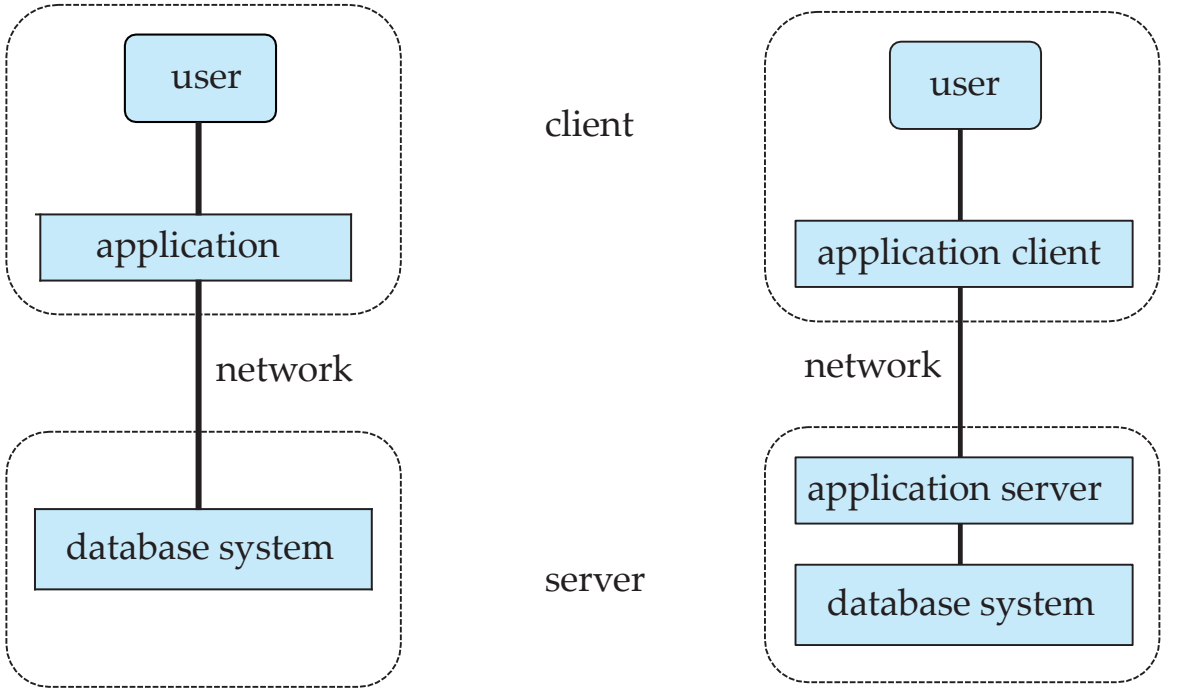
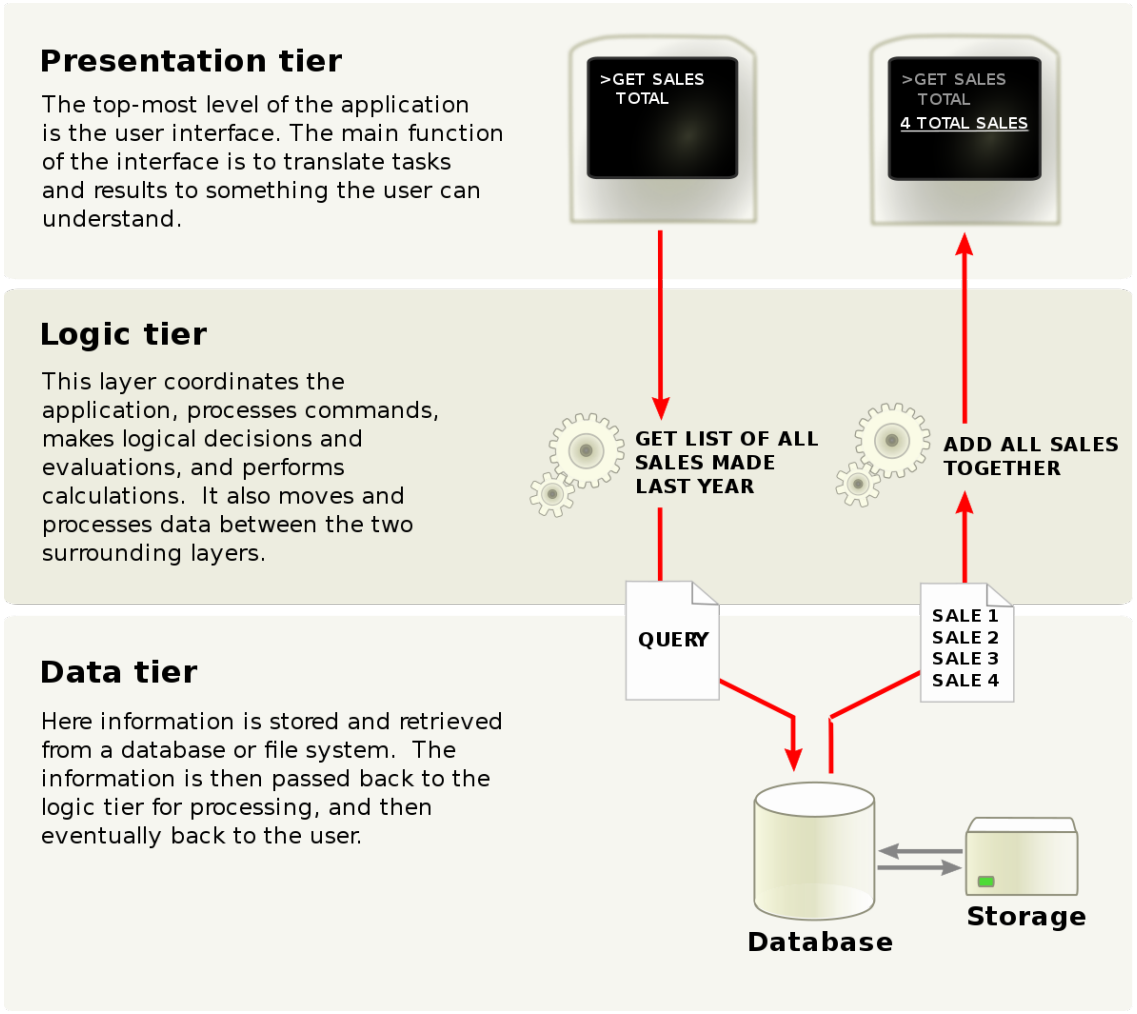
Client-server Architectures

- Many different possibilities to build end-to-end app
  - 2-tier and 3-tier architectures are popular



(a) Two-tier architecture (b) Three-tier architecture

Three-tier architecture



- E.g. browser
- E.g. Ruby on Rails, Java EE, ASP.NET, PHP, ColdFusion, etc.
- E.g. PostgreSQL, Oracle, MySQL, SQL Server, etc.

JDBC and ODBC

- API (application-program interface) for a program to interact with a database server
- Application makes calls to
  - Connect with the database server
  - Send SQL commands to the database server
  - Fetch tuples of result one-by-one into program variables
- ODBC (Open Database Connectivity) works with C, C++, C#, and Visual Basic
  - Other API's such as ADO.NET sit on top of ODBC
- JDBC (Java Database Connectivity) works with Java

JDBC Code

```
public static void JDBCexample(String dbid, String userid, String passwd)
{
    try (Connection conn = DriverManager.getConnection(
          "jdbc:oracle:thin:@db.umd.edu:2000:univdb", userid, passwd);
          Statement stmt = conn.createStatement();
        )
    {
          … Do Actual Work ….
    }
    catch (SQLException sqle) {
       System.out.println("SQLException : " + sqle);
    }
}
```

NOTE: Above syntax works with Java 7, and JDBC 4 onwards.

Resources opened in "try (….)" syntax ("try with resources") are automatically closed at the end of the try block

JDBC Code (Cont.)

- Update to database

```
try {
    stmt.executeUpdate(
        "insert into instructor values('77987', 'Kim', 'Physics', 98000)");
} catch (SQLException sqle)
{
   System.out.println("Could not insert tuple. " + sqle);
}
```

- Execute query and fetch and print results

```
ResultSet rset = stmt.executeQuery(
                          "select dept_name, avg (salary)
                           from instructor
                           group by dept_name");
while (rset.next()) {
      System.out.println(rset.getString("dept_name") + " " +
                                  rset.getFloat(2));
}
```

JDBC Code Details

- Getting result fields:
  - rs.getString(“dept_name”) and rs.getString(1) equivalent if dept_name is the first argument of select result.
- Dealing with Null values

```
int a = rs.getInt(“a”);
if (rs.wasNull()) Systems.out.println(“Got null value”);
```

Metadata Features

- ResultSet metadata
- E.g.after executing query to get a ResultSet rs:
  - ResultSetMetaData rsmd = rs.getMetaData();

```
for(int i = 1; i <= rsmd.getColumnCount(); i++) {
    System.out.println(rsmd.getColumnName(i));
    System.out.println(rsmd.getColumnTypeName(i));
}
```

- How is this useful?

Prepared Statement

- PreparedStatement pStmt = conn.prepareStatement(
  "insert into instructor values(?,?,?,?)");
  pStmt.setString(1, "88877");
  pStmt.setString(2, "Perry");
  pStmt.setString(3, "Finance");
  pStmt.setInt(4, 125000);
  pStmt.executeUpdate();
  pStmt.setString(1, "88878");
  pStmt.executeUpdate();
- WARNING: always use prepared statements when taking an input from the user and adding it to a query
  - NEVER create a query by concatenating strings
  - "insert into instructor values(' " + ID + " ', ' " + name + " ', " + " ' + dept name + " ', " ' salary + ")“
  - What if name is “D’Souza”?

SQL Injection

- Suppose query is constructed using
  - "select * from instructor where name = '" + name + "'"
- Suppose the user, instead of entering a name, enters:
  - X' or 'Y' = 'Y
- then the resulting statement becomes:
  - "select * from instructor where name = '" + "X' or 'Y' = 'Y" + "'"
  - which is:
    - select * from instructor where name = 'X' or 'Y' = 'Y'
  - User could have even used
    - X'; update instructor set salary = salary + 10000; --
- Prepared statement internally uses:
  "select * from instructor where name = 'X\' or \'Y\' = \'Y'
  - Always use prepared statements, with user inputs as parameters

SQL Injection: XKCD