Databases and MySQL in 21 minutes

- **Relational Database Management Systems**
  - MySQL, Postgres, Oracle, Sybase, DB2, ...
- **a database is a collection of tables**
- **each table has a fixed number of columns**
  - each column is an "attribute" common to all rows
- **and a variable number of rows**
  - each row is a "record" that contains data

isbn	*title*	*author*	*price*
1234	*MySQL*	*DuBois*	*49.95*
4321	*TPOP*	*K & P*	*24.95*
2468	*Algs in Python*	*Sedgewick*	*79.99*
2467	*Algs in Perl*	*Sedgewick*	*79.99*
2466	*Algs in Awk*	*Sedgewick*	*79.99*
1357	*Networks*	*Peterson*	*105.00*
1111	*Practical Ethics*	*Singer*	*25.00*
4320	*C Prog Lang*	*K & R*	*40.00*

Relational model

- **simplest database has one table holding all data**
  - e.g., Excel spreadsheet
- **relational model puts data into separate tables that are "related" by common values**
  - e.g., **id** in custs matches **custid** in sales

```
books
     isbn   title   author   price
custs
     id   name   adr
sales
     isbn   custid   date   price   qty
stock
     isbn   count
```

- **extract desired info by queries**
- **query processing figures out what info comes from what tables, extracts it efficiently**

Sample database

- **books**

```
1234  MySQL           DuBois    49.95
4321  TPOP            K & P     24.95
2468  Algs in Python  Sedgewick 79.99
2467  Algs in Perl    Sedgewick 79.99
```

- **custs**

```
11   Brian   Princeton
22   Bob     Princeton
33   Bill    Redmond
```

- **sales**

```
4321   11  2004-02-29  45.00   1
2467   22  2004-01-01  60.00  10
```

- **stock**

```
1234   100
4321    20
2468     5
```

Retrieving data from table

- **SQL ("Structured Query Language") is the standard language for expressing queries**
  - all major database systems support it
- **general format**
  - select *column-names* from *tables* where *condition* **;**

```
select * from books;

select name, adr from custs;

select title, price from books where price > 50;

select * from books where author = "Sedgewick";

select author, title from books where author like "S%";

select author, title from books order by author;

select author, count(*) from books group by author;
```

Multiple tables and joins

- **if desired info comes from multiple tables, this implies a "join" operator to relate data in different tables**
  - in effect join makes a big table for later selection

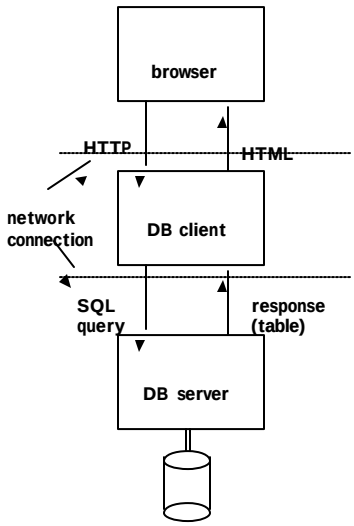
```
select title, count from books, stock
   where books.isbn = stock.isbn;

select * from books, sales
   where books.isbn = sales.isbn
     and books.author like "S%";

select custs.name, books.title
  from books, custs, sales
    where custs.id = sales.custid
      and sales.isbn = books.isbn;

select price, count(*) as count from books
   where author like 'S%'
     group by author order by count desc;
```

Database system organization



MySQL

- **open source relational database system**
  www.mysql.com

- **"LAMP"**
  - **L**inux
  - **A**pache
  - **M**ySQL
  - **P***: Perl, Python, PHP

- **command-line interface: connect to server using command interface**

```
mysql -h studentdb -u bwk -p
```

- **type commands, read responses**

```
show databases;
use bwk;
show tables;
select now(), version(), user();
source cmdfile;
```

Creating and loading a table

- **create table**

```
create table books (
  isbn varchar(15) primary key,
  title varchar(35), author varchar(20),
  price decimal(10,2)
);
```

- **load table from file (tab-separated text)**

```
load data local infile "books"
          into table books
     fields terminated by "\t"
     ignore 1 lines;
```

- **fields have to be left justified.**
- **terminated clause must be single character**
  - (not whitespace)
  - multiple blanks are NOT treated as single separator

- **can also insert one record at a time**

```
insert into books
   values('2464','Algs in MySQL',
              'Sedgewick','89.99');
```

Item types

- **INT**
  - of several sizes
- **FLOAT, DOUBLE, DECIMAL**
- **CHAR, VARCHAR**
- **BLOB (binary large object)**
  - of several sizes
- **TEXT**
  - of several sizes
- **ENUM**
  - e.g., 'M', 'F'
- **SET**
- **DATE, TIME, …**

Select statement

- **most frequently used command**

```
select what to display
from tables
where condition
group by columns
order by columns
having condition
limit value
```

- **all parts optional except "what to display"**

Other statements

- **use**
```
use bwk;
```
- **show**
```
show tables;
```
- **describe**
```
describe books;
```
- **insert**
```
insert into sales
  values('1234','44','2004-03-10','27.95');
```
- **update**
```
update books set price = 99.99
        where author = "Sedgewick";
```
- **delete**
```
delete from books where author = "Anon";
```
- **drop**
```
drop tables if exists books, custs;
```

Program interfaces to MySQL

- **original and basic interface is in C**
  - other interfaces build on this
  - most efficient access
    - though query complexity is where the time goes
  - about 50 functions
  - significant complexity in managing storage for query results
- **API's exist for most other programming languages**
  - Perl
  - Python, PHP, C++, Java, ...
  - can use MySQL from Excel, etc., with ODBC module
- **basic structure for all API's is**

dbh = *connect* to database
repeat until tired
    sth = *prepare* an SQL statement
    execute (sth)
    fetch result
disconnect (dbh)

Simple standalone Perl example

```
#!/usr/local/bin/perl -w

use strict;
use DBI;

my $dsn =
  "DBI:mysql:bwk:studentdb.cs.princeton.edu";

my $dbh = DBI->connect(
  $dsn, "bwk", "xxx", {RaiseError=>1});

while (<>) {
  chomp;
  $sth = $dbh->prepare("$_");
  $sth->execute();
  while (my @ary = $sth->fetchrow_array()) {
       print join ("\t", @ary), "\n";
  }
}

$sth->finish();

$dbh->disconnect();
```

Perl CGI version (part 1: get query, access db)

```
#!/usr/local/bin/perl -w

use strict;
use DBI;
use CGI;
my $query = new CGI;
my $ret = "";
my $passwd = $query->param("password");

if (defined($query->param("sql"))) {
  my $dsn =
    "DBI:mysql:bwk:studentdb.cs.princeton.edu";

  my $dbh = DBI->connect($dsn, "bwk", $passwd,
                         {RaiseError=>1});
  my $q = $query->param("sql");
  my $sth = $dbh->prepare($q);
  my $nchg = $sth->execute();
  my @ary;
  if ($nchg > 0) {
     while (@ary = $sth->fetchrow_array()) {
        $ret .= join ("\t", @ary), "\n";
     }
  }
  $sth->finish();
  $dbh->disconnect();
}
```

Perl CGI version (part 2: generate HTML)

```
print $query->header;
print $query->start_html(-title=>'MySQL test',
  -bgcolor=>'white');

print qq( <P><form METHOD=POST
  enctype="multipart/form-data"
  ACTION="http://www.cs.princeton.edu/
                    ~bwk/mysql.cgi">\n );
my $s = $query->param("sql");
print qq(Password: <input type="password"
   name=password text="" size="30">\n );
print qq( <br><textarea name=sql rows=5
   cols=65 wrap>$s</textarea>\n);
print qq( <br><input type="submit"
   value="Submit"> <input type=reset>\n);
print qq( <br><textarea name=results
    rows=15 cols=60 wrap>\n
    $ret\n</textarea>\n );
print "</form>\n";

print $query->end_html();
```

PHP version

- **just enough to demonstrate connectivity**

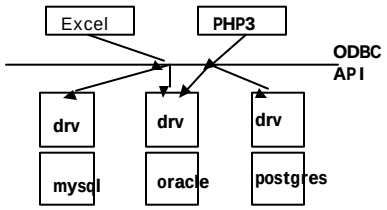
```
<html>
<title>test</title>
<body bgcolor=white>
<?php
$con = mysql_connect(
  "studentdb.cs.princeton.edu", "bwk", "xx");
if (!$con) {
  echo "Error: couldn't connect<br>\n";
  $er = mysql_error($con);
  echo "<li> $er\n";
  exit;
}

mysql_select_db("bwk", $con);

$result = mysql_query("select * from books");
while ($row = mysql_fetch_array($result)) {
  for ($i = 0; $i < mysql_num_fields($result);
     $i++) {
        printf("%s ", $row[$i]);
  }
  printf("<br>\n");
}
?>
</body></html>
```

ODBC, JDBC, and all that

- **ODBC ("open database connectivity")**
  - Microsoft standard interface between applications and databases
  - API provides basic SQL interface
  - driver does whatever work is needed to convert
  - underlying database has to provide basic services
  - used for applications like Excel, Visual Basic, C/C++, ...
  - drivers exist for all major databases
  - makes applications relatively independent of specific database being used
- **JDBC is the same thing for Java**
  - passes calls through to ODBC drivers or other database software



MySQL access from Java

- **uses Connector/J JDBC package**

```
import java.sql.*;

public class mysql {
  public static void main(String args[]) {
   String url = "jdbc:mysql://studentdb.cs.princeton.edu/bwk";

   try {
      Class.forName("com.mysql.jdbc.Driver");
   } catch(java.lang.ClassNotFoundException e) {
      System.err.print("ClassNotFoundException: " + e.getMessag
   }
   try {
      Connection con = DriverManager.getConnection(url, "bwk", "
      Statement stmt = con.createStatement();
      ResultSet rs = stmt.executeQuery("select * from books");
      while (rs.next()) {
         System.out.println(rs.getString("title") + " "
                            + rs.getString("author"));
      }
      stmt.close();
      con.close();
   } catch(SQLException ex) {
      System.err.println("SQLException: " + ex.getMessage());
   }
  }
}
```