Introduction to Databases Data Definition and Datatypes

How Do RDBMS Work?

SoftUni Team

Technical Trainers

Software University

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Questions

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#java-db

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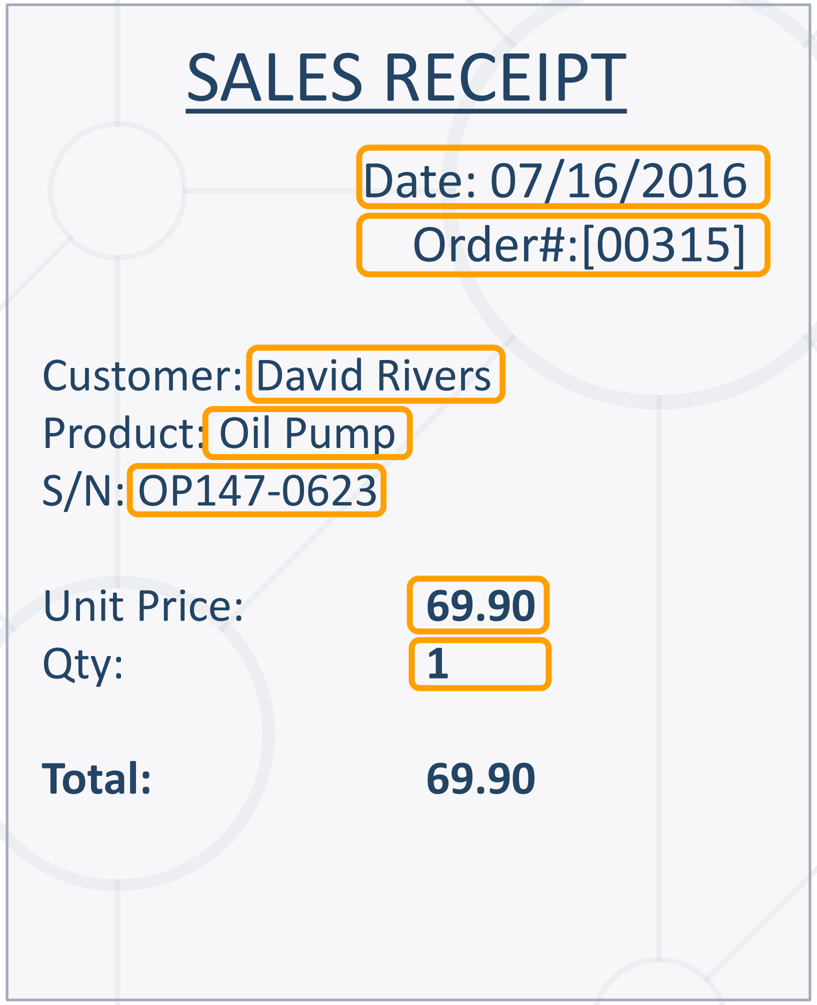
Data Management

Storage vs. Management



SALES RECEIPT

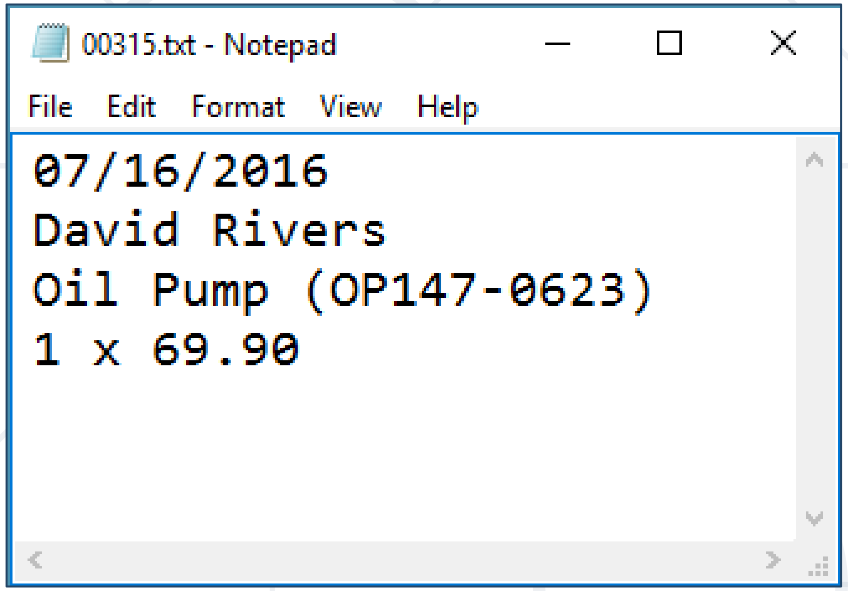
Date: 07/16/2016
Order#:[00315]

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



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

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

Storage vs. Management

- 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

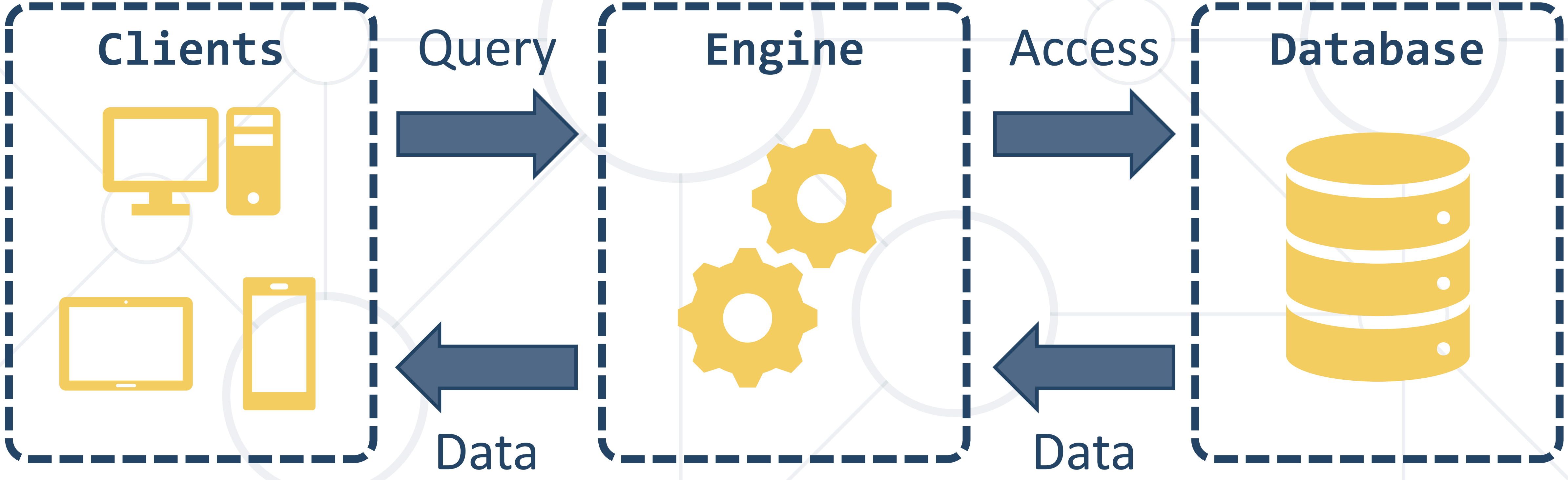
RDBMS

- **R**elational **D**ata **B**ase **M**anagement **S**ystem
  - 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

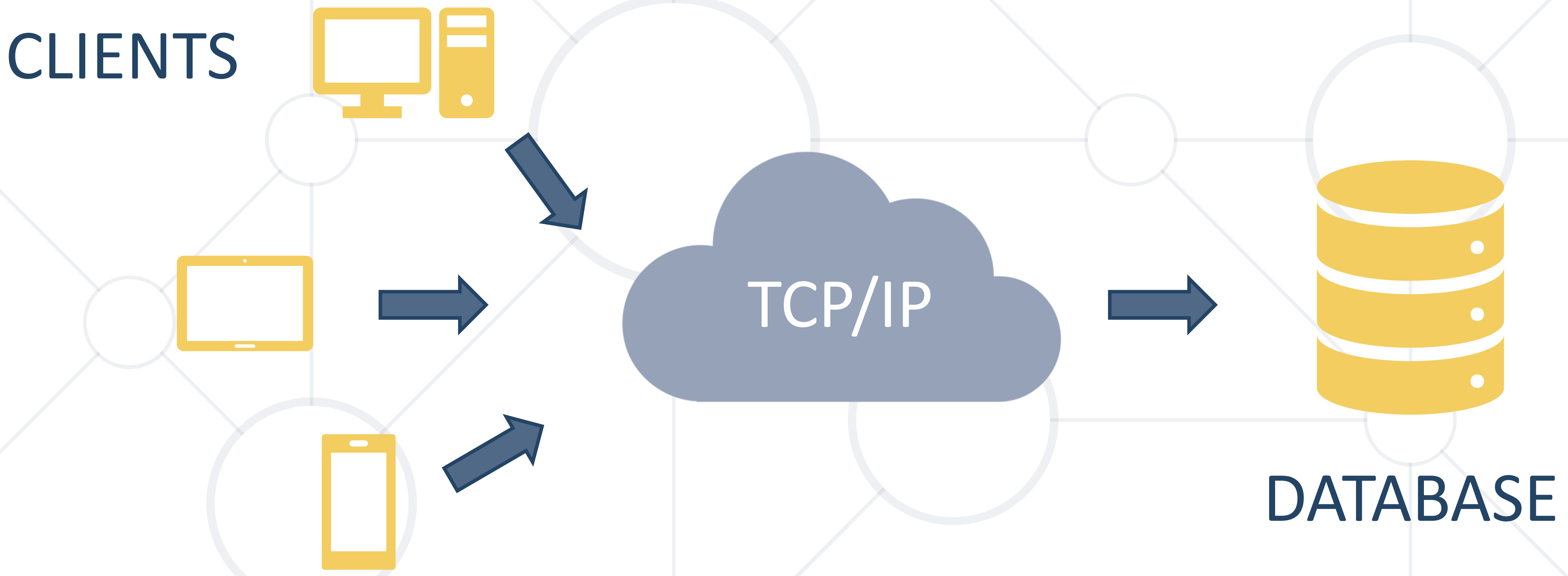
Database Engine

Database Engine Flow

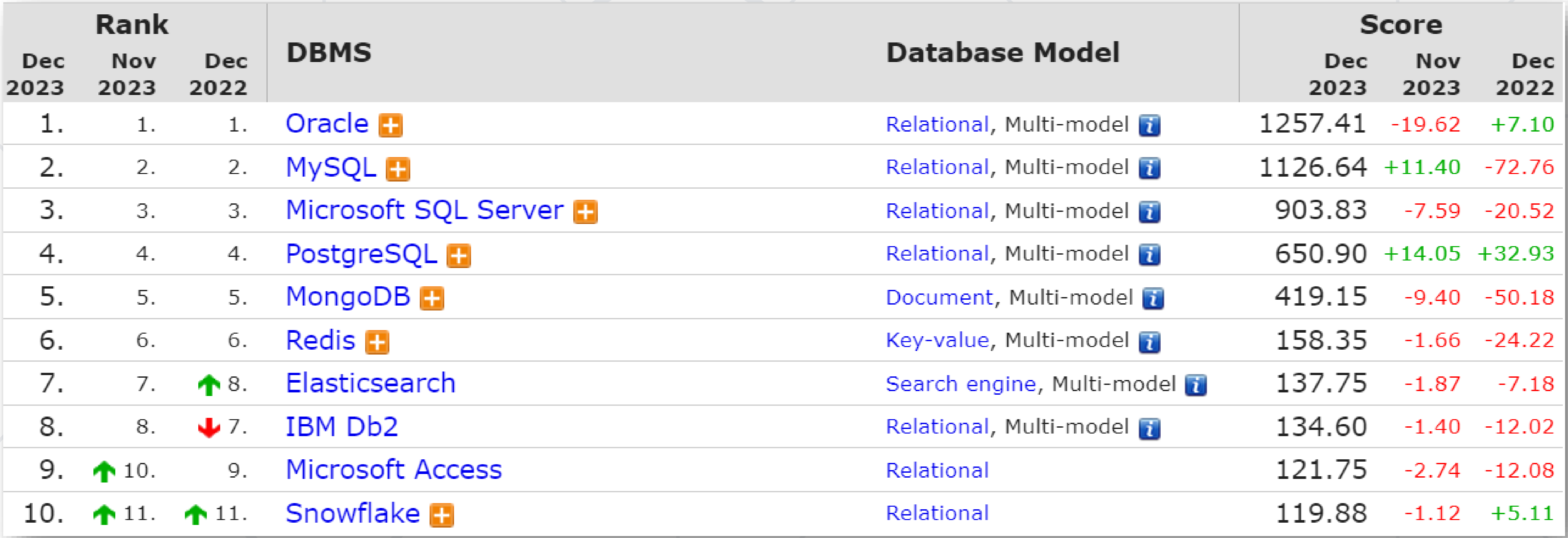
- SQL Server uses the Client-Server Model



Client-Server Model



Top Database Engines



Rank			DBMS	Database Model	Score		
Dec 2023	Nov 2023	Dec 2022			Dec 2023	Nov 2023	Dec 2022
1.	1.	1.	Oracle	Relational, Multi-model	1257.41	-19.62	+7.10
2.	2.	2.	MySQL	Relational, Multi-model	1126.64	+11.40	-72.76
3.	3.	3.	Microsoft SQL Server	Relational, Multi-model	903.83	-7.59	-20.52
4.	4.	4.	PostgreSQL	Relational, Multi-model	650.90	+14.05	+32.93
5.	5.	5.	MongoDB	Document, Multi-model	419.15	-9.40	-50.18
6.	6.	6.	Redis	Key-value, Multi-model	158.35	-1.66	-24.22
7.	7.	↑ 8.	Elasticsearch	Search engine, Multi-model	137.75	-1.87	-7.18
8.	8.	↓ 7.	IBM Db2	Relational, Multi-model	134.60	-1.40	-12.02
9.	↑ 10.	9.	Microsoft Access	Relational	121.75	-2.74	-12.08
10.	↑ 11.	↑ 11.	Snowflake	Relational	119.88	-1.12	+5.11

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

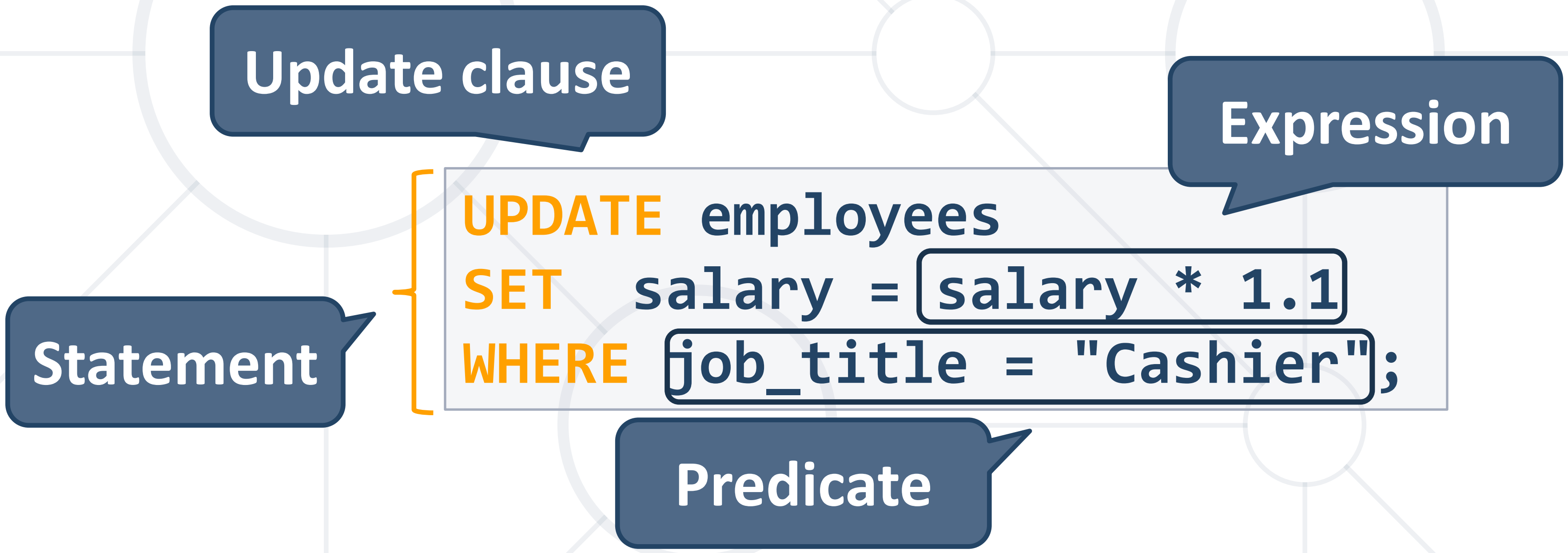
Structured Query Language

Structured Query Language

- 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

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

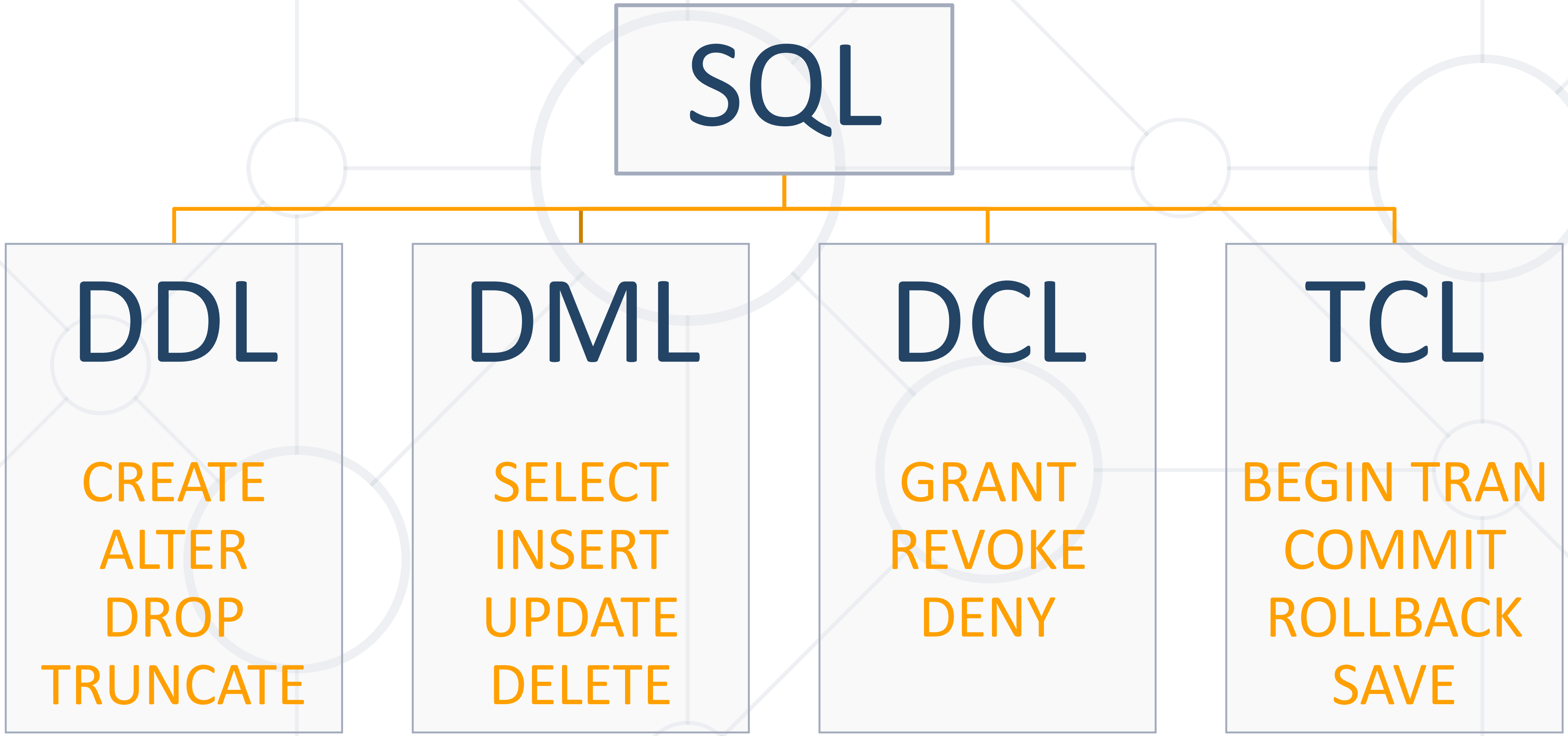


```sql
UPDATE employees
SET   salary = salary * 1.1
WHERE job_title = "Cashier";
```

Structured Query Language

- 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



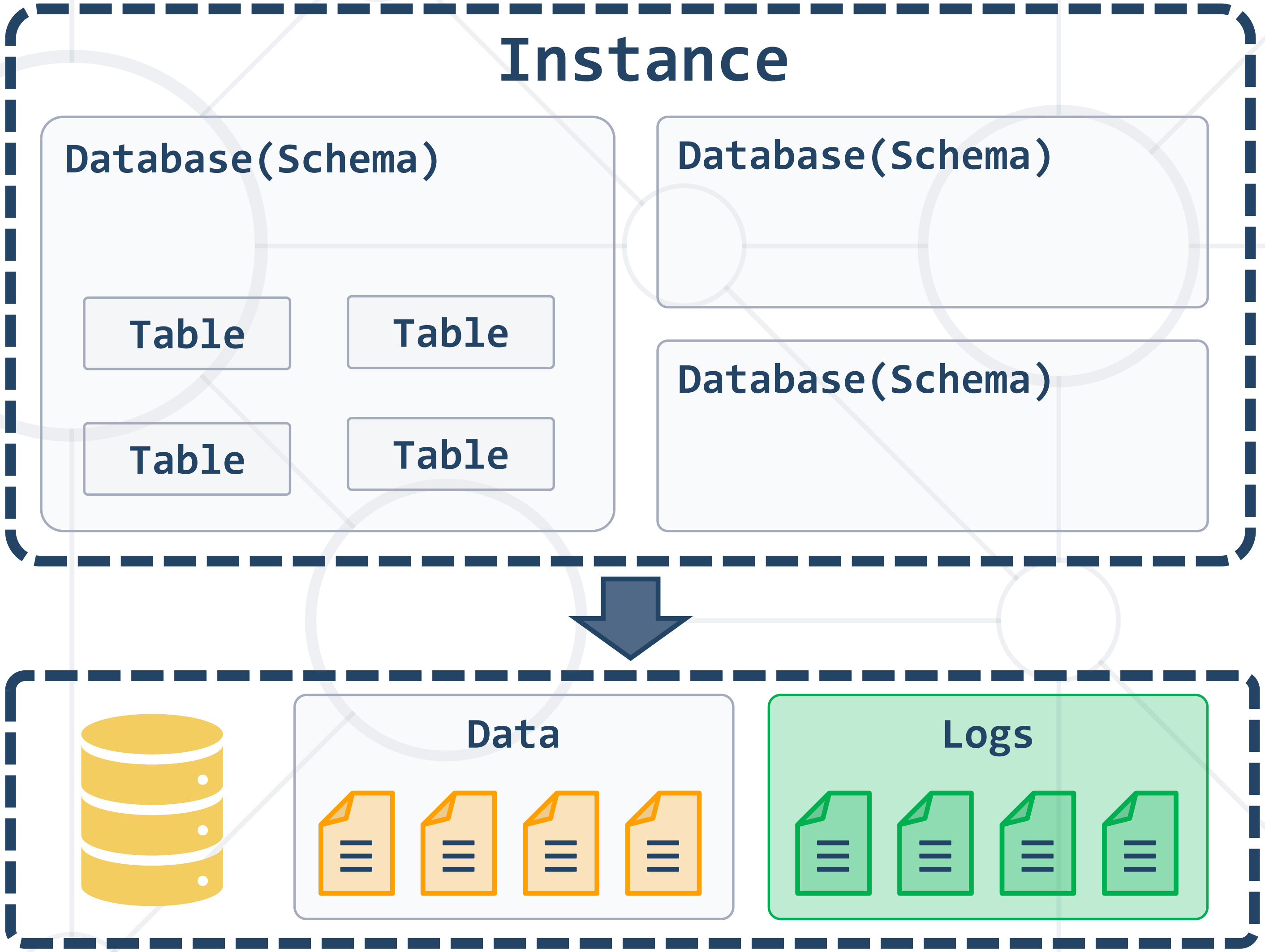
MySQL

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

Column

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

Row

Cell

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

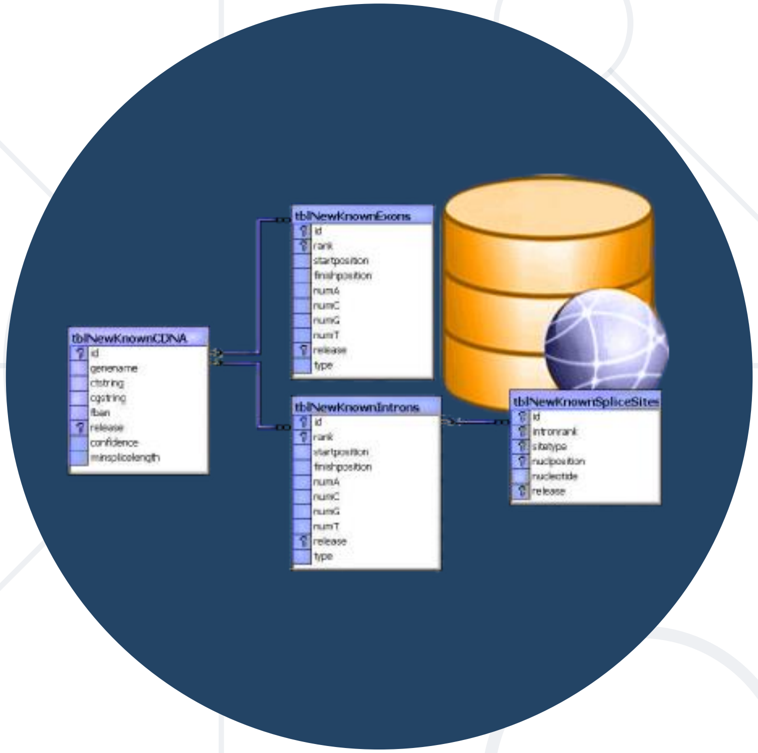


Table Relationships

Why Split Related Data?

Empty records

first	last	registered	email	email2
David	Rivers	05/02/2016	drivers@mail.cx	*NULL*
Sarah	Thorne	07/17/2016	sarah@mail.cx	*NULL*
Michael	Walters	11/23/2015	walters_michael@mail.cx	*walters_michael@abv.bg*

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

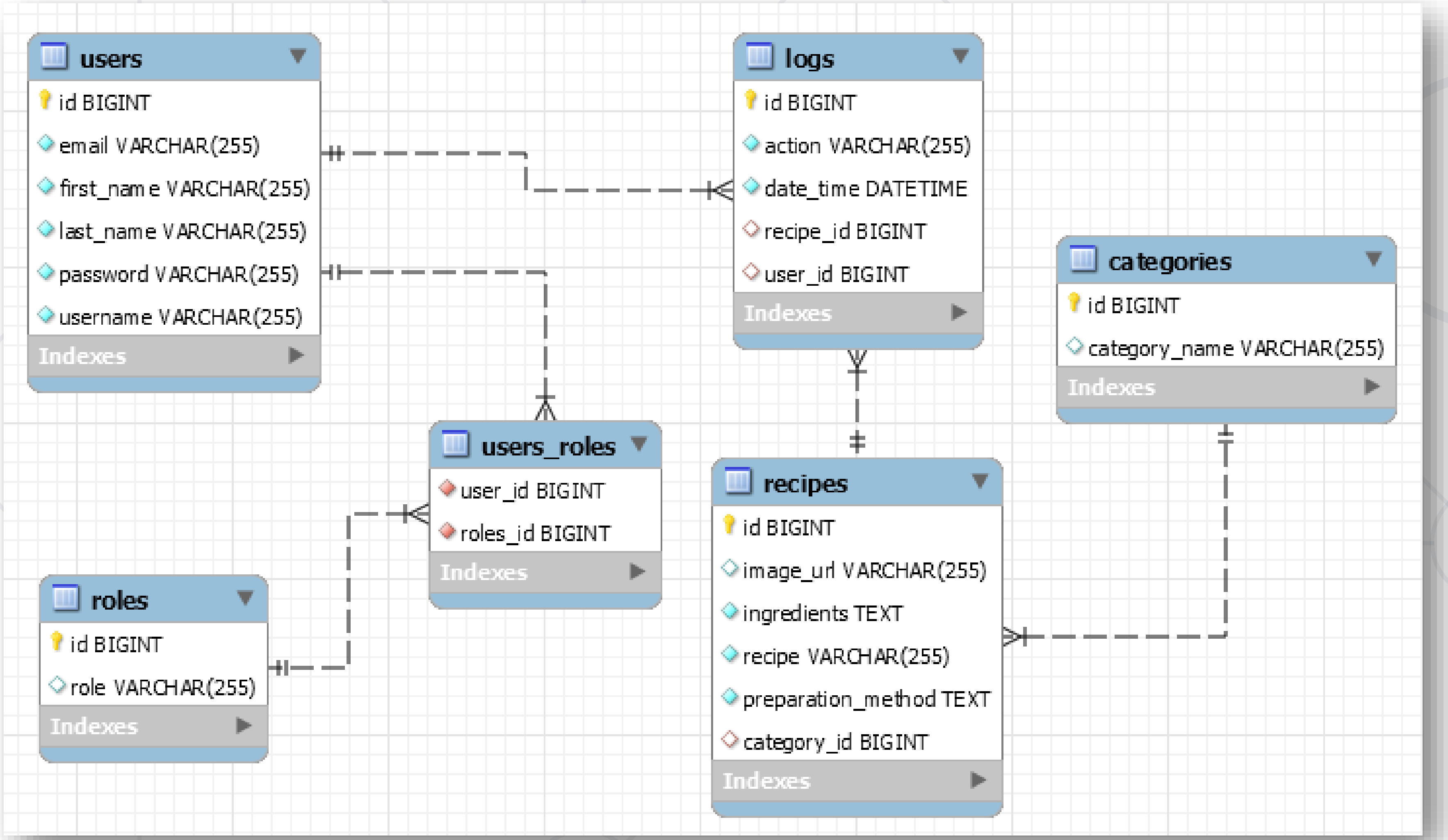
user_id	email
203	drivers@mail.cx
204	sarah@mail.cx
205	walters_michael@mail.cx
203	david@homedomain.cx

Primary Key

Foreign Key

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

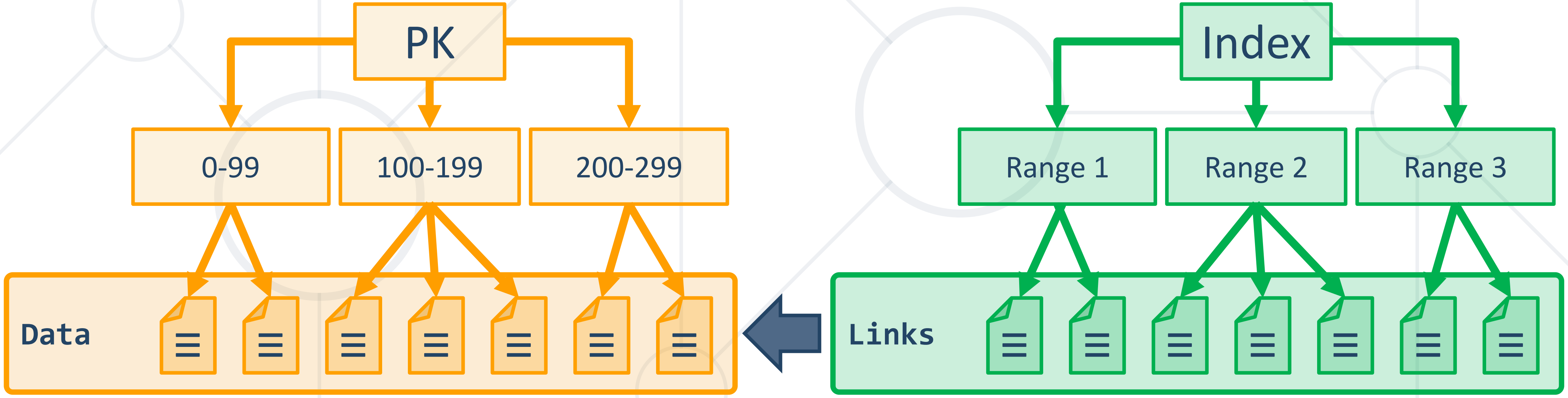
E/R Diagrams


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

- 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

- 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

- **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

- **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

- 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

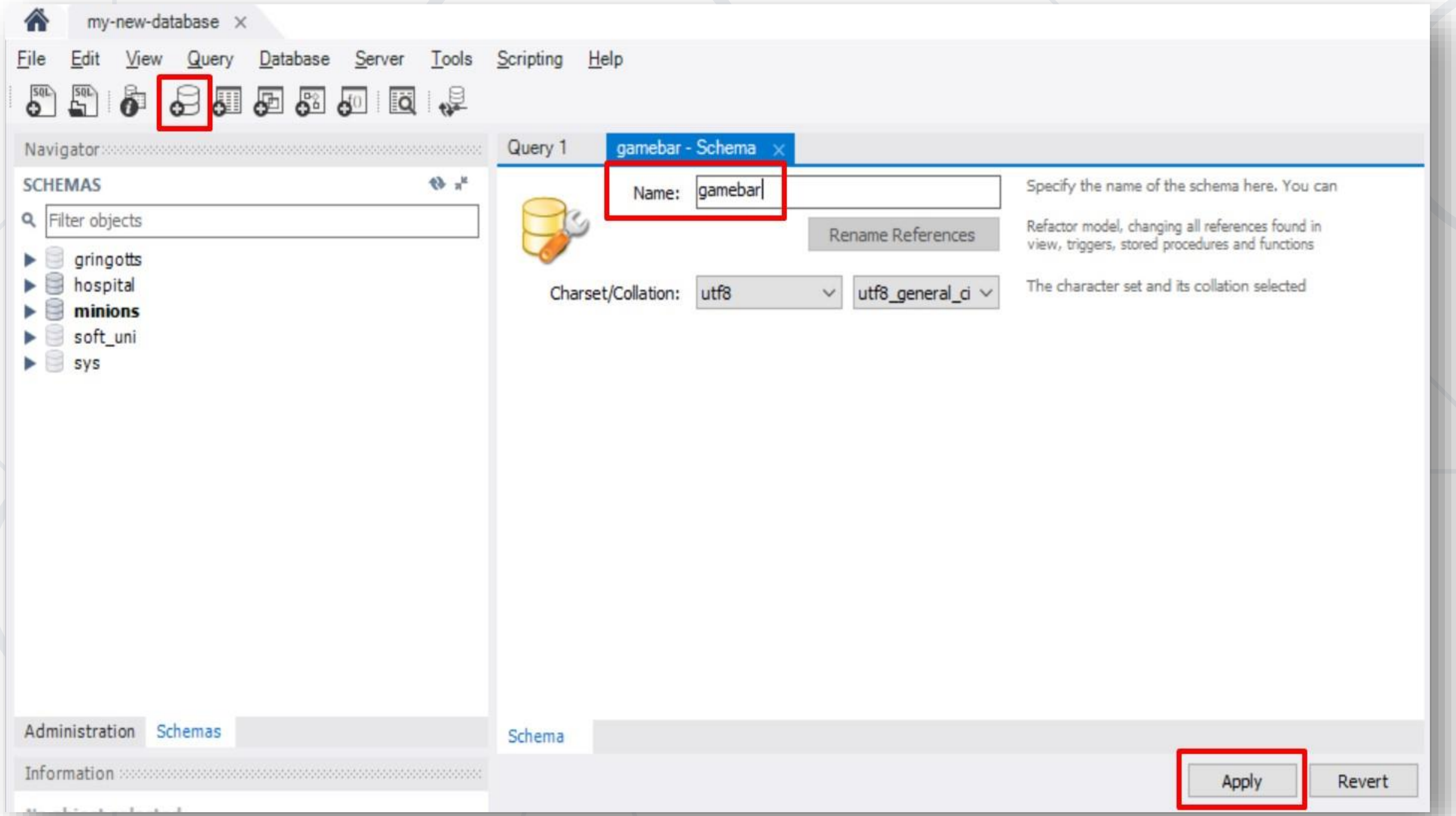
Database Modeling

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**



gringotts
hospital
minions
soft_uni
sys

Name: gamebar

Charset/Collation: utf8 utf8_general_ci

Specify the name of the schema here. You can

Refactor model, changing all references found in view, triggers, stored procedures and functions

The character set and its collation selected

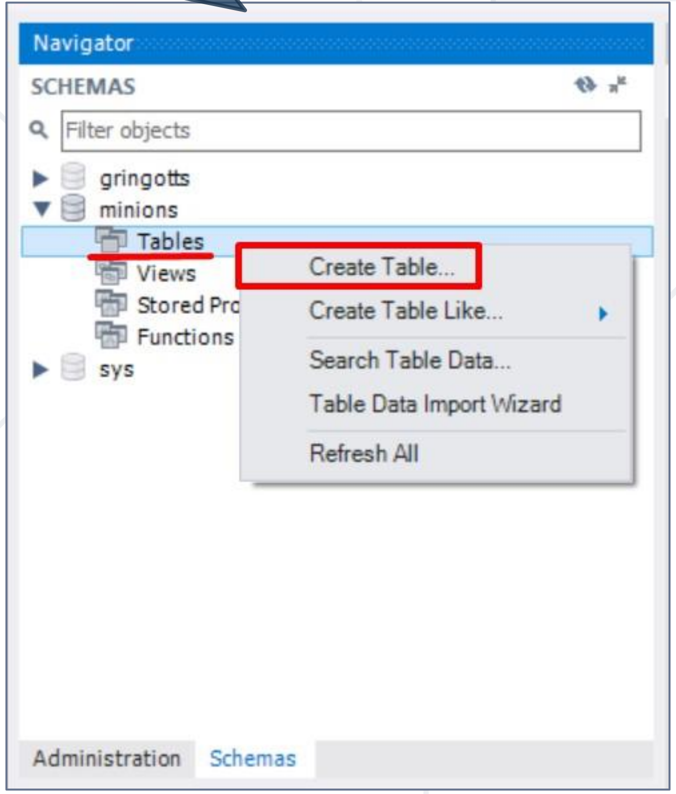
Creating Tables

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

Create new table

Add new record

Set up table name



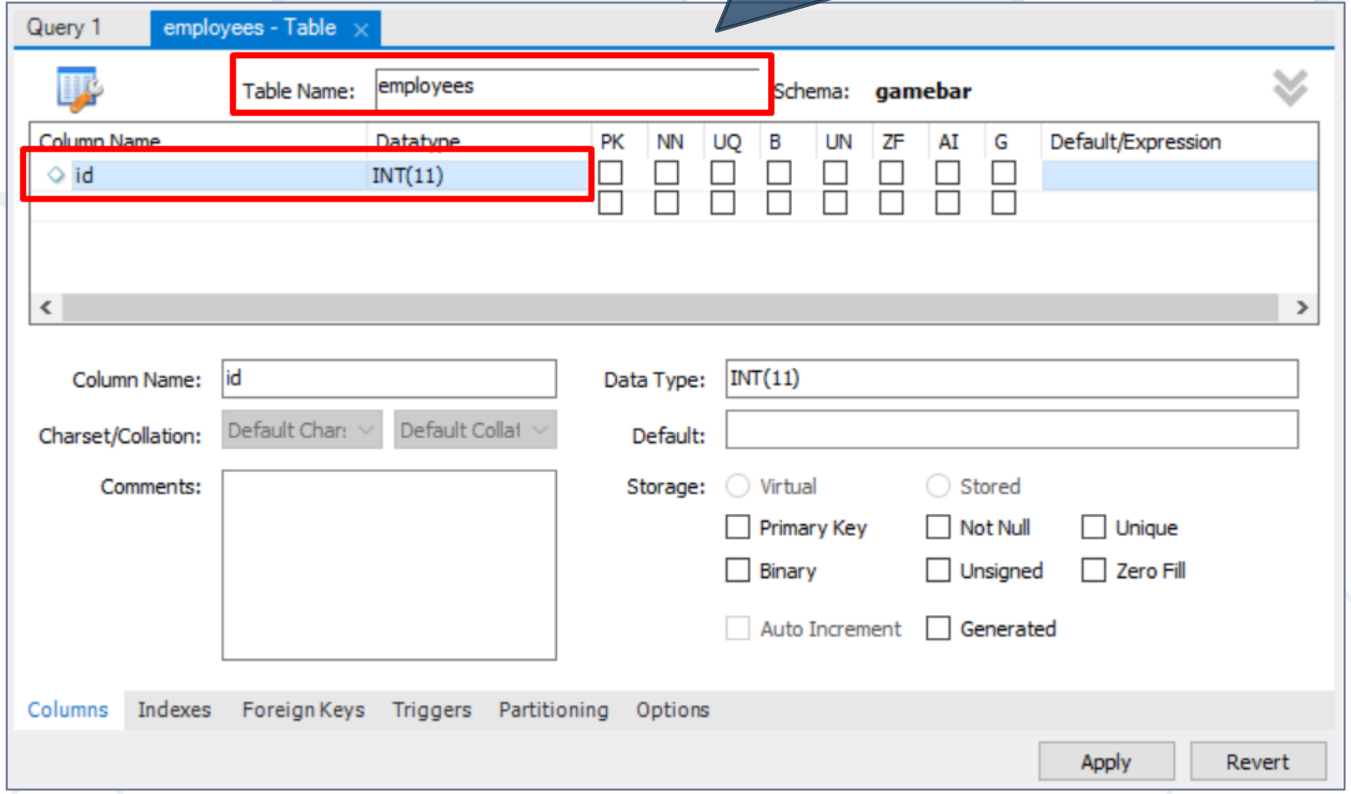


Table Name: employees
Schema: gamebar

Column Name	Datatype	PK	NN	UQ	B	UN	ZF	AI	G	Default/Expression
id	INT(11)	☐	☐	☐	☐	☐	☐	☐	☐	

Column Name: id
Data Type: INT(11)
Charset/Collation: Default Char: Default Collat
Default:
Comments:
Storage: ○ Virtual ○ Stored
☐ Primary Key ☐ Not Null ☐ Unique
☐ Binary ☐ Unsigned ☐ Zero Fill
☐ Auto Increment ☐ Generated

Creating Tables

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

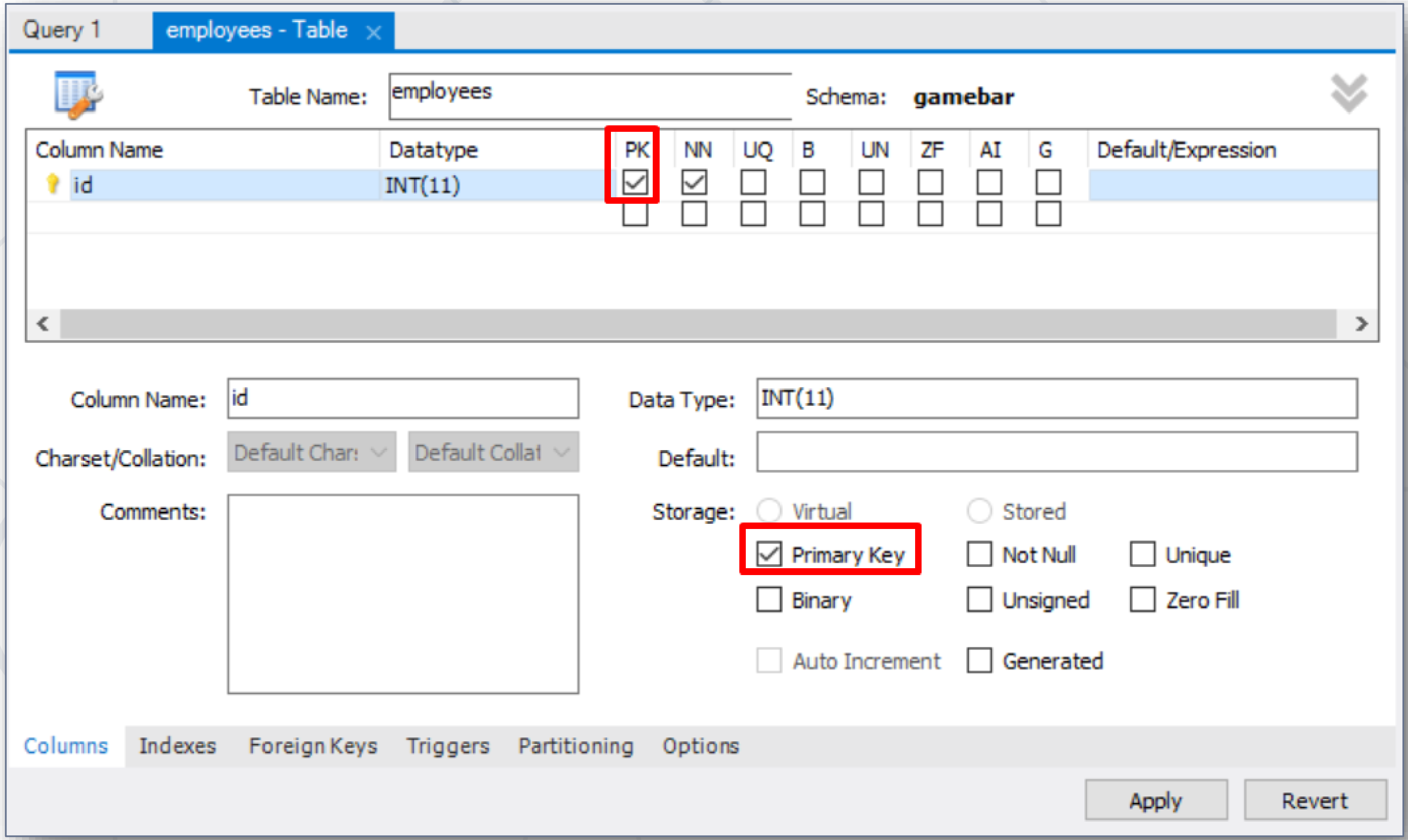


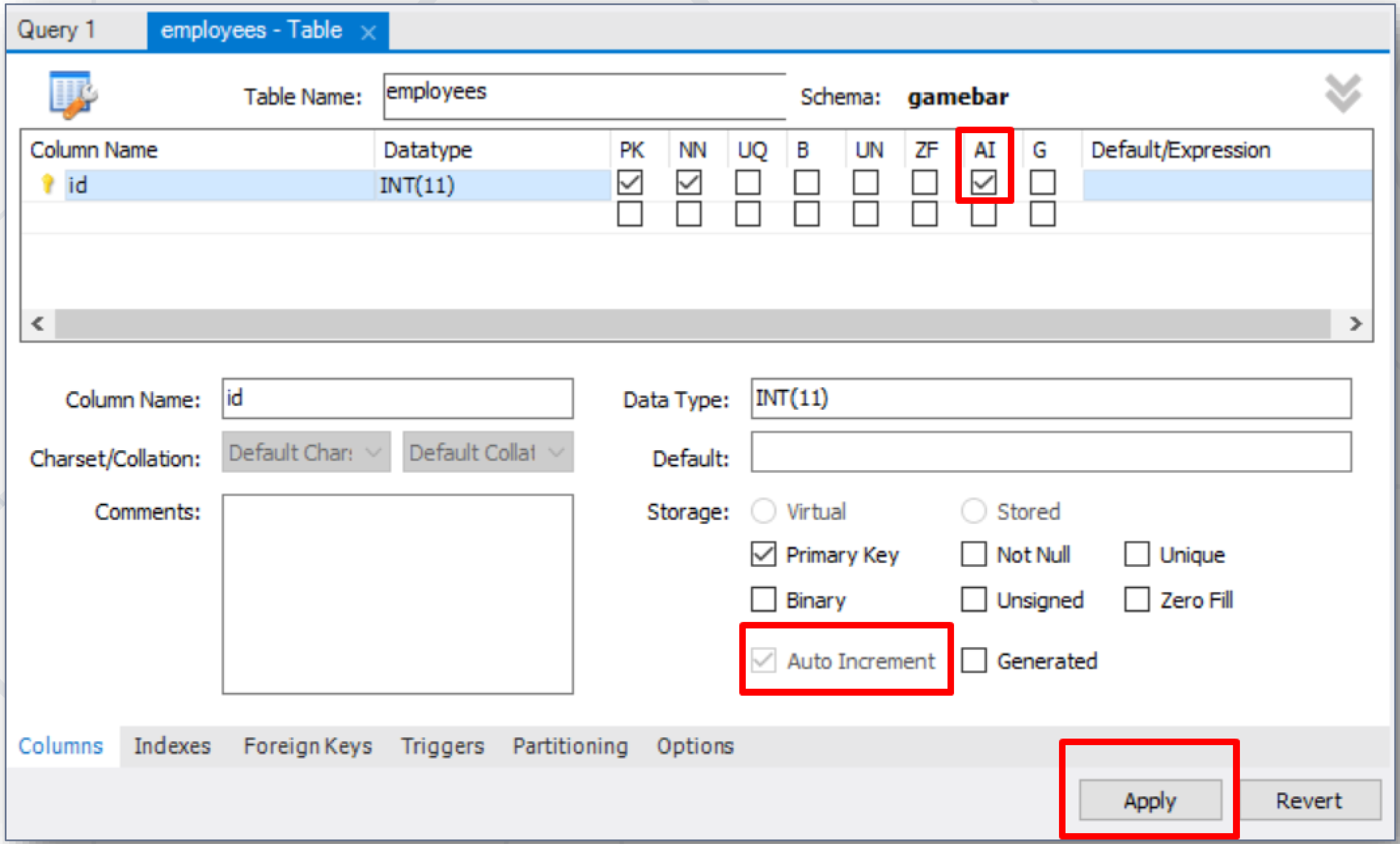
Table Name: employees Schema: **gamebar**

Column Name	Datatype	PK	NN	UQ	B	UN	ZF	AI	G	Default/Expression
id	INT(11)	☑	☑	☐	☐	☐	☐	☐	☐	
		☐	☐	☐	☐	☐	☐	☐	☐	

Column Name: id
Data Type: INT(11)
Charset/Collation: Default Char: Default Collat
Default:
Comments:
Storage: ○ Virtual ○ Stored
☑ Primary Key ☐ Not Null ☐ Unique
☐ Binary ☐ Unsigned ☐ Zero Fill
☐ Auto Increment ☐ Generated

Creating Tables

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



Query 1 | employees - Table

Table Name: employees
Schema: gamebar

Column Name	Datatype	PK	NN	UQ	B	UN	ZF	AI	G	Default/Expression
id	INT(11)	✓	✓					✓		

Column Name: id
Data Type: INT(11)
Charset/Collation: Default Char: | Default Collat
Default:
Comments:
Storage: Virtual | Stored
[✓] Primary Key | [ ] Not Null | [ ] Unique
[ ] Binary | [ ] Unsigned | [ ] Zero Fill
[✓] Auto Increment | [ ] Generated

Storing and Retrieving Data

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

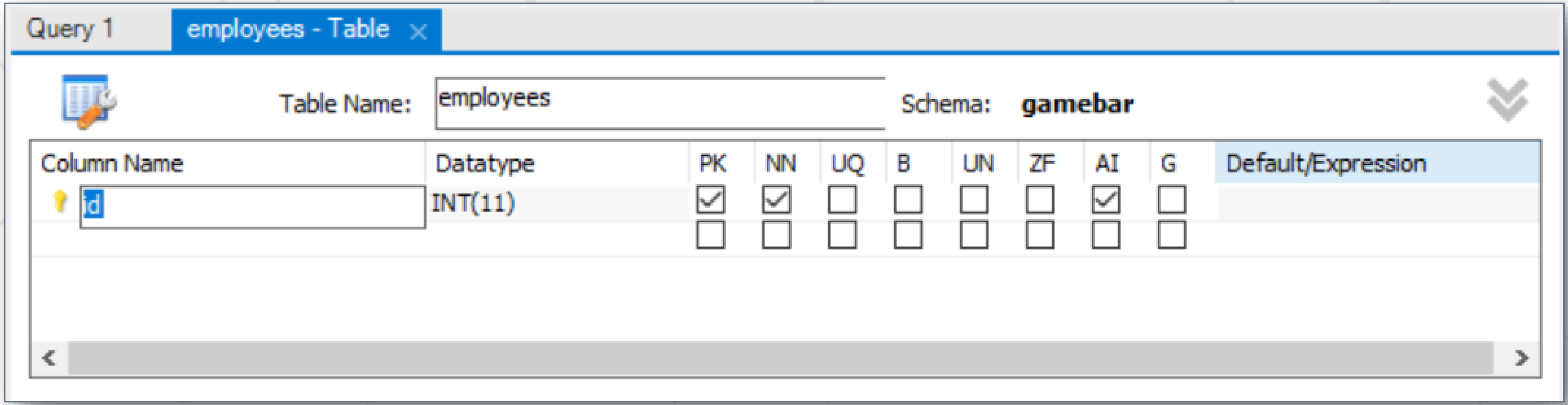


Table Name: employees Schema: gamebar

Column Name	Datatype	PK	NN	UQ	B	UN	ZF	AI	G	Default/Expression
id	INT(11)	✓	✓	☐	☐	☐	☐	✓	☐	
		☐	☐	☐	☐	☐	☐	☐	☐	

```
CREATE TABLE people
(
  id INT NOT NULL,
  email VARCHAR(50) NOT
NULL,
  first_name VARCHAR(50),
  last_name VARCHAR(50)
);
```

Basic SQL Queries

SQL Queries

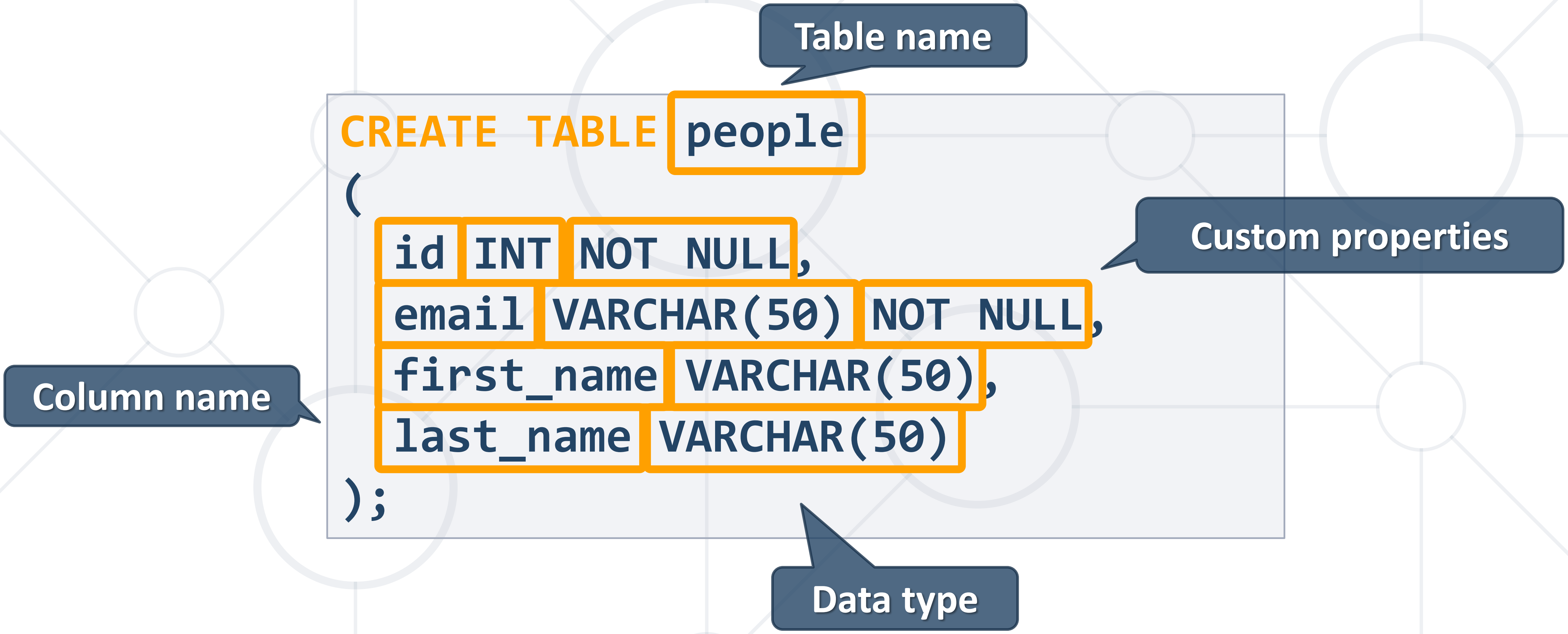
- We communicate with the database engine using SQL
- Queries provide greater **control** and **flexibility**
- To create a database using SQL:

```
CREATE DATABASE employees;
```

Database name

- SQL keywords are conventionally **capitalized**

Table Creation in SQL



```sql
CREATE TABLE people
(
  id INT NOT NULL,
  email VARCHAR(50) NOT NULL,
  first_name VARCHAR(50),
  last_name VARCHAR(50)
);
```

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

- 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

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

```sql
ALTER TABLE employees;
```

Table name

- Add new column

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

Column name

Data type

Altering Tables Using SQL

- 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

- Add primary key to existing column

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

Constraint name

Column name (more than one for composite key)

- Add unique constraint

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

Constraint name

Columns name(s)

Altering Tables Using SQL

- Set default value

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

Column name

Default value

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

- 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

Column 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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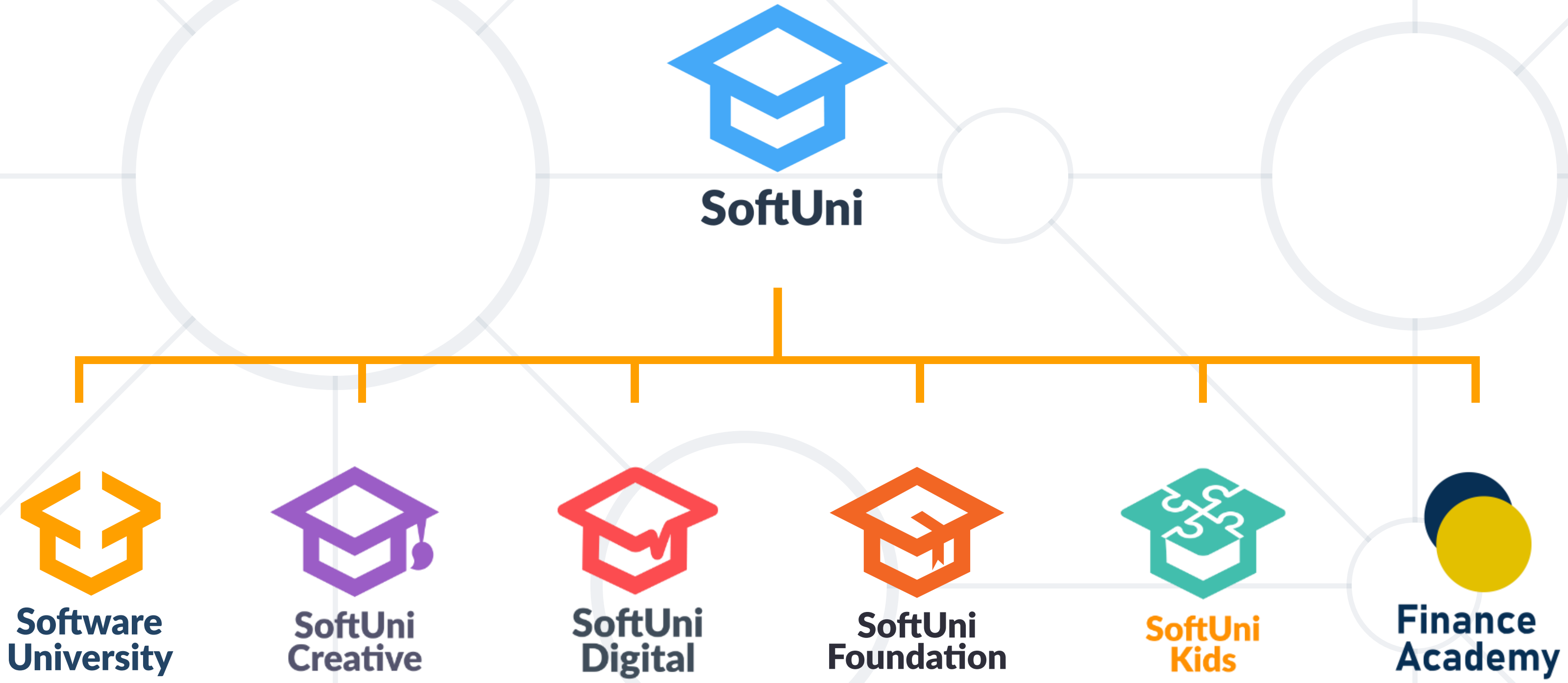

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