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SQL in a Server Environment (ii)

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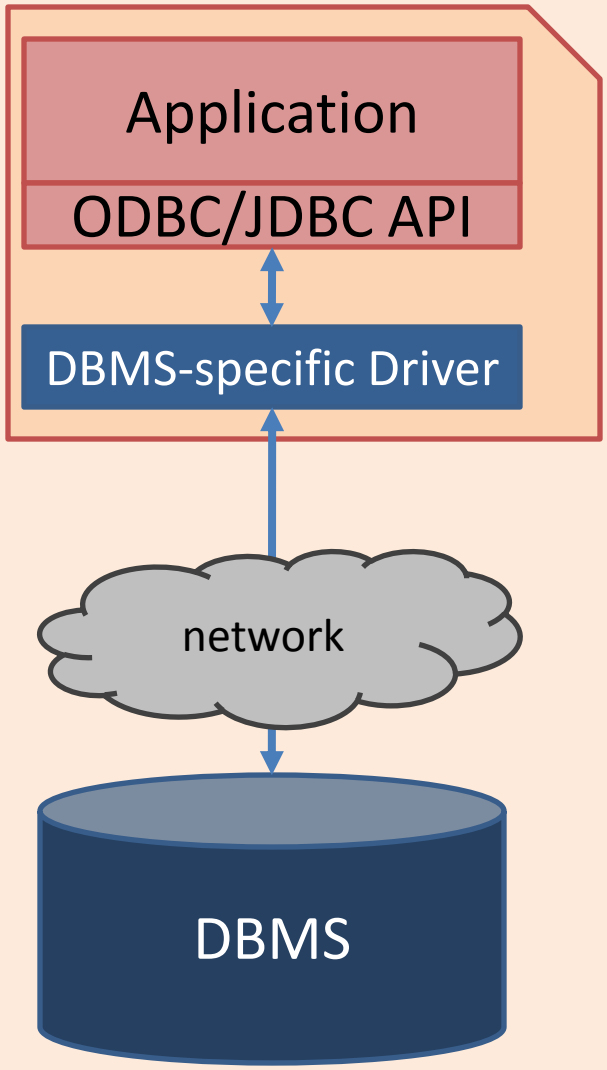
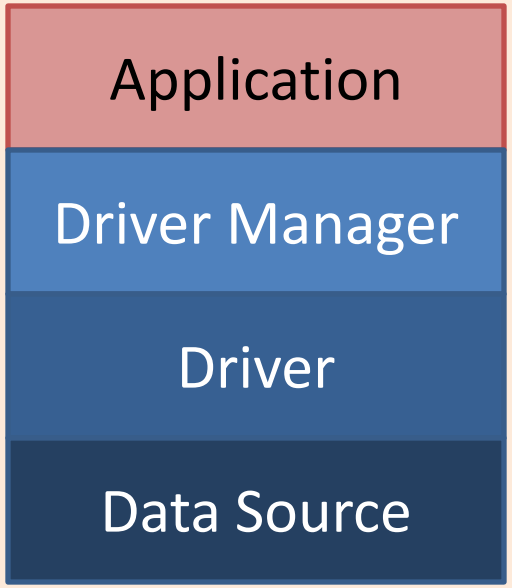
Alternative to Embedded SQL

- 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 ?

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

- 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

cf. Static vs Dynamic SQL

ResultSet

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

- 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

SQL Type	Java Class	accessor
BIT	Boolean	getBoolean
CHAR, VARCHAR	String	getString
DOUBLE, FLOAT	Double	getDouble
INTEGER	Integer	getInt
REAL	Double	getFloat
DATE	Java.sql.Date	getDate
TIME	Java.sql.Time	getTime
TIMESTAMP	Java.sql.TimeStamp	getTimestamp

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

SQL Stored Procedures

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 cstmt =  conn.prepareCall("{call Show Sailors});
ResultSet rs=cstmt.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. Built-ing 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

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

- Reverses a string

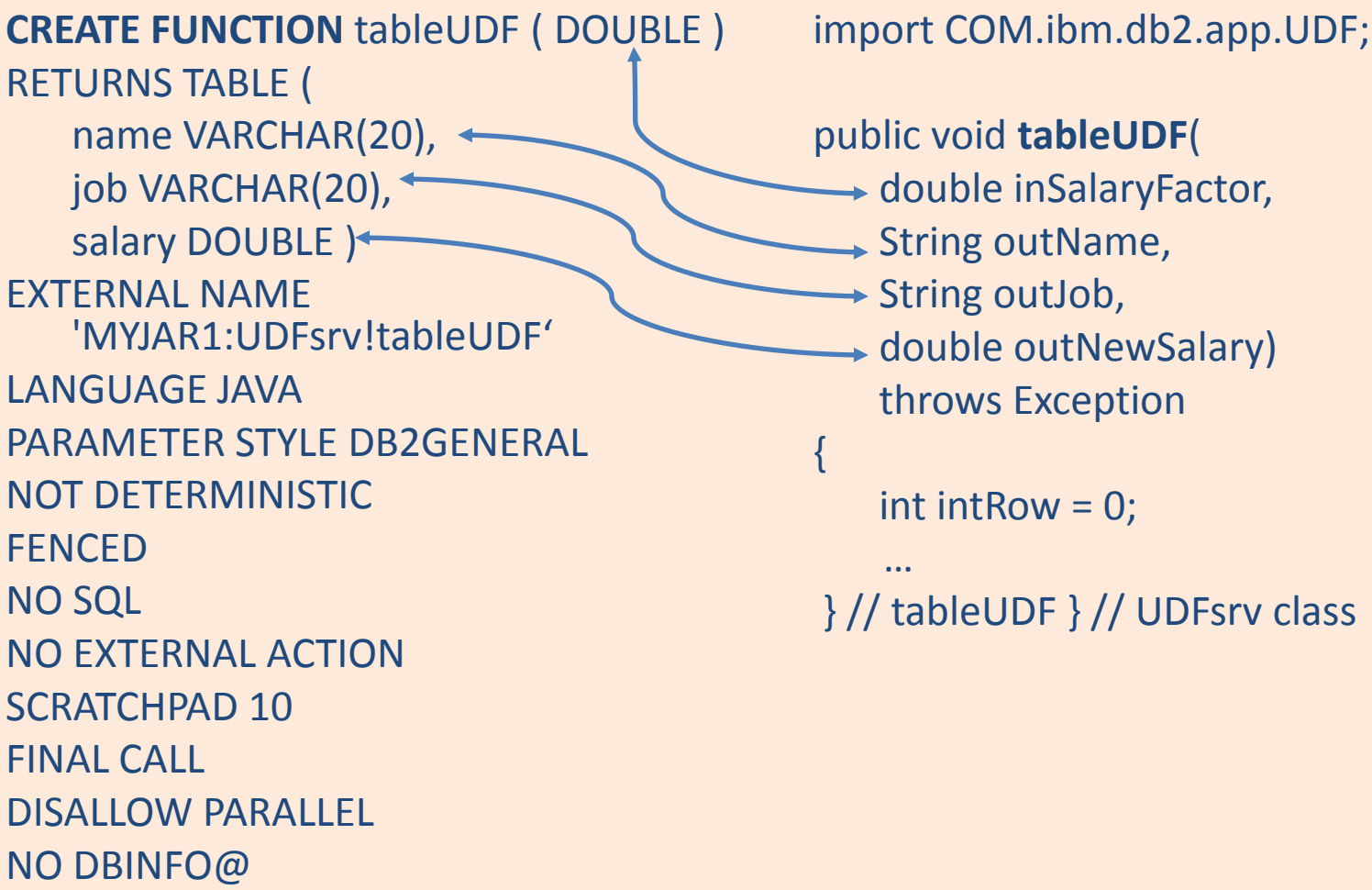
```
CREATE FUNCTION REVERSE(INSTR
    VARCHAR(4000))
    RETURNS VARCHAR(4000)
    CONTAINS SQL
BEGIN ATOMIC
    DECLARE REVSTR, RESTSTR
        VARCHAR(4000) DEFAULT '';
    DECLARE LEN INT;
    IF INSTR IS NULL THEN
        RETURN NULL;
    END IF;
    SET (RESTSTR, LEN) = (INSTR,
        LENGTH(INSTR));
    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, FIRSTNME
        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