BUSINESS INTELLIGENCE LABORATORY

Data Access: Relational Data Bases

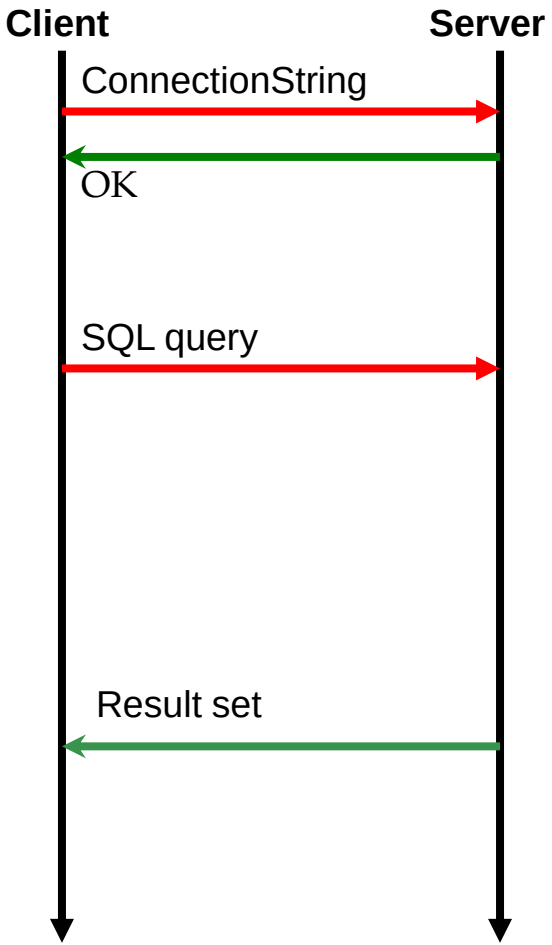
Business Informatics Degree

RDBMS data access

- Protocols and API
  - ODBC, OLE DB, ADO, ADO.NET, JDBC
- JDBC Programming
  - Java classes java.sql

Connecting to a RDBMS

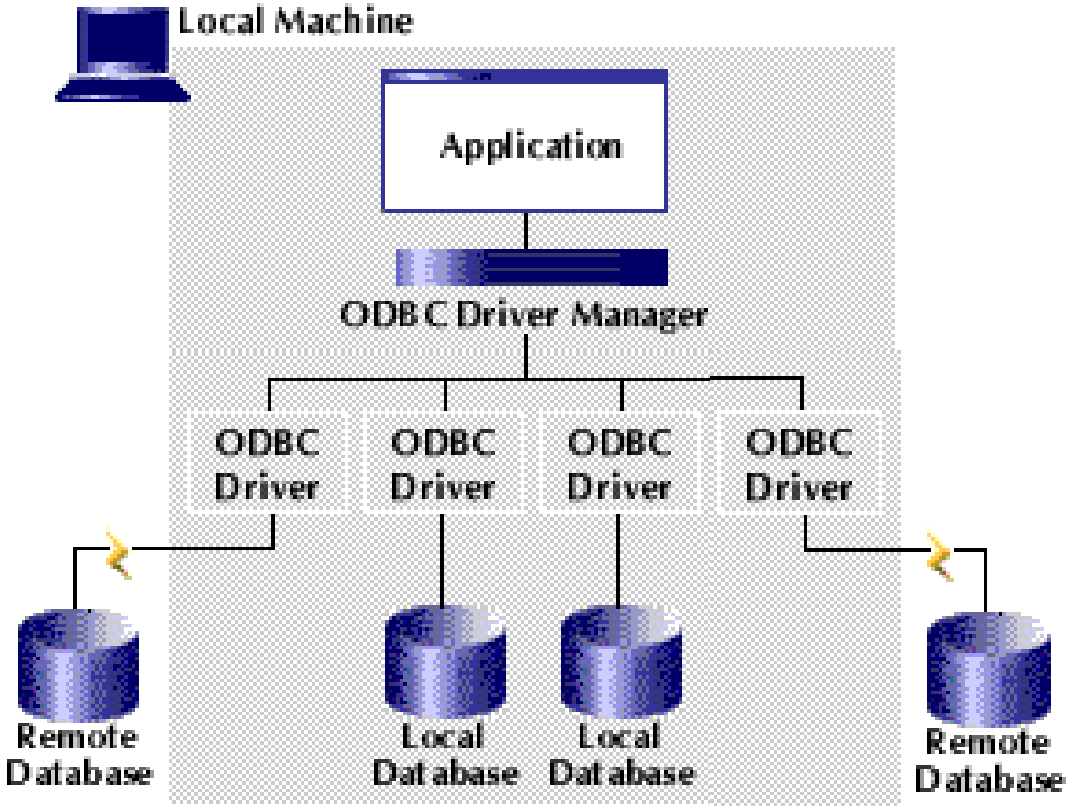
- **Connection protocol**
  - locate the RDBMS server
  - open a connection
  - user autentication
- **Querying**
  - query SQL
    - SELECT
    - UPDATE/INSERT/CREATE
  - stored procedures
  - prepared query SQL
- **Scan Result set**
  - scan row by row
  - access result meta-data



Connection Standards

- ODBC - Open DataBase Connectivity
  - Windows: odbc Linux: unixodbc, iodbc
  - Tabular Data
- JDBC – Java DataBase Connectivity
  - See later on
- OLE DB (Microsoft) – Object Linking and Embedding
  - Tabular data, XML, multi-dimensional data
- ADO (Microsoft) – ActiveX Data Objects
  - Object-oriented API on top of OLE DB
- ADO.NET
    - evolution of ADO in the .NET framework

ODBC Open DataBase Connectivity



ODBC Demo

- Registering an ODBC data source
  - pubs on access
  - pubs on SQL Server (driver SQL Server)
- Data access
  - copy Access table to Excel
- Linked tables
  - Linking SQL Server Table from Access

OLE DB Demo

- Creating **.udl** data links
- Data access
  - accessing Access data from Excel
- Linked tables
  - accessing Excel data from Access
- OLE DB Drivers
  - By Microsoft

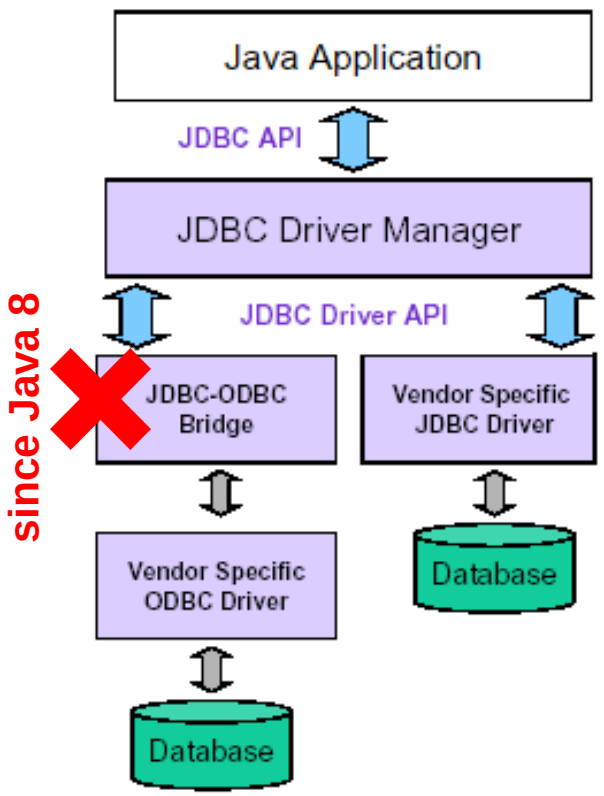
RDBMS data access

- Protocols and API
  - ODBC, OLE DB, ADO, ADO.NET, JDBC
- JDBC Programming
  - Java classes java.sql

Java DataBase Connectivity

- JDBC is a library of API's for the uniform access to relational databases
  - It includes classes for:
    - Connecting to a database
    - Submitting SQL queries
    - Scanning the results of queries
    - Accessing meta-data on tables
  - Versions
    - Latest: JDBC 4.3 – Java 7
    - We use features from: **JDBC 2.0 – Java 3**
  - Java Packages
    - **java.sql**
    - javax.sql

JDBC Architecture



- Type 1 Drivers
  - Translate JDBC in ODBC
    - JDBC-ODBC Bridge
- Type 2 Drivers
  - Part in Java and part in native code
- Type 3 Drivers
  - Pure Java,
  - Protocol independent from the RDBMS
- Type 4 Drivers (the most portable)
  - Pure Java,
  - Protocol specific/optimized for the RDBMS

JDBC: on-line resources

- JDBC web site
  - http://www.oracle.com/technetwork/java/javase/jdbc/index.html
- Java API
  - http://docs.oracle.com/javase/8/docs/api/java/sql/package-summary.html
- Tutorial
  - http://docs.oracle.com/javase/tutorial/jdbc/

JDBC: Programming pattern

1. Register the JDBC driver
2. Connect to the RDBMS
3. Submit a SQL query
4. Process query results
5. Close the connection

JDBC: (1) Register the JDBC driver


```
import java.sql.*; // JDBC package

public int count(String[] args)
    throws ClassNotFoundException
 {
    // MS Sql Server driver
    Class.forName("com.microsoft.sqlserver.jdbc.SQLServerDriver");
    …

    // alternative way (driver list separated by ':')
    System.setProperty("jdbc.drivers", "
    com.microsoft.sqlserver.jdbc.SQLServerDriver :
     oracle.jdbc.OracleDriver");
```

JDBC: (1) Register the JDBC driver

- It consists of loading a Java class in the JVM
- Common drivers:
  - SQL Server
    - Microsoft com.microsoft.sqlserver.jdbc.SQLServerDriver
    - JTDS net.sourceforge.jtds.jdbc.Driver
  - Oracle oracle.jdbc.OracleDriver
  - MySQL com.mysql.jdbc.Driver
  - Microsoft Access net.ucanaccess.jdbc.UcanaccessDriver
  - IBM DB2 com.ibm.db2.jcc.DB2Driver

JDBC: (1) Register the JDBC driver

- To locate the Java library with the driver:
  - running from commandline
    - java -classpath <jar file>
    - or, add <jar file> to the CLASSPATH
  - in Eclipse, add jar files in
    - Properties->Java Build Path -> Libraries
- Sample jar files:
  - SQL Server driver:
    - Microsoft: sqljdbcXX.jar
    - JTDS: jtdsXX.jar
  - Oracle driver:
    - ojdbcXX.jar
  - MySQL driver:
    - mysql-connector-java-XX-bin.jar

JDBC: (2) Connect to the RDBMS


```
String url = "jdbc:sqlserver:" +                    // driver
             "//apa.di.unipi.it/" +                 // host
             ";DatabaseName=pubs";                  // database
String user = "foo";
String password = "hello";
Connection conn =
      DriverManager.getConnection(url, user, password);
 …
```

JDBC: (2) Connect to the RDBMS

- The connection URL syntax depends on the driver
  - See driver documentation
  - SQL Server via JTDS
    - url = “jdbc:jtds:sqlserver://apa.di.unipi.it/pubs”
  - Oracle
    - url = “jdbc:oracle:thin:@apa.di.unipi.it:1521:PUBS”
  - MySQL
    - String url = “jdbc:mysql://apa.di.unipi.it/pubs”
  - MS Access
    - String url = “jdbc:ucanaccess://pubs.mdb ”

JDBC: (3) Submit a SQL query


```
// SQL statements processing object
Statement stmt = con.createStatement();

String query = "SELECT name, age FROM students";
// submit the SQL query, get result set
ResultSet rs = stmt.executeQuery( query );

String update = "UPDATE students SET age = age + 1";
// method for update/insert/create table
int affectedRows = stmt.executeUpdate( update );
```

JDBC: (4) Scan query results


```
// ResultSet is an iterator over the rows of the result
while ( rs.next() )
{
  // get field values by field name
  String nome = rs.getString("name");
  int age = rs.getInt("age");

  // get field values by field position (starts from 1!)
  int ageAgain = rs.getInt( 2 );

   System.out.println(name + "," + age);
}
…
```

JDBC: (5) Close the connection


```
…

// close the statement object
  stmt.close();

// close connection to the database
  conn.close();
…
```

The meta-data problem

- The meta-data problem
  - How a value of a '**numeric**' data type column in a MS Access DB is mapped into a Java variable?

- Solution
  - (1) JDBC defines a set of common data types,
  - (2) MS Access driver maps '**numeric**' column values to the common '**REAL**' data type
  - (3) Java maps the common '**REAL**' data type to '**double**'
  - (4) Java programmers call the getDouble() method to assign a program variable with the column value

The meta-data problem

JDBC Type	Java Type
BIT	boolean
TINYINT	byte
SMALLINT	short
INTEGER	int
BIGINT	long
REAL	float
FLOAT DOUBLE	double
BINARY VARBINARY LONGVARBINARY	byte[]
CHAR VARCHAR LONGVARCHAR	String

JDBC Type	Java Type
NUMERIC DECIMAL	BigDecimal
DATE	java.sql.Date
TIME TIMESTAMP	java.sql.Timestamp
CLOB	Clob*
BLOB	Blob*
ARRAY	Array*
DISTINCT	mapping of underlying type
STRUCT	Struct*
REF	Ref*
JAVA_OBJECT	underlying Java class

*SQL3 data type supported in JDBC 2.0

Date, time, timestamp

- Package java.sql
  - Date, Time, Timestamp
    - Inherit from java.util.Date
    - Represent SQL data types:
      - DATE getDate()
      - TIME getTime()
      - TIMESTAMP getTimeStamp() it is DATE + TIME
  - Date birth = resultSet.getDate("BornDate");

Date, time, timestamp: issues

- A plethora of formats for
  - Dates
    - 30.1.2004, 30/1/2004, 1.30.2004, Jan 30, 2004, 30 Gen 2004, 30/Gen/2004, January 30, 2004
  - Time (5:03:35.25 PM, 17:03:35.25)
  - Timestamp (= Date + Time)
- Reasoning about
  - TimeZones
    - Fuse and summertime/standard time
  - Locale
    - Conventions on date format
  - Calendars

Date, time, timestamp: solutions

- (Since Java 8) Package java.time
  - Basic classes: LocalDate, LocalTime, LocalDateTime
  - Utility classes:
    - DateTimeFormatter, Duration, Period, …

```
Date birth = resultSet.getDate("BornDate");
LocalDate birthdate = birth.toLocalDate();
DateTimeFormatter dform = DateTimeFormatter.ofPattern("dd/MMM/yyyy hh:mm:ss.S");
System.out.println(dform.format(birthdate) );
```

- Tutorial on Java 8 time

Meta-data on ResultSet


```
public static void printRS(ResultSet rs) throws SQLException
{
  ResultSetMetaData md = rs.getMetaData();

  // output column names
  int nCols = md.getColumnCount();
  for(int i=1; i < nCols; ++i)
        System.out.print( md.getColumnName(i)+",");
  System.out.println( md.getColumnName(nCols));

…
```

Meta-data on ResultSet


```
        ....
        // output resultset
        while ( rs.next() )
        {
                for(int i=1; i < nCols; ++i)
                        System.out.print( rs.getString(i)+",");
                System.out.println( rs.getString(nCols));
        }
}
```

Meta-data on DB tables


```
…
Connection con = …. ;
DatabaseMetaData dbmd = con.getMetaData();
String catalog = null;  // null = all
String schema = null;
String table = "sys%";  // table names starting with sys
String[] types = null;
ResultSet rs =
        dbmd.getTables(catalog , schema , table , types );
…
```

Prepared commands

- **Problem:** read N rows from a CSV file, and insert each one into a database table
  - N SQL queries?

```
INSERT INTO names (id, name) VALUES (1, 'Luigi Rossi')
INSERT INTO names (id, name) VALUES (2, 'Mario Bianchi')
…
```

    - Inefficiency: an execution plan has to be computed for every query, yet all of them share a common structure
  - Use ? as a placeholder for parameters

```
INSERT INTO names (id, name) VALUES (?, ?)
```

Prepared commands


```
Connection con = …. ;
String query =
   "INSERT INTO names (id, name) VALUES (?, ?)";
PreparedStatement st = con.prepareStatement(query);

BufferedReader r = … ;
int id = 1;
String name;
while(  (name = r.readLine()) != null ) {
        st.setInt( 1, id++);
        st.setString( 2, name);
        st.executeUpdate();
}
```

JDBC: (4) Scrolling results


```
…
Statement stmt =
con.createStatement(ResultSet.TYPE_SCROLL_INSENSITIVE,
            ResultSet.CONCUR_READ_ONLY);

String query = "SELECT name, age FROM students“;
ResultSet rs = stmt.executeQuery( query );

rs.previous();   // previous row
rs.relative(-5); // 5 rows behind
rs.relative(7);  // 7 rows ahead
rs.absolute(100);        // 100th row
…
```

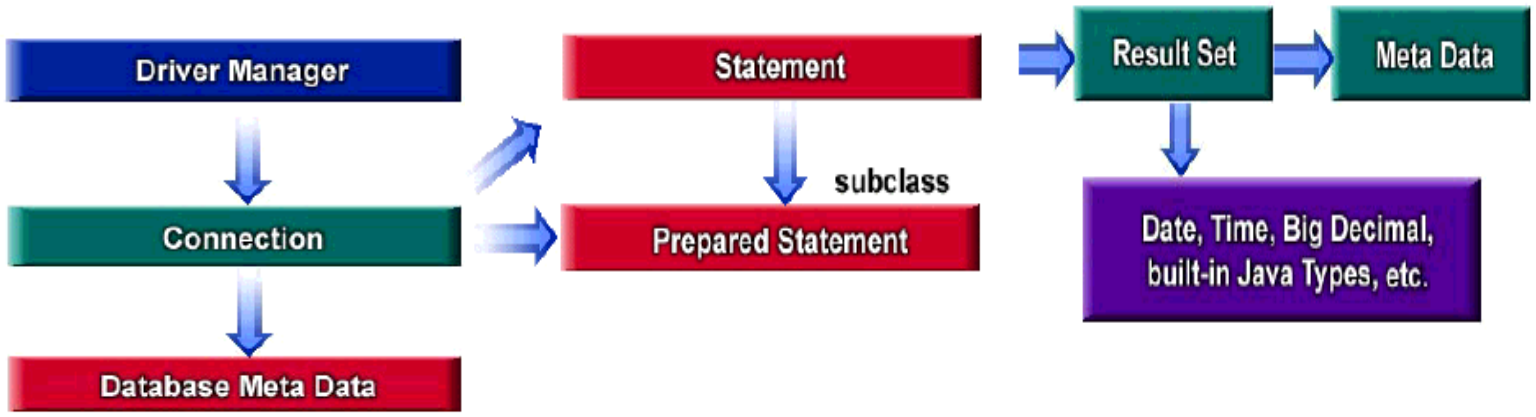
MEMORY CONSUMPTION

JDBC: (4) Updating results


```
…
Statement stmt = con.createStatement(ResultSet.TYPE_FORWARD_ONLY,
                                     ResultSet.CONCUR_UPDATABLE);

String query = "SELECT name, age FROM students“;
ResultSet rs = stmt.executeQuery( query );
…
while ( rs.next() )
{
        int age = rs.getInt(“age”);
        rs.updateInt(“age”, age+1);
        rs.updateRow();
}
```

Summary of java.sql classes



JDBC: Other features

- We will not discuss…
  - Transactions
  - Stored procedures
  - Batch UPDATE/INSERT
  - SQL embedded in Java (SQLJ)
  - Java Naming and Directory Interface (JNDI) URL repository
  - Java Persistent API (JPA)
    - Competitors: JDO, Hibernate, Toplink, …
  - Front ends for DB querying and administration
    - Competitors: Oracle SQL Developer, Squirrel, …
  - …

Exercise: Pivoting

- Pivoting a column A with distinct values V1 … Vk consists of yielding k binary columns A1 … Ak such that Ai = 1 iff A=Vi

A	**=>**	**high**	**avg**	**low**
high		1	0	0
avg		0	1	0
avg		0	1	0
low		0	0	1

- Develop a Java program that given a database column yields in output an ARFF file obtained by pivoting the column.

Exercise : Stratified subsampling

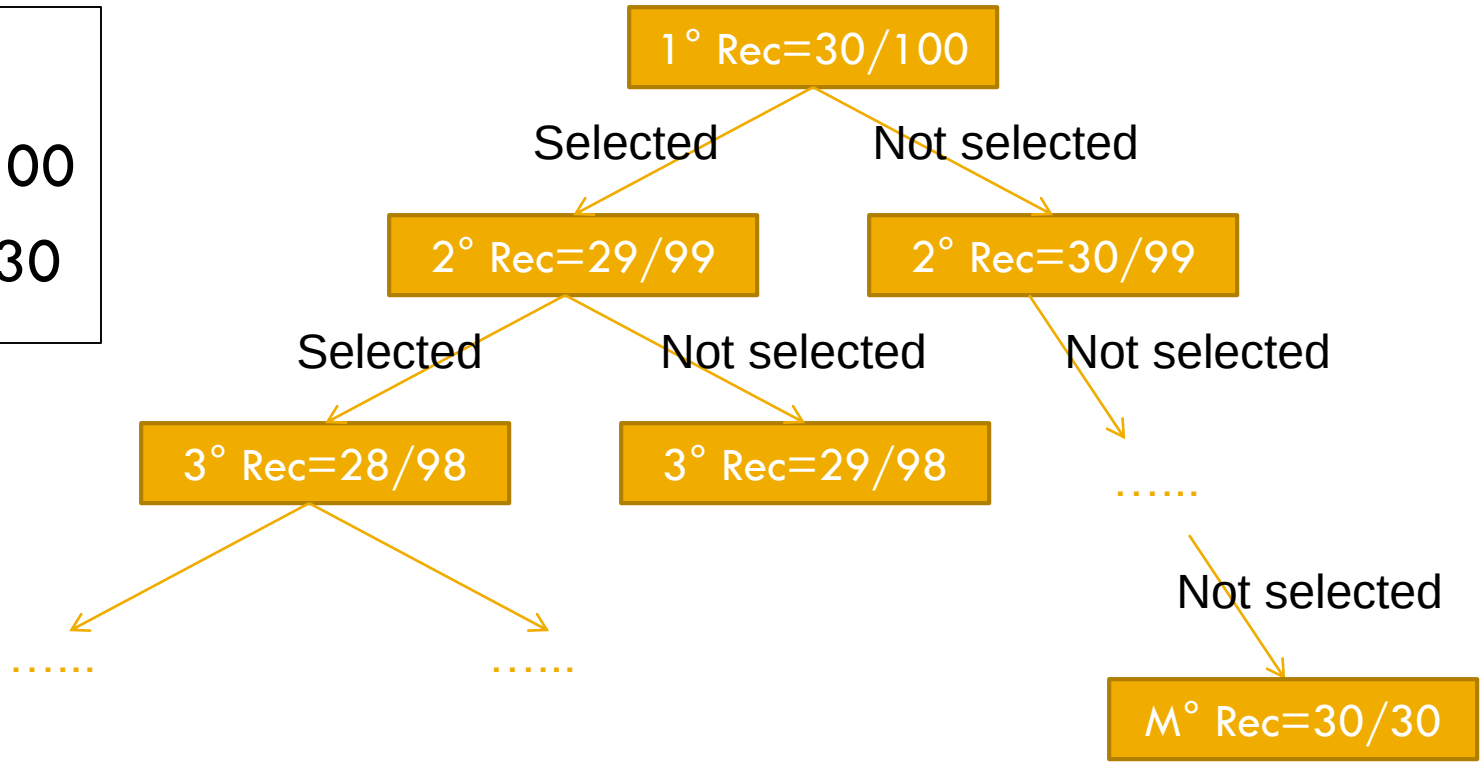
- Let T be a database table (e.g., census), and A a column in T (e.g., sex)
- Develop a Java program that exports on a CSV file a subset of 30% of rows of T:
  - the subset is randomly chosen;
  - but it must preserve the proportion of distinct values of column A
    - e.g., if there are 65% of male students, the subset must contain 65% of males and 35% of females).

Intuition on the solution!

Males

Nrows=100

SelRow=30



All records selected!!!

How to generate an element with probability x/y?

- Generate a number n in the range [0 …. Y]
- The element is selected if n < x the record is selected
- For random selection of a number in the above range

```
(int)(Math.random()*Y)
```