Information Technologies

Anselm Spoerri PhD (MIT)
SC&I @ Rutgers University
aspoerri@rutgers.edu
anselm.spoerri@gmail.com

Lecture 10 - Overview

Relational Databases

SQL = Structured Query Language

MySQL & MySQL Workbench

- Create MySQL Database on Server
- Grant Access to MySQL Workbench
- Create & Test "Connection" in MySQL Workbench
- Create Table and Perform SQL Queries in MySQL Workbench

Lectures – Week 10 Content

http://comminfo.rutgers.edu/~aspoerri/Teaching/InfoTech/Lectures.html#week10

Websites that use **Relational Databases**

Is the WWW a Relational Database?

Fairly sophisticated search available

- Crawler indexes pages on the Web
- Keyword-based search for pages

But, currently

- Data is mostly *unstructured* and *untyped*
- Can't modify the data
- Can't get summaries, complex combinations of data
- Few guarantees provided for freshness of data, consistency across data items, …

The picture is changing

- New standards, e.g., XML, Semantic Web, etc., can provide richer models of data

How is Relational Database different from Spreadsheet?

Spreadsheet	Relational Database
• Your data is of a manageable data size • There is no need for relationships between data • You are primarily creating calculations and statistics	• You are working with **large amounts of data** • You **need** to create **relationships** between your data • You rely on external databases to analyze data

Relational Database

http://en.wikipedia.org/wiki/Relational_database

- Collection of data, **organized** to support access
- **Models** some aspects of reality

Components of Relational Database

Field = an "atomic" unit of data city

Record = a collection of related fields address

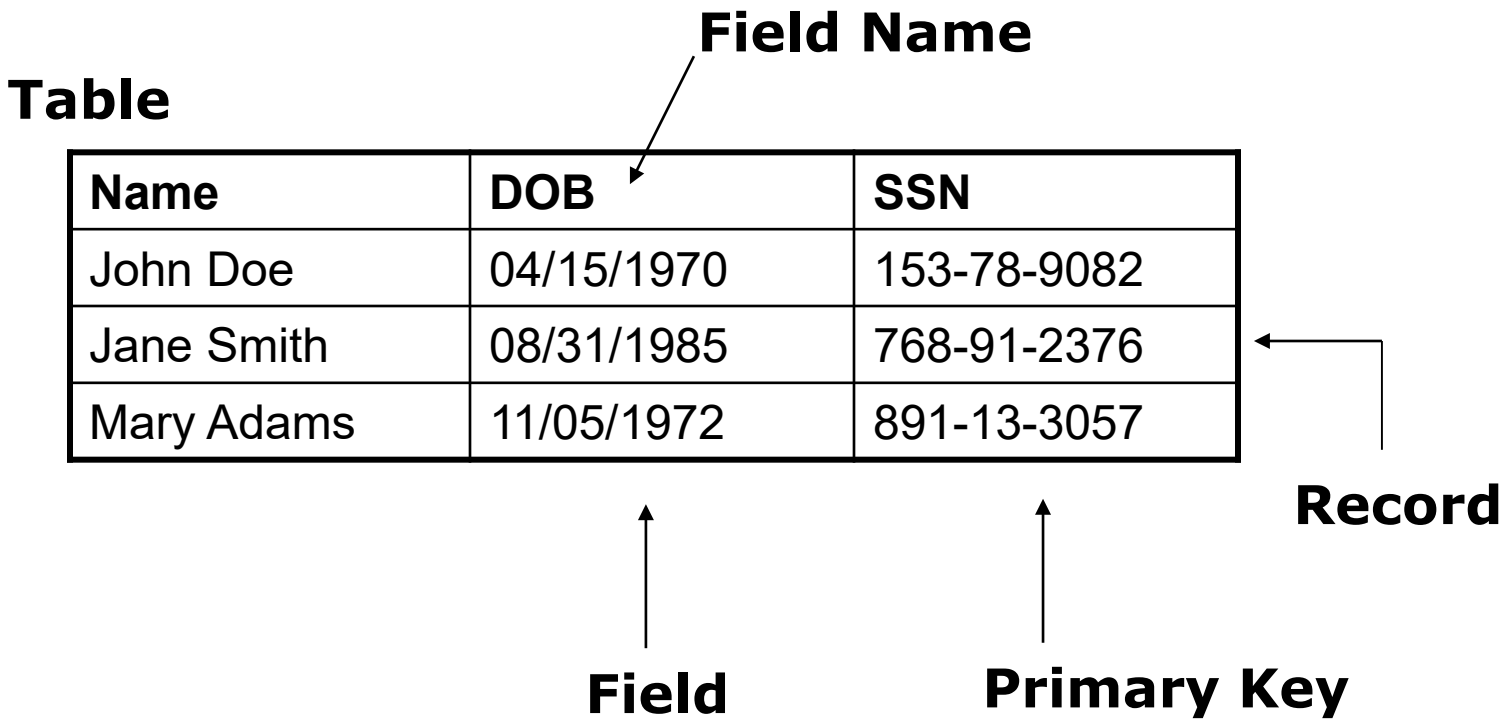
Table = a collection of related records addresses

- Each **record** is one **row** in the table
- Each **field** is one **column** in the table

Database = a collection of tables student data

Primary Key = **field** that ***uniquely*** **identifies** a record

Simple Example



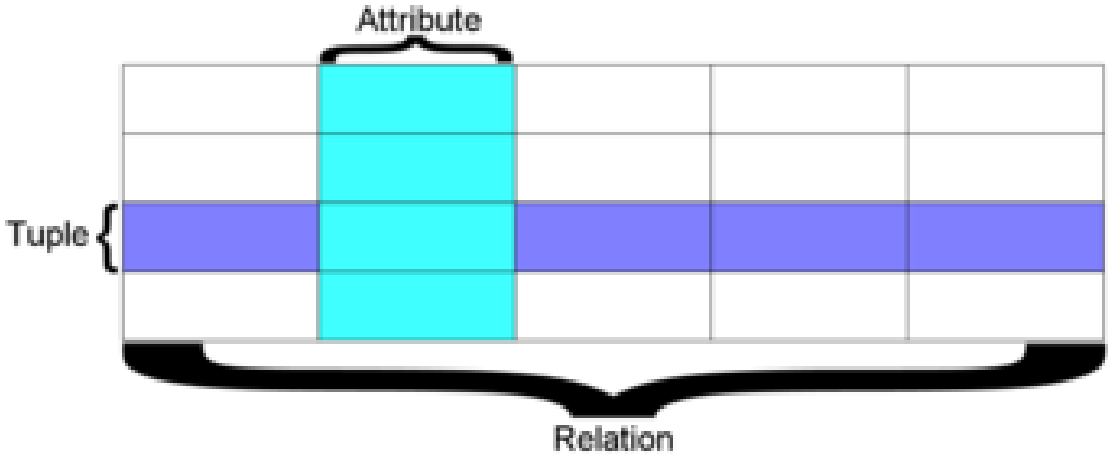
Why “Relational”?

Databases Model some Aspects of Reality

Relational Database groups data using Common Attributes found in data set

- The resulting "clumps" of organized data are much easier for people to understand
- The grouping uses the **relational model**

Relational Database – Terminology



A **relation** is defined as a set of tuples that have the same attributes.

A relation is usually described as a **table**, which is organized into **rows** and **columns**.

All the data referenced by an **attribute** are in the **same domain** and conform to the same constraints.

Registrar Example

Want to create Database to Collect Enrolled Student Data

What do we need to know (i.e., model)**?**

- Something about **students**
  (e.g., first name, last name, email, department)
- Something about **courses**
  (e.g., course ID, description, enrolled students, grades)
- Which students are in which courses

First Try

Put everything in a big table…

1	Arrows	John	EE	EE	lis550	Information Technology	90	jarrows@wam
1	Arrows	John	EE	Elec Engin	ee750	Communication	95	ja_2002@yahoo
2	Peters	Kathy	HIST	HIST	lis550	Informatino Technology	95	kpeters2@wam
2	Peters	Kathy	HIST	history	hist405	American History	80	kpeters2@wma
3	Smith	Chris	HIST	history	hist405	American History	90	smith2002@glue
4	Smith	John	CLIS	Info Sci	lis550	Information Technology	98	js03@wam

Discussion: Why is this a bad idea?

Need to **Normalize** the Data

➔ Attribute can only have one value

Goals of "Normalization"

http://en.wikipedia.org/wiki/Database_normalization

Remove Duplicates / Save Space

- Save each fact only once

More Rapid Updates

- Every fact only needs to be **updated once**

More Rapid Search

- **Finding it once** is good enough

Avoid Inconsistency

- Changing data once changes it everywhere

Second Try ... With Normalization in Mind

Student Table

Student ID	Last Name	First Name	Department ID	email
1	Arrows	John	EE	jarrows@wam
2	Peters	Kathy	HIST	kpeters2@wam
3	Smith	Chris	HIST	smith2002@glue
4	Smith	John	LIS	js03@wam

Department Table

Department ID	Department
EE	Electrical Engineering
HIST	History
LIS	Library and Info Science

Course Table

Course ID	Course Name
lis550	Information Technology
ee750	Communication
hist405	American History

Enrollment Table

Enroll ID	Student ID	Course ID
1	1	lis550
2	1	ee750
3	2	lis550
4	2	hist405
5	3	hist405
6	4	lis550

Approaches to Normalization and Keys

Simple Data Domains

- Start with “binary relationships” (pairs of related fields)
- Group Attributes together wherever possible
- Add keys where necessary

Complicated Data Domain

- Entity relationship modeling

“Primary Key” uniquely identifies a record

- Example: student ID in student table

“Foreign Key” is primary key in other table

- Does not have to be unique in the table where it is “foreign key”

Second Try ... With Normalization in Mind

Student Table

Foreign key

Primary Key

Student ID	Last Name	First Name	Department ID	email
1	Arrows	John	EE	jarrows@wam
2	Peters	Kathy	HIST	kpeters2@wam
3	Smith	Chris	HIST	smith2002@glue
4	Smith	John	LIS	js03@wam

Department Table

Primary Key

Department ID	Department
EE	Electrical Engineering
HIST	History
LIS	Library and Info Science

Course Table

Course ID	Course Name
lis550	Information Technology
ee750	Communication
hist405	American History

Primary Key

Enrollment Table

Primary Key

Enroll ID	Student ID	Course ID
1	1	lis550
2	1	ee750
3	2	lis550
4	2	hist405
5	3	hist405
6	4	lis550

Joining Tables: JOIN

Choosing Columns: SELECT

- Based on their label

Choosing Rows: WHERE

- Based on their contents

These can be specified together

SELECT **Student ID, Dept** WHERE **Dept = "History"**

Relational Database Operation – **Join Tables**

Student ID	Last Name	First Name	Department ID	email
1	Arrows	John	EE	jarrows@wam
2	Peters	Kathy	HIST	kpeters2@wam
3	Smith	Chris	HIST	smith2002@glue
4	Smith	John	LIS	js03@wam

Department ID	Department
EE	Electrical Engineering
HIST	History
LIS	Library and Info Science

Student ID	Last Name	First Name	Dept ID	Department	email
1	Arrows	John	EE	Electrical Engineering	jarrows@wam
2	Peters	Kathy	HIST	History	kpeters2@wam
3	Smith	Chris	HIST	History	smith2002@glue
4	Smith	John	LIS	Library and Info Science	js03@wam

Relational Database Operation – **SELECT**

Student ID	Last Name	First Name	Dept ID	Department	email
1	Arrows	John	EE	Electrical Engineering	jarrows@wam
2	Peters	Kathy	HIST	History	kpeters2@wam
3	Smith	Chris	HIST	History	smith2002@glue
4	Smith	John	LIS	Library and Info Science	js03@wam

SELECT Student ID, Department

Student ID	Department
1	Electrical Engineering
2	History
3	History
4	Library and Info Science

Relational Database Operation – **WHERE**

Student ID	Last Name	First Name	Dept ID	Department	email
1	Arrows	John	EE	Electrical Engineering	jarrows@wam
2	Peters	Kathy	HIST	History	kpeters2@wam
3	Smith	Chris	HIST	History	smith2002@glue
4	Smith	John	LIS	Library and Info Scienc	js03@wam

WHERE Department ID = “HIST”

Student ID	Last Name	First Name	Department ID	Department	email
2	Peters	Kathy	HIST	History	kpeters2@wam
3	Smith	Chris	HIST	History	smith2002@glue

Database Integrity and Integrity Constraints

Example: Registrar Database

Database must be Internally Consistent

- All enrolled students must have entry in student table
- All courses must have a name
- …

These Conditions must be true at any time

- Specified when the database is **designed**
- Checked when the database is **modified**

Relational Database Management System

- **Ensures Integrity Constraints** are always kept
- Database contents need to reflect the real world
- Helps **avoid data entry errors**

Database Design Considerations

Field Size Property

- Set Field Size …
- Always anticipate current field size **may need to be larger**

Validation Rules

- Used to **avoid data entry errors** by restricting what can be entered
- **Validation text** needs to be used to **provide explanation** of the type of **allowed data** in a field

Store Data in its Smallest Part for Greater Flexibility

- Instead of one field for an address, use many
- Instead of one field for a name, two or three

Use Multiple Tables to Reduce Redundancy

- The process is also referred to as normalization

SQL = Structured Query Language

http://en.wikipedia.org/wiki/SQL

Database computer language designed for **Managing & Accessing Data in Relational Database**

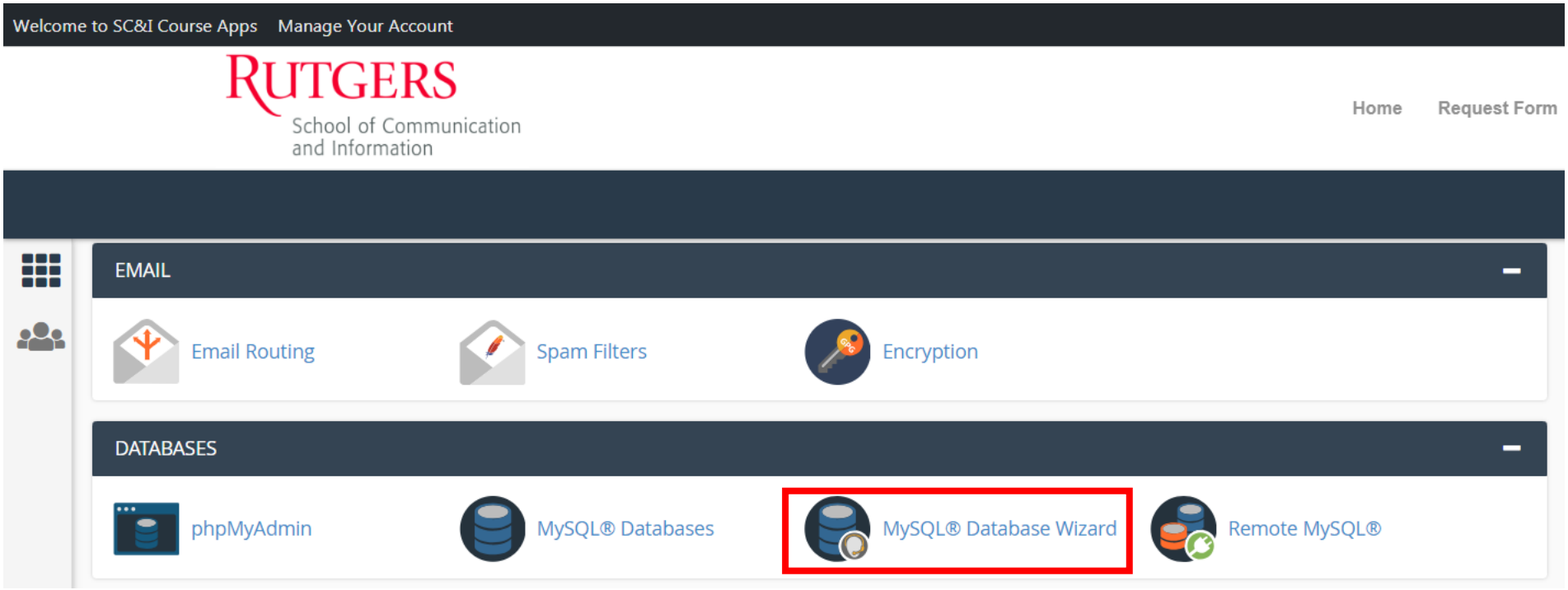
Queries

- Ask question about data
- Receive answer back by **returning subset of table data**.
- Use JOIN, SELECT, WHERE
- **Need semicolon ;** at the end of query
- SQL commands and keywords are **case-insensitive**

rutgers-sci.domains – **Create MySQL Database**

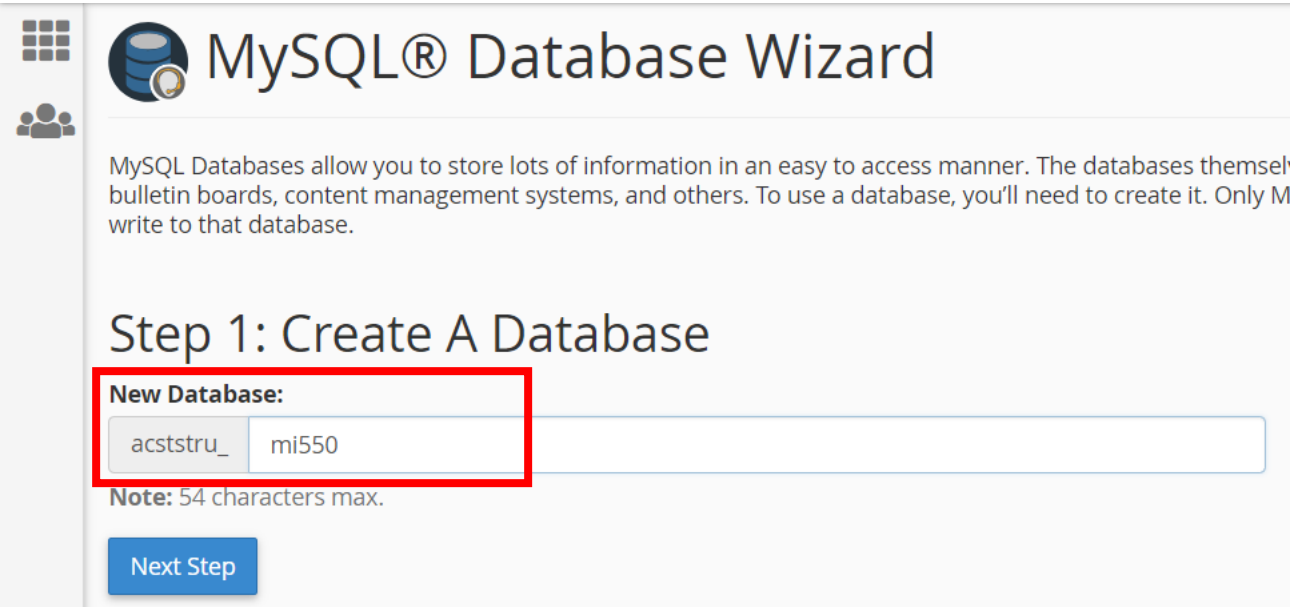
Log into **rutgers-sci.domains** using your NetID and Password

In Dashboard: **Databases** – click on **MySQL Database Wizard**



rutgers-sci.domains – **Create MySQL Database**

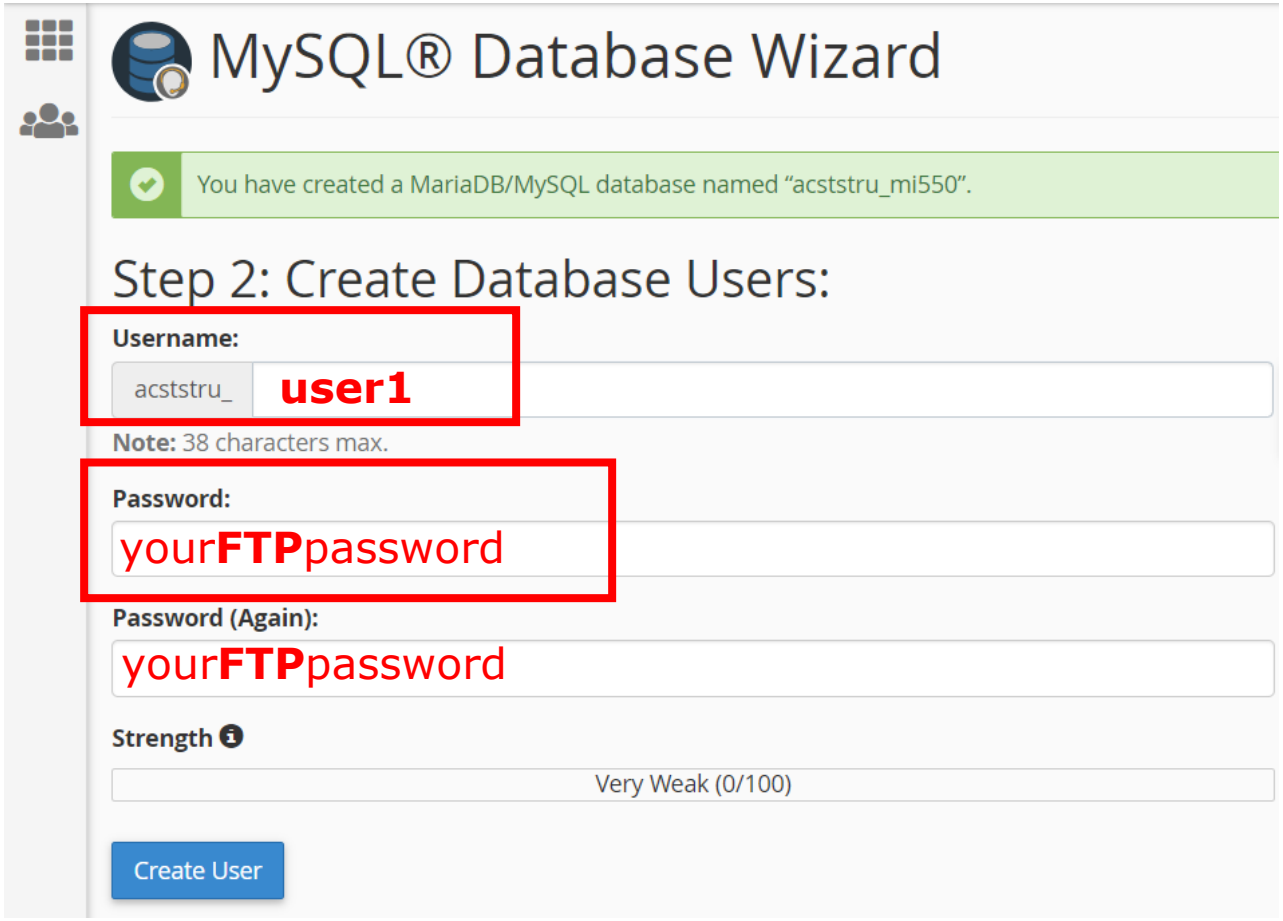
Step 1: **New Database** enter "**mi550**"



➔ Database name = **yourFTPusername_**mi550

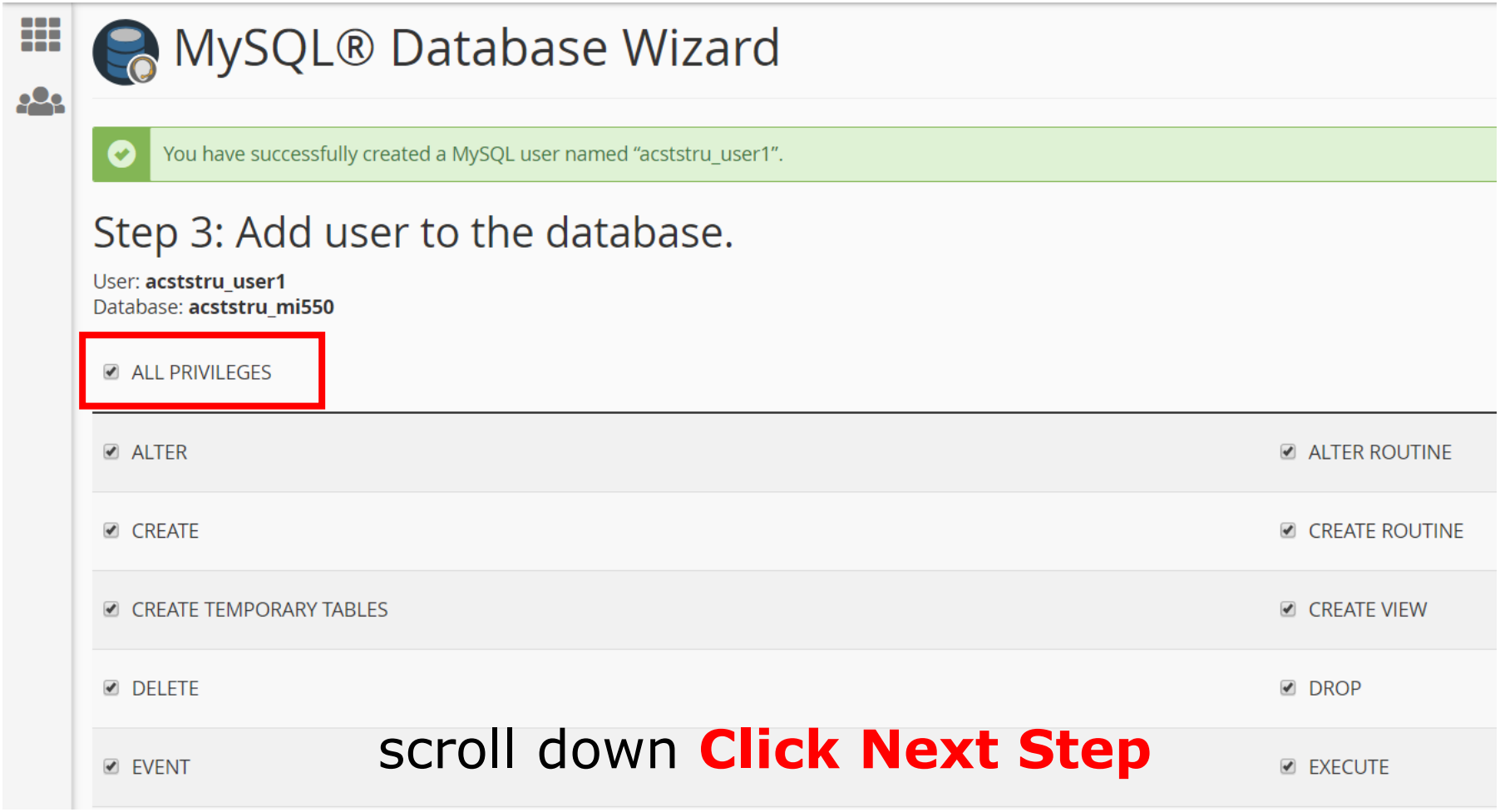
rutgers-sci.domains – **Create MySQL Database**

Step 2: **Create** enter "**user**" and Password = your**FTP**password



rutgers-sci.domains – **Create MySQL Database**

Step 3: **Select ALL PRIVILEGES** checkbox



MySQL Username & Password

Name of Your MySQL database =
yourFTPusername_mi550

Example: **acststru_mi550**

MySQL username = **yourFTPusername**

or

yourFTPusername_user1 (when created)

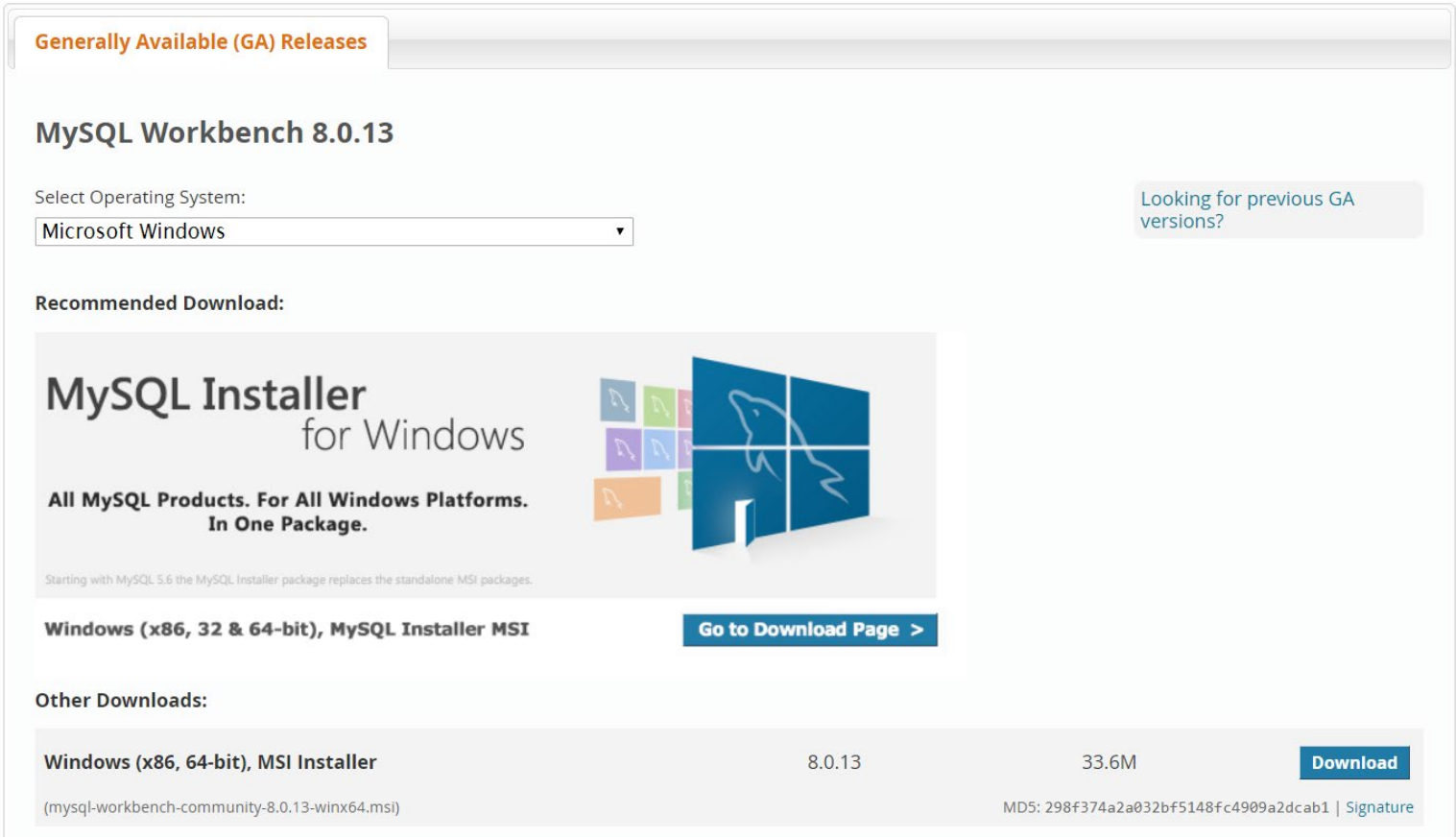
MySQL password = **yourFTPpassword**

Please **contact help@comminfo.rutgers.edu**
if you have any **technical problems** accessing your server account or mysql database.

MySQL Workbench – Installation

MySQL Workbench http://www.mysql.com/products/workbench/

- **Documentation**: https://dev.mysql.com/doc/workbench/en/
- **Download**: Windows | Mac https://dev.mysql.com/downloads/workbench/

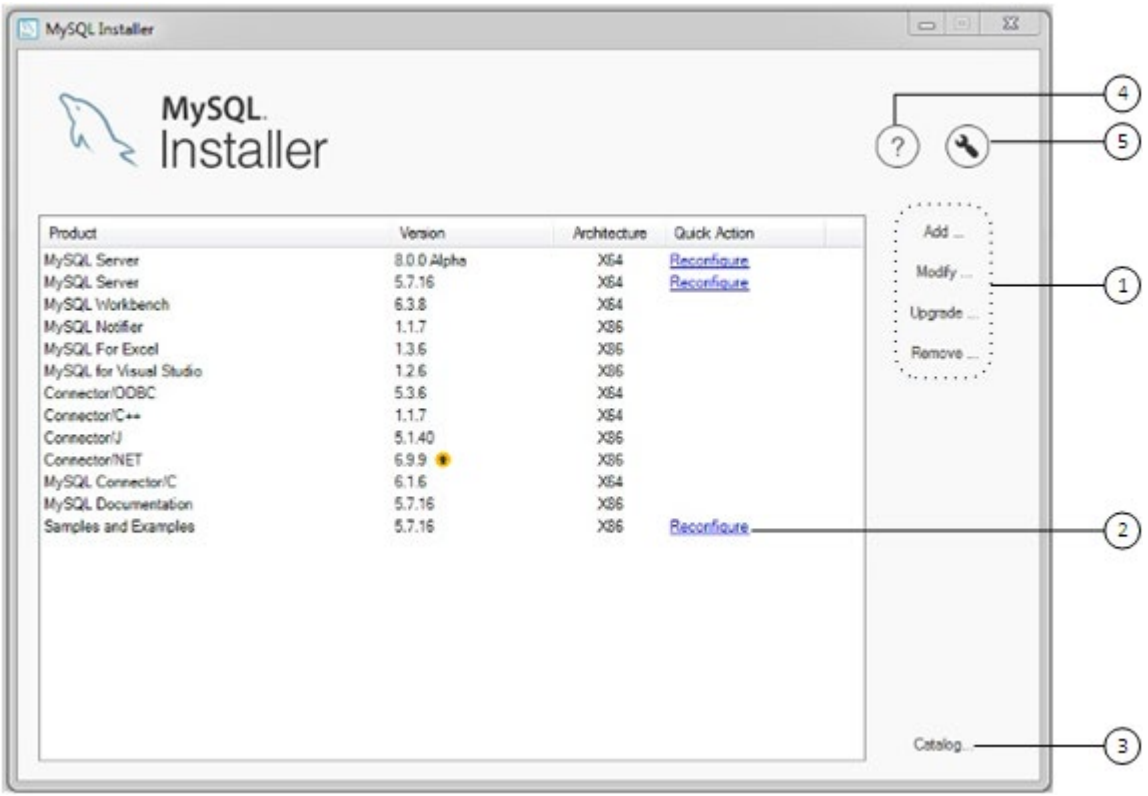


MySQL Installer – Client or Custom

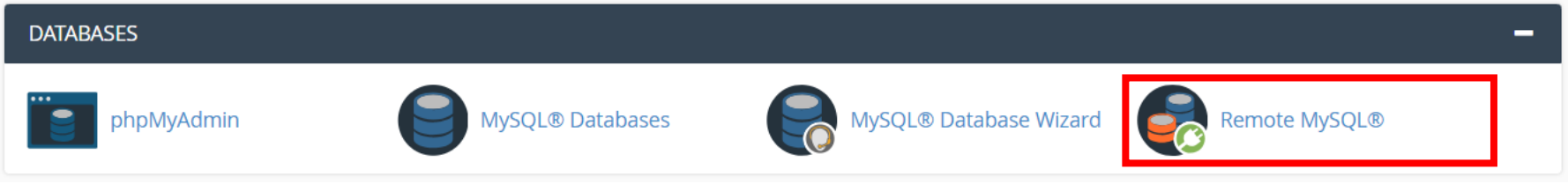
Client only: Only install most recent MySQL client applications, such as **MySQL Workbench**, and **MySQL connectors**.

Custom You can install MySQL Workbench, instead of installing all client applications for Windows.

https://dev.mysql.com/doc/refman/8.0/en/mysql-installer.html



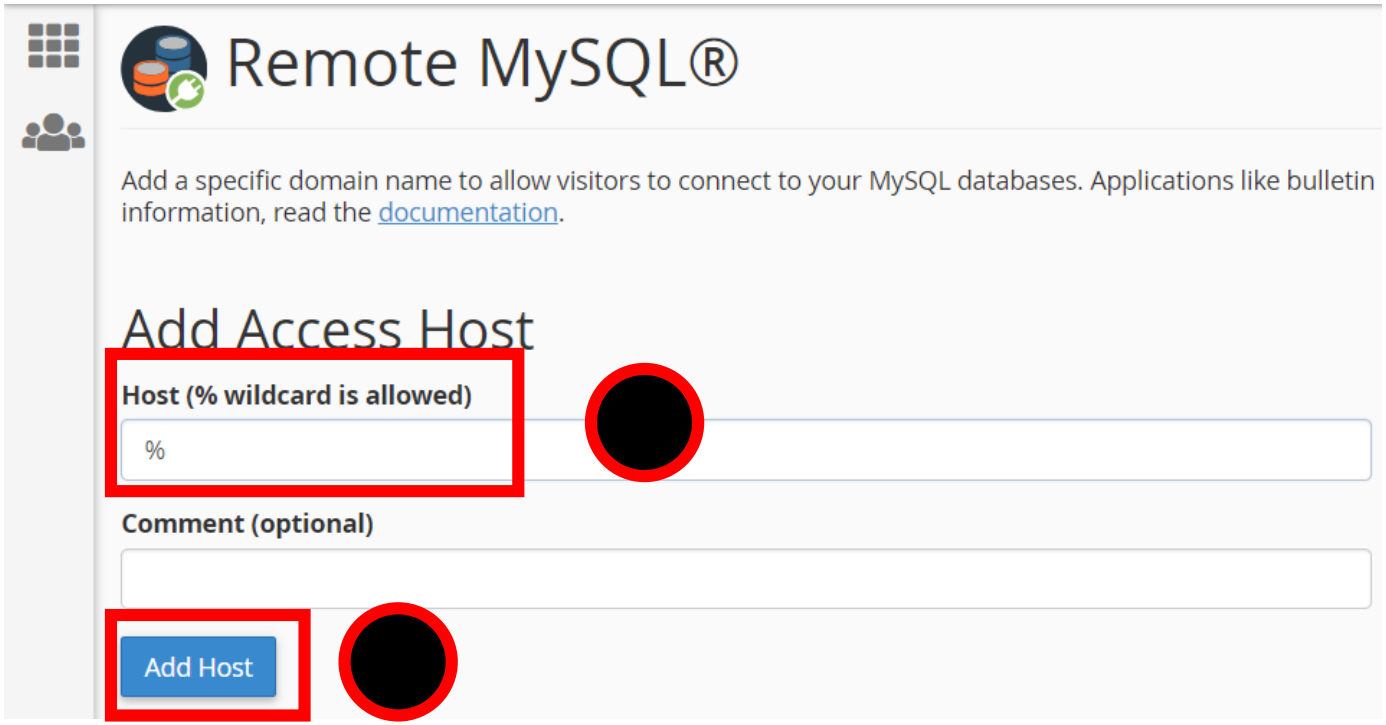
Remote MySQL – Grant Access to MySQL Workbench



Dashboard – Databases: click on **Remote MySQL**

1 **Host** text box, enter **"%"** (stands for all IP addresses allowed)

2 **Click Add Host**



MySQL Workbench – Create New Connection

New Connection

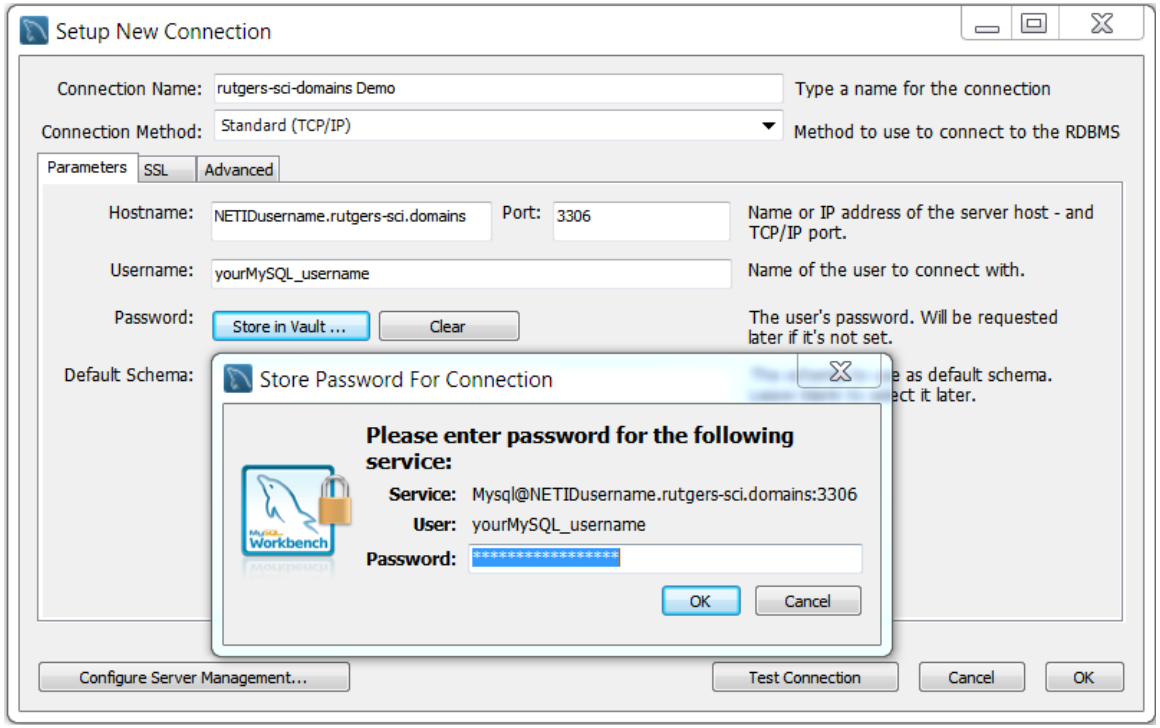
Connection Method: **Standard TCP / IP**

Hostname: your**NetID**username**.rutgers-sci.domains**

Port: **3306**

Username: your**MySQL**username (= yourFTPusername or yourFTPusername_user1)

Password: your**MySQL**password (= yourFTPpassword)



SQL Demo – Create Table

DatabaseToUse = **yourFTPusername_**mi550 created by you

USE DatabaseToUse**;** // tells SQL which database to use

Note: if DatabaseToUse **contains – hyphens** then will **trigger SQL error**

You can use the grave mark ` to escape names that contain reserved lexical symbols

MySQL Workbench:
Double-click icon of database to use in left-hand panel below "Schemas"
to tell SQL which database to use.

```
CREATE TABLE classics (
    author VARCHAR(128),
    title VARCHAR(128),
    type VARCHAR(16),
    year CHAR(4),
    id INT UNSIGNED NOT NULL AUTO_INCREMENT KEY)
    ENGINE MyISAM;

DESCRIBE classics;
```

SQL Demo – Add Data and Add Column

INSERT INTO classics (author, title, type, year) VALUES('Mark Twain','The Adventures of Tom Sawyer','Fiction','1876');INSERT INTO classics(author, title, type, year) VALUES('Jane Austen','Pride and Prejudice','Fiction','1811');INSERT INTO classics(author, title, type, year) VALUES('Charles Darwin','The Origin of Species','Non-Fiction','1856');INSERT INTO classics(author, title, type, year) VALUES('Charles Dickens','The Old Curiosity Shop','Fiction','1841');INSERT INTO classics(author, title, type, year) VALUES('William Shakespeare','Romeo and Juliet','Play','1594');

DESCRIBE classics**;**

ALTER TABLE classics **ADD** isbn CHAR(13);

UPDATE classics **SET** isbn='9781598184891' **WHERE** year='1876';
UPDATE classics SET isbn='9780582506206' WHERE year='1811';
UPDATE classics SET isbn='9780517123201' WHERE year='1856';
UPDATE classics SET isbn='9780099533474' WHERE year='1841';
UPDATE classics SET isbn='9780192814968' WHERE year='1594';
DESCRIBE classics;

SQL Demo – Querying MySQL Database

SELECT *something* FROM *tablename*;

SELECT author **FROM** classics;

SELECT DISTINCT author **FROM** classics;

SELECT author, title **FROM** classics;

SELECT author, title **FROM** classics **WHERE** author="Mark Twain";

SELECT author, title **FROM** classics **WHERE** isbn="9781598184891";

http://comminfo.rutgers.edu/~aspoerri/Teaching/InfoTech/Lectures/Lec10/Steps/MySQLdemo.txt