

## 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

<i>isbn</i>	<i>title</i>	<i>author</i>	<i>price</i>
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

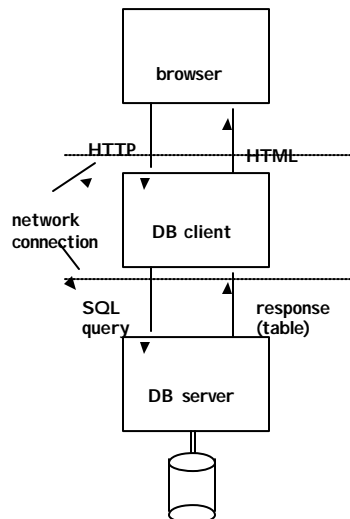
```
select title, count from books, stock
  where books.isbn = stock.isbn;
```

```
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](http://www.mysql.com)
- "LAMP"
  - Linux
  - Apache
  - MySQL
  - 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

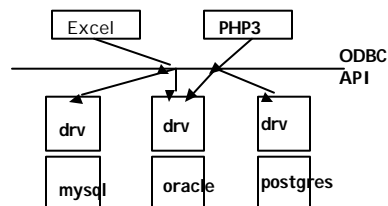
```
<html>
<title>test</title>
<body bgcolor=white>
<?php
$con = mysql_connect(
    "studentdb.cs.princeton.edu", "bwk", "xx");
if (!$con) {
    echo "Error: couldn't connect<br>\n";
    $er = mysql_error($con);
    echo "<li> $er\n";
    exit;
}

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.println("ClassNotFoundException: " + e.getMessage());
        }

        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());
        }
    }
}
```