Alternative to Embedded SQL

• What if we want to compile an application without the need for a DBMS-specific pre-compiler?

• Use a library of database calls
  – Standardized (non-DBMS-specific) API
  – Pass SQL-strings from host language and presents result sets in a language friendly way
  – Eg. ODBC for C/C++ and JDBC for Java
  – DBMS-neutral
  • A driver traps the calls and translates them into DBMS-specific code
ODBC/JDBC Architecture

• **Application**
  – Initiates connections
  – Submits SQL statements
  – Terminates connections

• **Driver Manager**
  – Loads the right JDBC driver

• **Driver**
  – Connects to the data source,
  – Transmit requests,
  – Returns results and error codes

• **Data Source**
  – DBMS
4 Types of Drivers

• Type I: Bridge
  – Translate SQL commands to non-native API
  – eg. JDBC-ODBC bridge. JDBC is translated to ODBC to access an ODBC compliant data source.

• Type II: Direct Translation to native API via non-Java driver
  – Translates SQL to native API of data source.
  – Needs DBMS-specific library on each client.

• Type III: Network bridge
  – SQL stmts sent to a middleware server that talks to the data source. Hence small JDBC driver at each client

• Type IV: Direct Translation to native API via Java driver
  – Converts JDBC calls to network protocol used by DBMS.
  – Needs DBMS-specific Java driver at each client.
High Level Steps

1. Load the ODBC/JDBC driver
2. Connect to the data source
3. [optional] Prepare the SQL statements
4. Execute the SQL statements
5. Iterate over the resultset
6. Close the connection
Getting Data to/fro Host Language

• No declaration of shared variables
• Variables in host language is bound to columns of a SQL cursor
• ODBC
  – SQLBindCol – gets data from SQL environment to host variables.
  – SQLBindParameter – gets data from host variables to SQL environment
• JDBC
  – ResultSet class
  – PreparedStatement class
Prepare Statement or Not?

- Executing without preparing statement
  - After DBMS receives SQL statement,
    - The SQL is compiled,
    - An execution plan is chosen by the optimizer,
    - The execution plan is evaluated by the DBMS engine
    - The results are returned

- `conn.prepareStatement`
  - Compiles and picks an execution plan

- `pstmt.executeUpdate`
  - Evaluates the execution plan with the parameters and gets the results

```java
String sql="SELECT * FROM books WHERE price < ?";
PreparedStatement pstmt = conn.prepareStatement(sql);
pstmt.setFloat(1, usermaxprice);
pstmt.executeUpdate();
```

cf. Static vs Dynamic SQL
Iterate over the results of a SQL statement -- cf. cursor

Note that types of column values do not need to be known at compile time

```
ResultSet rs = stmt.executeQuery(sqlstr);
while (rs.next()) {
    col1val = rs.getString(1); ...}
```

<table>
<thead>
<tr>
<th>SQL Type</th>
<th>Java Class</th>
<th>accessor</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIT</td>
<td>Boolean</td>
<td>getBoolean</td>
</tr>
<tr>
<td>CHAR, VARCHAR</td>
<td>String</td>
<td>getString</td>
</tr>
<tr>
<td>DOUBLE, FLOAT</td>
<td>Double</td>
<td>getDouble</td>
</tr>
<tr>
<td>INTEGER</td>
<td>Integer</td>
<td>getInt</td>
</tr>
<tr>
<td>REAL</td>
<td>Double</td>
<td>getFloat</td>
</tr>
<tr>
<td>DATE</td>
<td>Java.sql.Date</td>
<td>getDate</td>
</tr>
<tr>
<td>TIME</td>
<td>Java.sql.Time</td>
<td>getTime</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>Java.sql.Timestamp</td>
<td>getTimestamp</td>
</tr>
</tbody>
</table>
RowSet

• When inserting lots of data, calling an execute statement for each row can be inefficient
  – A message is sent for each execute
• Many APIs provide a rowset implementation
  – A set of rows is maintained in-memory on the client
  – A single execute will then insert the set of rows in a single message
• Pros: high performance
• Cons: data can be lost if client crashes.
• Analogous rowset for reads (ie. ResultSet) also available
Stored Procedures

• What?
  – A procedure that is called and executed via a single SQL statement
  – Executed in the same process space of the DBMS server
  – Can be programmed in SQL, C, java etc
  – The procedure is stored within the DBMS

• Advantages:
  – Encapsulate application logic while staying close to the data
  – Re-use of application logic by different users
  – Avoid tuple-at-a-time return of records through cursors
CREATE PROCEDURE ShowNumReservations
    SELECT S.sid, S.sname, COUNT(*)
    FROM Sailors S, Reserves R
    WHERE S.sid = R.sid
    GROUP BY S.sid, S.sname

• Parameters modes: IN, OUT, INOUT

CREATE PROCEDURE IncreaseRating ( IN sailor_sid INTEGER, IN increase INTEGER )
UPDATE Sailors
    SET rating = rating + increase
    WHERE sid = sailor_sid
Java Stored Procedures

CREATE PROCEDURE TopSailors ( 
    IN num INTEGER)

LANGUAGE JAVA

EXTERNAL NAME

“file:///c:/storedProcs/rank.jar”
Calling Stored Procedures

• SQL: **CALL** IncreaseRating(101, 2);

• Embedded SQL in C:
  EXEC SQL BEGIN DECLARE SECTION
  int sid; int rating;
  EXEC SQL END DECLARE SECTION
  EXEC SQL CALL IncreaseRating(:sid, :rating);

• JDBC
  CallableStatement cst = conn.prepareCall("{call Show Sailors}");
  ResultSet rs = cst.executeQuery();

• ODBC
  SQLCHAR *stmt = (SQLCHAR *)"CALL ShowSailors";
  cliRC = SQLPrepare(hstmt, stmt, SQL_NTS);
  cliRC = SQLExecute(hstmt);
User Defined Functions (UDFs)

• Extend and add to the support provided by SQL built-in functions

• Three types of UDFs
  – **Scalar**: returns a single-valued answer. Eg. Building SUBSTR()
  – **Column**: returns a single-valued answer from a column of values. Eg. AVG()
  – **Table**: returns a table. Invoked in the FROM clause.

• Programable in SQL, C, JAVA.
Scalar UDFs

- Returns the tangent of a value

```sql
CREATE FUNCTION TAN (X DOUBLE) RETURNS DOUBLE LANGUAGE SQL CONTAINS SQL
RETURN SIN(X)/COS(X)
```

- Reverses a string

```sql
CREATE FUNCTION REVERSE(INSTR VARCHAR(4000)) RETURNS VARCHAR(4000) CONTAINS SQL
BEGIN ATOMIC
DECLARE REVSTR, RESTSTR VARCHAR(4000) DEFAULT '';
DECLARE LEN INT;
IF INSTR IS NULL THEN
    RETURN NULL;
END IF;
SET (RESTSTR, LEN) = (INSTR, LENGTH(INSTR));
WHILE LEN > 0 DO
    SET (REVSTR, RESTSTR, LEN) = (SUBSTR(RESTSTR, 1, 1) CONCAT REVSTR, SUBSTR(RESTSTR, 2, LEN - 1), LEN - 1);
END WHILE;
RETURN REVSTR;
END
```
Table UDFs

• returns the employees in a specified department number.

CREATE FUNCTION DEPTEMPLOYEES (DEPTNO CHAR(3))
RETURNS TABLE (
    EMPNO CHAR(6),
    LASTNAME VARCHAR(15),
    FIRSTNAME VARCHAR(12))
LANGUAGE SQL
READS SQL DATA
RETURN
SELECT EMPNO, LASTNAME, FIRSTNAME
FROM EMPLOYEE
WHERE EMPLOYEE.WORKDEPT = DEPTEMPLOYEES.DEPTNO
Java UDFs

CREATE FUNCTION tableUDF ( DOUBLE )
RETURNS TABLE ( name VARCHAR(20),
job VARCHAR(20),
salary DOUBLE )
EXTERNAL NAME 'MYJAR1:UDFsrv!tableUDF'
LANGUAGE JAVA
PARAMETER STYLE DB2GENERAL
NOT DETERMINISTIC
FENCED
NO SQL
NO EXTERNAL ACTION
SCRATCHPAD 10
FINAL CALL
DISALLOW PARALLEL
NO DBINFO@

import COM.ibm.db2.app.UDF;

public void tableUDF( double inSalaryFactor,
String outName,
String outJob,
double outNewSalary)
throws Exception
{
    int intRow = 0;
    ...
} // tableUDF } // UDFsrv class