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Oracle Database 19c: Advanced PL/SQL

Activity Guide

D1101121GC10

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Practices for Lesson 1

There are no practices for this lesson.

Practices for Lesson 2: Working with Exadata Express Cloud Service

Practices for Lesson 2

There are no practices for this lesson.

Practices for Lesson 3: Overview of Collections

Practices for Lesson 3: Overview

In this practice, you analyze collections for common errors, and create a collection.
Use the `OE` schema for this practice.

Practice 3-1: Analyzing Collections

Overview

In this practice, you create a nested table collection and use PL/SQL code to manipulate the collection.

Use the `OE` connection for this practice.

Before starting the tasks, you may need to start the database listener and also start up the database. In a new terminal window, issue the following commands and use the screenshots for reference. If your listener and database are already running, then proceed on to the tasks:

Command 1: `lsnrctl status`

Command 2: `lsnrctl start`

Command 3: `sqlplus / as sysdba`

Command 4: `startup`

```
[oracle@edvmr1p0 ~]$ lsnrctl status

LSNRCTL for Linux: Version 19.0.0.0.0 - Production on 19-OCT-2020 17:51:37

Copyright (c) 1991, 2019, Oracle.  All rights reserved.

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=edvmr1p0)(PORT=1521)))
TNS-12541: TNS:no listener
 TNS-12560: TNS:protocol adapter error
  TNS-00511: No listener
   Linux Error: 111: Connection refused
```

```
[oracle@edvmr1p0 ~]$ lsnrctl start

LSNRCTL for Linux: Version 19.0.0.0.0 - Production on 19-OCT-2020 17:51:48

Copyright (c) 1991, 2019, Oracle.  All rights reserved.

Starting /u01/app/oracle/product/19.3.0/dbhome_1/bin/tnslsnr: please wait...

TNSLSNR for Linux: Version 19.0.0.0.0 - Production
System parameter file is /u01/app/oracle/product/19.3.0/dbhome_1/network/admin/listener.ora
Log messages written to /u01/app/oracle/diag/tnslsnr/edvmr1p0/listener/alert/log.xml
Listening on: (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=edvmr1p0.us.oracle.com)(PORT=1521)))

Connecting to (DESCRIPTION=(ADDRESS=(PROTOCOL=TCP)(HOST=edvmr1p0)(PORT=1521)))
STATUS of the LISTENER
------------------------
Alias                     LISTENER
Version                   TNSLSNR for Linux: Version 19.0.0.0.0 - Production
Start Date                19-OCT-2020 17:51:48
Uptime                    0 days 0 hr. 0 min. 0 sec
Trace Level               off
Security                  ON: Local OS Authentication
SNMP                      OFF
Listener Parameter File   /u01/app/oracle/product/19.3.0/dbhome_1/network/admin/listener.ora
Listener Log File         /u01/app/oracle/diag/tnslsnr/edvmr1p0/listener/alert/log.xml
Listening Endpoints Summary...
  (DESCRIPTION=(ADDRESS=(PROTOCOL=tcp)(HOST=edvmr1p0.us.oracle.com)(PORT=1521)))
The listener supports no services
The command completed successfully
```

```
[oracle@edvmr1p0 ~]$ sqlplus / as sysdba

SQL*Plus: Release 19.0.0.0.0 - Production on Mon Oct 19 17:51:56 2020
Version 19.3.0.0.0

Copyright (c) 1982, 2019, Oracle.  All rights reserved.

Connected to an idle instance.

SQL> startup
ORACLE instance started.

Total System Global Area 2013264224 bytes
Fixed Size                  9136480 bytes
Variable Size             805306368 bytes
Database Buffers         1191182336 bytes
Redo Buffers                7639040 bytes
Database mounted.
Database opened.
SQL>
```

Task

1. Examine the following definitions. Run task 1 of the `lab_03.sql` script to create these objects.

```
CREATE TYPE typ_item AS OBJECT  --create object
 (prodid  NUMBER(5),
  price   NUMBER(7,2) )
/
CREATE TYPE typ_item_nst -- define nested table type
  AS TABLE OF typ_item
/
CREATE TABLE pOrder (  -- create database table
     ordid     NUMBER(5),
     supplier  NUMBER(5),
     requester NUMBER(4),
     ordered   DATE,
     items     typ_item_nst)
     NESTED TABLE items STORE AS item_stor_tab
/
```

2. The following code generates an error. Run task 2 of the `lab_03.sql` script to generate and view the error.

```
BEGIN
  -- Insert an order
  INSERT INTO pOrder
    (ordid, supplier, requester, ordered, items)
    VALUES (1000, 12345, 9876, SYSDATE, NULL);
  -- insert the items for the order created
  INSERT INTO TABLE (SELECT items
                     FROM   pOrder
                     WHERE  ordid = 1000)
    VALUES(typ_item(99, 129.00));
END;
/
```

   a. Why does the error occur?
   b. How can you fix the error?

3. Examine the following code, which produces an error. Which line causes the error, and how do you fix it?

   Note: You can run task 3 of the `lab_03.sql` script to view the error output.

```
DECLARE
  TYPE credit_card_typ
  IS VARRAY(100) OF VARCHAR2(30);

  v_mc   credit_card_typ := credit_card_typ();
  v_visa credit_card_typ := credit_card_typ();
  v_am   credit_card_typ;
  v_disc credit_card_typ := credit_card_typ();
  v_dc   credit_card_typ := credit_card_typ();

BEGIN
  v_mc.EXTEND;
  v_visa.EXTEND;
  v_am.EXTEND;
  v_disc.EXTEND;
  v_dc.EXTEND;
END;
/
```

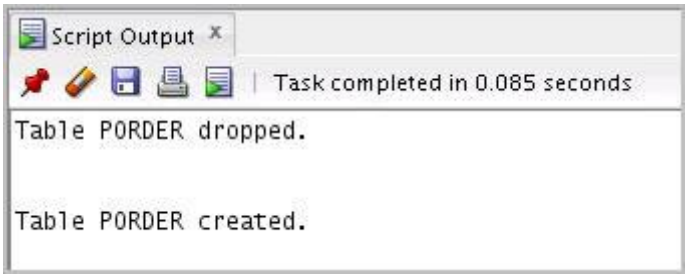
Solution 3-1: Analyzing Collections

In this practice, you create a nested table collection and use PL/SQL code to manipulate the collection.

Use the `OE` connection to complete the practice.

1. Examine the following definitions. Run task 1 of the `lab_03.sql` script to create these objects.

```
CREATE TYPE typ_item AS OBJECT  --create object
 (prodid  NUMBER(5),
  price   NUMBER(7,2) )
/
CREATE TYPE typ_item_nst -- define nested table type
  AS TABLE OF typ_item
/
CREATE TABLE pOrder (  -- create database table
     ordid     NUMBER(5),
     supplier  NUMBER(5),
     requester NUMBER(4),
     ordered   DATE,
     items     typ_item_nst)
     NESTED TABLE items STORE AS item_stor_tab
/
```



Note: The `CREATE TYPE` commands can return an exception `ORA-00955` if the types already exist in the database. The `drop` command will throw an error if the `porder` table does not exist.

2. The following code generates an error. Run task 2 of the `lab_03.sql` script to generate and view the error.

```
BEGIN
  -- Insert an order
  INSERT INTO pOrder
    (ordid, supplier, requester, ordered, items)
    VALUES (1000, 12345, 9876, SYSDATE, NULL);
  -- insert the items for the order created
  INSERT INTO TABLE (SELECT items
                     FROM   pOrder
                     WHERE  ordid = 1000)
    VALUES(typ_item(99, 129.00));
END;
/
```

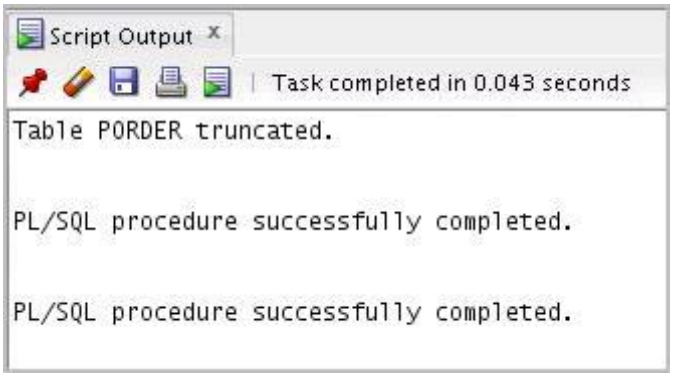
```
Error report -
ORA-22908: reference to NULL table value
ORA-06512: at line 7
22908. 00000 -  "reference to NULL table value"
*Cause:    The evaluation of the THE subquery or nested table column
           resulted in a NULL value implying a NULL table instance.
           The THE subquery or nested table column must identify a
           single non-NULL table instance.
*Action:   Ensure that the evaluation of the THE subquery or nested table
           column results in a single non-null table instance. If happening
           in the context of an insert statement where the THE subquery is
           the target of an insert, then ensure that an empty nested table
           instance is created by updating the nested table column of the
           parent table's row specifying an empty nested table constructor.
```

a. Why does the error occur?
The error "`ORA-22908: reference to NULL table value`" results from setting the table columns to NULL.

b. How can you fix the error?
You should always use a nested table's default constructor to initialize it:

```
TRUNCATE TABLE pOrder;

-- A better approach is to avoid setting the table
-- column to NULL, and instead, use a nested table's
-- default constructor to initialize
BEGIN
  -- Insert an order
  INSERT INTO pOrder
    (ordid, supplier, requester, ordered, items)
    VALUES (1000, 12345, 9876, SYSDATE,
            typ_item_nst(typ_item(99, 129.00)));
```

```
END;
/

BEGIN
  -- Insert an order
  INSERT INTO pOrder
    (ordid, supplier, requester, ordered, items)
    VALUES (1000, 12345, 9876, SYSDATE, null);
  -- Once the nested table is set to null, use the update
  -- update statement
  UPDATE pOrder
    SET items = typ_item_nst(typ_item(99, 129.00))
    WHERE ordid = 1000;
END;
/
```



Alternatively, run the code from task 2 of `sol_03.sql`.

3. Examine the following code. This code produces an error. Which line causes the error, and how do you fix it?

   Note: You can run task 3 of the `lab_03.sql` script to view the error output.

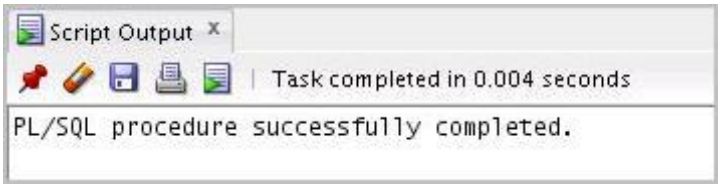
```
DECLARE
  TYPE credit_card_typ
  IS VARRAY(100) OF VARCHAR2(30);

  v_mc   credit_card_typ := credit_card_typ();
  v_visa credit_card_typ := credit_card_typ();
  v_am   credit_card_typ;
  v_disc credit_card_typ := credit_card_typ();
  v_dc   credit_card_typ := credit_card_typ();

BEGIN
  v_mc.EXTEND;
  v_visa.EXTEND;
  v_am.EXTEND;
```

```
  v_disc.EXTEND;
  v_dc.EXTEND;
END;
/
```

```
Error report -
ORA-06531: Reference to uninitialized collection
ORA-06512: at line 14
06531. 00000 -  "Reference to uninitialized collection"
*Cause:    An element or member function of a nested table or varray
           was referenced (where an initialized collection is needed)
           without the collection having been initialized.
*Action:   Initialize the collection with an appropriate constructor
           or whole-object assignment.
```

This causes an `ORA-06531: Reference to uninitialized collection` error. To fix it, initialize the `v_am` variable by using the same technique as the others:

```
DECLARE
  TYPE credit_card_typ
  IS VARRAY(100) OF VARCHAR2(30);

  v_mc   credit_card_typ := credit_card_typ();
  v_visa credit_card_typ := credit_card_typ();
  v_am   credit_card_typ := credit_card_typ();
  v_disc credit_card_typ := credit_card_typ();
  v_dc   credit_card_typ := credit_card_typ();

BEGIN
  v_mc.EXTEND;
  v_visa.EXTEND;
  v_am.EXTEND;
  v_disc.EXTEND;
  v_dc.EXTEND;
END;
/
```



Alternatively, run the code from task 3 of `sol_03.sql`.

Practices for Lesson 4: Using Collections

Practices for Lesson 4: Overview

In this practice, you write a PL/SQL package to manipulate the collection.

Use the `OE` schema for this practice.

Practice 4-1: Using Collections

Overview

In this practice, you use PL/SQL code to manipulate the collection.

Assumptions

Practice 03 is completed.

Task

Implement a nested table column in the `CUSTOMERS` table and write PL/SQL code to manipulate the nested table.

Use the `OE` schema to complete the tasks.

1. Create a nested table to hold credit card information.
   a. Create an object type called `typ_cr_card`. It should have the following specification:
      ```
      card_type  VARCHAR2(25)
      card_num   NUMBER
      ```
   b. Create a nested table type called `typ_cr_card_nst`, which is a table of `typ_cr_card`.
   c. Add a column called `credit_cards` to the `CUSTOMERS` table. Make this column a nested table of type `typ_cr_card_nst`. You can use the following syntax:

```
ALTER TABLE customers ADD
(credit_cards typ_cr_card_nst)
   NESTED TABLE credit_cards STORE AS c_c_store_tab;
```

2. Create a PL/SQL package that manipulates the `credit_cards` column in the `CUSTOMERS` table.
   a. Open the `lab_04.sql` file. It contains the package specification and part of the package body. Examine task 2 of `lab_04.sql`.
   b. Complete the following code so that the package:
      - Inserts credit card information (the credit card name and number for a specific customer)
      - Displays credit card information in an unnested format

```
CREATE OR REPLACE PACKAGE credit_card_pkg
IS
  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no
VARCHAR2);
  PROCEDURE display_card_info
    (p_cust_id NUMBER);
END credit_card_pkg;  -- package spec
/

CREATE OR REPLACE PACKAGE BODY credit_card_pkg
```

```
IS

  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no VARCHAR2)
  IS
    v_card_info typ_cr_card_nst;
    i INTEGER;
  BEGIN
    SELECT credit_cards
      INTO v_card_info
      FROM customers
      WHERE customer_id = p_cust_id;
    IF v_card_info.EXISTS(1) THEN
 -- cards exist, add more

 -- fill in code here

    ELSE -- no cards for this customer, construct one

 -- fill in code here

    END IF;
  END update_card_info;


  PROCEDURE display_card_info
    (p_cust_id NUMBER)
  IS
    v_card_info typ_cr_card_nst;
    i INTEGER;
  BEGIN
    SELECT credit_cards
      INTO v_card_info
      FROM customers
      WHERE customer_id = p_cust_id;

 -- fill in code here to display the nested table
 -- contents

  END display_card_info;
END credit_card_pkg;  -- package body
/
```

3. Test your package with the following statements and compare the output:

```
SET SERVEROUTPUT ON

EXECUTE credit_card_pkg.display_card_info(120);

SET SERVEROUTPUT ON

EXECUTE credit_card_pkg.update_card_info(120, 'Visa', 11111111);

SELECT  c1.*
FROM   customers,TABLE(customers.credit_cards) c1
WHERE  customer_id = 120;

SET SERVEROUTPUT ON

EXECUTE credit_card_pkg.display_card_info(120);

SET SERVEROUTPUT ON

EXECUTE credit_card_pkg.update_card_info(120, 'MC', 2323232323);

SET SERVEROUTPUT ON

EXECUTE credit_card_pkg.update_card_info (120, 'DC', 4444444);

SET SERVEROUTPUT ON

EXECUTE credit_card_pkg.display_card_info(120);
```

Alternatively, you can execute the code of task 3 from `lab_04.sql`.

4. Write a `SELECT` statement against the `credit_cards` column to unnest the data. Use the `TABLE` expression. Use SQL*Plus.
   Write a query using `TABLE` expression so that the results look like the following:

```
-- Use the table expression so that the result is:
CUSTOMER_ID CUST_LAST_NAME  CARD_TYPE        CARD_NUM
----------- --------------- ------------- -----------
        120 Higgins         Visa             11111111
        120 Higgins         MC             2323232323
        120 Higgins         DC                4444444
```

Alternatively, you can execute the code of task 4 from `lab_04.sql`.

Solution 4-1: Using Collections

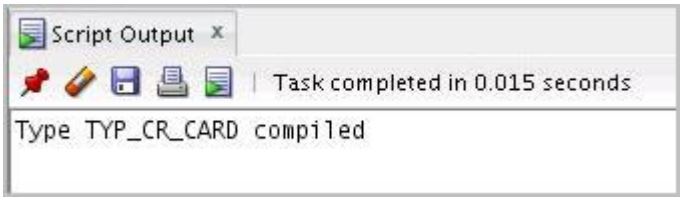
In this practice, you use PL/SQL code to manipulate the collection.

1. Create a nested table to hold credit card information.

   a. Create an object type called `typ_cr_card`. It should have the following specification:

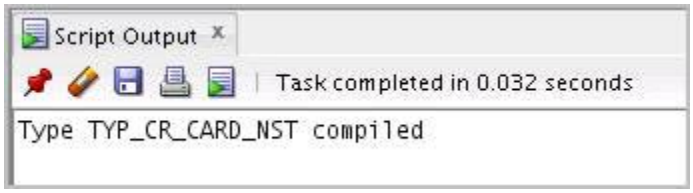
   ```
   card_type VARCHAR2(25)
   card_num  NUMBER
   ```

   ```
   CREATE TYPE typ_cr_card AS OBJECT  --create object
    (card_type  VARCHAR2(25),
     card_num   NUMBER);
   /
   ```

   b. Create a nested table type called `typ_cr_card_nst`, which is a table of `typ_cr_card`.

   ```
   CREATE TYPE typ_cr_card_nst -- define nested table type
     AS TABLE OF typ_cr_card;
   /
   ```

   c. Add a column called `credit_cards` to the `CUSTOMERS` table.

   Make this column a nested table of type `typ_cr_card_nst`.

   You can use the following syntax:

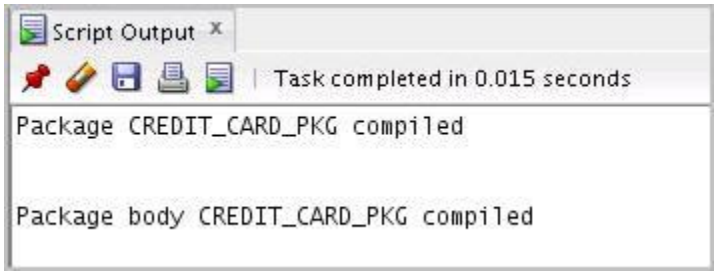
   ```
   ALTER TABLE customers ADD
   credit_cards typ_cr_card_nst
      NESTED TABLE credit_cards STORE AS c_store_tab;
   ```

Alternatively, you can run the solution of 1_a, 1_b, and 1_c from `sol_04.sql`.

2. Create a PL/SQL package that manipulates the `credit_cards` column in the `CUSTOMERS` table.
   a. Open the `lab_04.sql` file. It contains the package specification and part of the package body.
   b. Here is the complete code of the package that inserts the credit card information and displays the credit card information in an unnested format

```
CREATE OR REPLACE PACKAGE credit_card_pkg
IS
  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no
VARCHAR2);

  PROCEDURE display_card_info
    (p_cust_id NUMBER);
END credit_card_pkg;  -- package spec
/

CREATE OR REPLACE PACKAGE BODY credit_card_pkg
IS

  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no VARCHAR2)
  IS
    v_card_info typ_cr_card_nst;
    i INTEGER;
  BEGIN
    SELECT credit_cards
      INTO v_card_info
      FROM customers
      WHERE customer_id = p_cust_id;
    IF v_card_info.EXISTS(1) THEN  -- cards exist, add more
      i := v_card_info.LAST;
      v_card_info.EXTEND(1);
      v_card_info(i+1) := typ_cr_card(p_card_type, p_card_no);
      UPDATE customers
        SET  credit_cards = v_card_info
        WHERE customer_id = p_cust_id;
    ELSE   -- no cards for this customer yet, construct one
      UPDATE customers
        SET  credit_cards = typ_cr_card_nst
            (typ_cr_card(p_card_type, p_card_no))
        WHERE customer_id = p_cust_id;
    END IF;
```

```
  END update_card_info;


  PROCEDURE display_card_info
    (p_cust_id NUMBER)
  IS
    v_card_info typ_cr_card_nst;
    i INTEGER;
  BEGIN
    SELECT credit_cards
      INTO v_card_info
      FROM customers
      WHERE customer_id = p_cust_id;
    IF v_card_info.EXISTS(1) THEN
      FOR idx IN v_card_info.FIRST..v_card_info.LAST LOOP
          DBMS_OUTPUT.PUT('Card Type: ' ||
v_card_info(idx).card_type || ' ');
        DBMS_OUTPUT.PUT_LINE('/ Card No: ' ||
v_card_info(idx).card_num );
      END LOOP;
    ELSE
      DBMS_OUTPUT.PUT_LINE('Customer has no credit cards.');
    END IF;
  END display_card_info;
END credit_card_pkg;  -- package body
/
```



Alternatively, you can execute the solution of task 2 from `sol_04.sql`.

3. Test your package with the following statements and compare the output:

```
EXECUTE credit_card_pkg.display_card_info(120)
```

```
PL/SQL procedure successfully completed.

Customer has no credit cards.
```

```
EXECUTE credit_card_pkg.update_card_info
    (120, 'Visa', 11111111)
```

```
PL/SQL procedure successfully completed.
```

```
SELECT c1.*
FROM   customers, TABLE(customers.credit_cards) c1
WHERE  customer_id = 120;
```

	CARD_TYPE	CARD_NUM
1	Visa	11111111

```
EXECUTE credit_card_pkg.display_card_info(120)
```

```
PL/SQL procedure successfully completed.

Card Type: Visa / Card No: 11111111
```

```
EXECUTE credit_card_pkg.update_card_info
    (120, 'MC', 2323232323)
EXECUTE credit_card_pkg.update_card_info
    (120, 'DC', 4444444)
```

```
PL/SQL procedure successfully completed.


PL/SQL procedure successfully completed.
```

```
EXECUTE credit_card_pkg.display_card_info(120)
```

```
PL/SQL procedure successfully completed.

Card Type: Visa / Card No: 11111111
Card Type: MC / Card No: 2323232323
Card Type: DC / Card No: 4444444
```

Alternatively, you can execute the code of task 3 from `lab_04.sql`.

4. Write a `SELECT` statement against the `credit_cards` column to unnest the data using `TABLE` expression. Use SQL*Plus.

   The results of the query should look like the following:

```
-- Use the table expression so that the result is:
CUSTOMER_ID CUST_LAST_NAME  CARD_TYPE        CARD_NUM
----------- --------------- ------------- -----------
        120 Higgins         Visa             11111111
        120 Higgins         MC             2323232323
        120 Higgins         DC                4444444
```

```
SELECT c1.customer_id, c1.cust_last_name, c2.*
FROM   customers c1, TABLE(c1.credit_cards) c2
WHERE  customer_id = 120;
```

Alternatively, you can execute the code of task 4 from `lab_04.sql`.

Practices for Lesson 5:
Handling Large Objects

Practices for Lesson 5: Overview

This practice covers the following topics:

- Creating object types of the CLOB and BLOB data types
- Creating a table with the LOB data types as columns
- Using the `DBMS_LOB` package to populate and interact with the LOB data
- Setting up the environment for LOBs

Practice 5-1: Working with LOBS

Overview

In this practice, you create a table with both BLOB and CLOB columns. Then, you use the DBMS_LOB package to populate the table and manipulate the data.

Use the OE connection to complete this practice.

Task

1. Create a table called PERSONNEL. The table should contain the following attributes and data types:

Column Name	Data Type	Length
ID	NUMBER	6
LAST_NAME	VARCHAR2	35
REVIEW	CLOB	N/A
PICTURE	BLOB	N/A

2. Insert two rows into the PERSONNEL table, one each for employee 2034 (whose last name is Allen) and employee 2035 (whose last name is Bond). Use the empty function for the CLOB, and provide NULL as the value for the BLOB.
3. Examine and execute the /home/oracle/labs/labs/lab_05.sql script. The script creates a table named REVIEW_TABLE. This table contains the annual review information for each employee. The script also contains two statements to insert review details about two employees.
4. Update the PERSONNEL table.
   a. Populate the CLOB for the first row by using this subquery in an UPDATE statement:
   ```
   SELECT ann_review
   FROM   review_table
   WHERE  employee_id = 2034;
   ```
   b. Populate the CLOB for the second row by using PL/SQL and the DBMS_LOB package. Use the following SELECT statement to provide a value for the LOB locator:
   ```
   SELECT ann_review
   FROM   review_table
   WHERE  employee_id = 2035;
   ```
5. Create a procedure that adds a locator to a binary file in the PICTURE column of the PRODUCT_INFORMATION table. The binary file is a picture of the product. The image files are named after the product IDs. You must load an image file locator into all rows in the Printers category (CATEGORY_ID = 12) in the PRODUCT_INFORMATION table.
   a. Using the PDB1-sys connection (sys user in PDB1), create a DIRECTORY object called PRODUCT_PIC that references the location of the binary. These files are available in the /home/oracle/labs/DATA_FILES/PRODUCT_PIC folder.

b. Add the image column to the `PRODUCT_INFORMATION` table.

c. Create a PL/SQL procedure called `load_product_image` that uses `DBMS_LOB.FILEEXISTS` to test whether the product picture file exists. If the file exists, set the `BFILE` locator for the file in the `PICTURE` column; otherwise, display a message that the file does not exist. Use the `DBMS_OUTPUT` package to report file size information about each image associated with the `PICTURE` column.

d. Invoke the procedure by passing the name of the `PRODUCT_PIC` directory object as a string literal parameter value.

e. Check the `LOB` space usage of the `PRODUCT_INFORMATION` table. Use the `/home/oracle/labs/labs/lab_05.sql` file to create the procedure and execute it.

Solution 5-1: Working with LOBs

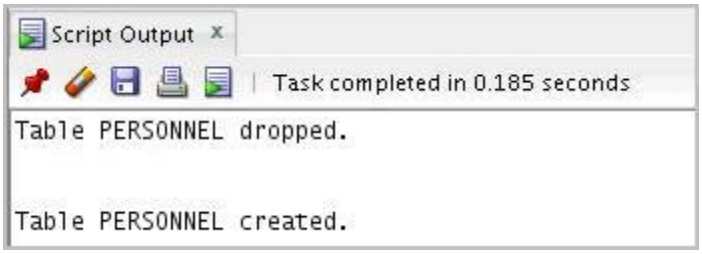
In this practice, you create a table with both BLOB and CLOB columns. Then you use the DBMS_LOB package to populate the table and manipulate the data.

Use your OE connection.

1. Create a table called PERSONNEL. The table should contain the following attributes and data types:

Column Name	Data Type	Length
ID	NUMBER	6
LAST_NAME	VARCHAR2	35
REVIEW	CLOB	N/A
PICTURE	BLOB	N/A

```
DROP TABLE personnel
/
CREATE TABLE personnel
(id NUMBER(6) constraint personnel_id_pk PRIMARY KEY,
 last_name VARCHAR2(35),
 review CLOB,
 picture BLOB);
```

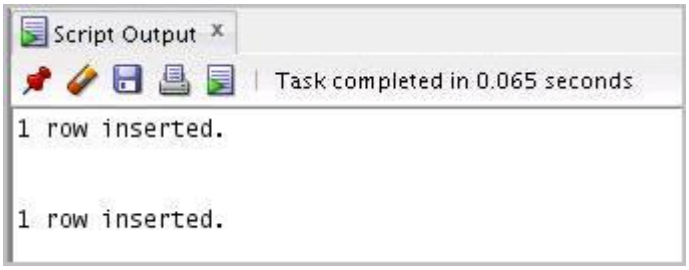


The drop command would return an error if the PERSONNEL table is not already created.

Alternatively, you can run the solution for task 1 from sol_05.sql.

2. Insert two rows into the PERSONNEL table, one each for employee 2034 (whose last name is Allen) and employee 2035 (whose last name is Bond). Use the empty function for the CLOB, and provide NULL as the value for the BLOB.

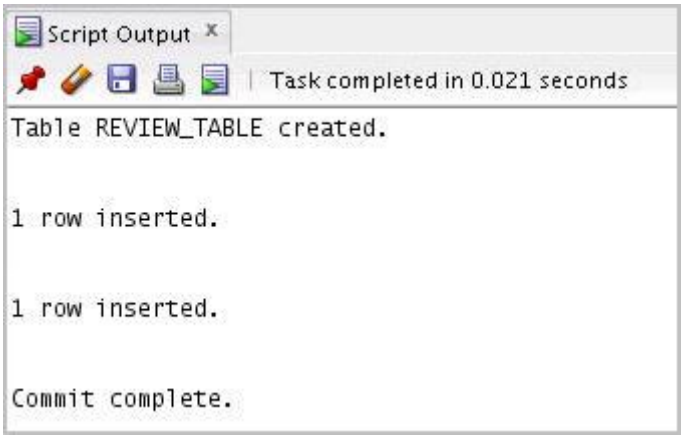
```
INSERT INTO  personnel
VALUES (2034, 'Allen', empty_clob(), NULL);

INSERT INTO  personnel
VALUES (2035, 'Bond', empty_clob(), NULL);
```



Alternatively, you can run the solution for task 2 from `sol_05.sql`.

3. Examine and execute task 3 located in the `/home/oracle/labs/labs/lab_05.sql` script. The script creates a table named `REVIEW_TABLE`. This table contains annual review information for each employee. The script also contains two statements to insert review details for two employees.

```
CREATE TABLE review_table (
 employee_id number,
 ann_review  VARCHAR2(2000));

INSERT INTO review_table
VALUES (2034,
       'Very good performance this year. '||
       'Recommended to increase salary by $500');

INSERT INTO review_table
VALUES (2035,
       'Excellent performance this year. '||
       'Recommended to increase salary by $1000');

COMMIT;
```

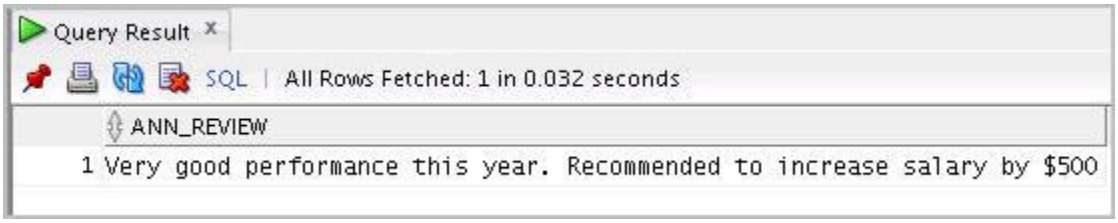


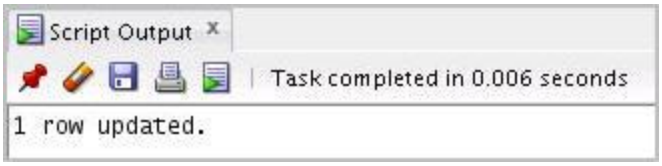
4. Update the `PERSONNEL` table.

   a. Populate the `CLOB` for the first row by using the following subquery in an `UPDATE` statement:

```
SELECT ann_review
FROM   review_table
WHERE  employee_id = 2034;
```

```
UPDATE personnel
 SET review = (SELECT ann_review
               FROM   review_table
               WHERE  employee_id = 2034)
 WHERE last_name = 'Allen';
```

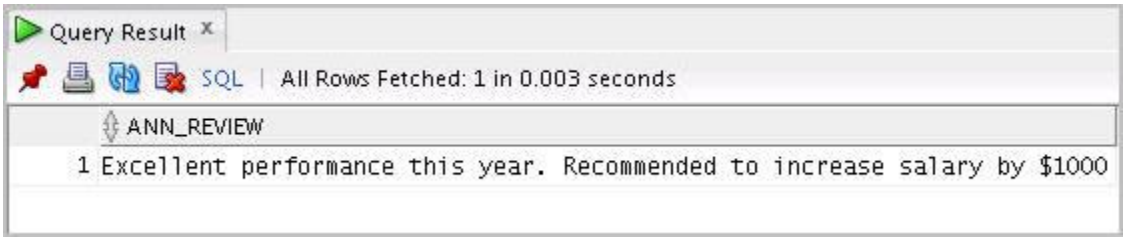


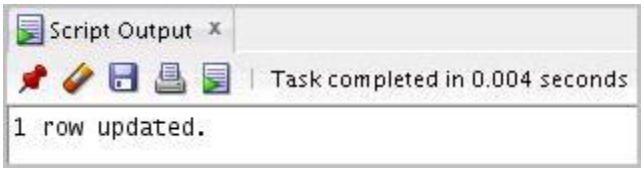


   b. Populate the `CLOB` for the second row by using PL/SQL and the `DBMS_LOB` package. Use the following `SELECT` statement to provide a value for the `LOB` locator:

```
SELECT ann_review
FROM   review_table
WHERE  employee_id = 2035;
```

```
UPDATE personnel
 SET review = (SELECT ann_review
               FROM   review_table
               WHERE  employee_id = 2035)
 WHERE last_name = 'Bond';
```



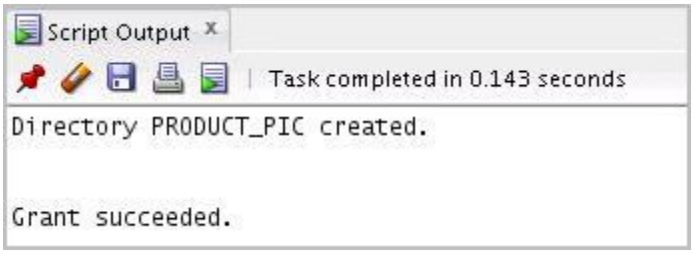


Alternatively, you can run the solution for task 4_a, 4_b from `sol_06.sql`.

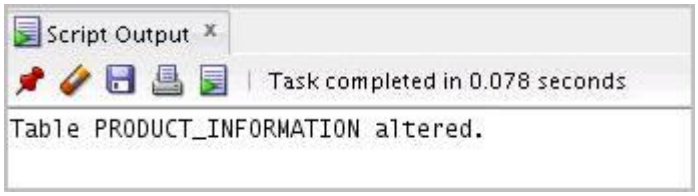
5. Create a procedure that adds a locator to a binary file to the `PICTURE` column of the `PRODUCT_INFORMATION` table. The binary file is a picture of the product. The image files are named after the product IDs. You must load an image file locator into all rows in the Printers category (`CATEGORY_ID = 12`) in the `PRODUCT_INFORMATION` table.

   a. Create a `DIRECTORY` object called `PRODUCT_PIC` that references the location of the binary file. These files are available in the `/home/oracle/labs/DATA_FILES/PRODUCT_PIC` folder.

```
--Execute as SYS user
CREATE OR REPLACE DIRECTORY product_pic AS
'/home/oracle/labs/DATA_FILES/PRODUCT_PIC';
GRANT READ on DIRECTORY product_pic TO OE;
```



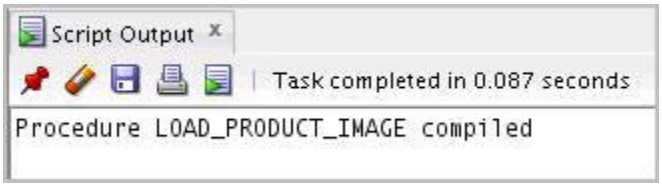
   b. Add the image column to the `PRODUCT_INFORMATION` table by using:
   `ALTER TABLE product_information ADD (picture BFILE);`



   c. Create a PL/SQL procedure called `load_product_image` that uses `DBMS_LOB.FILEEXISTS` to test whether the product picture file exists. If the file exists, set the BFILE locator for the file in the `PICTURE` column; otherwise, display a message that the file does not exist. Use the `DBMS_OUTPUT` package to report file size information for each image associated with the `PICTURE` column.
   (Alternatively, use the code snippet contained in task 5c of the `lab_05.sql` file.)

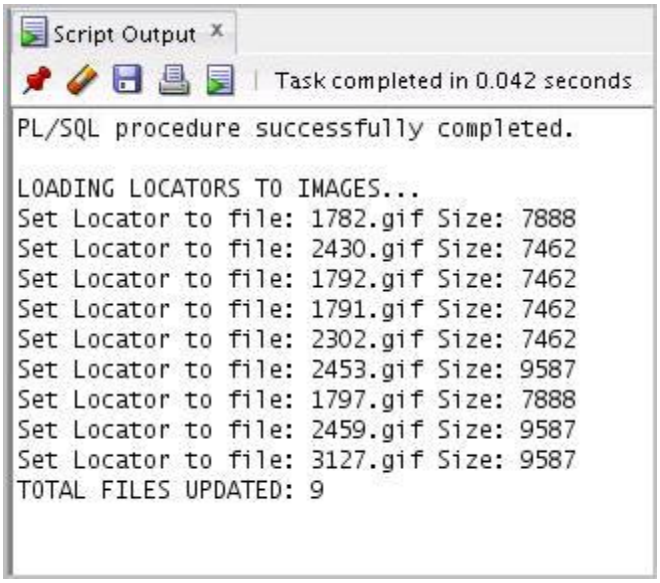
```
CREATE OR REPLACE PROCEDURE load_product_image
(p_dir IN VARCHAR2)
IS
  v_file           BFILE;
  v_filename       VARCHAR2(40);
  v_rec_number     NUMBER;
  v_file_exists    BOOLEAN;
```

```
  CURSOR product_csr IS
    SELECT product_id
    FROM product_information
    WHERE category_id = 12
    FOR UPDATE;
BEGIN
  DBMS_OUTPUT.PUT_LINE('LOADING LOCATORS TO IMAGES...');
  FOR rec IN product_csr
  LOOP
    v_filename := rec.product_id || '.gif';
    v_file := BFILENAME(p_dir, v_filename);
    v_file_exists := (DBMS_LOB.FILEEXISTS(v_file) = 1);
    IF v_file_exists THEN
     DBMS_LOB.FILEOPEN(v_file);
     UPDATE product_information
       SET picture = v_file
       WHERE CURRENT OF product_csr;
     DBMS_OUTPUT.PUT_LINE('Set Locator to file: '|| v_filename
       || ' Size: ' || DBMS_LOB.GETLENGTH(v_file));
     DBMS_LOB.FILECLOSE(v_file);
     v_rec_number := product_csr%ROWCOUNT;
    ELSE
     DBMS_OUTPUT.PUT_LINE('File ' || v_filename ||
      ' does not exist');
    END IF;
  END LOOP;
  DBMS_OUTPUT.PUT_LINE('TOTAL FILES UPDATED: ' ||
                       v_rec_number);
  EXCEPTION
    WHEN OTHERS THEN
      DBMS_LOB.FILECLOSE(v_file);
      DBMS_OUTPUT.PUT_LINE('Error: '|| to_char(SQLCODE) ||
        SQLERRM);
END load_product_image;
/
```



d. Invoke the procedure by passing the name of the `PRODUCT_PIC` directory object as a string literal parameter value.

```
SET SERVEROUTPUT ON
EXECUTE load_product_image('PRODUCT_PIC');
```



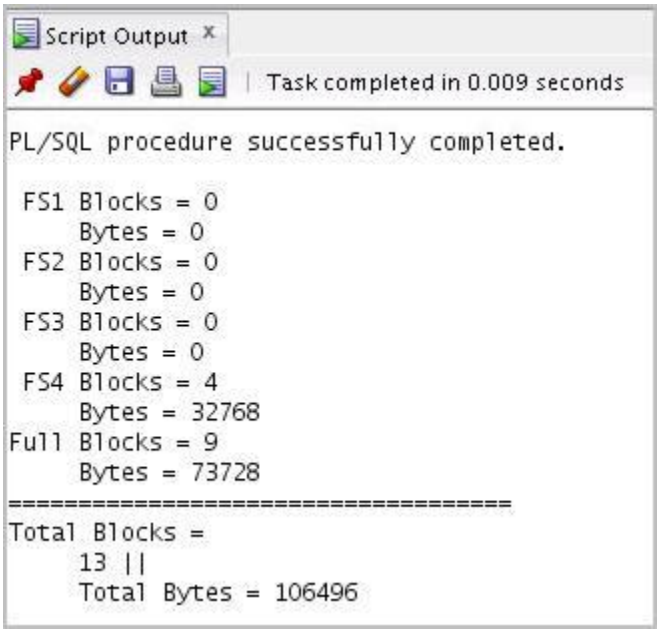
Alternatively, you can run the code for the solutions 5_a, 5_b, 5_c, 5_d from `sol_05.sql`.

e. Check the `LOB` space usage of the `PRODUCT_INFORMATION` table. Use the `/home/oracle/labs/labs/lab_05.sql` file to create the procedure and execute it.

```
CREATE OR REPLACE PROCEDURE check_space
IS
  l_fs1_bytes NUMBER;
  l_fs2_bytes NUMBER;
  l_fs3_bytes NUMBER;
  l_fs4_bytes NUMBER;
  l_fs1_blocks NUMBER;
  l_fs2_blocks NUMBER;
  l_fs3_blocks NUMBER;
  l_fs4_blocks NUMBER;
  l_full_bytes NUMBER;
  l_full_blocks NUMBER;
  l_unformatted_bytes NUMBER;
  l_unformatted_blocks NUMBER;
BEGIN
  DBMS_SPACE.SPACE_USAGE(
    segment_owner      => 'OE',
    segment_name       => 'PRODUCT_INFORMATION',
    segment_type       => 'TABLE',
```

```
    fs1_bytes          => l_fs1_bytes,
    fs1_blocks         => l_fs1_blocks,
    fs2_bytes          => l_fs2_bytes,
    fs2_blocks         => l_fs2_blocks,
    fs3_bytes          => l_fs3_bytes,
    fs3_blocks         => l_fs3_blocks,
    fs4_bytes          => l_fs4_bytes,
    fs4_blocks         => l_fs4_blocks,
    full_bytes         => l_full_bytes,
    full_blocks        => l_full_blocks,
    unformatted_blocks => l_unformatted_blocks,
    unformatted_bytes  => l_unformatted_bytes
   );
  DBMS_OUTPUT.ENABLE;
  DBMS_OUTPUT.PUT_LINE(' FS1 Blocks = '||l_fs1_blocks||'
     Bytes = '||l_fs1_bytes);
  DBMS_OUTPUT.PUT_LINE(' FS2 Blocks = '||l_fs2_blocks||'
     Bytes = '||l_fs2_bytes);
  DBMS_OUTPUT.PUT_LINE(' FS3 Blocks = '||l_fs3_blocks||'
     Bytes = '||l_fs3_bytes);
  DBMS_OUTPUT.PUT_LINE(' FS4 Blocks = '||l_fs4_blocks||'
     Bytes = '||l_fs4_bytes);
  DBMS_OUTPUT.PUT_LINE('Full Blocks = '||l_full_blocks||'
     Bytes = '||l_full_bytes);
  DBMS_OUTPUT.PUT_LINE('==============================');
  DBMS_OUTPUT.PUT_LINE('Total Blocks =
     '||to_char(l_fs1_blocks + l_fs2_blocks +
     l_fs3_blocks + l_fs4_blocks + l_full_blocks)||  ' ||
     Total Bytes = '|| to_char(l_fs1_bytes + l_fs2_bytes
     + l_fs3_bytes + l_fs4_bytes + l_full_bytes));
END;
/
```

```
set serveroutput on
execute check_space;
```



Practices for Lesson 6: JSON Data in Database

Practices for Lesson 6: Overview

This practice covers the following topics:

- Creating JSON object column types in tables and inserting data in it
- Generating JSON data from data in tables

Practice 6-1: JSON Data in Tables

Overview

In this practice, you create a table with JSON columns and set constraints on the column. Insert data into the JSON data column.

Use the `OE` connection to complete this practice.

Task

a. Create a table called `SALES_REPORT`. The table should contain the following attributes and data types:

Column Name	Data Type	Length
SALES_REP_ID	NUMBER	6
SALES_REP_FNAME	VARCHAR2	20
SALES_REP_LNAME	VARCHAR2	20
ORDER_DETAILS	VARCHAR2	4000

This table contains the information of all the sales representatives who are handling various orders as indicated in table `ORDERS`.

Note: The `SALES_REP_ID` column in the `ORDERS` table references the `EMPLOYEES` table in the `HR` schema.

b. Define `IS_JSON` constraint on the `ORDER_DETAILS` column.

c. Populate the `SALES_REPORT` table with first name and last name data of the sales representatives referred to in the `ORDERS` table.

d. Update the `SALES_REPORT` table, to populate the `ORDER_DETAILS` column. Insert a group of JSON objects into the column, where each JSON object has details of the order handled by the sales representative. The JSON object should have information on `order_id` with the corresponding `customer_id` and order value.

Practice 6-2: JSON Data in PL/SQL Blocks

Create a procedure `SALES_DATA`, which initializes a nested JSON object with properties `sales_rep_fname`, `sales_rep_lname`, and `order_details`. `order_details` is a JSON object with properties `customer_id` and `order_value`. Access the `order_value` value of the JSON object by using the `get_number` method and display it to the output.

Solution 6-1: JSON Data in Tables

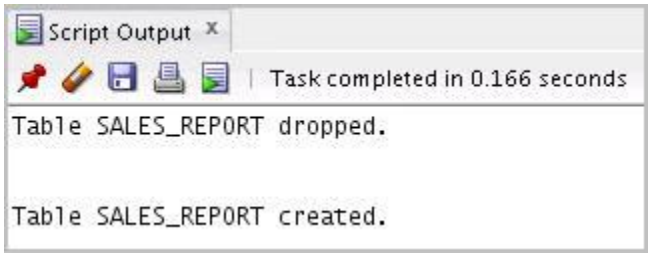
In this practice, you create a table with both `BLOB` and `CLOB` columns. Then you use the `DBMS_LOB` package to populate the table and manipulate the data.

Use your `OE` connection.

a. Create a table called `SALES_REPORT`. The table should contain the following attributes and data types:

Column Name	Data Type	Length
SALES_REP_ID	NUMBER	6
SALES_REP_FNAME	VARCHAR2	20
SALES_REP_LNAME	VARCHAR2	20
ORDER_DETAILS	VARCHAR2	4000

```
DROP TABLE sales_report
/
CREATE TABLE sales_report(sales_rep_id number(6,0) PRIMARY
KEY,sales_rep_fname VARCHAR2(20) , sales_rep_lname VARCHAR2(20),
order_details VARCHAR2(4000));
```

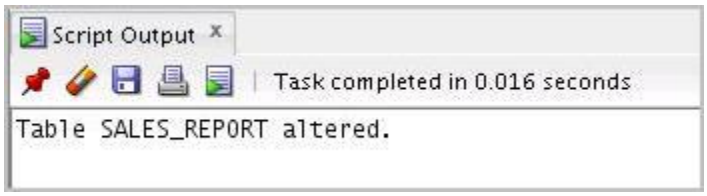


The `drop` command would return an error if the `SALES_REPORT` table is not already created.

Alternatively, you can run the solution for task 1 from `sol_06.sql`.

b. Define `IS_JSON` constraint on the `ORDER_DETAILS` column.

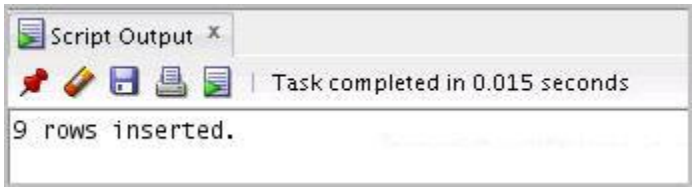
```
ALTER TABLE sales_report ADD CONSTRAINT ensure_json CHECK
(order_details IS JSON);
```



Alternatively, you can run the solution for task 2 from `sol_06.sql`.

c. Populate the `SALES_REPORT` table with first name and last name data of the sales representatives referred to in the `ORDERS` table.

```
INSERT INTO sales_report(sales_rep_id, sales_rep_fname,
sales_rep_lname)
SELECT DISTINCT o.sales_rep_id, emp.first_name, emp.last_name
FROM hr.employees emp, oe.orders o
WHERE emp.employee_id = o.sales_rep_id;
```



d. Update the `SALES_REPORT` table to populate the `ORDER_DETAILS` column. Insert a group of JSON objects into the column, where each JSON object has details of the order handled by the sales representative. The JSON object should have information on `order_id` with the corresponding `customer_id` and order value.

```
SELECT * FROM sales_report;
```

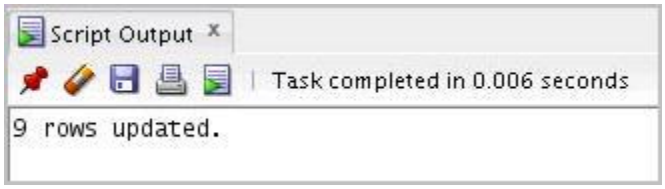
Query Result

SQL | All Rows Fetched: 9 in 0.006 seconds

	SALES_REP_ID	SALES_REP_FNAME	SALES_REP_LNAME	ORDER_DETAILS
1	155	Oliver	Tuvault	(null)
2	156	Janette	King	(null)
3	163	Danielle	Greene	(null)
4	153	Christopher	Olsen	(null)
5	161	Sarath	Sewall	(null)
6	160	Louise	Doran	(null)
7	154	Nanette	Cambrault	(null)
8	158	Allan	McEwen	(null)
9	159	Lindsey	Smith	(null)

```
UPDATE sales_report sr
SET order_details = (SELECT JSON_ARRAYAGG(JSON_OBJECT(
                     'order_id' VALUE o.order_id,
                     'customer_id' VALUE o.customer_id,
                     'order_value' VALUE o.order_total))
FROM  oe.orders o
WHERE o.sales_rep_id = sr.sales_rep_id
```

```
group by sales_rep_id);
commit;
```

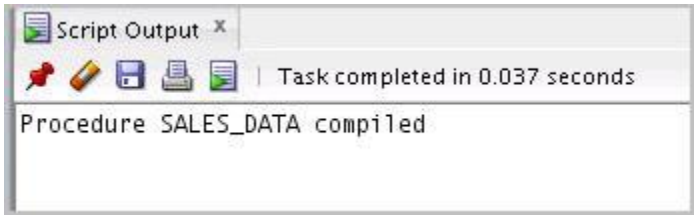


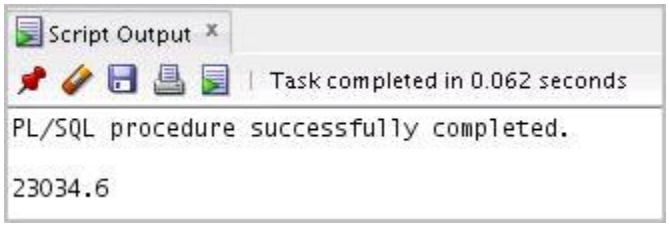
Alternatively, you can run the solution for task 4_a, 4_b from `sol_06.sql`.

Solution 6-2: JSON Data in PL/SQL Blocks

Create a procedure `SALES_DATA`, which initializes a nested JSON object with properties `sales_rep_fname`, `sales_rep_lname`, and `order_details`. `order_details` is a JSON object with properties `customer_id` and `order_value`. Access the `order_value` value of the JSON object by using the `get_number` method and display it to the output. If you would rather use the solution file, ensure that the create statement and the execute statement are executed as individual blocks.

```
CREATE OR REPLACE PROCEDURE sales_data AS
input_data JSON_OBJECT_T;
ord_det JSON_OBJECT_T;
o_val number;
BEGIN
input_data := new JSON_OBJECT_T('{"sales_rep_fname" : "Janette",
                                 "sales_rep_lname" : "King",
                                 "order_details" : {
"customer_id" : "106","order_value" : "23034.6"}}');

ord_det := input_data.get_object('order_details');
o_val := ord_det.get_number('order_value');
DBMS_OUTPUT.PUT_LINE(o_val);
END sales_data;
/
EXECUTE sales_data;
/
```





Practices for Lesson 7:
Advanced Interface Methods

Practices for Lesson 7: Overview

In this practice, you write two PL/SQL programs: one program calls an external C routine, and the other calls a Java routine.

Practice 7-1: Using Advanced Interface Methods

Overview

In this practice, you will execute programs to interact with C routines and Java code.

Use the `OE` connection.

Task

An external C routine definition is created for you. The `.c` file is stored in the `/home/oracle/labs/labs` directory. This function returns the tax amount based on the total sales figure that is passed to the function as a parameter. The `.c` file is named `calc_tax.c`. The function is defined as:

```
#include <ctype.h>
int calc_tax(int n)
{
int tax;
tax = (n*8)/100;
return(tax);

}
```

1. A shared library file called `calc_tax.so` was created for you. Copy the file from the `/home/oracle/labs/labs` directory into your `/u01/app/oracle/product/19.3.0/dbhome_1/bin` directory.
2. Connect to the `sys` connection, and create the alias library object. Name the library object `c_code` and define its path as:

```
CREATE OR REPLACE LIBRARY c_code
AS '/u01/app/oracle/product/19.3.0/dbhome_1/bin/calc_tax.so';
/
```

3. Grant the execute privilege on the library to the `OE` user by executing the following command:

```
GRANT EXECUTE ON c_code TO OE;
```

4. Publish the external C routine. As the `OE` user, create a function named `call_c`. This function has one numeric parameter and it returns a binary integer. Identify the `AS LANGUAGE`, `LIBRARY`, and `NAME` clauses of the function.
5. Create a procedure to call the `call_c` function that was created in the previous step. Name this procedure `C_OUTPUT`. It has one numeric parameter. Include a `DBMS_OUTPUT.PUT_LINE` statement so that you can view the results returned from your C function.

6. Set `SERVEROUTPUT ON` and execute the `C_OUTPUT` procedure.

   Calling Java from PL/SQL

   A Java method definition is created for you. The method accepts a 16-digit credit card number as the argument and returns the formatted credit card number (4 digits followed by a space). The name of the `.class` file is `FormatCreditCardNo.class`. The method is defined as:

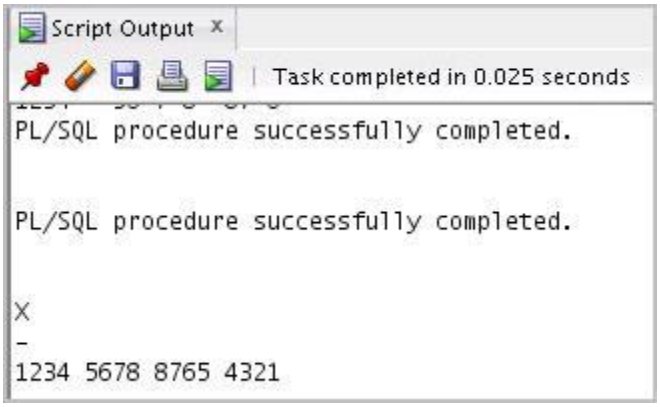
```
public class FormatCreditCardNo
{
public static final void formatCard(String[] cardno)
{
int count=0, space=0;
String oldcc=cardno[0];
String[] newcc= {""};
while (count<16)
{
newcc[0]+= oldcc.charAt(count);
space++;
if (space ==4)
{  newcc[0]+=" "; space=0;  }
count++;
}
cardno[0]=newcc [0];
}
}
```

7. Load the `.java` source file.
8. Publish the Java class method by defining a PL/SQL procedure named `CCFORMAT`. This procedure accepts one `IN OUT` parameter.
   Use the following definition for the `NAME` parameter:

```
NAME 'FormatCreditCardNo.formatCard(java.lang.String[])';
```

9. Execute the Java class method. Define one SQL*Plus or Oracle SQL Developer variable, initialize it, and use the `EXECUTE` command to execute the `CCFORMAT` procedure.
   Your output should match the `PRINT` output as shown here:

```
VARIABLE x VARCHAR2(20)
EXECUTE :x := '1234567887654321'
EXECUTE ccformat(:x)
PRINT x
```



Solution 7-1: Using Advanced Interface Methods

In this practice, you will execute programs to interact with C routines and Java code.

Use the `OE` connection.

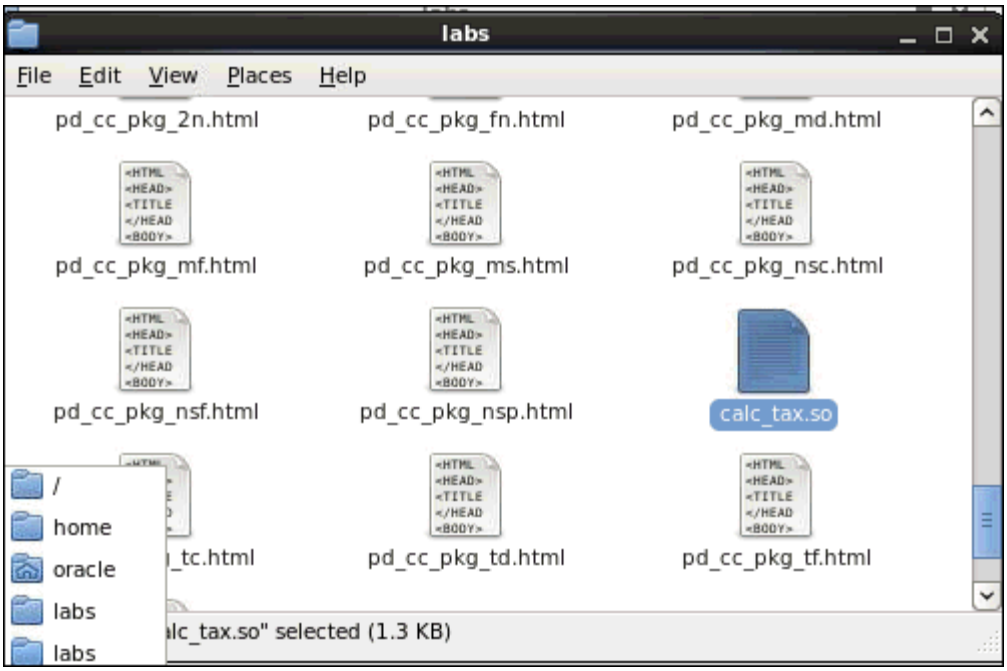
Using External C Routines

An external C routine definition is created for you. The `.c` file is stored in the `/home/oracle/labs/labs` directory. This function returns the tax amount based on the total sales figure that is passed to the function as a parameter. The `.c` file is named `calc_tax.c`. The function is defined as:

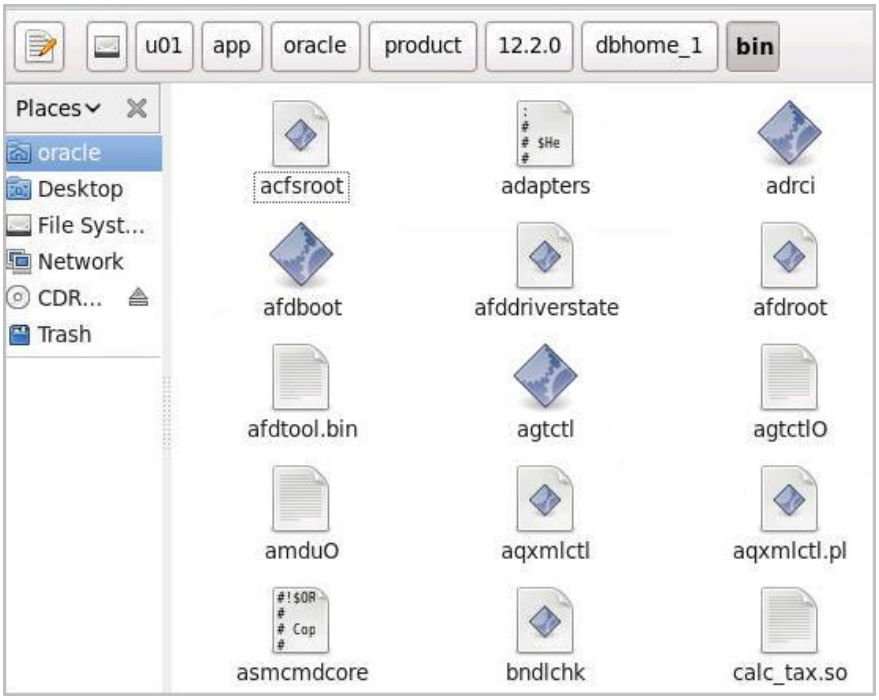
```
#include <ctype.h>
int calc_tax(int n)
{

int tax;
tax = (n*8)/100;
return(tax);

}
```

1. A shared library file called `calc_tax.so` was created for you. Copy the file from the `/home/oracle/labs/labs` directory into your `/u01/app/oracle/product/19.3.0/dbhome_1/bin` directory.

   Open the `/home/oracle/labs/labs` directory. Select `calc_tax.so`. Select Edit > Copy.

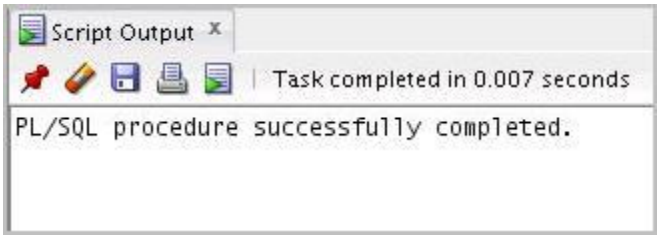


Navigate to the `/u01/app/oracle/product/19.3.0/dbhome_1/bin` folder. Right-click the `BIN` directory and select Paste from the shortcut menu.



2. Connect to the `sys` connection, and create the alias library object. Name the library object `c_code` and define its path as:

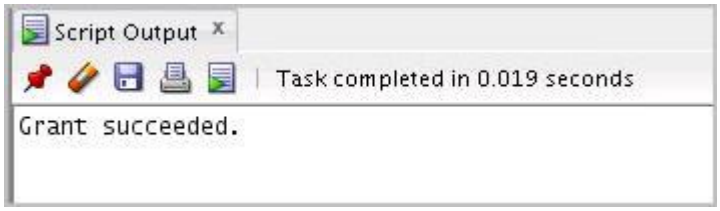
```
-- Use SYS connection
CREATE OR REPLACE LIBRARY c_code
AS '/u01/app/oracle/product/19.3.0/dbhome_1/bin/calc_tax.so';
/
```



Alternatively, you can run the solution for task 2 from `sol_07.sql`.

3. Grant the execute privilege on the library to the `OE` user by executing the following command:

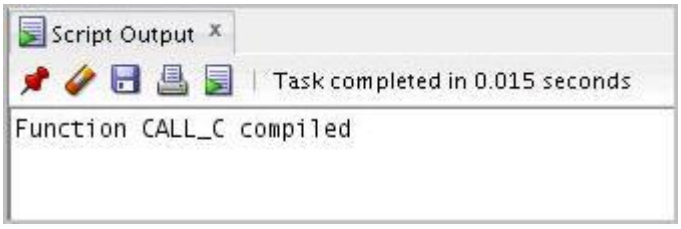
```
-- Use SYS connection
GRANT EXECUTE ON c_code TO OE;
```



Alternatively, you can run the solution for task 3 from `sol_07.sql`.

4. Publish the external C routine. As the `OE` user, create a function named `call_c`. This function has one numeric parameter and it returns a binary integer. Identify the `AS LANGUAGE`, `LIBRARY`, and `NAME` clauses of the function.

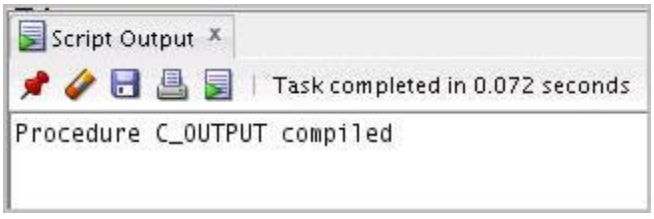
```
-- Use OE Connection
CREATE OR REPLACE FUNCTION call_c
(x BINARY_INTEGER)
RETURN BINARY_INTEGER
AS LANGUAGE C
LIBRARY sys.c_code
NAME "calc_tax";
/
```



Alternatively, you can run the solution for task 4 from `sol_07.sql`.

5. Create a procedure to call the `call_c` function created in the previous step. Name this procedure `C_OUTPUT`. It has one numeric parameter. Include a `DBMS_OUTPUT.PUT_LINE` statement so that you can view the results returned from your C function.

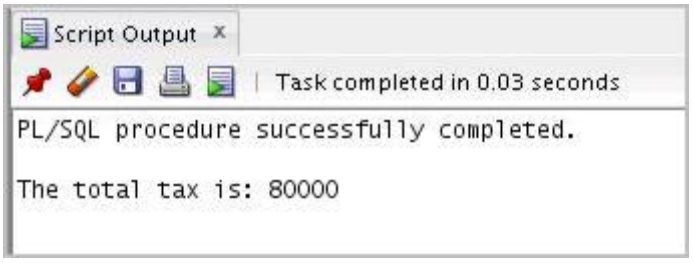
```
-- Use OE connection
CREATE OR REPLACE PROCEDURE c_output
  (p_in IN BINARY_INTEGER)
IS
  i BINARY_INTEGER;
BEGIN
  i := call_c(p_in);
  DBMS_OUTPUT.PUT_LINE('The total tax is: ' || i);
END c_output;
/
```



Alternatively, you can run the solution for task 5 from `sol_07.sql`.

6. Set `SERVEROUTPUT ON` and execute the `C_OUTPUT` procedure.

```
SET SERVEROUTPUT ON

EXECUTE c_output(1000000)
```



Alternatively, you can run the solution for task 6 from `sol_07.sql`.

Calling Java from PL/SQL

A Java method definition is created for you. The method accepts a 16-digit credit card number as the argument and returns the formatted credit card number (four digits followed by a space). The name of the `.class` file is `FormatCreditCardNo.class`. The method is defined as:

```
public class FormatCreditCardNo
{
public static final void formatCard(String[] cardno)
{
int count=0, space=0;
String oldcc=cardno[0];
String[] newcc= {""};
while (count<16)
{
newcc[0]+= oldcc.charAt(count);
space++;
if (space ==4)
{  newcc[0]+=" "; space=0;  }
count++;
}
cardno[0]=newcc [0];
}
}
```

7. Load the `.java` source file.

   You can execute the individual commands from the Linux terminal window.

   Alternatively, you can copy and paste the commands in the Linux terminal for task 7 from `sol_07.sql`. Please ensure you use the cloud_4U password instead of oe as in this example:

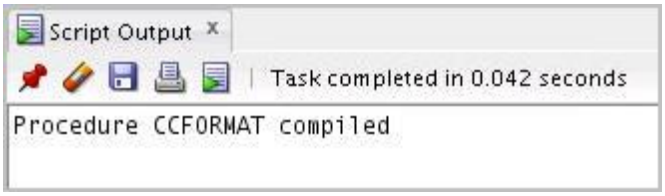
```
loadjava -user oe/cloud_4U@pdborcl FormatCreditCardNo.java
```

8. Publish the Java class method by defining a PL/SQL procedure named `CCFORMAT`. This procedure accepts one `IN OUT` parameter.
   Use the following definition for the `NAME` parameter:

   Use the `OE` connection.

```
NAME 'FormatCreditCardNo.formatCard(java.lang.String[])';
```

```
CREATE OR REPLACE PROCEDURE ccformat
(x IN OUT VARCHAR2)
AS LANGUAGE JAVA
NAME 'FormatCreditCardNo.formatCard(java.lang.String[])';
/
```



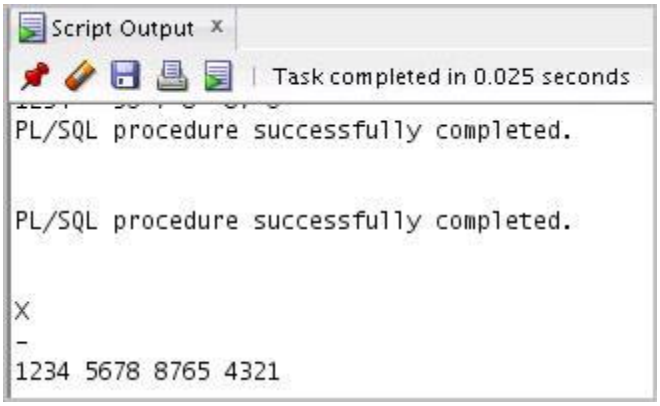
   Alternatively, you can run the solution for task 8 from `sol_07.sql`.

9. Execute the Java class method. Define one SQL*Plus or Oracle SQL Developer variable, initialize it, and use the `EXECUTE` command to execute the `CCFORMAT` procedure. Your output should match the `PRINT` output shown here:

   Use the `OE` connection.

```
EXECUTE ccformat(:x);

X
--------------------
1234 5678 8765 4321
```

```
VARIABLE x VARCHAR2(20)
EXECUTE :x := '1234567887654321'

EXECUTE ccformat(:x)

PRINT x
```



Alternatively, you can run the solution for task 9 from `sol_07.sql`.

Practices for Lesson 8: Performance and Tuning

Practices for Lesson 8: Overview

In this practice, you measure and examine performance and tuning, and tune some of the code that you created for the `OE` application.

- Break a previously built subroutine into smaller executable sections.
- Pass collections into subroutines.

Add error handling for `BULK INSERT`.

Practice 8-1: Performance and Tuning

Overview

In this practice, you will tune a PL/SQL code and include bulk binds to improve performance.

Task

Writing Better Code

1. Open the `lab_08.sql` file and examine the package given in task 1. The package body is shown here:

```
CREATE OR REPLACE PACKAGE credit_card_pkg
IS
  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no
VARCHAR2);

  PROCEDURE display_card_info
    (p_cust_id NUMBER);
END credit_card_pkg;  -- package spec
/

CREATE OR REPLACE PACKAGE BODY credit_card_pkg
IS

  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no VARCHAR2)
  IS
    v_card_info typ_cr_card_nst;
    i INTEGER;
  BEGIN
    SELECT credit_cards
      INTO v_card_info
      FROM customers
      WHERE customer_id = p_cust_id;

  IF v_card_info.EXISTS(1) THEN  -- cards exist, add more
      i := v_card_info.LAST;
      v_card_info.EXTEND(1);
      v_card_info(i+1) := typ_cr_card(p_card_type,
                                      p_card_no);
      UPDATE customers
        SET  credit_cards = v_card_info
        WHERE customer_id = p_cust_id;
```

```
    ELSE   -- no cards for this customer yet, construct one
      UPDATE customers
        SET  credit_cards = typ_cr_card_nst
            (typ_cr_card(p_card_type, p_card_no))
        WHERE customer_id = p_cust_id;
    END IF;
  END update_card_info;

PROCEDURE display_card_info
    (p_cust_id NUMBER)
  IS
    v_card_info typ_cr_card_nst;
    i INTEGER;
  BEGIN
    SELECT credit_cards
      INTO v_card_info
      FROM customers
      WHERE customer_id = p_cust_id;
    IF v_card_info.EXISTS(1) THEN
      FOR idx IN v_card_info.FIRST..v_card_info.LAST LOOP
          DBMS_OUTPUT.PUT('Card Type: ' ||
            v_card_info(idx).card_type || ' ');
        DBMS_OUTPUT.PUT_LINE('/ Card No: ' ||
            v_card_info(idx).card_num );
      END LOOP;
    ELSE
      DBMS_OUTPUT.PUT_LINE('Customer has no credit cards.');
    END IF;
  END display_card_info;
END credit_card_pkg;  -- package body
/
```

This code needs to be improved. The following issues exist in the code:

- The local variables use the `INTEGER` data type.
- The same `SELECT` statement is run in the two procedures.
- The same `IF v_card_info.EXISTS(1) THEN` statement is in the two procedures.

Using Efficient Data Types

2. To improve the code, make the following modifications:
   a. Change the local `INTEGER` variables to use a more efficient data type.
   b. Move the duplicated code into a function. The package specification for the modification is:

```
CREATE OR REPLACE PACKAGE credit_card_pkg
IS
  FUNCTION cust_card_info
    (p_cust_id NUMBER, p_card_info IN OUT typ_cr_card_nst )
    RETURN BOOLEAN;
  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no
VARCHAR2);
   PROCEDURE display_card_info
    (p_cust_id NUMBER);
END credit_card_pkg;  -- package spec
/
```

   c. Have the function return `TRUE` if the customer has credit cards. The function should return `FALSE` if the customer does not have credit cards. Pass an uninitialized nested table into the function. The function places the credit card information into this uninitialized parameter.
3. Test your modified code with the following data:

```
EXECUTE credit_card_pkg.update_card_info
        (120, 'AM EX', 55555555555)

EXECUTE credit_card_pkg.display_card_info(120)
```

4. You must modify the `UPDATE_CARD_INFO` procedure to return information (by using the `RETURNING` clause) about the credit cards being updated. Assume that this information will be used by another application developer in your team, who is writing a graphical reporting utility on customer credit cards.
   a. Open the `lab_08.sql` file. It contains the code as modified in step 2.
   b. Modify the code to use the `RETURNING` clause to find information about the rows that are affected by the `UPDATE` statements.
   c. You can test your modified code with the following procedure (contained in task 4_c of `lab_08.sql`):

```
CREATE OR REPLACE PROCEDURE test_credit_update_info
(p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no NUMBER)
IS
  v_card_info typ_cr_card_nst;
BEGIN
  credit_card_pkg.update_card_info
    (p_cust_id, p_card_type, p_card_no, v_card_info);
```

```
END test_credit_update_info;
/
```

d. Test your code with the following statements that are set in bold:

```
EXECUTE test_credit_update_info(125, 'AM EX', 123456789)

SELECT credit_cards FROM customers WHERE customer_id = 125;
```

Collecting Exception Information

5. Now you test exception handling with the `SAVE EXCEPTIONS` clause.

a. Run the statement from task 5_a of the `lab_08.sql` file to create a test table:

```
CREATE TABLE card_table
(accepted_cards VARCHAR2(50) NOT NULL);
```

b. Open the `lab_08.sql` file and run task 5_b:

```
DECLARE
  type typ_cards is table of VARCHAR2(50);
  v_cards typ_cards := typ_cards
  ( 'Citigroup Visa', 'Nationscard MasterCard',
    'Federal American Express', 'Citizens Visa',
    'International Discoverer', 'United Diners Club' );
BEGIN
  v_cards.Delete(3);
  v_cards.DELETE(6);
  FORALL j IN v_cards.first..v_cards.last
    SAVE EXCEPTIONS
    EXECUTE IMMEDIATE
   'insert into card_table (accepted_cards) values ( :the_card)'
    USING v_cards(j);
END;
/
```

c. Note the output:_____

d. Open the `lab_08.sql` file and run task 5_d:

```
    DECLARE
  type typ_cards is table of VARCHAR2(50);
  v_cards typ_cards := typ_cards
  ( 'Citigroup Visa', 'Nationscard MasterCard',
    'Federal American Express', 'Citizens Visa',
    'International Discoverer', 'United Diners Club' );
  bulk_errors EXCEPTION;
  PRAGMA exception_init (bulk_errors, -24381 );
BEGIN
```

```
  v_cards.Delete(3);
  v_cards.DELETE(6);
  FORALL j IN v_cards.first..v_cards.last
    SAVE EXCEPTIONS
    EXECUTE IMMEDIATE
   'insert into card_table (accepted_cards) values ( :the_card)'
    USING v_cards(j);
 EXCEPTION
  WHEN  bulk_errors THEN
    FOR j IN 1..sql%bulk_exceptions.count
  LOOP
    Dbms_Output.Put_Line (
      TO_CHAR( sql%bulk_exceptions(j).error_index ) || ':
      ' || SQLERRM(-sql%bulk_exceptions(j).error_code) );
  END LOOP;
END;
/
```

e. Note the output:_____

f. Why is the output different?

Timing Performance of `SIMPLE_INTEGER` and `PLS_INTEGER`

6. Now you compare the performance between the `PLS_INTEGER` and `SIMPLE_INTEGER` data types with native compilation:

   a. Run task 6_a from the `lab_08.sql` file to create a testing procedure that contains conditional compilation:

```
CREATE OR REPLACE PROCEDURE p
IS
  t0       NUMBER :=0;
  t1       NUMBER :=0;

 $IF $$Simple $THEN
  SUBTYPE My_Integer_t IS                    SIMPLE_INTEGER;
  My_Integer_t_Name CONSTANT VARCHAR2(30) := 'SIMPLE_INTEGER';
 $ELSE
  SUBTYPE My_Integer_t IS                    PLS_INTEGER;
  My_Integer_t_Name CONSTANT VARCHAR2(30) := 'PLS_INTEGER';
 $END

 v00  My_Integer_t := 0;     v01  My_Integer_t := 0;
 v02  My_Integer_t := 0;     v03  My_Integer_t := 0;
 v04  My_Integer_t := 0;     v05  My_Integer_t := 0;
```

```
 two      CONSTANT My_Integer_t := 2;
 lmt      CONSTANT My_Integer_t := 100000000;

BEGIN
  t0 := DBMS_UTILITY.GET_CPU_TIME();
  WHILE v01 < lmt LOOP
    v00 := v00 + Two;
    v01 := v01 + Two;
    v02 := v02 + Two;
    v03 := v03 + Two;
    v04 := v04 + Two;
    v05 := v05 + Two;
  END LOOP;

  IF v01 <> lmt OR v01 IS NULL THEN
    RAISE Program_Error;
  END IF;

  t1 := DBMS_UTILITY.GET_CPU_TIME();
  DBMS_OUTPUT.PUT_LINE(
    RPAD(LOWER($$PLSQL_Code_Type), 15)||
    RPAD(LOWER(My_Integer_t_Name), 15)||
    TO_CHAR((t1-t0), '9999')||' centiseconds');
END p;
```

b. Open the `lab_08.sql` file and run task 6_b:

```
ALTER PROCEDURE p COMPILE
PLSQL_Code_Type = NATIVE PLSQL_CCFlags = 'simple:true'
REUSE SETTINGS;

EXECUTE p()

ALTER PROCEDURE p COMPILE
PLSQL_Code_Type = native PLSQL_CCFlags = 'simple:false'
REUSE SETTINGS;

EXECUTE p()
```

c. Note the output:_____

d. Explain the output.

Solution 8-1: Performance and Tuning

In this practice, you will tune a PL/SQL code and include bulk binds to improve performance.

Writing Better Code

1. Open the `lab_08.sql` file and examine the package (the package body is as follows) in task 1:

```
CREATE OR REPLACE PACKAGE credit_card_pkg
IS
  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no
VARCHAR2);

  PROCEDURE display_card_info
    (p_cust_id NUMBER);
END credit_card_pkg;  -- package spec
/
CREATE OR REPLACE PACKAGE BODY credit_card_pkg
IS


  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2,
     p_card_no VARCHAR2)
  IS
    v_card_info typ_cr_card_nst;
    i INTEGER;
  BEGIN
    SELECT credit_cards
      INTO v_card_info
      FROM customers
      WHERE customer_id = p_cust_id;
   IF v_card_info.EXISTS(1) THEN  -- cards exist, add more
      i := v_card_info.LAST;
      v_card_info.EXTEND(1);
      v_card_info(i+1) := typ_cr_card(p_card_type,
                                      p_card_no);
      UPDATE customers
        SET  credit_cards = v_card_info
        WHERE customer_id = p_cust_id;
    ELSE   -- no cards for this customer yet, construct one
      UPDATE customers
        SET  credit_cards = typ_cr_card_nst
            (typ_cr_card(p_card_type, p_card_no))
        WHERE customer_id = p_cust_id;
    END IF;
```

```
  END update_card_info;
  -- continued on next page.


PROCEDURE display_card_info
    (p_cust_id NUMBER)
  IS
    v_card_info typ_cr_card_nst;
    i INTEGER;
  BEGIN
    SELECT credit_cards
      INTO v_card_info
      FROM customers
      WHERE customer_id = p_cust_id;
    IF v_card_info.EXISTS(1) THEN
      FOR idx IN v_card_info.FIRST..v_card_info.LAST LOOP
          DBMS_OUTPUT.PUT('Card Type: ' ||
            v_card_info(idx).card_type || ' ');
        DBMS_OUTPUT.PUT_LINE('/ Card No: ' ||
            v_card_info(idx).card_num );
      END LOOP;
    ELSE
      DBMS_OUTPUT.PUT_LINE('Customer has no credit
        cards.');
    END IF;
  END display_card_info;
END credit_card_pkg;  -- package body
/
```

This code needs to be improved. The following issues exist in the code:

- The local variables use the `INTEGER` data type.
- The same `SELECT` statement is run in the two procedures.
- The same `IF v_card_info.EXISTS(1) THEN` statement is in the two procedures.

Using Efficient Data Types

2. To improve the code, make the following modifications:
   a. Change the local `INTEGER` variables to use a more efficient data type.
   b. Move the duplicated code into a function. The package specification for the modification is:

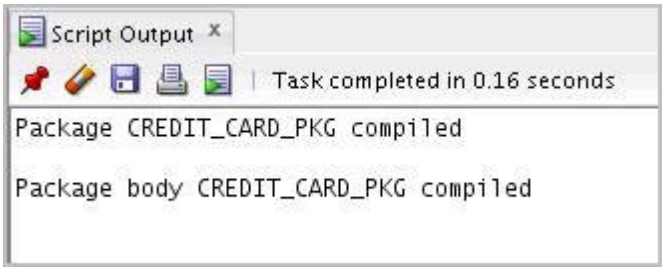
```
CREATE OR REPLACE PACKAGE credit_card_pkg
IS

  FUNCTION cust_card_info
    (p_cust_id NUMBER, p_card_info IN OUT typ_cr_card_nst )
    RETURN BOOLEAN;
  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2,
     p_card_no VARCHAR2);
   PROCEDURE display_card_info
    (p_cust_id NUMBER);

END credit_card_pkg;  -- package spec
/
```

   c. Have the function return `TRUE` if the customer has credit cards. The function should return `FALSE` if the customer does not have credit cards. Pass an uninitialized nested table into the function. The function places the credit card information into this uninitialized parameter.

```
-- note: If you did not complete lesson 4 practice, you will
need
-- to run solution scripts for tasks 1_a, 1_b, 1_c from
sol_04.sql
-- in order to have the supporting structures in place.

CREATE OR REPLACE PACKAGE credit_card_pkg
IS
  FUNCTION cust_card_info
    (p_cust_id NUMBER, p_card_info IN OUT typ_cr_card_nst )
    RETURN BOOLEAN;
  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2,
     p_card_no VARCHAR2);
  PROCEDURE display_card_info
    (p_cust_id NUMBER);
END credit_card_pkg;  -- package spec
/

CREATE OR REPLACE PACKAGE BODY credit_card_pkg
```

```
IS

  FUNCTION cust_card_info
    (p_cust_id NUMBER, p_card_info IN OUT typ_cr_card_nst )
    RETURN BOOLEAN
  IS
    v_card_info_exists BOOLEAN;
  BEGIN
    SELECT credit_cards
      INTO p_card_info
      FROM customers
      WHERE customer_id = p_cust_id;
    IF p_card_info.EXISTS(1) THEN
      v_card_info_exists := TRUE;
    ELSE
      v_card_info_exists := FALSE;
    END IF;
    RETURN v_card_info_exists;
  END cust_card_info;

  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2,
     p_card_no VARCHAR2)
  IS
    v_card_info typ_cr_card_nst;
    i PLS_INTEGER;
  BEGIN
    IF cust_card_info(p_cust_id, v_card_info) THEN
-- cards exist, add more
      i := v_card_info.LAST;
      v_card_info.EXTEND(1);
      v_card_info(i+1) := typ_cr_card(p_card_type, p_card_no);
      UPDATE customers
        SET  credit_cards = v_card_info
        WHERE customer_id = p_cust_id;
    ELSE   -- no cards for this customer yet, construct one
      UPDATE customers
        SET  credit_cards = typ_cr_card_nst
            (typ_cr_card(p_card_type, p_card_no))
        WHERE customer_id = p_cust_id;
    END IF;
  END update_card_info;
```

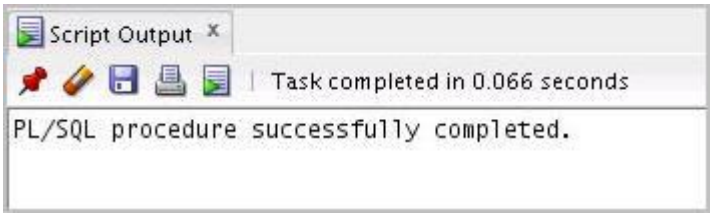
```
  PROCEDURE display_card_info
    (p_cust_id NUMBER)
  IS
    v_card_info typ_cr_card_nst;
    i PLS_INTEGER;
  BEGIN
    IF cust_card_info(p_cust_id, v_card_info) THEN
      FOR idx IN v_card_info.FIRST..v_card_info.LAST LOOP
          DBMS_OUTPUT.PUT('Card Type: ' ||
            v_card_info(idx).card_type || ' ');
        DBMS_OUTPUT.PUT_LINE('/ Card No: ' ||
             v_card_info(idx).card_num );
      END LOOP;
    ELSE
      DBMS_OUTPUT.PUT_LINE('Customer has no credit cards.');
    END IF;
  END display_card_info;
END credit_card_pkg;  -- package body
/
```



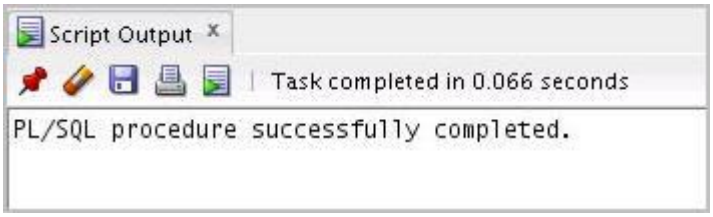
Alternatively, run the code from task 2_c of `sol_08.sql`.

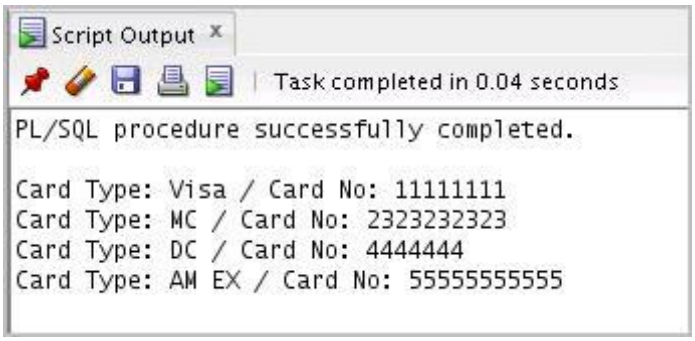
3. Test your modified code with the following data:

```
EXECUTE credit_card_pkg.update_card_info
        (120, 'AM EX', 55555555555)
```



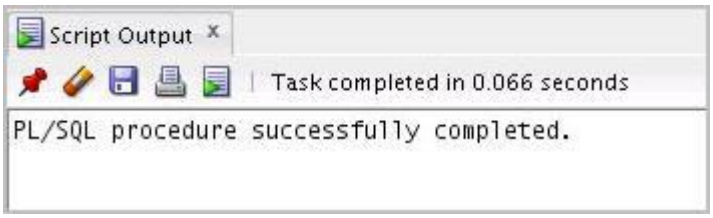

```
EXECUTE credit_card_pkg.display_card_info(120)
```

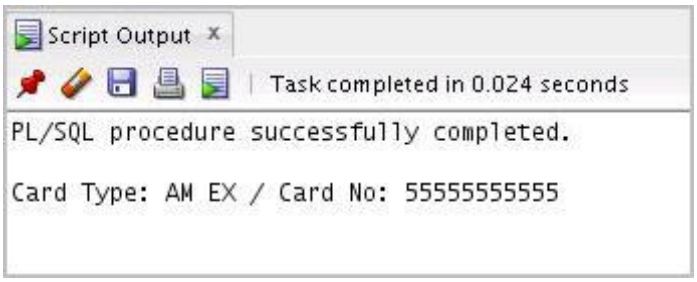




Note: If you did not complete Practice 4, your results will be:

```
EXECUTE credit_card_pkg.display_card_info(120)
```



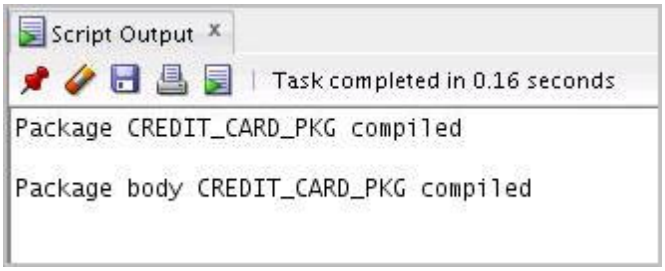


4. You must modify the `UPDATE_CARD_INFO` procedure to return information (by using the `RETURNING` clause) about the credit cards being updated. Assume that this information will be used by another application developer on your team, who is writing a graphical reporting utility on customer credit cards.
   a. Open the `lab_08.sql` file. It contains the code in task 4_a as modified in step 2.
   b. Modify the code to use the `RETURNING` clause to find information about the rows that are affected by the `UPDATE` statements.

```
CREATE OR REPLACE PACKAGE credit_card_pkg
IS
  FUNCTION cust_card_info
    (p_cust_id NUMBER, p_card_info IN OUT typ_cr_card_nst )
    RETURN BOOLEAN;
  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2,
```

```
     p_card_no VARCHAR2, o_card_info OUT typ_cr_card_nst);
  PROCEDURE display_card_info
    (p_cust_id NUMBER);
END credit_card_pkg;  -- package spec
/

CREATE OR REPLACE PACKAGE BODY credit_card_pkg
IS
  FUNCTION cust_card_info
    (p_cust_id NUMBER, p_card_info IN OUT typ_cr_card_nst )
    RETURN BOOLEAN
  IS
    v_card_info_exists BOOLEAN;
  BEGIN
    SELECT credit_cards
      INTO p_card_info
      FROM customers
      WHERE customer_id = p_cust_id;
    IF p_card_info.EXISTS(1) THEN
      v_card_info_exists := TRUE;
    ELSE
      v_card_info_exists := FALSE;
    END IF;
    RETURN v_card_info_exists;
  END cust_card_info;

  PROCEDURE update_card_info
    (p_cust_id NUMBER, p_card_type VARCHAR2,
     p_card_no VARCHAR2, o_card_info OUT typ_cr_card_nst)
  IS
    v_card_info typ_cr_card_nst;
    i PLS_INTEGER;
  BEGIN

    IF cust_card_info(p_cust_id, v_card_info) THEN
  -- cards exist, add more
      i := v_card_info.LAST;
      v_card_info.EXTEND(1);
      v_card_info(i+1) := typ_cr_card(p_card_type, p_card_no);
      UPDATE customers
        SET  credit_cards = v_card_info
        WHERE customer_id = p_cust_id
```

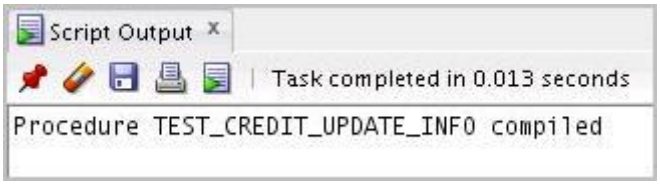
```
        RETURNING credit_cards INTO o_card_info;
    ELSE   -- no cards for this customer yet, construct one
      UPDATE customers
        SET  credit_cards = typ_cr_card_nst
            (typ_cr_card(p_card_type, p_card_no))
        WHERE customer_id = p_cust_id
        RETURNING credit_cards INTO o_card_info;
    END IF;
  END update_card_info;

  PROCEDURE display_card_info
    (p_cust_id NUMBER)
  IS
    v_card_info typ_cr_card_nst;
    i PLS_INTEGER;
  BEGIN
    IF cust_card_info(p_cust_id, v_card_info) THEN
      FOR idx IN v_card_info.FIRST..v_card_info.LAST LOOP
          DBMS_OUTPUT.PUT('Card Type: ' ||
            v_card_info(idx).card_type || ' ');
        DBMS_OUTPUT.PUT_LINE('/ Card No: ' ||
            v_card_info(idx).card_num );
      END LOOP;
    ELSE
      DBMS_OUTPUT.PUT_LINE('Customer has no credit cards.');
    END IF;
  END display_card_info;
END credit_card_pkg;  -- package body
/
```



Alternatively, run the code from task 4_b of `sol_08.sql`.

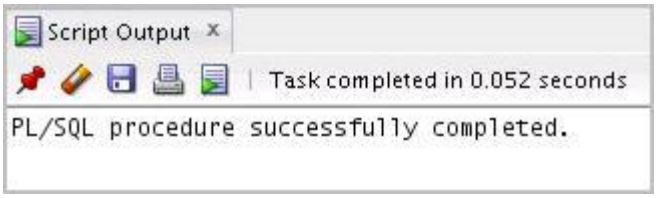
c. You can test your modified code with the following procedure (contained in task 4_c of `lab_08.sql`):

```
CREATE OR REPLACE PROCEDURE test_credit_update_info
(p_cust_id NUMBER, p_card_type VARCHAR2, p_card_no NUMBER)
IS
  v_card_info typ_cr_card_nst;
BEGIN
  credit_card_pkg.update_card_info
    (p_cust_id, p_card_type, p_card_no, v_card_info);
END test_credit_update_info;
/
```

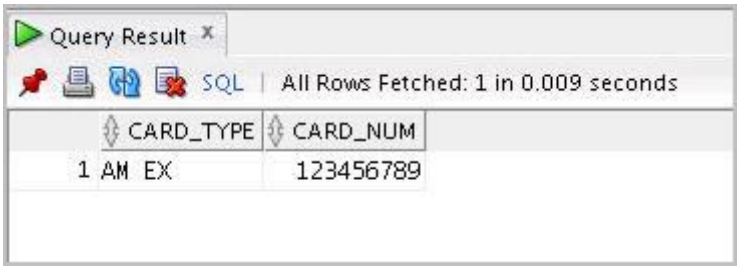


d. Test your code with the following statements that are set in bold:

```
EXECUTE test_credit_update_info(125, 'AM EX', 123456789)
```




```
SELECT * FROM TABLE(SELECT credit_cards FROM customers WHERE
customer_id = 125);
```

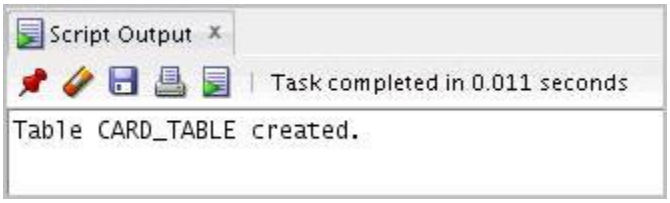


Collecting Exception Information

5. Now you test exception handling with the `SAVE EXCEPTIONS` clause.

   a. Run task 5_a of the `lab_08.sql` file to create a test table:

```
CREATE TABLE card_table
(accepted_cards VARCHAR2(50) NOT NULL);
```



   b. Open the `lab_08.sql` file and run task 5_b:

```
DECLARE
  type typ_cards is table of VARCHAR2(50);
  v_cards typ_cards := typ_cards
  ( 'Citigroup Visa', 'Nationscard MasterCard',
    'Federal American Express', 'Citizens Visa',
    'International Discoverer', 'United Diners Club' );
BEGIN
  v_cards.Delete(3);
  v_cards.DELETE(6);
  FORALL j IN v_cards.first..v_cards.last
    SAVE EXCEPTIONS
    EXECUTE IMMEDIATE
   'insert into card_table (accepted_cards) values
   ( :the_card)'
    USING v_cards(j);
/
END;
/
```

   c. Note the output:

```
Error report -
ORA-24381: error(s) in array DML
ORA-06512: at line 10
24381. 00000 -  "error(s) in array DML"
*Cause:    One or more rows failed in the DML.
*Action:   Refer to the error stack in the error handle.
```

This returns an "Error in Array DML (at line 10)," which is not very informative. The cause of this error: One or more rows failed in the DML.

d. Open the `lab_08.sql` file and run task 5_d:

```
DECLARE
  type typ_cards is table of VARCHAR2(50);
  v_cards typ_cards := typ_cards
  ( 'Citigroup Visa', 'Nationscard MasterCard',
    'Federal American Express', 'Citizens Visa',
    'International Discoverer', 'United Diners Club' );
  bulk_errors EXCEPTION;
  PRAGMA exception_init (bulk_errors, -24381 );
BEGIN
  v_cards.Delete(3);
  v_cards.DELETE(6);
  FORALL j IN v_cards.first..v_cards.last
    SAVE EXCEPTIONS
    EXECUTE IMMEDIATE
   'insert into card_table (accepted_cards) values (
    :the_card)'
    USING v_cards(j);
 EXCEPTION
  WHEN  bulk_errors THEN
    FOR j IN 1..sql%bulk_exceptions.count
  LOOP
    Dbms_Output.Put_Line (
      TO_CHAR( sql%bulk_exceptions(j).error_index ) || ':
      ' || SQLERRM(-sql%bulk_exceptions(j).error_code) );
  END LOOP;
END;
/
```

e. Note the output:

```
3:
      ORA-22160: element at index [] does not exist
```

f. Why is the output different?

The PL/SQL block raises the exception 22160 when it encounters an array element that was deleted. The exception is handled and the block is completed successfully.

Timing Performance of `SIMPLE_INTEGER` and `PLS_INTEGER`

6. Now you compare the performance between the `PLS_INTEGER` and `SIMPLE_INTEGER` data types with native compilation:
   a. Run task 6_a of `lab_08.sql` to create a testing procedure that contains conditional compilation:

```
CREATE OR REPLACE PROCEDURE p
IS
  t0       NUMBER :=0;
  t1       NUMBER :=0;

 $IF $$Simple $THEN
  SUBTYPE My_Integer_t IS                    SIMPLE_INTEGER;
  My_Integer_t_Name CONSTANT VARCHAR2(30) := 'SIMPLE_INTEGER';
 $ELSE
  SUBTYPE My_Integer_t IS                    PLS_INTEGER;
  My_Integer_t_Name CONSTANT VARCHAR2(30) := 'PLS_INTEGER';
 $END

 v00  My_Integer_t := 0;     v01  My_Integer_t := 0;
 v02  My_Integer_t := 0;     v03  My_Integer_t := 0;
 v04  My_Integer_t := 0;     v05  My_Integer_t := 0;

 two      CONSTANT My_Integer_t := 2;
 lmt      CONSTANT My_Integer_t := 100000000;

BEGIN
  t0 := DBMS_UTILITY.GET_CPU_TIME();
  WHILE v01 < lmt LOOP
    v00 := v00 + Two;
    v01 := v01 + Two;
    v02 := v02 + Two;
    v03 := v03 + Two;
    v04 := v04 + Two;
    v05 := v05 + Two;
  END LOOP;

  IF v01 <> lmt OR v01 IS NULL THEN
    RAISE Program_Error;
  END IF;

  t1 := DBMS_UTILITY.GET_CPU_TIME();
  DBMS_OUTPUT.PUT_LINE(
```

```
    RPAD(LOWER($$PLSQL_Code_Type), 15)||
    RPAD(LOWER(My_Integer_t_Name), 15)||
    TO_CHAR((t1-t0), '9999')||' centiseconds');
END p;
/
```

b. Open the `lab_08.sql` file and run task 6_b:

```
ALTER PROCEDURE p COMPILE
PLSQL_Code_Type = NATIVE PLSQL_CCFlags = 'simple:true'
REUSE SETTINGS;

EXECUTE p()

ALTER PROCEDURE p COMPILE
PLSQL_Code_Type = native PLSQL_CCFlags = 'simple:false'
REUSE SETTINGS;

EXECUTE p()
```

c. Note the output:

First run:

```
Procedure P altered.

PL/SQL procedure successfully completed.

native         simple_integer    12 centiseconds
```

Second run:

```
Procedure P altered.

PL/SQL procedure successfully completed.

native         pls_integer      141 centiseconds
```

d. Explain the output.

`SIMPLE_INTEGER` runs much faster in this scenario. If you can use the `SIMPLE_INTEGER` data type, it can improve performance.

Practices for Lesson 9: Improving Performance with Caching

Practices for Lesson 9: Overview

In this practice, you implement SQL query result caching and PL/SQL result function caching. You run scripts to measure the cache memory values, manipulate queries and functions to turn caching on and off, and then examine cache statistics.

Practice 9-1: Improving Performance with Caching

Overview

In this practice, you examine the Explain Plan for a query, add the `RESULT_CACHE` hint to the query, and reexamine the Explain Plan results. You also execute some code and modify the code so that PL/SQL result caching is turned on.

Use the `OE` connection to complete this practice.

Task

Examining SQL and PL/SQL Result Caching

1. Use SQL Developer to connect to the `OE` schema. Examine the Explain Plan for the following query, which is found in the `lab_09.sql` file. To view the Explain Plan, click the Execute Explain Plan button on the toolbar in the Code Editor window.

```
SELECT count(*),
       round(avg(quantity_on_hand)) AVG_AMT,
       product_id, product_name
FROM inventories natural join product_information
GROUP BY product_id, product_name;
```

2. Add the `RESULT_CACHE` hint to the query and reexamine the Explain Plan results.

```
SELECT /*+ result_cache */
       count(*),
       round(avg(quantity_on_hand)) AVG_AMT,
       product_id, product_name
FROM inventories natural join product_information
GROUP BY product_id, product_name;
```

   Examine the Explain Plan results, compared to the previous results.

3. The following code is used to generate a list of warehouse names for pick lists in applications. The `WAREHOUSES` table is fairly stable and is not modified often.

   Click the Run Script button to compile this code: (You can use the `lab_09.sql` file.)

```
CREATE OR REPLACE TYPE list_typ IS TABLE OF VARCHAR2(35);
/
```

```
CREATE OR REPLACE FUNCTION get_warehouse_names
RETURN list_typ
IS
  v_wh_names list_typ;
BEGIN
  SELECT warehouse_name
  BULK COLLECT INTO v_wh_names
  FROM   warehouses;
  RETURN v_wh_names;
  END get_warehouse_names;
```

4. Because the function is called frequently, and because the content of the data returned does not change frequently, this code is a good candidate for PL/SQL result caching.

   Modify the code so that PL/SQL result caching is turned on. Click the Run Script button to compile this code again.

Solution 9-1: Improving Performance with Caching

In this practice, you examine the Explain Plan for a query, add the `RESULT_CACHE` hint to the query, and reexamine the Explain Plan results. You also execute some code and modify the code so that PL/SQL result caching is turned on.

Use the `OE` connection.

Examining SQL and PL/SQL Result Caching

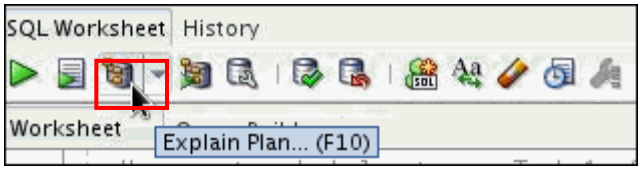
1. Use SQL Developer to connect to the `OE` schema. Examine the Explain Plan for the following query, which is found in the `lab_09.sql` file. To view the Explain Plan, click the Execute Explain Plan button on the toolbar in the Code Editor window.

   In Oracle SQL Developer, open the `lab_09.sql` file:

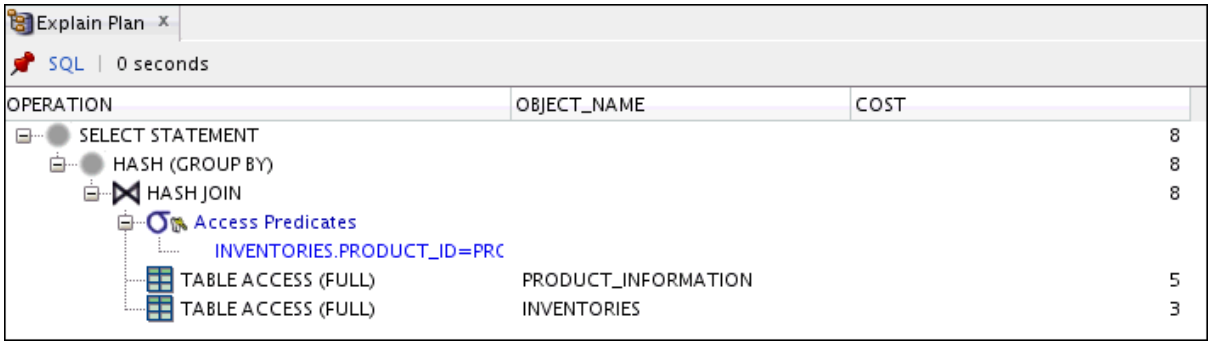
   ```
   SELECT count(*),
          round(avg(quantity_on_hand)) AVG_AMT,
          product_id, product_name
   FROM inventories natural join product_information
   GROUP BY product_id, product_name;
   ```

   Select the `OE` connection.

   Click the Execute Explain Plan button on the toolbar and observe the results in the lower region:

   Results: SQL caching is not enabled and not visible in the Explain Plan.

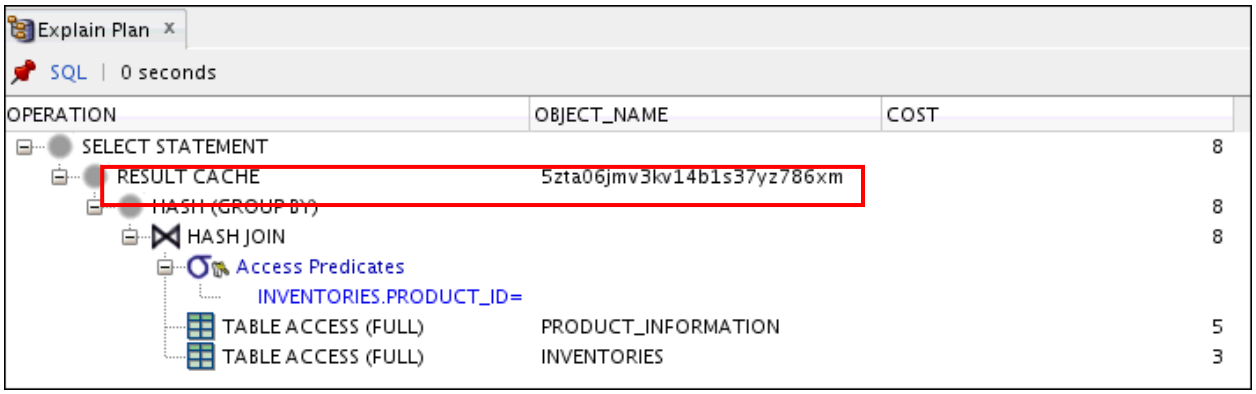
   

2. Add the `RESULT_CACHE` hint to the query and reexamine the Explain Plan results.

   ```
   SELECT /*+ result_cache */
          count(*),
          round(avg(quantity_on_hand)) AVG_AMT,
          product_id, product_name
   FROM inventories natural join product_information
   GROUP BY product_id, product_name;
   ```

   Examine the Explain Plan results, compared to the previous Results.

Click the Execute Explain Plan button on the toolbar again, and compare the results in the lower region with the previous results:

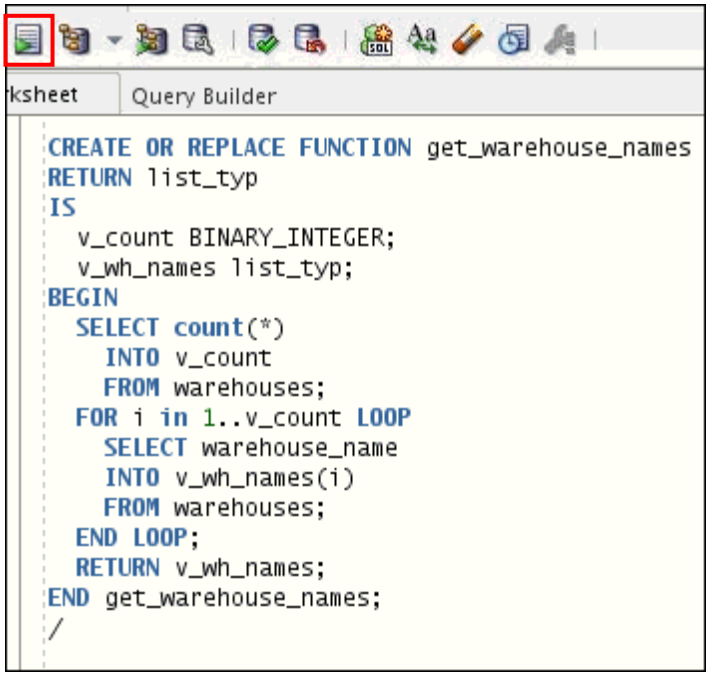


Results: Note that result caching is used in the Explain Plan.

3. The following code is used to generate a list of warehouse names for pick lists in applications. The `WAREHOUSES` table is fairly stable and is not modified often.

   Click the Run Script button to compile this code: (You can use the `lab_09.sql` file.)

```
CREATE OR REPLACE TYPE list_typ IS TABLE OF VARCHAR2(35);
/

CREATE OR REPLACE FUNCTION get_warehouse_names
RETURN list_typ
IS
  v_count BINARY_INTEGER;
  v_wh_names list_typ;
BEGIN
  SELECT count(*)
    INTO v_count
    FROM warehouses;
  FOR i in 1..v_count LOOP
    SELECT warehouse_name
    INTO v_wh_names(i)
    FROM warehouses;
  END LOOP;
  RETURN v_wh_names;
END get_warehouse_names;
```



Open `lab_09.sql`. Click the Run Script button. You have compiled the function without PL/SQL result caching.

4. Because the function is called frequently, and because the content of the data returned does not frequently change, this code is a good candidate for PL/SQL result caching.

   Modify the code so that PL/SQL result caching is turned on. Click the Run Script button to compile this code again.

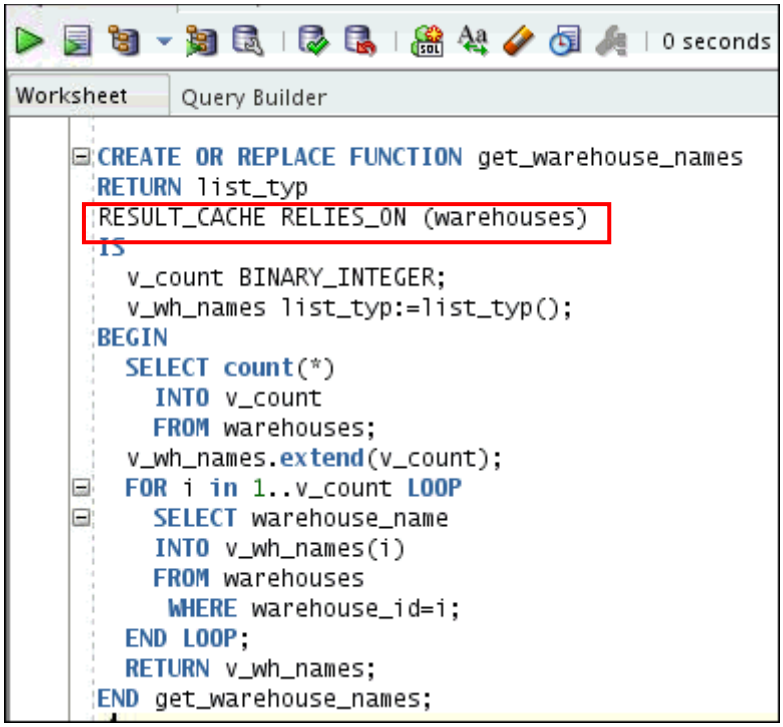
   Insert the following line after RETURN list_typ:

   `RESULT_CACHE RELIES_ON (warehouses)`

```
CREATE OR REPLACE FUNCTION get_warehouse_names
RETURN list_typ
RESULT_CACHE RELIES_ON (warehouses)
IS
  v_count BINARY_INTEGER;
  v_wh_names list_typ:=list_typ();
BEGIN
  SELECT count(*)
    INTO v_count
    FROM warehouses;
  v_wh_names.extend(v_count);
  FOR i in 1..v_count LOOP
    SELECT warehouse_name
    INTO v_wh_names(i)
```

```
    FROM warehouses
    WHERE warehouse_id=i;
  END LOOP;
  RETURN v_wh_names;
END get_warehouse_names;
```

Click the Run Script button to recompile the code.




```
SELECT * FROM TABLE(get_warehouse_names)
/
```

	COLUMN_VALUE
1	Southlake, Texas
2	San Francisco
3	New Jersey
4	Seattle, Washington
5	Toronto
6	Sydney
7	Mexico City
8	Beijing
9	Bombay

Alternatively, you can execute the solution for task 4 from sol_09.sql.

Practices for Lesson 10: Analyzing PL/SQL Code

Practices for Lesson 10: Overview

In this practice, you will perform the following:

- Find coding information
- Use PL/Scope

Practice 10-1: Analyzing PL/SQL Code

Overview

In this practice, you use PL/SQL and Oracle SQL Developer to analyze your code.

Use your OE connection.

Task

Finding Coding Information

1. Create the QUERY_CODE_PKG package to search your source code.

   Use the OE connection.

   a. Run task 1_a of the lab_10.sql script to create the QUERY_CODE_PKG package.
   b. Run the ENCAP_COMPLIANCE procedure to see which of your programs reference tables or views. (**Note:** Your results might differ slightly.)
   c. Run the FIND_TEXT_IN_CODE procedure to find all references to 'ORDERS'. (**Note:** Your results might differ slightly.)
   d. Use the SQL Developer Reports feature to find the same results for step C shown above.

Using PL/Scope

2. In the following steps, you use PL/Scope.

   Use the OE connection.

   a. Enable your session to collect identifiers.
   b. Recompile your CREDIT_CARD_PKG code.
   c. Verify that your PLSCOPE_SETTING is set correctly by issuing the following statement:

```
SELECT PLSCOPE_SETTINGS
FROM USER_PLSQL_OBJECT_SETTINGS
WHERE NAME='CREDIT_CARD_PKG' AND TYPE='PACKAGE BODY';
```

   d. Execute the following statement to create a hierarchical report on the identifier information about the CREDIT_CARD_PKG code. You can run task 2_d of the lab_10.sql script file.

```
WITH v AS
 (SELECT    Line,
            Col,
            INITCAP(NAME) Name,
            LOWER(TYPE)   Type,
            LOWER(USAGE)  Usage,
            USAGE_ID, USAGE_CONTEXT_ID
  FROM USER_IDENTIFIERS
  WHERE Object_Name = 'CREDIT_CARD_PKG'
    AND Object_Type = 'PACKAGE BODY'  )
    SELECT RPAD(LPAD(' ', 2*(Level-1)) ||
```

```
                Name, 20, '.')||' '||
                RPAD(Type, 20)|| RPAD(Usage, 20)
                IDENTIFIER_USAGE_CONTEXTS
    FROM v
    START WITH USAGE_CONTEXT_ID = 0
    CONNECT BY PRIOR USAGE_ID = USAGE_CONTEXT_ID
    ORDER SIBLINGS BY Line, Col;
```

3. Use `DBMS_METADATA` to find the metadata for the `ORDER_ITEMS` table.

   Use the `OE` connection.

   a. Create the `GET_TABLE_MD` function. You can run task 3_a of the `lab_10.sql` script.

```
CREATE FUNCTION get_table_md RETURN CLOB IS
 v_hdl  NUMBER; -- returned by 'OPEN'
 v_th   NUMBER; -- returned by 'ADD_TRANSFORM'
 v_doc  CLOB;
BEGIN
 -- specify the OBJECT TYPE
 v_hdl := DBMS_METADATA.OPEN('TABLE');
 -- use FILTERS to specify the objects desired
 DBMS_METADATA.SET_FILTER(v_hdl ,'SCHEMA','OE');
 DBMS_METADATA.SET_FILTER
                      (v_hdl ,'NAME','ORDER_ITEMS');
 -- request to be TRANSFORMED into creation DDL
 v_th := DBMS_METADATA.ADD_TRANSFORM(v_hdl,'DDL');
 -- FETCH the object
 v_doc := DBMS_METADATA.FETCH_CLOB(v_hdl);
 -- release resources
 DBMS_METADATA.CLOSE(v_hdl);
 RETURN v_doc;
END;
/
```

   b. Issue the following statements to view the metadata generated from the `GET_TABLE_MD` function:

      You can run task 3_b of the `lab_10.sql` script.

```
set pagesize 0
set long  1000000
SELECT get_table_md FROM dual;
```

   c. Generate an XML representation of the `ORDER_ITEMS` table by using the `DBMS_METADATA.GET_XML` function. Spool the output to a file named `ORDER_ITEMS_XML.txt` in the `/home/oracle/labs` folder.

d. Verify that the `ORDER_ITEMS_XML.txt` file was created in the `/home/oracle/labs` folder.

Solution 10-1: Analyzing PL/SQL Code

In this practice, you use PL/SQL and Oracle SQL Developer to analyze your code.

Use your `OE` connection.

Finding Coding Information

1. Create the `QUERY_CODE_PKG` package to search your source code.

   Use the `OE` connection.

   a. Run task 1_a of the `lab_10.sql` script to create the `QUERY_CODE_PKG` package.

```
CREATE OR REPLACE PACKAGE query_code_pkg
AUTHID CURRENT_USER
IS
  PROCEDURE find_text_in_code (str IN VARCHAR2);
  PROCEDURE encap_compliance ;
END query_code_pkg;
/

CREATE OR REPLACE PACKAGE BODY query_code_pkg IS
  PROCEDURE find_text_in_code (str IN VARCHAR2)
  IS
    TYPE info_rt IS RECORD (NAME user_source.NAME%TYPE,
      text user_source.text%TYPE );
    TYPE info_aat IS TABLE OF info_rt INDEX BY PLS_INTEGER;
    info_aa info_aat;
  BEGIN
    SELECT NAME || '-' || line, text
    BULK COLLECT INTO info_aa FROM user_source
      WHERE UPPER (text) LIKE '%' || UPPER (str) || '%'
      AND NAME != 'VALSTD' AND NAME != 'ERRNUMS';
    DBMS_OUTPUT.PUT_LINE ('Checking for presence of '||
                          str || ':');
    FOR indx IN info_aa.FIRST .. info_aa.LAST LOOP
      DBMS_OUTPUT.PUT_LINE (
          info_aa (indx).NAME|| ',' || info_aa (indx).text);
    END LOOP;
  END find_text_in_code;

  PROCEDURE encap_compliance IS
    SUBTYPE qualified_name_t IS VARCHAR2 (200);
    TYPE refby_rt IS RECORD (NAME qualified_name_t,
         referenced_by qualified_name_t );
    TYPE refby_aat IS TABLE OF refby_rt INDEX BY PLS_INTEGER;
    refby_aa refby_aat;
```

```
  BEGIN
    SELECT owner || '.' || NAME refs_table
          , referenced_owner || '.' || referenced_name
          AS table_referenced
    BULK COLLECT INTO refby_aa
      FROM all_dependencies
      WHERE owner = USER
      AND TYPE IN ('PACKAGE', 'PACKAGE BODY',
                   'PROCEDURE', 'FUNCTION')
      AND referenced_type IN ('TABLE', 'VIEW')
      AND referenced_owner NOT IN ('SYS', 'SYSTEM')
     ORDER BY owner, NAME, referenced_owner, referenced_name;
    DBMS_OUTPUT.PUT_LINE ('Programs that reference tables or
views');
    FOR indx IN refby_aa.FIRST .. refby_aa.LAST LOOP
      DBMS_OUTPUT.PUT_LINE (refby_aa (indx).NAME || ',' ||
            refby_aa (indx).referenced_by);
    END LOOP;
 END encap_compliance;
END query_code_pkg;
/
```

```
PACKAGE QUERY_CODE_PKG compiled
PACKAGE BODY QUERY_CODE_PKG compiled
```

b. Run the `ENCAP_COMPLIANCE` procedure to see which of your programs reference tables or views. (**Note:** Your results might differ slightly.)

```
SET SERVEROUTPUT ON
EXECUTE query_code_pkg.encap_compliance
```

```
PL/SQL procedure successfully completed.

Programs that reference tables or views
OE.ADD_ORDER_ITEMS,OE.PORDER
OE.ALLOCATE_NEW_PROJ_LIST,OE.DEPARTMENT
OE.CHANGE_CREDIT,OE.CUSTOMERS
OE.CREDIT_CARD_PKG,OE.CUSTOMERS
OE.GET_EMAIL,OE.CUSTOMERS
OE.GET_WAREHOUSE_NAMES,OE.WAREHOUSES
OE.LIST_PRODUCTS_DYNAMIC,OE.PRODUCT_INFORMATION
OE.LIST_PRODUCTS_STATIC,OE.PRODUCT_INFORMATION
OE.LOAD_PRODUCT_IMAGE,OE.PRODUCT_INFORMATION
OE.LOB_TXT,OE.LOB_TEXT
OE.MANAGE_DEPT_PROJ,OE.DEPARTMENT
OE.ORDERS_CTX_PKG,OE.CUSTOMERS
OE.ORD_COUNT,OE.ORDERS
OE.PRINT_CUSTOMERS,OE.CUSTOMERS
OE.PRINT_CUSTOMERS,OE.ORDERS
OE.PRINT_EMPLOYEES,OE.CUSTOMERS
```

c. Run the `FIND_TEXT_IN_CODE` procedure to find all references to `'ORDERS'`. (**Note:** Your results might differ slightly.)

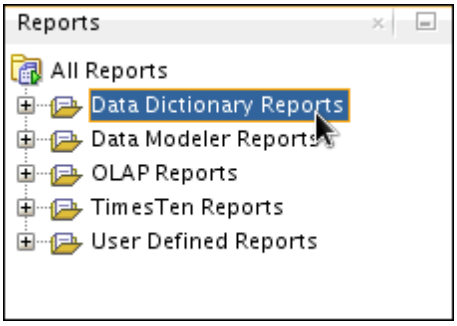
```
SET SERVEROUTPUT ON
EXECUTE query_code_pkg.find_text_in_code('ORDERS')
```

```
PL/SQL procedure successfully completed.

Checking for presence of ORDERS:
CUSTOMER_TYP-12,    , cust_orders        order_list_typ

GET_TABLE_MD-11,                       (v_hdl ,'NAME','ORDERS');

JSON_PUT_PRACTICE-8,                                  FROM orders o

ORDERS_APP_PKG-1,PACKAGE orders_app_pkg

ORDERS_APP_PKG-1,PACKAGE BODY orders_app_pkg

ORDERS_CTX_PKG-1,PACKAGE orders_ctx_pkg IS

ORDERS_CTX_PKG-1,PACKAGE BODY orders_ctx_pkg IS
```

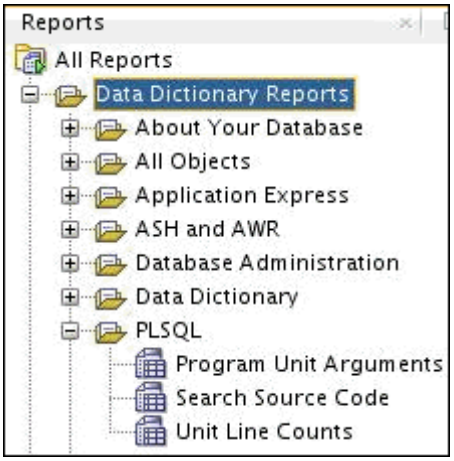
Alternatively, you can execute the solutions for tasks 1_b and 1_c from `sol_10.sql`.

d. Use the Oracle SQL Developer Reports feature to find the same results obtained in step c.

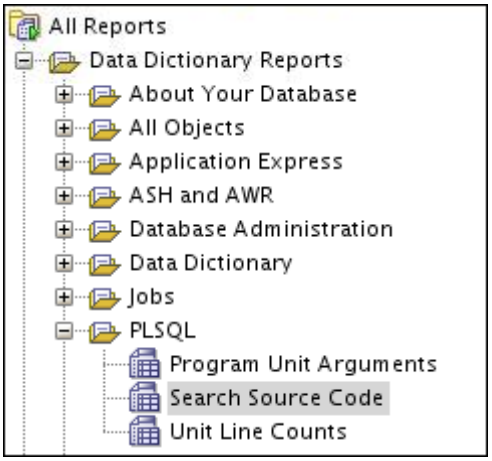
Navigate to the Reports tabbed page in Oracle SQL Developer.



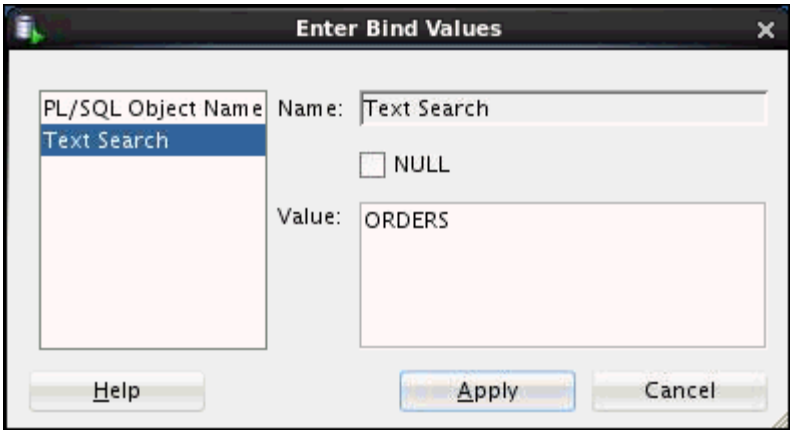
Expand the Data Dictionary Reports node and expand the PL/SQL node.



Select Search Source Code, and then select your `OE` connection and click OK.



Select Text search and enter `ORDERS` in the Value: field. Click the Apply button.



	Owner	PL/SQL Object Name	Type	Line	Text
1	OE	CUSTOMER_TYP	TYPE	12	, cust_orders order_list_typ
2	OE	GET_TABLE_MD	FUNCTION	11	(v_hdl ,'NAME','ORDERS');
3	OE	JSON_PUT_PRACTICE	PROCEDURE	8	FROM orders o
4	OE	ORDERS_APP_PKG	PACKAGE	1	PACKAGE orders_app_pkg
5	OE	ORDERS_APP_PKG	PACKAGE BODY	1	PACKAGE BODY orders_app_pkg
6	OE	ORDERS_CTX_PKG	PACKAGE	1	PACKAGE orders_ctx_pkg IS
7	OE	ORDERS_CTX_PKG	PACKAGE BODY	1	PACKAGE BODY orders_ctx_pkg IS
8	OE	ORDERS_CTX_PKG	PACKAGE BODY	8	DBMS_SESSION.SET_CONTEXT('orders_ctx', 'customer_id', custnum);
9	OE	ORDERS_ITEMS_TRG	TRIGGER	1	TRIGGER orders_items_trg INSTEAD OF INSERT ON NESTED
10	OE	ORDERS_ITEMS_TRG	TRIGGER	2	TABLE order_item_list OF oc_orders FOR EACH ROW
11	OE	ORDERS_TRG	TRIGGER	1	TRIGGER orders_trg INSTEAD OF INSERT
12	OE	ORDERS_TRG	TRIGGER	2	ON oc_orders FOR EACH ROW
13	OE	ORDERS_TRG	TRIGGER	4	INSERT INTO ORDERS (order_id, order_mode, order_total,
14	OE	ORD_COUNT	FUNCTION	3	RESULT_CACHE RELIES_ON (orders)
15	OE	ORD_COUNT	FUNCTION	8	FROM orders
16	OE	PRINT_CUSTOMERS	PROCEDURE	11	from oe.customers c, oe.orders o
17	OE	PRINT_EMPLOYEES	PROCEDURE	12	from oe.customers c, oe.orders o

Note: The report content might vary based on the objects created by using your schema.

Using PL/Scope

Use the `OE` connection.

2. In the following steps, you use PL/Scope.
   a. Enable your session to collect identifiers.

```
ALTER SESSION SET PLSCOPE_SETTINGS = 'IDENTIFIERS:ALL';
```

```
session SET altered.
```

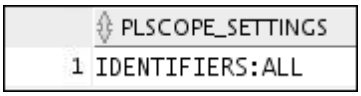
   b. Recompile your `CREDIT_CARD_PKG` code.

```
ALTER PACKAGE credit_card_pkg COMPILE;
```

```
package CREDIT_CARD_PKG altered.
```

c. Verify that your `PLSCOPE_SETTING` is set correctly by issuing the following statement:

```
SELECT PLSCOPE_SETTINGS
FROM USER_PLSQL_OBJECT_SETTINGS
WHERE NAME='CREDIT_CARD_PKG' AND TYPE='PACKAGE BODY';
```



	PLSCOPE_SETTINGS
1	IDENTIFIERS:ALL

Alternatively, you can execute the solutions for tasks 2_a, 2_b, and 2_c from `sol_10.sql`.

d. Execute the following statement to create a hierarchical report on the identifier information about the `CREDIT_CARD_PKG` code. You can run task 2_d of the `lab_10.sql` script file.

```
WITH v AS
 (SELECT    Line,
            Col,
            INITCAP(NAME) Name,
            LOWER(TYPE)   Type,
            LOWER(USAGE)  Usage,
            USAGE_ID, USAGE_CONTEXT_ID
  FROM USER_IDENTIFIERS
  WHERE Object_Name = 'CREDIT_CARD_PKG'
    AND Object_Type = 'PACKAGE BODY'  )
    SELECT RPAD(LPAD(' ', 2*(Level-1)) ||
                Name, 20, '.')||' '||
                RPAD(Type, 20)|| RPAD(Usage, 20)
                IDENTIFIER_USAGE_CONTEXTS
    FROM v
    START WITH USAGE_CONTEXT_ID = 0
    CONNECT BY PRIOR USAGE_ID = USAGE_CONTEXT_ID
    ORDER SIBLINGS BY Line, Col;
```

	IDENTIFIER_USAGE_CONTEXTS		
1	Credit_Card_Pkg.....	package	definition
2	Cust_Card_Info....	function	definition
3	P_Cust_Id.....	formal in	declaration
4	Number.....	number datatype	reference
5	P_Card_Info.....	formal in out	declaration
6	Typ_Cr_Card_Ns	nested table	reference
7	Boolean.....	boolean datatype	reference
8	V_Card_Info_Exis	variable	declaration
9	Boolean.....	boolean datatype	reference
10	P_Card_Info.....	formal in out	assignment
11	P_Cust_Id.....	formal in	reference
12	V_Card_Info_Exis	variable	assignment
13	V_Card_Info_Exis	variable	reference

3. Use DBMS_METADATA to find the metadata for the ORDER_ITEMS table.

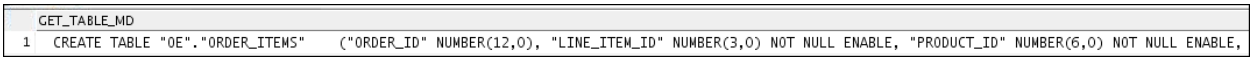
   Use the OE connection.

   a. Create the GET_TABLE_MD function. You can run task 3_a of the lab_10.sql script.

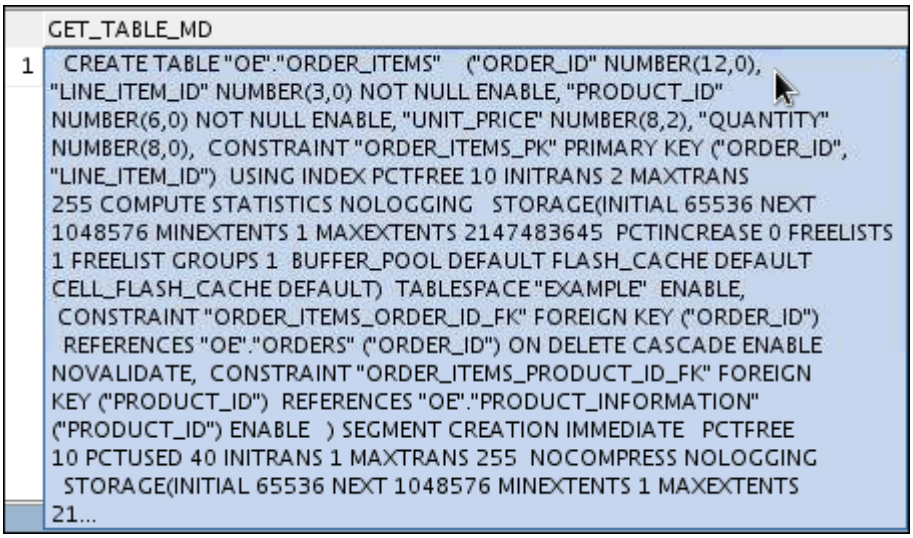
```
CREATE OR REPLACE FUNCTION get_table_md RETURN CLOB IS
 v_hdl  NUMBER; -- returned by 'OPEN'
 v_th   NUMBER; -- returned by 'ADD_TRANSFORM'
 v_doc  CLOB;
BEGIN
 -- specify the OBJECT TYPE
 v_hdl := DBMS_METADATA.OPEN('TABLE');
 -- use FILTERS to specify the objects desired
 DBMS_METADATA.SET_FILTER(v_hdl ,'SCHEMA','OE');
 DBMS_METADATA.SET_FILTER
                      (v_hdl ,'NAME','ORDER_ITEMS');
 -- request to be TRANSFORMED into creation DDL
 v_th := DBMS_METADATA.ADD_TRANSFORM(v_hdl,'DDL');
 -- FETCH the object
 v_doc := DBMS_METADATA.FETCH_CLOB(v_hdl);
 -- release resources
 DBMS_METADATA.CLOSE(v_hdl);
 RETURN v_doc;
END;
/
```

b. Issue the following statements to view the metadata generated from the `GET_TABLE_MD` function:

```
set pagesize 0
set long  1000000

SELECT get_table_md FROM dual;
```



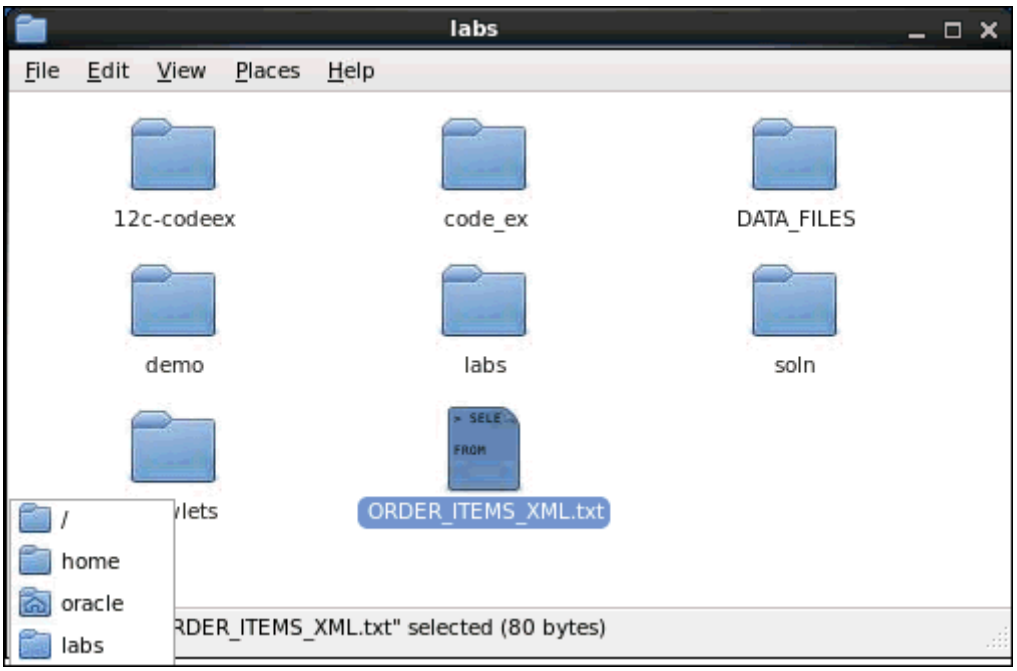
Move the cursor over the `get_table_md` column to see the detailed view of the record.



c. Generate an XML representation of the `ORDER_ITEMS` table by using the `DBMS_METADATA.GET_XML` function. Spool the output to a file named `ORDER_ITEMS_XML.txt` in the `/home/oracle/labs` folder.

```
SET PAGESIZE 0
SET LONG 1000000
SPOOL /home/oracle/labs/ORDER_ITEMS_XML.txt

SELECT DBMS_METADATA.GET_XML
      ('TABLE', 'ORDER_ITEMS', 'OE')
FROM   dual;

SPOOL OFF
```

d. Verify that the `ORDER_ITEMS_XML.txt` file was created in the `/home/oracle/labs` folder.



Practices for Lesson 11: Profiling and Tracing PL/SQL Code

Practices for Lesson 11: Overview

Overview

In this practice, you write code to profile components in your application.

Practice 11-1: Profiling and Tracing PL/SQL Code

Overview

In this practice, you generate profiler data and analyze it.

Task

Use your `OE` connection.

1. Generate profiling data for your `CREDIT_CARD_PKG`.
   a. Re-create `CREDIT_CARD_PKG` by running the `/home/oracle/labs/labs/lab_11.sql` script.
   b. You must identify the location of the profiler files. Create a `DIRECTORY` object to identify this information and grant the necessary privileges. Use the `SYS` connection.
   c. Use `DBMS_HPROF.START_PROFILING` to start the profiler for your session.
   d. Run your `CREDIT_CARD_PKG.UPDATE_CARD_INFO` with the following data.
   ```
   credit_card_pkg.update_card_info
       (154, 'Discover', '123456789');
   ```
   e. Use `DBMS_HPROF.STOP_PROFILING` to stop the profiler.
2. Run the following code to set up the profiler tables:
   ```
   Begin
   DBMS_HPROF.CREATE_TABLES;
   end;
   ```
3. Use `DBMS_HPROF.ANALYZE` to analyze the raw data and write the information to the profiler tables.
   a. Get `RUN_ID`.
   b. Query the `DBMSHP_RUNS` table to find top-level information for `RUN_ID` that you retrieved.
   c. Query the `DBMSHP_FUNCTION_INFO` table to find information about each function profiled.
4. Use the `plshprof` command-line utility to generate simple HTML reports directly from the raw profiler data.
   a. Open a command window.
   b. Change the working directory to `/home/oracle/labs/labs`.
   c. Run the `plshprof` utility.

   Open the report in your browser and review the data.

Solution 11-1: Profiling and Tracing PL/SQL Code

In this practice, you generate profiler data and analyze it.

Use your OE connection.

1. Generate profiling data for your CREDIT_CARD_PKG.

   a. Re-create CREDIT_CARD_PKG by running the /home/oracle/labs/labs/lab_11.sql script.

      Use the OE connection.

```
PACKAGE CREDIT_CARD_PKG compiled
PACKAGE BODY CREDIT_CARD_PKG compiled
```

   b. You must identify the location of the profiler files. Create a DIRECTORY object to identify this information and grant the necessary privileges:

      Use the SYS connection.

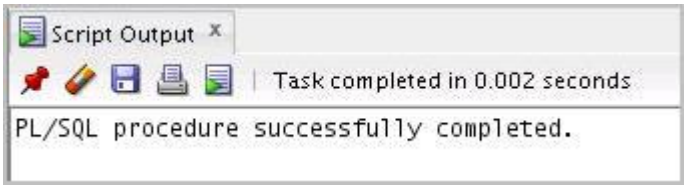
```
CREATE DIRECTORY profile_data AS '/home/oracle/labs/labs';
GRANT READ, WRITE, EXECUTE ON DIRECTORY profile_data TO OE;
GRANT EXECUTE ON DBMS_HPROF TO OE;
```

```
directory PROFILE_DATA created.
GRANT succeeded.
GRANT succeeded.
```

   c. Use DBMS_HPROF.START_PROFILING to start the profiler for your session.

      Use the OE connection.

```
BEGIN
-- start profiling
  DBMS_HPROF.START_PROFILING('PROFILE_DATA', 'pd_cc_pkg.txt');
END;
/
```



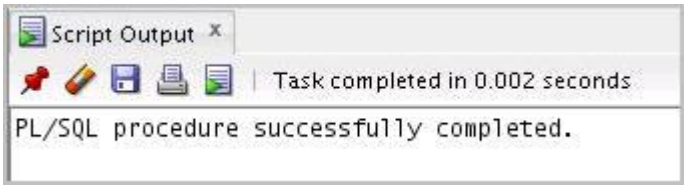
   d. Run your CREDIT_CARD_PKG.UPDATE_CARD_INFO with the following data.

```
credit_card_pkg.update_card_info
    (154, 'Discover', '123456789');
```

      Use the OE connection.

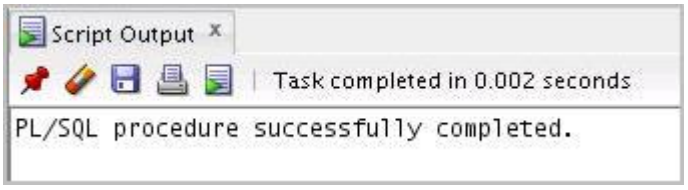
```
DECLARE
  v_card_info typ_cr_card_nst;
BEGIN
-- run application
  credit_card_pkg.update_card_info
    (154, 'Discover', '123456789');
```

```
END;
/
```



e. Use `DBMS_HPROF.STOP_PROFILING` to stop the profiler.
Use the `OE` connection.

```
BEGIN
  DBMS_HPROF.STOP_PROFILING;
END;
/
```



Alternatively, you can run the solutions for tasks 1_b, 1_c, 1_d, and 1_e from `sol_11.sql`.

2. Run the following code to set up the profiler tables:

```
Begin
DBMS_HPROF.CREATE_TABLES;
end;
```

3. Use `DBMS_HPROF.ANALYZE` to analyze the raw data and write the information to the profiler tables.

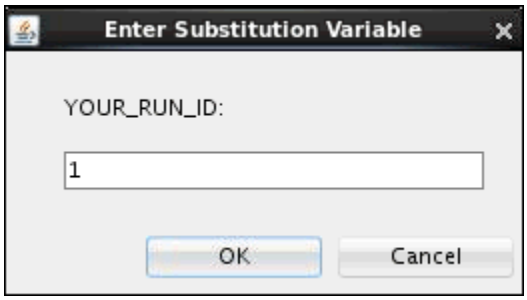
a. Get `RUN_ID`.

```
SET SERVEROUTPUT ON

DECLARE
  v_runid NUMBER;
BEGIN
  v_runid := DBMS_HPROF.ANALYZE (LOCATION => 'PROFILE_DATA',
                                 FILENAME => 'pd_cc_pkg.txt');
  DBMS_OUTPUT.PUT_LINE('Run ID: ' || v_runid);
END;
/
```

```
Run ID: 1
```

b. Query the `DBMSHP_RUNS` table to find top-level information for `RUN_ID` that you retrieved.

```
SET VERIFY OFF

SELECT runid, run_timestamp, total_elapsed_time
FROM dbmshp_runs
WHERE runid = &your_run_id;
```



	RUNID	RUN_TIMESTAMP	TOTAL_ELAPSED_TIME
1	1	27-JAN-14 11.32.59.543393000 PM	10267

c. Query the `DBMSHP_FUNCTION_INFO` table to find information about each function profiled.

```
SELECT owner, module, type, function line#, namespace,
       calls, function_elapsed_time
FROM   dbmshp_function_info
WHERE  runid = 1;
```

	OWNER	MODULE	TYPE	LINE#	NAMESPACE	CALLS	FUNCTION_ELAPSED_TIME
1	(null)	(null)	(null)	__anonymous_block	PLSQL	8	467
2	(null)	(null)	(null)	__plsql_vm	PLSQL	8	39
3	OE	CREDIT_CARD_PKG	PACKAGE BODY	UPDATE_CARD_INFO	PLSQL	2	202
4	SYS	DBMS_HPROF	PACKAGE BODY	STOP_PROFILING	PLSQL	1	0
5	SYS	DBMS_OUTPUT	PACKAGE BODY	GET_LINE	PLSQL	5	15
6	OE	CREDIT_CARD_PKG	PACKAGE BODY	__static_sql_exec_line17	SQL	2	5179
7	OE	CREDIT_CARD_PKG	PACKAGE BODY	__static_sql_exec_line9	SQL	2	771

Alternatively, you can run the solutions for tasks 3_a, 3_b, and 3_c from `sol_11.sql`.

4. Use the `plshprof` command-line utility to generate simple HTML reports directly from the raw profiler data.

a. Open a command window.

b. Change the working directory to `/home/oracle/labs/labs`.

c. Run the `plshprof` utility.

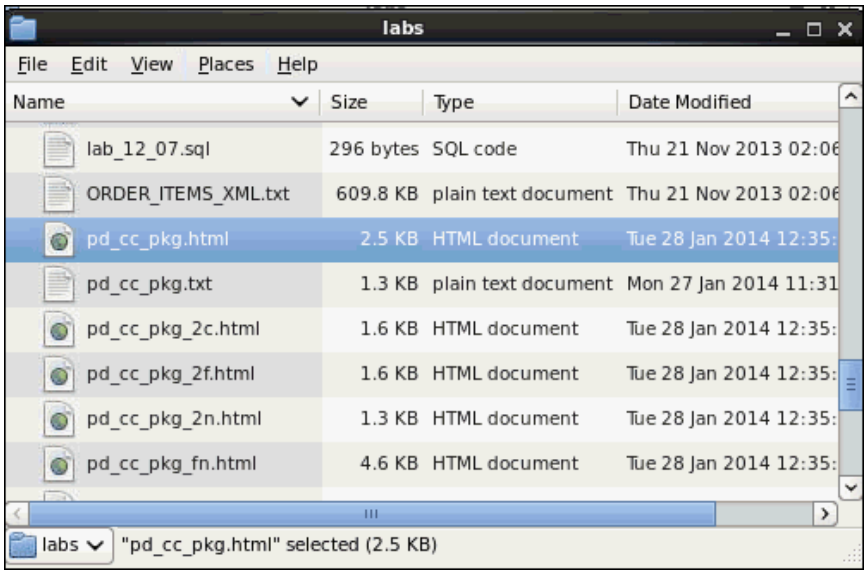
```
--at your command window, change your working directory to
/home/oracle/labs/labs
cd /home/oracle/labs/labs
plshprof  -output pd_cc_pkg  pd_cc_pkg.txt
```

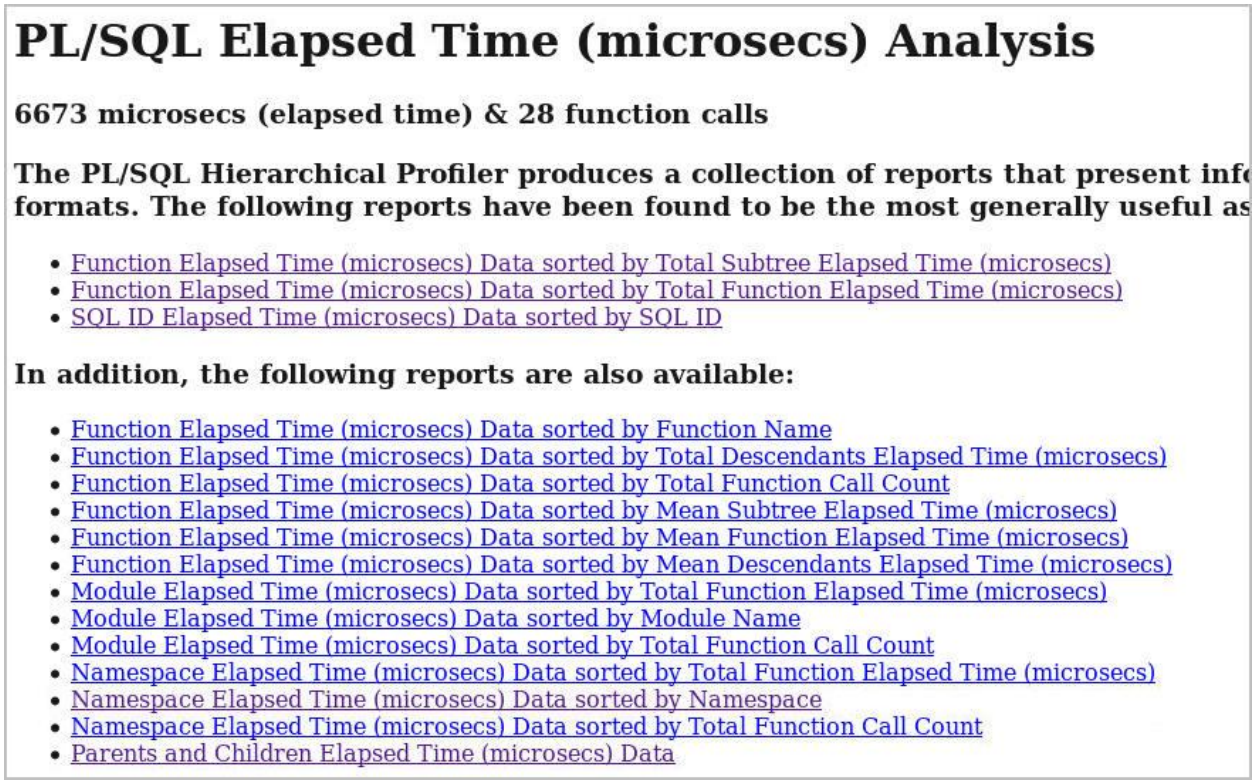
```
[7 symbols processed]
[Report written to 'pd_cc_pkg.html']
```

Note : The number of symbols should be equal to the number of values returned in Step 3c

5. Open the report in your browser and review the data.

Navigate to the `/home/oracle/labs/labs` folder.





PL/SQL Elapsed Time (microsecs) Analysis

6673 microsecs (elapsed time) & 28 function calls

The PL/SQL Hierarchical Profiler produces a collection of reports that present inf
formats. The following reports have been found to be the most generally useful as

- Function Elapsed Time (microsecs) Data sorted by Total Subtree Elapsed Time (microsecs)
- Function Elapsed Time (microsecs) Data sorted by Total Function Elapsed Time (microsecs)
- SQL ID Elapsed Time (microsecs) Data sorted by SQL ID

In addition, the following reports are also available:

- Function Elapsed Time (microsecs) Data sorted by Function Name
- Function Elapsed Time (microsecs) Data sorted by Total Descendants Elapsed Time (microsecs)
- Function Elapsed Time (microsecs) Data sorted by Total Function Call Count
- Function Elapsed Time (microsecs) Data sorted by Mean Subtree Elapsed Time (microsecs)
- Function Elapsed Time (microsecs) Data sorted by Mean Function Elapsed Time (microsecs)
- Function Elapsed Time (microsecs) Data sorted by Mean Descendants Elapsed Time (microsecs)
- Module Elapsed Time (microsecs) Data sorted by Total Function Elapsed Time (microsecs)
- Module Elapsed Time (microsecs) Data sorted by Module Name
- Module Elapsed Time (microsecs) Data sorted by Total Function Call Count
- Namespace Elapsed Time (microsecs) Data sorted by Total Function Elapsed Time (microsecs)
- Namespace Elapsed Time (microsecs) Data sorted by Namespace
- Namespace Elapsed Time (microsecs) Data sorted by Total Function Call Count
- Parents and Children Elapsed Time (microsecs) Data

Practices for Lesson 12: Securing Applications through PL/SQL

Practices for Lesson 12: Overview

Overview

In this practice, you:

- Create an application context
- Create a policy
- Create a logon trigger
- Implement a Virtual Private Database

Test the Virtual Private Database.

Practice 12-1: Implementing Fine-Grained Access Control for VPD

Overview

In this practice, you define an application context and security policy to implement the policy: "Sales Representatives can see only their own order information in the `ORDERS` table." You create sales representative IDs to test the success of your implementation.

Task

Examine the definition of the `ORDERS` table and the `ORDER` count for each sales representative:

```
DESCRIBE orders
```

```
Name                 Null?    Type
-------------------- -------- ------------------------------
ORDER_ID             NOT NULL NUMBER(12)
ORDER_DATE           NOT NULL TIMESTAMP(6) WITH LOCAL TIME ZONE
ORDER_MODE                    VARCHAR2(8)
CUSTOMER_ID          NOT NULL NUMBER(6)
ORDER_STATUS                  NUMBER(2)
ORDER_TOTAL                   NUMBER(8,2)
SALES_REP_ID                  NUMBER(6)
PROMOTION_ID                  NUMBER(6)
```

```
SELECT sales_rep_id, count(*)
FROM   orders
GROUP BY sales_rep_id;
```

Run this step to check the `ORDERS` table.

Note: Use SQL*Plus to complete the following steps.

1. Use your `SYS` connection. Examine and then run the `lab_12.sql` script.
   This script creates the sales representative ID accounts with appropriate privileges to access the database.
2. Set up an application context:
   a. Connect to the database as `SYS` before creating this context.
   b. Create an application context named `sales_orders_ctx`.
   c. Associate this context to `oe.sales_orders_pkg`.
3. Connect as `OE`.
   a. Examine this package specification:

```
CREATE OR REPLACE PACKAGE sales_orders_pkg
IS
 PROCEDURE set_app_context;
 FUNCTION the_predicate
```

```
  (p_schema VARCHAR2, p_name VARCHAR2)
   RETURN VARCHAR2;
END sales_orders_pkg;    -- package spec
/
```

b. Create this package specification and the package body in the OE schema.

c. When you create the package body, set up two constants as follows:

```
c_context CONSTANT VARCHAR2(30) := 'SALES_ORDERS_CTX';
c_attrib  CONSTANT VARCHAR2(30) := 'SALES_REP';
```

d. Use these constants in the SET_APP_CONTEXT procedure to set the application context to the current user.

4. Connect as SYS and define the policy.

a. Use DBMS_RLS.ADD_POLICY to define the policy.

b. Use these specifications for the parameter values:

```
object_schema   OE
object_name     ORDERS
policy_name     OE_ORDERS_ACCESS_POLICY
function_schema OE
policy_function SALES_ORDERS_PKG.THE_PREDICATE
statement_types SELECT, UPDATE, DELETE
update_check    FALSE,
enable          TRUE);
```

5. Connect as SYS and create a logon trigger to implement fine-grained access control. Name the trigger SET_ID_ON_LOGON. This trigger causes the context to be set as each user is logged on.

6. Test the fine-grained access implementation. Connect as your `SR` user and query the `ORDERS` table. For example, your results should match:

```
CONNECT sr153/oracle@orclpdb1

SELECT sales_rep_id, COUNT(*)
FROM   orders
GROUP BY sales_rep_id;

SALES_REP_ID   COUNT(*)
------------ ----------
         153          5

CONNECT sr154/oracle@orclpdb1

SELECT sales_rep_id, COUNT(*)
FROM   orders
GROUP BY sales_rep_id;

SALES_REP_ID   COUNT(*)
------------ ----------
         154         10
```

Note: During debugging, you may need to disable or remove some of the objects created for this lesson.

- If you need to disable the logon trigger, as `SYS`, issue the following command:

```
ALTER TRIGGER set_id_on_logon DISABLE;
```

- If you need to remove the policy that you created, as `SYS`, issue the following command:

```
EXECUTE DBMS_RLS.DROP_POLICY('OE', 'ORDERS', -
'OE_ORDERS_ACCESS_POLICY')
```

Solution 12-1: Implementing Fine-Grained Access Control for VPD

In this practice, you define an application context and security policy to implement the policy: “Sales representatives can see only their own order information in the `ORDERS` table.” You create sales representative IDs to test the success of your implementation. Examine the definition of the `ORDERS` table and the `ORDER` count for each sales representative.

Note: Use SQL*Plus to complete the following steps.

1. Use your `SYS` connection. Examine and then run the `lab_12.sql` script.
   This script creates the sales representative ID accounts with appropriate privileges to access the database.

```
DROP USER sr153;
CREATE USER sr153 IDENTIFIED BY oracle
 DEFAULT TABLESPACE USERS
 TEMPORARY TABLESPACE TEMP
 QUOTA UNLIMITED ON USERS;

DROP USER sr154;
CREATE USER sr154 IDENTIFIED BY oracle
 DEFAULT TABLESPACE USERS
 TEMPORARY TABLESPACE TEMP
 QUOTA UNLIMITED ON USERS;

GRANT create session
    , alter session
TO sr153, sr154;

GRANT SELECT, INSERT, UPDATE, DELETE ON
  oe.orders TO sr153, sr154;

GRANT SELECT, INSERT, UPDATE, DELETE ON
  oe.order_items TO sr153, sr154;

CREATE PUBLIC SYNONYM orders FOR oe.orders;
CREATE PUBLIC SYNONYM order_items FOR oe.order_items;
```

```
Error starting at line : 3 in command -
DROP USER sr153
Error report -
SQL Error: ORA-01918: user 'SR153' does not exist
01918. 00000 -  "user '%s' does not exist"
*Cause:    User does not exist in the system.
*Action:   Verify the user name is correct.
user SR153 created.

Error starting at line : 9 in command -
DROP USER sr154
Error report -
SQL Error: ORA-01918: user 'SR154' does not exist
01918. 00000 -  "user '%s' does not exist"
*Cause:    User does not exist in the system.
*Action:   Verify the user name is correct.
user SR154 created.
GRANT succeeded.
GRANT succeeded.
GRANT succeeded.
public synonym ORDERS created.
public synonym ORDER_ITEMS created.
```

2. Set up an application context:
   a. Connect to the database as `SYS` before creating this context.
   b. Create an application context named `sales_orders_ctx`.
   c. Associate this context with the `oe.sales_orders_pkg`.

```
CREATE CONTEXT sales_orders_ctx
USING oe.sales_orders_pkg;
```

```
context SALES_ORDERS_CTX created.
```

Alternatively, run the code from task 2 of `sol_12.sql`.

3. Connect as `OE`.
   a. Examine this package specification:

```
CREATE OR REPLACE PACKAGE sales_orders_pkg
IS
 PROCEDURE set_app_context;
 FUNCTION the_predicate
  (p_schema VARCHAR2, p_name VARCHAR2)
   RETURN VARCHAR2;
END sales_orders_pkg;    -- package spec
/
```

   b. Create this package specification and then the package body in the `OE` schema.
   c. When you create the package body, set up two constants as follows:

```
c_context CONSTANT VARCHAR2(30) := 'SALES_ORDERS_CTX';
c_attrib  CONSTANT VARCHAR2(30) := 'SALES_REP';
```

d. Use these constants in the `SET_APP_CONTEXT` procedure to set the application context to the current user.

```
CREATE OR REPLACE PACKAGE BODY sales_orders_pkg
IS
  c_context CONSTANT VARCHAR2(30) := 'SALES_ORDERS_CTX';
  c_attrib  CONSTANT VARCHAR2(30) := 'SALES_REP';

PROCEDURE set_app_context
  IS
    v_user VARCHAR2(30);
BEGIN
  SELECT user INTO v_user FROM dual;
  DBMS_SESSION.SET_CONTEXT
    (c_context, c_attrib, v_user);
END set_app_context;

FUNCTION the_predicate
(p_schema VARCHAR2, p_name VARCHAR2)
RETURN VARCHAR2
IS
  v_context_value VARCHAR2(100) :=
     SYS_CONTEXT(c_context, c_attrib);
  v_restriction VARCHAR2(2000);
BEGIN
  IF v_context_value LIKE 'SR%'  THEN
    v_restriction :=
     'SALES_REP_ID =
      SUBSTR(''' || v_context_value || ''', 3, 3)';
  ELSE
    v_restriction := null;
  END IF;
  RETURN v_restriction;
END the_predicate;

END sales_orders_pkg; -- package body
/
```

```
PACKAGE SALES_ORDERS_PKG compiled
PACKAGE BODY SALES_ORDERS_PKG compiled
```

Alternatively, run the code from task 3 of `sol_12.sql`.

4. Connect as SYS and define the policy.
   a. Use DBMS_RLS.ADD_POLICY to define the policy.
   b. Use the following specifications for the parameter values:

```
object_schema   OE
object_name     ORDERS
policy_name     OE_ORDERS_ACCESS_POLICY
function_schema OE
policy_function SALES_ORDERS_PKG.THE_PREDICATE
statement_types SELECT, INSERT, UPDATE, DELETE
update_check    FALSE,
enable          TRUE
```

```
DECLARE
BEGIN
  DBMS_RLS.ADD_POLICY (
   'OE',
   'ORDERS',
   'OE_ORDERS_ACCESS_POLICY',
   'OE',
   'SALES_ORDERS_PKG.THE_PREDICATE',
   'SELECT, UPDATE, DELETE',
   FALSE,
   TRUE);
END;
/
```

```
PL/SQL procedure successfully completed.
```

Alternatively, run the code from task 4 of `sol_12.sql`.

5. Connect as SYS and create a logon trigger to implement fine-grained access control. Name the trigger SET_ID_ON_LOGON. This trigger causes the context to be set as each user is logged on.

```
CREATE OR REPLACE TRIGGER set_id_on_logon
AFTER logon on DATABASE
BEGIN
  oe.sales_orders_pkg.set_app_context;
END;
/
```

```
TRIGGER SET_ID_ON_LOGON compiled
```

Alternatively, run the code from task 5 of `sol_12.sql`.

6. Test the fine-grained access implementation. Connect as your `SR` user and query the `ORDERS` table. For example, your results should match the following:

```
CONNECT sr153/oracle@orclpdb1

SELECT sales_rep_id, COUNT(*)
FROM   orders
GROUP BY sales_rep_id;

SALES_REP_ID   COUNT(*)
------------ ----------
         153          5

CONNECT sr154/oracle@orclpdb1

SELECT sales_rep_id, COUNT(*)
FROM   orders
GROUP BY sales_rep_id;

SALES_REP_ID   COUNT(*)
------------ ----------
         154         10
```

```
SQL> CONNECT sr153/oracle
Connected.
SQL> SELECT sales_rep_id, COUNT(*) FROM   orders GROUP BY sales_rep_id;

SALES_REP_ID   COUNT(*)
------------ ----------
         153          5

SQL>
```

```
SQL> CONNECT sr154/oracle
Connected.
SQL> SELECT sales_rep_id, COUNT(*) FROM   orders GROUP BY sales_rep_id;

SALES_REP_ID   COUNT(*)
------------ ----------
         154         10
```

Note: During debugging, you may need to disable or remove some of the objects created for this lesson.

- If you need to disable the logon trigger, as `SYS`, issue the following command:
  `ALTER TRIGGER set_id_on_logon DISABLE;`
- If you need to remove the policy that you created, as `SYS`, issue the following command:
  ```
  EXECUTE DBMS_RLS.DROP_POLICY('OE', 'ORDERS',-
  'OE_ORDERS_ACCESS_POLICY')
  ```

Alternatively, run the code from task 6 of `sol_12.sql`.

Practices for Lesson 13: Safeguarding Your Code against SQL Injection Attacks

Practices for Lesson 13: Overview

Overview

In this practice, you examine PL/SQL code, test it for SQL injection, and rewrite it to protect against SQL injection vulnerabilities.

Practice 13-1: Safeguarding Your Code against SQL Injection Attacks

Overview

In this practice, you examine PL/SQL code, test it for SQL injection, and rewrite it to protect against SQL injection vulnerabilities.

Use the `OE` connection for this practice.

Task

1. Only code that is used in web applications is vulnerable to SQL injection attack.
   a. True
   b. False
2. Code that is most vulnerable to SQL injection attack contains: (Check all those that apply.)
   a. Input parameters
   b. Dynamic SQL with bind arguments
   c. Dynamic SQL with concatenated input values
   d. Calls to exterior functions
3. By default, a stored procedure or SQL method executes with the privileges of the owner (definer's rights).
   a. True
   b. False
4. By using `AUTHID CURRENT_USER` in your code, you are: (Check all those that apply.)
   a. Specifying that the code executes with invoker's rights
   b. Specifying that the code executes with the highest privilege level
   c. Eliminating any possible SQL injection vulnerability
   e. Not eliminating all possible SQL injection vulnerabilities
5. Match each attack surface reduction technique with an example of the technique.

Technique	Example
Executes code with minimal privileges	Specify appropriate parameter types
Locks the database	Revoke privileges from `PUBLIC`
Reduces arbitrary input	Use invoker's rights

6. Examine the following code. Run task 6 of the `lab_13.sql` script to create the procedure.

```
CREATE OR REPLACE PROCEDURE get_income_level (p_email VARCHAR2
DEFAULT NULL)
IS
  TYPE      cv_custtyp IS REF CURSOR;
  cv        cv_custtyp;
  v_income  customers.income_level%TYPE;
  v_stmt    VARCHAR2(400);
BEGIN
  v_stmt := 'SELECT income_level FROM customers WHERE
             cust_email = ''' || p_email || '''';

  DBMS_OUTPUT.PUT_LINE('SQL statement: ' || v_stmt);
  OPEN cv FOR v_stmt;
  LOOP
      FETCH cv INTO v_income;
      EXIT WHEN cv%NOTFOUND;
      DBMS_OUTPUT.PUT_LINE('Income level is: '||v_income);
  END LOOP;
  CLOSE cv;

EXCEPTION WHEN OTHERS THEN
   dbms_output.PUT_LINE(sqlerrm);
   dbms_output.PUT_LINE('SQL statement: ' || v_stmt);
END get_income_level;
/
```

   a. Execute the following statements and note the results.

```
exec get_income_level('Kris.Harris@DIPPER.EXAMPLE.COM')

exec get_income_level('x'' union select username from all_users
where ''x''=''x')
```

   b. Has SQL injection occurred?

7. Rewrite the code to protect against SQL injection. You can run step 7 of the `lab_13.sql` script to re-create the procedure.

   a. Execute the following statements and note the results:

```
exec get_income_level('Kris.Harris@DIPPER.EXAMPLE.COM')

exec get_income_level('x'' union select username from all_users
where ''x''=''x')
```

   b. Has SQL injection occurred?

Solution 13-1: Safeguarding Your Code Against SQL Injection Attacks

In this practice, you examine PL/SQL code, test it for SQL injection, and rewrite it to protect against SQL injection vulnerabilities.

Use the `OE` connection for this practice.

Understanding SQL Injection

1. Only code used in web applications is vulnerable to SQL injection attack.
   b) False

2. Code that is most vulnerable to SQL injection attack contains: (Check all those that apply.)
   c) Dynamic SQL with concatenated input values

3. By default, a stored procedure or SQL method executes with the privileges of the owner (definer's rights).
   a) **True**

4. By using `AUTHID CURRENT_USER` in your code, you are: (Check all those that apply.)
   a. **Specifying that the code executes with invoker's rights**
   d. **Not eliminating all possible SQL injection vulnerabilities**

5. Match each attack surface reduction technique to an example of the technique.

   Technique: Example

   Executes code with minimal privileges: Use invoker's rights

   Locks the database: Revoke privileges from `PUBLIC`

   Reduces arbitrary input: Specify appropriate parameter types

Rewriting Code to Protect Against SQL Injection

6. Examine this code. Run task 6 in the `lab_13.sql` script to create the procedure.

```
CREATE OR REPLACE PROCEDURE get_income_level
  (p_email VARCHAR2 DEFAULT NULL)
IS
  TYPE      cv_custtyp IS REF CURSOR;
  cv        cv_custtyp;
  v_income  customers.income_level%TYPE;
  v_stmt    VARCHAR2(400);
BEGIN
  v_stmt := 'SELECT income_level FROM customers WHERE
             cust_email = ''' || p_email || '''';
```

```
  DBMS_OUTPUT.PUT_LINE('SQL statement: ' || v_stmt);
  OPEN cv FOR v_stmt;
  LOOP
      FETCH cv INTO v_income;
      EXIT WHEN cv%NOTFOUND;
      DBMS_OUTPUT.PUT_LINE('Income level is: '||v_income);
  END LOOP;
  CLOSE cv;

EXCEPTION WHEN OTHERS THEN
   dbms_output.PUT_LINE(sqlerrm);
   dbms_output.PUT_LINE('SQL statement: ' || v_stmt);
END get_income_level;
/
```

```
PROCEDURE GET_INCOME_LEVEL compiled
```

a. Execute the following statements and note the results.

```
SET SERVEROUTPUT ON
exec get_income_level('Kris.Harris@DIPPER.EXAMPLE.COM')
```

```
PL/SQL procedure successfully completed.

SQL statement: SELECT income_level FROM customers WHERE cust_email = 'Kris.Harris@DIPPER.EXAMPLE.COM'
Income level is: G: 130,000 - 149,999
```

```
exec get_income_level('x'' union select username from all_users
where ''x''=''x')
```

```
PL/SQL procedure successfully completed.

SQL statement: SELECT income_level FROM customers WHERE cust_email = 'x' union select username
Income level is: AM145
Income level is: AM147
Income level is: AM148
Income level is: AM149
Income level is: ANONYMOUS
```

Alternatively, you can execute the solution for task 6_a from `sol_13.sql`.

b. Has SQL injection occurred?
Yes, by using dynamic SQL constructed via concatenation of input values, you see all users in the database.

7. Rewrite the code to protect against SQL injection. You can run step `07` in the `lab_13.sql` script to re-create the procedure.

```
CREATE OR REPLACE
PROCEDURE get_income_level (p_email VARCHAR2 DEFAULT NULL)
AS
BEGIN
FOR i IN
  (SELECT income_level
   FROM customers
   WHERE cust_email = p_email)
  LOOP
      DBMS_OUTPUT.PUT_LINE('Income level is:
        '||i.income_level);
  END LOOP;
END get_income_level;
/
```

a. Execute the following statements and note the results.

```
SET SERVEROUTPUT ON
exec get_income_level('Kris.Harris@DIPPER.EXAMPLE.COM')
```

```
PL/SQL procedure successfully completed.

Income level is: G: 130,000 - 149,999
```

```
exec get_income_level('x'' union select username from all_users
where ''x''=''x')
```

```
PL/SQL procedure successfully completed.
```

Alternatively, you can execute the solution for task 7_a from `sol_13.sql`.

b. Has SQL injection occurred?
No

Practices for Lesson 14: Advanced Security Mechanisms

Practices for Lesson 14: Overview

Overview

There are no practices for this lesson.