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

  \texttt{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.

\[
\text{Sells(bar, beer, price)}
\]

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

- SQL expects **FROM** in fetch-statement.
- SQL 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

```sql
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:

  ```sql
  EXEC SQL EXECUTE IMMEDIATE :query;
  ```
Call-Level Interfaces

A more modern approach to the host-language/SQL connection is a call-level interface, in which the C (or other language) program creates SQL statements as character strings and passes them to functions that are part of a library.

- Similar to what really happens in embedded SQL implementations.
- Two major approaches: SQL/CLI (standard of ODBC = open database connectivity) and JDBC (Java database connectivity).
CLI

- In C, library calls let you create a *statement handle* = struct in which you can place an SQL statement.
  
  ✦ See text.

- Use `SQLPrepare(myHandle, <statement>, ...)` to make `myHandle` represent the SQL statement in the second argument.

- Use `SQLEexecute(myHandle)` to execute that statement.

Example

```c
SQLPrepare(handle1, "SELECT beer, price
  FROM Sells
  WHERE bar = 'Joe’s Bar', ...");
SQLEexecute(handle1);
```
Fetching Data

To obtain the data returned by an executed query, we:

1. Bind variables to the component numbers of the returned query.
   - `SQLBindCol` applies to a handle, column number, and variable, plus other arguments (see text).

2. Fetch, using the handle of the query’s statement.
   - `SQLFetch` applies to a handle.

Example

```sql
SQLBindCol(handle1, 1, SQL_CHAR, &theBar,...)
SQLBindCol(handle1, 2, SQL_REAL, &thePrice,...)
SQLExecute(handle1);
...
while(SQLFetch(handle1) != SQL_NO_DATA) {
    ...
```
JDBC

- Start with a *Connection* object, obtained from the DBMS (see text).
- Method `createStatement()` returns an object of class *Statement* (if there is no argument) or *PreparedStatement* if there is an SQL statement as argument.

Example

```java
Statement stat1 = myCon.createStatement();
PreparedStatement stat2 =
    myCon.createStatement(
        "SELECT beer, price " +
        "FROM Sells " +
        "WHERE bar = 'Joe’s Bar'"
    );
```

- `myCon` is a connection, `stat1` is an “empty” statement object, and `stat2` is a (prepared) statement object that has an SQL statement associated.
Executing Statements

- JDBC distinguishes queries (statements that return data) from updates (statements that only affect the database).

- Methods `executeQuery()` and `executeUpdate()` are used to execute these two kinds of SQL statements.
  - They must have an argument if applied to a `Statement`, never if applied to a `PreparedStatement`.

- When a query is executed, it returns an object of class `ResultSet`.

Example

```java
stat1.executeUpdate(
    "INSERT INTO Sells " +
    "VALUES('Brass Rail', 'Bud', 3.00)"
);
ResultSet Menu = stat2.executeQuery();
```
Getting the Tuples of a ResultSet

- Method `Next()` applies to a `ResultSet` and moves a “cursor” to the next tuple in that set.
  - Apply `Next()` once to get to the first tuple.
  - `Next()` returns `FALSE` if there are no more tuples.

- While a given tuple is the current of the cursor, you can get its `i`th component by applying to a `ResultSet` a method of the form `getX(i)`, where `X` is the name for the type of that component.

Example

```java
while(Menu.Next()) {
    theBeer = Menu.getString(1);
    thePrice = Menu.getFloat(2);
    ...
}
```