Relational Databases

- Most common type of client/server software is where the server is an RDBMS server:
  - Oracle
  - SQLserver
  - Sybase
  - Informix

Relational Databases

- Stores data into tables

order		
orderid	orderdate	custid
239	Nov.13	2349
267	Nov.14	3903

customer		
custid	custname	credit
2394	Fred	ok
3903	Susan	ok
3453	Mandy	bad

orderitems		
orderid	itemid	quantity
239	12	1
239	28	4
267	42	10

items		
itemid	itemname	onhand
12	bread	2142
28	sugar	345
42	beer	2134

Database Access

- Access using SQL (Standard Query Language)
  - select itemname,quantity
    - from
      - orderitems,items
    - where
      - orderid = 239
        - » and
      - orderitems.itemid = items.itemid

"stored procedure" if this is parameterized and the whole thing is named

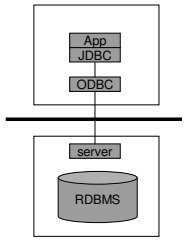
query result	
itemname	quantity
bread	2142
sugar	345

Programmatic Database Access

- Can access database by
  - typing commands at an sql command prompt
  - by running a GUI tool
  - programmatically
    - ODBC
      - Open Database Connectivity – Microsoft standard API
      - ANSI/ISO CLI is ODBC level1 compliant (Call Level Interface)
        - » (see also DAO, OLE DB and ADO)
    - JDBC
      - very similar to ODBC
    - Various embedded SQL hacks

JDBC

- All sorts of possible configurations of client-side & server-side drivers



Database Access from Java

```
import java.sql.*;
public class Main {
   private static final query =
       "select itemname,quantity " +
       "from orderitems,items " +
       "where orderid=1 and orderitems.itemid=items.itemid";

    public static void main(String[] args) throws Exception {
        Class.forName("sun.jdbc.odbc.JdbcOdbcDriver");
        Connection c = DriverManager.getConnection("jdbc:odbc:grocery");
        Statement s = c.createStatement();
        if( s.execute(query) ) {
            ResultSet r = s.getResultSet();
            printResults(r);
        }
    }

     private static void printResults(ResultSet r) throws Exception {
        final int nC = printHeadings(r);
        printRows(nC, r);
    }
    …
}
```

Database Access from Java

```
private static int printHeadings(ResultSet r)
        throws Exception {

    ResultSetMetaData m = r.getMetaData();
    final int nC = m.getColumnCount();
    for(int c = 1; c <= nC; c++) {
        System.out.print(m.getColumnName(c));
        System.out.print("\t");
    }
    System.out.println();
    return nC;
}
```


Database Access from Java

```
private static void printRows(int nC, ResultSet r)
        throws Exception {
    while( r.next() ) {
        for(int c = 1; c <= nC; c++) {
            System.out.print(r.getString(c));
            System.out.print("\t");
        }
        System.out.println();
    }
}
```


Without ODBC

```
Class.forName(
    "org.gjt.mm.mysql.Driver"
    );


Connection c = DriverManager.getConnection(
    "jdbc:mysql://penny.dhcp.cs.toronto.edu/grocery"
    );
```


Performance

- localhost
  - JDBC:ODBC
    - 850 us/query
  - JDBC:MYSQL
    - 500 us/query
- over network
  - JDBC:ODBC
    - 3,800 us/query
  - JDBC:MYSQL
    - 1,600 us/query
- local Java method call
  - 0.13 us/query
- C socket over network
  - 840 us/query

Performance

	In Process	DB Network
Latency	1	12,300