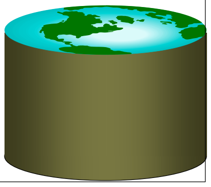
SQL: The Query Language Part 3

R &G - Chapter 5

It is not every question that deserves an answer.

Publius Syrus. 42 B. C.



Sorting the Results of a Query

- **ORDER BY *column* [ASC | DESC] [, ...]**

```
SELECT  S.rating, S.sname, S.age
        FROM  Sailors S, Boats B, Reserves R
        WHERE  S.sid=R.sid
                AND R.bid=B.bid AND B.color='red'
        ORDER BY  S.rating, S.sname;
```

- **Can order by any column in SELECT list, including expressions or aggs:**

```
SELECT  S.sid, COUNT (*) AS redrescnt
        FROM  Sailors S, Boats B, Reserves R
        WHERE  S.sid=R.sid
                AND R.bid=B.bid AND B.color='red'
        GROUP BY S.sid
        ORDER BY  redrescnt DESC;
```

Views (repeat from last class)

```
CREATE VIEW  view_name
AS select_statement
```

Makes development simpler
Often used for security
Not instantiated - makes updates tricky

```
CREATE VIEW Reds
AS SELECT  B.bid,  COUNT (*) AS scount
   FROM Boats B, Reserves R
   WHERE  R.bid=B.bid AND   B.color='red'
   GROUP BY  B.bid
```

Views Instead of Relations in Queries

```
CREATE VIEW Reds
AS SELECT  B.bid,  COUNT (*) AS scount
   FROM Boats B, Reserves R
   WHERE  R.bid=B.bid AND   B.color='red'
   GROUP BY  B.bid
```

bid	scount
102	1

Reds

```
SELECT  bname, scount
    FROM Reds R, Boats B
    WHERE  R.bid=B.bid
        AND scount < 10
```

Discretionary Access Control

```
GRANT  privileges  ON object TO users
[WITH GRANT OPTION]
```

- **Object can be a Table or a View**
- **Privileges can be:**
  - **Select**
  - **Insert**
  - **Delete**
  - **References (cols) – allow to create a foreign key that references the specified column(s)**
  - **All**
- **Can later be REVOKEd**
- **Users can be single users or groups**
- **See Chapter 17 for more details.**

Two more important topics

- **Constraints**
- **SQL embedded in other languages**

Integrity Constraints (Review)

- **An IC describes conditions that every *legal instance* of a relation must satisfy.**
  - Inserts/deletes/updates that violate IC's are disallowed.
  - Can be used to ensure application semantics (e.g., *sid* is a key), or prevent inconsistencies (e.g., *sname* has to be a string, *age* must be < 200)
- ***Types of IC's*: Domain constraints, primary key constraints, foreign key constraints, general constraints.**
  - *Domain constraints*: Field values must be of right type. Always enforced.
  - *Primary key and foreign key constraints*: you know them.

General Constraints

- **Useful when more general ICs than keys are involved.**
- **Can use queries to express constraint.**
- **Checked on insert or update.**
- **Constraints can be named.**

```
CREATE TABLE  Sailors
        ( sid  INTEGER,
        sname  CHAR(10),
        rating  INTEGER,
        age  REAL,
        PRIMARY KEY  (sid),
        CHECK  ( rating >= 1
                AND rating <= 10 ))
CREATE TABLE  Reserves
        ( sname  CHAR(10),
        bid  INTEGER,
        day  DATE,
        PRIMARY KEY  (bid,day),
        CONSTRAINT  noInterlakeRes
        CHECK  (`Interlake' <>
                ( SELECT  B.bname
                FROM  Boats B
                WHERE  B.bid=bid)))
```

Constraints Over Multiple Relations

```
CREATE TABLE  Sailors
        ( sid  INTEGER,
        sname  CHAR(10),
        rating  INTEGER,
        age  REAL,
        PRIMARY KEY  (sid),
        CHECK
        ( (SELECT COUNT (S.sid) FROM Sailors S)
        + (SELECT COUNT (B.bid) FROM
                Boats B) < 100 )
```

Number of boats plus number of sailors is < 100

- **Awkward and wrong!**
- **Only checks sailors!**
- **Only required to hold if the associated table is non-empty.**

- **ASSERTION is the right solution; not associated with either table.**
- **Unfortunately, not supported in many DBMS.**
- ***Triggers* are another solution.**

```
CREATE ASSERTION  smallClub
CHECK
( (SELECT COUNT (S.sid) FROM Sailors S)
+ (SELECT COUNT (B.bid)
 FROM Boats B) < 100 )
```

Writing Applications with SQL

- **SQL is not a general purpose programming language.**
  - + Tailored for data retrieval and manipulation
  - + Relatively easy to optimize and parallelize
  - - Can't write entire apps in SQL alone

Options:

Make the query language "turing complete"

Avoids the "impedance mismatch"

but, loses advantages of relational lang simplicity

Allow SQL to be embedded in regular programming languages.

Q: What needs to be solved to make the latter approach work?

Embedded SQL

- **DBMS vendors usually provide "host language bindings"**
  - E.g. for C or COBOL
  - Allow SQL statements to be called from within a program
  - Typically you preprocess your programs
  - Preprocessor generates calls to a proprietary DB connectivity library
- **General pattern**
  - One call to *connect* to the right database (login, etc.)
  - SQL statements can refer to host variables from the language
- **Typically vendor-specific**
  - We won't look at any in detail, we'll look at standard stuff
- **Problem**
  - SQL relations are (multi-)sets, no *a priori* bound on the number of records. No such data structure in C.
  - SQL supports a mechanism called a *cursor* to handle this.

Just to give you a flavor

```
EXEC SQL SELECT S.sname, S.age
   INTO :c_sname,:c_age
   FROM Sailors S
   WHERE S.sid = :c_sid
```

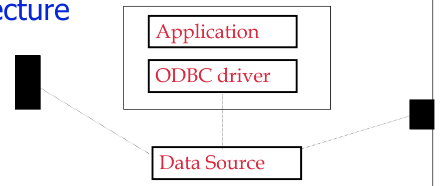
Cursors

- **Can declare a cursor on a relation or query**
- **Can *open* a cursor**
- **Can repeatedly *fetch* a tuple (moving the cursor)**
- **Special return value when all tuples have been retrieved.**
- **ORDER BY allows control over the order in which tuples are returned.**
    - Fields in ORDER BY clause must also appear in SELECT clause.
- **Can also modify/delete tuple pointed to by a cursor**
    – A "non-relational" way to get a handle to a particular tuple
- **There's an Embedded SQL syntax for cursors**
    – DECLARE <cursorname> CURSOR FOR <select stmt>
    – FETCH FROM <cursorname> INTO <variable names>
    – But we'll use JDBC instead

Database APIs: alternative to embedding

- **Rather than modify compiler, add a library with database calls (API)**
    – special procedures/objects
    – passes SQL strings from language, presents result sets in a language-friendly way
    – *ODBC* a C/C++ standard started on Windows
    – *JDBC* a Java equivalent
    – Most scripting languages have similar things
        - E.g. For Perl there is DBI, "oraPerl", other packages
- **Mostly DBMS-neutral**
    – at least try to hide distinctions across different DBMSs

Architecture



- A lookup service maps "data source names" ("DSNs") to drivers
    – Typically handled by OS
- Based on the DSN used, a "driver" is linked into the app at runtime
- The driver traps calls, translates them into DBMS-specific code
- Database can be across a network
- ODBC is standard, so the same program can be used (in theory) to access multiple database systems
- Data source may not even be an SQL database!

ODBC/JDBC

- **Various vendors provide drivers**
    – MS bundles a bunch into Windows
    – Vendors like DataDirect and OpenLink sell drivers for multiple OSes
- **Drivers for various data sources**
    – Relational DBMSs (Oracle, DB2, SQL Server, Informix, etc.)
    – "Desktop" DBMSs (Access, Dbase, Paradox, FoxPro, etc.)
    – Spreadsheets (MS Excel, Lotus 1-2-3, etc.)
    – Delimited text files (.CSV, .TXT, etc.)
- **You can use JDBC/ODBC *clients* over many data sources**
    – E.g. MS Query comes with many versions of MS Office (msqry32.exe)
- **Can write your own Java or C++ programs against xDBC**

JDBC

- **Part of Java, very easy to use**
- **Java comes with a JDBC-to-ODBC bridge**
    – So JDBC code can talk to any ODBC data source
    – E.g. look in your Windows Control Panel for ODBC drivers!
- **JDBC tutorial online**
    – http://developer.java.sun.com/developer/Books/JDBCTutorial/

JDBC Basics: Connections

- **A Connection is an object representing a login to a database**

```
// GET CONNECTION
Connection con;
try {
    con = DriverManager.getConnection(
        "jdbc:odbc:sailorsDB",
        userName,password);
} catch(Exception e){ System.out.println(e);  }
```

- **Eventually you close the connection**

```
// CLOSE CONNECTION
try { con.close(); }
catch (Exception e) { System.out.println(e); }
```

JDBC Basics: Statements

- **You need a Statement object for each SQL statement**

```
// CREATE STATEMENT
Statement stmt;
try {
   stmt = con.createStatement();
} catch (Exception e){
   System.out.println(e);
}
```

Soon we'll say stmt.executeQuery("select …");

CreateStatement cursor behavior

- **Two optional args to createStatement:**
  - `createStatement(ResultSet.<TYPE>,`
    `                ResultSet.<CONCUR>)`
  - Corresponds to SQL cursor features
- **<TYPE> is one of**
  - TYPE_FORWARD_ONLY: can't move cursor backward
  - TYPE_SCROLL_INSENSITIVE: can move backward, but doesn't show results of any updates
  - TYPE_SCROLL_SENSITIVE: can move backward, will show updates from this statement
- **<CONCUR> is one of**
  - CONCUR_READ_ONLY: this statement doesn't allow updates
  - CONCUR_UPDATABLE: this statement allows updates
- **Defaults:**
  - TYPE_FORWARD_ONLY and CONCUR_READ_ONLY

JDBC Basics: ResultSet

- **A ResultSet object serves as a *cursor* for the statement's results (stmt.executeQuery())**

```
// EXECUTE QUERY
ResultSet results;
try {
    results = stmt.executeQuery(
           "select * from Sailors")
} catch (Exception e){
    System.out.println(e);  }
```

- **Obvious handy methods:**
  - results.next() advances cursor to next tuple
    - Returns "false" when the cursor slides off the table (beginning or end)
  - "scrollable" cursors:
    - results.previous(), results.relative(int), results.absolute(int), results.first(), results.last(), results.beforeFirst(), results.afterLast()

ResultSet Metadata

- **Can find out stuff about the ResultSet schema via ResultSetMetaData**

```
ResultSetMetaData rsmd = results.getMetaData();
int numCols = rsmd.getColumnCount();
int i, rowcount = 0;

// get column header info
for (i=1; i <= numCols; i++){
    if (i > 1) buf.append(",");
    buf.append(rsmd.getColumnLabel(i));
}
buf.append("\n");
```

- **Other ResultSetMetaData methods:**
  - getColumnType(i), isNullable(i), etc.

Getting Values in Current of Cursor

- **getString**

```
 // break it off at 100 rows max
   while (results.next() && rowcount < 100){
       // Loop through each column, getting the
       // column data and displaying

       for (i=1; i <= numCols; i++) {
           if (i > 1) buf.append(",");
           buf.append(results.getString(i));
       }
       buf.append("\n");
       rowcount++;
   }
```

- **Similarly, getFloat, getInt, etc.**

Updating Current of Cursor

- **Update fields in current of cursor:**

```
result.next();
result.updateInt("Rating", 10);
```

- **Also updateString, updateFloat, etc.**
- **Or can always submit a full SQL UPDATE statement**
  - Via executeQuery()
- **The original statement must have been CONCUR_UPDATABLE in either case!**

Cleaning up Neatly

```
try {
  // CLOSE RESULT SET
  results.close();
  // CLOSE STATEMENT
  stmt.close();
  // CLOSE CONNECTION
  con.close();
} catch (Exception e) {
    System.out.println(e);
}
```

Putting it Together (w/o try/catch)

```
Connection con =
   DriverManager.getConnection("jdbc:odbc:weblog",userName,pas
   sword);
Statement stmt = con.createStatement();
ResultSet results =
   stmt.executeQuery("select * from Sailors")
ResultSetMetaData rsmd = results.getMetaData();
int numCols = rsmd.getColumnCount(), i;
StringBuffer buf = new StringBuffer();

while (results.next() && rowcount < 100){
  for (i=1; i <= numCols; i++) {
     if (i > 1) buf.append(",");
     buf.append(results.getString(i));
  }
  buf.append("\n");
}
results.close(); stmt.close();  con.close();
```

Similar deal for web scripting langs

- **Common scenario today is to have a web client**
  - A web form issues a query to the DB
  - Results formatted as HTML
- **Many web scripting languages used**
  - jsp, asp, PHP, etc.
  - we'll use PHP in our class
  - most of these are similar, look a lot like jdbc with HTML mixed in

E.g. PHP/Postgres

```
<?php   $conn = pg_pconnect("dbname=cowbook user=jmh\
                             password=secret");
  if (!$conn) {
    echo "An error occured.\n";
    exit;
  }
  $result = pg_query ($conn, "SELECT * FROM Sailors");
  if (!$result) {
    echo "An error occured.\n";  exit;
  }
  $num = pg_num_rows($result);
  for ($i=0; $i < $num; $i++) {
    $r = pg_fetch_row($result, $i);
    for ($j=0; $j < count($r); $j++) {
        echo "$r[$j]&nbsp;";
    }
    echo "<BR>";
  }
?>
```

API Summary

APIs are needed to interface DBMSs to programming languages

- Embedded SQL uses "native drivers" and is usually faster but less standard
- ODBC (used to be Microsoft-specific) for C/C++.
- JDBC the standard for Java
- Scripting languages (PHP, Perl, JSP) are becoming the preferred technique for web-based systems.