In the Lecture Series Introduction to Database Systems

SQL and Programming Languages

Presented
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SQL and programming languages

- Procedural SQL,
- Database Connectivity, and
- Embedded SQL
- PL SQL,
- JDBC, and
- SQLj

SQL alone is not enough

- SQL is not **computationally complete**

Computational completeness is the ability to express all possible computations

- SQL is not **system complete**

System completeness is the ability to access and control the resources of the computer

Incomplete by design

SQL incompleteness makes it a simpler language

- Easy to use (for the programmer)
- Easy to optimize (for the DBMS)

Example: flight connections

flight

number	departure	arrival	origin	destination
AF235	10:15:00 AM	12:10:00 PM	CDG	VCE
GA826	1:00:00 PM	2:00:00 PM	CGK	SIN
MH364	2:30:00 PM	3:30:00 PM	SIN	LGK
NZ4319	11:00:00 PM	2:15:00 PM	LHR	SIN
SQ5051	11:55:00 AM	1:00:00 PM	HKT	SIN
SQ866	1:30:00 PM	5:00:00 PM	SIN	HKG
TG401	3:00:00 PM	5:25:00 PM	SIN	BKK
TG952	11:55:00 PM	7:00:00 AM	BKK	CDG

Example: flight connections

```
SELECT flight.destination
   FROM flight
   WHERE flight.origin=‘CGK’
```

number	departure	arrival	origin	destination
AF235	10:15:00 AM	12:10:00 PM	CDG	VCE
GA826	1:00:00 PM	2:00:00 PM	CGK	SIN
MH364	2:30:00 PM	3:30:00 PM	SIN	LGK
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Example: flight connections

```
SELECT f2.destination
   FROM flight f1, flight f2
   WHERE f1.origin=‘CGK’
   AND f2.origin=f1.destination
```

number	departure	arrival	origin	destination
AF235	10:15:00 AM	12:10:00 PM	CDG	VCE
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MH364	2:30:00 PM	3:30:00 PM	SIN	LGK
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Example: flight connections

```
WITH RECURSIVE
   connection ( origin, destination ) AS
   ( ( SELECT origin, destination
       FROM flight )
   UNION
     ( SELECT f.origin AS origin,
                    c.destination AS destination
        FROM flight f, connection c
        WHERE c.origin = f.destination ) )

SELECT destination
   FROM connection
   WHERE origin = ‘CGK’
```

Example: flight connections

number	departure	arrival	origin	destination
AF235	10:15:00 AM	12:10:00 PM	CDG	VCE
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In Summary

We need to connect SQL and programming languages

Coupling approaches

- External coupling
- Internal coupling

Three solutions

- Procedural SQL
- Database Connectivity
- Embedded SQL

Program structure

- Connection (external coupling)
- Statement preparation
- Statement execution
- Collection of results
- Exception handling
- Disconnection (external coupling)

Statement preparation

- **Prepare data structures** for communication between program and DBMS

- Request DBMS to **Compile SQL statement** (if possible)

Statement execution

- **Static** SQL statements

  Written in the program source

- **Dynamic** SQL statements

  Build at runtime

Collection of results

- INSERT, DELETE, UPDATE statements return single values
- SELECT statements return a collection of t-uples

Cursor

If result is too big or its size unknown, a ***cursor*** is used to fetch individual t-uples, one at the time, while the result is kept in the database

Transactions and exception handling

- Transactions:
  - Begin
  - Commit
  - Rollback

- Exception
  - Catch

Running example

```
CREATE TABLE employee
  (name VARCHAR(24) PRIMARY KEY,
   address VARCHAR(36)
                   DEFAULT 'company address',
   department VARCHAR(24)
                   REFERENCES department(name),
   salary NUMERIC);

CREATE TABLE department
  (name VARCHAR(24) PRIMARY KEY,
   location VARCHAR(36),
   budget NUMERIC);
```

Procedural SQL

Most DBMS support a procedural extension of SQL

PL/SQL is the procedural extension of Oracle 9i

Stored procedures are written in PL/SQL

Structure of a PL/SQL program

```
DECLARE

  /* Declarative section: variables, types, and local subprograms. */

 BEGIN

  /* Executable section: procedural and SQL statements go here. */

  /* This is the only section of the block that is required. */

   EXCEPTION

  /* Exception handling section: error handling statements go here. */

 END;
```

Preparation

```
DECLARE
  salary NUMERIC NOT NULL;
  credit_bound  NUMERIC := 3000000;
  date DATE;
  employee_number NUMERIC := 0;
  manager BOOLEAN;
```

Execution

```
DECLARE
my_department_name VARCHAR;
BEGIN
  my_department_name := 'sales';
  SELECT name
  FROM employee
  WHERE department = my_department_name;

END;
```

Execution: variables

```
DECLARE
  my_salary NUMERIC;
BEGIN
  SELECT salary INTO my_salary WHERE name = 'Nancy Santi';
END;
```

Execution: control

```
DECLARE
  sales NUMERIC;
  sal NUMERIC;
BEGIN
    [...]
    IF sales > 50000 THEN sal := 1500;
          ELSIF sales > 35000 THEN sal := 1200;
          ELSE sal := 1000;
    END IF;
    INSERT INTO employee
    VALUES ('Tiziana Dezza', '132, via Dellatti',
                                                      'research', sal);
END;
```

Preparation: cursor

```
CURSOR high_budget IS
  SELECT name, budget
  FROM department
  WHERE budget > 10000;
```

Execution: cursor

- Open

```
OPEN high_budget;
```

- Fetch

```
FETCH [orientation] FROM high_budget
INTO name, budget;
```

(orientation is one of NEXT, PRIOR, FIRST, LAST,…)

- Close

```
CLOSE high_budget;
```

Execution: cursor

```
DECLARE
name VARCHAR(24);
budget NUMERIC;

CURSOR high_budget IS
  SELECT name, budget
  FROM department
  WHERE budget > 10000;

BEGIN
     OPEN high_budget;

     LOOP
             FETCH NEXT FROM high_budget INTO name, budget;
             EXIT WHEN high_budget%NOTFOUND;
             dbmsoutput.put_line('Name: '|| name);
             dbmsoutput.put_line('  Budget: '|| budget);
     END LOOP;

     CLOSE high_budget;
END;
```

Execution: dynamic statements

```
EXECUTE IMMEDIATE dm;
```

Transactions

A transaction

- Starts implicitly
- Ends with execution, or
- COMMIT, or
- ROLLBACK

Exception Handling

```
DECLARE
  sum_bud NUMERIC;
  avg_bud NUMERIC;
BEGIN
  SELECT SUM(budget) INTO sum_bud FROM
    department;
  IF sum_bud = 0  THEN RAISE ZERO_BUDGET END IF;
  SELECT sum_bud/COUNT(*) INTO avg_bud FROM
    employee;
  EXCEPTION
    WHEN ZERO_DIVIDE
         THEN PRINT "Division by Zero";
    WHEN ZERO_BUDGET
         THEN PRINT "No budget has been assigned yet";
END;
```

Database connectivity

- Database connectivity is a programming interface called “Call Level Interface”
- The CLI is implemented as a library for the host language
- SQL-99 specifies how CLIs must be defined

Database connectivity

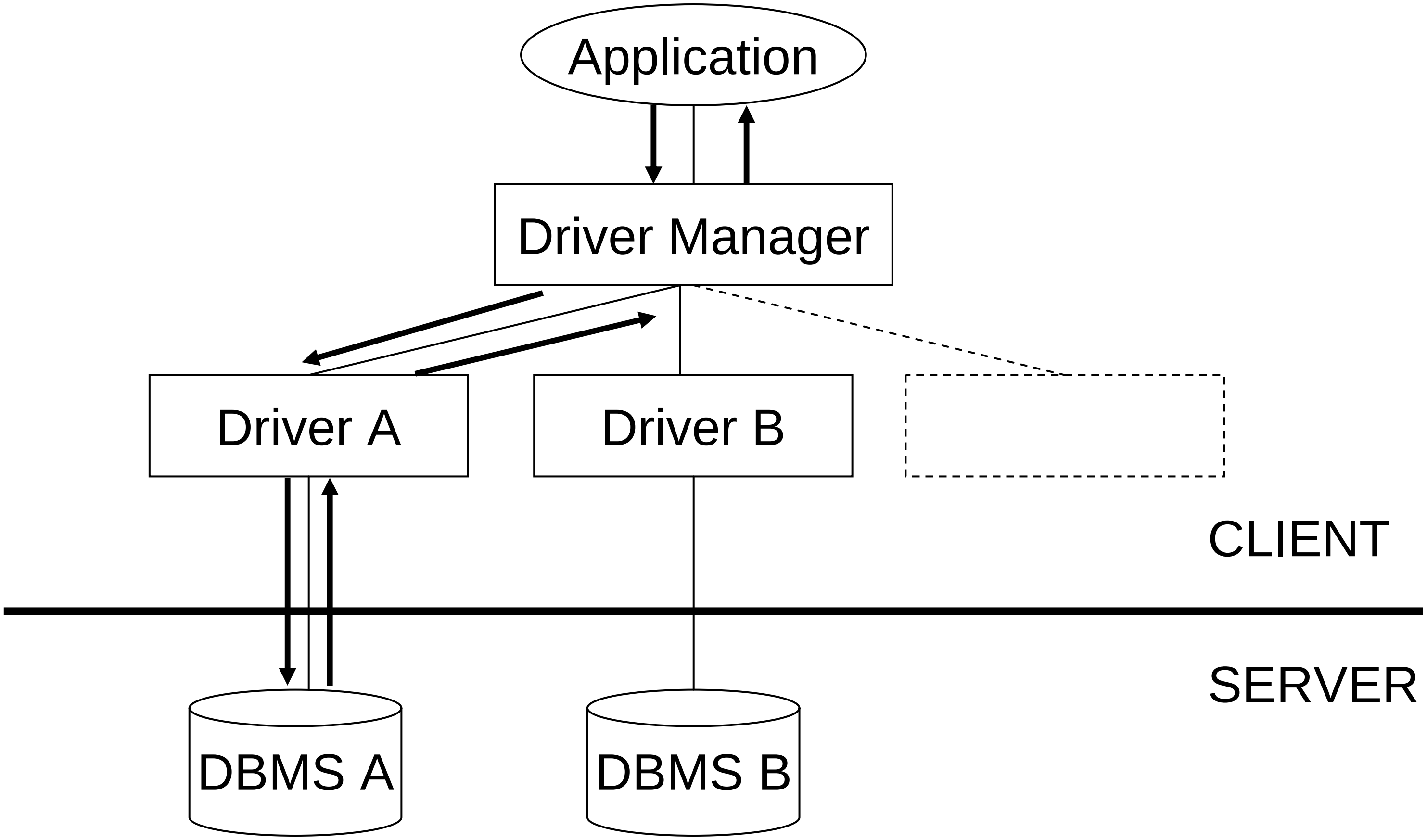
- ODBC:

  Open Database Connectivity

- JDBC:

  Java Database Connectivity

Database connectivity architecture



Connection

Driver specification:

```
Class.forName("sun.jdbc.odbc.JdbcOdbcDriver");
```

Connection:

```
Connection con =
DriverManager.getConnection("jdbc:odbc:myDB",
                                    "myLogin", "myPassword");
```

Preparation and execution

SQL statements are strings

- They are dynamic statements

```
Statement stmt = con.createStatement();
stmt.executeQuery("SELECT * FROM employee");
```

- They can be ‘prepared’

```
PreparedStatement pstmt =
con.prepareStatement("SELECT * FROM employee");
pstmt.executeQuery();
```

Prepared Statements can be parameterized

```
PreparedStatement pstmt =
   con.prepareStatement("SELECT *
                                              FROM employee
                                              WHERE department = ?");
pstmt.setString(1, 'research');
pstmt.executeQuery();
```

- *Parameters identifed by ‘?’*
- *Values assigned to parameters by ‘setXXX’ methods*
- *Parameters identified by their position in the string*

Execution: cursor

```
Statement selstmt = con.createStatement();

     String stmt =  "SELECT *
                          FROM employee
                          WHERE salary > 1000";
     ResultSet  res = selstmt.executeQuery (stmt);

    while ( res.next() )
     {
        System.out.println (res.getString ("salary"));
     }
```

Transactions and exception handling

- Auto commit:

  every connection is a transaction

- Auto commit can be turned off:

  explicit commit or abort

- Exceptions can be caught:

  java.sql.SQLException

Embedded SQL

Embedded SQL is a form of external coupling

Programming languages like C, Pascal, Fortran or Cobol are extended to the execution of SQL statements

- prefix is keyword **EXEC SQL**
- suffix is the semi-colon

SQLj is an ANSI/ISO for embedding SQL into Java

- prefix is **#sql**
- suffix is the semi-colon

Connection

```
oracle.connect("jdbc:odbc:my_DB",
               "my_login",
               "my_password");
```

Execution

```
#sql { INSERT INTO employee VALUES (
      'Stefano Olivaro', 'Piazzale Roma',
      'research',1500) };
```

Execution: variables

```
String department = 'research';
 BigDecimal my_budget;
 #sql { SELECT budget INTO :my_budget
        FROM department
        WHERE name = :department };
```

Execution: result and cursor

```
#sql iterator EmpIter (String name, Real salary);
EmpIter my_empiter = null;
#sql my_empiter = {SELECT name, salary FROM
    employee};
while (my_empiter.next())
    {
   System.out.println("Name: " + my_empiter.name());
   System.out.println("Salary: " + my_empiter.salary());
    }
my_empiter.close();
```

Transactions and exception handling

- Explicit COMMIT and ABORT
- Auto commit can be turned on
- Exceptions can be caught

In conclusion

- Procedural SQL,
- Database Connectivity, and
- Embedded SQL
- PL SQL,
- JDBC, and
- SQLj

Credits

The content of this lecture is based on chapter 6 of the book "Introduction to database Management Systems"
By
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