Assignment

Assign expressions to declared variables with `:=`.

Branches

```
IF <condition> THEN
    <statement(s)>
ELSE
    <statement(s)>
END IF;
```

- But in nests, use `ELSIF` in place of `ELSE IF`.

Loops

```
LOOP
        . . .
    EXIT WHEN <condition>
        . . .
END LOOP;
```

Queries in PL/SQL

1. *Single-row selects* allow retrieval into a variable of the result of a query that is guaranteed to produce one tuple.

2. *Cursors* allow the retrieval of many tuples, with the cursor and a loop used to process each in turn.

Single-Row Select

- Select-from-where in PL/SQL *must* have an `INTO` clause listing variables into which a tuple can be placed.
- It is an *error* if the select-from-where returns more than one tuple; you should have used a cursor.

Example

Find the price Joe charges for Bud (and drop it on the floor).

```
Sells(bar, beer, price)

DECLARE
    p Sells.price%TYPE;
BEGIN
    SELECT price
    INTO p
    FROM Sells
    WHERE bar = 'Joe''s Bar' AND
        beer = 'Bud';
END;
.
run
```

Cursors

Declare by:

```
CURSOR <name> IS
    select-from-where statement
```

- Cursor gets each tuple from the relation produced by the select-from-where, in turn, using a *fetch statement* in a loop.
    - Fetch statement:

      ```
      FETCH <cursor name> INTO
          variable list;
      ```

- Break the loop by a statement of the form:

  ```
  EXIT WHEN <cursor name>%NOTFOUND;
  ```

    - True when there are no more tuples to get.

- Open and close the cursor with `OPEN` and `CLOSE`.

Example

A procedure that examines the menu for Joe's Bar and raises by $1.00 all prices that are less than $3.00.

```
Sells(bar, beer, price)
```

- This simple price-change algorithm can be implemented by a single `UPDATE` statement, but more complicated price changes could not.

```
CREATE PROCEDURE joeGouge() AS
        theBeer Sells.beer%TYPE;
        thePrice Sells.price%TYPE;
        CURSOR c IS
            SELECT beer, price
            FROM Sells
            WHERE bar = 'Joe''s bar';
    BEGIN
        OPEN c;
        LOOP
            FETCH c INTO theBeer, thePrice;
            EXIT WHEN c%NOTFOUND;
            IF thePrice < 3.00 THEN
                UDPATE Sells
                SET price = thePrice + 1.00
                WHERE bar = 'Joe''s Bar'
                    AND beer = theBeer;
            END IF;
        END LOOP;
        CLOSE c;
    END;
.
run
```

Row Types

Anything (e.g., cursors, table names) that has a tuple type can have its type captured with `%ROWTYPE`.

- We can create temporary variables that have tuple types and access their components with dot.
- Handy when we deal with tuples with many attributes.

Example

The same procedure with a tuple variable `bp`.

```
CREATE PROCEDURE joeGouge() AS
        CURSOR c IS
            SELECT beer, price
            FROM Sells
            WHERE bar = 'Joe''s bar';
        bp c%ROWTYPE;
    BEGIN
        OPEN c;
        LOOP
            FETCH c INTO bp;
            EXIT WHEN c%NOTFOUND;
            IF bp.price < 3.00 THEN
                UDPATE Sells
                SET price = bp.price + 1.00
                WHERE bar = 'Joe''s Bar'
                    AND beer = bp.beer;
            END IF;
        END LOOP;
        CLOSE c;
    END;
.
run
```

SQL2 Embedded SQL

Add to a conventional programming language (C in our examples) certain statements that represent SQL operations.

- Each embedded SQL statement introduced with `EXEC SQL`.
- Preprocessor converts C + SQL to pure C.
  - SQL statements become procedure calls.

Shared Variables

A special place for C declarations of variables that are accessible to both SQL and C.

- Bracketed by

  ```
  EXEC SQL BEGIN/END DECLARE SECTION;
  ```

- In Oracle Pro/C (not C++) the "brackets" are optional.
- In C, variables used normally; in SQL, they must be preceded by a colon.

Example

Find the price for a given beer at a given bar.

```
Sells(bar, beer, price)

EXEC SQL BEGIN DECLARE SECTION;
    char theBar[21], theBeer[21];
    float thePrice;
EXEC SQL END DECLARE SECTION;
            . . .
/* assign to theBar and theBeer */
            . . .
EXEC SQL SELECT price
    INTO :thePrice
    FROM Sells
    WHERE beer = :theBeer AND
        bar = :theBar;
            . . .
```

Cursors

Similar to PL/SQL cursors, with some syntactic differences.

Example

Print Joe's menu.

```
Sells(bar, beer, price)

EXEC SQL BEGIN DECLARE SECTION;
    char theBeer[21];
    float thePrice;
EXEC SQL END DECLARE SECTION;
EXEC SQL DECLARE c CURSOR FOR
    SELECT beer, price
    FROM Sells
    WHERE bar = 'Joe''s Bar';
EXEC SQL OPEN CURSOR c;
while(1) {
    EXEC SQL FETCH c
        INTO :theBeer, :thePrice;
    if(NOT FOUND) break;
/* format and print beer and price */
}
EXEC SQL CLOSE CURSOR c;
```

Oracle Vs. SQL2 Features

- SQL2 expects `FROM` in fetch-statement.
- SQL2 defines an array of characters `SQLSTATE` that is set every time the system is called.
  - Errors are signaled there.
  - A failure for a cursor to find any more tuples is signaled there.
  - However, Oracle provides us with a header file `sqlca.h` that declares a *communication area* and defines macros to access it.
  - In particular, `NOT FOUND` is a macro that says "the no-tuple-found signal was set."

Dynamic SQL

Motivation:

- Embedded SQL is fine for fixed applications, e.g., a program that is used by a sales clerk to book an airline seat.

- It fails if you try to write a program like `sqlplus`, because you have compiled the code for `sqlplus` before you see the SQL statements typed in response to the `SQL>` prompt.

- Two special statements of embedded SQL:

  - `PREPARE` turns a character string into an SQL query.

  - `EXECUTE` executes that query.

Example: Sqlplus Sketch

```
EXEC SQL BEGIN DECLARE SECTION;
    char query[MAX_QUERY_LENGTH];
EXEC SQL END DECLARE SECTION;

/* issue SQL> prompt */

/* read user's text into array query */

EXEC SQL PREPARE q FROM :query;
EXEC SQL EXECUTE q;
/* go back to reissue prompt */
```

- Once prepared, a query can be executed many times.
  - ❖ "Prepare" = optimize the query, e.g., find a way to execute it using few disk-page I/O's.
- Alternatively, `PREPARE` and `EXECUTE` can be combined into:

```
EXEC SQL EXECUTE IMMEDIATE :query;
```