Introduction to Databases
Data Definition and Datatypes

How Do RDBMS Work?

SoftUni Team

Technical Trainers

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Have a Question?

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#java-db

Data Management

Storage vs. Management (1)

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SALES RECEIPT

Date: 07/16/2016
Order#:[00315]

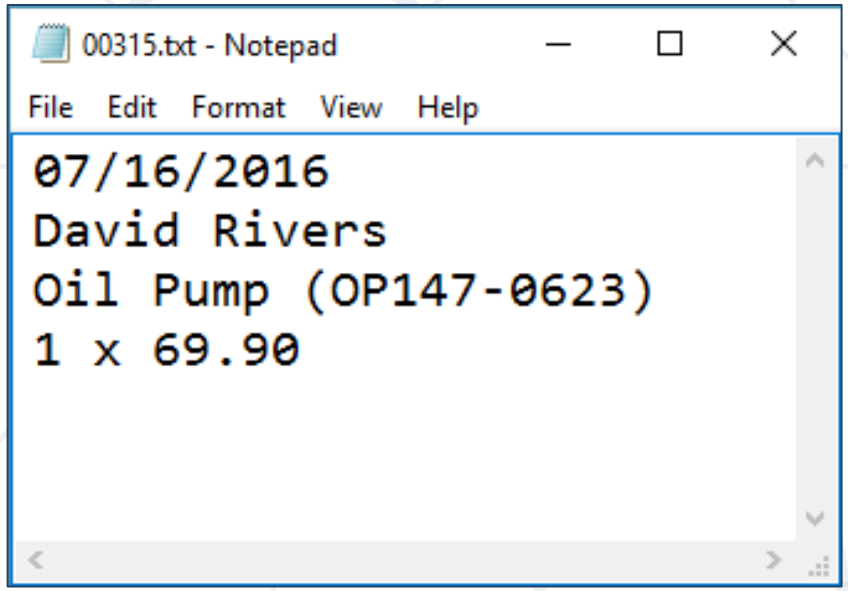
Customer: David Rivers
Product: Oil Pump
S/N: OP147-0623

Unit Price: **69.90**
Qty: **1**

Total: **69.90**

00315 – 07/16/2016
David Rivers
Oil Pump (OP147-0623)
1 x 69.90

Storage vs. Management (2)



Order#	Date	Customer	Product	S/N	Qty
00315	07/16/2016	David Rivers	Oil Pump	OP147-063	1

Storage vs. Management (3)

- Storing data is **not** the primary reason to use a database
- Flat storage **eventually** runs into **issues** with
  - Size
  - Ease of updating
  - Accuracy
  - Security
  - Redundancy
  - Importance

Databases

- A database is an **organized** collection of **related** information
  - It imposes **rules** on the contained data
  - Access to data is usually provided by a "**system**" (DBMS) **database management**
  - Relational storage first proposed by Edgar Codd in 1970

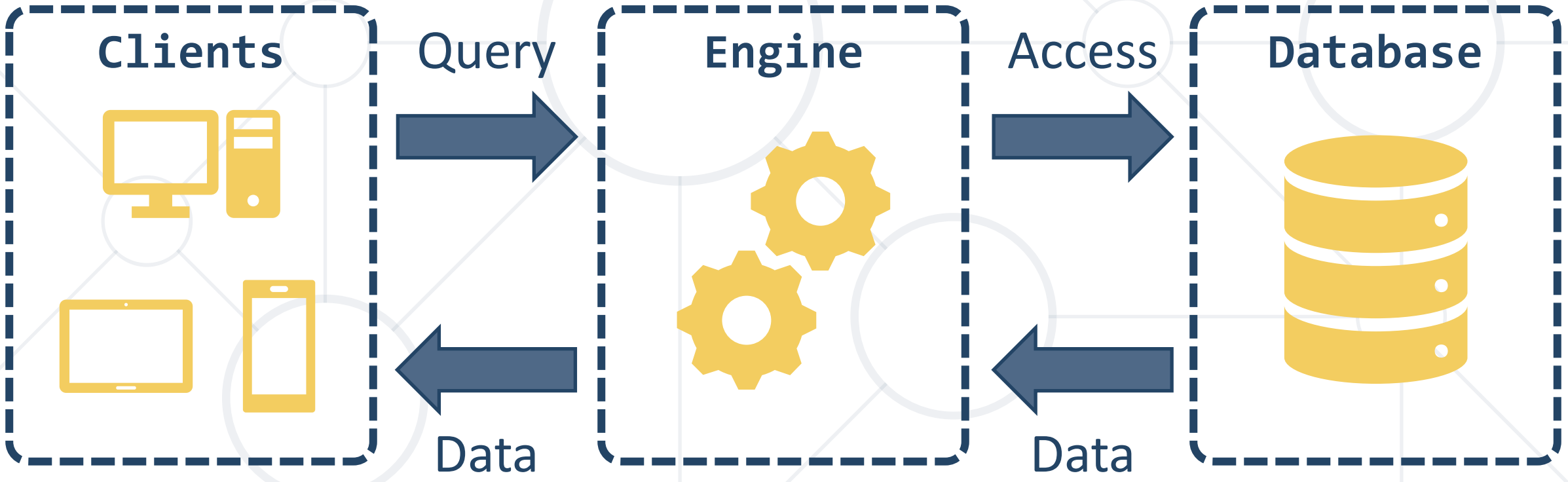
RDBMS

- Relational Data Base Management System
  - Database **management**
  - It **parses requests** from the user and takes the **appropriate** action
  - The user **doesn't have direct access** to the stored data
  - Data is presented by **relations** – collection of tables related by **common fields**
  - MS SQL Server, DB2, Oracle and MySQL

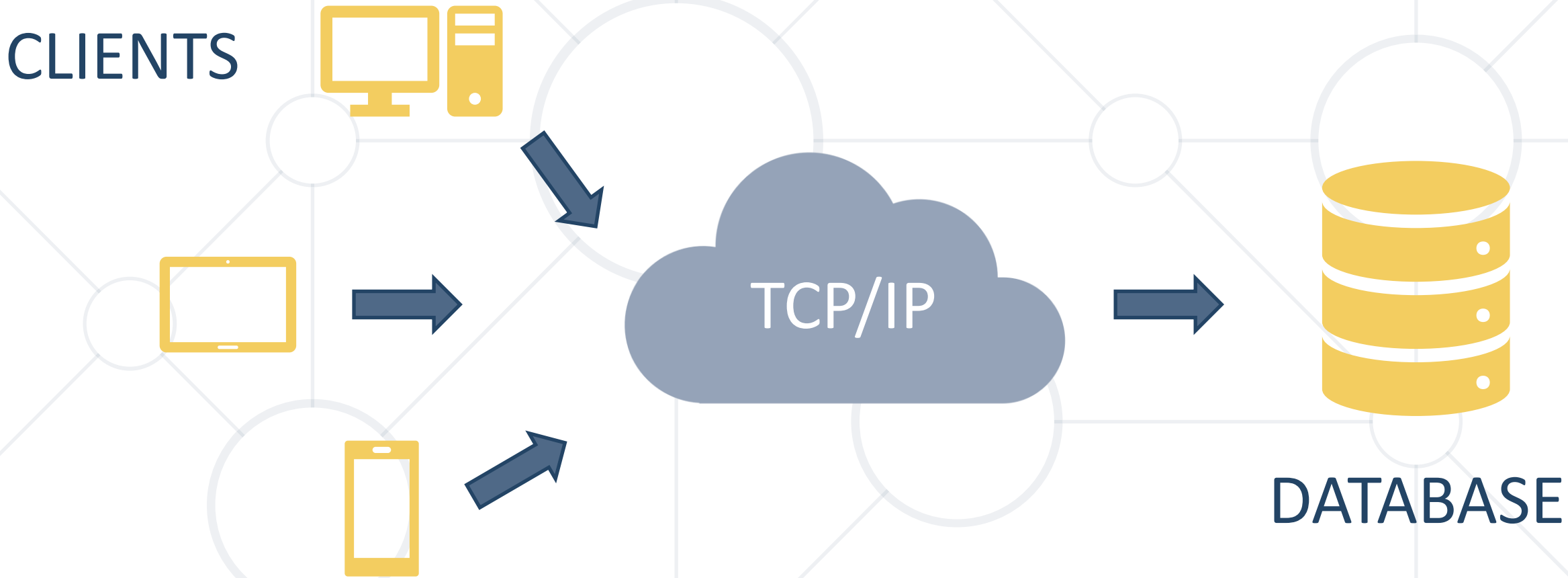
Database Engine

Database Engine Flow

- SQL Server uses the Client-Server Model



Client-Server Model



Top Database Engines

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Rank			DBMS	Database Model	Score		
May 2021	Apr 2021	May 2020			May 2021	Apr 2021	May 2020
1.	1.	1.	Oracle	Relational, Multi-model	1269.94	-4.98	-75.50
2.	2.	2.	MySQL	Relational, Multi-model	1236.38	+15.69	-46.26
3.	3.	3.	Microsoft SQL Server	Relational, Multi-model	992.66	-15.30	-85.64
4.	4.	4.	PostgreSQL	Relational, Multi-model	559.25	+5.73	+44.45
5.	5.	5.	MongoDB	Document, Multi-model	481.01	+11.04	+42.02
6.	6.	6.	IBM Db2	Relational, Multi-model	166.66	+8.88	+4.02
7.	7.	↑ 8.	Redis	Key-value, Multi-model	162.17	+6.28	+18.69
8.	8.	↓ 7.	Elasticsearch	Search engine, Multi-model	155.35	+3.18	+6.23
9.	9.	9.	SQLite	Relational	126.69	+1.64	+3.66
10.	10.	10.	Microsoft Access	Relational	115.40	-1.33	-4.50

Source: http://db-engines.com/en/ranking

Structured Query Language

Structured Query Language (1)

- Programming language designed for managing data in a relational database
- Developed at **IBM** in the early 1970s
- To communicate with the Engine we use **SQL**

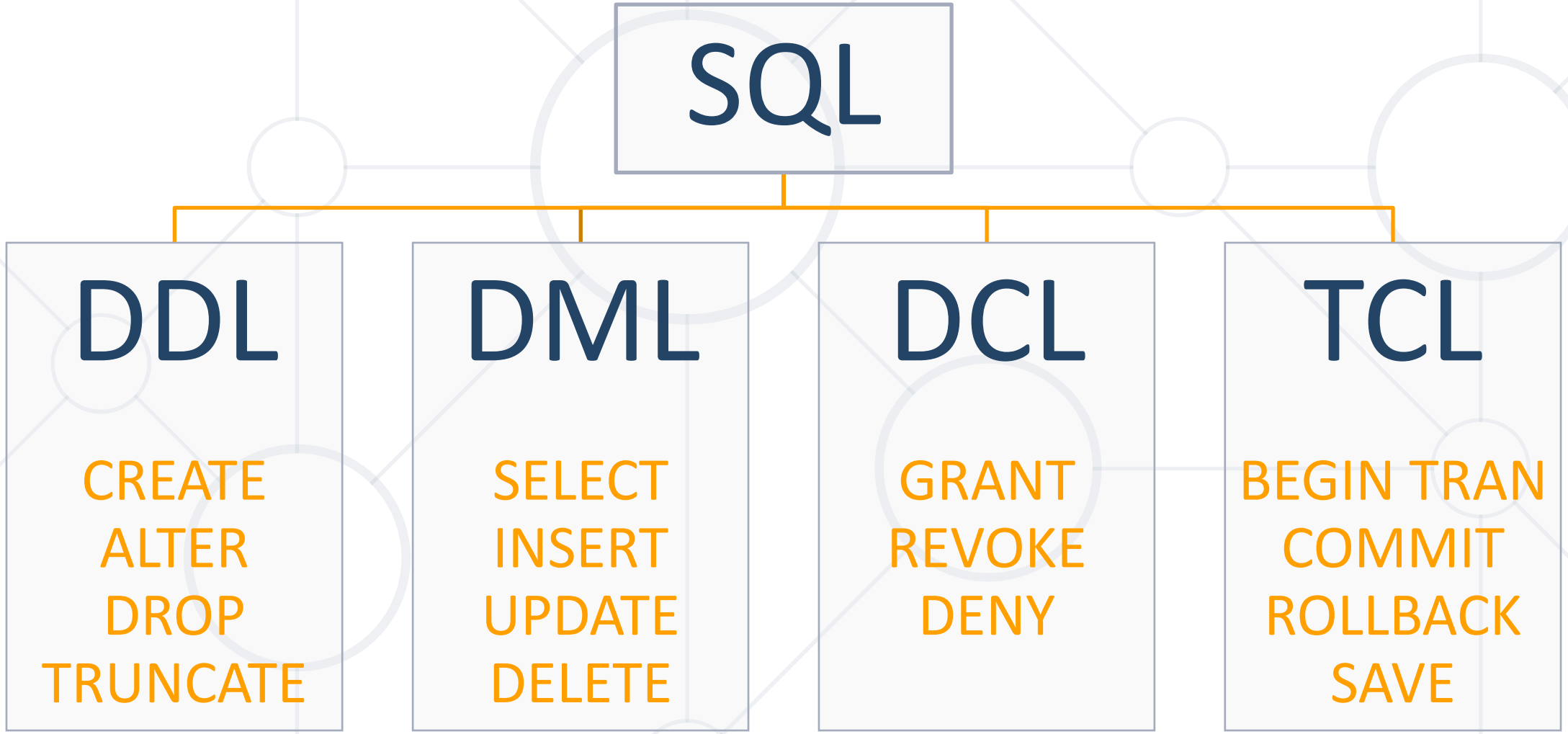
Structured Query Language (2)

- Subdivided into several language elements
  - Queries
  - Clauses
  - Expressions
  - Predicates
  - Statements

Structured Query Language (3)

- Logically divided in four sections
  - **Data Definition** – describe the structure of our data
  - **Data Manipulation** – store and retrieve data
  - **Data Control** – define who can access the data
  - **Transaction Control** – bundle operations and allow rollback

Structured Query Language (4)



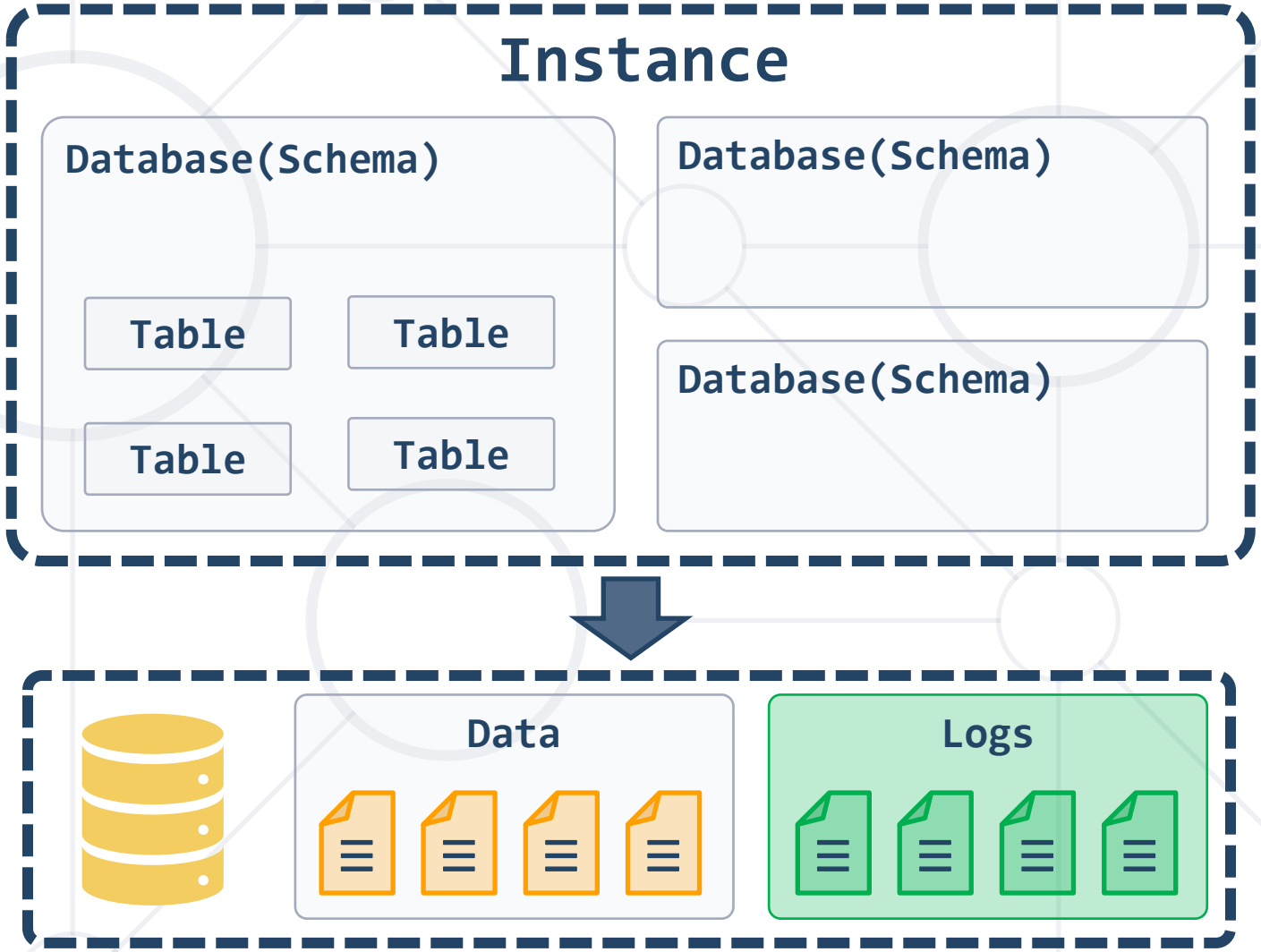
MySQL

MySQL

- **Open-source** relational database management system
- Used in many **large-scale websites** like including Google, Facebook, YouTube etc.
- Works on **many** system platforms – MAC OS, Windows, Linux
- Download **MySQL Server**
  - **Windows**: https://dev.mysql.com/downloads/mysql/
  - **Ubuntu/Debian**: https://dev.mysql.com/downloads/repo/apt/

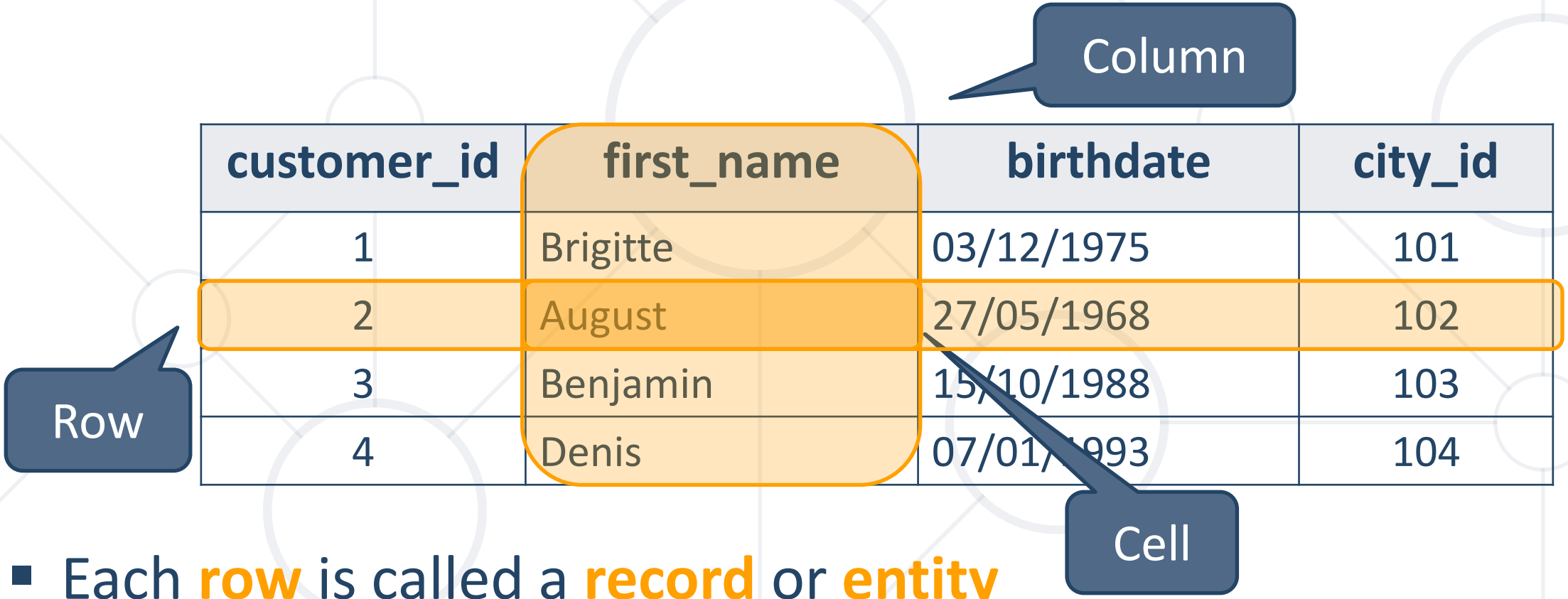
MySQL Server Architecture

- Logical Storage
  - Instance
  - Database/Schema
  - Table
- Physical Storage
  - Data files and Log files
  - Data pages



Database Table Elements

- The table is the main **building block** of any database



customer_id	first_name	birthdate	city_id
1	Brigitte	03/12/1975	101
2	August	27/05/1968	102
3	Benjamin	15/10/1988	103
4	Denis	07/01/1993	104

- Each **row** is called a **record** or **entity**
- Columns (**fields**) define the **type** of data they contain

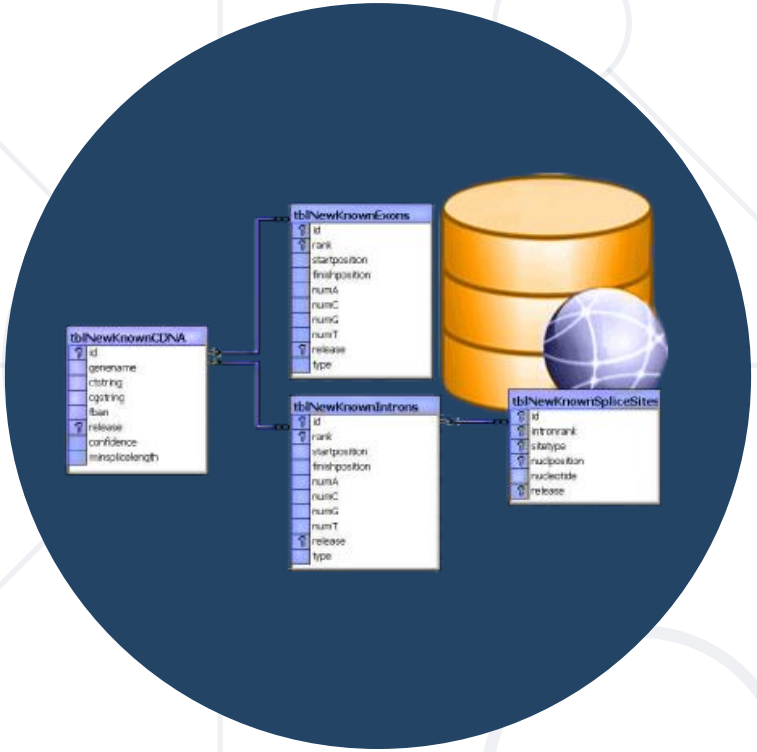


Table Relationships

Why Split Related Data?

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Empty records

first	last	registered	email	email2
David	Rivers	05/02/2016	drivers@mail.cx	david@homedomain.cx
Sarah	Thorne	07/17/2016	sarah@mail.cx	*NULL*
M		5	walters_michael@mail.cx	*NULL*

Redundant information

order_id	date	customer	product	s/n	price
00315	07/16/2016	David Rivers	Oil Pump	OP147-0623	69.90
00315	07/16/2016	David Rivers	Accessory Belt	AB544-1648	149.99
00316	07/17/2016	Sarah Thorne	Wiper Fluid	WF000-0001	99.90
00317	07/18/2016	Michael Walters	Oil Pump	OP147-0623	69.90

Related Tables

- We split the data and introduce **relationships** between the tables to **avoid** repeating information

user_id	first	last	registered
203	David	Rivers	05/02/2016
204	Sarah	Thorne	07/17/2016
205	Michael	Walters	11/23/2015

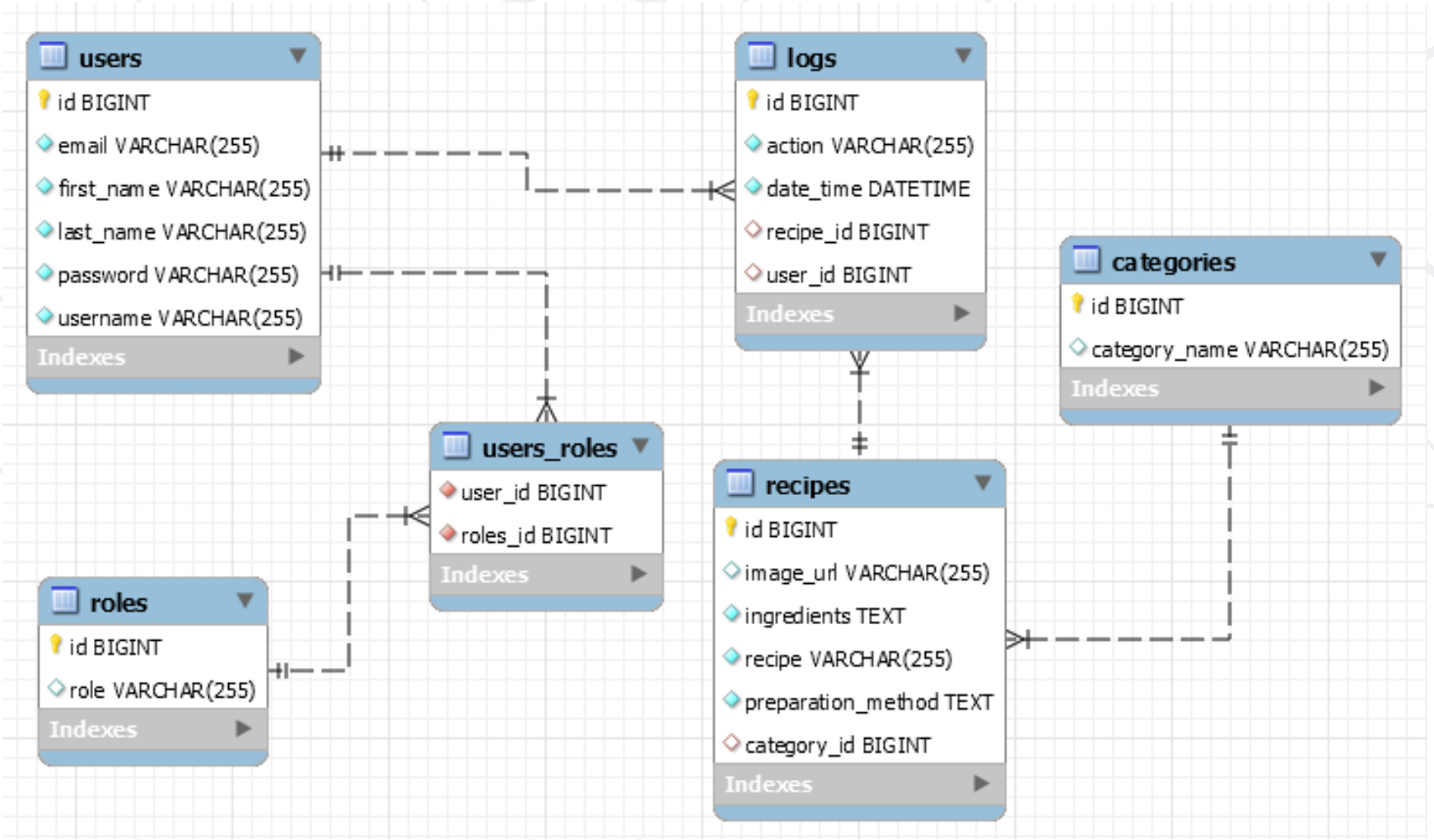
Primary Key

user_id	email
203	drivers@mail.cx
204	sarah@mail.cx
205	walters_michael@mail.cx
203	david@homedomain.cx

Foreign Key

- Connection via **Foreign Key** in one table pointing to the **Primary Key** in another

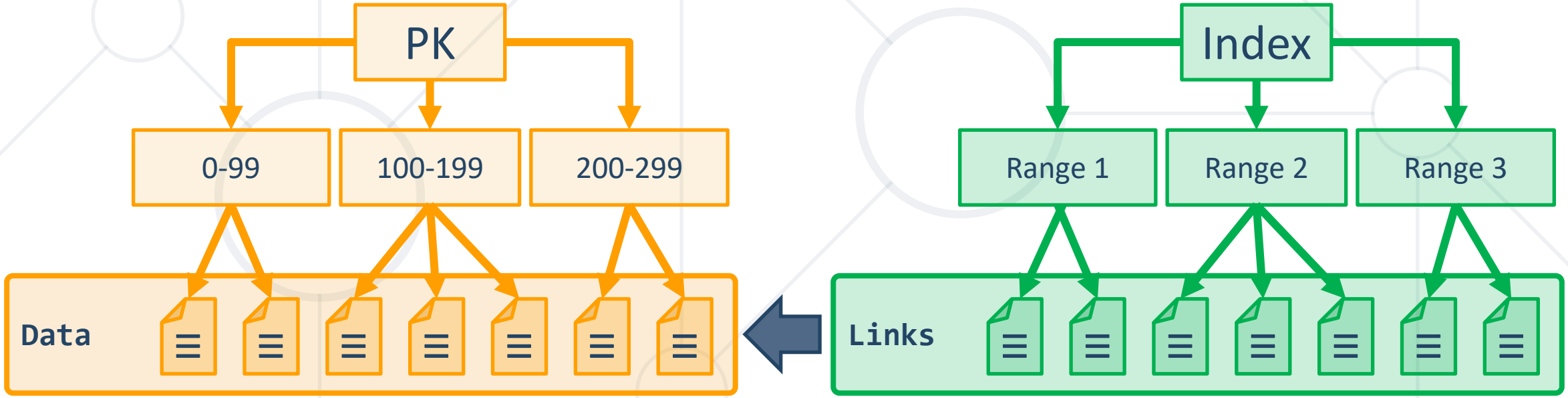
E/R Diagrams


users
id BIGINT
email VARCHAR(255)
first_name VARCHAR(255)
last_name VARCHAR(255)
password VARCHAR(255)
username VARCHAR(255)
Indexes
logs
id BIGINT
action VARCHAR(255)
date_time DATETIME
recipe_id BIGINT
user_id BIGINT
Indexes
categories
id BIGINT
category_name VARCHAR(255)
Indexes
users_roles
user_id BIGINT
roles_id BIGINT
Indexes
recipes
id BIGINT
image_url VARCHAR(255)
ingredients TEXT
recipe VARCHAR(255)
preparation_method TEXT
category_id BIGINT
Indexes
roles
id BIGINT
role VARCHAR(255)
Indexes

Programmability

Indices

- Indices make data lookup faster
  - Clustered – bound to the **primary key**, physically sorts data
  - Non-Clustered – can be **any field**, references the primary index
- Structured as an **ordered tree**



Views

- Views are **prepared queries** for displaying **sections** of our data

```
CREATE VIEW v_employee_names AS
     SELECT employee_id,
            first_name,
            last_name
       FROM employees
```

```
SELECT * FROM v_employee_names
```

- Evaluated at **run time** – they do not increase performance

Procedures, Functions and Triggers

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- A database can further be customized with reusable code
- **Procedures** – carry out a predetermined **action**
  - E.g. get all employees with salary above 35000
- **Functions** – receive **parameters** and return a **result**
  - E.g. get the age of a person using their birthdate and current date
- **Triggers** – **watch** for activity in the database and **react** to it
  - E.g. when a record is deleted, write it to an archive

Data Types in MySQL Server

Numeric Data Types

- Numeric data types have certain range
- Their range can be changed if they are:
  - **Signed** - represent numbers both in the positive **and** negative ranges
  - **Unsigned** - represent numbers **only** in the positive range
- E.g. signed and unsigned INT:

Signed Range		Unsigned Range	
Min Value	Max Value	Min Value	Max Value
-2147483648	2147483648	0	4294967295

Numeric Data Types

- **INT** [(M)] [UNSIGNED]
  - TINYINT, SMALLINT, MEDIUMINT, BIGINT
- **DOUBLE** [(M, D)] [UNSIGNED]

Digits stored for value

Decimals after floating point

  - E.g. DOUBLE[5, 2] – 999.99
- **DECIMAL** [(M, D)] [UNSIGNED] [ZEROFILL]

String Types (1)

- String column definitions include attributes that specify the **character set** or **collation**
  - **CHARACTER SET** (Encoding)
    - E.g. utf8, ucs2
  - **CHARACTER COLLATION** – rules for encoding comparison
    - E.g. latin1_general_cs, Traditional_Spanish_ci_ai etc.
- Set and collation can be defined at the database, table or column level

Determines the storage of each character (single or multiple bytes)

Determines the sorting order and case-sensitivity

CHARACTER COLLATION – Example

- **ORDER BY** with different collations

latin1_swedish_ci	latin1_german1_ci	latin1_german2_ci
Muffler	Muffler	Müller
MX Systems	Müller	Muffler
Müller	MX Systems	MX Systems
MySQL	MySQL	MySQL

String Types (2)

- **CHAR** [(M)] - up to 255 characters
  - fixed-length character type (example CHAR(30))
- **VARCHAR**(M) - up to 65 535. The effective maximum length is a subject to the maximum row size (65,535 bytes, which is shared among all columns) and the character set used
  - Variable max size
- **TEXT** - up to 65 535 characters
  - TINYTEXT, MEDIUMTEXT, LONGTEXT
- **BLOB** - **B**inary **L**arge **Ob**ject [(M)] - 65 535 (2^{16} - 1) characters
  - TINYBLOB, MEDIUMBLOB, LONGBLOB

CHAR vs VARCHAR

- Storing data in CHAR and VARCHAR examples

Value	CHAR(4)	Storage Required	VARCHAR(4)	Storage Required
''	' '	4 bytes	''	1 bytes
'ab'	'ab '	4 bytes	'ab'	3 bytes
'abcd'	'abcd'	4 bytes	'abcd'	5 bytes
'abcdefgh'	'abcd'	4 bytes	'abcd'	5 bytes

Date Types (1)

- **DATE** - for values with a date part but **no time part**
- **TIME** - for values with time but **no date part**
- **DATETIME** - values that contain both date **and** time parts
- **TIMESTAMP** - both date **and** time parts

Column name	Column Type
`birthdate`	`DATE`
`last_time_online`	`TIMESTAMP`
`start_at`	`TIME`
`deleted_on`	`DATETIME`

DATETIME and TIMESTAMP have different time ranges

Date Types (2)

- MySQL retrieves values for a given date type in a **standard output format**
  - E.g. as a string in either 'YYYY-MM-DD' or 'YY-MM-DD'

Data Type	Column Type
DATE	'0000-00-00'
TIME	'00:00:00'
DATETIME	'0000-00-00 00:00:00'
TIMESTAMP	'0000-00-00 00:00:00'
YEAR	0000

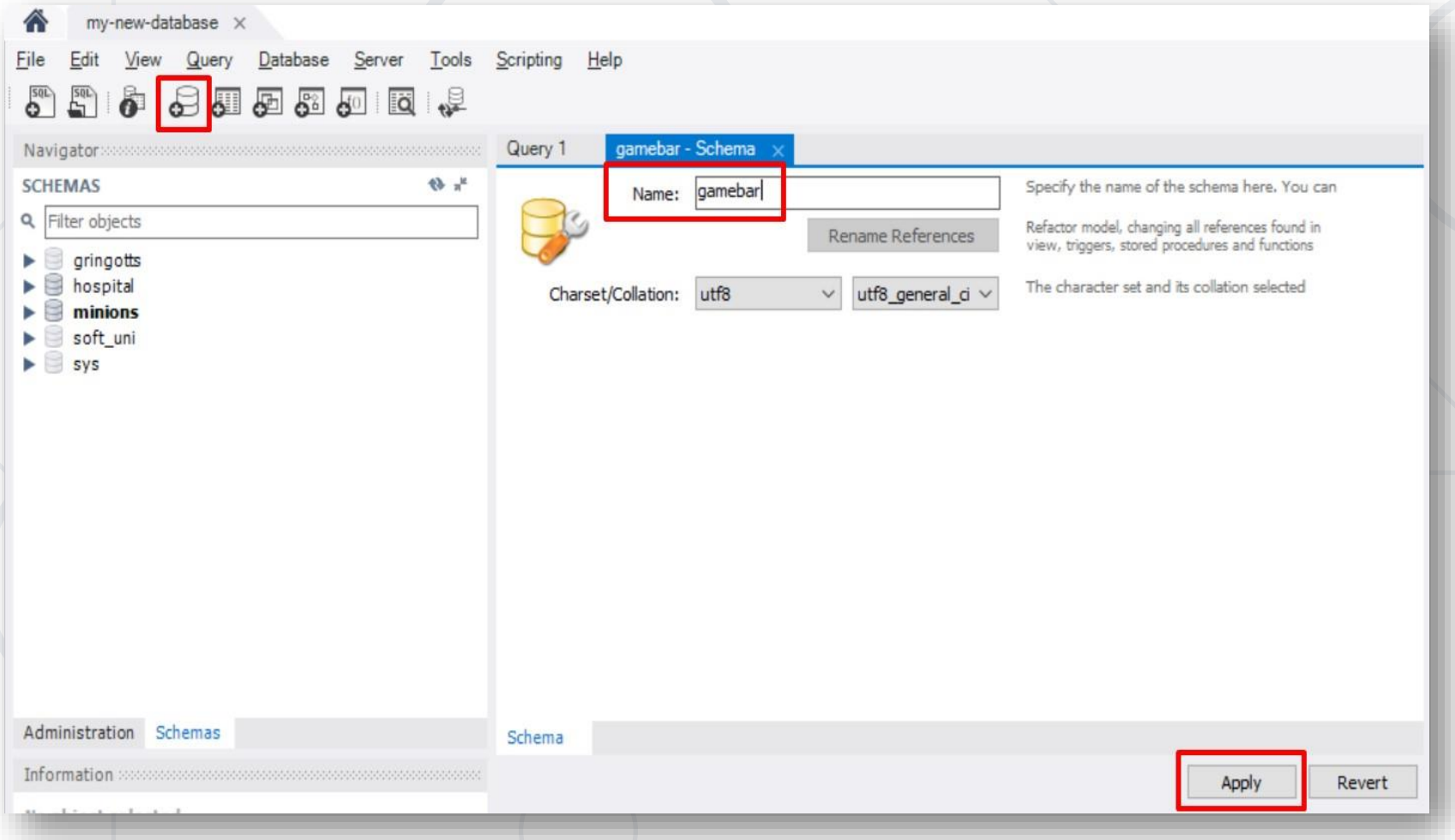
Database Modeling

Working with IDEs

- We will **manage** databases with **MySQL Workbench**
- Enables us:
  - To **create** a new database
  - To create **objects in the database** (tables, stored procedures, relationships and others)
  - To **change** the properties of objects
  - To **enter records** into the tables

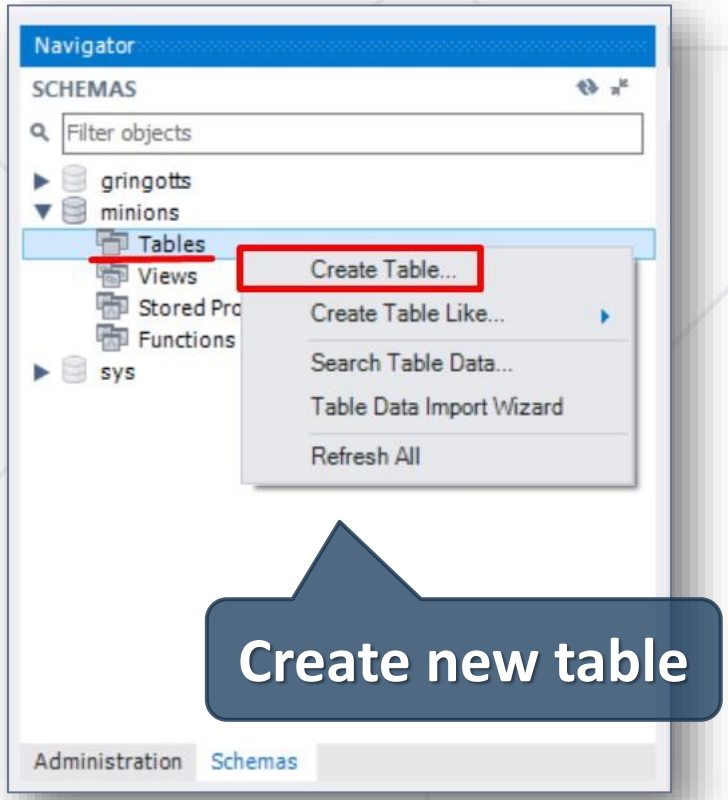
Creating a New Database

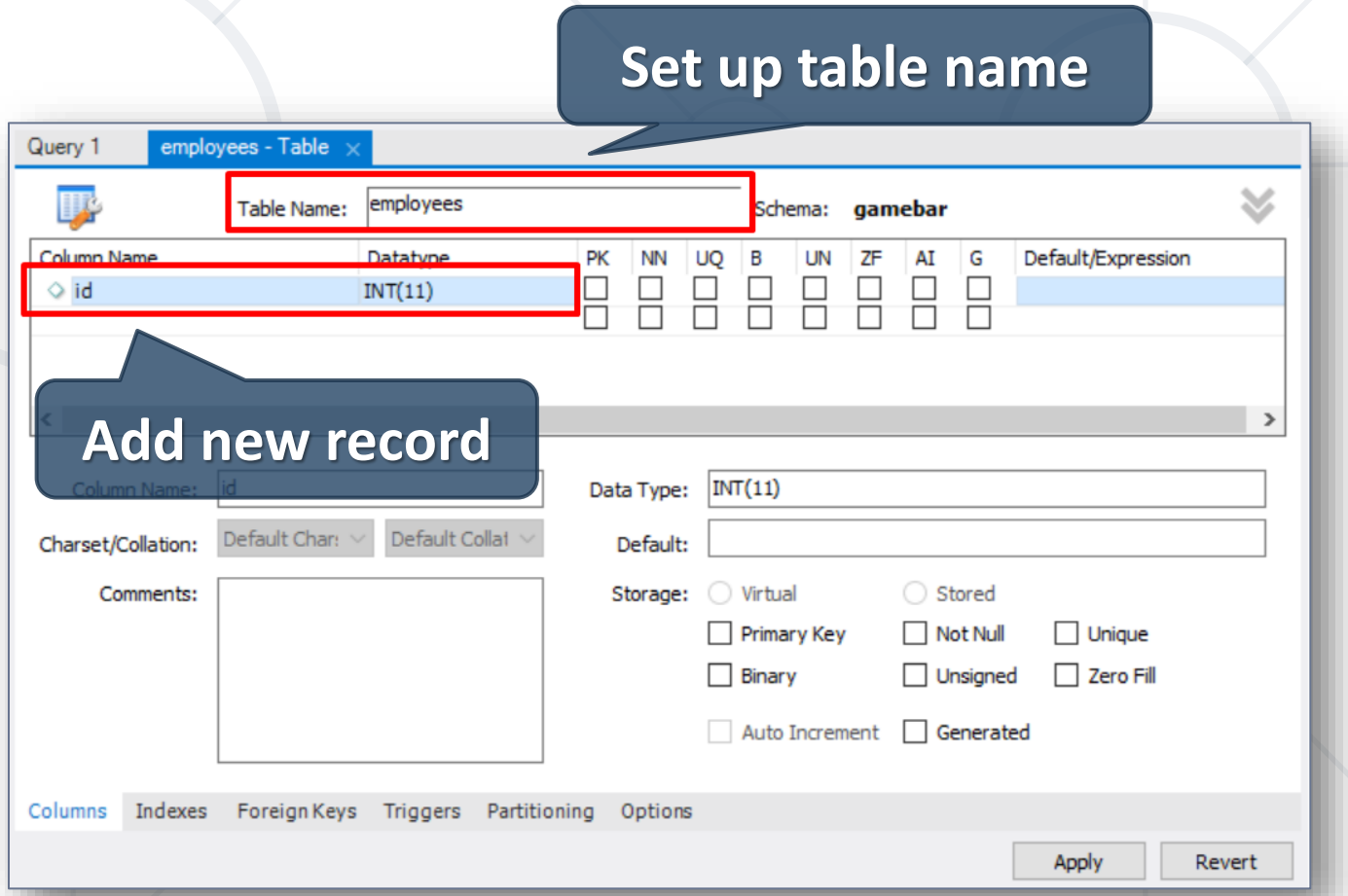
- Select **Create new schema** from the **command menu**



Creating Tables

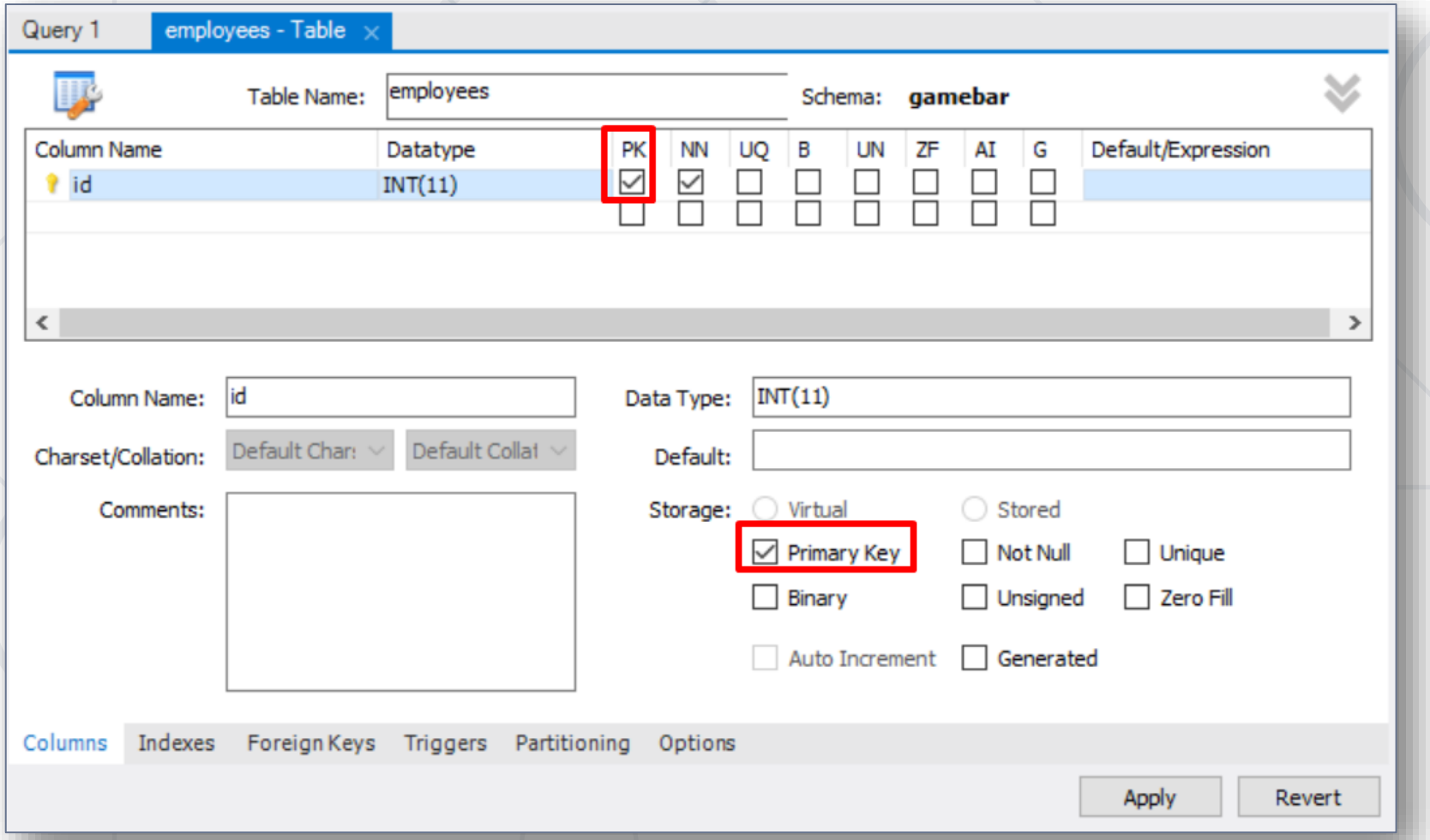
- Right click on "Tables" **Select Create Table**





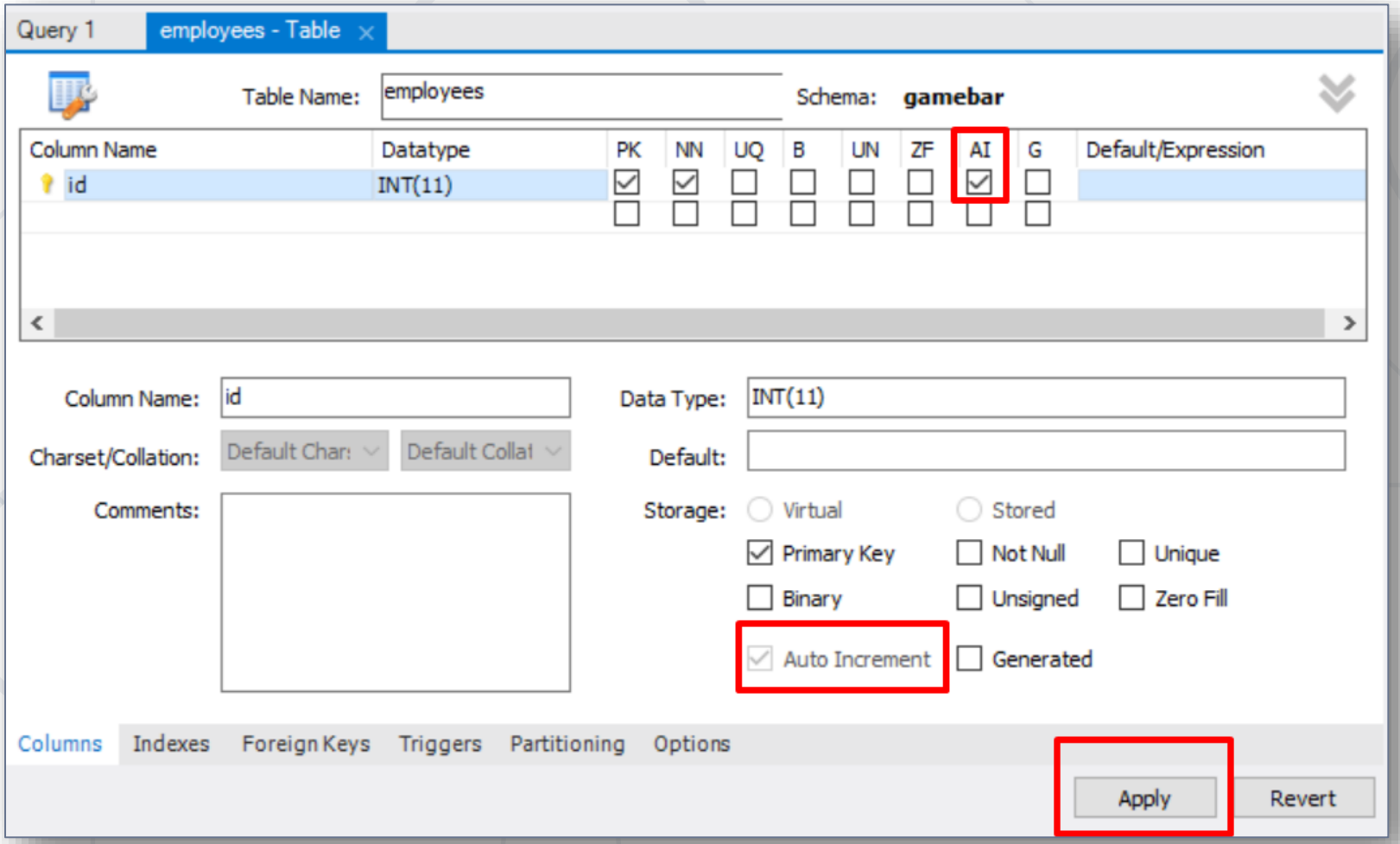
Creating Tables (2)

- A **Primary Key** is used to uniquely identify and index records



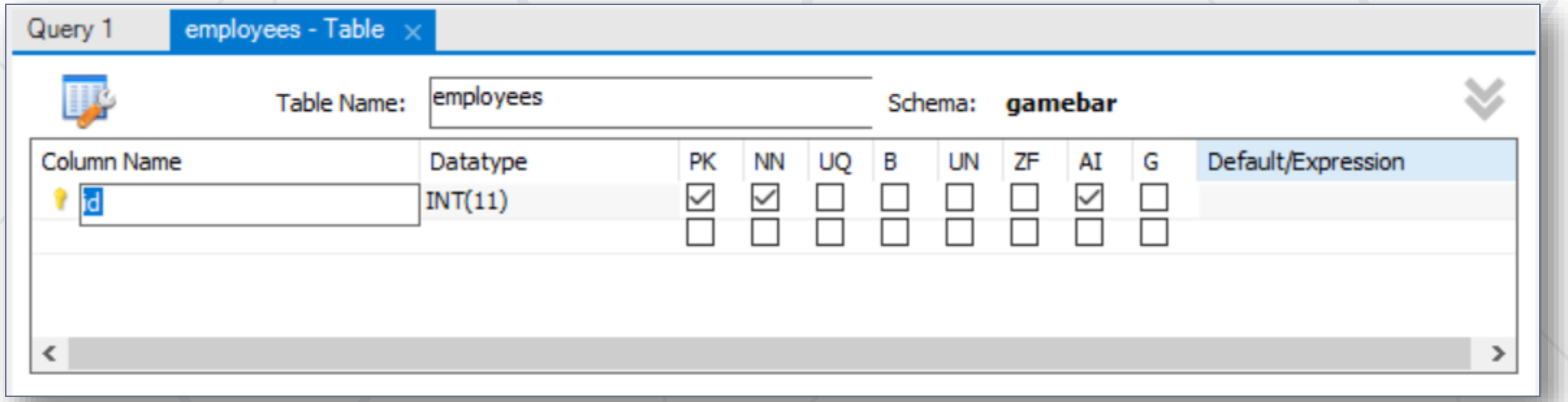
Creating Tables (3)

- Auto increment – on the "**Default**" field



Storing and Retrieving Data

- We can **add**, **modify** and **read** records with **GUI Clients**
- To insert or edit a record, click inside the **cell**



Basic SQL Queries

SQL Queries

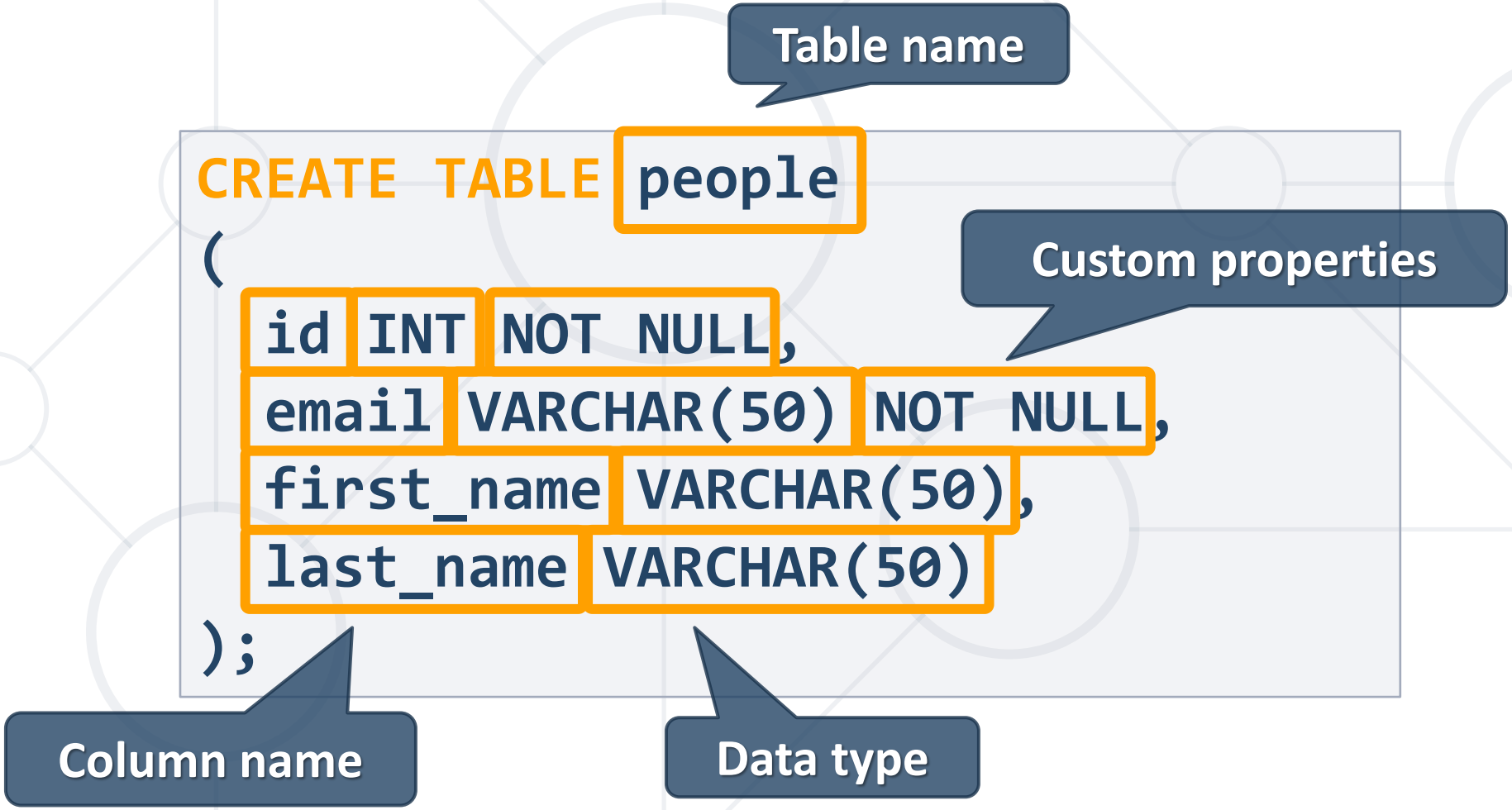
- We communicate with the database engine using SQL
- Queries provide greater **control** and **flexibility**
- To create a database using SQL:

Database name

```
CREATE DATABASE employees;
```

- SQL keywords are conventionally **capitalized**

Table Creation in SQL



Retrieve Records in SQL

- Get all information from a table

```
SELECT * FROM employees;
```

Table name

- You can limit the columns and number of records

```
SELECT first_name, last_name FROM employees
LIMIT 5;
```

List of columns

Number of records

Table Customization

Custom Column Properties

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- Primary Key

```
id INT NOT NULL PRIMARY KEY
```

- Auto-Increment (Identity)

```
id INT AUTO_INCREMENT PRIMARY KEY
```

- Unique constraint – no repeating values in entire table

```
email VARCHAR(50) UNIQUE
```

- Default value – if not specified (otherwise set to NULL)

```
balance DECIMAL(10,2) DEFAULT 0
```

Problems: Create and Insert

- **Create** new Database "gamebar"
- **Create Tables**:
  - **employees** - id, first_name, last_name
  - **categories** - id, name
  - **products** - id, name, category_id
- **Insert** Data:
  - Populate the **employees** table with 3 test values

Altering Tables

Altering Tables Using SQL (1)

- A table can be changed using the keywords **ALTER TABLE**

```
ALTER TABLE employees;
```

Table name

- Add new column

```
ALTER TABLE employees
ADD COLUMN salary DECIMAL;
```

Column name

Data type

Altering Tables Using SQL (2)

- Delete existing column

```
ALTER TABLE people
DROP COLUMN full_name;
```

Column name

- Modify data type of existing column

```
ALTER TABLE people
MODIFY COLUMN email VARCHAR(100);
```

Column name

New data type

Altering Tables Using SQL (3)

- Add primary key to existing column

```
ALTER TABLE people
ADD CONSTRAINT pk_id
PRIMARY KEY (id);
```

Constraint name

Column name
(more than one for composite key)

- Add unique constraint

```
ALTER TABLE people
ADD CONSTRAINT uq_email
UNIQUE (email)
```

Constraint name

Columns name(s)

Altering Tables Using SQL (4)

- Set default value

```
ALTER TABLE people
ALTER COLUMN balance SET DEFAULT 0;
```

Default value

Column name

Problems: Alter Tables

- **Alter** table
  - Add a new column – "middle_name" to the "employees" table
- Adding **Constraints**
  - Make "category_id" **foreign key** linked to "id" in the "categories" table
- **Modifying** Columns
  - Change the property "VARCHAR(50)" to "VARCHAR(100)" to the "middle_name" column in "employees" table

Deleting Data and Structures

Deleting from Database

- Deleting structures is called **dropping**
  - You can drop **keys**, **constraints**, **tables** and entire **databases**
- Deleting all data in a table is called **truncating**
- Both of these actions **cannot be undone** – use with caution!

Dropping and Truncating

- To delete all the entries in a table

```
TRUNCATE TABLE employees;
```

Table name

- To drop a table – delete data and structure

```
DROP TABLE employees;
```

Table name

- To drop entire database

```
DROP DATABASE soft_uni;
```

Database name

Dropping and Truncating (2)

- To remove a constraining rule from a column
  - Primary keys, value constraints and unique fields

```
ALTER TABLE employess
DROP CONSTRAINT pk_id;
```

Table name

Constraint name

- To remove **DEFAULT** value (if not specified, revert to **NULL**)

```
ALTER TABLE employess
ALTER COLUMN clients
DROP DEFAULT;
```

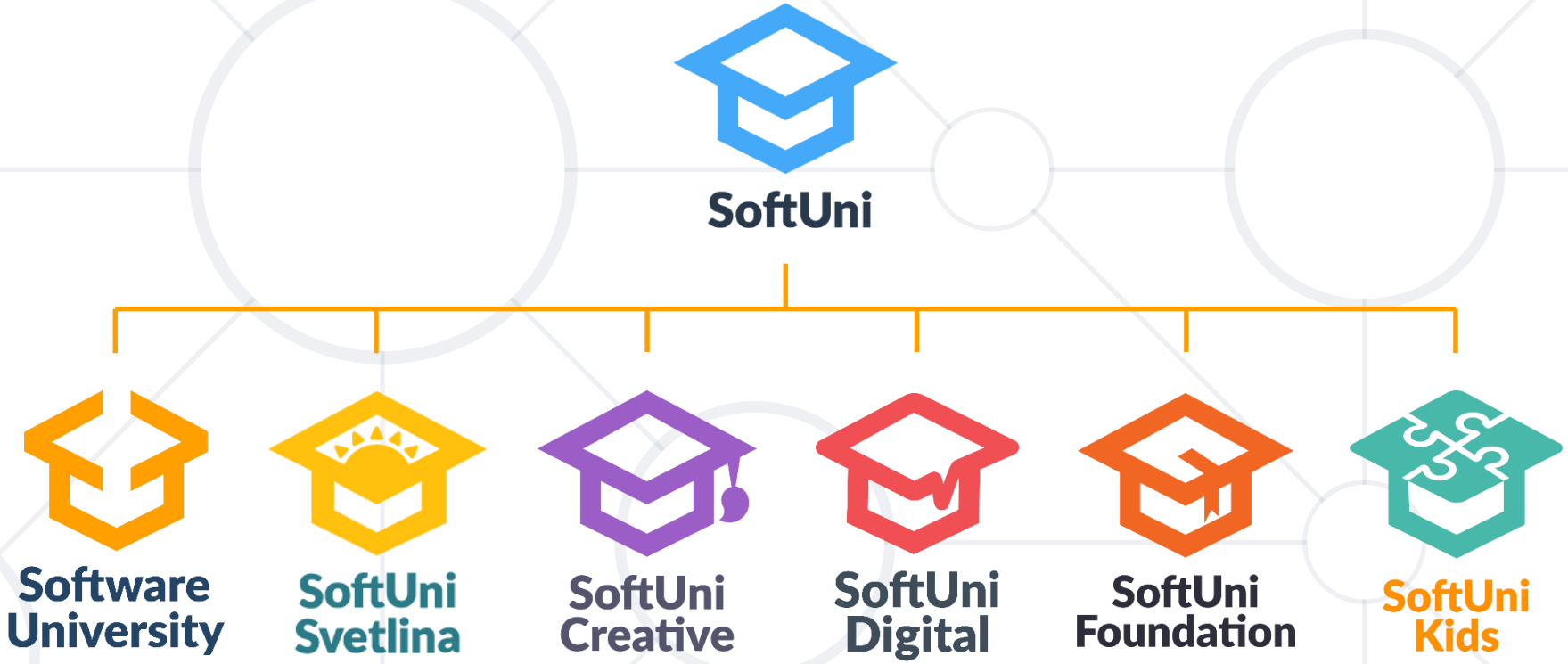
Table name

Columns name

Summary

- We communicate with the DB engine via **SQL**
- MySQL is a **multiplatform** RDBMS using SQL
- Table columns have a **fixed type**
- We can use GUI Clients to **create** and **customize** tables
- SQL provides **greater control**

Questions?



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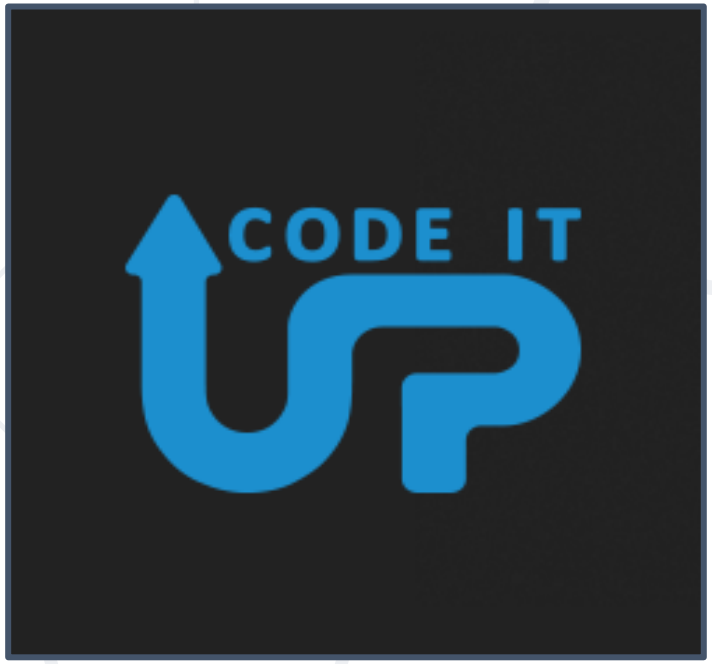

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