Table Relations

Database Design and Rules

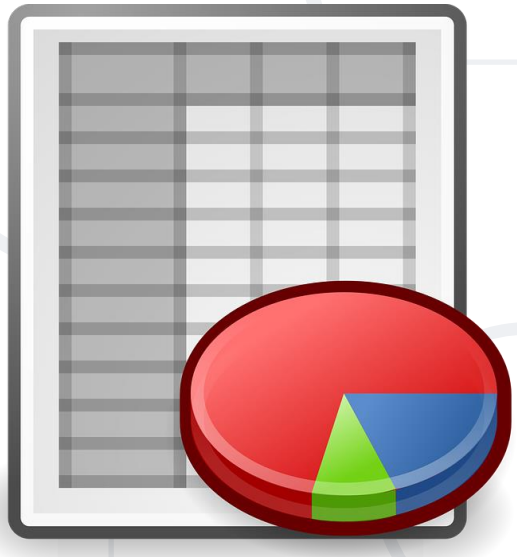

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Table of Contents

Database Design

Fundamental Concepts

Steps in Database Design

- Steps in the database design process:
  - Identify entities
  - Identify table columns
  - Define a primary key for each table
  - Identify and model relationships
  - Define other constraints
  - Fill tables with test data

DB Design: Identify Entities

- Entity tables represent objects from the real world
  - Most often they are nouns in the specification
  - For example:

> We need to develop a system that stores information about students which are trained in various courses. The courses are held in different towns. When registering a new student the following information is entered: name, faculty number, photo and date.

  - Entities: **Student**, **Course**, **Town**

DB Design: Identify Table Columns

- Columns are clarifications for the entities in the text of the specification, for example:

```
We need to develop a system that stores
information about students, which are trained
in various courses. The courses are held in
different towns. When registering a new
student the following information is entered:
name, faculty number, photo and date
```

- Students have the following characteristics:
  - **Name**, **faculty number**, **photo**, **date of enlistment** and a **list of courses** they visit

How to Choose a Primary Key?

- Always define an **additional column** for the primary key
  - Don't use an existing column (for example SSN)
  - Must be an **integer** number
  - Must be **declared** as a primary key
  - Use `IDENTITY` to implement auto-increment
  - Put the **primary key** as a **first column**
- Exceptions
  - Entities that have **well known ID**, e.g. **countries** (BG, DE, US) and **currencies** (USD, EUR, BGN)

DB Design: Identify Entity Relationships

- Relationships are **dependencies** between the entities:

```
We need to develop a system that stores
information about students, which are trained in
various courses. The courses are held in
different towns. When registering a new student,
the following information is entered: name,
faculty number, photo and date.
```

  - "**Students** are trained in courses" ➔ many-to-many relationship
  - "**Courses** are held in towns" ➔ many-to-one (or many-to-many) relationship

Database Normalization

Database Normalization

- It is a technique of organizing the data in the database
- **Normalization** is a systematic approach of **decomposing** tables to eliminate data redundancy (repetition) and undesirable characteristics like insertion, update and deletion **anomalies**
- It is a multi-step process that puts data into **tabular form** removing duplicated data from the relation tables

Normal Forms

- **First Normal Form (1NF)**
  - Table should only have single (atomic) valued attributes/columns
  - Values stored in a column should be of the same domain (same type)
  - All the columns in a table should have unique names
  - The order in which data is stored should not matter
- **Second Normal Form (2NF)**
  - The table should be in the **First Normal form**
  - It shouldn't have **Partial Dependency** (dependency on part of the primary key)
- **Third Normal Form (3NF)**
  - The table is in the **Second Normal form**
  - It doesn't have **Transitive Dependency**

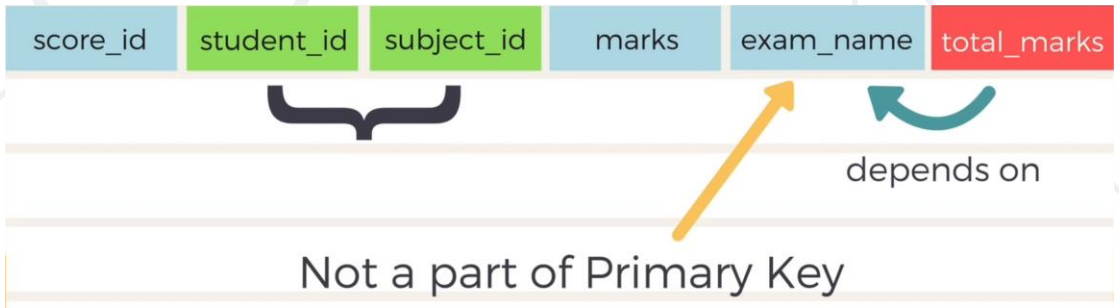
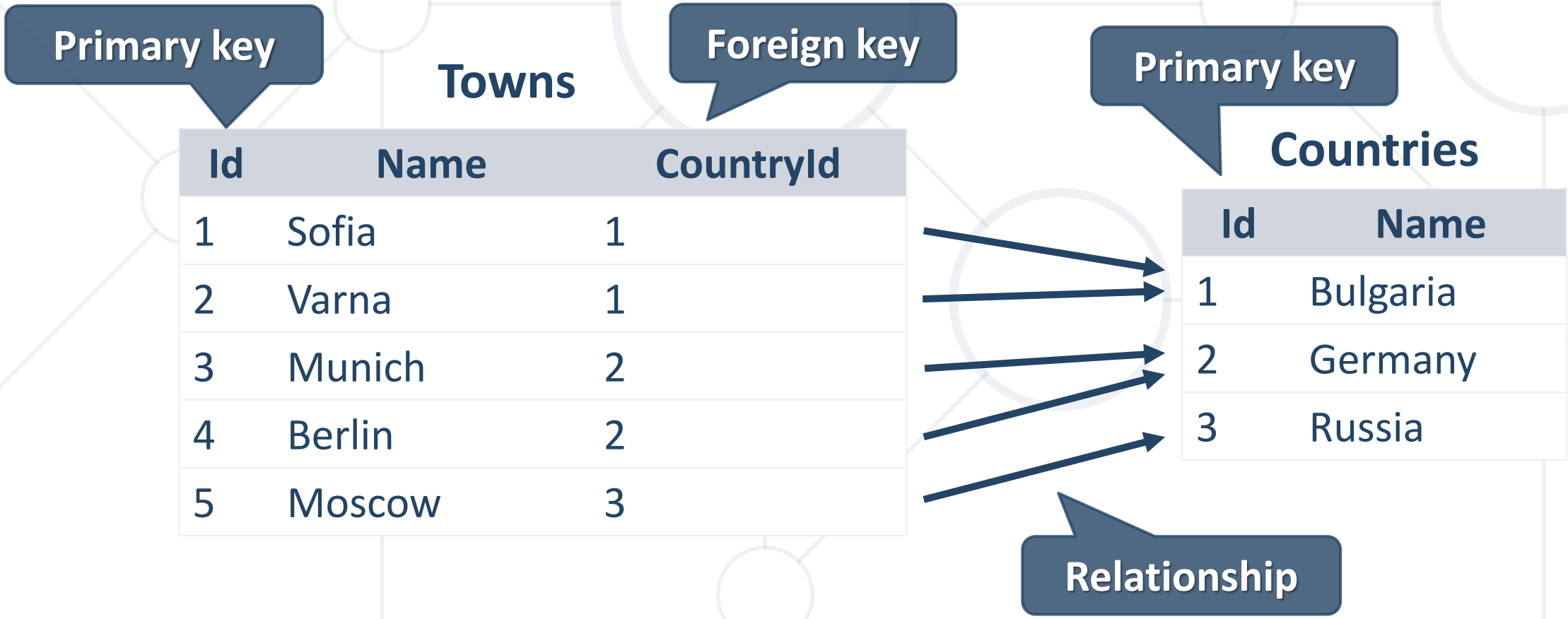


Table Relations

Relational Database Model in Action

Table Relations

- **Relationships** between tables are based on interconnections: **primary key ➔ foreign key**



Id	Name	CountryId
1	Sofia	1
2	Varna	1
3	Munich	2
4	Berlin	2
5	Moscow	3

Id	Name
1	Bulgaria
2	Germany
3	Russia

Custom Column Properties

- Primary Key

```
Id INT NOT NULL PRIMARY KEY
```

- Identity (auto-increment)

```
Id INT PRIMARY KEY IDENTITY
```

- Unique constraint – no repeating values in entire table

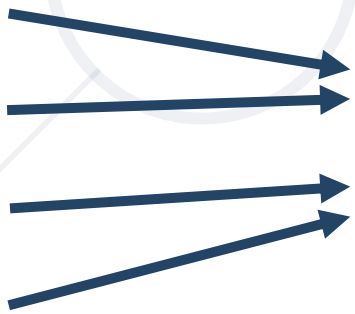
```
Email VARCHAR(50) UNIQUE
```

Table Relations: Foreign Key

- The **foreign key** is an **identifier** of a record located in **another table** (usually a primary key)
- Using relationships, we **refer** to data instead of **repeating** data
  - Country name is **not repeated**, it is **referred** to by its **primary key**

Towns

Id	Name	CountryId
1	Sofia	1
2	Varna	1
3	Munich	2
4	Berlin	2



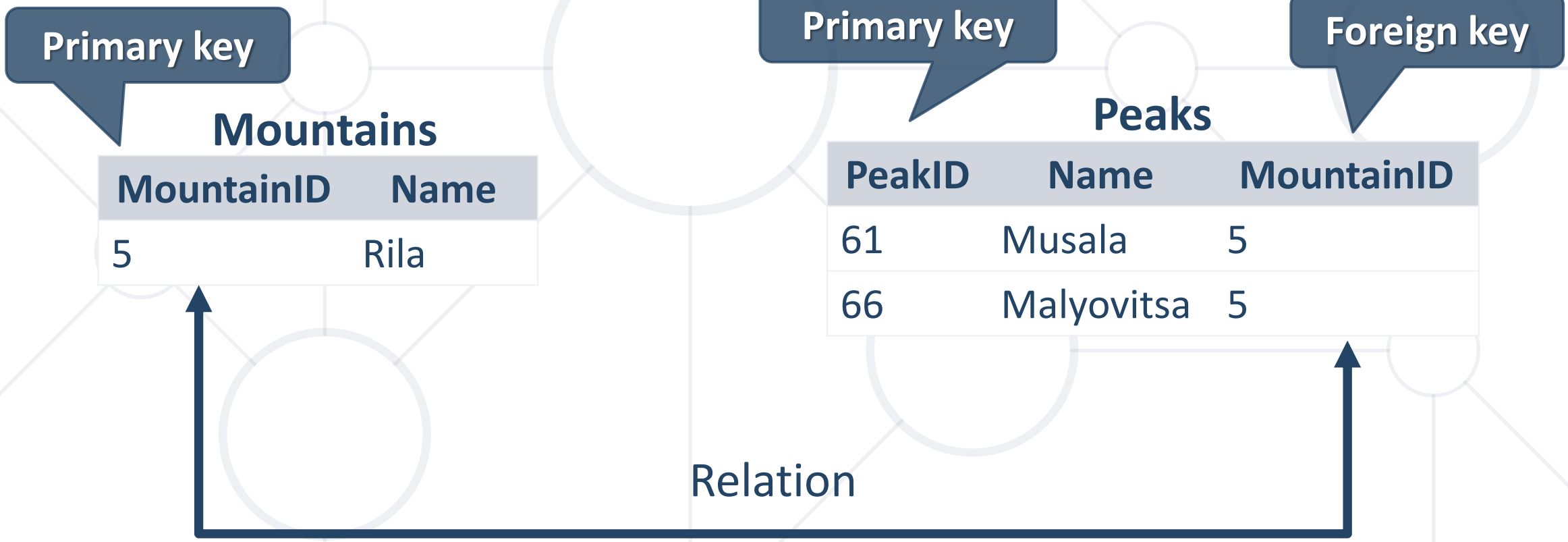
Countries

Id	Name
1	Bulgaria
2	Germany

Table Relations: Multiplicity

- **One-to-many** – e.g. country / towns
  - One country has many towns
- **Many-to-many** – e.g. student / course
  - One student has many courses
  - One course has many students
- **One-to-one** – e.g. example driver / car
  - One driver has only one car
  - Rarely used

One-to-Many/Many-to-One



One-to-Many: Tables

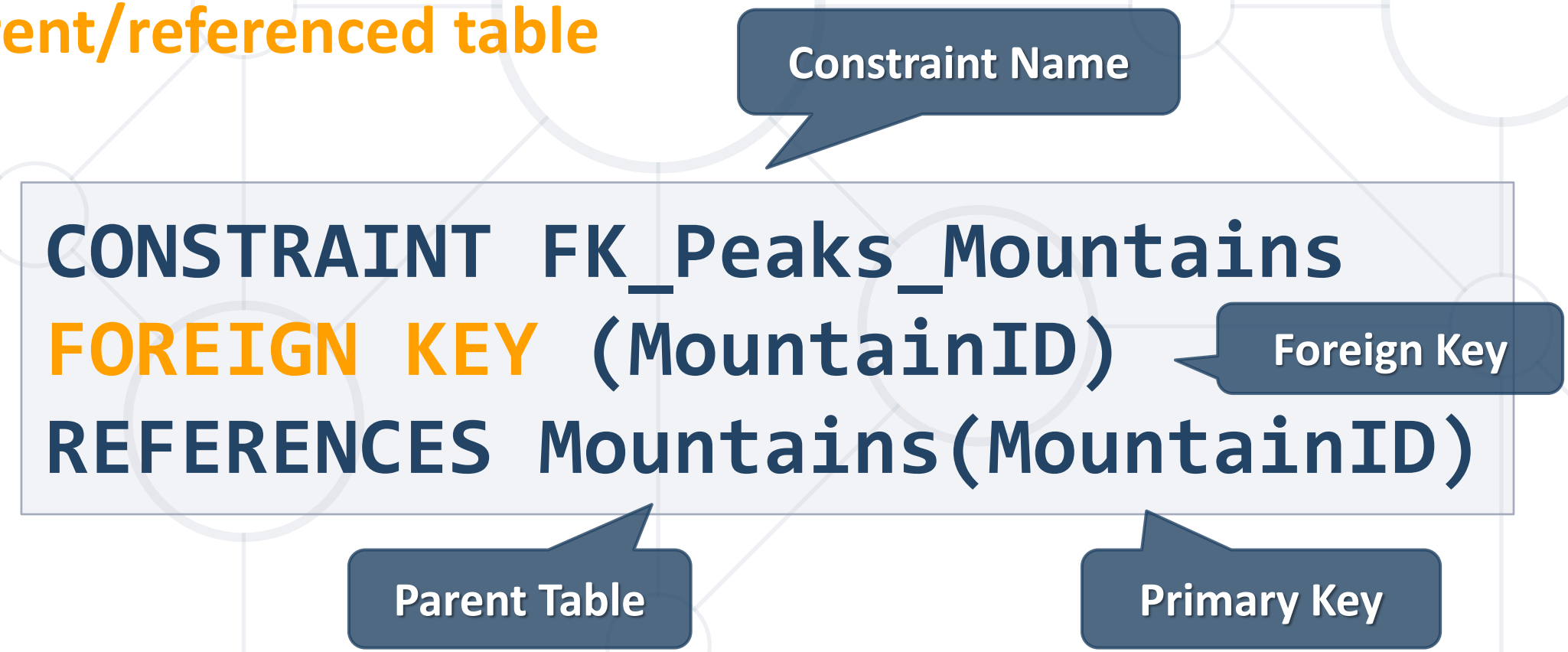
```
CREATE TABLE Mountains(
  MountainID INT PRIMARY KEY,
  MountainName VARCHAR(50)
)

CREATE TABLE Peaks(
  PeakId INT PRIMARY KEY,
  MountainID INT,
  CONSTRAINT FK_Peaks_Mountains
  FOREIGN KEY (MountainID)
  REFERENCES Mountains(MountainID)
)
```

Primary key

Foreign Key

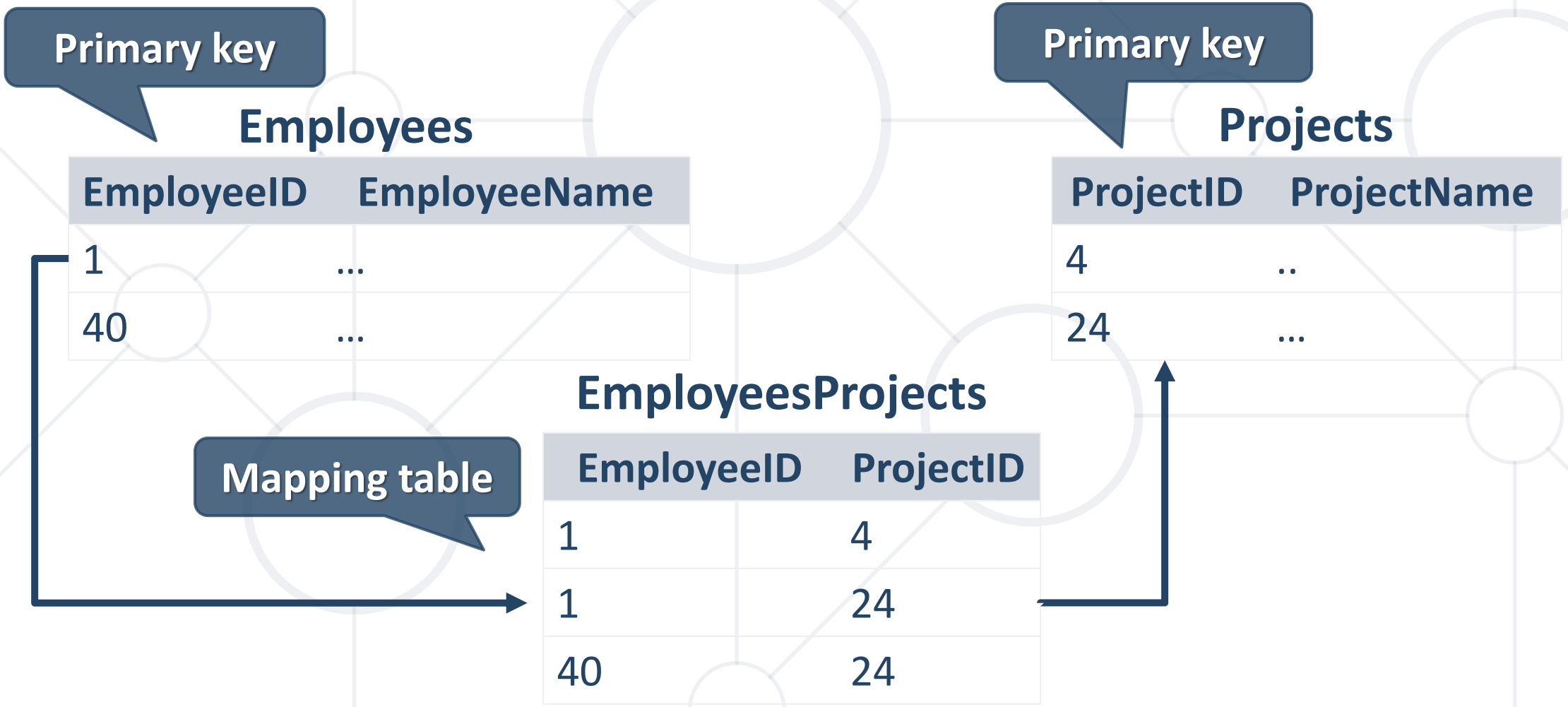
One-to-Many: Foreign Key

- The table holding the **foreign key** is the **child table**
- The table holding the **referenced primary key** is the **parent/referenced table**



Many-to-Many

- **Many-to-many relations** use a **mapping/join table**



Many-to-Many: Tables

```
CREATE TABLE Employees(
   EmployeeID INT PRIMARY KEY,
   EmployeeName VARCHAR(50)
)

CREATE TABLE Projects(
   ProjectID INT PRIMARY KEY,
   ProjectName VARCHAR(50)
)
```

Many-to-Many: Mapping Table

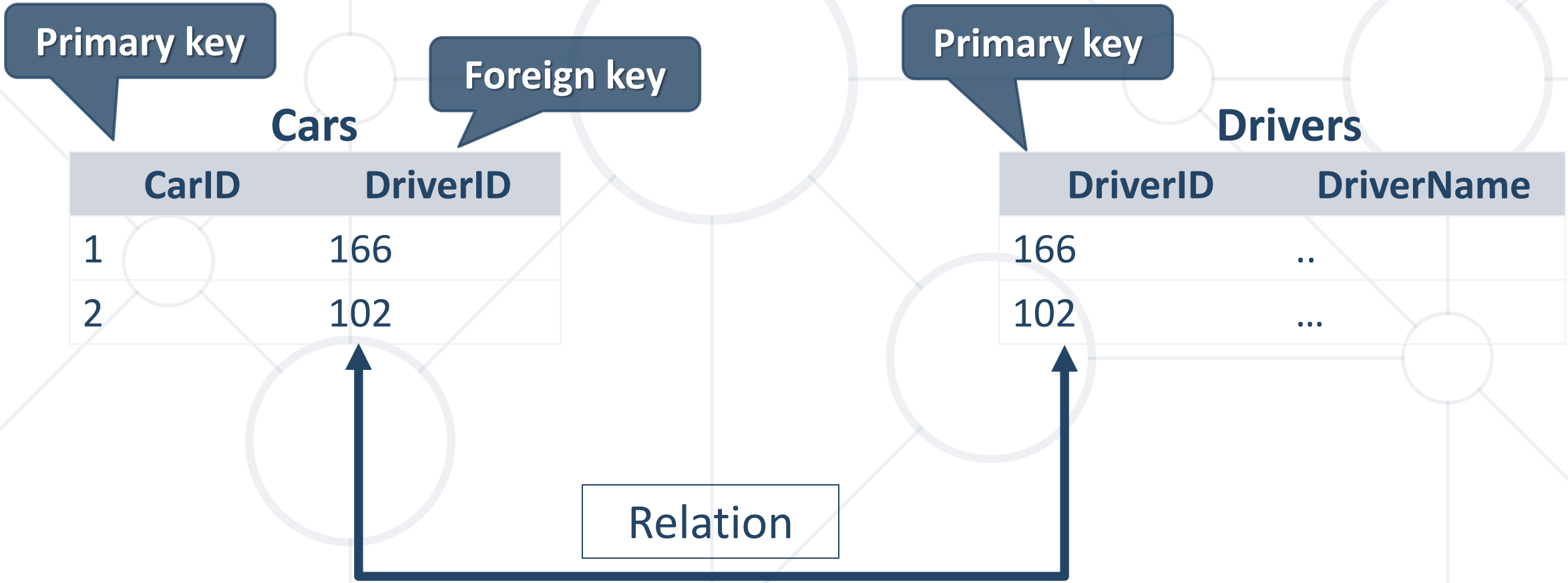
```
CREATE TABLE EmployeesProjects(
  EmployeeID INT,
  ProjectID INT,
  CONSTRAINT PK_EmployeesProjects
  PRIMARY KEY(EmployeeID, ProjectID),
  CONSTRAINT FK_EmployeesProjects_Employees
  FOREIGN KEY(EmployeeID)
  REFERENCES Employees(EmployeeID),
  CONSTRAINT FK_EmployeesProjects_Projects
  FOREIGN KEY(ProjectID)
  REFERENCES Projects(ProjectID)
)
```

Composite Primary Key

Foreign Key to Employees

Foreign Key to Projects

One-to-One


Primary key
Foreign key
Cars
CarID
DriverID
1
166
2
102
Primary key
Drivers
DriverID
DriverName
166
..
102
...
Relation

One-to-One

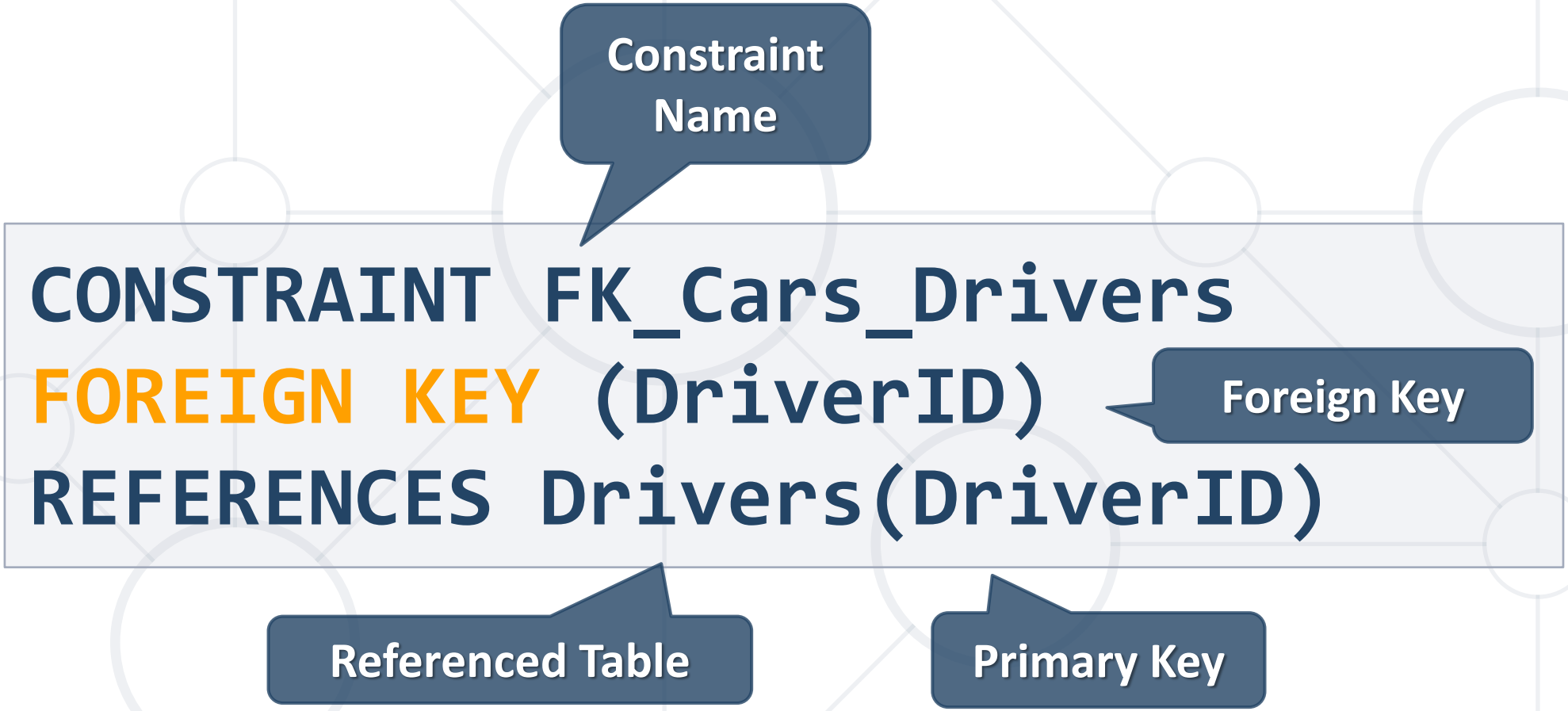
```
CREATE TABLE Drivers(
  DriverID INT PRIMARY KEY,
  DriverName VARCHAR(50)
)

CREATE TABLE Cars(
  CarID INT PRIMARY KEY,
  DriverID INT UNIQUE,
  CONSTRAINT FK_Cars_Drivers FOREIGN KEY
  (DriverID) REFERENCES Drivers(DriverID)
)
```

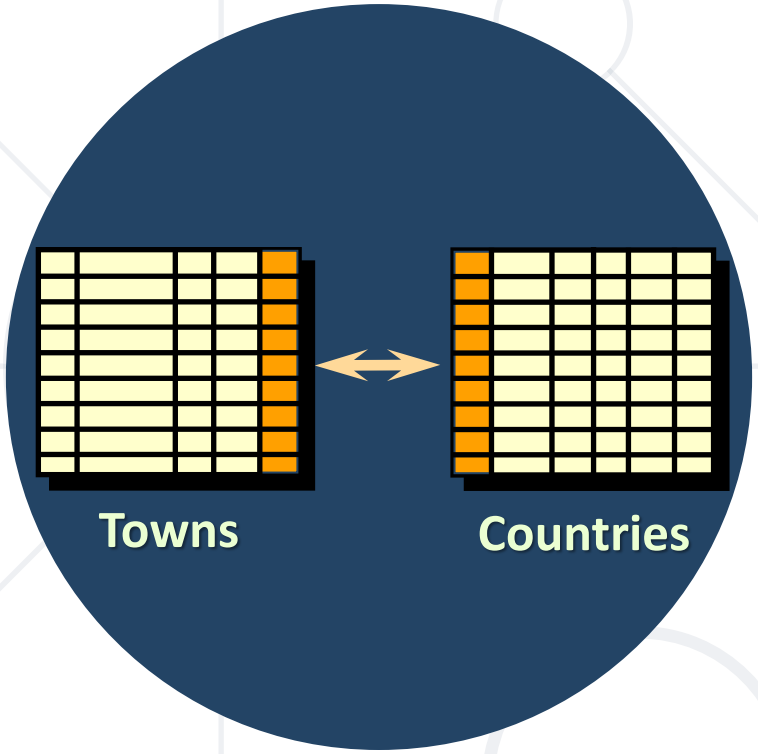
Primary key

One driver per car

Foreign Key

One-to-One: Foreign Key





Retrieving Related Data

Using Simple JOIN Statements

JOIN Statements

- With a **JOIN** statement, we can get data from two tables **simultaneously**
  - **JOINs** require at least two tables and a "**join condition**"

```
SELECT * FROM Towns
  JOIN Countries ON
    Countries.Id = Towns.CountryId
```

Join Condition

Problem: Peaks in Rila

- Use database "**Geography**". Report all peaks for "**Rila**" mountain.
  - Report includes mountain's name, peak's name and also peak's elevation
  - Peaks should be **sorted** by elevation descending

	MountainRange	PeakName	Elevation
1	Rila	Musala	2925
2	Rila	Malka Musala	2902
3	Rila	Malyovitsa	2729
4	Rila	Orlovets	2685

Check your solution here: https://judge.softuni.org/Contests/Compete/Index/292#6

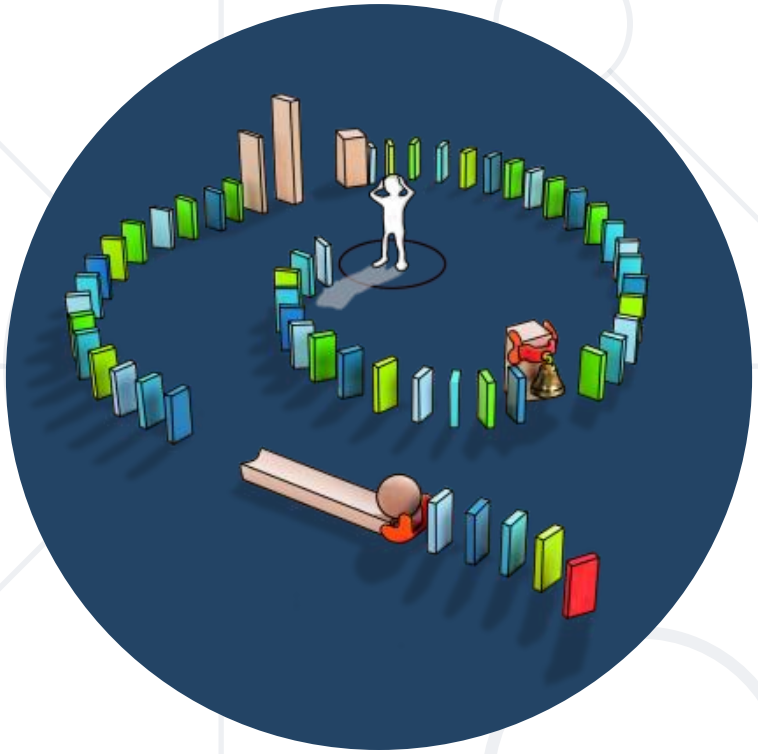
Solution: Peaks in Rila

Cross Table Selection

```
   SELECT m.MountainRange, p.PeakName, p.Elevation
     FROM Mountains AS m
     JOIN Peaks As p ON p.MountainId = m.Id
    WHERE m.MountainRange = 'Rila'
ORDER BY p.Elevation DESC
```

Join Condition

Check your solution here: https://judge.softuni.org/Contests/Compete/Index/292#6

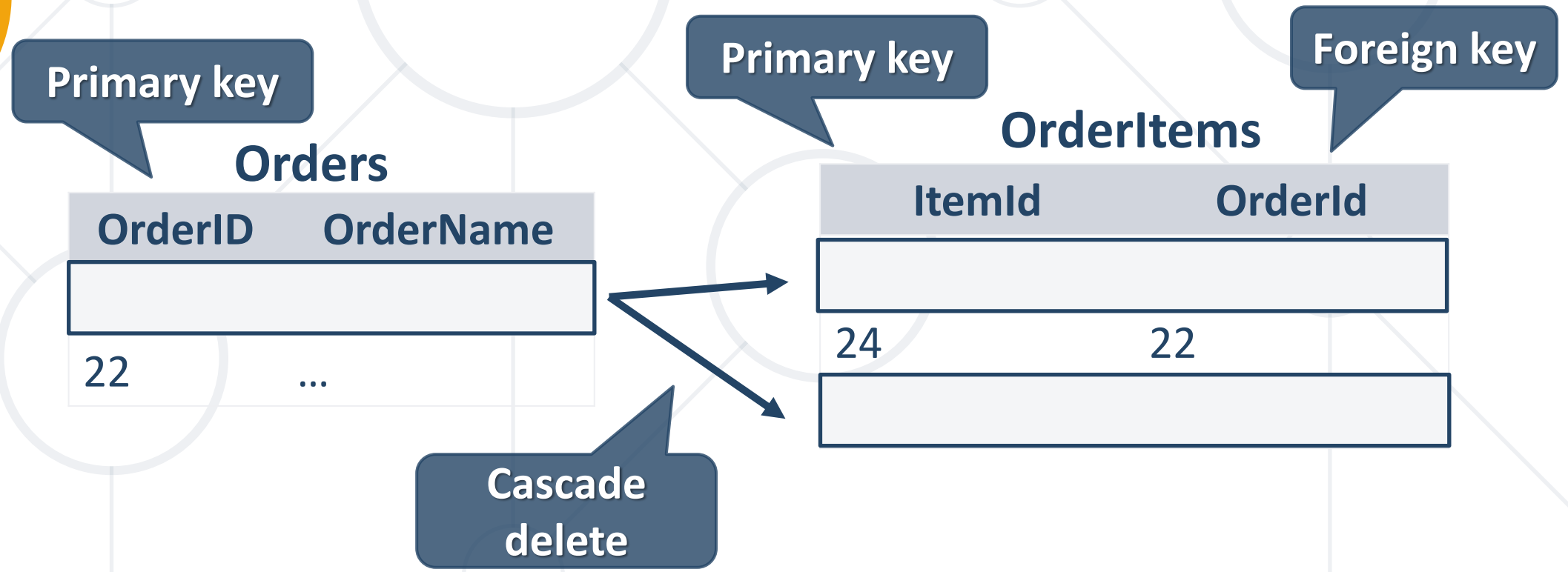


Cascade Operations

Cascade Delete/Update

Definition

- Cascading allows when a change is made to certain entity, this change to apply to all related entities



Cascade Delete

- **Cascade** can be either **Delete** or **Update**
- Use **Cascade Delete** when:
  - The related entities are **meaningless** without the "main" one
- Do **not** use **Cascade Delete** when:
  - You perform a "**logical delete**"
    - Entities are **marked** as deleted (but not actually deleted)
  - In more complicated relations, cascade delete won't work with **circular** references

Cascade Update

- Use **Cascade Update** when:
  - The primary key is not identity (not auto-increment) and therefore it **can** be changed
  - Best used with unique constraint
- Do **not** use **Cascade Update** when:
  - The primary is identity (auto-increment)
- Cascading can be avoided using **triggers** or **procedures**

Cascade Delete: Example

```
CREATE TABLE Drivers(
  DriverID INT PRIMARY KEY,
  DriverName VARCHAR(50)
)

CREATE TABLE Cars(
  CarID INT PRIMARY KEY,
  DriverID INT,
  CONSTRAINT FK_Car_Driver FOREIGN KEY(DriverID)
  REFERENCES Drivers(DriverID) ON DELETE CASCADE
)
```

Foreign Key

Cascade

Cascade Update: Example

```
CREATE TABLE Products(
  BarcodeId INT PRIMARY KEY,
  Name VARCHAR(50)
)

CREATE TABLE Stock(
  Id INT PRIMARY KEY,
  Barcode INT,
  CONSTRAINT FK_Stock_Products FOREIGN KEY(BarcodeId)
  REFERENCES Products(BarcodeId) ON UPDATE CASCADE
)
```

Foreign Key

Cascade

E/R Diagrams

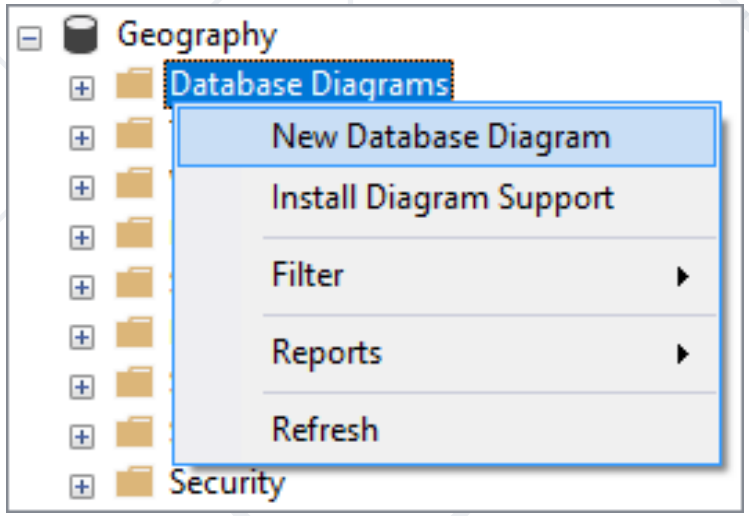
Entity / Relationship Diagrams

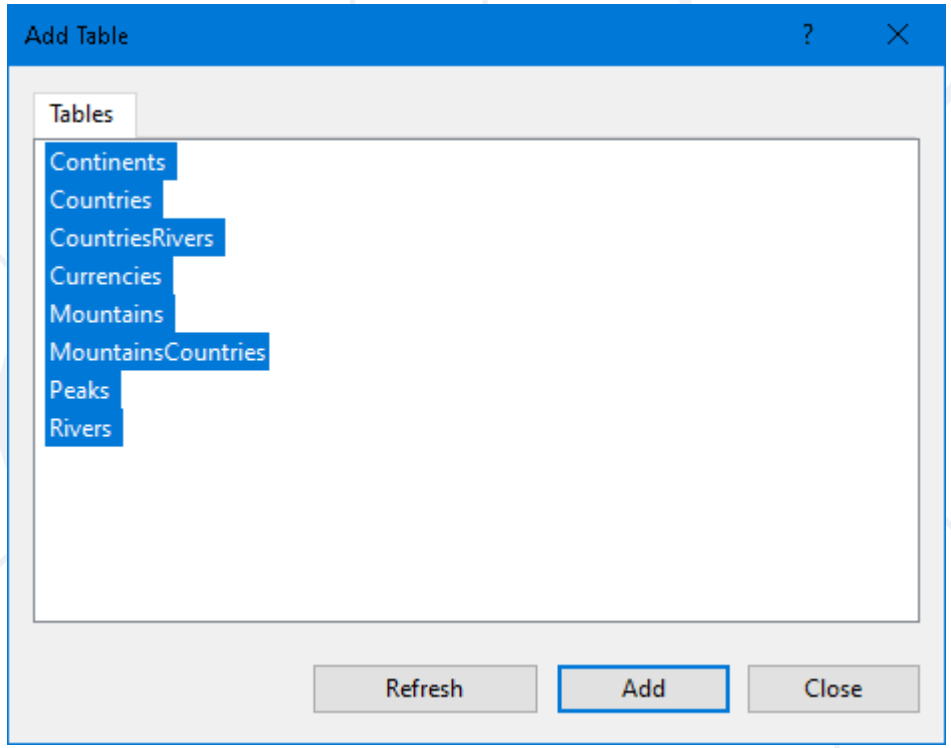
Relational Schema

- **Relational schema** of a DB is the collection of:
  - The schemas of all tables
  - Relationships between the tables
  - Any other database objects (e.g. constraints)
- The relational schema describes the structure of the database
  - Doesn't contain data, but metadata
- Relational schemas are graphically displayed in Entity / Relationship diagrams (**E/R Diagrams**)

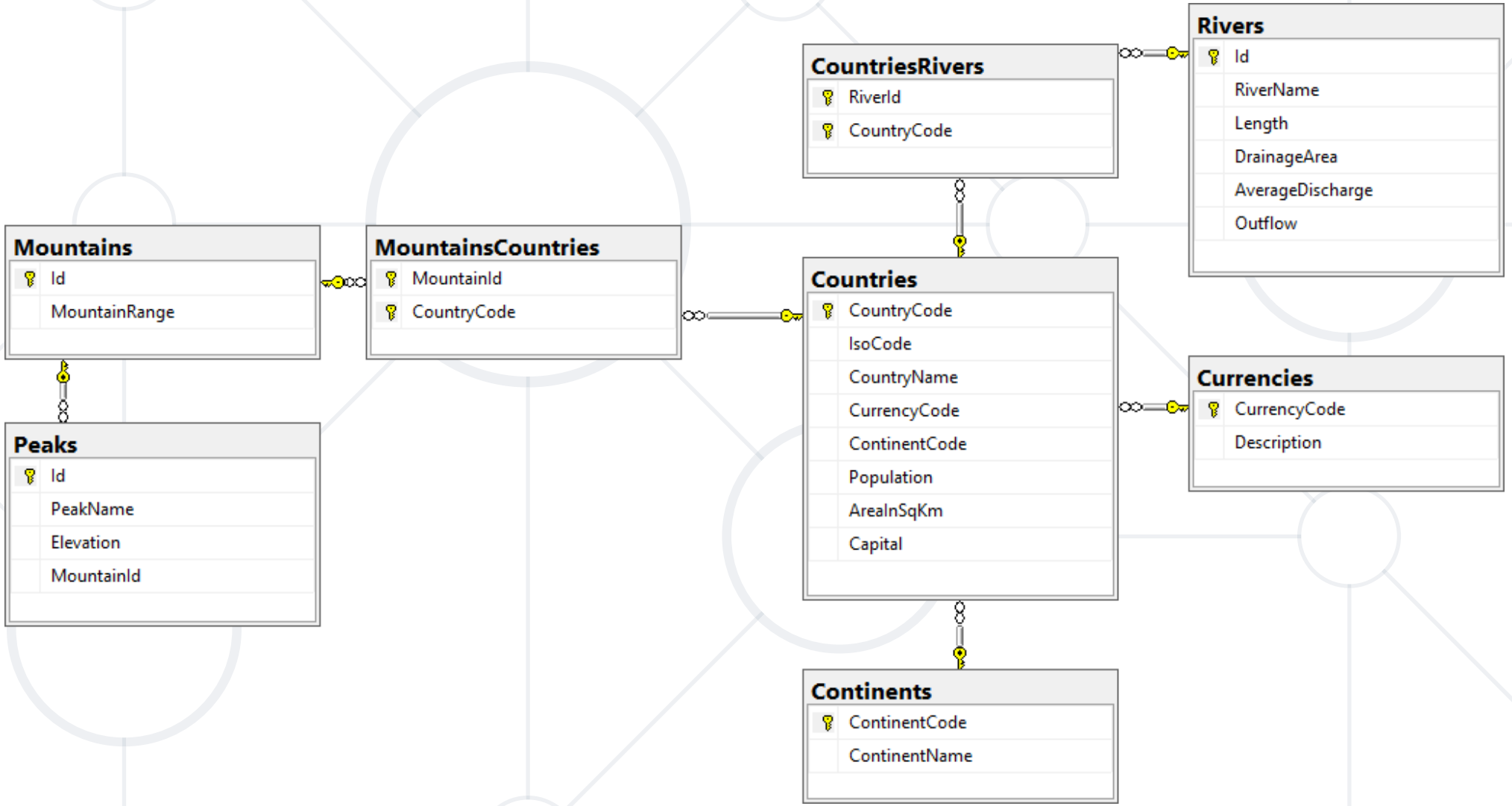
SSMS E/R Diagram: Usage

- Expand a database in **Object Explorer**
  - Right click "**Database Diagrams**" then select "**New Database Diagram**"





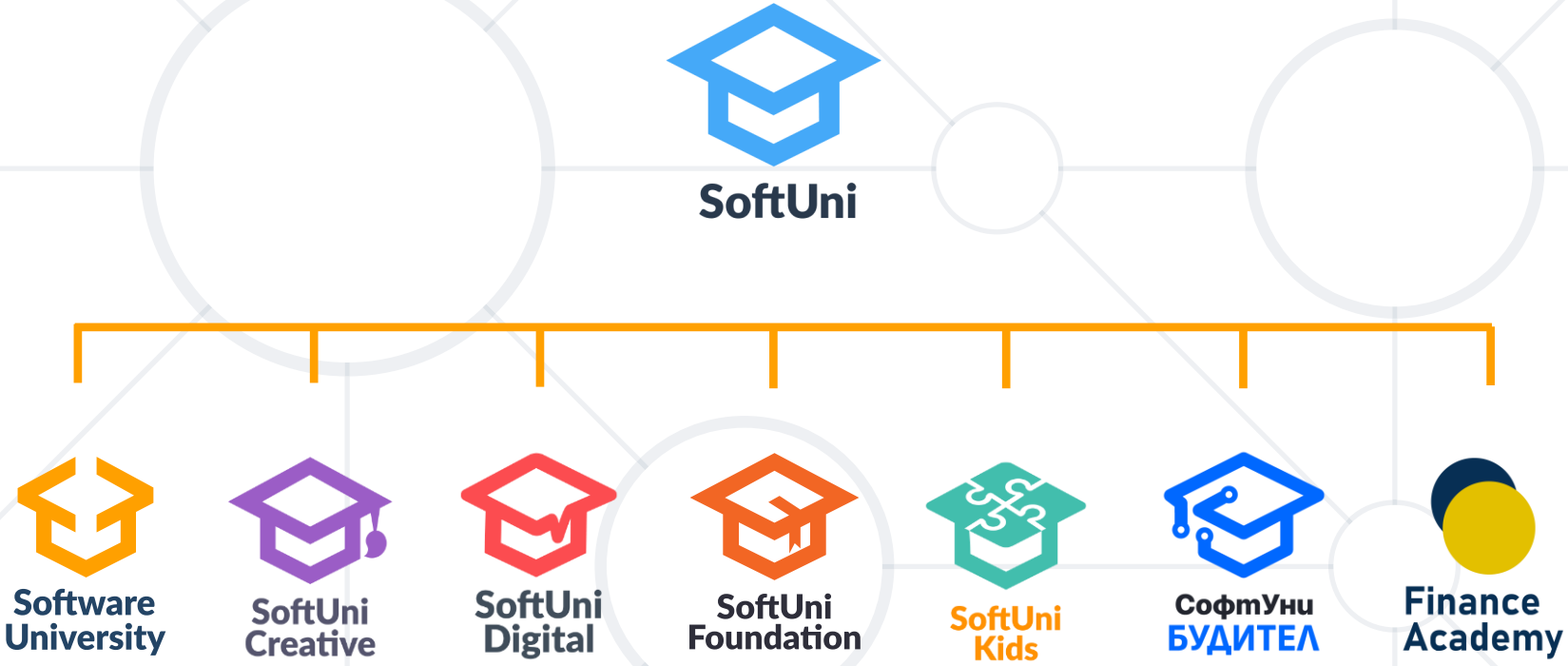
SSMS E/R Diagram



Summary

- Design **multiple** tables with related data
- Types of table relations
- **Cascading** – Pros and Cons
- Entity / Relationship Diagrams

Questions?



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