Database Application Development Oracle PL/SQL

CS430/630
Lecture 15

Slides based on "Database Management Systems" 3rd ed, Ramakrishnan and Gehrke

Outline

- Embedded SQL
- Dynamic SQL

Many host languages:
C, Cobol, Pascal, etc.

- JDBC (API)
- SQLJ (Embedded)

Java

- Stored procedures

Stored Procedures

Why Stored Procedures?

- So far, all data processing is done at the client
  - Lots of data may have to be transferred
  - Functionality (code) replicated at each client
  - Lots of state (e.g., locks, transaction data) at the DBMS
    - While client processes the data
- Stored procedures execute in same process space as DBMS
  - Encapsulates application logic and is close to the data
  - Reuse of common functionality by different clients
- Vendors introduced their own procedural extensions
  - e.g., Oracle's PL/SQL

SQL/PSM

- SQL Persistent Stored Modules
  - SQL standard for stored procedures, available in SQL:2003
  - Commercial vendors may offer own extensions of PSM
- Standard language for stored procedures
  - Supports both procedures and functions
  - Functions can return results through RETURN statement
  - Procedures can return results in parameters
- In this course we focus on Oracle PL/SQL

PL/SQL

PL/SQL (Procedural Language SQL)

- Procedural extension to SQL developed by Oracle
  - Most prominent DBMS procedural language
  - Another language is T-SQL from Microsoft (MS SQL)
- Only DML allowed in PL/SQL
  - DDL such as creating or dropping tables NOT allowed
- Basic program structure is a block
  - There can be nested blocks
- PL/SQL syntax is not case sensitive (variable names as well)

PL/SQL Program Structure

```
DECLARE
   variable_declarations
BEGIN
   procedural_code
EXCEPTION
   error_handling
END;
```

PL/SQL in SQL Plus

- Ensure output goes to screen

  SET SERVEROUTPUT ON
- Executing PL/SQL in command line

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

  The / must be by itself on separate line
- DBMS_OUTPUT.PUT_LINE equivalent of printf() in C or System.out.println() in Java

Data Types

- It is possible to use ORACLE SQL types

  NUMBER, VARCHAR, etc
- PL/SQL allows directly referring to a column type

  tablename.columnname%TYPE

  e.g. SAILORS.SNAME%TYPE
- Also possible to define a row type (e.g., tuple)

  tablename%ROWTYPE
- Declaring a variable: <var_name> <TYPE>;

  sailor_rec SAILORS%ROWTYPE;
- Can later refer to individual fields using column names

```
DBMS_OUTPUT.PUT_LINE('Name: ' || sailor_rec.name ||
                 'Age:' || sailor_rec.age);
```

|| means string concatenation (like + in Java)

Assignments and Branches

- Assignment

```
A := B + C;
```

- Branch

```
IF condition  THEN statements;
ELSIF (condition) statements;
ELSIF …
ELSE statements;
END IF;
```

Branch Example

```
DECLARE
   A  NUMBER(6) := 10;
   B  NUMBER(6);
BEGIN
   A  :=  23;
   B  :=  A  *  5;
   IF  A  <  B  THEN
       DBMS_OUTPUT.PUT_LINE(A || ' is  less  than ' || B);
   ELSE
       DBMS_OUTPUT.PUT_LINE(B || ' is less-or-equal than ' || A);
   END  IF;
END;
```

- Output is: 23 is less than 115

Branch Example (2)

```
DECLARE
   NGRADE  NUMBER;
   LGRADE  CHAR(2);
BEGIN
   NGRADE  :=  82.5;
   IF  NGRADE  >  95  THEN
       LGRADE  :=  'A+';
   ELSIF  NGRADE  >  90  THEN
       LGRADE  :=  'A';
   ELSIF  NGRADE  >  85  THEN
       LGRADE  :=  'B+';
   ELSIF  NGRADE  >  80  THEN
       LGRADE  :=  'B';
   ELSE
       LGRADE  :=  'F';
END  IF;
```

Loops

```
LOOP                              LOOP
   statements                        statements
IF  condition  THEN               EXIT  WHEN  condition;
   EXIT;                             statements
END  IF;                          END  LOOP;
   statements
END  LOOP;
```

Loop Example

```
DECLARE
   J  NUMBER(6);
BEGIN
   J  :=  1;
   LOOP
       DBMS_OUTPUT.PUT_LINE('J=  ' || J);
       J  :=  J  +  1;
       EXIT  WHEN  J > 5;
       DBMS_OUTPUT.PUT_LINE('J=  ' || J);
   END  LOOP;
END;
```

Output = ?

Loop Variants

```
WHILE  condition
LOOP
   various_statements
END  LOOP;

FOR  counter  IN  startvalue  ..  endvalue
LOOP
   various_statements
END  LOOP;
```

"For Loop" Example

```
BEGIN
   FOR  K  IN  1..5
   LOOP
       DBMS_OUTPUT.PUT_LINE('K=  ' || K);
   END  LOOP;
END;
```

SQL Statements

- Data can be manipulated (DML) from PL/SQL
  - SELECT must have INTO when cursors not used

```
DECLARE
   SID  NUMBER(6);
BEGIN
   SID  :=  20;
   INSERT  INTO  Sailors  (sid, name) VALUES  (SID, 'Rusty');
   SID  :=  SID  +  1;
   INSERT  INTO  Sailors  (sid, name) VALUES  (SID, 'Yuppy');
END;
```

SQL Statements – retrieving data

- As before, there are two cases

1. Single-tuple result (the "easy" case)

```
SELECT  selectfields  INTO  declared_variables
FROM  table_list  WHERE  search_criteria;

DECLARE
  VAR_NAME  Sailors.name%TYPE;
  VAR_AGE     Sailors.age%TYPE;
BEGIN
  SELECT  name, age INTO  VAR_NAME, VAR_AGE
  FROM  Sailors WHERE  SID  =  10;
  DBMS_OUTPUT.PUT_LINE('Age of  '  ||  VAR_NAME  ||  '  is  '  ||
  VAR_AGE);
END;
```

SQL Statements – retrieving data

2. Multiple-tuples result: ***cursors*** are needed

```
CURSOR  cursorname  IS  SELECT_statement;

OPEN  cursorname;
FETCH  cursorname  INTO  variable_list;
CLOSE  cursorname;
```

Cursor Example

```
DECLARE
  S  Sailors%ROWTYPE;
  CURSOR  SAILORCURSOR  IS
     SELECT  *  FROM  Sailors;
BEGIN
  OPEN  SAILORCURSOR;
  LOOP
     FETCH  SAILORCURSOR  INTO  S;
     EXIT  WHEN SAILORCURSOR %NOTFOUND;
     DBMS_OUTPUT.PUT_LINE('AGE  OF  '  ||  S.sname  ||  '
     IS  '  ||  S.age);
  END  LOOP;
  CLOSE SAILORCURSOR ;
END;
```

Cursor Attributes

%NOTFOUND: Evaluates to TRUE when cursor has no more rows to read. FALSE otherwise

%FOUND: Evaluates to TRUE if last FETCH was successful and FALSE otherwise

%ROWCOUNT: Returns the number of rows that the cursor has already fetched from the database

%ISOPEN: Returns TRUE if this cursor is already open, and FALSE otherwise

Declaring a Procedure

```
CREATE  OR  REPLACE
PROCEDURE  procedure_name  (  parameters  )  IS
  variable declarations
BEGIN
  procedure_body
END;
```

- Parameters can be IN, OUT or INOUT, default is IN

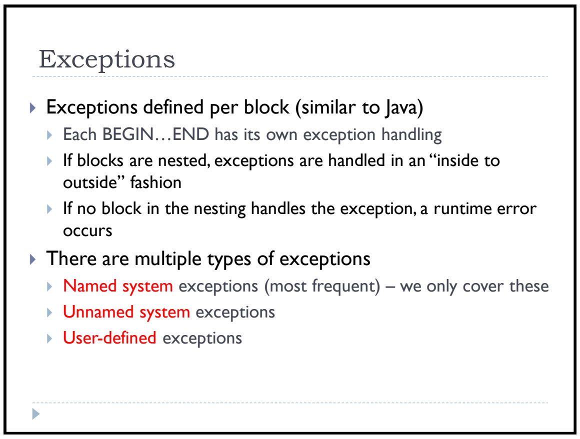
```
CREATE  OR  REPLACE
PROCEDURE  SUM_AB  (A  INT,  B  INT,  C  OUT  INT)  IS
BEGIN
     C  :=  A  +  B;
END;
```

Declaring a Function

```
CREATE  OR  REPLACE
FUNCTION  function_name  (function_params)  RETURN  return_type  IS
  variable declarations
BEGIN
  function_body
  RETURN  something_of_return_type;
END;
```

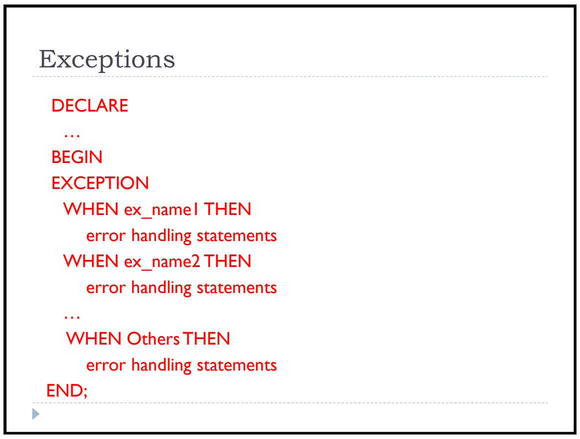
- Example

```
CREATE  OR  REPLACE
FUNCTION  ADD_TWO  (A  INT, B  INT)  RETURN  INT  IS
BEGIN
     RETURN  (A  +  B);
END;
```



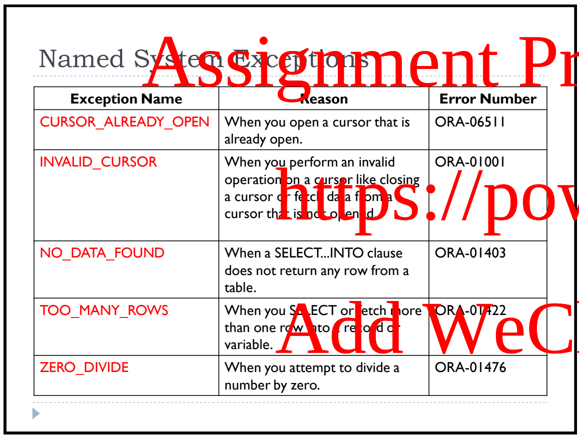
Exceptions

- Exceptions defined per block (similar to Java)
  - Each BEGIN…END has its own exception handling
  - If blocks are nested, exceptions are handled in an "inside to outside" fashion
  - If no block in the nesting handles the exception, a runtime error occurs
- There are multiple types of exceptions
  - Named system exceptions (most frequent) – we only cover these
  - Unnamed system exceptions
  - User-defined exceptions



Exceptions

```
DECLARE
 …
BEGIN
EXCEPTION
  WHEN ex_name1 THEN
     error handling statements
  WHEN ex_name2 THEN
     error handling statements
  …
  WHEN Others THEN
     error handling statements
END;
```



Named System Exceptions

Exception Name	Reason	Error Number
CURSOR_ALREADY_OPEN	When you open a cursor that is already open.	ORA-06511
INVALID_CURSOR	When you perform an invalid operation on a cursor like closing a cursor or fetch data from a cursor that is not opened.	ORA-01001
NO_DATA_FOUND	When a SELECT...INTO clause does not return any row from a table.	ORA-01403
TOO_MANY_ROWS	When you SELECT or fetch more than one row into a record or variable.	ORA-01422
ZERO_DIVIDE	When you attempt to divide a number by zero.	ORA-01476