr=0 pw=0 time=0 us)						
782731	UNION-ALL	(cr=1448 pr=0 pw=0 time=5177587 us)						
782731	PARTITION RANGE ALL PARTITION:	1 28 (cr=1448 pr=0 pw=0 time=2384664 us cost=489 size=26646447 card=918843)						
782731	TABLE ACCESS FULL SALES PARTITION:	1 28 (cr=1448 pr=0 pw=0 time=1087553 us cost=489 size=26646447 card=918843)						
0	TABLE ACCESS FULL SALES	(cr=0 pr=0 pw=0 time=0 us cost=1233 size=78831570 card=906110)						
 Elapsed times include waiting on following events:								
Event waited on				Times	Max. Wait	Total Waited		
				Waited				
Disk file operations I/O				1	0.00	0.00		
db file sequential read				13	0.02	0.09		
log file switch completion				2	0.04	0.05		
log file sync				1	0.00	0.00		
SQL*Net break/reset to client				2	0.01	0.01		
SQL*Net message to client				1	0.00	0.00		
SQL*Net message from client				1	0.22	0.22		
*****								
SQL ID: bsa0wjtftg3uw								
Plan Hash: 1512486435								
select file#								
from								
file\$ where ts#:=1								
call	count	cpu	elapsed	disk	query	current		rows
Parse	769	0.02	0.02	0	0	0		0
Execute	769	0.02	0.02	0	0	0		0
Fetch	1538	0.02	0.03	0	3072	0		769
total	3076	0.07	0.08	0	3072	0		769

```

Misses in library cache during parse: 1
Misses in library cache during execute: 1
Optimizer mode: CHOOSE
Parsing user id: SYS      (recursive depth: 1)

Rows      Row Source Operation
-----
1  TABLE ACCESS FULL FILE$ (cr=4 pr=0 pw=0 time=0 us cost=2
size=6 card=1)

*****
SQL ID: 0kkhhb2w93cx0
Plan Hash: 2170058777
update seg$ set
type#:=4,blocks=:5,extents=:6,minexts=:7,maxexts=:8,extsize=
:9,extpct=:10,user#:=11,iniexts=:12,lists=decode(:13, 65535, NULL,
:13),
groups=decode(:14, 65535, NULL, :14), cachehint=:15, hwmincr=:16,
spare1=
DECODE(:17,0,NULL,:17),scanhint=:18, bitmappranges=:19
where
ts#:=1 and file#=:2 and block#=:3

call      count      cpu    elapsed      disk      query      current      rows
-----
Parse     763       0.02     0.01        0          0          0          0          0
Execute   763       0.16     0.16        0      2289        801        763
Fetch      0       0.00     0.00        0          0          0          0          0
-----
total    1526       0.19     0.18        0      2289        801        763

Misses in library cache during parse: 1
Misses in library cache during execute: 1
Optimizer mode: CHOOSE
Parsing user id: SYS      (recursive depth: 1)

Rows      Row Source Operation
-----
0  UPDATE  SEG$ (cr=3 pr=0 pw=0 time=0 us)
1  TABLE ACCESS CLUSTER SEG$ (cr=3 pr=0 pw=0 time=0 us cost=2
size=68 card=1)
1  INDEX UNIQUE SCAN I_FILE#_BLOCK# (cr=2 pr=0 pw=0 time=0 us
cost=1 size=0 card=1) (object id 9)
*****
...

```

```

SQL ID: cxnuy9bystsx5
Plan Hash: 0
alter session set tracefile_identifier='mytraceS5'
...

SQL ID: 0949qykm7q1t0
Plan Hash: 3659198364
insert into sales3 select * from sh.sales union all select * from
sales

call      count      cpu    elapsed      disk      query     current          rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse        1      0.01      0.03          1          2          0          0
Execute       1      1.53      1.76         15      5534     22362    533382
Fetch         0      0.00      0.00          0          0          0          0
-----  -----  -----  -----  -----  -----  -----  -----
total        2      1.54      1.80         16      5536     22362    533382

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95

Rows      Row Source Operation
-----
      0 LOAD TABLE CONVENTIONAL  (cr=0 pr=0 pw=0 time=0 us)
  533383 UNION-ALL  (cr=992 pr=0 pw=0 time=3671608 us)
  533383 PARTITION RANGE ALL PARTITION: 1 28 (cr=992 pr=0 pw=0
time=1746800 us cost=489 size=26646447 card=918843)
  533383 TABLE ACCESS FULL SALES PARTITION: 1 28 (cr=992 pr=0 pw=0
time=816851 us cost=489 size=26646447 card=918843)
      0 TABLE ACCESS FULL SALES (cr=0 pr=0 pw=0 time=0 us cost=1233
size=78831570 card=906110)

Elapsed times include waiting on following events:
Event waited on                      Times     Max. Wait  Total Waited
-----  -----  -----  -----
Disk file operations I/O                  2          0.00      0.00
db file sequential read                 15          0.01      0.06
log file sync                           1          0.00      0.00
SQL*Net break/reset to client           2          0.00      0.00
SQL*Net message to client                1          0.00      0.00
SQL*Net message from client              1          0.00      0.00
*****
```

23. Interpret the trace generated for case 6 (step 11). This trace starts at the string **bxraux4u04and**, which is the SQL ID for the statement. What do you observe and what are your conclusions?

This case is more difficult to understand. Here, you select a table that is entirely locked by another transaction. This forces the query to generate consistent read blocks for almost the entire table, causing undo segments to be accessed. This is shown in the statistics by the large query value, and almost no current blocks.

```
...
SQL ID: bxraux4u04and
Plan Hash: 3229864837
select cust_id, sum(amount_sold)
from
  sales group by cust_id order by cust_id

call      count      cpu    elapsed      disk      query      current      rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse        1      0.00      0.00          0          1          0          0
Execute       1      0.00      0.00          0          0          0          0
Fetch      472      3.17      3.45     4047  978282          0      7059
-----  -----  -----  -----  -----  -----  -----  -----
total      474      3.17      3.45     4047  978283          0      7059

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95

Rows      Row Source Operation
-----
  7059  SORT GROUP BY (cr=978282 pr=4047 pw=0 time=9496 us cost=1259
size=23558860 card=906110)
  918843  TABLE ACCESS FULL SALES (cr=978282 pr=4047 pw=0 time=4061770
us cost=1233 size=23558860 card=906110)

Elapsed times include waiting on following events:
Event waited on      Times      Max. Wait      Total Waited
-----  -----  -----
SQL*Net message to client      472      0.00      0.00
Disk file operations I/O          1      0.00      0.00
db file sequential read      3679      0.00      0.03
db file scattered read          5      0.00      0.00
SQL*Net message from client      472      0.00      0.03
```

24. Interpret the trace generated for case 7 (step 12). What do you observe and what are your conclusions?

- a. For case 7, you should compare the content in `myreport.txt` with the content in `myreport2.txt`. You should see that an index was added after the first trace was generated. This situation can cause confusion, especially if the trace does not contain an execution plan to begin with. This is what you can see from within `myreport.txt`:

```
*****
SQL ID: 51xxq509gnbbc
Plan Hash: 1729043503
select cust_id, sum(amount_sold)
from
  sales where cust_id=2 group by cust_id order by cust_id

call      count      cpu    elapsed      disk      query      current      rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse        1      0.00      0.00          0          1          0          0
Execute      1      0.00      0.00          0          0          0          0
Fetch        1     1.75     1.77          1  978282          0          1
-----  -----  -----  -----  -----  -----  -----  -----
total       3     1.75     1.77          1  978283          0          1

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95      (recursive depth: 1)

Rows      Row Source Operation
-----
          1 RESULT CACHE  gxd1gfy5dxhzzagytkv7nng9a2 (cr=978282 pr=1 pw=0
time=0 us)
          1 SORT GROUP BY NOSORT (cr=978282 pr=1 pw=0 time=0 us
cost=1231 size=3718 card=143)
      176 TABLE ACCESS FULL SALES (cr=978282 pr=1 pw=0 time=375637 us
cost=1231 size=3718 card=143)

Elapsed times include waiting on following events:
Event waited on                      Times      Max. Wait  Total Waited
-----  -----  -----  -----
Disk file operations I/O                  1          0.00      0.00
db file sequential read                  1          0.00      0.00
*****

```

- b. This is what you see from myreport2.txt. Notice that the row source section shows a TABLE ACCESS FULL and the explain plan shows a TABLE ACCESS BY INDEX ROWID. This is an indication that the explain plan is not accurate.

```

SQL ID: 51xxq509gnbbc
Plan Hash: 1729043503
select cust_id, sum(amount_sold)
from
sales where cust_id=2 group by cust_id order by cust_id

call      count      cpu    elapsed      disk      query      current      rows
-----  -----  -----  -----  -----  -----  -----  -----
Parse        1      0.00      0.00          0          1          0          0
Execute      2      0.00      0.00          0          0          0          0
Fetch        1      1.75      1.77          1  978282          0          1
-----  -----  -----  -----  -----  -----  -----  -----
total       4      1.75      1.77          1  978283          0          1

Misses in library cache during parse: 1
Optimizer mode: ALL_ROWS
Parsing user id: 95 (TRACE) (recursive depth: 1)

Rows      Row Source Operation
-----
         1 RESULT CACHE  gxd1gfy5dxhzzagytkv7nng9a2 (cr=978282 pr=1 pw=0
time=0 us)
         1 SORT GROUP BY NOSORT (cr=978282 pr=1 pw=0 time=0 us
cost=1231 size=3718 card=143)
      176  TABLE ACCESS FULL SALES (cr=978282 pr=1 pw=0 time=375637 us
cost=1231 size=3718 card=143)

Rows      Execution Plan
-----
         0 SELECT STATEMENT MODE: ALL_ROWS
         1 RESULT CACHE OF 'gxd1gfy5dxhzzagytkv7nng9a2'
           column-count=2; type=AUTO; dependencies=(TRACE.SALES);
name=
           "select cust_id, sum(amount_sold) from sales where
cust_id=2
           group by cust_id order by cust_id"
         1 SORT (GROUP BY NOSORT)
      176  TABLE ACCESS MODE: ANALYZED (BY INDEX ROWID) OF 'SALES'
           (TABLE)
         0  INDEX MODE: ANALYZED (RANGE SCAN) OF 'SALES_CUST_INDX'

```

(INDEX)

Elapsed times include waiting on following events:

Event waited on	Times Waited	Max. Wait	Total Waited
SQL*Net message to client	1	0.00	0.00
SQL*Net message from client	1	0.00	0.00
Disk file operations I/O	1	0.00	0.00
db file sequential read	1	0.00	0.00

25. You can now exit your terminal window.

## **Practices for Lesson 4: Using Basic Techniques**

## Practices for Lesson 4: Overview

---

### Practices Overview

In this practice, you perform the following:

- Rewrite queries for better performance
- Rewrite applications for better performance

### List of Cases:

- Case 1: Correlated Subquery
- Case 2: Join Conditions
- Case 3: Simple Predicate
- Case 4: Union
- Case 5: Combining SQL Statements
- Case 6: Database Connection Management

## Practice 4: Avoiding Common Mistakes

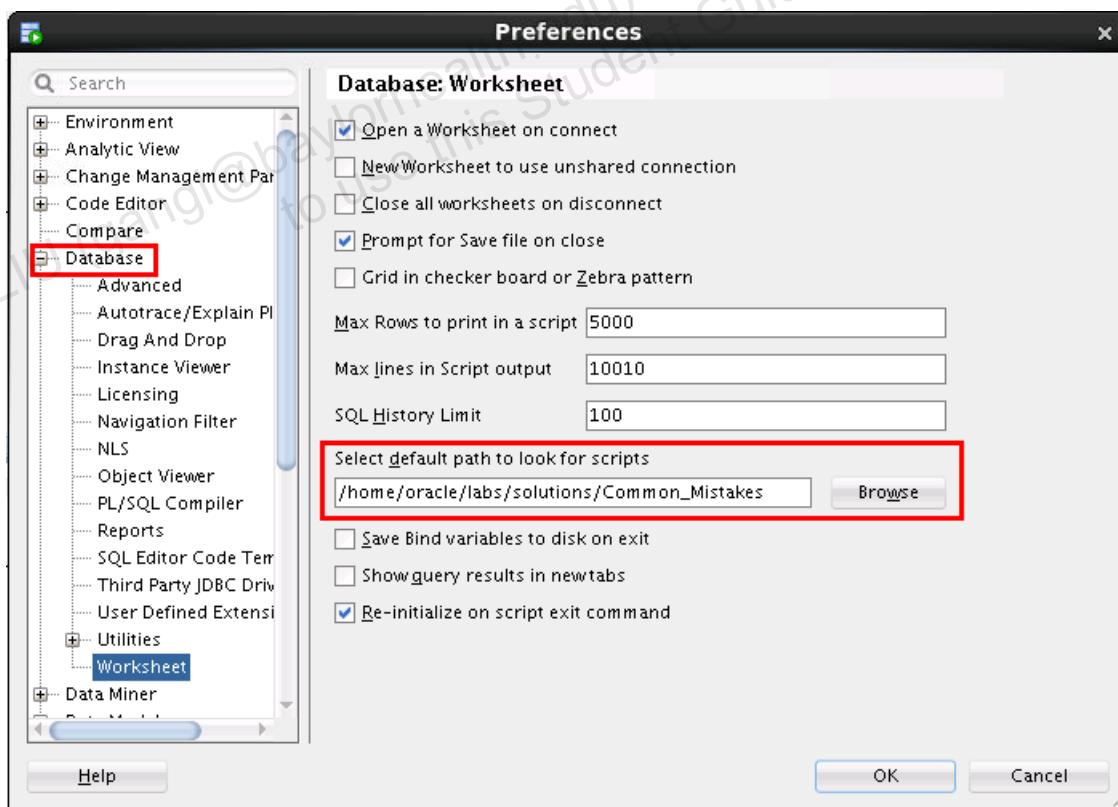
### Overview

In this practice, you examine some common mistakes in writing SQL statements. You have to find a workaround to enhance performance.

### Tasks

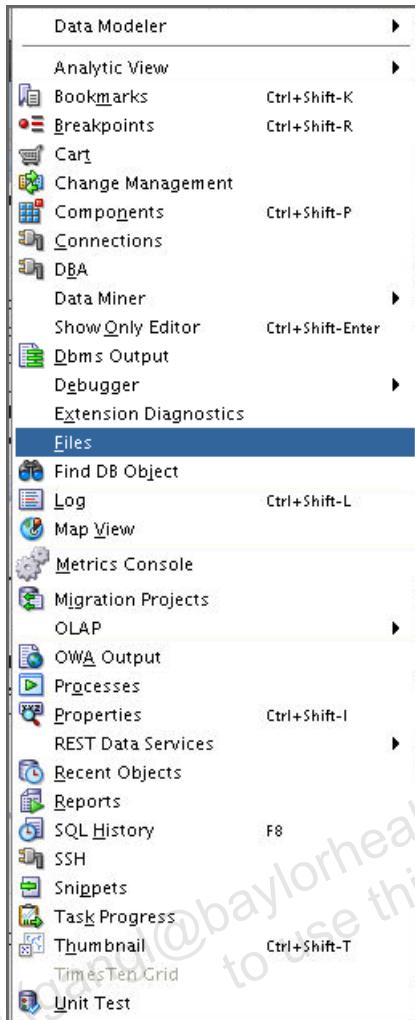
#### Case 1: Correlated Subquery

1. Execute the `correlation_setup.sh` script from the `$HOME/labs/solutions/Common_Mistakes` directory. You can find the scripts for all the following cases in your `$HOME/labs/solutions/Common_Mistakes` directory.
2. Analyze a correlated subquery in SQL Developer.
  - a. Go to Tools > Preferences.
  - b. Click Database > Worksheet.
  - c. Select `/home/oracle/labs/solutions/Common_Mistakes` as the default path.

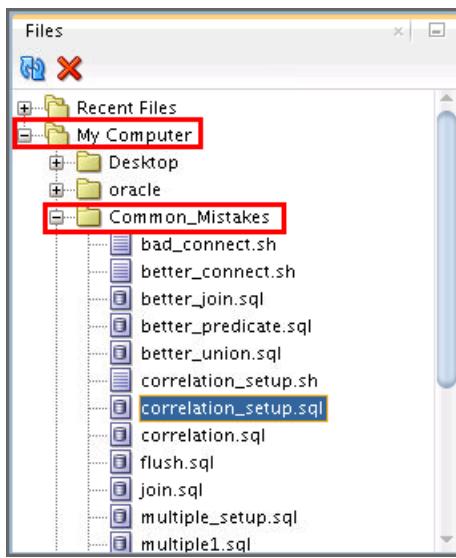


- d. Click OK.

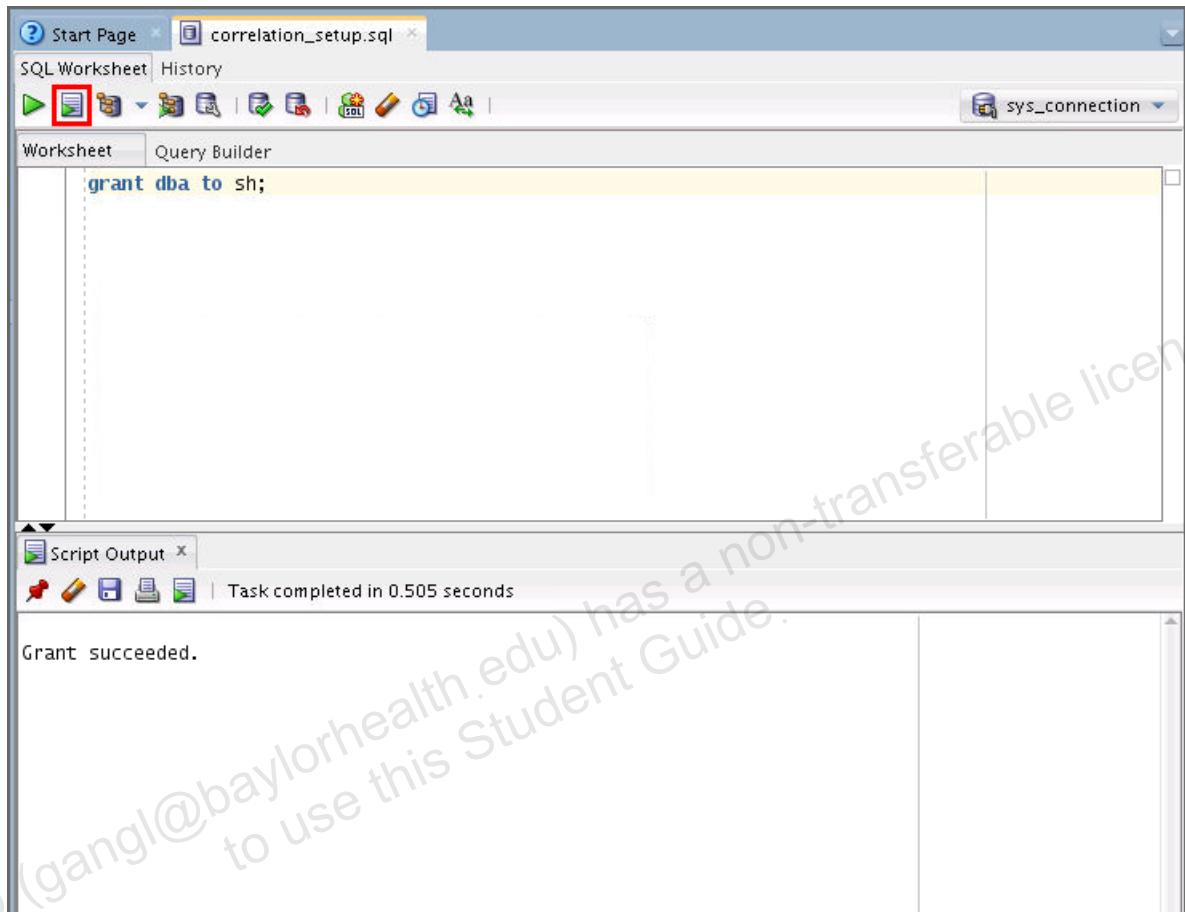
- e. Add the Files tab to the navigator pane. Select **View > Files**.



- f. In the file explorer, browse for the file under  
**My Computer > Common\_Mistakes > correlation\_setup.sql**



- g. Run the script by clicking the Run Script icon. (Alternatively, press F5.) When you execute the script, you must select a connection. Choose `sys_connection` from the drop-down list.



3. Open a SQL Worksheet as the `SH` user. (Stay connected to that session until the end of this case.)

Click the SQL Worksheet button and select `sh_connection` from the drop-down list.



4. Execute the following command:

```
set timing on  
@flush
```

The goal of the first command is to tell you how long any command takes to execute. The `flush.sql` script flushes both the shared pool and the buffer cache to avoid most caching.

effects so that you can make good comparisons between two executions. **Note:** You should *not* use commands found in this script on a production system.

The screenshot shows the SQL Developer interface. In the top right corner of the main window, there is a status bar with the text "4.35699987 seconds". Below the main window, the "Script Output" pane is visible, containing the following text:  
System FLUSH altered.  
Elapsed: 00:00:00.988  
System FLUSH altered.  
Elapsed: 00:00:03.297  
Elapsed: 00:00:03.299

The text "Task completed in 4.357 seconds" is highlighted with a red box in the "Script Output" pane.

**Note:** SQL Developer displays the timing information in the worksheet by default and in the output pane as a result of the `SET TIMING ON` command.

5. From the same session, execute the following statement and note the time it takes to execute. (You can use the correlation.sql script.)

```
SELECT COUNT(*)
FROM   products p
WHERE  prod_list_price < 1.15 * (SELECT avg(unit_cost)
                                    FROM costs c
                                    WHERE c.prod_id = p.prod_id);
```

The screenshot shows the Oracle SQL Developer interface. In the top navigation bar, there are tabs for 'Start Page', 'correlation.sql' (which is the active tab), 'correlation\_setup.sql', and 'sh\_connection'. Below the tabs is a toolbar with various icons. To the right of the toolbar, the text '0.206 seconds' is displayed in a red box, indicating the execution time. The main workspace is titled 'Worksheet' and contains the SQL query:

```
SELECT COUNT(*)
FROM   products p
WHERE  prod_list_price < 1.15 * (SELECT avg(unit_cost)
                                    FROM costs c
                                    WHERE c.prod_id = p.prod_id);
```

Below the worksheet is a 'Script Output' window. It displays the output of the query:

```
COUNT(*)
-----
46
```

The text 'Task completed in 0.206 seconds' is also highlighted with a red box in the script output window.

6. Before trying to fix the previous statement, flush your environment again by using the `flush.sql` script from the SQL Developer `sh_connection` session.

The screenshot shows the SQL Developer interface. The top menu bar has tabs for "Start Page", "correlation.sql", "correlation\_setup.sql", "sh\_connection", and "flush.sql". The "sh\_connection" tab is selected. The main workspace is titled "Worksheet" and contains the following SQL code:

```
alter system flush shared_pool;
alter system flush buffer_cache;
```

Below the worksheet is a "Script Output" panel. It shows the message "Task completed in 1.2 seconds" and two lines of output:

```
System FLUSH altered.  
System FLUSH altered.
```

A large watermark across the image reads: "GANG LIU (gangli@baylorhealth.edu) has a non-transferable license to use this Student Guide."

7. How do you rewrite this statement to enhance performance? Test your solution. You should discuss this with your instructor. (Alternatively, execute `nocorrelation.sql`.)

The screenshot shows an Oracle SQL Worksheet window. The top menu bar has tabs for "...sql", "correlation\_setup.sql", "sh\_connection", "flush.sql", and "nocorrelation.sql". Below the menu is a toolbar with various icons, one of which is highlighted with a red box. The status bar at the bottom of the toolbar also has a red box around it, showing the time "0.045 seconds". The main workspace contains a SQL query:

```
SELECT COUNT(*)
  FROM products p, (SELECT prod_id, AVG(unit_cost) ac FROM costs GROUP BY prod_id) c
 WHERE p.prod_id = c.prod_id AND
       p.prod_list_price < 1.15 * c.ac;
```

Below the workspace is a "Script Output" panel with a red box around its title. It displays the message "Task completed in 0.045 seconds". The output results show:

COUNT(*)
46

Elapsed: 00:00:00.018

8. The `setup_rest.sh` script was executed by the `oracle` user as part of the class setup to set up the environment for all the examples that follow. The `setup_rest.sh` script is listed here. You can find the scripts for all the following cases in your `/home/oracle/labs/solutions/Common_Mistakes` directory.

```
#!/bin/bash

cd /home/oracle/labs/solutions/Common_Mistakes

sqlplus sys/oracle_4U as sysdba <<EOF

alter session set container = orcldb;
set echo on
drop user cm cascade;

create user cm identified by cm default tablespace users
temporary tablespace temp;

grant connect, resource, dba to cm;

connect cm/cm@orclpdb
```

```
drop table orders purge;

create table orders (order_id_char varchar2(50) primary key,
order_total number, customer_name varchar2(300));

begin
for i in 1..500000 loop
insert into orders
values(i,100,'aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
end loop;
commit;
end;
/

begin
for i in 1..500000 loop
insert into orders
values(500000+i,100,'aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
end loop;
commit;
end;
/

drop table employees purge;
drop table job_history purge;

create table employees (employee_id number primary key, name
varchar2(500));

begin
for i in 1..500000 loop
insert into employees
values(i,'aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
end loop;
commit;
```

```
end;
/

create table job_history (employee_id number, job
varchar2(500));

begin
for i in 1..500000 loop
insert into job_history
values(mod(i,1000), 'aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa');

end loop;
commit;
end;
/


create index job_history_empid_indx on job_history(employee_id);

drop table old purge;
drop table new purge;

create table old(name varchar2(10), other varchar2(500));
create table new(name varchar2(10), other varchar2(500));

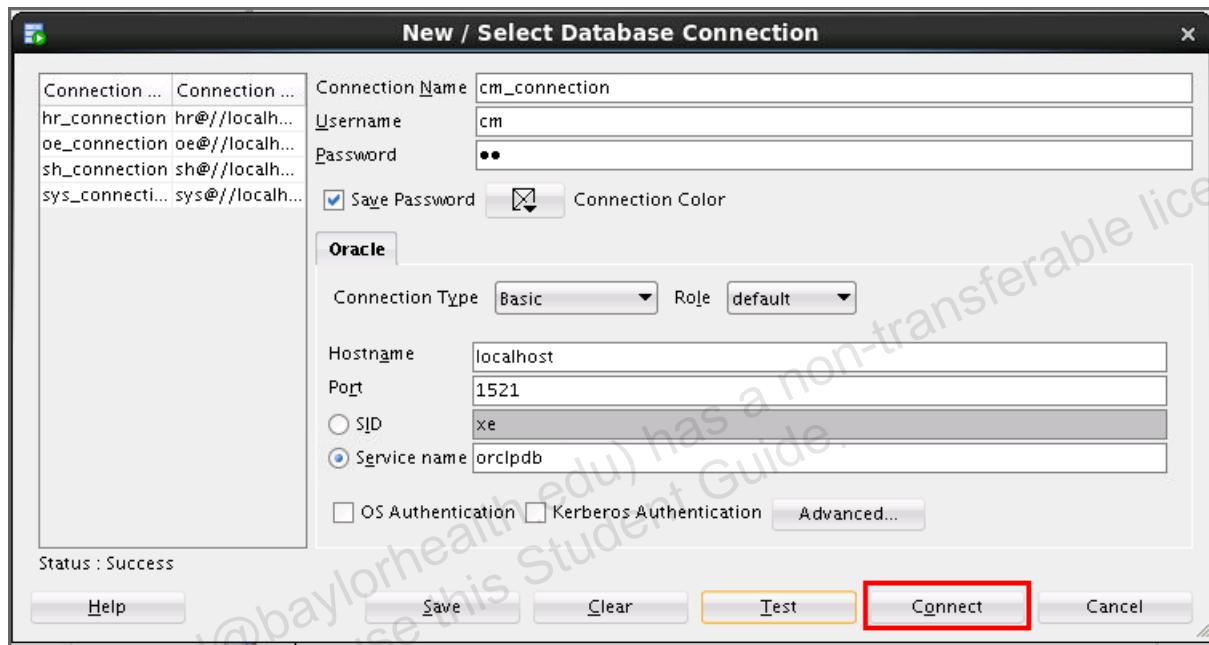
begin
for i in 1..500000 loop
insert into old
values(i, 'aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaa');

end loop;
commit;
end;
/


begin
for i in 1..500000 loop
insert into new
values(500000+i, 'aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa');
```

```
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa  
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa') ;  
end loop;  
commit;  
end;  
/  
;
```

9. Create and connect to the CM user. Stay connected in that session until further notice.



10. Set timings on and flush your environment again before starting the second case. You can use the `set timing on` command and the `flush.sql` script for this.

The screenshot shows the Oracle SQL Developer interface. In the top-left corner, there are two tabs: "flush.sql" and "cm\_connection". The "cm\_connection" tab is active, showing a green play button icon. Below the tabs is a toolbar with various icons. The main workspace is titled "Worksheet" and contains the SQL command: `set timing on` followed by `@flush`. To the right of the workspace is a status bar displaying "4.19500017 seconds". Below the workspace is a "Script Output" window with a toolbar. The output window displays the results of the executed commands:

```
System FLUSH altered.  
Elapsed: 00:00:01.111  
System FLUSH altered.  
Elapsed: 00:00:03.056  
Elapsed: 00:00:03.057
```

### Case 2: Join Conditions

11. The second case that you analyze is a join case. Using the `cm_connection`, open and execute the `join.sql` script shown here. Note the time it takes to complete:

```
SELECT count(*)  
FROM   job_history jh, employees e  
WHERE  substr(to_char(e.employee_id),1) =  
       substr(to_char(jh.employee_id),1);
```

A screenshot of the SQL Developer interface. The top menu bar shows tabs for 'flush.sql', 'cm\_connection', and 'join.sql'. The main workspace is titled 'Worksheet' and contains the following SQL code:

```
SELECT count(*)
FROM job_history jh, employees e
WHERE substr(to_char(e.employee_id),1) = substr(to_char(jh.employee_id),1);
```

The bottom pane, titled 'Script Output', displays the results of the query. A red box highlights the message 'Task completed in 6.078 seconds'. Below this, the output shows:

COUNT(*)
499500

12. Before trying to fix the previous statement, flush your environment again by using the `flush.sql` script from your SQL Developer `cm_connection` session.

A screenshot of the SQL Developer interface. The top menu bar shows tabs for 'flush.sql', 'cm\_connection', and 'join.sql'. The main workspace is titled 'Worksheet' and contains the following SQL code:

```
alter system flush shared_pool;
alter system flush buffer_cache;
```

The bottom pane, titled 'Script Output', displays the results of the script execution. A red box highlights the message 'Task completed in 1.297 seconds'. Below this, the output shows two lines of text:

System FLUSH altered.  
System FLUSH altered.

13. How would you rewrite the previous query for better performance? Test your solution. You should discuss this with your instructor. (Alternatively, open and execute the `better_join.sql` script.) Why is this query so much faster?

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are three tabs: "flush.sql", "cm\_connection", and "better\_join.sql". The "better\_join.sql" tab is active. Below the tabs is a toolbar with various icons for file operations, search, and help. The main workspace is divided into two panes: "Worksheet" on the left and "Query Builder" on the right. The Worksheet pane contains the following SQL code:

```
SELECT count(*)
FROM job_history jh, employees e
WHERE e.employee_id = jh.employee_id;
```

The Query Builder pane is currently empty. Below the workspace is a "Script Output" window. It has a toolbar with icons for script, edit, run, and save. A message box in the center of the output window says "Task completed in 0.627 seconds". The output results section shows the following data:

COUNT(*)
499500

- The function on the join conditions in the first query prevents the use of a normal index. Removing the functions allows the indexes to be used.

14. Before analyzing the third case, flush your environment again by using the `flush.sql` script from your SQL Developer `cm_connection` session.

The screenshot shows the SQL Developer interface. In the top tab bar, there are three tabs: "flush.sql", "cm\_connection", and "better\_join.sql". The "cm\_connection" tab is selected. Below the tabs is a toolbar with various icons. The main workspace is titled "Worksheet" and contains the following SQL code:

```
alter system flush shared_pool;
alter system flush buffer_cache;
```

Below the worksheet is a "Script Output" window. It shows the results of the execution:

```
System FLUSH altered.
System FLUSH altered.
```

### Case 3: Simple Predicate

15. The third case you analyze is a simple predicate case. Still using `cm_connection` from your SQL Developer session, execute the following query (alternatively, open and execute the `simple_predicate.sql` script) and note the time it takes to complete:

```
SELECT * FROM orders WHERE order_id_char = 1205;
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are three tabs: 'flush.sql', 'cm\_connection', and 'simple\_predicate.sql'. The 'simple\_predicate.sql' tab is active. Below the tabs is a toolbar with various icons. The main area is a 'Worksheet' tab showing the SQL query: 'SELECT \* FROM orders WHERE order\_id\_char = 1205;'. Below the worksheet is a 'Script Output' tab which displays the execution results. The output shows a single row from the 'orders' table:

ORDER_ID_CHAR	ORDER_TOTAL	CUSTOMER_NAME
1205	100	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

In the 'Script Output' tab, there is a message: 'Task completed in 5.116 seconds'.

16. Before trying to fix the SELECT statement in step 15, flush your environment again using the `flush.sql` script.

The screenshot shows the Oracle SQL Developer interface. The 'simple\_predicate.sql' tab is active. Below the tabs is a toolbar with various icons. The main area is a 'Worksheet' tab showing the SQL statements: 'alter system flush shared\_pool; alter system flush buffer\_cache;'. Below the worksheet is a 'Script Output' tab which displays the execution results. The output shows two messages: 'System FLUSH altered.' and 'System FLUSH altered.'

17. How would you rewrite the previous statement for better performance? Test your solution. You should discuss this with your instructor. (Alternatively, open and execute the better\_predicate.sql.) Why does this query execute more quickly?

```
SELECT * FROM orders WHERE order_id_char = '1205';
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are three tabs: 'flush.sql', 'cm\_connection', and 'better\_predicate.sql'. The 'cm\_connection' tab is selected. Below the tabs is a toolbar with various icons. The main area is a 'Worksheet' tab where the query `SELECT * FROM orders WHERE order_id_char = '1205';` is entered. To the right of the worksheet is a 'Script Output' window. Inside the script output window, a message says 'Task completed in 0.078 seconds'. Below the script output is a table result set:

ORDER_ID_CHAR	ORDER_TOTAL	CUSTOMER_NAME
1205	100	aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

- This version runs faster because the data type `order_id_char` column matches the data type of the literal value.

18. Before proceeding with the next analysis, flush your environment again by using the `flush.sql` script.

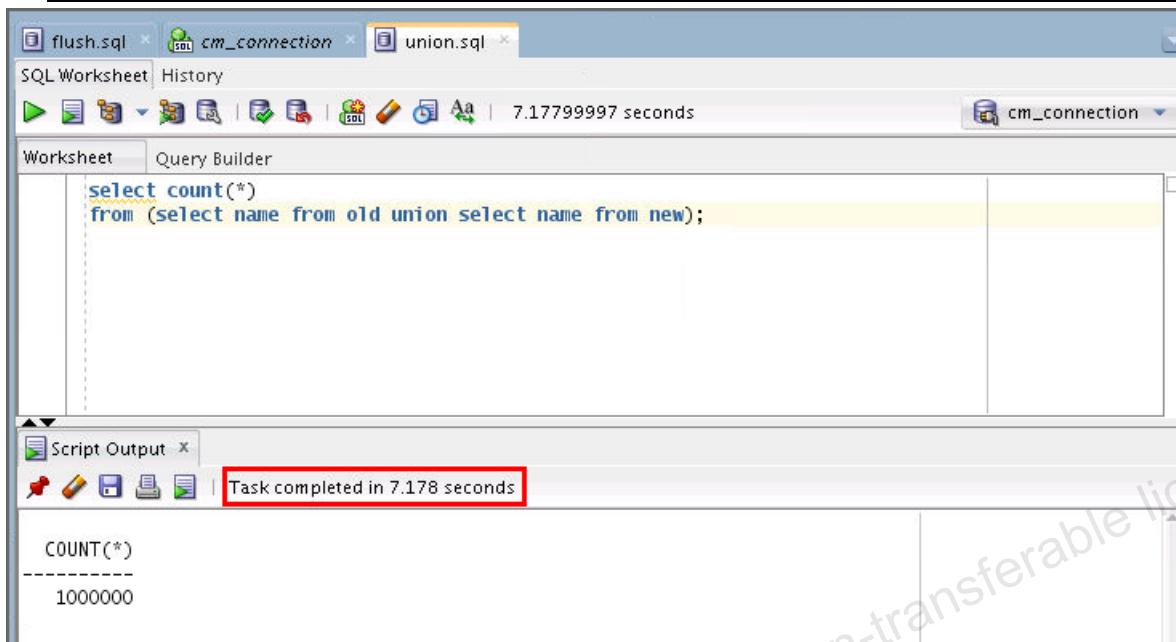
The screenshot shows the Oracle SQL Developer interface. The top tab bar has 'flush.sql', 'cm\_connection', and 'better\_predicate.sql' tabs, with 'cm\_connection' selected. The 'Worksheet' tab contains the SQL command `alter system flush shared_pool;` and `alter system flush buffer_cache;`. The 'Script Output' window below shows the results: 'Task completed in 0.924 seconds', followed by two messages: 'System FLUSH altered.' and 'System FLUSH altered.'

#### Case 4: Union

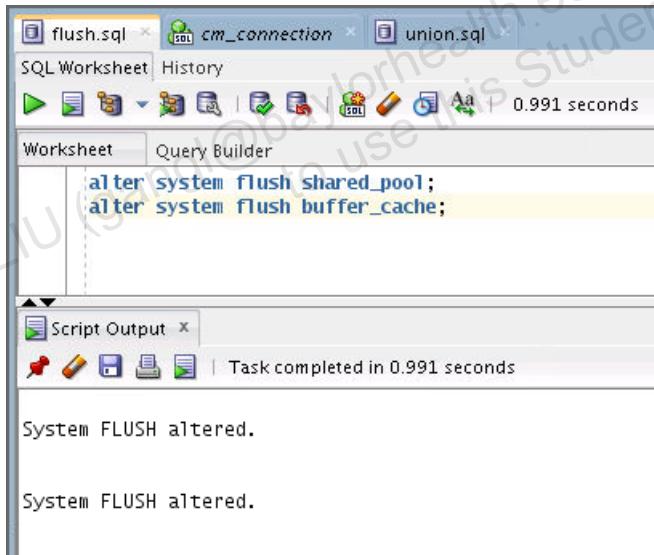
19. The fourth case is a `UNION` case. Execute the following query (alternatively, you can use `union.sql`) and note the time it takes to complete:

```
select count(*)
```

```
from (select name from old union select name from new);
```



20. Before investigating a better solution, flush your environment again by using the `flush.sql` script.



21. How would you rewrite the previous statement for better performance? Test your solution. You should discuss this with your instructor. (Alternatively, open and execute the `better_union.sql` script.) Why does this query execute more quickly?

**Note:** This query assumes that the `old` and `new` tables are disjoint sets, and there are no duplicate rows.

```
select count(*)
from (select name from old union all select name from new);
```

The screenshot shows the Oracle SQL Developer interface. At the top, there are three tabs: 'flush.sql', 'cm\_connection', and 'better\_union.sql'. The 'better\_union.sql' tab is active. Below the tabs is a toolbar with various icons. The main area has two tabs: 'Worksheet' and 'Query Builder', with 'Worksheet' selected. In the worksheet, the following SQL code is written:

```
select count(*)  
from (select name from old union all select name from new);
```

Below the worksheet is a 'Script Output' window. It displays the execution message: 'Task completed in 1.302 seconds'. Underneath this message, the output of the query is shown:

COUNT(*)
1000000

- The first query uses a `UNION`, which requires a sort to remove duplicate rows. The second uses a `UNION ALL`, which does not remove duplicates. This strategy works well when the tables are disjoint or the duplicate rows can be removed from one of the tables by using a `WHERE` clause.

## Case 5: Combining SQL Statements

22. Execute the `multiple_setup.sql` script the `cm_connection` to set up the environment for this case.

## Output:

The screenshot shows the 'Script Output' window of Oracle SQL Developer. The window title is 'Script Output'. The status bar at the top right says 'Task completed in 1.147 seconds'. The main area contains the following SQL commands and their output:

```
SQL> create table myemp as select * from hr.employees;
Table MYEMP created.

SQL>
SQL>
SQL> insert into myemp select * from myemp;
107 rows inserted.

SQL> /
SQL> commit;

Commit complete.

SQL>
SQL> insert into myemp select * from myemp;
214 rows inserted.

SQL> commit;

Commit complete.
```

23. Open and execute the `multiple1.sql` script by using the `cm_connection` and note the total time it takes to execute.

```
set echo on
set timing on
SELECT COUNT (*)
FROM myemp
WHERE salary < 2000;
SELECT COUNT (*)
FROM myemp
WHERE salary BETWEEN 2000 AND 4000;
SELECT COUNT (*)
FROM myemp
WHERE salary>4000;
set timing off
```

## Output:

The screenshot shows a 'Script Output' window with the following content:

```
SQL> set timing on
SQL>
SQL> SELECT COUNT (*)
  2  FROM myemp
  3  WHERE salary < 2000;

COUNT(*)
-----
0

Elapsed: 00:00:00.005
SQL>
SQL> SELECT COUNT (*)
  2  FROM myemp
  3  WHERE salary BETWEEN 2000 AND 4000;

COUNT(*)
-----
172

Elapsed: 00:00:00.003
SQL>
SQL> SELECT COUNT (*)
  2  FROM myemp
  3  WHERE salary>4000;

COUNT(*)
-----
256

Elapsed: 00:00:00.003
SQL>
SQL> set timing off
```

The status bar at the top right of the window displays 'Task completed in 0.105 seconds'.

24. How would you rewrite the statements found in the `multiple1.sql` script for better performance? Use the `multiple2.sql` script.

```

SQL> set echo on
SQL> set timing on
SQL>
SQL> SELECT COUNT (CASE WHEN salary < 2000
   THEN 1 ELSE null END) count1,
      COUNT (CASE WHEN salary BETWEEN 2001 AND 4000
   THEN 1 ELSE null END) count2,
      COUNT (CASE WHEN salary > 4000
   THEN 1 ELSE null END) count3
   FROM myemp;

COUNT1      COUNT2      COUNT3
-----      -----      -----
          0        172        256

Elapsed: 00:00:00.008
  
```

- A single SQL statement will usually execute more quickly than multiple statements.

### Case 6: Database Connection Management

25. You now analyze a sixth case that deals with database connections. Execute the `bad_connect.sh` script from your terminal window connected as the `oracle` user. Note the time it takes to complete.

```

$ cd /home/oracle/labs/solutions/Common_Mistakes
$ ./bad_connect.sh
  
```

```

#!/bin/bash

cd /home/oracle/labs/solutions/Common_Mistakes

STREAM_NUM=0
  
```

```

MAX_STREAM=500

date

while [ $STREAM_NUM -lt $MAX_STREAM ]; do

    # one more
    let STREAM_NUM=$STREAM_NUM+1

    # start one more stream
    sqlplus -s cm/cm@orclpdb @select.sql >> /tmp/bad_connect.log
2>&1

done

date

```

```

oracle@edvmr1p0:~/labs/solutions/Common_Mistakes
File Edit View Search Terminal Help
[oracle@edvmr1p0 ~]$ cd /home/oracle/labs/solutions/Common_Mistakes/
[oracle@edvmr1p0 Common_Mistakes]$ ./bad_connect.sh
Wed Jan 31 07:01:21 GMT 2018
Wed Jan 31 07:02:20 GMT 2018
[oracle@edvmr1p0 Common_Mistakes]$

```

26. Analyze the `bad_connect.sh` script and try to find a better solution to enhance the performance of that application. Test your solution. You should discuss this with your instructor. Run the `./better_connect.sh` script.

```

$ cd /home/oracle/labs/solutions/Common_Mistakes
$ ./better_connect.sh

```

```

#!/bin/bash

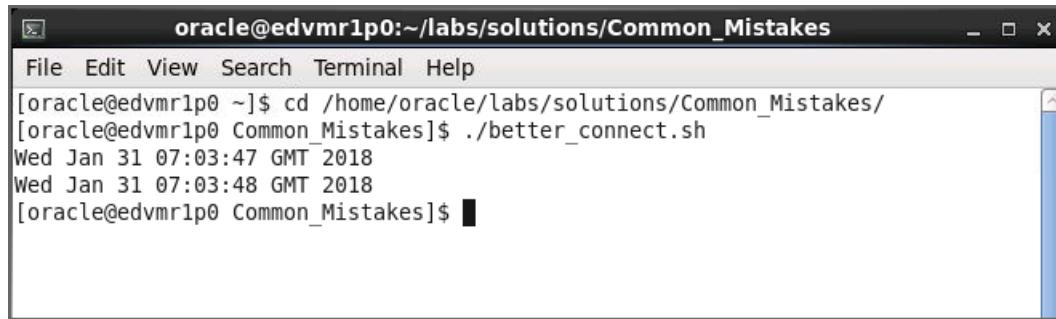
cd /home/oracle/labs/solutions/Common_Mistakes

date

sqlplus -s cm/cm@orclpdb @select2.sql >> /tmp/better_connect.log
2>&1

date

```



A screenshot of a terminal window titled "oracle@edvmr1p0:~/labs/solutions/Common\_Mistakes". The window shows the following command sequence:

```
[oracle@edvmr1p0 ~]$ cd /home/oracle/labs/solutions/Common_Mistakes/  
[oracle@edvmr1p0 Common_Mistakes]$ ./better_connect.sh  
Wed Jan 31 07:03:47 GMT 2018  
Wed Jan 31 07:03:48 GMT 2018  
[oracle@edvmr1p0 Common_Mistakes]$
```

- The first script executes a SQL 500 times in a loop that creates 500 connections and executes the SQL statement once in each. The second script creates one connection, and then executes the same SQL statement 500 times.

## **Practices for Lesson 5: Optimizer Fundamentals**

## Practices for Lesson 5: Overview

---

### Practices Overview

In these practices, you will create an event 10053 trace file, and then review the sections to recognize the contents of this file. You also open and analyze a SQL trace file by using SQL Developer. It is an optional practice.

**Note:** This practice is only for demonstration purposes. Do *not* use it on your production system unless explicitly asked to by Oracle Support Services.

## Practice 5-1: Understanding Optimizer Decisions (Optional)

### Overview

In this practice, you analyze optimizer decisions related to which execution plan to use. All the scripts needed for this practice can be found in your \$HOME/labs/solutions/Trace\_Event directory.

### Tasks

1. Execute the te\_setup.sh script. This script executes the following query and generates a trace file that contains all optimizer decisions:

```
SELECT ch.channel_class, c.cust_city, t.calendar_quarter_desc,
SUM(s.amount_sold) sales_amount
FROM sh.sales s,sh.times t,sh.customers c,sh.channels ch
WHERE s.time_id = t.time_id AND
s.cust_id = c.cust_id AND
s.channel_id = ch.channel_id AND
c.cust_state_province = 'CA' AND
ch.channel_desc IN ('Internet', 'Catalog') AND
t.calendar_quarter_desc IN ('1999-Q1', '1999-Q2')
GROUP BY ch.channel_class, c.cust_city, t.calendar_quarter_desc;
```

```
$ cd /home/oracle/labs/solutions/Trace_Event
$ ./te_setup.sh
```

2. With the help of your instructor, examine the generated trace file and interpret the important parts of the trace file.

The 10053 trace file output is broken down into a number of sections that broadly reflect the stages that the optimizer goes through in evaluating a plan. These stages are as follows: query, parameters used by the optimizer, base statistical information, base table access cost, join order and method computations, and recosting for special features, such as query transformations.

**Note:** The output can be different based on your practice environment.

```
$ cd /home/oracle/labs/solutions/Trace_Event
$ cat myoptimizer.trc
```

**Output:**

```
Trace file
/u01/app/oracle/diag/rdbms/orcl/orcl/trace/orcl_ora_7721_MYOPTIMIZER.trc
Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 -
64bit Production
```

```

Build label:      RDBMS_12.2.0.1.0_LINUX.X64_170125
ORACLE_HOME:     /u01/app/oracle/product/12.2.0/dbhome_1
System name:    Linux
Node name:      edvmr1p0
Release:        3.8.13-118.19.7.el6uek.x86_64
Version:        #2 SMP Fri Sep 15 18:08:56 PDT 2017
Machine:        x86_64
VM name:        Xen Version: 4.1 (HVM)
Instance name:  orcl
Redo thread mounted by this instance: 1
Oracle process number: 50
Unix process pid: 7721, image: oracle@edvmr1p0 (TNS V1-V3)

*** 2018-01-31T08:15:37.630041+00:00 (ORCLPDB(3))
*** SESSION ID:(29.61112) 2018-01-31T08:15:37.630115+00:00
*** CLIENT ID:() 2018-01-31T08:15:37.630127+00:00
*** SERVICE NAME:(orclpdb) 2018-01-31T08:15:37.630141+00:00
*** MODULE NAME:(sqlplus@edvmr1p0 (TNS V1-V3)) 2018-01-
31T08:15:37.630153+00:00
*** ACTION NAME:() 2018-01-31T08:15:37.630165+00:00
*** CLIENT DRIVER:(SQL*PLUS) 2018-01-31T08:15:37.630175+00:00
*** CONTAINER ID:(3) 2018-01-31T08:15:37.630187+00:00
Registered qb: SEL$1 0x5c3a04 (PARSER)
-----
QUERY BLOCK SIGNATURE
-----
signature (): qb_name=SEL$1 nbfrs=4 flg=0
fro(0): flg=4 objn=74136 hint_alias="C@"SEL$1"
fro(1): flg=4 objn=74132 hint_alias="CH@"SEL$1"
fro(2): flg=4 objn=74068 hint_alias="S@"SEL$1"
fro(3): flg=4 objn=74126 hint_alias="T@"SEL$1"

*** 2013-06-14 07:51:05.363
SPM: statement not found in SMB

*****
Automatic degree of parallelism (ADOP)
*****
Automatic degree of parallelism is disabled: Parameter.

PM: Considering predicate move-around in query block SEL$1 (#0)

```

```
*****
Predicate Move-Around (PM)
*****
OPTIMIZER INFORMATION

*****
----- Current SQL Statement for this session
(sql_id=70fqjd9u1zk7c) -----
SELECT ch.channel_class, c.cust_city, t.calendar_quarter_desc,
SUM(s.amount_sold) sales_amount
FROM sh.sales s,sh.times t,sh.customers c,sh.channels ch
WHERE s.time_id = t.time_id AND
s.cust_id = c.cust_id AND
s.channel_id = ch.channel_id AND
c.cust_state_province = 'CA' AND
ch.channel_desc IN ('Internet','Catalog') AND
t.calendar_quarter_desc IN ('1999-Q1','1999-Q2')
GROUP BY ch.channel_class, c.cust_city, t.calendar_quarter_desc
*****
```

Legend

The following abbreviations are used by optimizer trace.

CBQT - cost-based query transformation  
JPPD - join predicate push-down  
OJPPD - old-style (non-cost-based) JPPD  
FPD - filter push-down  
PM - predicate move-around  
CVM - complex view merging  
SPJ - select-project-join  
SJC - set join conversion  
SU - subquery unnesting  
OBYE - order by elimination  
OST - old style star transformation  
ST - new (cbqt) star transformation  
CNT - count(col) to count(\*) transformation  
JE - Join Elimination  
JF - join factorization  
SLP - select list pruning  
DP - distinct placement  
qb - query block  
LB - leaf blocks  
DK - distinct keys  
LB/K - average number of leaf blocks per key  
DB/K - average number of data blocks per key

```

CLUF - clustering factor
NDV - number of distinct values
Resp - response cost
Card - cardinality
Resc - resource cost
NL - nested loops (join)
SM - sort merge (join)
HA - hash (join)
CPUSPEED - CPU Speed
IOTFRSPEED - I/O transfer speed
IOSEEKTIM - I/O seek time
SREADTIM - average single block read time
MREADTIM - average multiblock read time
MBRC - average multiblock read count
MAXTHR - maximum I/O system throughput
SLAVETHR - average slave I/O throughput
dmeth - distribution method
  1: no partitioning required
  2: value partitioned
  4: right is random (round-robin)
 128: left is random (round-robin)
   8: broadcast right and partition left
  16: broadcast left and partition right
  32: partition left using partitioning of right
  64: partition right using partitioning of left
 256: run the join in serial
   0: invalid distribution method
sel - selectivity
ptn - partition
*****
PARAMETERS USED BY THE OPTIMIZER
*****
*****
PARAMETERS WITH ALTERED VALUES
*****
*****
Compilation Environment Dump
_smm_min_size          = 286 KB
_smm_max_size           = 57344 KB
_smm_px_max_size        = 143360 KB
Bug Fix Control Environment

```

```
*****
PARAMETERS WITH DEFAULT VALUES
*****  

Compilation Environment Dump  

optimizer_mode_hinted = false  

optimizer_features_hinted = 0.0.0  

parallel_execution_enabled = true  

parallel_query_forced_dop = 0  

parallel_dml_forced_dop = 0  

parallel_ddl_forced_degree = 0  

parallel_ddl_forced_instances = 0  

_query_rewrite_fudge = 90  

optimizer_features_enable = 12.1.0.1  

_optimizer_search_limit = 5  

cpu_count = 1  

...  

parallel_hinted = none  

_sql_compatibility = 0  

_optimizer_use_feedback = true  

_optimizer_try_st_before_jppd = true  

Bug Fix Control Environment  

fix 3834770 = 1  

fix 3746511 = enabled  

fix 4519016 = enabled  

fix 3118776 = enabled  

fix 4488689 = enabled  

fix 2194204 = disabled  

...  

*****  

PARAMETERS IN OPT_PARAM HINT
*****  

*****  

Column Usage Monitoring is ON: tracking level = 1
*****  

*****  

Considering Query Transformations on query block SEL$1 (#0)
*****  

Query transformations (QT)
*****  

CBQT: Validity checks passed for 70fqjd9u1zk7c.
```

```

CSE: Considering common sub-expression elimination in query
block SEL$1 (#0)
*****
Common Subexpression elimination (CSE)
*****
CSE:      CSE not performed on query block SEL$1 (#0).
OBYE:     Considering Order-by Elimination from view SEL$1 (#0)
*****
Order-by elimination (OBYE)
*****
OBYE:     OBYE bypassed: no order by to eliminate.
JE:       Considering Join Elimination on query block SEL$1 (#0)
*****
Join Elimination (JE)
*****
SQL:***** UNPARSED QUERY IS *****
SELECT "CH"."CHANNEL_CLASS" "CHANNEL_CLASS", "C"."CUST_CITY"
"CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
"CALENDAR_QUARTER_DESC", SUM("S"."AMOUNT_SOLD") "SALES_AMOUNT"
FROM "SH"."SALES" "S", "SH"."TIMES" "T", "SH"."CUSTOMERS"
"C", "SH"."CHANNELS" "CH" WHERE "S"."TIME_ID"="T"."TIME_ID" AND
"S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR
"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
"T"."CALENDAR_QUARTER_DESC"='1999-Q2') GROUP BY
"CH"."CHANNEL_CLASS", "C"."CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
SQL:***** UNPARSED QUERY IS *****
SELECT "CH"."CHANNEL_CLASS" "CHANNEL_CLASS", "C"."CUST_CITY"
"CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
"CALENDAR_QUARTER_DESC", SUM("S"."AMOUNT_SOLD") "SALES_AMOUNT"
FROM "SH"."SALES" "S", "SH"."TIMES" "T", "SH"."CUSTOMERS"
"C", "SH"."CHANNELS" "CH" WHERE "S"."TIME_ID"="T"."TIME_ID" AND
"S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR
"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
"T"."CALENDAR_QUARTER_DESC"='1999-Q2') GROUP BY
"CH"."CHANNEL_CLASS", "C"."CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
Query block SEL$1 (#0) unchanged
CNT:   Considering count(col) to count(*) on query block SEL$1
(#0)
*****

```

```

Count(col) to Count(*) (CNT)
*****
CNT:      COUNT() to COUNT(*) not done.
JE:      Considering Join Elimination on query block SEL$1 (#0)
*****
Join Elimination (JE)
*****
SQL:***** UNPARSED QUERY IS *****
SELECT "CH"."CHANNEL_CLASS" "CHANNEL_CLASS", "C"."CUST_CITY"
"CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
"CALENDAR_QUARTER_DESC", SUM("S"."AMOUNT_SOLD") "SALES_AMOUNT"
FROM "SH"."SALES" "S", "SH"."TIMES" "T", "SH"."CUSTOMERS"
"C", "SH"."CHANNELS" "CH" WHERE "S"."TIME_ID"="T"."TIME_ID" AND
"S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR
"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
"T"."CALENDAR_QUARTER_DESC"='1999-Q2') GROUP BY
"CH"."CHANNEL_CLASS", "C"."CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
SQL:***** UNPARSED QUERY IS *****
SELECT "CH"."CHANNEL_CLASS" "CHANNEL_CLASS", "C"."CUST_CITY"
"CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
"CALENDAR_QUARTER_DESC", SUM("S"."AMOUNT_SOLD") "SALES_AMOUNT"
FROM "SH"."SALES" "S", "SH"."TIMES" "T", "SH"."CUSTOMERS"
"C", "SH"."CHANNELS" "CH" WHERE "S"."TIME_ID"="T"."TIME_ID" AND
"S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR
"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
"T"."CALENDAR_QUARTER_DESC"='1999-Q2') GROUP BY
"CH"."CHANNEL_CLASS", "C"."CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
Query block SEL$1 (#0) unchanged
query block SEL$1 (#0) unchanged
Considering Query Transformations on query block SEL$1 (#0)
*****
Query transformations (QT)
*****
CSE: Considering common sub-expression elimination in query
block SEL$1 (#0)
*****
Common Subexpression elimination (CSE)
*****
CSE:      CSE not performed on query block SEL$1 (#0).

```

```

query block SEL$1 (#0) unchanged
apadrv-start sqlid=8087006336042125548
:
call(in-use=62772, alloc=81864), compile(in-use=73112,
alloc=77156), execution(in-use=3504, alloc=4060)

*****
Peeked values of the binds in SQL statement
*****

CBQT: Considering cost-based transformation on query block SEL$1
(#0)
*****
COST-BASED QUERY TRANSFORMATIONS
*****
FPD: Considering simple filter push (pre rewrite) in query block
SEL$1 (#0)
FPD: Current where clause predicates
"S"."TIME_ID"="T"."TIME_ID" AND "S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR
"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR "T"."C

OBYE: Considering Order-by Elimination from view SEL$1 (#0)
*****
Order-by elimination (OBYE)
*****
OBYE: OBYE bypassed: no order by to eliminate.
Considering Query Transformations on query block SEL$1 (#0)
*****
Query transformations (QT)
*****
CSE: Considering common sub-expression elimination in query
block SEL$1 (#0)
*****
Common Subexpression elimination (CSE)
*****
CSE: CSE not performed on query block SEL$1 (#0).
kkqctdrvTD-start on query block SEL$1 (#0)
kkqctdrvTD-start: :
call(in-use=62772, alloc=81864), compile(in-use=114972,
alloc=117532), execution(in-use=3504, alloc=4060)

```

```

kkqctdrvTD-cleanup: transform(in-use=0, alloc=0) :
  call(in-use=62772, alloc=81864), compile(in-use=115560,
alloc=117532), execution(in-use=3504, alloc=4060)

kkqctdrvTD-end:
  call(in-use=62772, alloc=81864), compile(in-use=115976,
alloc=117532), execution(in-use=3504, alloc=4060)

SJC: Considering set-join conversion in query block SEL$1 (#1)
*****
Set-Join Conversion (SJC)
*****
SJC: not performed
CNT: Considering count(col) to count(*) on query block SEL$1
(#1)
*****
Count(col) to Count(*) (CNT)
*****
CNT: COUNT() to COUNT(*) not done.
JE: Considering Join Elimination on query block SEL$1 (#1)
*****
Join Elimination (JE)
*****
SQL:***** UNPARSED QUERY IS *****
SELECT "CH"."CHANNEL_CLASS" "CHANNEL_CLASS", "C"."CUST_CITY"
"CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
"CALENDAR_QUARTER_DESC", SUM("S"."AMOUNT SOLD") "SALES_AMOUNT"
FROM "SH"."SALES" "S", "SH"."TIMES" "T", "SH"."CUSTOMERS"
"C", "SH"."CHANNELS" "CH" WHERE "S"."TIME_ID"="T"."TIME_ID" AND
"S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR
"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
"T"."CALENDAR_QUARTER_DESC"='1999-Q2') GROUP BY
"CH"."CHANNEL_CLASS", "C"."CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
SQL:***** UNPARSED QUERY IS *****
SELECT "CH"."CHANNEL_CLASS" "CHANNEL_CLASS", "C"."CUST_CITY"
"CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
"CALENDAR_QUARTER_DESC", SUM("S"."AMOUNT SOLD") "SALES_AMOUNT"
FROM "SH"."SALES" "S", "SH"."TIMES" "T", "SH"."CUSTOMERS"
"C", "SH"."CHANNELS" "CH" WHERE "S"."TIME_ID"="T"."TIME_ID" AND
"S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR

```

```

"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
 "T"."CALENDAR_QUARTER_DESC"='1999-Q2') GROUP BY
"CH"."CHANNEL_CLASS","C"."CUST_CITY","T"."CALENDAR_QUARTER_DESC"
Query block SEL$1 (#1) unchanged
PM: Considering predicate move-around in query block SEL$1 (#1)
*****
Predicate Move-Around (PM)
*****
PM:      PM bypassed: Outer query contains no views.
PM:      PM bypassed: Outer query contains no views.
kkqctdrvTD-start on query block SEL$1 (#1)
kkqctdrvTD-start: :
    call(in-use=82748, alloc=98240), compile(in-use=118884,
alloc=121656), execution(in-use=3504, alloc=4060)

kkqctdrvTD-cleanup: transform(in-use=0, alloc=0) :
    call(in-use=82748, alloc=98240), compile(in-use=119440,
alloc=121656), execution(in-use=3504, alloc=4060)

kkqctdrvTD-end:
    call(in-use=82748, alloc=98240), compile(in-use=119840,
alloc=121656), execution(in-use=3504, alloc=4060)

kkqctdrvTD-start on query block SEL$1 (#1)
kkqctdrvTD-start: :
    call(in-use=82748, alloc=98240), compile(in-use=119840,
alloc=121656), execution(in-use=3504, alloc=4060)

Registered qb: SEL$1 0x610068 (COPY SEL$1)
-----
QUERY BLOCK SIGNATURE
-----
signature(): NULL
*****
Cost-Based Group-By/Distinct Placement
*****
GBP/DP: Checking validity of GBP/DP for query block SEL$1 (#1)
GBP: Checking validity of group-by placement for query block
SEL$1 (#1)
GBP: Bypassed: QB has disjunction.
DP: Checking validity of distinct placement for query block
SEL$1 (#1)
DP: Bypassed: Query has invalid constructs.

```

```

kkqctdrvTD-cleanup: transform(in-use=9592, alloc=10596) :
  call(in-use=86820, alloc=98240), compile(in-use=139896,
alloc=146064), execution(in-use=3504, alloc=4060)

kkqctdrvTD-end:
  call(in-use=86820, alloc=98240), compile(in-use=129604,
alloc=146064), execution(in-use=3504, alloc=4060)

kkqctdrvTD-start on query block SEL$1 (#1)
kkqctdrvTD-start: :
  call(in-use=86820, alloc=98240), compile(in-use=129604,
alloc=146064), execution(in-use=3504, alloc=4060)

TE: Checking validity of table expansion for query block SEL$1
(#1)
TE: Bypassed: No relevant table found.
kkqctdrvTD-cleanup: transform(in-use=0, alloc=0) :
  call(in-use=87076, alloc=98240), compile(in-use=133212,
alloc=146064), execution(in-use=3504, alloc=4060)

kkqctdrvTD-end:
  call(in-use=87076, alloc=98240), compile(in-use=133612,
alloc=146064), execution(in-use=3504, alloc=4060)

TE: Checking validity of table expansion for query block SEL$1
(#1)
TE: Bypassed: No relevant table found.
ST: Query in kkqstardrv:***** UNPARSED QUERY IS *****
SELECT "CH"."CHANNEL_CLASS" "CHANNEL_CLASS", "C"."CUST_CITY"
"CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
"CALENDAR_QUARTER_DESC", SUM("S"."AMOUNT SOLD") "SALES_AMOUNT"
FROM "SH"."SALES" "S", "SH"."TIMES" "T", "SH"."CUSTOMERS"
"C", "SH"."CHANNELS" "CH" WHERE "S"."TIME_ID"="T"."TIME_ID" AND
"S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR
"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
"T"."CALENDAR_QUARTER_DESC"='1999-Q2') GROUP BY
"CH"."CHANNEL_CLASS", "C"."CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
ST: not valid since star transformation parameter is FALSE
kkqctdrvTD-start on query block SEL$1 (#1)
kkqctdrvTD-start: :
  call(in-use=87296, alloc=98240), compile(in-use=136524,
alloc=146064), execution(in-use=3504, alloc=4060)

```

```

JF: Checking validity of join factorization for query block
SEL$1 (#1)
JF: Bypassed: not a UNION or UNION-ALL query block.
kkqctdrvTD-cleanups: transform(in-use=0, alloc=0) :
    call(in-use=87296, alloc=98240), compile(in-use=137092,
alloc=146064), execution(in-use=3504, alloc=4060)

kkqctdrvTD-end:
    call(in-use=87296, alloc=98240), compile(in-use=137492,
alloc=146064), execution(in-use=3504, alloc=4060)

JPPD: Considering Cost-based predicate pushdown from query
block SEL$1 (#1)
*****
Cost-based predicate pushdown (JPPD)
*****
kkqctdrvTD-start on query block SEL$1 (#1)
kkqctdrvTD-start:
    call(in-use=87296, alloc=98240), compile(in-use=137492,
alloc=146064), execution(in-use=3504, alloc=4060)

kkqctdrvTD-cleanups: transform(in-use=0, alloc=0) :
    call(in-use=87296, alloc=98240), compile(in-use=138048,
alloc=146064), execution(in-use=3504, alloc=4060)

kkqctdrvTD-end:
    call(in-use=87296, alloc=98240), compile(in-use=138448,
alloc=146064), execution(in-use=3504, alloc=4060)

JPPD: Applying transformation directives
query block SEL$1 (#1) unchanged
FPD: Considering simple filter push in query block SEL$1 (#1)
"S"."TIME_ID"="T"."TIME_ID" AND "S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR
"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR "T"."C
try to generate transitive predicate from check constraints for
query block SEL$1 (#1)
finally: "S"."TIME_ID"="T"."TIME_ID" AND
"S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR

```

```

"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR "T"."C

Final query after transformations:***** UNPARSED QUERY IS
*****  

SELECT "CH"."CHANNEL_CLASS" "CHANNEL_CLASS", "C"."CUST_CITY"
"CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
"CALENDAR_QUARTER_DESC", SUM("S"."AMOUNT_SOLD") "SALES_AMOUNT"
FROM "SH"."SALES" "S", "SH"."TIMES" "T", "SH"."CUSTOMERS"
"C", "SH"."CHANNELS" "CH" WHERE "S"."TIME_ID"="T"."TIME_ID" AND
"S"."CUST_ID"="C"."CUST_ID" AND
"S"."CHANNEL_ID"="CH"."CHANNEL_ID" AND
"C"."CUST_STATE_PROVINCE"='CA' AND
("CH"."CHANNEL_DESC"='Internet' OR
"CH"."CHANNEL_DESC"='Catalog') AND
("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
"T"."CALENDAR_QUARTER_DESC"='1999-Q2') GROUP BY
"CH"."CHANNEL_CLASS", "C"."CUST_CITY", "T"."CALENDAR_QUARTER_DESC"
kkoqbc: optimizing query block SEL$1 (#1)

:  

call(in-use=87604, alloc=98240), compile(in-use=138896,
alloc=146064), execution(in-use=3504, alloc=4060)

kkoqbc-subheap (create addr=0x61b144)
*****  

QUERY BLOCK TEXT
*****  

SELECT ch.channel_class, c.cust_city, t.calendar_quarter_desc,
SUM(s.amount_sold) sales_amount
FROM sh.sales s,sh.times t,sh.customers c,sh.channels ch
WHERE s.time_id = t.time_id AND
s.cust_id = c.cust_id AND
s.channel_id = ch.channel_id
-----  

QUERY BLOCK SIGNATURE
-----  

signature (optimizer): qb_name=SEL$1 nbffros=4 flg=0
fro(0): flg=0 objn=74136 hint_alias="C@"SEL$1"
fro(1): flg=0 objn=74132 hint_alias="CH@"SEL$1"
fro(2): flg=0 objn=74068 hint_alias="S@"SEL$1"
fro(3): flg=0 objn=74126 hint_alias="T@"SEL$1"
-----  

SYSTEM STATISTICS INFORMATION
-----
```

```

Using NOWORKLOAD Stats
CPUSPEEDNW: 2696 millions instructions/sec (default is 100)
IOTFRSPEED: 4096 bytes per millisecond (default is 4096)
IOSEEKTIM: 10 milliseconds (default is 10)
MBRC: -1 blocks (default is 8)

*****
BASE STATISTICAL INFORMATION
*****

Table Stats:::
Table: CHANNELS Alias: CH
#Rows: 5 #Blks: 4 AvgRowLen: 41.00

Index Stats:::
Index: CHANNELS_PK Col#: 1
LVLS: 0 #LB: 1 #DK: 5 LB/K: 1.00 DB/K: 1.00 CLUF: 1.00
*****


Table Stats:::
Table: CUSTOMERS Alias: C
#Rows: 55500 #Blks: 1486 AvgRowLen: 181.00

Index Stats:::
Index: CUSTOMERS_GENDER_BIX Col#: 4
LVLS: 1 #LB: 3 #DK: 2 LB/K: 1.00 DB/K: 2.00 CLUF: 5.00
Index: CUSTOMERS_MARITAL_BIX Col#: 6
LVLS: 1 #LB: 5 #DK: 11 LB/K: 1.00 DB/K: 1.00 CLUF: 18.00
Index: CUSTOMERS_PK Col#: 1
LVLS: 1 #LB: 115 #DK: 55500 LB/K: 1.00 DB/K: 1.00 CLUF: 54405.00
Index: CUSTOMERS_YOB_BIX Col#: 5
LVLS: 1 #LB: 19 #DK: 75 LB/K: 1.00 DB/K: 1.00 CLUF: 75.00
Index: CUST_CUST_CITY_IDX Col#: 9
LVLS: 1 #LB: 161 #DK: 620 LB/K: 1.00 DB/K: 83.00 CLUF: 51600.00
*****


Table Stats:::
Table: TIMES Alias: T
#Rows: 1826 #Blks: 59 AvgRowLen: 198.00

Index Stats:::
Index: TIMES_PK Col#: 1
LVLS: 1 #LB: 5 #DK: 1826 LB/K: 1.00 DB/K: 1.00 CLUF: 53.00
*****
```

```

Table Stats::
  Table: SALES Alias: S (Using composite stats)
    #Rows: 918843 #Blks: 1769 AvgRowLen: 29.00
Index Stats::
  Index: SALES_CHANNEL_BIX Col#: 4
    USING COMPOSITE STATS
    LVLS: 1 #LB: 47 #DK: 4 LB/K: 11.00 DB/K: 23.00 CLUF:
92.00
  Index: SALES_CUST_BIX Col#: 2
    USING COMPOSITE STATS
    LVLS: 1 #LB: 475 #DK: 7059 LB/K: 1.00 DB/K: 5.00 CLUF:
35808.00
  Index: SALES_PROD_BIX Col#: 1
    USING COMPOSITE STATS
    LVLS: 1 #LB: 32 #DK: 72 LB/K: 1.00 DB/K: 14.00 CLUF:
1074.00
  Index: SALES_PROMO_BIX Col#: 5
    USING COMPOSITE STATS
    LVLS: 1 #LB: 30 #DK: 4 LB/K: 7.00 DB/K: 13.00 CLUF:
54.00
  Index: SALES_TIME_BIX Col#: 3
    USING COMPOSITE STATS
    LVLS: 1 #LB: 59 #DK: 1460 LB/K: 1.00 DB/K: 1.00 CLUF:
1460.00
Access path analysis for SALES
*****
SINGLE TABLE ACCESS PATH
  Single Table Cardinality Estimation for SALES[S]
  Table: SALES Alias: S
    Card: Original: 918843.000000 Rounded: 918843 Computed:
918843.00 Non Adjusted: 918843.00
  Access Path: TableScan
    Cost: 489.06 Resp: 489.06 Degree: 0
      Cost_io: 481.00 Cost_cpu: 260685437
      Resp_io: 481.00 Resp_cpu: 260685437
***** trying bitmap/domain indexes *****
  Access Path: index (FullScan)
    Index: SALES_CHANNEL_BIX
      resc_io: 75.00 resc_cpu: 552508
      ix_sel: 1.000000 ix_sel_with_filters: 1.000000
      Cost: 75.02 Resp: 75.02 Degree: 0
  Access Path: index (FullScan)
    Index: SALES_CUST_BIX
      resc_io: 503.00 resc_cpu: 10743684

```

```

ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 503.33 Resp: 503.33 Degree: 0
Access Path: index (FullScan)
Index: SALES_PROD_BIX
resc_io: 60.00 resc_cpu: 642086
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 60.02 Resp: 60.02 Degree: 0
Access Path: index (FullScan)
Index: SALES_PROMO_BIX
resc_io: 58.00 resc_cpu: 423844
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 58.01 Resp: 58.01 Degree: 0
Access Path: index (FullScan)
Index: SALES_TIME_BIX
resc_io: 60.00 resc_cpu: 719286
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 60.02 Resp: 60.02 Degree: 0
Access Path: index (FullScan)
Index: SALES_PROMO_BIX
resc_io: 58.00 resc_cpu: 423844
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 58.01 Resp: 58.01 Degree: 0
Bitmap nodes:
Used SALES_PROMO_BIX
Cost = 58.013101, sel = 1.000000
Access path: Bitmap index - accepted
Cost: 2881.534284 Cost_io: 2869.400000 Cost_cpu:
392576474.936000 Sel: 1.000000
Not Believed to be index-only
***** finished trying bitmap/domain indexes *****
Best:: AccessPath: TableScan
Cost: 489.06 Degree: 1 Resp: 489.06 Card: 918843.00
Bytes: 0

Access path analysis for TIMES
*****
SINGLE TABLE ACCESS PATH
Single Table Cardinality Estimation for TIMES[T]
Table: TIMES Alias: T
Card: Original: 1826.000000 Rounded: 183 Computed: 182.60
Non Adjusted: 182.60
Access Path: TableScan
Cost: 18.07 Resp: 18.07 Degree: 0

```

```

        Cost_io: 18.00  Cost_cpu: 2314640
        Resp_io: 18.00  Resp_cpu: 2314640
***** trying bitmap/domain indexes *****
Access Path: index (FullScan)
Index: TIMES_PK
resc_io: 6.00  resc_cpu: 407929
ix_sel: 1.000000  ix_sel_with_filters: 1.000000
Cost: 6.01  Resp: 6.01  Degree: 0
***** finished trying bitmap/domain indexes *****
Best:: AccessPath: TableScan
Cost: 18.07  Degree: 1  Resp: 18.07  Card: 182.60
Bytes: 0

Access path analysis for CUSTOMERS
*****
SINGLE TABLE ACCESS PATH
Single Table Cardinality Estimation for CUSTOMERS [C]
Table: CUSTOMERS  Alias: C
Card: Original: 55500.000000  Rounded: 383  Computed: 382.76
Non Adjusted: 382.76
Access Path: TableScan
Cost: 405.01  Resp: 405.01  Degree: 0
Cost_io: 404.00  Cost_cpu: 32782460
Resp_io: 404.00  Resp_cpu: 32782460
***** trying bitmap/domain indexes *****
Access Path: index (FullScan)
Index: CUSTOMERS_GENDER_BIX
resc_io: 4.00  resc_cpu: 29486
ix_sel: 1.000000  ix_sel_with_filters: 1.000000
Cost: 4.00  Resp: 4.00  Degree: 0
Access Path: index (FullScan)
Index: CUSTOMERS_MARITAL_BIX
resc_io: 6.00  resc_cpu: 46329
ix_sel: 1.000000  ix_sel_with_filters: 1.000000
Cost: 6.00  Resp: 6.00  Degree: 0
Access Path: index (FullScan)
Index: CUSTOMERS_PK
resc_io: 116.00  resc_cpu: 11926087
ix_sel: 1.000000  ix_sel_with_filters: 1.000000
Cost: 116.37  Resp: 116.37  Degree: 0
Access Path: index (FullScan)
Index: CUSTOMERS_YOB_BIX
resc_io: 20.00  resc_cpu: 157429

```

```

ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 20.00 Resp: 20.00 Degree: 0
Access Path: index (FullScan)
Index: CUST_CUST_CITY_IDX
resc_io: 162.00 resc_cpu: 12253673
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 162.38 Resp: 162.38 Degree: 0
Access Path: index (FullScan)
Index: CUSTOMERS_GENDER_BIX
resc_io: 4.00 resc_cpu: 29486
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 4.00 Resp: 4.00 Degree: 0
Bitmap nodes:
Used CUSTOMERS_GENDER_BIX
Cost = 4.000911, sel = 1.000000
Access path: Bitmap index - accepted
Cost: 2365.912518 Cost_io: 2364.560000 Cost_cpu:
43757572.166400 Sel: 1.000000
Not Believed to be index-only
***** finished trying bitmap/domain indexes *****
Best:: AccessPath: TableScan
Cost: 405.01 Degree: 1 Resp: 405.01 Card: 382.76
Bytes: 0

Access path analysis for CHANNELS
*****
SINGLE TABLE ACCESS PATH
Single Table Cardinality Estimation for CHANNELS[CH]
Table: CHANNELS Alias: CH
Card: Original: 5.000000 Rounded: 2 Computed: 2.00 Non
Adjusted: 2.00
Access Path: TableScan
Cost: 3.00 Resp: 3.00 Degree: 0
Cost_io: 3.00 Cost_cpu: 29826
Resp_io: 3.00 Resp_cpu: 29826
***** trying bitmap/domain indexes *****
Access Path: index (FullScan)
Index: CHANNELS_PK
resc_io: 1.00 resc_cpu: 8121
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 1.00 Resp: 1.00 Degree: 0
***** finished trying bitmap/domain indexes *****
Best:: AccessPath: TableScan

```

```

Cost: 3.00  Degree: 1  Resp: 3.00  Card: 2.00  Bytes: 0

Grouping column cardinality [CHANNEL_CL]      2
Grouping column cardinality [ CUST_CITY]     286
Grouping column cardinality [CALENDAR_Q]      2
*****
```

**OPTIMIZER STATISTICS AND COMPUTATIONS**

**GENERAL PLANS**

Considering cardinality-based initial join order.

Permutations for Starting Table :0

Join order[1]: CHANNELS[CH]#0 TIMES[T]#1 CUSTOMERS[C]#2  
SALES[S]#3

Now joining: TIMES[T]#1

NL Join

Outer table: Card: 2.00 Cost: 3.00 Resp: 3.00 Degree: 1  
Bytes: 21

Access path analysis for TIMES

Inner table: TIMES Alias: T

Access Path: TableScan

NL Join: Cost: 37.14 Resp: 37.14 Degree: 1  
Cost\_io: 37.00 Cost\_cpu: 4659106  
Resp\_io: 37.00 Resp\_cpu: 4659106

\*\*\*\*\* trying bitmap/domain indexes \*\*\*\*\*

Access Path: index (FullScan)

Index: TIMES\_PK  
resc\_io: 6.00 resc\_cpu: 407929  
ix\_sel: 1.000000 ix\_sel\_with\_filters: 1.000000  
Cost: 6.01 Resp: 6.01 Degree: 0

\*\*\*\*\* finished trying bitmap/domain indexes \*\*\*\*\*

Best NL cost: 37.14  
resc: 37.14 resc\_io: 37.00 resc\_cpu: 4659106  
resp: 37.14 resp\_io: 37.00 resc\_cpu: 4659106

Join Card: 365.200000 = = outer (2.000000) \* inner (182.600000)  
\* sel (1.000000)

Join Card - Rounded: 365 Computed: 365.20

```

Grouping column cardinality [CHANNEL_CL]          2
Grouping column cardinality [ CUST_CITY]         286
Grouping column cardinality [CALENDAR_Q]          2
Best::: JoinMethod: NestedLoop
      Cost: 37.14  Degree: 1  Resp: 37.14  Card: 365.20 Bytes:
37

*****
Now joining: CUSTOMERS[C]#2
*****
NL Join
  Outer table: Card: 365.20  Cost: 37.14  Resp: 37.14  Degree: 1
Bytes: 37
Access path analysis for CUSTOMERS
  Inner table: CUSTOMERS  Alias: C
  Access Path: TableScan
    NL Join:  Cost: 147305.99  Resp: 147305.99  Degree: 1
              Cost_io: 146936.00  Cost_cpu: 11970256947
              Resp_io: 146936.00  Resp_cpu: 11970256947
    ***** trying bitmap/domain indexes *****
  Access Path: index (FullScan)
    Index: CUSTOMERS_GENDER_BIX
    resc_io: 4.00  resc_cpu: 29486
    ix_sel: 1.000000  ix_sel_with_filters: 1.000000
    Cost: 4.00  Resp: 4.00  Degree: 0
  Access Path: index (FullScan)
    Index: CUSTOMERS_MARITAL_BIX
    resc_io: 6.00  resc_cpu: 46329
    ix_sel: 1.000000  ix_sel_with_filters: 1.000000
    Cost: 6.00  Resp: 6.00  Degree: 0
  Access Path: index (FullScan)
    Index: CUSTOMERS_PK
    resc_io: 116.00  resc_cpu: 11926087
    ix_sel: 1.000000  ix_sel_with_filters: 1.000000
    Cost: 116.37  Resp: 116.37  Degree: 0
  Access Path: index (FullScan)
    Index: CUSTOMERS_YOB_BIX
    resc_io: 20.00  resc_cpu: 157429
    ix_sel: 1.000000  ix_sel_with_filters: 1.000000
    Cost: 20.00  Resp: 20.00  Degree: 0
  Access Path: index (FullScan)
    Index: CUST_CUST_CITY_IDX
    resc_io: 162.00  resc_cpu: 12253673

```

```

ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 162.38 Resp: 162.38 Degree: 0
Access Path: index (FullScan)
Index: CUSTOMERS_GENDER_BIX
resc_io: 4.00 resc_cpu: 29486
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
NL Join : Cost: 1497.48 Resp: 1497.48 Degree: 1
Cost_io: 1497.00 Cost_cpu: 15421408
Resp_io: 1497.00 Resp_cpu: 15421408
Bitmap nodes:
Used CUSTOMERS_GENDER_BIX
Cost = 1497.476666, sel = 1.000000
Access path: Bitmap index - accepted
Cost: 863632.357158 Cost_io: 863138.400000 Cost_cpu:
15980832052.096001 Sel: 1.000000
Not Believed to be index-only
***** finished trying bitmap/domain indexes *****

Best NL cost: 147305.99
resc: 147305.99 resc_io: 146936.00 resc_cpu:
11970256947
resp: 147305.99 resp_io: 146936.00 resc_cpu:
11970256947
Join Card: 139783.448276 = = outer (365.200000) * inner
(382.758621) * sel (1.000000)
Join Card - Rounded: 139783 Computed: 139783.45
Grouping column cardinality [CHANNEL_CL] 2
Grouping column cardinality [ CUST_CITY] 286
Grouping column cardinality [CALENDAR_Q] 2
Best:: JoinMethod: NestedLoop
Cost: 147305.99 Degree: 1 Resp: 147305.99 Card:
139783.45 Bytes: 63

*****
Now joining: SALES[S]#3
*****
NL Join
Outer table: Card: 139783.45 Cost: 147305.99 Resp: 147305.99
Degree: 1 Bytes: 63
Access path analysis for SALES
Inner table: SALES Alias: S
Access Path: TableScan
NL Join: Cost: 2579339.46 Resp: 2579339.46 Degree: 1
Cost_io: 2538743.82 Cost_cpu: 1313377131608

```

```

        Resp_io: 2538743.82  Resp_cpu: 1313377131608
***** trying bitmap/domain indexes *****
Access Path: index (AllEqJoinGuess)
Index: SALES_CHANNEL_BIX
resc_io: 11.00  resc_cpu: 83786
ix_sel: 0.250000  ix_sel_with_filters: 0.250000
NL Join : Cost: 1685281.00  Resp: 1685281.00  Degree: 1
    Cost_io: 1684549.00  Cost_cpu: 23682093020
    Resp_io: 1684549.00  Resp_cpu: 23682093020
Access Path: index (AllEqJoinGuess)
Index: SALES_CUST_BIX
resc_io: 1.00  resc_cpu: 9171
ix_sel: 0.000142  ix_sel_with_filters: 0.000142
NL Join : Cost: 287128.62  Resp: 287128.62  Degree: 1
    Cost_io: 286719.00  Cost_cpu: 13252268345
    Resp_io: 286719.00  Resp_cpu: 13252268345
Access Path: index (AllEqJoinGuess)
Index: SALES_TIME_BIX
resc_io: 1.00  resc_cpu: 8171
ix_sel: 0.000685  ix_sel_with_filters: 0.000685
NL Join : Cost: 287124.30  Resp: 287124.30  Degree: 1
    Cost_io: 286719.00  Cost_cpu: 13112485345
    Resp_io: 286719.00  Resp_cpu: 13112485345
Bitmap nodes:
Used SALES_TIME_BIX
Cost = 287124.298421, sel = 0.000685
Used SALES_CUST_BIX
Cost = 287128.619023, sel = 0.000142
Not used SALES_CHANNEL_BIX
Cost = 1685280.998142, sel = 0.250000
Access path: Bitmap index - accepted
Cost: 721678.844307 Cost_io: 720497.059076 Cost_cpu:
38233905490.990532 Sel: 0.000000
Not Believed to be index-only
***** finished trying bitmap/domain indexes *****

Best NL cost: 721678.84
    resc: 721678.84  resc_io: 720497.06  resc_cpu:
38233905491
    resp: 721678.84  resp_io: 720497.06  resp_cpu:
38233905491
Join Card: 3115.595241 = = outer (139783.448276) * inner
(918843.000000) * sel (0.000000)

```

```

Join Card - Rounded: 3116 Computed: 3115.60
Grouping column cardinality [CHANNEL_CL]      2
Grouping column cardinality [ CUST_CITY]      286
Grouping column cardinality [CALENDAR_Q]       2
    Outer table: CUSTOMERS Alias: C
        resc: 147305.99   card 139783.45   bytes: 63   deg: 1   resp:
147305.99
    Inner table: SALES Alias: S
        resc: 489.06   card: 918843.00   bytes: 21   deg: 1   resp:
489.06
        using dmeth: 2 #groups: 1
        SORT ressource           Sort statistics
            Sort width:          334 Area size:      292864 Max Area
size: 58720256
            Degree:             1
            Blocks to Sort: 1370 Row size:      80 Total Rows:
139783
            Initial runs: 2 Merge passes: 1 IO Cost / pass:
744
            Total IO sort cost: 2114      Total CPU sort cost:
173738577
            Total Temp space used: 21423000
            SORT ressource           Sort statistics
                Sort width:          334 Area size:      292864 Max Area
size: 58720256
                Degree:             1
                Blocks to Sort: 3825 Row size:      34 Total Rows:
918843
                Initial runs: 2 Merge passes: 1 IO Cost / pass:
2074
                Total IO sort cost: 5899      Total CPU sort cost:
946620547
                Total Temp space used: 66626000
                SM join: Resc: 155842.68   Resp: 155842.68
[multiMatchCost=0.00]
SM Join
    SM cost: 155842.68
        resc: 155842.68   resc_io: 155430.00   resc_cpu: 13351301509
        resp: 155842.68   resp_io: 155430.00   resp_cpu: 13351301509
    Outer table: CUSTOMERS Alias: C
        resc: 147305.99   card 139783.45   bytes: 63   deg: 1   resp:
147305.99
    Inner table: SALES Alias: S
        resc: 489.06   card: 918843.00   bytes: 21   deg: 1   resp:
489.06

```

```

        using dmeth: 2 #groups: 1
        Cost per ptn: 1936.46 #ptns: 1
        hash_area: 124 (max=14336) buildfrag: 1280 probefrag: 3702
ppasses: 1
        Hash join: Resc: 149731.51 Resp: 149731.51
[multiMatchCost=0.00]
HA Join
    HA cost: 149731.51
        resc: 149731.51 resc_io: 149346.00 resc_cpu: 12472293183
        resp: 149731.51 resp_io: 149346.00 resp_cpu: 12472293183
GROUP BY sort
GROUP BY adjustment factor: 0.500000
GROUP BY cardinality: 572.000000, TABLE cardinality:
3116.000000
    SORT ressource          Sort statistics
        Sort width:           334 Area size:      292864 Max Area
size: 58720256
        Degree:               1
        Blocks to Sort: 40 Row size:   103 Total Rows:
3116
        Initial runs: 1 Merge passes: 0 IO Cost / pass:
0
        Total IO sort cost: 0 Total CPU sort cost: 33981962
        Total Temp space used: 0
Best::: JoinMethod: Hash
    Cost: 149732.56 Degree: 1 Resp: 149732.56 Card:
3115.60 Bytes: 84
*****
Best so far: Table#: 0 cost: 3.0009 card: 2.0000 bytes: 42
              Table#: 1 cost: 37.1440 card: 365.2000 bytes:
13505
              Table#: 2 cost: 147305.9929 card: 139783.4483
bytes: 8806329
              Table#: 3 cost: 149732.5609 card: 3115.5952
bytes: 261744
*****
Join order[2]: CHANNELS[CH]#0 TIMES[T]#1 SALES[S]#3
CUSTOMERS[C]#2

*****
Now joining: SALES[S]#3
*****
NL Join
    Outer table: Card: 365.20 Cost: 37.14 Resp: 37.14 Degree: 1
Bytes: 37

```

```

Access path analysis for SALES
  Inner table: SALES Alias: S
  Access Path: TableScan
    NL Join: Cost: 6387.72 Resp: 6387.72 Degree: 1
      Cost_io: 6282.54 Cost_cpu: 3402879986
      Resp_io: 6282.54 Resp_cpu: 3402879986
***** trying bitmap/domain indexes *****
  Access Path: index (AllEqJoinGuess)
    Index: SALES_CHANNEL_BIX
    resc_io: 11.00 resc_cpu: 83786
    ix_sel: 0.250000 ix_sel_with_filters: 0.250000
    NL Join : Cost: 4053.09 Resp: 4053.09 Degree: 1
      Cost_io: 4052.00 Cost_cpu: 35240937
      Resp_io: 4052.00 Resp_cpu: 35240937
  Access Path: index (AllEqJoinGuess)
    Index: SALES_TIME_BIX
    resc_io: 1.00 resc_cpu: 8171
    ix_sel: 0.000685 ix_sel_with_filters: 0.000685
    NL Join : Cost: 402.24 Resp: 402.24 Degree: 1
      Cost_io: 402.00 Cost_cpu: 7641681
      Resp_io: 402.00 Resp_cpu: 7641681
  Bitmap nodes:
    Used SALES_TIME_BIX
      Cost = 402.236199, sel = 0.000685
    Used SALES_CHANNEL_BIX
      Cost = 4053.089275, sel = 0.250000
  Access path: Bitmap index - accepted
    Cost: 1390.849950 Cost_io: 1390.085842 Cost_cpu:
24720933.612843 Sel: 0.000171
    Not Believed to be index-only
***** finished trying bitmap/domain indexes *****

  Best NL cost: 1390.85
    resc: 1390.85 resc_io: 1390.09 resc_cpu: 24720934
    resp: 1390.85 resp_io: 1390.09 resp_cpu: 24720934
  Join Card: 57459.154726 = = outer (365.200000) * inner
(918843.000000) * sel (0.000171)
  Join Card - Rounded: 57459 Computed: 57459.15
  Grouping column cardinality [CHANNEL_CL] 2
  Grouping column cardinality [ CUST_CITY] 286
  Grouping column cardinality [CALENDAR_Q] 2
  Outer table: TIMES Alias: T
    resc: 37.14 card 365.20 bytes: 37 deg: 1 resp: 37.14

```

```

Inner table: SALES Alias: S
  resc: 489.06 card: 918843.00 bytes: 21 deg: 1 resp:
489.06
    using dmeth: 2 #groups: 1
    SORT ressource          Sort statistics
      Sort width:           334 Area size:       292864 Max Area
size: 58720256
      Degree:               1
      Blocks to Sort: 3 Row size:      51 Total Rows:
365
      Initial runs: 1 Merge passes: 0 IO Cost / pass:
0
      Total IO sort cost: 0      Total CPU sort cost: 32492643
      Total Temp space used: 0
      SORT ressource          Sort statistics
        Sort width:           334 Area size:       292864 Max Area
size: 58720256
        Degree:               1
        Blocks to Sort: 3825 Row size:     34 Total Rows:
918843
        Initial runs: 2 Merge passes: 1 IO Cost / pass:
2074
        Total IO sort cost: 5899      Total CPU sort cost:
946620547
        Total Temp space used: 66626000
      SM join: Resc: 6455.47 Resp: 6455.47 [multiMatchCost=0.00]
SM Join
      SM cost: 6455.47
      resc: 6455.47 resc_io: 6417.00 resc_cpu: 1244457733
      resp: 6455.47 resp_io: 6417.00 resp_cpu: 1244457733
Outer table: TIMES Alias: T
  resc: 37.14 card 365.20 bytes: 37 deg: 1 resp: 37.14
Inner table: SALES Alias: S
  resc: 489.06 card: 918843.00 bytes: 21 deg: 1 resp:
489.06
    using dmeth: 2 #groups: 1
    Cost per ptn: 3.34 #ptns: 1
    hash_area: 124 (max=14336) buildfrag: 3 probefrag: 3702
ppasses: 1
    Hash join: Resc: 529.54 Resp: 529.54 [multiMatchCost=0.00]
HA Join
    HA cost: 529.54
    resc: 529.54 resc_io: 518.00 resc_cpu: 373459927
    resp: 529.54 resp_io: 518.00 resp_cpu: 373459927

```

```

Best::: JoinMethod: Hash
      Cost: 529.54  Degree: 1  Resp: 529.54  Card: 57459.15
      Bytes: 58

*****
Now joining: CUSTOMERS[C]#2
*****
NL Join
  Outer table: Card: 57459.15  Cost: 529.54  Resp: 529.54
  Degree: 1  Bytes: 58
  Access path analysis for CUSTOMERS
    Inner table: CUSTOMERS  Alias: C
    Access Path: TableScan
      NL Join:  Cost: 23183606.86  Resp: 23183606.86  Degree: 1
      Cost_io: 23125373.00  Cost_cpu: 1884020819874
      Resp_io: 23125373.00  Resp_cpu: 1884020819874
      Access Path: index (UniqueScan)
        Index: CUSTOMERS_PK
        resc_io: 1.00  resc_cpu: 9421
        ix_sel: 0.000018  ix_sel_with_filters: 0.000018
        NL Join : Cost: 58005.28  Resp: 58005.28  Degree: 1
        Cost_io: 57977.00  Cost_cpu: 914806448
        Resp_io: 57977.00  Resp_cpu: 914806448
      Access Path: index (AllEqUnique)
        Index: CUSTOMERS_PK
        resc_io: 1.00  resc_cpu: 9421
        ix_sel: 0.000018  ix_sel_with_filters: 0.000018
        NL Join : Cost: 58005.28  Resp: 58005.28  Degree: 1
        Cost_io: 57977.00  Cost_cpu: 914806448
        Resp_io: 57977.00  Resp_cpu: 914806448
***** trying bitmap/domain indexes *****
***** finished trying bitmap/domain indexes *****

Best NL cost: 58005.28
      resc: 58005.28  resc_io: 57977.00  resc_cpu: 914806448
      resp: 58005.28  resp_io: 57977.00  resp_cpu: 914806448
Join Card: 3115.595241 = = outer (57459.154726) * inner
(382.758621) * sel (0.000142)
Join Card - Rounded: 3116 Computed: 3115.60
Grouping column cardinality [CHANNEL_CL] 2
Grouping column cardinality [CUST_CITY] 286
Grouping column cardinality [CALENDAR_Q] 2
Outer table: SALES Alias: S

```

```

    resc: 529.54  card 57459.15  bytes: 58  deg: 1  resp: 529.54
Inner table: CUSTOMERS Alias: C
    resc: 405.01  card: 382.76  bytes: 26  deg: 1  resp: 405.01
    using dmeth: 2  #groups: 1
    SORT ressource          Sort statistics
        Sort width:           334 Area size:       292864 Max Area
size:      58720256
        Degree:               1
        Blocks to Sort: 521 Row size:       74 Total Rows:
57459
        Initial runs: 2 Merge passes: 1 IO Cost / pass:
284
        Total IO sort cost: 805      Total CPU sort cost: 86112225
        Total Temp space used: 8348000
    SORT ressource          Sort statistics
        Sort width:           334 Area size:       292864 Max Area
size:      58720256
        Degree:               1
        Blocks to Sort: 2 Row size:       39 Total Rows:
383
        Initial runs: 1 Merge passes: 0 IO Cost / pass:
0
        Total IO sort cost: 0      Total CPU sort cost: 32500745
        Total Temp space used: 0
    SM join: Resc: 1743.22  Resp: 1743.22  [multiMatchCost=0.00]
SM Join
    SM cost: 1743.22
        resc: 1743.22  resc_io: 1727.00  resc_cpu: 524855356
        resp: 1743.22  resp_io: 1727.00  resp_cpu: 524855356
Outer table: SALES Alias: S
    resc: 529.54  card 57459.15  bytes: 58  deg: 1  resp: 529.54
Inner table: CUSTOMERS Alias: C
    resc: 405.01  card: 382.76  bytes: 26  deg: 1  resp: 405.01
    using dmeth: 2  #groups: 1
    Cost per ptn: 192.83  #ptns: 1
    hash_area: 124 (max=14336) buildfrag: 491 probefrag: 2
ppasses: 1
    Hash join: Resc: 1127.40  Resp: 1127.40  [multiMatchCost=0.01]
Outer table: CUSTOMERS Alias: C
    resc: 405.01  card 382.76  bytes: 26  deg: 1  resp: 405.01
Inner table: SALES Alias: S
    resc: 529.54  card: 57459.15  bytes: 58  deg: 1  resp:
529.54
    using dmeth: 2  #groups: 1

```

```

Cost per ptn: 0.68 #ptns: 1
hash_area: 124 (max=14336) buildfrag: 2 probefrag: 491
ppasses: 1
Hash join: Resc: 935.24 Resp: 935.24 [multiMatchCost=0.00]
HA Join
  HA cost: 935.24 swapped
    resc: 935.24 resc_io: 922.00 resc_cpu: 428222071
    resp: 935.24 resp_io: 922.00 resp_cpu: 428222071
GROUP BY sort
GROUP BY adjustment factor: 0.500000
GROUP BY cardinality: 572.000000, TABLE cardinality:
3116.000000
  SORT ressource           Sort statistics
    Sort width:            334 Area size:        292864 Max Area
size:      58720256
    Degree:                 1
    Blocks to Sort: 40 Row size:       103 Total Rows:
3116
    Initial runs: 1 Merge passes: 0 IO Cost / pass:
0
    Total IO sort cost: 0 Total CPU sort cost: 33981962
    Total Temp space used: 0
Best::: JoinMethod: Hash
  Cost: 936.29 Degree: 1 Resp: 936.29 Card: 3115.60
Bytes: 84
*****
Best so far: Table#: 0 cost: 3.0009 card: 2.0000 bytes: 42
              Table#: 1 cost: 37.1440 card: 365.2000 bytes:
13505
              Table#: 3 cost: 529.5434 card: 57459.1547
bytes: 3332622
              Table#: 2 cost: 936.2864 card: 3115.5952 bytes:
261744
*****
...
Join order[22]: SALES[S]#3 CUSTOMERS[C]#2 TIMES[T]#1
CHANNELS[CH]#0

*****
Now joining: TIMES[T]#1
*****
NL Join
  Outer table: Card: 49822.22 Cost: 897.41 Resp: 897.41
Degree: 1 Bytes: 47

```

```

Access path analysis for TIMES
  Inner table: TIMES Alias: T
  Access Path: TableScan
    NL Join: Cost: 800577.88 Resp: 800577.88 Degree: 1
      Cost_io: 797001.00 Cost_cpu: 115721578068
      Resp_io: 797001.00 Resp_cpu: 115721578068
  Access Path: index (UniqueScan)
    Index: TIMES_PK
    resc_io: 1.00 resc_cpu: 10059
    ix_sel: 0.000548 ix_sel_with_filters: 0.000548
    NL Join : Cost: 50734.90 Resp: 50734.90 Degree: 1
      Cost_io: 50707.00 Cost_cpu: 902742490
      Resp_io: 50707.00 Resp_cpu: 902742490
  Access Path: index (AllEqUnique)
    Index: TIMES_PK
    resc_io: 1.00 resc_cpu: 10059
    ix_sel: 0.000548 ix_sel_with_filters: 0.000548
    NL Join : Cost: 50734.90 Resp: 50734.90 Degree: 1
      Cost_io: 50707.00 Cost_cpu: 902742490
      Resp_io: 50707.00 Resp_cpu: 902742490
***** trying bitmap/domain indexes *****
***** finished trying bitmap/domain indexes *****

  Best NL cost: 50734.90
    resc: 50734.90 resc_io: 50707.00 resc_cpu: 902742490
    resp: 50734.90 resp_io: 50707.00 resp_cpu: 902742490
Join Card: 6231.190483 == outer (49822.224013) * inner
(182.600000) * sel (0.000685)
Join Card - Rounded: 6231 Computed: 6231.19
Grouping column cardinality [CHANNEL_CL] 2
Grouping column cardinality [ CUST_CITY] 286
Grouping column cardinality [CALENDAR_Q] 2
Outer table: CUSTOMERS Alias: C
  resc: 897.41 card 49822.22 bytes: 47 deg: 1 resp: 897.41
Inner table: TIMES Alias: T
  resc: 18.07 card: 182.60 bytes: 16 deg: 1 resp: 18.07
  using dmeth: 2 #groups: 1
    SORT ressource           Sort statistics
      Sort width:          334 Area size:        292864 Max Area
size:      58720256
      Degree:              1
      Blocks to Sort: 379 Row size:       62 Total Rows:
49822

```

```

Initial runs: 2 Merge passes: 1 IO Cost / pass:
206
    Total IO sort cost: 585      Total CPU sort cost: 76713467
    Total Temp space used: 6022000
    SORT ressource           Sort statistics
        Sort width:          334 Area size:       292864 Max Area
size: 58720256
        Degree:              1
        Blocks to Sort: 1 Row size:     28 Total Rows:
183
    Initial runs: 1 Merge passes: 0 IO Cost / pass:
0
    Total IO sort cost: 0      Total CPU sort cost: 32414635
    Total Temp space used: 0
    SM join: Resc: 1503.86 Resp: 1503.86 [multiMatchCost=0.00]
SM Join
    SM cost: 1503.86
        resc: 1503.86 resp_io: 1488.00 resp_cpu: 513028724
        resp: 1503.86 resp_io: 1488.00 resp_cpu: 513028724
    Outer table: CUSTOMERS Alias: C
        resc: 897.41 card 49822.22 bytes: 47 deg: 1 resp: 897.41
    Inner table: TIMES Alias: T
        resc: 18.07 card: 182.60 bytes: 16 deg: 1 resp: 18.07
        using dmeth: 2 #groups: 1
        Cost per ptn: 140.78 #ptns: 1
        hash_area: 124 (max=14336) buildfrag: 359 probefrag: 1
ppasses: 1
    Hash join: Resc: 1056.28 Resp: 1056.28 [multiMatchCost=0.02]
Outer table: TIMES Alias: T
    resc: 18.07 card 182.60 bytes: 16 deg: 1 resp: 18.07
Inner table: CUSTOMERS Alias: C
    resc: 897.41 card: 49822.22 bytes: 47 deg: 1 resp:
897.41
    using dmeth: 2 #groups: 1
    Cost per ptn: 0.65 #ptns: 1
    hash_area: 124 (max=14336) buildfrag: 1 probefrag: 359
ppasses: 1
    Hash join: Resc: 916.14 Resp: 916.14 [multiMatchCost=0.00]
HA Join
    HA cost: 916.14 swapped
        resc: 916.14 resp_io: 903.00 resp_cpu: 425086605
        resp: 916.14 resp_io: 903.00 resp_cpu: 425086605
Best:: JoinMethod: Hash

```

```

Cost: 916.14  Degree: 1  Resp: 916.14  Card: 6231.19
Bytes: 63

*****
Now joining: CHANNELS [CH] #0
*****
NL Join
Outer table: Card: 6231.19  Cost: 916.14  Resp: 916.14
Degree: 1  Bytes: 63
Access path analysis for CHANNELS
Inner table: CHANNELS  Alias: CH
Access Path: TableScan
NL Join: Cost: 7673.88  Resp: 7673.88  Degree: 1
Cost_io: 7655.00  Cost_cpu: 610930916
Resp_io: 7655.00  Resp_cpu: 610930916
Access Path: index (UniqueScan)
Index: CHANNELS_PK
resc_io: 1.00  resc_cpu: 8451
ix_sel: 0.200000  ix_sel_with_filters: 0.200000
NL Join : Cost: 7148.77  Resp: 7148.77  Degree: 1
Cost_io: 7134.00  Cost_cpu: 477747528
Resp_io: 7134.00  Resp_cpu: 477747528
Access Path: index (AllEqUnique)
Index: CHANNELS_PK
resc_io: 1.00  resc_cpu: 8451
ix_sel: 0.200000  ix_sel_with_filters: 0.200000
NL Join : Cost: 7148.77  Resp: 7148.77  Degree: 1
Cost_io: 7134.00  Cost_cpu: 477747528
Resp_io: 7134.00  Resp_cpu: 477747528
***** trying bitmap/domain indexes *****
***** finished trying bitmap/domain indexes *****

Best NL cost: 7148.77
resc: 7148.77  resc_io: 7134.00  resc_cpu: 477747528
resp: 7148.77  resp_io: 7134.00  resp_cpu: 477747528
Join Card: 3115.595241 = = outer (6231.190483) * inner
(2.000000) * sel (0.250000)
Join Card - Rounded: 3116 Computed: 3115.60
Grouping column cardinality [CHANNEL_CL]      2
Grouping column cardinality [ CUST_CITY]     286
Grouping column cardinality [CALENDAR_Q]      2
Outer table: TIMES  Alias: T
resc: 916.14  card 6231.19  bytes: 63  deg: 1  resp: 916.14

```

```

Inner table: CHANNELS Alias: CH
  resc: 3.00 card: 2.00 bytes: 21 deg: 1 resp: 3.00
  using dmeth: 2 #groups: 1
  SORT ressource          Sort statistics
    Sort width:           334 Area size:       292864 Max Area
size:      58720256
  Degree:                1
  Blocks to Sort: 62 Row size:       80 Total Rows:
6231
  Initial runs: 2 Merge passes: 1 IO Cost / pass:
36
  Total IO sort cost: 98      Total CPU sort cost: 37418215
  Total Temp space used: 926000
  SORT ressource          Sort statistics
    Sort width:           334 Area size:       292864 Max Area
size:      58720256
  Degree:                1
  Blocks to Sort: 1 Row size:       34 Total Rows:
2
  Initial runs: 1 Merge passes: 0 IO Cost / pass:
0
  Total IO sort cost: 0      Total CPU sort cost: 32352758
  Total Temp space used: 0
  SM join: Resc: 1019.30 Resp: 1019.30 [multiMatchCost=0.00]
SM Join
  SM cost: 1019.30
    resc: 1019.30 resc_io: 1004.00 resc_cpu: 494887404
    resp: 1019.30 resp_io: 1004.00 resp_cpu: 494887404
Outer table: TIMES Alias: T
  resc: 916.14 card 6231.19 bytes: 63 deg: 1 resp: 916.14
Inner table: CHANNELS Alias: CH
  resc: 3.00 card: 2.00 bytes: 21 deg: 1 resp: 3.00
  using dmeth: 2 #groups: 1
  Cost per ptn: 0.53 #ptns: 1
  hash_area: 124 (max=14336) buildfrag: 58 probefrag: 1
ppasses: 1
  Hash join: Resc: 919.68 Resp: 919.68 [multiMatchCost=0.01]
Outer table: CHANNELS Alias: CH
  resc: 3.00 card 2.00 bytes: 21 deg: 1 resp: 3.00
Inner table: TIMES Alias: T
  resc: 916.14 card: 6231.19 bytes: 63 deg: 1 resp: 916.14
  using dmeth: 2 #groups: 1
  Cost per ptn: 0.52 #ptns: 1

```

```

    hash_area: 124 (max=14336) buildfrag: 1 probefrag: 58
ppasses: 1
    Hash join: Resc: 919.66 Resp: 919.66 [multiMatchCost=0.00]
HA Join
    HA cost: 919.66 swapped
        resc: 919.66 resc_io: 906.00 resc_cpu: 441916165
        resp: 919.66 resp_io: 906.00 resp_cpu: 441916165
GROUP BY sort
GROUP BY adjustment factor: 0.500000
GROUP BY cardinality: 572.000000, TABLE cardinality:
3116.000000
    SORT ressource          Sort statistics
        Sort width:           334 Area size:       292864 Max Area
size:      58720256
        Degree:               1
        Blocks to Sort: 40 Row size:       103 Total Rows:
3116
        Initial runs:     1 Merge passes:  0 IO Cost / pass:
0
        Total IO sort cost: 0      Total CPU sort cost: 33981962
        Total Temp space used: 0
Join order aborted: cost > best plan cost
*****
(newjo-stop-1) k:0, spcnt:0, perm:22, maxperm:2000

*****
Number of join permutations tried: 22
*****
Consider using bloom filter between C[CUSTOMERS] and S[SALES]
kkoBloomFilter: join (lcdn:383 rcdn:918843 jcdn:49822
limit:175847540)
Computing bloom ndv for creator:C[CUSTOMERS] ccdn:382.8 and
user:S[SALES] ucdn:918843.0
kkopqComputeBloomNdv: predicate (bndv:7059 ndv:7059) and
(bndv:55500 ndv:370)
kkopqComputeBloomNdv: pred cnt:2 ndv:383 reduction:0
kkoBloomFilter: join ndv:383 reduction:0.000417 (limit:0.500000)
accepted invalidated
Consider using bloom filter between S[SALES] and T[TIMES] ,with
join inputs swapped
kkoBloomFilter: join (lcdn:49822 rcdn:183 jcdn:6231
limit:4548769)
Computing bloom ndv for creator:T[TIMES] ccdn:182.6 and
user:S[SALES] ucdn:49822.2

```

```

kkopqComputeBloomNdv: predicate (bndv:1460 ndv:1460) and
(bndv:1826 ndv:183)
kkopqComputeBloomNdv: pred cnt:2 ndv:183 reduction:0
kkoBloomFilter: join ndv:183 reduction:0.003665 (limit:0.500000)
accepted invalidated
Consider using bloom filter between T[TIMES] and CH[CHANNELS]
,with join inputs swapped
kkoBloomFilter: join (lcdn:6231 rcdn:2 jcdn:3116 limit:6231)
Computing bloom ndv for creator:CH[CHANNELS] ccdn:2.0 and
user:T[TIMES] ucdn:6231.2
kkopqComputeBloomNdv: predicate (bndv:4 ndv:4) and (bndv:5
ndv:2)
kkopqComputeBloomNdv: pred cnt:2 ndv:2 reduction:0
kkoBloomFilter: join ndv:2 reduction:0.000321 (limit:0.500000)
accepted invalidated
(newjo-save) [1 3 2 0 ]
GROUP BY adjustment factor: 0.500000
GROUP BY cardinality: 572.000000, TABLE cardinality:
3116.000000
      SORT ressource          Sort statistics
      Sort width:            334 Area size:       292864 Max Area
size:    58720256
      Degree:                1
      Blocks to Sort: 40 Row size:       103 Total Rows:
3116
      Initial runs:   1 Merge passes:  0 IO Cost / pass:
0
      Total IO sort cost: 0      Total CPU sort cost: 33981962
      Total Temp space used: 0
Trying or-Expansion on query block SEL$1 (#1)
Transfer Optimizer annotations for query block SEL$1 (#1)
id=0 frofand predicate="C"."CUST_STATE_PROVINCE"='CA'
id=0 frofksm[i] (sort-merge/hash)
predicate="S"."CUST_ID"="C"."CUST_ID"
id=0 frosand (sort-merge/hash)
predicate="S"."CUST_ID"="C"."CUST_ID"
id=0 frofksm[i] (sort-merge/hash)
predicate="S"."TIME_ID"="T"."TIME_ID"
id=0 frosand (sort-merge/hash)
predicate="S"."TIME_ID"="T"."TIME_ID"
id=0 frofand predicate="T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
"T"."CALENDAR_QUARTER_DESC"='1999-Q2'
id=0 frofksm[i] (sort-merge/hash)
predicate="S"."CHANNEL_ID"="CH"."CHANNEL_ID"
id=0 frosand (sort-merge/hash)
predicate="S"."CHANNEL_ID"="CH"."CHANNEL_ID"

```

```

id=0 frofand predicate="CH"."CHANNEL_DESC"='Catalog' OR
"CH"."CHANNEL_DESC"='Internet'
GROUP BY adjustment factor: 1.000000
Final cost for query block SEL$1 (#1) - All Rows Plan:
  Best join order: 16
  Cost: 920.7097  Degree: 1  Card: 3116.0000  Bytes: 261744
  Resc: 920.7097  Resc_io: 906.0000  Resc_cpu: 475898127
  Resp: 920.7097  Resp_io: 906.0000  Resc_cpu: 475898127
  kkoqbc-subheap (delete addr=0x61b144, in-use=119500,
alloc=135000)
  kkoqbc-end:
  :
    call(in-use=131436, alloc=284540), compile(in-use=147780,
alloc=150188), execution(in-use=3504, alloc=4060)

  kkoqbc: finish optimizing query block SEL$1 (#1)
  apadrv-end
  :
    call(in-use=131436, alloc=284540), compile(in-use=148496,
alloc=150188), execution(in-use=3504, alloc=4060)

Starting SQL statement dump

user_id=0 user_name=SYS module=sqlplus@EDRSR10P1 (TNS V1-V3)
action=
sql_id=70fqjd9u1zk7c plan_hash_value=593420798 problem_type=3
----- Current SQL Statement for this session
(sql_id=70fqjd9u1zk7c) -----
SELECT ch.channel_class, c.cust_city, t.calendar_quarter_desc,
SUM(s.amount_sold) sales_amount
FROM sh.sales s,sh.times t,sh.customers c,sh.channels ch
WHERE s.time_id = t.time_id AND
      s.cust_id = c.cust_id AND
      s.channel_id = ch.channel_id AND
      c.cust_state_province = 'CA' AND
      ch.channel_desc IN ('Internet','Catalog') AND
      t.calendar_quarter_desc IN ('1999-Q1','1999-Q2')
GROUP BY ch.channel_class, c.cust_city, t.calendar_quarter_desc
sql_text_length=473
sql=SELECT ch.channel_class, c.cust_city,
t.calendar_quarter_desc, SUM(s.amount_sold) sales_amount
FROM sh.sales s,sh.times t,sh.customers c,sh.channels ch
WHERE s.time_id = t.time_id AND

```

```

        s.cust_id = c.cust_id AND
        s.channel_id = ch.channel_id
sql=AND
        c.cust_state_province = 'CA' AND
        ch.channel_desc IN ('Internet','Catalog') AND
        t.calendar_quarter_desc IN ('1999-Q1','1999-Q2')
GROUP BY ch.channel_class, c.cust_city, t.calendar_quarter_desc
----- Explain Plan Dump -----
----- Plan Table -----

=====
Plan Table
=====

-----+-----+
| Id | Operation                                | Name   | Rows  |
Bytes | Cost  | Time          | Pstart| Pstop |
-----+-----+
-----+-----+
| 0  | SELECT STATEMENT                          |        |        | |
| 921 |           |           |        |        |
| 1  | HASH GROUP BY                           |        | 572   |
47K  | 921 | 00:00:12 |        |        |
| 2  | HASH JOIN                                |        | 3116  |
256K | 920 | 00:00:12 |        |        |
| 3  | TABLE ACCESS FULL                         | CHANNELS | 2     |
42 | 3 | 00:00:01 |        |        |
| 4  | HASH JOIN                                |        | 6231  |
383K | 916 | 00:00:11 |        |        |
| 5  | PART JOIN FILTER CREATE                  | :BF0000 | 183   |
2928 | 18 | 00:00:01 |        |        |
| 6  | TABLE ACCESS FULL                         | TIMES   | 183   |
2928 | 18 | 00:00:01 |        |        |
| 7  | HASH JOIN                                |        | 49K   |
2287K | 897 | 00:00:11 |        |        |
| 8  | TABLE ACCESS FULL                         | CUSTOMERS | 383   |
9958 | 405 | 00:00:05 |        |        |
| 9  | PARTITION RANGE JOIN-FILTER              |        | 897K  |
18M  | 489 | 00:00:06 | :BF0000| :BF0000|
| 10 | TABLE ACCESS FULL                        | SALES   | 897K  |
18M  | 489 | 00:00:06 | :BF0000| :BF0000|
-----+-----+
-----+-----+
Predicate Information:
-----
```

```

2 - access("S"."CHANNEL_ID"="CH"."CHANNEL_ID")
3 - filter(("CH"."CHANNEL_DESC"='Catalog' OR
"CH"."CHANNEL_DESC"='Internet'))
4 - access("S"."TIME_ID"="T"."TIME_ID")
6 - filter(("T"."CALENDAR_QUARTER_DESC"='1999-Q1' OR
"T"."CALENDAR_QUARTER_DESC"='1999-Q2'))
7 - access("S"."CUST_ID"="C"."CUST_ID")
8 - filter("C"."CUST_STATE_PROVINCE"='CA')

Content of other_xml column
=====
nodeid/pflags: 10 513nodeid/pflags: 9 513 db_version      :
11.2.0.1
parse_schema      : SYS
plan_hash         : 593420798
plan_hash_2       : 1128146253
Outline Data:
/*
BEGIN_OUTLINE_DATA
  IGNORE_OPTIM_EMBEDDED_HINTS
  OPTIMIZER_FEATURES_ENABLE('12.1.0.1')
  DB_VERSION('12.1.0.1')
  ALL_ROWS
  OUTLINE_LEAF(@"SEL$1")
  FULL(@"SEL$1" "C@"SEL$1")
  FULL(@"SEL$1" "S@"SEL$1")
  FULL(@"SEL$1" "T@"SEL$1")
  FULL(@"SEL$1" "CH@"SEL$1")
  LEADING(@"SEL$1" "C@"SEL$1" "S@"SEL$1" "T@"SEL$1"
"CH@"SEL$1")
  USE_HASH(@"SEL$1" "S@"SEL$1")
  USE_HASH(@"SEL$1" "T@"SEL$1")
  USE_HASH(@"SEL$1" "CH@"SEL$1")
  PX_JOIN_FILTER(@"SEL$1" "T@"SEL$1")
  SWAP_JOIN_INPUTS(@"SEL$1" "T@"SEL$1")
  SWAP_JOIN_INPUTS(@"SEL$1" "CH@"SEL$1")
  USE_HASH_AGGREGATION(@"SEL$1")
END_OUTLINE_DATA
*/
Optimizer state dump:
Compilation Environment Dump
optimizer_mode_hinted          = false

```

```
optimizer_features_hinted          = 0.0.0
parallel_execution_enabled        = true
parallel_query_forced_dop         = 0
parallel_dml_forced_dop          = 0
parallel_ddl_forced_degree       = 0
parallel_ddl_forced_instances    = 0
_query_rewrite_fudge             = 90
optimizer_features_enable         = 12.1.0.1
...
Bug Fix Control Environment
fix 3834770 = 1
fix 3746511 = enabled
fix 4519016 = enabled
fix 3118776 = enabled
fix 4488689 = enabled
fix 2194204 = disabled
...
Query Block Registry:
SEL$1 0x5c3a04 (PARSER) [FINAL]
:
call(in-use=150804, alloc=284540), compile(in-use=182764,
alloc=243324), execution(in-use=15240, alloc=16288)

End of Optimizer State Dump
Dumping Hints
=====
===== END SQL Statement Dump
=====
```

3. Execute the `te_cleanup.sh` script to clean up your environment for this practice.

```
$ cd /home/oracle/labs/solutions/Trace_Event
$ ./te_cleanup.sh
```

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## **Practices for Lesson 6: Generating and Displaying Execution Plans**

## Practices for Lesson 6: Overview

---

### Practices Overview

In these practices, you use SQL Developer to create and view execution plans and use SQL\*Plus to create and retrieve execution plans from various sources.

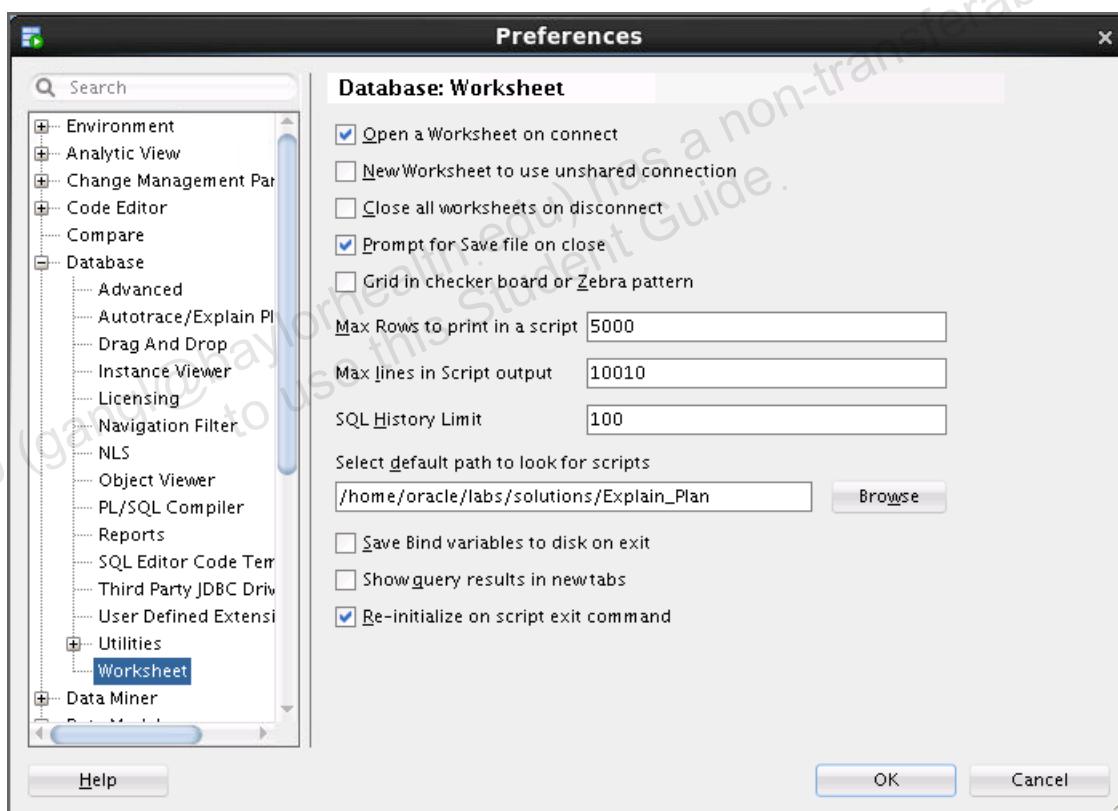
## Practice 6-1: Extracting an Execution Plan by Using SQL Developer

### Overview

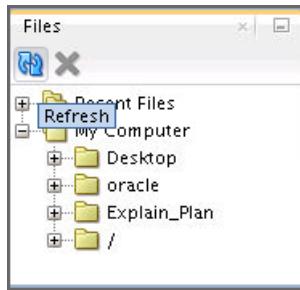
In this practice, you use SQL Developer to display the execution plan of a SQL query, and then use the Autotrace option.

### Tasks

1. The scripts for this practice are in the `/home/oracle/labs/solutions/Explain_Plan` directory. Set the SQL worksheet preferences to set the default directory.
  - a. From the menu, select Tools > Preferences, expand the Database item, and select Worksheet. On the Worksheet, browse for the `/home/oracle/labs/solutions/Explain_Plan` directory. Click Select, and then click OK.



- b. In the navigator pane, click the Files tab. Select My Computer and click the Refresh button. The default Worksheet directory appears in the list.



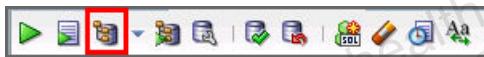
2. Display the explain plan for the following query using the `hr` user:

- a. On the SQL worksheet, enter the following command:

```
SELECT last_name, job_id, salary, department_name  
FROM employees, departments  
WHERE departments.department_id = employees.department_id;
```

You may instead open the `ep_join.sql` script in the  
`/home/oracle/labs/solutions/Explain_Plan` directory.

- b. Click the Explain Plan button.



- c. Note the explain plan.

The screenshot shows the Oracle SQL Developer interface. The top window is a Worksheet containing the following SQL query:

```
SELECT last_name, job_id, salary, department_name
FROM employees, departments
WHERE departments.department_id = employees.department_id;
```

Below the worksheet is the Explain Plan window, which displays the execution plan for the query. The plan is a tree structure with the following details:

OPERATION	OBJECT_NAME	OPTIONS
SELECT STATEMENT		
MERGE JOIN		
TABLE ACCESS	DEPARTMENTS	BY INDEX ROWID
INDEX	DEPT_ID_PK	FULL SCAN
SORT		JOIN
Access Predicates	DEPARTMENTS.DEPARTMENT_ID=EMPLOYEES.DEPARTMENT_ID	
Filter Predicates	DEPARTMENTS.DEPARTMENT_ID=EMPLOYEES.DEPARTMENT_ID	
TABLE ACCESS	EMPLOYEES	FULL

3. Change the query to the following and note the difference in the explain plan. You may instead open the ep\_not\_exists.sql script.

```
SELECT last_name, job_id, salary, department_name
FROM employees, departments
WHERE departments.department_id = employees.department_id
and not exists
(select * from jobs where employees.salary between min_salary
and max_salary);
```

- On the SQL worksheet, enter the preceding query.
- Click the Explain Plan button.



- c. Note the difference in the explain plan.

The screenshot shows the Oracle SQL Developer interface. At the top, there are three tabs: 'Start Page', 'hr\_connection', and 'ep\_not\_exists.sql'. The 'hr\_connection' tab is selected. Below the tabs is a toolbar with various icons. The main area has two panes: 'Worksheet' and 'Query Builder'. The 'Worksheet' pane contains the following SQL code:

```

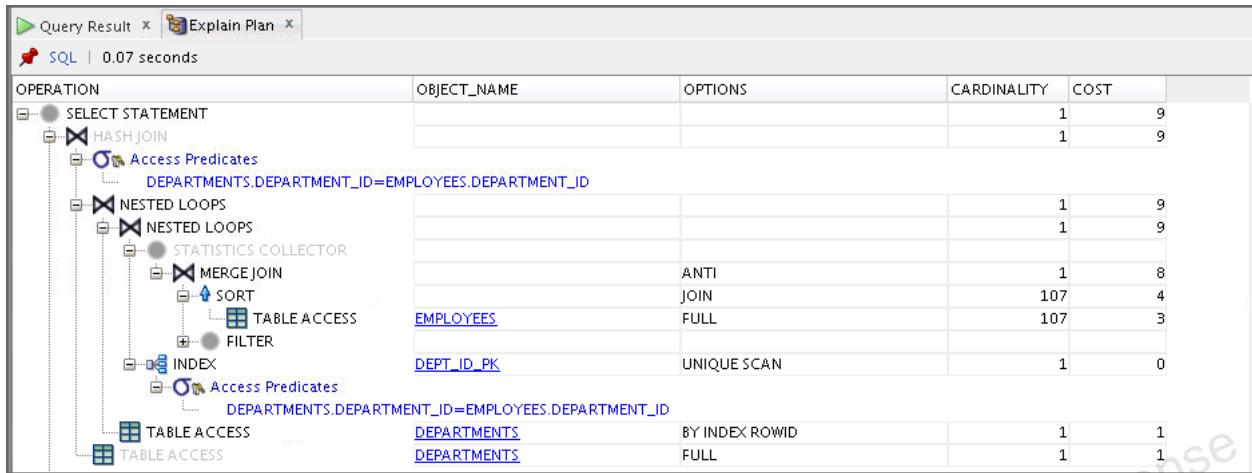
SELECT last_name, job_id, salary, department_name
FROM employees, departments
WHERE departments.department_id = employees.department_id
and not exists
(select * from jobs where employees.salary between min_salary and max_salary);

```

The 'Query Result' tab is visible at the bottom left, and the 'Explain Plan' tab is active. The 'Explain Plan' pane displays the execution plan for the query. It is a hierarchical tree where each node represents an operation. The root node is 'SELECT STATEMENT'. The plan includes several nested loops, a hash join, a merge join, and table access operations. The 'JOINS' section of the plan shows the following details:

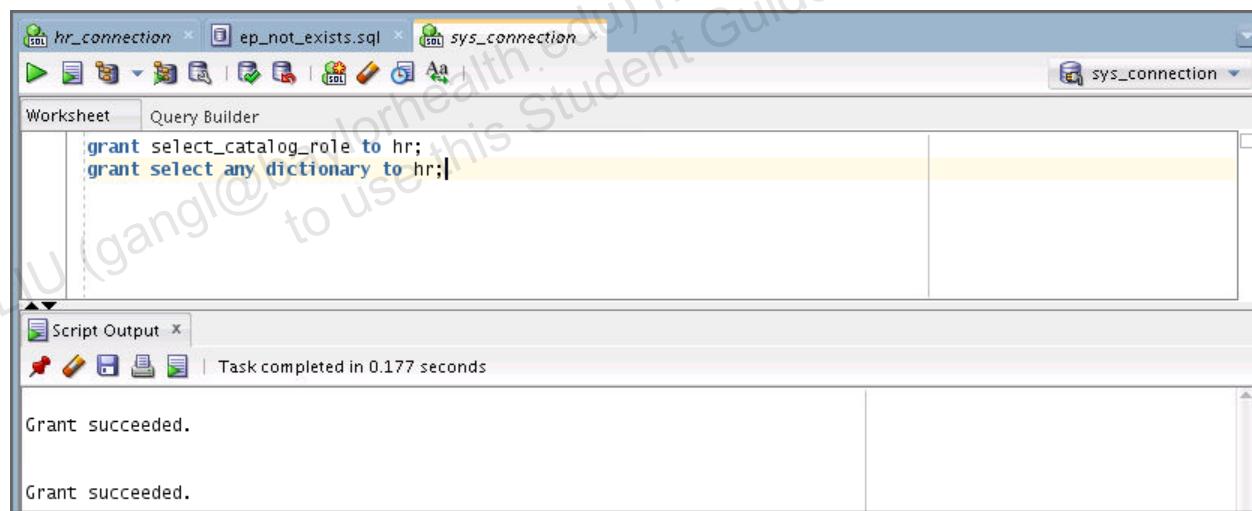
OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY	COST
SELECT STATEMENT			1	9
HASH JOIN			1	9
Access Predicates	DEPARTMENTS.DEPARTMENT_ID=EMPLOYEES.DEPARTMENT_ID			
NESTED LOOPS			1	9
NESTED LOOPS			1	9
STATISTICS COLLECTOR			1	9
MERGEJOIN		ANTI JOIN	1	8
SORT	EMPLOYEES	FULL	107	4
FILTER			107	3
Filter Predicates	EMPLOYEES.SALARY<=MAX_SALARY			
SORT		JOIN	19	4
Access Predicates	INTERNAL_FUNCTION(EMPLOYEES.SALARY)>=INTERNAL_FUNCTION(MIN_SALARY)			
Filter Predicates	INTERNAL_FUNCTION(EMPLOYEES.SALARY)>=INTERNAL_FUNCTION(MIN_SALARY)			
TABLE ACCESS	JOB\$	FULL	19	3
INDEX	DEPT_ID_PK	UNIQUE SCAN	1	0
Access Predicates	DEPARTMENTS.DEPARTMENT_ID=EMPLOYEES.DEPARTMENT_ID			
TABLE ACCESS	DEPARTMENTS	BY INDEX ROWID	1	1
TABLE ACCESS	DEPARTMENTS	FULL	1	1

- d. Collapse the information about the filters.



4. From sys\_connection, grant select\_catalog\_role and Select Any Dictionary to hr.

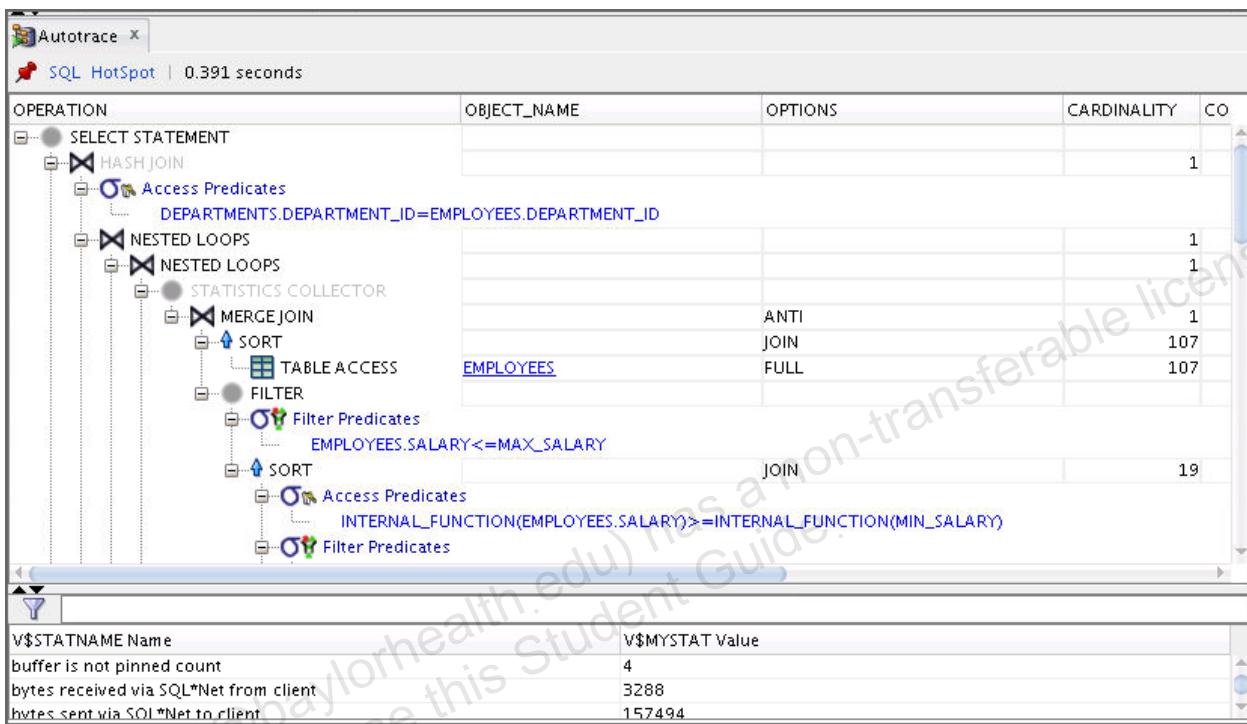
```
grant select_catalog_role to hr;
grant select any dictionary to hr;
```



5. Display Autotrace for the query in the `ep_not_exists.sql` script.
  - a. In the `hr` connection, click the Autotrace button.



- b. Note the Autotrace output tab.



## Practice 6-2: Extracting Execution Plans

In this practice, you use various methods to extract the execution plan used by the optimizer to execute a query. Note that all scripts needed for this practice can be found in your \$HOME/labs/solutions/Explain\_Plan directory.

1. Connected as the oracle user from a terminal session, change the working directory to \$HOME/labs/solutions/Explain\_Plan, and then execute the ep\_startup.sh script. This script initializes the environment for this practice. A user called EP and a table called TEST have already been created that will be used throughout this practice.

```
$ cd /home/oracle/labs/solutions/Explain_Plan  
$ ./ep_startup.sh
```

```
[oracle@... ~]$ cd /home/oracle/labs/solutions/Explain_Plan/  
[oracle@... Explain_Plan]$ ./ep_startup.sh  
  
SQL*Plus: Release 12.2.0.1.0 Production on Mon Apr 16 15:51:12 2018  
  
Copyright (c) 1982, 2016, Oracle. All rights reserved.  
  
Last Successful login time: Mon Apr 16 2018 15:37:27 +00:00  
  
Connected to:  
Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 - 64bit Production  
  
SQL>  
SQL> alter system flush shared_pool;  
  
System altered.  
  
SQL>  
SQL> alter system flush buffer_cache;  
  
System altered.  
  
SQL>  
SQL> set echo off  
■
```

2. From the same terminal session (referred to as session 1 in the rest of this practice), be ready to execute the ep\_session\_issue.sh script. Enter the command, but do not execute it yet.

```
Session 1:  
-----  
  
$ ./ep_session_issue.sh
```

3. From a second terminal session (referred to as session 2 in the rest of this practice), connect as the `oracle` user. After this, connect to a SQL\*Plus session as the `SYS` user. From this SQL\*Plus session, be ready to use SQL Monitoring to monitor the execution plan used by session 1. You can execute the `ep_monitor.sql` script for this purpose. Enter the command, but do not execute it yet.
- Note:** Ensure that you understand the coordination between both sessions by pre-reading steps 4 and 5 before you continue.

```
Session 2:
-----
$ cd /home/oracle/labs/solutions/Explain_Plan

$ sqlplus / as sysdba
...
SQL> alter session set container = orclpdb;
SQL> @ep_monitor.sql
```

4. After you are ready in both the sessions, press Enter in session 1 to start the execution of the `ep_session_issue.sh` script.

**Note:** Do not wait. Proceed with the next step immediately.

```
Session 1:
-----
$ ./ep_session_issue.sh

[oracle@... Explain_Plan]$ ./ep_session_issue.sh
SQL*Plus: Release 12.2.0.1.0 Production on Mon Apr 16 15:57:00 2018
Copyright (c) 1982, 2016, Oracle. All rights reserved.

Last Successful login time: Mon Apr 16 2018 15:51:12 +00:00

Connected to:
Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 - 64bit Production
```

5. In session 2, press the Enter key to start the execution of the `ep_monitor.sql` script.

After the execution, enter “/” and go back to your SQL\*Plus session as many times as necessary until session 1 is finished with its execution. What do you observe?

You can see that session 1 uses NESTED LOOPS on top of two INDEX RANGE SCANS to execute the query. It takes approximately 47 seconds to execute session 1’s query. The time depends on your environment. The big advantage of SQL Monitoring is that you can clearly see which steps in the execution plan take up most of the resources. In this case, you clearly see that you do only one scan of the index, and that for each row returned, you

execute another index scan to probe. This is not really efficient. Also, there is no cost information for this monitored plan.

Session 2:

-----  
SQL> @ep\_monitor.sql

```
SQL> @ep_monitor.sql
SQL> set echo on
SQL> set long 10000000
SQL> set longchunksize 10000000
SQL> set linesize 200
SQL> set pagesize 1000
SQL>
SQL> exec dbms_lock.sleep(8);

PL/SQL procedure successfully completed.

SQL>
SQL> select dbms_sqltune.report_sql_monitor(sql_id=>'dkz7v96ym42c6',report_level=>'ALL') from dual;
DBMS_SQLTUNE.REPORT_SQL_MONITOR(SQL_ID=>'DKZ7V96YM42C6',REPORT_LEVEL=>'ALL')
-----
-----
```

SQL Monitoring Report

SQL Text

```
-----
```

select count(\*) from test t1, test t2 where t1.c=t2.c and t1.c=1

Global Information

```
-----
```

Status	:	DONE (ALL ROWS)
Instance ID	:	1
Session	:	EP (57:887)
SQL ID	:	dkz7v96ym42c6
SQL Execution ID	:	16777219
Execution Started	:	03/05/2018 08:52:37
First Refresh Time	:	03/05/2018 08:52:43
Last Refresh Time	:	03/05/2018 08:52:56
Duration	:	19s
Module/Action	:	SQL*Plus/-
Service	:	orclpdb
Program	:	sqlplus@[REDACTED] (TNS V1-V3)
Fetch Calls	:	1

```

Global Stats
=====
| Elapsed | Cpu   | Other  | Fetch | Buffer |
| Time(s) | Time(s)| Waits(s)| Calls | Gets  |
=====
| 20      | 19    | 0.30   | 1     | 780K |
=====

SQL Plan Monitoring Details (Plan Hash Value=1643938535)
=====
=====
| Id | Operation          | Name       | Rows | Cost | Time      | Start | Execs | Rows | Activity | Activity Data |
|   |                      | (Estim)   |       |       | Active(s) | Active |        | (Actual) | (%)    | (# samples) |
|   |                      |           |       |       |           |        |        |           |         |         |
=====
| 0 | SELECT STATEMENT  |           |       |       |           |        |        |           |         |         |
| 1 |   SORT AGGREGATE  |           |       |       |           |        |        |           |         |         |
| 2 |   NESTED LOOPS    |           |       |       |           |        |        |           |         |         |
| 3 |     INDEX RANGE SCAN | TEST_C_INDX |       |       |           |        |        |           |         |         |
| 4 |     INDEX RANGE SCAN | TEST_C_INDX |       |       |           |        |        |           |         |         |
=====

SQL>
SQL> /
DBMS_SQLTUNE.REPORT_SQL_MONITOR(SQL_ID=>'DKZ7V96YM42C6',REPORT_LEVEL=>'ALL')

SQL Monitoring Report
SQL Text
-----
select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1

```

...

After 30–50 seconds (depending on your environment), you should see the following output in your session 1:

Session 1:

```

SQL>
SQL> set timing on
SQL>
SQL> select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1;

COUNT(*)
-----
4000000000

Elapsed: 00:00:26.33
SQL>
SQL> exit;

```

6. From session 1, connect as the EP user in the SQL\*Plus session.

```
Session 1:
-----
$ sqlplus ep/ep@orclpdb
...
SQL>
```

7. Use PLAN\_TABLE to determine the execution plan of the query that was executed in step 4. Run the ep\_explain.sql script. What do you observe?

This time, the execution plan uses a hash join on top of two index fast full scans.

```
SQL> @ep_explain.sql
SQL>
SQL> alter session set container = orclpdb;
Session altered.

SQL>
SQL> set linesize 200 pagesize 1000
SQL>
SQL> explain plan for
  2 select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1;
Explained.

SQL>
SQL> select * from table(dbms_xplan.display);

PLAN_TABLE_OUTPUT
-----
Plan hash value: 3253233075

| Id  | Operation          | Name      | Rows   | Bytes | Cost (%CPU) | Time      |
|---|---|---|---|---|---|---|
| 0  | SELECT STATEMENT |           | 1     | 6    | 1165 (98)  | 00:00:01  |
| 1  | SORT AGGREGATE   |           | 1     | 6    |             |           |
|* 2  | HASH JOIN         |           | 400M  | 2288M | 1165 (98)  | 00:00:01  |
|* 3  | INDEX FAST FULL SCAN| TEST_C_INDX | 20000 | 60000 | 12 (0)    | 00:00:01  |
|* 4  | INDEX FAST FULL SCAN| TEST_C_INDX | 20000 | 60000 | 12 (0)    | 00:00:01  |

Predicate Information (identified by operation id):
-----
2 - access("T1"."C"="T2"."C")
3 - filter("T1"."C"=1)
4 - filter("T2"."C"=1)

18 rows selected.
```

8. Now, you want to monitor this execution plan that uses a hash join to compare it with the one generated in step 4. In addition, you want to make sure that you use the correct plan this time. So, in your session 1, start Autotrace and be ready to execute the following query. Do not execute it yet because you need to start SQL Monitoring in your session 2:

```
Session 1:  
-----  
SQL> set autotrace on  
SQL> @ep_execute
```

9. From your session 2, be ready to execute the SQL Monitoring command again. Do not execute it yet, though.

```
Session 2:  
-----  
SQL> @ep_monitor.sql
```

10. Start the execution of your query from session 1 by pressing Enter.

**Note:** Move to the next step without waiting.

```
Session 1:  
-----  
SQL> @ep_execute
```

```
SQL>  
SQL> set autotrace on  
SQL> @ep_execute  
SQL> set echo on  
SQL>  
SQL> set timing on  
SQL>  
SQL> select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1;
```

11. From session 2, start monitoring your query by pressing Enter. After the query is executed, enter “/” and go back to your SQL\*Plus session as many times as necessary until session 1 is finished with its execution. What do you observe?

You can see that the optimizer uses a hash join on top of two index fast full scans. Looking at the various reports, you can clearly see how the optimizer processes a hash join by reading the driving index in memory first. This operation is quick. Though you cannot see it run, it is already done the first time you look at it. Then the probe is performed on the index again. This operation takes more time. Also, note that cost information is provided in the execution plan.

```
Session 2:
```

```
SQL> @ep_monitor.sql
SQL> set echo on
```

```
SQL> @ep monitor.sql
SQL> set echo on
SQL> set long 10000000
SQL> set longchunksize 10000000
SQL> set linesize 200
SQL> set pagesize 1000
SQL>
SQL> exec dbms_lock.sleep(8);

PL/SQL procedure successfully completed.

SQL>
SQL> select dbms_sqltune.report_sql_monitor(sql_id=>'dkz7v96ym42c6', report_level=>'ALL') from dual;
DBMS_SQLTUNE.REPORT_SQL_MONITOR(SQL_ID=>'DKZ7V96YM42C6', REPORT_LEVEL=>'ALL')
-----
SQL Monitoring Report
SQL Text
-----
select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1

Global Information
-----
Status          : EXECUTING
Instance ID     : 1
Session         : EP (39:18147)
SQL ID          : dkz7v96ym42c6
SQL Execution ID: 16777221
Execution Started: 03/05/2018 09:27:46
First Refresh Time: 03/05/2018 09:27:52
Last Refresh Time: 03/05/2018 09:27:58
Duration        : 12s
Module/Action   : SQL*Plus/-
Service         : orclpdb
Program         : sqlplus@edvmr1p0 (TNS V1-V3)

Global Stats
=====
| Elapsed | Cpu    | Other   | Buffer |
| Time(s) | Time(s) | Waits(s) | Gets   |
=====
```

Elapsed	Cpu	Other	Buffer
Time(s)	Time(s)	Waits(s)	Gets
11	11	0.18	79

SQL Plan Monitoring Details (Plan Hash Value=3253233075)

Id	Operation	Name	Rows (Estim)	Cost	Time Active(s)	Start Active	Execs	Rows (Actual)	Mem	Activity (%)	Activity Detail (# samples)
-> 0	SELECT STATEMENT				7	+6	1	0	.	.	
-> 1	SORT AGGREGATE		1		7	+6	1	0	.	.	
-> 2	HASH JOIN		400M	1165	11	+2	1	276M	2MB	100.00	Cpu (11)
-> 3	INDEX FAST FULL SCAN	TEST_C_INDX	20000	12	1	+6	1	20000	.	.	
-> 4	INDEX FAST FULL SCAN	TEST_C_INDX	20000	12	7	+6	1	13824	.	.	

SQL>  
SQL> /

DBMS\_SQLTUNE.REPORT\_SQL\_MONITOR(SQL\_ID=>'DKZ7V96YM42C6',REPORT\_LEVEL=>'ALL')

---

SQL Monitoring Report

SQL Text

-----

```
select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1
```

Global Information

-----

Status	:	EXECUTING
Instance ID	:	1
Session	:	EP (39:18147)
SQL ID	:	dkz7v96ym42c6
SQL Execution ID	:	16777221
Execution Started	:	03/05/2018 09:27:46
First Refresh Time	:	03/05/2018 09:27:52
Last Refresh Time	:	03/05/2018 09:28:00
Duration	:	16s
Module/Action	:	SQL*Plus/-
Service	:	orclpdb
Program	:	sqlplus@edvmr1p0 (TNS V1-V3)

Global Stats

Elapsed	Cpu	Other	Buffer
Time(s)	Time(s)	Waits(s)	Gets
13	13	0.19	84

```
SQL Plan Monitoring Details (Plan Hash Value=3253233075)
=====
| Id | Operation | Name | Rows | Cost | Time | Start | Execs | Rows | Mem | Activity | Activity Detail |
| | | | (Estim) | | Active(s) | Active | | (Actual) | (%) | (# samples) |
=====
| -> 0 | SELECT STATEMENT | | | | 9 | +6 | 1 | 0 | . | |
| -> 1 | SORT AGGREGATE | | 1 | | 9 | +6 | 1 | 0 | . |
| -> 2 | HASH JOIN | 400M | 1165 | 14 | +2 | 1 | 328M | 2MB | 100.00 | Cpu (14) |
| 3 | INDEX FAST FULL SCAN | TEST_C_INDX | 20000 | 12 | 1 | +6 | 1 | 20000 | . |
| -> 4 | INDEX FAST FULL SCAN | TEST_C_INDX | 20000 | 12 | 9 | +6 | 1 | 16384 | . |
=====

SQL> /
DBMS_SQLTUNE.REPORT_SQL_MONITOR(SQL_ID=>'DKZ7V96YM42C6',REPORT_LEVEL=>'ALL')

SQL Monitoring Report

SQL Text
-----
select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1

Global Information
-----
Status : DONE (ALL ROWS)
Instance ID : 1
Session : EP (39:18147)
SQL ID : dkz7v96ym42c6
SQL Execution ID : 16777221
Execution Started : 03/05/2018 09:27:46
First Refresh Time : 03/05/2018 09:27:52
Last Refresh Time : 03/05/2018 09:28:03
Duration : 17s
Module/Action : SQL*plus/-
Service : orclpdb
Program : sqlplus@edvmrlp0 (TNS V1-V3)
Fetch Calls : 1

Global Stats
=====
| Elapsed | Cpu | Other | Fetch | Buffer |
| Time(s) | Time(s) | Waits(s) | Calls | Gets |
=====
| 16 | 16 | 0.19 | 1 | 92 |
=====

SQL Plan Monitoring Details (Plan Hash Value=3253233075)
=====
| Id | Operation | Name | Rows | Cost | Time | Start | Execs | Rows | Mem | Activity | Activity Detail |
| | | | (Estim) | | Active(s) | Active | | (Actual) | (%) | (# samples) |
=====
| 0 | SELECT STATEMENT | | | | 12 | +6 | 1 | 1 | . | |
| 1 | SORT AGGREGATE | | 1 | | 12 | +6 | 1 | 1 | . |
| 2 | HASH JOIN | 400M | 1165 | 16 | +2 | 1 | 400M | 2MB | 100.00 | Cpu (16) |
| 3 | INDEX FAST FULL SCAN | TEST_C_INDX | 20000 | 12 | 1 | +6 | 1 | 20000 | . |
=====
```

12. When your query is executed, what do you observe in your session 1?

Session 1 also reports the same execution plan as the one you observed in session 2.

```

SQL> @ep_execute
SQL> set echo on
SQL>
SQL> set timing on
SQL>
SQL> select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1;

  COUNT(*)
-----
 4000000000

Elapsed: 00:00:16.27

Execution Plan
-----
Plan hash value: 3253233075

-----| Id  | Operation          | Name      | Rows  | Bytes | Cost (%CPU)| Time
-----| 0   | SELECT STATEMENT   |           |       1 |     6 | 1165 (98) | 00:00:01
| 1   | SORT AGGREGATE    |           |       1 |     6 |
* 2  | HASH JOIN          |           | 400M  | 2288M | 1165 (98) | 00:00:01
* 3  | INDEX FAST FULL SCAN| TEST_C_INDX | 20000 | 60000 | 12 (0)  | 00:00:01
* 4  | INDEX FAST FULL SCAN| TEST_C_INDX | 20000 | 60000 | 12 (0)  | 00:00:01

-----| Predicate Information (identified by operation id): |
-----| 2 - access("T1"."C"="T2"."C")
| 3 - filter("T1"."C"=1)
| 4 - filter("T2"."C"=1)

Statistics
-----
 0 recursive calls
 0 db block gets
 92 consistent gets
 0 physical reads
 0 redo size
 542 bytes sent via SQL*Net to client
 607 bytes received via SQL*Net from client
 2 SQL*Net roundtrips to/from client
 0 sorts (memory)
 0 sorts (disk)
 1 rows processed

```

13. In session 1, disable Autotrace.

```

Session 1:
-----
SQL> set autotrace off
SQL>
```

14. From session 1, how can you ensure that you gather all execution plan statistics for the following query without changing any session parameters? Implement your solution.

```
Select /*+ gather_plan_statistics */ count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1;
```

Session 1:

-----

```
SQL> @ep_execute_with_all
```

```
SQL> @ep_execute_with_all
SQL> set echo on
SQL>
SQL> set timing on
SQL>
SQL> select /*+ gather_plan_statistics */ count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1;

  COUNT(*)
-----
  400000000

Elapsed: 00:00:16.22
SQL>
SQL> █
```

15. From session 1, retrieve all execution plans corresponding to all the queries that you executed since the beginning of this practice. What is your conclusion?

- The easiest way to find all the plans is to look at the content of the SGA by using the `dbms_xplan.display_cursor` function. First, you must determine the `SQL_IDS` used to represent your queries. You essentially have two queries, and one that has two children. You should now understand what happened in step 4. There was no cost information due to the use of the rule-based optimizer instead of the cost-based one.

Session 1:

-----

```
SQL> @ep_retrieve_all_plans
```

```

SQL> @ep_retrieve_all_plans
SQL> set echo on
SQL>
SQL> set linesize 200 pagesize 1000
SQL>
SQL> col sql_text format a50
SQL>
SQL> select sql_id,plan_hash_value,sql_text from v$sql where sql_text like '%from test t1, test t2%';

SQL_ID          PLAN_HASH_VALUE SQL_TEXT
-----  -----
dkz7v96ym42c6    3253233075 select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1
dkz7v96ym42c6    1643938535 select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1
8w580dd6ncgqw   3253233075 select /*+ gather_plan_statistics */ count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1
0w0va2d7hhtxa   3253233075 explain plan for select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1
dd09kf5dnplgt   903671040 select sql_id,plan hash_value,sql_text from v$sql where sql_text like '%from test t1, test t2%'
77xh10nuft3bv   3253233075 EXPLAIN PLAN SET STATEMENT_ID='PLUS6260755' FOR select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1
77xh10nuft3bv   3253233075 EXPLAIN PLAN SET STATEMENT_ID='PLUS6260755' FOR select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1

7 rows selected.

Elapsed: 00:00:00.33
SQL>
SQL> select * from table(dbms_xplan.display_cursor('dkz7v96ym42c6',null,'TYPICAL'));

PLAN_TABLE_OUTPUT
-----
SQL_ID dkz7v96ym42c6, child number 0
-----  -----
select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1
Plan hash value: 3253233075

```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT				1165 (100)	
1	SORT AGGREGATE		1	6		
* 2	HASH JOIN		400M	2288M	1165 (98)	00:00:01
* 3	INDEX FAST FULL SCAN	TEST_C_INDX	20000	60000	12 (0)	00:00:01
* 4	INDEX FAST FULL SCAN	TEST_C_INDX	20000	60000	12 (0)	00:00:01

Predicate Information (identified by operation id):

```

2 - access("T1"."C"="T2"."C")
3 - filter("T1"."C"=1)
4 - filter("T2"."C"=1)

```

SQL\_ID dkz7v96ym42c6, child number 1

```

select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1

```

Plan hash value: 1643938535

Id	Operation	Name
0	SELECT STATEMENT	
1	SORT AGGREGATE	
2	NESTED LOOPS	
* 3	INDEX RANGE SCAN	TEST_C_INDX
* 4	INDEX RANGE SCAN	TEST_C_INDX

Predicate Information (identified by operation id):

```

3 - access("T1"."C"=1)
4 - access("T1"."C"="T2"."C")

```

Note

```

- rule based optimizer used (consider using cbo)

```

49 rows selected.

Elapsed: 00:00:00.11

SQL>

SQL> select \* from table(dbms\_xplan.display\_cursor('8w580dd6ncgqw',null,'ADVANCED ALLSTATS LAST'));

```

PLAN_TABLE_OUTPUT
-----
SQL_ID 8w580dd6ncgw, child number 0
-----  

select /*+ gather_plan_statistics */ count(*) from test t1, test t2  

where t1.c=t2.c and t1.c=1  

Plan hash value: 3253233075

| Id | Operation | Name | Starts | E-Rows | Cost (%CPU) | E-Time | A-Rows | A-Time | Buffers | OMem | 1Mem | Used-Mem | |
| 0 | SELECT STATEMENT | | 1 | 1 | 1165 (100) | | 1 | 00:00:16.22 | 92 | | | |
| 1 | SORT AGGREGATE | | 1 | 1 | 6 | | 1 | 00:00:16.22 | 92 | | | |
|* 2 | HASH JOIN | | 1 | 400M | 2288M | 1165 (98) | 00:00:01 | 400M | 00:00:16.87 | 92 | 2757K | 2757K | 1833K (0) |
|* 3 | INDEX FAST FULL SCAN | TEST_C_indx | 1 | 20000 | 60000 | 12 (0) | 00:00:01 | 20000 | 00:00:00.04 | 46 | | | |
|* 4 | INDEX FAST FULL SCAN | TEST_C_indx | 1 | 20000 | 60000 | 12 (0) | 00:00:01 | 20000 | 00:00:00.15 | 46 | | | |

Query Block Name / Object Alias (identified by operation id):
-----
1 - SEL$1
3 - SEL$1 / T1@SEL$1
4 - SEL$1 / T2@SEL$1

Outline Data
-----
/*+
 BEGIN OUTLINE DATA
 IGNORE_OPTIM_EMBEDDED_HINTS
 OPTIMIZER_FEATURES_ENABLE('12.2.0.1')
 DB_VERSION('12.2.0.1')
 ALL_ROWS
 OUTLINE_LEAF(@SEL$1)
 INDEX_FFS(@SEL$1 "T1"@SEL$1 ("TEST"."C"))
 INDEX_FFS(@SEL$1 "T2"@SEL$1 ("TEST"."C"))
 LEADING(@SEL$1 "T1"@SEL$1 "T2"@SEL$1)
 USE_HASH(@SEL$1 "T2"@SEL$1)
 END_OUTLINE_DATA
*/
Predicate Information (identified by operation id):
-----
2 - access("T1"."C"="T2"."C")
3 - filter("T1"."C"=1)
4 - filter("T2"."C"=1)

```

```

Column Projection Information (identified by operation id):
-----
1 - (#keys=0) COUNT(*)[22]
2 - (#keys=1; rowset=1019)
3 - "T1"."C"[NUMBER,22]
4 - "T2"."C"[NUMBER,22]

56 rows selected.

```

16. From session 1, try to retrieve your execution plans from the Automatic Workload Repository. What happens and why?
- You can use the previously found SQL\_IDS to search through the DBA\_HIST\_SQLTEXT view. You should see that right now, none of your queries are stored in AWR.  
**Note:** It is possible that a snapshot was taken during this practice. If so, some or all of your queries are stored in AWR.

```

Session 1:
-----
SQL> @ep_retrieve_awr

```

```
SQL> @ep_retrieve_awr
SQL> set echo on
SQL>
SQL> set linesize 200
SQL>
SQL> SELECT SQL_ID, SQL_TEXT FROM dba_hist_sqltext
  2 WHERE SQL_ID in ('dkz7v96ym42c6','8w580dd6ncgqw');

SQL_ID          SQL_TEXT
-----
8w580dd6ncgqw select /*+ gather_plan_statistics */ count(*) from
                      test t1, test t2 where t1.c=t
dkz7v96ym42c6 select count(*) from test t1, test t2 where t1.c=t
                      2.c and t1.c=1

Elapsed: 00:00:00.04
SQL>
SQL> █
```

17. How can you ensure that you retrieve your queries from the Automatic Workload Repository? Implement your solution.
- You must flush the SGA information to AWR. You can use DBMS\_WORKLOAD\_REPOSITORY.CREATE\_SNAPSHOT for this purpose.

```
Session 1:
-----
SQL> @ep_save_awr
```

```
SQL> @ep_save_awr
SQL> set echo on
SQL>
SQL> EXEC DBMS_WORKLOAD_REPOSITORY.CREATE_SNAPSHOT('ALL');

PL/SQL procedure successfully completed.

Elapsed: 00:00:04.95
SQL>
SQL> █
```

18. Verify that your solution works.

```
Session 1:
-----
SQL> @ep_show_awr
```

```

SQL> @ep_show_awr
SQL> set echo on
SQL>
SQL> set linesize 200 pagesize 1000
SQL>
SQL> SELECT PLAN_TABLE_OUTPUT
  2  FROM
  3  TABLE (DBMS_XPLAN.DISPLAY_AWR('dkz7v96ym42c6'));

PLAN_TABLE_OUTPUT
-----
SQL_ID dkz7v96ym42c6
-----
select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1

Plan hash value: 1643938535

| Id | Operation          | Name      |
|---|---|---|
| 0 | SELECT STATEMENT   |          |
| 1 |  SORT AGGREGATE    |          |
| 2 |   NESTED LOOPS     |          |
| 3 |     INDEX RANGE SCAN| TEST_C_INDX |
| 4 |     INDEX RANGE SCAN| TEST_C_INDX |

Note
-----
- rule based optimizer used (consider using cbo)

SQL_ID dkz7v96ym42c6
-----
select count(*) from test t1, test t2 where t1.c=t2.c and t1.c=1

Plan hash value: 3253233075

| Id | Operation          | Name      | Rows  | Bytes | Cost (%CPU) | Time      |
|---|---|---|---|---|---|---|
| 0 | SELECT STATEMENT   |          |       |       | 1015 (100)  |           |
| 1 |  SORT AGGREGATE    |          |       |       | 6           |           |
| 2 |   HASH JOIN         |          | 1     |       | 1015 (98)   | 00:00:01  |
| 3 |     INDEX FAST FULL SCAN| TEST_C_INDX | 20000 | 60000 | 12 (0)    | 00:00:01  |
| 4 |     INDEX FAST FULL SCAN| TEST_C_INDX | 20000 | 60000 | 12 (0)    | 00:00:01  |

36 rows selected.

```

```

SQL>
SQL> SELECT PLAN_TABLE_OUTPUT
  2  FROM
  3  TABLE (DBMS_XPLAN.DISPLAY_AWR('8w580dd6ncgqw',null,null,'TYPICAL ALLSTATS LAST'));

PLAN_TABLE_OUTPUT
-----
SQL_ID 8w580dd6ncgqw
-----
select /*+ gather_plan_statistics */ count(*) from test t1, test t2
where t1.c=t2.c and t1.c=1

Plan hash value: 3253233075

| Id  | Operation          | Name      | E-Rows | E-Bytes | Cost (%CPU) | E-Time   |
|-----|-----|-----|-----|-----|-----|-----|
| 0   | SELECT STATEMENT  |           |         |         | 1022 (100)  |          |
| 1   | SORT AGGREGATE    |           | 1       | 6        | 1022 (98)   | 00:00:01 |
| 2   | HASH JOIN          |           | 400M    | 2288M   | 1022 (0)    | 00:00:01 |
| 3   | INDEX FAST FULL SCAN| TEST_C_INDX | 20000   | 60000   | 12 (0)     | 00:00:01 |
| 4   | INDEX FAST FULL SCAN| TEST_C_INDX | 20000   | 60000   | 12 (0)     | 00:00:01 |

Note
-----
- Warning: basic plan statistics not available. These are only collected when:
  * hint 'gather_plan_statistics' is used for the statement or
  * parameter 'statistics_level' is set to 'ALL', at session or system level

23 rows selected.

```

19. Exit from both SQL\*Plus sessions.

```

Session 1:
-----
SQL> exit
Disconnected ...
$
```

Do not forget to exit from session 2:

```

Session 2:
-----
SQL> exit
Disconnected ...
$
```

## **Practices for Lesson 7: Interpreting Execution Plans and Enhancements**

## Practices for Lesson 7: Overview

---

### Practices Overview

This practice covers the dynamic plans part of the Adaptive Execution Plans feature in Oracle Database 12c.

## Practice 7-1: Using Dynamic Plans

---

### Overview

In this practice, you use the dynamic plans part of the Adaptive Execution Plans feature.

### Tasks

1. Start SQL\*Plus as SYS.

```
$ sqlplus / as sysdba
$ alter session set container = orclpdb;
```

2. Grant the SELECT ANY DICTIONARY privilege to OE.

```
grant select any dictionary to oe;
```

```
[oracle@        ~]$ sqlplus / as sysdba
SQL*Plus: Release 12.2.0.1.0 Production on Mon Mar 5 10:50:36 2018
Copyright (c) 1982, 2016, Oracle. All rights reserved.

Connected to:
Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 - 64bit Production
SQL> alter session set container = orclpdb;
Session altered.

SQL> grant select any dictionary to oe;
Grant succeeded.

SQL> ■
```

3. From the same SQL\*Plus session, connect as the OE user and show the execution plan of the following query without executing it:

```
select /*+ monitor*/ product_name
from order_items o, product_information p
where o.unit_price = 15
and quantity > 1
and p.product_id = o.product_id;
```

- a. Connect as oe with oe as the password.
- b. Execute the following query:

```
EXPLAIN PLAN FOR
select /*+ monitor*/ product_name
from order_items o, product_information p
where o.unit_price = 15
```

```
and quantity > 1
and p.product_id = o.product_id;
```

```
SQL> set linesize 132
SQL> select * from table(dbms_xplan.display());
```

```
SQL> connect oe/oe@orclpdb
Connected.
SQL> explain plan for
2  select /*+ monitor*/ product_name
3  from order_items o, product_information p
4  where o.unit_price = 15 and quantity > 1
5  and p.product_id = o.product_id;
```

Explained.

```
SQL> set linesize 300
SQL> select * from table(dbms_xplan.display());
```

PLAN_TABLE_OUTPUT						
Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		4	128	7 (0)	00:00:01
1	NESTED LOOPS		4	128	7 (0)	00:00:01
2	NESTED LOOPS		4	128	7 (0)	00:00:01
* 3	TABLE ACCESS FULL	ORDER_ITEMS	4	48	3 (0)	00:00:01
* 4	INDEX UNIQUE SCAN	PRODUCT_INFORMATION_PK	1	0	0 (0)	00:00:01
5	TABLE ACCESS BY INDEX ROWID	PRODUCT_INFORMATION	1	20	1 (0)	00:00:01

PLAN\_TABLE\_OUTPUT

Predicate Information (identified by operation id):

```
3 - filter("O"."UNIT_PRICE"=15 AND "QUANTITY">>1)
4 - access("P"."PRODUCT_ID"="O"."PRODUCT_ID")
```

Note

- this is an adaptive plan

22 rows selected.

#### 4. What do you observe?

The plan is using a simple NESTED LOOPS join.

5. Now, execute the same query, as follows:

```
select /*+ monitor*/ product_name
from order_items o, product_information p
where o.unit_price = 15
and quantity > 1
and p.product_id = o.product_id;
```

```
SQL> select /*+ monitor*/ product_name
  2  from order_items o, product_information p
  3  where o.unit_price = 15 and quantity>1
  4  and p.product_id = o.product_id;

PRODUCT_NAME
-----
Screws <B.28.S>

PRODUCT_NAME
-----
Screws <B.28.S>
Screws <B.28.S>

13 rows selected.
```

6. Show the resulting execution plan by using the following command:

```
select * from table(dbms_xplan.display_cursor());
```

```

SQL> select * from table(dbms_xplan.display_cursor());
PLAN_TABLE_OUTPUT
-----
SQL_ID  axnckp3w6xn6v, child number 0
select /*+ monitor*/ product_name from order_items o,
product_information p where o.unit_price = 15 and quantity>1 and
p.product_id = o.product_id
Plan hash value: 1553478007

| Id | Operation          | Name           | Rows | Bytes | Cost (%CPU)| Time      |
|---|---|---|---|---|---|---|
PLAN_TABLE_OUTPUT
-----
| 0 | SELECT STATEMENT   |                |       |        |    7 (100)|          |
|* 1 | HASH JOIN          |                |     4 |   128 |      7 (0) | 00:00:01 |
|* 2 |  TABLE ACCESS FULL | ORDER_ITEMS   |     4 |    48 |      3 (0) | 00:00:01 |
| 3 |  TABLE ACCESS FULL | PRODUCT_INFORMATION |    1 |    20 |      1 (0) | 00:00:01 |

Predicate Information (identified by operation id):
-----
1 - access("P"."PRODUCT_ID"="O"."PRODUCT_ID")
2 - filter(("O"."UNIT_PRICE"=15 AND "QUANTITY">>1))

PLAN_TABLE_OUTPUT
-----
Note
-----
- this is an adaptive plan

27 rows selected.

```

7. What do you observe and conclude?

**Answer:** The actual plan used at execution was a HASH\_JOIN.

Why did the plan change?

The plan changed because the optimizer realized during execution that the number of rows actually returned from the `order_items` table was much larger than expected. Multiple single-column predicates on the `order_items` table caused the initial cardinality estimate to be incorrect. The mis-estimation cannot be corrected by extended statistics because one of the predicates is a non-equality predicate.

8. How would you confirm whether the plan change was caused by dynamic plans?

By looking in `V$SQL` and checking the value of the new column

`IS_RESOLVED_ADAPTIVE_PLAN`

```

SQL> column sql_text format a30
SQL> select sql_id, sql_text, is_resolved_adaptive_plan
  from v$sql
 where sql_text like 'select /*+ monitor*/ product_name%';

```

```
SQL> column sql_text format a30
SQL>
SQL> select sql_id, sql_text, is_resolved_adaptive_plan from v$sql
  2 where sql_text like 'select /*+ monitor*/ product_name%';

SQL_ID          SQL_TEXT
-----          -
axnckp3w6xn6v select /*+ monitor*/ product_n Y
ame from order_items o, produc
t_information p where o.unit_p
rice = 15 and quantity>1 and p
.product_id = o.product_id
```

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## **Practices for Lesson 8: Optimizer: Table and Index Access Paths**

## Practices for Lesson 8: Overview

---

### Practices Overview

In these practices, you will examine the access paths chosen by the optimizer for 12 different cases of table and index access.

#### List of Cases:

- Case 1: With and Without Index
- Case 2: Compare Single Column Index Access
- Case 3: Concatenated Index
- Case 4: Bitmap Index Access
- Case 5: Complex Predicate with Bitmap Indexes
- Case 6: Index Only Access
- Case 7: Index Join
- Case 8: Bitmap Index Only Access
- Case 9: B\*-Tree Index Only Access
- Case 10: Function Based Index
- Case 11: Index Organized Table
- Case 12: Index Skip Scan

## Practice 8-1: Using Different Access Paths

### Overview

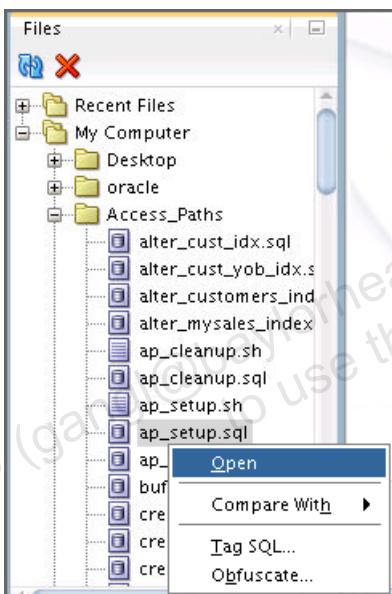
In this practice, you explore various access paths that the optimizer can use, and compare them. You have the possibility of exploring 12 different scenarios, each of which is self-contained. All the scripts needed for this practice can be found in the `$HOME/labs/solutions/Access_Paths` directory. It is helpful to set the worksheet preferences to use `/home/oracle/labs/solutions/Access_Paths` as the default lookup path for scripts.

### Tasks

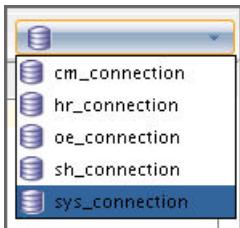
#### 1. Case 1: With and Without Index

- Use the SQL Developer Files tab and open the

`$HOME/labs/solutions/Access_Paths/ap_setup.sql` script.



- Select `sys_connection`.



- c. Execute the script (F5).

The screenshot shows the Oracle SQL Worksheet interface. The title bar says "Start Page" and "ap\_setup.sql". The toolbar includes icons for Start Page, New Worksheet, Open, Save, Print, Copy, Paste, Find, Replace, Undo, Redo, and Font Size. The status bar shows "0.33399999 seconds". A connection icon labeled "sys\_connection" is in the top right. The main area has tabs for "Worksheet" and "Query Builder", with "Worksheet" selected. The code in the worksheet pane is:

```
--Execute as the sys user
alter session set container = orclpdb;
grant dba to sh;
exit;
```

The "Script Output" pane at the bottom shows the results of the execution:

```
Session altered.

Grant succeeded.

Disconnected from Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 - 64bit Production
```

2. Open `idx_setup.sql` and execute it with `sh_connection`.

The screenshot shows the Oracle SQL Worksheet interface. The title bar says "Start Page" and "idx\_setup.sql". The connection dropdown at the top right is set to "sh\_connection". The main area is titled "Worksheet" and contains the following SQL code:

```
set echo on
alter session set container = orclpdb;
drop table mysales purge;

create table mysales as select * from sh.sales;

insert into mysales select * from mysales;
commit;

insert into mysales values (0,0,sysdate,0,0,0);
commit;

exec dbms_stats.gather_schema_stats('SH');

create index mysales_prodid_idx on mysales(prod_id) nologging;

exit;
```

```
Script Output X | Task completed in 147.053 seconds
SQL> alter session set container = orclpdb;
Session altered.

SQL> drop table mysales purge;
Table MYSALES dropped.

SQL>
SQL> create table mysales as select * from sh.sales;
Table MYSALES created.

SQL>
SQL> insert into mysales select * from mysales;
921,647 rows inserted.

SQL> commit;
Commit complete.

SQL>
SQL> insert into mysales select * from mysales;
1,843,294 rows inserted.

SQL> commit;
```

```
Commit complete.

SQL>
SQL> insert into mysales select * from mysales;
3,675,372 rows inserted.

SQL> commit;
Commit complete.

SQL>
SQL> insert into mysales select * from mysales;
7,350,744 rows inserted.

SQL> commit;
Commit complete.

SQL>
SQL> insert into mysales select * from mysales;
14,701,488 rows inserted.

SQL> commit;
```

```
Commit complete.

SQL>
SQL> insert into mysales values (0,0,sysdate,0,0,0);

1 row inserted.

SQL> commit;

Commit complete.

SQL>
SQL> exec dbms_stats.gather_schema_stats('SH');

PL/SQL procedure successfully completed.

SQL>
SQL> create index mysales_prodid_idx on mysales(prod_id) nologging;

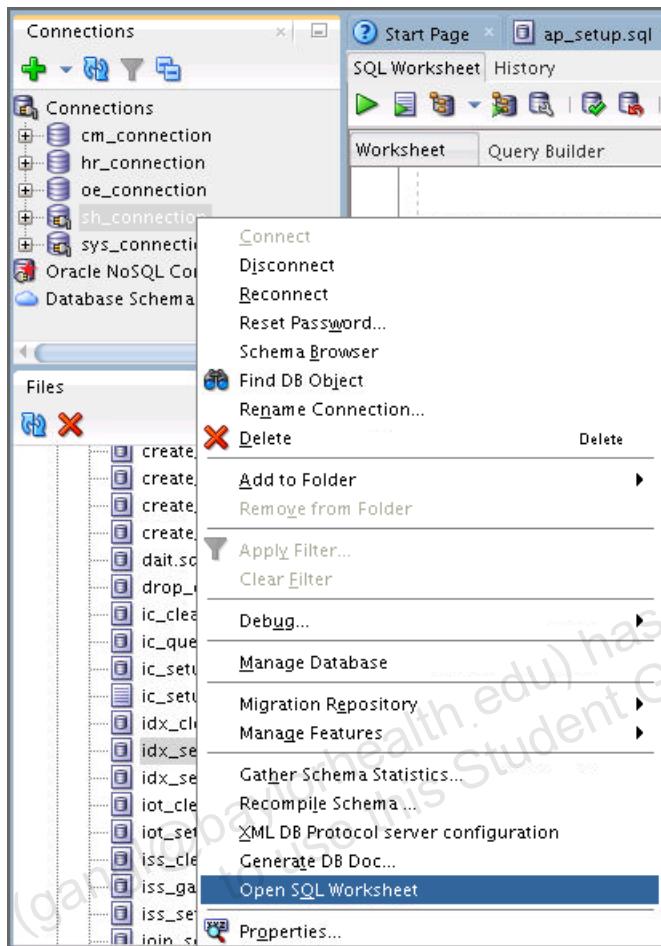
Index MYSALES_PRODID_IDX created.

SQL>
SQL> exit;

Disconnected from Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 - 64bit Production
```

3. What do you observe when you execute the following query in the sh\_connection worksheet?

- a. Right-click sh\_connection and select Open SQL Worksheet.

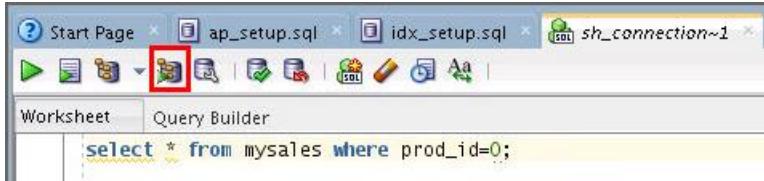


- b. Autotrace the query.

```
select * from mysales where prod_id=0;
```

Note: Drop any indexes available on prod\_id column of the MYSALES table.

```
DROP INDEX mysales_prodid_idx;
```

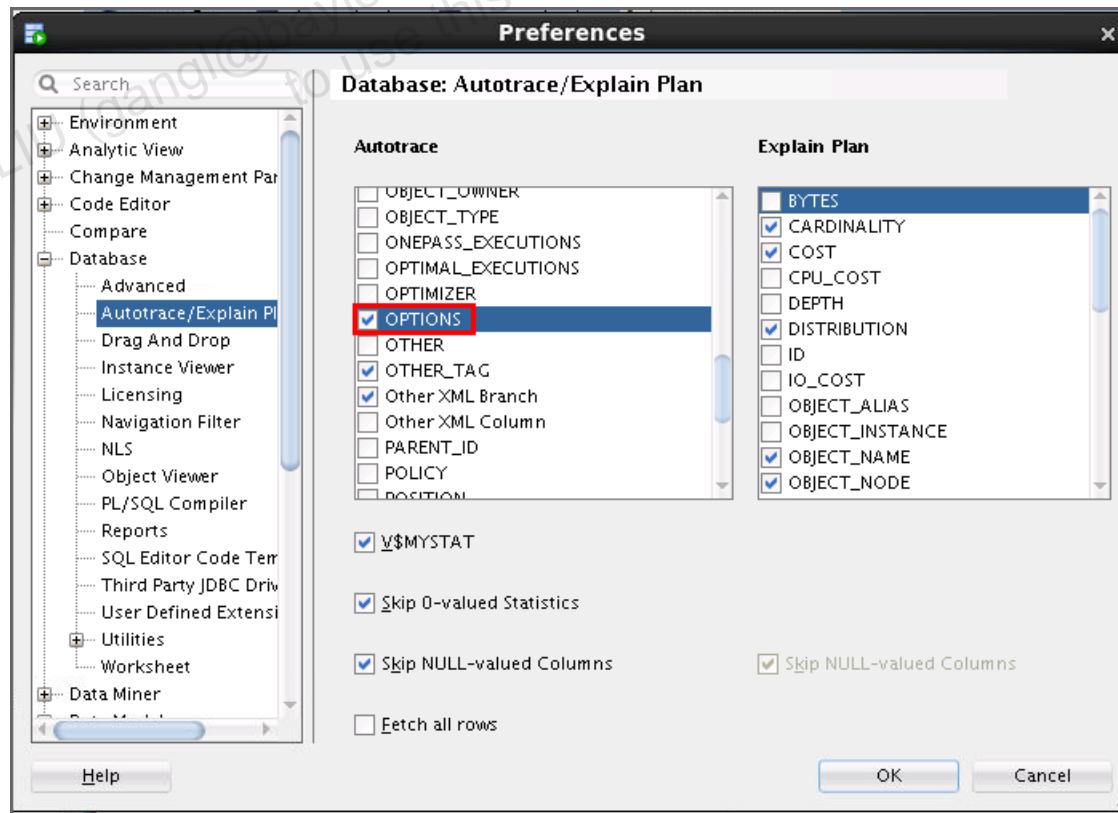


c. Observe the output.

The screenshot shows the SQL Developer interface. In the top navigation bar, the tab 'sh\_connection~1' is highlighted with a red box. Below the tabs, the status bar displays '0.60000002 seconds'. The main area shows a 'Worksheet' tab with the query: 'select \* from mysales where prod\_id=0;'. Below the worksheet is the 'Autotrace' tab, which displays the execution plan. The plan shows a 'SELECT STATEMENT' node with a child 'TABLE ACCESS' node. Under 'TABLE ACCESS', there is a 'Filter Predicates' node with the condition 'PROD\_ID=0'. The 'OPTIONS' column for the 'TABLE ACCESS' node is highlighted with a red box and contains the value 'FULL'. The 'CARDINALITY' column shows the value '402781'.

- Basically, there are no indexes on the MYSALES table.
- The only possibility for the optimizer is to use a full table scan to retrieve only one row. You can see that the full table scan takes a long time.

**Note:** To see the options as a separate column in the execution plan, go to **Tools > Preferences > Database > Autotrace/Explain Plan** and select the **Options** check box under **Autotrace**. If you do not select the Options check box, the options will be attached to the Operations column in the plan.



4. To enhance the performance of the query in step 3, re-execute the query in step 3(b) after executing `create_mysales_index.sql`.
  - a. Open the `create_mysales_index.sql` file and execute it with `sh_connection`.

The screenshot shows the Oracle SQL Worksheet interface. The top window is titled "create\_mysales\_index.sql" and contains the following SQL code:

```
set echo on
alter session set container = orclpdb;
drop index mysales_prodid_idx;
create index mysales_prodid_idx on mysales(prod_id) nologging;
exit;
```

The bottom window is titled "Script Output" and shows the execution results:

```
SQL> alter session set container = orclpdb;
Session altered.

SQL> drop index mysales_prodid_idx;
Index NYSALES_PRODID_IDX dropped.

SQL> create index mysales_prodid_idx on mysales(prod_id) nologging;
Index NYSALES_PRODID_IDX created.

SQL> exit;

Disconnected from Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 - 64bit Production
```

- b. Autotrace the query in step 3(b) again. Observe the output.

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, the current connection is labeled 'sh\_connection~1' and the execution time is shown as '0.25400001 seconds'. The main area displays a query in the 'Worksheet' tab:

```
select * from mysales where prod_id=0;
```

Below the worksheet, the 'Autotrace' tab is selected, showing the execution plan and statistics:

OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY
SELECT STATEMENT			
TABLE ACCESS	mysales	BY INDEX ROWID BATCHED	402781
INDEX	mysales_prodid_idx	RANGE SCAN	402781
Access Predicates			
PROD_ID=0			
Other XML			
{Info}			
info type="db_version"	12.2.0.1		
info type="parse_schema"			

At the bottom, a table of V\$STATNAME statistics is shown:

V\$STATNAME Name	V\$MYSTAT Value
buffer is not pinned count	3
bytes received via SQL*Net from client	2840
bytes sent via SQL*Net to client	80548
calls to get snapshot scn: kcmgss	7
calls to kcmgcs	7

You can see a dramatic improvement in performance. Notice the difference in time, cost, and physical reads.

5. Clean up your environment for case 1 by executing the `idx_cleanup.sql` script.

The screenshot shows the Oracle SQL Developer interface with the connection set to 'sh\_connection'. The 'Script Output' tab is selected, showing the execution of the `idx_cleanup.sql` script:

```
set echo on
drop table mysales purge;
```

The output window shows the results of the command:

```
SQL> drop table mysales purge;
Table MYSALES dropped.
```

6. **Case 2: Compare Single Column Index Access:** Open a terminal window. Connect to sh and drop all the indexes that are currently created on the CUSTOMERS table, except its primary key index, by executing drop\_customers\_indexes.sql.

```
$ cd /home/oracle/labs/solutions/Access_Paths/  
$ sqlplus sh/sh@orclpdb  
  
...  
Connected to:...  
  
SQL> @drop_customers_indexes.sql
```

7. Autotrace the query in query00.sql. What do you observe?

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, the 'sh\_connection~1' connection is selected, and the current file is 'query00.sql'. The main area displays the following SQL code:

```
SELECT /*+ FULL(c) */ c.*  
FROM   customers c  
WHERE  cust_gender  = 'M'  
AND    cust_postal_code = 40804  
AND    cust_credit_limit = 10000  
/
```

Below the code, the 'Autotrace' tab is open, showing the execution plan for the query. The plan details a 'SELECT STATEMENT' that involves a 'TABLE ACCESS' operation on the 'CUSTOMERS' table. The 'OPTIONS' column indicates a 'FULL' scan, and the 'CARDINALITY' is listed as 6. The 'Filter Predicates' section shows the WHERE clause conditions:

- CUST\_CREDIT\_LIMIT=10000
- TO\_NUMBER(CUST\_POSTAL\_CODE)=40804
- CUST\_GENDER='M'

8. Create three B\*-tree indexes on the following CUSTOMERS table columns by using sh\_connection:  
cust\_gender  
cust\_postal\_code  
cust\_credit\_limit

- a. Open and execute the `create_cust_gender_index.sql` script.

The screenshot shows the Oracle SQL Worksheet interface. The title bar has tabs for "sh\_connection~1", "query00.sql", and "create\_cust\_gender\_index.sql". The main area is titled "Worksheet" and contains the following SQL code:

```
set echo on
CREATE INDEX cust_cust_gender_idx
ON customers(cust_gender)
NOLOGGING COMPUTE STATISTICS;
```

Below the worksheet is a "Script Output" window showing the execution results:

```
SQL>
SQL> CREATE INDEX cust_cust_gender_idx
2  ON customers(cust_gender)
3  NOLOGGING COMPUTE STATISTICS;
Index CUST_CUST_GENDER_IDX created.
```

- b. Open and execute the `create_cust_postal_code_index.sql` script.

The screenshot shows the Oracle SQL Worksheet interface. The title bar has tabs for "sh\_connection~1", "query00.sql", "create\_cust\_gender\_index.sql", and "create\_cust\_postal\_code\_index.sql". The main area is titled "Worksheet" and contains the following SQL code:

```
set echo on
CREATE INDEX cust_cust_postal_code_idx
ON customers(cust_postal_code)
NOLOGGING COMPUTE STATISTICS;
```

Below the worksheet is a "Script Output" window showing the execution results:

```
SQL>
SQL> CREATE INDEX cust_cust_postal_code_idx
2  ON customers(cust_postal_code)
3  NOLOGGING COMPUTE STATISTICS;
Index CUST_CUST_POSTAL_CODE_IDX created.
```

- c. Open and execute the `create_cust_credit_limit_index.sql` script.

The screenshot shows the Oracle SQL Developer interface. A window titled "sh\_connection~1" contains a SQL Worksheet with the following code:

```
set echo on
CREATE INDEX cust_cust_credit_limit_idx
ON customers(cust_credit_limit)
NOLOGGING COMPUTE STATISTICS;
```

Below the worksheet is a "Script Output" window showing the execution results:

```
SQL> CREATE INDEX cust_cust_credit_limit_idx
2 ON customers(cust_credit_limit)
3 NOLOGGING COMPUTE STATISTICS;
Index CUST_CUST_CREDIT_LIMIT_IDX created.
```

- d. To verify that the indexes exist, execute `list_customers_indexes.sql`.

The screenshot shows the Oracle SQL Developer interface. A window titled "sh\_connection~1" contains a SQL Worksheet with the following query:

```
SELECT ui.table_name
, decode(ui.index_type
, 'NORMAL', ui.uniqueness
, ui.index_type) AS index_type
, ui.index_name
FROM user_indexes ui
WHERE ui.table_name = 'CUSTOMERS'
ORDER BY ui.table_name
, ui.uniqueness desc;
```

Below the worksheet is a "Script Output" window showing the execution results:

```
SQL> Task completed in 0.196 seconds
```

A results grid displays the index information for the CUSTOMERS table:

TABLE_NAME	INDEX_TYPE	INDEX_NAME
CUSTOMERS	UNIQUE	CUSTOMERS_PK
CUSTOMERS	NONUNIQUE	CUST_CUST_CREDIT_LIMIT_IDX
CUSTOMERS	NONUNIQUE	CUST_CUST_GENDER_IDX
CUSTOMERS	NONUNIQUE	CUST_CUST_POSTAL_CODE_IDX

9. Start monitoring all the CUSTOMERS indexes. Notice that the value in the USED column is NO.
- Open and execute the start\_monitoring\_indexes.sql script by using sh\_connection.

The screenshot shows the Oracle SQL Developer interface. The top window is titled "sh\_connection~1" and contains the script "start\_monitoring\_indexes.sql". The script content is:

```
set echo on
ALTER INDEX CUSTOMERS_PK MONITORING USAGE;
ALTER INDEX CUST_CUST_POSTAL_CODE_IDX MONITORING USAGE;
ALTER INDEX CUST_CUST_GENDER_IDX MONITORING USAGE;
ALTER INDEX CUST_CUST_CREDIT_LIMIT_IDX MONITORING USAGE;
```

The bottom window is titled "Script Output" and shows the results of the execution:

```
SQL> ALTER INDEX CUSTOMERS_PK MONITORING USAGE;
Index CUSTOMERS_PK altered.

SQL> ALTER INDEX CUST_CUST_POSTAL_CODE_IDX MONITORING USAGE;
Index CUST_CUST_POSTAL_CODE_IDX altered.

SQL> ALTER INDEX CUST_CUST_GENDER_IDX MONITORING USAGE;
Index CUST_CUST_GENDER_IDX altered.

SQL> ALTER INDEX CUST_CUST_CREDIT_LIMIT_IDX MONITORING USAGE;
Index CUST_CUST_CREDIT_LIMIT_IDX altered.
```

- b. Open and execute the statement (Ctrl + Enter) in the `show_index_usage.sql` script.

The screenshot shows the Oracle SQL Developer interface. A window titled "sh\_connection~1" contains a query worksheet with the command:

```
select * from v$object_usage;
```

Below the worksheet is a "Query Result" window showing the output of the query:

INDEX_NAME	TABLE_NAME	MONITORING	USED	START_MONITORING	END_MONITORING
1 CUSTOMERS_PK	CUSTOMERS	YES	NO	03/06/2018 09:06:00	(null)
2 CUST_CUST_POSTAL_CODE_IDX	CUSTOMERS	YES	NO	03/06/2018 09:06:00	(null)
3 CUST_CUST_GENDER_IDX	CUSTOMERS	YES	NO	03/06/2018 09:06:00	(null)
4 CUST_CUST_CREDIT_LIMIT_IDX	CUSTOMERS	YES	NO	03/06/2018 09:06:00	(null)

10. Autotrace the query in `query01.sql`. What do you observe?

```
SELECT /*+ INDEX(c) */ c.*  
FROM   customers c  
WHERE  cust_gender    = 'M'  
AND    cust_postal_code = 40804  
AND    cust_credit_limit = 10000  
/
```

**Hint:** Check the estimated cost in the execution plan and the sum of db block gets and consistent gets in the statistics.

```

SELECT /*+ INDEX(c) */ c.*
FROM   customers c
WHERE  cust_gender    = 'M'
AND    cust_postal_code = 40804
AND    cust_credit_limit = 10000
/

```

**Autotrace**

SQL HotSpot | 0.151 seconds

OPERATION	OBJECT_NAME	OPTIONS	CARDINALITY
SELECT STATEMENT			6
TABLE ACCESS	CUSTOMERS	BY INDEX ROWID BATCHED	
Filter Predicates			
AND			
CUST_CREDIT_LIMIT=10000			
CUST_GENDER='M'			
INDEX	CUST_CUST_POSTAL_CODE_IDX	FULL SCAN	89
Filter Predicates			
TO_NUMBER(CUST_POSTAL_CODE)=40804			

V\$STATNAME	Name	V\$MYSTAT	Value
blocks cleaned out using minact		1	
buffer is not pinned count		123	
buffer is pinned count		122	
bytes received via SQL*Net from client		2958	
bytes sent via SQL*Net to client		82697	

- The optimizer chooses to use only one index to do a full scan. The cost is lower than the full table scan.

11. Autotrace the query in `query02.sql` by using `sh_connection`. What do you observe?

```

SELECT /*+ INDEX_COMBINE(c) */ c.*
FROM   customers c
WHERE  cust_gender    = 'M'
AND    cust_postal_code = 40804
AND    cust_credit_limit = 10000;

```

SQL Worksheet History

Worksheet Query Builder

```
SELECT /*+ INDEX_COMBINE(c) */ c.*  
FROM customers c  
WHERE cust_gender = 'M'  
AND cust_postal_code = 40804  
AND cust_credit_limit = 10000
```

Autotrace x

SQL HotSpot | 0.206 seconds

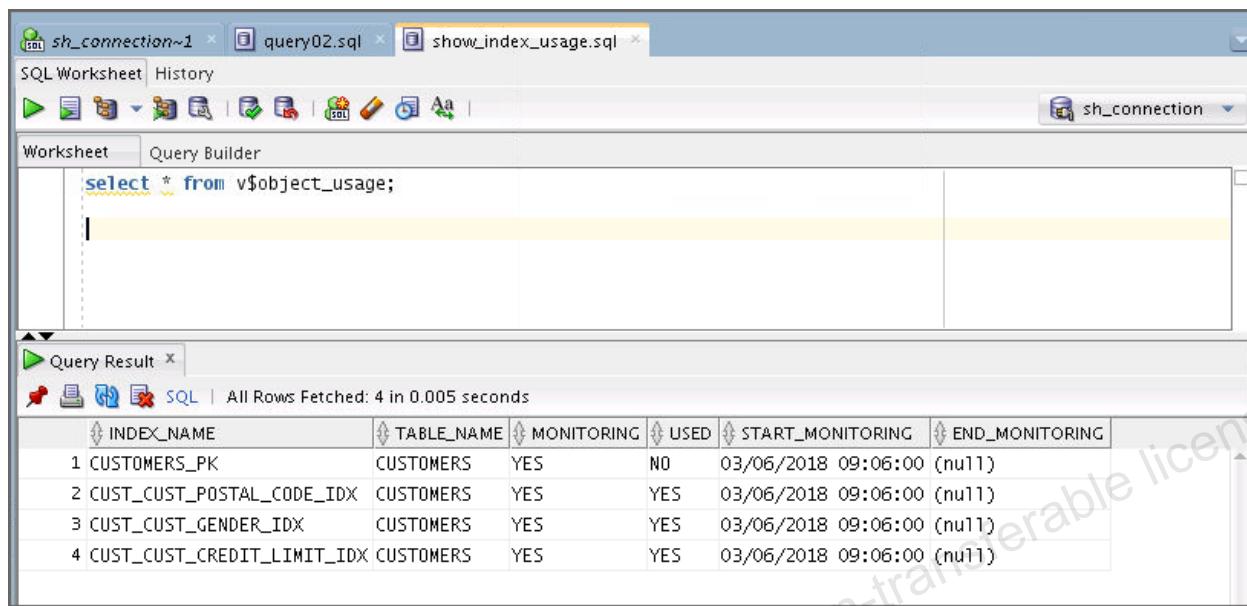
OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAS...
SELECT STATEMENT				480	
TABLE ACCESS	<a href="#">CUSTOMERS</a>	BY INDEX ROWID BATCHED	6	480	
Filter Predicates					
TO_NUMBER(CUST_POSTAL_CODE)=40804					
BITMAP CONVERSION		TO ROWIDS			
BITMAP AND					
BITMAP CONVERSION		FROM ROWIDS			
INDEX	<a href="#">CUST_CUST_CREDIT_LIMIT_IDX</a>	RANGE SCAN		14	
Access Predicates					
CUST_CREDIT_LIMIT=10000					
BITMAP CONVERSION		FROM ROWIDS			
INDEX	<a href="#">CUST_CUST_GENDER_IDX</a>	RANGE SCAN		51	
Access Predicates					
CUST_GENDER='M'					

V\$STATNAME Name V\$MYSTAT Value

buffer is not pinned count	839
buffer is pinned count	7373

- This time the optimizer uses multiple indexes and combines them to access the table. However, the cost is higher than that from the previous step, but is still lower than the full table scan.

12. Execute `show_index_usage.sql` to confirm the list of indexes that were accessed in this case.



The screenshot shows the Oracle SQL Worksheet interface. In the top tab bar, there are three tabs: "sh\_connection~1", "query02.sql", and "show\_index\_usage.sql". The "show\_index\_usage.sql" tab is active. Below the tabs is a toolbar with various icons. The main workspace is titled "Worksheet" and contains the SQL query:

```
select * from v$object_usage;
```

Below the query is a "Query Result" pane with the title "SQL". It displays the results of the query as a table:

INDEX_NAME	TABLE_NAME	MONITORING	USED	START_MONITORING	END_MONITORING
1 CUSTOMERS_PK	CUSTOMERS	YES	NO	03/06/2018 09:06:00 (null)	
2 CUST_CUST_POSTAL_CODE_IDX	CUSTOMERS	YES	YES	03/06/2018 09:06:00 (null)	
3 CUST_CUST_GENDER_IDX	CUSTOMERS	YES	YES	03/06/2018 09:06:00 (null)	
4 CUST_CUST_CREDIT_LIMIT_IDX	CUSTOMERS	YES	YES	03/06/2018 09:06:00 (null)	

The results show four indexes: CUSTOMERS\_PK, CUST\_CUST\_POSTAL\_CODE\_IDX, CUST\_CUST\_GENDER\_IDX, and CUST\_CUST\_CREDIT\_LIMIT\_IDX, all of which are currently being monitored and used.

13. **Case 3: Concatenated Index:** Open a terminal window. Connect to `sh` and drop all the indexes that are currently created on the `CUSTOMERS` table, except its primary key index, by executing `drop_customers_indexes.sql`.

```
$ cd /home/oracle/labs/solutions/Access_Paths/
$ sqlplus sh/sh@orclpdb
...
Connected to:...

SQL> @drop_customers_indexes.sql
```

14. Open and execute the `create_gender_limit_code_index.sql` script by using `sh_connection` to make sure that you create a concatenated index on the following `CUSTOMERS` columns, and in the order mentioned here:

```
cust_gender
cust_credit_limit
cust_postal_code
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, the connection is named 'sh\_connection~1' and the worksheet is titled 'create\_gender\_limit\_code\_index.sql'. The main worksheet area contains the following SQL code:

```
set echo on
CREATE INDEX cust_gender_limit_code_idx
ON customers(cust_gender,cust_credit_limit,cust_postal_code)
NOLOGGING COMPUTE STATISTICS;
```

In the bottom Script Output pane, the results of the execution are shown:

```
SQL>
SQL> CREATE INDEX cust_gender_limit_code_idx
  2  ON customers(cust_gender,cust_credit_limit,cust_postal_code)
  3  NOLOGGING COMPUTE STATISTICS;
Index CUST_GENDER_LIMIT_CODE_IDX created.
```

15. Autotrace the query in `query01.sql`. What do you observe?

The screenshot shows the Oracle SQL Developer interface with a new worksheet titled 'query01.sql'. The worksheet contains the following SQL query:

```
SELECT /*+ INDEX(c) */ c.*
FROM   customers c
WHERE  cust_gender  = 'M'
AND    cust_postal_code = 40804
AND    cust_credit_limit = 10000
/
```

Below the worksheet is the 'Autotrace x' pane, which displays the execution plan and statistics. The execution plan tree is as follows:

- OPERATION: SELECT STATEMENT
  - OBJECT\_NAME: CUSTOMERS
  - OPTIONS: BY INDEX ROWID BATCHED
  - COST: 18
- TABLE ACCESS
  - INDEX: CUST\_GENDER\_LIMIT\_CODE\_IDX
    - Access Predicates: AND
      - CUST\_GENDER='M'
      - CUST\_CREDIT\_LIMIT=10000
    - Filter Predicates: TO\_NUMBER(CUST\_POSTAL\_CODE)=40804

The cost for the entire statement is 18, and the cost for the index access is 12. Below the execution plan, there is a table of V\$STATNAME statistics:

V\$STATNAME Name	V\$MYSTAT Value
buffer is not pinned count	8
buffer is pinned count	5
bytes received via SQL*Net from client	2958
bytes sent via SQL*Net to client	82863
Cached Commit SCN referenced	6

- The optimizer uses your concatenated index and the resulting cost is by far the best compared to the preceding steps.

16. Autotrace the query in `query03.sql`. What do you observe?

The screenshot shows the Oracle SQL Developer interface with three tabs at the top: `sh_connection~1`, `query01.sql`, and `query03.sql`. The `query03.sql` tab is active, displaying the following SQL code:

```
SELECT /*+ INDEX(c) */ c.*  
FROM customers c  
WHERE cust_gender  = 'M'  
AND  cust_credit_limit = 10000
```

Below the code is the Autotrace report for the execution of this query. The report details the execution plan:

- OPERATION:** SELECT STATEMENT
- OBJECT\_NAME:** CUSTOMERS
- OPTIONS:** BY INDEX ROWID BATCHED
- COST:** 3457
- ACCESS PREDICATES:**
  - AND
  - CUST\_GENDER='M'
  - CUST\_CREDIT\_LIMIT=10000
- INDEX:** CUST\_GENDER\_LIMIT\_CODE\_IDX
- OPTIONS:** RANGE SCAN
- COST:** 3469

At the bottom of the Autotrace report, there is a table of V\$STATNAME statistics:

V\$STATNAME	Name	V\$MYSTAT	Value
buffer is not pinned count		52	
buffer is pinned count		49	
bytes received via SQL*Net from client		2917	
bytes sent via SQL*Net to client		88425	

- The query is almost the same as in the previous step, but the predicate on `cust_postal_code` is removed. The optimizer can still use the concatenated index, but the resulting cost is much higher because neither `cust_credit_limit` nor `cust_gender` are very selective.

17. Autotrace the query in `query04.sql`. What do you observe?

```

SELECT /*+ INDEX(c) */ c.*
FROM   customers c
WHERE  cust_gender = 'M'
AND    cust_postal_code = 40804
/

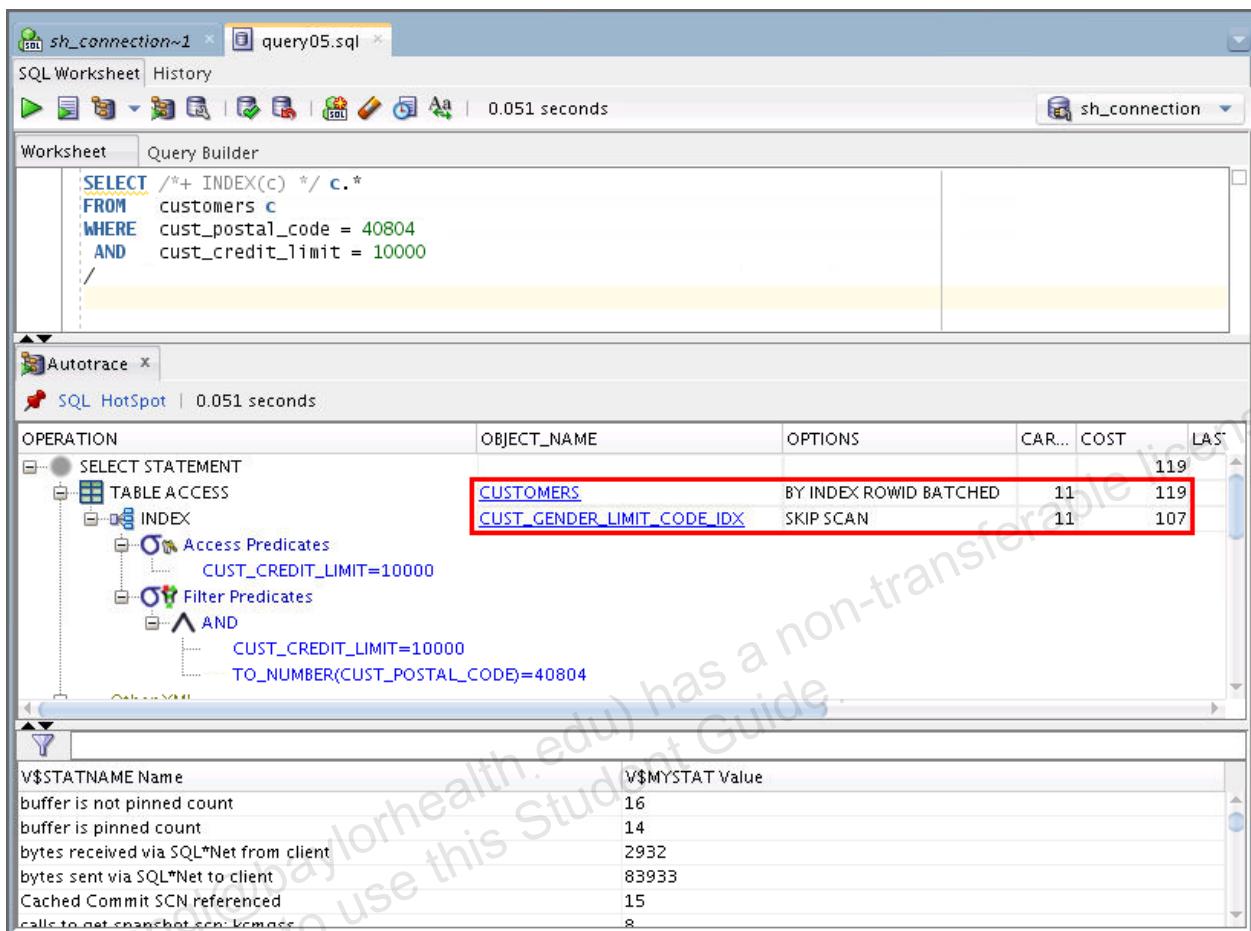
```

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAS*
SELECT STATEMENT				132	
TABLE ACCESS	CUSTOMERS	BY INDEX ROWID BATCHED	45	132	
INDEX	CUST_GENDER_LIMIT_CODE_IDX	RANGE SCAN	45	87	
Access Predicates	CUST_GENDER='M'				
Filter Predicates	TO_NUMBER(CUST_POSTAL_CODE)=40804				
Other XML	(info)				

V\$STATNAME	Name	V\$MYSTAT	Value
buffer is not pinned count		52	
buffer is pinned count		49	
bytes received via SQL*Net from client		2922	
bytes sent via SQL*Net to client		87920	
Cached Commit SCN referenced		50	
calls to get snapshot scn: kcmgss		8	
calls to kcmocs		7	

- You replaced `cust_credit_limit` with `cust_postal_code`, which has better selectivity. The index is used, and the resulting cost is better.

18. Autotrace the query in `query05.sql`. What do you observe?



— The leading part of the concatenated index is no longer part of the query. However, the optimizer is still able to use the index by doing an index skip scan.

19. **Case 4: Bitmap Index Access:** Open a terminal window. Connect to `sh` and drop all the indexes that are currently created on the `CUSTOMERS` table, except its primary key index, by executing `drop_customers_indexes.sql`.

```
$ cd /home/oracle/labs/solutions/Access_Paths/
$ sqlplus sh/sh@orclpdb

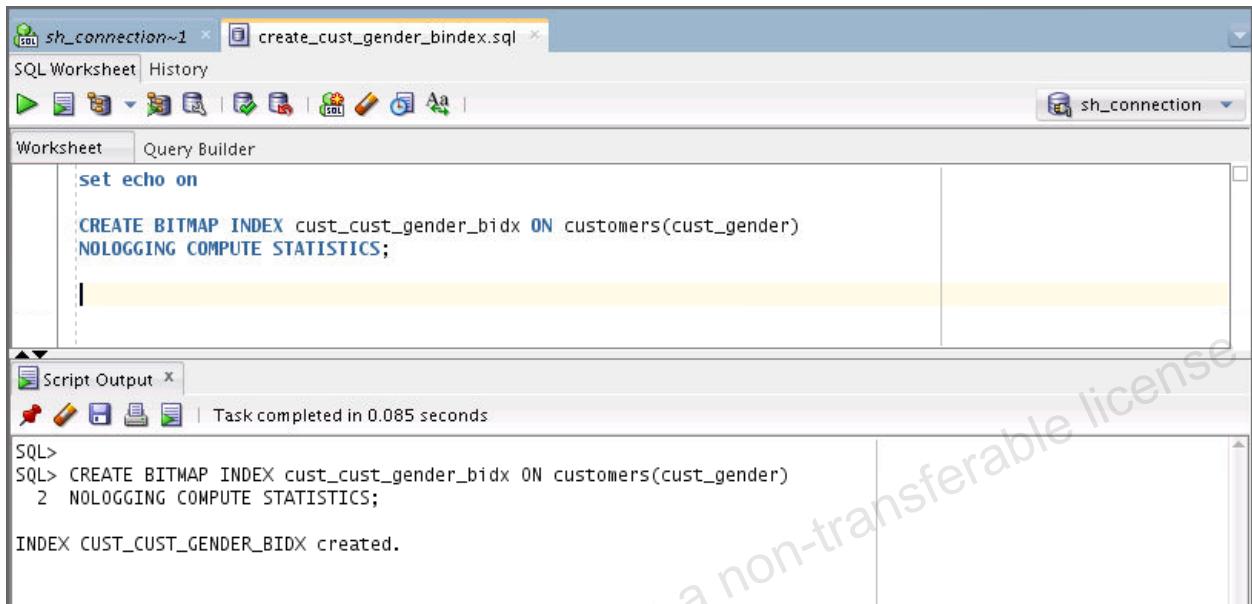
...
Connected to:...

SQL> @drop_customers_indexes.sql
```

20. Open and execute three scripts by using `sh_connection` to create three different bitmap indexes on the following columns of the `CUSTOMERS` table:

`cust_gender` (`create_cust_gender_bindex.sql`)

cust\_postal\_code (create\_cust\_postal\_code\_bindex.sql)  
cust\_credit\_limit (create\_cust\_credit\_limit\_bindex.sql)  
a. Open and execute the create\_cust\_gender\_bindex.sql script.



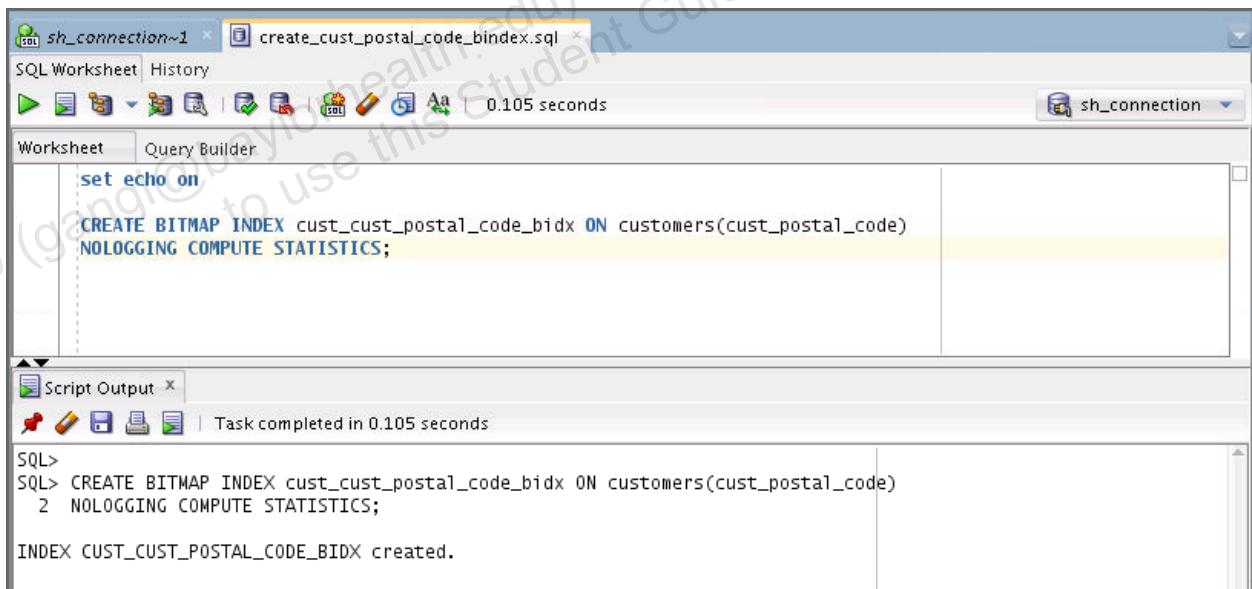
The screenshot shows the Oracle SQL Worksheet interface. The title bar says "sh\_connection~1" and "create\_cust\_gender\_bindex.sql". The main area contains the following SQL code:

```
set echo on
CREATE BITMAP INDEX cust_cust_gender_bidx ON customers(cust_gender)
NOLOGGING COMPUTE STATISTICS;
```

The "Script Output" pane at the bottom shows the execution results:

```
SQL> CREATE BITMAP INDEX cust_cust_gender_bidx ON customers(cust_gender)
2 NOLOGGING COMPUTE STATISTICS;
INDEX CUST_CUST_GENDER_BIDX created.
```

b. Open and execute the create\_cust\_postal\_code\_bindex.sql script.



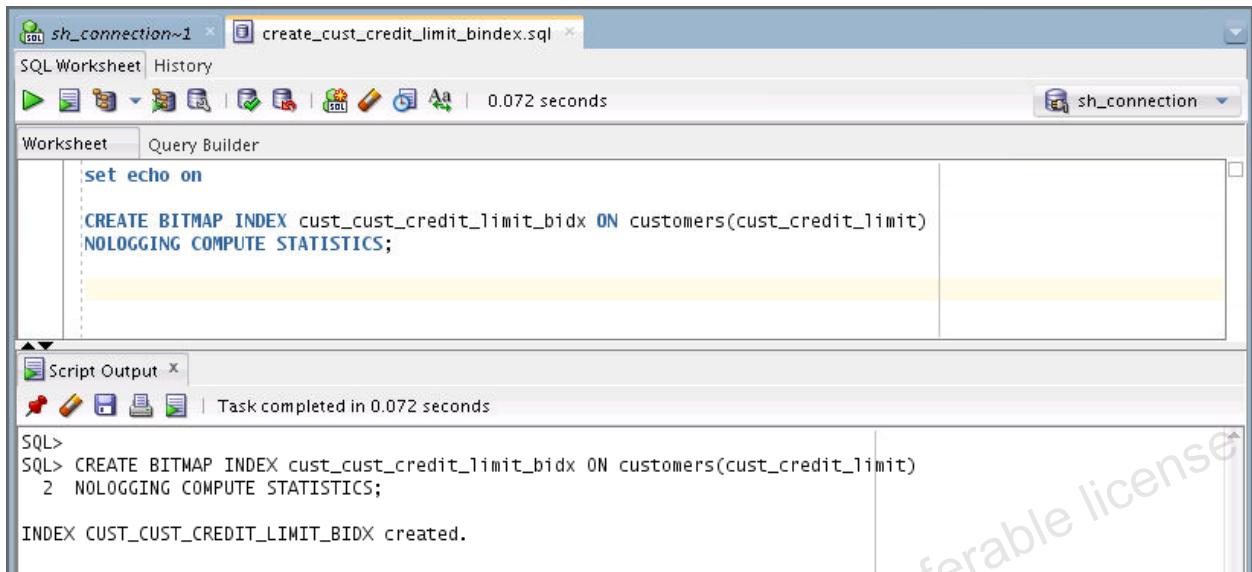
The screenshot shows the Oracle SQL Worksheet interface. The title bar says "sh\_connection~1" and "create\_cust\_postal\_code\_bindex.sql". The main area contains the following SQL code:

```
set echo on
CREATE BITMAP INDEX cust_cust_postal_code_bidx ON customers(cust_postal_code)
NOLOGGING COMPUTE STATISTICS;
```

The "Script Output" pane at the bottom shows the execution results:

```
SQL> CREATE BITMAP INDEX cust_cust_postal_code_bidx ON customers(cust_postal_code)
2 NOLOGGING COMPUTE STATISTICS;
INDEX CUST_CUST_POSTAL_CODE_BIDX created.
```

- c. Open and execute the `create_cust_credit_limit_bindex.sql` script.



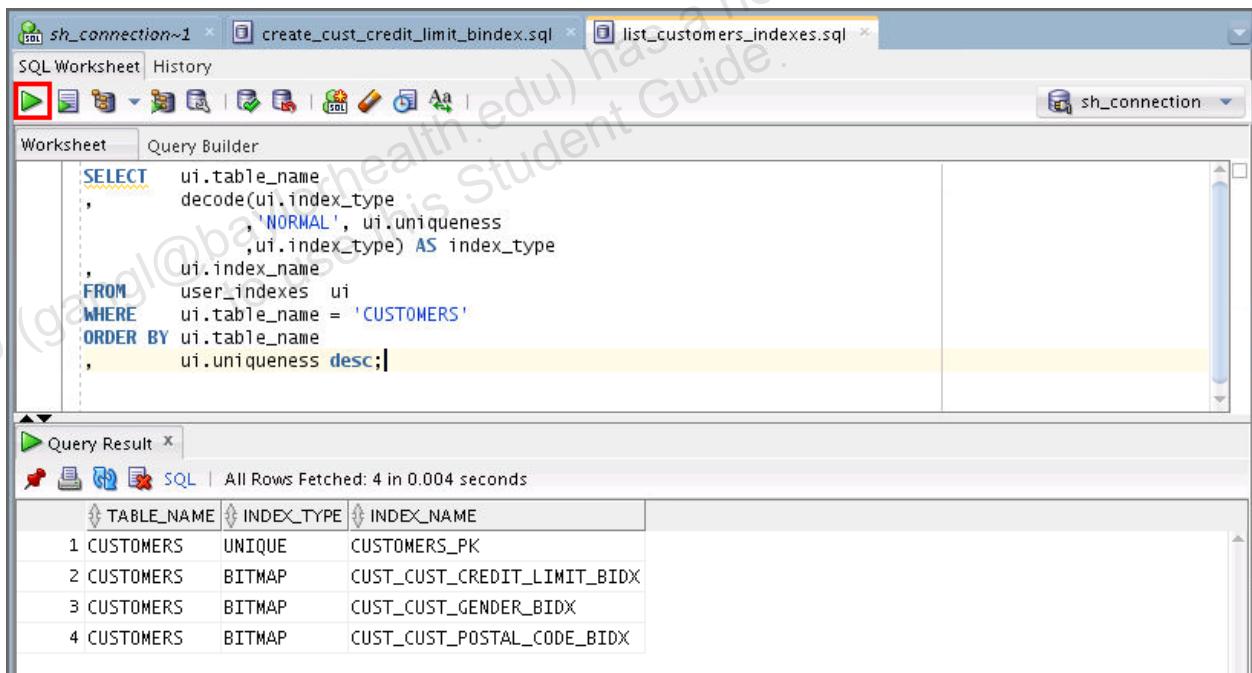
```
set echo on

CREATE BITMAP INDEX cust_cust_credit_limit_bidx ON customers(cust_credit_limit)
NOLOGGING COMPUTE STATISTICS;

SQL> CREATE BITMAP INDEX cust_cust_credit_limit_bidx ON customers(cust_credit_limit)
2 NOLOGGING COMPUTE STATISTICS;

INDEX CUST_CUST_CREDIT_LIMIT_BIDX created.
```

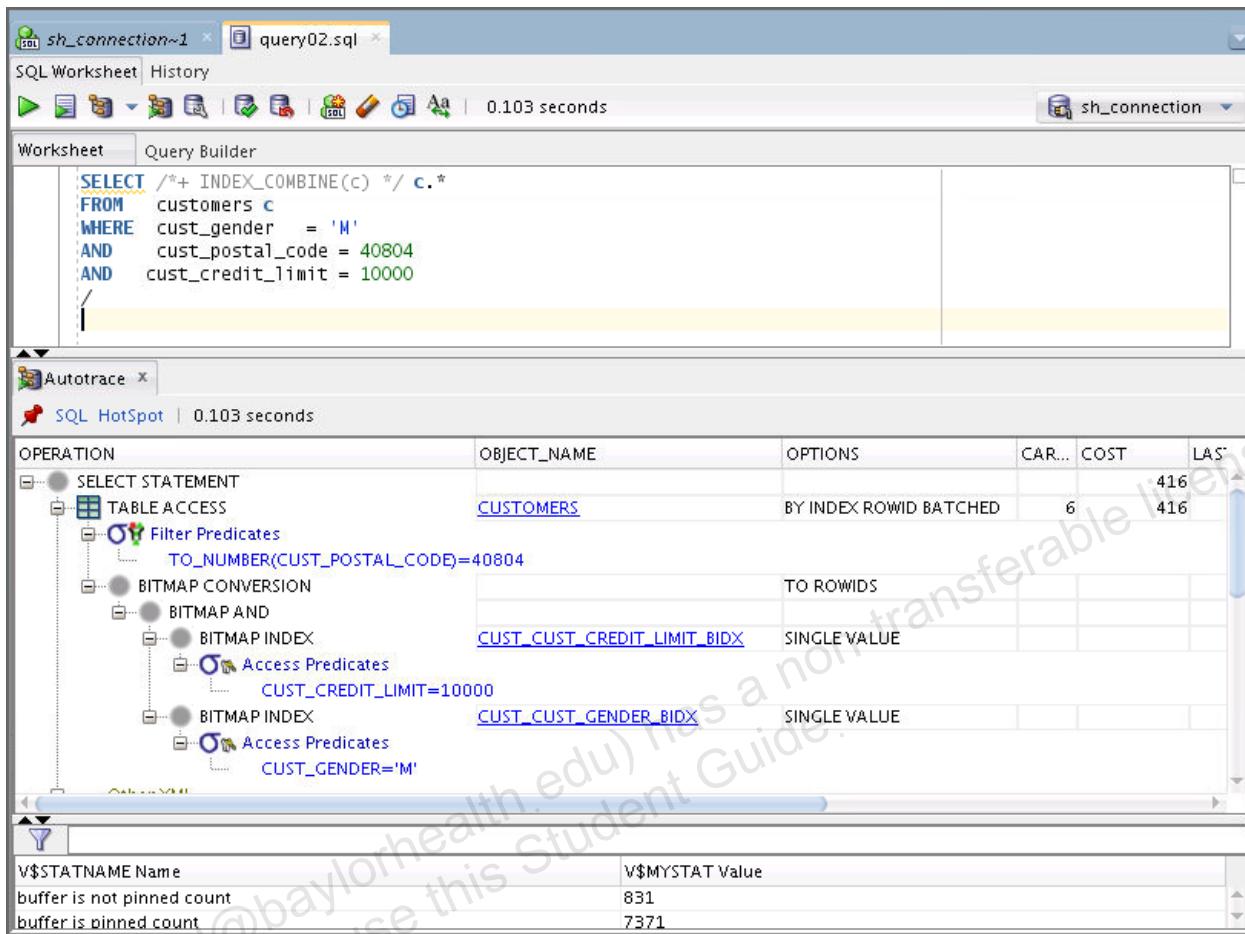
- d. Confirm that the indexes have been created by executing the statement in the `list_customers_indexes.sql` script.



```
SELECT ui.table_name
,
decode(ui.index_type
,'NORMAL', ui.uniqueness
,ui.index_type) AS index_type
,
ui.index_name
FROM user_indexes ui
WHERE ui.table_name = 'CUSTOMERS'
ORDER BY ui.table_name
,
ui.uniqueness desc;
```

TABLE_NAME	INDEX_TYPE	INDEX_NAME
1 CUSTOMERS	UNIQUE	CUSTOMERS_PK
2 CUSTOMERS	BITMAP	CUST_CUST_CREDIT_LIMIT_BIDX
3 CUSTOMERS	BITMAP	CUST_CUST_GENDER_BIDX
4 CUSTOMERS	BITMAP	CUST_CUST_POSTAL_CODE_BIDX

21. Autotrace the query in `query02.sql`. What do you observe?



- The optimizer uses only two bitmap indexes to solve this query. However, the cost is not good. The cost is a little lower than the cost of the full table scan.

22. **Case 5: Complex Predicate with Bitmap Indexes:** Open a terminal window. Connect to `sh` and drop all the indexes that are currently created on the `CUSTOMERS` table, except its primary key index, by executing `drop_customers_indexes.sql`.

```
$ cd /home/oracle/labs/solutions/Access_Paths/
$ sqlplus sh/sh@orclpdb

...
Connected to:...

SQL> @drop_customers_indexes.sql
```

23. After this, create two bitmap indexes on the following columns of the `CUSTOMERS` table:

`cust_year_of_birth` (`create_cust_year_of_birth_bindex.sql`)  
`cust_credit_limit` (`create_cust_credit_limit_bindex.sql`)

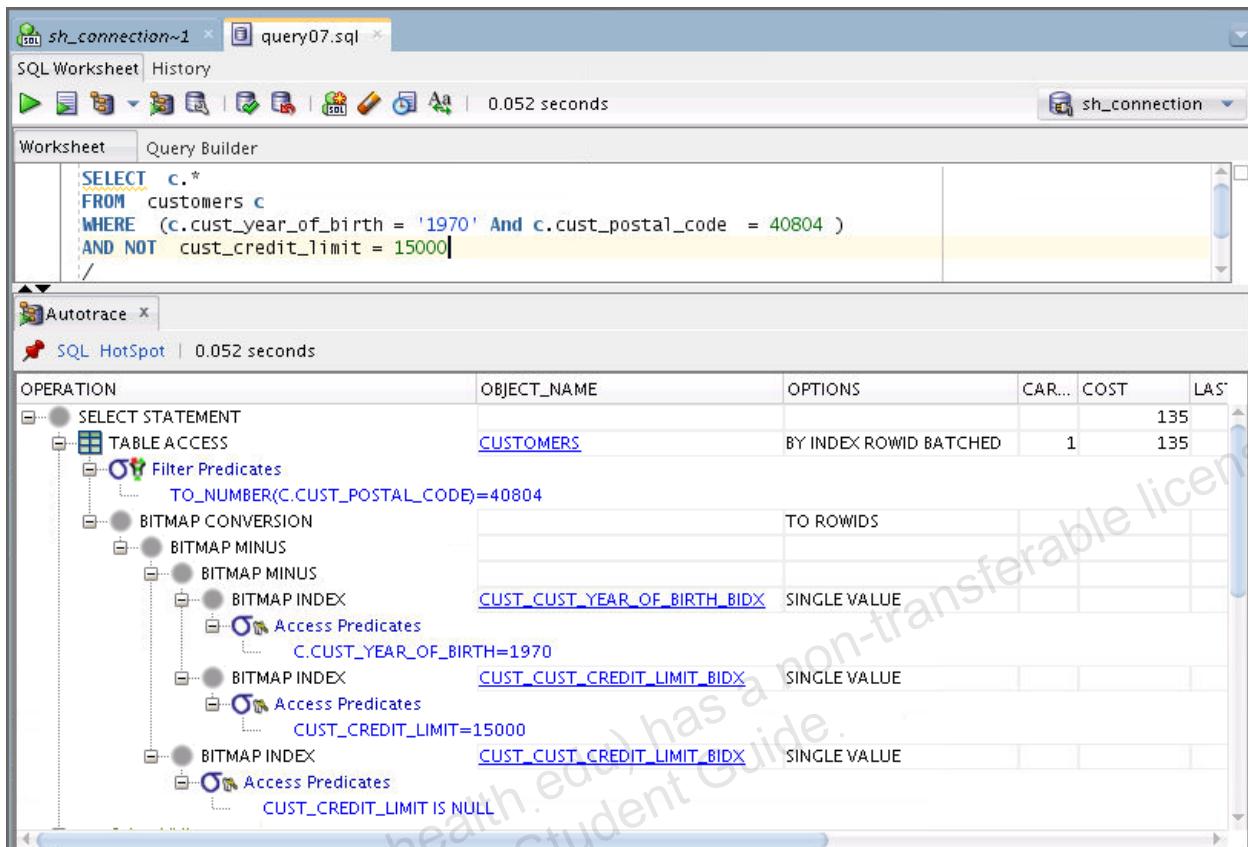
- a. Open and execute the `create_cust_year_of_birth_bindex.sql` script.

The screenshot shows the Oracle SQL Developer interface. The top window is titled "sh\_connection~1" and contains the SQL script "create\_cust\_year\_of\_birth\_bindex.sql". The script includes the command `CREATE BITMAP INDEX cust_cust_year_of_birth_bidx ON customers(cust_year_of_birth) NOLOGGING COMPUTE STATISTICS;`. Below this is the "Script Output" window, which displays the SQL prompt "SQL>" followed by the executed command and the message "INDEX CUST\_CUST\_YEAR\_OF\_BIRTH\_BIDX created." The output window also indicates a task completion time of 0.117 seconds.

- b. Open and execute the `create_cust_credit_limit_bindex.sql` script.

The screenshot shows the Oracle SQL Developer interface. The top window is titled "sh\_connection~1" and contains the SQL script "create\_cust\_credit\_limit\_bindex.sql". The script includes the command `CREATE BITMAP INDEX cust_cust_credit_limit_bidx ON customers(cust_credit_limit) NOLOGGING COMPUTE STATISTICS;`. Below this is the "Script Output" window, which displays the SQL prompt "SQL>" followed by the executed command and the message "INDEX CUST\_CUST\_CREDIT\_LIMIT\_BIDX created." The output window also indicates a task completion time of 0.055 seconds.

24. Autotrace the query in `query07.sql`. What do you observe?



- The query has a complex WHERE clause that is well suited for using bitmap indexes. The optimizer uses two bitmap indexes and the resulting cost is better than the full table scan cost.

25. Make sure that the optimizer can no longer use the bitmap index that you created on the `cust_year_of_birth` column.

- The best solution is to render it invisible. Open and execute the `alter_cust_yob_idx.sql` script. Verify that the `optimizer_use_invisible_indexes` parameter is set to FALSE.

```
select * from v$parameter
where name = 'optimizer_use_invisible_indexes';

alter index cust_cust_year_of_birth_bidx invisible;

select index_name, visibility from user_indexes
where table_owner='SH' and table_name='CUSTOMERS';
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are three tabs: 'sh\_connection~1' (highlighted), 'alter\_cust\_yob\_idx.sql', and 'sh\_connection~23'. Below the tabs, the status bar indicates 'SQL Worksheet History' and '0.096 seconds'. The main area is a 'Worksheet' tab with 'Query Builder' selected. The query editor contains the following SQL code:

```
select * from v$parameter
where name = 'optimizer_use_invisible_indexes';

alter index cust_cust_year_of_birth_bidx invisible;

select index_name, visibility from user_indexes
where table_owner='SH' and table_name='CUSTOMERS';
```

Below the worksheet is a 'Script Output' tab showing the results of the executed queries. The output is as follows:

NAME	TYPE
optimizer_use_invisible_indexes	1
FALSE	
FALSE	
FALSE	

Index CUST\_CUST\_YEAR\_OF\_BIRTH\_BIDX altered.

INDEX_NAME	VISIBILITY
CUST_CUST_YEAR_OF_BIRTH_BIDX	INVISIBLE
CUST_CUST_CREDIT_LIMIT_BIDX	VISIBLE
CUSTOMERS_PK	VISIBLE

26. Autotrace the query in `query07.sql`. What do you observe?

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, the connection is set to `sh_connection~1` and the query is `query07.sql`. The main area displays the following SQL statement:

```
SELECT c.*  
FROM customers c  
WHERE (c.cust_year_of_birth = '1970' And c.cust_postal_code = 40804 )  
AND NOT cust_credit_limit = 15000  
/
```

Below the SQL statement, the **Autotrace** window is open, showing the execution plan and statistics. The execution plan details the following steps:

- SELECT STATEMENT**: Full scan of the **CUSTOMERS** table.
- TABLE ACCESS**: Filtered by **Filter Predicates**:
  - AND**:
    - C.CUST\_YEAR\_OF\_BIRTH=1970**
    - TO\_NUMBER(C.CUST\_POSTAL\_CODE)=40804**
    - CUST\_CREDIT\_LIMIT<>15000**
- Other XML**: Contains an **{info}** node.

At the bottom, the **V\$STATNAME** and **V\$MYSTAT** table provides detailed performance metrics:

V\$STATNAME Name	V\$MYSTAT Value
buffer is not pinned count	128
bytes received via SQL*Net from client	2956
bytes sent via SQL*Net to client	81697
Cached Commit SCN referenced	1507
collects not snapshot consumer	34

- This is the same query as in step 24. However, the optimizer can no longer find a good plan that uses bitmap indexes.

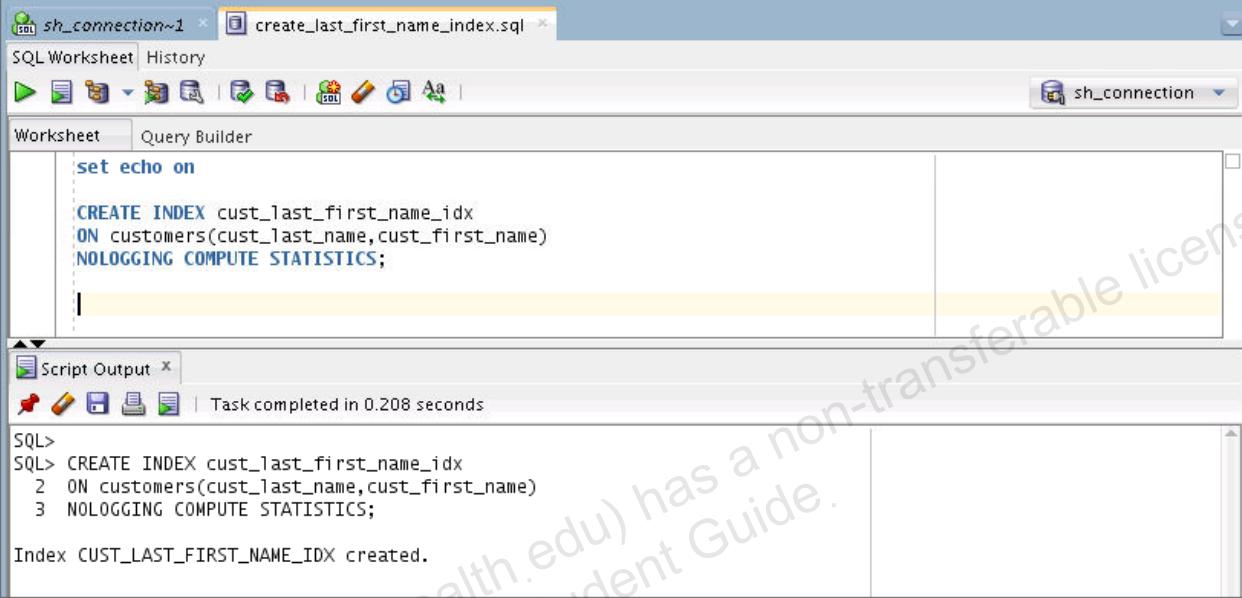
27. **Case 6: Index Only Access:** Open a terminal window. Connect to `sh` and drop all the indexes that are currently created on the `CUSTOMERS` table, except its primary key index, by executing `drop_customers_indexes.sql`.

```
$ cd /home/oracle/labs/solutions/Access_Paths/  
$ sqlplus sh/sh@orclpdb  
  
...  
Connected to:...  
  
SQL> @drop_customers_indexes.sql
```

28. After this, use `create_last_first_name_index.sql` to create a concatenated B\*-tree index on the following columns of the `CUSTOMERS` table, and in the order shown here:

`cust_last_name`  
`cust_first_name`

Open and execute the `create_last_first_name_index.sql` script.



The screenshot shows the Oracle SQL Developer interface. The top window is titled "sh\_connection~1" and contains a tab for "create\_last\_first\_name\_index.sql". The "Worksheet" tab is selected, showing the SQL code for creating the index:

```
set echo on
CREATE INDEX cust_last_first_name_idx
ON customers(cust_last_name,cust_first_name)
NOLOGGING COMPUTE STATISTICS;
```

Below the worksheet is a "Script Output" window showing the execution results:

```
SQL>
SQL> CREATE INDEX cust_last_first_name_idx
2  ON customers(cust_last_name,cust_first_name)
3  NOLOGGING COMPUTE STATISTICS;
Index CUST_LAST_FIRST_NAME_IDX created.
```

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29. Autotrace the query in `query09.sql`. What do you observe?

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are three tabs: `sh_connection~1`, `create_last_first_name_index.sql`, and `query09.sql`. The `query09.sql` tab is active. Below the tabs is a toolbar with various icons. The main workspace has two panes: "Worksheet" and "Query Builder". The "Worksheet" pane contains the SQL query:

```
SELECT c.cust_last_name
,      c.cust_first_name
FROM    customers c
/
```

The "Query Builder" pane is empty. Below the workspace is the "Autotrace" section. It shows the execution plan for the query:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAS...
SELECT STATEMENT				54	
INDEX	<a href="#">CUST_LAST_FIRST_NAME_IDX</a>	FAST FULL SCAN	55500	54	
Other XML					
(info)					
info type="db_version"					

Below the execution plan is a table of V\$STATNAME statistics:

V\$STATNAME Name	V\$MYSTAT Value
bytes received via SQL*Net from client	2881
bytes sent via SQL*Net to client	80178
calls to get snapshot scn: kcmgss	6
calls to kcmgcs	13
cell physical IO interconnect bytes	32768
consistent gets	8
consistent gets from cache	8
consistent gets pin	8
consistent gets pin (fastpath)	7
CPU used by this session	5
CPU used when call started	5

- The optimizer can use the index to retrieve the entire select list without accessing the table itself. The resulting cost is very good.

30. **Case 7: Index Join:** Open a terminal window. Connect to `sh` and drop all the indexes that are currently created on the `CUSTOMERS` table, except its primary key index, by executing `drop_customers_indexes.sql`.

```
$ cd /home/oracle/labs/solutions/Access_Paths/
$ sqlplus sh/sh@orclpdb

...
Connected to:...

SQL> @drop_customers_indexes.sql
```

31. After this, create two B\*-tree indexes on the following columns of the `CUSTOMERS` table:

`cust_last_name` (`create_last_name.index.sql`)  
`cust_first_name` (`create_first_name.index.sql`)

- a. Open and execute the `create_last_name_index.sql` script.

The screenshot shows the SQL Developer interface with the connection set to "sh\_connection". A new worksheet titled "create\_last\_name\_index.sql" is open. The code within the worksheet is:

```
set echo on
CREATE INDEX cust_cust_last_name_idx
ON customers(cust_last_name)
NOLOGGING COMPUTE STATISTICS;
```

Below the worksheet, the "Script Output" window shows the results of the execution:

```
SQL>
SQL> CREATE INDEX cust_cust_last_name_idx
2  ON customers(cust_last_name)
3  NOLOGGING COMPUTE STATISTICS;
Index CUST_CUST_LAST_NAME_IDX created.
```

- b. Open and execute the `create_first_name_index.sql` script.

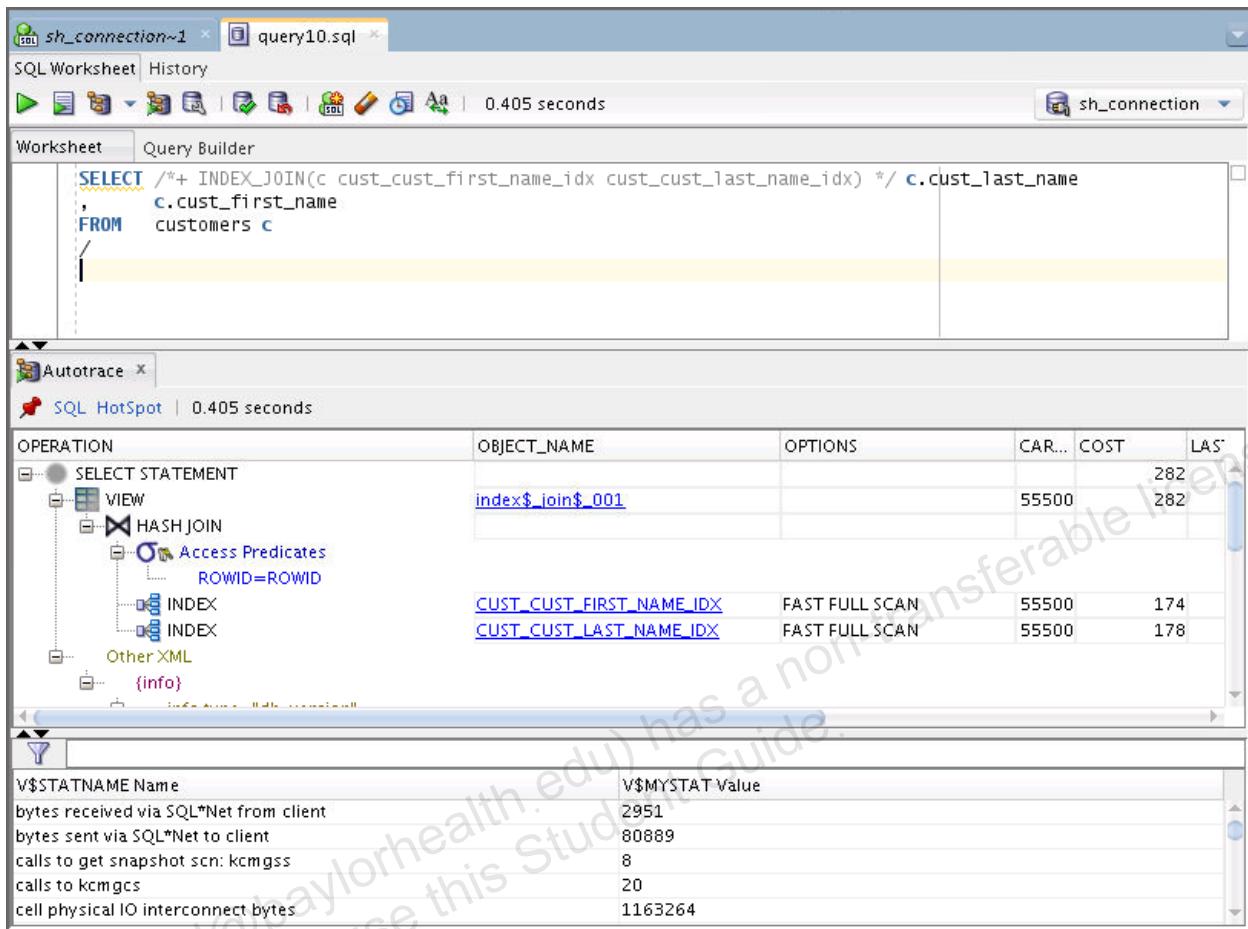
The screenshot shows the SQL Developer interface with the connection set to "sh\_connection". A new worksheet titled "create\_first\_name\_index.sql" is open. The code within the worksheet is:

```
set echo on
CREATE INDEX cust_cust_first_name_idx
ON customers(cust_first_name)
NOLOGGING COMPUTE STATISTICS;
```

Below the worksheet, the "Script Output" window shows the results of the execution:

```
SQL>
SQL> CREATE INDEX cust_cust_first_name_idx
2  ON customers(cust_first_name)
3  NOLOGGING COMPUTE STATISTICS;
Index CUST_CUST_FIRST_NAME_IDX created.
```

32. Autotrace the query in the `query10.sql` script. What do you observe?



- Although the optimizer can use both the indexes, the resulting cost is not better than the concatenated index.

33. **Case 8: Bitmap Index Only Access:** Open a terminal window. Connect to `sh` and drop all the indexes that are currently created on the `CUSTOMERS` table, except its primary key index, by executing `drop_customers_indexes.sql`.

```
$ cd /home/oracle/labs/solutions/Access_Paths/
$ sqlplus sh/sh@orclpdb

...
Connected to:...

SQL> @drop_customers_indexes.sql
```

34. Then create one bitmap index on the following column of the CUSTOMERS table:

`cust_credit_limit (create_cust_credit_limit_bindex.sql)`

You can open and execute the `create_cust_credit_limit_bindex.sql` script.

The screenshot shows the Oracle SQL Developer interface. In the top-left pane, there is a worksheet containing the following SQL code:

```
set echo on
CREATE BITMAP INDEX cust_cust_credit_limit_bidx ON customers(cust_credit_limit)
NOLOGGING COMPUTE STATISTICS;
```

In the bottom-right pane, the output of the execution is shown:

```
SQL>
SQL> CREATE BITMAP INDEX cust_cust_credit_limit_bidx ON customers(cust_credit_limit)
  2 NOLOGGING COMPUTE STATISTICS;
INDEX CUST_CUST_CREDIT_LIMIT_BIDX created.
```

35. Autotrace the query in `query11.sql`. What do you observe?

The screenshot shows the Oracle SQL Developer interface with Autotrace results. In the top-left pane, the query is defined as:

```
SELECT count(*) credit_limit
FROM   customers
WHERE  cust_credit_limit = 10000
```

In the bottom-left pane, the Autotrace results are displayed:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAS...
SELECT STATEMENT					
SORT		AGGREGATE		1	
BITMAP CONVERSION		COUNT		6938	1
BITMAP INDEX	<a href="#">CUST_CUST_CREDIT_LIMIT_BIDX</a>	SINGLE VALUE			
Access Predicates					
CUST_CREDIT_LIMIT=10000					

Below the Autotrace results, a table of statistics is shown:

V\$STATNAME Name	V\$MYSTAT Value
bytes received via SQL*Net from client	2888
bytes sent via SQL*Net to client	80101
calls to get snapshot scn: kcmgss	6
calls to kcmgcs	7
connections made	2

- Although `cust_credit_limit` is not a selective column, the `COUNT` operation on its bitmap index is very efficient.

36. **Case 9: B\*-Tree Index Only Access:** Drop all the `CUSTOMERS` indexes, except its primary key index. Open a terminal window. Connect to `sh` and drop all the indexes that are currently created on the `CUSTOMERS` table, except its primary key index, by executing `drop_customers_indexes.sql`.

```
$ cd /home/oracle/labs/solutions/Access_Paths/
$ sqlplus sh/sh@orclpdb

...
Connected to:...

SQL> @drop_customers_indexes.sql
```

37. After this, create one B\*-tree index on the following column of the `CUSTOMERS` table:

`cust_credit_limit` (`create_cust_credit_limit_index.sql`)

Open and execute the `create_cust_credit_limit_index.sql` script.

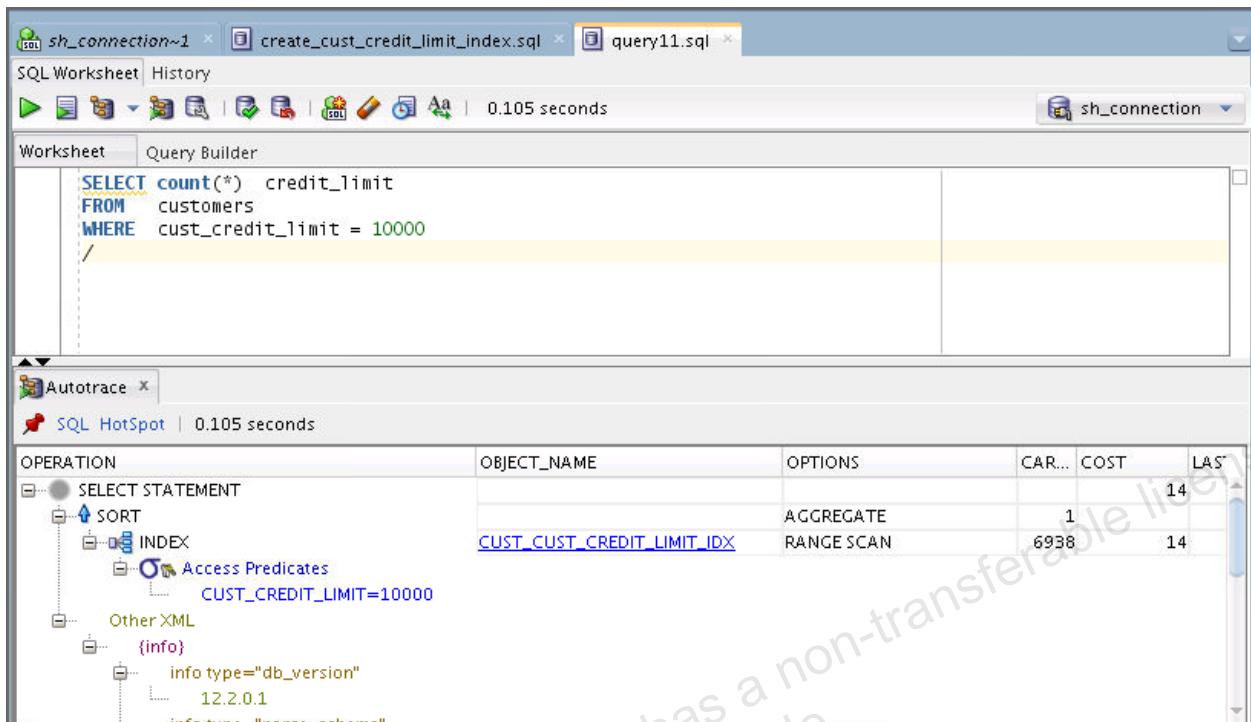
The screenshot shows the Oracle SQL Developer interface. In the top-left corner, there's a connection icon labeled "sh\_connection~1". Next to it is a tab labeled "create\_cust\_credit\_limit\_index.sql". Below the tabs is a toolbar with various icons. The main workspace is divided into two panes: "Worksheet" on the left and "Query Builder" on the right. In the Worksheet pane, the following SQL code is visible:

```
set echo on
CREATE INDEX cust_credit_limit_idx
ON customers(cust_credit_limit)
NOLOGGING COMPUTE STATISTICS;
```

In the bottom-left corner of the main area, there's a "Script Output" pane. It contains the command and the output from the database:

```
SQL>
SQL> CREATE INDEX cust_credit_limit_idx
  2 ON customers(cust_credit_limit)
  3 NOLOGGING COMPUTE STATISTICS;
Index CUST_CREDIT_LIMIT_IDX created.
```

38. Autotrace the query in `query11.sql`. What do you observe?



- The optimizer uses the B\*-Tree index; however, this is less efficient compared to the corresponding bitmap index from the previous case in step 35.

39. **Case 10: Function Based Index:** Drop all the CUSTOMERS indexes, except its primary key index. Open a terminal window. Connect to `sh` and drop all the indexes that are currently created on the CUSTOMERS table, except its primary key index, by executing `drop_customers_indexes.sql`.

```
$ cd /home/oracle/labs/solutions/Access_Paths/
$ sqlplus sh/sh@orclpdb

...
Connected to:...

SQL> @drop_customers_indexes.sql
```

40. After this, create one B\*-tree index on the following column of the CUSTOMERS table:

`cust_last_name (create_last_name_index.sql)`

The screenshot shows the Oracle SQL Worksheet interface. In the top-left pane, there is a code editor window titled "create\_last\_name\_index.sql" containing the following SQL command:

```
set echo on
CREATE INDEX cust_cust_last_name_idx
ON customers(cust_last_name)
NOLOGGING COMPUTE STATISTICS;
```

In the bottom-right pane, the "Script Output" window displays the results of the execution:

```
SQL> CREATE INDEX cust_cust_last_name_idx
2 ON customers(cust_last_name)
3 NOLOGGING COMPUTE STATISTICS;
Index CUST_CUST_LAST_NAME_IDX created.
```

41. Autotrace the query in `query12.sql`. What do you observe?

The screenshot shows the Oracle SQL Worksheet interface. In the top-left pane, there is a code editor window titled "query12.sql" containing the following SQL query:

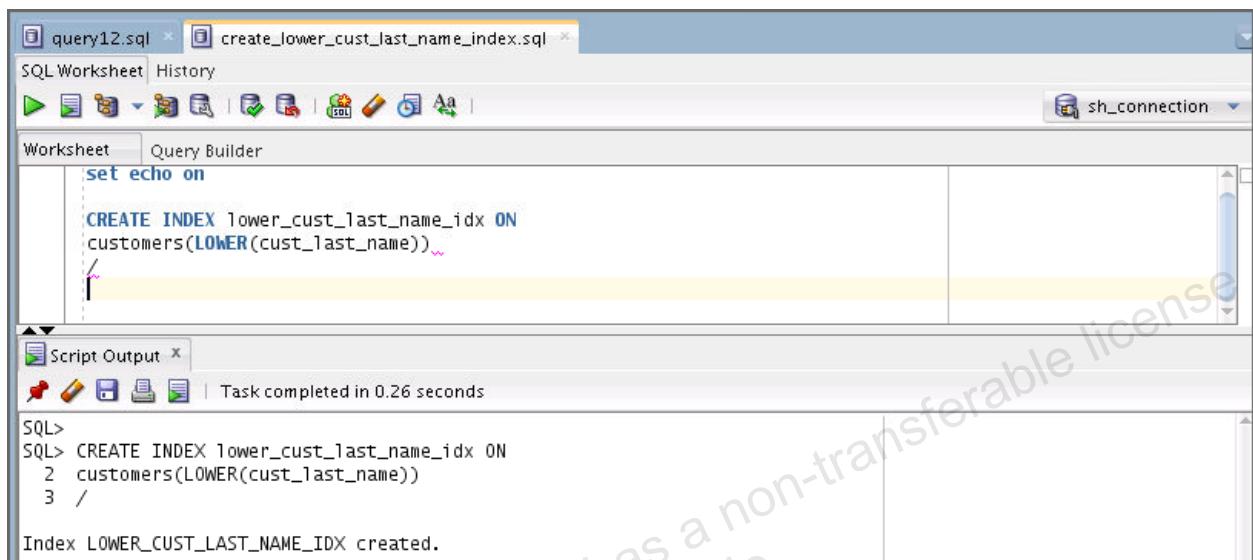
```
SELECT cust_id, country_id
FROM customers
WHERE LOWER( cust_last_name) LIKE 'gentle'
```

In the bottom-right pane, the "Autotrace" window displays the execution plan and statistics:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAS...
SELECT STATEMENT				423	
TABLE ACCESS	CUSTOMERS	FULL	555	423	
Filter Predicates					
LOWER(CUST_LAST_NAME)='gentle'					

- Although there is an index, it cannot be used because its column is modified by a function.

42. How can you enhance the performance of the previous query without modifying the statement itself? Implement your solution.
- You can create a function-based index by using  
`create_lower_cust_last_name_index.sql`.



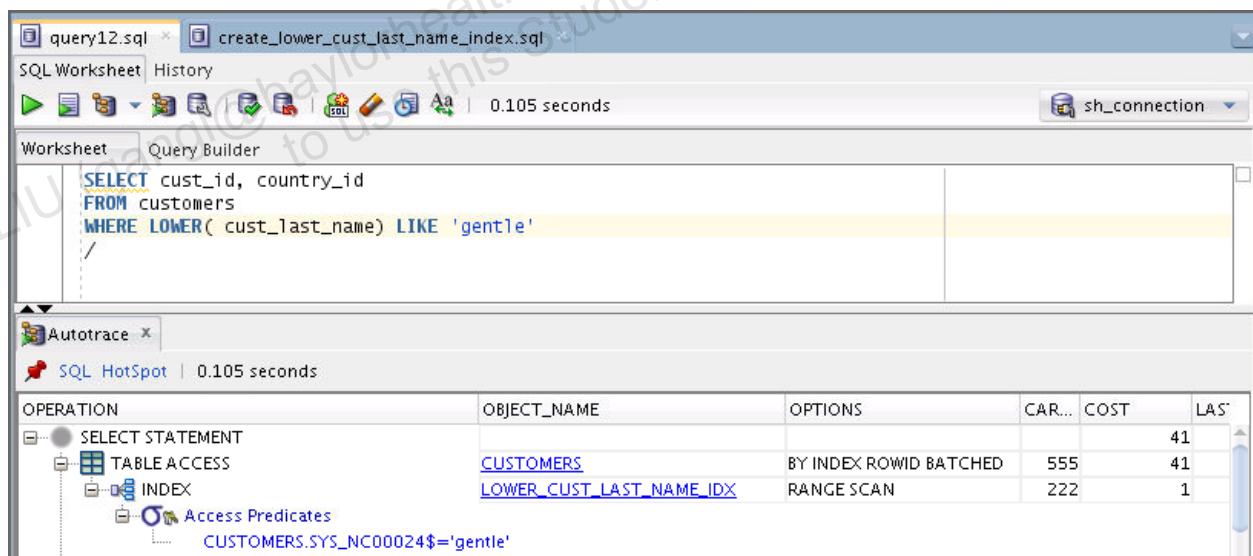
The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are two tabs: "query12.sql" and "create\_lower\_cust\_last\_name\_index.sql". The "create\_lower\_cust\_last\_name\_index.sql" tab is active. The "Worksheet" tab is selected in the toolbar. The code in the worksheet window is:

```
set echo on
CREATE INDEX lower_cust_last_name_idx ON
customers(LOWER(cust_last_name))
```

Below the worksheet, the "Script Output" window shows the execution results:

```
SQL>
SQL> CREATE INDEX lower_cust_last_name_idx ON
2 customers(LOWER(cust_last_name))
3 /
Index LOWER_CUST_LAST_NAME_IDX created.
```

43. Check if your solution executes faster than in the case of the query in step 41.



The screenshot shows the Oracle SQL Developer interface. The "create\_lower\_cust\_last\_name\_index.sql" tab is active. The "Worksheet" tab is selected in the toolbar. The code in the worksheet window is:

```
SELECT cust_id, country_id
FROM customers
WHERE LOWER( cust_last_name) LIKE 'gentle'
```

Below the worksheet, the "Autotrace" window shows the execution plan:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAS...
SELECT STATEMENT				41	
TABLE ACCESS	CUSTOMERS	BY INDEX ROWID BATCHED	555	41	
INDEX	LOWER_CUST_LAST_NAME_IDX	RANGE SCAN	222	1	
Access Predicates	CUSTOMERS.SYS_NC00024\$='gentle'				

The "Autotrace" window also displays the execution time: 0.105 seconds.

44. **Case 11: Index Organized Table:** Execute the `iot_setup.sql` script by using the `sh` user to set up the environment for this case.

```

set echo on

CREATE table promotions_iot
(promo_id number primary key
, promo_name VARCHAR2(40)
, promo_subcategory VARCHAR2 (30)
, promo_category VARCHAR2 (30)
, promo_cost NUMBER
, promo_begin_date DATE
, promo_end_date DATE)
ORGANIZATION INDEX
/

INSERT INTO promotions_iot
SELECT promo_id, promo_name, promo_subcategory, promo_category, promo_cost, promo_begin_date, promo_end_date
FROM promotions
/

```

Script Output x | Task completed in 0.317 seconds

```

SQL> SQL> CREATE table promotions_iot
2 (promo_id number primary key
3 , promo_name VARCHAR2(40)
4 , promo_subcategory VARCHAR2 (30)
5 , promo_category VARCHAR2 (30)
6 , promo_cost NUMBER
7 , promo_begin_date DATE
8 , promo_end_date DATE)
9 ORGANIZATION INDEX
10 /
Table PROMOTIONS_IOT created.

SQL>
SQL> INSERT INTO promotions_iot
2 SELECT promo_id, promo_name, promo_subcategory, promo_category, promo_cost, promo_begin_date, promo_end_date
3 FROM promotions
4 /
503 rows inserted.

```

45. Autotrace the query in `query13a.sql` and `query13b.sql`. What do you observe?

```

SELECT *
FROM promotions
WHERE promo_id > 300
/

```

Autotrace x | SQL HotSpot | 0.055 seconds

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED
SELECT STATEMENT				17		21
TABLE ACCESS	PROMOTIONS	FULL		364	17	21
Filter Predicates						
PROMO_ID>300						

Autotrace report for query13b.sql:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED
SELECT STATEMENT				353	49	
TABLE ACCESS	PROMOTIONS	BY INDEX ROWID BATCHED	364	353	49	
INDEX	PROMO_PK	RANGE SCAN	364	1	1	
Access Predicates	PROMO_ID>300					

- The first query lets the optimizer decide the plan and the best that it can find is to perform a full table scan. Forcing the use of an index is not a good idea because it takes longer to execute.

#### 46. Autotrace the query in query14.sql.

```
SELECT *
FROM promotions_iot
WHERE promo_id > 300;
```

What do you observe?

Autotrace report for query14.sql:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED
SELECT STATEMENT				2	5	
INDEX	SYS_IOT_TOP_532042	RANGE SCAN	1	2	5	
Access Predicates	PROMO_ID>300					

- The optimizer directly uses the index-organized structure, which is extremely efficient in this case compared to the previous step.

47. Open and execute the `iot_cleanup.sql` script to clean up your environment.

The screenshot shows the Oracle SQL Developer interface. The top window is titled "iot\_cleanup.sql" and contains the following SQL code:

```
set echo on
drop table promotions_iot purge;
```

The bottom window, titled "Script Output", shows the results of the execution:

```
SQL> drop table promotions_iot purge;
Table PROMOTIONS_IOT dropped.
```

48. **Case 12: Index Skip Scan:** Execute the `iss_setup.sql` script by using the `sh` user to set up your environment for this practice.

The screenshot shows the Oracle SQL Developer interface. The top window is titled "iss\_setup.sql" and contains the following PL/SQL code:

```
set echo on
create table t(c number, d number);
begin
  for i in 1..10000 loop
    insert into t values(1,i);
  end loop;
end;
/
create index it on t(c,d);
```

The bottom window, titled "Script Output", shows the results of the execution:

```
SQL> create table t(c number, d number);
Table T created.

SQL> begin
 2   for i in 1..10000 loop
 3     insert into t values(1,i);
 4   end loop;
 5 end;
 6 /
PL/SQL procedure successfully completed.

SQL> create index it on t(c,d);
Index IT created.
```

49. Autotrace the query in `query20.sql`. What do you observe?

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAST_CR_BUFFER_GETS	LAST_ELAPSED
SELECT STATEMENT				7		23
SORT		AGGREGATE		1		23
TABLE ACCESS	T	FULL		1	7	23
Filter Predicates	D=1					

- The optimizer is not using the index and does a full table scan.

50. How would you improve the performance of a query, such as the one in the previous step? Implement your solution.

- a. Execute `iss_gather_stats.sql` to make sure that you gather the statistics for your table correctly so that the index skip scan can be used.

```

set echo on
execute dbms_stats.gather_table_stats('SH','T',cascade=>TRUE);

```

Script Output:

```

Task completed in 0.61 seconds
SQL>
SQL> execute dbms_stats.gather_table_stats('SH','T',cascade=>TRUE);
PL/SQL procedure successfully completed.

```

51. Autotrace the query in `query20.sql`. What do you observe?

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, three files are open: `iss_setup.sql`, `query20.sql` (which is the active file), and `iss_gather_stats.sql`. The main area is a Worksheet showing the query `select count(*) from t where d=1;`. Below the worksheet is an Autotrace window titled "Autotrace" which displays the execution plan. The plan starts with a "SELECT STATEMENT" node, which branches into "SORT" and "INDEX" nodes. The "INDEX" node further branches into "Access Predicates" (with condition `D=1`) and "Filter Predicates" (with condition `D=1`). The "INDEX" node is associated with the object name `IT`. The "OPTIONS" column for the "INDEX" node lists "AGGREGATE" and "SKIP SCAN". The "COST" column shows values of 1 and 2 respectively. The "LAST\_CR\_BUFFER" column is empty.

- The optimizer now uses the index to perform an index skip scan.

52. Compare the result of `query20.sql` with the result that you obtain when you autotrace the following query (`query21.sql`):

```
select /*+ INDEX_FFS(t it) */ count(*) from t where d=1;
```

What do you observe?

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, three files are open: `iss_setup.sql`, `query20.sql`, and `query21.sql` (which is the active file). The main area is a Worksheet showing the query `select /*+ INDEX_FFS(t it) */ count(*) from t where d=1;`. Below the worksheet is an Autotrace window titled "Autotrace" which displays the execution plan. The plan starts with a "SELECT STATEMENT" node, which branches into "SORT" and "INDEX" nodes. The "INDEX" node further branches into "Access Predicates" (with condition `D=1`) and "Filter Predicates" (with condition `D=1`). The "INDEX" node is associated with the object name `IT`. The "OPTIONS" column for the "INDEX" node lists "AGGREGATE" and "FAST FULL SCAN". The "COST" column shows values of 1 and 9 respectively. The "LAST\_CR\_BUFFER" column is empty.

- The optimizer uses a fast full index scan, but this is not better than the index skip scan.

53. Execute the `iss_cleanup.sql` script to clean up your environment for this case.

The screenshot shows the Oracle SQL Worksheet interface. The title bar says "iss\_cleanup.sql". The main area is titled "Worksheet" and contains the following SQL code:

```
set echo on
drop table t purge;
```

The "Script Output" window below shows the results of the execution:

```
SQL> drop table t purge;
Table T dropped.
```

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## **Practices for Lesson 9: Optimizer: Join Operators**

## Practices for Lesson 9: Overview

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### Practices Overview

In these practices, you will examine three SQL statements and compare the different join methods for each statement.

## Practice 9: Using Join Paths

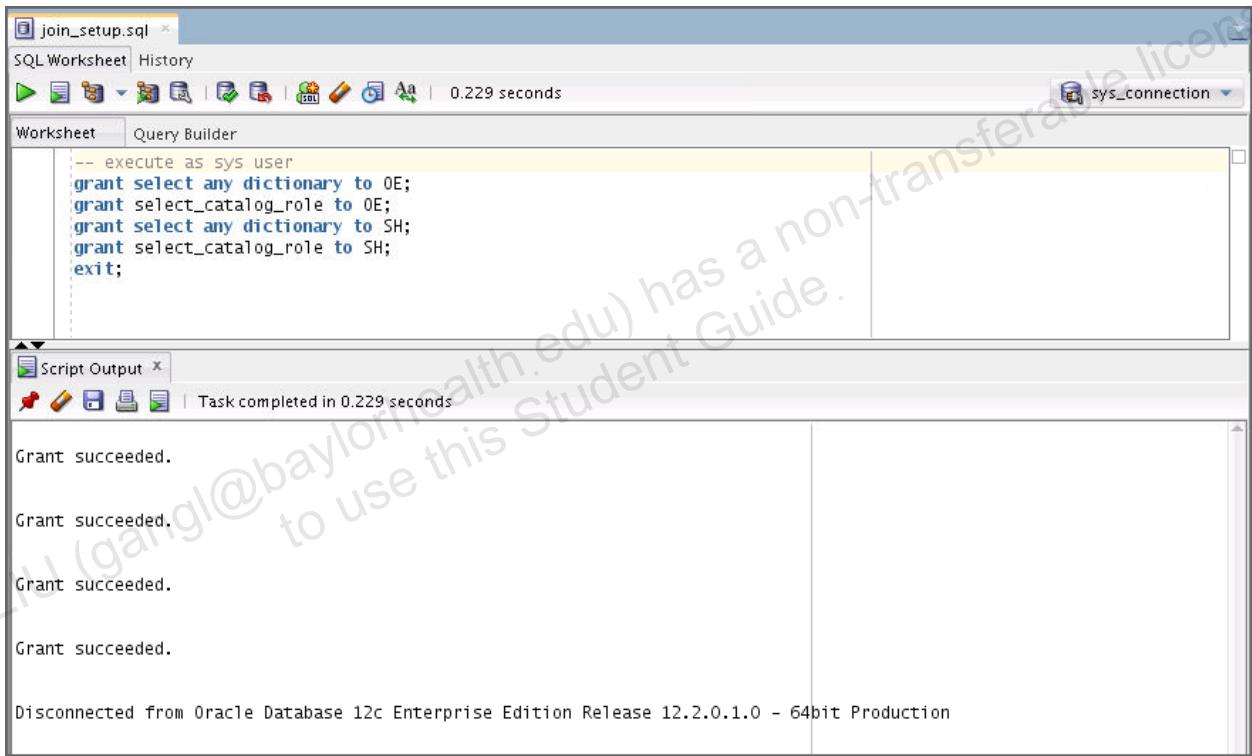
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### Overview

In this practice, you explore the various access paths that the optimizer can use and compare them. You have the possibility of exploring different scenarios, each of which is self-contained. All scripts needed for this practice can be found in your \$HOME/labs/solutions/Access\_Paths directory.

### Tasks

1. Open and execute the `join_setup.sql` script by using `sys_connection`.



```
-- execute as sys user
grant select any dictionary to OE;
grant select_catalog_role to OE;
grant select any dictionary to SH;
grant select_catalog_role to SH;
exit;
```

Script Output | Task completed in 0.229 seconds

Grant succeeded.  
Grant succeeded.  
Grant succeeded.  
Grant succeeded.

Disconnected from Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 - 64bit Production

2. Open the connection named `hr` that you created in Practice 2. If you have not created this connection, create it now with the following attributes.

Create a connection with the following specifications:

Name: `hr_connection`

Username: `hr`

Password: `hr`

Select Save Password.

Service Name: `orclpdb`

Click Test.

Click Connect.

3. **Case 1: Nested Loops Join Path:** The nested loops join method works well with very small tables, and larger tables with indexes on the join column, and at least one table that produces a small row source. The nested loops method will produce joined rows as soon as a match is found, so it is sometimes the preferred method for the FIRST\_ROWS access goal.

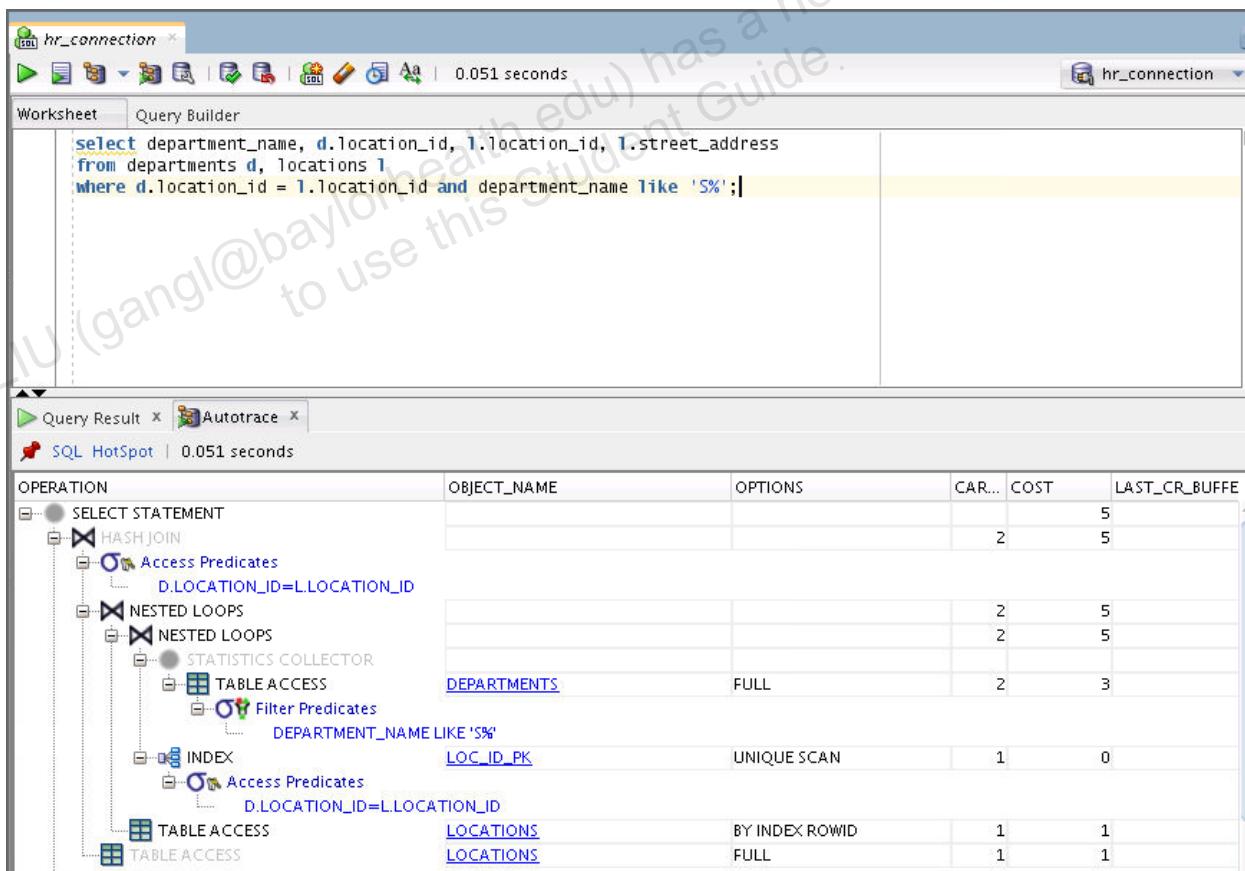
- a. Enter the following query or open `small_tables_join.sql` as the `hr` user:

```
select department_name, d.location_id, l.location_id,
l.street_address
from departments d, locations l
where d.location_id = l.location_id and department_name like
'S%';
```

Run Autotrace twice to load the buffer cache. Observe the statistics in the second run.

What do you observe?

- b. The optimizer chooses the nested loops join method for this query by default. The cost is low. This is expected because both tables in the query are very small.

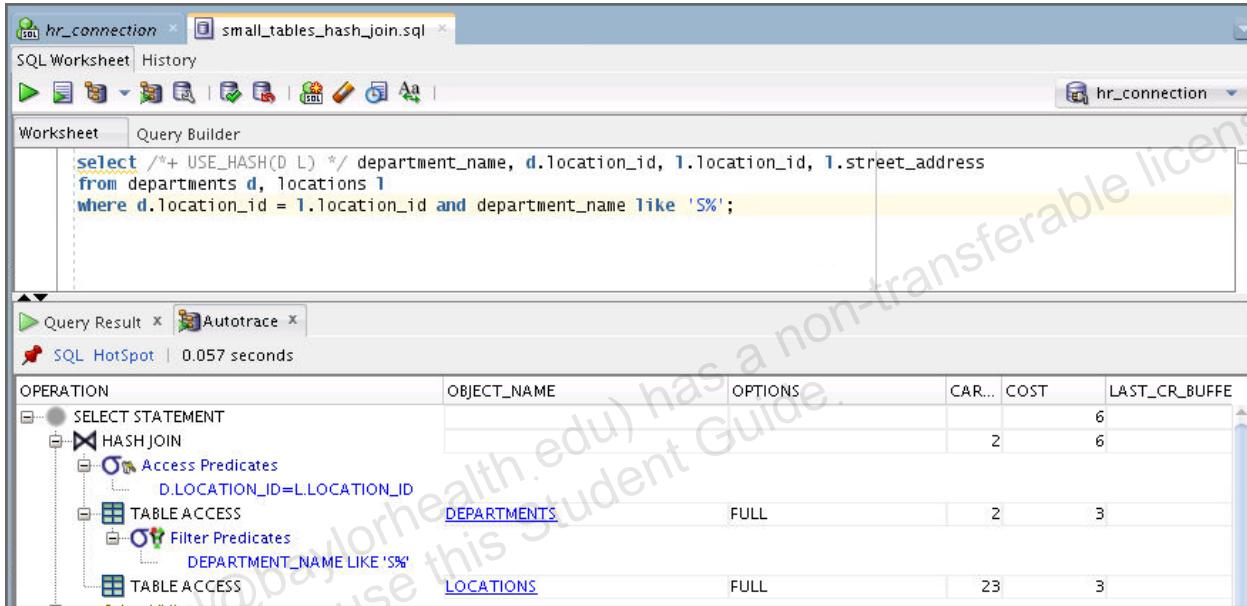


- c. Enter the same query in SQL Developer or open the `small_tables_hash_join.sql` script, but force the use of a hash join by using the following query with hints. Then use Autotrace to observe the differences in the execution plan and statistics.

```
select /*+ USE_HASH(D L) */ department_name, d.location_id,
l.location_id, l.street_address
from departments d, locations l
where d.location_id = l.location_id
and department_name like 'S%';
```

What do you observe?

The optimizer is forced to use the hash join method. The number of consistent gets is higher and the estimated cost is higher. Note that the elapsed time may vary depending on any other activity on the machine.

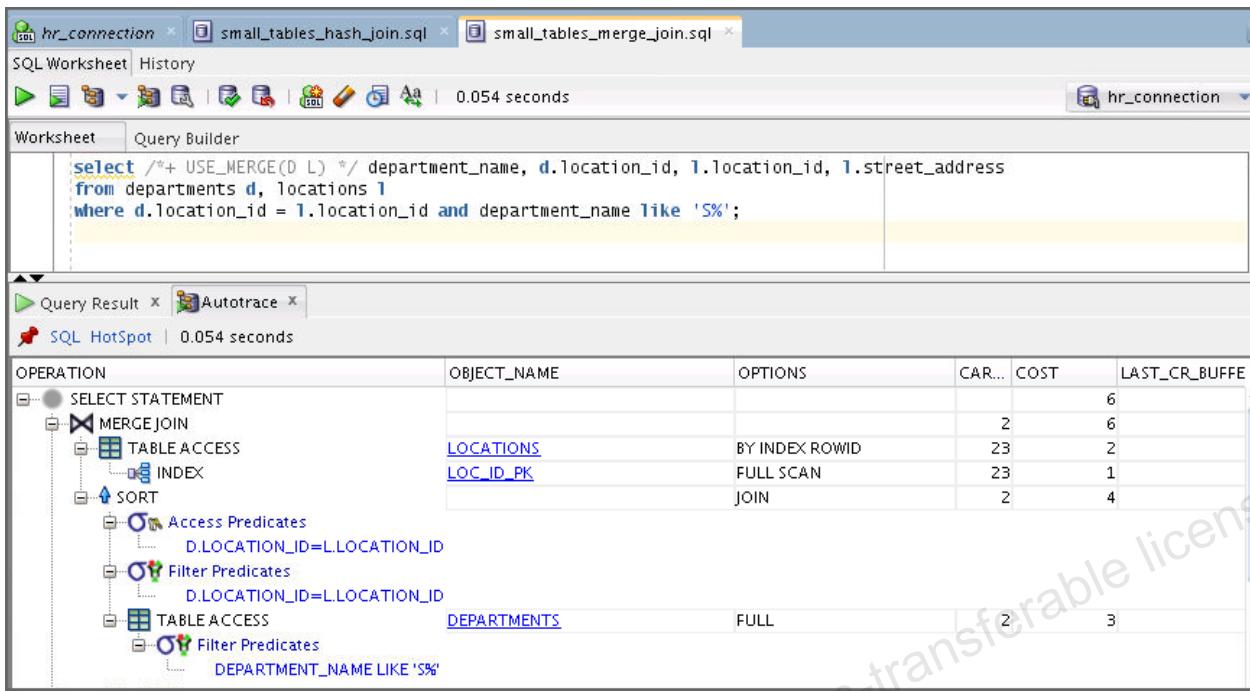


- d. Enter the same query in SQL Developer or open `small_tables_merge_join.sql`, but force the use of a sort-merge join by using the following query with hints. Then use Autotrace to observe the differences in the execution plan and statistics.

```
select /*+ USE_MERGE(D L) */ department_name, d.location_id,
l.location_id, l.street_address
from departments d, locations l
where d.location_id = l.location_id
and department_name like 'S%';
```

What do you observe?

The optimizer is forced to use the sort-merge join method. The number of consistent gets is lower than nested loops, but there is the additional cost of the sorts that is not included in the consistent gets. The estimated cost is higher. Note that the elapsed time may vary depending on any other activity on the machine.



4. Open the connection named `oe_connection` that you created in Practice 2. If you have not created this connection, create it now with the following attributes.
    - a. Click the Add Connection button.
    - b. Create a connection with following specifications:
 

Name: `oe_connection`  
 Username: `oe`  
 Password: `oe`  
 Select Save Password.  
 Service Name: `orclpdb`  
 Click Test.  
 Click Connect.
  
  5. **Case 2: Merge Join:** The merge join is a general-purpose join method that can work when other methods cannot. The merge join must sort each of the two row sources before performing the join. Because both row sources must be sorted before the first joined row is returned, the merge join method is not well suited for use with the `FIRST_ROWS` goal.
    - a. Enter the following query in a SQL Developer worksheet connected as the `OE` user or open the `oe_query.sql` script.
 

```
SELECT *
FROM orders h, order_items l
WHERE l.order_id = h.order_id;
```
    - b. Autotrace this query twice to warm the buffer cache.
- What do you observe?

Notice that the merge join is chosen by the optimizer.

V\$STATNAME	Name	V\$MYSTAT	Value
buffer is not pinned count		5	
buffer is pinned count		10	
bytes received via SQL*Net from client		2867	
bytes sent via SQL*Net to client		82863	
calls to get snapshot scn: kcmgss		4	
calls to kcmgcs		9	
consistent gets		9	
consistent gets from cache		9	
consistent gets pin		9	
consistent gets pin (fastpath)		9	
CPU used by this session		5	
CPU used when call started		5	
DB time		5	
execute count		4	
index scans kdliixs1		1	
logical read bytes from cache		73728	
no work - consistent read gets		6	

- c. Enter the same query with a hint to force the use of a hash join or open the oe\_query\_hash.sql script.

```
SELECT /*+ USE_HASH(h l) */ *
  FROM orders h, order_items l
 WHERE l.order_id = h.order_id;
```

What do you observe?

Compare the estimated cost to the merge join in the preceding step, and the consistent gets. In this case, the additional sort required by the merge join method does not raise the cost enough to cause the hash join to be chosen by the optimizer.

SQL Worksheet History

Worksheet Query Builder

```
SELECT /*+ USE_HASH(h 1) */ *
FROM orders h, order_items l
WHERE l.order_id = h.order_id;
```

Autotrace SQL HotSpot | 0.051 seconds

OPERATION	OBJECT_NAME	OPTIONS	CAR...	COST	LAST_CR_BUFFER
SELECT STATEMENT				6	
HASH JOIN				665	6
Access Predicates					
L_ORDER_ID=H.ORDER_ID					
TABLE ACCESS	ORDERS	FULL		105	3
TABLE ACCESS	ORDER_ITEMS	FULL		665	3
Other XML					
(info)					
info type="db_version"					
12.2.0.1					
info type="parse_schema"					

V\$STATNAME	Name	V\$MYSTAT	Value
ASSM cbk:blocks examined		1	
ASSM gsp:get free block		1	
ASSM gsp:L1 bitmaps examined		1	
ASSM gsp:L2 bitmaps examined		1	
blocks cleaned out using minact		5	
buffer is not pinned count		27	
bytes received via SQL*Net from client		2891	
bytes sent via SQL*Net to client		83279	
calls to get snapshot scn: kcmgss		22	
calls to kcmgas		3	
calls to kcmgcs		14	
cell physical IO interconnect bytes		40960	
commit cleanouts		6	
commit cleanouts successfully completed		6	
consistent gets		36	
consistent gets examination		18	
consistent gets examination (fastpath)		18	
consistent gets from cache		36	
consistent gets pin		18	

- d. Enter the same query again, changing the hint to force the use of nested loops, or open the oe\_query\_nl.sql script.

```
SELECT /*+ USE_NL(h 1) */ *
FROM orders h, order_items l
WHERE l.order_id = h.order_id;
```

Autotrace this query.

What do you observe?

Notice the estimated cost and the consistent gets. The cost of the nested loops join method is much higher than either the hash join method or the merge join method. The nested loops method depends on either very small tables or indexes to be an efficient access path.

The screenshot shows the Oracle SQL Developer interface. At the top, there are three tabs: oe\_query.sql, oe\_query\_hash.sql, and oe\_query\_nl.sql. The oe\_query\_nl.sql tab is active. Below the tabs is a toolbar with various icons. The main area has two panes: 'Worksheet' and 'Query Builder'. The Worksheet pane contains the following SQL code:

```
SELECT /*+ USE_NL(h 1) */ *
  FROM orders h, order_items l
 WHERE l.order_id = h.order_id;
```

Below the Worksheet is the 'Autotrace' section, which includes a 'SQL HotSpot' section showing execution time of 0.055 seconds. The 'Autotrace' tree shows the execution plan:

- SELECT STATEMENT
  - NESTED LOOPS
    - TABLE ACCESS (OBJECT\_NAME: ORDERS)
    - TABLE ACCESS (OBJECT\_NAME: ORDER\_ITEMS)
      - Filter Predicates: L.ORDER\_ID=H.ORDER\_ID
  - Other XML
    - {info}
      - info type="db\_version": 12.2.0.1
      - info type="parse\_schema"

At the bottom is a table titled 'V\$STATNAME' with columns 'V\$STATNAME' and 'Value'.

V\$STATNAME	Value
buffer is not pinned count	20
buffer is pinned count	1
bytes received via SQL*Net from client	2889
bytes sent via SQL*Net to client	82402
calls to get snapshot scn: kcmgcs	8
calls to kcmgcs	23
consistent gets	59
consistent gets from cache	59
consistent gets pin	59
consistent gets pin (fastpath)	59
CPU used by this session	5
CPU used when call started	5
DB time	6
enqueue releases	1
enqueue requests	1
execute count	6
logical read bytes from cache	483328
no work - consistent read gets	43
non-idle wait count	56
opened cursors cumulative	7

6. Open the connection named `sh_connection` that you created in Practice 2. If you have not created this connection, create it now with the following attributes.
  - a. Click the Add Connection button.
  - b. Create a connection with the following specifications:
    - Name: `sh_connection`
    - Username: `sh`
    - Password: `sh`

Select Save Password.  
Service Name: orclpdb  
Click Test.  
Click Connect.

7. **Case 3: Hash Join:** The hash join method performs very well on large row sources and on row sources where one row source is smaller. The hash join builds a hash table in memory (and overflows to the temp tablespace if the row source is too large) on the smaller of the row sources. The procedure then reads the second row source, probing for the hash value in the first. Because the rows are joined as soon as a match is found, the hash join method is also preferred for the FIRST\_ROWS goal.

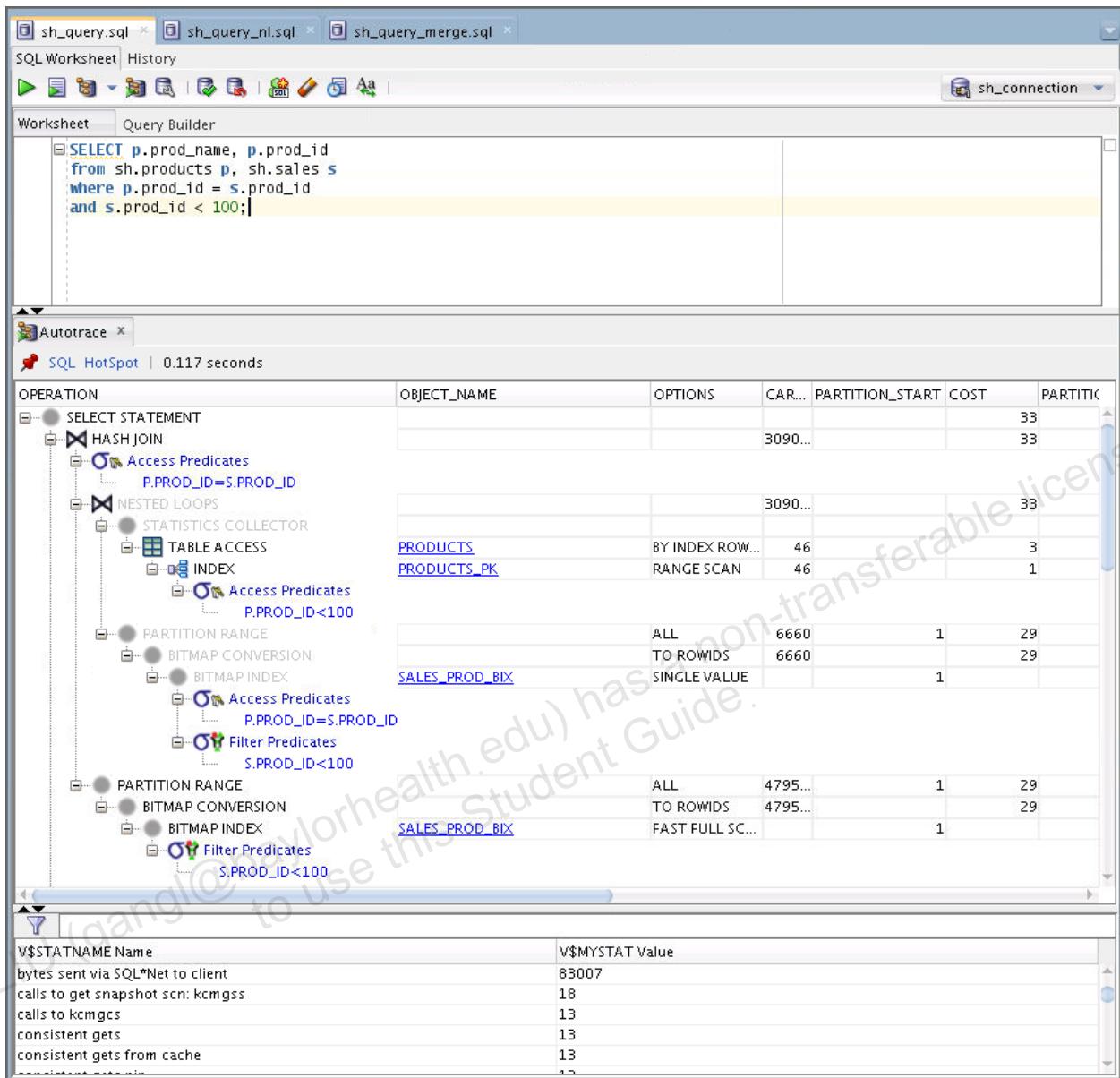
- a. Enter the following query in SQL Developer or open sh\_query.sql:

```
SELECT p.prod_name, p.prod_id
FROM sh.products p, sh.sales s
where p.prod_id = s.prod_id
and s.prod_id < 100;
```

Run Autotrace twice to warm the buffer cache.

What do you observe?

Notice the consistent gets and the estimated cost.



- b. Enter the same query again, but use a hint to force the nested loops method or open the sh\_query\_nl.sql script.

```
SELECT /*+ USE_NL(p s) */ p.prod_name, p.prod_id
FROM sh.products p, sh.sales s
WHERE p.prod_id = s.prod_id
AND s.prod_id < 100 ;
```

Run Autotrace. What do you observe?

The consistent gets and estimated cost values are much higher than the values for the hash join method.

SQL Worksheet History

sh\_connection

Worksheet Query Builder

```
SELECT /*+ use_nl(p s) */ p.prod_name, p.prod_id
  from sh.products p, sh.sales s
 where p.prod_id = s.prod_id
   and s.prod_id < 100;
```

Query Result Autotrace SQL HotSpot | 0.063 seconds

OPERATION	OBJECT_NAME	OPTIONS	CAR...	PARTITION_START	COST	PARTITI
SELECT STATEMENT					1291	
NESTED LOOPS				3090...	1291	
TABLEACCESS	PRODUCTS	BY INDEX ROW...	46		3	
INDEX	PRODUCTS_PK	RANGE SCAN	46		1	
Access Predicates						
P.PROD_ID<100						
PARTITION RANGE						
BITMAP CONVERSION						
BITMAP INDEX	SALES_PROD_BIX					
Access Predicates						
P.PROD_ID=S.PROD_ID						
Filter Predicates						
S.PROD_ID<100						
Other XML						
(info)						
info type="nodeid/pflags"						
nnnnnnnnnnnnnnnnn17						

V\$STATNAME Name	V\$MYSTAT Value
bytes sent via SQL*Net to client	321637
calls to get snapshot scn: kcmgss	469
calls to kcmgcs	587
CCursor + sql area evicted	24
cell physical IO interconnect bytes	8192
concurrency wait time	15
consistent changes	60
consistent gets	73016
consistent gets examination	218
consistent gets examination (fastpath)	218
consistent gets from cache	73016

- c. Enter the same query again. This time use a hint to force the merge join method or open the sh\_query\_merge.sql script.

```
SELECT /*+ USE_MERGE(p s) */ p.prod_name, p.prod_id
  FROM sh.products p, sh.sales s
 where p.prod_id = s.prod_id
   and s.prod_id < 100 ;
```

Run Autotrace. What do you observe?

The estimated cost is higher than the hash join and nested loops method, but the consistent gets is lower than the nested loops method.

sh\_query.sql   sh\_query\_nl.sql   sh\_query\_merge.sql

SQL Worksheet | History

Worksheet   Query Builder

```
SELECT /*+ use_merge(p s)*/ p.prod_name, p.prod_id
  from sh.products p, sh.sales s
 where p.prod_id = s.prod_id
   and s.prod_id < 100;
```

Query Result | Autotrace | SQL HotSpot | 6.148 seconds

OPERATION	OBJECT_NAME	OPTIONS	CAR...	PARTITION_START	COST	PARTITI
SELECT STATEMENT					1404	
MERGEJOIN			3090...		1404	
TABLE ACCESS	PRODUCTS	BY INDEX ROW...	46		3	
INDEX	PRODUCTS_PK	RANGE SCAN	46		1	
Access Predicates						
P.PROD_ID<100						
SORT		JOIN	4795...		1401	
Access Predicates						
P.PROD_ID=S.PROD_ID						
Filter Predicates						
P.PROD_ID=S.PROD_ID						
PARTITION RANGE						
BITMAP CONVERSION						
BITMAP INDEX	SALES_PROD_BIX					
Filter Predicates						
S.PROD_ID<100						
Other XML						

V\$STATNAME Name   V\$MYSTAT Value

bytes sent via SQL*Net to client	80916
calls to get snapshot scn: kcmgss	7
calls to kcmgcs	103
consistent gets	194
consistent gets from cache	194
consistent gets pin	194
consistent gets pin (fastpath)	194
CPU used by this session	235
CPU used when call started	235
cursor authentications	1
db block gets	48
db block gets from cache	48

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## **Practices for Lesson 10: Other Optimizer Operators**

## Practices for Lesson 10: Overview

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### Practices Overview

In these practices, you use the Results Cache to improve SQL performance with repeated queries and examine the SQL statements that use other access paths.

## Practice 10-1: Using the Result Cache

In this practice, you explore the various possibilities of caching query results in the system global area (SGA). Perform the following steps to understand the use of Query Result Cache. All the scripts for this practice can be found in the \$HOME/labs/solutions/Query\_Result\_Cache/ directory.

1. The result\_cache\_setup.sh script was executed in the setup of this practice as the SYS user to create and populate the QRC schema. This script is listed as follows:

```
#!/bin/bash

cd /home/oracle/labs/solutions/Query_Result_Cache

sqlplus sys/oracle_4U as sysdba <<FIN!

set echo on
alter session set container = orclpdb;

drop user qrc cascade;

create user qrc identified by qrc
default tablespace users
temporary tablespace temp;

grant connect, resource, dba to qrc;

connect qrc/qrc@orclpdb

exec dbms_result_cache.flush;

drop table cachejfv purge;

create table cachejfv(c varchar2(500)) tablespace users;

insert into cachejfv
values('aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa');
insert into cachejfv select * from cachejfv;
```

```
insert into cachejfv select * from cachejfv;
insert into cachejfv values('b');

commit;

alter system flush buffer_cache;

FIN!

$
```

2. Create a connection for the qrc user.
  - a. Click the New Connection button.
  - b. Create a connection with the following specifications:

Name: qrc

Username: qrc

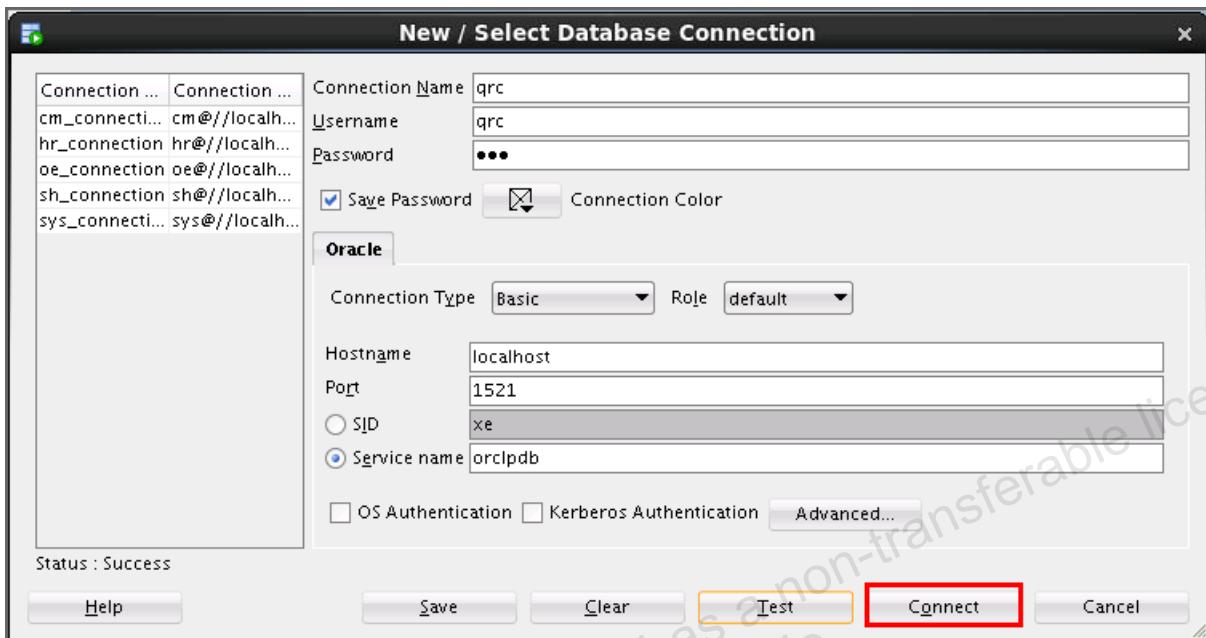
Password: qrc

Select “Save Password.”

Service Name: orclpdb

Click Test.

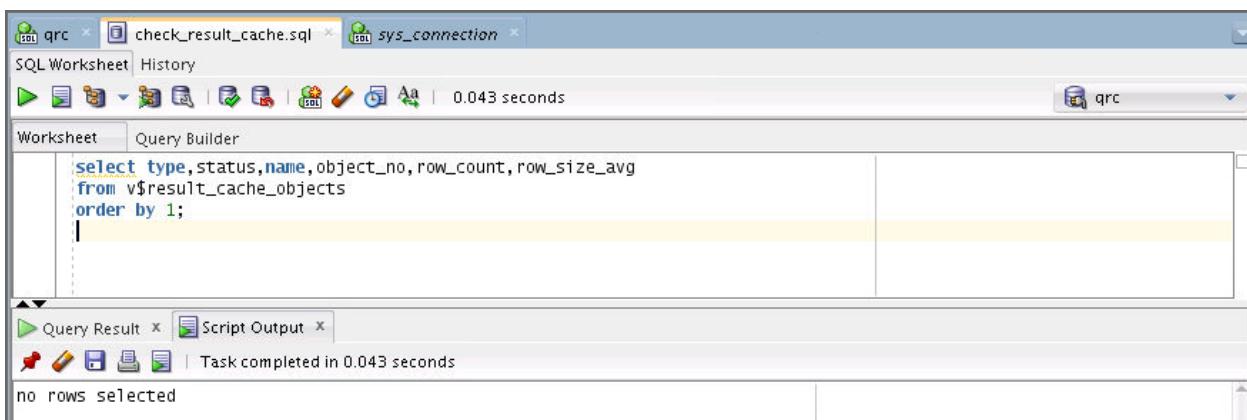
Click Connect.



- As the `qrc` user, determine the current content of the query cache by using the following statement or open and execute the statement in the `check_result_cache.sql` file in the `$HOME/labs/solutions/Query_Result_Cache/` directory. From now on, execute all scripts as the `qrc` user.

```
select type,status,name,object_no,row_count,row_size_avg
from v$result_cache_objects order by 1;
```

What do you observe?



- No row is selected because the query cache is empty.

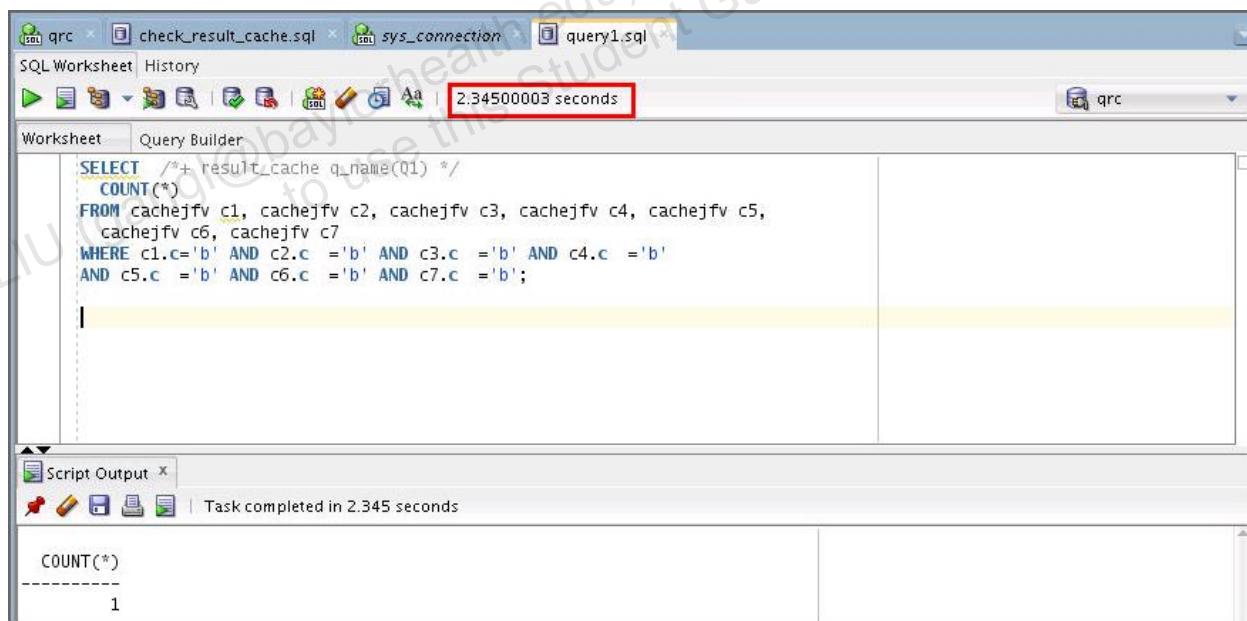
**Note:** If the result shows some rows, then execute the following query by using the sys user and then execute the check\_result\_cache.sql script again by using the qrc user.

```
begin
dbms_result_cache.flush;
end;
```

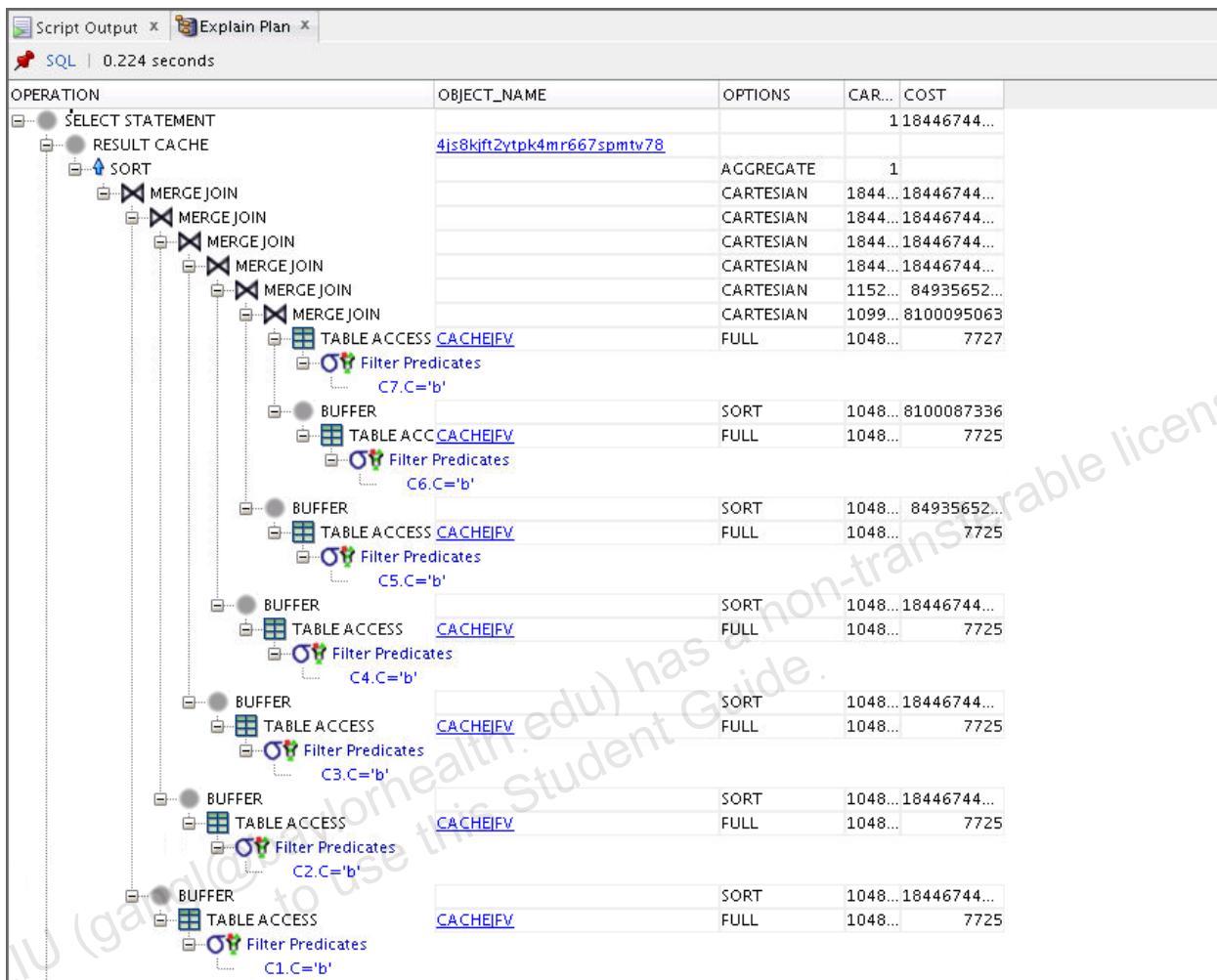
Disconnect from the SYS connection.

- Open and execute the query1.sql script. Note the time it takes for this statement to execute.

```
SELECT /*+ result_cache q_name(Q1) */
COUNT(*)
FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4,
cachejfv c5, cachejfv c6, cachejfv c7
WHERE c1.c='b' AND c2.c = 'b' AND c3.c = 'b' AND c4.c = 'b'
AND c5.c = 'b' AND c6.c = 'b' AND c7.c = 'b';
```



5. Determine the execution plan of the query in `query1.sql`. What do you observe?



- Because of the `result_cache` hint, the result of the query is computed using the result cache.

6. As the `qrc` user, determine the current content of the query cache by using the following statement or the `check_result_cache.sql` script. What do you observe?

```
select type,status,name,object_no,row_count,row_size_avg
from v$result_cache_objects order by 1;
```

The screenshot shows the Oracle SQL Developer interface. In the top navigation bar, there are tabs for 'qrc', 'check\_result\_cache.sql', 'sys\_connection', and 'query1.sql'. The 'Worksheet' tab is selected. A SQL query is entered in the worksheet:

```
select type,status,name,object_no,row_count,row_size_avg
from v$result_cache_objects
order by 1;
```

The results are displayed in the 'Query Result' tab:

TYPE	STATUS	NAME
Dependency	Published	QRC.CACHEJFV
Result	Published	SELECT /*+ result_cache q_name(Q1) */ COUNT(*) FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5, cachej

A note at the bottom of the results pane says 'Task completed in 0.027 seconds'.

- You can now see that the result of your query is cached.

## 7. Flush the buffer cache of your instance.

```
alter system flush buffer_cache;
```

The screenshot shows the Oracle SQL Developer interface. The 'Worksheet' tab is selected, displaying the command:

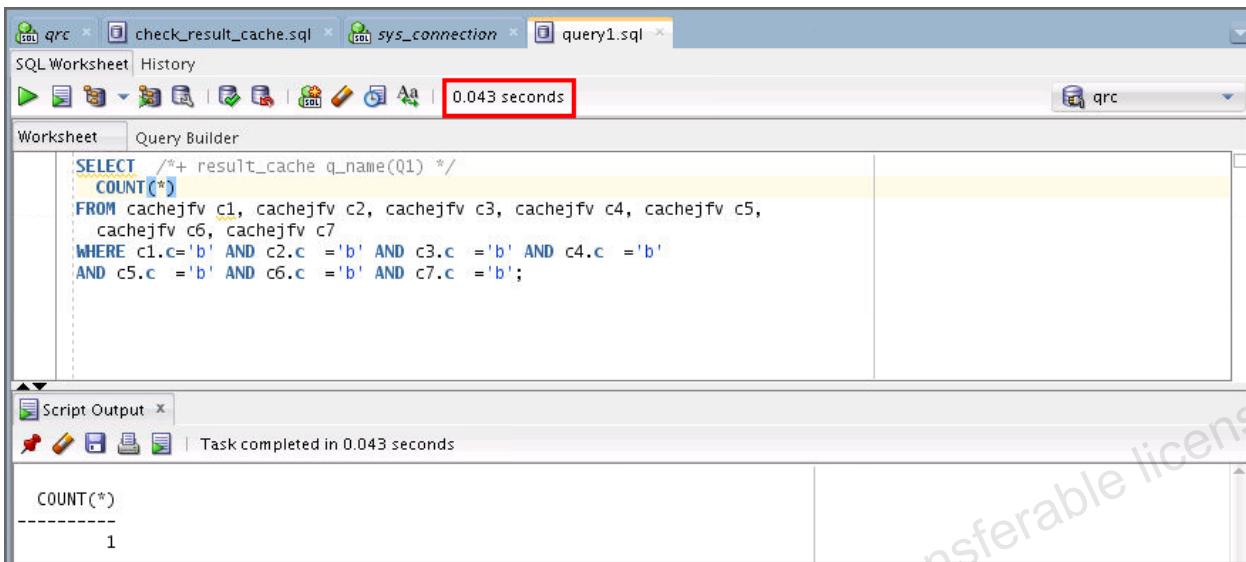
```
alter system flush buffer_cache;
```

The results are shown in the 'Script Output' tab:

```
System FLUSH altered.
```

A note at the bottom of the output pane says 'Task completed in 1.455 seconds'.

8. Rerun query1.sql. What do you observe?



The screenshot shows the Oracle SQL Developer interface. The top menu bar has tabs for 'qrc', 'check\_result\_cache.sql', 'sys\_connection', and 'query1.sql'. The 'query1.sql' tab is active. Below the tabs is a toolbar with various icons. The main area is labeled 'Worksheet' and contains the following SQL code:

```
SELECT /*+ result_cache q_name(Q1) */
  COUNT(*)
FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5,
  cachejfv c6, cachejfv c7
WHERE c1.c='b' AND c2.c = 'b' AND c3.c = 'b' AND c4.c = 'b'
AND c5.c = 'b' AND c6.c = 'b' AND c7.c = 'b';
```

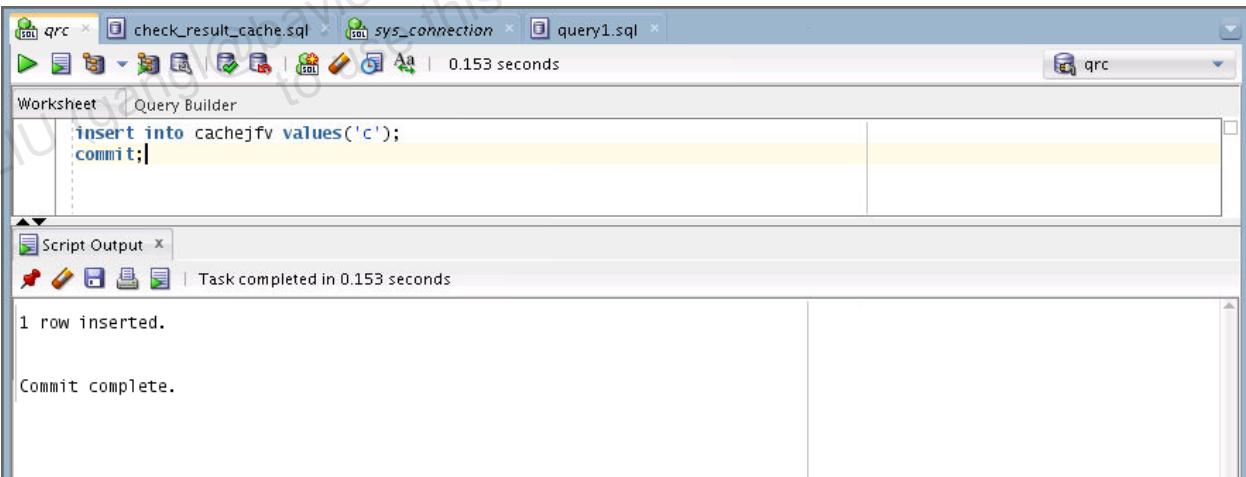
To the right of the worksheet, a status bar displays '0.043 seconds'. Below the worksheet is a 'Script Output' window showing the results of the query:

```
COUNT(*)
-----
1
```

- The execution time for the query is now almost instantaneous.

9. Insert a new row into the CACHEJFV table by using the following statement:

```
insert into cachejfv values('c');
commit;
```



The screenshot shows the Oracle SQL Developer interface. The top menu bar has tabs for 'qrc', 'check\_result\_cache.sql', 'sys\_connection', and 'query1.sql'. The 'query1.sql' tab is active. Below the tabs is a toolbar with various icons. The main area is labeled 'Worksheet' and contains the following SQL code:

```
insert into cachejfv values('c');
commit;
```

To the right of the worksheet, a status bar displays '0.153 seconds'. Below the worksheet is a 'Script Output' window showing the results of the insert operation:

```
1 row inserted.

Commit complete.
```

10. As the `qrc` user, determine the current content of the query cache by using the following statement or the `check_result_cache.sql` script. What do you observe?

```
select type,status,name,object_no,row_count,row_size_avg
from v$result_cache_objects order by 1;
```

The screenshot shows the Oracle SQL Worksheet interface. The top tab bar has three tabs: 'qrc', 'check\_result\_cache.sql', and 'query1.sql'. The 'query1.sql' tab is active. The 'Worksheet' tab is selected. In the main workspace, the following SQL code is displayed:

```
select type,status,name,object_no,row_count,row_size_avg
from v$result_cache_objects
order by 1;
```

Below the code, the results are shown in a table:

TYPE	STATUS	NAME
Dependency	Published	QRC.CACHEJFV
Result	Invalid	SELECT /*+ result_cache q_name(Q1) */ COUNT(*) FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5, cachej

- The corresponding result cache entry is automatically invalidated.

11. Rerun `query1.sql`.

The screenshot shows the Oracle SQL Worksheet interface again. The top tab bar has three tabs: 'qrc', 'check\_result\_cache.sql', and 'query1.sql'. The 'query1.sql' tab is active. The 'Worksheet' tab is selected. In the main workspace, the following SQL code is displayed:

```
SELECT /*+ result_cache q_name(Q1) */
COUNT(*)
FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5,
cachejfv c6, cachejfv c7
WHERE c1.c='b' AND c2.c = 'b' AND c3.c = 'b' AND c4.c = 'b'
AND c5.c = 'b' AND c6.c = 'b' AND c7.c = 'b';
```

Below the code, the results are shown in a table:

COUNT(*)
1

12. As the `qrc` user, determine the current content of the query cache by using the following statement or execute the `check_result_cache.sql` script. What do you observe?

```
select type,status,name,object_no,row_count,row_size_avg  
from v$result_cache_objects order by 1;
```

The screenshot shows the Oracle SQL Developer interface. In the top navigation bar, there are tabs for 'qrc' (selected), 'check\_result\_cache.sql' (selected), and 'query1.sql'. Below the tabs, there's a toolbar with icons for running queries, saving, and zooming. The main workspace is titled 'Worksheet' and contains a 'Query Builder' section with the following SQL code:

```
select type,status,name,object_no,row_count,row_size_avg  
from v$result_cache_objects  
order by 1;
```

Below the query builder, the 'Script Output' tab is selected, showing the results of the query. The results are displayed in a table format:

TYPE	STATUS	NAME
Dependency	Published	QRC.CACHEJFV
Result	Invalid	SELECT /*+ result_cache q_name(Q1) */ COUNT(*) FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5, cachej
Result	Published	SELECT /*+ result_cache q_name(Q1) */ COUNT(*) FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5, cachej

The 'Script Output' tab also displays a message: 'Task completed in 0.034 seconds'.

- Again, it takes some time to execute the query. The result cache shows that a new entry has been added for the new result.

13. Generate a detailed result cache memory report by entering the following commands:

```
set serveroutput on
EXEC DBMS_RESULT_CACHE.MEMORY_REPORT(detailed=>true);
```

The screenshot shows the Oracle SQL Developer interface. In the top-left corner, there are tabs for 'check\_result\_cache.sql' and 'query1.sql'. The main workspace is titled 'Worksheet' and contains the command: 'set serveroutput on EXEC DBMS\_RESULT\_CACHE.MEMORY\_REPORT(detailed=>true);'. Below the workspace is a 'Script Output' window with the title 'Task completed in 0.103 seconds'. The output displays the 'Result Cache Memory Report' with the following details:

```
Result Cache Memory Report
[Parameters]
Block Size = 1K bytes
Maximum Cache Size = 4768K bytes (4768 blocks)
Maximum Result Size = 238K bytes (238 blocks)
[Memory]
Total Memory = 12152 bytes [0.001% of the Shared Pool]
... Fixed Memory = 12152 bytes [0.001% of the Shared Pool]
..... State Obs = 12152 bytes
... Dynamic Memory = 0 bytes [0.000% of the Shared Pool]

PL/SQL procedure successfully completed.
```

14. Rerun the query1.sql script. What do you observe?

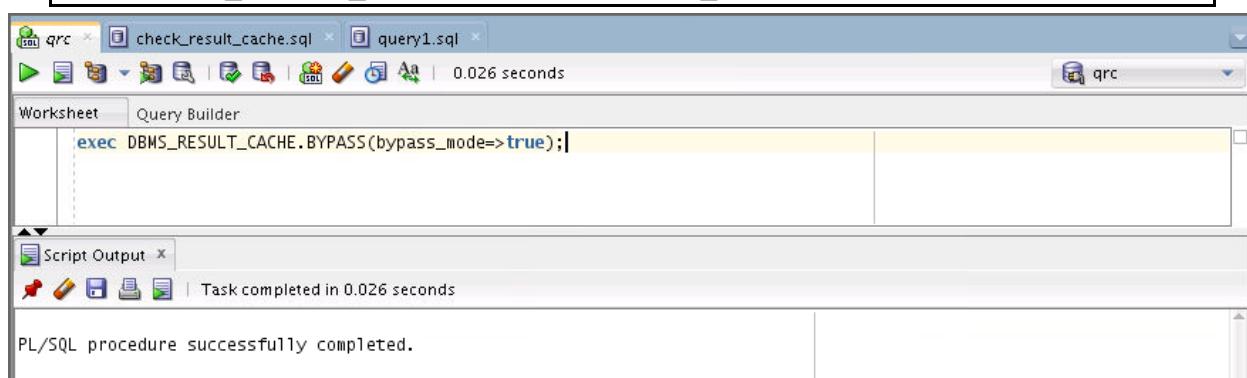
The screenshot shows the Oracle SQL Developer interface. In the top-left corner, there are tabs for 'check\_result\_cache.sql' and 'query1.sql'. The main workspace is titled 'Worksheet' and contains the query: 'SELECT /\*+ result\_cache q\_name(Q1) \*/ COUNT(\*) FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5, cachejfv c6, cachejfv c7 WHERE c1.c='b' AND c2.c ='b' AND c3.c ='b' AND c4.c ='b' AND c5.c ='b' AND c6.c ='b' AND c7.c ='b';'. Below the workspace is a 'Script Output' window with the title 'Task completed in 0.03 seconds'. The output shows the result of the query:

```
COUNT(*)
-----
1
```

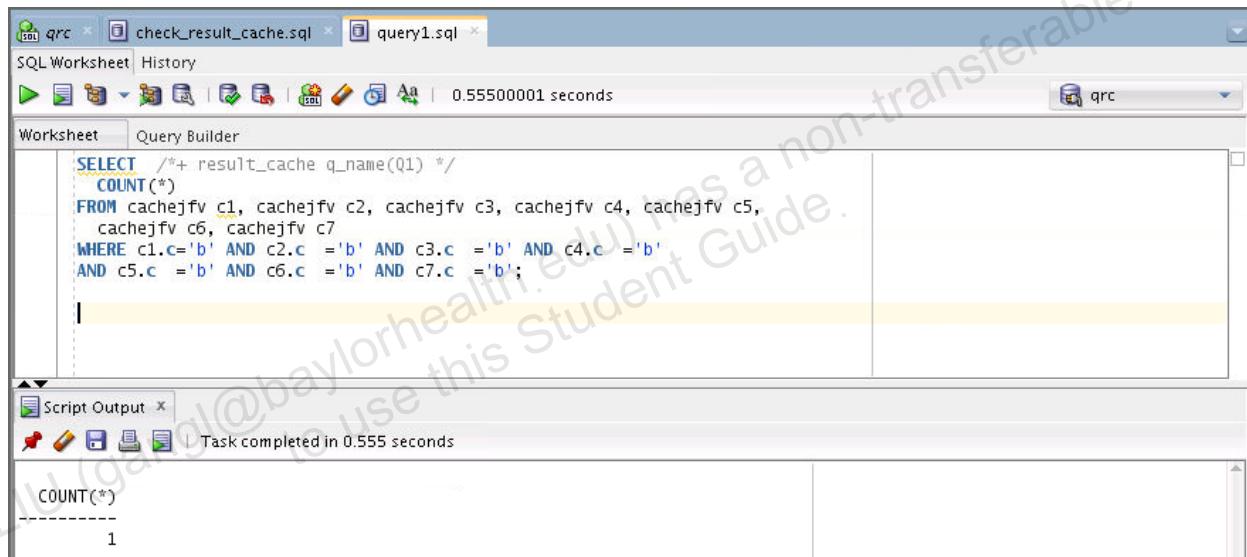
- The query again uses the result that was previously cached.

15. Ensure that you bypass the result cache before performing the next step.

```
exec DBMS_RESULT_CACHE.BYPASS(bypass_mode=>true);
```



16. Rerun query1.sql. What do you observe?



- The query again takes longer to execute because it no longer uses the result cache.

17. Ensure that you no longer bypass the result cache and check whether your query uses it again.
- Execute the following statement:

```
exec DBMS_RESULT_CACHE.BYPASS(bypass_mode=>false);
```

The screenshot shows the Oracle SQL Developer interface. In the top navigation bar, there are tabs for 'PL/SQL' (selected), 'check\_result\_cache.sql', and 'query1.sql'. Below the tabs, the status bar shows '0.02 seconds'. The main area is a 'Worksheet' tab with the following content:

```
exec DBMS_RESULT_CACHE.BYPASS(bypass_mode=>false);
```

Below the worksheet, the 'Script Output' tab displays the results:

Task completed in 0.02 seconds.

PL/SQL procedure successfully completed.

b. Rerun query1.sql.

```

SELECT /*+ result_cache q_name(Q1) */
  COUNT(*)
FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5,
  cachejfv c6, cachejfv c7
WHERE c1.c='b' AND c2.c  ='b' AND c3.c  ='b' AND c4.c  ='b'
  AND c5.c  ='b' AND c6.c  ='b' AND c7.c  ='b';
  
```

Script Output

Task completed in 0.013 seconds

COUNT(*)
1

18. Open and execute the query2.sql script or enter the following query:

```

SELECT COUNT(*)
FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4,
  cachejfv c5, cachejfv c6, cachejfv c7
WHERE c1.c='b' AND c2.c  ='b' AND c3.c  ='b' AND c4.c  ='b'
  AND c5.c  ='b' AND c6.c  ='b' AND c7.c  ='b';
  
```

What do you observe?

```

SELECT COUNT(*)
FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4,
  cachejfv c5, cachejfv c6, cachejfv c7
WHERE c1.c='b' AND c2.c  ='b' AND c3.c  ='b' AND c4.c  ='b'
  AND c5.c  ='b' AND c6.c  ='b' AND c7.c  ='b';
  
```

Script Output

Task completed in 0.58 seconds

COUNT(*)
1

- Although the query is the same as the one in query1.sql, it is not recognized as cached because it does not contain the hint. So its execution time is long again.

19. How would you force the previous query to use the cached result without using hints?
- Use the following code to force the use of the cached result or open and execute the `force_result_cache.sql` script.

```
set echo on

show parameter result_cache_mode

select type,status,name,object_no,row_count,row_size_avg from
v$result_cache_objects order by 1;

alter session set result_cache_mode=force;
```

The screenshot shows the Oracle SQL Worksheet interface. The top navigation bar has tabs for Start Page, qrc, check\_result\_cache.sql, query1.sql, query2.sql, and force\_result\_cache.sql (which is currently selected). The bottom status bar shows "0.097 seconds".

The main area is divided into two panes. The left pane is the "Worksheet" pane, which contains the SQL code:

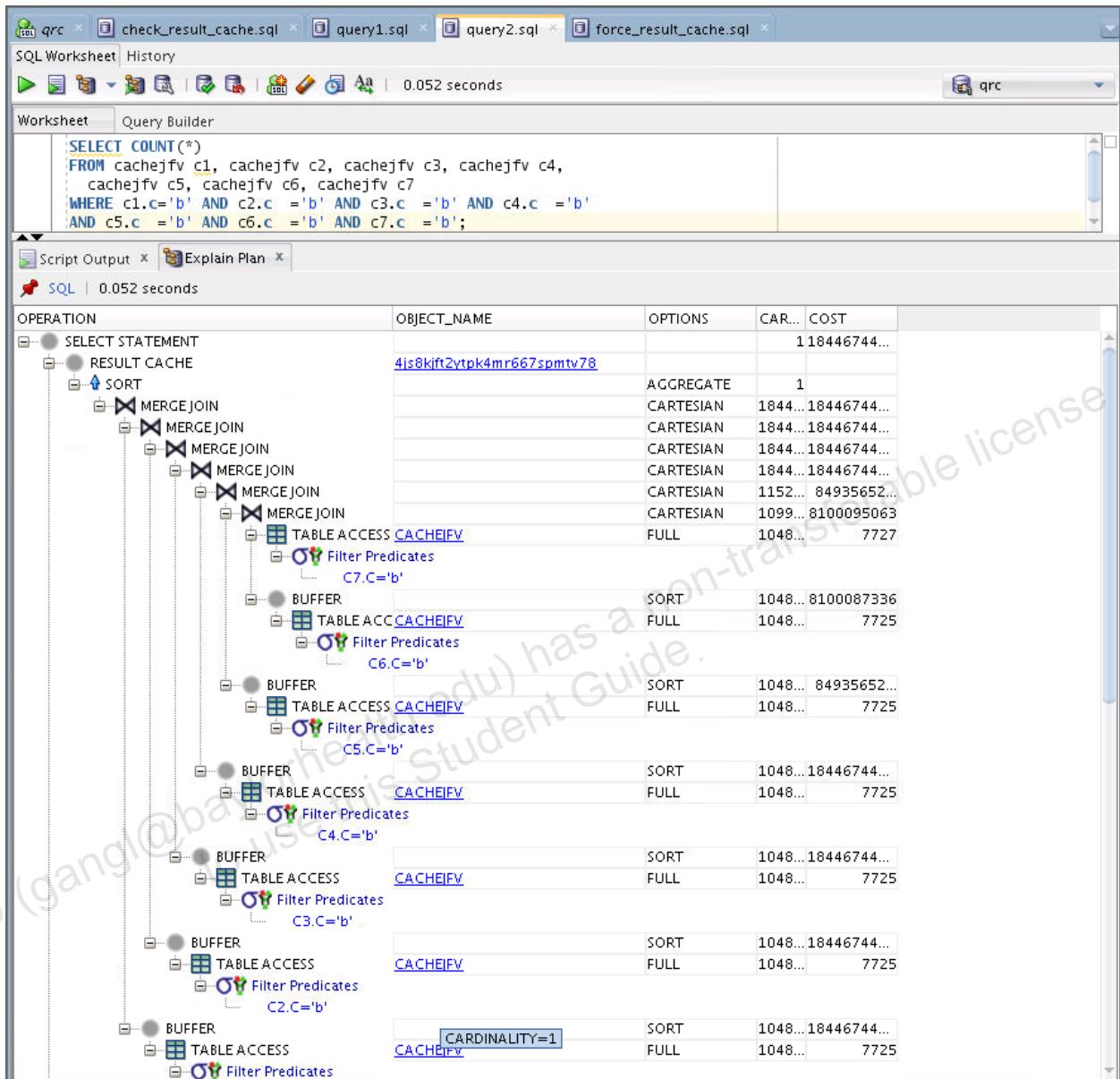
```
set echo on
show parameter result_cache_mode
select type,status,name,object_no,row_count,row_size_avg from v$result_cache_objects order by 1;
alter session set result_cache_mode=force;
```

The right pane is the "Script Output" pane, which displays the results of the executed commands:

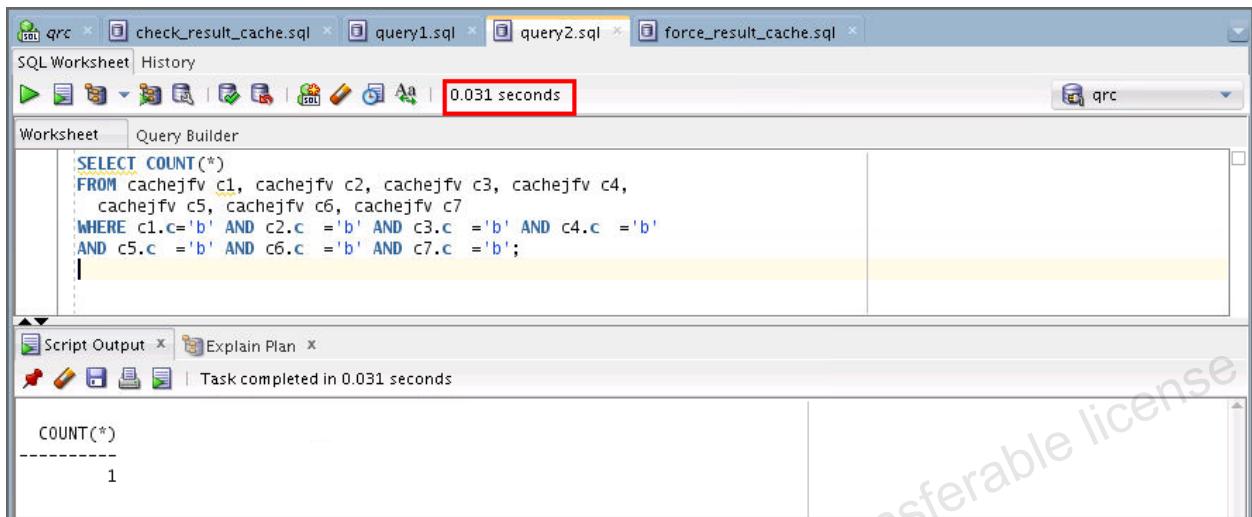
```
SQL> set echo on
SQL>
SQL> show parameter result_cache_mode
NAME          TYPE    VALUE
result_cache_mode string  MANUAL
SQL>
SQL> select type,status,name,object_no,row_count,row_size_avg from v$result_cache_objects order by 1;
TYPE      STATUS     NAME
-----  -----
Dependency Published SYS.WRI$_ADV_TASKS
Dependency Published QRC.CACHEJFV
Dependency Published SYS.WRI$_ADV_EXECUTIONS
Dependency Published SYS.DBA_ADVISOR_TASKS
Result     Published SELECT /*+ NO_STATEMENT_QUEUEING RESULT_CACHE (SYSOBJ=TRUE) */ ADVISOR_NAME,EXECUTION_END FROM "SY
Result     Published SELECT /*+ result_cache q_name(Q1) */
               COUNT(*)
               FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5,
               cachej
Result     Invalid   SELECT /*+ result_cache q_name(Q1) */
TYPE      STATUS     NAME
-----  -----
               COUNT(*)
               FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4, cachejfv c5,
               cachej
7 rows selected.

SQL>
SQL> alter session set result_cache_mode=force;
Session altered.
```

- b. View the explain plan for the query2.sql script.



- c. Rerun the query2.sql script to verify that the query runs instantaneously because you successfully used the cached result.



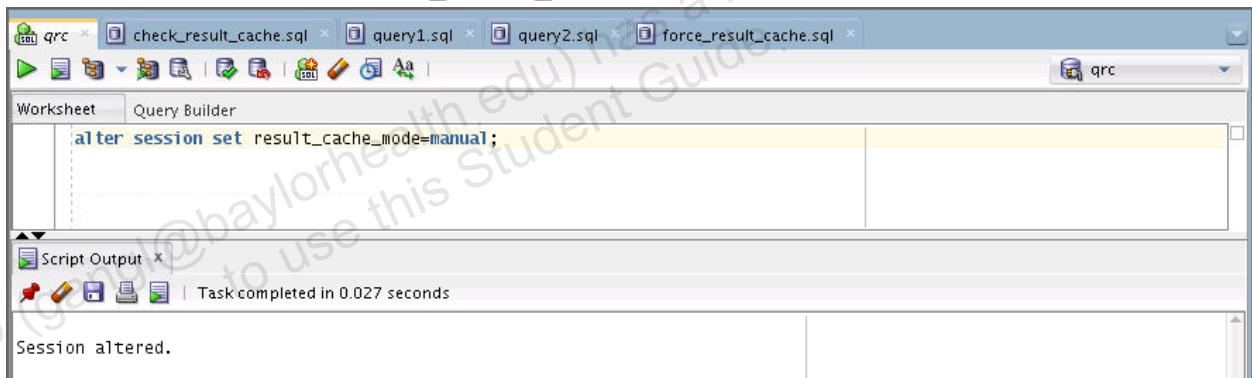
The screenshot shows the Oracle SQL Developer interface. The top menu bar has tabs for 'qrc', 'check\_result\_cache.sql', 'query1.sql', 'query2.sql', and 'force\_result\_cache.sql'. The 'Worksheet' tab is selected. In the main workspace, there is a SQL statement:

```
SELECT COUNT(*)
FROM cachejfv c1, cachejfv c2, cachejfv c3, cachejfv c4,
      cachejfv c5, cachejfv c6, cachejfv c7
WHERE c1.c='b' AND c2.c = 'b' AND c3.c = 'b' AND c4.c = 'b'
AND c5.c = 'b' AND c6.c = 'b' AND c7.c = 'b';
```

The status bar at the bottom of the window displays 'Task completed in 0.031 seconds'. Below the status bar, the 'Script Output' and 'Explain Plan' panes are visible, along with a message: 'COUNT(\*)' and '1'.

- d. Finally, undo your change.

```
alter session set result_cache_mode=manual;
```



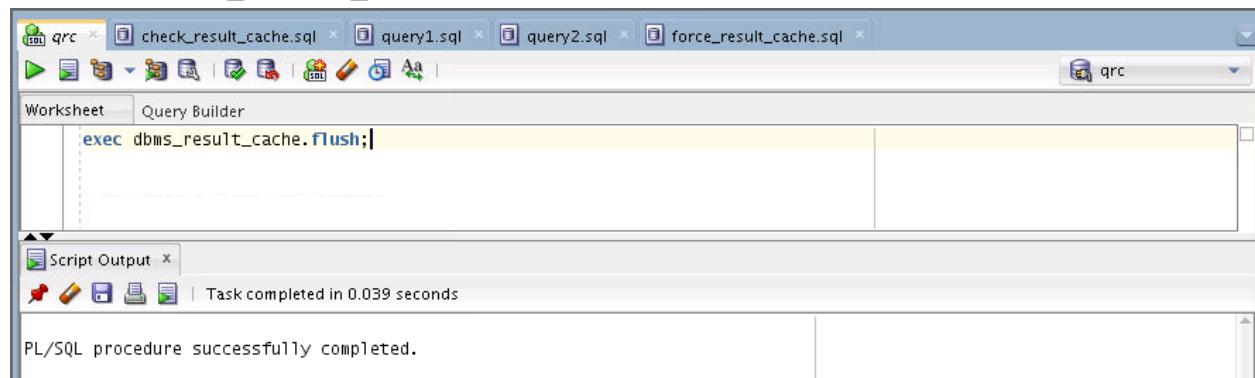
The screenshot shows the Oracle SQL Developer interface. The top menu bar has tabs for 'qrc', 'check\_result\_cache.sql', 'query1.sql', 'query2.sql', and 'force\_result\_cache.sql'. The 'Worksheet' tab is selected. In the main workspace, there is a SQL statement:

```
alter session set result_cache_mode=manual;
```

The status bar at the bottom of the window displays 'Task completed in 0.027 seconds'. Below the status bar, the 'Script Output' and 'Explain Plan' panes are visible, along with a message: 'Session altered.'

20. Clear the result cache. Query V\$RESULT\_CACHE\_OBJECTS to verify the clear operation.

```
exec dbms_result_cache.flush;
```



The screenshot shows the Oracle SQL Developer interface. The top menu bar has tabs for 'qrc', 'check\_result\_cache.sql', 'query1.sql', 'query2.sql', and 'force\_result\_cache.sql'. The 'Worksheet' tab is selected. In the main workspace, there is a PL/SQL block:

```
exec dbms_result_cache.flush;
```

The status bar at the bottom of the window displays 'Task completed in 0.039 seconds'. Below the status bar, the 'Script Output' and 'Explain Plan' panes are visible, along with a message: 'PL/SQL procedure successfully completed.'

21. Open and execute the `cre_func.sql` script. This script creates a PL/SQL function that uses the result cache.

```
create or replace function CACHEJFV_COUNT(v varchar2)
return number
result_cache relies_on (cachejfv)
is
cnt number;
begin
select count(*) into cnt
from cachejfv c1,cachejfv c2,cachejfv c3,cachejfv c4,cachejfv c5,cachejfv c6, cachejfv c7
where c1.c=v and c2.c=v and c3.c=v and c4.c=v and c5.c=v and c6.c=v and c7.c=v;
return cnt;
end;
/

```

Script Output | Task completed in 1.198 seconds

Function CACHEJFV\_COUNT compiled

22. Determine what is in the result cache by querying `V$RESULT_CACHE_OBJECTS`. (This is the `check_result_cache.sql` script.)

```
select type,status,name,object_no,row_count,row_size_avg
from v$result_cache_objects
order by 1;
```

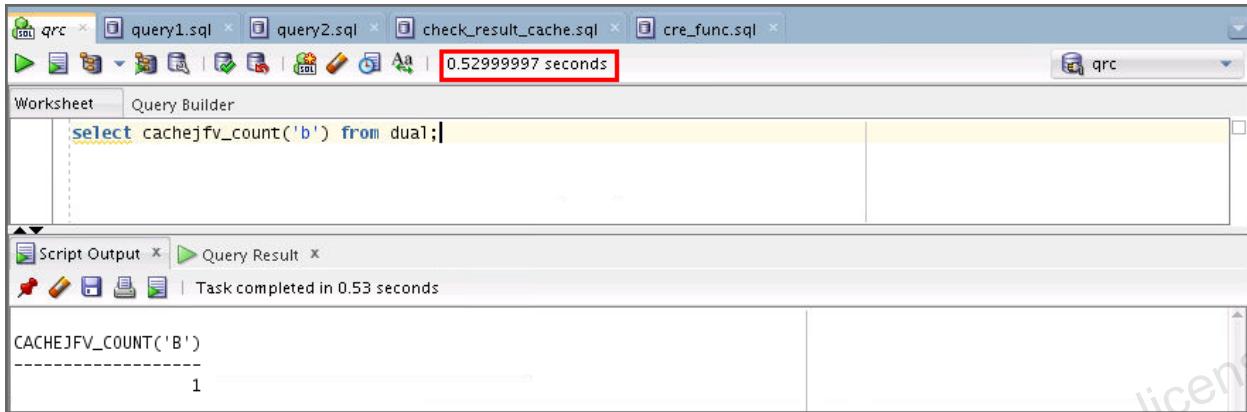
```
select type,status,name,object_no,row_count,row_size_avg
from v$result_cache_objects
order by 1;
```

Script Output | Query Result | All Rows Fetched: 0 in 0.002 seconds

TYPE	STATUS	NAME	OBJECT_NO	ROW_COUNT	ROW_SIZE_AVG

23. Call the new function with 'b' as its argument. What do you observe?

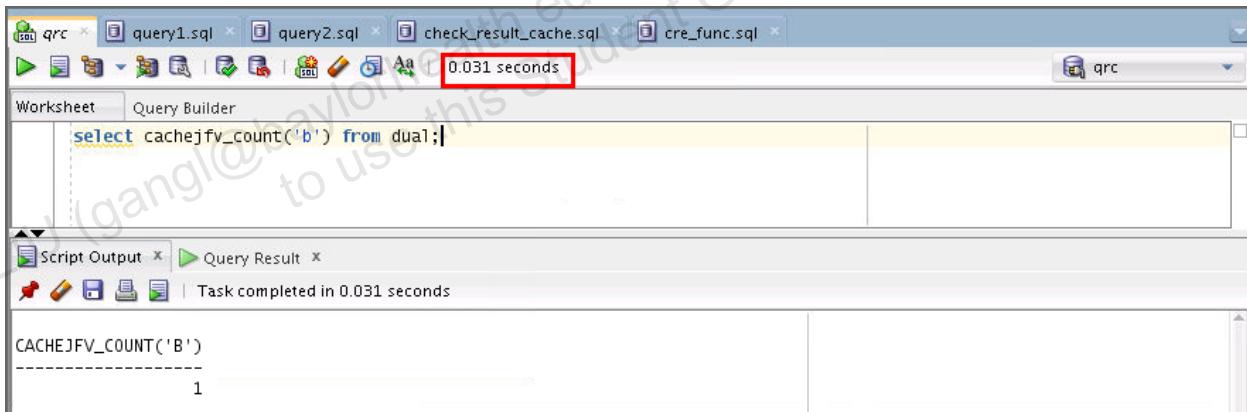
```
select cachejfv_count('b') from dual;
```



- It takes a long time to execute because the result is not cached yet. After executing the function, the function's result for the 'b' argument is cached.

24. Call the new function with 'b' as its argument again. What do you observe?

```
select cachejfv_count('b') from dual;
```



- This time the function executes almost instantaneously.

25. Call the new function again, but with 'c' as its argument. What do you observe?

The screenshot shows the Oracle SQL Developer interface. In the top navigation bar, there are tabs for 'qrc', 'query1.sql', 'query2.sql', 'check\_result\_cache.sql', and 'cre\_func.sql'. The 'check\_result\_cache.sql' tab is active. Below the tabs, there are icons for file operations like New, Open, Save, and Print, along with a magnifying glass icon for search. A status bar at the bottom right shows '0.52600002 seconds'. The main area has two tabs: 'Worksheet' and 'Query Builder', with 'Worksheet' selected. The worksheet contains the SQL query: 'select cachejfv\_count('c') from dual;'. Below the worksheet is a 'Script Output' tab and a 'Query Result' tab. The 'Query Result' tab shows the output of the query: 'CACHEJFV\_COUNT('C')' followed by a dashed line and the value '2187'. The status bar at the bottom of the result tab indicates 'Task completed in 0.526 seconds'.

- Again, it takes a long time to execute the function because of the new value for the argument. After execution, the second result is cached.

## Practice 10-2: Using Other Access Paths (Optional)

### Overview

In this practice, you explore the various access paths that the optimizer can use, and compare them. You have the possibility of exploring three scenarios, each of which is self-contained. All scripts needed for this practice can be found in your \$HOME/labs/solutions/Access\_Paths directory.

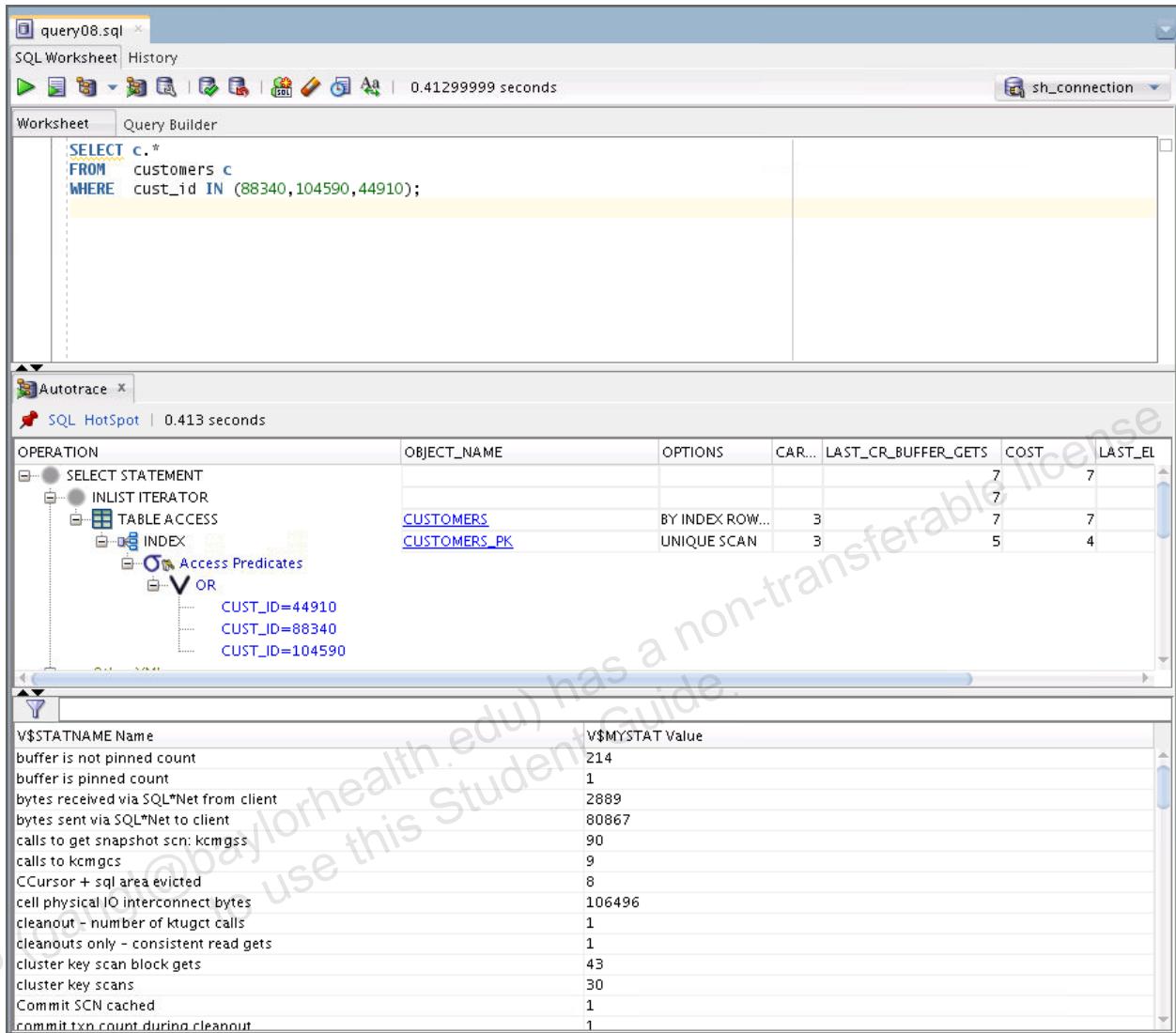
### Tasks

1. Open the connection named `sh_connection` that you created in Practice 2. If you have not created this connection, create it now with the following attributes:
  - a. Click the New Connection button.
  - b. Create a connection with the following specifications:

Name: `sh_connection`  
Username: `sh`  
Password: `sh`  
Select “Save Password.”  
Service Name: `orclpdb`  
Click Test.  
Click Connect.
2. **Case 1: Inlist Iterator:** Open the \$HOME/labs/solutions/Access\_Paths/query08.sql script. Use `sh_connection` to autotrace the query.

```
SELECT c.*  
FROM   customers c  
WHERE  cust_id IN (88340,104590,44910);
```

What do you observe?



- The optimizer can use the CUSTOMERS primary key index to resolve this query.  
The cost is very low for the resulting plan.

3. **Case 2: Using Hash Clusters:** The SHC schema was created and populated in the practice setup using \$HOME/labs/solutions/Access\_Paths/shc\_setup.sql to set up your environment for this practice. This script creates the bigemp\_fact table as a member of bigemp\_cluster. bigemp\_cluster is a single-table hash cluster. The rows of the table are sorted on the deptno and sal columns before the hash function is applied. The script is listed as follows:

```
-- run with sqlplus /nolog @shc_setup.sql
connect sys/oracle_4U as sysdba
alter session set container =orclpdb;

drop user shc cascade;
```

```
create user shc identified by shc;
Grant DBA to SHC;
GRANT select_catalog_role to SHC;
GRANT select any dictionary to SHC;

connect shc/shc@orclpdb

set echo on

set linesize 200

drop cluster bigemp_cluster including tables;

CREATE CLUSTER bigemp_cluster
(deptno number, sal number sort)
HASHKEYS 10000
single table HASH IS deptno SIZE 50
tablespace users;

create table bigemp_fact (
empno number primary key, sal number sort, job varchar2(12) not
null,
deptno number not null, hiredate date not null)
CLUSTER bigemp_cluster (deptno, sal);

begin
for i in 1..1400000 loop
  insert into bigemp_fact values(i,i,'J1',10,sysdate);
end loop;
commit;
end;
/

begin
for i in 1..1400000 loop
  insert into bigemp_fact values(1400000+i,i,'J1',20,sysdate);
end loop;
commit;
end;
/
```

```
exec dbms_stats.gather_schema_stats('SHC');

exit
```

4. Create a connection for the `shc` user. Use this connection for all the scripts in the Hash Cluster case.
  - a. Click the New Connection button.
  - b. Create a connection with the following specifications:

Name: `shc`  
Username: `shc`  
Password: `shc`  
Select “Save Password.”  
Service Name: `orclpdb`  
Click Test.  
Click Connect.
5. Use the `shc` connection to execute the `query15a.sql` script. This script sets `workarea_size_policy` to `MANUAL`, and `sort_area_size` to a small value. Because you may have a lot of memory on your system, the script reduces the amount of memory available to your session. It then flushes the cache and shared pool to eliminate the possibility of the cost being reduced by previous queries loading the cache.

The screenshot shows the Oracle SQL Worksheet interface. The title bar indicates the connection is set to `shc` and the script being run is `query15a.sql`. The main area is titled "Worksheet" and contains the following SQL code:

```
set echo off
alter session set workarea_size_policy=manual;
alter session set sort_area_size=5000;

alter system flush shared_pool;
alter system flush buffer_cache;
```

The "Script Output" pane at the bottom shows the results of the execution:

```
Session altered.

Session altered.

System FLUSH altered.

System FLUSH altered.
```

6. Use the shc connection to autotrace the query in the query15b.sql script. What do you observe?

The screenshot shows the Oracle SQL Developer interface with three tabs at the top: 'shc' (selected), 'query15a.sql', and 'query15b.sql'. The 'query15b.sql' tab contains the query:

```
select * from bigemp_fact where deptno=10;
```

The 'Autotrace x' window displays the execution plan and statistics. The execution plan tree shows a 'SELECT STATEMENT' node with a 'TABLE ACCESS' child node, which has an 'Access Predicates' child node containing the predicate 'DEPTNO=10'. This node is highlighted with a red rectangle.

OPERATION	OBJECT_NAME	OPTIONS	CAR...	LAST_CR_BUFFER_GETS	COST	LAST_EL
SELECT STATEMENT					4	1
TABLE ACCESS	BIGEMP_FACT	HASH	1400...		4	1
Access Predicates						
DEPTNO=10						
Other XML						

The 'V\$STATNAME' window shows various system statistics:

V\$STATNAME Name	V\$MYSTAT Value
buffer is not pinned count	561
buffer is pinned count	10
bytes received via SQL*Net from client	2841
bytes sent via SQL*Net to client	79583
calls to get snapshot scn: kcmgss	234
calls to kcmgcs	39
cell physical IO interconnect bytes	1523712
cluster key scan block gets	37
cluster key scans	22
consistent gets	848
consistent gets examination	379
consistent gets examination (fastpath)	375

- The optimizer decides to use the cluster access path to retrieve data. The cost is minimal.

7. Execute the query15a.sql script again.

```

set echo off
alter session set workarea_size_policy=manual;
alter session set sort_area_size=50000;

alter system flush shared_pool;
alter system flush buffer_cache;

```

Session altered.  
Session altered.  
System FLUSH altered.  
System FLUSH altered.

8. Open and autotrace the query in the query16.sql script as the SHC user. What do you observe?

```

select * from bigemp_fact where deptno=10 order by sal;

```

Autotrace report:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	LAST_CR_BUFFER_GETS	COST	LAST_EL
SELECT STATEMENT				4	1	
TABLE ACCESS	BIGEMP_FACT	HASH	1400...	4	1	
Access Predicates						
DEPTNO=10						
Other XML						

V\$STATNAME table:

V\$STATNAME Name	V\$MYSTAT Value
buffer is not pinned count	543
buffer is pinned count	10
bytes received via SQL*Net from client	2857
bytes sent via SQL*Net to client	79714
calls to get snapshot scn: kcmgss	234
calls to kcmgcs	39
cell physical IO interconnect bytes	1523712
cluster key scan block gets	37

- The script executes a slightly different query, one that requires ordering the result based on the sorted `sal` column. The optimizer can still use the cluster access path without sorting the data. The cost is still minimal.

9. Execute the query15a.sql script again.

```
set echo off
alter session set workarea_size_policy=manual;
alter session set sort_area_size=50000;

alter system flush shared_pool;
alter system flush buffer_cache;
```

Script Output | Task completed in 0.588 seconds

Session altered.  
Session altered.  
System FLUSH altered.  
System FLUSH altered.

10. Autotrace the query in the query17.sql script. What do you observe?

```
select * from bigemp_fact where deptno=10 order by sal desc;
```

Autotrace | 0.359 seconds

OPERATION	OBJECT_NAME	OPTIONS	CAR...	LAST_CR_BUFFER_GETS	COST	LAST_EL
SELECT STATEMENT					2	1
> TABLE ACCESS	BIGEMP_FACT	HASH	1400...		2	1
> Access Predicates						
DEPTNO=10						
- Other XML						

- The query17.sql script executes the query; the difference is that the result is ordered based on the sorted `sal` column in descending order. The optimizer can still use the cluster access path without sorting the data. The cost is still minimal.

11. Execute the query15a.sql script again.

```

set echo off
alter session set workarea_size_policy=manual;
alter session set sort_area_size=50000;

alter system flush shared_pool;
alter system flush buffer_cache;

```

Script Output:

- | Task completed in 0.918 seconds
- Session altered.
- Session altered.
- System FLUSH altered.
- System FLUSH altered.

12. Open and autotrace the query in the query18.sql script as the SHC user. What do you observe?

```

select * from bigemp_fact where deptno=10 order by empno;

```

Autotrace:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	LAST_CR_BUFFER_GETS	COST	LAST_EL
SELECT STATEMENT				5982	48942	
SORT		ORDER BY	1400...	5982	48942	
TABLE ACCESS	BIGEMP_FACT	HASH	1400...	5982	1	
Access Predicates DEPTNO=10						

V\$STATNAME Name V\$MYSTAT Value

buffer is not pinned count	543
buffer is pinned count	10
bytes received via SQL*Net from client	2858
bytes sent via SQL*Net to client	80111
calls to get snapshot scn: kcmgss	234
calls to kcmgcs	39
cell physical IO interconnect bytes	101523456
cluster key scan block gets	37
cluster key scans	22
consistent gets	6802
consistent gets examination	367
consistent gets examination (fastpath)	365

- The script executes the same query, but this time asks to order the result based on the nonsorted `empno` column. The optimizer can still make use of the cluster access path, but must sort the data making the cost of the query higher.

13. Execute the `query15a.sql` script again.

The screenshot shows the Oracle SQL Developer interface. The top menu bar has tabs for 'SQL Worksheet' and 'History'. Below the menu is a toolbar with various icons. The main workspace is titled 'query15a.sql' and contains the following SQL code:

```
set echo off
alter session set workarea_size_policy=manual;
alter session set sort_area_size=50000;

alter system flush shared_pool;
alter system flush buffer_cache;
```

Below the workspace is a 'Script Output' window with the following log entries:

```
Session altered.

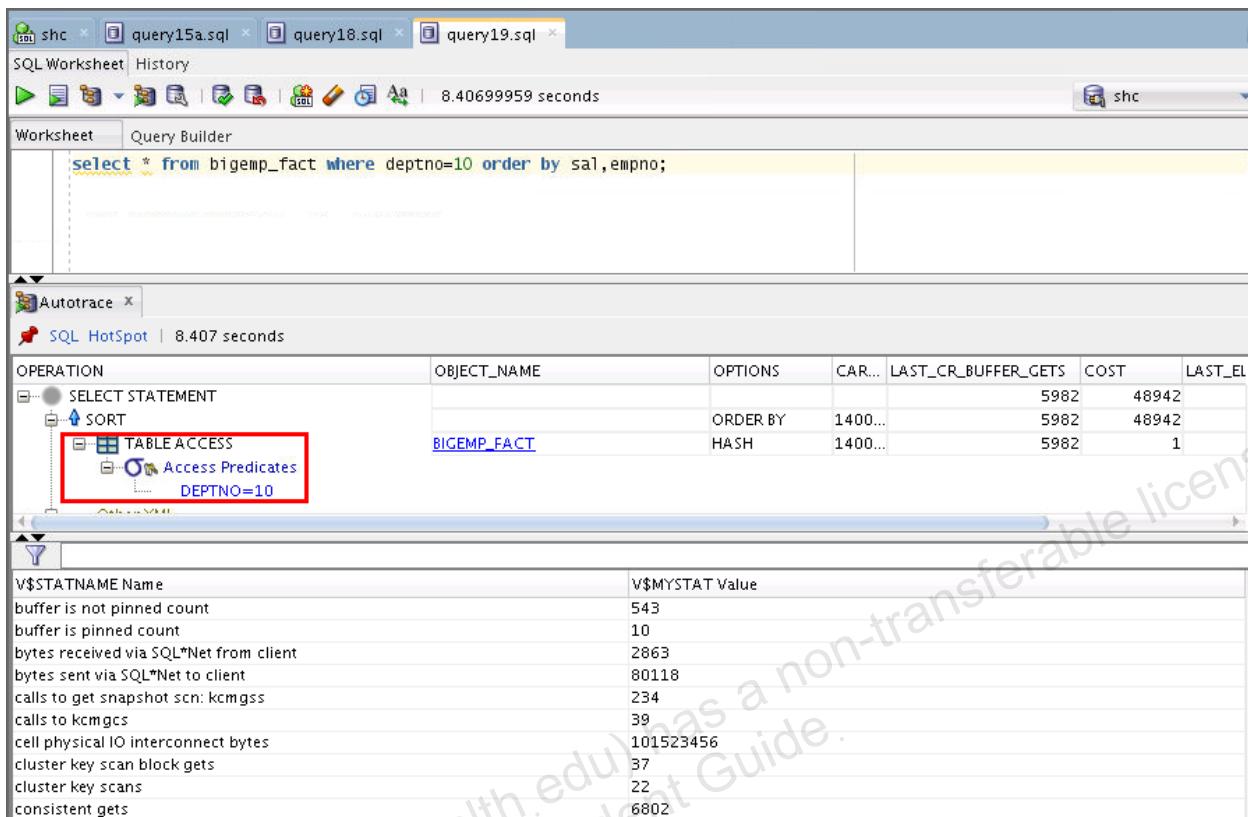
Session altered.

System FLUSH altered.

System FLUSH altered.
```

A watermark across the image reads: 'GANG LIU (gangli@baylorhealth.edu) has a non-transferable license to use this Student Guide.'

14. Autotrace the query in the query19.sql script. What do you observe?



- The script executes the same query, but this time asks to order the result based on the sal, empno key. The optimizer can make use of the cluster access path, but must sort the data making the cost of the query higher.

15. **Case 3: Using Index Cluster:** The nic\_setup.sql script was executed as part of the setup for this practice. This script creates and populates the nic schema to set up your environment for this case. It creates large emp and dept tables. Each of these tables has an index on the deptno value. The nic\_setup.sql script is listed as follows:

```
-- run with sqlplus /nolog
connect sys/oracle_4U as sysdba
alter session set container = orclpdb;

DROP user NIC cascade;

create user nic identified by nic;
GRANT DBA to NIC;
GRANT SELECT_CATALOG_ROLE to NIC;
GRANT select any dictionary to NIC;

connect nic/nic@orclpdb

set echo on
```

```
drop cluster emp_dept including tables;

drop table emp purge;
drop table dept purge;

CREATE TABLE emp (
    empno      NUMBER(7)          ,
    ename      VARCHAR2(15) NOT NULL,
    job        VARCHAR2(9)         ,
    mgr        NUMBER(7)          ,
    hiredate   DATE              ,
    sal        NUMBER(7)          ,
    comm       NUMBER(7)          ,
    deptno    NUMBER(3)          )
;

CREATE TABLE dept (
    deptno    NUMBER(3)          ,
    dname     VARCHAR2(14)        ,
    loc       VARCHAR2(14)        ,
    c         VARCHAR2(500)       )
;

CREATE INDEX emp_index
    ON emp(deptno)
    TABLESPACE users
    STORAGE (INITIAL 50K
             NEXT 50K
             MINEXTENTS 2
             MAXEXTENTS 10
             PCTINCREASE 33);

CREATE INDEX dept_index
    ON dept(deptno)
    TABLESPACE users
    STORAGE (INITIAL 50K
             NEXT 50K
             MINEXTENTS 2
             MAXEXTENTS 10
             PCTINCREASE 33);

begin
    for i in 1..999 loop
```

```
insert into dept values
(i,'D'||i,'L'||i,dbms_random.string('u',500));
end loop;
commit;
end;
/

begin
for i in 1..500000 loop
insert into emp values
(i,dbms_random.string('u',15),dbms_random.string('u',9),i,sysdate,i,i,
mod(i,999));
end loop;
commit;
end;
/

exec dbms_stats.gather_schema_stats('NIC');

exit;
```

16. Create a connection for the `nic` user.
  - a. Click the New Connection button.
  - b. Create a connection with the following specifications:  
**Name:** nic  
**Username:** nic  
**Password:** nic  
Select “Save Password.”  
**Service Name:** orclpdb  
Click Test.  
Click Connect.

17. Use the `nic` connection to execute the `nic_query_a.sql` script.

**Note:** `sort_area_size` remains small and `hash_area_size` is also set to a small value.

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are tabs for `shc`, `nic`, and `nic_query_a.sql`. The `nic_query_a.sql` tab is active. The main area is a `Worksheet` containing the following SQL code:

```
alter session set workarea_size_policy=manual;
alter session set sort_area_size=50000;
alter session set hash_area_size=5000;
```

Below the worksheet, the `Script Output` pane shows the results of the execution:

```
Session altered.
Session altered.
Session altered.
```

18. Open and autotrace the query in the `nic_query_b.sql` script as the `NIC` user. What do you observe?

The screenshot shows the Oracle SQL Developer interface with the `nic_query_b.sql` script running. The top tab bar shows `shc`, `nic`, `nic_query_a.sql`, and `nic_query_b.sql`. The `nic_query_b.sql` tab is active. The `Autotrace` feature is enabled, and the `SQL HotSpot` section shows a execution time of 1.802 seconds.

The `Autotrace` report details the execution plan:

- SELECT STATEMENT**
- HASH JOIN**
  - Access Predicates**: `EMP.DEPTNO=DEPT.DEPTNO`
  - NESTED LOOPS**
    - NESTED LOOPS**
      - STATISTICS COLLECTOR**
        - TABLE ACCESS**
          - INDEX**
            - Access Predicates**: `DEPT.DEPTNO>800`
      - TABLE ACCESS**
        - INDEX**
          - Access Predicates**: `EMP.DEPTNO=DEPT.DEPTNO`
          - Filter Predicates**: `EMP.DEPTNO>800`

The script executes a join between the `EMP` and `DEPT` tables. The optimizer is able to make use of the index to resolve the join.

19. How would you enhance the performance of the previous query? Implement your solution.

The `ic` user was created in the setup of the practices with the `ic_setup.sql` script to create an index cluster to store the two tables. These tables have exactly the same rows in both the `nic` and `ic` schemas. This script creates an index cluster containing the `emp` and `dept` tables. The rows of these tables are stored together clustered by the `deptno` value. This script is listed as follows:

```
-- run with sqlplus /nolog

connect sys/oracle_4U as sysdba
alter session set container = orclpdb;

DROP user IC cascade;

CREATE USER ic IDENTIFIED BY ic;

GRANT DBA TO ic;
GRANT SELECT_CATALOG_ROLE TO ic;
GRANT SELECT ANY DICTIONARY TO ic;

connect ic/ic@orclpdb

set echo on

drop table emp purge;
drop table dept purge;

drop cluster emp_dept including tables;

CREATE CLUSTER emp_dept (deptno NUMBER(3))
  SIZE 600
  TABLESPACE users
  STORAGE (INITIAL 200K
    NEXT 300K
    MINEXTENTS 2
    PCTINCREASE 33);

CREATE TABLE emp (
  empno      NUMBER(7)          ,
  ename      VARCHAR2(15) NOT NULL,
  job        VARCHAR2(9)         ,
  mgr        NUMBER(7)          ,
  hiredate   DATE              ,
  sal        NUMBER(7)          ,
  comm      NUMBER(7)          ,
```

```

deptno      NUMBER(3))
CLUSTER emp_dept (deptno);

CREATE TABLE dept (
    deptno NUMBER(3) ,
    dname  VARCHAR2(14),
    loc    VARCHAR2(14),
    c      VARCHAR2(500))
CLUSTER emp_dept (deptno);

CREATE INDEX emp_dept_index
ON CLUSTER emp_dept
TABLESPACE users
STORAGE (INITIAL 50K
NEXT 50K
MINEXTENTS 2
MAXEXTENTS 10
PCTINCREASE 33);

begin
  for i in 1..999 loop
    insert into dept values
(i,'D'||i,'L'||i,dbms_random.string('u',500));
  end loop;
  commit;
end;
/

begin
  for i in 1..500000 loop
    insert into emp values
(i,dbms_random.string('u',15),dbms_random.string('u',9),i,sysdate,i,i,
mod(i,999));
  end loop;
  commit;
end;
/

exec dbms_stats.gather_schema_stats('IC');

exit;

```

20. Create a connection for the `ic` user.
- Click the New Connection button.
  - Create a connection with the following specifications:

Name: ic  
Username: ic  
Password: ic  
Select “Save Password.”  
Service Name: orclpdb  
Click Test.  
Click Connect.

21. Open and execute the `nic_query_a.sql` script as the `ic` user.

The screenshot shows the Oracle SQL Worksheet interface. The title bar has tabs for 'shc', 'nic', 'ic', and 'nic\_query\_a.sql'. The main area is titled 'Worksheet' and contains the following SQL code:

```
alter session set workarea_size_policy=manual;
alter session set sort_area_size=50000;
alter session set hash_area_size=5000;
```

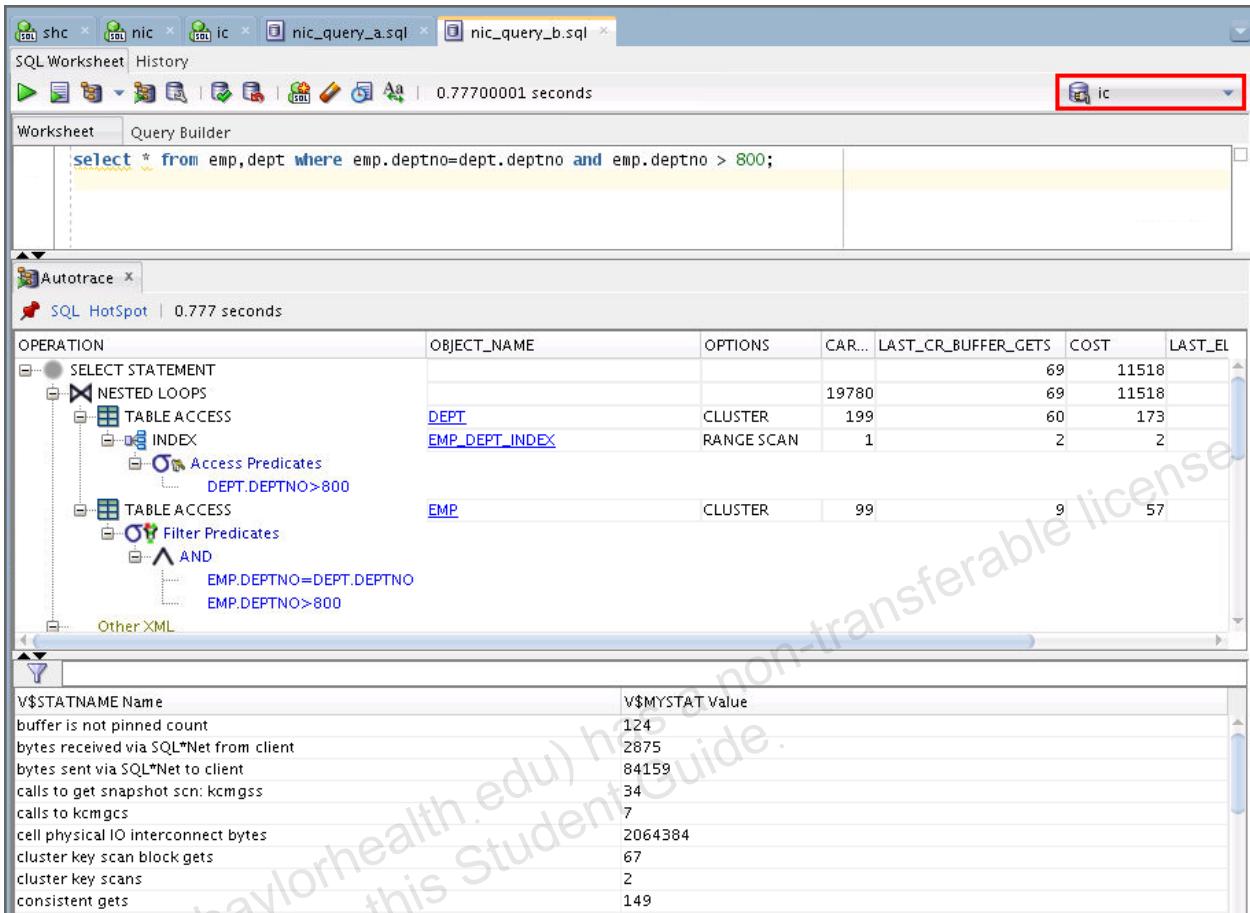
Below the worksheet, there is a 'Script Output' window showing the results of the execution:

```
Session altered.
Session altered.
Session altered.
```

22. Use the `ic` connection to autotrace the query in the `nic_query_b.sql` script again.

```
select *
  from emp,dept
 where emp.deptno=dept.deptno and emp.deptno > 800;
```

What do you observe?



- The optimizer is able to use the cluster access path that makes the query execute faster.

23. **Important:** Close all connections to the SH user. In SQL Developer, find and close all sh\_connection windows. Select sh\_connection in the Connections pane and disconnect. Close all SQL\*Plus sessions.
24. Execute the ap\_cleanup.sh script to clean up your environment for this practice. This script rebuilds the SH schema. If the User dropped message does not appear, or there is an error message in place of it, wait until the script finishes, find and exit from any sessions that are connected as the SH user, and then execute this script again.

**Note:** Ignore the OLAP errors.

```
$ cd /home/oracle/labs/solutions/Access_Paths/
$ ./ap_cleanup.sh
$ ORACLE_SID = [orcl]?

...
Connected to:...
```

```
SQL>
SQL> @ORACLE_HOME/demo/schema/sales_history/sh_main.sh users
temp oracle_4U
/u01/app/oracle/product/12.2.0/dbhome_1/demo/schema/sales_history/ /home/oracle/ v3 localhost:1521/orclpdb
SQL> Rem
SQL> Rem $Header: dbms/demo/schema/sales_history/sh_main.sql
/main/12 2015/03/19 10:23:26 smtaylor Exp $
SQL> Rem
SQL> Rem sh_main.sql
SQL> Rem
SQL> Rem Copyright (c) 2001, 2015, Oracle and/or its affiliates.
All rights reserved.
SQL> Rem
SQL> Rem      NAME
SQL> Rem          sh_main.sql - Main schema creation and load
script
SQL> Rem
SQL> Rem      DESCRIPTION
SQL> Rem          SH is the Sales History schema of the Oracle
Sample
SQL> Rem          Schemas
SQL> Rem
SQL> Rem      NOTES
SQL> Rem          CAUTION: use absolute pathnames as parameters 5
and 6.
SQL> Rem          Example (UNIX) echo
$ORACLE_HOME/demo/schema/sales_history
SQL> Rem          Please make sure that parameters 5 and 6 are
specified
SQL> Rem          INCLUDING the trailing directory delimiter,
since the
SQL> Rem          directory parameters and the filenames are
concatenated
SQL> Rem          without adding any delimiters.
SQL> Rem          Run this as SYS or SYSTEM
SQL> Rem
SQL> Rem      MODIFIED    (MM/DD/YY)
SQL> Rem          smtaylor          03/19/15 - added parameter 8,
connect_string
SQL> Rem          smtaylor          03/19/15 - added
@&connect_string to CONNECT
SQL> Rem          smtaylor          03/19/15 - added parameter
&connect_string to script calls
SQL> Rem          awesley           04/03/12 - Remove cwm_user
```

```

SQL> Rem      jmadduku    02/18/11 - Grant Unlimited
Tablespace priv with RESOURCE
SQL> Rem      cbauwens     03/06/08 - NLS settings for load
SQL> Rem      cbauwens     07/10/07 - NLS fix bug 5684394
SQL> Rem      glyon       06/28/07 - grant CWM_USER role, if it
exists
SQL> Rem      cbauwens     02/23/05 - deprecating connect
role
SQL> Rem      ahunold     10/14/02 -
> Rem      hyeh        08/29/02 - hyeh_mv_comschema_to_rdbms
SQL> Rem      ahunold     08/20/02 - path > dir
SQL> Rem      ahunold     08/15/02 - versioning
SQL> Rem      ahunold     04/30/02 - Reduced DIRECTORY privileges
SQL> Rem      ahunold     08/28/01 - roles
SQL> Rem      ahunold     07/13/01 - NLS Territory
SQL> Rem      ahunold     04/13/01 - spool, notes
SQL> Rem      ahunold     04/10/01 - flexible log and data paths
SQL> Rem      ahunold     03/28/01 - spool
SQL> Rem      ahunold     03/23/01 - absolute path names
SQL> Rem      ahunold     03/14/01 - prompts
SQL> Rem      ahunold     03/09/01 - privileges
SQL> Rem      hbaer       03/01/01 - changed loading from COSTS
table from
SQL> Rem      SQL*Loader to external table
with GROUP BY
SQL> Rem      privilege
SQL> Rem
SQL>
SQL> SET ECHO OFF

specify password for SH as parameter 1:

specify default tablespace for SH as parameter 2:

specify temporary tablespace for SH as parameter 3:

specify password for SYS as parameter 4:

specify directory path for the data files as parameter 5:

writeable directory path for the log files as parameter 6:

specify version as parameter 7:

```

specify connect string as parameter 8:

Session altered.

**User dropped.**

```
old  1: CREATE USER sh IDENTIFIED BY &pass  
new  1: CREATE USER sh IDENTIFIED BY sh
```

User created.

```
old  1: ALTER USER sh DEFAULT TABLESPACE &tbs  
new  1: ALTER USER sh DEFAULT TABLESPACE example  
old  2: QUOTA UNLIMITED ON &tbs  
new  2: QUOTA UNLIMITED ON example
```

User altered.

```
old  1: ALTER USER sh TEMPORARY TABLESPACE &ttbs  
new  1: ALTER USER sh TEMPORARY TABLESPACE temp
```

User altered.

Grant succeeded.

...

<<<< FINAL PROCESSING >>>>

- Changes have been committed

PL/SQL procedure successfully completed.

Commit complete.

gathering statistics ...

PL/SQL procedure successfully completed.

```
PL/SQL procedure successfully completed.  
  
Disconnected ...  
$
```

## **Practices for Lesson 11: Introduction to Optimizer Statistics Concepts**

## Practices for Lesson 11: Overview

---

### Practices Overview

In these practices, you perform the following:

- Experiment with the index clustering factor
- Create expression statistics
- Enable automatic statistics gathering (optional)
- Use system statistics (optional)

## Practice 11-1: Index Clustering Factor

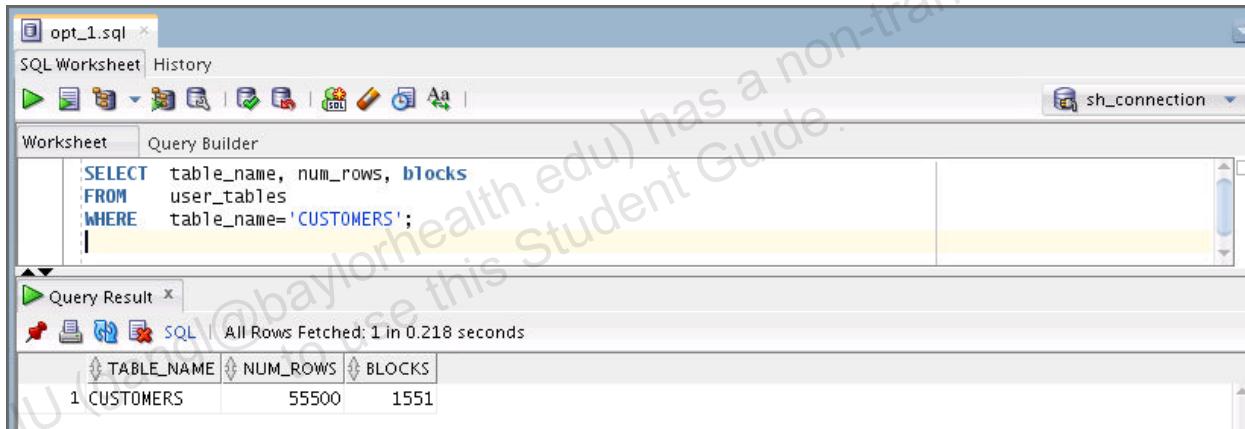
### Overview

In this practice, you experiment with the index clustering factor. Here, you learn how the optimizer uses the index clustering factor to determine whether using an index is more effective than a full table scan.

### Tasks

- Change directories to \$HOME/labs/solutions/Optimizer\_Statistics. Start a SQL Developer session, connect to the database as the SH user, and then query the number of rows and blocks in the sh.customers table. Use the opt\_1.sql file.

```
SELECT  table_name, num_rows, blocks
FROM    user_tables
WHERE   table_name='CUSTOMERS';
```



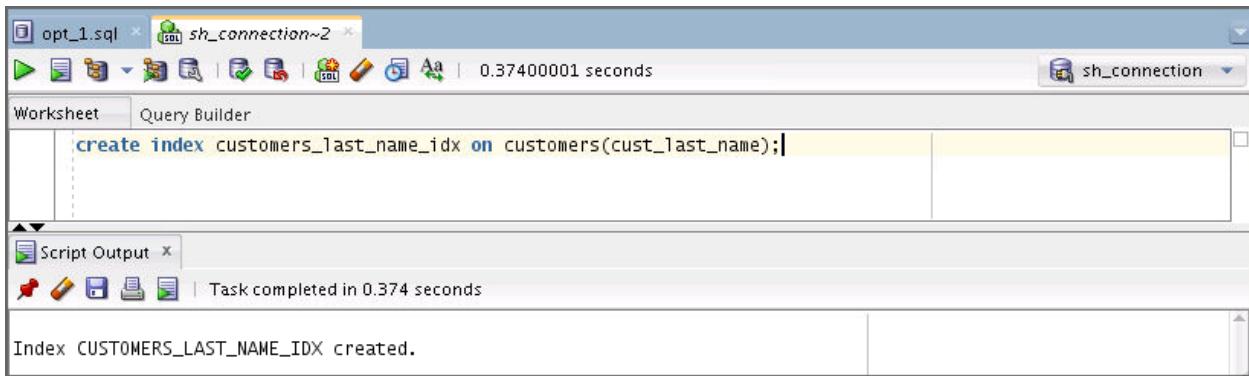
- Drop all the CUSTOMERS indexes, except its primary key index. Open a terminal window. Connect to sh and drop all the indexes that are currently created on the CUSTOMERS table, except its primary key index, by executing drop\_customers\_indexes.sqlscript. And create an index on the customers.cust\_last\_name column. Use the opt\_2.sql file.

```
$ cd /home/oracle/labs/solutions/Access_Paths/
$ sqlplus sh/sh@orclpdb

...
Connected to:...

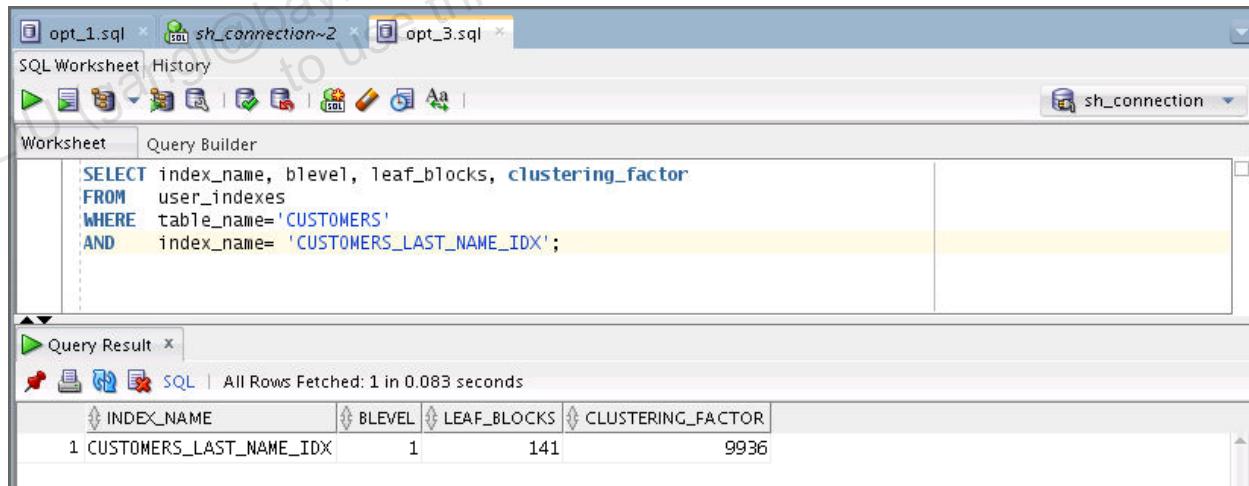
SQL> @drop_customers_indexes.sql
```

```
CREATE INDEX CUSTOMERS_LAST_NAME_IDX ON
customers(cust_last_name);
```



- Query the index clustering factor of the newly created index. The following query shows that the `customers_last_name_idx` index has a high clustering factor because the clustering factor is significantly more than the number of blocks in the table. Use the `opt_3.sql` file.

```
SELECT index_name, blevel, leaf_blocks, clustering_factor
FROM user_indexes
WHERE table_name='CUSTOMERS'
AND index_name= 'CUSTOMERS_LAST_NAME_IDX';
```



4. Create a new copy of the `customers` table, with rows ordered by `cust_last_name`. Use the `opt_4.sql` file.

```
DROP TABLE customers3 PURGE;
CREATE TABLE customers3 AS
  SELECT *
    FROM customers
   ORDER BY cust_last_name;

DESCRIBE customers3;
```

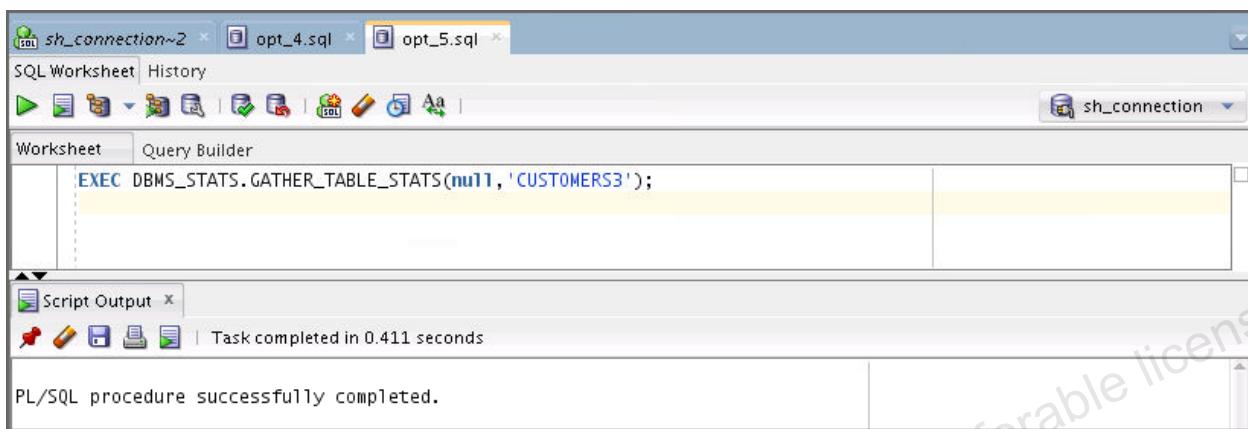
The screenshot shows a SQL Worksheet interface with multiple tabs at the top: opt\_1.sql, sh\_connection~2, opt\_3.sql, opt\_4.sql (which is the active tab), and sh\_connection. The main area displays the SQL code for creating a new table 'customers3'. Below the code, the 'Script Output' pane shows the results of the execution: 'Table CUSTOMERS3 created.' followed by a detailed description of the table's structure with columns and their types.

Name	Null?	Type
CUST_ID	NOT NULL	NUMBER
CUST_FIRST_NAME	NOT NULL	VARCHAR2(20)
CUST_LAST_NAME	NOT NULL	VARCHAR2(40)
CUST_GENDER	NOT NULL	CHAR(1)
CUST_YEAR_OF_BIRTH	NOT NULL	NUMBER(4)
CUST_MARITAL_STATUS		VARCHAR2(20)
CUST_STREET_ADDRESS	NOT NULL	VARCHAR2(40)
CUST_POSTAL_CODE	NOT NULL	VARCHAR2(10)
CUST_CITY	NOT NULL	VARCHAR2(30)
CUST_CITY_ID	NOT NULL	NUMBER
CUST_STATE_PROVINCE	NOT NULL	VARCHAR2(40)
CUST_STATE_PROVINCE_ID	NOT NULL	NUMBER
COUNTRY_ID	NOT NULL	NUMBER
CUST_MAIN_PHONE_NUMBER	NOT NULL	VARCHAR2(25)
CUST_INCOME_LEVEL		VARCHAR2(30)

...

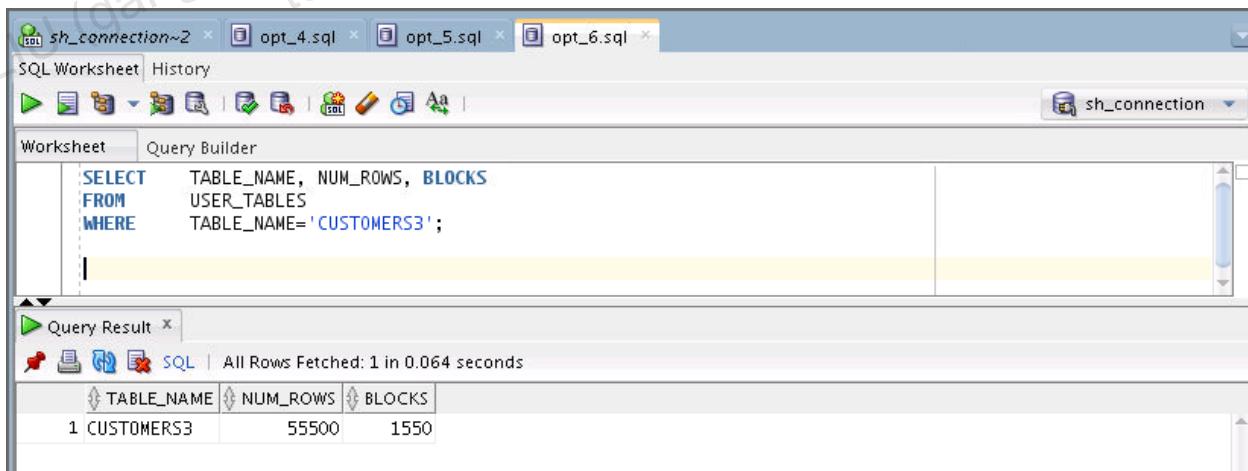
5. Gather statistics on the CUSTOMERS3 table. Use the opt\_5.sql file.

```
EXEC DBMS_STATS.GATHER_TABLE_STATS(null, 'CUSTOMERS3');
```



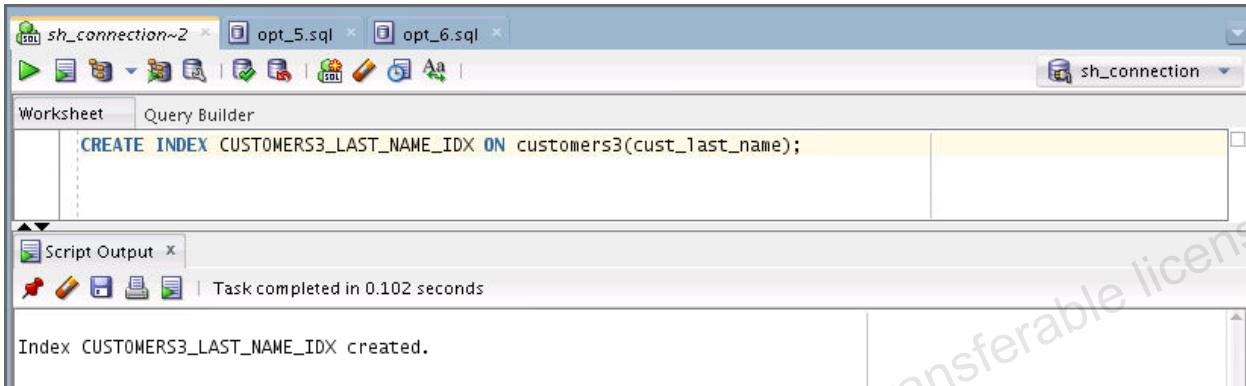
6. Query the number of rows and blocks in the CUSTOMERS3 table by using the following code. Use the opt\_6.sql file.

```
SELECT      TABLE_NAME,  NUM_ROWS,  BLOCKS
FROM        USER_TABLES
WHERE       TABLE_NAME='CUSTOMERS3';
```



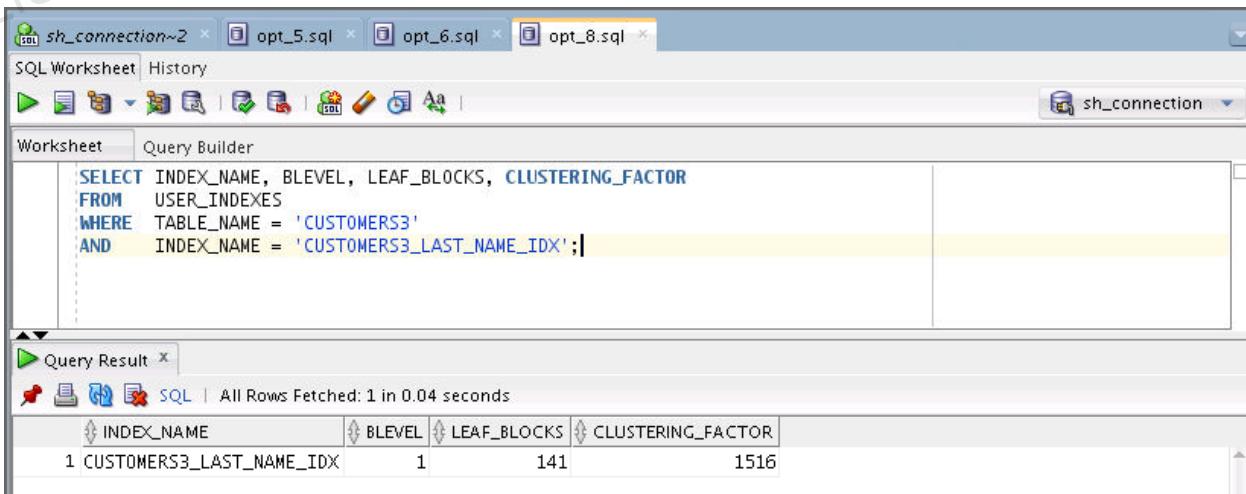
7. Create an index on the `cust_last_name` column of the `CUSTOMERS3` table. Use the `opt_7.sql` file.

```
CREATE INDEX CUSTOMERS3_LAST_NAME_IDX ON
customers3(cust_last_name);
```



8. Query the index clustering factor of the `customers3_last_name_idx` index. The following query shows that the `customers3_last_name_idx` index has a lower clustering factor. Use the `opt_8.sql` file.

```
SELECT INDEX_NAME, BLEVEL, LEAF_BLOCKS, CLUSTERING_FACTOR
FROM   USER_INDEXES
WHERE  TABLE_NAME = 'CUSTOMERS3'
AND    INDEX_NAME = 'CUSTOMERS3_LAST_NAME_IDX';
```



**Note:** The `CUSTOMERS3` table has the same data as the original `customers` table, but the index on `CUSTOMERS3` has a much lower clustering factor because the data in the table is

ordered by `cust_last_name`. The clustering factor is now about 10 times the number of blocks instead of 70 times.

9. Query the `CUSTOMERS` table. Use the `opt_9.sql` file.

```
SELECT cust_first_name, cust_last_name  
FROM   customers  
WHERE  cust_last_name BETWEEN 'Puleo' AND 'Quinn';
```

The screenshot shows the Oracle SQL Developer interface. At the top, there are three tabs: `sh_connection~2`, `opt_8.sql`, and `opt_9.sql`. The `opt_9.sql` tab is active. Below the tabs is a toolbar with various icons. The main area is divided into two panes: `Worksheet` and `Query Builder`. The `Worksheet` pane contains the SQL query:SELECT cust\_first\_name, cust\_last\_name  
FROM customers  
WHERE cust\_last\_name BETWEEN 'Puleo' AND 'Quinn';The `Query Result` pane at the bottom shows the results of the query:|  | CUST\_FIRST\_NAME | CUST\_LAST\_NAME |
| --- | --- | --- |
| 1 | Vida | Puleo |
| 2 | Harriett | Quinlan |
| 3 | Madeleine | Quinn |
| 4 | Caresse | Puleo |

Below the table, it says `All Rows Fetched: 4 in 0.008 seconds`.

10. Execute the following query to display the cursor for the query. Use the opt\_10.sql file.

```
SELECT * FROM TABLE(DBMS_XPLAN.DISPLAY_CURSOR());
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are four tabs: sh\_connection~2, opt\_8.sql, opt\_9.sql, and opt\_10.sql. The opt\_10.sql tab is active. Below the tabs is a toolbar with various icons. The main area has two tabs: Worksheet and Query Builder. The Worksheet tab is selected and contains the SQL command: `SELECT * FROM TABLE(DBMS_XPLAN.DISPLAY_CURSOR());`. Below the worksheet is a status bar indicating "SQL | All Rows Fetched: 19 in 0.025 seconds". The bottom half of the window displays the execution plan. It starts with the PLAN\_TABLE\_OUTPUT section, which includes the SQL\_ID (Ovpc3qhg8xmyn), child number (0), and the query itself: `SELECT cust_first_name, cust_last_name FROM customers WHERE cust_last_name BETWEEN 'Puleo' AND 'Quinn'`. It also shows the plan hash value (2008213504). The next section is the execution plan itself, which is a table with columns: Id, Operation, Name, Rows, Bytes, Cost (%CPU), and Time. The plan shows one SELECT STATEMENT operation (Id 0) and one TABLE ACCESS FULL operation (Id 1) on the CUSTOMERS table. The final section is Predicate Information, which lists the WHERE clause predicate: `filter(("CUST_LAST_NAME">>='Puleo' AND "CUST_LAST_NAME"><='Quinn'))`.

11. Query the CUSTOMERS3 table. Use the opt\_11.sql file.

```
SELECT cust_first_name, cust_last_name
FROM   customers3
WHERE  cust_last_name BETWEEN 'Puleo' AND 'Quinn';
```

The screenshot shows the SQL Worksheet interface in SQL Developer. The connection is set to 'sh\_connection'. There are three tabs open in the top bar: 'sh\_connection~2' (selected), 'opt\_10.sql', and 'opt\_11.sql'. The 'Worksheet' tab is active. A SQL statement is entered:

```
SELECT cust_first_name, cust_last_name
FROM customers3
WHERE cust_last_name BETWEEN 'Puleo' AND 'Quinn';
```

The 'Query Result' tab shows the output of the query:

	CUST_FIRST_NAME	CUST_LAST_NAME
1	Vida	Puleo
2	Caresse	Puleo
3	Harriett	Quinlan
4	Madeleine	Quinn

Below the table, it says 'All Rows Fetched: 4 in 0.008 seconds'.

12. Execute the following query to display the cursor for the query. Use the opt\_12.sql file.

```
SELECT * FROM TABLE(DBMS_XPLAN.DISPLAY_CURSOR());
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are three tabs: 'sh\_connection~2' (highlighted), 'opt\_11.sql', and 'opt\_12.sql'. The main workspace is titled 'Worksheet' and contains the SQL command:

```
SELECT * FROM TABLE(DBMS_XPLAN.DISPLAY_CURSOR());
```

Below the worksheet is the 'Query Result' pane, which displays the output of the executed command. The output is as follows:

```
SQL> SELECT * FROM TABLE(DBMS_XPLAN.DISPLAY_CURSOR());
PLAN_TABLE_OUTPUT
1 SQL_ID 7qrf03wyn0k0m, child number 0
2 -
3 SELECT cust_first_name, cust_last_name FROM customers3 WHERE
4 cust_last_name BETWEEN 'Puleo' AND 'Quinn'
5
6 Plan hash value: 843745509
7
8
9 | Id  | Operation          | Name           | Rows | Bytes | Cost (%CPU) | Time      |
10 |---|---|---|---|---|---|---|
11 | 0  | SELECT STATEMENT   |                |       |       |    71 (100) |           |
12 | 1  |  TABLE ACCESS BY INDEX ROWID BATCHED | CUSTOMERS3   | 2335 | 35025 |    71 (0)  | 00:00:01 |
13 |* 2  |  INDEX RANGE SCAN   | CUSTOMERS3_LAST_NAME_IDX | 2335 |       |     7 (0)  | 00:00:01 |
14
15
16 Predicate Information (identified by operation id):
17
18
19   2 - access("CUST_LAST_NAME">>='Puleo' AND "CUST_LAST_NAME"=<'Quinn')
20
```

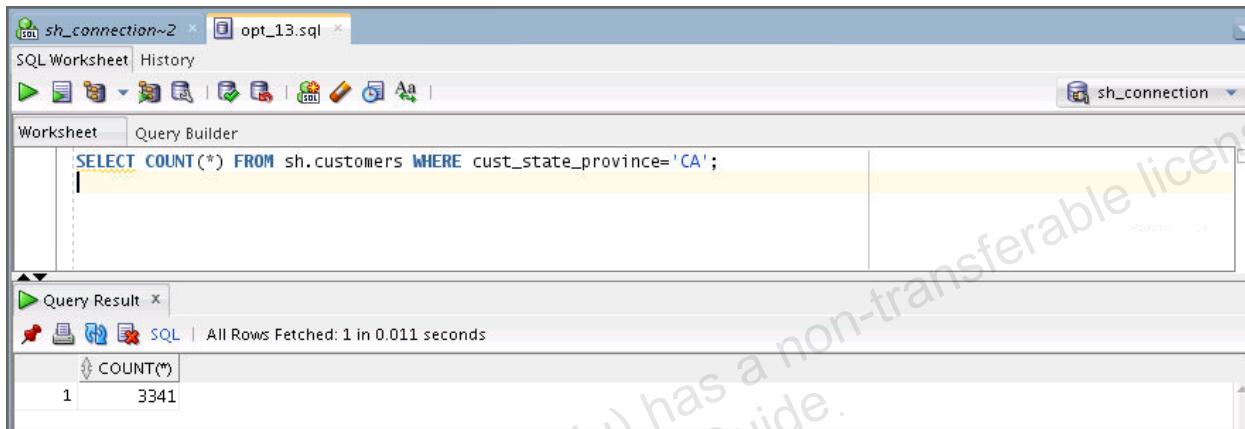
## Practice 11-2: Creating Expression Statistics

In this practice, you investigate the use of expression statistics.

1. You can find all the necessary scripts for this practice in your \$HOME/labs/solutions/Optimizer\_Statistics directory.

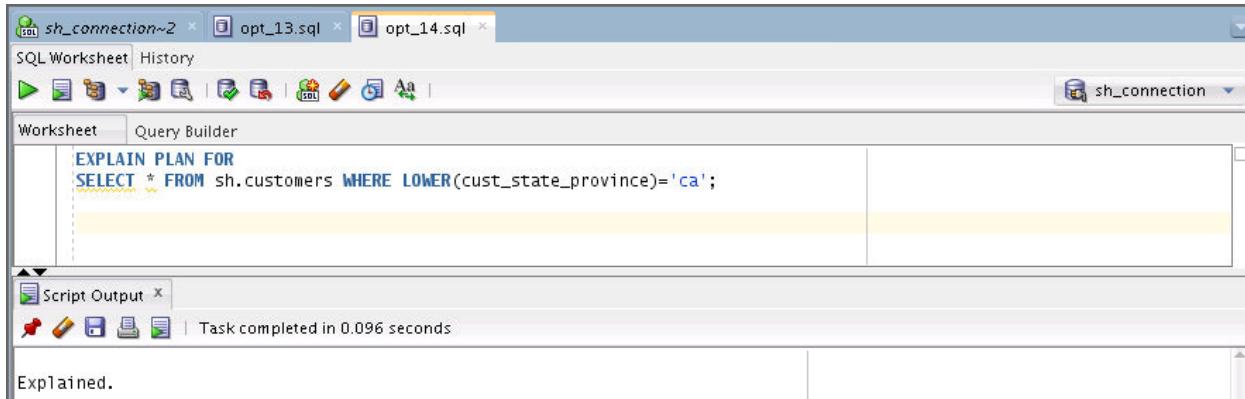
Run the following query on the CUSTOMERS table or use the opt\_13.sql file.

```
SELECT COUNT(*) FROM sh.customers WHERE
cust_state_province='CA';
```



2. Run the EXPLAIN PLAN command for the same query with the LOWER() function applied. Use the opt\_14.sql file.

```
EXPLAIN PLAN FOR
SELECT * FROM sh.customers WHERE
LOWER(cust_state_province)='ca';
```



3. Run the query to display the plan. Use the opt\_15.sql file.

```
select * from table(dbms_xplan.display);
```

The screenshot shows the Oracle SQL Worksheet interface. In the top tab bar, there are tabs for 'sh\_connection~2', 'opt\_13.sql', 'opt\_14.sql', 'opt\_15.sql', and 'opt\_16.sql'. The 'opt\_15.sql' tab is active. Below the tabs is a toolbar with various icons. The main area has two tabs: 'Worksheet' and 'Query Builder', with 'Worksheet' selected. The worksheet contains the SQL query:

```
select * from table(dbms_xplan.display);
```

Below the worksheet is a 'Query Result' tab. It shows the output of the query, which is the execution plan. The output is formatted as follows:

```
PLAN_TABLE_OUTPUT
1 Plan hash value: 2008213504
2
3 -----
4 | Id  | Operation          | Name        | Rows  | Bytes | Cost (%CPU) | Time      |
5 -----
6 | 0   | SELECT STATEMENT   |             | 555   | 102K  |    423    (1)| 00:00:01  |
7 |* 1  | TABLE ACCESS FULL | CUSTOMERS  | 555   | 102K  |    423    (1)| 00:00:01  |
8 -----
9
10 Predicate Information (identified by operation id):
11 -----
12
13   1 - filter(LOWER("CUST_STATE_PROVINCE")='ca')
```

**Note:** Because no expression statistics exist for LOWER(cust\_state\_province)='ca', the optimizer estimate is significantly off. You can use DBMS\_STATS procedures to correct these estimates.

4. You can use DBMS\_STATS to create statistics for a user-specified expression. Gather table statistics using the following code. Use the opt\_16.sql file.

```
BEGIN
  DBMS_STATS.GATHER_TABLE_STATS( 'sh','customers', method_opt =>
  'FOR ALL COLUMNS SIZE SKEWONLY FOR
  COLUMNS(LOWER(cust_state_province)) SIZE SKEWONLY');
END;
/
```

The screenshot shows the Oracle SQL Worksheet interface. In the top tab bar, there are three tabs: 'sh\_connection~2', 'opt\_15.sql', and 'opt\_16.sql'. The 'opt\_16.sql' tab is active. The main workspace contains the following PL/SQL code:

```

BEGIN
  DBMS_STATS.GATHER_TABLE_STATS( 'sh','customers', method_opt => 'FOR ALL COLUMNS SIZE SKEWONLY FOR COLUMNS(LOWER(cus
END;
/

```

Below the code, the 'Script Output' pane shows the message: 'Task completed in 2.828 seconds'. The bottom pane displays the message: 'PL/SQL procedure successfully completed.'

5. You can use the database view `DBA_STAT_EXTENSIONS` and the `DBMS_STATS.SHOW_EXTENDED_STATS_NAME` function to obtain information about expression statistics. Query the name and definition of the statistics extension by using the following code or use the `opt_17.sql` file:

```

COL EXTENSION_NAME FORMAT a30
COL EXTENSION FORMAT a35

SELECT EXTENSION_NAME, EXTENSION
FROM   USER_STAT_EXTENSIONS
WHERE  TABLE_NAME='CUSTOMERS';

```

The screenshot shows the Oracle SQL Worksheet interface. In the top tab bar, there are four tabs: 'sh\_connection~2', 'opt\_15.sql', 'opt\_16.sql', and 'opt\_17.sql'. The 'opt\_17.sql' tab is active. The main workspace contains the same SQL query as the previous screenshot:

```

COL EXTENSION_NAME FORMAT a30
COL EXTENSION FORMAT a35

SELECT EXTENSION_NAME, EXTENSION
FROM   USER_STAT_EXTENSIONS
WHERE  TABLE_NAME='CUSTOMERS';

```

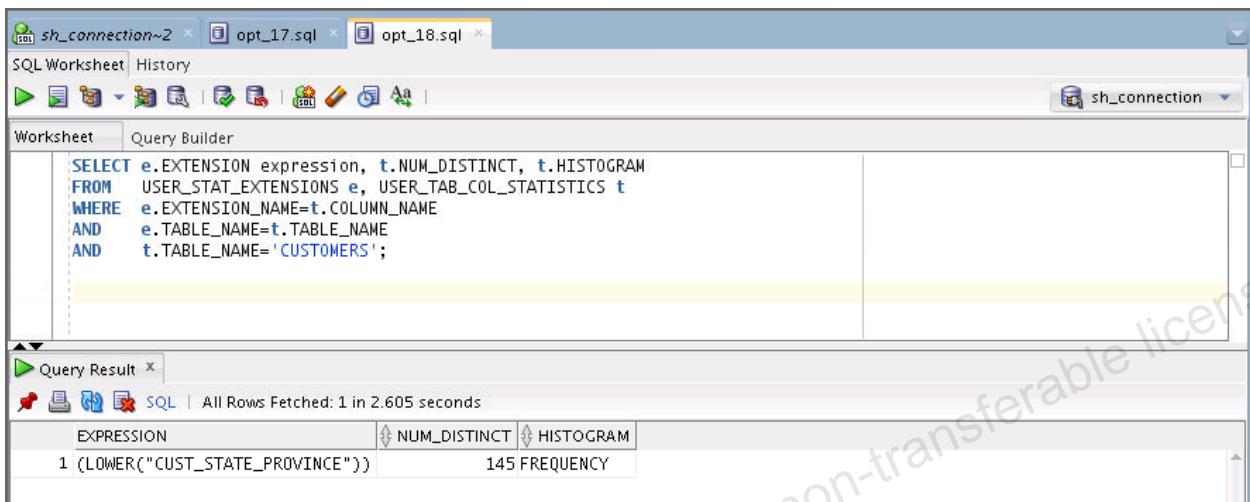
Below the code, the 'Query Result' pane shows the output:

EXTENSION_NAME	EXTENSION
1	SYS_STUBPHJSBRK902YV3WSHOU
	(LOWER("CUST_STATE_PROVINCE"))

6. Run the following code to query the number of distinct values and find whether a histogram has been created for the expression. Use the `opt_18.sql` file.

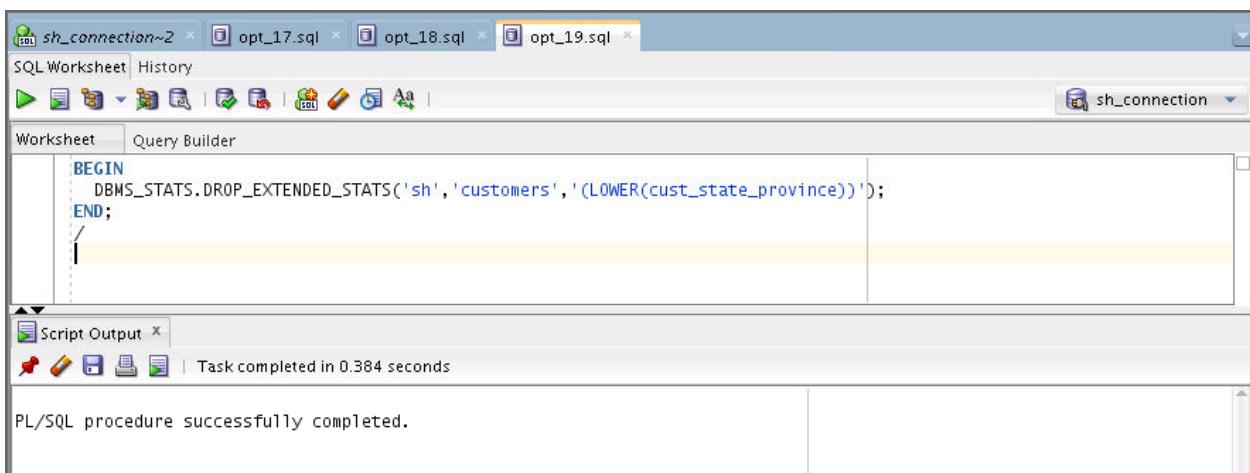
```
SELECT e.EXTENSION expression, t.NUM_DISTINCT, t.HISTOGRAM
```

```
FROM    USER_STAT_EXTENSIONS e, USER_TAB_COL_STATISTICS t
WHERE  e.EXTENSION_NAME=t.COLUMN_NAME
AND    e.TABLE_NAME=t.TABLE_NAME
AND    t.TABLE_NAME='CUSTOMERS';
```



7. You created extended statistics for the LOWER(cust\_state\_province) expression. Now to drop the expression statistics, use the opt\_19.sql file.

```
BEGIN
  DBMS_STATS.DROP_EXTENDED_STATS('sh','customers','(LOWER(cust_state_province))');
END;
/
```



8. Drop all the CUSTOMERS indexes, except its primary key index. Open a terminal window. Connect to `sh` and drop all the indexes that are currently created on the CUSTOMERS table, except its primary key index, by executing the `drop_customers_indexes.sql` script. And create an index on the `customers.cust_last_name` column. Use the `opt_2.sql` file.

```
$ cd /home/oracle/labs/solutions/Access_Paths/  
$ sqlplus sh/sh@orclpdb  
  
...  
Connected to:...  
  
SQL> @drop_customers_indexes.sql
```

## Practice 11-3: Enabling Automatic Statistics Gathering (Optional)

In this practice, you manipulate object statistics to see the effect of your SQL statements on the execution plans.

**Note:** All the scripts needed for this practice can be found in your \$HOME/labs/solutions/Automatic\_Gather\_Stats directory.

1. The environment for this practice has been set up with the ags\_setup.sh script. This script created a user called AGS that you use throughout this practice. The script also created a table called EMP and an index. The script is listed as follows:

```
-----  
#!/bin/bash  
  
cd /home/oracle/labs/solutions/Automatic_Gather_Stats  
  
sqlplus / as sysdba @ags_setup.sql  
  
alter session set container = orclpdb;  
-----  
  
set echo on  
  
drop user ags cascade;  
  
create user ags identified by ags;  
  
grant dba to ags;  
  
connect ags/ags@orclpdb  
  
drop table emp purge;  
  
create table emp  
(  
empno  number,  
ename   varchar2(20),  
phone   varchar2(20),  
deptno  number  
);  
  
insert into emp  
with tdata as  
(select rownum empno  
from all_objects
```

```

        where rownum <= 1000)
select rownum,
       dbms_random.string ('u', 20),
       dbms_random.string ('u', 20),
       case
           when rownum/100000 <= 0.001 then mod(rownum, 10)
           else 10
       end
  from tdata a, tdata b
 where rownum <= 100000;

commit;

create index emp_i1 on emp(deptno);

exit;

```

2. Execute the `ags_start.sql` script in SQL\*Plus from the `$HOME/labs/solutions/Automatic_Gather_Stats` directory.

```

$ cd $HOME/labs/solutions/Automatic_Gather_Stats
$ ./ags_start.sh

...
SQL>
SQL> connect / as sysdba
Connected.
SQL>
SQL> alter system flush shared_pool;

System altered.

SQL>
SQL> --
SQL> -- Turn off AUTOTASK
SQL> --
SQL>
SQL> alter system set "_enable_automatic_maintenance"=0;

System altered.

SQL>alter session set container = orclpdb;
Session altered.

```

```
SQL>
SQL> exec dbms_stats.delete_schema_stats('AGS');

PL/SQL procedure successfully completed.

SQL>
SQL> exit;
Disconnected ...
$
```

3. Connect as the ags user in a SQL\*Plus session.

```
$ sqlplus ags/ags@orclpdb
...
SQL>
```

4. Create a new connection in SQL Developer for the ags user with the following properties:

Name: ags

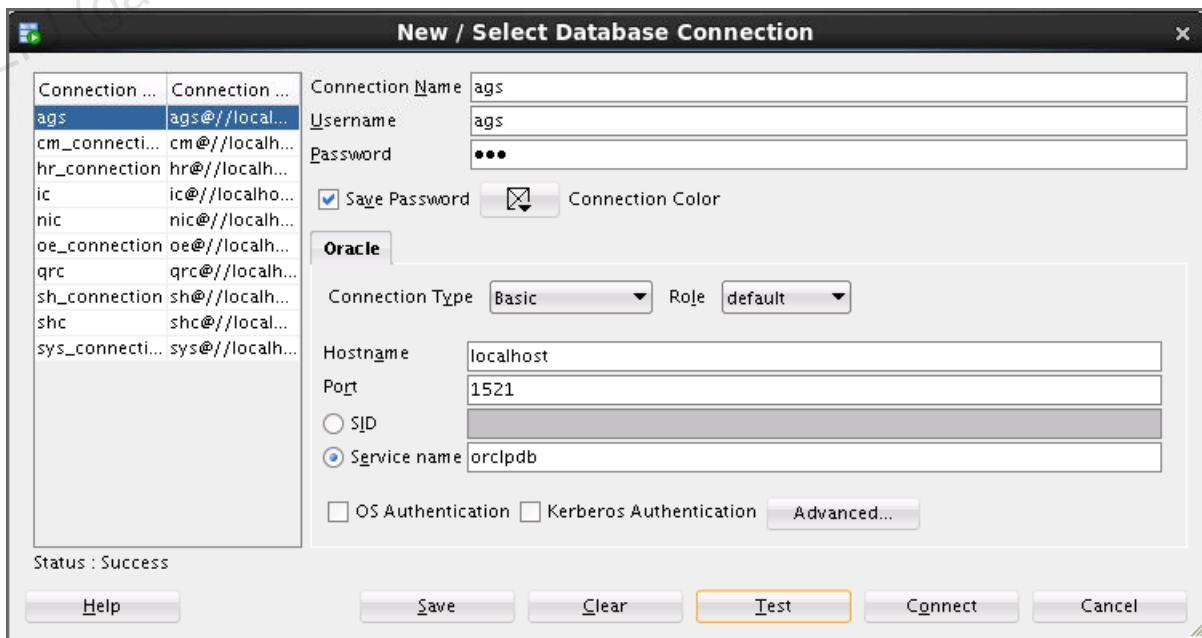
User: ags

Password: ags

Service Name: orclpdb

Click Test.

Click Connect.



5. Using ags, determine the distribution of the deptno values found in the EMP table. What do you observe?

Open and execute the `show_deptno_distribution.sql` file in the `$HOME/labs/solutions/Automatic_Gather_Stats` directory. You can see that there are 11 department values, each repeating 0.01% of the time, except value 10 that repeats 99.9% of the time.

The screenshot shows the Oracle SQL Developer interface. In the top-left window, titled "show\_deptno\_distribution.sql", the following SQL query is displayed:

```
select deptno, count(*) cnt_per_deptno, (count(*)*100)/nr deptno_percent
from emp, (select max(emppno) nr
            from emp)
group by deptno, nr
order by deptno;
```

In the bottom-right window, titled "Script Output", the results of the query are shown:

DEPTNO	CNT_PER_DEPTNO	DEPTNO_PERCENT
0	10	.01
1	10	.01
2	10	.01
3	10	.01
4	10	.01
5	10	.01
6	10	.01
7	10	.01
8	10	.01
9	10	.01
10	99900	99.9

Below the table, the message "11 rows selected." is visible.

6. Determine if there are histograms available on any column of the `EMP` table. What do you observe?

Open the `check_emp_histogram.sql` file and execute it in SQL Developer. Currently, there are no histograms defined on any column of the `EMP` table.

```
select column_name, histogram, num_buckets
from user_tab_columns
where table_name='EMP';
```

COLUMN_NAME	HISTOGRAM	NUM_BUCKETS
1 EMPNO	NONE	(null)
2 ENAME	NONE	(null)
3 PHONE	NONE	(null)
4 DEPTNO	NONE	(null)

7. Determine if you currently have statistics gathered on your `EMP` table. What do you observe?
- In the SQL Developer navigator pane, click the Connections tab. Expand `ags` connection, and then the Tables node and the `EMP` table node. Select the `EMP` table node.
  - On the `EMP` tab, click the Statistics subtab.
  - Currently, there are no statistics gathered on your `EMP` table.

Name	Value
1 NUM_ROWS	(null)
2 BLOCKS	(null)
3 AVG_ROW_LEN	(null)
4 SAMPLE_SIZE	(null)
5 LAST_ANALYZED	(null)
6 LAST_ANALYZED_SINCE	(null)

**Column Statistics**

OWNER	TABLE_N...	COLUMN...	NUM_DIS...	LOW_VALUE	HIGH_VALUE	DENSITY	NUM_NU...	NUM_BU...	LAST_AN...	SAMPLE...
-------	------------	-----------	------------	-----------	------------	---------	-----------	-----------	------------	-----------

8. Determine if you currently have statistics gathered on the index that is created on top of the EMP table. What do you observe?
- Click the Indexes subtab of the EMP pane.

INDEX_OWNER	INDEX_NAME	UNIQUENESS	STATUS	INDEX_TYPE	TEMPORARY	PARTITIONED	FUNCIDX_STATUS	JOIN_INDEX	COLUMN
1 AGS	EMP_I1	NONUNIQUE	VALID	NORMAL	N	NO	(null)	NO	DEPTNO

- In the Connections navigator pane, under ags connection, expand the indexes node, and then select the EMP\_I1 index. In the EMP\_I1 pane, click the Statistics subtab. Currently, EMP\_I1 has no statistics gathered.

Name	Value
1 OWNER	AGS
2 INDEX_NAME	EMP_I1
3 TABLE_OWNER	AGS
4 TABLE_NAME	EMP
5 PARTITION_NAME	(null)
6 PARTITION_POSITION	(null)
7 SUBPARTITION_NAME	(null)
8 SUBPARTITION_POSITION	(null)
9 OBJECT_TYPE	INDEX
10 BLEVEL	(null)
11 LEAF_BLOCKS	(null)
12 DISTINCT_KEYS	(null)
13 AVG_LEAF_BLOCKS_PER_KEY	(null)
14 AVG_DATA_BLOCKS_PER_KEY	(null)
15 CLUSTERING_FACTOR	(null)
16 NUM_ROWS	(null)
17 AVG_CACHED_BLOCKS	(null)
18 AVG_CACHE_HIT_RATIO	(null)
19 SAMPLE_SIZE	(null)
20 LAST_ANALYZED	(null)
21 GLOBAL_STATS	NO
22 USER_STATS	NO
23 STATTYPE_LOCKED	(null)
24 STALE_STATS	(null)
25 SCOPE	SHARED

9. Autotrace the following two statements and determine their execution plans:

```
select count(*), max(empno) from emp where deptno = 9;
select count(*), max(empno) from emp where deptno = 10;
```

These statements are in the literal9.sql and literal10.sql files. What do you observe and why?

- a. Open the literal9.sql file and autotrace using ags. You see that for deptno = 9, the optimizer decided to use the index.

The screenshot shows the Oracle SQL Developer interface with the Autotrace feature. The query in the worksheet is:

```
select count(*), max(emphno) from emp where deptno = 9;
```

The Autotrace output shows the execution plan:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	LAST_CR_BUFFER_GETS	COST	LAS
SELECT STATEMENT					3	2
SORT		AGGREGATE	1		3	
TABLE ACCESS	EMP	BY INDEX ROW...	10		3	2
INDEX	EMP_I1	RANGE SCAN	10		2	1
Access Predicates						
DEPTNO=9						

- b. Open the literal10.sql file and autotrace using ags. Notice that for deptno = 10, the optimizer decided to do TABLE ACCESS FULL. The optimizer determined the correct plan in both cases. This is because dynamic statistics was used and there were no statistics gathered on either object.

The screenshot shows the Oracle SQL Developer interface with the Autotrace feature. The query in the worksheet is:

```
select count(*), max(emphno) from emp where deptno = 10;
```

The Autotrace output shows the execution plan:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	LAST_CR_BUFFER_GETS	COST	LAS
SELECT STATEMENT					806	239
SORT		AGGREGATE	1		806	
TABLE ACCESS	EMP	FULL	89842		806	239
Filter Predicates						
DEPTNO=10						

10. Confirm your assumption from the previous step.

On the `ags` tab, enter the following query and execute:

```
SELECT * FROM v$parameter WHERE NAME LIKE '%dynamic%';
```

**Note:** In SQL Developer, there is only one session for a connection even though there may be multiple windows using that session.

The screenshot shows the SQL Developer interface with the 'ags' tab selected. In the 'Worksheet' tab, the query `SELECT * FROM v$parameter WHERE NAME LIKE '%dynamic%';` is entered. The 'Query Result' tab displays the following table:

NUM	NAME	TYPE	VALUE	DISPLAY_VALUE	DEFAULT_VALUE	ISDEFAULT	ISSES_MODIFIABLE	ISSYS_MODIF
1	optimizer_dynamic_sampling	32	2	2	2	TRUE	TRUE	IMMEDIATE

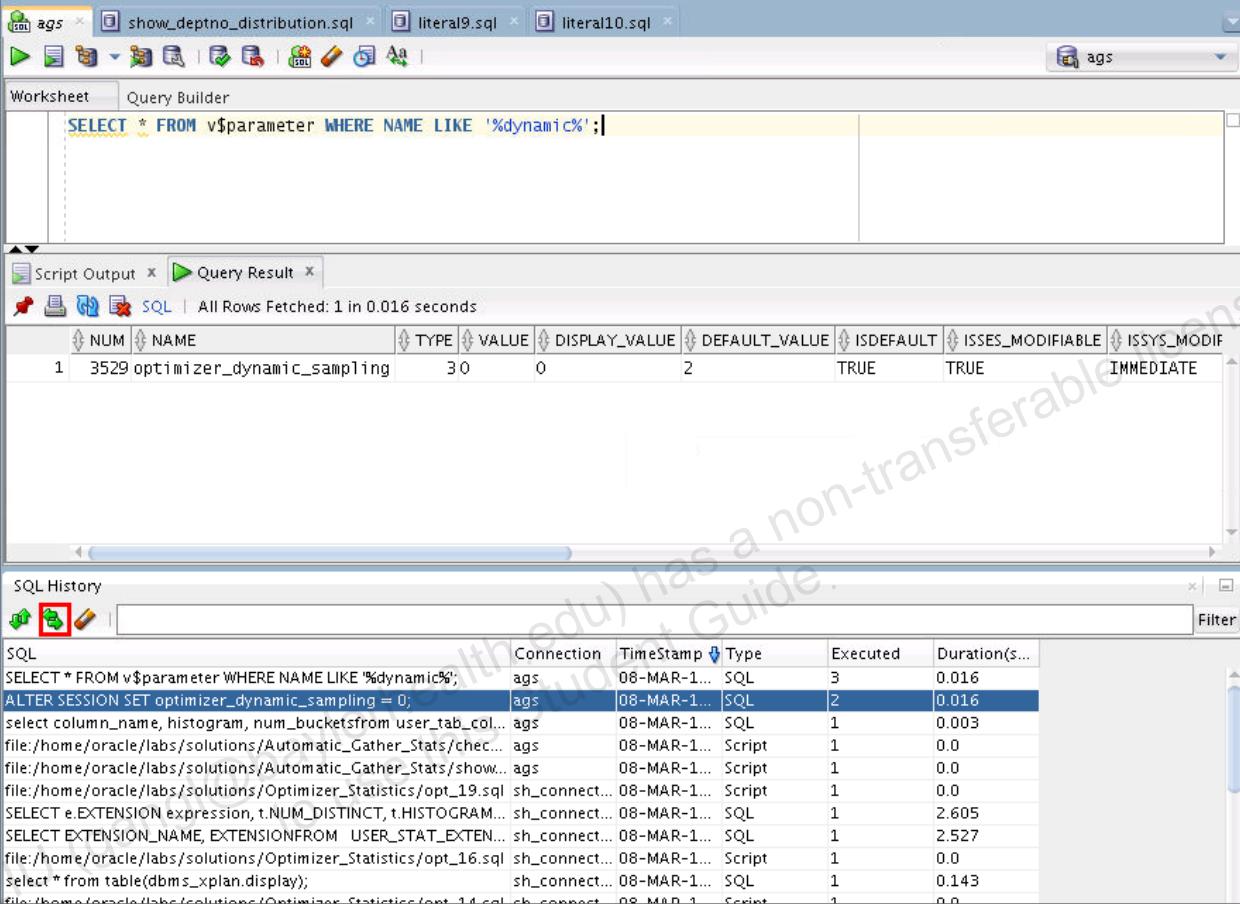
11. Turn off dynamic statistics.

- a. Set the parameter for your session to 0. Use the following command.

```
ALTER session SET optimizer_dynamic_sampling = 0;
```

The screenshot shows the SQL Developer interface with the 'ags' tab selected. In the 'Worksheet' tab, the command `ALTER SESSION SET optimizer_dynamic_sampling = 0;` is entered. The 'Query Result' tab shows the output: "Task completed in 0.029 seconds". Below the result, a message "Session altered." is displayed.

- b. Confirm that the parameter has changed. Open SQL\_HISTORY [SQL H], select the select \* from V\$parameter command, click Replace, and execute.



The screenshot shows the Oracle SQL Developer interface. At the top, there are tabs for 'Worksheet' and 'Query Builder'. Below them is a code editor containing the SQL query: 'SELECT \* FROM v\$parameter WHERE NAME LIKE '%dynamic%';'. In the bottom panel, there are two tabs: 'Script Output' and 'Query Result'. The 'Query Result' tab is selected and displays a table with one row of data. The table has columns: NUM, NAME, TYPE, VALUE, DISPLAY\_VALUE, DEFAULT\_VALUE, ISDEFAULT, ISSES\_MODIFIABLE, and ISSYS\_MODIF. The data is as follows:

NUM	NAME	TYPE	VALUE	DISPLAY_VALUE	DEFAULT_VALUE	ISDEFAULT	ISSES_MODIFIABLE	ISSYS_MODIF
1	3529 optimizer_dynamic_sampling	30	0	2		TRUE	TRUE	IMMEDIATE

Below the results is a 'SQL History' window. It contains a table with several rows of historical SQL statements. One row is highlighted with a red box around the 'SQL' column. The table has columns: SQL, Connection, TimeStamp, Type, Executed, and Duration(s...). The highlighted row shows the following data:

SQL	Connection	TimeStamp	Type	Executed	Duration(s...)
SELECT * FROM v\$parameter WHERE NAME LIKE '%dynamic%';	ags	08-MAR-1...	SQL	3	0.016
ALTER SESSION SET optimizer_dynamic_sampling = 0;	ags	08-MAR-1...	SQL	2	0.016
select column_name, histogram, num_buckets from user_tab_col...	ags	08-MAR-1...	SQL	1	0.003
file:/home/oracle/labs/solutions/Automatic_Gather_Stats/check...	ags	08-MAR-1...	Script	1	0.0
file:/home/oracle/labs/solutions/Automatic_Gather_Stats/show...	ags	08-MAR-1...	Script	1	0.0
file:/home/oracle/labs/solutions/Optimizer_Statistics/opt_19.sql	sh_connect...	08-MAR-1...	Script	1	0.0
SELECT e.EXTENSION expression, t.NUM_DISTINCT, t.HISTOGRAM...	sh_connect...	08-MAR-1...	SQL	1	2.605
SELECT EXTENSION_NAME, EXTENSION FROM USER_STAT_EXTEN...	sh_connect...	08-MAR-1...	SQL	1	2.527
file:/home/oracle/labs/solutions/Optimizer_Statistics/opt_16.sql	sh_connect...	08-MAR-1...	Script	1	0.0
select * from table(dbms_xplan.display);	sh_connect...	08-MAR-1...	SQL	1	0.143
file:/home/oracle/labs/solutions/Optimizer_Statistics/opt_14.sql	sh_connect...	08-MAR-1...	Script	1	0.0

12. Autotrace both literal9.sql and literal10.sql again. What do you observe and why?

Because dynamic statistics is not used, the optimizer cannot use any real-time statistics. It uses default statistics that are not a good choice for the second statement. The cost is estimated to be the same, but when you compare the actual statistics, you can see the difference.

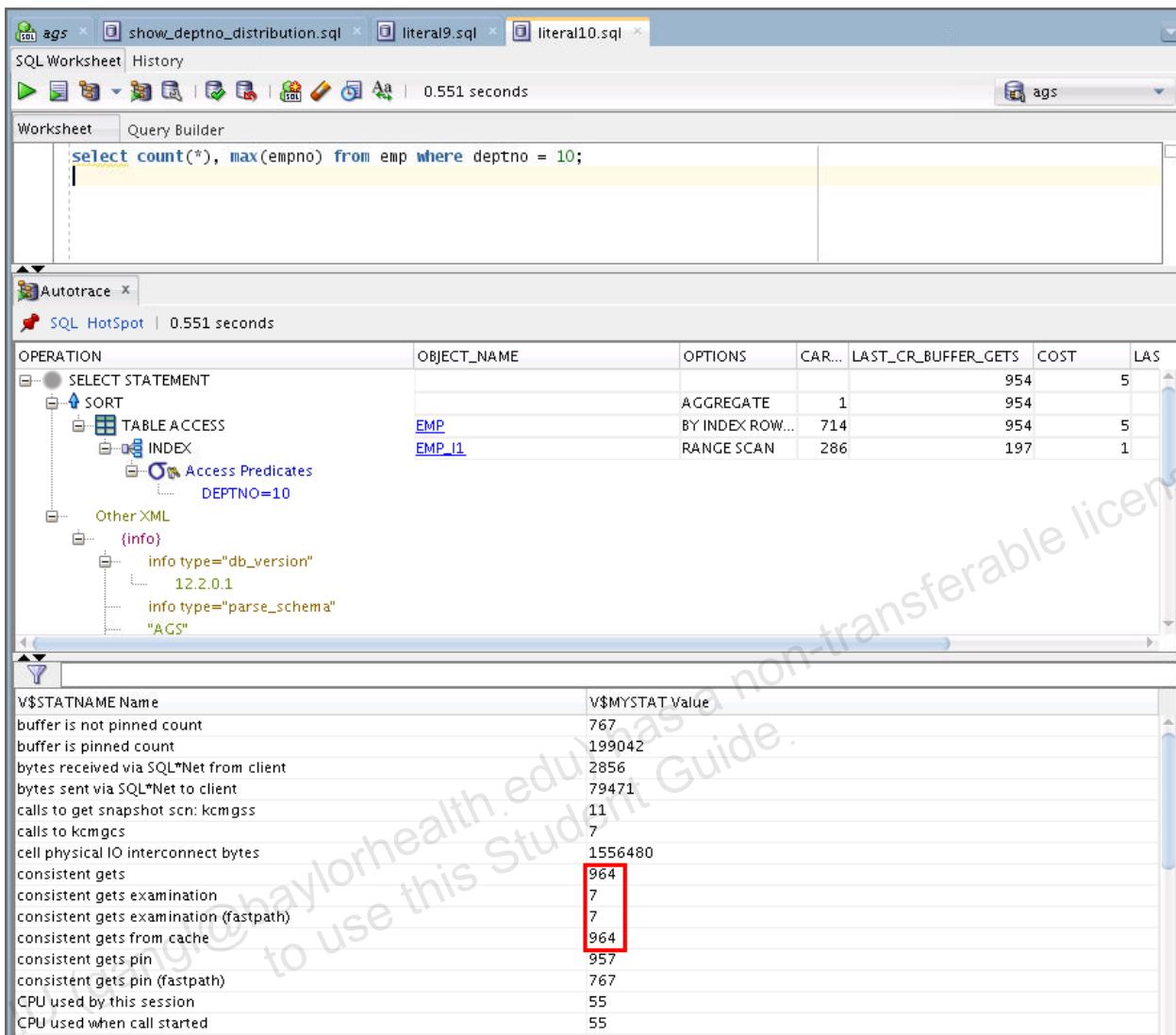
The screenshot shows the Oracle SQL Developer interface. At the top, there are tabs for 'ags', 'show\_deptno\_distribution.sql', 'literal9.sql' (which is the active tab), and 'literal10.sql'. The 'SQL Worksheet' tab is selected, showing the query:

```
select count(*), max(emphno) from emp where deptno = 9;
```

Below the worksheet is the 'Autotrace' section, which includes a 'SQL HotSpot' report. The report details the execution plan for the query, showing a 'SELECT STATEMENT' node with a 'SORT' operation, which further breaks down into 'TABLE ACCESS' and 'INDEX' operations. It also includes 'Access Predicates' like 'DEPTNO=9' and 'Other XML' information. The 'Autotrace' section has a timestamp of '0.12 seconds'.

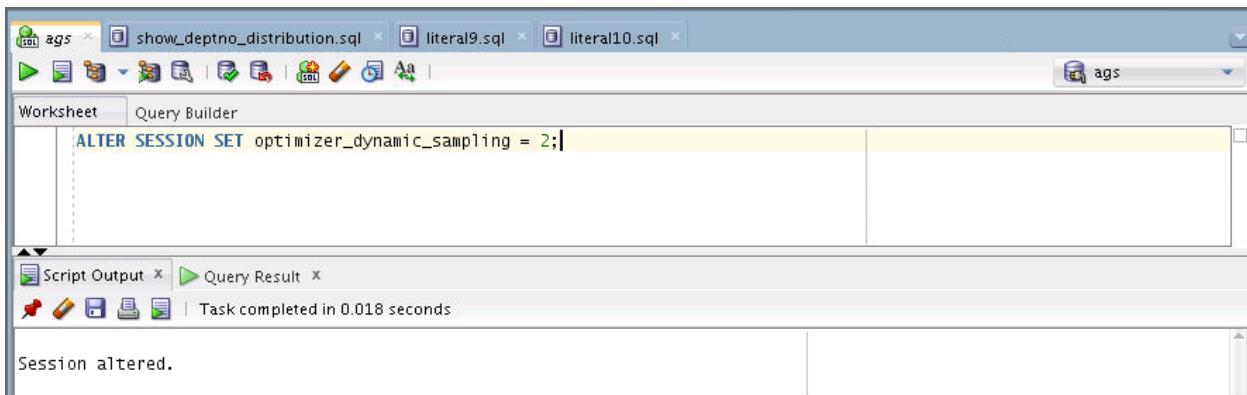
The bottom part of the interface shows the 'V\$STATNAME' view, which lists various Oracle statistics with their current values. Several values are highlighted with red boxes:

V\$STATNAME	Name	V\$MYSTAT Value
consistent gets		45
consistent gets examination		26
consistent gets examination (fastpath)		26
consistent gets from cache		45
consistent gets pin		19
consistent gets pin (fastpath)		19
CPU used by this session		5
CPU used when call started		5



13. Reset dynamic statistics as it was at the beginning of this practice. Use the following command:

```
ALTER session SET optimizer_dynamic_sampling = 2;
```



14. Set the following wrong statistic values for your EMP table:

- Set its number of rows to 10.
  - Set its number of blocks to 5.

Open the set wrong stats.sql file and execute.

The screenshot shows the Oracle SQL Developer interface. The top menu bar has tabs for 'sql' and 'ags'. Below it, the title bar shows three open windows: 'show\_deptno\_distribution.sql', 'set\_wrong\_stats.sql', and 'set\_table\_stats.sql'. The main workspace is titled 'Worksheet' and contains the following PL/SQL code:

```
exec dbms_stats.set_table_stats('AGS','EMP',null,null,null,10,5);
```

Below the worksheet is a 'Script Output' window with the message 'Task completed in 0.073 seconds'. At the bottom, a status bar displays 'PL/SQL procedure successfully completed.'

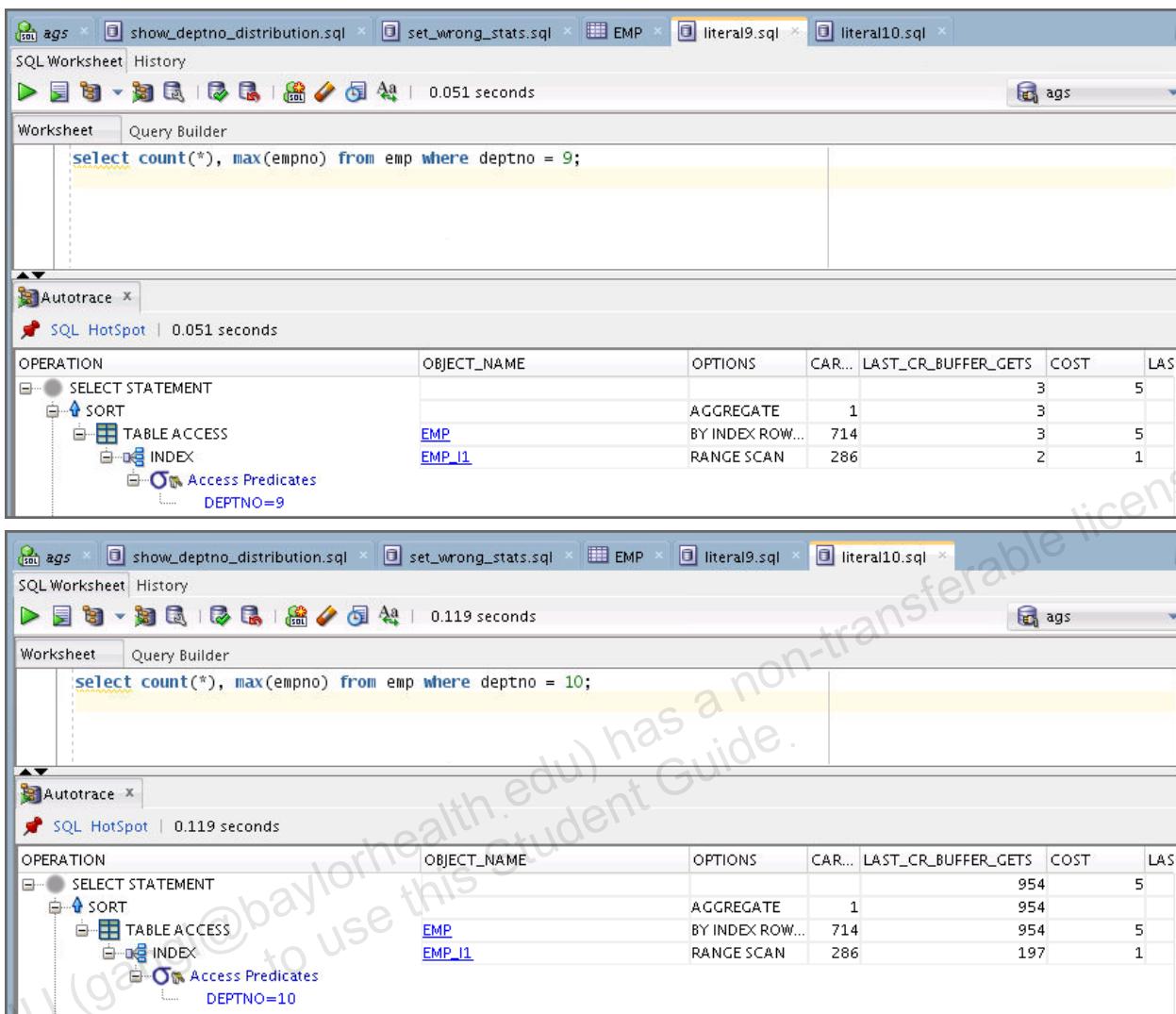
15. Verify that you modified the statistics of the EMP table correctly.

In the navigator pane, select the EMP table under `ags`. On the EMP tab, click the Statistics subtab.

Name	Value
1 NUM_ROWS	10
2 BLOCKS	5
3 AVG_ROW_LEN	100
4 SAMPLE_SIZE	2000
5 LAST_ANALYZED	08-MAR-18
6 LAST_ANALYZED_SINCE	08-MAR-18

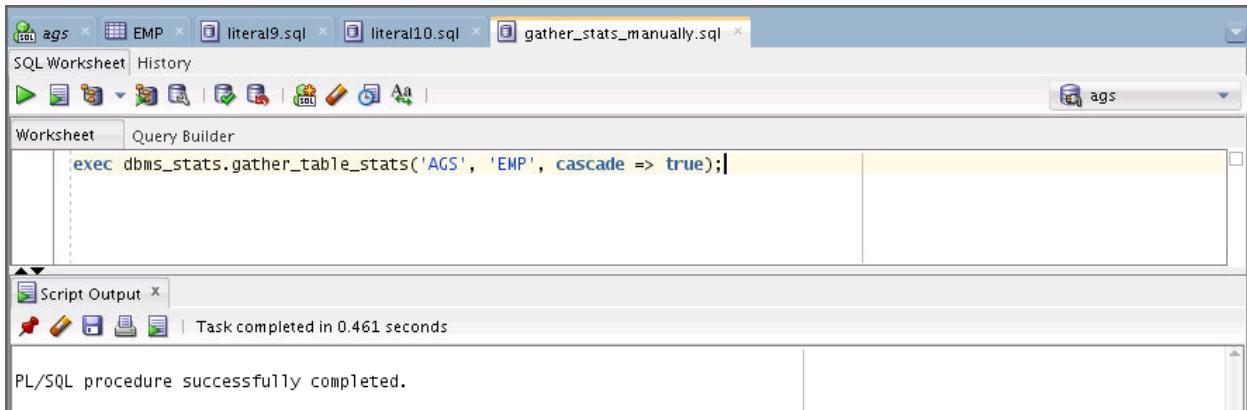
16. Autotrace both literal9.sql and literal10.sql again. What do you observe and why?

Because there are statistics defined on the EMP table, the optimizer uses them, and not dynamic statistics. However, because the statistics are incorrect, the generated plans are also incorrect, at least for the second statement. This is noticeable in the execution time.



17. Make sure that you manually gather statistics on your EMP table and its corresponding index. Enter the following or execute the `gather_stats_manually.sql` script:

```
exec dbms_stats.gather_table_stats('AGS', 'EMP', cascade => true);
```



18. Make sure that statistics were gathered on your objects. Select the EMP table in the navigator pane. Click the Statistics subtab on the EMP tab. Click the Refresh button to ensure that the latest statistics are displayed. Notice that Column Statistics are populated.

The screenshot shows the Oracle Database Navigator interface. The top navigation bar has tabs for 'ags' (selected), 'EMP' (selected), 'literal9.sql', 'literal10.sql', and 'gather\_stats\_manually.sql'. Below the tabs is a toolbar with icons for 'Columns', 'Data', 'Model', 'Constraints', 'Grants', 'Statistics' (which is selected), 'Triggers', 'Flashback', 'Dependencies', 'Details', 'Partitions', 'Indexes', and 'SQL'. The main area displays two tables. The first table, 'Table Statistics', has columns 'Name' and 'Value' and contains the following data:

Name	Value
1 NUM_ROWS	10
2 BLOCKS	5
3 AVG_ROW_LEN	100
4 SAMPLE_SIZE	2000
5 LAST_ANALYZED	08-MAR-18
6 LAST_ANALYZED_SINCE	08-MAR-18

The second table, 'Column Statistics', has columns 'OWNER', 'TABLE\_NAME', 'COLUMN\_NAME', 'NUM\_DISTINCT', 'LOW\_VALUE', and 'HIGH\_VALUE'. It contains the following data:

OWNER	TABLE_NAME	COLUMN_NAME	NUM_DISTINCT	LOW_VALUE	HIGH_VALUE
1 AGS	EMP	EMPNO	100000	C102	C308
2 AGS	EMP	ENAME	100000	414141444946505459554B4C464F4E4A45465348	5A5A5A524E544848434643424A4
3 AGS	EMP	PHONE	100000	414141474D56584C484D4454425A59414D585452	5A5A5A57454A4354524747575959
4 AGS	EMP	DEPTNO	1180		C108

19. Autotrace both literal9.sql and literal10.sql again. What do you observe and why?

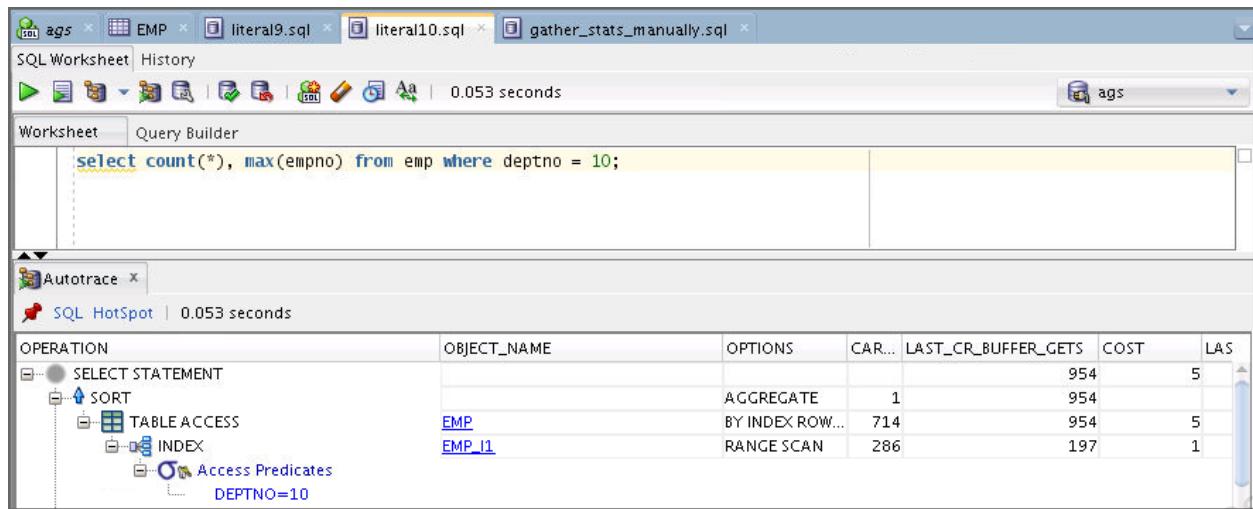
Because statistics were correctly gathered on both objects, the optimizer is able to use the correct execution plans for both statements.

The screenshot shows the Oracle Database SQL Worksheet interface. The top navigation bar has tabs for 'ags' (selected), 'EMP' (selected), 'literal9.sql' (selected), 'literal10.sql', and 'gather\_stats\_manually.sql'. Below the tabs is a toolbar with icons for 'SQL Worksheet' (selected), 'History', and other database operations. The main area has tabs for 'Worksheet' (selected) and 'Query Builder'. A SQL statement is entered in the worksheet:

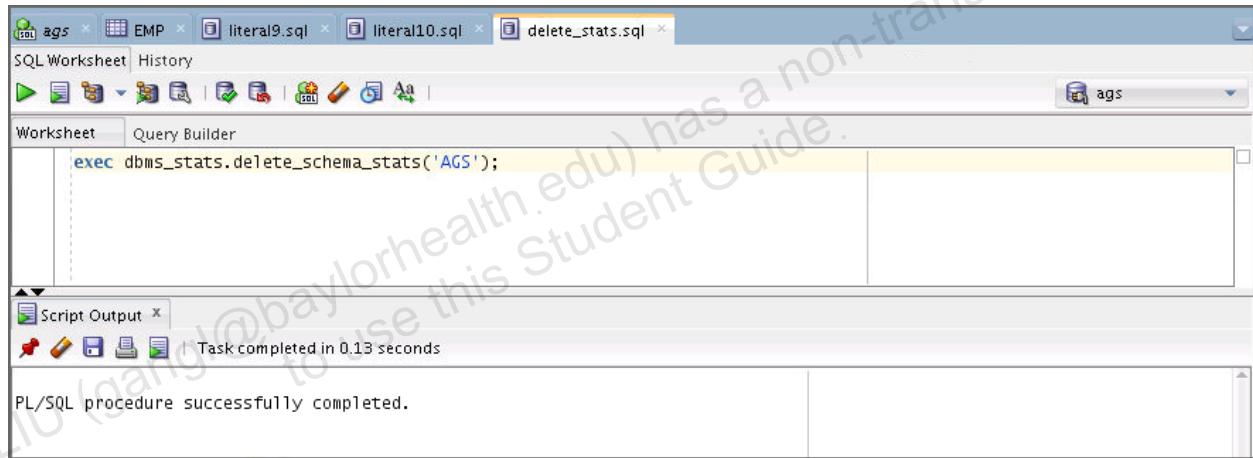
```
select count(*), max(empno) from emp where deptno = 9;
```

Below the worksheet is an 'Autotrace' window titled 'SQL HotSpot | 0.051 seconds'. It displays the execution plan for the query:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	LAST_CR_BUFFER_GETS	COST	LAS
SELECT STATEMENT					3	5
SORT		AGGREGATE	1		3	
TABLE ACCESS	EMP	BY INDEX ROW...	714		3	5
INDEX	EMP_I1	RANGE SCAN	286		2	1
Access Predicates DEPTNO=9						



20. Delete all the statistics that were previously generated on the EMP tab and the EMP\_I1 index. Open and execute the `delete_stats.sql` script.



21. Verify that you no longer have statistics gathered on both objects.

- In the navigator pane, select the EMP table and click the Statistics subtab on the EMP tab, and refresh.

The screenshot shows the Oracle SQL Developer interface. The top menu bar has tabs for 'Columns', 'Data', 'Model', 'Constraints', 'Grants', 'Statistics' (which is highlighted in blue), 'Triggers', 'Flashback', 'Dependencies', 'Details', 'Partitions', 'Indexes', and 'SQL'. Below the menu is a toolbar with icons for 'New', 'Edit', 'Run', and 'Actions...'. The main area displays a table titled 'Statistics' with two columns: 'Name' and 'Value'. The table contains six rows, all of which have '(null)' in the 'Value' column. At the bottom of the main area, there is a section titled 'Column Statistics' with a 'Refresh: 0' button and a row of icons representing various statistical metrics: OWNER, TABLE\_N..., COLUMN..., NUM\_DIS..., LOW\_VALUE, HIGH\_VALUE, DENSITY, NUM\_NU..., NUM\_BU..., LAST\_AN..., and SAMPLE....

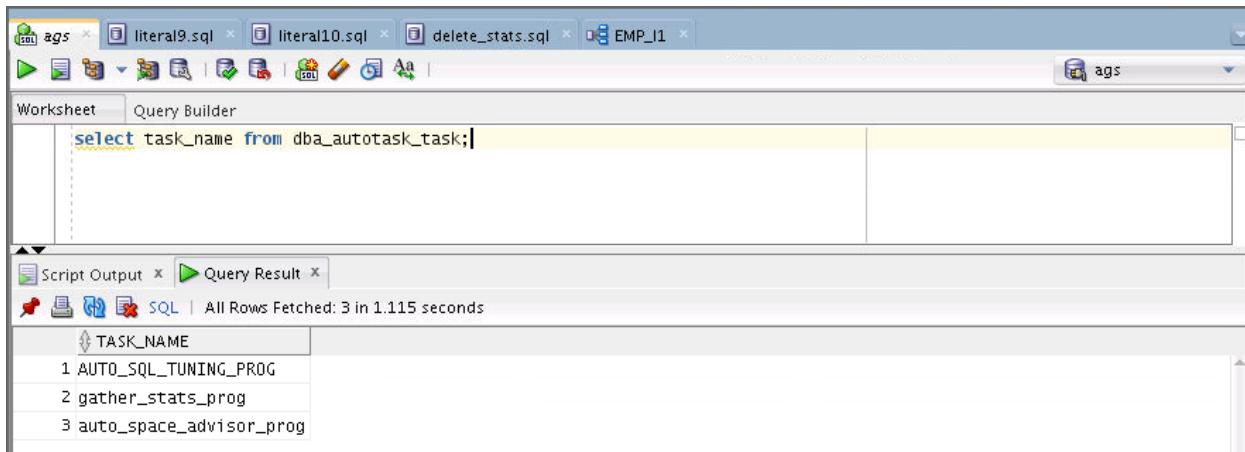
Name	Value
1 NUM_ROWS	(null)
2 BLOCKS	(null)
3 AVG_ROW_LEN	(null)
4 SAMPLE_SIZE	(null)
5 LAST_ANALYZED	(null)
6 LAST_ANALYZED_SINCE	(null)

- b. In the navigator pane, select the `EMP_I1` index, click the Statistics subtab on the `EMPI1` tab, and refresh.

Name	Value
1 OWNER	AGS
2 INDEX_NAME	EMP_I1
3 TABLE_OWNER	AGS
4 TABLE_NAME	EMP
5 PARTITION_NAME	(null)
6 PARTITION_POSITION	(null)
7 SUBPARTITION_NAME	(null)
8 SUBPARTITION_POSITION	(null)
9 OBJECT_TYPE	INDEX
10 BLEVEL	(null)
11 LEAF_BLOCKS	(null)
12 DISTINCT_KEYS	(null)
13 AVG_LEAF_BLOCKS_PER_KEY	(null)
14 AVG_DATA_BLOCKS_PER_KEY	(null)
15 CLUSTERING_FACTOR	(null)
16 NUM_ROWS	(null)
17 AVG_CACHED_BLOCKS	(null)
18 AVG_CACHE_HIT_RATIO	(null)
19 SAMPLE_SIZE	(null)
20 LAST_ANALYZED	(null)
21 GLOBAL_STATS	NO
22 USER_STATS	NO
23 STATTYPE_LOCKED	(null)
24 STALE_STATS	(null)
25 SCOPE	SHARED

22. How would you determine the list of automated tasks that exist on your database?
- You can use Enterprise Manager Database Control by navigating to the Automated Maintenance Tasks page (Home > Targets > Databases > orcl > Administration > Oracle Scheduler > Automated Maintenance Tasks). On the Automated Maintenance Tasks page, you can see the three automated tasks implemented by default on your database.
  - Another possibility is to use the `DBA_AUTOTASK_TASK` table as shown by the following statement:

```
select task_name from dba_autotask_task;
```



23. You now want to observe the effects of the automatic statistics gathering feature of your database. However, you do not want to wait until the database automatically opens the next maintenance window. Run the following command from the terminal as the `sys` user:

```
alter system set "_enable_automatic_maintenance"=1;
```

```
[oracle@... Automatic_Gather_Stats]$ sqlplus / as sysdba
SQL*Plus: Release 12.2.0.1.0 Production on Wed Apr 18 09:43:39 2018
Copyright (c) 1982, 2016, Oracle. All rights reserved.

Connected to:
Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 - 64bit Production
SQL> alter system set "_enable_automatic_maintenance"=1;
System altered.

SQL> ■
```

24. From SQL Developer, open and execute the `run_ags_pl.sql` script. This script forces the execution of the automatic statistics gathering task.
- If you do not already have a `sys_connection`, create a connection as the `sysdba` user.

Name: `sys_connection`  
Username: `sys`  
Password: `oracle_4U`  
Role: `sysdba`  
Service Name: `orclpdb`
  - Test and save the connection.
  - Open the `run_ags_pl.sql` file.

- d. Open the Dbms Output pane (View > Dbms Output) and click the green plus sign to connect to sys\_connection.

The screenshot shows the Oracle SQL Developer interface. In the top navigation bar, there are tabs for 'Start Page' and 'run\_ags\_pl.sql'. Below the tabs, the 'Worksheet' tab is selected. The main workspace contains the following PL/SQL code:

```

Set SERVEROUTPUT ON;

DECLARE
  WINDOW VARCHAR2 (20);
BEGIN
  DBMS_WORKLOAD_REPOSITORY.CREATE_SNAPSHOT;

  SELECT UPPER(TO_CHAR(SYSDATE,'fmday'))||'_WINDOW' INTO WINDOW FROM DUAL;
  DBMS_OUTPUT.PUT_LINE('Window is: '||WINDOW);

  -- Open the corresponding maintenance window, but with other clients disabled
  --

  dbms_auto_task_admin.enable;
  dbms_auto_task_admin.disable('auto space advisor', null, window);
  dbms_auto_task_admin.disable('sql tuning advisor', null, window);

  dbms_scheduler.open_window(window, null, true);

  -- Close the maintenance window when auto optimizer stats collection is done
  DBMS_LOCK.SLEEP(120);

  dbms_scheduler.close_window(window);

  --
  -- Re-enable the other guys so they look like they are enabled in EM.
  -- Still they will be disabled because we have set the underscore.
  dbms_auto_task_admin.enable('auto space advisor', null, window);
  dbms_auto_task_admin.enable('sql tuning advisor', null, window);

end;
  
```

Below the worksheet, the 'Dbms Output' pane is visible, showing a connection named 'sys\_connection'. A watermark across the entire screenshot reads: 'ANG VIU (gangl@baylorhealth.edu) has a non-transferable license to use this Student Guide.'

- e. Execute the run\_ags\_pl.sql script as the sys user. Use the sys\_connection connection. This script takes two minutes to run.

The screenshot shows the Oracle SQL Developer interface. In the top navigation bar, there are tabs for 'Start Page' and 'run\_ags\_pl.sql'. Below the tabs, there are icons for 'SQL Worksheet' (selected), 'History', and other connection management tools. The status bar at the bottom indicates '124.11399841 seconds' and shows a connection to 'sys\_connection'.

The main area consists of three panes:

- Worksheet**: This pane contains the PL/SQL code being run:

```
Set SERVEROUTPUT ON
DECLARE
  WINDOW VARCHAR2 (20);
BEGIN
  DBMS_WORKLOAD_REPOSITORY.CREATE_SNAPSHOT;

  SELECT UPPER(TO_CHAR(SYSDATE,'fmday'))||'_WINDOW' INTO WINDOW FROM DUAL;
  DBMS_OUTPUT.PUT_LINE('Window is: '|| WINDOW);

  -- Open the corresponding maintenance window, but with other clients disabled
  --

  dbms_auto_task_admin.enable;
  dbms_auto_task_admin.disable('auto space advisor', null, window);
  dbms_auto_task_admin.disable('sql tuning advisor', null, window);
```
- Script Output**: This pane displays the execution results:

```
Task completed in 124.114 seconds
Window is: WEDNESDAY_WINDOW
PL/SQL procedure successfully completed.
```
- Dbms Output**: This pane also displays the results:

```
Buffer Size: 20000
sys_connection *
Window is: WEDNESDAY_WINDOW
```

- f. Close the Dbms Output pane.

25. Navigate to the EMP table and view the statistics. Be sure to refresh the view. What do you observe and why?

The statistics were automatically gathered by the database during the maintenance window. You can also see this directly from the Automated Maintenance Tasks page in Enterprise Manager. The important thing is that the database automatically gathered the right statistics and histograms. Depending on your environment, you may see different sample sizes.

The screenshot shows the Oracle Database Statistics View interface. At the top, there are tabs for Columns, Data, Model, Constraints, Grants, Statistics, Triggers, Flashback, Dependencies, Details, Partitions, Indexes, and SQL. The Statistics tab is selected. Below the tabs is a toolbar with icons for Refresh, Create, Edit, and Actions... A table displays various statistics for the EMP table:

Name	Value
1 NUM_ROWS	100000
2 BLOCKS	874
3 AVG_ROW_LEN	50
4 SAMPLE_SIZE	100000
5 LAST_ANALYZED	08-MAR-18
6 LAST_ANALYZED_SINCE	08-MAR-18

Below this is a section titled "Column Statistics" with a "Refresh: 0" button. It contains a table with four rows of column statistics for the EMP table:

OWNER	TABLE_NAME	COLUMN_NAME	NUM_DISTINCT	LOW_VALUE	HIGH_VALUE
1 AGS	EMP	EMPNO	100000	C102	C30B
2 AGS	EMP	ENAME	100000	414141444946505459554B4C464F4E4A45465348	5A5A5A524E544848434643424A4
3 AGS	EMP	PHONE	100000	414141474D56584C484D4454425A59414D585452	5A5A5A57454A435452474757595
4 AGS	EMP	DEPTNO	1180		C10B

26. Autotrace literal9.sql and literal10.sql again. What do you observe and why?

The optimizer can make the right decisions for both statements. This is because of the statistics that were automatically gathered by the database previously.

The screenshot shows two separate sessions in Oracle SQL Developer. Each session has a worksheet tab, a toolbar, and an Autotrace tab.

**Session 1 (Top):**

- Worksheet tab: `select count(*), max(empno) from emp where deptno = 9;`
- Autotrace tab (SQL HotSpot): 0.051 seconds
- Autotrace Results:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	LAST_CR_BUFFER_GETS	COST	LAS
SELECT STATEMENT					3	5
SORT		AGGREGATE	1		3	
TABLE ACCESS	EMP	BY INDEX ROW...	714		3	5
INDEX	EMP_I1	RANGE SCAN	286		2	1
Access Predicates: DEPTNO=9						

**Session 2 (Bottom):**

- Worksheet tab: `select count(*), max(empno) from emp where deptno = 10;`
- Autotrace tab (SQL HotSpot): 0.078 seconds
- Autotrace Results:

OPERATION	OBJECT_NAME	OPTIONS	CAR...	LAST_CR_BUFFER_GETS	COST	LAS
SELECT STATEMENT					954	5
SORT		AGGREGATE	1		954	
TABLE ACCESS	EMP	BY INDEX ROW...	714		954	5
INDEX	EMP_I1	RANGE SCAN	286		197	1
Access Predicates: DEPTNO=10						

27. Close the `ags` connection and the file tabs in SQL Developer.
28. From your terminal window, clean up your environment by executing the `ags_cleanup.sh` script.

```
$ ./ags_cleanup.sh
...
SQL>
SQL> alter system set "_enable_automatic_maintenance"=1;
System altered.

SQL>
SQL> exit;
Disconnected ...
$
```

## Practice 11- 4: Using System Statistics (Optional)

### Overview

In this practice, you manipulate system statistics and show that they are important for the optimizer to select the correct execution plans. All the scripts used in this practice are located in the \$HOME/labs/solutions/System\_Stats directory.

### Tasks

1. The sysstats\_setup.sh script located in your \$HOME/labs/solutions/System\_Stats directory was run as part of the class setup. This script creates a user called JFV and some tables that are used throughout this practice. The script also makes sure that object statistics are correctly gathered. The script is listed as follows:

```
#!/bin/bash

cd /home/oracle/labs/solutions/System_Stats

sqlplus / as sysdba @sysstats_setup.sql

-----
set echo on

connect sys/oracle_4U as sysdba;
alter session set container = orclpdb;
drop user jfv cascade;

create user jfv identified by jfv default tablespace users temporary
tablespace temp;

grant connect, resource, dba to jfv;

connect jfv/jfv@orclpdb

drop table t purge;

drop table z purge;

create table t(c number);

insert into t values (1);
```



2. In a terminal window, execute the `sysstats_start.sh` script to flush the caches, and set `CPUSPEEDNW` to 0 in the system statistics.

```
$ cd /home/oracle/labs/solutions/System_Stats
$ ./sysstats_start.sh

...
SQL> alter session set container = orclpdb;
Session altered.

SQL>
SQL> alter system flush shared_pool;

System altered.

SQL>
SQL> alter system flush buffer_cache;

System altered.

SQL>
SQL> execute dbms_stats.delete_system_stats;

PL/SQL procedure successfully completed.

SQL>
SQL> execute DBMS_STATS.SET_SYSTEM_STATS (pname => 'cpuspeednw',
pvalue => 0);

PL/SQL procedure successfully completed.

SQL>
SQL> select sname,pname,pval1 from aux_stats$;

SNAME          PNAME          PVAL1
-----
SYSSTATS_INFO   STATUS
SYSSTATS_INFO   DSTART
SYSSTATS_INFO   DSTOP
SYSSTATS_INFO   FLAGS           1
SYSSTATS_MAIN   CPUSPEEDNW    0
SYSSTATS_MAIN   IOSEEKTIM      10
SYSSTATS_MAIN   IOTFRSPEED     4096
SYSSTATS_MAIN   SREADTIM
SYSSTATS_MAIN   MREADTIM
SYSSTATS_MAIN   CPUSPEED
```

```

SYSSTATS_MAIN MBRC

SNAME          PNAME
PVAL1

-----
SYSSTATS_MAIN MAXTHR
SYSSTATS_MAIN SLAVETHR

13 rows selected.

SQL>
SQL> exit;
...
$
```

3. From your terminal session, connect as the JFV user in a SQL\*Plus session. Then execute the `select_without_sysstats.sql` script, which contains the following statement, and determine how long it takes to execute:

```

select /* Without system stats */ count(*)
from t,z
where t.c=z.d;

$ sqlplus jfv/jfv@orclpdb

...
SQL> @select_without_sysstats
SQL>
SQL> set timing on
SQL>
SQL> select /* Without system stats */ count(*)
2   from t,z
3   where t.c=z.d;

COUNT(*)
-----
524288

Elapsed: 00:00:00.23
SQL>
SQL> set timing off
SQL>
SQL>
```

4. Determine the execution plan that was used to execute the previous statement. In addition, determine the optimizer's cost, CPU cost, and I/O cost for the previous execution. Use the `show_latest_exec_plan.sql` script. What do you observe?

The optimizer does not use CPU costing. This is because system statistics were deleted during the first step of this practice. The plan chosen by the optimizer might not be the best one.

```
SQL> @show_latest_exec_plan
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor);

PLAN_TABLE_OUTPUT
-----
-----
SQL_ID  6avdu58tamzju, child number 0
-----
select /* Without system stats */ count(*) from t,z where t.c=z.d
Plan hash value: 3698032250

-----
| Id  | Operation          | Name | Rows  | Bytes | Cost |
-----
|   0 | SELECT STATEMENT   |       |        |        | 134  | |
|   1 |   SORT AGGREGATE    |       |     1  |    6  |       |
|   2 |   NESTED LOOPS      |       | 524K  | 3072K | 134  |
|   3 |     TABLE ACCESS FULL| T    | 524K  | 1536K | 134  |
|*  4 |     INDEX UNIQUE SCAN| IZ  |       |     1  |    3  |       |

PLAN_TABLE_OUTPUT
-----
-----
Predicate Information (identified by operation id):
-----
4 - access("T"."C"="Z"."D")

Note

PLAN_TABLE_OUTPUT
-----
-----
- cpu costing is off (consider enabling it)
```

```

25 rows selected.

SQL>
SQL> col operations      format a20
SQL> col object_name format a11
SQL> col options format a15
SQL> col cost_cpu_io format a30
SQL>
SQL>
SQL> select operation operations, object_name, options,
2          cost||' -- '||cpu_cost||' -- '||io_cost cost_cpu_io
3  from (select * from v$sql_plan where address in (select address
4                                         from v$sql
5                                         where sql_text like
'%system stats%' and
6                                         sql_text not like
'%connect%'));

OPERATIONS      OBJECT_NAME OPTIONS      COST_CPU_IO
-----
-----
SELECT STATEMENT           134  --  --
SORT                  AGGREGATE   --  --
NESTED LOOPS            134  --  -- 134
TABLE ACCESS             T          FULL      134  --  -- 134
INDEX                 IZ         UNIQUE SCAN   --  --
SQL>
SQL>
```

5. How can you ensure that the optimizer finds a better plan during future executions of the same statement? Implement your solution.

Gather system statistics again. Because you do not have a real workload yet, you can gather system statistics in NOWORKLOAD mode.

```

SQL> connect / as sysdba;
Connected.
SQL> alter session set container = orclpdb;
Session altered.
SQL> @gather_system_stats
SQL> set echo on
SQL>
SQL> execute DBMS_STATS.GATHER_SYSTEM_STATS(gathering_mode =>
'NOWORKLOAD');

PL/SQL procedure successfully completed.
```

```

SQL>
SQL> select sname, pname, pval1 from aux_stats$;

SNAME                      PNAME          PVAL1
-----
SYSSTATS_INFO               STATUS
SYSSTATS_INFO               DSTART
SYSSTATS_INFO               DSTOP
SYSSTATS_INFO               FLAGS           1
SYSSTATS_MAIN               CPUSPEEDNW    1882.885
SYSSTATS_MAIN               IOSEEKTIM     10.506
SYSSTATS_MAIN               IOTFRSPEED    4096
SYSSTATS_MAIN               SREADTIM
SYSSTATS_MAIN               MREADTIM
SYSSTATS_MAIN               CPUSPEED
SYSSTATS_MAIN               MBRC

SNAME                      PNAME
PVAL1

SYSSTATS_MAIN               MAXTHR
SYSSTATS_MAIN               SLAVETHR

13 rows selected.

SQL>

```

6. Before verifying your solution, you should flush the System Global Area (SGA) pools, such as the shared pool and the buffer cache. This is done to prevent the already loaded buffers or SQL plans from affecting the results.

```

SQL> @flush_sga
SQL>
SQL> set echo on
SQL>
SQL> alter system flush shared_pool;

System altered.

SQL>
SQL> alter system flush buffer_cache;

System altered.

SQL>
SQL>

```

7. Connected as the JFV user again, check your solution against the following query in the select\_with\_sysstats.sql script:

```
select /* With system stats */ count(*)
from t,z
where t.c=z.d;
```

What do you observe?

The optimizer can make a better decision because it was able to use meaningful system statistics. You can see that the execution time is now half the value it was previously, and the execution plan now includes CPU costing information.

```
SQL> connect jfv/jfv@orclpdb
Connected.
SQL> @select_with_sysstats
SQL> set timing on
SQL>
SQL> select /* With system stats */ count(*)
  2  from t,z
  3  where t.c=z.d;

  COUNT(*)
-----
      524288

Elapsed: 00:00:00.11
SQL>
SQL> set timing off
SQL>
SQL>
SQL> @show_latest_exec_plan
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor);

PLAN_TABLE_OUTPUT
-----
SQL_ID  2x55txn3742by, child number 0
-----
select /* With system stats */ count(*) from t,z where t.c=z.d

Plan hash value: 2407521827

-----
| Id  | Operation          | Name   | Rows  | Bytes | Cost (%CPU) | Time
|    |                    |        |       |       |            |
```

```

-----
|   0 | SELECT STATEMENT      |           |       |       | 123 (100) |   |
|   1 |   SORT AGGREGATE      |           |   1 |   6 |           |   |
-----
```

PLAN\_TABLE\_OUTPUT

```

-----
|* 2 | HASH JOIN            |           | 524K| 3072K| 123 (3) |
00:00:01 |
| 3 | INDEX FULL SCAN      | IZ        | 100 | 300 | 1 (0)  |
00:00:01 |
| 4 | TABLE ACCESS FULL    | T         | 524K| 1536K| 121 (2) |
00:00:01 |
-----
```

Predicate Information (identified by operation id):

```

2 - access("T"."C"="Z"."D")
```

21 rows selected.

SQL>

SQL> col operations format a20

SQL> col object\_name format a11

SQL> col options format a15

SQL> col cost\_cpu\_io format a30

SQL>

SQL>

SQL> select operation operations, object\_name, options,

2 cost||' -- '||cpu\_cost||' -- '||io\_cost cost\_cpu\_io

3 from (select \* from v\$sql\_plan where address in (select address

4 from v\$sql

5 where sql\_text like

'%system stats%' and

6 sql\_text not like

'%connect%'));

OPERATIONS	OBJECT_NAME	OPTIONS	COST_CPU_IO
SELECT STATEMENT			123 -- --
SORT		AGGREGATE	-- --
HASH JOIN			123 -- 137938260 -- 120
INDEX	IZ	FULL SCAN	1 -- 27121 -- 1

TABLE ACCESS	T	FULL	121 -- 84867339 -- 119
SQL>			

8. Exit your SQL\*Plus session and clean up your environment for this practice by executing the `sysstats_cleanup.sh` script.

```
SQL> exit  
  
...  
  
$ ./sysstats_cleanup.sh  
  
...  
SQL> alter session set container = orclpdb;  
  
Session altered.  
SQL>  
SQL> drop user jfv cascade;  
  
User dropped.  
  
SQL>  
SQL> alter system flush shared_pool;  
  
System altered.  
SQL>  
SQL> exit;
```

## **Practices for Lesson 12: Using Bind Variables**

## Practices for Lesson 12: Overview

---

### Practices Overview

In these practices, you examine the behavior of adaptive cursor sharing and the effect of various settings of the `CURSOR_SHARING` parameter on execution plans.

## Practice 12-1: Using Adaptive Cursor Sharing

### Overview

In this practice, you experiment with bind variable peeking and adaptive cursor sharing.

### Tasks

1. The `acs_setup.sh` script was executed as part of the class setup to set up the environment used for this practice. This script is in your `$HOME/labs/solutions/Adaptive_Cursor_Sharing` directory and is listed as follows:

```
#!/bin/bash

cd /home/oracle/labs/solutions/Adaptive_Cursor_Sharing

sqlplus / as sysdba @acs_setup.sql
-----
set echo on
alter session set container = orclpdb;
drop user acs cascade;

create user acs identified by acs default tablespace users temporary
tablespace temp;

grant dba, connect to acs;

connect acs/acs@orclpdb

drop table emp purge;

create table emp
(
empno    number,
ename     varchar2(20),
phone    varchar2(20),
deptno   number
);

insert into emp
with tdata as
(select rownum empno
from all_objects
where rownum <= 1000)
select rownum,
dbms_random.string ('u', 20),
```

```

dbms_random.string ('u', 20),
case
    when rownum/100000 <= 0.001 then mod(rownum, 10)
    else 10
end
from tdata a, tdata b
where rownum <= 100000;

create index emp_il on emp(deptno);

exec dbms_stats.gather_table_stats(null, 'EMP', METHOD_OPT => 'FOR
COLUMNS DEPTNO SIZE 10', CASCADE => TRUE);

alter system flush shared_pool;
exit;

```

2. Change directories to \$HOME/labs/solutions/Adaptive\_Cursor\_Sharing. In your terminal session, connect to the SQL\*Plus session as the ACS user. Ensure that you stay connected to the same SQL\*Plus session until the end of this practice. After you are connected, identify the columns of the EMP table that have histograms. Flush the shared pool before you start.

Only the DEPTNO column has a 10-buckets histogram.

```

$ cd $HOME/labs/solutions/Adaptive_Cursor_Sharing
$ sqlplus acs/acs@orclpdb
...
SQL> alter system flush shared_pool;

System altered.

SQL> @check_emp_histogram
SQL>
SQL> select column_name, histogram, num_buckets
  2  from user_tab_columns
  3  where table_name='EMP';

COLUMN_NAME          HISTOGRAM      NUM_BUCKETS
-----  -----
EMPNO                NONE
ENAME                NONE
PHONE               NONE
DEPTNO              TOP-FREQUENCY      10

SQL>

```

3. Determine the distribution of all the distinct values found in the DEPTNO column of the EMP table. What do you find?

Values distribution is uniform for all (0.01%), except for value 10 (99.9%). This is typical of what is called data skew.

```
SQL> @show_deptno_distribution
SQL> set echo on
SQL>
SQL> select deptno, count(*) cnt_per_deptno, (count(*)*100)/nr
deptno_percent
  2  from emp, (select max(empno) nr
  3            from emp)
  4  group by deptno, nr
  5  order by deptno;

DEPTNO CNT_PER_DEPTNO DEPTNO_PERCENT
-----
      0          10        .01
      1          10        .01
      2          10        .01
      3          10        .01
      4          10        .01
      5          10        .01
      6          10        .01
      7          10        .01
      8          10        .01
      9          10        .01
     10         99900      99.9

11 rows selected.
```

4. Before you study the adaptive cursor-sharing feature, disable its functionality by setting the OPTIMIZER\_FEATURES\_ENABLE session parameter back to 10.2.0.1. After this is done, ensure that you execute the following command in your SQL\*Plus session: set lines 200 pages 10000. This is used in the practice to print the execution plans correctly.

```
SQL> alter session set optimizer_features_enable="10.2.0.1";
Session altered.

SQL> set lines 200 pages 10000
SQL>
```

5. Determine the execution plan for the following statement:

```
select /*ACS_L9*/ count(*), max(empno)
from emp
where deptno = 9;
```

This statement is in the `select_deptno_literal_9.sql` file.

What do you notice and why?

The optimizer uses an index range scan because value 9 is very selective.

```
SQL> @select_deptno_literal_9
SQL> set echo on
SQL>
SQL> select /*ACS_L9*/ count(*), max(empno)
  2  from emp
  3  where deptno = 9;

  COUNT(*)  MAX(EMPNO)
  -----
    10          99

SQL>
SQL> @show_latest_exec_plan.sql
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL
+PEEKED_BINDS'));

PLAN_TABLE_OUTPUT
-----
-----
-----
```

SQL\_ID 64ngy4j55d1z5, child number 0

```
-----
select /*ACS_L9*/ count(*), max(empno) from emp where deptno = 9
Plan hash value: 3184478295
```

```
-----
| Id  | Operation           | Name   | Rows  | Bytes | Cost
(%CPU) | Time      |
-----
|   0 | SELECT STATEMENT  |        |       |       | 2
(100) |           |
|   1 |  SORT AGGREGATE   |        |       | 1   | 16  |
|       |           |
|   2 | TABLE ACCESS BY INDEX ROWID| EMP    | 10   | 160  | 2
(0) | 00:00:01 |
```

```

| * 3 |      INDEX RANGE SCAN      | EMP_I1 |    10 |      |    1
(0) | 00:00:01 |
-----
-----
Predicate Information (identified by operation id):
-----
3 - access ("DEPTNO"=9)

20 rows selected.

SQL>

```

6. Determine the execution plan for the following statement:

```

select /*ACS_L10*/ count(*), max(empno)
from emp
where deptno = 10;

```

This statement is in the `select_deptno_literal_10.sql` file.

What do you notice and why?

The optimizer uses a full table scan because value 10 is not a selective value.

```

SQL> @select_deptno_literal_10
SQL> set echo on
SQL>
SQL> select /*ACS_L10*/ count(*), max(empno)
  2  from emp
  3 where deptno = 10;

COUNT(*)  MAX(EMPNO)
-----
99900      100000

SQL>
SQL> @show_latest_exec_plan
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL
+PEEKED_BINDS'));

PLAN_TABLE_OUTPUT
-----
-----
-----
SQL_ID  3232j5gkp2u5h, child number 0

```

```

-----+
select /*ACS_L10*/ count(*), max(empno) from emp where deptno = 10

Plan hash value: 2083865914

-----
| Id  | Operation          | Name | Rows  | Bytes | Cost (%CPU) | Time
|
-----+
|   0 | SELECT STATEMENT   |      |       |       | 120 (100) | 
|   1 |  SORT AGGREGATE    |      | 1     | 16   |           | 
|*  2 |   TABLE ACCESS FULL| EMP  | 99900 | 1560K| 120   (1) |
00:00:02 |

-----
| Predicate Information (identified by operation id): |
|* 2 - filter("DEPTNO"=10)

19 rows selected.
SQL>

```

7. Define a bind variable called DEPTNO in your SQL\*Plus session, set it to value 9, execute the following query, and determine its execution plan:

```

select /*ACS_1*/ count(*), max(empno)
from emp
where deptno = :deptno;

```

This statement is in the `select_deptno_bind.sql` file.

What do you notice and why?

Because the optimizer uses bind peeking the first time you execute a statement with a bind variable and because, for this first execution, value 9 is used, the execution plan with index access is used.

```

SQL> variable deptno number;
SQL> exec :deptno := 9

PL/SQL procedure successfully completed.

SQL> @select_deptno_bind
SQL> set echo on
SQL>

```

```

SQL> select /*ACS_1*/ count(*), max(empno)
  2  from emp
  3  where deptno = :deptno;

      COUNT(*)  MAX(EMPNO)
-----
          10          99

SQL>
SQL> @show_latest_exec_plan
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL
+PEEKED_BINDS'));

PLAN_TABLE_OUTPUT
-----
-----
-----
SQL_ID  272gr4hapc9w1, child number 0
-----
select /*ACS_1*/ count(*), max(empno) from emp where deptno = :deptno

Plan hash value: 3184478295

-----
| Id  | Operation           | Name   | Rows  | Bytes | Cost |
| (%CPU)| Time     |        |        |       |       |       |
-----
|   0 | SELECT STATEMENT  |        |        |       |       | 2    |
| (100)|          |        |        |       |       |       |
|   1 |  SORT AGGREGATE   |        |        |       | 16   |       |
|       |        |        |        |       |       |       |
|   2 |   TABLE ACCESS BY INDEX ROWID| EMP    | 10   | 160  | 2    |
| (0)| 00:00:01  |        |        |       |       |       |
|*  3 |   INDEX RANGE SCAN | EMP_I1 | 10   |       |       | 1    |
| (0)| 00:00:01  |        |        |       |       |       |

Peeked Binds (identified by position):
-----
1 - :DEPTNO (NUMBER): 9

Predicate Information (identified by operation id):
-----

```

```

3 - access ("DEPTNO"=:DEPTNO)

25 rows selected.

SQL>
SQL>
```

8. Determine the execution statistics in terms of child cursors, executions, and buffer gets for the previously executed statement. What do you observe?

In V\$SQL, only one child cursor exists, and it has been executed only once (first time ever in this case). Also, the number of buffer gets is small due to the efficient access path that was used.

```

SQL> @show_latest_exec_stats
SQL> set echo on
SQL>
SQL> select child_number, executions, buffer_gets
2   from v$sql
3  where sql_text like 'select /*ACS_1%';

CHILD_NUMBER EXECUTIONS BUFFER_GETS
-----
0             1                 3

SQL>
```

9. Perform steps 7 and 8 again, but this time using 10 as the bind value for DEPTNO. What do you observe and why?

The execution plan is identical. The index path is used, although value 10 is not selective. This is because bind peeking operates only the first time you execute your statement. Notice that the PEEK\_BIND value is still 9. Looking at V\$SQL, you can clearly see that there is still only one child cursor associated with your statement. However, this time, the number of buffer gets was raised significantly due to the number of accesses required to retrieve all the rows from first the index, and then the table.

```

SQL> exec :deptno := 10

PL/SQL procedure successfully completed.
SQL> @select_deptno_bind
SQL> set echo on
SQL>
SQL> select /*ACS_1*/ count(*), max(empno)
2   from emp
```

```

3 where deptno = :deptno;

COUNT(*)  MAX(EMPNO)
-----
99900      100000

SQL>
SQL> @show_latest_exec_plan
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL
+PEEKED_BINDS'));

PLAN_TABLE_OUTPUT
-----
-----
SQL_ID 272gr4hapc9w1, child number 0
-----
select /*ACS_1*/ count(*), max(empno) from emp where deptno = :deptno

Plan hash value: 3184478295

-----
| Id  | Operation          | Name   | Rows  | Bytes | Cost |
| (%CPU)| Time       |        |        |        |       |
-----
|  0  | SELECT STATEMENT |        |       |       |    2  |
| (100)|           |        |       |       |       |
|   1  |  SORT AGGREGATE |        |       |       |    16 |
|       |        |        |       |       |       |
|   2  | TABLE ACCESS BY INDEX ROWID| EMP    |     10 |    160 |    2  |
| (0)| 00:00:01 |        |        |       |       |
|*  3  | INDEX RANGE SCAN | EMP_I1 |     10 |       |    1  |
| (0)| 00:00:01 |        |       |       |       |

Peeked Binds (identified by position):
-----
1 - :DEPTNO (NUMBER): 9

Predicate Information (identified by operation id):
-----

```

```

3 - access ("DEPTNO"=:DEPTNO)

25 rows selected.

SQL>
SQL> @show_latest_exec_stats
SQL> set echo on
SQL>
SQL> select child_number, executions, buffer_gets
  2  from v$sql
  3  where sql_text like 'select /*ACS_1%';

CHILD_NUMBER EXECUTIONS BUFFER_GETS
-----
          0            2           957

SQL>
```

10. Before the next step, flush your shared pool to make sure that you clear all the cursor information.

```

SQL> alter system flush shared_pool;

System altered.

SQL>
```

11. Perform step 9 again. This time, set the bind variable to 10. What do you observe and why?

The execution plan is a full table scan because you used value 10 as your first bind value. You can see this in the peeked binds. There is only one child cursor that is created so far to handle your statement.

```

SQL> exec :deptno := 10

PL/SQL procedure successfully completed.

SQL> @select_deptno_bind
SQL> set echo on
SQL>
SQL> select /*ACS_1*/ count(*), max(empno)
  2  from emp
  3  where deptno = :deptno;

COUNT(*)  MAX(EMPNO)
```

```

-----  

99900      100000  

SQL>  

SQL> @show_latest_exec_plan  

SQL> set echo on  

SQL>  

SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL  

+PEEKED_BINDS'));  

PLAN_TABLE_OUTPUT
-----
-----  

SQL_ID 272gr4hapc9w1, child number 0
-----
select /*ACS_1*/ count(*), max(empno) from emp where deptno = :deptno  

Plan hash value: 2083865914
-----
-----  

| Id  | Operation          | Name | Rows  | Bytes | Cost (%CPU) | Time
|  

-----  

|   0 | SELECT STATEMENT   |      |       |       | 120 (100) |  

|   1 |   SORT AGGREGATE    |      |       | 1 | 16 |           |  

|*  2 |   TABLE ACCESS FULL| EMP  | 99900 | 1560K| 120 (1) |  

00:00:02 |
-----  

-----  

Peeked Binds (identified by position):
-----  

1 - :DEPTNO (NUMBER): 10  

Predicate Information (identified by operation id):
-----  

2 - filter("DEPTNO"=:DEPTNO)  

24 rows selected.
SQL>
SQL>
```

```

SQL> @show_latest_exec_stats
SQL> set echo on
SQL>
SQL> select child_number, executions, buffer_gets
  2  from v$sql
  3  where sql_text like 'select /*ACS_1%';

CHILD_NUMBER EXECUTIONS BUFFER_GETS
-----
          0           1         878

SQL>
```

12. Perform step 9 again, but this time, use 9 as your bind value. What do you observe and why?

Although value 9 is very selective, a full table scan is still used. This is because the second time you execute your statement, bind peeking is not done. So you continue to use the same child cursor.

```

SQL> exec :deptno := 9
PL/SQL procedure successfully completed.

SQL> @select_deptno_bind
SQL> set echo on
SQL>
SQL> select /*ACS_1*/ count(*), max(empno)
  2  from emp
  3  where deptno = :deptno;

COUNT(*) MAX(EMPNO)
-----
          10        99

SQL>
SQL> @show_latest_exec_plan
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL
+PEEKED_BINDS'));

PLAN_TABLE_OUTPUT
-----
SQL_ID 272gr4hapc9w1, child number 0
-----
select /*ACS_1*/ count(*), max(empno) from emp where deptno = :deptno
```

```

Plan hash value: 2083865914

-----
| Id  | Operation          | Name   | Rows  | Bytes | Cost (%CPU)| Time
|
-----
|   0 | SELECT STATEMENT   |        |       |       | 120 (100) | 
|   1 |   SORT AGGREGATE   |        |       |       | 16      | 
|*  2 |     TABLE ACCESS FULL| EMP   | 99900 | 1560K| 120 (1)  |
00:00:02 |

-----
| Peeked Binds (identified by position): |
-----
1 - :DEPTNO (NUMBER): 10

Predicate Information (identified by operation id):
-----
2 - filter("DEPTNO"=:DEPTNO)

24 rows selected.

SQL>
SQL> @show_latest_exec_stats
SQL> set echo on
SQL>
SQL> select child_number, executions, buffer_gets
2  from v$sql
3  where sql_text like 'select /*ACS_1%';
CHILD_NUMBER EXECUTIONS BUFFER_GETS
-----
0           2          1684
SQL>

```

13. Before the next step, reset your session to use adaptive cursor sharing and ensure that you flush your shared pool again.

```
SQL> alter session set optimizer_features_enable="12.2.0.1";
Session altered.

SQL> alter system flush shared_pool;
System altered.

SQL>
```

14. Perform step 12 again. What do you observe and why?

Because this is the first time you execute the statement, bind peeking is used, and because value 9 is very selective, the index path is used. Only one child cursor is used to handle this statement.

```
SQL> exec :deptno := 9
PL/SQL procedure successfully completed.

SQL> @select_deptno_bind
SQL> set echo on
SQL>
SQL> select /*ACS_1*/ count(*), max(empno)
  2  from emp
  3  where deptno = :deptno;

COUNT(*)  MAX(EMPNO)
-----
          10           99

SQL>
SQL> @show_latest_exec_plan
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL
+PEEKED_BINDS'));

PLAN_TABLE_OUTPUT
-----
-----
-----
SQL_ID  272gr4hapc9w1, child number 0
-----
```

```

select /*ACS_1*/ count(*), max(empno) from emp where deptno = :deptno

Plan hash value: 588610755

-----
| Id  | Operation          | Name   | Rows  | Bytes |
| Cost (%CPU) | Time      |
-----
| 0  | SELECT STATEMENT   |        |        |        |
2 (100)|           |        |        |        |
| 1  |  SORT AGGREGATE    |        |        | 1  | 16 |
|    |           |        |        |        |
| 2  |    TABLE ACCESS BY INDEX ROWID BATCHED| EMP    | 10  | 160
|    2  (0)| 00:00:01 |
| * 3  |    INDEX RANGE SCAN | EMP_I1 | 10  |        |
1 (0)| 00:00:01 |
-----


Peeked Binds (identified by position):
-----
1 - :DEPTNO (NUMBER): 9

Predicate Information (identified by operation id):
-----
3 - access("DEPTNO"=:DEPTNO)

25 rows selected.

SQL>
SQL> @show_latest_exec_stats
SQL> set echo on
SQL>
SQL> select child_number, executions, buffer_gets
2  from v$sql
3  where sql_text like 'select /*ACS_1%';

CHILD_NUMBER EXECUTIONS BUFFER_GETS
-----
0          1          72

SQL>

```

15. Perform step 14 again, but this time using value 10 as your bind value. What do you observe and why?

Although value 10 is not selective, the same index path as in the previous step is used. Only one child cursor is currently needed to represent your statement.

```
SQL> exec :deptno := 10

PL/SQL procedure successfully completed.

SQL> @select_deptno_bind
SQL> set echo on
SQL>
SQL> select /*ACS_1*/ count(*), max(empno)
  2  from emp
  3  where deptno = :deptno;

COUNT(*)  MAX(EMPNO)
-----
99900      100000

SQL>
SQL> @show_latest_exec_plan
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL
+PEEKED_BINDS'));

PLAN_TABLE_OUTPUT
-----
-----
SQL_ID 272gr4hapc9w1, child number 0
-----
select /*ACS_1*/ count(*), max(empno) from emp where deptno = :deptno

Plan hash value: 588610755

-----
| Id  | Operation          | Name   | Rows  | Bytes |
Cost (%CPU) | Time       |
-----
|   0 | SELECT STATEMENT   |        |       |       |
2 (100)|           |
|   1 |  SORT AGGREGATE    |        |       |       |
|       |           |

```

```

|   2 | TABLE ACCESS BY INDEX ROWID BATCHED| EMP      |    10 |  160
|   2   (0) | 00:00:01 |
|* 3 | INDEX RANGE SCAN           | EMP_I1 |    10 |      |
1   (0) | 00:00:01 |

-----
-----

Peeked Binds (identified by position):
-----

1 - :DEPTNO (NUMBER): 9

Predicate Information (identified by operation id):
-----

3 - access("DEPTNO"=:DEPTNO)

25 rows selected.

SQL>
SQL> @show_latest_exec_stats
SQL> set echo on
SQL>
SQL> select child_number, executions, buffer_gets
2  from v$sql
3  where sql_text like 'select /*ACS_1%';

CHILD_NUMBER EXECUTIONS BUFFER_GETS
-----
0            2          1026

```

## 16. Perform step 15 again. What do you observe and why?

Because you now use adaptive cursor sharing, the system realizes that you benefit from another child cursor for handling your statement. This time, a full table access path is used to better handle your statement.

```

SQL> exec :deptno := 10

PL/SQL procedure successfully completed.

SQL> @select_deptno_bind
SQL> set echo on
SQL>
SQL> select /*ACS_1*/ count(*), max(empno)
2  from emp
3  where deptno = :deptno;

```

```
COUNT(*) MAX(EMPNO)
-----
99900      100000

SQL>
SQL> @show_latest_exec_plan
SQL> set echo on
SQL>
SQL> select * from table(dbms_xplan.display_cursor(null,null,'TYPICAL
+PEEKED_BINDS'));
PLAN_TABLE_OUTPUT
-----
SQL_ID 272gr4hapc9w1, child number 1
-----
select /*ACS_1*/ count(*), max(empno) from emp where deptno = :deptno
\Plan hash value: 2083865914
-----
| Id  | Operation          | Name | Rows  | Bytes | Cost (%CPU) | Time
|
| 0  | SELECT STATEMENT   |       |        |        | 120  (100) | 
| 1  |   SORT AGGREGATE   |       | 1     | 16    |           | 
|* 2  |   TABLE ACCESS FULL| EMP   | 99900 | 1560K| 120  (1) |
0:00:01 |

Peeked Binds (identified by position):
-----
1 - :DEPTNO (NUMBER): 10

Predicate Information (identified by operation id):
-----
2 - filter("DEPTNO"=:DEPTNO)

24 rows selected.
SQL>
```

```
SQL> @show_latest_exec_stats
SQL> set echo on
SQL>
SQL> select child_number, executions, buffer_gets
  2  from v$sql
  3  where sql_text like 'select /*ACS_1%';

CHILD_NUMBER EXECUTIONS BUFFER_GETS
-----
          0           2         1026
          1           1         809

SQL>
```

17. Flush the shared pool to clean up your environment, and then exit your SQL\*Plus session.

```
SQL> alter system flush shared_pool;
System altered.

SQL> exit;
```

## Practice 12-2: Using CURSOR\_SHARING (Optional)

In this practice, you investigate the use of the CURSOR\_SHARING initialization parameter.

1. You can find all the necessary scripts for this practice in your

\$HOME/labs/solutions/Cursor\_Sharing directory. The environment for this practice has been set up with the class setup, using the cs\_setup.sh script. This script created a new user called CS and the EMP table that are used throughout this practice. The script is listed as follows:

```
#!/bin/bash

cd /home/oracle/labs/solutions/Cursor_Sharing

sqlplus / as sysdba @cs_setup.sql

-----
set echo on
alter session set container = orclpdb;
drop user cs cascade;

create user cs identified by cs default tablespace users temporary
tablespace temp;

grant dba, connect to cs;

connect cs/cs@orclpdb

drop table emp purge;

create table emp
(
empno    number,
ename     varchar2(20),
phone    varchar2(20),
deptno   number
);

insert into emp
with tdata as
(select rownum empno
from all_objects
where rownum <= 1000)
select rownum,
dbms_random.string ('u', 20),
```

```

dbms_random.string ('u', 20),
case
    when rownum/100000 <= 0.001 then mod(rownum, 10)
    else 10
end
from tdata a, tdata b
where rownum <= 100000;

create index emp_il on emp(deptno);

execute dbms_stats.gather_table_stats(null, 'EMP', cascade => true);

--alter system flush shared_pool;

--connect / as sysdba

--shutdown immediate;

--startup;

exit;

```

2. In a terminal session, change the directory to the \$HOME/labs/solutions/Cursor\_Sharing directory. Connect as the CS user in a SQL\*Plus session and stay connected to that session until the end of this practice. For formatting reasons, after you have connected in the SQL\*Plus session, execute the following command:

```
set linesize 200 pagesize 1000
```

```

$ cd $HOME/labs/solutions/Cursor_Sharing
$ sqlplus cs/cs@orclpdb
...
Connected to: ...
SQL> set linesize 200 pagesize 1000
SQL>

```

3. Check the existence of histograms on the columns of the EMP table by using the check\_emp\_histogram.sql script, and then determine the data distribution in the DEPTNO column of the EMP table with the statement in the show\_deptno\_distribution.sql file. What do you observe?

Currently, there are no histograms created on the columns of the EMP table. Also, it is clear that you have data skew in the DEPTNO column. Value 10 repeats most of the time (99.9%), whereas all other values repeat only 0.01%.

```
SQL> @check_emp_histogram
SQL>
SQL> select column_name, histogram, num_buckets
  2  from user_tab_columns
  3  where table_name='EMP';

COLUMN_NAME          HISTOGRAM      NUM_BUCKETS
-----            -----
EMPNO                NONE             1
ENAME                NONE             1
PHONE                NONE             1
DEPTNO               NONE             1

SQL>
SQL> @show_deptno_distribution
SQL> set echo on
SQL>
SQL> select deptno, count(*) cnt_per_deptno, (count(*)*100)/nr
deptno_percent
  2  from emp, (select max(emplno) nr
  3           from emp)
  4  group by deptno, nr
  5  order by deptno;

DEPTNO CNT_PER_DEPTNO DEPTNO_PERCENT
-----      -----
        0          10       .01
        1          10       .01
        2          10       .01
        3          10       .01
        4          10       .01
        5          10       .01
        6          10       .01
        7          10       .01
        8          10       .01
        9          10       .01
       10         99900    99.9

11 rows selected.

SQL>
```

4. Before you continue, ensure that you flush your shared pool.

```
SQL> alter system flush shared_pool;

System altered.

SQL>
```

5. How would you force your SQL\*Plus session to automatically replace statement literals with bind variables to make sure that the same cursor is used independently of the literal values?

```
SQL> alter session set cursor_sharing = force;

Session altered.

SQL>
```

6. From the same SQL\*Plus session, execute the following two queries. Then determine how many cursors are generated to handle these two statements and what execution plans were used. What do you observe and why?

```
select /*CS*/ count(*), max(empno) from emp where deptno = 9;
select /*CS*/ count(*), max(empno) from emp where deptno = 10;
```

- a. Because of the previous step, literal values are replaced with bind variables. The FORCE option forces the system to share only one child cursor in this case and use the exact same execution plan (index range scan).

```
SQL> @select_deptno_literal_9
SQL> set echo on
SQL>
SQL> select /*CS*/ count(*), max(empno) from emp where deptno = 9;

          COUNT(*)  MAX(EMPNO)
-----
          10            99

SQL>
SQL> @select_deptno_literal_10
SQL> set echo on
SQL>
SQL> select /*CS*/ count(*), max(empno) from emp where deptno = 10;

          COUNT(*)  MAX(EMPNO)
```

```
-----  
      99900      100000  
  
SQL>
```

- b. Now execute the `show_latest_cursors.sql` file to check the latest cursors.

```
SQL> @show_latest_cursors  
SQL> set echo on  
SQL>  
SQL> col sql_text format a70  
SQL>  
SQL> select sql_text,hash_value  
  2  from v$sql  
  3  where sql_text like '%select /*CS%';  
  
SQL_TEXT  
-----  
-----  
HASH_VALUE  
-----  
-----  
select /*CS*/ count(*), max(empno) from emp where deptno =  
:"SYS_B_0"  
3434097775
```

- c. Execute the `show_latest_exec_plans.sql` file to check the latest execution plans.

```
SQL> @show_latest_exec_plans
```

```

SQL> @show_latest_cursors
SQL> set echo on
SQL>
SQL> col sql_text format a70
SQL>
SQL> select sql_text,hash_value
  2  from v$sql
  3  where sql_text like '%select /*CS%';

SQL_TEXT                                              HASH_VALUE
-----
select /*CS*/ count(*), max(empno) from emp where deptno = :"SYS_B_0"  3434097775

SQL> @show_latest_exec_plans
SQL> set echo on
SQL>
SQL> col child_number Heading 'CHILD|NUMBER'
SQL> col object_name format a6
SQL> col operation format a16
SQL> col options format a15
SQL>
SQL> select address,hash_value,child_number, operation,options,object_name
  2  from v$sql_plan
  3  where (address,hash_value) in
  4    (select address,hash_value
  5     from v$sql
  6     where sql_text like '%select /*CS%');

          CHILD
ADDRESS      HASH_VALUE      NUMBER OPERATION      OPTIONS      OBJECT
-----
000000006EF41E20 3434097775      0 SELECT STATEMENT
000000006EF41E20 3434097775      0 SORT          AGGREGATE
000000006EF41E20 3434097775      0 TABLE ACCESS BY INDEX ROWID  EMP
                                         BATCHED
000000006EF41E20 3434097775      0 INDEX         RANGE SCAN   EMP_I1

```

7. Ensure that you create a 10-bucket histogram on the DEPTNO column of the EMP table.

```

SQL> exec dbms_stats.gather_table_stats(null, 'EMP', METHOD_OPT =>
'FOR COLUMNS DEPTNO SIZE 10', CASCADE => TRUE);

PL/SQL procedure successfully completed.

SQL> @check_emp_histogram
SQL> set echo on
SQL>
SQL> select column_name, histogram, num_buckets
  2  from user_tab_columns
  3  where table_name='EMP';

COLUMN_NAME          HISTOGRAM      NUM_BUCKETS
-----
EMPNO                NONE             1
ENAME                NONE             1

```

PHONE	NONE	1
DEPTNO	TOP-FREQUENCY	10
SQL>		

8. Before you continue, ensure that you flush your shared pool.

```
SQL> alter system flush shared_pool;

System altered.

SQL>
```

9. Perform step 6 again. What do you observe and why?

Although you captured a histogram for the DEPTNO column that shows data skew, the system continues to share only one child cursor to handle both statements. This behavior is due to the FORCE option for the CURSOR\_SHARING initialization parameter.

```
SQL> @select_deptno_literal_9
SQL> set echo on
SQL>
SQL> select /*CS*/ count(*), max(empno) from emp where deptno = 9;

COUNT(*)  MAX(EMPNO)
-----
          10           99

SQL>
SQL> @select_deptno_literal_10
SQL> set echo on
SQL>
SQL> select /*CS*/ count(*), max(empno) from emp where deptno = 10;

COUNT(*)  MAX(EMPNO)
-----
         99900        100000

SQL>
SQL> @show_latest_cursors
SQL> set echo on
SQL>
SQL> col sql_text format a70
SQL>
```

```
SQL> select sql_text,hash_value
  2  from v$sql
  3  where sql_text like '%select /*CS%';

SQL_TEXT
-----
HASH_VALUE
-----
select /*CS*/ count(*), max(empno) from emp where deptno = :"SYS_B_0"
3434097775
```

10. Flush the shared pool script to clean up your environment for this practice. Then exit your SQL\*Plus session.

```
SQL> alter system flush shared_pool;
System altered.

SQL> exit
Disconnected ...

$
```

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## **Practices for Lesson 13: SQL Plan Management**

## Practices for Lesson 123: Overview

---

### Practices Overview

SQL Plan Management (SPM) is an Oracle Database 11g feature that provides controlled execution plan evolution.

With SPM, the optimizer automatically manages execution plans and ensures that only known or verified plans are used.

When a new plan is found for a SQL statement, it will not be used until it has been verified to have comparable or better performance than the current plan.

SPM has three main components:

- Plan Capture
- Plan Selection
- Plan Verification

In these practices, you see each of these components in action.

## Practice 13-1: Using SQL Plan Management (SPM)

### Overview

In this practice, you see all the phases of using SQL Plan Management.

### Tasks

- Before you start this practice, change directories to the \$HOME/labs/solutions/SPM directory. Flush the shared pool to be sure that there is no interference from preceding practices.

```
$ cd /home/oracle/labs/solutions/SPM
$ sqlplus / as sysdba
SQL> alter session set container = orclpdb;
Session altered.
SQL> alter system flush shared_pool;

System altered.

SQL> exit;
```

### Automatic Plan Capture

- The first component of SPM is Plan Capture. There are two main ways to capture plans: automatically (at run time) or bulk load. In this practice, you enable automatic plan capture so that the SPM repository is automatically populated for any repeatable SQL statement. Enable automatic plan capture by setting the optimizer\_capture\_sql\_plan\_baselines initialization parameter to TRUE in your SQL\*Plus session, connected as the SPM user. After you have connected in your session, do not disconnect.

```
$ sqlplus spm/spm@orclpdb;

-- Execute the below Statement

SQL> show parameter baseline

NAME                                     TYPE        VALUE
-----
-----
optimizer_capture_sql_plan_baselines    boolean    FALSE
optimizer_use_sql_plan_baselines        boolean    TRUE

-- Execute the below Statement
```

```

SQL> alter session set optimizer_capture_sql_plan_baselines =
TRUE;

Session altered.

SQL> alter session set optimizer_mode = all_rows;
Session altered.

SQL>

```

3. Execute the following query in your SQL\*Plus session. (**Note:** There are no spaces in /\*LOAD\_AUTO\*/.)

```

select /*LOAD_AUTO*/ * from sh.sales
where quantity_sold > 40 order by prod_id;

```

Use the `query1.sql` script to execute the query.

```

SQL> @query1.sql

SQL> select /*LOAD_AUTO*/ * from sh.sales
2> where quantity_sold > 40 order by prod_id;

no rows selected

SQL>

```

4. An initial plan baseline is automatically created for a new statement. Check whether the plan baseline was loaded for the previous statement. What do you observe?

You can see from the output that a baseline has been created and enabled for this SQL statement. You can also tell that this plan was captured automatically by checking the values of the `ORIGIN` column. (Use the `check_baselines.sql` script.)

```

-- You should see one accepted entry
SQL> @check_baselines.sql
SQL> set echo on
SQL> set pagesize 30
SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2          origin, enabled, accepted, fixed, autopurge
3      from dba_sql_plan_baselines
4     where sql_text like 'select /*LOAD_AUTO*/%';

```

```

SIGNATURE SQL_HANDLE
-----
SQL_TEXT
-----
PLAN_NAME          ORIGIN      ENA ACC FIX AUT
-----
8.0622E+18 SQL_6fe28d438dfc352f
select /*LOAD_AUTO*/ * from sh.sales
where quantity_sold > 40 order by prod_id
SQL_PLAN_6zsnd8f6zsd9g54bc8843 AUTO-CAPTURE YES YES NO YES

SQL>

```

5. Change or alter the optimizer mode to use FIRST\_ROWS optimization and execute your statement. Describe what happens.

This causes the optimizer to create a different plan for the SQL statement execution.

```

SQL> alter session set optimizer_mode = first_rows;

Session altered.

-- Execute the query1.sql

SQL> @query1.sql
SQL> set echo on
SQL>
SQL> select /*LOAD_AUTO*/ * from sh.sales
   2 where quantity_sold > 40 order by prod_id;

no rows selected

SQL>

```

- a. Because the SQL statement has a new plan, another plan baseline is automatically captured. You can confirm this by checking the plan baseline again.

```

SQL> @check_baselines.sql
SQL> set echo on
SQL> set pagesize 30
SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
   2          origin, enabled, accepted, fixed, autopurge
   3  from dba_sql_plan_baselines

```

```

4 where sql_text like 'select /*LOAD_AUTO*/%';

SIGNATURE SQL_HANDLE
-----
SQL_TEXT
-----
PLAN_NAME          ORIGIN      ENA ACC FIX AUT
-----
8.0622E+18 SQL_6fe28d438dfc352f
select /*LOAD_AUTO*/ * from sh.sales
where quantity_sold > 40 order by prod_id
SQL_PLAN_6zsnd8f6zsd9g11df68d0 AUTO-CAPTURE YES YES NO YES

8.0622E+18 SQL_6fe28d438dfc352f
select /*LOAD_AUTO*/ * from sh.sales
where quantity_sold > 40 order by prod_id
SQL_PLAN_6zsnd8f6zsd9g54bc8843 AUTO-CAPTURE YES NO NO YES

SQL>

```

- b. Now you see two plan baselines for your query, but notice that the new plan has not been accepted. This new plan will have to be validated before it is acceptable as a good plan to use.
6. Reset the optimizer mode to the default values and disable automatic capture of plan baselines.

```

-- Execute the below Statement

SQL> alter session set optimizer_mode = all_rows;

Session altered.

-- Execute the below Statement

SQL> alter session set optimizer_capture_sql_plan_baselines =
FALSE;

Session altered.

```

7. Purge the plan baselines and confirm that the SQL plan baseline is empty. Use `purge_auto_baseline.sql`.

```

SQL> @purge_auto_baseline.sql
SQL> set echo on
SQL>
SQL> variable cnt number;
SQL>
SQL> exec :cnt :=
dbms_spm.drop_sql_plan_baseline('SQL_6fe28d438dfc352f');

PL/SQL procedure successfully completed.

SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2       origin, enabled, accepted, fixed, autopurge
3   from dba_sql_plan_baselines
4  where sql_text like 'select /*LOAD_AUTO*/%';

no rows selected

SQL>
```

### **Loading Plans from SQL Tuning Sets**

8. Still connected to your SQL\*Plus session, check the execution plan for the following SQL statement, and then execute it. (Use `explain_query2.sql` and `query2.sql`.)

```

select /*LOAD_STS*/ * from sh.sales
where quantity_sold > 40 order by prod_id;
```

```

SQL> @explain_query2.sql

-- You should see a Full Table Scan

SQL> set echo on
SQL>
SQL> explain plan for
2  select /*LOAD_STS*/ * from sh.sales
3  where quantity_sold > 40 order by prod_id;

Explained.

SQL>
```

```

SQL> select * from table(dbms_xplan.display(null,null,'basic'));

PLAN_TABLE_OUTPUT
-----
Plan hash value: 3803407550

-----
| Id  | Operation          | Name   |
-----
|   0 | SELECT STATEMENT   |        |
|   1 |  SORT ORDER BY     |        |
|   2 |   PARTITION RANGE ALL|        |
|   3 |     TABLE ACCESS FULL | SALES  |
-----

10 rows selected.

-- Execute the query2.sql Statement

SQL> @query2.sql
SQL> set echo on
SQL>
SQL> select /*LOAD_STS*//* from sh.sales
2 where quantity_sold > 40 order by prod_id;
no rows selected

```

9. Alter the optimizer mode to use `FIRST_ROWS` optimization, check the execution plan, and execute the query.

```

-- Execute the below Statement

SQL> alter session set optimizer_mode = first_rows;

Session altered.

-- You should see a different plan
-- (Table Access By Local Index)

SQL> @explain_query2.sql
SQL> set echo on
SQL>
```

```
SQL> explain plan for
  2  select /*LOAD_STS*/ * from sh.sales
  3  where quantity_sold > 40 order by prod_id;

Explained.

SQL>
SQL> select * from table(dbms_xplan.display(null,null,'basic'));

PLAN_TABLE_OUTPUT
-----
Plan hash value: 899219946
-----
| Id  | Operation          | Name   |
|---|---|---|
| 0  | SELECT STATEMENT   |        |
| 1  |  SORT ORDER BY     |        |
| 2  |   PARTITION RANGE ALL |
| 3  |     TABLE ACCESS BY LOCAL INDEX ROWID| SALES |
| 4  |       BITMAP CONVERSION TO ROWIDS  |        |
| 5  |       BITMAP INDEX FULL SCAN    | SALES_PROMO_BIX |

PLAN_TABLE_OUTPUT
-----
12 rows selected.

SQL>

-- Execute the query2.sql Statement

SQL> @query2.sql
SQL> set echo on
SQL>
SQL> select /*LOAD_STS*/ * from sh.sales
  2  where quantity_sold > 40 order by prod_id;
no rows selected

SQL>
```

10. Reset the optimizer mode to ALL\_ROWS optimization.

```
-- Execute the below Statement
```

```
SQL> alter session set optimizer_mode = all_rows;
Session altered.
```

11. Verify that there are no baseline plans for your statement. (Use the check\_baselines2.sql script.)

```
SQL> @check_baselines2.sql
SQL> set echo on
SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2       origin, enabled, accepted, fixed, autopurge
3   from dba_sql_plan_baselines
4  where sql_text like 'select /*LOAD_STS*/%';
no rows selected

SQL>
```

12. Create a SQL tuning set that captures the SELECT statements that contain the LOAD\_STS hint. These statements are in the cursor cache. The STS should be called SPM\_STS and owned by the SPM user. Use the catchup\_sts.sql script to capture these statements.

```
SQL> @catchup_sts.sql
SQL> set echo on
SQL>
SQL> exec sys.dbms_sqltune.create_sqlset(
> sqlset_name => 'SPM_STS', sqlset_owner => 'SPM');

PL/SQL procedure successfully completed.

SQL>
SQL> DECLARE
2      stscur    dbms_sqltune.sqlset_cursor;
3  BEGIN
4      OPEN stscur FOR
5          SELECT VALUE(P)
6      FROM TABLE(dbms_sqltune.select_cursor_cache(
7          'sql_text like ''select /*LOAD_STS*/%'''',
8          null, null, null, null, null, null, 'ALL')) P;
```

```

9
10    -- populate the sqlset
11    dbms_sqltune.load_sqlset(sqlset_name      => 'SPM_STS',
12                           populate_cursor   => stscur,
13                           sqlset_owner     => 'SPM');
14 END;
15 /

```

PL/SQL procedure successfully completed.

SQL>

**13. Verify the SQL statements that are in SPM\_STS. (Use the check\_sts.sql script.)**

SPM\_STS has your SQL statement with two different plans.

```

SQL> @check_sts.sql
SQL> set echo on
SQL>
SQL> select sql_text from dba_sqlset_statements
  2 where sqlset_name='SPM_STS';

SQL_TEXT
-----
-----
select /*LOAD_STS*/ * from sh.sales
where quantity_sold > 40 order by prod_id

select /*LOAD_STS*/ * from sh.sales
where quantity_sold > 40 order by prod_id

SQL>

```

**14. Populate the plan baseline repository with the plans found in SPM\_STS. Use the populate\_baseline.sql script:**

```

SQL> @populate_baseline.sql
SQL> set echo on
SQL>
SQL> variable cnt number;
SQL>
SQL> exec :cnt := dbms_spm.load_plans_from_sqlset( -
>           sqlset_name  => 'SPM_STS', -

```

```
>           basic_filter => 'sql_text like ''select
/*LOAD_STS*/%''');

PL/SQL procedure successfully completed.

SQL>
```

15. Confirm whether the plan baselines are loaded and note the value in the `origin` column. What do you observe? (Use `check_baselines2.sql`.)

You should see `MANUAL-LOAD` because you manually loaded these plans. Also note that this time, both plans are accepted.

```
SQL> @check_baselines2.sql
SQL> set echo on
SQL> set pagesize 30
SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2       origin, enabled, accepted, fixed, autopurge
3   from dba_sql_plan_baselines
4  where sql_text like 'select /*LOAD_STS*/%';

SIGNATURE SQL_HANDLE
-----
SQL_TEXT
-----
PLAN_NAME          ORIGIN      ENA ACC FIX AUT
-----
1.2134E+19 SQL_a8632bd857a4a25e
select /*LOAD_STS*/ * from sh.sales
where quantity sold > 40 order by prod_id
SQL_PLAN_ahstbv1bu98ky11df68d0 MANUAL-LOAD    YES YES NO  YES

1.2134E+19 SQL_a8632bd857a4a25e
select /*LOAD_STS*/ * from sh.sales
where quantity sold > 40 order by prod_id
SQL_PLAN_ahstbv1bu98ky54bc8843 MANUAL-LOAD    YES YES NO  YES
```

16. Purge the plan baselines and drop `SPM_STS`. Use the `purge_sts_baseline.sql` script.

```
SQL> @purge_sts_baseline.sql
SQL> set echo on
```

```

SQL>
SQL> variable cnt number;
SQL>
SQL> exec :cnt := dbms_spm.drop_sql_plan_baseline(-
>                               'SQL_a8632bd857a4a25e');

PL/SQL procedure successfully completed.

SQL>
SQL> print cnt;

      CNT
-----
      2

SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2          origin, enabled, accepted, fixed, autopurge
3  from dba_sql_plan_baselines
4  where sql_text like 'select /*LOAD_STS*/%';

no rows selected

SQL>
SQL> exec sys.dbms_sqltune.drop_sqlset(
>                               sqlset_name  => 'SPM_STS', -
>                               sqlset_owner => 'SPM');

PL/SQL procedure successfully completed.

SQL>

```

### **Loading Plans from the Cursor Cache**

17. Now, you see how to directly load plan baselines from the cursor cache. Before you begin, you need some SQL statements. Still connected to your SQL\*Plus session, check the execution plan for the following SQL statement, and then execute it. (Use the `explain_query3.sql` and `query3.sql` scripts.)

```

select /*LOAD_CC*/ * from sh.sales
where quantity_sold > 40 order by prod_id;

```

```
SQL> @explain_query3.sql
```

```
SQL> set echo on
SQL>
SQL> explain plan for
  2  select /*LOAD_CC*/ * from sh.sales
  3  where quantity_sold > 40 order by prod_id;

Explained.

SQL>
SQL> select * from table(dbms_xplan.display(null,null,'basic'));

PLAN_TABLE_OUTPUT
-----
-----
Plan hash value: 3803407550

-----
| Id  | Operation          | Name   |
-----
|   0 | SELECT STATEMENT  |        |
|   1 |   SORT ORDER BY    |        |
|   2 |     PARTITION RANGE ALL|        |
|   3 |       TABLE ACCESS FULL | SALES  |
-----
10 rows selected.

SQL>
SQL>

-- Execute the query3.sql

SQL> @query3.sql
SQL> set echo on
SQL>
SQL> select /*LOAD_CC*/ * from sh.sales
  2  where quantity_sold > 40 order by prod_id;

no rows selected

SQL>
```

18. Now, change the optimizer mode to use FIRST\_ROWS optimization and execute the same script as in the previous step. What do you observe?

You should see a different execution plan.

```
-- Execute the below Statement

SQL> alter session set optimizer_mode = first_rows;

Session altered.

-- Execute the explain_query3.sql

SQL> @explain_query3.sql
SQL> set echo on
SQL>
SQL> explain plan for
2  select /*LOAD_CC*/ * from sh.sales
3  where quantity_sold > 40 order by prod_id;

Explained.

SQL>
SQL> select * from table(dbms_xplan.display(null,null,'basic'));

PLAN_TABLE_OUTPUT
-----
-----
Plan hash value: 899219946

-----
| Id  | Operation          | Name   |
-----
|   0 | SELECT STATEMENT  |        |
|   1 |  SORT ORDER BY    |        |
|   2 | PARTITION RANGE ALL|        |
|   3 |   TABLE ACCESS BY LOCAL INDEX ROWID| SALES |
|   4 |     BITMAP CONVERSION TO ROWIDS  |        |
|   5 |     BITMAP INDEX FULL SCAN    | SALES_PROMO_BIX |
-----
12 rows selected.
```

```
SQL>
SQL>

-- Execute the query3.sql

SQL> @query3.sql
SQL> set echo on
SQL>
SQL> select /*LOAD_CC*/ * from sh.sales
  2 where quantity_sold > 40 order by prod_id;

no rows selected

SQL>
```

19. Reset the optimizer mode to ALL\_ROWS.

```
-- Execute the below Statement

SQL> alter session set optimizer_mode = all_rows;

Session altered.
```

20. Now that the cursor cache is populated, you must get the SQL ID for your SQL statement. Use the SQL ID to filter the content of the cursor cache and load the baselines with these two plans. Use the `load_cc_baseline.sql` script.

```
SQL> @load_cc_baseline.sql
SQL> set echo on
SQL>
SQL> variable cnt number;
SQL>
SQL> variable sqlid varchar2(20);
SQL>
SQL> begin
  2   select distinct sql_id into :sqlid from v$sql
  3   where sql_text like 'select /*LOAD_CC*/%';
  4 end;
  5 /

PL/SQL procedure successfully completed.
```

```

SQL>
SQL> print sqlid;

SQLID
-----
6qc9wxhgzzz8g

SQL>
SQL> exec :cnt := dbms_spm.load_plans_from_cursor_cache (
>           sql_id => :sqlid);

PL/SQL procedure successfully completed.

SQL>

```

21. Confirm whether the baselines were loaded. (Use `check_baselines3.sql`.)

```

SQL> @check_baselines3.sql
SQL> set echo on
SQL> set pagesize 30
SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
  2       origin, enabled, accepted, fixed, autopurge
  3   from dba_sql_plan_baselines
  4  where sql_text like 'select /*LOAD_CC*/%';

  SIGNATURE SQL_HANDLE
-----
SQL_TEXT
-----
PLAN_NAME          ORIGIN      ENA ACC FIX AUT
-----
1.7783E+19 SQL_f6cb7f742ef93547
select /*LOAD_CC*/ * from sh.sales
where quantity_sold > 40 order by prod_id
SQL_PLAN_gdkvzfhrkgkda711df68d0 MANUAL-LOAD-      YES YES NO  YES
                                         FROM-CURSOR-CACHE
1.7783E+19 SQL_f6cb7f742ef93547
select /*LOAD_CC*/ * from sh.sales
where quantity_sold > 40 order by prod_id
SQL_PLAN_gdkvzfhrkgkda754bc8843 MANUAL-LOAD      YES YES NO  YES

```

```
FROM-CURSOR-CACHE

SQL>
-- You should see two accepted baselines
```

22. Purge the plan baselines. Use the `purge_cc_baselines.sql` script.

```
SQL> @purge_cc_baseline.sql
SQL> set echo on
SQL>
SQL> variable cnt number;
SQL>
SQL> exec :cnt := dbms_spm.drop_sql_plan_baseline(
>           'SQL_f6cb7f742ef93547');

PL/SQL procedure successfully completed.

SQL>
SQL> print cnt;

      CNT
-----
      2

SQL>
SQL> REM Check that plan baselines were purged:
SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2       origin, enabled, accepted, fixed, autopurge
3   from dba_sql_plan_baselines
4  where sql_text like 'select /*LOAD_CC*/%';

no rows selected

SQL>
```

## Optimizer Plan Selection

23. Now that you know how to capture plans, look at how the optimizer selects which plan baselines to use. First, you create two baselines for a statement and show them being used. Then you disable one of the baselines and see the second baseline being used. Finally, you disable both baselines and show that now the optimizer falls back to the default behavior of a cost-based plan. Start by executing the same query twice, with different plans.

Determine the execution of the following statement, and then execute it. (Use the `explain_query4.sql` and `query4.sql` scripts.)

```
select /*SPM_USE*/ * from sh.sales  
where quantity_sold > 40 order by prod_id
```

```
SQL> @explain_query4.sql  
SQL> set echo on  
SQL>  
SQL> explain plan for  
2  select /*SPM_USE*/ * from sh.sales  
3  where quantity_sold > 40 order by prod_id;  
  
Explained.  
  
SQL>  
SQL> select * from table(dbms_xplan.display(null,null,'basic'));  
  
PLAN_TABLE_OUTPUT  
-----  
Plan hash value: 3803407550  
  
-----  
| Id  | Operation          | Name   |  
-----  
| 0  | SELECT STATEMENT  |        |  
| 1  |  SORT ORDER BY    |        |  
| 2  |    PARTITION RANGE ALL|  
| 3  |      TABLE ACCESS FULL | SALES |  
-----  
  
10 rows selected.  
  
SQL>  
SQL> @query4.sql  
SQL> set echo on  
SQL>  
SQL> select /*SPM_USE*/ * from sh.sales  
2  where quantity_sold > 40 order by prod_id;  
  
no rows selected
```

SQL&gt;

24. Change the optimizer mode to use FIRST\_ROWS optimization and execute the same script as in the previous step. What do you observe?

You should see a different execution plan.

```
-- Execute the below Statement

SQL> alter session set optimizer_mode = first_rows;

Session altered.
SQL> @explain_query4.sql
SQL> set echo on
SQL>
SQL> explain plan for
  2  select /*SPM_USE*/ * from sh.sales
  3  where quantity_sold > 40 order by prod_id;

Explained.

SQL>
SQL> select * from table(dbms_xplan.display(null,null,'basic'));

PLAN_TABLE_OUTPUT
-----
Plan hash value: 899219946
-----
| Id  | Operation          | Name   |
| --- | ---                | ---    |
| 0   | SELECT STATEMENT   |        |
| 1   |  SORT ORDER BY     |        |
| 2   |  PARTITION RANGE ALL
| 3   |    TABLE ACCESS BY LOCAL INDEX ROWID| SALES
| 4   |      BITMAP CONVERSION TO ROWIDS |        |
| 5   |      BITMAP INDEX FULL SCAN  | SALES_PROMO_BIX

PLAN_TABLE_OUTPUT
-----
12 rows selected.

SQL>
SQL> @query4.sql
```

```

SQL> set echo on
SQL>
SQL> select /*SPM_USE*/ * from sh.sales
  2 where quantity_sold > 40 order by prod_id;

no rows selected

SQL>
```

25. Reset the optimizer mode to ALL\_ROWS.

```

-- Execute the below Statement

SQL> alter session set optimizer_mode = all_rows;

Session altered.
```

26. Populate the baseline with the two plans for your statement directly from the cursor cache. Use the `load_use_baseline.sql` script. Then verify that the baselines were loaded. What do you observe?

You should see both plan baselines loaded. Note that both plans have been marked acceptable. This is because both plans were present in the cursor cache at the time of the load, and because these plans have been manually loaded, it is assumed that both plans have acceptable performance.

```

SQL> @load_use_baseline.sql
SQL> set echo on
SQL>
SQL> variable cnt number;
SQL>
SQL> variable sqlid varchar2(20);
SQL>
SQL> begin
  2   select distinct sql_id into :sqlid from v$sql
  3   where sql_text like 'select /*SPM_USE*/%';
  4 end;
 5 /

PL/SQL procedure successfully completed.

SQL>
SQL> print sqlid;
```

```

SQLID
-----
2pma6tcaczdc8

SQL>
SQL> exec :cnt := dbms_spm.load_plans_from_cursor_cache(
>                      sql_id => :sqlid);

PL/SQL procedure successfully completed.

SQL>
SQL> print cnt;

      CNT
-----
      2

SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2          origin, enabled, accepted, fixed, autopurge
3  from dba_sql_plan_baselines
4 where sql_text like 'select /*SPM_USE*/%';

      SIGNATURE SQL_HANDLE
-----
      SQL_TEXT
-----
      PLAN_NAME          ORIGIN          ENA ACC FIX AUT
-----
      7.6492E+17 SQL_0a9d872600ece455
      select /*SPM_USE*/ * from sh.sales
      where quantity_sold > 40 order by prod_id
      SQL_PLAN_0p7c74s0ftt2p54bc8843 MANUAL-LOAD    YES YES NO   YES
                                         FROM-CURSOR-CACHE

      7.6492E+17 SQL_0a9d872600ece455
      select /*SPM_USE*/ * from sh.sales
      where quantity_sold > 40 order by prod_id
      SQL_PLAN_0p7c74s0ftt2pce885bc0 MANUAL-LOAD    YES YES NO   YES

```

## FROM-CURSOR-CACHE

SQL>

27. Determine the baseline and the execution plan used to execute the following query:

```
select /*SPM_USE*/ * from sh.sales  
where quantity_sold > 40 order by prod_id.
```

## What do you observe?

The note at the end of the explain output tells you that the system is using a baseline. From the execution plan, you can see that you are using the first baseline, a full table scan. Use the `explain query4 note.sql` script.

```
SQL> @explain_query4_note.sql
SQL> set echo on
SQL>
SQL> explain plan for
  2  select /*SPM_USE*/ * from sh.sales
  3  where quantity_sold > 40 order by prod_id;

Explained.

SQL>
SQL> select * from table(dbms_xplan.display(null,null,'basic
+note'));

```

PLAN\_TABLE\_OUTPUT

---

---

Plan hash value: 3803407550

---

---

Id   Operation   Name
0   SELECT STATEMENT
1   SORT ORDER BY
2   PARTITION RANGE ALL
3   TABLE ACCESS FULL   SALES

---

Note

```
-----
- SQL plan baseline "SQL_PLAN_0p7c74s0ftt2p54bc8843" used for
this statement

14 rows selected.

SQL>
SQL>
```

28. Disable this plan baseline, and check whether the system uses the other plan baseline when executing the statement again. Use the `check_baseline_used.sql` script. What do you observe?

Now from the execution plan, you see that you are using an index scan instead of a full table scan. So this is the second baseline.

```
SQL> @check_baseline_used.sql
SQL> set echo on
SQL>
SQL> variable cnt number;
SQL>
SQL> select sql_handle,plan_name
  2  from dba_sql_plan_baselines
  3  where sql_text like 'select /*SPM_USE*/%';

SQL_HANDLE          PLAN_NAME
-----
SQL_0a9d872600ece455      SQL_PLAN_0p7c74s0ftt2p54bc8843
SQL_0a9d872600ece455      SQL_PLAN_0p7c74s0ftt2pce885bc0

SQL>
SQL>
SQL> exec :cnt := dbms_spm.alter_sql_plan_baseline( -
  >           sql_handle      => 'SQL_0a9d872600ece455', -
  >           plan_name       => 'SQL_PLAN_0p7c74s0ftt2p54bc8843', -
  >           attribute_name  => 'ENABLED', -
  >           attribute_value   => 'NO');

PL/SQL procedure successfully completed.

SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
  2        origin, enabled, accepted, fixed, autopurge
  3  from dba_sql_plan_baselines
```

```

4 where sql_text like 'select /*SPM_USE*/%';

SIGNATURE SQL_HANDLE
-----
SQL_TEXT
-----
PLAN_NAME          ORIGIN      ENA ACC FIX AUT
-----
7.6492E+17 SQL_0a9d872600ece455
select /*SPM_USE*/ * from sh.sales
where quantity_sold > 40 order by prod_id
SQL_PLAN_0p7c74s0ftt2p54bc8843 MANUAL-LOAD-
                                         FROM-CURSOR-CACHE NO YES NO YES

7.6492E+17 SQL_0a9d872600ece455
select /*SPM_USE*/ * from sh.sales
where quantity_sold > 40 order by prod_id
SQL_PLAN_0p7c74s0ftt2pce885bc0 MANUAL-LOAD-
                                         FROM-CURSOR-CACHE YES YES NO YES

SQL>
SQL>
SQL> explain plan for select /*SPM_USE*/ * from sh.sales
   2       where quantity_sold > 40 order by prod_id;

Explained.

SQL>
SQL> select * from table(dbms_xplan.display(null, null, 'BASIC
NOTE'));

PLAN_TABLE_OUTPUT
-----
Plan hash value: 899219946

-----
| Id  | Operation           | Name |
| 0  | SELECT STATEMENT    |
| 1  |  SORT ORDER BY      |
| 2  |   PARTITION RANGE ALL |

```

```

|   3 | TABLE ACCESS BY LOCAL INDEX ROWID| SALES          |
|   4 |      BITMAP CONVERSION TO ROWIDS |               |
|   5 |      BITMAP INDEX FULL SCAN    | SALES_PROMO_BIX |
-----

```

Note

-----

- SQL plan baseline "SQL\_PLAN\_0p7c74s0ftt2pce885bc0" used  
for this statement

16 rows selected.

29. Disable the other plan baseline and check whether the system falls back to the cost-based approach when executing the explain plan for the statement. Use the `check_baseline_used2.sql` script.

You know that the optimizer has gone back to the default cost-based approach because there is no note at the end of the plan stating that a baseline was used.

```

SQL> @check_baseline_used2.sql
SQL> set echo on
SQL>
SQL> variable cnt number;
SQL>
SQL> exec :cnt := dbms_spm.alter_sql_plan_baseline( -
>           sql_handle      => 'SQL_0a9d872600ece455', -
>           plan_name       => 'SQL_PLAN_0p7c74s0ftt2pce885bc0', -
>           attribute_name  => 'ENABLED', -
>           attribute_value  => 'NO');

PL/SQL procedure successfully completed.

SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2        origin, enabled, accepted, fixed, autopurge
3  from dba_sql_plan_baselines
4 where sql_text like 'select /*SPM_USE*/%';

SIGNATURE SQL_HANDLE
-----
SQL_TEXT
-----

```

PLAN_NAME	ORIGIN	ENA	ACC	FIX	AUT
7.6492E+17 SQL_0a9d872600ece455 select /*SPM_USE*/ * from sh.sales where quantity_sold > 40 order by prod_id SQL_PLAN_0p7c74s0ftt2p54bc8843	MANUAL-LOAD-				
	FROM-CURSOR-CACHE	NO	YES	NO	YES
7.6492E+17 SQL_0a9d872600ece455 select /*SPM_USE*/ * from sh.sales where quantity_sold > 40 order by prod_id SQL_PLAN_0p7c74s0ftt2pce885bc0	MANUAL-LOAD-				
	FROM-CURSOR-CACHE	NO	YES	NO	YES
SQL>					
SQL>					
SQL> explain plan for select /*SPM_USE*/ * from sh.sales 2 where quantity_sold > 40 order by prod_id;					
Explained.					
SQL>					
SQL> select * from table(dbms_xplan.display(null, null, 'basic +note'));					
PLAN_TABLE_OUTPUT					
-----					
-----					
Plan hash value: 3803407550					
-----					
Id   Operation   Name					
-----					
0   SELECT STATEMENT					
1   SORT ORDER BY					
2   PARTITION RANGE ALL					
3   TABLE ACCESS FULL   SALES					
-----					
10 rows selected.					
SQL>					

30. Drop the plan baselines and check whether they are purged. Use the `purge_use_baseline.sql` script.

```

SQL> @purge_use_baseline
SQL> set echo on
SQL>
SQL> variable cnt number;
SQL>
SQL> exec :cnt := dbms_spm.drop_sql_plan_baseline(-
>           'SQL_0a9d872600ece455');

PL/SQL procedure successfully completed.

SQL>
SQL> print cnt;

          CNT
-----
          2

SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2       origin, enabled, accepted, fixed, autopurge
3   from dba_sql_plan_baselines
4  where sql_text like 'select /*SPM_USE*/%';

no rows selected

SQL>
```

31. One of the methods used to enable plan evolution (or plan verification) is Automatic SQL Tuning that is run as an automated task in a maintenance window. Automatic SQL Tuning targets only the high-load SQL statements; for them, it automatically implements actions such as making a successfully verified plan an accepted plan. Here, you manually trigger SQL tuning to find a better plan for a given SQL statement. First, determine the execution plan of the following statement:

```

select /*+ USE_NL(s c) FULL(s) FULL(c) */
c.cust_id, sum(s.quantity_sold)
from sh.sales s, sh.customers c
```

```
where s.cust_id = c.cust_id and c.cust_id < 2  
group by c.cust_id
```

Some optimizer hints to the statements have been added to ensure that you get a less than optimal plan at first. Use the `check evolve plan.sql` script. What do you observe?

As you can see, the execution plan is being forced by the hints to perform two full table scans, followed by a nested loop join.

```
SQL> @check_evolve_plan.sql
SQL> set echo on
SQL>
SQL> explain plan for
  2  select /*+ USE_NL(s c) FULL(s) FULL(c) */
  3        c.cust_id, sum(s.quantity_sold)
  4  from sh.sales s, sh.customers c
  5 where s.cust_id = c.cust_id and c.cust_id < 2
  6 group by c.cust_id;

Explained.

SQL>
SQL> select * from table(dbms_xplan.display(null, null));
PLAN_TABLE_OUTPUT
-----
-----
Plan hash value: 212151715
-----
| Id  | Operation          | Name      | Rows  | Bytes | Cost
(%CPU) | Time
| Pstart| Pstop |           |
-----
|   0  | SELECT STATEMENT |          |       | 23    | 471   (2) | 00:00
:01 |           |           |
|   1  | HASH GROUP BY    |          |       | 23    | 471   (2) |
00:00
```

```
:01 |           |   |
|   2 |     NESTED LOOPS          |           |   1 | 23 | 471   (2) |
00:00
:01 |           |   |
|   3 |     VIEW                 | VW_GBC_5 |   1 | 18 | 260   (3) |
00:00
:01 |           |   |
|   4 |     HASH GROUP BY        |           |   1 | 8  | 260   (3) | 00:00
:01 |           |   |
|   5 |     PARTITION RANGE ALL |           | 130 | 1040 | 259
(2) | 00:00

PLAN_TABLE_OUTPUT
-----
-----
:01 |           1 | 28 |
|* 6 |     TABLE ACCESS FULL | SALES      | 130 | 1040 |
259  (2) | 00:00
:01 |           1 | 28 |

|* 7 |     TABLE ACCESS FULL | CUSTOMERS |   1 | 5  | 211
(1) | 00:00
:01 |           |   |

-----
-----
-----
```

Predicate Information (identified by operation id):

```
6 - filter("S"."CUST_ID"<2)
7 - filter("C"."CUST_ID"<2 AND "ITEM_1"="C"."CUST_ID")
```

20 rows selected.  
SQL>

32. Now execute the statement so that you can get the plan in the cursor cache and load the corresponding plan baseline. Use the `load_evolve_baseline.sql` script. What do you observe?

You see that the current plan is both enabled and accepted, but not fixed.

```

SQL> @load_evolve_baseline
SQL> set echo on
SQL>
SQL> variable cnt number;
SQL>
SQL> variable sqlid varchar2(20);
SQL>
SQL> select /*+ USE_NL(s c) FULL(s) FULL(c) */
  2       c.cust_id, sum(s.quantity_sold)
  3   from sh.sales s, sh.customers c
  4  where s.cust_id = c.cust_id and c.cust_id < 2
  5 group by c.cust_id;

no rows selected

SQL>
SQL> begin
  2   select sql_id into :sqlid from v$sql
  3   where sql_text like 'select /*+ USE_NL(s c) FULL(s)
FULL(c) */%';
  4 end;
  5 /
PL/SQL procedure successfully completed.

SQL>
SQL> exec :cnt := dbms_spm.load_plans_from_cursor_cache(
->           sql_id => :sqlid);

PL/SQL procedure successfully completed.

SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
  2          origin, enabled, accepted, fixed, autopurge
  3      from dba_sql_plan_baselines
  4  where sql_text like 'select /*+ USE_NL(s c) FULL(s) FULL(c)
*/%';
SIGNATURE SQL_HANDLE

```

```

SQL_TEXT
-----
PLAN_NAME          ORIGIN      ENA ACC FIX AUT
-----
1.7750E+18 SQL_18a1ef14c17f5b75
select /*+ USE_NL(s c) FULL(s) FULL(c) */
       c.cust_id, sum(s.quantity_sold)
SQL_PLAN_1j8gg2m0ryqvpa496391d MANUAL-LOAD-
                                         FROM-CURSOR-CACHE YES YES NO YES
SQL>

```

33. Manually create and execute a SQL tuning task to tune your statement. Use the `tune_evolve_sql.sql` script.

```

SQL> @tune_evolve_sql.sql
SQL> set echo on
SQL>
SQL> variable sqltext varchar2(4000);
SQL>
SQL> BEGIN
  2   :sqltext := q'# select /*+ USE_NL(s c) FULL(s) FULL(c) */
  3                         c.cust_id, sum(s.quantity_sold)
  4                         from sh.sales s, sh.customers c
  5                         where s.cust_id = c.cust_id
  6                               and c.cust_id < 2
  7                         group by c.cust_id
  8 #';
  9 END;
10 /
PL/SQL procedure successfully completed.

SQL>
SQL> variable spmtune    varchar2(30);
SQL>
SQL> exec :spmtune := dbms_sqltune.create_tuning_task(
->                               sql_text => :sqltext);

PL/SQL procedure successfully completed.

```

```

SQL>
SQL> exec dbms_sqltune.execute_tuning_task(:spmtune);

PL/SQL procedure successfully completed.

SQL>
```

34. Now that the tuning task has been completed, run the report and see what recommendations have been made for your statement. What do you observe?

There are two recommendations: a SQL profile or a new index creation. Use the `report_evolve_tuning.sql` script.

```

SQL> @report_evolve_tuning.sql
SQL> set echo on
SQL>
SQL> set long 10000
SQL>
SQL> select dbms_sqltune.report_tuning_task(:spmtune, 'TEXT')
  2  from dual;

-- Report is not included here -
-- For a sample report see the sql_tuning_report.lst file -
```

35. Accept the SQL profile proposed by the SQL Tuning Advisor. Use the `accept_evolve_baseline.sql` script to accept the recommended SQL profile. What happens?

Accepting the profile causes a new SQL profile and plan baseline to be created for your statement. Now you see two baselines for your statement. Both of them are enabled and accepted.

**Note:** One is MANUAL-LOAD and the other is MANUAL-SQLTUNE.

```

SQL> @accept_evolve_baseline.sql
SQL> set echo on
SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
  2  origin, enabled, accepted, fixed, autopurge
  3  from dba_sql_plan_baselines
  4  where sql_text like
  5  'select /*+ USE_NL(s c) FULL(s) FULL(c) */';

SIGNATURE SQL_HANDLE
```

```

-----
SQL_TEXT
-----

PLAN_NAME          ORIGIN      ENA ACC FIX AUT
-----
1.7750E+18 SQL_18a1ef14c17f5b75
select /*+ USE_NL(s c) FULL(s) FULL(c) */
       c.cust_id, sum(s.quantity_sold)
  from sh.sales s, sh.customers c
 where s.cust_id = c.cust_id and c.cust_id < 2
 group by c.cust_id
SQL_PLAN_1j8gg2m0ryqvpdc5f94e5 MANUAL-LOAD YES YES NO YES

SQL>
SQL> exec dbms_sqltune.accept_sql_profile(
>           task_name => :spmtune,-
>           name => 'SPM_SQL_PROF');
PL/SQL procedure successfully completed.

SQL>
SQL> select signature, category, name, sql_text
  2  from dba_sql_profiles where name like 'SPM%';

SIGNATURE CATEGORY          NAME
-----
SQL_TEXT
-----

1.7750E+18 DEFAULT          SPM_SQL_PROF
select /*+ USE_NL(s c) FULL(s) FULL(c) */
       c.cust_id, sum(s.quantity_sold)
  from sh.sales s, sh.customers c
 where s.cust_id = c.cust_id and c.cust_id < 2
 group by c.cust_id

SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
  2  origin, enabled, accepted, fixed, autopurge

```

```

3  from dba_sql_plan_baselines
4  where sql_text like
5      'select /*+ USE_NL(s c) FULL(s) FULL(c) */%';

SIGNATURE SQL_HANDLE
-----
SQL_TEXT
-----
PLAN_NAME          ORIGIN      ENA ACC FIX AUT
-----
1.7750E+18 SQL_18alef14c17f5b75
select /*+ USE_NL(s c) FULL(s) FULL(c) */
       c.cust_id, sum(s.quantity_sold)
from sh.sales s, sh.customers c
where s.cust_id = c.cust_id and c.cust_id < 2
group by c.cust_id
SQL_PLAN_1j8gg2m0ryqvp08763816 MANUAL-SQLTUNE YES YES NO YES

1.7750E+18 SQL_18alef14c17f5b75
select /*+ USE_NL(s c) FULL(s) FULL(c) */
       c.cust_id, sum(s.quantity_sold)
from sh.sales s, sh.customers c
where s.cust_id = c.cust_id and c.cust_id < 2
group by c.cust_id
SQL_PLAN_1j8gg2m0ryqvp08763816 MANUAL-LOAD      YES YES NO YES

SQL>

```

36. Determine the plan used for your statement when executing it. What do you observe?

The next time you execute the query, it uses the plan baseline and the SQL profile.

Use the `explain_query5.sql` script.

```

SQL> @explain_query5.sql
SQL> set echo on
SQL>
SQL> explain plan for
2  select /*+ USE_NL(s c) FULL(s) FULL(c) */
3      c.cust_id, sum(s.quantity_sold)
4  from sh.sales s, sh.customers c
5  where s.cust_id = c.cust_id and c.cust_id < 2
6  group by c.cust_id;

```

Explained.

```
SQL>
SQL> select * from table(dbms_xplan.display(null,
2                               null, 'basic +note'));
```

PLAN\_TABLE\_OUTPUT

---



---

Plan hash value: 34974602

---



---

Id   Operation	Name
0   SELECT STATEMENT	-
1   HASH GROUP BY	-
2   NESTED LOOPS	-
3   PARTITION RANGE ALL	-
4   TABLE ACCESS BY LOCAL INDEX	SALES
	ROWID BATCHED
5   BITMAP CONVERSION TO ROWIDS	-
6   BITMAP INDEX RANGE SCAN	SALES_CUST_BIX
7   INDEX UNIQUE SCAN	CUSTOMERS_PK

---

Note

---

- SQL profile "SPM\_SQL\_PROF" used for this statement
- SQL plan baseline "SQL\_PLAN\_1j8gg2m0ryqvp08763816" used for this statement

19 rows selected.

### 37. Execute the `cleanup_spm.sql` script to purge your environment for this practice.

```
SQL> @cleanup_spm.sql
SQL> set echo on
SQL>
SQL> exec dbms_sqltune.drop_sql_profile(
->       name => 'SPM_SQL_PROF');
```

PL/SQL procedure successfully completed.

```
SQL>
```

```
SQL> exec :cnt := dbms_spm.drop_sql_plan_baseline(-
>                               'SQL_18a1ef14c17f5b75');

PL/SQL procedure successfully completed.

SQL>
SQL> select signature, sql_handle, sql_text, plan_name,
2          origin, enabled, accepted, fixed, autopurge
3    from dba_sql_plan_baselines
4   where sql_text like
5         'select /*+ USE_NL(s c) FULL(s) FULL(c) */%';

no rows selected

SQL>
SQL> select signature, category, name, sql_text
2    from dba_sql_profiles where name like 'SPM%';

no rows selected

SQL>
SQL> alter system set optimizer_use_sql_plan_baselines=FALSE;

System altered.

SQL>
SQL> exit
```

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## **Workshop 1**

## Workshop 1: Overview

---

### Workshop Overview

In this workshop, you will perform the following tasks:

- Analyze a SQL query statement.
- Create a new index.
- Perform additional tasks.

### Scripts Used in the Workshop

- setup01.sql
- ws01.sql
- w1\_s1\_e.sql
- ws01a.sql
- w1\_s2\_b.sql
- cleanup01.sql

**Note:** Use the scripts provided for each workshop rather than copying and pasting the codes.

# Workshop 1: Enhancing the Performance of a SQL Query Statement

## Overview

In this workshop, you have to find a workaround to enhance performance. You analyze a poorly written SQL statement and perform additional tasks such as creating a function-based index, redesigning a simple table, and rewriting the SQL statement.

## Index Information

Index Name: HR.DEPT\_DEPT\_ID\_IDX1 : DEPT\_ID

## Tasks

1. Analyze a SQL query statement.

- a. Open Oracle SQL Developer.

On the desktop, double-click the SQL Developer desktop icon.



- b. Connect to the hr schema.

The connection details are as follows:

Connection Name: hr\_connection

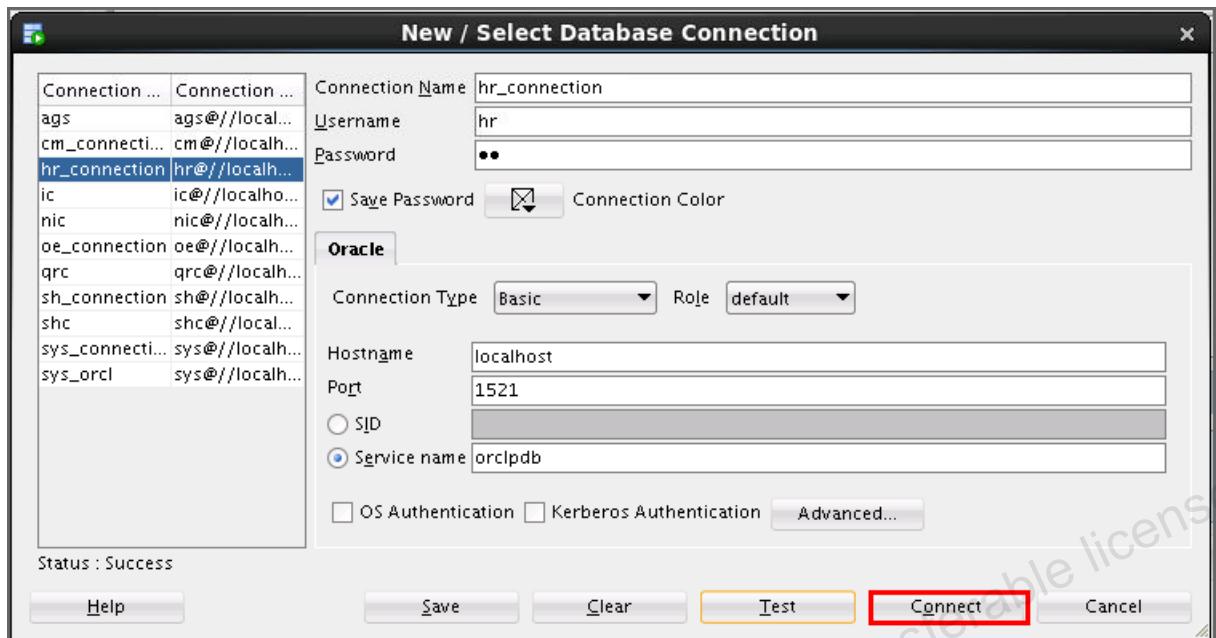
Username: hr

Password: hr

Hostname: localhost

Port: 1521

Service name: orclpdb



- c. Execute `setup01.sql` to set up the environment for this workshop.

**Note:** The scripts for this workshop are available in the workshops folder located in `/home/oracle/labs/workshops`.

**setup01.sql**

```
set echo on

DROP TABLE hr.emp PURGE
/
CREATE TABLE hr.emp AS SELECT * FROM hr.employees
/
DESCRIBE HR.EMP
/
DROP TABLE hr.dept PURGE
/
CREATE TABLE hr.dept AS
SELECT (department_id||'-'||department_name) dept_id,
manager_id, location_id
FROM hr.departments
/
DESCRIBE HR.DEPKT
/
DROP INDEX hr.dept_dept_id_idx1
/
CREATE INDEX hr.dept_dept_id_idx1
ON hr.dept (dept_id)
```

```

NOLOGGING
COMPUTE STATISTICS
/
exec DBMS_STATS.GATHER_TABLE_STATS('HR','EMP')
/
exec DBMS_STATS.GATHER_TABLE_STATS('HR','DEPT')
/
Set echo off

```

- d. Review and check the execution plan of the SQL statement in ws01.sql. Click the Explain Plan tool to check the plan.

```

SELECT employee_id, first_name, last_name, salary, substr
(b.dept_id, instr (b.dept_id,'-') +1) dept_name
FROM hr.emp a, hr.dept b
WHERE a.department_id = substr (b.dept_id, 1, instr
(b.dept_id,'-')-1)
AND salary >= 1000

```

OPERATION	OBJECT_NAME	OPTIONS	COST
SELECT STATEMENT			263
HASH JOIN			4
Access Predicates			263
A.DEPARTMENT_ID=TO_NUMBER(SUBSTR(B.DEPT_ID,1,INSTR(B.DEPT_ID,'-')-1))			4
TABLE ACCESS	DEPT	FULL	27
TABLE ACCESS	EMP	FULL	107
Filter Predicates	SALARY>=1000		2

**Note:** You can use either the EXPLAIN PLAN command, as shown in the script

w1\_s1\_e.sql, or the SQL Developer EXPLAIN PLAN tool icon in the SQL Worksheet to gather the execution plan.

- e. Gather the execution plan of the SQL statement by using the following EXPLAIN PLAN command. Use the **w1\_s1\_e.sql** file and click the **Run script** icon.

```
EXPLAIN PLAN FOR SELECT employee_id, first_name, last_name,
salary, substr (b.dept_id, instr (b.dept_id,'-') +1) dept_name
FROM hr.emp a, hr.dept b
WHERE a.department_id = substr (b.dept_id, 1,
instr (b.dept_id,'-')-1)
AND salary >= 1000
/
SELECT * FROM TABLE (dbms_xplan.display);
```

The screenshot shows the Oracle SQL Developer interface. The top navigation bar has tabs for 'hr\_connection', 'setup01.sql', 'ws01.sql', and 'w1\_s1\_e.sql'. The 'w1\_s1\_e.sql' tab is active. Below the tabs is a toolbar with icons for running scripts, saving, and zooming. The main workspace is titled 'Worksheet' and contains the SQL code for the EXPLAIN PLAN. The code is as follows:

```
EXPLAIN PLAN FOR SELECT employee_id, first_name, last_name,
salary, substr(b.dept_id, instr(b.dept_id,'-')+1) dept_name
FROM hr.emp a, hr.dept b
WHERE a.department_id = substr(b.dept_id,1, instr(b.dept_id,'-')-1)
AND salary >= 1000
/
Select * from table(dbms_xplan.display);
```

Below the worksheet is a 'Script Output' window showing the results of the EXPLAIN PLAN command. It displays the execution plan with the following details:

**Explained.**

**PLAN\_TABLE\_OUTPUT**

Plan hash value: 615168685

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		263	11046	4 (0)	00:00:01
*	1 HASH JOIN		263	11046	4 (0)	00:00:01
2	TABLE ACCESS FULL	DEPT	27	432	2 (0)	00:00:01
*	3 TABLE ACCESS FULL	EMP	107	2782	2 (0)	00:00:01

**PLAN\_TABLE\_OUTPUT**

Predicate Information (identified by operation id):

```

1 - access("A"."DEPARTMENT_ID"=TO_NUMBER(SUBSTR("B"."DEPT_ID",1,INSTR
          ("B"."DEPT_ID",'-' )-1)))
3 - filter("SALARY">>=1000)

```

17 rows selected.

**Note:** The EXPLAIN PLAN command is used to gather the execution plan.

- f. Review the execution plan. What do you observe?

- 1) Was the DEPT\_DEPT\_ID\_IDX1 index used?

- 2) If the index is not used, try to explain why the index is not used.

**Answer:**

- 1) No, the index DEPT\_DEPT\_ID\_IDX1 is not used.
  - 2) Internal transformation occurred due to the function in the indexed column.
2. Create a new index.

- a. Execute the following sample code to create a new index DEPT\_DEPT\_ID\_IDX2 that is usable by the optimizer, or you can use the **ws01a.sql** file.

```
DROP INDEX hr.dept_dept_id_idx2
/
CREATE INDEX hr.dept_dept_id_idx2
ON hr.dept (substr (dept_id, 1, instr (dept_id, '-')-1))
NOLOGGING
COMPUTE STATISTICS
/
```

- b. Use the sample code to gather the execution plan of the SQL statement or you can use the **w1\_s2\_b.sql** file.

```
EXPLAIN PLAN FOR SELECT employee_id, first_name, last_name,
salary, substr (b.dept_id, instr (b.dept_id,'-') +1) dept_name
FROM hr.emp a, hr.dept b
WHERE a.department_id = substr (b.dept_id, 1,
instr (b.dept_id,'-')-1)
AND salary >= 1000
/
SELECT * FROM TABLE (dbms_xplan.display);
```

- c. Review the execution plan. What do you observe?

- 1) Was the DEPT\_DEPT\_ID\_IDX2 index used?
- 2) If the index is not used, try to explain why the index is not used.

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are several tabs: hr\_connection, ws01.sql, w1\_s1\_e.sql, ws01a.sql, and w1\_s2\_b.sql. The active tab is 'hr\_connection'. Below the tabs, the toolbar includes icons for New Worksheet, Open, Save, Print, Copy, Paste, Find, Replace, and others. The status bar indicates '0.103 seconds'.

The main workspace contains a 'Worksheet' tab selected. The code entered is:

```
EXPLAIN PLAN FOR SELECT employee_id, first_name, last_name, salary,
       substr(b.dept_id, instr(b.dept_id, '-')+1) dept_name
  FROM hr.emp a, hr.dept b
 WHERE a.department_id = substr(b.dept_id,1, instr(b.dept_id, '-')-1)
   AND salary >= 1000
/
select * from table(dbms_xplan.display);
```

Below the code, the 'Script Output' pane shows the results of the EXPLAIN PLAN command:

```
Explained.

PLAN_TABLE_OUTPUT
-----
Plan hash value: 615168685

| Id | Operation          | Name | Rows | Bytes | Cost (%CPU)| Time     |
|---|---|---|---|---|---|---|
| 0 | SELECT STATEMENT   |      | 260 | 11960 | 4 (0)| 00:00:01 |
| * 1 | HASH JOIN          |      | 260 | 11960 | 4 (0)| 00:00:01 |
|  2 |  TABLE ACCESS FULL | DEPT | 27  | 540  | 2 (0)| 00:00:01 |
| * 3 |  TABLE ACCESS FULL | EMP  | 107 | 2782 | 2 (0)| 00:00:01 |

PLAN_TABLE_OUTPUT
-----
Predicate Information (identified by operation id):
-----
1 - access("A"."DEPARTMENT_ID"=TO_NUMBER(SUBSTR("DEPT_ID",1,INSTR("DEPT_ID",'-')-1)))
3 - filter("SALARY">>=1000)

17 rows selected.
```

### Answer:

- 1) No, the index DEPT\_DEPT\_ID\_IDX2 is not used.
- 2) There was a data type mismatch. `emp.department_id` (NUMBER) `dept.dept_id` (CHAR).
3. Perform additional tasks.
  - a. Perform additional tasks and rewrite the SQL statements to take advantage of an index.
    - Assume that you have a chance to redesign the DEPT table.

**Note:** To normalize the DEPT table, check all the columns with matching data type. You can create an index on the `dept_id` column and check the execution plan.

- b. Gather the execution plan of the SQL statement by using the EXPLAIN PLAN command.
- c. Review the execution plan. What do you observe?  
Was an index used?
- d. Execute cleanup01.sql to clean up your environment for the next task.

```
DROP INDEX hr.dept_dept_id_idx1  
/  
DROP INDEX hr.dept_dept_id_idx2  
/  
DROP TABLE hr.emp PURGE  
/  
DROP TABLE hr.dept PURGE  
/
```

4. After a function-based index is created, it is always chosen by the optimizer even if there is a condition that forces implicit data type conversion.
  - a. True
  - b. False

**Answer: b**

5. When computing selectivity on predicates of the form function (Column) = constant (for example, function-based index or built-in functions), the optimizer assumes a static selectivity value of 1 percent.
  - a. True
  - b. False

**Answer: b**

**Note:** The EXPLAIN PLAN command will be used in subsequent practices.

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## **Workshop 2**

## Workshop 2: Overview

---

### Workshop Overview

In this workshop, you will perform the following tasks:

- Display an execution plan by using the EXPLAIN PLAN command.
- Display an execution plan by using the V\$ view.
- Analyze and fix the issue.

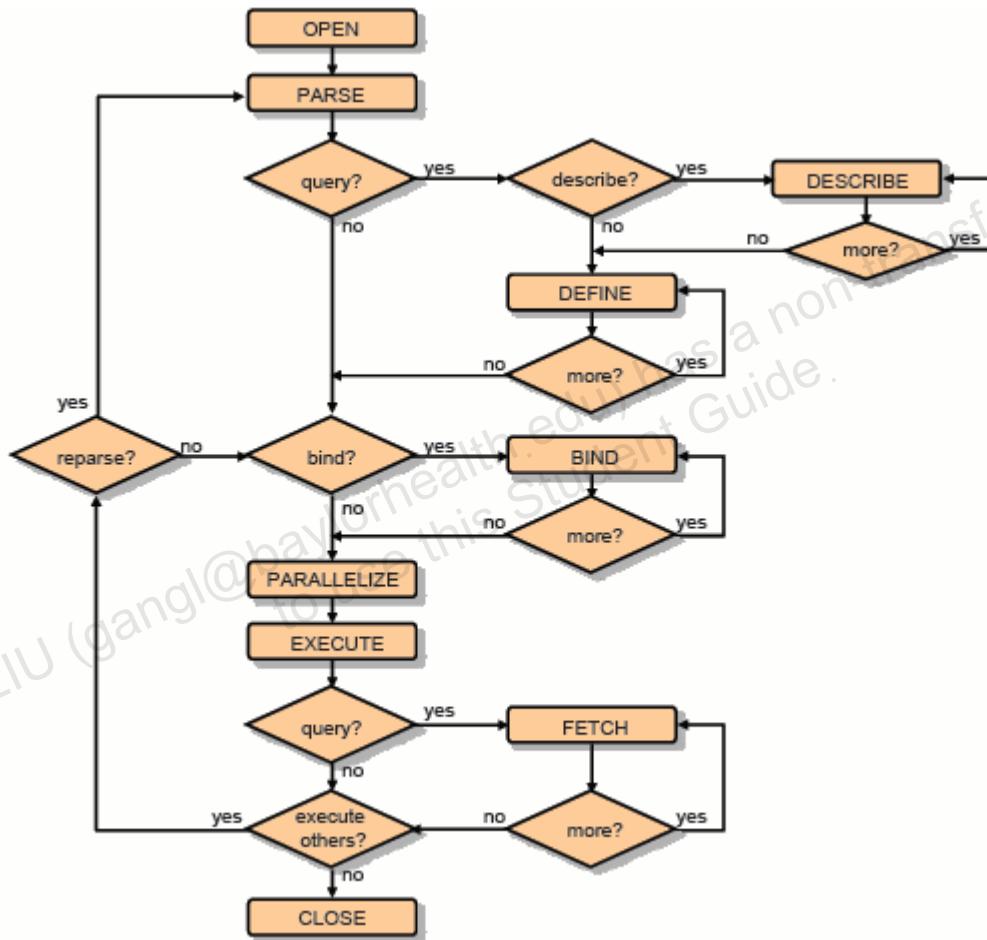
### Scripts Used in the Workshop

- setup02.sql
- ws02.sql
- w2\_s2\_b.sql
- w2\_s2\_b1.sql
- cleanup02.sql

## Workshop 2: Reviewing the Execution Steps of the SQL Statement

### Overview

This workshop is to review the execution steps of a SQL statement section. You review the SQL statement that uses a bind variable in the indexed column. You also analyze two execution plans of the SQL statement using the EXPLAIN PLAN command and the V\$ view. After completing this workshop, you should be able to understand why the two execution plans are different for the same SQL statement.



### Index Information

- Index Name: HR.EMP\_ID\_PK : EMP\_ID

## Tasks

1. Display an execution plan using the EXPLAIN PLAN command.
  - a. Connect to the hr schema in SQL Developer.
  - b. Execute setup02.sql to set up the environment for this workshop.

**Note:** The scripts used in this workshop are available in the workshops folder located in /home/oracle/labs/workshops.

```
DROP TABLE hr.emp PURGE
/
CREATE TABLE emp (
    emp_id varchar2(5) CONSTRAINT emp_id_pk PRIMARY KEY,
    emp_fn varchar2(20),
    emp_ln varchar2(20),
    dept_id varchar2(5)
)
/
/

INSERT INTO emp
SELECT employee_id, first_name, last_name, department_id from employees
/
commit
/

exec DBMS_STATS.GATHER_TABLE_STATS ('HR','EMP', METHOD_OPT =>
'for all indexed columns', CASCADE => TRUE)
/
```

- c. Execute the ws02.sql script and analyze the execution plan by using the EXPLAIN

PLAN command. Click the Run Script  icon to run the script.

Was the EMP\_ID\_IDX index used?

```
variable empid number
exec :empid:= 190

EXPLAIN PLAN FOR
SELECT * FROM hr.emp WHERE emp_id = :empid
/
SELECT * FROM TABLE (dbms_xplan.display);
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are three tabs: 'hr\_connection' (selected), 'setup02.sql', and 'ws02.sql'. The 'ws02.sql' tab is active, displaying the following PL/SQL code:

```

variable empid number
exec :empid := 190

EXPLAIN PLAN FOR
SELECT * FROM hr.emp WHERE emp_id = :empid
/
Select * from table(dbms_xplan.display);

```

Below the code, the 'Script Output' window shows the results of the execution:

```

PL/SQL procedure successfully completed.

Explained.

PLAN_TABLE_OUTPUT
-----
Plan hash value: 1252232671

| Id | Operation          | Name      | Rows | Bytes | Cost (%CPU) | Time      |
| 0 | SELECT STATEMENT   |           | 1    | 21   | 1 (0) | 00:00:01 |
| 1 |  TABLE ACCESS BY INDEX ROWID | EMP       | 1    | 21   | 1 (0) | 00:00:01 |
|* 2 |   INDEX UNIQUE SCAN | EMP_ID_PK | 1    | 0    | 0 (0) | 00:00:01 |

Predicate Information (identified by operation id):
PLAN_TABLE_OUTPUT
-----
2 - access("EMP_ID"=:EMPID)
14 rows selected.

```

### Answer:

Yes, the `EMP_ID_IDX` index is used.

2. Display an execution plan by using the `V$` view.
  - a. Execute the SQL statement in the `ws02.sql` script again.
  - b. Use the following sample codes to review the execution plan by using the `V$SQLAREA` view and format it by using the `DBMS_XPLAN` package; or you can use `w2_s2_b.sql` and `w2_s2_b1.sql` files.

```

variable empid number
exec: empid: =190
SELECT * FROM hr.emp WHERE emp_id=:empid
/
select sql_id, plan_hash_value, sql_text

```

```
from v$sqlarea  
where sql_text = 'SELECT * FROM hr.emp WHERE emp_id=:empid';
```

```
select * from table(dbms_xplan.display_cursor(<<'Please Enter the  
SQL_ID value'>>)) ;
```

- 1) What is the SQL\_ID of the SQL statement?
- 2) What function of DBMS\_XPLAN is used to format and display the contents of the execution plan of any loaded cursor?
- 3) Was the EMP\_ID\_IDX index used?

The screenshot shows an Oracle SQL Worksheet interface. In the top tab bar, there are three tabs: 'w2\_s2\_b.sql' (selected), 'w2\_s2\_b1.sql', and 'ws02.sql'. The main workspace is titled 'Worksheet' and contains the following PL/SQL code:

```
variable empid number  
exec :empid := 190  
  
SELECT * FROM hr.emp WHERE emp_id = :empid;  
  
select sql_id, plan_hash_value,sql_text  
from v$sqlarea  
where sql_text='SELECT * FROM hr.emp WHERE emp_id = :empid';
```

Below the code, the 'Script Output' pane displays the results of the execution:

```
PL/SQL procedure successfully completed.  
  
EMP_ID EMP_FN EMP_LN DEPT_  
-----  
190 Timothy Gates 50  
  
SQL_ID PLAN_HASH_VALUE  
-----  
SQL_TEXT  
-----  
Ovy06dgmbqh9q 3956160932  
SELECT * FROM hr.emp WHERE emp_id = :empid
```

The screenshot shows an Oracle SQL Worksheet interface. The top menu bar has tabs for 'w2\_s2\_b.sql', 'w2\_s2\_b1.sql', and 'ws02.sql'. Below the menu is a toolbar with various icons. The main area is divided into two panes: 'Worksheet' and 'Query Builder'. The 'Worksheet' pane contains the SQL query:select \* from table(dbms\_xplan.display\_cursor('0vy06dgmbqh9q'));The 'Query Result' pane shows the output of the query, which is the execution plan (PLAN\_TABLE\_OUTPUT). The plan details a full table access for the 'hr.emp' table, with one row fetched. The output is as follows:PLAN\_TABLE\_OUTPUT
1 SQL\_ID 0vy06dgmbqh9q, child number 0
2 -----
3 SELECT \* FROM hr.emp WHERE emp\_id = :empid
4
5 Plan hash value: 3956160932
6
7 -----
8 | Id | Operation | Name | Rows | Bytes | Cost (%CPU)| Time |
9 -----
10| 0 | SELECT STATEMENT | | | | 2 (100) | |
11|/\* 1 | TABLE ACCESS FULL| EMP | 1 | 21 | 2 (00) | 00:00:01 |
12-----
13
14 Predicate Information (identified by operation id):
15 -----
16
17 1 - filter(TO\_NUMBER("EMP\_ID")=:EMPID)
18

**Answer:**

- 1) 0vy06dgmbqh9q SQL\_ID
  - 2) dbms\_xplan.display\_cursor is used to format and display the contents of the execution plan of any loaded cursor.
  - 3) No, EMP\_ID\_IDX index is not used.
3. Analyze and fix the issue.
- a. Discuss why the two plans shown in Task 1 and Task 2 are different.  
**Note:** In Task 1, the plan is executed before peeking at the value in the bind variable. And in Task 2, the plan is executed after peeking at the value in the bind variable. Data types are mismatched between the bind variable and indexed column.
  - b. Determine a cause and fix it to use the emp\_id\_pk index.
  - c. Execute the cleanup02.sql script for the next workshop.

```
DROP TABLE hr.emp PURGE
/
```

4. What statements are true?
- The EXPLAIN PLAN command is used to generate an optimizer execution plan.
  - The EXPLAIN PLAN command executes the statement.
  - When a bind variable is used, the EXPLAIN PLAN command peek at the value in the bind variable.

**Answer:** a

5. The following steps are involved in query execution. Fill in the blank.

Parse → ( \_\_\_\_\_ ) → Execute → Fetch

**Answer:** Bind

## **Workshop 3**

## Workshop 3: Overview

---

### Workshop Overview

In this workshop, you will perform the following tasks:

- Perform an initial setup.
- Examine the indexed ORDER BY columns.

### Scripts Used in the Workshop

- `setup03.sql`
- `ws03.sql`
- `w3_s1_c.sql`
- `w3_s2_a.sql`
- `w3_s2_b.sql`
- `w3_s2_b1.sql`
- `w3_s2_c.sql`
- `w3_s2_d.sql`
- `w3_s3_a.sql`
- `w3_s3_b.sql`
- `w3_s3_b1.sql`
- `cleanup03.sql`

## Workshop 3: Learn to Tune Sort Operation Using an Index in the ORDER BY Clauses

---

### Overview

This workshop shows the possible usage of an index in the `ORDER BY` clause to tune a sort operation. You perform several tasks to be able to use the indexed `ORDER BY` column. After all tasks are done, you verify if the index always produces a better plan cost.

Table Name	Column Name	Constraint
SH.CUST	CUST_ID	PRIMARY KEY
	CUST_FN	
	CUST_LN	
	CUST_CREDIT_LIMIT	
	CUST_STATE_PROVINCE	

### Tasks

1. Initial Setup
  - a. Connect to the `sh` schema in SQL Developer.  
Connection details are as follows:  
Connection Name: `sh_connection`  
Username: `sh`  
Password: `sh`  
Hostname: `localhost`  
Service name: `orclpdb`
  - b. Execute the `setup03.sql` to set up the environment for this workshop.

```
DROP TABLE sh.country PURGE
/
CREATE TABLE sh.country (
    country_id number primary key,
    country_name varchar(40),
    country_subregion varchar(30),
    country_region varchar2(20)
)
/
INSERT INTO sh.country
```

```

SELECT country_id, country_name, country_subregion,
country_region
FROM sh.countries
/

commit
/


CREATE INDEX sh.count_country_region_idx
ON sh.country(country_region)
NOLOGGING
COMPUTE STATISTICS
/


exec
dbms_stats.gather_table_stats('SH', 'COUNTRY', method_opt=>'for
all indexed columns', cascade=>true)
/


DESC sh.country
/

```

**Note:** The scripts used in this workshop are available under the workshops folder located in /home/oracle/labs/workshops.

Make sure the **sh** user has the following privilege:

```
GRANT DBA TO sh;
```

If not, connect as the **sys** user in SQL Developer and grant the privilege to **sh**.

- c. Review the **ws03.sql** file. Gather the execution plan of the SQL statement using the **EXPLAIN PLAN** command given as follows or you can use **w3\_s1\_c.sql** file.

```

EXPLAIN PLAN FOR SELECT country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_name
/

SELECT * FROM TABLE(dbms_xplan.display);

```

- 1) What is the name of the index used?
- 2) What is the total cost?

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are tabs for 'setup03.sql', 'sys\_connection', 'ws03.sql', and 'w3\_s1\_c.sql'. The 'ws03.sql' tab is active. Below the tabs, there are icons for running, saving, and connecting. The main workspace is titled 'Worksheet' and contains the following SQL code:

```
EXPLAIN PLAN FOR SELECT country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_name
/
SELECT * FROM TABLE(dbms_xplan.display);
```

Below the worksheet, a 'Script Output' window is open, showing the results of the EXPLAIN PLAN command. It includes the following text:

Task completed in 0.109 seconds

Explained.

PLAN\_TABLE\_OUTPUT

Plan hash value: 1522101967

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		10	340	3 (34)	00:00:01
1	SORT ORDER BY		10	340	3 (34)	00:00:01
2	TABLE ACCESS BY INDEX ROWID BATCHED	COUNTRY	10	340	2 (0)	00:00:01
3	INDEX RANGE SCAN	COUNT_COUNTRY_REGION_IDX	10		1 (0)	00:00:01

PLAN\_TABLE\_OUTPUT

Predicate Information (identified by operation id):

3 - access("COUNTRY\_REGION"='Europe')

15 rows selected.

**Answer:**

- 1) The COUNT\_COUNTRY\_REGION\_IDX index is used.
- 2) Cost is 3.

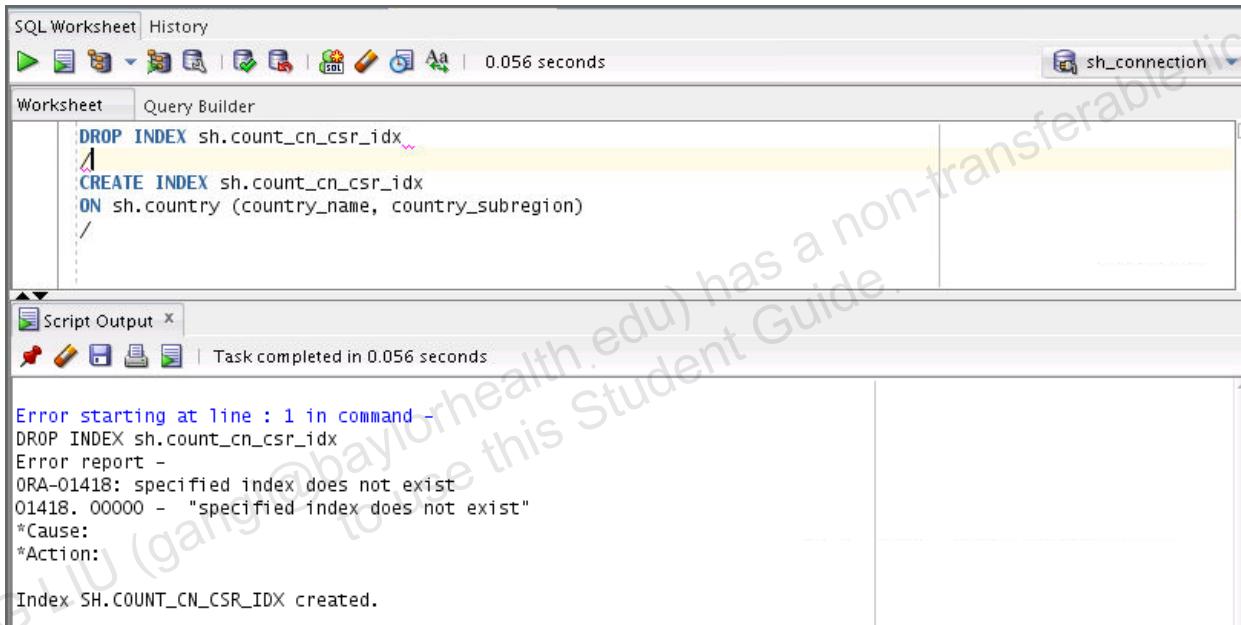
**Note:** Your cost might differ depending on your environment.

2. Examine the indexed ORDER BY columns.

- a. Use the following sample code to create a composite index, COUNT\_CN\_CSR\_IDX or you can use the w3\_s2\_a.sql file.

**Note:** Index order: country\_name, country\_subregion

```
DROP INDEX sh.count_cn_csr_idx
/
CREATE INDEX sh.count_cn_csr_idx
ON sh.country (country_name, country_subregion)
/
```



- b. Gather and analyze the execution plan of the SQL statement again by using the EXPLAIN PLAN command or you can use the w3\_s2\_b.sql file.

```
EXPLAIN PLAN FOR SELECT country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_name, country_subregion
/
SELECT * FROM TABLE(dbms_xplan.display);
```

The screenshot shows the Oracle SQL Developer interface. In the top-left corner, the file tab says "w3\_s2\_b.sql". The title bar includes "SQL Worksheet History" and a connection dropdown "sh\_connection". The toolbar has various icons for operations like Run, Save, and Undo. Below the toolbar, tabs "Worksheet" and "Query Builder" are visible, with "Worksheet" selected. The main workspace contains the following SQL code:

```

EXPLAIN PLAN FOR SELECT country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_name, country_subregion
/
SELECT * FROM TABLE(dbms_xplan.display);

```

Below the code, a message "Task completed in 0.074 seconds" is displayed. The results section starts with "Explained." followed by "PLAN\_TABLE\_OUTPUT". The output shows the execution plan with a plan hash value of 1522101967. The plan details four operations:

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		10	310	3 (34)	00:00:01
1	SORT ORDER BY		10	310	3 (34)	00:00:01
2	TABLE ACCESS BY INDEX ROWID BATCHED	COUNTRY	10	310	2 (0)	00:00:01
3	INDEX RANGE SCAN	COUNT_COUNTRY_REGION_IDX	10	1	1 (0)	00:00:01

Another "PLAN\_TABLE\_OUTPUT" section follows, showing predicate information for operation 3: "access("COUNTRY\_REGION"='Europe')". The message "15 rows selected." is at the bottom.

- Was the COUNT\_CN\_CSR\_IDX index used? If not, add an index hint to allow the optimizer to use the COUNT\_CN\_CSR\_IDX index and gather the execution plan by using the EXPLAIN PLAN command. You can use w3\_s2\_b1.sql.

```

EXPLAIN PLAN FOR SELECT /*+ index (count_cn_csr_idx) */
country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_name, country_subregion
/
SELECT * FROM TABLE(dbms_xplan.display);

```

The screenshot shows the Oracle SQL Developer interface. In the top window (SQL Worksheet), the code is:

```
EXPLAIN PLAN FOR SELECT /*+ index (count_cn_csr_idx) */ country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_name, country_subregion
/
SELECT * FROM TABLE(dbms_xplan.display);
```

In the bottom window (Script Output), the output is:

```
Explained.

PLAN_TABLE_OUTPUT
-----
Plan hash value: 1522101967

| Id | Operation | Name | Rows | Bytes | Cost (%CPU)| Time
| 0 | SELECT STATEMENT | | 1 | 51 | 2 (50) | 00:00:01
| 1 | SORT ORDER BY | | 1 | 51 | 2 (50) | 00:00:01
| 2 | TABLE ACCESS BY INDEX ROWID BATCHED | COUNTRY | 1 | 51 | 1 (0) | 00:00:01
|* 3 | INDEX RANGE SCAN | COUNT_COUNTRY_REGION_IDX | 1 | 1 (0) | 00:00:01

PLAN_TABLE_OUTPUT
-----
Predicate Information (identified by operation id):
-----
3 - access("COUNTRY_REGION"='Europe')

15 rows selected.
```

- 2) Was a sort operation avoided?
- 3) Was the cost of the plan better than the one in Task 1?

**Note:** sh.count\_cn\_csr\_idx is not used. At least, one of the indexed columns in the ORDER BY clause should have the NOT NULL constraint.

- c. If the index is not used, take additional tasks to use the indexed ORDER BY columns.

**Hint:** Consider adding the NOT NULL constraint.

Use the sample code or you can use the w3\_s2\_c.sql file.

```
ALTER TABLE sh.country MODIFY (country_name NOT NULL)
/
```

- d. After step c is performed, repeat Step b to verify if the composite index is used. Use the w3\_s2\_d.sql file.

**Note:** If the composite index is not used even after adding a NOT NULL constraint to the ORDER BY columns, then move to Task 3.

The screenshot shows the Oracle SQL Developer interface. The top window is titled "w3\_s2\_d.sql" and contains the following SQL code:

```

EXPLAIN PLAN FOR SELECT country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_name, country_subregion
/
SELECT * FROM TABLE(dbms_xplan.display);

```

The bottom window is titled "Script Output" and displays the results of the explain plan. It includes the following text and tables:

Explained.

PLAN\_TABLE\_OUTPUT

Plan hash value: 660165367

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		10	310	2 (0)	00:00:01
1	TABLE ACCESS BY INDEX ROWID	COUNTRY	10	310	2 (0)	00:00:01
2	INDEX FULL SCAN	COUNT_CNR_CSR_IDX	23		1 (0)	00:00:01

Predicate Information (identified by operation id):

PLAN\_TABLE\_OUTPUT

---

```

1 - filter("COUNTRY_REGION"='Europe')
14 rows selected.

```

3. Examine the indexed ORDER BY columns.

- a. Use the sample code to create another composite index, COUNT\_CSR\_CN\_IDX, on the ORDER BY columns or you can use the w3\_s3\_a.sql file.

**Note:** Index order: country\_subregion, country\_name

```

DROP INDEX sh.count_csr_cn_idx
/
CREATE INDEX sh.count_csr_cn_idx

```

```
ON sh.country (country_subregion, country_name)
/
```

The screenshot shows an Oracle SQL Worksheet window titled 'w3\_s3\_a.sql'. The 'Worksheet' tab is selected, displaying the following SQL code:

```
DROP INDEX sh.count_csr_cn_idx;
/
CREATE INDEX sh.count_csr_cn_idx
ON sh.country (country_subregion, country_name);
/
```

Below the worksheet, the 'Script Output' tab shows the execution results:

```
Error starting at line : 1 in command -
DROP INDEX sh.count_csr_cn_idx
Error report -
ORA-01418: specified index does not exist
01418. 00000 - "specified index does not exist"
*Cause:
*Action:

Index SH.COUNT_CSR_CN_IDX created.
```

A yellow horizontal bar highlights the error message 'ORA-01418: specified index does not exist'.

- b. Gather and analyze the execution plan of the SQL statement again by using the EXPLAIN PLAN command. You can use the w3\_s3\_b.sql file.

```
EXPLAIN PLAN FOR SELECT country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_name, country_subregion
/
SELECT * FROM TABLE (dbms_xplan.display);
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are two tabs: 'w3\_s3\_a.sql' and 'w3\_s3\_b.sql'. The main workspace is titled 'Worksheet' and contains the following SQL code:

```

EXPLAIN PLAN FOR SELECT country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_subregion, country_name
/
SELECT * FROM TABLE(dbms_xplan.display);

```

Below the worksheet, a 'Script Output' window displays the results of the EXPLAIN PLAN command. It starts with the message 'Explained.' followed by the 'PLAN\_TABLE\_OUTPUT' section, which includes the plan hash value and a detailed table of operations:

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		1	51	2 (50)	00:00:01
1	SORT ORDER BY		1	51	2 (50)	00:00:01
2	TABLE ACCESS BY INDEX ROWID BATCHED	COUNTRY	1	51	1 (0)	00:00:01
* 3	INDEX RANGE SCAN	COUNT_COUNTRY_REGION_IDX	1	1 (0)	00:00:01	

Following the execution plan, the output continues with the 'PLAN\_TABLE\_OUTPUT' section, showing predicate information and the number of rows selected:

```

PLAN_TABLE_OUTPUT
Predicate Information (identified by operation id):
   3 - access("COUNTRY_REGION"='Europe')
15 rows selected.

```

- Was the COUNT\_CSR\_CN\_IDX index used? If not, add an index hint to allow the optimizer to use the count\_csr\_cn\_idx index and gather the execution plan using the EXPLAIN PLAN command. You can use the w3\_s3\_b1.sql file.

```

EXPLAIN PLAN FOR SELECT /*+ index (count_csr_cn_idx) */ 
country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_subregion, country_name
/
SELECT * FROM TABLE (dbms_xplan.display);

```

The screenshot shows the Oracle SQL Developer interface. In the top window, titled 'w3\_s3\_a.sql' and 'w3\_s3\_b1.sql', there is a 'Worksheet' tab where the following SQL code is entered:

```

EXPLAIN PLAN FOR SELECT /*+ index (count_csr_cn_idx) */ country_name, country_subregion
FROM sh.country
WHERE country_region = 'Europe'
ORDER BY country_subregion, country_name
/
SELECT * FROM TABLE(dbms_xplan.display);

```

Below this, in the 'Script Output' window, the results of the EXPLAIN PLAN are displayed:

```

Explained.

PLAN_TABLE_OUTPUT
-----
Plan hash value: 664967298

| Id | Operation          | Name        | Rows | Bytes | Cost (%CPU)| Time     |
|---|---|---|---|---|---|---|
| 0 | SELECT STATEMENT   |             | 1    | 51   | 0  (0) | 00:00:01 |
|/* 1 | TABLE ACCESS BY INDEX ROWID | COUNTRY    | 1    | 51   | 0  (0) | 00:00:01 |
| 2 |  INDEX FULL SCAN   | COUNT_CSR_CN_IDX | 1    |       | 0  (0) | 00:00:01 |

Predicate Information (identified by operation id):
PLAN_TABLE_OUTPUT
-----
1 - filter("COUNTRY_REGION"='Europe')

14 rows selected.

```

- 2) Was a sort operation avoided?
- 3) Was the cost of the plan better than the one in Task 1?

**Note:** The COUNT\_CSR\_CN\_IDX index is used. However, you learned that using the indexed ORDER by column that avoids a sort operation doesn't always produce better performance.

#### 4. Your Observation

**Note:** You have performed several tasks to see the possible usage of an index in the ORDER BY clause to tune a sort operation. Take a minute to answer the following questions based on your observation.

- a. What do you observe?
- b. Execute the cleanup03.sql script for the next workshop.

```
DROP INDEX sh.count_country_region_idx  
/  
DROP INDEX sh.count_cn_csr_idx  
/  
DROP INDEX sh.count_csr_cn_idx  
/  
DROP TABLE sh.country PURGE  
/
```

5. When using the indexed ORDER BY column to avoid a sort operation, you should consider the following:
- All the order by columns should be in the composite index.
  - ORDER BY columns should be of the same order as those of the composite index.
  - At least one of the composite columns should have the NOT NULL constraint.
  - All composite columns should have the NOT NULL constraint.
  - Using the indexed ORDER BY column that avoids a sort operation always produces better performance.

**Answer:** a, b, and c

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## **Workshop 4**

## Workshop 4: Overview

---

### Workshop Overview

In this workshop, you will perform the following tasks:

- Identify a poorly written SQL statement.
- Tune the SQL statement by rewriting it.

### Scripts Used in the Workshop

- setup04.sql
- ws04.sql
- w4\_s1\_d.sql
- w4\_s2\_a.sql
- w4\_s2\_b.sql

## Workshop 4: Identifying and Tuning a Poorly Written SQL Statement

### Overview

In this workshop, you assume that you have identified a poorly running SQL statement. You already noticed that the root cause of the issue is the table design. However, re-creating the table is not an option at this point. The table is already in use. Try to tune the SQL statement by rewriting it.

### Index Information

Index Name	Columns
TIME_IDX	YYYY + MM + DD

### Tasks

1. Initial setup
  - a. Connect to the sh schema in SQL Developer.
  - b. Use `setup04.sql` to set up the environment for this workshop.

**Note:** The scripts used in this workshop are available in the workshops folder located in `/home/oracle/labs/workshops`.

```
DROP TABLE sh.sales1 PURGE
/
CREATE TABLE sh.sales1 (
    sales_id number primary key,
    prod_id number,
    yyyy char(4),
    mm char(2),
    dd char(2),
    amount_sold number(10,2)
)
/
DROP SEQUENCE sh.sales_id_seq
/
CREATE SEQUENCE sh.sales_id_seq
    START WITH 1
    INCREMENT BY 1
    NOCACHE
    NOCYCLE
/
```

```

INSERT INTO sh.sales1
SELECT sales_id_seq.nextval, prod_id,
to_char (time_id, 'YYYY'), to_char (time_id, 'MM'), to_char
(time_id, 'DD'), amount_sold
FROM sh.sales
/
COMMIT
/

DROP TABLE sh.prod1 PURGE
/
CREATE TABLE sh.prod1 AS SELECT * FROM sh.products
/
DROP INDEX sh.time_idx
/
CREATE INDEX sh.time_idx
ON sh.sales1 (YYYY, MM, DD, sales_id)
NOLOGGING
COMPUTE STATISTICS
/
exec DBMS_STATS.GATHER_TABLE_STATS ('SH','SALES1', METHOD_OPT =>
'FOR ALL INDEXED COLUMNS', CASCADE => TRUE)
/
exec DBMS_STATS.GATHER_TABLE_STATS ('SH','PROD1', METHOD_OPT =>
'FOR ALL INDEXED COLUMNS', CASCADE => TRUE)
/
DESC sh.sales1
DESC sh.prod1

```

c. Review the SQL statement in ws04.sql.

```

SELECT (s.yyyy || s.mm || s.dd) TIME, s.prod_id, sum
(amount_sold)
FROM sh.sales1 s, sh.prod1 p
WHERE s.prod_id = p.prod_id
AND s.yyyy || s.mm || s.dd BETWEEN '19980901' AND '19980907'
AND p.prod_category = 'Hardware'

```

```
GROUP BY s.prod_id, s.yyyy || s.mm || s.dd  
ORDER BY 1  
/
```

- d. Gather the execution plan of the SQL statement by using the EXPLAIN PLAN command by using the following sample code, or you can use the w4\_s1\_d.sql file.

```
EXPLAIN PLAN FOR SELECT (s.yyyy || s.mm || s.dd) TIME,  
s.prod_id, sum (amount_sold)  
FROM sh.sales1 s, sh.prod1 p  
WHERE s.prod_id = p.prod_id  
AND s.yyyy || s.mm || s.dd BETWEEN '19980901' AND '19980907'  
AND p.prod_category = 'Hardware'  
GROUP BY s.prod_id, s.yyyy || s.mm || s.dd  
ORDER BY 1  
  
SELECT * FROM TABLE (dbms_xplan.display);
```

- 1) Was the TIME\_IDX index used?
- 2) What is the total cost?

```

EXPLAIN PLAN FOR SELECT (s.yyyy || s.mm || s.dd) TIME, s.prod_id, sum (amount_sold)
FROM sh.sales1 s, sh.prod1 p
WHERE s.prod_id = p.prod_id
AND s.yyyy || s.mm || s.dd BETWEEN '19980901' AND '19980907'
AND p.prod_category = 'Hardware'
GROUP BY s.prod_id, s.yyyy || s.mm || s.dd
ORDER BY 1
/
SELECT * FROM TABLE(dbms_xplan.display);

Explained.

PLAN_TABLE_OUTPUT
-----
Plan hash value: 281941987

| Id  | Operation          | Name   | Rows  | Bytes | Cost (%CPU) | Time      |
|---|---|---|---|---|---|---|
| 0  | SELECT STATEMENT |        | 24    | 1056  | 511  (4) | 00:00:01 |
| 1  | SORT GROUP BY    |        | 24    | 1056  | 511  (4) | 00:00:01 |
|* 2  | HASH JOIN         |        | 461   | 20284 | 510  (4) | 00:00:01 |
|* 3  | TABLE ACCESS FULL | PROD1  | 14    | 294   | 2     (0) | 00:00:01 |
|* 4  | TABLE ACCESS FULL | SALES1 | 2304  | 52992 | 508  (4) | 00:00:01 |

PLAN_TABLE_OUTPUT
-----
Predicate Information (identified by operation id):
-----
2 - access("S"."PROD_ID"="P"."PROD_ID")
3 - filter("P"."PROD_CATEGORY"='Hardware')
4 - filter("S"."YYYY"||"S"."MM"||"S"."DD">>='19980901' AND
     "S"."YYYY"||"S"."MM"||"S"."DD"><='19980907')

19 rows selected.

```

**Answer:**

- 1) The TIME\_IDX index is not used.
- 2) Cost is 511 in this case.

**Note:** In this case, the cost is 511. It might differ also.

2. Rewrite the SQL statement.

- a. If the TIME\_IDX is not used, rewrite and review the SQL statement in w4\_s2\_a.sql to take advantage of the index.

**Hint:** Modify the BETWEEN operator.

```

SELECT (s.yyyy || s.mm || s.dd) TIME, s.prod_id, sum
(amount_sold)
FROM sh.sales1 s, sh.prod1 p
WHERE s.prod_id = p.prod_id
AND (s.yyyy = '1998' AND s.mm = '09' AND s.dd BETWEEN '01' AND
'07')
AND p.prod_category = 'Hardware'
GROUP BY s.yyyy || s.mm || s.dd, s.prod_id
ORDER BY 1
/

```

- b. Use the sample code to gather the execution plan of the rewritten SQL statement by using the EXPLAIN PLAN command. You can use the `w4_s2_b.sql` file.

```

EXPLAIN PLAN FOR SELECT (s.yyyy || s.mm || s.dd) TIME,
s.prod_id, sum (amount_sold)
FROM sh.sales1 s, sh.prod1 p
WHERE s.prod_id = p.prod_id
AND (s.yyyy = '1998' AND s.mm = '09' AND s.dd BETWEEN '01' AND
'07')
AND p.prod_category = 'Hardware'
GROUP BY s.yyyy || s.mm || s.dd, s.prod_id
ORDER BY 1
/
SELECT * FROM TABLE (dbms_xplan.display);

```

- 1) Was the `TIME_IDX` index used?
- 2) What is the total cost?

```

EXPLAIN PLAN FOR SELECT (s.yyyy || s.mm || s.dd) TIME, s.prod_id, sum(amount_sold)
FROM sh.sales1 s, sh.prod1 p
WHERE s.prod_id = p.prod_id
AND (s.yyyy = '1998' AND s.mm = '09' AND s.dd BETWEEN '01' AND '07')
AND p.prod_category = 'Hardware'
GROUP BY s.yyyy || s.mm || s.dd, s.prod_id
ORDER BY 1
/
SELECT * FROM TABLE(dbms_xplan.display);

```

Script Output | Task completed in 0.072 seconds

Explained.

PLAN\_TABLE\_OUTPUT

Plan hash value: 41534641

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		2	88	175 (1)	00:00:01
1	SORT GROUP BY		2	88	175 (1)	00:00:01
2	HASH JOIN		551	24244	174 (0)	00:00:01
3	TABLE ACCESS FULL	PROD1	14	294	2 (0)	00:00:01
4	TABLE ACCESS BY INDEX ROWID BATCHED	SALES1	2754	63342	172 (0)	00:00:01
5	INDEX RANGE SCAN	TIME_IDX	2754		13 (0)	00:00:01

PLAN\_TABLE\_OUTPUT

Predicate Information (identified by operation id):

- 2 - access("S"."PROD\_ID"="P"."PROD\_ID")
- 3 - filter("P"."PROD\_CATEGORY"='Hardware')
- 5 - access("S"."YYYY"='1998' AND "S"."MM"='09' AND "S"."DD">>='01' AND "S"."DD"<='07')

19 rows selected.

### Answer:

- 1) The TIME\_IDX index is used.

**Note:** Redesigning the SALES1 table would be a better choice. But if the table is already in use, you could rewrite the SQL statement to take advantage of the index.

- 2) The total cost is 175.

**Note:** In this case, the cost is 175. It might differ also.

### 3. Your observation

What was your observation?

## **Workshop 5**

## Workshop 5: Overview

---

### Workshop Overview

In this workshop, you will perform the following tasks:

- Write several SQL statements that return the same output to see which SQL statement is more efficient.
- Examine the effects of changing the column order in a composite index.

### Scripts Used in the Workshop

- setup05.sql
- ws05.sql
- w5\_s1\_c.sql
- w5\_s2\_b.sql
- w5\_s3\_b.sql
- w5\_s4\_a.sql
- w5\_s4\_b.sql
- w5\_s5\_a.sql
- w5\_s5\_c.sql
- w5\_s5\_d.sql
- cleanup05.sql

## Workshop 5: Effects of Changing the Column Order in a Composite Index

---

### Overview

In this workshop, you write several SQL statements that return the same output to see which SQL statement is more efficient. You also examine the effects of changing the column order in a composite index.

### Index Information

Index Name	Columns	Initial Status
cust_state_idx	cust_state_province	Visible
cust_income_state_idx	cust_income_level + cust_state_province	Invisible
cust_state_gender_idx	cust_state_province + cust_gender	Invisible

### Tasks

1. Set up.
  - a. Connect to the sh schema in SQL Developer.
  - b. Use the `setup05.sql` script to set up your environment for this task.

**Note:** The scripts used in this workshop are available under the `workshops` folder located in `/home/oracle/labs/workshops`.

```

DROP TABLE sh.cust PURGE
/
CREATE TABLE sh.cust AS SELECT * FROM sh.customers
/

DROP INDEX sh.cust_state_idx
/

CREATE INDEX sh.cust_state_idx
ON sh.cust (cust_state_province)
NOLOGGING
COMPUTE STATISTICS
/

DROP INDEX sh.cust_state_gender_idx
/

```

```

CREATE INDEX sh.cust_state_gender_idx
ON sh.cust(cust_state_province,cust_gender)
NOLOGGING
COMPUTE STATISTICS
/

ALTER INDEX sh.cust_state_gender_idx INVISIBLE
/

DROP INDEX sh.cust_income_state_idx
/

CREATE INDEX sh.cust_income_state_idx
ON sh.cust(cust_income_level,cust_state_province)
NOLOGGING
COMPUTE STATISTICS
/

ALTER INDEX sh.cust_income_state_idx INVISIBLE
/

exec DBMS_STATS.GATHER_TABLE_STATS('SH','CUST', METHOD_OPT =>
'FOR ALL INDEXED COLUMNS', CASCADE => TRUE)
/

```

- c. Make two indexes, CUST\_INCOME\_STATE\_IDX and CUST\_STATE\_GENDER\_IDX visible to the optimizer by using the following code, or you can use the w5\_s1\_c.sql file.

```

ALTER INDEX sh.cust_income_state_idx VISIBLE
/
ALTER INDEX sh.cust_state_gender_idx VISIBLE
/

```

2. Test the first query.

- a. Review the SQL statement (Query 1) in ws05.sql. In the first query, you transformed the indexed columns, CUST\_STATE\_PROVINCE and CUST\_GENDER explicitly on purpose.

```

SELECT cust_first_name, cust_last_name, cust_income_level,
cust_credit_limit
FROM sh.cust
WHERE cust_income_level like 'F%'
AND cust_state_province||'' in ('NJ', 'NY')
AND cust_gender || '' = 'M'

```

- b. Execute the following sample code and gather the execution plan of the SQL statement by using the EXPLAIN PLAN command. You can use the `w5_s2_b.sql` file.

```
EXPLAIN PLAN FOR SELECT cust_first_name, cust_last_name,
cust_income_level, cust_credit_limit
FROM sh.cust
WHERE cust_income_level like 'F%'
AND cust_state_province in ('NJ', 'NY')
AND cust_gender = 'M'
/
SELECT * FROM TABLE (dbms_xplan.display);
```

- 1) Which index was used?
- 2) What is the total cost?

```

EXPLAIN PLAN FOR SELECT cust_first_name, cust_last_name, cust_income_level, cust_credit_limit
FROM sh.cust
WHERE cust_income_level Like 'F%'
AND cust_state_province||'' in ('NJ', 'NY')
AND cust_gender ||'' = 'M'
/
SELECT * FROM TABLE(dbms_xplan.display);

```

Script Output x

Task completed in 0.19 seconds

Explained.

PLAN\_TABLE\_OUTPUT

Plan hash value: 1367750724

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		121	6413	202 (0)	00:00:01
*	1	TABLE ACCESS BY INDEX ROWID BATCHED  CUST	121	6413	202 (0)	00:00:01
*	2	INDEX RANGE SCAN   CUST_INCOME_STATE_IDX	181		64 (0)	00:00:01

Predicate Information (identified by operation id):

PLAN\_TABLE\_OUTPUT

---

```

1 - filter("CUST_GENDER"||''='M')
2 - access("CUST_INCOME_LEVEL" LIKE 'F%')
   filter("CUST_INCOME_LEVEL" LIKE 'F%' AND ("CUST_STATE_PROVINCE"||''='NY' OR
      "CUST_STATE_PROVINCE"||''='NJ'))

```

17 rows selected.

### Answer:

- 1) The CUST\_INCOME\_STATE\_IDX index is used.
- 2) The cost is 202.

**Note:** The cost is 202 in this case. It might differ also.

- c. Did the optimizer consider the CUST\_STATE\_GENDER\_IDX index? If not, try to explain why the index was not considered.

**Note:** The CUST\_STATE\_GENDER\_IDX index was not considered due to the transformed columns.

3. Test the second query.

- a. Rewrite the SQL statement (Query 2) to consider the CUST\_STATE\_GENDER\_IDX index as an option as well.

```
SELECT cust_first_name, cust_last_name, cust_income_level,  
cust_credit_limit  
FROM sh.cust  
WHERE cust_income_level like 'F%'  
AND cust_state_province in ('NJ', 'NY')  
AND cust_gender = 'M'  
AND rownum < 31  
/
```

- b. Execute the following sample code and gather the execution plan of the SQL statement using the EXPLAIN PLAN command. You can use the w5\_s3\_b.sql file.

```
EXPLAIN PLAN FOR SELECT cust_first_name, cust_last_name,  
cust_income_level, cust_credit_limit  
FROM sh.cust  
WHERE cust_income_level like 'F%'  
AND cust_state_province in ('NJ', 'NY')  
AND cust_gender = 'M'  
AND rownum < 31  
/  
SELECT * FROM TABLE (dbms_xplan.display);
```

- 1) Which index was used?
- 2) What is the total cost?

```

EXPLAIN PLAN FOR SELECT cust_first_name, cust_last_name, cust_income_level, cust_credit_limit
FROM sh.cust
WHERE cust_income_level Like 'F%'
AND cust_state_province in ('NJ', 'NY')
AND cust_gender = 'M'
AND rownum < 31
/
SELECT * FROM TABLE(dbms_xplan.display);

```

Script Output | Task completed in 0.151 seconds

Explained.

PLAN\_TABLE\_OUTPUT

Plan hash value: 2872430508

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		30	1590	53 (0)	00:00:01
*	1 COUNT STOPKEY					
*	2 TABLE ACCESS BY INDEX ROWID BATCHED CUST	CUST	30	1590	53 (0)	00:00:01
*	3 INDEX RANGE SCAN CUST_INCOME_STATE_IDX	CUST_INCOME_STATE_IDX	181		18 (0)	00:00:01

PLAN\_TABLE\_OUTPUT

Predicate Information (identified by operation id):

```

1 - filter(ROWNUM<31)
2 - filter("CUST_GENDER"='M')
3 - access("CUST_INCOME_LEVEL" LIKE 'F%')
filter(("CUST_STATE_PROVINCE"='NJ' OR "CUST_STATE_PROVINCE"='NY') AND "CUST_INCOME_LEVEL" LIKE 'F%')

```

19 rows selected.

**Answer:**

- 1) The CUST\_INCOME\_STATE\_IDX index is used.
- 2) The cost is 53.

**Note:** The cost is 53 in this case. It might differ also.

- c. Did the optimizer consider the CUST\_STATE\_GENDER\_IDX index? If no, try to explain why the index was not considered in Task 3.

**Note:** In Task 3, the CUST\_STATE\_GENDER\_IDX index was considered, but was not an optimal access path.

4. Test the third query.

- a. Rewrite the SQL statement that returns the same output using an IN-LINE VIEW.  
Use the following sample code, or you can use the `w5_s4_a.sql` file.
- The usage of both OR and ROWNUM sometimes causes performance problems. So, you rewrite the SQL statement that includes an IN-LINE VIEW.

```

SELECT cust_first_name, cust_last_name, cust_income_level,
cust_credit_limit
FROM (SELECT cust_first_name, cust_last_name, cust_income_level,
cust_credit_limit
FROM sh.cust
WHERE cust_income_level like 'F%' AND cust_state_province = 'NJ'
AND cust_gender= 'M'
union all
SELECT cust_first_name, cust_last_name, cust_income_level,
cust_credit_limit
FROM sh.cust
WHERE cust_income_level like 'F%' AND cust_state_province = 'NY'
AND cust_gender= 'M')
WHERE rownum < 31
/

```

**Note:** The inline view is a construct in Oracle SQL where you can place a query in the SQL FROM clause, as if the query was a table name.

- b. Execute the following sample code and gather the execution plan of the SQL statement by using the EXPLAIN PLAN command. You can use the `w5_s4_b.sql` file.

```

EXPLAIN PLAN FOR SELECT cust_first_name, cust_last_name,
cust_income_level, cust_credit_limit
FROM (SELECT cust_first_name, cust_last_name, cust_income_level,
cust_credit_limit
FROM sh.cust
WHERE cust_income_level like 'F%' AND cust_state_province = 'NJ'
AND cust_gender= 'M'
union all
SELECT cust_first_name, cust_last_name, cust_income_level,
cust_credit_limit
FROM sh.cust
WHERE cust_income_level like 'F%' AND cust_state_province = 'NY'
AND cust_gender= 'M')
WHERE rownum < 31

```

```
/  
SELECT * FROM TABLE (dbms_xplan.display);
```

- 1) Which index was used?
- 2) What is the total cost?

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, the fourth tab is active and contains the query: `EXPLAIN PLAN FOR SELECT cust_first_name, cust_last_name, cust_income_level, cust_credit_limit FROM ( SELECT cust_first_name, cust_last_name, cust_income_level, cust_credit_limit FROM sh.cust WHERE cust_income_level like 'F%' AND cust_state_province = 'NJ' AND cust_gender= 'M' union all SELECT cust_first_name, cust_last_name, cust_income_level, cust_credit_limit FROM sh.cust WHERE cust_income_level like 'F%' AND cust_state_province = 'NY' AND cust_gender= 'M' ) WHERE rownum < 31 / SELECT * FROM TABLE(dbms_xplan.display);`. Below the tabs, the status bar shows "0.087 seconds". The main area displays the execution plan table:

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		30	1920	154 (0)	00:00:01
*	COUNT STOPKEY					
2	VIEW		57	3648	154 (0)	00:00:01
3	UNION-ALL					
*	4 TABLE ACCESS BY INDEX ROWID BATCHED	CUST	26	1378	95 (0)	00:00:01
*	5 INDEX RANGE SCAN	CUST_INCOME_STATE_IDX	39	64	(0)	00:00:01

Below the table, there are two more sections: "PLAN\_TABLE\_OUTPUT" and "Predicate Information (identified by operation id)".

### Answer:

- 1) The CUST\_INCOME\_STATE\_IDX index is used.
- 2) The cost is 154.

**Note:** The cost is 154 in this case. It might differ also.

- c. Compare the total costs of three SQL statements.
- 1) Cost (Query 1)
  - 2) Cost (Query 2)
  - 3) Cost (Query 3)
5. Review the composite index.
- a. You have tested three SQL statements that return the same output. All three SQL statements used the same index, which is CUST\_INCOME\_STATE\_IDX. You still feel that the performance could be improved. Now, you are investigating the CUST\_INCOME\_STATE\_IDX index for further improvement. Retrieve the order of columns in the composite index. You can use the w5\_s5\_a.sql file.
- Hint:** Use the USER\_IND\_COLUMNS view.
- 1) Column Name in Position 1: (\_\_\_\_\_)
  - 2) Column Name in Position 2: (\_\_\_\_\_)

```
select COLUMN_NAME from USER_IND_COLUMNS where INDEX_NAME =  
'CUST_INCOME_STATE_IDX';
```

The screenshot shows the Oracle SQL Developer interface. In the top navigation bar, there are tabs for 'setup05.sql' and 'w5\_s5\_a.sql'. The main area is a 'Worksheet' tab, which contains the SQL query: 'select COLUMN\_NAME from USER\_IND\_COLUMNS where INDEX\_NAME = 'CUST\_INCOME\_STATE\_IDX''. Below the query, the 'Query Result' tab is open, showing the following data:

COLUMN_NAME
1 CUST_INCOME_LEVEL
2 CUST_STATE_PROVINCE

**Answer:**

- 1) Column name in position 1 is cust\_income\_level.
  - 2) Column name in position 2 is cust\_state\_province.
- b. Check how these columns are used in the WHERE clause (Query 2).
- 1) WHERE (\_\_\_\_\_ ) LIKE '...'
  - 2) AND (\_\_\_\_\_ ) IN (....)

**Answer:**

- 1) WHERE cust\_income\_level LIKE 'F%'
  - 2) AND cust\_state\_province IN ('NJ', 'NY')
- c. Execute the following sample code and create a new composite index, CUST\_STATE\_INCOME\_IDX, after considering the order of columns in the CUST\_INCOME\_STATE\_IDX index for better performance. Make sure that you update statistics on the newly created index. You can use the w5\_s5\_c.sql file.

**Hint:** Think about the order of the Index column.

**Rule of thumb:** If all columns in a composite index are equally used, then consider the following:

- Point condition
- Distribution
- Access paths

```
DROP INDEX sh.cust_state_income_idx
/
CREATE INDEX sh.cust_state_income_idx
ON sh.cust (cust_state_province, cust_income_level);
NOLOGGING
COMPUTE STATISTICS
/
Exec DBMS_STATS_GATHER_TABLE_STATS ('SH','CUST', METHOD_OPT =>
'FOR ALL INDEXED COLUMNS', CASCADE =>TRUE)
/
```

```

DROP INDEX sh.cust_state_income_idx;
/
CREATE INDEX sh.cust_state_income_idx
ON sh.cust (cust_state_province, cust_income_level)
NOLOGGING
COMPUTE STATISTICS
/
exec DBMS_STATS.GATHER_TABLE_STATS('SH','CUST', METHOD_OPT => 'FOR ALL INDEXED COLUMNS', CASCADE => TRUE)
/

```

Script Output

Error starting at line : 1 in command -  
 DROP INDEX sh.cust\_state\_income\_idx  
 Error report -  
 ORA-01418: specified index does not exist  
 01418. 00000 - "specified index does not exist"  
 \*Cause:  
 \*Action:  
 Index SH.CUST\_STATE\_INCOME\_IDX created.  
 PL/SQL procedure successfully completed.

- d. Execute the SQL statement (Query 2) and review the execution plan by using the sample code, or you can use the `w5_s5_d.sql` file.

```

EXPLAIN PLAN FOR SELECT cust_first_name, cust_last_name,
cust_income_level, cust_credit_limit
FROM sh.cust
WHERE cust_income_level like 'F%'
AND cust_state_province in ('NJ', 'NY')
AND cust_gender = 'M'
AND rownum < 31
/
SELECT * FROM TABLE (dbms_xplan.display);

```

- 1) Which index was used?
- 2) What is the total cost?

The screenshot shows the Oracle SQL Developer interface. In the top window, titled 'SQL Worksheet', there are two tabs: 'setup05.sql' and 'w5\_s5\_d.sql'. The 'w5\_s5\_d.sql' tab is active, containing the following SQL code:

```

EXPLAIN PLAN FOR SELECT cust_first_name, cust_last_name, cust_income_level, cust_credit_limit
FROM sh.cust
WHERE cust_income_level like 'F%'
AND cust_state_province in ('NJ', 'NY')
AND cust_gender = 'M'
AND rownum < 31
/
SELECT * FROM TABLE(dbms_xplan.display);

```

Below this, the 'Script Output' window shows the results of the EXPLAIN PLAN command:

```

Explained.

PLAN_TABLE_OUTPUT
-----
Plan hash value: 1371959703

| Id | Operation          | Name      | Rows | Bytes | Cost (%CPU) | Time      |
| 0 | SELECT STATEMENT   |           | 30   | 1590  |    37 (0)  | 00:00:01 |
|* 1 | COUNT STOPKEY     |           |       |        |            |            |
| 2 | INLIST ITERATOR   |           |       |        |            |            |
|* 3 | TABLE ACCESS BY INDEX ROWID BATCHED | CUST    | 30   | 1590  |    37 (0)  | 00:00:01 |
|* 4 | INDEX RANGE SCAN   | CUST_STATE_INCOME_IDX | 164  | 2      |    2 (0)  | 00:00:01 |

PLAN_TABLE_OUTPUT
-----
Predicate Information (identified by operation id):
-----
1 - filter(ROWNUM<31)
3 - filter("CUST_GENDER"='M')
4 - access(("CUST_STATE_PROVINCE"='NJ' OR "CUST_STATE_PROVINCE"='NY') AND "CUST_INCOME_LEVEL" LIKE 'F%')
   filter("CUST_INCOME_LEVEL" LIKE 'F%')

20 rows selected.

```

**Answer:**

- 1) The CUST\_STATE\_INCOME\_IDX index is used.
- 2) The cost is 37.

**Note:** The cost is 37 in this case. It might differ also.

- e. Did you observe a better cost?

**Answer:** Yes, the cost is better.

- f. Clean up the environment. Use the cleanup05.sql file.

```
DROP INDEX sh.cust_state_idx  
/  
  
DROP INDEX sh.cust_state_gender_idx  
/  
  
DROP INDEX sh.cust_income_state_idx  
/  
  
DROP INDEX sh.cust_state_income_idx  
/
```

6. Which statements are true regarding guidelines for ordering keys in composite indexes?
- a. Create the index so that the keys used in WHERE clauses make up a leading portion.
  - b. If some keys appear in WHERE clauses more frequently, then create the index so that the more frequently selected keys make up a leading portion in order to allow the statements that use only these keys to use the index.
  - c. If all keys appear in WHERE clauses equally often but the data is physically ordered on one of the keys, then place this key first in the composite index.

**Answer:** a, b, and c

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## **Workshop 6**

## Workshop 6: Overview

---

### Workshop Overview

In this workshop, you will perform the following tasks:

- Review the execution plan and several sections in an event 10053 trace file.
- Interpret the information to understand the optimizer's decision.
- Learn how to use the information in the 10053 file to tune the SQL statement.

## Workshop-6: Using Information in the 10053 File to Tune a SQL Statement

### Overview

In this workshop, you review the following execution plan and several sections in an event 10053 trace file. There are also several questions on cost model, selectivity, and cardinality. You interpret the information to understand the optimizer's decision. Finally, you learn how to verify the cost of a nested loop manually. Note that this workshop is only for demonstration purposes.

```
SELECT ename, e.deptno, d.deptno, d.dname
  FROM emp e, dept d
 WHERE e.deptno = d.deptno and ename like 'A%'
 /
```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	
0	SELECT STATEMENT		1	22	4	(0)	00:00:01
1	NESTED LOOPS						
2	NESTED LOOPS		1	22	4	(0)	00:00:01
*  3	TABLE ACCESS FULL	EMP	1	9	3	(0)	00:00:01
*  4	INDEX UNIQUE SCAN	PK_DEPT	1		0	(0)	00:00:01
5	TABLE ACCESS BY INDEX ROWID	DEPT	1	13	1	(0)	00:00:01

### Tasks

- From where/how is the cost of the simple nested loops 4 derived?
  - First of all, review the information needed to understand the CBO cost model:
  - a. Cost = I/O cost + CPU cost
  - b. sreadtim = ioseektim + db\_block\_size / iotfrspeed
  - c. mreadtim = ioseektim + db\_file\_multiblock\_read\_count \* db\_block\_size / iotfrspeed
  - d. CPU Costing Factor = cpuspeed \* 1000 \* sreadtim
  - e. CPU Cost Scale Factor = 1 / CPU Costing Factor
  - f. CPU Cost = Resp\_cpu \* CPU Cost Scale Factor
  - g. NL Cost = Outer Table Cost + (Outer Table Card \* Inner Table Cost)
  - h. HJ/SMJ Cost = Outer Table Cost + Inner Table Cost + Join Cost2

2. Review the SYSTEM STATISTICS section in an event 10053 trace file and calculate the following information:
- sreadtim (db\_block\_size: 8K): (\_\_\_\_\_)
  - CPU cost scale factor: (\_\_\_\_\_)

```
-----  
SYSTEM STATISTICS INFORMATION  
-----  
Using NOWORKLOAD Stats  
CPUSPEEDNW: 1999 millions instructions/sec (default is 100)  
IOTFRSPEED: 4096 bytes per millisecond (default is 4096)  
IOSEEKTIM: 10 milliseconds (default is 10)  
MBRC: -1 blocks (default is 8)
```

$$\begin{aligned} \text{sreadtim} &= \text{ioseektim} + \text{db\_block\_size} / \text{iotfrspeed} \\ &= 10\text{ms} + 8096/4096 = 12 \text{ ms} \\ \text{CPU Costing Factor} &= \text{cpuspeed} * 1000 * \text{sreadtim} \\ &= 1999 * 1000 * 12 = 23988000 \\ \text{CPU Cost Scale Factor} &= 1 / \text{CPU Costing Factor} \\ &= 1/(1999 * 1000 * 12) = 0.000000417 \\ &\text{(nearly zero)} \end{aligned}$$

3. Review the following section for the outer table. Where is the outer table cost 3 from?
- Outer Table Cost (3) = IO Cost (\_\_\_\_\_) + CPU Cost (\_\_\_\_\_)

```
Access path analysis for EMP
*****
SINGLE TABLE ACCESS PATH
Single Table Cardinality Estimation for EMP[E]
Column (#2): ENAME
  AvgLen: 6 NDV: 14 Nulls: 0 Density: 0.071429
Table: EMP Alias: E
  Card: Original: 14.000000 Rounded: 1 Computed: 1.00 Non Adjusted: 1.00
Access Path: TableScan
  Cost: 3.00 Resp: 3.00 Degree: 0
  Cost io: 3.00 Cost cpu: 39507
  Resp_io: 3.00 Resp_cpu: 39507
Best:: AccessPath: TableScan
  Cost: 3.00 Degree: 1 Resp: 3.00 Card: 1.00 Bytes: 0
```

$$\begin{aligned} \text{Outer Table Cost} &= \text{IO Cost} + \text{CPU Cost} \\ &= \text{Resp\_io} + (\text{Resp\_cpu} * \text{CPU Cost Scale Factor}) \\ &= 3 + (39507 * 0.000000417) \\ &= 3 + 0.0162 \text{ (nearly zero)} \end{aligned}$$

4. Review the following section that includes the inner table information.
- Outer Table Card: (\_\_\_\_)
  - Inner Table Cost (\_\_\_\_) = IO Cost (\_\_\_\_) + CPU Cost (\_\_\_\_)

```
*****
Now joining: DEPT[D]#1
*****
NL Join
Outer table: Card: 1.00 Cost: 3.00 Resp: 3.00 Degree: 1 Bytes: 9
Access path analysis for DEPT
  Inner table: DEPT Alias: D
  Access Path: TableScan
    NL Join: Cost: 6.00 Resp: 6.00 Degree: 1
      Cost_io: 6.00 Cost_cpu: 75794
      Resp_io: 6.00 Resp_cpu: 75794
    Access Path: index (UniqueScan)
      Index: PK_DEPT
      resc_io: 1.00 resc_cpu: 8341
      ix_sel: 0.250000 ix_sel_with_filters: 0.250000
    NL Join : Cost: 4.00 Resp: 4.00 Degree: 1
      Cost_io: 4.00 Cost_cpu: 47849
      Resp_io: 4.00 Resp_cpu: 47849
Best NL cost: 4.00
  resc: 4.00 resc_io: 4.00 resc_cpu: 47849
  resp: 4.00 resp_io: 4.00 resp_cpu: 47849
Join Card: 1.000000 = outer (1.000000) * inner (4.000000) * sel (0.250000)
Join Card - Rounded: 1 Computed: 1.00

```

(Output truncated)

$$\begin{aligned} \text{Inner Table Cost} &= \text{IO Cost} + \text{CPU Cost} \\ &= \text{resc\_io} + (\text{resc\_cpu} * \text{CPU Cost Scale Factor}) \\ &= 1 + (8341 * 0.000000417) \\ &= 1 + 0.0162 \text{ (nearly zero)} \end{aligned}$$

5. Where is the cost of the nested loops from?
- NL Cost = Outer Table Cost + (Outer Table Card \* Inner Table Cost)
  - $4 = 3 + (1 * 1)$
6. Which statements regarding nested loop joins are TRUE?
- The optimizer uses nested loop joins when joining a small number of rows, with a good driving condition between the two tables.
  - The cost of nested loops is easy to verify manually by using an event 10053.
  - A major component of nested loops cost is CPU cost.
  - A major component of nested loops cost is I/O cost.
- Answer:** a, b, d

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## **Workshop 7**

## Workshop 7: Overview

---

### Workshop Overview

In this workshop, you will perform the following tasks:

- Review the execution plan and several sections in an event 10053 trace file.
- Interpret the information to understand the optimizer's decision.
- Learn how to use the information in the 10053 file to tune a SQL statement.

## Workshop 7: Understanding the Optimizer's Decision

### Overview

In this workshop, you review the following execution plan and several sections in an event 10053 trace file. You interpret the information to understand the optimizer's decision. Note that this workshop is only for demonstration purposes.

```

SELECT ch.channel_class, c.cust_city,
       t.calendar_quarter_desc,
       SUM(s.amount_sold) sales_amount
  FROM sales s,times t,customers c,channels ch
 WHERE s.time_id = t.time_id AND
       s.cust_id = c.cust_id AND
       s.channel_id = ch.channel_id AND
       c.cust_state_province = 'CA' AND
       ch.channel_desc IN ('Internet','Catalog') AND
       t.calendar_quarter_desc IN ('1999-Q1','1999-Q2')
 GROUP BY ch.channel_class, c.cust_city,
          t.calendar_quarter_desc
/

```

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	Pstart	Pstop
0	SELECT STATEMENT		572	48048	962 (2)	00:00:12		
1	HASH GROUP BY		572	48048	962 (2)	00:00:12		
* 2	HASH JOIN		3116	255K	961 (2)	00:00:12		
* 3	TABLE ACCESS FULL	CHANNELS	2	42	3 (0)	00:00:01		
* 4	HASH JOIN		6231	383K	957 (2)	00:00:12		
5	PART JOIN FILTER CREATE	:BF0000	183	2928	18 (0)	00:00:01		
* 6	TABLE ACCESS FULL	TIMES	183	2928	18 (0)	00:00:01		
* 7	HASH JOIN		49822	2286K	939 (2)	00:00:12		
* 8	TABLE ACCESS FULL	CUSTOMERS	383	9958	405 (1)	00:00:05		
9	PARTITION RANGE JOIN-FILTER		918K	18M	529 (3)	00:00:07   :BF0000	:BF0000	
10	TABLE ACCESS FULL	SALES	918K	18M	529 (3)	00:00:07   :BF0000	:BF0000	

### Tasks

1. Review the preceding execution plan.
  - a. What is the plan cost? (\_\_\_\_\_)
  - b. Where does the 00:00:12 time come from? (\_\_\_\_\_)

### Answer:

- a. Plan cost is 962.
- b.  $12 \text{ sec} = \text{Plan Cost} * \text{sreadtim} = 962 * 12\text{ms}$

2. What is the meaning of a cost of 962 and 00:00:12 time.

**Note:** The meaning of the cost 962 is that the Oracle Optimizer computed that the preceding query should take as long as 962 single block reads. The cost of 962 equals an elapsed time of 12 sec.

3. Review the following section in an event 10053. What should be checked here?

```
*****
PARAMETERS USED BY THE OPTIMIZER
*****
*****
PARAMETERS WITH ALTERED VALUES
*****
Compilation Environment Dump

*** 2011-06-27 16:49:55.273
_db_file_optimizer_read_count      = 16
cursor_sharing                     = force
db_file_multiblock_read_count     = 16
Bug Fix Control Environment

*****
PARAMETERS WITH DEFAULT VALUES
*****
Compilation Environment Dump
optimizer_mode_hinted              = false
optimizer_features_hinted          = 0.0.0
parallel_execution_enabled          = true
```

#### Notes

- You have learned in the lesson titled “Optimizer Fundamentals” that there are several parameters that could control the behavior of the optimizer.
- The example in 10053 shows parameters used by the optimizer.
- While reviewing this section, you can examine if any altered parameter values influenced the optimizer’s decision.
- You can also compare 10053 traces between two versions or two different plans to see why the plan cost is different.

4. Review the following section in an event 10053. What should be checked here?

```
*****
BASE STATISTICAL INFORMATION
*****
Table Stats::
Table: CHANNELS Alias: CH
#Rows: 5 #Blks: 4 AvgRowLen: 40.00
Index Stats::
Index: CHANNELS_PK Col#: 1
■ LVLS: 0 #LB: 1 #DK: 5 LB/K: 1.00 DB/K: 1.00 CLUF: 1.00
*****
Table Stats::
Table: CUSTOMERS Alias: C
#Rows: 55500 #Blks: 1486 AvgRowLen: 180.00
Index Stats::
Index: CUSTOMERS_GENDER_BIX Col#: 4
LVLS: 1 #LB: 3 #DK: 2 LB/K: 1.00 DB/K: 2.00 CLUF: 5.00
Index: CUSTOMERS_MARITAL_BIX Col#: 6
```

**Note:** It shows statistics gathered for each table and index referred by the query.

Look for any tables that were not analyzed. You see “NOT ANALYZED” in the table stats section if there is no analysis. Indexes that are not analyzed can be identified by default.

5. Review the following section in an event 10053. What should be checked here?

```
Access path analysis for SALES
*****
SINGLE TABLE ACCESS PATH
Single Table Cardinality Estimation for SALES[S]
Table: SALES Alias: S
Card: Original: 918843.000000 Rounded: 918843 Computed: 918843.00 Non Adjusted
918843.00
Access Path: TableScan
Cost: 405.99 Resp: 405.99 Degree: 0
Cost_io: 389.00 Cost_cpu: 260685437
Resp_io: 389.00 Resp_cpu: 260685437
***** trying bitmap/domain indexes *****
Access Path: index (FullScan)
Index: SALES_CHANNEL_BIX
resc_io: 75.00 resc_cpu: 552508
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 75.04 Resp: 75.04 Degree: 0
Access Path: index (FullScan)
Index: SALES_CUST_BIX
resc_io: 503.00 resc_cpu: 10743684
ix_sel: 1.000000 ix_sel_with_filters: 1.000000
Cost: 503.70 Resp: 503.70 Degree: 0
Access Path: index (FullScan)
Index: SALES_PROD_BIX
```

Best:: AccessPath: TableScan  
Cost: 405.99 Degree: 1 Resp: 405.99 Card: 918843.00 Bytes: 0

**Note:** Single table access path: You can determine the path that correlates to the execution plan. At the end of this section, you can see the best single table access cost.

6. Review the following section in an event 10053. What should be checked here?

```

OPTIMIZER STATISTICS AND COMPUTATIONS
*****
GENERAL PLANS
*****
Considering cardinality-based initial join order.
Permutations for Starting Table :0
Join order[1]: CHANNELS[CH]#0 TIMES[T]#1 CUSTOMERS[C]#2 SALES[S]#3

*****
Now joining: TIMES[T]#1
*****
NL Join
Outer table: Card: 2.00 Cost: 3.00 Resp: 3.00 Degree: 1 Bytes: 21
Access path analysis for TIMES
  Inner table: TIMES Alias: T
  Access Path: TableScan
    NL Join: Cost: 31.30 Resp: 31.30 Degree: 1
      Cost_io: 31.00 Cost_cpu: 4659106
      Resp_io: 31.00 Resp_cpu: 4659106

```

**Note:** Join orders and join methods

7. Suppose that a user is complaining of slow response time of a query. According to the user's observation, it took 20 minutes to complete. You reviewed the execution plan and cost by using the explain plan and plan\_table. The plan cost is 4000.
- What is the computed elapsed time based on the cost of 4000?
  - Was the Oracle Optimizer estimated accurately?
    - Yes
    - No
  - What could be the possible reasons for an inaccurate cost?

**Answer:**

- Computed elapsed time = Plan Cost \* sreadtim (12 ms)
 
$$= 4000 \times 12(\text{ms})$$

$$= 48000 \text{ ms}$$
- No
- The reasons for inaccurate cost are:
  - Large IN list
  - Large OR statement
  - Different estimated cardinality
  - Incorrect selectivity estimate

8. Which statements are TRUE regarding hash joins?
  - a. System statistics can influence the optimizer's decision because hash joins require the intense use of memory and CPU.
  - b. Hash joins are performed for equijoins, non-equijoins, and are most useful when joining large amounts of data.
  - c. Hash joins can take advantage of the index on the join key column.

**Answer:** a

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## **Workshop 8**

## Workshop 8: Overview

---

### Workshop Overview

In this workshop, you will perform the following tasks:

- Review parse time reduction strategy.
- Test without cursor sharing.
- Use CURSOR\_SHARING.
- Use user-defined bind variables.
- Load SQL statements into a SQL plan baseline.

### Scripts used in the Workshop

- ws08.sql
- w8\_s2\_c.sql
- w8\_s2\_d.sql
- w8\_s2\_e.sql
- w8\_s2\_f.sql
- w8\_s2\_g.sql
- w8\_s3\_a.sql
- w8\_s3\_c.sql
- w8\_s3\_c1.sql
- w8\_s3\_d.sql
- w8\_s4\_b.sql
- w8\_s4\_c.sql
- w8\_s5\_a.sql
- w8\_s5\_a1.sql
- w8\_s5\_b.sql

## Workshop 8: Tuning Strategy

---

### Overview

You have identified a slow-running SQL statement. It was run 555 times in a certain time period. You noticed that a different literal was used in each execution. This caused the system to parse the same statement 555 times with the high parse time, which is not efficient. What tuning strategy could be used?

	call	count	cpu	elapsed	disk	query	current	rows
Parse	555	100.09	300.83	0	0	0	0	0
Execute	555	0.42	0.78	0	0	0	0	0
Fetch	555	14.04	85.03	513	1448514	0	11724	
total	1665	114.55	386.65	513	1448514	0	11724	

### Tasks

1. Review parse time reduction strategy.
  - a. Review the preceding output of `TKPROF` and provide your answers for the following questions.
    - 1) What is the elapsed time spent parsing? (\_\_\_\_\_).
    - 2) What is the elapsed time spent executing? (\_\_\_\_\_)
    - 3) What is the elapsed time spent fetching? (\_\_\_\_\_)
    - 4) Would normal query tuning techniques that alter the execution plan help?
    - 5) Would reducing parse time help? (**Note:** Assume that there is no client network bottleneck issue.)

#### Answer:

- 1) 300.83
- 2) 0.78
- 3) 85.03
- 4) No
- 5) Parse time reduction strategy can be used when you have determined that the query spends most of its time in the parse phase.

- b. How would you reduce the parse time? You could consider the following two options:

**Possible Option 1:** Minimize hard parses.

- 1) Cursor sharing using bind variables
- 2) Adaptive cursor sharing

**Possible Option 2:** Reduce the parse elapsed time.

- a. If CPU time dominates the parse time, check the following common observations, and others, and apply solutions to resolve the issue.
    - 1) Dynamic sampling is being used for the query and impacting the parse time
    - 2) Query has many IN-list parameters
    - 3) Query has many OR operators
    - 4) Partitioned table with many partitions (for example, more than 1000)
  - b. If wait time dominates the parse time, check the following common observations, and others, and apply solutions to resolve the issue.

Waits for large query text to be sent from the client
  - c. In this workshop, you choose option 1 to reduce the number of hard parses, eventually to reduce the total parse time.
2. Test without cursor sharing.
- a. Connect to the sh schema in SQL Developer.
  - b. Review and execute the SQL statements in ws08.sql. You consider the use of bind variables to reduce the parse time.

**Note:** The scripts used in this workshop are available in the workshops folder located in /home/oracle/labs/workshops.

```
SELECT cust_city, sum (amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = 52790
GROUP BY cust_city
ORDER BY 2;
SELECT cust_city, sum (amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = 52787
GROUP BY cust_city
ORDER BY 2;
```

- 1) Which column is a good candidate for a bind variable? (\_\_\_\_\_)

**Answer:** country\_id

- c. Determine the distribution of all distinct values found in the candidate column in step b.

You can use the w8\_s2\_c.sql file.

```

SELECT country_id, count(*), (count(*)*100)/55500 PCT
FROM sh.customers
GROUP BY country_id
ORDER BY country_id
  
```

COUNTRY_ID	COUNT(*)	PCT
1	52769	597 1.07567567567567567567567567567567567568
2	52770	7780 14.01801801801801801801801801801801802
3	52771	712 1.28288288288288288288288288288288288
4	52772	2010 3.62162162162162162162162162162162162
5	52773	403 0.7261261261261261261261261261261261261
6	52774	831 1.4972972972972972972972972972972972973
7	52775	832 1.4990990990990990990990990990990990991
8	52776	8173 14.72612612612612612612612612612612613
9	52777	383 0.6900900900900900900900900900900900901
10	52778	2039 3.67387387387387387387387387387387387
11	52779	3833 6.90630630630630630630630630630630631
12	52782	624 1.12432432432432432432432432432432432
13	52785	244 0.4396396396396396396396396396396396396
14	52786	708 1.27567567567567567567567567567567568
15	52787	75 0.1351351351351351351351351351351351
16	52788	91 0.163963963963963963963963963963963964
17	52789	7557 13.61621621621621621621621621621621622
18	52790	18520 33.3693693693693693693693693693693693693
19	52791	88 0.158558558558558558558558558558558558558586

- d. If needed, create a histogram on the column and check it by using the USER\_TAB\_COLUMNS view. You can use the w8\_s2\_d.sql file.

- 1) What is the histogram type? (\_\_\_\_\_)

- 2) How many buckets exist in the histogram? (\_\_\_\_\_)

```

exec DBMS_STATS.GATHER_TABLE_STATS(OWNNAME=>'SH',
TABNAME=>'CUSTOMERS', METHOD_OPT => 'FOR COLUMNS SIZE 25
country_id', CASCADE => TRUE)
  
```

```

SELECT column_name, histogram, num_buckets
FROM user_tab_columns
  
```

```
WHERE table_name = 'CUSTOMERS'  
/
```

COLUMN_NAME	HISTOGRAM	NUM_BUCKETS
1 CUST_LAST_NAME	HYBRID	254
2 CUST_GENDER	NONE	1
3 CUST_YEAR_OF_BIRTH	NONE	1
4 CUST_MARITAL_STATUS	NONE	1
5 CUST_STREET_ADDRESS	NONE	1
6 CUST_POSTAL_CODE	NONE	1
7 CUST_CITY	NONE	1
8 CUST_CITY_ID	NONE	1
9 CUST_STATE_PROVINCE	FREQUENCY	145
10 CUST_STATE_PROVINCE_ID	NONE	1
11 COUNTRY_ID	FREQUENCY	19
12 CUST_MAIN_PHONE_NUMBER	NONE	1
13 CUST_INCOME_LEVEL	NONE	1
14 CUST_CREDIT_LIMIT	NONE	1
15 CUST_EMAIL	NONE	1
16 CUST_TOTAL	NONE	1
17 CUST_TOTAL_ID	NONE	1
18 CUST_SRC_ID	NONE	0
19 CUST_EFF_FROM	NONE	1
20 CUST_EFF_TO	NONE	0
21 CUST_VALID	NONE	1
22 CUST_ID	HYBRID	254
23 CUST_FIRST_NAME	NONE	1

**Answer:**

- 1) A frequency histogram is used.
  - 2) Number of buckets for COUNTRY\_ID: 19. It means there are only 19 distinct values in the column.
- e. Create an index on the column identified in step d by using the following sample code, or use the w8\_s2\_e.sql file.

```
DROP INDEX sh.cust_country_id_idx  
/  
CREATE INDEX sh.cust_country_id_idx  
ON sh.customers (country_id)  
/
```

```
DROP INDEX sh.cust_country_id_idx
/
CREATE INDEX sh.cust_country_id_idx
ON sh.customers(country_id)

Task completed in 0.168 seconds
```

```
Error starting at line : 1 in command -
DROP INDEX sh.cust_country_id_idx
Error report -
ORA-01418: specified index does not exist
01418. 00000 - "specified index does not exist"
*Cause:
*Action:

Index SH.CUST_COUNTRY_ID_IDX created.
```

- f. Determine the execution plan of the following SQL statement. You can use the `w8_s2_f.sql` file.

```
SELECT cust_city, sum(amount_sold)
FROM sales s,customers c
WHERE s.cust_id=c.cust_id and country_id = 52790
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table (dbms_xplan.display_cursor);
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are three tabs: ws08.sql, w8\_s2\_e.sql, and w8\_s2\_f.sql. The w8\_s2\_f.sql tab is active. The main workspace shows the following SQL code:

```

SELECT cust_city,sum(amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = 52790
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table (dbms_xplan.display_cursor);

```

Below the code, the "Script Output" window displays the execution plan:

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	Pstart	Pstop
0	SELECT STATEMENT				499 (100)			
1	SORT ORDER BY		620	23560	499 (6)	00:00:01		
2	HASH GROUP BY		620	23560	499 (6)	00:00:01		
* 3	HASH JOIN		7059	261K	497 (6)	00:00:01		
4	VIEW	VW_GBC_5	7059	124K	286 (10)	00:00:01		
5	HASH GROUP BY		7059	70590	286 (10)	00:00:01		
6	PARTITION RANGE ALL		921K	9000K	266 (3)	00:00:01	1	28
7	TABLE ACCESS FULL	SALES	921K	9000K	266 (3)	00:00:01	1	28
* 8	TABLE ACCESS FULL	CUSTOMERS	18520	361K	211 (1)	00:00:01		

Below the execution plan, the "Script Output" window continues with:

```

PLAN_TABLE_OUTPUT
Predicate Information (identified by operation id):
   3 - access("ITEM_1"="C"."CUST_ID")
   8 - filter("COUNTRY_ID"=52790)

Note
-----
- this is an adaptive plan

32 rows selected.

```

**Note:** 33.3% of the duplicated data is present in the COUNTRY\_ID column where the value of country\_id = 52790.

- g. Determine the execution plan of the following SQL statement. You can use the w8\_s2\_g.sql file.

```

SELECT cust_city, sum (amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = 52787
GROUP BY cust_city
ORDER BY 2
/

```

```
SELECT * FROM table (dbms_xplan.display_cursor);
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, 'ws08.sql' and 'w8\_s2\_g.sql' are listed, with 'w8\_s2\_g.sql' being the active tab. The title bar includes 'SQL Worksheet History', a toolbar with various icons, and a status bar indicating '0.484 seconds'. A connection named 'sh\_connection' is selected. The main area has two tabs: 'Worksheet' and 'Query Builder'. The 'Worksheet' tab contains the following SQL code:

```

SELECT cust_city,sum(amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = 52787
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table(dbms_xplan.display_cursor);

```

Below the code, the 'Script Output' tab shows the results of the execution:

```

Plan hash value: 2854028564

| Id | Operation          | Name      | Rows | Bytes | Cost (%CPU) | Time      | Pst |
-----+-----+-----+-----+-----+-----+-----+-----+
PLAN_TABLE_OUTPUT
-----+-----+-----+-----+-----+-----+-----+-----+
| 0 | SELECT STATEMENT   |          |      |      | 289 (100) |          |      |
| 1 |   SORT ORDER BY    |          |      |      | 289 (4)  | 00:00:01 |      |
| 2 |   HASH GROUP BY    |          |      |      | 289 (4)  | 00:00:01 |      |
|* 3 |   HASH JOIN         |          |      |      | 286 (3)  | 00:00:01 |      |
| 4 |     TABLE ACCESS BY INDEX ROWID BATCHED | CUSTOMERS | 75 | 1500 | 18 (0) | 00:00:01 |      |
|* 5 |     INDEX RANGE SCAN | CUST_COUNTRY_ID_IDX | 75 | 1 | 1 (0) | 00:00:01 |      |
| 6 |     PARTITION RANGE ALL |          | 921K | 9000K | 266 (3) | 00:00:01 |      |
| 7 |     TABLE ACCESS FULL | SALES    | 921K | 9000K | 266 (3) | 00:00:01 |      |

Predicate Information (identified by operation id):
PLAN_TABLE_OUTPUT
-----+-----+-----+-----+-----+-----+-----+-----+
3 - access("S"."CUST_ID"="C"."CUST_ID")
5 - access("COUNTRY_ID"=52787)

Note
-----
- this is an adaptive plan

31 rows selected.

```

**Note:** 0.135% of the duplicated data is present in the COUNTRY\_ID column where the value of country\_id = 52787. In this plan, CUST\_COUNTRY\_ID\_IDX is used.

- h. Try to explain why the execution plans are different in step f and g.
  - 1) Why are the plans different? Does the optimizer consider two similar SQL statements in step f and g as the same SQL statements?
  - 2) How many hard parses occurred?
- i. Reduce the number of hard parses in Task 3.

3. Use CURSOR\_SHARING.

Assume that the identified SQL statements in ws08.sql are all hard-coded. That means that you cannot use any user-defined bind variables because the SQL statements cannot be modified. In this task, you use system-level bind variable instead.

**Note:** In this workshop, you will choose option 1 to reduce the number of hard parses, eventually to reduce the total parse time.

Remember that the optimizer assigns a value to a bind variable only in the first invocation to generate a good execution plan. The same execution plan is used for the subsequent SQL statements as if the plan is the optimal plan in all cases. In general, this behavior is good in most cases. But it would not work if a bind variable column has a skewed data distribution and even with histograms. A histogram is used only for the peeked value in the first invocation due to bind variable peeking. You know that a bind variable does not work well with a histogram.

You have learned about adaptive cursor sharing in the lesson titled “Introduction to Optimizer Statistics Concepts”. You will examine if adaptive cursor sharing can help the optimizer share a cursor safely and in an intelligent way instead of sharing a cursor blindly.

- Use the following sample trigger to create a LOGON trigger. **You have to set the cursor\_sharing parameter to a proper value for system bind variables as soon as the sh user logs on.**

Connect as user sys and execute the sample code, or you can use the w8\_s3\_a.sql file. Connection details are as follows:

Connection Name: sys\_connection

Username: sys

Password: oracle\_4U

Role: SYSDBA

Host Name: localhost

Service name: orclpdb

```
create or replace trigger set_cursor_sharing
after logon
on database
declare
begin
    if user = 'SH' then execute immediate 'alter session
set cursor_sharing=<value>';
    end if;
exception
    when others then
        null;
end;
/
```

The screenshot shows the SQL Worksheet interface in SQL Developer. The title bar says 'w8\_s3\_a.sql'. The worksheet tab is selected. The code in the worksheet pane is:

```

create or replace trigger set_cursor_sharing
after logon
on database
declare
begin
    if user = 'SH' then execute immediate 'alter session set cursor_sharing=<value>';
    end if;
exception
    when others then
        null;
end;

```

The script output pane below shows:

- Task completed in 1.173 seconds
- Trigger SET\_CURSOR\_SHARING compiled

- Connect to the sh schema in SQL Developer.
- Execute the following SQL statements to verify whether the system bind variable was used. You can use the w8\_s3\_c.sql and w8\_s3\_c1.sql files.

```

SELECT /* TASK04 */ cust_city, sum(amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = 52790
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table (dbms_xplan.display_cursor)
/

```

```

SELECT /* TASK04 */ cust_city, sum(amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = 52787
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table (dbms_xplan.display_cursor)
/

```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, three tabs are open: w8\_s3\_a.sql, w8\_s3\_c.sql, and w8\_s3\_c1.sql. The w8\_s3\_c1.sql tab is active, displaying the following SQL code:

```
SELECT /* TASK04 */ cust_city, sum(amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = 52790
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table(dbms_xplan.display_cursor)
```

Below the code, the "Script Output" tab shows the results of the execution:

```
233 rows selected.
```

Then, the "PLAN\_TABLE\_OUTPUT" section displays the execution plan:

```
SQL_ID bku7bn21mqnjr, child number 0
-----
SELECT /* TASK04 */ cust_city, sum(amount_sold) FROM sales s, customers
c WHERE s.cust_id=c.cust_id and country_id = 52790 GROUP BY cust_city
ORDER BY 2

Plan hash value: 1733060975
```

ID	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	Pstart	Pstop
0	SELECT STATEMENT				499 (100)			
1	SORT ORDER BY		620	23560	499 (6)	00:00:01		
2	HASH GROUP BY		620	23560	499 (6)	00:00:01		
* 3	HASH JOIN		7059	261K	497 (6)	00:00:01		
4	VIEW	VW_GBC_5	7059	124K	286 (10)	00:00:01		
5	HASH GROUP BY		7059	70590	286 (10)	00:00:01		
6	PARTITION RANGE ALL		921K	9000K	266 (3)	00:00:01	1	28
7	TABLE ACCESS FULL	SALES	921K	9000K	266 (3)	00:00:01	1	28
* 8	TABLE ACCESS FULL	CUSTOMERS	18520	361K	211 (1)	00:00:01		

Finally, the "PLAN\_TABLE\_OUTPUT" section shows predicate information:

```
Predicate Information (identified by operation id):
```

SQL Worksheet History

sh\_connection

Worksheet Query Builder

```

SELECT /* TASK04 */ cust_city,sum(amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = 52787
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table(dbms_xplan.display_cursor)

```

Script Output Task completed in 0.232 seconds

PLAN\_TABLE\_OUTPUT

```

SQL_ID c1yprd639fkh7, child number 0
-
SELECT /* TASK04 */ cust_city,sum(amount_sold) FROM sales s, customers
c WHERE s.cust_id=c.cust_id and country_id = 52787 GROUP BY cust_city
ORDER BY 2

Plan hash value: 2854028564

```

Id   Operation	Name	Rows	Bytes	Cost (%CPU)	Time	Pst
PLAN_TABLE_OUTPUT						
0   SELECT STATEMENT				289 (100)		
1   SORT ORDER BY		71	2130	289 (4)	00:00:01	
2   HASH GROUP BY		71	2130	289 (4)	00:00:01	
* 3   HASH JOIN		9792	286K	286 (3)	00:00:01	
4   TABLE ACCESS BY INDEX ROWID BATCHED	CUSTOMERS	75	1500	18 (0)	00:00:01	
* 5   INDEX RANGE SCAN	CUST_COUNTRY_ID_IDX	75		1 (0)	00:00:01	
6   PARTITION RANGE ALL		921K	9000K	266 (3)	00:00:01	
7   TABLE ACCESS FULL	SALES	921K	9000K	266 (3)	00:00:01	

Predicate Information (identified by operation id):

PLAN\_TABLE\_OUTPUT

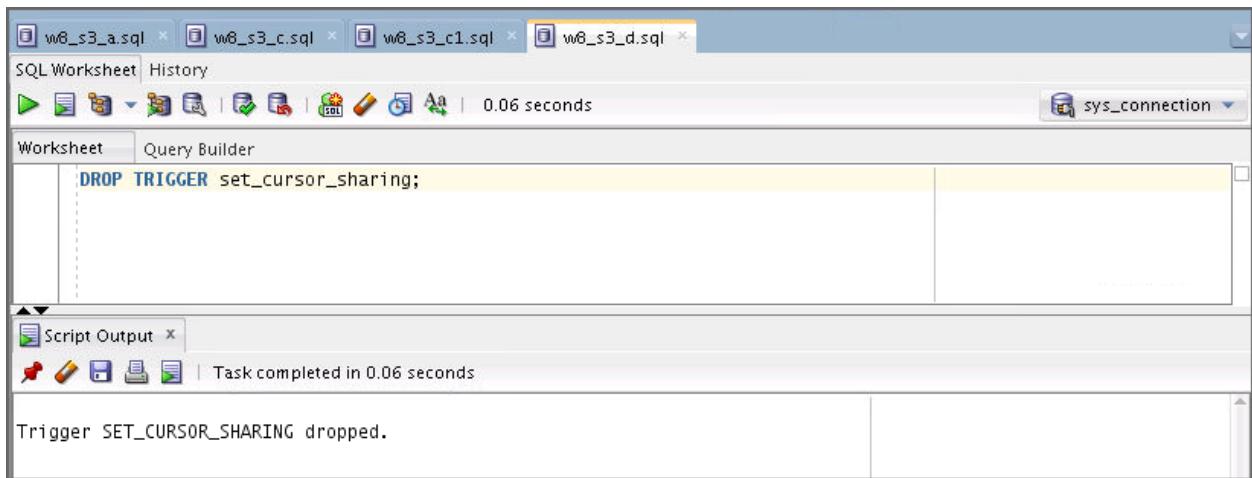
```

3 - access("S"."CUST_ID"="C"."CUST_ID")
5 - access("COUNTRY_ID"=52787)

```

Note

- d. Drop the set\_cursor\_sharing trigger by connecting as user sys. Use the w8\_s3\_d.sql file.



4. Use a user-defined bind variable.

Assume that the identified SQL statements in ws08.sql can be modified. Use a user-defined bind variable.

- Connect to the sh schema in SQL Developer.
- Execute the following SQL statement and verify if a user-defined bind variable was used. You can use the w8\_s4\_b.sql file.

```
variable country_id number
exec :country_id:= 52790

SELECT /* ACS */ cust_city, sum (amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id =:country_id
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table (dbms_xplan.display_cursor)
/
```

The screenshot shows the Oracle SQL Developer interface. In the top window (Worksheet), the code is:

```

variable country_id number
exec :country_id:= 52790

SELECT /* ACS */ cust_city, sum(amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = :country_id
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table(dbms_xplan.display_cursor)
/

```

In the bottom window (Script Output), the output is:

```

Task completed in 0.486 seconds

PLAN_TABLE_OUTPUT
-----
SQL_ID azam9q46hrhjt, child number 0
SELECT /* ACS */ cust_city, sum(amount_sold) FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = :country_id GROUP BY
cust_city ORDER BY 2

Plan hash value: 1733060975

| Id | Operation           | Name      | Rows   | Bytes | Cost (%CPU)| Time     | Pstart| Pstop |
|---|---|---|---|---|---|---|---|---|
PLAN_TABLE_OUTPUT
| 0 | SELECT STATEMENT    |          |       |       | 499 (100)|          |       |       |
| 1 |  SORT ORDER BY      |          | 620   | 23560 | 499 (6) | 00:00:01 |       |       |
| 2 |  HASH GROUP BY      |          | 620   | 23560 | 499 (6) | 00:00:01 |       |       |
|* 3 |  HASH JOIN          |          | 7059  | 261K  | 497 (6) | 00:00:01 |       |       |
| 4 |  VIEW                | VW_GBC_5 | 7059  | 124K  | 286 (10) | 00:00:01 |       |       |
| 5 |  HASH GROUP BY      |          | 7059  | 70590 | 286 (10) | 00:00:01 |       |       |
| 6 |  PARTITION RANGE ALL|          | 921K  | 9000K | 266 (3) | 00:00:01 |       |       |
| 7 |  TABLE ACCESS FULL  | SALES    | 921K  | 9000K | 266 (3) | 00:00:01 |       |       |
|* 8 |  TABLE ACCESS FULL  | CUSTOMERS| 18520 | 361K  | 211 (1) | 00:00:01 |       |       |

PLAN_TABLE_OUTPUT
-----
Predicate Information (identified by operation id):
-----
```

- c. Execute the following SQL statement and verify if a user-defined bind variable was used. You can use the w8\_s4\_c.sql file.

```

variable country_id number
exec :country_id:= 52787

SELECT /* ACS */ cust_city, sum (amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id =:country_id
GROUP BY cust_city

```

```

ORDER BY 2
/
SELECT * FROM table (dbms_xplan.display_cursor)
/

```

The screenshot shows an Oracle SQL Worksheet interface. The top window displays a script with bind variable definitions and a query using the bind variable. The bottom window shows the execution plan output, which includes a detailed breakdown of the operations, their costs, and statistics.

```

variable country_id number
exec :country_id := 52787

SELECT /* ACS */ cust_city,sum(amount_sold)
FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = :country_id
GROUP BY cust_city
ORDER BY 2
/
SELECT * FROM table(dbms_xplan.display_cursor)
/

```

**PLAN\_TABLE\_OUTPUT**

---

```

SQL_ID 9pcz9ymvf88na, child number 0

SELECT /* ACS */ cust_city,sum(amount_sold) FROM sales s, customers c
WHERE s.cust_id=c.cust_id and country_id = :country_id GROUP BY
cust_city ORDER BY 2

Plan hash value: 2854028564

| Id | Operation           | Name          | Rows | Bytes | Cost (%CPU)| Time      | Pst |
|:--|:-----|:-----|:---|:---|:---|:---|:---|

```

**PLAN\_TABLE\_OUTPUT**

---

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time	Pst
0	SELECT STATEMENT				289 (100)		
1	SORT ORDER BY		71	2130	289 (4)	00:00:01	
2	HASH GROUP BY		71	2130	289 (4)	00:00:01	
*	HASH JOIN		9792	286K	286 (3)	00:00:01	
4	TABLE ACCESS BY INDEX ROWID BATCHED	CUSTOMERS	75	1500	18 (0)	00:00:01	
*	INDEX RANGE SCAN	CUST_COUNTRY_ID_IDX	75		1 (0)	00:00:01	
6	PARTITION RANGE ALL		921K	9000K	266 (3)	00:00:01	
7	TABLE ACCESS FULL	SALES	921K	9000K	266 (3)	00:00:01	

**Predicate Information (identified by operation id):**

**PLAN\_TABLE\_OUTPUT**

---

- d. Even though the `country_id` user bind variable was defined, the optimizer created two plans. This is different optimizer behavior from Oracle 10g. Try to explain what made it possible.
- 1) Do you know the Bind Variable Peeking feature?
  - 2) Do you know the Adaptive Cursor Sharing feature?

## 5. Using SQL Plan Baseline

- Load the following two plans found in Step b and c into SQL Plan Baseline to maintain these plans over time. Use the following same code. You can use the w8\_s5\_a.sql and w8\_s5\_a1.sql files. **Note:** If you get an “Insufficient Privilege” error, grant the following permission to the sh user.

```
GRANT ADMINISTER SQL MANAGEMENT OBJECT TO SH;
```

```
var res number ;
exec :res := dbms_spm.load_plans_from_cursor_cache(sql_id =>
'<<Please enter the SQL_ID value>>', plan_hash_value => '<<Please enter
the PLAN_HASH_VALUE value>>')
/
```

- Execute the SQL statement and verify if two plans were successfully loaded into the SQL plan baseline. You can use the w8\_s5\_b.sql file.

```
select sql_text, sql_handle, plan_name, enabled, accepted
from dba_sql_plan_baselines
where sql_text like 'SELECT /* ACS %';
```

The screenshot shows the Oracle SQL Worksheet interface. At the top, there are three tabs: 'w8\_s4\_b.sql', 'w8\_s4\_c.sql', and 'w8\_s5\_b.sql'. The 'w8\_s5\_b.sql' tab is active. Below the tabs is a toolbar with various icons. The main area is divided into two panes: 'Worksheet' and 'Query Builder'. In the 'Worksheet' pane, the following SQL command is entered:

```
select sql_text, sql_handle, plan_name, enabled, accepted
from dba_sql_plan_baselines
where sql_text like 'SELECT /* ACS %';
```

Below the worksheet, there are two tabs: 'Script Output' and 'Query Result'. The 'Query Result' tab is selected, showing the results of the executed query:

SQL_TEXT	SQL_HANDLE	PLAN_NAME	ENABLED	ACCEPTED
1 SELECT /* ACS */ cust_city, sum(amo...	SQL_b689bc3d113261fa	SQL_PLAN_bd2dw7n8m4sgu5188c70e	YES	YES
2 SELECT /* ACS */ cust_city, sum(amo...	SQL_b689bc3d113261fa	SQL_PLAN_bd2dw7n8m4sgu9026c799	YES	YES

The results show two rows, both marked as 'YES' for both 'ENABLED' and 'ACCEPTED' columns.

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## **Workshop 9**

## Workshop 9: Overview

---

### Workshop Overview

In this workshop, you will perform the following task:

Use SQL Plan Baseline to associate a hinted execution plan with a hard-coded SQL statement.

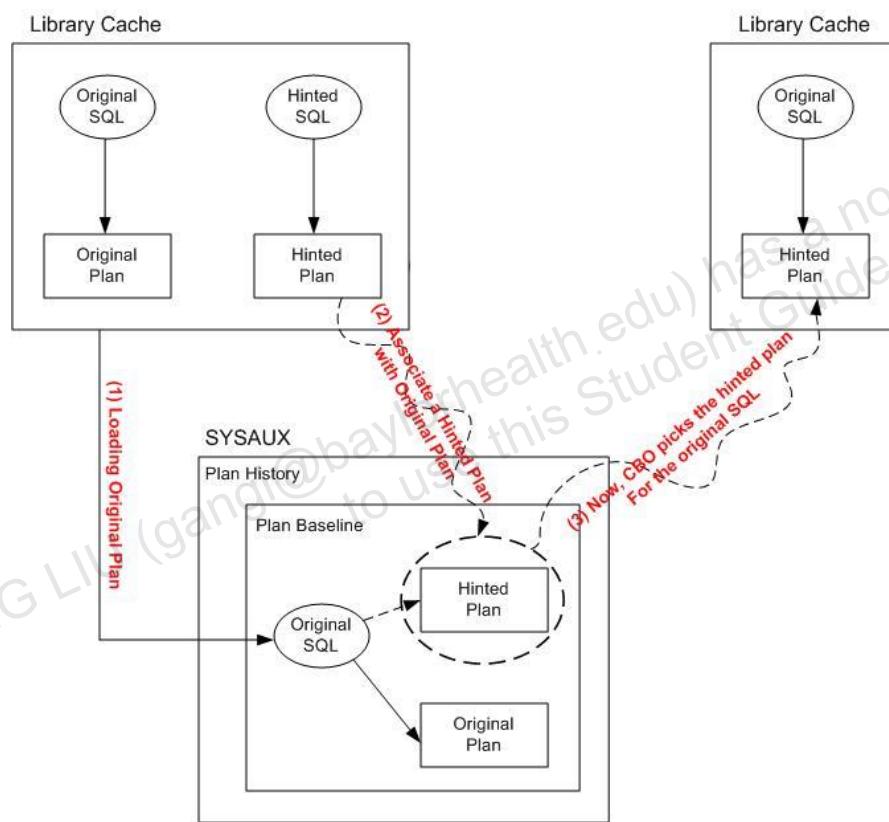
### Scripts Used in the Workshop

- setup09.sql
- ws09.sql
- cleanp09.sql
- w9\_s2\_a.sql
- w9\_s2\_b.sql
- w9\_s2\_c.sql
- w9\_s2\_d.sql
- w9\_s3\_a.sql
- w9\_s3\_b.sql
- w9\_s4\_a.sql
- w9\_s4\_b.sql
- w9\_s5\_a.sql
- w9\_s4\_c.sql
- w9\_s4\_c1.sql
- w9\_s5\_b.sql
- w9\_s5\_b1.sql
- w9\_s5\_b2.sql

# Workshop 9: Using SQL Plan Baseline to Manage a Better Execution Plan

## Overview

Oracle has introduced several methods to maintain the stable execution plans of SQL statements such as hints, stored outlines, and SQL profile. In Oracle Database, you can manage the execution plan through a methodology called SQL Plan Baseline. This feature allows the optimizer to make the right decision choosing a verified or tested execution plan in SQL Plan Baseline even if the optimizer generates a new plan during hard parse. In this workshop, you learn how to use this feature to associate a hinted execution plan with a hard-coded SQL statement.



## Tasks

1. Initial setup
    - a. Connect to `sh` schema in SQL Developer.
    - b. Execute the `setup09.sql` script to set up the environment for this workshop.
- Note:** The scripts used in this workshop are available in the workshops folder located in `/home/oracle/labs/workshops`.

```

DROP TABLE sh.cust
/
CREATE TABLE sh.cust AS SELECT * FROM sh.customers
/
DROP INDEX sh.cust_yob_bix
/
CREATE BITMAP INDEX sh.cust_yob_bix
ON sh.cust (cust_year_of_birth)
NOLOGGING
COMPUTE STATISTICS
/
DROP INDEX sh.cust_gender_bix
/
CREATE BITMAP INDEX sh.cust_gender_bix
ON sh.cust (cust_gender)
NOLOGGING
COMPUTE STATISTICS
/
exec DBMS_STATS.GATHER_TABLE_STATS('SH','CUST')
/
alter session set optimizer_use_sql_plan_baselines = true
/
alter session set optimizer_capture_sql_plan_baselines = true;

```

- c. Review and execute the SQL statement in ws09.sql.

**Note:** Assume that you have identified this hard-coded SQL statement. This has to be tuned, but there are only a few options available to improve performance.

**--Original SQL:**

```

SELECT /*+ INDEX_COMBINE (cust cust_gender_bix, cust_yob_bix) */
*
FROM sh.cust
WHERE cust_year_of_birth < 70
AND cust_gender = 'M'
/

```

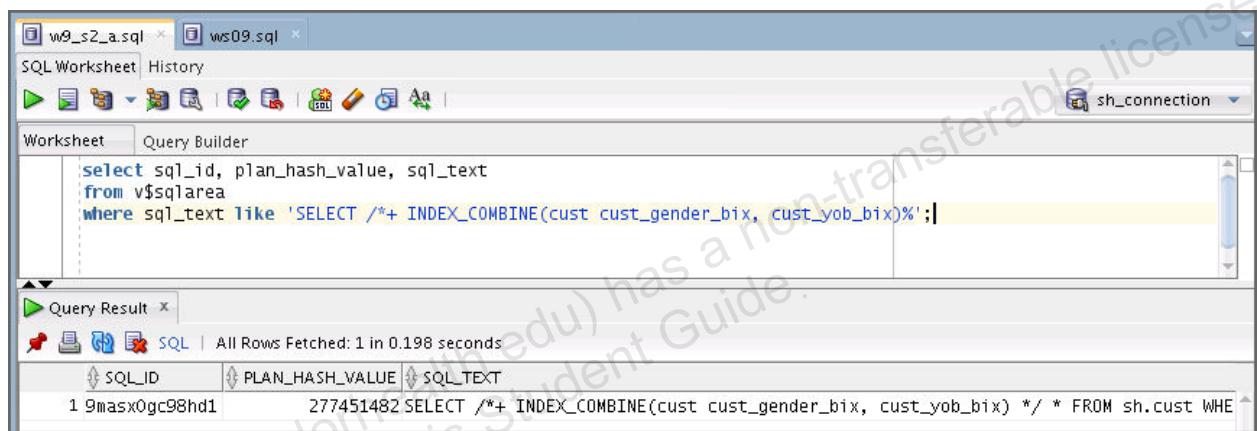
2. Review the identified SQL statement.

- a. Execute the SQL statement in ws09.sql. And check `sql_id` and `plan_hash_value` using `v$sqlarea`. Use the following sample code. You can also use the `w9_s2_a.sql` file.

**Note:** The workshop is used to see SQL plan management. The query in ws09.sql does not return any value on purpose. It is only to see which plan can be used. And the original query will use the hinted execution plan, not the original plan. That is the whole purpose of workshop 9.

In case SQL cannot be modified in the real world and you know a better plan, you can associate the original SQL with the new plan (hinted plan).

```
select sql_id, plan_hash_value, sql_text
from v$sqlarea
where sql_text like 'SELECT /*+ INDEX_COMBINE(cust
cust_gender_bix, cust_yob_bix)%';
```



- b. Execute the following sample code and review the execution plan of the SQL statement. You can use the w9\_s2\_b.sql file.

```
SELECT * FROM table (dbms_xplan.display_cursor ('<<Please Enter the
SQL_ID value>>'));
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, three tabs are open: 'w9\_s2\_a.sql', 'ws09.sql', and 'w9\_s2\_b.sql'. The 'w9\_s2\_b.sql' tab is active, displaying the following SQL statement:

```
SELECT * FROM table (dbms_xplan.display_cursor('9masx0gc98hd1'));
```

In the bottom pane, the 'Query Result' tab is selected, showing the execution plan. The plan starts with a 'PLAN\_TABLE\_OUTPUT' section:

```
1 SQL_ID 9masx0gc98hd1, child number 0
2 -----
3 SELECT /*+ INDEX_COMBINE(cust cust_gender_bix, cust_yob_bix) */ * FROM
4 sh.cust WHERE cust_year_of_birth < 70 AND cust_gender = 'M'
5
6 Plan hash value: 277451482
7
8 -----
9 | Id  | Operation          | Name           | Rows | Bytes | Cost (%CPU) | Time      |
10 -----
11 |   0 | SELECT STATEMENT    |                |       |        | 4 (100) |          |
12 |   1 |  TABLE ACCESS BY INDEX ROWID BATCHED | CUST          | 1 | 189 | 4 (0) | 00:00:01 |
13 |   2 |  BITMAP CONVERSION TO ROWIDS     |                |       |        |          |          |
14 |   3 |  BITMAP AND          |                |       |        |          |          |
15 |   4 |  BITMAP MERGE        |                |       |        |          |          |
16 /* 5 |  BITMAP INDEX RANGE SCAN  | CUST_YOB_BIX  |       |        |          |          |
17 /* 6 |  BITMAP INDEX SINGLE VALUE | CUST_GENDER_BIX|       |        |          |          |
18 -----
19
20 Predicate Information (identified by operation id):
21 -----
22
23   5 - access("CUST_YEAR_OF_BIRTH"<70)
24     filter("CUST_YEAR_OF_BIRTH"<70)
25   6 - access("CUST_GENDER"='M')
```

The execution plan details the following steps:

- Step 1: SELECT STATEMENT
- Step 2: TABLE ACCESS BY INDEX ROWID BATCHED on table 'CUST'
- Step 3: BITMAP CONVERSION TO ROWIDS
- Step 4: BITMAP AND
- Step 5: BITMAP INDEX RANGE SCAN on index 'CUST\_YOB\_BIX'
- Step 6: BITMAP INDEX SINGLE VALUE on index 'CUST\_GENDER\_BIX'

The total cost of the plan is 4, and it took 0.59 seconds to execute.

**Note:** The BITMAP MERGE operation is used. Total Cost is 4.

- c. Load the execution plan of the SQL statement in `ws09.sql` into the SQL Plan Baseline. You can use the `w9_s2_c.sql` file.

```
var res number ;
exec :res:= dbms_spm.load_plans_from_cursor_cache (sql_id =>
'<<Please enter the original SQL_ID value>>', plan_hash_value =>
'<<Please enter the &original_plan_hash_value>>');
```

The screenshot shows the Oracle SQL Developer interface. In the top tab bar, there are tabs for 'w9\_s2\_a.sql', 'ws09.sql', 'w9\_s2\_b.sql', and 'w9\_s2\_c.sql'. The active tab is 'w9\_s2\_c.sql'. The main workspace is titled 'Worksheet' and contains the following PL/SQL code:

```

var res number;
exec :res := dbms_spml.load_plans_from_cursor_cache(sql_id=> '9masx0gc98hd1', plan_hash_value=> '277451482');

```

Below the worksheet is a 'Script Output' window showing the message: 'Task completed in 0.478 seconds'. At the bottom of the interface, a status bar indicates: 'PL/SQL procedure successfully completed.'

- d. Check the loaded plan in SQL Plan Baseline by using the following sample code, or you can use the `w9_s2_d.sql` file.

```

select sql_handle, plan_name, sql_text, enabled, accepted
from dba_sql_plan_baselines
where sql_text like '%SELECT /*+ INDEX_COMBINE (cust
cust_gender_bix, cust_yob_bix)%';

```

The screenshot shows the Oracle SQL Developer interface with the tab 'w9\_s2\_d.sql' selected. The main workspace displays the following SQL query:

```

select sql_text, sql_handle, plan_name, enabled, accepted
from dba_sql_plan_baselines
where sql_text like 'SELECT /*+ INDEX_COMBINE(cust cust_gender_bix, cust_yob_bix)%';

```

Below the query is a 'Query Result' window showing the output of the query. The table has columns: SQL\_TEXT, SQL\_HANDLE, PLAN\_NAME, ENABLED, and ACCEPTED. The single row returned is:

SQL_TEXT	SQL_HANDLE	PLAN_NAME	ENABLED	ACCEPTED
1 SELECT /*+ INDEX_COMBINE(cust cust...	SQL_bd38613f52934cc0	SQL_PLAN_buf317x996m60f6d8b2e3	YES	YES

3. Find a better execution plan.

- a. Execute the following hinted SQL statement and check `sql_id` and `plan_hash_value`. Use the `w9_s3_a.sql` file.

```

SELECT /*+INDEX(cust cust_yob_bix) */ *
FROM sh.cust
WHERE cust_year_of_birth < 70
AND cust_gender = 'M'
/
select sql_id, plan_hash_value, sql_text
from v$sqlarea
where sql_text like 'SELECT /*+INDEX(cust cust_yob_bix)%';

```

The screenshot shows the Oracle SQL Developer interface. In the top navigation bar, several tabs are open: w9\_s2\_a.sql, ws09.sql, w9\_s2\_b.sql, w9\_s2\_c.sql, w9\_s2\_d.sql, and w9\_s3\_a.sql. The current tab is w9\_s3\_a.sql. Below the tabs, there are icons for running, saving, and connecting to a database, along with a status message "0.152 seconds". The main area is divided into two panes: "Worksheet" and "Query Builder". The "Worksheet" pane contains the following SQL code:

```
SELECT /*+INDEX(cust cust_yob_bix) */ *
FROM sh.cust
WHERE cust_year_of_birth < 70
AND cust_gender = 'M'
/
select sql_id, plan_hash_value, sql_text
from v$sqlarea
where sql_text like 'SELECT /*+INDEX(cust cust_yob_bix)%';
```

The "Script Output" pane below shows the results of the execution:

```
no rows selected
```

SQL_ID	PLAN_HASH_VALUE
gmnzkah3xhsbr	1264022301

```
SQL_TEXT
-----
SELECT /*+INDEX(cust cust_yob_bix) */ * FROM sh.cust WHERE cust_year_of_birth < 70 AND cust_gender = 'M'
```

- b. Execute the following sample code and review the execution plan of the SQL statement. You can use the w9\_s3\_b.sql file.

```
SELECT * FROM table (dbms_xplan.display_cursor ('<<Please enter the SQL_ID value>>'));
```

```

SELECT * FROM table(dbms_xplan.display_cursor('gnmzka3xhsbr'));

```

SQL_ID	Name	Rows	Bytes	Cost (%CPU)	Time
gnmzka3xhsbr, child number 0				2 (100)	
1	SELECT STATEMENT	1	189	2 (0)	00:00:01
12 /* 1	TABLE ACCESS BY INDEX ROWID  CUST	1	189	2 (0)	00:00:01
13   2	BITMAP CONVERSION TO ROWIDS				
14  * 3	BITMAP INDEX RANGE SCAN  CUST_YOB_BIX				

Predicate Information (identified by operation id):

```

1 - filter("CUST_GENDER"='M')
3 - access("CUST_YEAR_OF_BIRTH"<70)
2 - filter("CUST_YEAR_OF_BIRTH"<70)

```

**Note:** The BITMAP MERGE is avoided. Total cost is 2.

4. Load a hinted execution plan into SQL Plan Baseline.
  - a. Associate the better execution plan generated in step b of Task 3 with the original SQL statement. Use the w9\_s4\_a.sql file.

```

var res number;
exe :res := dbms_spm.load_plans_from_cursor_cache( sql_id =>
'<<Please enter the &hinted_SQL_ID value>>', plan_hash_value
=>'<<Please enter the &hinted_PLAN_HASH_VALUE>>', sql_handle =>
'<<Please enter the '&SQL_HANDLE_for_original>>');

```

The screenshot shows the Oracle SQL Worksheet interface. In the top tab bar, four tabs are open: w9\_s2\_d.sql, w9\_s3\_a.sql, w9\_s3\_b.sql, and w9\_s4\_a.sql. The w9\_s4\_a.sql tab is active. The main area is a 'Worksheet' tab showing the following PL/SQL code:

```
var res number;
exec :res := dbms_spm.load_plans_from_cursor_cache(sql_id=> 'gnmzka3xhsbr', plan_hash_value=> '1264022301', sql_handle=> 'SQL_bd38613f52934cc0');
```

Below the worksheet, a 'Script Output' pane shows the message: 'Task completed in 0.114 seconds'. At the bottom, a message box says 'PL/SQL procedure successfully completed.'

- b. Execute the following sample code and verify that the better plan is loaded successfully in SQL Plan Baseline for the original SQL statement. You can use the w9\_s4\_b.sql file.

```
select sql_text, sql_handle, plan_name, enabled, accepted
from dba_sql_plan_baselines
where sql_text like 'SELECT /*+ INDEX_COMBINE(cust%');
```

The screenshot shows the Oracle SQL Worksheet interface. The w9\_s4\_b.sql tab is active. The main area is a 'Worksheet' tab showing the following SQL query:

```
select sql_text, sql_handle, plan_name, enabled, accepted
from dba_sql_plan_baselines
where sql_text like 'SELECT /*+ INDEX_COMBINE(cust%');
```

Below the worksheet, a 'Query Result' pane displays the results of the query. The table has columns: SQL\_TEXT, SQL\_HANDLE, PLAN\_NAME, ENABLED, and ACCEPTED. There are two rows of data:

SQL_TEXT	SQL_HANDLE	PLAN_NAME	ENABLED	ACCEPTED
1 SELECT /*+ INDEX_COMBINE(cust...	SQL_bd38613f52934cc0	SQL_PLAN_buf317x996m60cdc46b71	YES	YES
2 SELECT /*+ INDEX_COMBINE(cust...	SQL_bd38613f52934cc0	SQL_PLAN_buf317x996m60f6d8b2e3	YES	YES

**Note:** The first plan is the hinted plan loaded.

- c. If the original plan is not needed, drop the original plan (**option1**) from SQL Plan Baseline or fix the better plan to guarantee the plan for the next hard parse (**option2**). Use the w9\_s4\_c.sql (**option1**) file to drop the original plan file and then execute the w9\_s4\_c1.sql file to check whether the original plan is dropped or not.

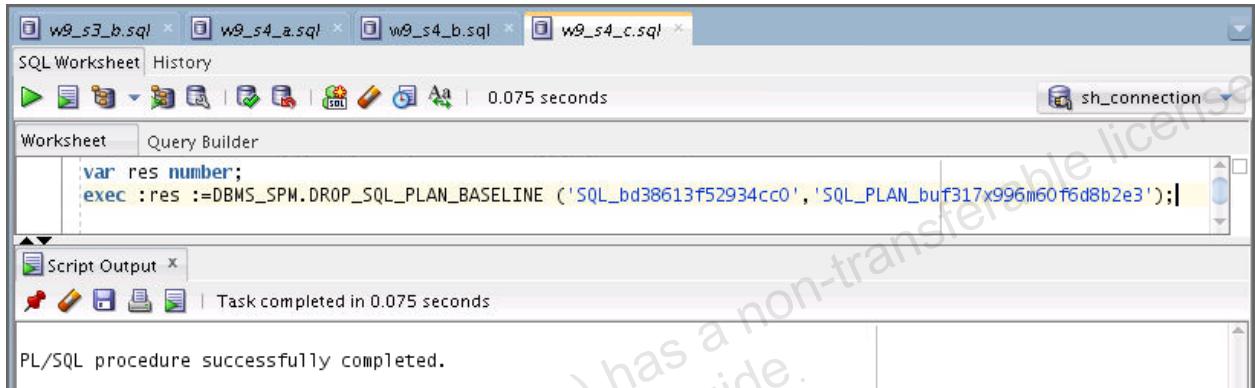
#### --Option 1

```
var res number;
```

```
exec :res :=DBMS_SPM.DROP_SQL_PLAN_BASELINE ('<< Please enter the
&original_SQL_HANDLE value>>', '<<Please enter the
&original_PLAN_NAME value>>');
```

**--Option 2**

```
var cnt number
exec :cnt := dbms_spm.alter_sql_plan_baseline(sql_handle =>'<<
Please enter the SQL_HANDLE value>>', plan_name=> '<<Please enter the
PLAN_NAME value>>');
```



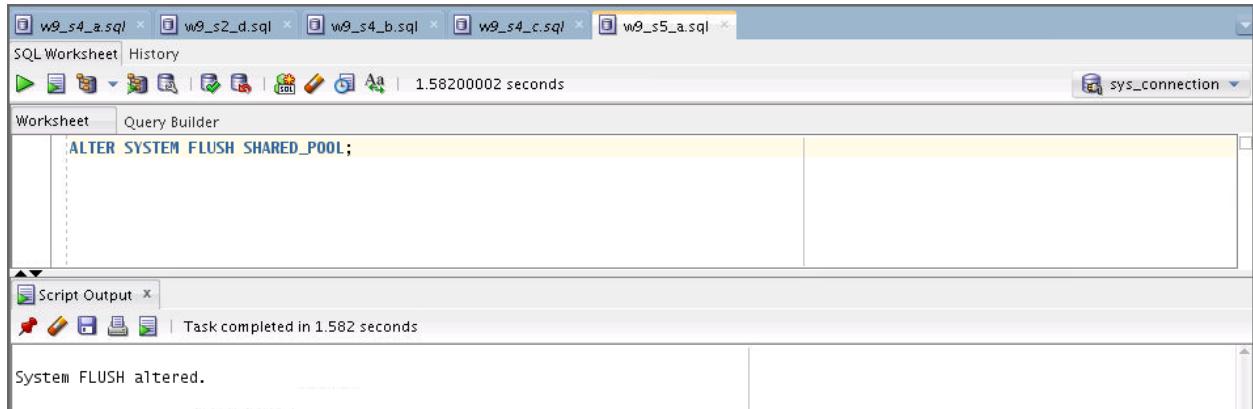
```
select sql_text, sql_handle, plan_name, enabled, accepted
from dba_sql_plan_baselines
where sql_text like 'SELECT /*+ INDEX_COMBINE(cust%';
```



5. Test the SQL statement with the loaded plan.

- Clean up the shared pool for testing in the next step. You can use the w9\_s5\_a.sql file. Use the sys user to execute this statement.

```
ALTER SYSTEM FLUSH SHARED_POOL;
```



- b. Execute the SQL statements (**option 1, option 2, and option 3**) and check if the optimizer uses the better execution plan for the original SQL statement. Use the w9\_s5\_b.sql, w9\_s5\_b1.sql, and then w9\_s5\_b2.sql files.

**--Option 1:**

```
EXPLAIN PLAN FOR
SELECT /*+ INDEX_COMBINE(cust cust_gender_bix, cust_yob_bix) */
*
FROM sh.cust
WHERE cust_year_of_birth < 70
AND cust_gender = 'M'
/
SELECT * FROM table(DBMS_XPLAN.DISPLAY);
```

The screenshot shows an Oracle SQL Worksheet interface. The top bar displays multiple tabs for other SQL scripts like w9\_s4\_a.sql, w9\_s4\_b.sql, etc., and the current tab is w9\_s5\_b.sql. The status bar indicates the execution time is 0.76999998 seconds. The connection is set to sh\_connection. The main area contains the following SQL code:

```

EXPLAIN PLAN FOR SELECT /*+ INDEX_COMBINE(cust cust_gender_bix, cust_yob_bix) */
FROM sh.cust
WHERE cust_year_of_birth < 70
AND cust_gender = 'M'
/
SELECT * FROM TABLE(DBMS_XPLAN.DISPLAY);

```

Below the code, the "Script Output" pane shows the results of the EXPLAIN PLAN command:

```

20 rows selected.

Explained.

PLAN_TABLE_OUTPUT
Plan hash value: 1264022301

| Id | Operation          | Name      | Rows | Bytes | Cost (%CPU)| Time     |
| 0 | SELECT STATEMENT   |           | 1    | 189   | 2 (0) 00:00:01 |
|* 1 |  TABLE ACCESS BY INDEX ROWID BATCHED | CUST    | 1    | 189   | 2 (0) 00:00:01 |
| 2 |   BITMAP CONVERSION TO ROWIDS        |          |      |       |            |
|* 3 |   BITMAP INDEX RANGE SCAN          | CUST_YOB_BIX |      |       |            |

Note
-----
- SQL plan baseline "SQL_PLAN_buf317x996#60cdc46b71" used for this statement
21 rows selected.

```

### --Option 2:

```

SELECT /*+ INDEX_COMBINE(cust cust_gender_bix, cust_yob_bix) */
*
FROM sh.cust
WHERE cust_year_of_birth < 70
AND cust_gender = 'M'
/
select sql_id, sql_plan_baseline from v$sqlarea where sql_text
like 'SELECT /*+ INDEX_COMBINE(cust%';

```

The screenshot shows an Oracle SQL Worksheet interface. The top menu bar includes tabs like 'SQL Worksheet' and 'History'. Below the menu is a toolbar with various icons. The main workspace is titled 'Worksheet' and contains a 'Query Builder' tab. A SQL statement is entered in the workspace:

```
SELECT /*+ INDEX_COMBINE(cust cust_gender_bix, cust_yob_bix) */ *
FROM sh.cust
WHERE cust_year_of_birth < 70
AND cust_gender = 'M'
/
select sql_id, sql_plan_baseline from v$sqlarea where sql_text like 'SELECT /*+ INDEX_COMBINE(cust%'
```

Below the workspace is a 'Script Output' window showing the results of the execution:

```
no rows selected
```

SQL_ID	SQL_PLAN_BASELINE
9masx0gc98hd1	SQL_PLAN_buf317x996m60cdc46b71

**--Option 3:**

```
SET LINESIZE 150
SET PAGESIZE 2000
SELECT t.* FROM TABLE (DBMS_XPLAN.DISPLAY_SQL_PLAN_BASELINE ('<<
Please enter SQL_HANDLE value>>')) t;
```

The screenshot shows the Oracle SQL Worksheet interface. In the top tab bar, several tabs are open, including ...sql, w9\_s4\_b.sql, w9\_s4\_c.sql, w9\_s4\_c1.sql, w9\_s5\_a.sql, w9\_s5\_b.sql, w9\_s5\_b1.sql, and w9\_s5\_b2.sql. The active tab is 'sh\_connection'. The main area shows a 'Worksheet' tab selected. The code entered is:

```
SET LINESIZE 150
SET PAGESIZE 2000
SELECT t.* FROM TABLE(DBMS_XPLAN.DISPLAY_SQL_PLAN_BASELINE('SQL_bd38613f52934cc0')) t;
```

The output pane shows the results of the query:

```
PLAN_TABLE_OUTPUT
```

---

```
SQL handle: SQL_bd38613f52934cc0
SQL text: SELECT /*+ INDEX_COMBINE(cust cust_gender_bix, cust_yob_bix) */ *
           FROM sh.cust WHERE cust_year_of_birth < 70 AND cust_gender = 'M'
```

---

```
Plan name: SQL_PLAN_buf317x996m60cdc46b71      Plan id: 3452201841
Enabled: YES   Fixed: NO    Accepted: YES   Origin: MANUAL-LOAD-FROM-CURSOR-CACHE
Plan rows: From dictionary
```

---

```
Plan hash value: 1264022301
```

---

Id   Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0   SELECT STATEMENT				2 (100)	
* 1   TABLE ACCESS BY INDEX ROWID BATCHED  CUST		1	189	2 (0)	00:00:01
2   BITMAP CONVERSION TO ROWIDS				0 (0)	
* 3   BITMAP INDEX RANGE SCAN	CUST_YOB_BIX			0 (0)	

---

```
Predicate Information (identified by operation id):
```

---

```
1 - filter("CUST_GENDER"='M')
3 - access("CUST_YEAR_OF_BIRTH"<70)
      filter("CUST_YEAR_OF_BIRTH"<70)
```

---

```
Plan name: SQL_PLAN_buf317x996m60f6d8b2e3      Plan id: 4141396707
Enabled: YES   Fixed: NO    Accepted: NO   Origin: AUTO-CAPTURE
Plan rows: From dictionary
```

## 6. Clean up the environment.

Execute the cleanup09.sql script.

```
select sql_text, sql_handle, plan_name, enabled, accepted
from dba_sql_plan_baselines
where sql_text like 'SELECT /*+ INDEX_COMBINE(cust%'
/
var res number;
exec :res :=DBMS_SPM.DROP_SQL_PLAN_BASELINE ('<<Please enter the
SQL_HANDLE value>>');
/
DROP TABLE sh.cust
/
```

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