Chapter 3, The Relational Model

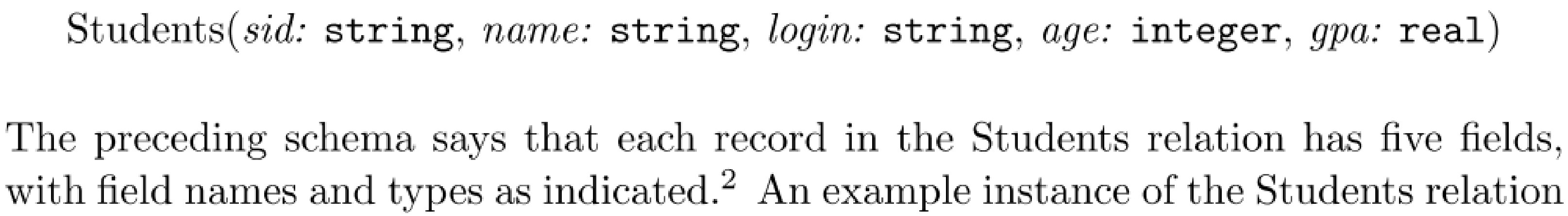
Introduction to Relational Model

- Codd proposed the relational data model in 1970.
  - Prior to that, database systems were based on older data models (the hierarchical model and the network model); the relational model revolutionized the database field and largely supplanted these earlier models
  - Main idea was to organize data as groups of relations
  - Each relation describes a group of objects with similar attributes

Student ID	Name	Major
1161234	Ahmad	ENCS
1161455	Noor	COMP

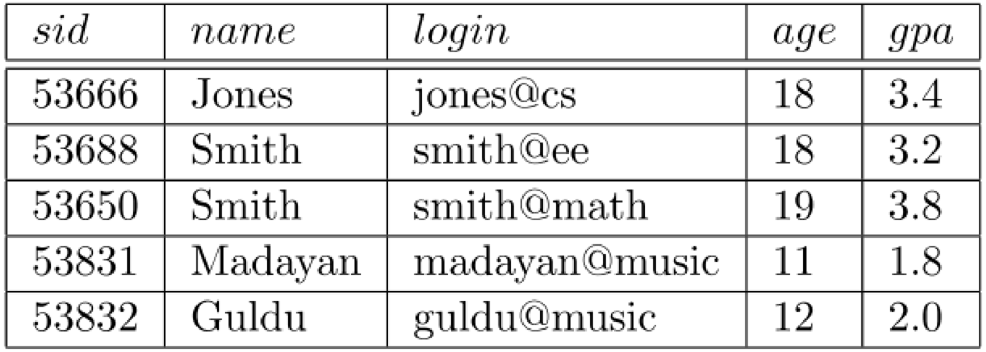
Course ID	CODE	Name
56478	COMP333	Database management Systems
56479	COMP232	Data Structures

Relational data model example



Students(*sid:* string, *name:* string, *login:* string, *age:* integer, *gpa:* real)

The preceding schema says that each record in the Students relation has five fields, with field names and types as indicated.[2] An example instance of the Students relation



sid	*name*	*login*	*age*	*gpa*
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@ee	18	3.2
53650	Smith	smith@math	19	3.8
53831	Madayan	madayan@music	11	1.8
53832	Guldu	guldu@music	12	2.0

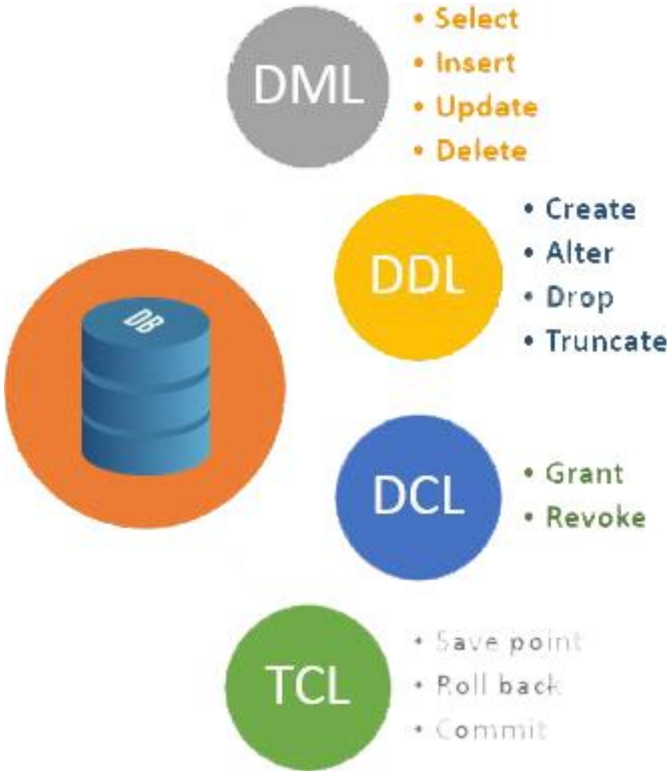
Simplicity

- The relational model is very simple and elegant; a database is a collection of one or more relations, where each relation is a table with rows and columns.

- A DBMS permits the use of SQL to query, and manipulate data and relations in a database.

SQL

- DBMS Supports **Structured Query Language.**
  - Based on Relational Algebra
- Composed of
  - DDL
  - DML



DML
- Select
- Insert
- Update
- Delete

DDL
- Create
- Alter
- Drop
- Truncate

DCL
- Grant
- Revoke

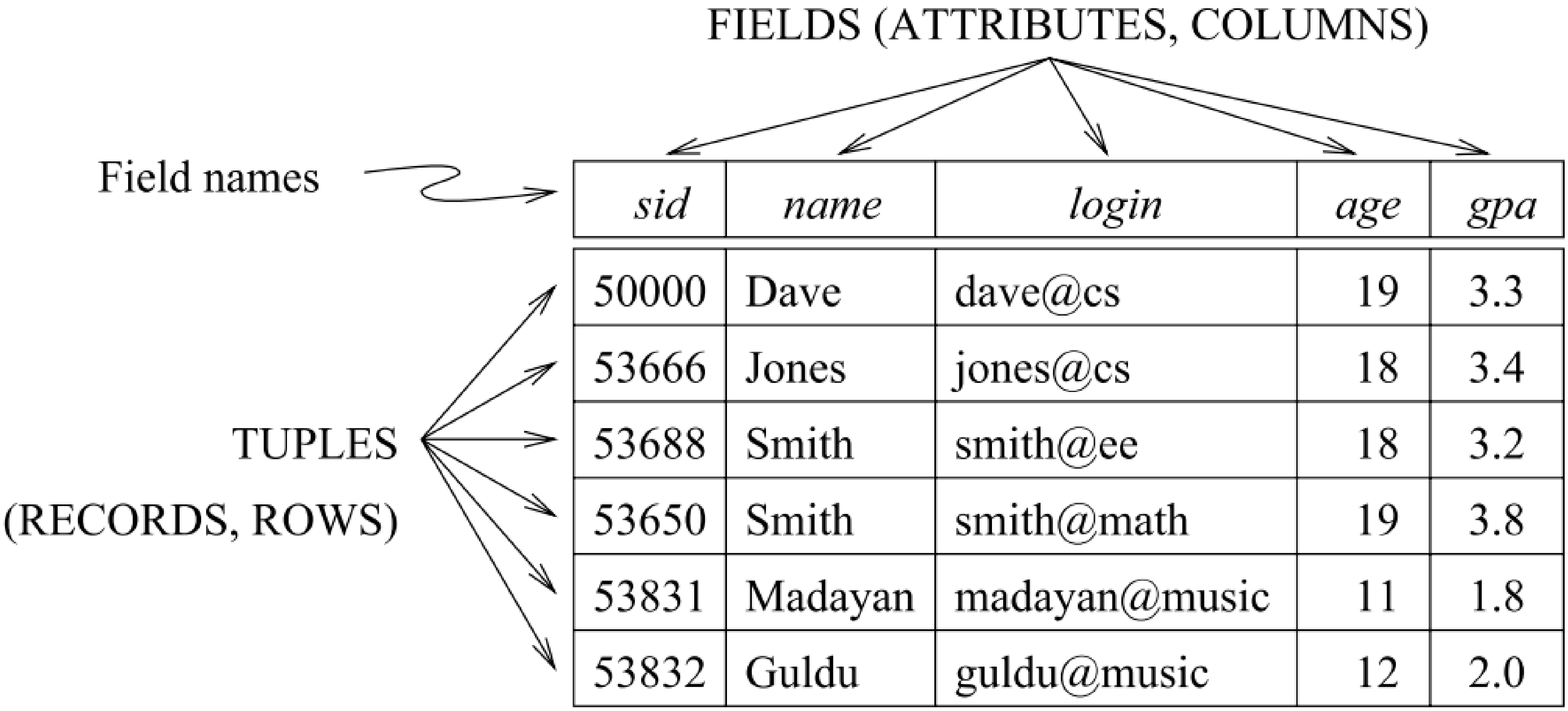
TCL
- Save point
- Roll back
- Commit

Main Constructs

- The main construct in relational model is Relation
- A Relation consist of:
  - Schema
  - Instance
- There should be no redundant data (rows) inside a database
- Degree: number of fields (attributes)
- Cardinality: number of records (tuples)

Example:

Students(*sid:* `string`, *name:* `string`, *login:* `string`, *age:* `integer`, *gpa:* `real`)



FIELDS (ATTRIBUTES, COLUMNS)

Field names

TUPLES

(RECORDS, ROWS)

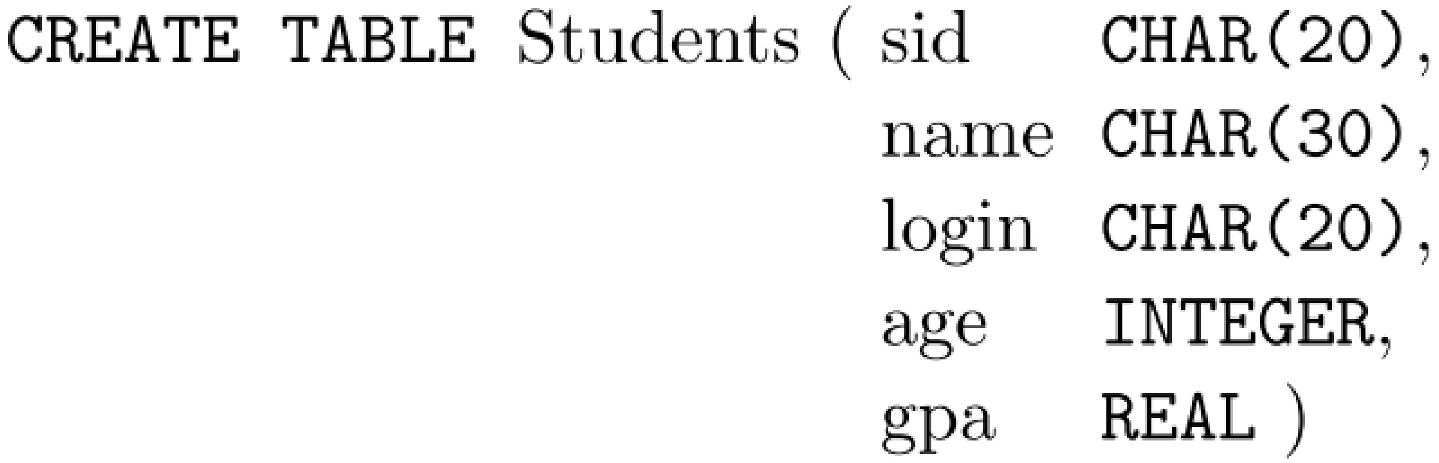
sid	*name*	*login*	*age*	*gpa*
50000	Dave	dave@cs	19	3.3
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@ee	18	3.2
53650	Smith	smith@math	19	3.8
53831	Madayan	madayan@music	11	1.8
53832	Guldu	guldu@music	12	2.0

Example Instance of Students Relation

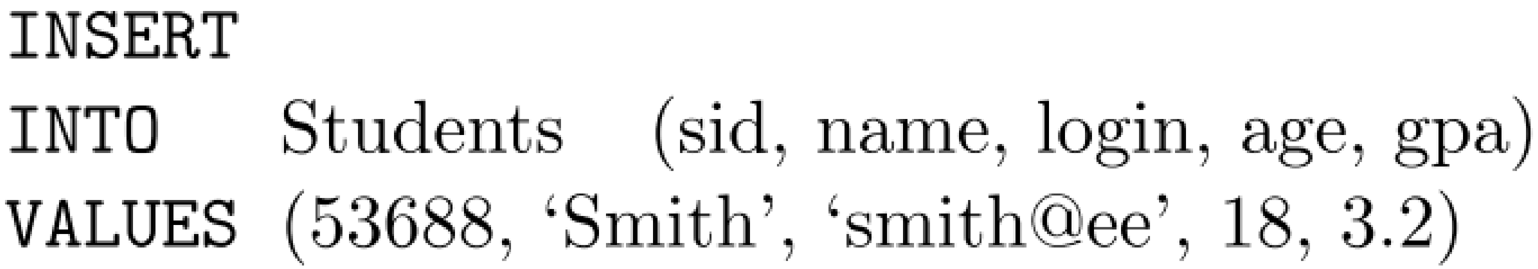
sid	name	login	age	gpa
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@eecs	18	3.2
53650	Smith	smith@math	19	3.8

- ❖ Cardinality = 3, degree = 5, all rows distinct
- ❖ Do all columns in a relation instance have to be distinct?

Example SQL

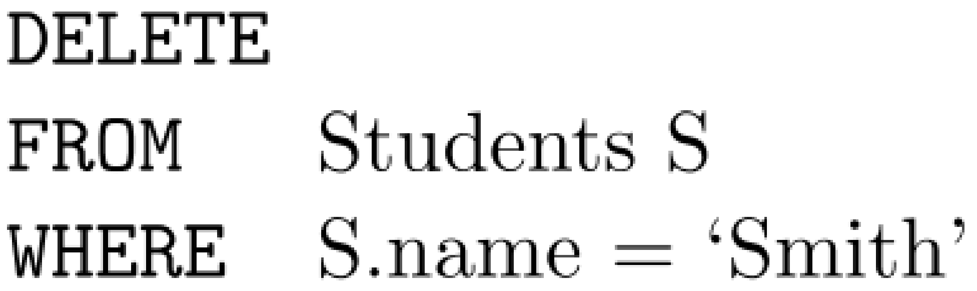


```
CREATE TABLE Students ( sid    CHAR(20),
                        name   CHAR(30),
                        login  CHAR(20),
                        age    INTEGER,
                        gpa    REAL )
```

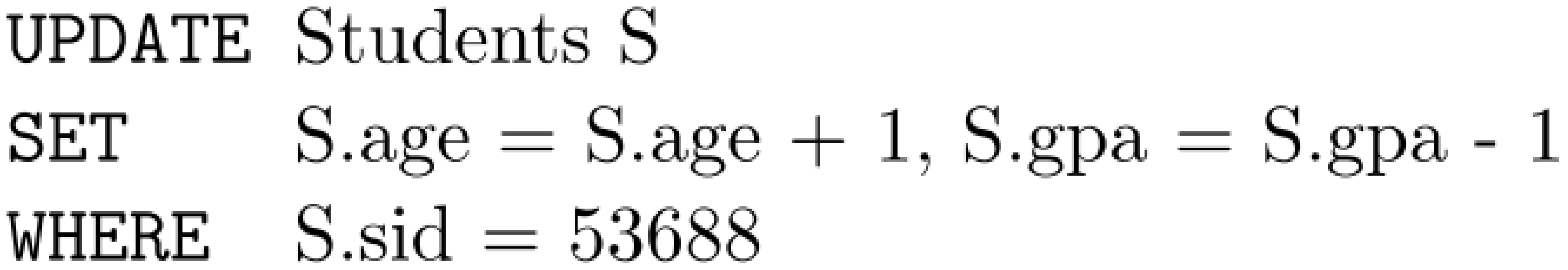


```
INSERT
INTO    Students   (sid, name, login, age, gpa)
VALUES  (53688, ‘Smith’, ‘smith@ee’, 18, 3.2)
```

Example SQL..2



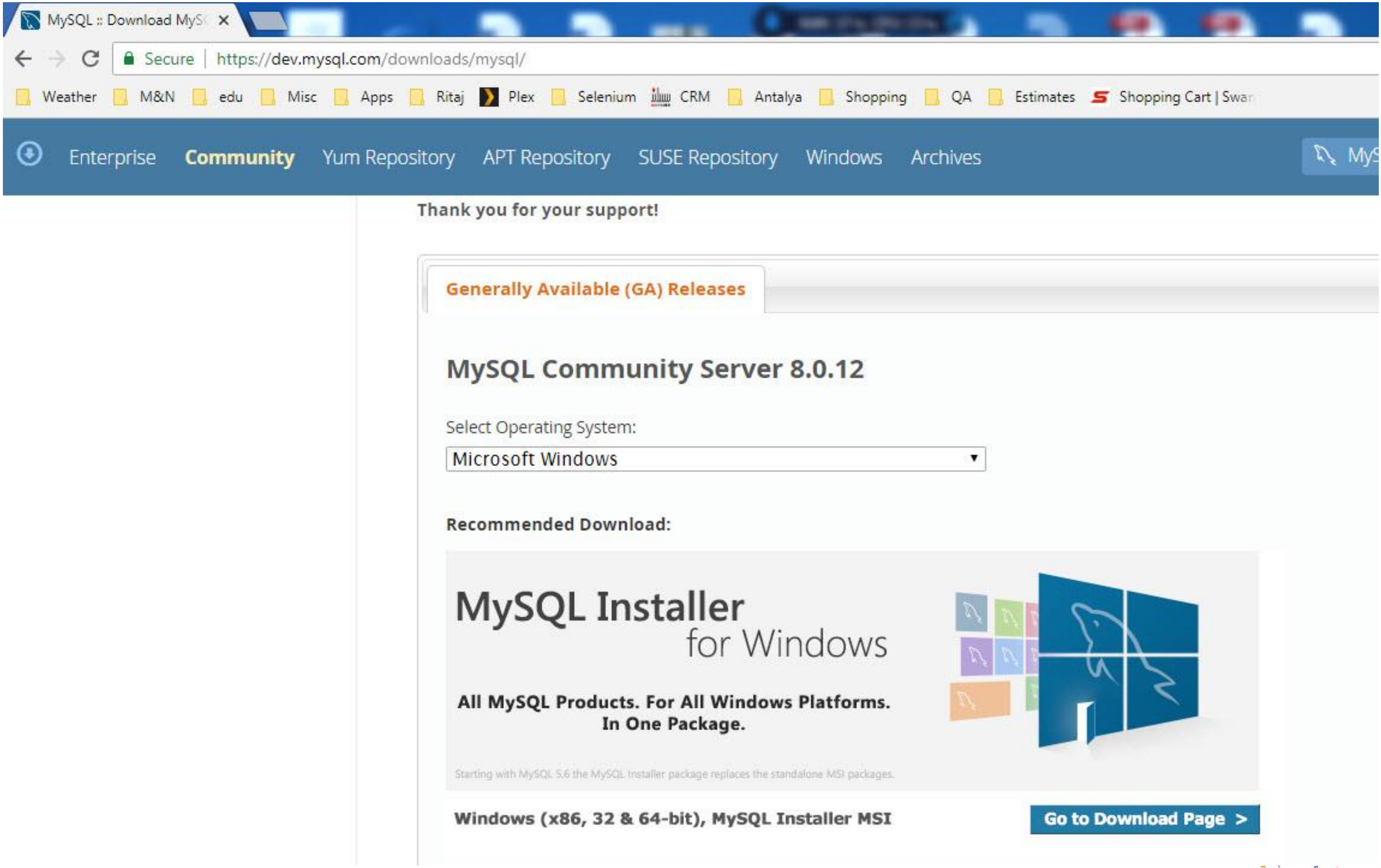
```
DELETE
FROM    Students S
WHERE   S.name = ‘Smith’
```



```
UPDATE  Students S
SET     S.age = S.age + 1, S.gpa = S.gpa - 1
WHERE   S.sid = 53688
```

mySql

- We will be using mySql server
  - Download from
  - https://dev.mysql.com/downloads/mysql/
- Must install a client to connect to server
  - Best: mySql WorkBench



Thank you for your support!

MySQL Community Server 8.0.12

Select Operating System:

Microsoft Windows ▾

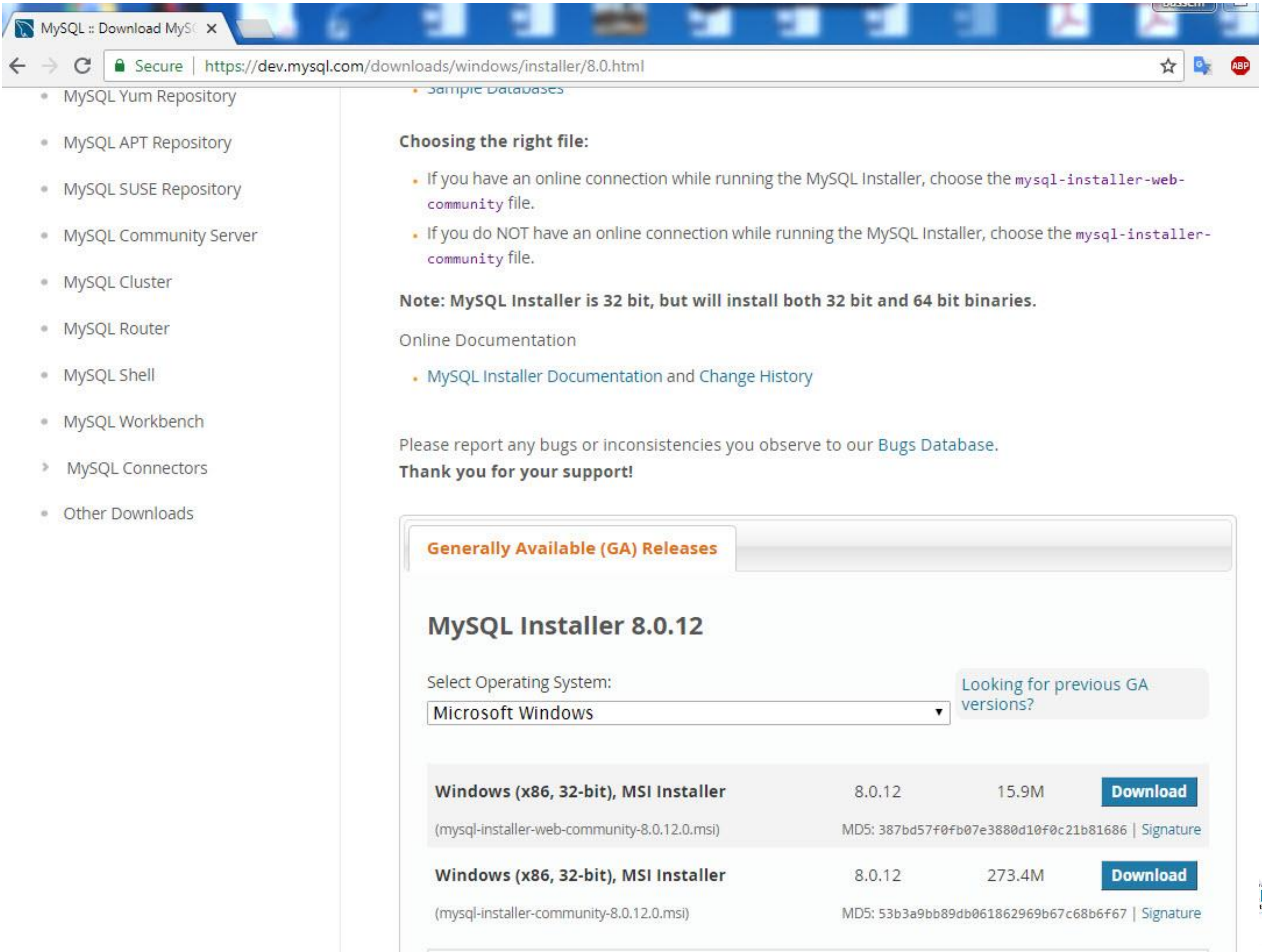
Recommended Download:

MySQL Installer for Windows

All MySQL Products. For All Windows Platforms. In One Package.

Starting with MySQL 5.6 the MySQL Installer package replaces the standalone MSI packages.

Windows (x86, 32 & 64-bit), MySQL Installer MSI



- MySQL Yum Repository
- MySQL APT Repository
- MySQL SUSE Repository
- MySQL Community Server
- MySQL Cluster
- MySQL Router
- MySQL Shell
- MySQL Workbench
- MySQL Connectors
- Other Downloads

- Sample Databases

Choosing the right file:

- If you have an online connection while running the MySQL Installer, choose the `mysql-installer-web-community` file.
- If you do NOT have an online connection while running the MySQL Installer, choose the `mysql-installer-community` file.

Note: MySQL Installer is 32 bit, but will install both 32 bit and 64 bit binaries.

Online Documentation

- MySQL Installer Documentation and Change History

Please report any bugs or inconsistencies you observe to our Bugs Database.
Thank you for your support!

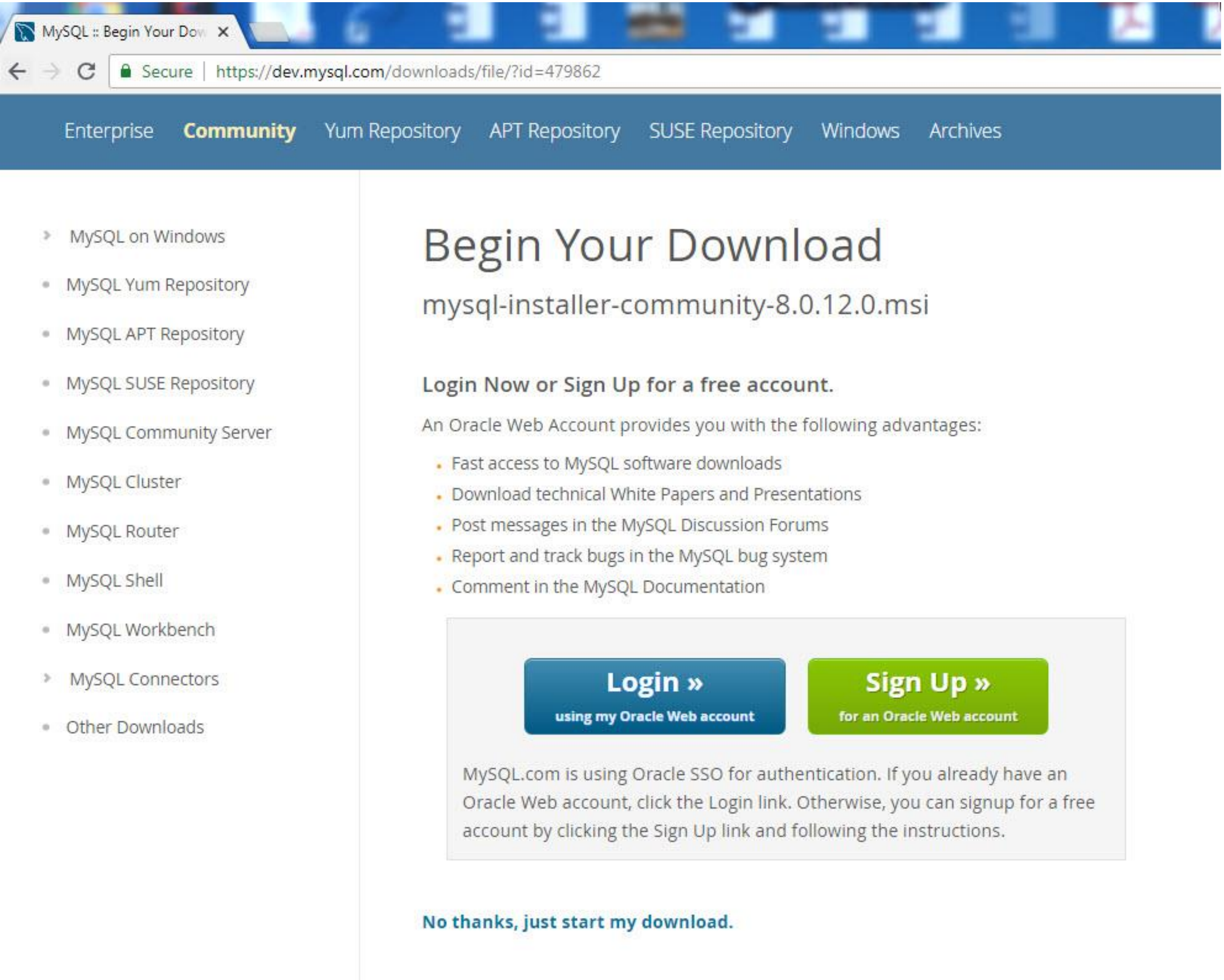
Generally Available (GA) Releases

MySQL Installer 8.0.12

Select Operating System:
Microsoft Windows ▾

Looking for previous GA versions?

Windows (x86, 32-bit), MSI Installer	8.0.12	15.9M	Download
(mysql-installer-web-community-8.0.12.0.msi)	MD5: 387bd57f0fb07e3880d10f0c21b81686 | Signature		
Windows (x86, 32-bit), MSI Installer	8.0.12	273.4M	Download
(mysql-installer-community-8.0.12.0.msi)	MD5: 53b3a9bb89db061862969b67c68b6f67 | Signature		



Begin Your Download

mysql-installer-community-8.0.12.0.msi

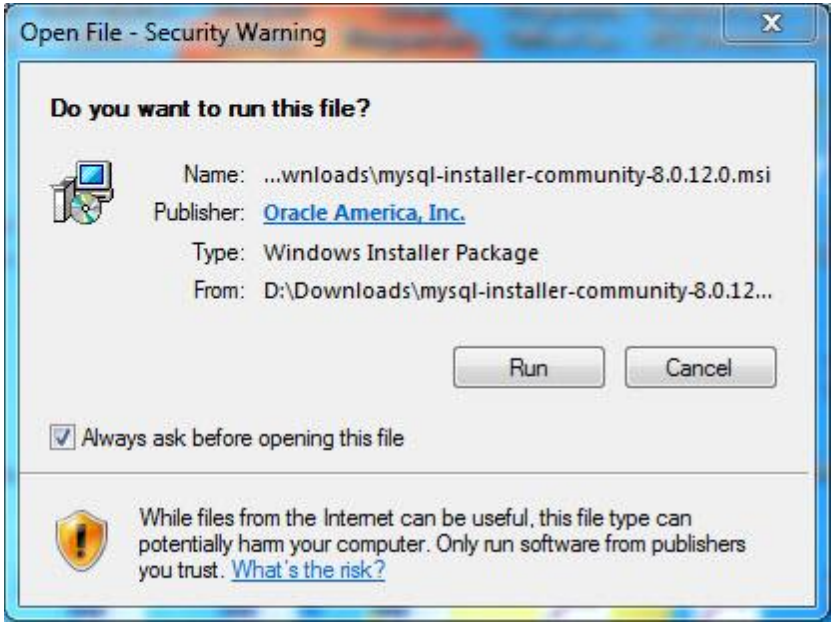
Login Now or Sign Up for a free account.

An Oracle Web Account provides you with the following advantages:

- Fast access to MySQL software downloads
- Download technical White Papers and Presentations
- Post messages in the MySQL Discussion Forums
- Report and track bugs in the MySQL bug system
- Comment in the MySQL Documentation

MySQL.com is using Oracle SSO for authentication. If you already have an Oracle Web account, click the Login link. Otherwise, you can signup for a free account by clicking the Sign Up link and following the instructions.

No thanks, just start my download.



Do you want to run this file?

Name: ...wnloads\mysql-installer-community-8.0.12.0.msi

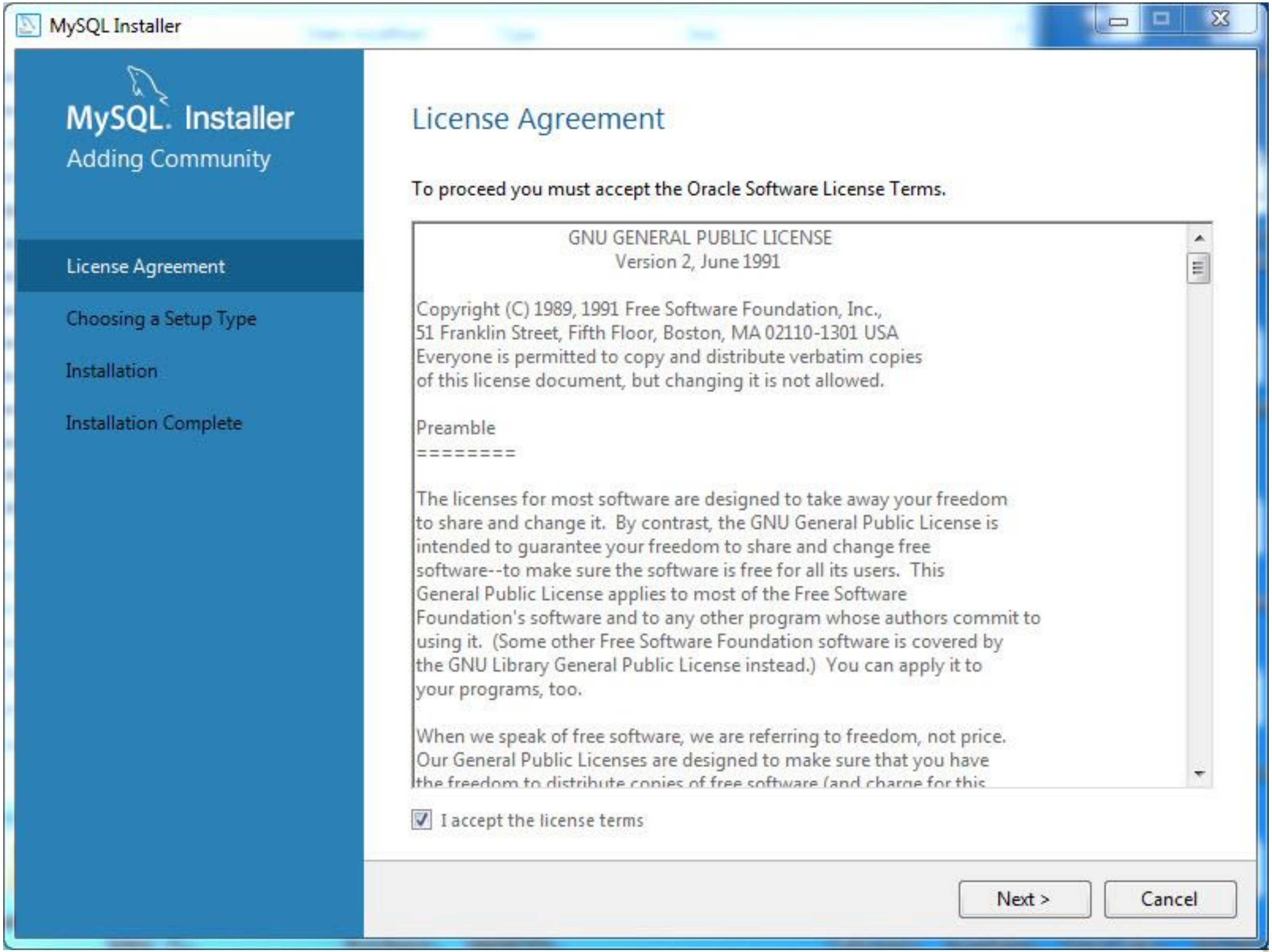
Publisher: Oracle America, Inc.

Type: Windows Installer Package

From: D:\Downloads\mysql-installer-community-8.0.12...

☑ Always ask before opening this file

While files from the Internet can be useful, this file type can potentially harm your computer. Only run software from publishers you trust. What's the risk?



License Agreement

To proceed you must accept the Oracle Software License Terms.

GNU GENERAL PUBLIC LICENSE
Version 2, June 1991

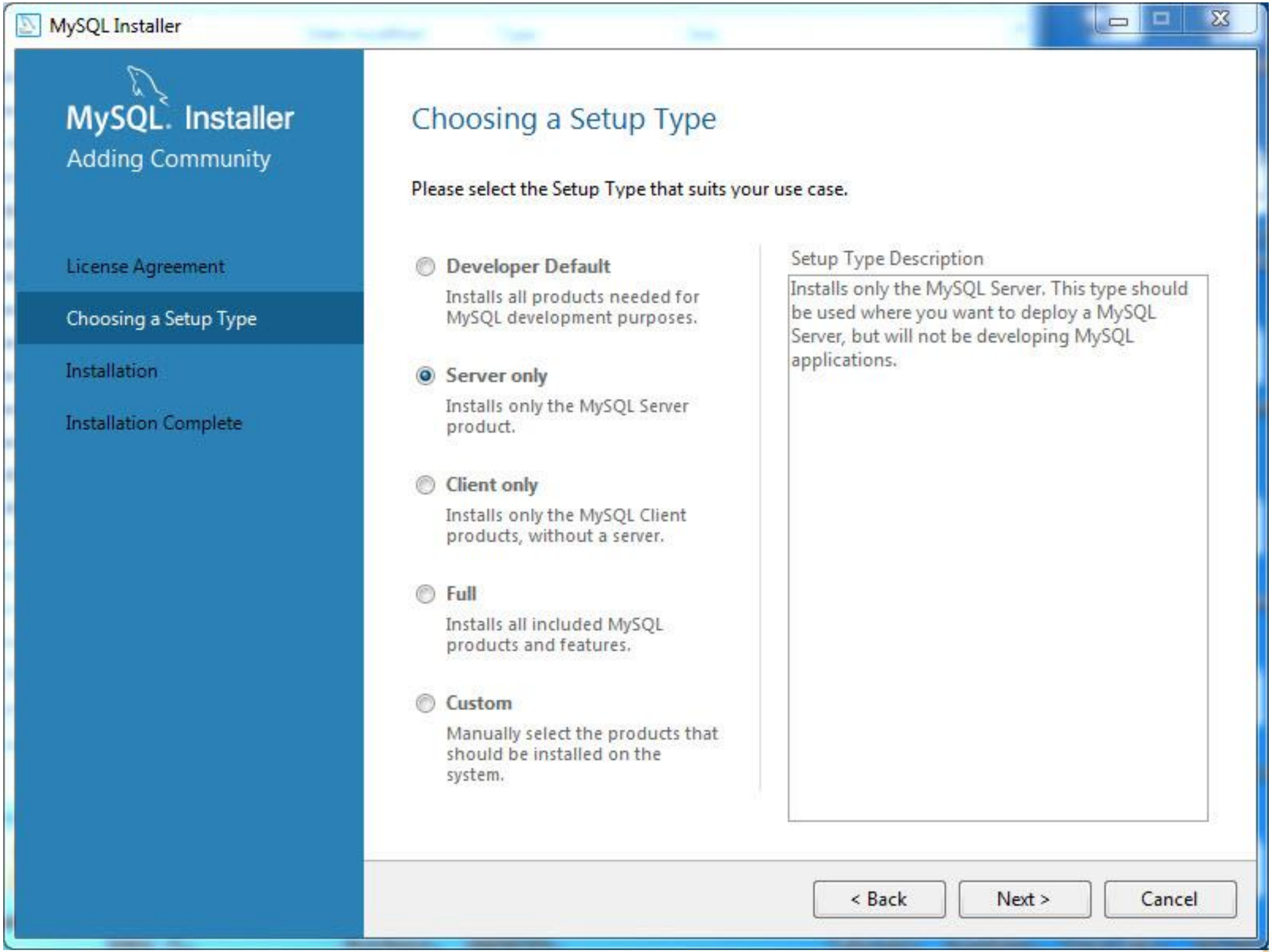
Copyright (C) 1989, 1991 Free Software Foundation, Inc.,
51 Franklin Street, Fifth Floor, Boston, MA 02110-1301 USA
Everyone is permitted to copy and distribute verbatim copies
of this license document, but changing it is not allowed.

Preamble
========

The licenses for most software are designed to take away your freedom to share and change it. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change free software--to make sure the software is free for all its users. This General Public License applies to most of the Free Software Foundation's software and to any other program whose authors commit to using it. (Some other Free Software Foundation software is covered by the GNU Library General Public License instead.) You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this

☑ I accept the license terms



Choosing a Setup Type

Please select the Setup Type that suits your use case.

○ **Developer Default**
Installs all products needed for MySQL development purposes.

● **Server only**
Installs only the MySQL Server product.

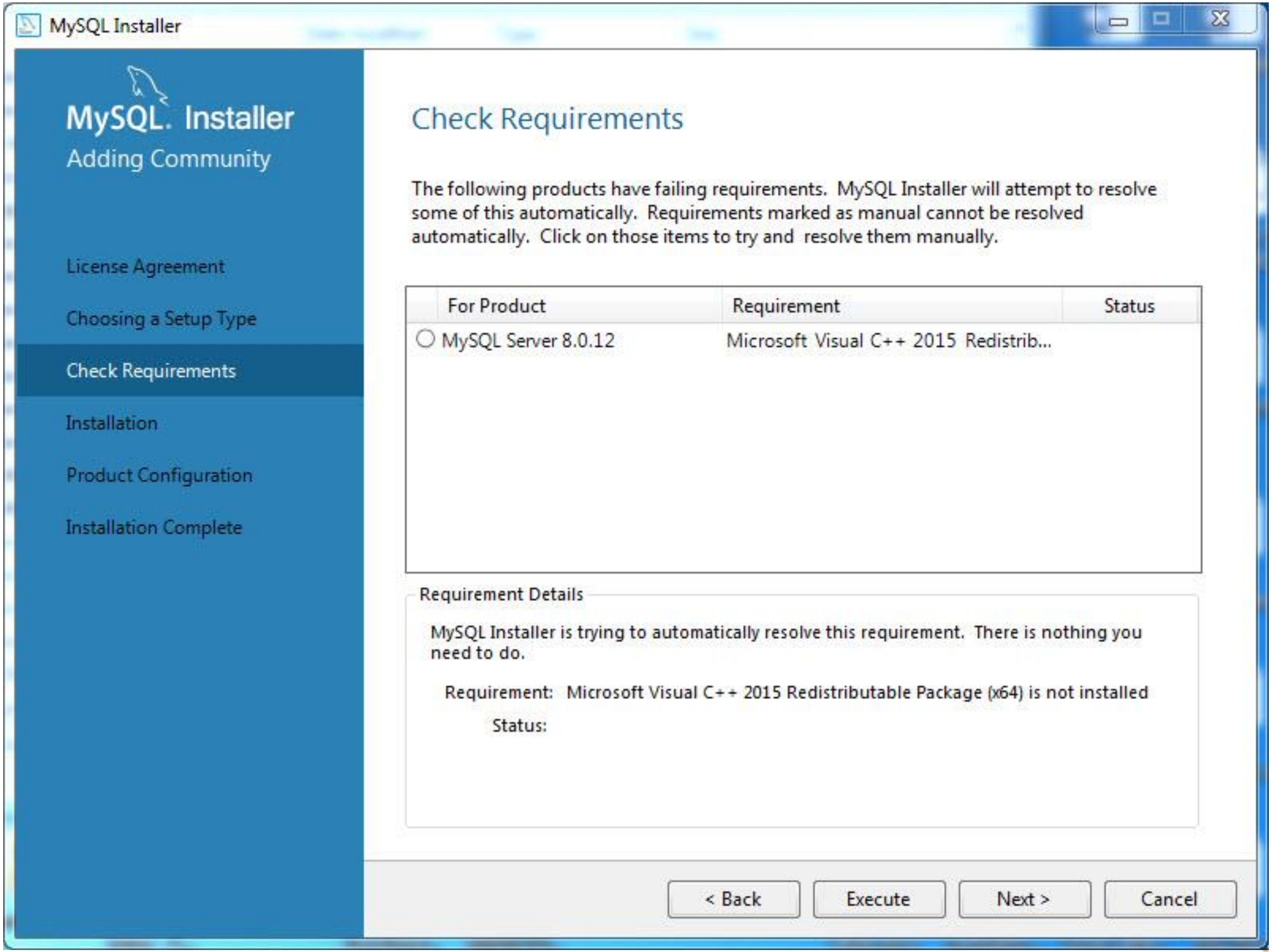
○ **Client only**
Installs only the MySQL Client products, without a server.

○ **Full**
Installs all included MySQL products and features.

○ **Custom**
Manually select the products that should be installed on the system.

Setup Type Description

Installs only the MySQL Server. This type should be used where you want to deploy a MySQL Server, but will not be developing MySQL applications.



Check Requirements

The following products have failing requirements. MySQL Installer will attempt to resolve some of this automatically. Requirements marked as manual cannot be resolved automatically. Click on those items to try and resolve them manually.

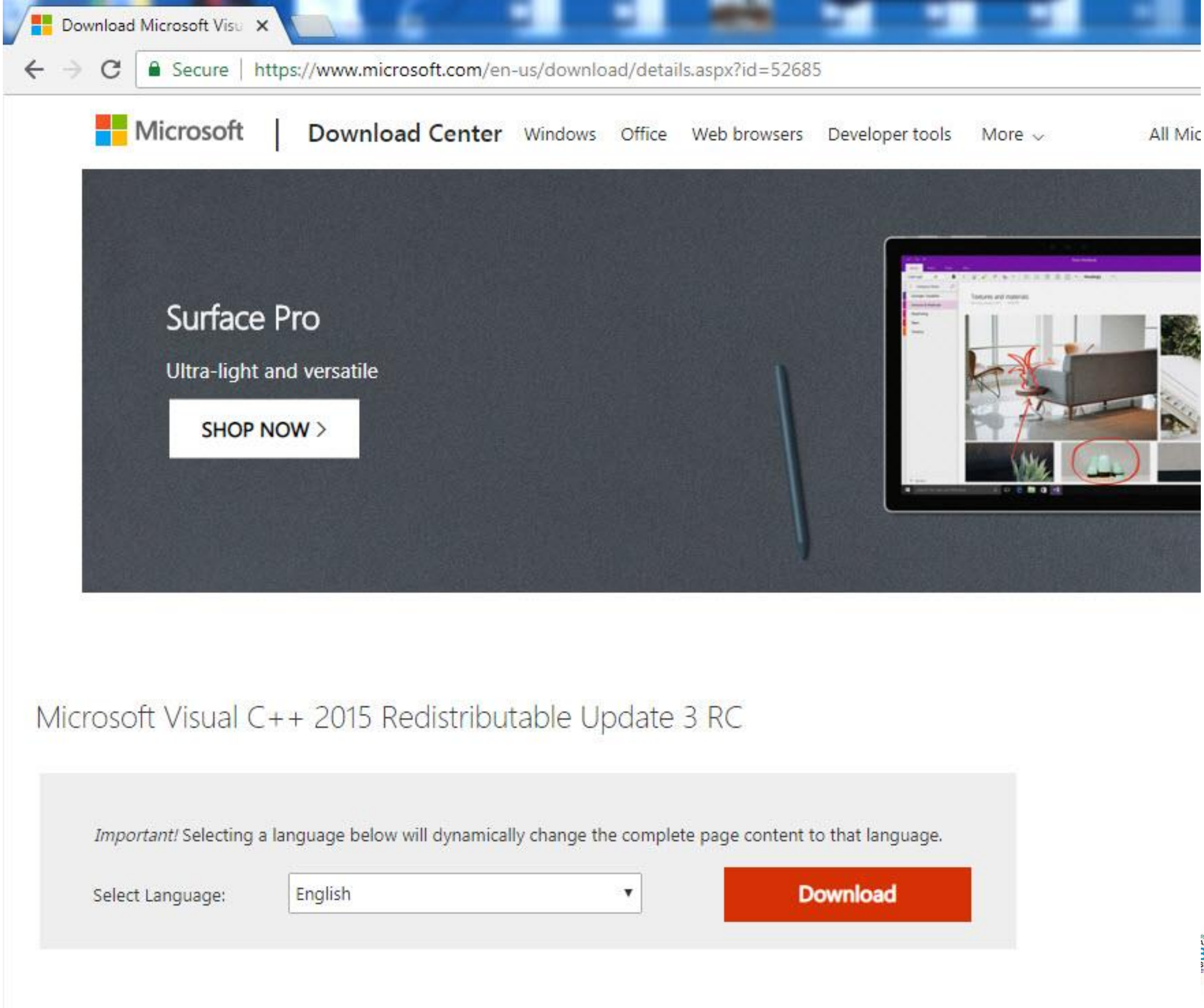
For Product	Requirement	Status
○ MySQL Server 8.0.12	Microsoft Visual C++ 2015 Redistrib...	

Requirement Details

MySQL Installer is trying to automatically resolve this requirement. There is nothing you need to do.

Requirement: Microsoft Visual C++ 2015 Redistributable Package (x64) is not installed

Status:

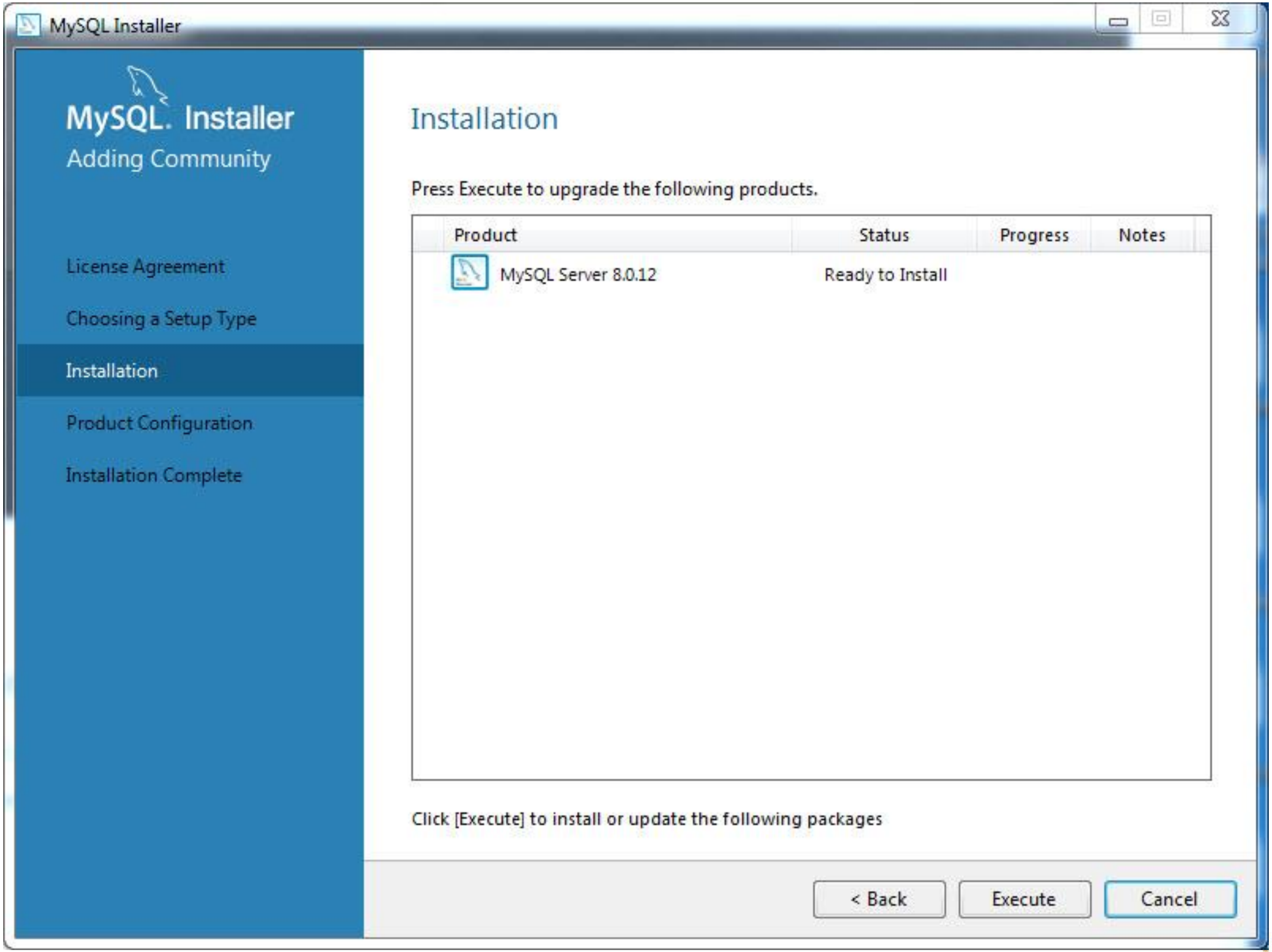


https://www.microsoft.com/en-us/download/details.aspx?id=52685

Microsoft Visual C++ 2015 Redistributable Update 3 RC

Important! Selecting a language below will dynamically change the complete page content to that language.

Select Language: English

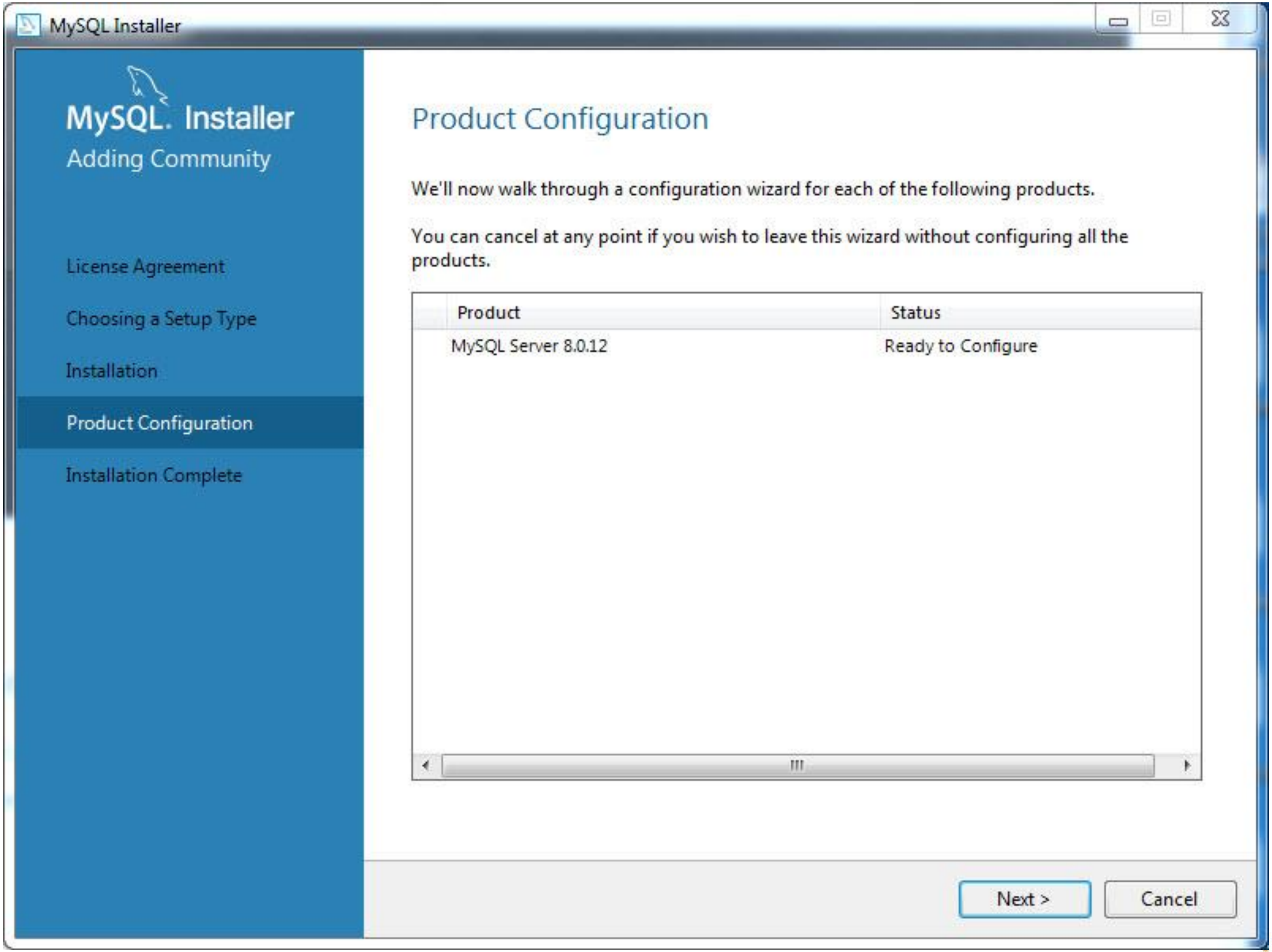


Installation

Press Execute to upgrade the following products.

Product	Status	Progress	Notes
MySQL Server 8.0.12	Ready to Install		

Click [Execute] to install or update the following packages

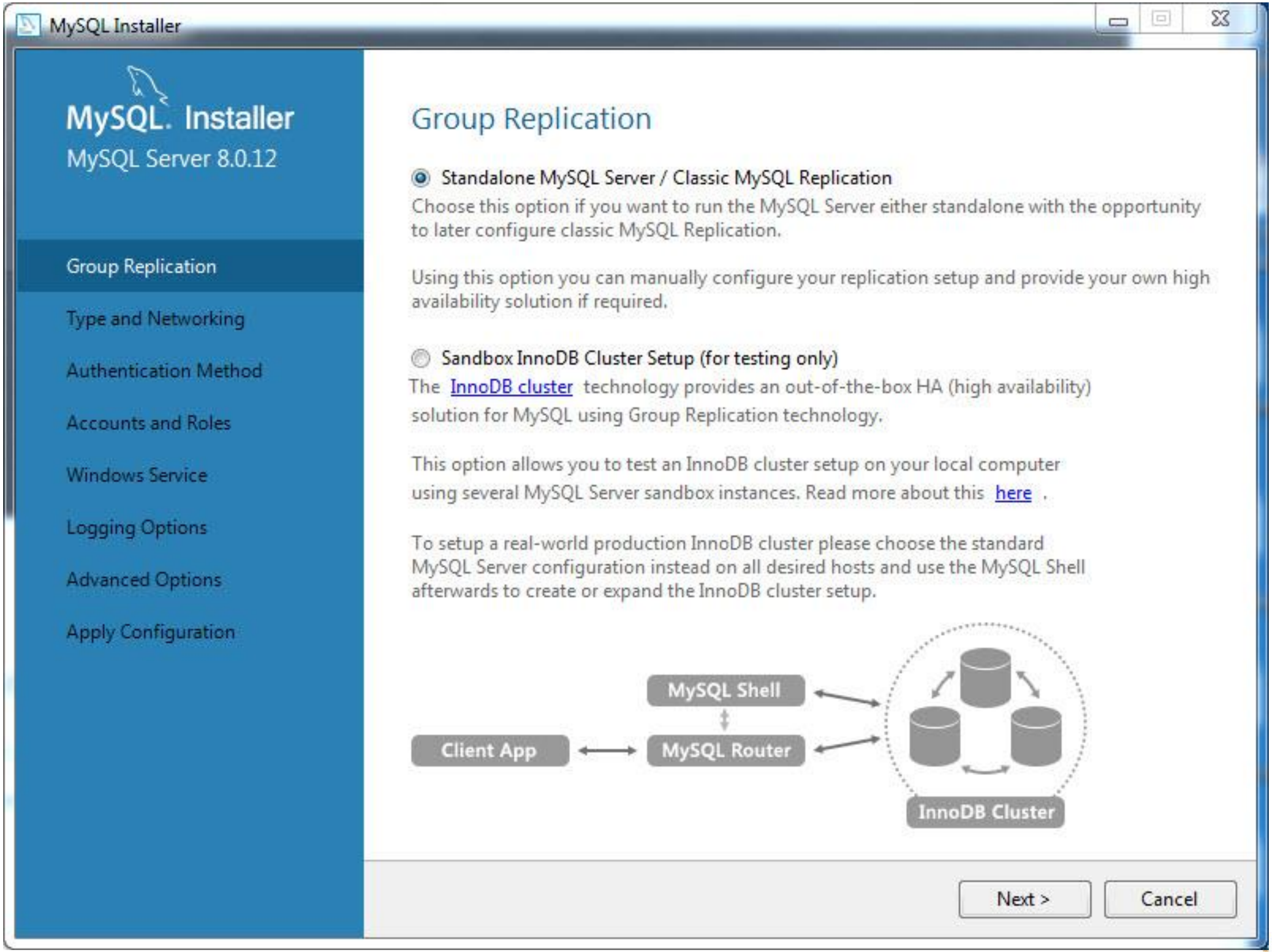


Product Configuration

We'll now walk through a configuration wizard for each of the following products.

You can cancel at any point if you wish to leave this wizard without configuring all the products.

Product	Status
MySQL Server 8.0.12	Ready to Configure



Group Replication

● Standalone MySQL Server / Classic MySQL Replication

Choose this option if you want to run the MySQL Server either standalone with the opportunity to later configure classic MySQL Replication.

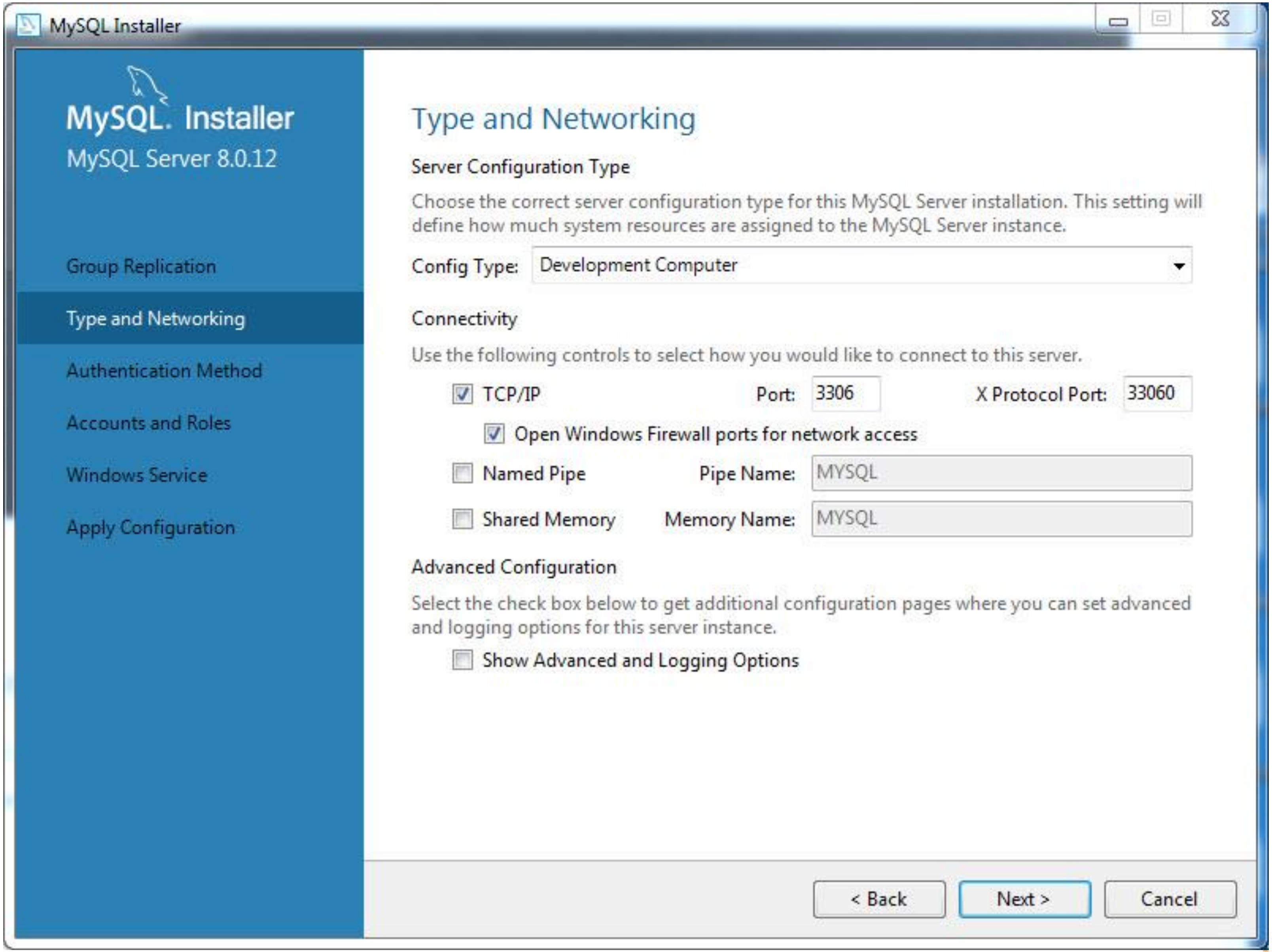
Using this option you can manually configure your replication setup and provide your own high availability solution if required.

○ Sandbox InnoDB Cluster Setup (for testing only)

The InnoDB cluster technology provides an out-of-the-box HA (high availability) solution for MySQL using Group Replication technology.

This option allows you to test an InnoDB cluster setup on your local computer using several MySQL Server sandbox instances. Read more about this here .

To setup a real-world production InnoDB cluster please choose the standard MySQL Server configuration instead on all desired hosts and use the MySQL Shell afterwards to create or expand the InnoDB cluster setup.



Type and Networking

Server Configuration Type

Choose the correct server configuration type for this MySQL Server installation. This setting will define how much system resources are assigned to the MySQL Server instance.

Config Type: Development Computer

Connectivity

Use the following controls to select how you would like to connect to this server.

☑ TCP/IP Port: 3306 X Protocol Port: 33060

☑ Open Windows Firewall ports for network access

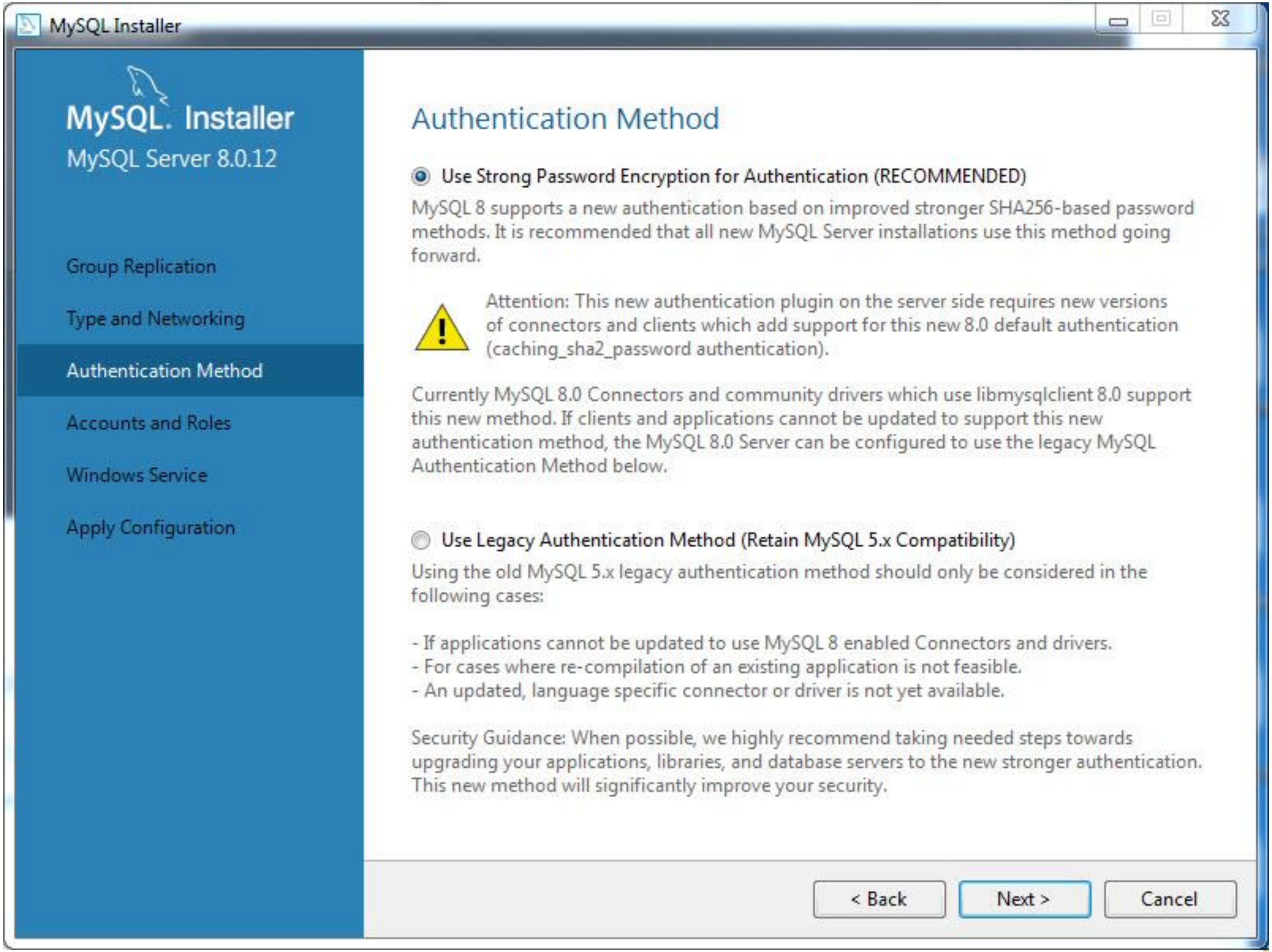
□ Named Pipe Pipe Name: MYSQL

□ Shared Memory Memory Name: MYSQL

Advanced Configuration

Select the check box below to get additional configuration pages where you can set advanced and logging options for this server instance.

□ Show Advanced and Logging Options



Authentication Method

● Use Strong Password Encryption for Authentication (RECOMMENDED)

MySQL 8 supports a new authentication based on improved stronger SHA256-based password methods. It is recommended that all new MySQL Server installations use this method going forward.

⚠ Attention: This new authentication plugin on the server side requires new versions of connectors and clients which add support for this new 8.0 default authentication (caching_sha2_password authentication).

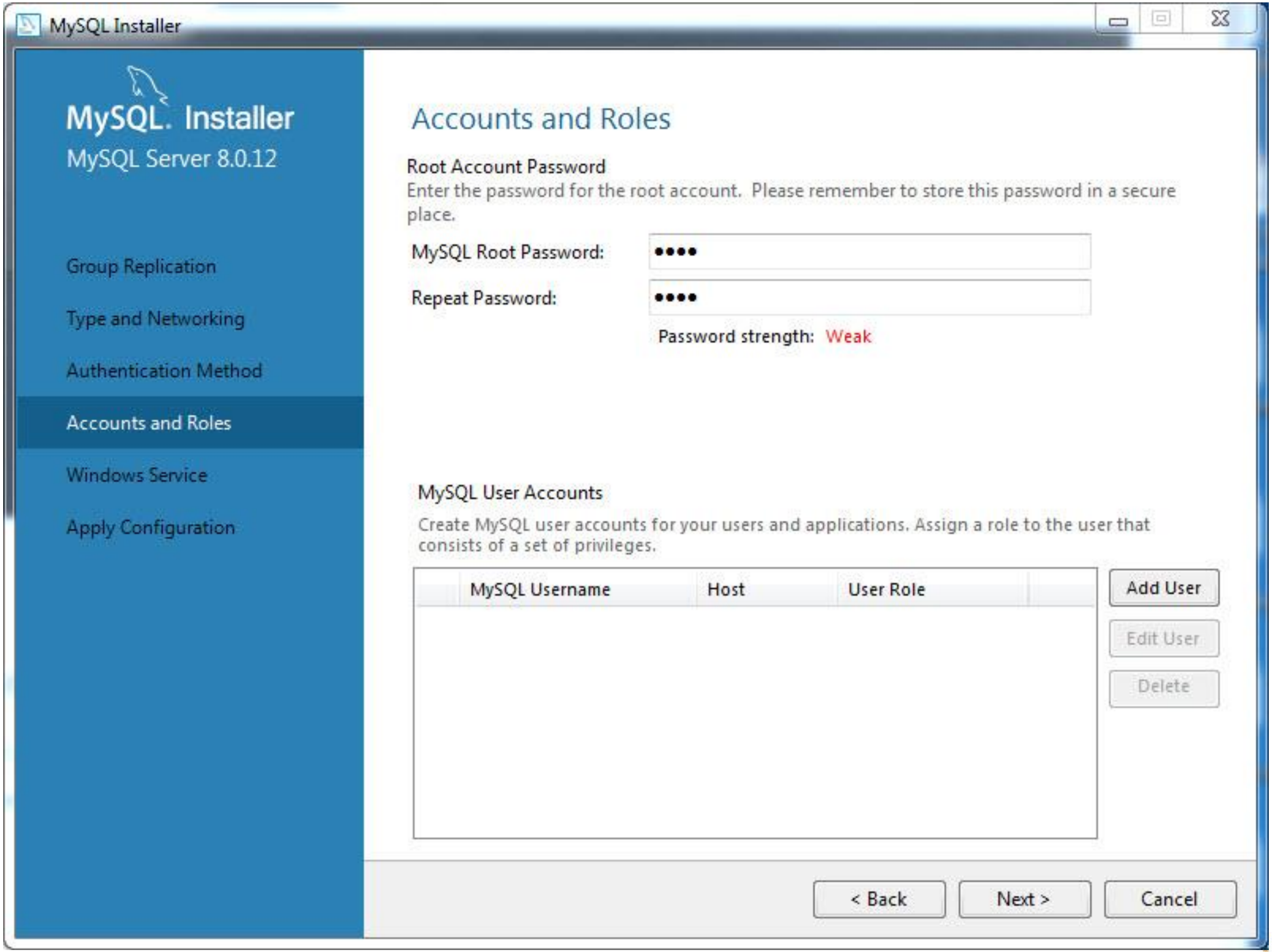
Currently MySQL 8.0 Connectors and community drivers which use libmysqlclient 8.0 support this new method. If clients and applications cannot be updated to support this new authentication method, the MySQL 8.0 Server can be configured to use the legacy MySQL Authentication Method below.

○ Use Legacy Authentication Method (Retain MySQL 5.x Compatibility)

Using the old MySQL 5.x legacy authentication method should only be considered in the following cases:

- If applications cannot be updated to use MySQL 8 enabled Connectors and drivers.
- For cases where re-compilation of an existing application is not feasible.
- An updated, language specific connector or driver is not yet available.

Security Guidance: When possible, we highly recommend taking needed steps towards upgrading your applications, libraries, and database servers to the new stronger authentication. This new method will significantly improve your security.



Accounts and Roles

Root Account Password

Enter the password for the root account. Please remember to store this password in a secure place.

MySQL Root Password: ••••

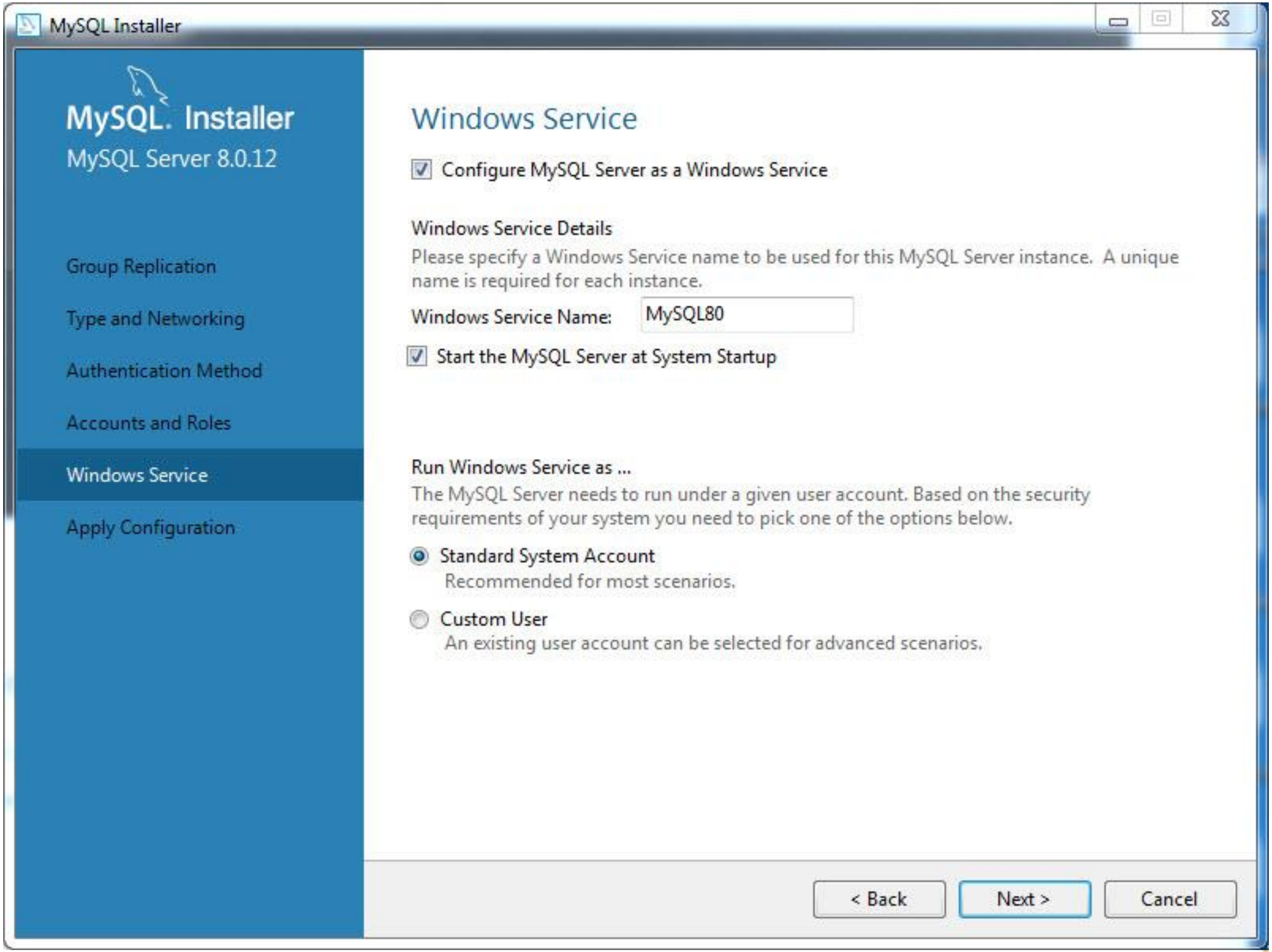
Repeat Password: ••••

Password strength: Weak

MySQL User Accounts

Create MySQL user accounts for your users and applications. Assign a role to the user that consists of a set of privileges.

MySQL Username	Host	User Role



Windows Service

☑ Configure MySQL Server as a Windows Service

Windows Service Details

Please specify a Windows Service name to be used for this MySQL Server instance. A unique name is required for each instance.

Windows Service Name: MySQL80

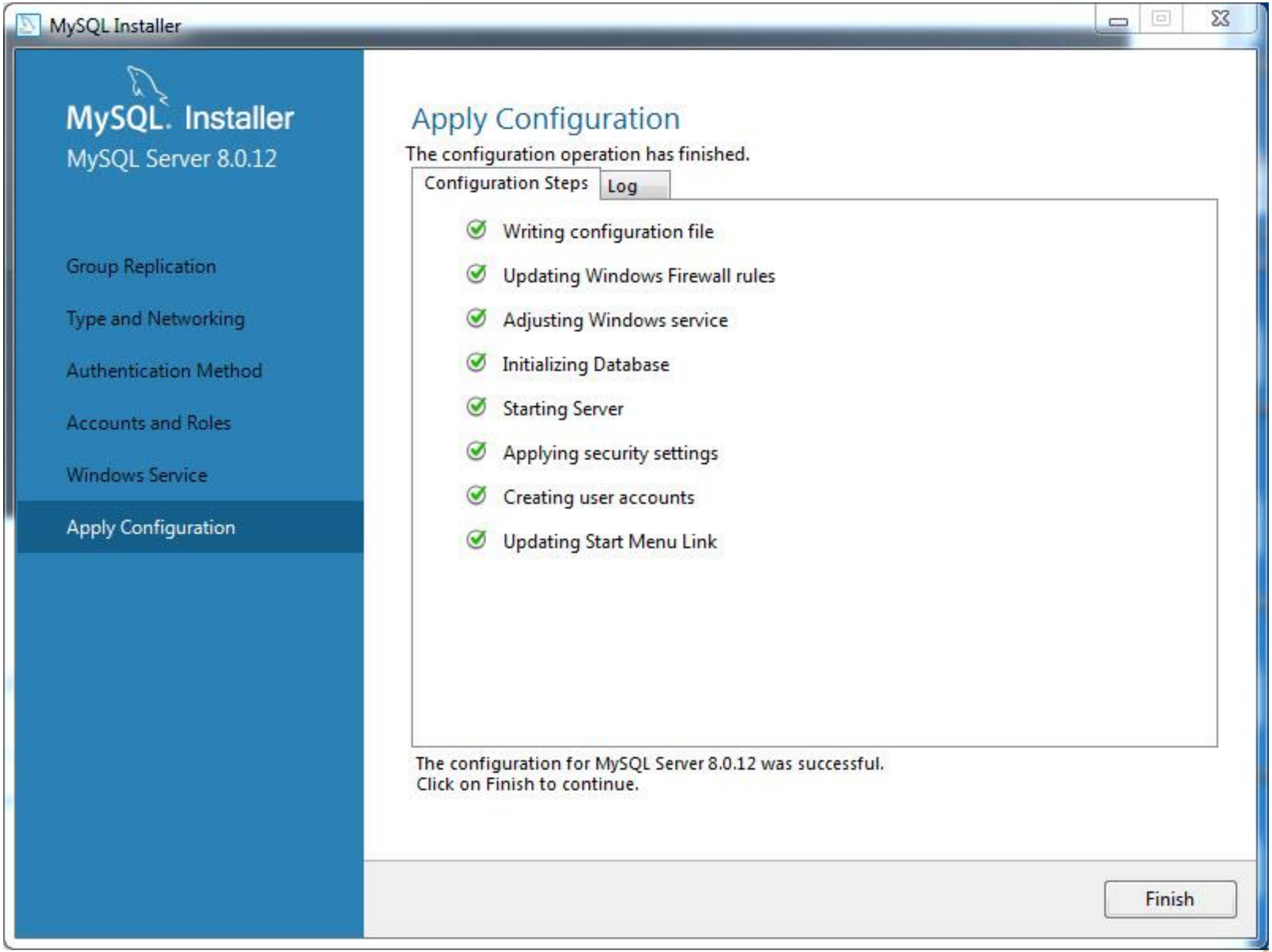
☑ Start the MySQL Server at System Startup

Run Windows Service as ...

The MySQL Server needs to run under a given user account. Based on the security requirements of your system you need to pick one of the options below.

● Standard System Account
Recommended for most scenarios.

○ Custom User
An existing user account can be selected for advanced scenarios.

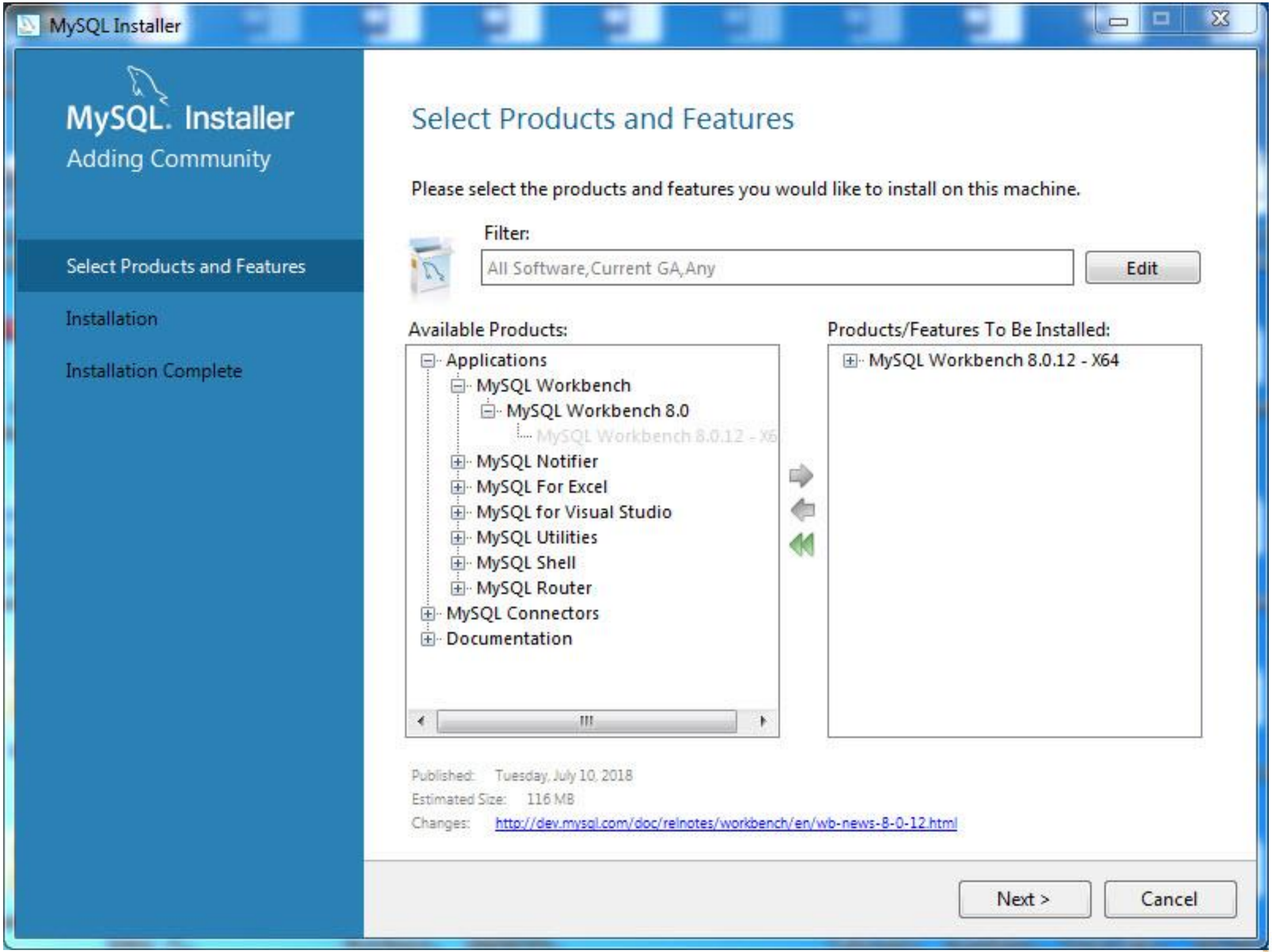


Apply Configuration

The configuration operation has finished.

- ✓ Writing configuration file
- ✓ Updating Windows Firewall rules
- ✓ Adjusting Windows service
- ✓ Initializing Database
- ✓ Starting Server
- ✓ Applying security settings
- ✓ Creating user accounts
- ✓ Updating Start Menu Link

The configuration for MySQL Server 8.0.12 was successful.
Click on Finish to continue.



Select Products and Features

Please select the products and features you would like to install on this machine.

Filter: All Software,Current GA,Any

Available Products:

- Applications
  - MySQL Workbench
    - MySQL Workbench 8.0
      - MySQL Workbench 8.0.12 - X6
  - MySQL Notifier
  - MySQL For Excel
  - MySQL for Visual Studio
  - MySQL Utilities
  - MySQL Shell
  - MySQL Router
- MySQL Connectors
- Documentation

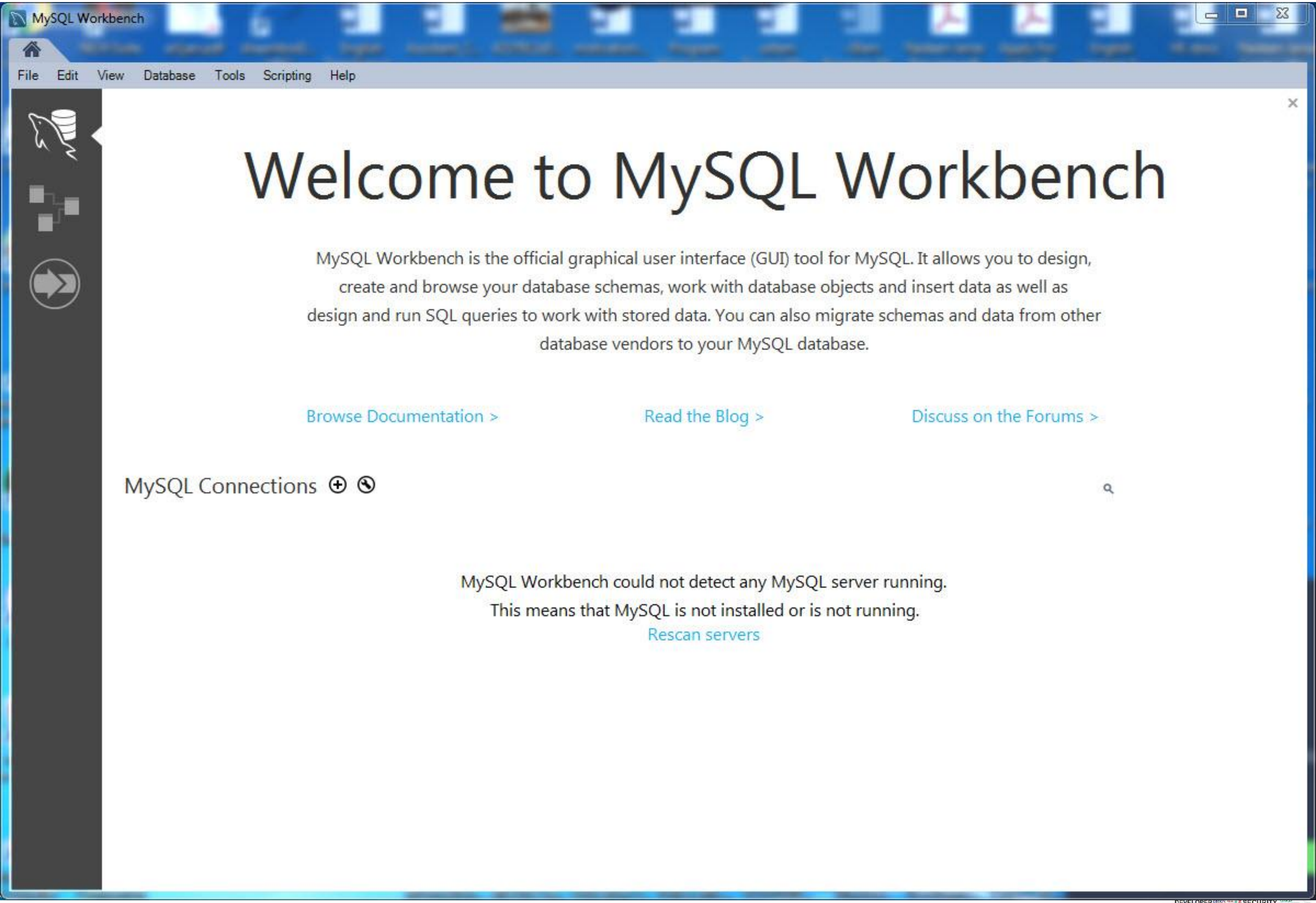
Products/Features To Be Installed:

- MySQL Workbench 8.0.12 - X64

Published: Tuesday, July 10, 2018

Estimated Size: 116 MB

Changes: http://dev.mysql.com/doc/relnotes/workbench/en/wb-news-8-0-12.html

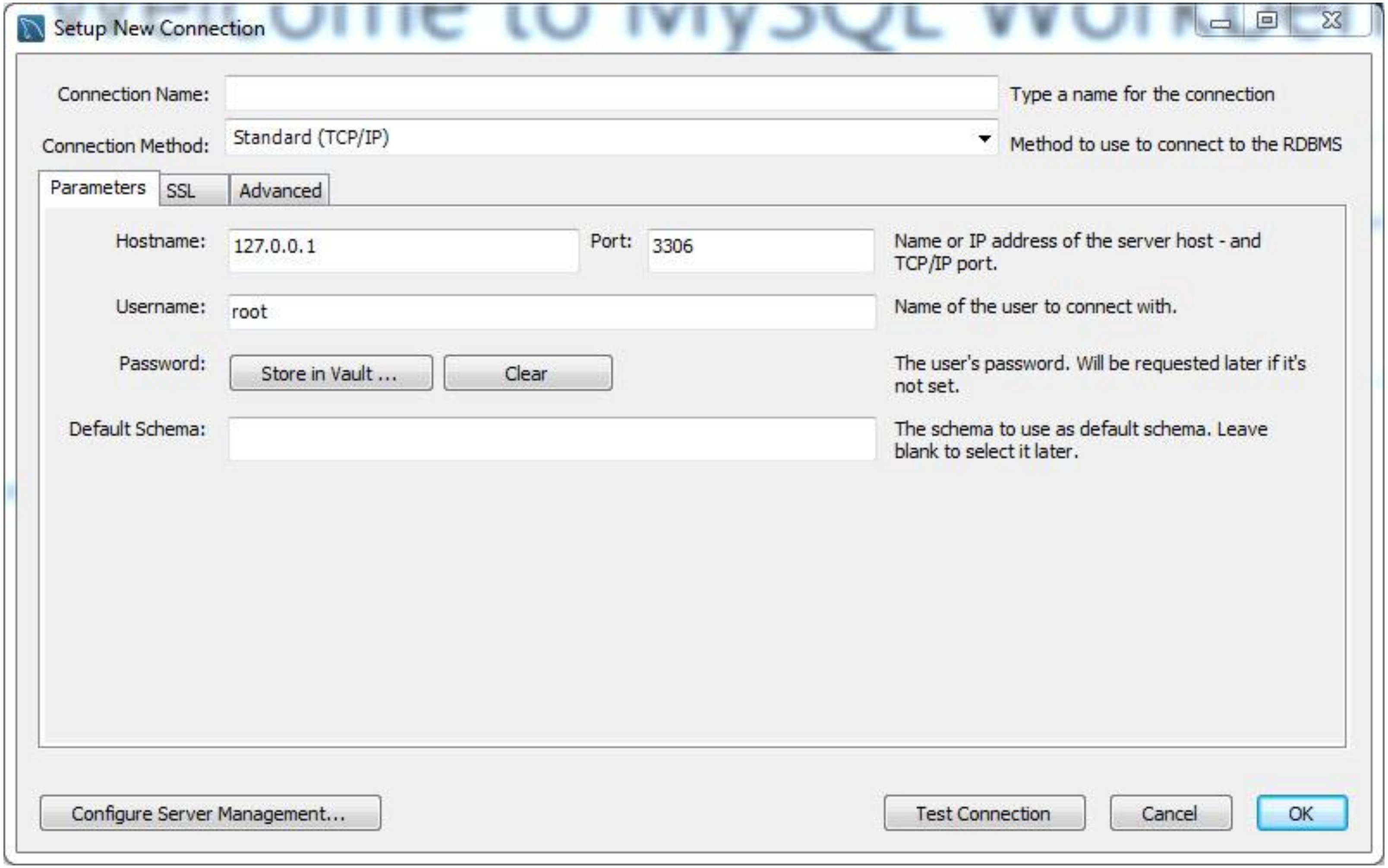


Welcome to MySQL Workbench

MySQL Workbench is the official graphical user interface (GUI) tool for MySQL. It allows you to design, create and browse your database schemas, work with database objects and insert data as well as design and run SQL queries to work with stored data. You can also migrate schemas and data from other database vendors to your MySQL database.

MySQL Connections ⊕ ⊗

MySQL Workbench could not detect any MySQL server running.
This means that MySQL is not installed or is not running.



Setup New Connection

Connection Name: Type a name for the connection

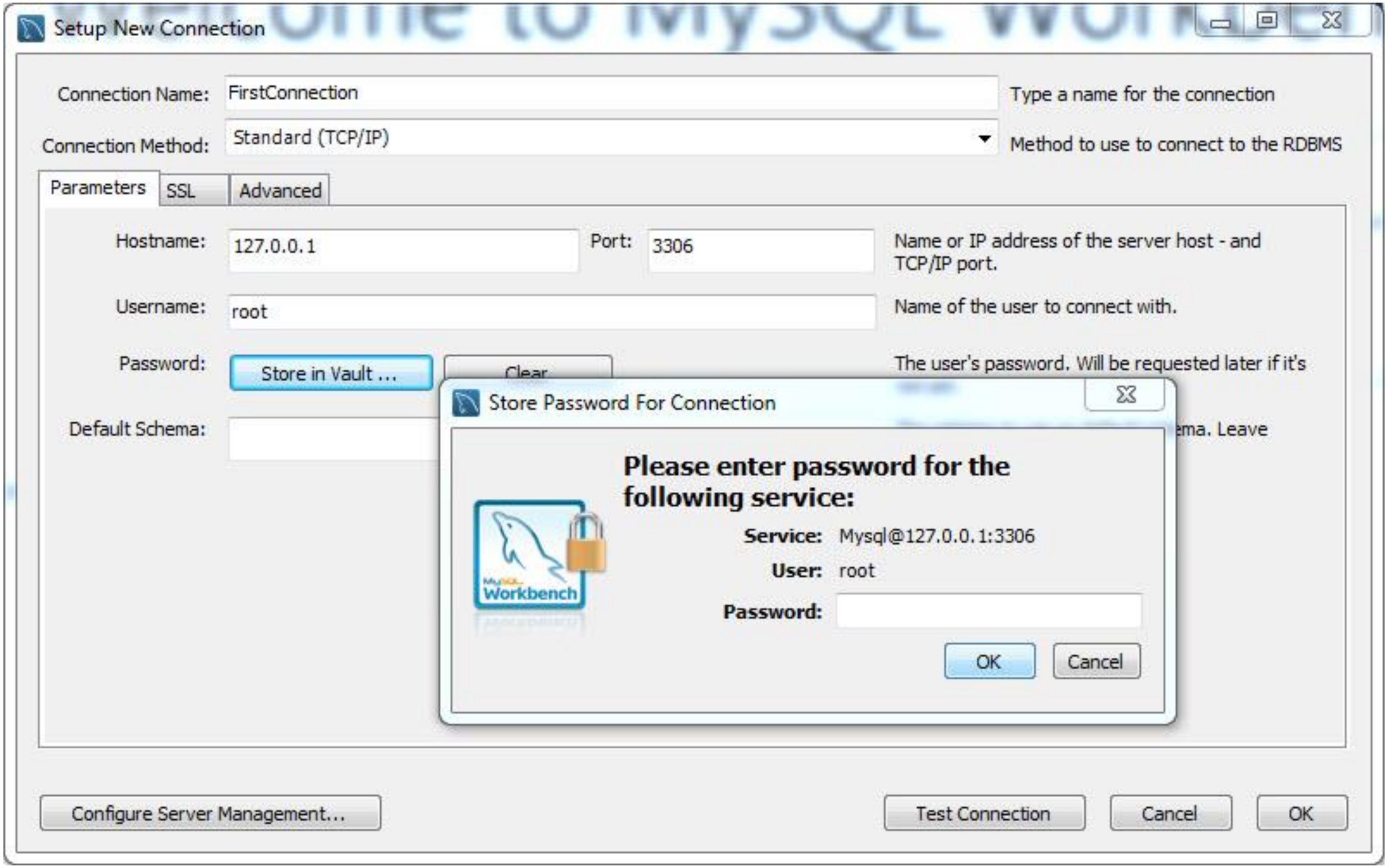
Connection Method: Standard (TCP/IP) Method to use to connect to the RDBMS

Hostname: 127.0.0.1 Port: 3306 Name or IP address of the server host - and TCP/IP port.

Username: root Name of the user to connect with.

Password: The user's password. Will be requested later if it's not set.

Default Schema: The schema to use as default schema. Leave blank to select it later.



Setup New Connection

Connection Name: FirstConnection

Type a name for the connection

Connection Method: Standard (TCP/IP)

Method to use to connect to the RDBMS

Hostname: 127.0.0.1

Port: 3306

Name or IP address of the server host - and TCP/IP port.

Username: root

Name of the user to connect with.

Password:

The user's password. Will be requested later if it's

Default Schema:

ema. Leave

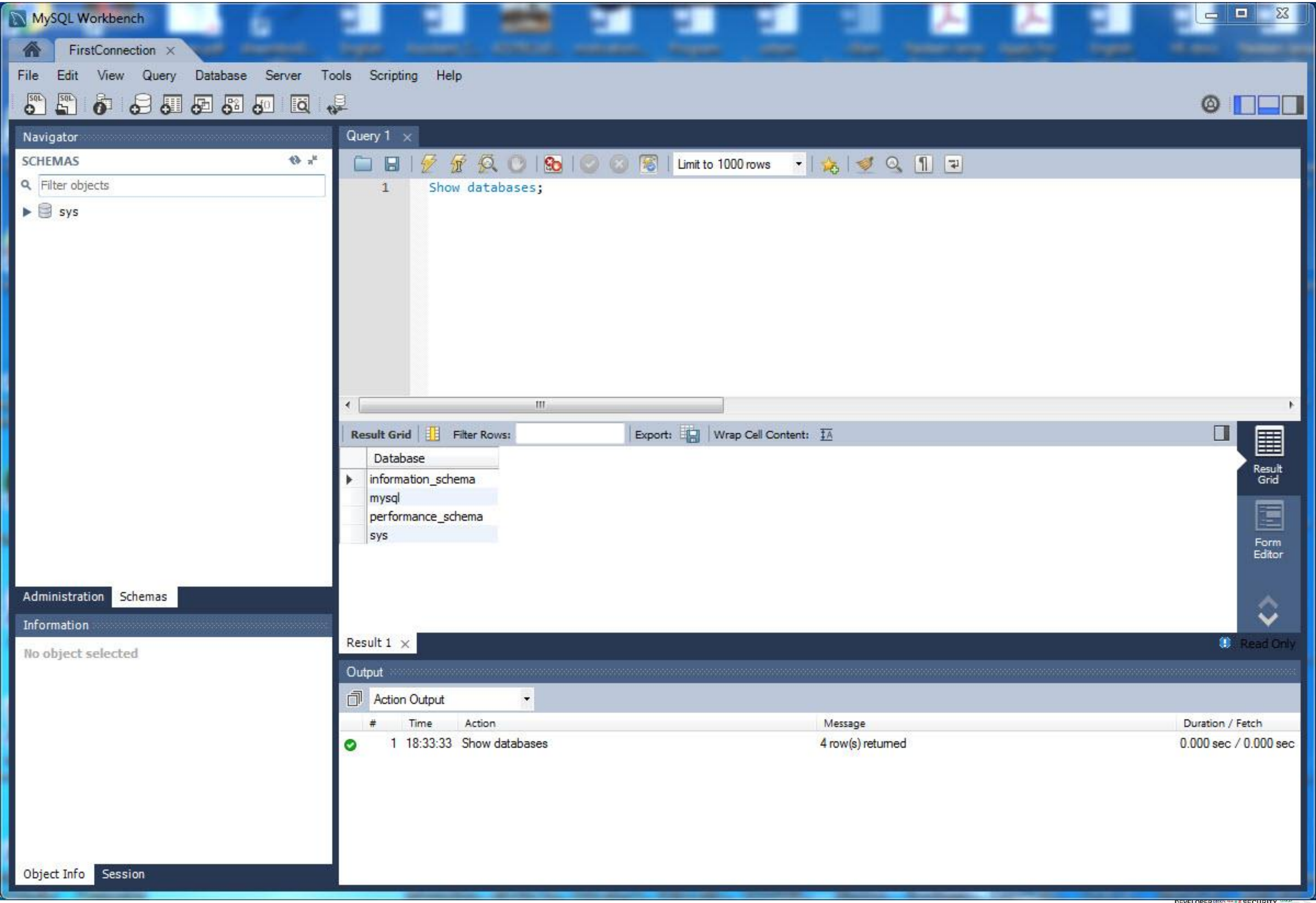
Store Password For Connection

Please enter password for the following service:

Service: Mysql@127.0.0.1:3306

User: root

Password:



```
Show databases;
```

Database
information_schema
mysql
performance_schema
sys

	#	Time	Action	Message	Duration / Fetch
✓	1	18:33:33	Show databases	4 row(s) returned	0.000 sec / 0.000 sec

MySQL Basics – Data Definition

- SHOW DATABASES;
- CREATE DATABASE university;
- SHOW DATABASES;
- USE university;
- DROP DATABASE university;

MySQL Basics

```
• CREATE TABLE student (
        sid INT,
        sname VARCHAR(32),
        bdate DATE,
        gpa REAL,
        PRIMARY KEY (sid));
• SHOW TABLES;
• SHOW CREATE TABLE student;
• ALTER TABLE STUDENT ADD major VARCHAR(16);
• ALTER TABLE STUDENT ADD phone VARCHAR(16) AFTER  bdate;
• DROP TABLE student;
```

MySQL Basics – Data Manipulation

- Query:

```
SELECT *
FROM student;
```

- INSERT INTO STUDENT VALUES (1051122, 'Ahmad', '1980-01-20', 99);
- SELECT * FROM student;
- INSERT INTO STUDENT (sid, sname) VALUES (1061122, 'Sireen’);
- DELETE FROM student WHERE sid>=1060000 AND sid<=1069999;
- Query:

```
SELECT sid, sname
FROM student
WHERE sname = ‘Ahmad’;
```

MySQL Basics – Auto increment

- ALTER TABLE student MODIFY sid int auto_increment;
- SELECT * FROM student;
- INSERT INTO student (sname) VALUES ('Iyad');
- ALTER TABLE student auto_increment=1070000;
- INSERT INTO student (sname) VALUES ('Gabi');
- ALTER TABLE student MODIFY gpa REAL DEFAULT 60;
- SELECT * FROM student;
- ALTER TABLE student MODIFY bdate DATE DEFAULT '1900-01-01';
- INSERT INTO student (sname) VALUES ('Gabi');

MySQL Basics – Data Control

- CREATE USER 'user1'@'localhost' IDENTIFIED BY ‘password';
- GRANT ALL PRIVILEGES ON university.* TO 'user1'@'localhost' WITH GRANT OPTION;
- CREATE USER 'user1'@'%' IDENTIFIED BY ‘password';
- GRANT ALL PRIVILEGES ON university.* TO 'user1'@'%' WITH GRANT OPTION;

- CREATE USER 'user2'@'localhost' IDENTIFIED BY ‘password2';
- GRANT SELECT ON university.* TO 'user2'@'localhost' WITH GRANT OPTION;
- CREATE USER 'user2'@'%' IDENTIFIED BY ‘password2';
- GRANT SELECT ON university.* TO 'user2'@'%' WITH GRANT OPTION;

Integrity Constraints Over Relations

- A database is only as good as the information stored in it, and a DBMS must therefore help prevent the entry of incorrect information.

- An integrity constraint (IC) is a condition that is specified on a database schema, and restricts the data that can be stored in an instance of the database.
- We already have seen the *Domain Constraints*

Key Constraints

- A key constraint is a statement that a certain minimal subset of the fields of a relation is a unique identifier for a tuple.
- Two Important Note:
  - Two distinct tuples in a legal instance cannot have identical values in all the fields of a key.
  - No subset of the set of fields in a key is a unique identifier for a tuple.
- Primary Key, Candidate Key, and Super key

Keys (continued)

- Composite key
  - Composed of more than one attribute
- Key attribute
  - Any attribute that is part of a key
- Superkey
  - Any key that uniquely identifies each row
- Candidate key
  - A superkey without redundancies

Keys (continued)

- Nulls:
  - No data entry
  - Not permitted in primary key
  - Should be avoided in other attributes
  - Can represent
    - An unknown attribute value
    - A known, but missing, attribute value
    - A “not applicable” condition
  - Can create problems when functions such as COUNT, AVERAGE, and SUM are used
  - Can create logical problems when relational tables are linked

SQL for Data Definition: CREATE with CONSTRAINT

- Creating database tables with PRIMARY KEY constraints
  - The SQL CREATE TABLE statement
  - The SQL CONSTRAINT keyword

```
CREATE      TABLE  Employee(
    EmpID          Integer        Not Null,
    EmpName        Char(25)                Not Null
    CONSTRAINT     EmpPK                   PRIMARY KEY (EmpID)
);
```

SQL for Data Definition: CREATE with CONSTRAINT

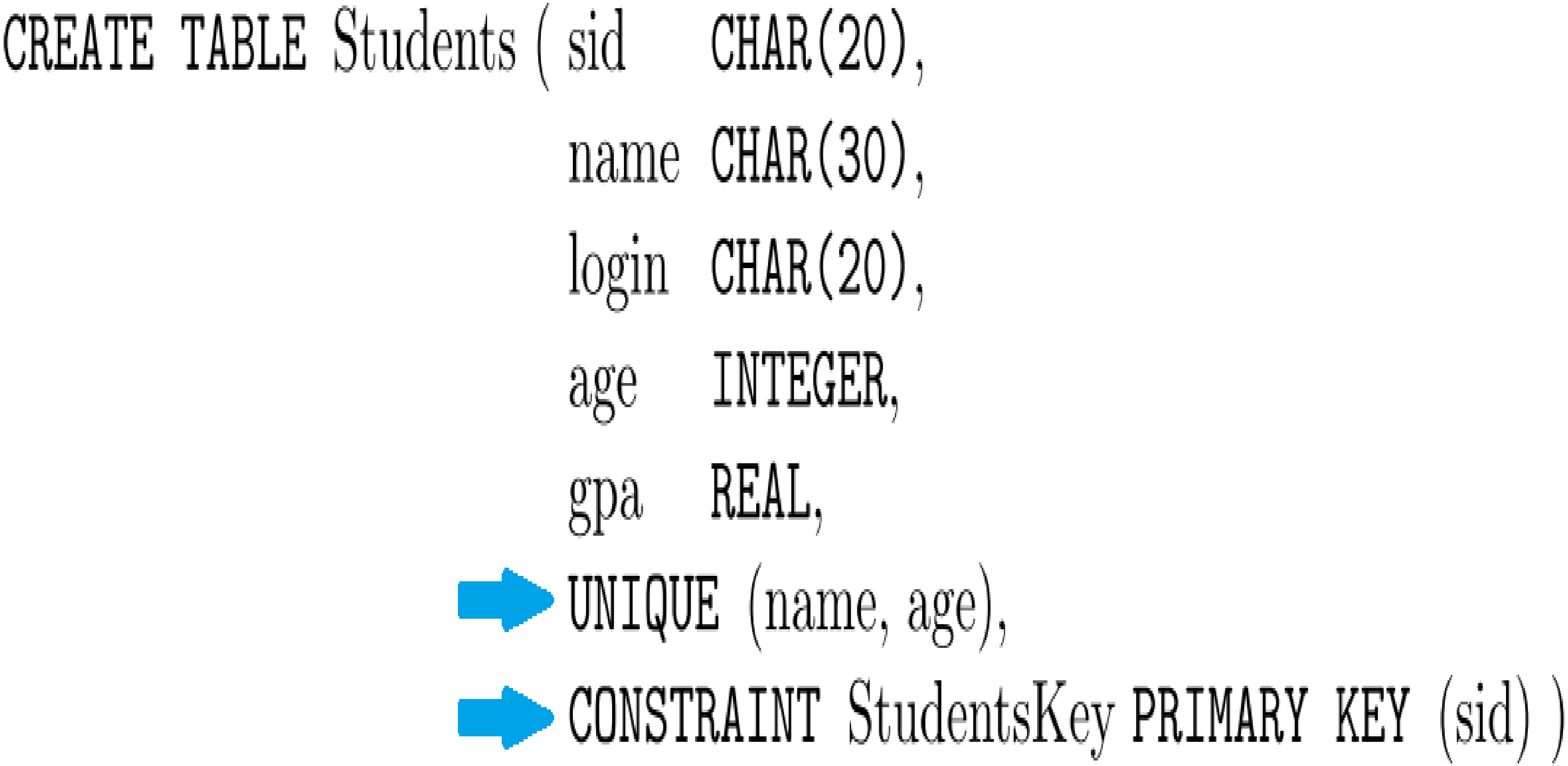
- Creating database tables with composite primary keys using PRIMARY KEY constraints
  - The SQL CREATE TABLE statement
  - The SQL CONSTRAINT keyword

```
CREATE     TABLE  Emp_Skill (
   EmpID           Integer      Not Null,
   SkillID         Integer      Not Null,
   SkillLevel      Integer,
   CONSTRAINT      EmpSkillPK      PRIMARY KEY (EmpID, SkillID)
);
```

Keys for Relationship Sets

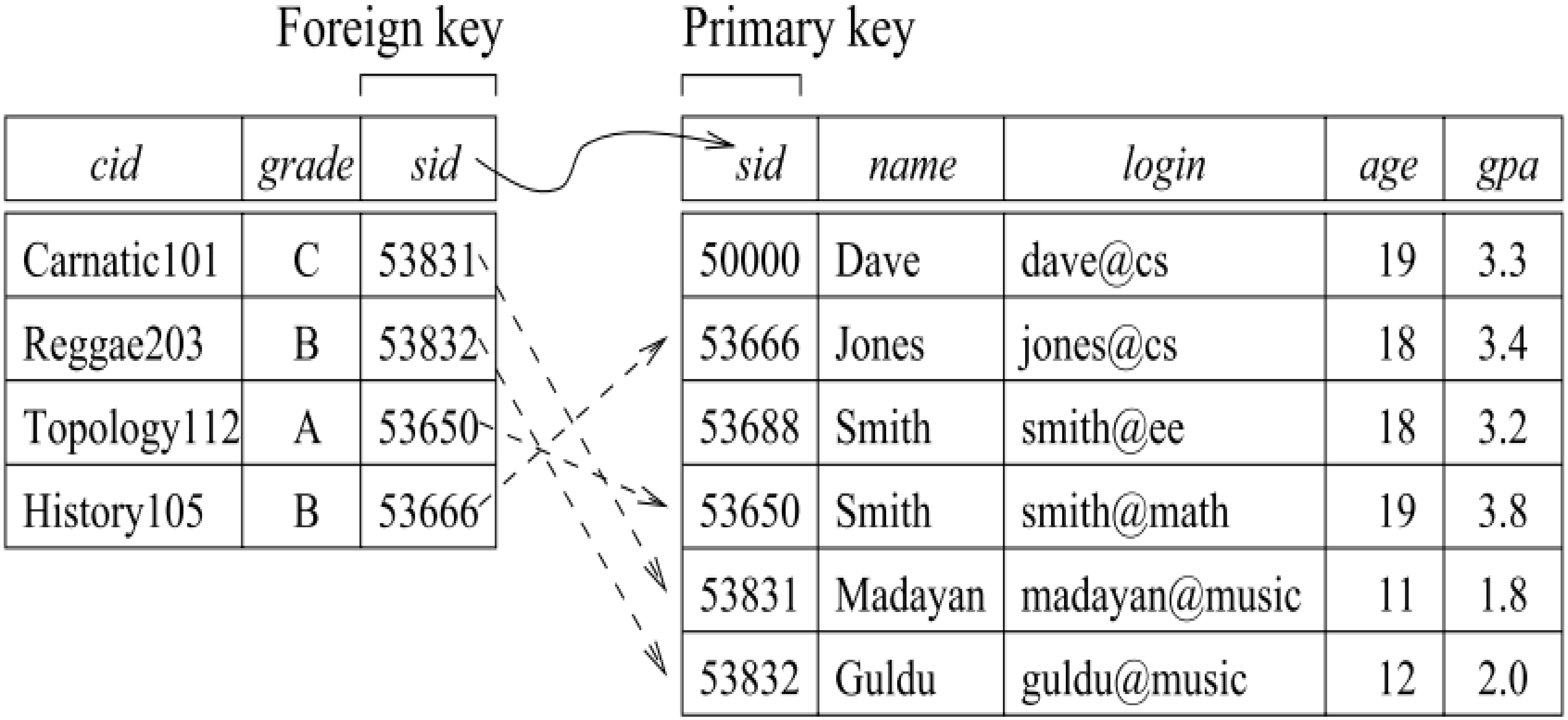
- The combination of primary keys of the participating entity sets forms a super key of a relationship set.
  - (s_id, i_id) is the super key of advisor
  - NOTE: this means a pair of entity sets can have at most one relationship in a particular relationship set.
    - Example: if we wish to track multiple meeting dates between a student and her advisor, we cannot assume a relationship for each meeting. We can use a multivalued attribute though
- Must consider the mapping cardinality of the relationship set when deciding what are the candidate keys
- Need to consider semantics of relationship set in selecting the primary key in case of more than one candidate key

Example in SQL



```
CREATE TABLE Students ( sid     CHAR(20),
                        name    CHAR(30),
                        login   CHAR(20),
                        age     INTEGER,
                        gpa     REAL,
                        UNIQUE (name, age),
                        CONSTRAINT StudentsKey PRIMARY KEY (sid) )
```

Foreign Key Constraints



Foreign key

cid	*grade*	*sid*
Carnatic101	C	53831
Reggae203	B	53832
Topology112	A	53650
History105	B	53666

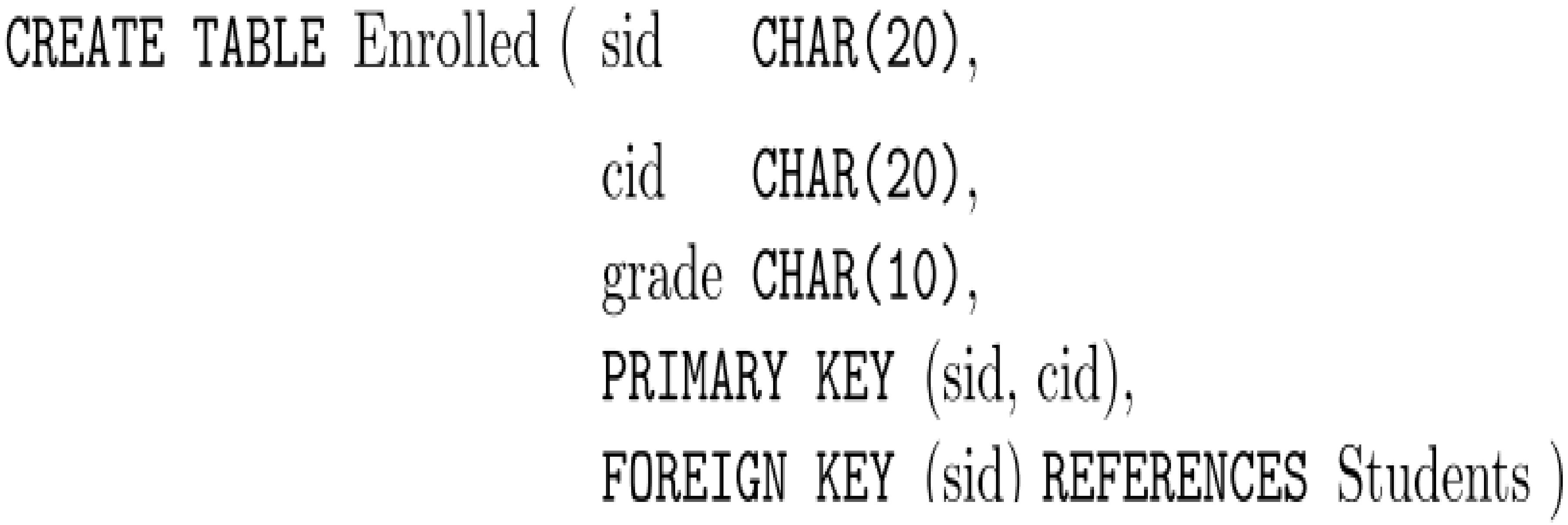
Enrolled (Referencing relation)

Primary key

sid	*name*	*login*	*age*	*gpa*
50000	Dave	dave@cs	19	3.3
53666	Jones	jones@cs	18	3.4
53688	Smith	smith@ee	18	3.2
53650	Smith	smith@math	19	3.8
53831	Madayan	madayan@music	11	1.8
53832	Guldu	guldu@music	12	2.0

Students (Referenced relation)

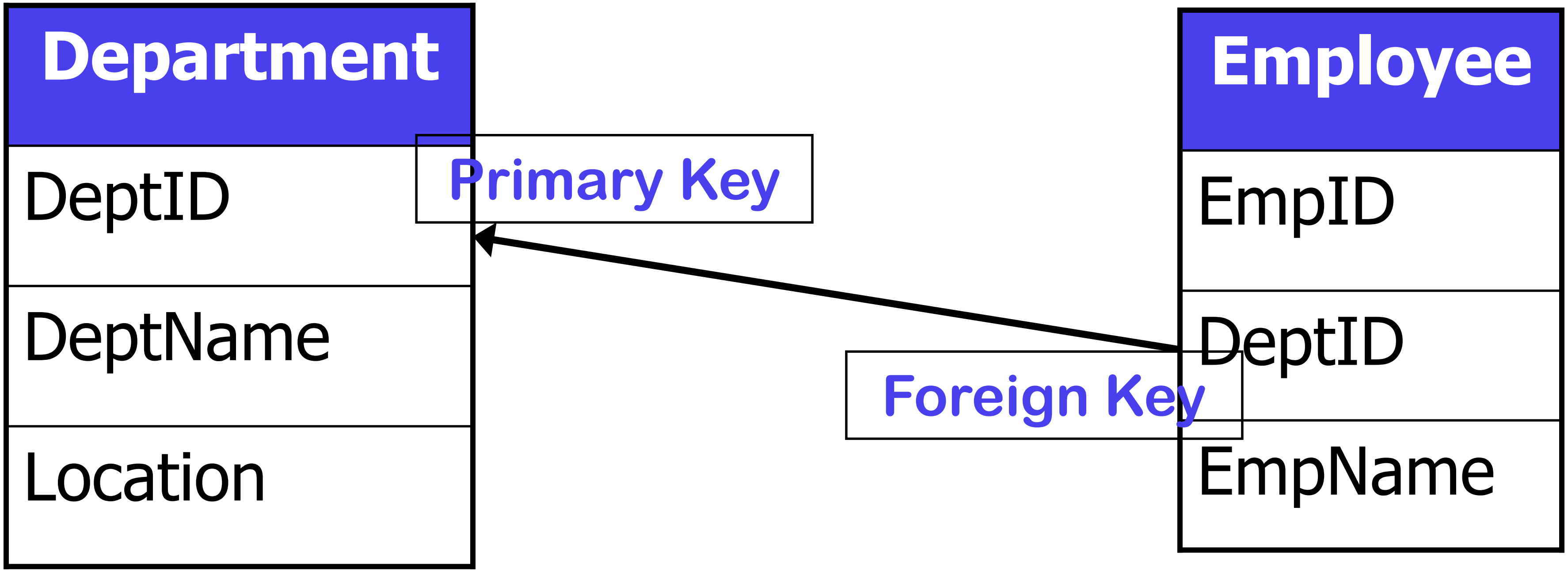
Specifying Foreign Keys



```
CREATE TABLE Enrolled ( sid   CHAR(20),
                        cid   CHAR(20),
                        grade CHAR(10),
                        PRIMARY KEY (sid, cid),
                        FOREIGN KEY (sid) REFERENCES Students )
```

Foreign Key (sid) References Students(sid)
Foreign Key (cid) References Course(cid));

Foreign Key Example



Department

DeptID

DeptName

Location

Primary Key

Employee

EmpID

DeptID

EmpName

Foreign Key

Referential Integrity

- Referential integrity states that every value of a foreign key must match a value of an existing primary key
- For example (see previous slide)
  - If EmpID = 4 in EMPLOYEE has a DeptID = 7 (a foreign key), a Department with DeptID = 7 **must exist** in DEPARTMENT

SQL for Data Definition: CREATE with CONSTRAINT

- Creating database tables using PRIMARY KEY and FOREIGN KEY constraints
  - The SQL CREATE TABLE statement
  - The SQL CONSTRAINT keyword

```
CREATE      TABLE    Emp_Skill (
   EmpID             Integer          Not Null,
   SkillID           Integer          Not Null,
   SkillLevel        Integer,
   CONSTRAINT        EmpSkillPK       PRIMARY KEY (EmpID, SkillID),
    CONSTRAINT       EmpFK            FOREIGN KEY
                     EmpID            REFERENCES Employee (EmpID),
   CONSTRAINT        SkillFK          FOREIGN KEY
                     SkillID          REFERENCES Skill (SkillID)
);
```

SQL for Data Definition: CREATE with CONSTRAINT

- Creating database tables using PRIMARY KEY and FOREIGN KEY constraints
  - The SQL CREATE TABLE statement
  - The SQL CONSTRAINT keyword
  - ON UPDATE CASCADE and ON DELETE CASCADE

```
CREATE       TABLE     Emp_Skill (
   EmpID               Integer          Not Null,
   SkillID             Integer          Not Null,
   SkillLevel          Integer,
   CONSTRAINT          EmpSkillPK       PRIMARY KEY (EmpID, SkillID),
    CONSTRAINT         EmpFK            FOREIGN KEY (EmpID)
                       REFERENCES       Employee (EmpID)
                       ON DELETE CASCADE,
   CONSTRAINT          SkillFK          FOREIGN KEY (SkillID)
                       REFERENCES       Skill (SkillID)
                       ON UPDATE CASCADE
);
```

When the row of EmpID (primary key) in Employee TABLE is deleted, the EmpFK (foreign key) is deleted also.

Deleting Database Objects: DROP

- To remove unwanted database objects from the database, use the SQL DROP statement
- Warning… The DROP statement will permanently remove the object and all data

```
DROP TABLE Employee;
```

Removing a Constraint: ALTER & DROP

- To change the constraints on existing tables, you may need to remove the existing constraints before adding new constraints

```
ALTER TABLE Employee DROP CONSTRAINT EmpFK;
```

Enforcing Integrity Constraints

- Deletion of ***Enrolled*** tuples do not violate referential integrity, but insertions could.
  - Inserting a tuple with an un-exist sid in ***Students***.

- Insertion of Students tuples do not violate referential integrity, but

```
INSERT INTO  Enrolled (sid, cid, grade) VALUES  (51111, ‘Hindi101’, ‘B’);
```

Ways to handle foreign key violations

- If an ***Enrolled*** row with un-existing sid is inserted, it is **rejected**.
- If a ***Students*** row is deleted/updated,
    - Option 1: **Delete/Update** all ***Enrolled*** rows that refer to the deleted sid in ***Students*** (CASCADE). **Both are affected**
    - Option 2: **Reject** the deletion/updating of the ***Students*** row if an ***Enrolled*** row refers to it (NO ACTION). [The default action for SQL]. **None is affected**.
    - Option 3: **Set** the sid of ***Enrolled*** to some existing (**default**) sid value in ***Students*** for every involved ***Enrolled*** row (SET NULL / SET DEFAULT). **Both are affected**.

Referential Integrity in SQL

- When a ***Students*** row is deleted, all ***Enrolled*** rows that refer to it are to be **deleted** as well.
- When a ***Students*** sid is modified, the update is to be **rejected** if an ***Enrolled*** row refers to the modified ***Students*** row.

```
CREATE TABLE Enrolled
   (sid CHAR(20),
    cid CHAR(20),
    grade CHAR(2),
    PRIMARY KEY  (sid,cid),
    FOREIGN KEY (sid)
      REFERENCES Students (sid)
              ON DELETE CASCADE
              ON UPDATE NO ACTION );
```

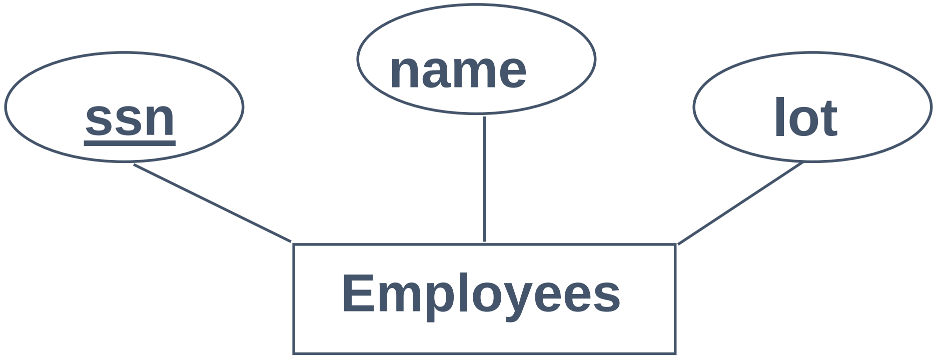
SQL Constraints

- NOT NULL constraint
  - Ensures that column does not accept nulls
- UNIQUE constraint
  - Ensures that all values in column are unique
- DEFAULT constraint
  - Assigns value to attribute when a new row is added to table
    - CUS_AREACODE CHAR(3) DEFAULT ‘615’ NOT NULL

    CHECK (CUS_AREACODE IN (‘615’, ‘713’, 931’))
- CHECK constraint
  - Validates data when attribute value is entered
    - Minimum order amount must be at least 10
    - Date must be after Jan 1, 2013
    - CONSTRAINT INV_CHK1 CHECK (INV_DATE>TO_DATE(‘01-JAN-2012’,’DD-MON-YYYY’))

ER to Relational Model - Entities

- Entity sets to tables:
  - Attributes to columns

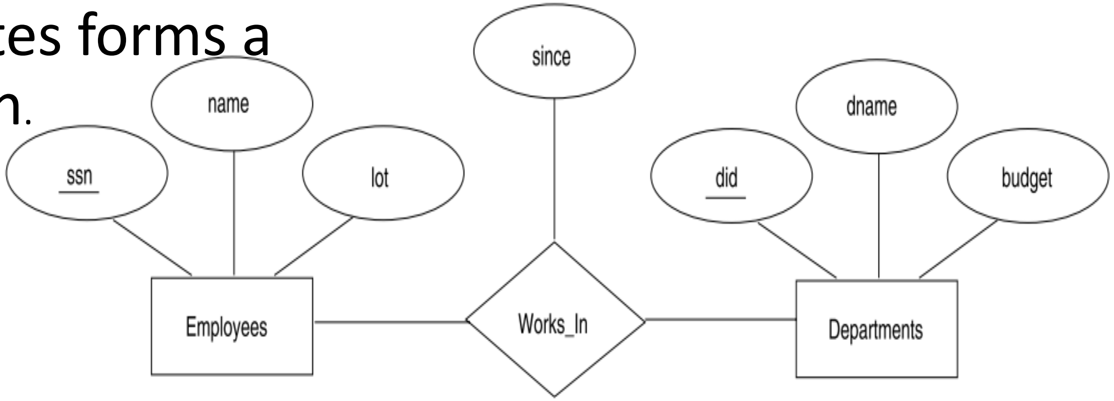


- CREATE TABLE Employees

```
        (ssn CHAR(11),
        name CHAR(20),
        lot  INTEGER,
        PRIMARY KEY  (ssn))
```

ER to Relational Model - Relationships

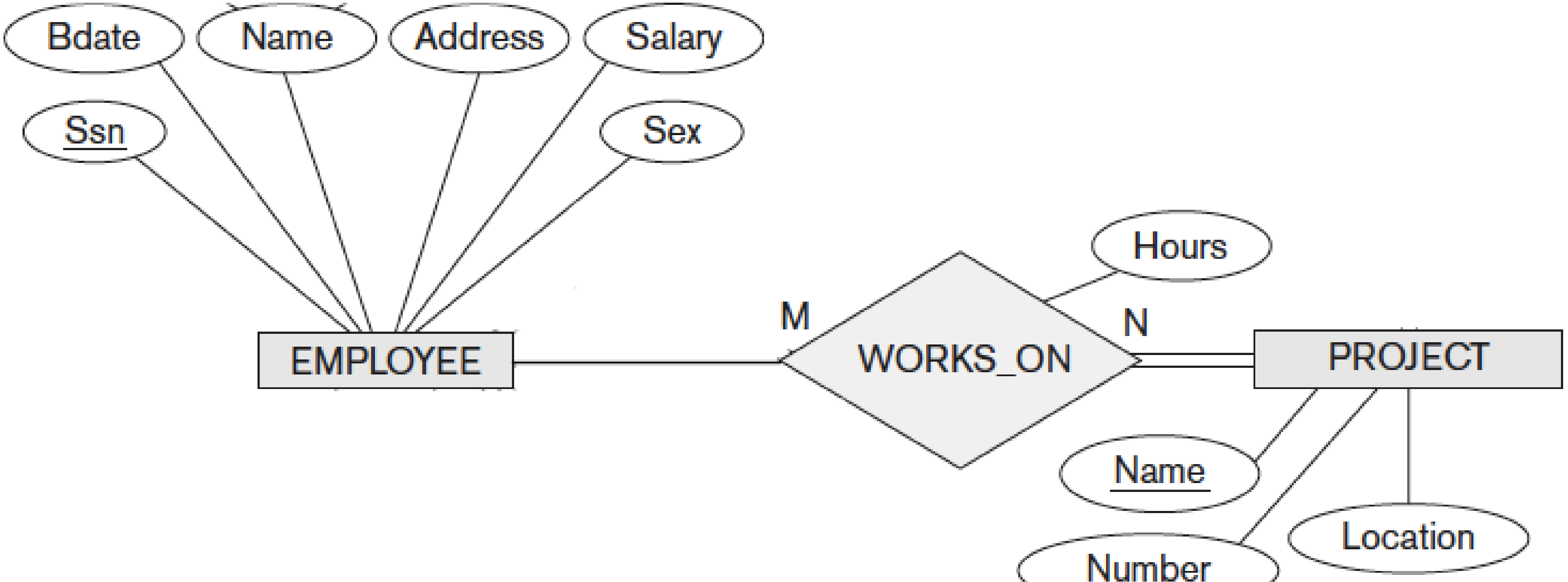
- Relationship Sets to Tables
    - Attributes to columns
- In translating a relationship set to a relation, attributes of the relation must include:
    - Keys for each participating entity set (as foreign keys).
        - This set of attributes forms a *key* for the relation.



ER to Relational Model - Relationships

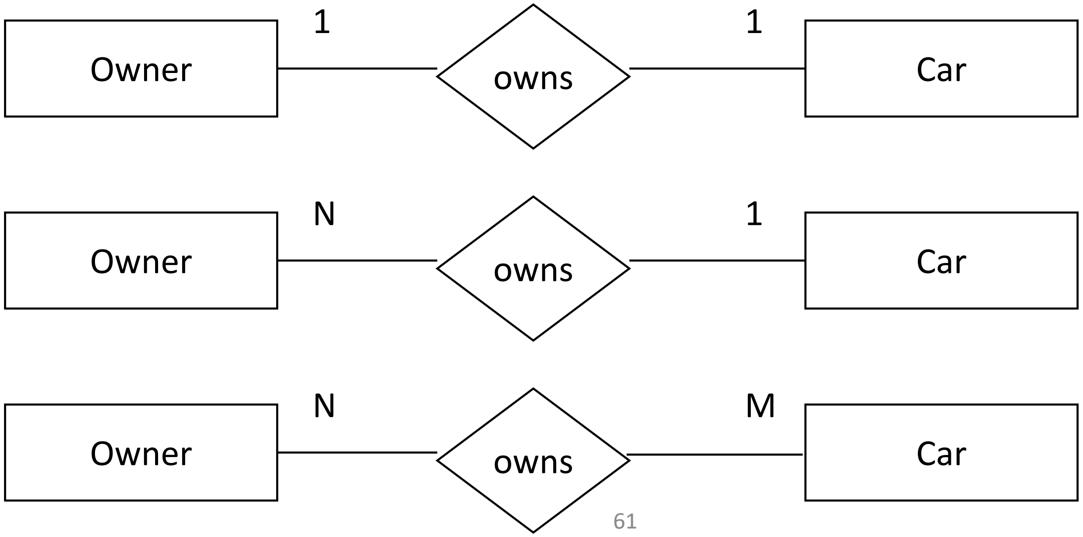
- EMP (SSN: int primary key, name: varchar(32), etc…)
- PROJ (Number: int primary key, Name: varchar(32), etc..)
- CREATE TABLE EMP2PROJ (SSN int, Proj_num int, Hours int,

```
        PRIMARY KEY (SSN, Proj_num)
        Foreign Key (SSN) References EMP(SSN)
        Foreign Key (Proj_num) References PROJ(Number));
```

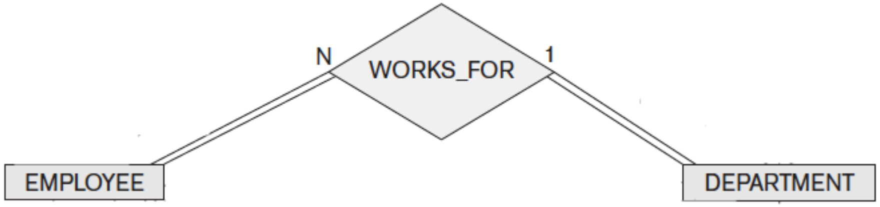


Relationship Types to Relational Model

- Possible cardinality ratio: 1:1, 1: N, N:1, and N:M
- Easiest is N:M
  - Every Entity is a relation
  - Every Relationship is a relation



One-to-Many

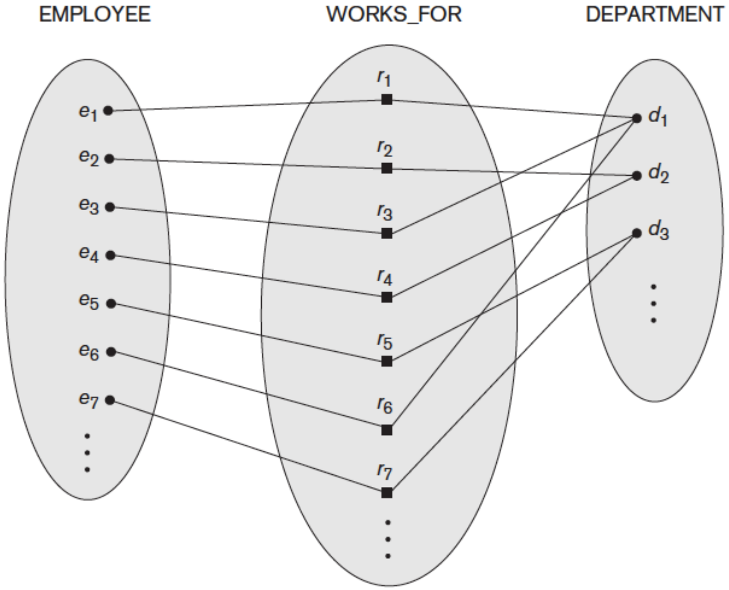


- Start with Each Entity as a relation
  - EMP(eid: int, name: varchar(32), etc..)
  - DEPT(did: int, dname: varchar(32), etc..)
- Relationship needs special care on the 1-1 side
  - Especially if total participation
- Relationship must be merged with Emp
- Result:
  - EMP(eid: int, name: varchar(32)

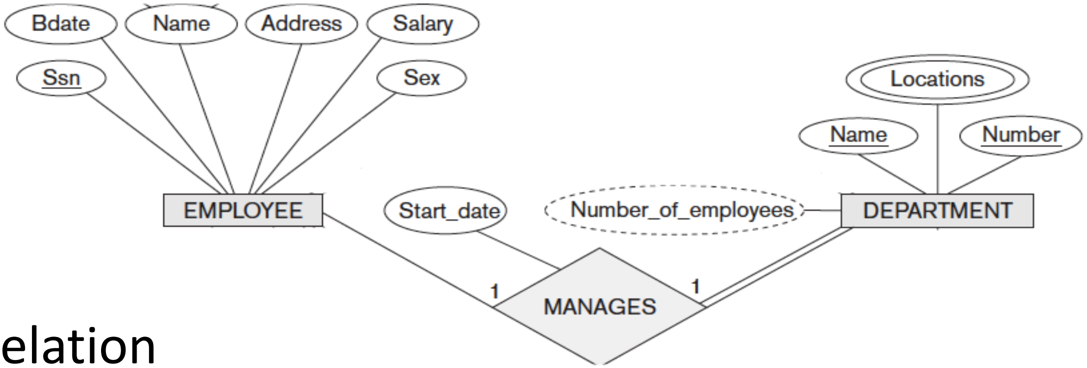
    did: int not null,

    primary key(eid),

    foreign key (did) references DEPT(did))



One-to-One



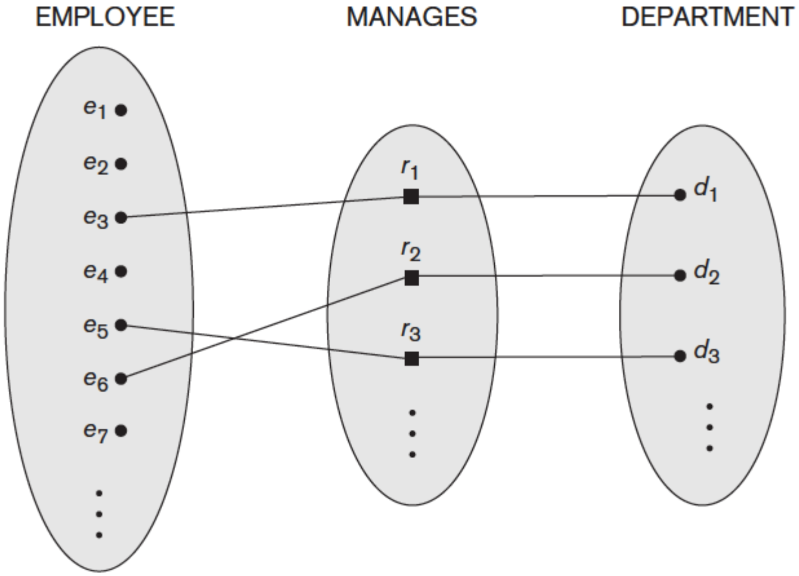
- Start with Each Entity as a relation
  - EMP(eid: int, name: varchar(32), etc..)
  - DEPT(did: int, dname: varchar(32), etc..)
- Relationship needs special care on the 1-1 side
  - Especially if total participation
- Relationship must be merged with DEPT
- Result:
  - DEPT(did: int, name: varchar(32)

    mgr_ssn: int not null,

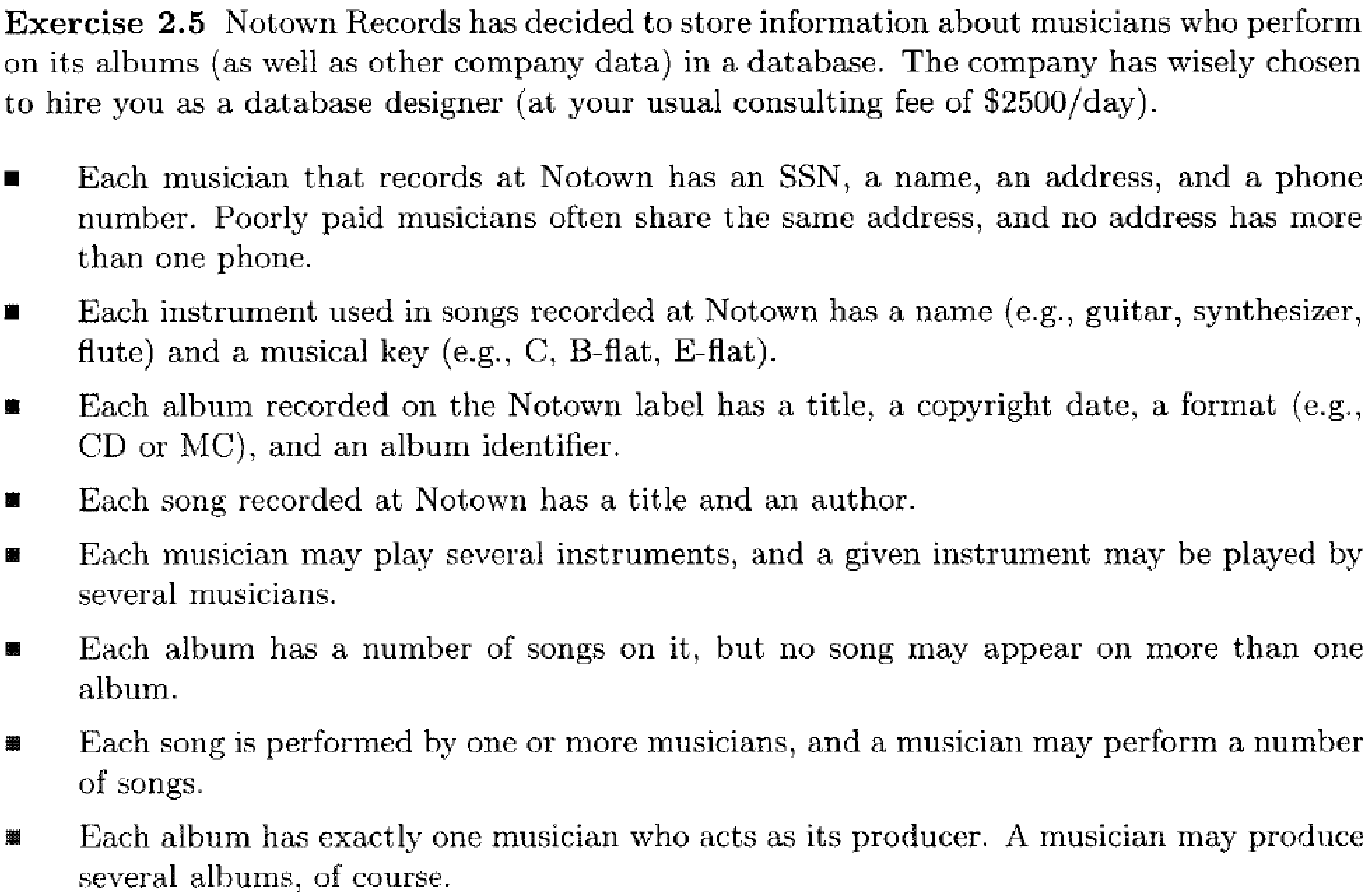
    primary key(did),

    foreign key (mgr_ssn)

    references EMP(eid))



Musicians Example



Exercise 2.5 Notown Records has decided to store information about musicians who perform on its albums (as well as other company data) in a database. The company has wisely chosen to hire you as a database designer (at your usual consulting fee of $2500/day).

- Each musician that records at Notown has an SSN, a name, an address, and a phone number. Poorly paid musicians often share the same address, and no address has more than one phone.
- Each instrument used in songs recorded at Notown has a name (e.g., guitar, synthesizer, flute) and a musical key (e.g., C, B-flat, E-flat).
- Each album recorded on the Notown label has a title, a copyright date, a format (e.g., CD or MC), and an album identifier.
- Each song recorded at Notown has a title and an author.
- Each musician may play several instruments, and a given instrument may be played by several musicians.
- Each album has a number of songs on it, but no song may appear on more than one album.
- Each song is performed by one or more musicians, and a musician may perform a number of songs.
- Each album has exactly one musician who acts as its producer. A musician may produce several albums, of course.

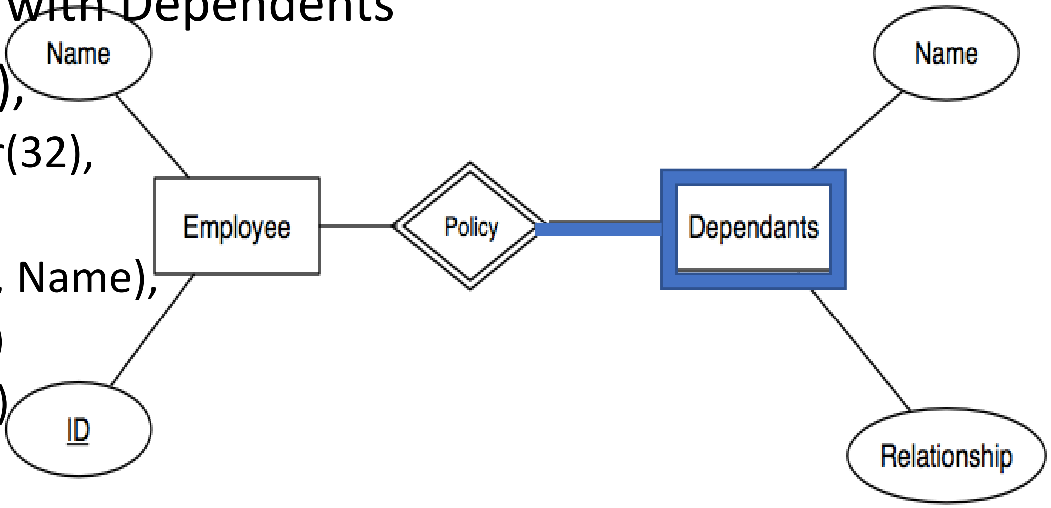
University Example

- Professors have an SSN, a name, an age, a rank, and a research specialty.
- Projects have a project number, a sponsor name (e.g., NSF), a starting date, an ending date, and a budget.
- Graduate students have an SSN, a name, an age, and a degree program (e.g., M.S. or Ph.D.).
- Each project is managed by one professor (known as the project's principal investigator).
- Each project is worked on by one or more professors (known as the project's co-investigators).
- Professors can manage and/or work on multiple projects.
- Each project is worked on by one or more graduate students (known as the project's research assistants).
- Graduate students can work on multiple projects, in which case they will have a (potentially different) supervisor for each one.
- Departments have a department number, a department name, and a main office.
- Departments have a professor (known as the chairman) who runs the department.
- Professors work in one or more departments, and for each department that they work in, a time percentage is associated with their job.
- Graduate students have one major department in which they are working on their degree.

Relational Model for Weak Entity Sets

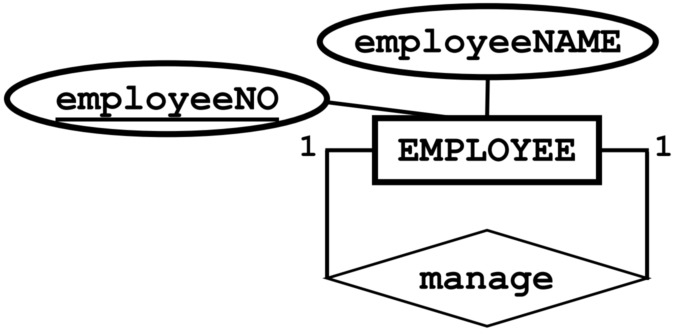
- Start with Each Entity as a relation
  - EMP(eid: int, name: varchar(32), etc..)
  - Dependents(Name: varchar(32), relationship: varchar(32), etc..)
- Weak Relationships needs special care
- Relationship must be merged with Dependents

Dependents(Name: Varchar(32),
Relationship: Varchar(32),
emp_id: int not null,
Primary key (emp_id, Name),
Foreign Key (emp_id)
References EMP(eid))

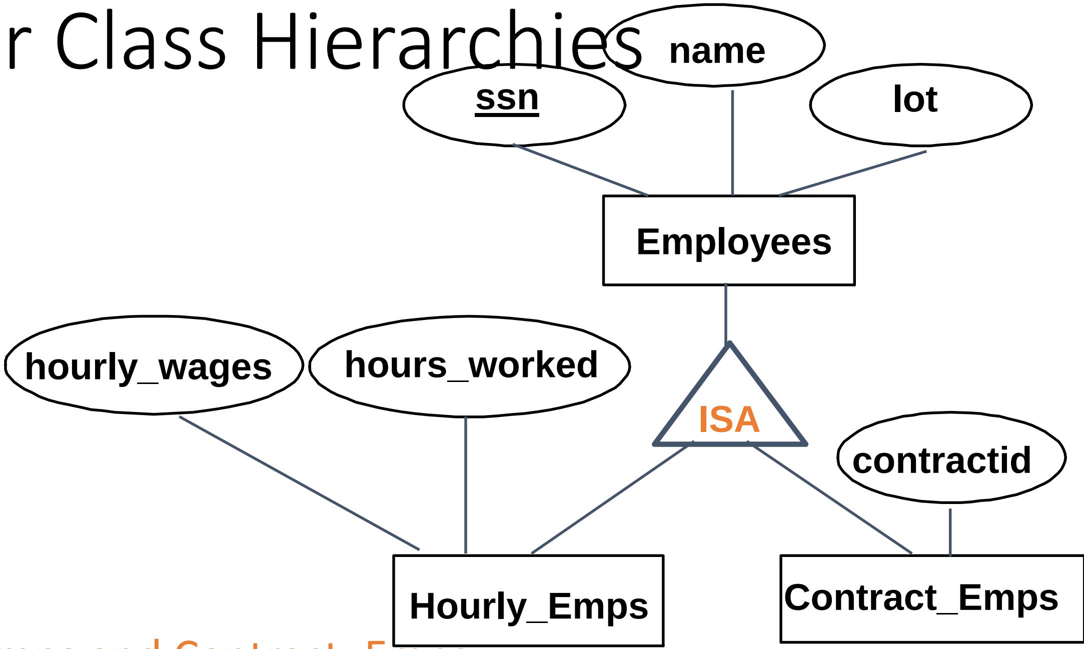


Relational Model for Recursive Relationships

- EMP (employeeNo int primary key,
  employeeName varchar(32),
  ManagerSSN int))



Relational Model for Class Hierarchies



Just Hourly_Emps and Contract_Emps.

Hourly_Emps: *ssn, name, lot, hourly_wages, hours_worked.* Each employee must be in one of these two subclasses.

- ***General approach:***
  - 3 relations: Employees, Hourly_Emps and Contract_Emps.
    - *Hourly_Emps*: Every employee is recorded in Employees. For hourly emps, extra info recorded in Hourly_Emps (*hourly_wages, hours_worked, ssn)*; must delete Hourly_Emps tuple if referenced Employees tuple is deleted).
    - Queries involving all employees easy, those involving just Hourly_Emps require a join to get some attributes.