Introduction to Databases
Data Definition And Datatypes

How do RDBMS work?

SoftUni Team

Technical Trainers

Software University

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Have a Question?

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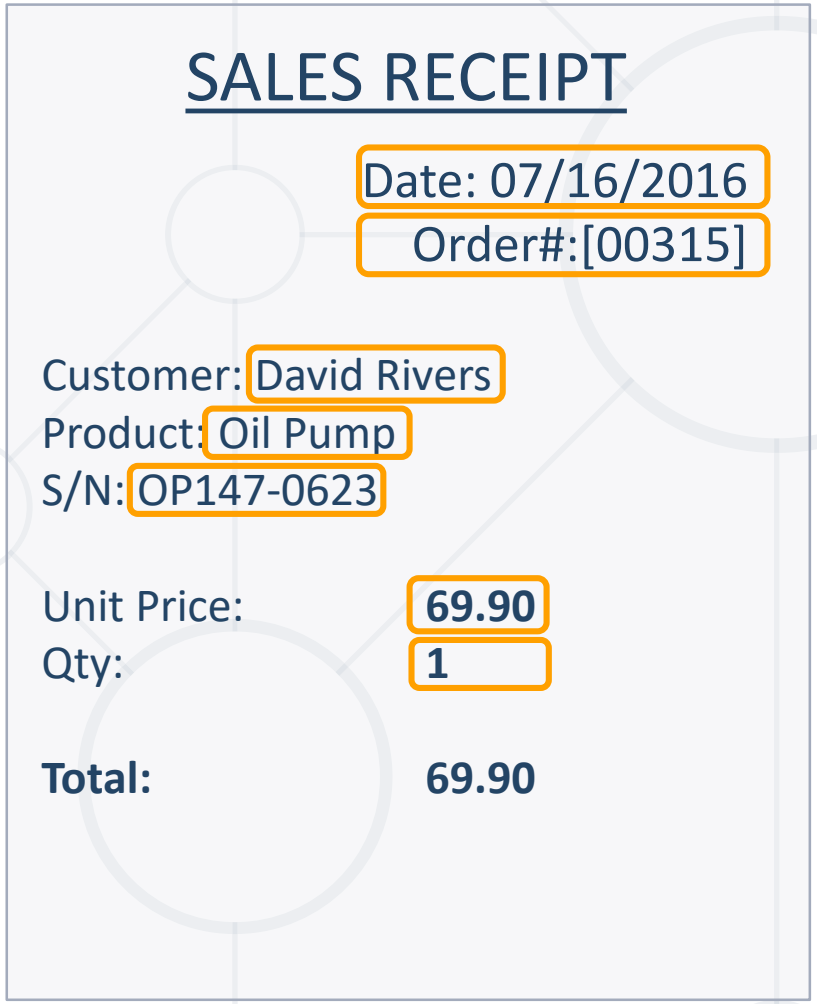
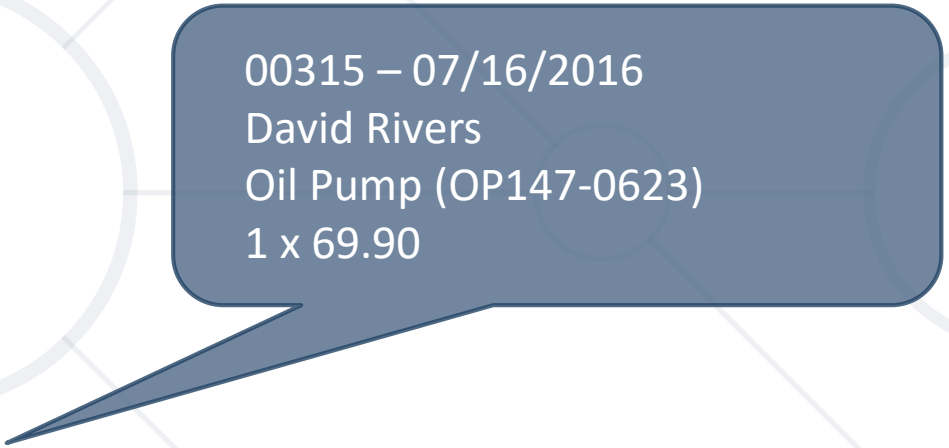
#JavaDB

Data Management

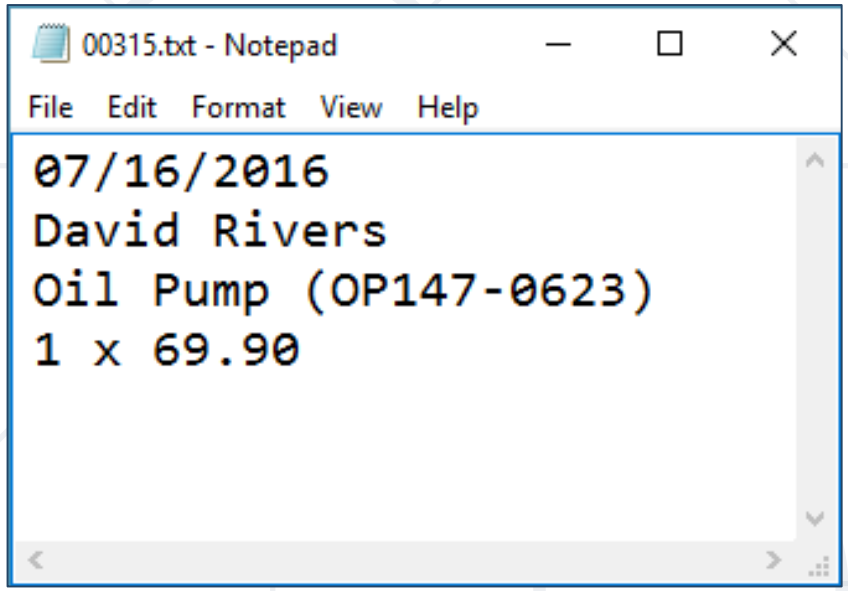
When Do We Need a Database?

Storage vs. Management





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)

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- 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

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- 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

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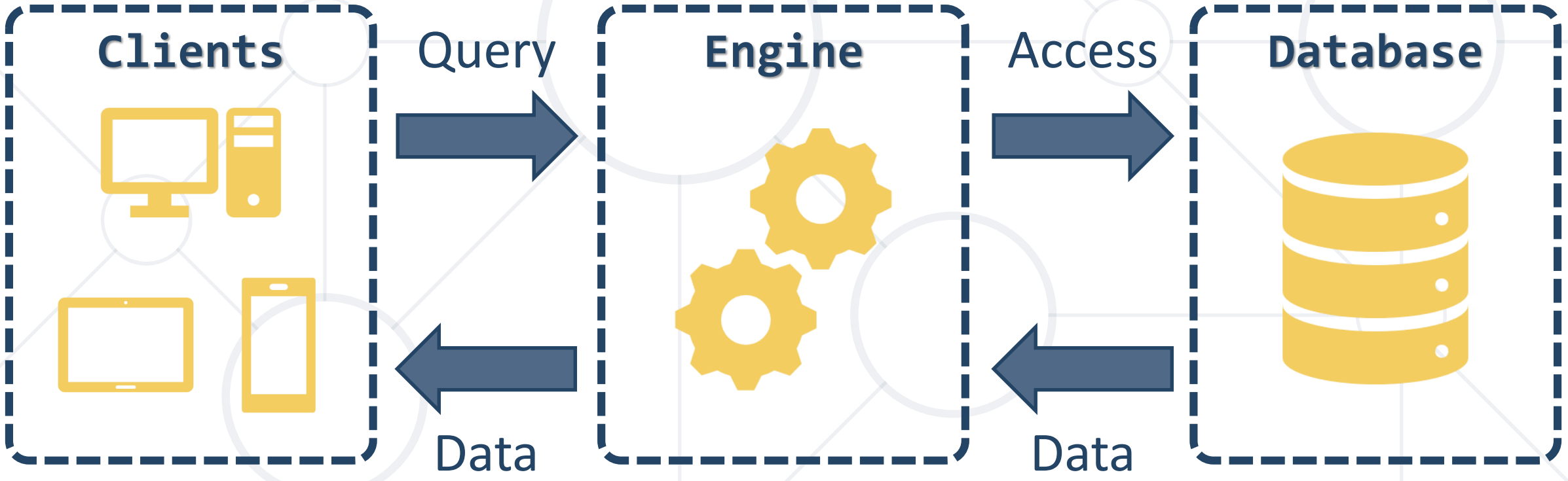
- Relational Data Base Management System
  - Database **management**
  - It **parses requests** from the user and takes the **appropriate** action
  - The user **doesn't have direct access** to the stored data
  - Data is presented by **relations** – collection of tables related by **common fields**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

Database Engine

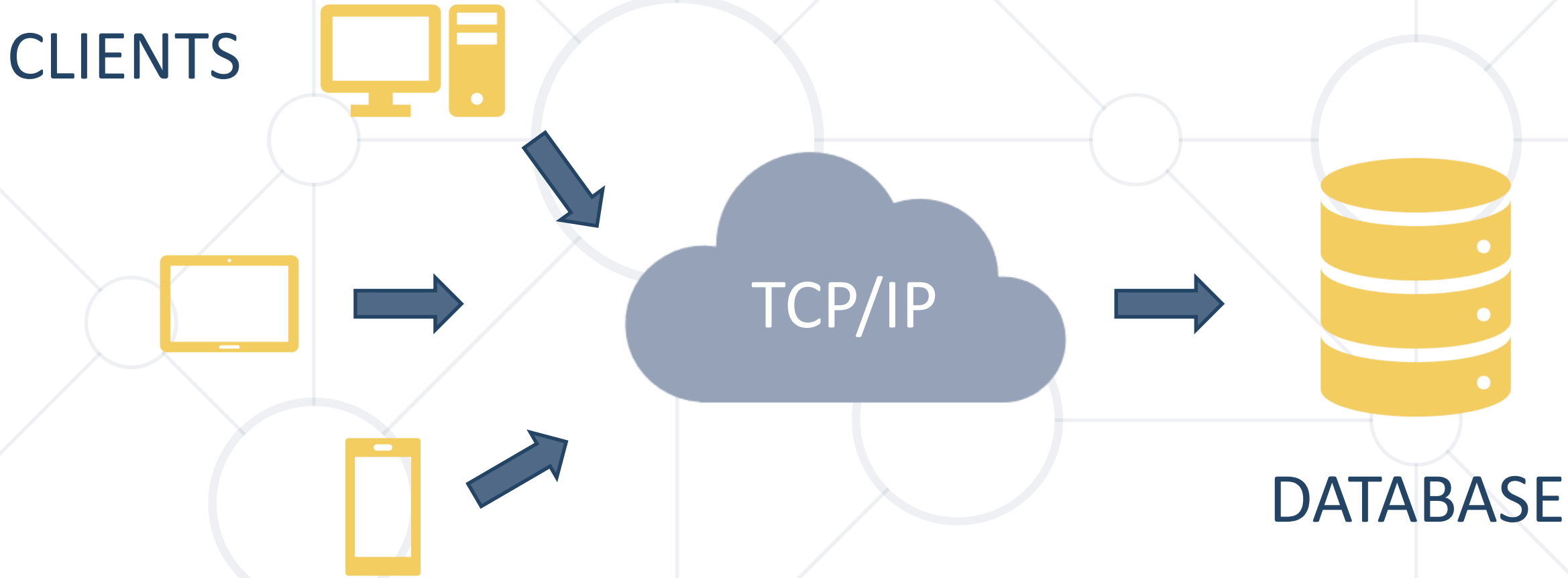
Client-Server Model

Database Engine Flow

- SQL Server uses the Client-Server Model



Client-Server Model



Top Database Engines

345 systems in ranking, September 2018

Rank			DBMS	Database Model	Score		
Sep 2018	Aug 2018	Sep 2017			Sep 2018	Aug 2018	Sep 2017
1.	1.	1.	Oracle	Relational DBMS	1309.12	-2.91	-49.97
2.	2.	2.	MySQL	Relational DBMS	1180.48	-26.33	-132.13
3.	3.	3.	Microsoft SQL Server	Relational DBMS	1051.28	-21.37	-161.26
4.	4.	4.	PostgreSQL	Relational DBMS	406.43	-11.07	+34.07
5.	5.	5.	MongoDB	Document store	358.79	+7.81	+26.06
6.	6.	6.	DB2	Relational DBMS	181.06	-0.78	-17.28
7.	↑ 8.	↑ 10.	Elasticsearch	Search engine	142.61	+4.49	+22.61
8.	↓ 7.	↑ 9.	Redis	Key-value store	140.94	+2.37	+20.54
9.	9.	↓ 7.	Microsoft Access	Relational DBMS	133.39	+4.30	+4.58
10.	10.	↓ 8.	Cassandra	Wide column store	119.55	-0.02	-6.65

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

Structured Query Language

Query Components

Structured Query Language

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- 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**

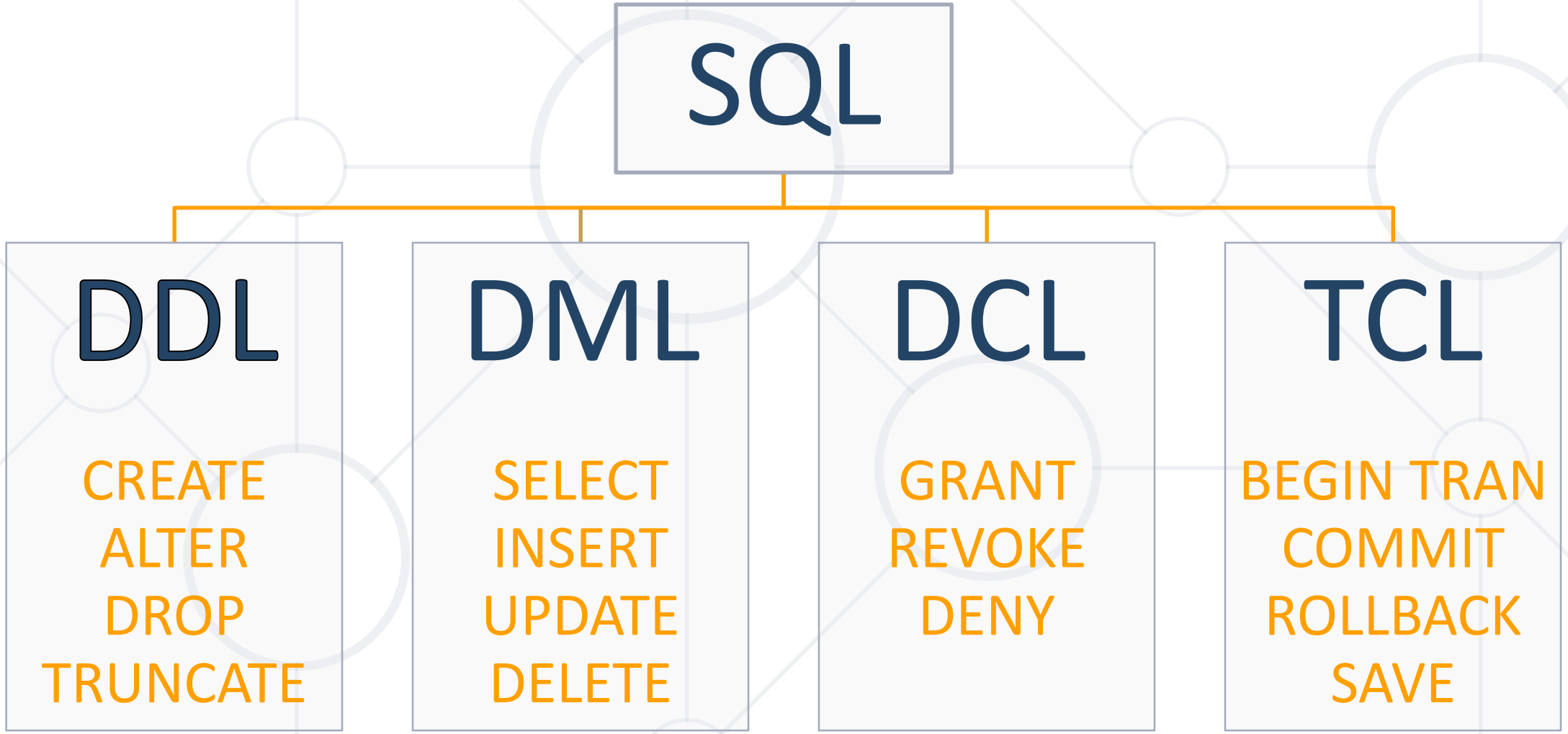
Structured Query Language (2)

- 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

Relational DB Management

MySQL

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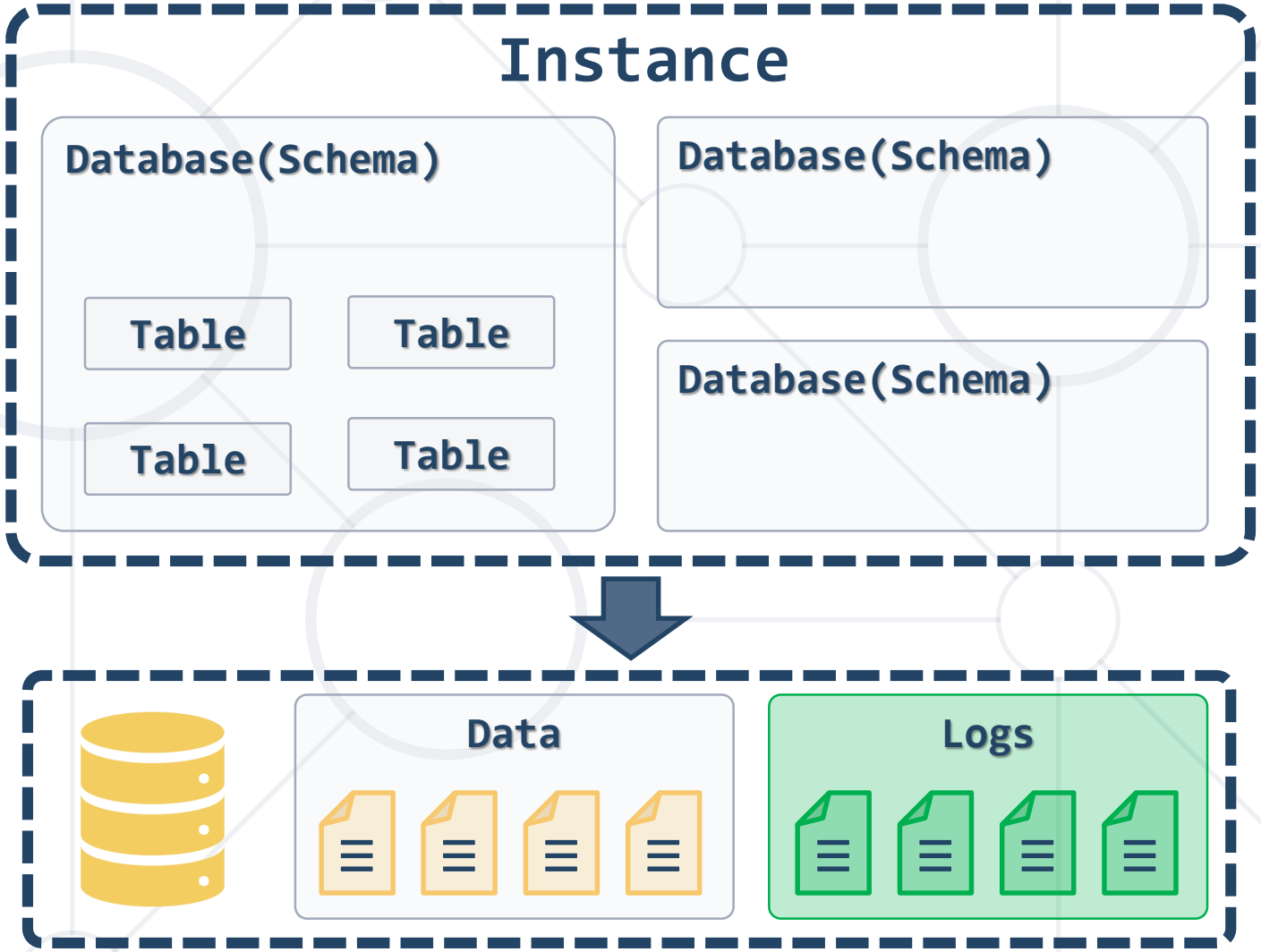
- **Open-source** relational database management system
- Used in many **large-scale websites** like including Google, Facebook, YouTube etc.
- Works on **many** system platforms –

  MAC OS, Windows, Linux
- Download **MySQL Server**
  - **Windows:** dev.mysql.com/downloads/windows/installer/
  - **Ubuntu/Debian:** dev.mysql.com/downloads/repo/apt/

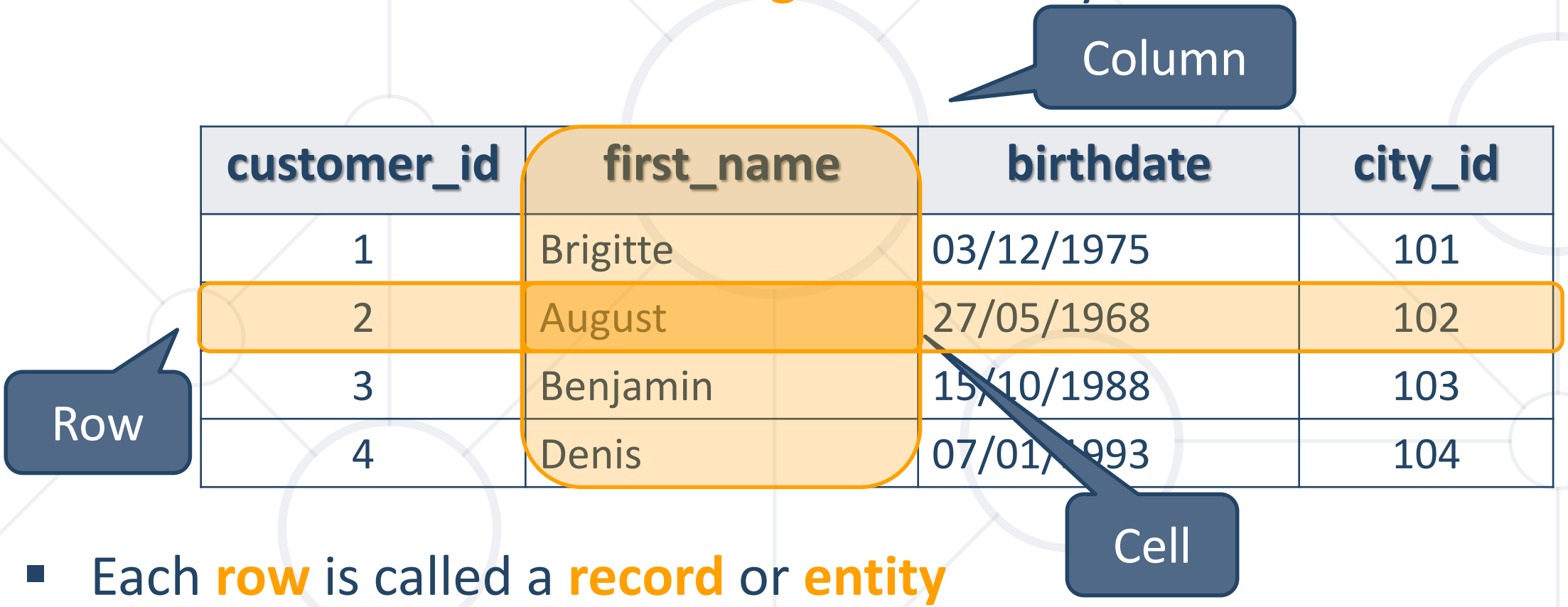
MySQL Server Architecture

- 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



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

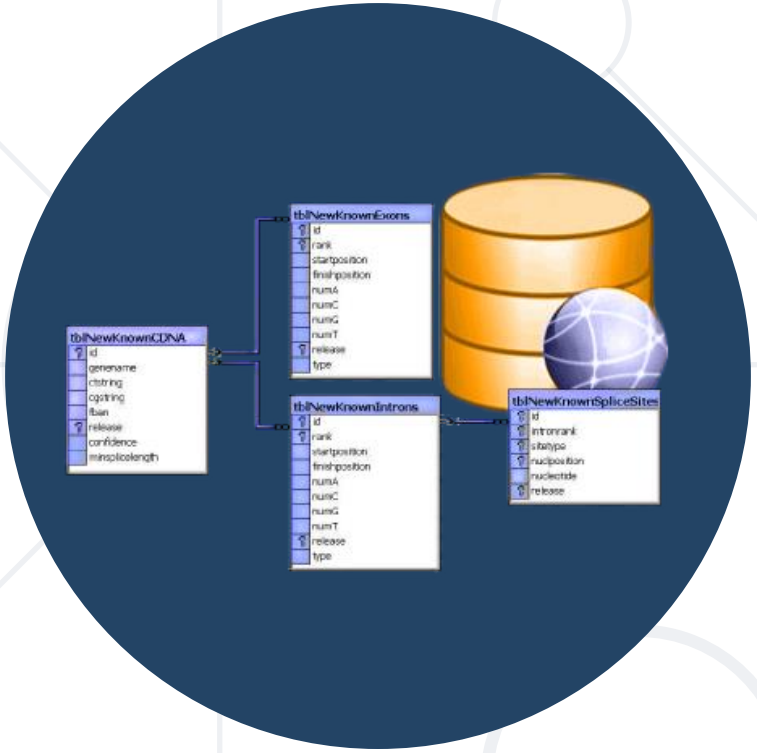


Table Relationships

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

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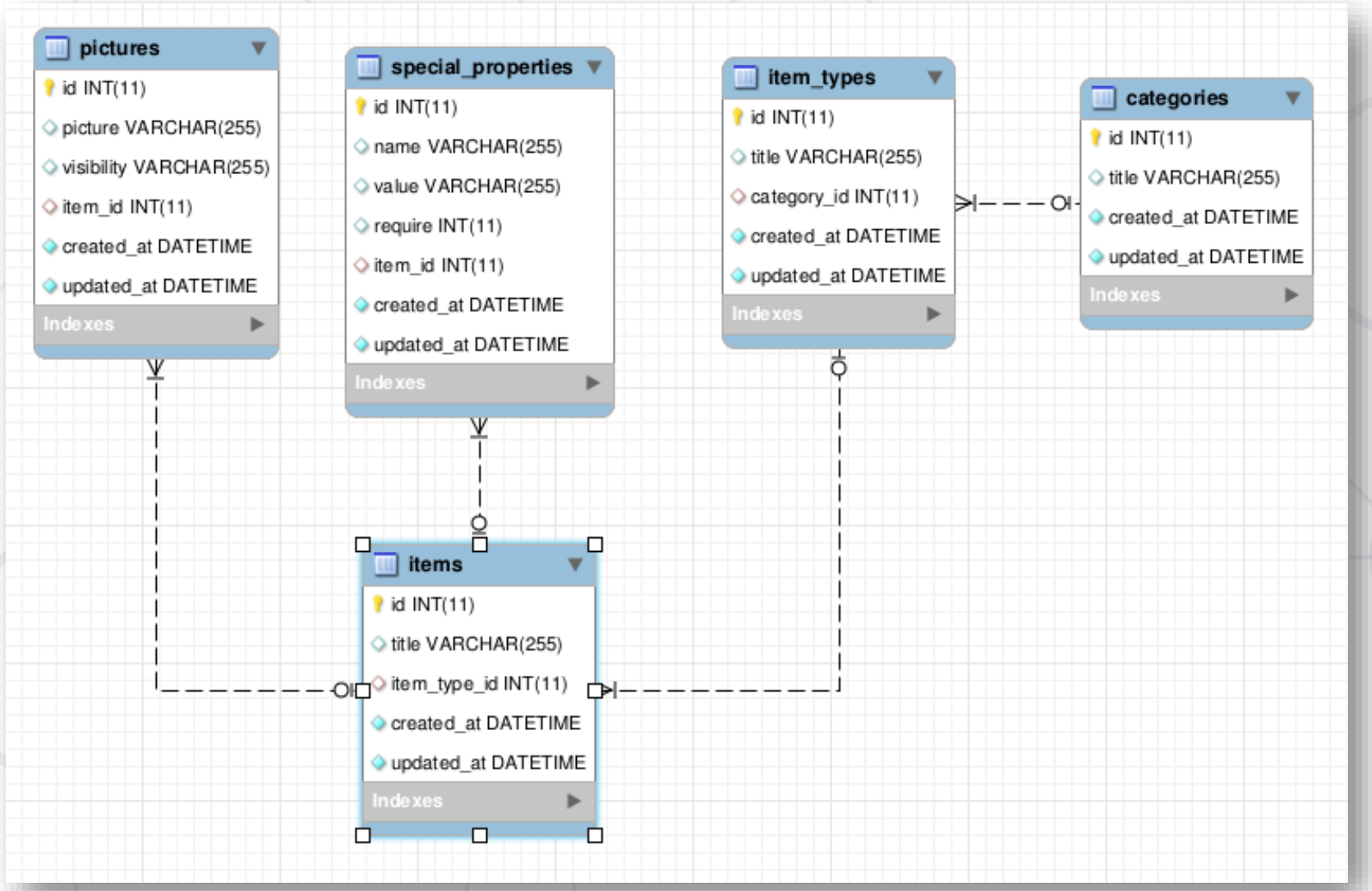
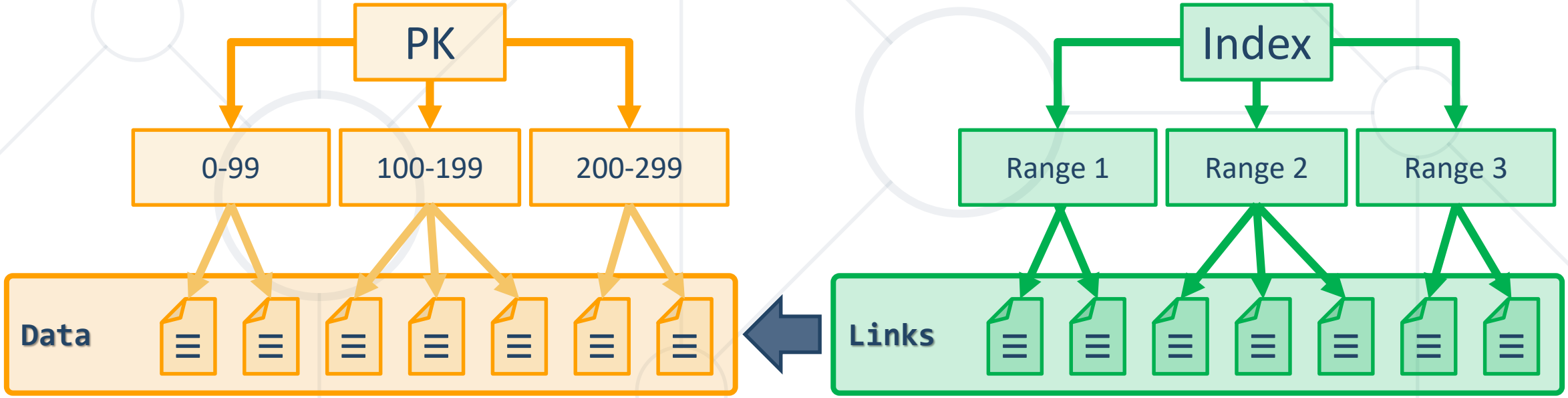


Programmability

Customizing Database Behavior

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 e.employee_id,
            e.first_name,
            e.last_name
       FROM   soft_uni.employees AS e
```

```
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

Procedures

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```
CREATE PROCEDURE udp_get_employees_salary_above_35000()
BEGIN
     SELECT first_name, last_name FROM employees
     WHERE salary > 35000;
END
```

```
CALL udp_get_employees_salary_above_35000
```

Functions

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```
CREATE FUNCTION udf_get_age (dateValue DATE)
RETURNS INT
	BEGIN
	DECLARE result INT;
	SET result = TIMESTAMPDIFF(YEAR, dateValue, NOW());
	RETURN result;
	END
```

```
SELECT udf_get_age('1988-12-21');
```

Data Types in MySQL Server

Numeric, String and Data Types

Numeric Data Types

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- 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

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- 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 30 characters
- **VARCHAR(M) –** up to 255 characters
- **TEXT** [(M)] – 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

Column name	Column Type
`title`	`VARCHAR(CHAR)`
`content`	`TEXT(LONGTEXT)`
`picture`	`BLOB(LONGBLOB)`

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 (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

Data Definition using GUI Clients

Working with IDEs

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- 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

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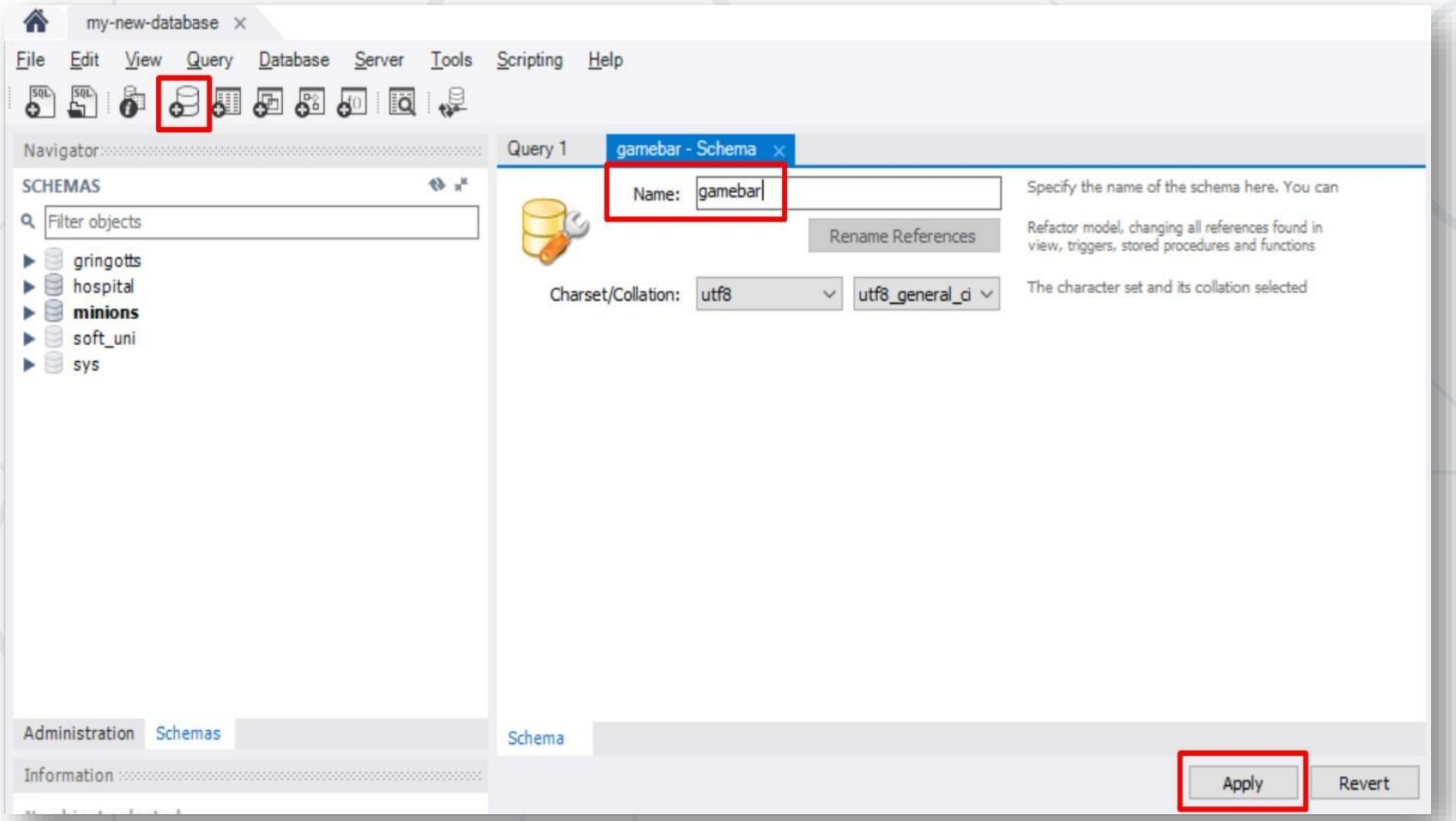
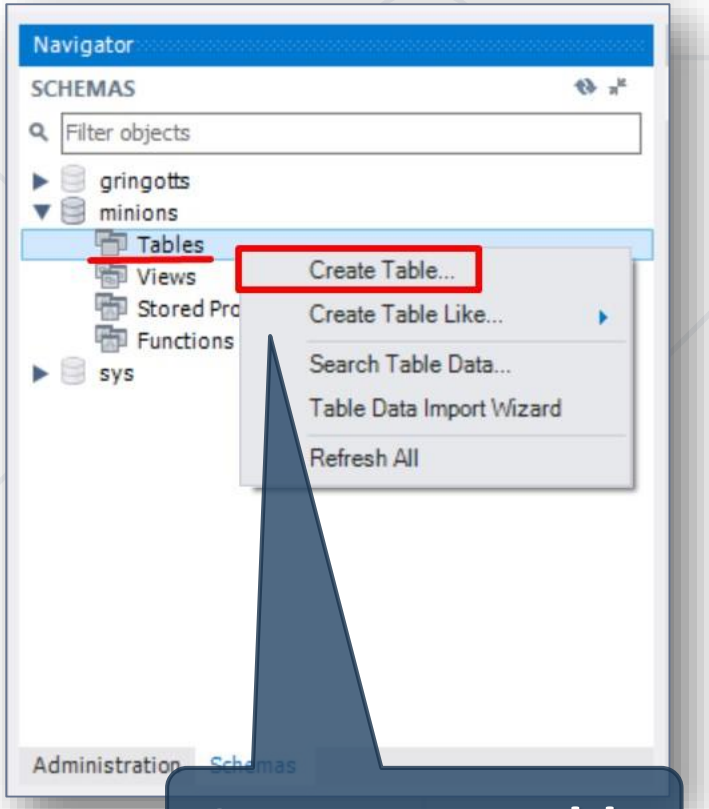
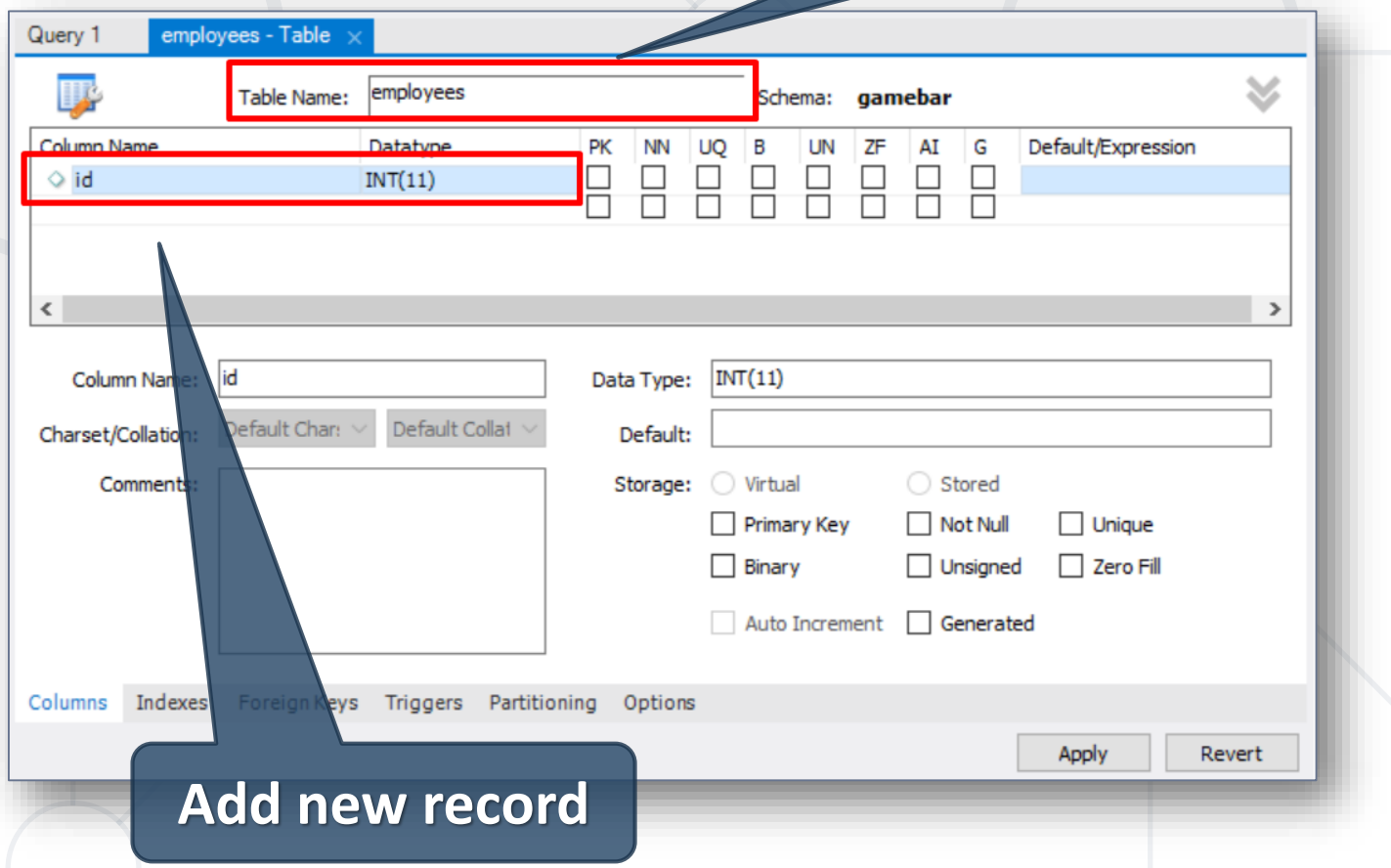
- Select **Create new schema** from the **command menu**



Creating Tables

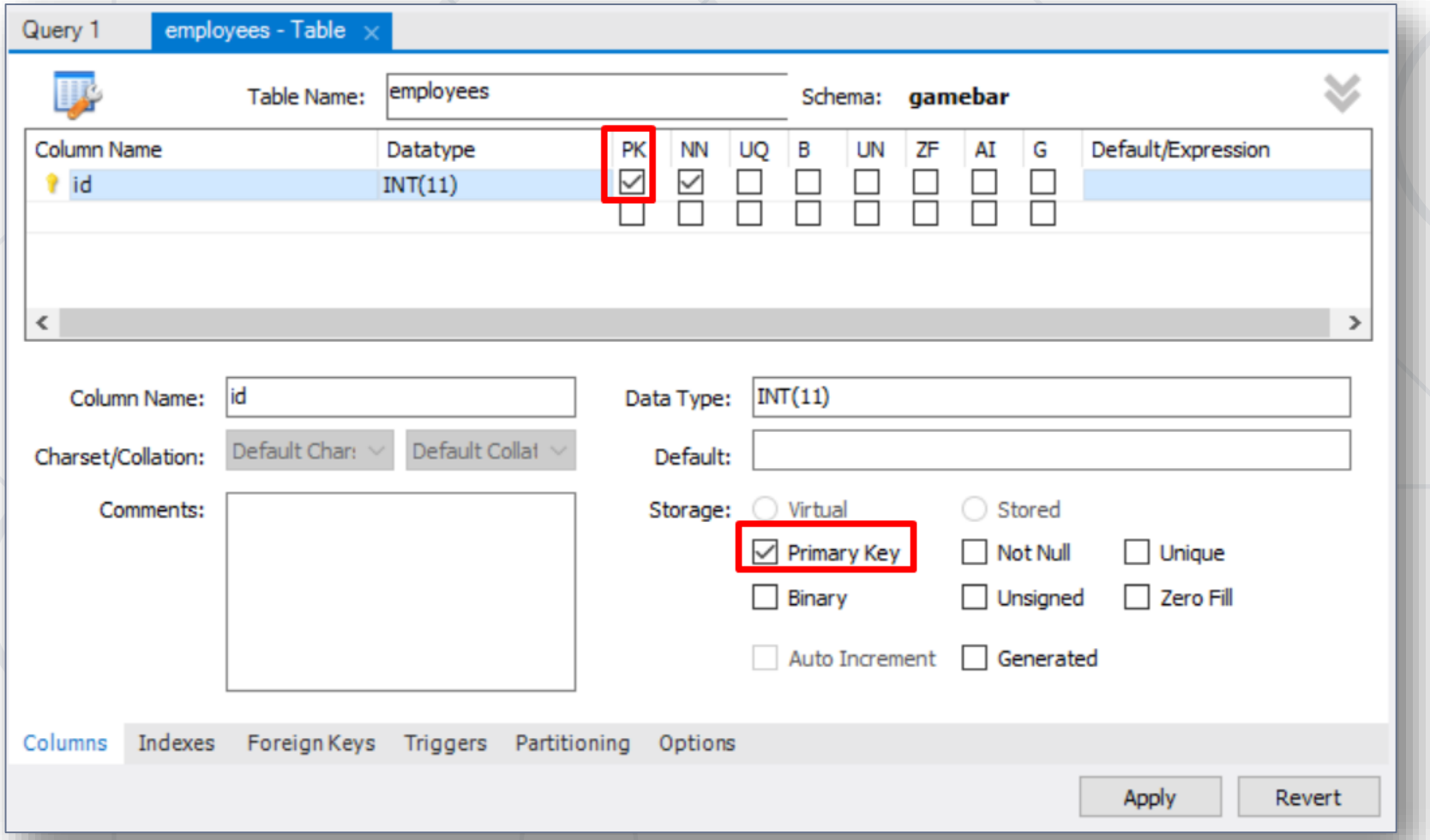
- Right click on “Tables” **Select Create Table**





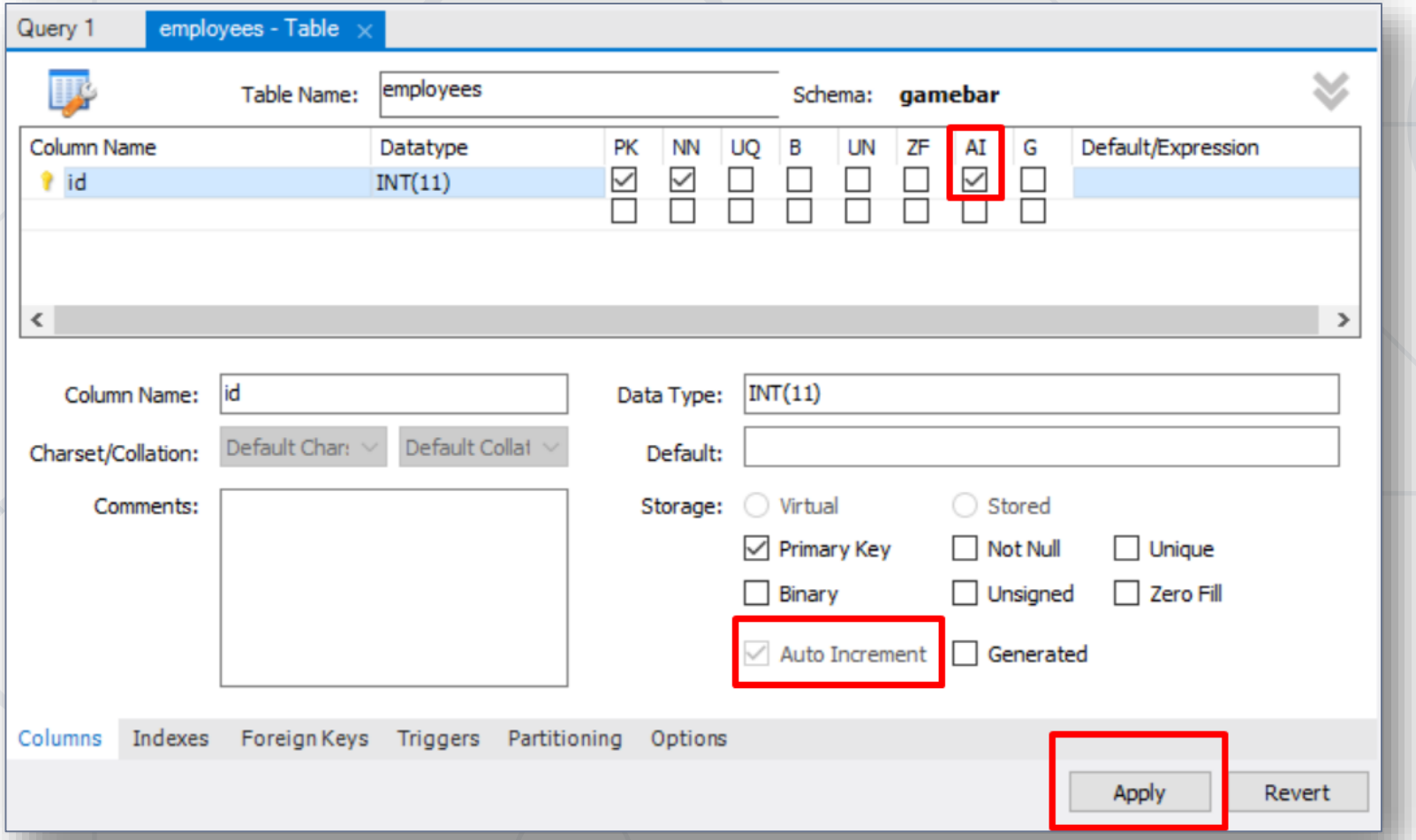
Creating Tables (2)

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



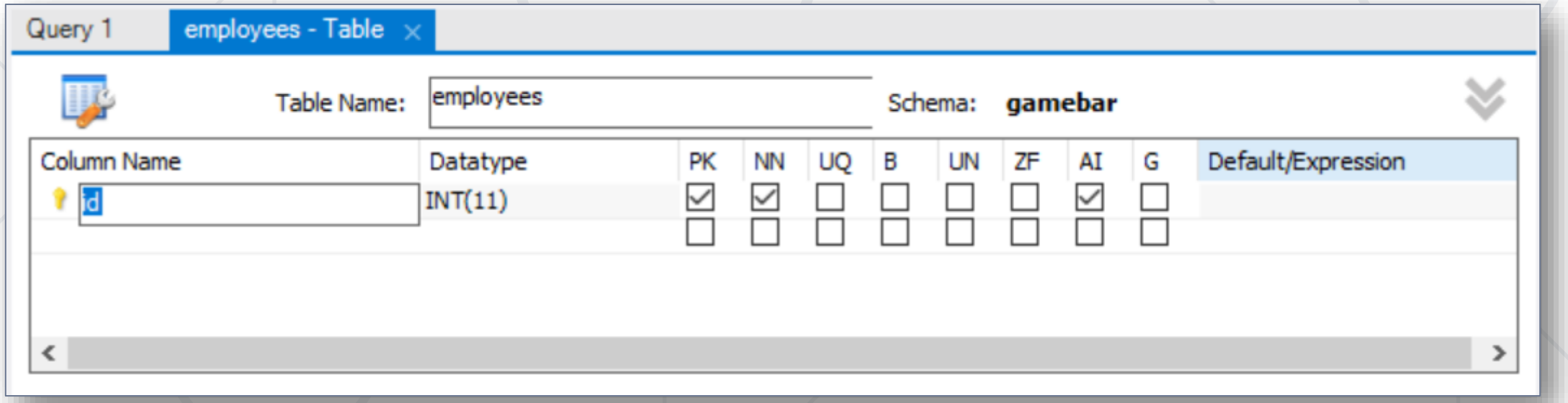
Creating Tables (3)

- 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



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

Basic SQL Queries

Data Definition using SQL

SQL Queries

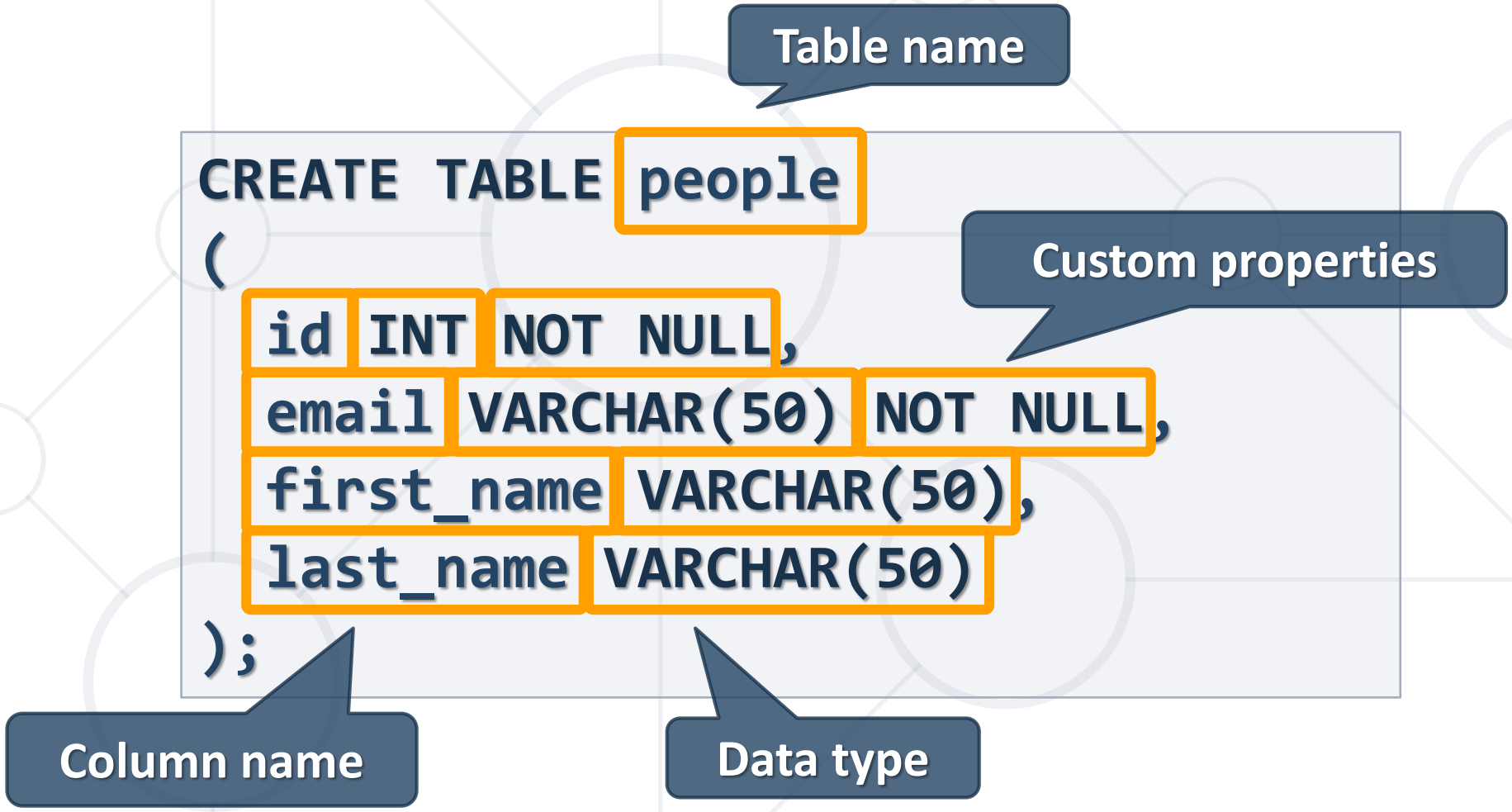
- We communicate with the database engine using SQL
- Queries provide greater **control** and **flexibility**
- To create a database using SQL:

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

Adding Rules, Constraints and Relationships

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

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Create new Database "gamebar".

1. **Create Tables**:
   - "employees" – id, first_name, last_name
   - "categories" – id, name
   - "products" – id, name, category_id
2. **Insert** Data:
   - Populate the "**employees**" table with 3 test values.

Check your solution here: https://judge.softuni.bg/Contests/729/Data-Definition-And-Data-Types-Lab

Altering Tables

Changing Table Properties After Creation

Altering Tables Using SQL

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

```
ALTER TABLE employees;
```

Table name

- Add new column

```
ALTER TABLE employees
ADD 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)

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- Set default value

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

Default value

Column name

Problems: Alter Tables

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

Check your solution here: https://judge.softuni.bg/Contests/729/Data-Definition-And-Data-Types-Lab

Deleting Data and Structures

Dropping and Truncating

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 S QL
- 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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