CM0133 Internet Computing

Database Management
PHP & MySQL

Objectives

- Transactions and Transaction Management
- Database Management System (What can it do for us)
- SQL
- PHP and MySQL
- Examples

Database Management Systems (DBMS)

- A database management system (DBMS) supports reliable and efficient sharing of large sets of data among several users. In particular, a DBMS provides the following features:
  - persistency
  - efficient storage management
  - recovery
  - concurrency control
  - ad-hoc queries (e.g. SQL)
  - data security
- A DBMS allows to insert, retrieve and maintain data.

Features of DBMS

- **Persistent storage** of data means that that data survive the execution of programs.
- **Efficient Storage Management:** Databases support efficient storage of large sets of data that do not fit entirely into main memory. Data is moved from a secondary storage e.g. disk to main memory using pages and buffers. There is a variety of buffering techniques that can not be covered in this course.

  Indexing techniqes are used to retrieve data from the disk. An index I associated to a data file D is an ordered file (a sequence of records) with entries (k_i,p_i) where k_i is the value of the indexing field of a record in D and p_i is the address of the block containing that record.

Indices

- Indices provide fast access to our records (e.g. binary search).
- A rule for your web databases: If you do a lot of search on an attribute (column) then use an index! No matter which it will improve your access.
- There are many ways to index data and they will be covered in other lectures. You will come across clustering index, hashing, B* Trees (hierarchical multilevel index).
- MySQL mostly implements a B-Tree index, if you work with memory tables than hashing is used and if you work with spatial data MySQL uses R-Trees.

http://dev.mysql.com/doc/refman/5.0/en/mysql-indexes.html

Transaction: An Execution of a DB Program

- Key concept is *transaction*, which is an *atomic* sequence of database actions (reads/writes).
- Each transaction, executed completely, must leave the DB in a *consistent state* if DB is consistent when the transaction begins.
  - Users can specify some simple *integrity constraints* on the data, and the DBMS will enforce these constraints.
  - Beyond this, the DBMS does not really understand the semantics of the data.
  - Thus, ensuring that a transaction (run alone) preserves consistency is ultimately the user’s/developer's responsibility!

Ensuring Atomicity

- DBMS ensures *atomicity* (all-or-nothing property) even if system crashes in the middle of a transaction.
- Idea: Keep a *log* (history) of all actions carried out by the DBMS while executing a set of transactions:
  - Before a change is made to the database, the corresponding log entry is forced to a safe location.
  - After a crash, the effects of partially executed transactions are *undone* using the log. (the change was not applied to database but to the log itself!)

Database Transactions - Atomicity

- **Atomicity**: Transactions are executed atomically. This means that either none of the actions of a transaction is carried out or all of them are carried out. Special commands are carried out to indicate the start of a transaction (begin transaction), the successful completion of a transaction (commit transaction), and the abort of a transaction (abort transaction).

Consistency

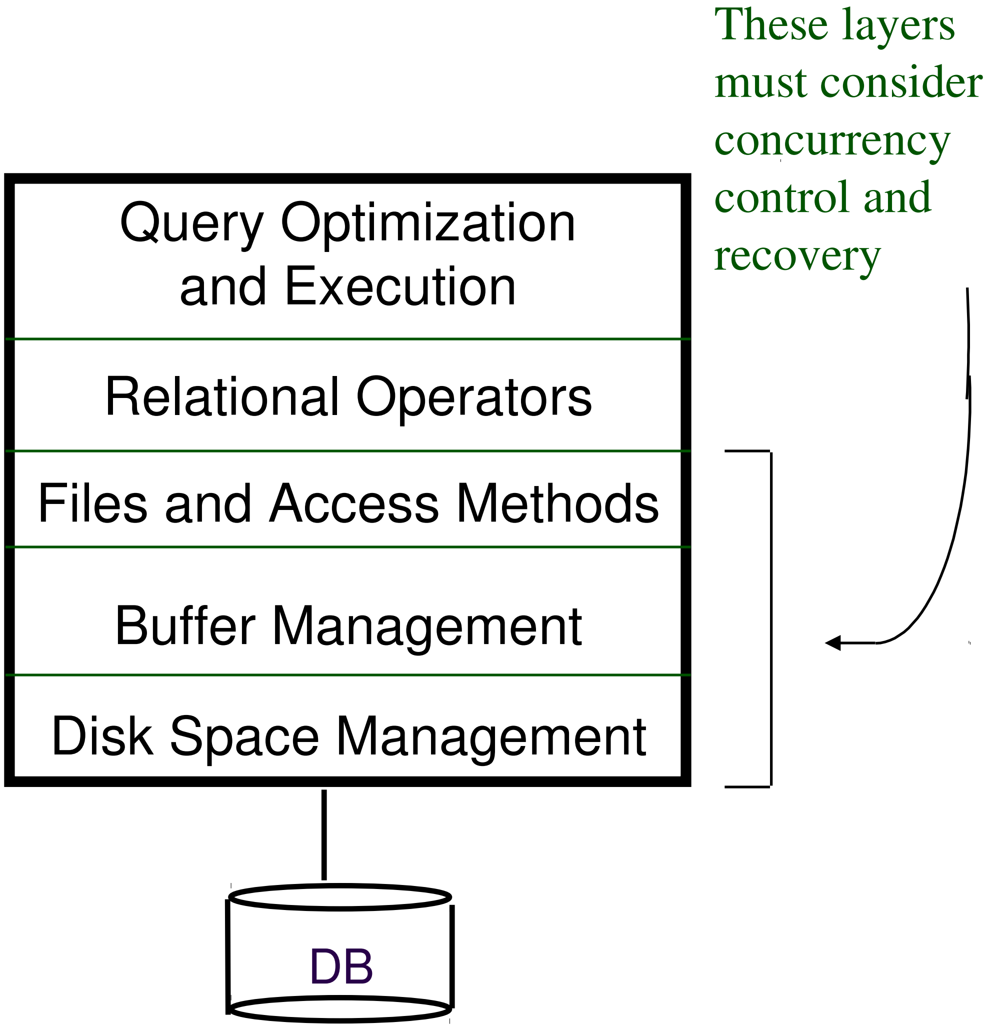
- Transactions move the database from one **consistent state** to another even if the database is accessed by several users simultaneously, executing several transactions interleaved (or in parallel). The traditional correctness criterion for executing several transactions interleaved is serializability.
- **Serializability** means that the overall effect of several transactions executed interleaved is the same as if these transaction had been executed in some serial order.

Isolation & Durability

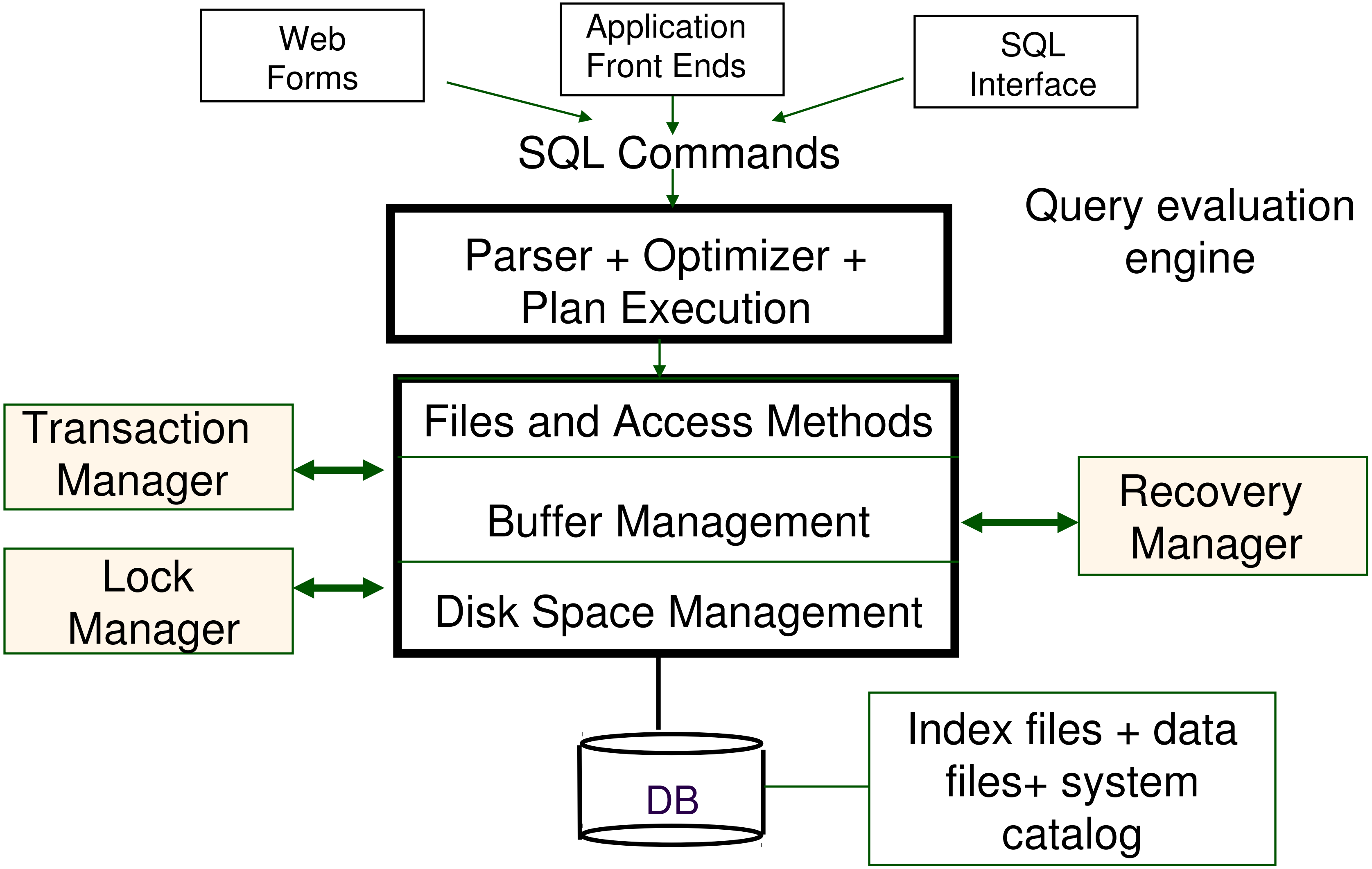
- Transactions are executed in **isolation**. Interim results of a transaction are not visible to other transactions. This means that effects of a transaction are visible to other transactions only after it has been completed successfully.
- **Durability** guarantees that once a transaction has been completed successfully, its effects remain persistent despite possible subsequent failures.

Structure of a DBMS

- A typical DBMS has a layered architecture.
- The figure does not show the concurrency control and recovery components.
- This is one of several possible architectures; each system has its own variations.


These layers must consider concurrency control and recovery
Query Optimization and Execution
Relational Operators
Files and Access Methods
Buffer Management
Disk Space Management
DB

Structure of a DBMS (cont.)



Question ?

How can you test if a database or information system supports data integrity and consistency?

Reasons for a DBMS

- Changes to the type and format of data may occur frequently. Data independence is important
- Large amounts of data must be stored and be retrieved efficiently
- Data must be updated reliably. Inconsistent database states due to hardware and software failure are not tolerable.
- Date are accessed by several users simultaneously.
- Unexpected queries should be handled fast.
- Data are very sensitive. Data security is very important.

Reasons against DBMS

- The amount of data is small.
- The application is very simple, no future changes to data types and data formats are expected.
- Concurrent access to the database is not required.
- The high costs of a data base management system (DBMS) are unjustified (although nowadays there are low cost solutions)
- The application has strict real time requirements and DBMS would be to slow.
- The application is very special and cannot be supported by a standard DBMS efficiently.

Querying a DBMS

- A DBMS provides a Query Language.
- Query languages allow querying and updating a DMBS in a simple way.
- Most popular DML (Data Manipulation Language) : SQL(Structured Query Language).
- Queries:
  - List the name of student with sid=27373
  - Name and age of students enrolled in CM0133

The following examples are SQL queries for MySQL. There might be a difference with another DBMS. MySQL often conforms with ANSI SQL standard.

SQL – CREATE TABLE

```
CREATE TABLE 'CM0133'.'students' (
     'uid' BIGINT NOT NULL AUTO_INCREMENT ,
     'firstName' VARCHAR( 100 ) NOT NULL ,
     'surname' VARCHAR( 100 ) NOT NULL ,
     'address' TEXT NULL ,
    PRIMARY KEY ( 'uid' )
    );
```

MySQL Data Types

CREATE TABLE

- Different database implementations support different data types. For our examples we can use integer (BIGINT), characters (VARCHAR (length)), Text, Date and Timestamp.
- NOT NULL indicates a constraint. Data has to be entered for this attribute. In our example key and full name has to be provided but not the address (NULL).
- AUTO_INCREMENT is a non standard SQL convenience function by MySQL that creates unique integers for you by incrementing.

INSERT

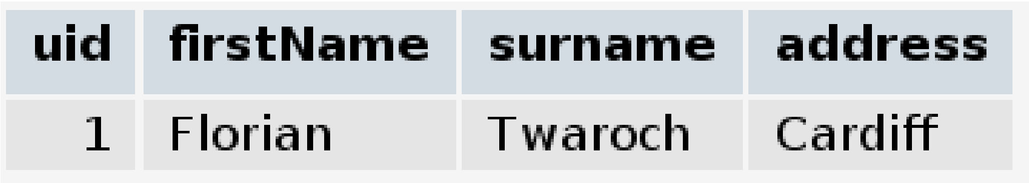
```
 INSERT INTO
CM0133.students (uid ,
firstName ,surname ,
address)

VALUES (

NULL , 'Florian', 'Twaroch',
'Cardiff'

);
```

- With INSERT we populate the created table.
- Note that NULL is entered for the uid, AUTOINCREMENT creates the value for us.



uid	firstName	surname	address
1	Florian	Twaroch	Cardiff

UPDATE

```
UPDATE CM0133.students
SET address = 'Zurich'
WHERE students.uid =1;
```

- To change an entry we use the UPDATE command together with a condition.
- We have a number of operators at hand to support that
  - Logical operators: AND, OR, NOT
  - Equivalence op: ==, !=
  - Comparision op: >,<, etc.

DELETE

```
DELETE * FROM
CM0133.students

WHERE students.uid =1;
```

- The DELETE command will delete entries. Again we can use conditions on which tuples we would like to delete.
- Here the user with the unique id 1 is deleted.

SELECT

The SELECT command allows you to extract tuples from your database, e.g.:

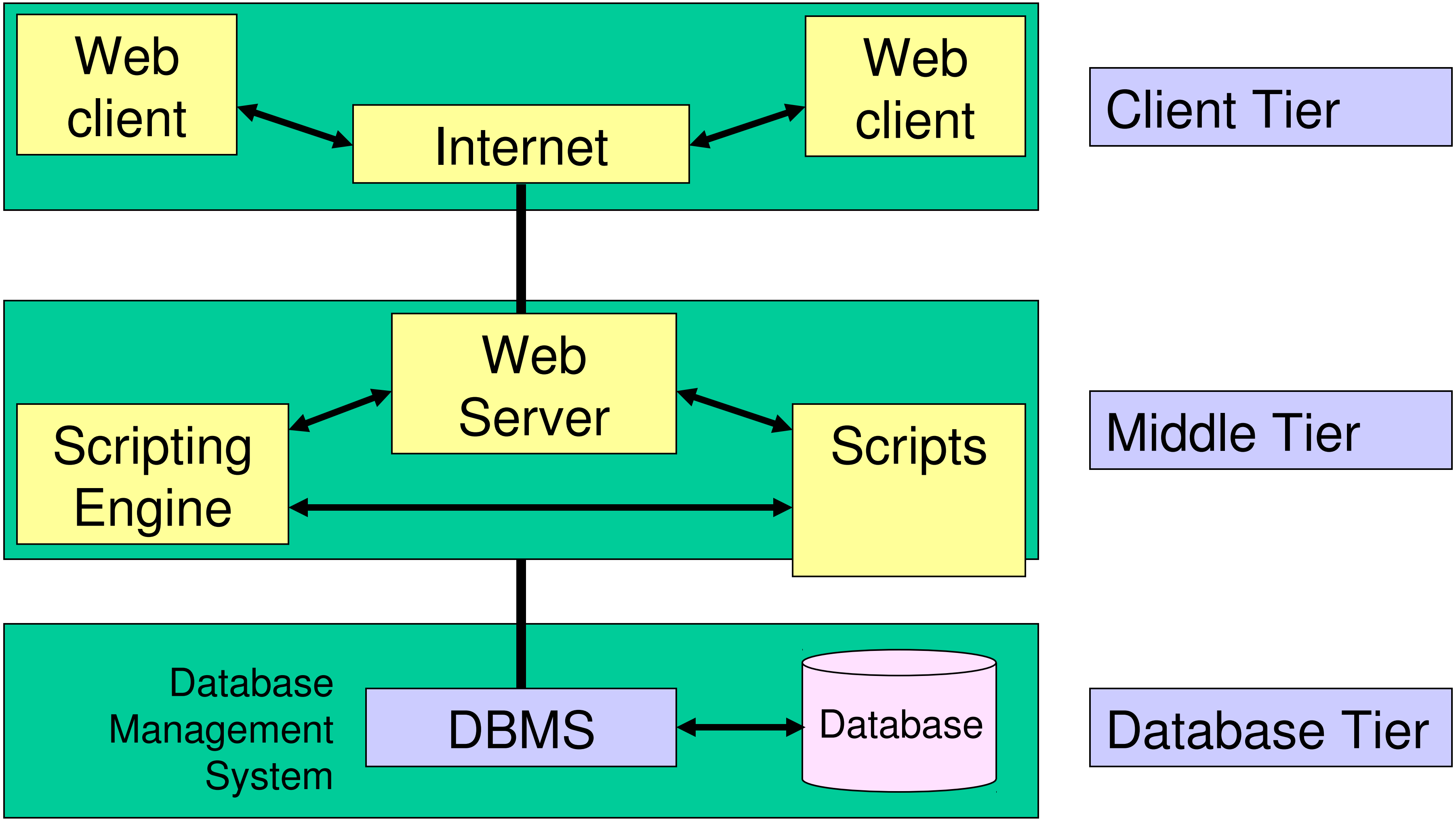
```
SELECT firstName, surname from CM0133.students
WHERE uid > 0 AND uid < 10
ORDER BY surname  DESC;
```

We will look closer at database queries in a tutorial and also how SQL queries interact with PHP in the next lectures.

Connecting to Databases in PHP

- Connecting to databases in PHP is very straightforward
- Databases are required for storing large amounts of data and quickly retrieving large amounts of data
- Example database data may be:
  - Personal information
  - Financial details
  - Usernames/Passwords
  - Stock for an online shop
  - Web site content (content management systems)
- Before we continue, where do databases fit in with PHP and the internet?

Three-tier model



MySQL

- MySQL is a database management system (DBMS) for relational databases, based on the Standard Query Language (SQL)
- MySQL is open source
- The focus of this course is NOT to learn SQL
- However: you can use these notes as a basis for making you sites interact with a database

MySQL

- MySQL manages a system of relational databases
- A username and password are required to access the database system

- Each database contains tables
- Each table contains records (rows)
- Records are made up of fields

- Warning – don't use a database unless you need one!

MySQL

- phpAdmin provides an easy way to interact with and manage a MySQL database
  - provides an administrative interface to MySQL

You have access through http://www.cs.cf.ac.uk/phpMyAdmin/ and through program API.

- You can find notes describing how to use phpMyAdmin together with PHP at

  http://docs.cs.cf.ac.uk/docs/notes/html/602

- Before you can use phpMyAdmin you first require a database to be created on the server – the administrator (e.g. Robert Evans) has to do this
- You then get a password to access the database

MySQL

- In the following example, we will create a database table using PHP and SQL

- All database interaction will be through PHP and SQL

- This includes database `table` creation using PHP and SQL

- Note that you can alternatively create database tables via the `phpMyAdmin` user interface.

Creating an empty Table

1. We first connect to the database management system using **`mysql_connect()`**
2. We then select the correct database within in that system using **`mysql_select_db()`**
3. We then use **`mysql_query()`** to create a new table on the database – e.g. we call this table **`login_info`**
4. The table is actually created by the SQL argument that we give **`mysql_query()`**. e.g:

```
create table login_info (
   id int(11) NOT NULL auto_increment,
   username char(30) NOT NULL,
   password char(80) NOT NULL,
   primary key (id)
```

- We then use **`mysql_close()`** to close the DBMS connection

Creating an empty table

```
<?php
$connection = mysql_connect("ephesus.cs.cf.ac.uk", “username",
   “password");
mysql_select_db("Florians_DB", $connection) or die("Failed!");

$create = "create table login_info(
   id int(11) NOT NULL auto_increment,
   username char(30) NOT NULL,
   password char(80) NOT NULL,
   primary key (id)
   );";
mysql_query($create)
or die ("Could not create tables because ".mysql_error());
mysql_close();
?>
```

Creating an empty table

- Note that **`mysql_connect()`** returns a DBMS connection handle, and takes as its arguments:
  - A server name
  - A username
  - A password
- Note that **`mysql_select_db()`** takes as its arguments:
  - The name of the database on the DBMS
  - A DBMS connection handle
- Note that (in this e.g.) the only argument **`mysql_query()`** takes is a string representing an SQL query

Inserting a row into a Table

```
<?php
 $connection = mysql_connect("ephesus.cs.cf.ac.uk", "username",
   "password");

 mysql_select_db("Florians_DB", $connection) or die("Failed!");

 $insert = "INSERT INTO login_info values('NULL',‘un1','pw1');
 mysql_query($insert);

 mysql_close();
?>
```

This example inserts a row into the table with the username **un1** and the password **pw1**

Retrieving data from a table

- The following program retrieves data from a database table
- Note that data is stored in a table in rows
- We therefore retrieve data from a table one row at a time
- Each row we retrieve is an array
- Each entry in the array corresponds to a field in the table

- E.g. `row[1]` corresponds to a username value and `row[2]` corresponds to a password value

```
<?php
  $connection = mysql_connect("ephesus.cs.cf.ac.uk",
   “password", “username");
  mysql_select_db("Florians_DB",$connection) or die("Failed!");

  $retrieve_all = "SELECT * FROM login_info";
  $result = mysql_query($retrieve_all);

  // loop over each row in the result set and print row values
  while($row = mysql_fetch_row($result)) {
    for($i=0; $i<mysql_num_fields($result); $i++){
       print $row[$i]." ";
     }
     print "<br>";
  }
mysql_close();
?>
```

Note the use of two new functions

A practical database example

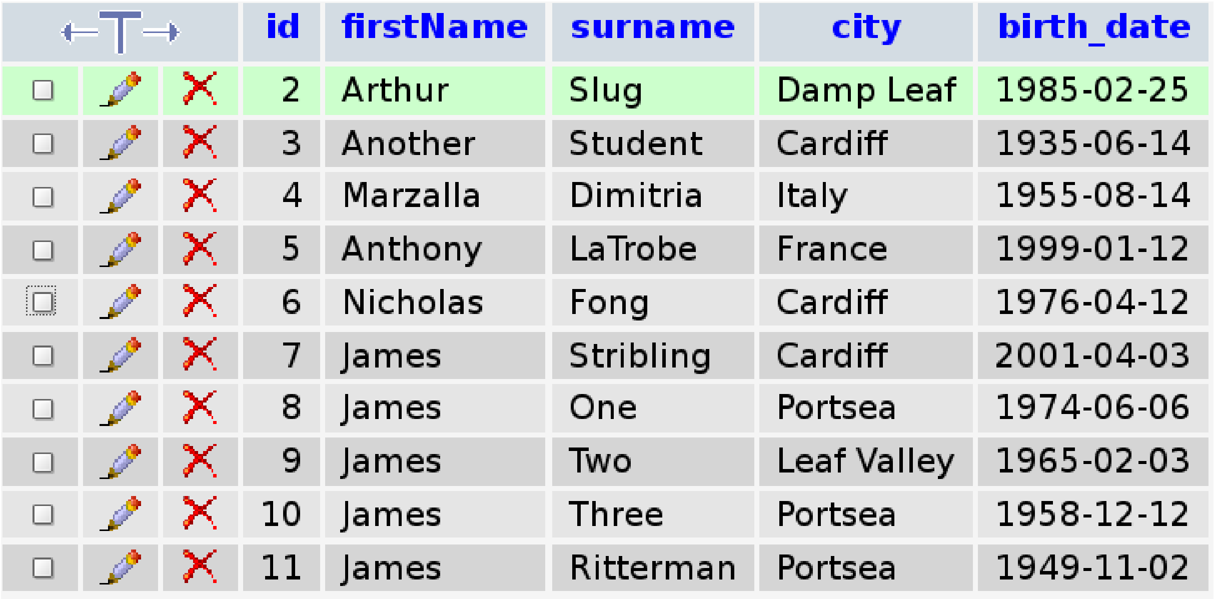
- Databases and PHP may be used with great effect to construct content management systems
- For example:
  - The entire content of a website may be stored in a database
  - Site content is updated or changed by not altering the HTML/PHP/JavaScript code – but by changing entries in a database
  - The database itself may be edited using a web-based interface
- For example, a news website may store its stories on a database. When new stories come in the database is altered, and the website is automatically updated without any new programming.

Links & Literature

- http://dev.mysql.com/tech-resources/articles/mysql_intro.html
- http://www.mysql.com/
- http://docs.cs.cf.ac.uk/docs/notes/html/602
- Hugh E. Williams and David Lane (2004) : PHP and MySQL, O'Reilly
- Come to the labs and practice !
- Attached are the example discussed in this lecture

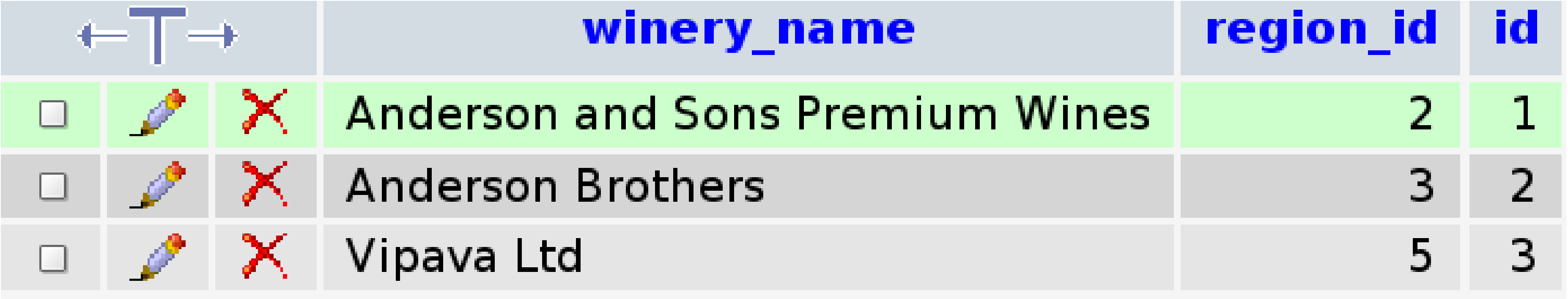
Used Tables

customer



←T→			id	firstName	surname	city	birth_date
□	✎	✗	2	Arthur	Slug	Damp Leaf	1985-02-25
□	✎	✗	3	Another	Student	Cardiff	1935-06-14
□	✎	✗	4	Marzalla	Dimitria	Italy	1955-08-14
□	✎	✗	5	Anthony	LaTrobe	France	1999-01-12
□	✎	✗	6	Nicholas	Fong	Cardiff	1976-04-12
□	✎	✗	7	James	Stribling	Cardiff	2001-04-03
□	✎	✗	8	James	One	Portsea	1974-06-06
□	✎	✗	9	James	Two	Leaf Valley	1965-02-03
□	✎	✗	10	James	Three	Portsea	1958-12-12
□	✎	✗	11	James	Ritterman	Portsea	1949-11-02

winery

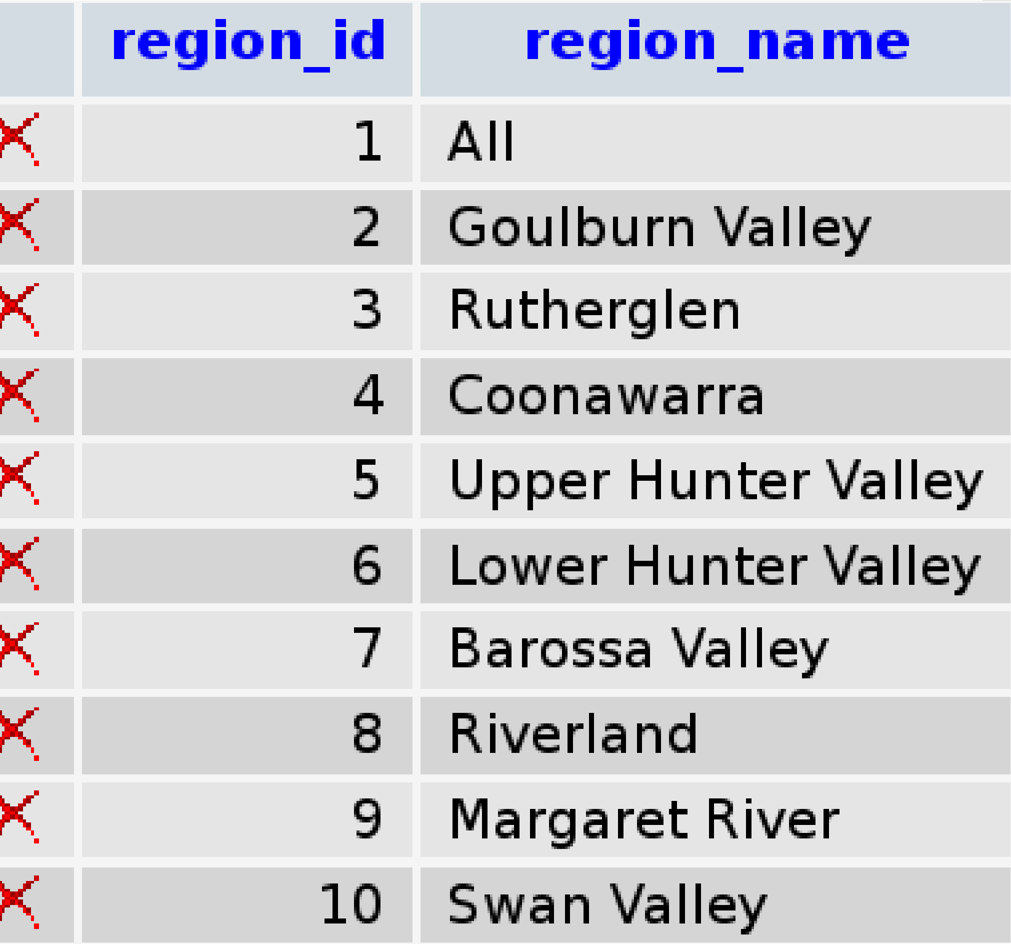


←T→			winery_name	region_id	id
□	✎	✗	Anderson and Sons Premium Wines	2	1
□	✎	✗	Anderson Brothers	3	2
□	✎	✗	Vipava Ltd	5	3

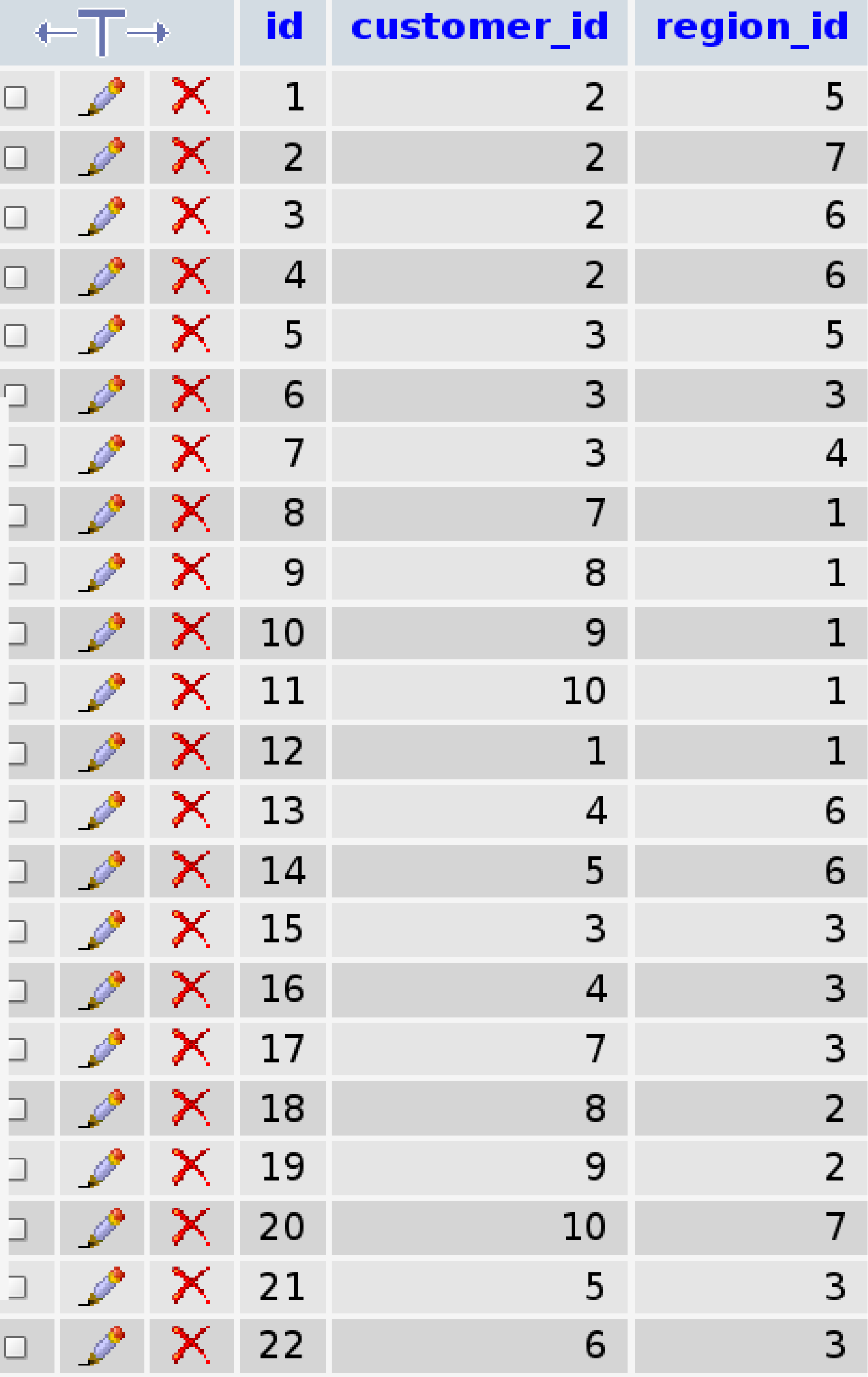
orders

Used Tables

region



	region_id	region_name
✗	1	All
✗	2	Goulburn Valley
✗	3	Rutherglen
✗	4	Coonawarra
✗	5	Upper Hunter Valley
✗	6	Lower Hunter Valley
✗	7	Barossa Valley
✗	8	Riverland
✗	9	Margaret River
✗	10	Swan Valley



←T→			id	customer_id	region_id
☐	✎	✗	1	2	5
☐	✎	✗	2	2	7
☐	✎	✗	3	2	6
☐	✎	✗	4	2	6
☐	✎	✗	5	3	5
☐	✎	✗	6	3	3
☐	✎	✗	7	3	4
☐	✎	✗	8	7	1
☐	✎	✗	9	8	1
☐	✎	✗	10	9	1
☐	✎	✗	11	10	1
☐	✎	✗	12	1	1
☐	✎	✗	13	4	6
☐	✎	✗	14	5	6
☐	✎	✗	15	3	3
☐	✎	✗	16	4	3
☐	✎	✗	17	7	3
☐	✎	✗	18	8	2
☐	✎	✗	19	9	2
☐	✎	✗	20	10	7
☐	✎	✗	21	5	3
☐	✎	✗	22	6	3

INSPECT DB (command line)

```
SHOW databases;     # show all available databases
USE CM0133;         # select one

SHOW tables;        # show tables of selected database

DESCRIBE customer;     # describe one of the tables
```

SQL EXAMPLES

```
SELECT surname, firstname FROM customer;
SELECT * FROM region ;
SELECT curtime();
SELECT pi()*(4*4);

SELECT * FROM region WHERE region_id <= 3;
SELECT region_name FROM region WHERE region_id <= 3;

SELECT id FROM customer WHERE (surname='Marzalla' AND firstname
LIKE 'M%' ) OR birth_date='1980-07-14';

SELECT * FROM customer WHERE birth_date > '1989-01-01';
SELECT * FROM customer WHERE birth_date < '1989-01-01';
```

SQL EXAMPLES

SELECT surname, firstname FROM customer WHERE city = 'Portsea' and firstname = 'James' ORDER by surname DESC;

SELECT city, COUNT(*) AS cnt FROM customer GROUP BY city;

SELECT city, count(*) as cnt from customer GROUP BY city HAVING cnt > 2

SELECT city, MAX(birth_date) FROM customer GROUP BY city;

SELECT city FROM customer GROUP BY city;   equivalent to SELECT DISTINCT city from customer ;

SQL EXAMPLES

```
# Querying details without JOIN - would have to be stored in php
arrays and then be further processed. Tables can be
# matched up using JOINS - see next examples.

SELECT surname FROM customer WHERE id=2;
SELECT * FROM region WHERE id=5;

# Natural Join via identical elements
SELECT * FROM winery NATURAL JOIN region ORDER BY
winery_name;
```

SQL EXAMPLES

```
# JOIN query with explicitly specifying attributes
SELECT winery_name, region_name FROM winery, region
WHERE winery.region_id = region.region_id ORDER BY
winery_name;

# Joining more than two tables
SELECT * FROM customer,orders, region WHERE
orders.customer_id = customer.id AND
orders.region_id=region.region_id;

# Variation number of orders
SELECT firstName,surname,count(*) as cnt FROM customer,orders,
region WHERE orders.customer_id = customer.id AND
orders.region_id=region.region_id group by surname order by cnt;
```