SWINBURNE UNIVERSITY OF TECHNOLOGY

Advanced Web Development : Databases and MySQL

Week 7

Outline

- Understanding the basics of databases and MySQL
- Working with MySQL databases
- Managing user accounts
- Managing databases and tables
- Working with data records
- Understanding Security Concepts

Reading: Textbook Chapter 7

MySQL:
https://dev.mysql.com/doc/refman/8.0/en/

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UNDERSTANDING THE BASICS OF DATABASES AND MYSQL

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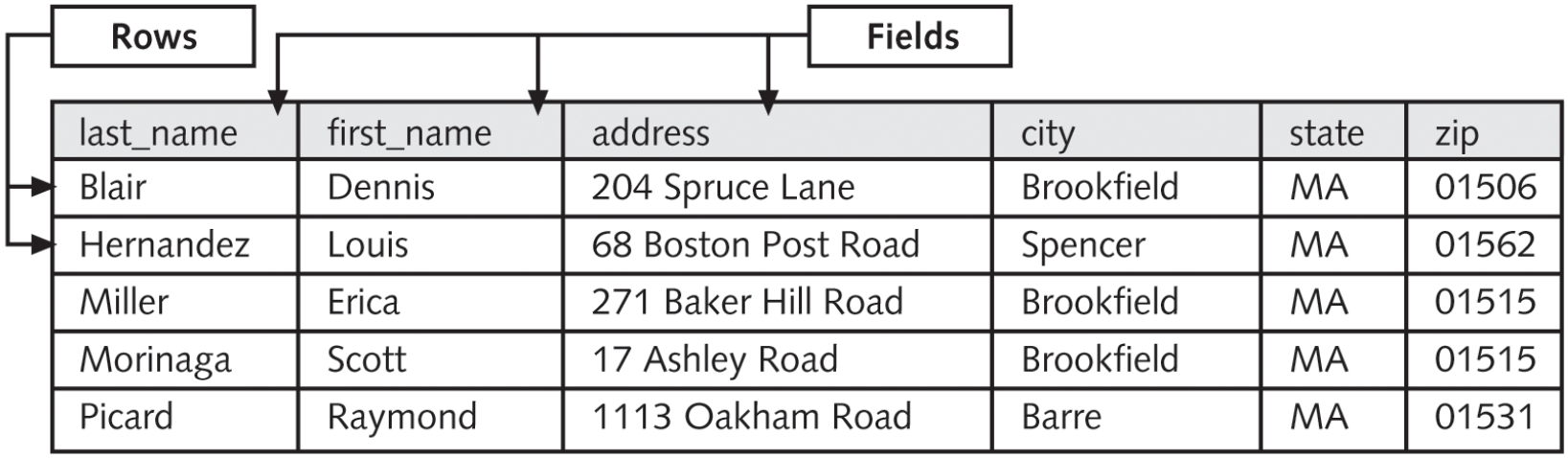
Introduction to Databases

- A **database** is an ordered collection of information from which a computer program can quickly access information
- Each row in a database table is called a **record**
- A **record** in a database is a single complete set of related information
- Each column in a database table is called a **field**
- **Fields** are the individual categories of information stored in a record

Introduction to Databases (continued)



last_name	first_name	address	city	state	zip
Blair	Dennis	204 Spruce Lane	Brookfield	MA	01506
Hernandez	Louis	68 Boston Post Road	Spencer	MA	01562
Miller	Erica	271 Baker Hill Road	Brookfield	MA	01515
Morinaga	Scott	17 Ashley Road	Brookfield	MA	01515
Picard	Raymond	1113 Oakham Road	Barre	MA	01531

Employee directory database

- A **flat-file database** stores information in a ***single*** table
- A **relational database** stores information across ***multiple*** related tables

Understanding Relational Databases

- **Relational databases** consist of one or more related tables
- A **primary table** is the main table in a relationship that is referenced by another table
- A **related table** (or “child table”) references a primary table in a relational database

Understanding Relational Databases (continued)

- A **primary key** is a field that contains a unique identifier for each record in a primary table
- A **primary key** is a type of index, which identifies records in a database to make retrievals and sorting faster
- A **foreign key** is a field in a related table that refers to the primary key in a primary table
- Primary and foreign keys link records across multiple tables in a relational database

One-to-One Relationships

- A **one-to-one relationship** exists between two tables when a related table contains exactly one record for each record in the primary table
- Create one-to-one relationships to break information into multiple, logical sets
- Information in the tables in a one-to-one relationship can be placed within a single table
- Make the information in one of the tables confidential and accessible only by certain individuals

One-to-One Relationships (continued)

Primary key

`Employees` table

employee_id	last_name	first_name	address	city	state	zip
101	Blair	Dennis	204 Spruce Lane	Brookfield	MA	01506
102	Hernandez	Louis	68 Boston Post Road	Spencer	MA	01562
103	Miller	Erica	271 Baker Hill Road	Brookfield	MA	01515
104	Morinaga	Scott	17 Ashley Road	Brookfield	MA	01515
105	Picard	Raymond	1113 Oakham Road	Barre	MA	01531

Foreign key

`Payroll` table

employee_id	start_date	pay_rate	health_coverage	year_vested	401k
101	2002	$21.25	none	na	no
102	1999	$28.00	Family Plan	2001	yes
103	1997	$24.50	Individual	na	yes
104	1994	$36.00	Family Plan	1996	yes
105	1995	$31.00	Individual	1997	yes

One-to-one relationship

One-to-Many Relationship

- A **one-to-many relationship** exists in a relational database when one record in a primary table has many related records in a related table
- Breaking tables into multiple related tables to reduce redundant and duplicate information is called **normalization**
- Provides a more efficient and less redundant method of storing this information in a database

One-to-Many Relationship (continued)

employee_id	last_name	first_name	language
101	Blair	Dennis	JavaScript
101	Blair	Dennis	ASP.NET
102	Hernandez	Louis	JavaScript
102	Hernandez	Louis	ASP.NET
102	Hernandez	Louis	Java
103	Miller	Erica	JavaScript
103	Miller	Erica	ASP.NET
103	Miller	Erica	Java
103	Miller	Erica	C++
104	Morinaga	Scott	JavaScript
104	Morinaga	Scott	ASP.NET
104	Morinaga	Scott	Java
105	Picard	Raymond	JavaScript
105	Picard	Raymond	ASP.NET

Table with redundant information

One-to-Many Relationship (continued)

`Employees` table

employee_id	last_name	first_name	address	city	state	zip
101	Blair	Dennis	204 Spruce Lane	Brookfield	MA	01506
102	Hernandez	Louis	68 Boston Post Road	Spencer	MA	01562
103	Miller	Erica	271 Baker Hill Road	Brookfield	MA	01515
104	Morinaga	Scott	17 Ashley Road	Brookfield	MA	01515
105	Picard	Raymond	1113 Oakham Road	Barre	MA	01531

`Languages` table ("many" side)

employee_id	language
101	JavaScript
101	ASP.NET
102	JavaScript
102	ASP.NET
102	Java
103	JavaScript
103	ASP.NET
103	Java
103	C++
104	JavaScript
104	ASP.NET
104	Java
105	JavaScript
105	ASP.NET

One record on the top table is linked to many records in the bottom table

Many-to-Many Relationship

- A **many-to-many relationship** exists in a relational database when many records in one table are related to many records in another table
  e.g. relationship between programmers and languages
- Must use a **junction table** which creates a one-to-many relationship for each of the two tables in a many-to-many relationship
- A junction table contains foreign keys from the two tables

Many-to-Many Relationship (continued)

`Employees` table

employee_id	last_name	first_name	address	city	state	zip
101	Blair	Dennis	204 Spruce Lane	Brookfield	MA	01506
102	Hernandez	Louis	68 Boston Post Road	Spencer	MA	01562
103	Miller	Erica	271 Baker Hill Road	Brookfield	MA	01515
104	Morinaga	Scott	17 Ashley Road	Brookfield	MA	01515
105	Picard	Raymond	1113 Oakham Road	Barre	MA	01531

`Languages` table

language_id	language
10	JavaScript
11	ASP.NET
12	Java
13	C++

Many-to-many relationship

`Experience` junction table

employee_id	language_id	years
101	10	5
101	11	4
102	10	3
102	11	2
102	12	3
103	10	2
103	11	3
103	12	6
103	13	3
104	10	7
104	11	5
104	12	8
105	10	4
105	11	2

Working with Database Management Systems

- A **database management system** (or DBMS) is an application or collection of applications used to access and manage a database
- A **schema** is the structure of a database including its tables, fields, and relationships
- A **flat-file database management system** is a system that stores data in a flat-file format
- A **relational database management system** (or RDBMS) is a system that stores data in a relational format

Examples of RDBMS

Working with Database Management Systems
(continued)

Important aspects of database management systems:

- The structuring and preservation of the database file
- Ensuring that data is stored correctly in a database's tables, regardless of the database format
- Querying capability

- (also security)

Working with Database Management Systems (continued)

- A **query** is a structured set of instructions and criteria for retrieving, adding, modifying, and deleting database information
- **Structured query language** (or SQL – pronounced as sequel) is a standard data manipulation language used among many database management systems
- **Open database connectivity** (or ODBC) allows ODBC-compliant applications to access any data source for which there is an ODBC driver

Querying Databases with Structured Query Language

Common SQL keywords

Keyword	Description
`DELETE`	Deletes a row from a table
`FROM`	Specifies the tables from which to retrieve or delete records
`INSERT`	Inserts a new row into a table
`INTO`	Determines the table into which records should be inserted
`ORDER BY`	Sorts the records returned from a table
`SELECT`	Returns information from a table
`UPDATE`	Saves changes to fields in a record
`WHERE`	Specifies the conditions that must be met for records to be returned from a query

e.g. **`select * from Employees`**

WORKING WITH MYSQL DATABASES

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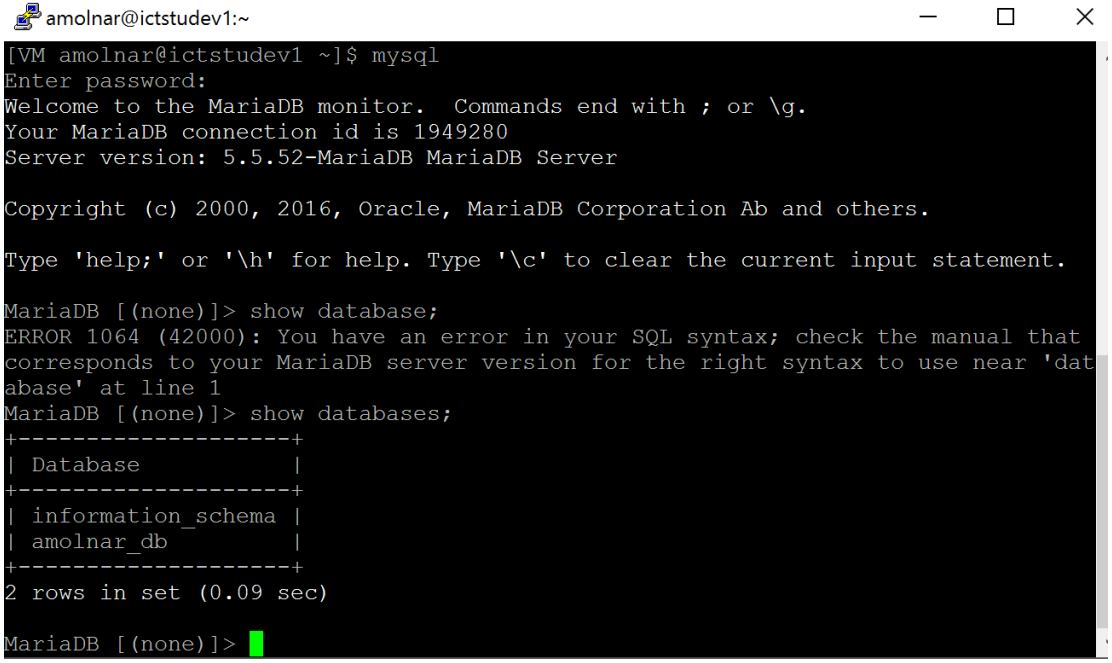
Getting Started with MySQL

- MySQL is an open source database server, and it is fast and reliable.
- There are several ways to interface with a MySQL database server:
  - Using **MySQL Monitor**, a command-line program
  - Using **phpMyAdmin**, a web interface program
    https://feenix-mariadb-web.swin.edu.au/ **- in new server**
  - Using **PHP database functions** within PHP scripts
- See: https://feenix.swin.edu.au/help/

Logging in to MySQL Monitor

- *We will be accessing the MySQL database server after you login to mercury. Your account and database have been created.*
  - ☐ Login to the mercury.swin.edu.au server using 'putty' client.
  - ☐ To access your MySQL (MariaDB) account, type in:

    `mysql (press Enter key, then password)



Working with the MySQL Monitor

- At the `mysql>` command prompt terminate the command with a semicolon

```
mysql> SELECT * FROM inventory;
```

- Without a semicolon, the MySQL Monitor enters a multiple-line command and changes the prompt to ->

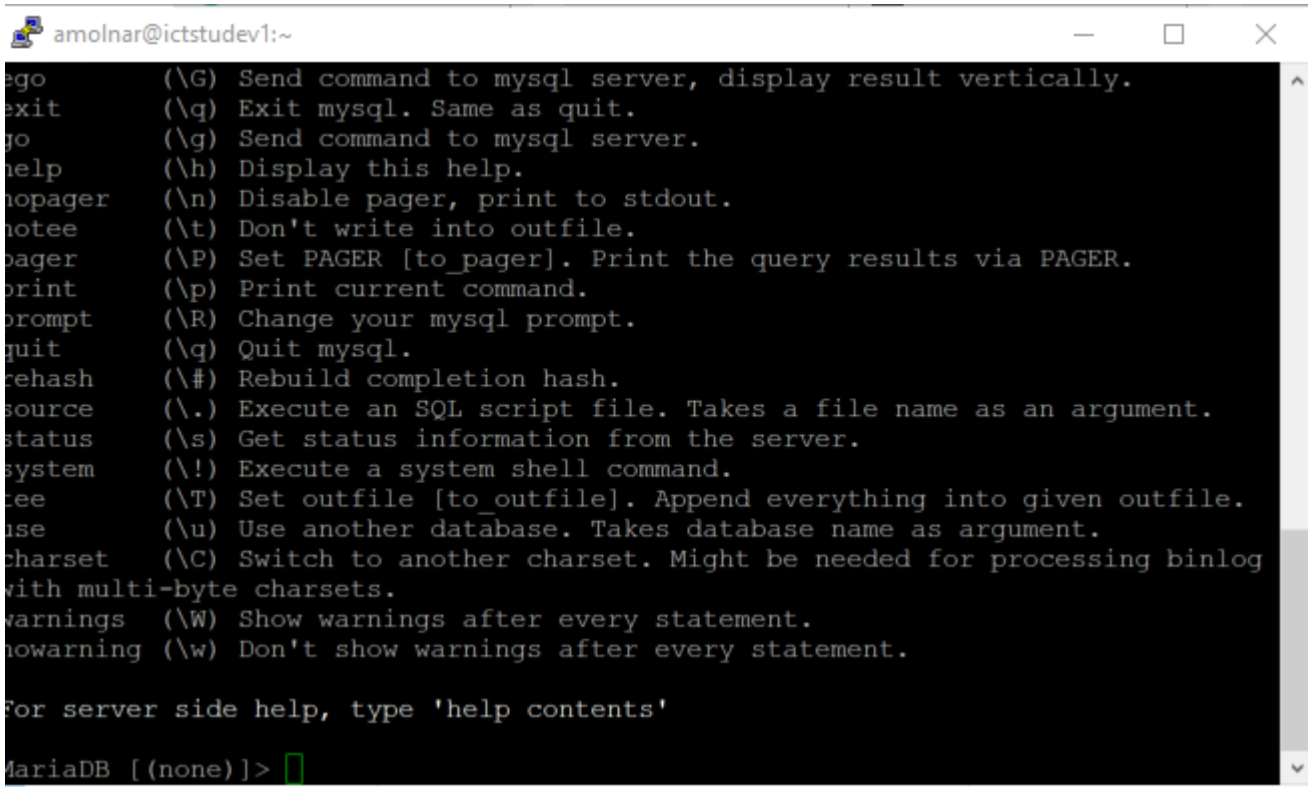
```
mysql> SELECT * FROM inventory
    -> WHERE make = "Holden";
```

- The SQL keywords entered in the MySQL Monitor are *not* case sensitive

Understanding MySQL Identifiers

- Identifiers for databases, tables, fields, indexes, and aliases
- An **alias** is an alternate name used to refer to a table or field in SQL statements
- The case sensitivity of database and table identifiers depends on the operating system
  - Not case sensitive on Windows platforms
  - Case sensitive on UNIX/Linux systems
- MySQL stores each database in a directory of the same name as the database identifier
- Field and index identifiers are case insensitive on all platforms

Getting Help with MySQL Commands



MySQL command help

MANAGING USER ACCOUNTS

Creating Users

- A **proxy** is someone or something that acts or performs a request for another person
- Create a separate account for each Web application that needs to access a database
- Use a `GRANT` statement to create user accounts and assign privileges
- **Privileges** are the operations that a user can perform with a database

Creating Users and Grant Privileges (root user)

- The `GRANT` statement creates the user account if it does not exist and assigns the specified privileges

```
GRANT privilege [(column)][, privilege [(columns)]]...
    ON {table | * | *.* | database.*}
    TO user [IDENTIFIED BY 'password'];
```

- If the user account already exists, the `GRANT` statement just updates the privileges

```
mysql> GRANT ALL ON amolnar_db.*  TO ‘amolnar'@'localhost'  IDENTIFIED B
```

Common MySQL Database Privileges

```
mysql> GRANT SELECT,INSERT,UPDATE,DELETE,CREATE,DROP
          -> ON TUTORIALS.*
          -> TO 'mary'@'localhost'
          -> IDENTIFIED BY 'mary123';
```

will add user **mary** with password **mary123** for a particular database, which is named as **TUTORIALS**.

Privilege	Description
ALL	Assigns all privileges to the user
CREATE	Allows the user to create databases, tables, and indexes
DROP	Allows the user to delete databases and tables
ALTER	Allows the user to modify table structure
DELETE	Allows the user to delete records
INDEX	Allows the user to create and delete indexes
INSERT	Allows the user to add records
SELECT	Allows the user to select records
UPDATE	Allows the user to modify records
USAGE	Creates a user with no privileges

(root) Revoking Privileges and Deleting Users

- You must be logged in with the root account or have sufficient privileges to revoke privileges from another user account

```
REVOKE privilege [(column)][, privilege [(columns)]]...
    ON {table | * | *.* | database.*}
    FROM user;
```

- The REVOKE ALL PRIVILEGES statement removes all privileges from a user account for a specified table or database
- Before deleting a user, you must first revoke all privileges assigned to the user account for all databases
  - Use the `REVOKE ALL PRIVILEGES` statement
  - View the privileges assigned to a user account with the `SHOW GRANTS FOR user` statement
- To delete an existing user, use the `DROP USER user` statement to delete the account from the user table in the `mysql` database

Securing the Initial MySQL Accounts

- Deleting the Anonymous User Account

```
mysql> DELETE FROM mysql.user WHERE User = '';
mysql> FLUSH PRIVILEGES;
```

- Assigning a Password to the Root Account

```
mysql> UPDATE mysql.user SET Password = PASSWORD('newpwd')
    -> WHERE User = 'root';
mysql> FLUSH PRIVILEGES;
```

- The password assigned to the root account and other user accounts is case sensitive

MANAGING DATABASES AND TABLES

Creating and Deleting Databases

- Use the `CREATE DATABASE` statement to create a new database:

```
mysql> CREATE DATABASE guitars;
Query OK, 1 row affected (0.02 sec)
```

- To use a new database, select it by executing the `use` *`database`* statement
- Before adding records to a new database, first define the tables and fields that will store the data
- Use the `DROP DATABASE` statement to remove all tables from the database and to delete the database

```
DROP DATABASE database;
```

- You must be logged in as the **root user** or have privileges to delete a database

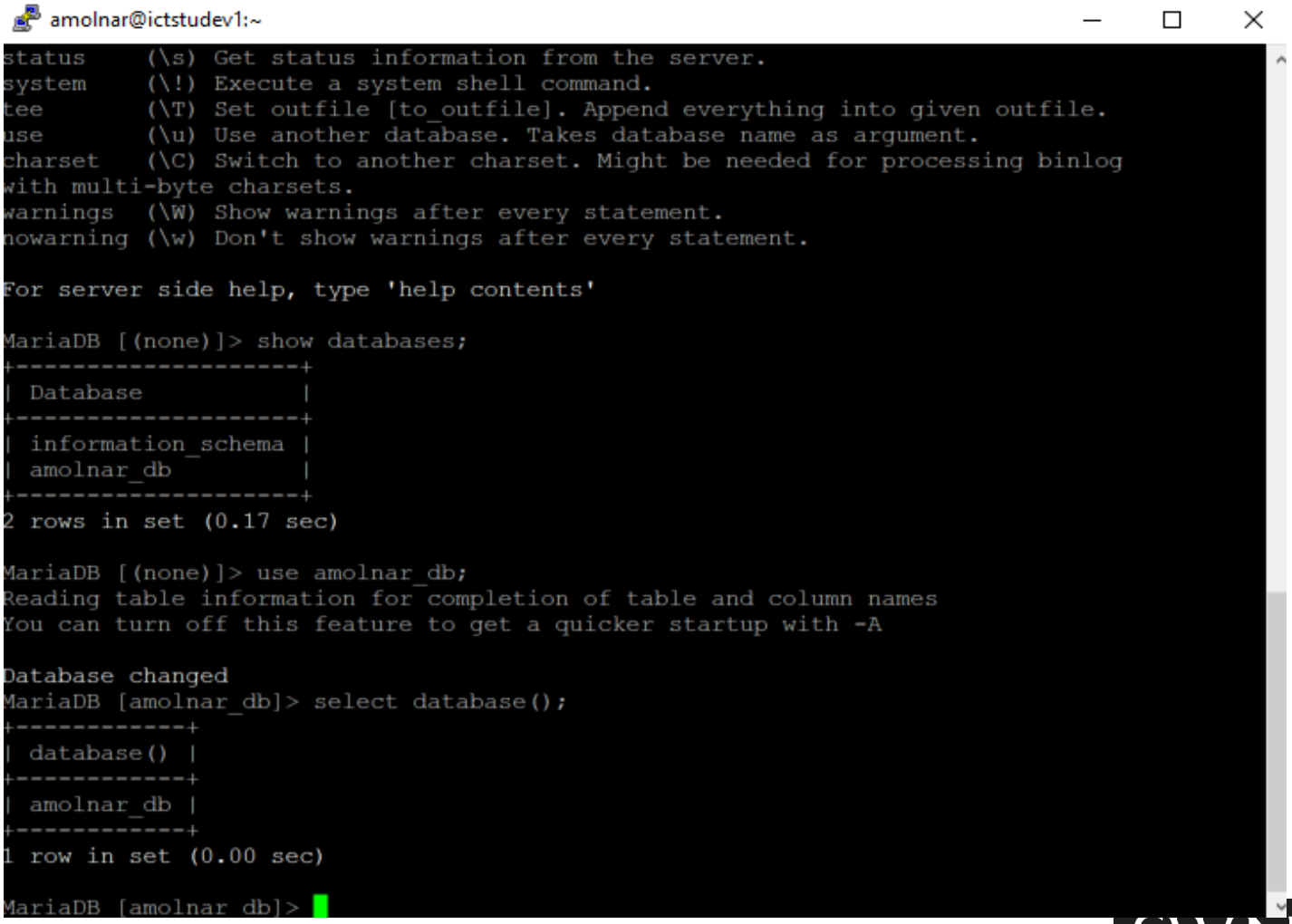
Selecting Databases (users)

- Use the `SHOW DATABASES` statement to view the databases that are available
- Use the `USE DATABASE` statement to select the database to work with
- Use the `SELECT DATABASE()` statement to display the name of the currently selected database
- The `mysql` database is installed to contain user accounts and information that is required for installation of the MySQL database server

```
MariaDB [(none)]> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| amolnar_db         |
+--------------------+
2 rows in set (0.09 sec)

MariaDB [(none)]>
```

Selecting Databases (continued)



MySQL Monitor after selecting a database

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Creating and Deleting Tables

- The `CREATE TABLE` statement specifies the table and column names and the data type for each column

```
CREATE TABLE table_name (column_name TYPE, ...);
```

- Execute the `USE` statement to select a database before executing the `CREATE TABLE` statement
- The `DROP TABLE` statement removes all data and the table definition

```
DROP TABLE table;
```

- You must be logged in as the `root` user or have `DROP` privileges to delete a table

Showing Tables

- Use the `SHOW TABLES` statement to show the non temporary tables of the selected database

Creating Tables (continued)

Type	Range	Storage
`BOOL`	-128 to 127; 0 is considered false	1 byte
`INT or INTEGER`	-2147483648 to 2147483647	4 bytes
`FLOAT`	-3.402823466E+38 to -1.175494351E-38, 0, and 1.175494351E-38 to 3.402823466E+38	4 bytes
`DOUBLE`	-1.7976931348623157E+308 to -2.2250738585072014E-308, 0, and 2.2250738585072014E-308 to 1.7976931348623157E+308	8 bytes
`DATE`	'1000-01-01' to '9999-12-31'	Varies
`TIME`	'-838:59:59' to '838:59:59'	Varies
`CHAR(`*m*`)`	Fixed length string between 0 to 255 characters	Number of bytes specified by *m*
`VARCHAR(`*m*`)`	Variable length string between 1 to 65,535 characters	Varies according to the number of bytes specified by *m*

Common MySQL field data types

Example - Creating Table

```
mysql> CREATE TABLE inventory (
        item_number int NOT NULL AUTO_INCREMENT,
        make varchar(30) NOT NULL,
        model varchar(30) NOT NULL,
        price double NOT NULL,
        quantity int NOT NULL,
        PRIMARY KEY (item_number)
        );
```

AUTO_INCREMENT tells MySQL to go ahead and add the next available number to the `item_number` field.

NOT NULL - we do not want this field to be NULL. So, if a user will try to create a record with a NULL value, then MySQL will raise an error.

WORKING WITH DATA RECORDS

Adding Records

- Use the `INSERT` statement to add individual records to a table
- The syntax for the `INSERT` statement is:

```
INSERT INTO table_name VALUES(value1, value2, ...);
```

- The values entered in the `VALUES` list must be in the same order in which you defined the table fields
- Specify `NULL` in any fields for which you do not have a value
- Add multiple records, use the `LOAD DATA` statement

```
LOAD DATA LOCAL INFILE 'file_path_name' INTO TABLE
table_name;
```

Updating Records

- To update records in a table, use the `UPDATE` statement
- The syntax for the `UPDATE` statement is:

```
UPDATE table_name
SET column_name=value
WHERE condition;
```

  - The `UPDATE` keyword specifies the name of the table to update
  - The `SET` keyword specifies the value to assign to the fields in the records that match the condition in the `WHERE` keyword

Deleting Records

- Use the `DELETE` statement to delete records in a table
- The syntax for the `DELETE` statement is:

```
DELETE FROM inventory;
```

- The `DELETE` statement deletes all records that match the condition
- To delete all the records in a table, leave off the `WHERE` keyword

Retrieving Records

- Use the `SELECT` statement to retrieve records from a table:

```
SELECT criteria FROM table_name;
```

- Use the asterisk (*) wildcard with the `SELECT` statement to retrieve all fields from a table
- To return multiple fields, separate field names with a comma

```
mysql> SELECT model, quantity FROM inventory;
```

Retrieving Records – Sorting

- Use the `ORDER BY` keyword with the `SELECT` statement
  to perform an alphanumeric sort of the results returned from a query

```
mysql> SELECT make, model FROM inventory ORDER BY make,
   model;
```

- To perform a reverse sort, add the `DESC` keyword after the name of the field by which you want to perform the sort

```
mysql> SELECT make, model FROM inventory ORDER BY make DESC,
   model;
```

Retrieving Records – Filter

- The **criteria** portion of the `SELECT` statement determines which fields to retrieve from a table
- You can also specify which records to return by using the `WHERE` keyword

```
mysql> SELECT * FROM inventory WHERE make='Martin';
```

- Use the keywords `AND` and `OR` to specify more detailed conditions about the records you want to return

```
mysql> SELECT * FROM inventory WHERE make='Washburn'
    -> AND price<400;
```

UNDERSTANDING SECURITY CONCEPTS

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Six Dumbest Ideas in Computer Security

1. **Default Permit**
   No! Use default deny and only allow what is good!
2. **Enumerating Badness**
   Trying to list all problems is bad - make a list of good.
   Kill anything outside good.
3. **Penetrate and Patch**
   Fixing bad code through the addition of more bad code.
   Get a good design.
4. **Hacking is Cool**
   No, it's not. Good engineering is cool.
5. **Educating Users**
   … is not "dumb", but users need a healthy skepticism to work with the web
6. **Action is Better than Inaction**
   No, good thinking and the right actions is MUCH better

http://www.ranum.com/security/computer_security/editorials/dumb/

SQL Injection

Common vulnerable login query

```
SELECT * FROM users
WHERE login = 'victor'
AND password = '123'
```

(If it returns something then login!)

ASP/MS SQL Server login syntax

```
var sql = "SELECT * FROM users
WHERE login = '" + formusr +
"' AND password = '" + formpwd + "'";
```

SQL Injection

Injection through strings

formusr = **' or 1=1 – –**

formpwd = anything

Final query would look like this:

SELECT * FROM users

WHERE username = **' ' or 1=1**

– – AND password = 'anything'

SQL Injection

If it were numeric?

```
SELECT * FROM clients
WHERE account = 12345678
AND pin = 1111
```

PHP/MySQL login syntax

```
$sql = "SELECT * FROM clients WHERE " .
"account = $formacct  AND " .
"pin = $formpin";
```

SQL Injection

Injecting Numeric Fields

$formacct = **1 or 1=1 #**

$formpin = 1111

Final query would look like this:

SELECT * FROM clients

WHERE account = **1 or 1=1**

AND pin = **1111**

Web Application Security

- ***Never trust the user! Never!***
- **Always** consider how values from the user will be used
- Don't trust that all the examples / tutorials from "the net" will be okay - many are ***not*!**
  …even examples that have shipped with commercial products!
- Do not use "defaults"

Why use a database and not a text file?

Summary

- A database is an ordered collection of information from which a computer program can quickly access information
- There are three basic types of relationships within a relational database: one-to-one, one-to- many, and many-to-many
- A database management system (or DBMS) is an application or collection of applications used to access and manage a database

Summary (continued)

- Structured query language (or SQL) is a standard data manipulation language used among many database management systems
- The case sensitivity of database and table identifiers depends on the operating system
- When you first install MySQL, two databases are installed: `mysql` and `test`
- You must be logged in as the root user or have `DROP` privileges to delete a database

Summary (continued)

- A proxy is someone or something that acts or performs a request for another person
- Privileges are the operations that a user can perform with a database
- You must be logged in with the `root` account or have sufficient privileges to revoke privileges from another user account
- You can specify which records to return from a database by using the `WHERE` keyword