COMP 3311
Database Management Systems

Lab 6

Oracle PL/SQL and Stored Procedures

Lab Topics

- □ Oracle PL/SQL basics.
- □ Using cursors in Oracle PL/SQL procedures/functions.
- □ Creating Oracle PL/SQL stored procedures/functions.

  General information about stored procedures and functions can be found in the Lecture 10 notes and Section 5.2 of the textbook.

  Specific information about Oracle PL/SQL stored procedures/ functions and cursors can be found by following the links given at the top of some of the slides.

Oracle PL/SQL (1)

http://docs.oracle.com/cd/A97630_01/appdev.920/a96624/02_funds.htm

- Oracle PL/SQL (Procedural Language/SQL) allows SQL statements to be embedded into a procedural programming language.
- Oracle PL/SQL extends the capabilities of SQL by adding functionalities that are supported by procedural programming languages.
- An Oracle PL/SQL program is stored as a database object and can be
  - a procedure, which does not return a value.
  - a function, which returns a value using the return keyword.

Oracle PL/SQL (2)

- □ Oracle PL/SQL statements:
  - ■ are *case insensitive*.
  - ■ use C style comments /*...*/.
  - ■ use := operator to assign values to a variable.
  - ■ use = operator for comparison.
- □ A block is the basic processing unit in Oracle PL/SQL and is delimited by begin...end.
- □ ALLOWED SQL statements: select, insert, update and delete (i.e., DML statements)
- □ NOT ALLOWED SQL statements: create, drop, alter, rename (i.e., DDL statements).

Oracle PL/SQL Basic Structure

create or replace procedure *procedure_name* [as | is]

Declarative section: declaration of variables, types, and local subprograms go here.

begin **Executable section:** procedural and SQL statements go here. This is the only required section of the block.

exception **Exception handling section:** error handling statements go here.

end;

Use of the exception section will be covered in the next lab.

Declaring Variables

http://docs.oracle.com/cd/A97630_01/appdev.920/a96624/02_funds.htm#27307

- A variable's data type can be either
  - a basic type (i.e., **number**, **int**, **char**, **varchar2**, **date**, etc.) or
  - the same type as a table attribute (*table_name.attribute_name%***type**) or a table row (*table_name%***rowtype**).

Examples

- Declare count to be a variable of basic type number.

```
count number;
```

- Declare projectors to be a variable with the same type as the numberProjectors attribute in the Facility table.

```
projectors Facility.numberProjectors%type;
```

- Declare facilityRecord to be a variable that is the same type as a row (tuple).

```
facilityRecord Facility%rowtype;
```

Select-Into Statement

The select-into statement must retrieve *at most* one record from only one table (i.e., cannot do a join with the select-into statement).

Example: Extract data of the Math department from the Department table into a table called MathDept.

```
create or replace procedure ExtractMathRecords as
   -- deptName is the same type as departmentName in the Department table
   deptName     Department.departmentName%type;
   -- deptRoom is the same type as roomNo in the Department table
   deptRoom     Department.roomNo%type;
begin
   select departmentName, roomNo into deptName, deptRoom from Department where
     departmentId='MATH';
   insert into MathDept values (deptName, deptRoom);
end;
```

- The value of the attributes departmentName and roomNo in the Department table are assigned to, respectively, the PL/SQL variables deptName and deptRoom by the select statement.

Flow of Control Statements

http://docs.oracle.com/cd/A97630_01/appdev.920/a96624/04_struc.htm

Sequential control

goto

- Branch to a label unconditionally.

null

- Pass control to the next statement.

return

- Return control to the calling block and possibly return a value (for a function).

Conditional control

if-then, if-then-else, if-then-elsif

- Conditional processing.

case

- Selects one sequence of statements to execute.

Iterative control

loop *statements* end loop;

while *condition* loop *statements* end loop;

- Executes the loop while *condition* is true.

for *index* in [reverse] *lower_bound..upper_bound* loop *statements* end loop;

- Iterates over a range of integers starting either from *lower_bound* to *upper_bound* or in *reverse* order.

exit / exit when *condition*

- Exits current loop completely either unconditionally or when *condition* is true.

continue / continue when *condition*

- Exits current loop iteration and continues with the next iteration either unconditionally or when *condition* is true.

If-Then-Else Example (1)

```
create or replace procedure IncrementRoomNumber as
    room    Department.roomNo%type; -- room is of type roomNo
begin
    select roomNo into room from Department where departmentId='COMP';
    if (room>3000 and room<4000) then
        update Department set roomNo=room+1000 where departmentId='COMP';
    else
        update Department set roomNo=5528 where departmentId='COMP';
    end if;
end;
```

This procedure adds 1000 to the room number of the COMP department if the room starts with 3. The room number is set to 5528 if the room number does not start with 3.

If-Then-Else Example (2)

```
create or replace procedure IncrementRoomNumber as
    room Department.roomNo%type; -- room is of type roomNo
begin
    -- Incorrect use of select statement
⇒   room := select roomNo from Department where departmentId='COMP';
    if (room>3000 and room<4000) then
        update Department set roomNo=room+1000 where departmentId='COMP';
    else
        update Department set roomNo=5528 where departmentId='COMP';
    end if;
end;
```

Cannot assign the result of a select statement to a variable as in the highlighted line since the result of a select statement is always a table even if the table contains only one value.

Loop Example

- Insert values 1 to 10 into table Testloop.

```
create or replace procedure LoopTest as
    i    Testloop.testValue%type := 1; -- i is of type testValue and is initialized to 1
begin
    loop
        insert into Testloop values (i);
        i := i + 1;
        exit when i > 10;
    end loop;
end;
```

Note: A loop can be terminated by the exit or exit when keywords.

Loop Label Example

- A loop label appears at the beginning of a loop statement enclosed by double angle brackets.

```
create or replace procedure LoopTest as
    i    Testloop.testValue%type := 1; -- i is of type testValue and is initialized to 1
begin
    «myLoop»
    loop
        insert into Testloop values (i);
        i := i + 1;
        exit myLoop when i > 10;
    end loop;
end;
```

Note: Several levels of nested loops can be terminated using a loop label.

For-Loop Example

- Increase the number of projectors in a department based on a loop counter i.

```
create or replace procedure IncrementProjectors as
    i    number(2) := 1;
begin
    for var in (select * from Facility order by departmentId) loop
        update Facility set numberComputers = numberComputers + i
            where departmentId=var.departmentId;
        i := i + 1;
    end loop;
end;
```

Note: In this example the for-loop acts like a for-each-loop where var is assigned the next record in the result of the select statement in each iteration of the for-loop.

Cursors

http://www.techonthenet.com/oracle/cursors/

- □ If a select statement returns more than one record, a cursor is needed to process the result records one-at-a-time.
- □ A cursor is like a pointer that points to a single record in the result of a select statement.
- □ When used with the for-loop statement, the cursor iterates over the result records one-at-a-time allowing the values in a record to be accessed and manipulated.
- □ A cursor is declared in the declare section using the syntax:

  cursor *cursor_name* is *select_statement;*

  Example: Declare a cursor that retrieves all the Facility table records.

  ```
  cursor facilityCursor is select * from Facility;
  ```

How to Use Cursors

- □ **Explicit cursor**
  - Is activated by the open command.
  - Fetches records one-at-a-time using the fetch command.
  - The status %notfound returns true when all the records are fetched.
  - Needs to be closed with the close command so as to free up resources.
- □ **Implicit cursor**
  - Is activated using the for-loop statement.
  - The *cursor_name* replaces the range limit so the loop ranges from the first record of the cursor to the last record of the cursor.

Cursor Status

- The possible values of a cursor status are:
  - Determine whether the previous fetch failed.

    cursor_name%notfound
  - Determine whether the previous fetch succeeded.

    cursor_name%found
  - Determine the number of records fetched so far.

    cursor_name%rowcount
  - Determine whether the cursor is still open.

    cursor_name%isopen

Explicit Cursor Example

```
create or replace procedure InsertExample as
    varDeptId        Facility.departmentId%type;
    varComputers   Facility.numberComputers%type;
    cursor facilityCursor is select departmentId, numberComputers from Facility;
begin
    open facilityCursor;
    loop
        fetch facilityCursor into varDeptId, varComputers;
        exit when facilityCursor%notfound;
        insert into ResultTable values (varDeptId, varComputers);
    end loop;
    close facilityCursor;
end;
```

The facilityCursor retrieves records from the Facility table and inserts the values one-by-one into another table called ResultTable.

Implicit (For-Loop) Cursor Example (1)

```
create or replace procedure InsertExample as
    varDeptId       Facility.departmentId%type;
    varComputers    Facility.numberComputers%type;
    cursor facilityCursor is select departmentId, numberComputers from Facility;
begin
    for record in facilityCursor loop
        varDeptId := record.departmentId;
        varComputers := record.numberComputers;
        insert into ResultTable values (varDeptId, varComputers);
    end loop;
end;
```

Each time through the for-loop, the variable record is assigned the next record from the cursor faciltyCursor which contains the result of the select statement.

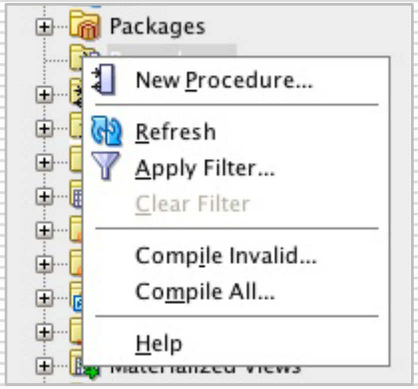
This is the same example as on the previous slide, but using a for-loop, which automatically opens the cursor, exits the loop when there are no more records in the cursor and closes the cursor.

Implicit (For-Loop) Cursor Example (2)

- The FacilityCursor on the previous slide is automatically opened by the for-loop.
- The variable record is of data type rowtype, but there is no need to declare it.
- Code inside the for-loop is executed once for each row of the cursor, and each time the two attributes departmentId, and departmentName are copied into record.
- The data in record can be accessed directly (as shown in the code).
- The for-loop terminates automatically once all the records in the cursor are fetched.
- The cursor is then closed automatically.

Creating A Procedure/Function (1)

- In the Connections navigator pane,
  - right-click the Procedures or Functions node;
  - select New Procedure… or New Function… in the context menu as shown to the right.

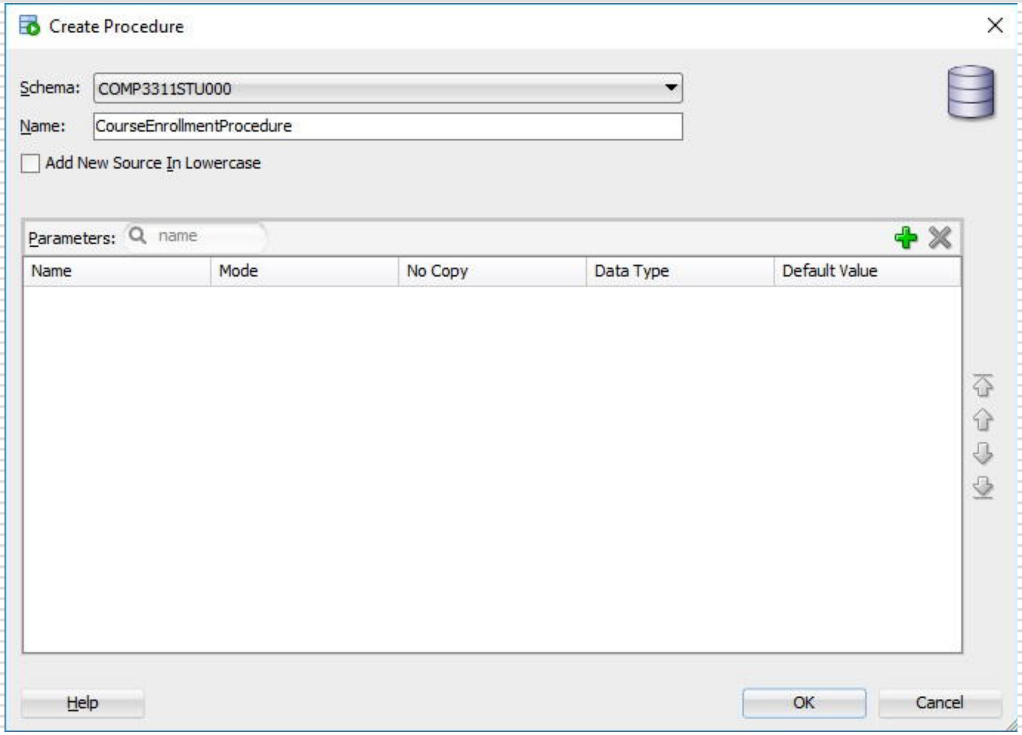


- In the Create Procedure dialog, shown on the next slide,
  - enter a name for the procedure (e.g., CourseEnrollmentReport);
  - specify any parameters by clicking the + symbol to add a parameter and specifying a name, mode, datatype and possibly a default value for the parameter;
  - click the **OK** button.

Creating A Procedure/Function (2)

- An outline of the procedure with a NULL executable section is created as shown in the figure at the bottom right.

- Add any declarations before the BEGIN statement and executable code between the BEGIN and END statements as shown on the next slide.



Create Procedure

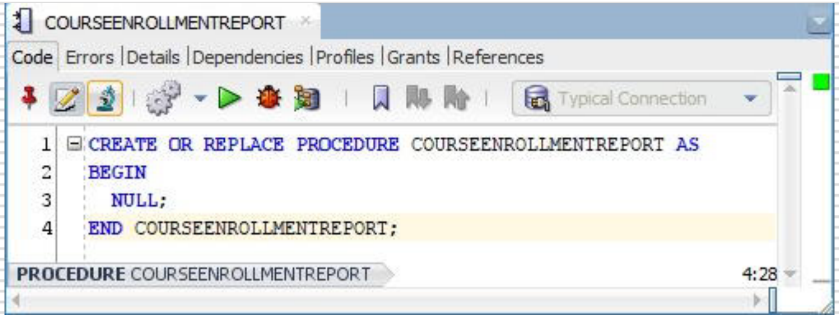
Schema: COMP3311STU000

Name: CourseEnrollmentProcedure

☐ Add New Source In Lowercase

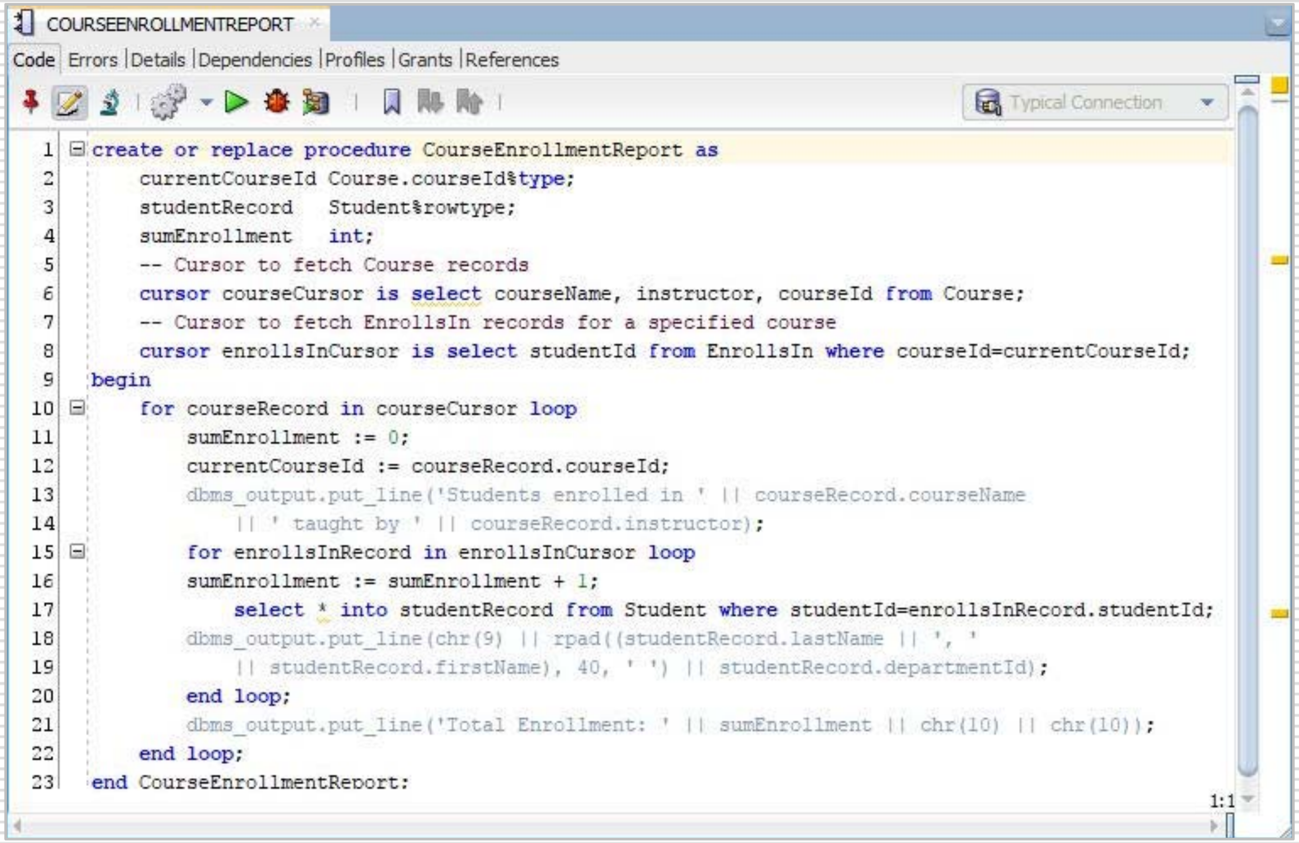
Parameters: name

Name	Mode	No Copy	Data Type	Default Value



```
CREATE OR REPLACE PROCEDURE COURSEENROLLMENTREPORT AS
BEGIN
  NULL;
END COURSEENROLLMENTREPORT;
```

Creating A Procedure/Function (3)

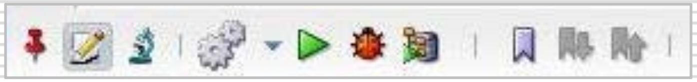


```
create or replace procedure CourseEnrollmentReport as
    currentCourseId Course.courseId%type;
    studentRecord   Student%rowtype;
    sumEnrollment   int;
    -- Cursor to fetch Course records
    cursor courseCursor is select courseName, instructor, courseId from Course;
    -- Cursor to fetch EnrollsIn records for a specified course
    cursor enrollsInCursor is select studentId from EnrollsIn where courseId=currentCourseId;
begin
    for courseRecord in courseCursor loop
        sumEnrollment := 0;
        currentCourseId := courseRecord.courseId;
        dbms_output.put_line('Students enrolled in ' || courseRecord.courseName
            || ' taught by ' || courseRecord.instructor);
        for enrollsInRecord in enrollsInCursor loop
        sumEnrollment := sumEnrollment + 1;
            select * into studentRecord from Student where studentId=enrollsInRecord.studentId;
        dbms_output.put_line(chr(9) || rpad((studentRecord.lastName || ', '
            || studentRecord.firstName), 40, ' ') || studentRecord.departmentId);
        end loop;
        dbms_output.put_line('Total Enrollment: ' || sumEnrollment || chr(10) || chr(10));
    end loop;
end CourseEnrollmentReport;
```

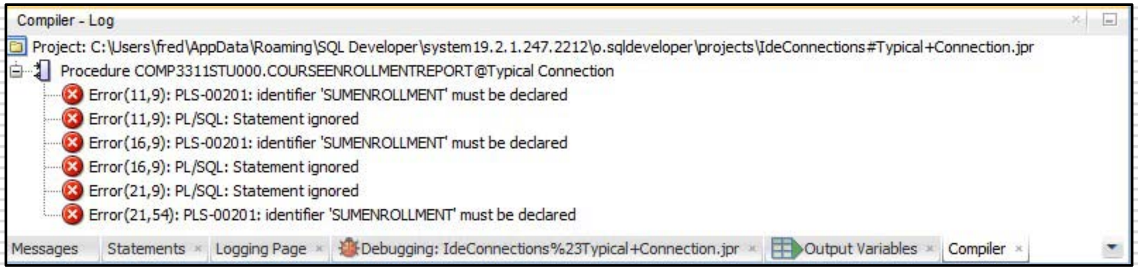
IMPORTANT

The name of the procedure must match exactly the name following the final **END** statement.

Code Editor Toolbar



- The PL/SQL Code Editor toolbar contains the following buttons (among others).
  - Compile compiles the procedure/function possibly for debugging. A procedure/function is also automatically compiled whenever it is saved. Any compile errors are displayed in the log of the Compiler tab shown below.



```
Project: C:\Users\fred\AppData\Roaming\SQL Developer\system19.2.1.247.2212\o.sqldeveloper\projects\IdeConnections#Typical+Connection.jpr
Procedure COMP3311STU000.COURSEENROLLMENTREPORT@Typical Connection
    Error(11,9): PLS-00201: identifier 'SUMENROLLMENT' must be declared
    Error(11,9): PL/SQL: Statement ignored
    Error(16,9): PLS-00201: identifier 'SUMENROLLMENT' must be declared
    Error(16,9): PL/SQL: Statement ignored
    Error(21,9): PL/SQL: Statement ignored
    Error(21,54): PLS-00201: identifier 'SUMENROLLMENT' must be declared
```

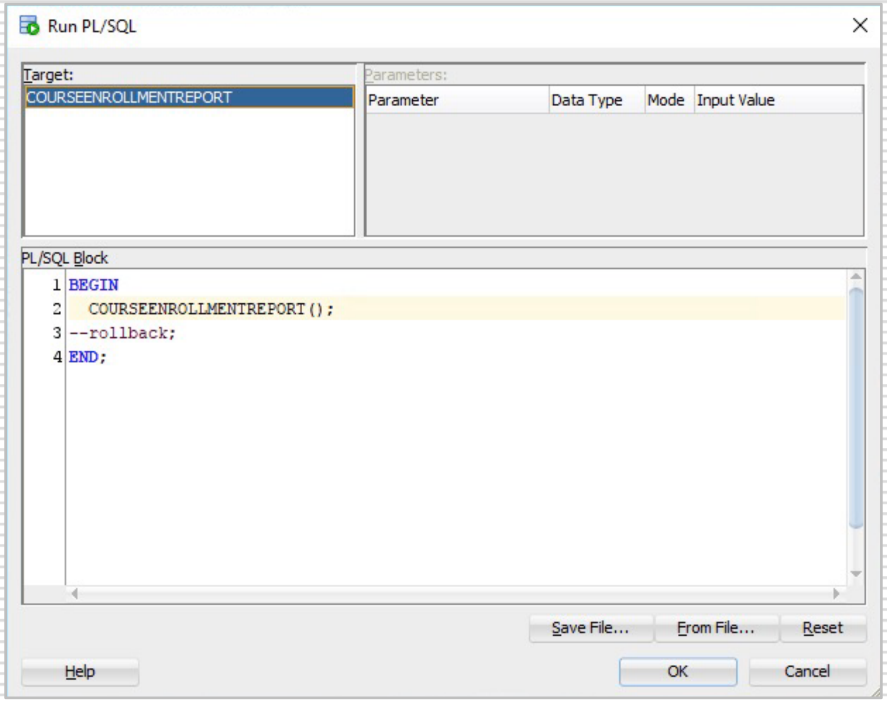
  - Run invokes the Run PL/SQL dialog allowing selection of the procedure/function to run and displaying a list of parameters for the selected procedure/function.
  - Debug runs the procedure/function in debug mode.

Running A Procedure/Function

- To run a procedure/ function, click the ▶ (**Run**) button or the 🐞 (**Debug**) button. Note that a procedure/function must be compiled as Compile for Debug to be run in debug mode.

- The Run PL/SQL dialog appears as shown on the right where the values of any required parameters can be provided.

- Click the **OK** button to run the procedure.

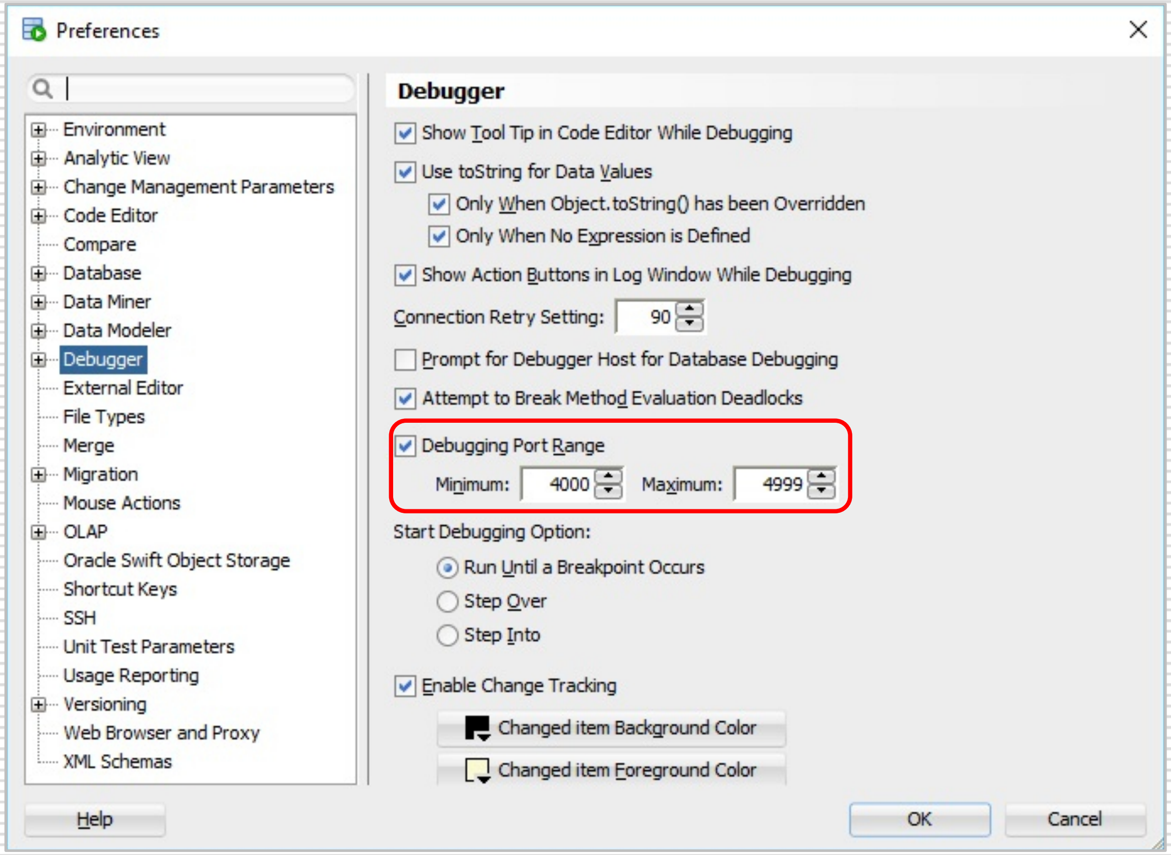


Target: COURSEENROLLMENTREPORT

```
BEGIN
  COURSEENROLLMENTREPORT();
--rollback;
END;
```

Enabling Debugging

- To enable debugging:
  - open the Preferences dialog.
  - select the Debugger option.
  - select the checkbox Debugging Port Range.
  - click OK.



Debugger

☑ Show Tool Tip in Code Editor While Debugging

☑ Use toString for Data Values

☑ Only When Object.toString() has been Overridden

☑ Only When No Expression is Defined

☑ Show Action Buttons in Log Window While Debugging

Connection Retry Setting: 90

☐ Prompt for Debugger Host for Database Debugging

☑ Attempt to Break Method Evaluation Deadlocks

☑ Debugging Port Range

Minimum: 4000 Maximum: 4999

Start Debugging Option:

● Run Until a Breakpoint Occurs

○ Step Over

○ Step Into

☑ Enable Change Tracking

Changed item Background Color

Changed item Foreground Color

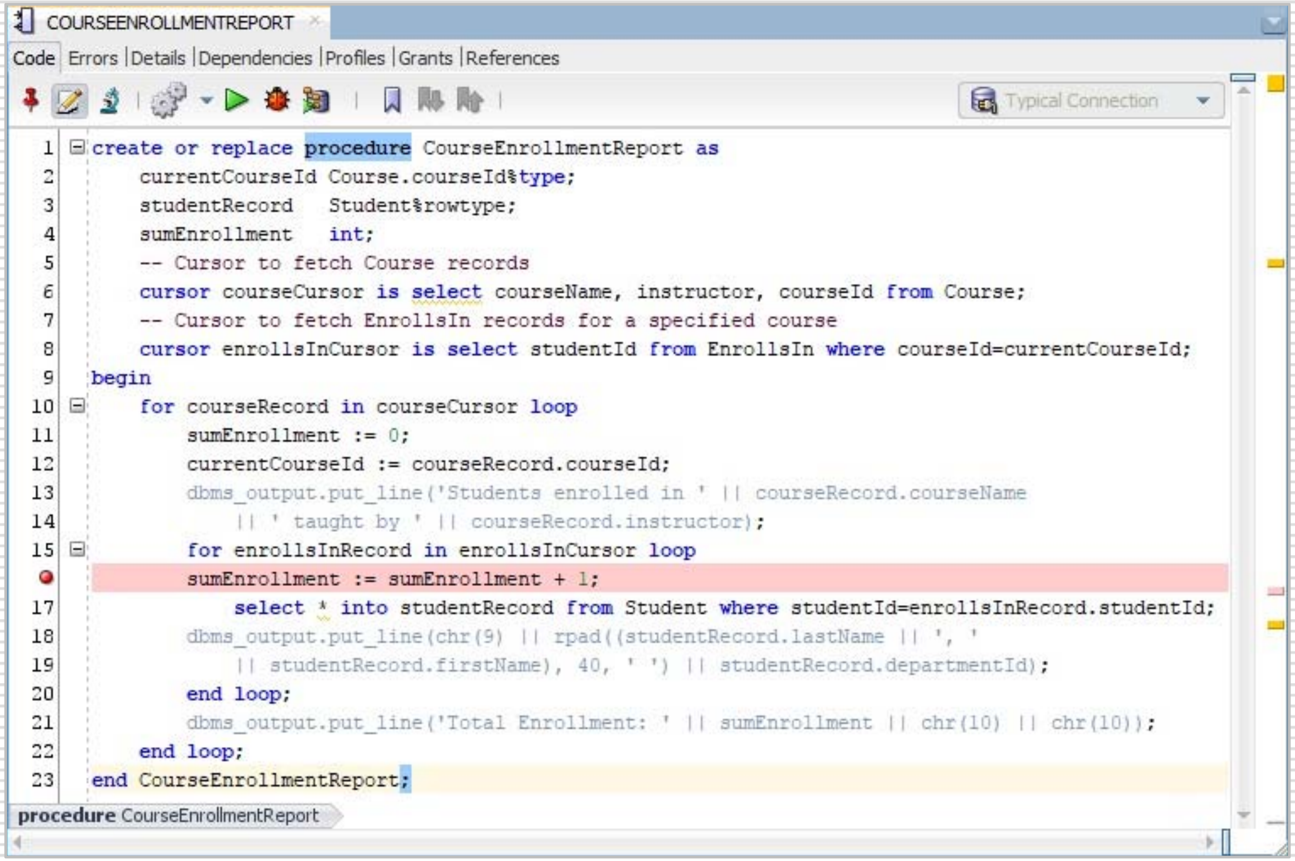
IMPORTANT

It is also necessary to configure your computer's firewall to allow incoming connections from SQL Developer.

Debugging With Breakpoints (1)

- □ To set a breakpoint for debugging, in the line gutter, select the line number of the statement where you want to pause execution as shown in the figure.

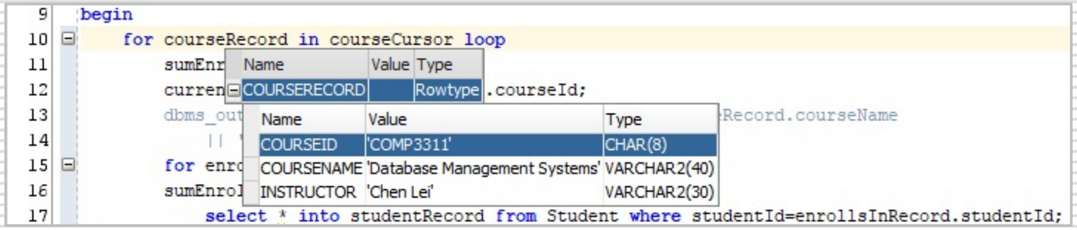
- □ Click the 🐞 (**Debug**) button to run the procedure/ function in debug mode.



```
create or replace procedure CourseEnrollmentReport as
    currentCourseId Course.courseId%type;
    studentRecord   Student%rowtype;
    sumEnrollment   int;
    -- Cursor to fetch Course records
    cursor courseCursor is select courseName, instructor, courseId from Course;
    -- Cursor to fetch EnrollsIn records for a specified course
    cursor enrollsInCursor is select studentId from EnrollsIn where courseId=currentCourseId;
begin
    for courseRecord in courseCursor loop
        sumEnrollment := 0;
        currentCourseId := courseRecord.courseId;
        dbms_output.put_line('Students enrolled in ' || courseRecord.courseName
            || ' taught by ' || courseRecord.instructor);
        for enrollsInRecord in enrollsInCursor loop
        sumEnrollment := sumEnrollment + 1;
            select * into studentRecord from Student where studentId=enrollsInRecord.studentId;
        dbms_output.put_line(chr(9) || rpad((studentRecord.lastName || ', '
            || studentRecord.firstName), 40, ' ') || studentRecord.departmentId);
        end loop;
        dbms_output.put_line('Total Enrollment: ' || sumEnrollment || chr(10) || chr(10));
    end loop;
end CourseEnrollmentReport;
```

Debugging With Breakpoints (2)

- When execution pauses at a breakpoint, the values of variables, including cursors, can be inspected either by hovering the mouse pointer over the variable (figure (a)) or by inspecting the Data tab (figure (b)) or Smart Data tab[1].

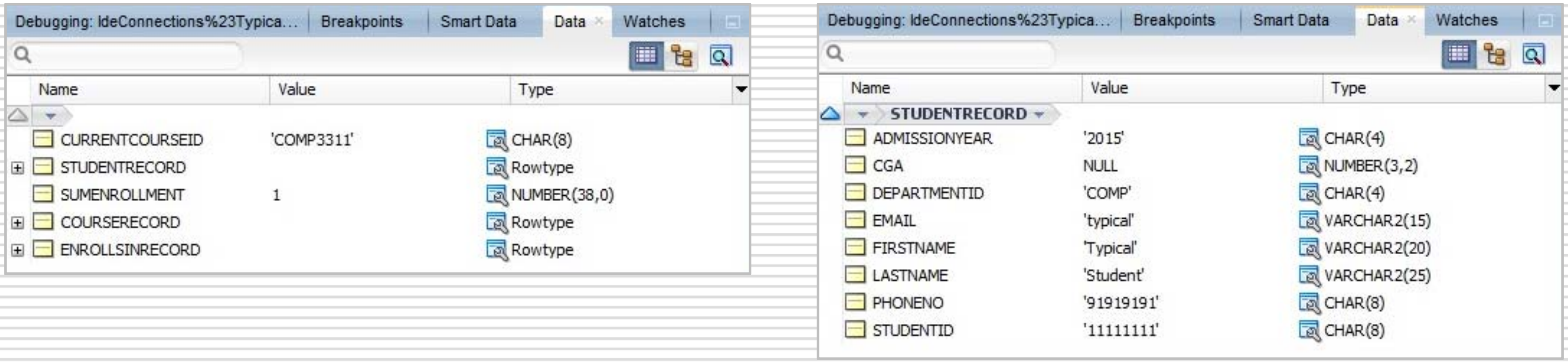


```
begin
    for courseRecord in courseCursor loop
        sumEnr
        curren                                  .courseId;
        dbms_out                                          Record.courseName
            ||
        for enro
        sumEnrol
            select * into studentRecord from Student where studentId=enrollsInRecord.studentId;
```

Name	Value	Type
COURSERECORD		Rowtype

Name	Value	Type
COURSEID	'COMP3311'	CHAR(8)
COURSENAME	'Database Management Systems'	VARCHAR2(40)
INSTRUCTOR	'Chen Lei'	VARCHAR2(30)

(a) inspecting variable values by hovering the mouse cursor over the variable.



Name	Value	Type
CURRENTCOURSEID	'COMP3311'	CHAR(8)
STUDENTRECORD		Rowtype
SUMENROLLMENT	1	NUMBER(38,0)
COURSERECORD		Rowtype
ENROLLSINRECORD		Rowtype

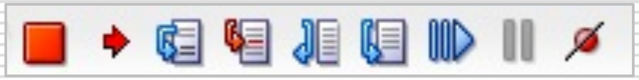
STUDENTRECORD

Name	Value	Type
ADMISSIONYEAR	'2015'	CHAR(4)
CGA	NULL	NUMBER(3,2)
DEPARTMENTID	'COMP'	CHAR(4)
EMAIL	'typical'	VARCHAR2(15)
FIRSTNAME	'Typical'	VARCHAR2(20)
LASTNAME	'Student'	VARCHAR2(25)
PHONENO	'91919191'	CHAR(8)
STUDENTID	'11111111'	CHAR(8)

(b) inspecting variable values in the Data tab.

[1] The Smart Data tab shows only the values of the variables, while the Data tab shows all the data manipulated in the procedure.

Debugging With Breakpoints (3)



- In the Debugging tab, the following buttons are available.
  - Terminate stops the debugging session.
  - Find Execution Point moves the cursor to where the execution has stopped.
  - Step Over moves to the next line in the code.
  - Step Into steps into the line of code selected, causing the debugger to continue inside the method or function of the current line of code.
  - Step Out steps out of the current method or function and returns to the level above.
  - Step To End Of Method goes to the end of the method.
  - Resume continues execution until another error or breakpoint is reached.
  - Pause pauses the debugger at its current statement.
  - Suspend All Breakpoints turns off all breakpoints in the current procedure/ function.