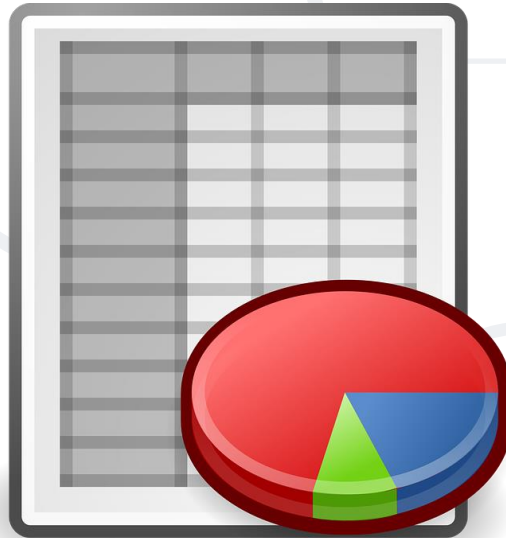


Table Relations

Database Design and Rules



SoftUni Team
Technical Trainers



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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



- 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**

- 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)

- 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



■ 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**

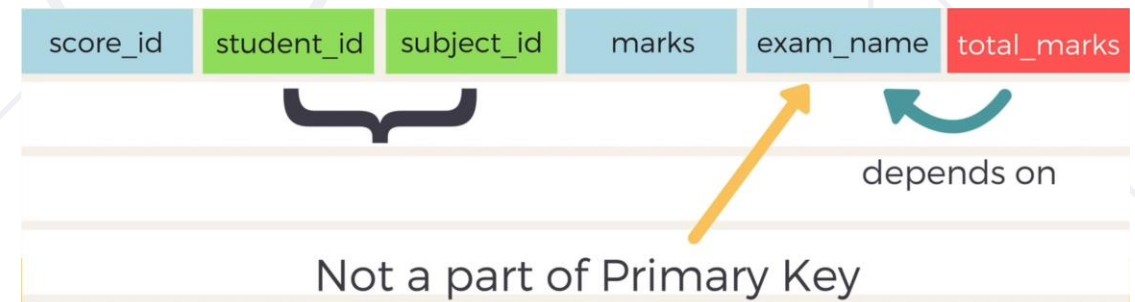
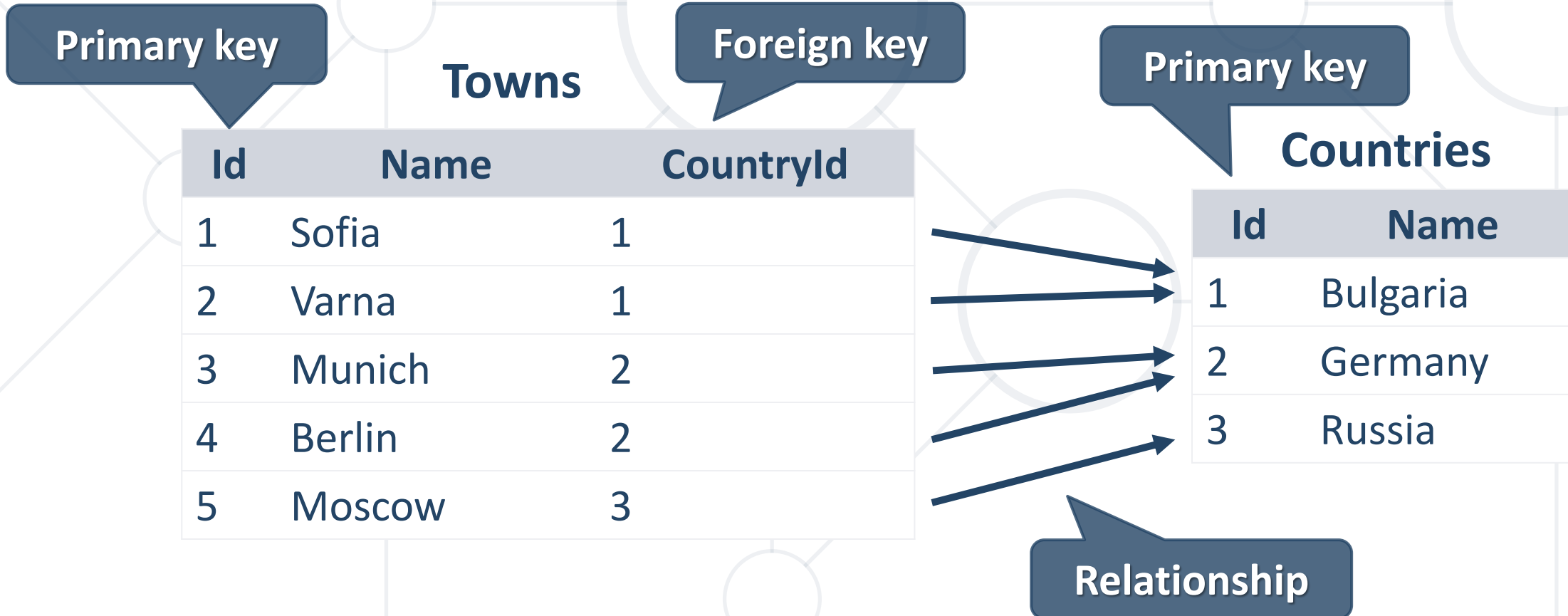




Table Relations

Relational Database Model in Action

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



- 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**

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

Id	Name
1	Bulgaria
2	Germany

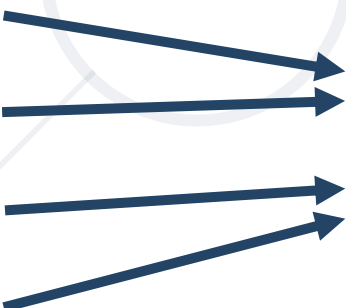
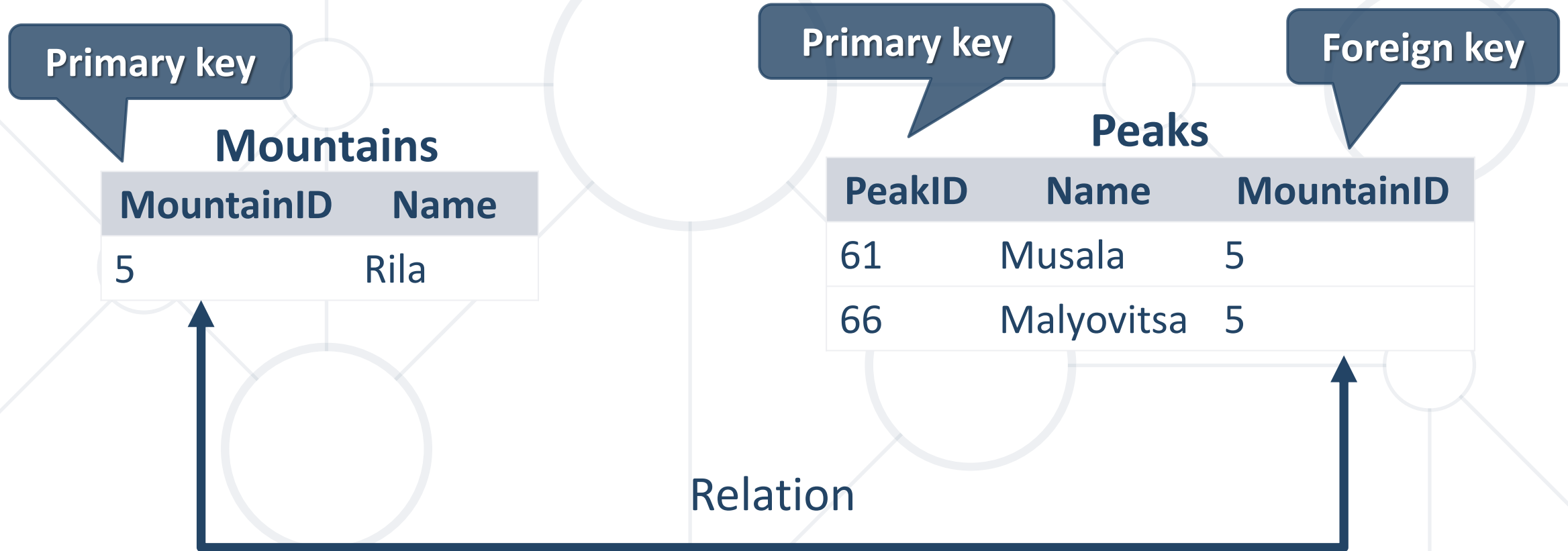


Table Relations: Multiplicity

- **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)  
)
```

Primary key

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

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**

```
CONSTRAINT FK_Peaks_Mountains  
FOREIGN KEY (MountainID)  
REFERENCES Mountains(MountainID)
```

Constraint Name

Foreign Key

Parent Table

Primary Key

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

Primary key

Employees

EmployeeID	EmployeeName
1	...
40	...

Primary key

Projects

ProjectID	ProjectName
4	..
24	...

Mapping table

EmployeesProjects

EmployeeID	ProjectID
1	4
1	24
40	24

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),
```

Composite
Primary Key

```
    CONSTRAINT FK_EmployeesProjects_Employees  
    FOREIGN KEY(EmployeeID)
```

Foreign Key to
Employees

```
    REFERENCES Employees(EmployeeID),
```

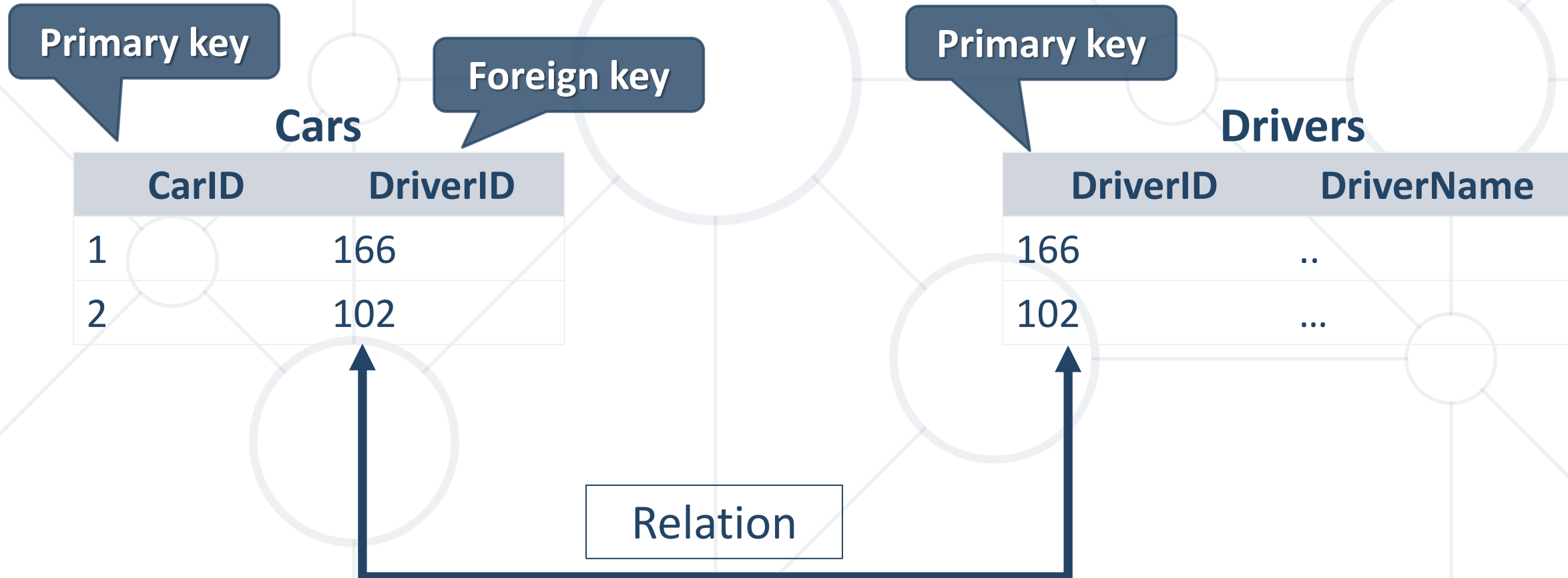
```
    CONSTRAINT FK_EmployeesProjects_Projects  
    FOREIGN KEY(ProjectID)
```

Foreign Key to
Projects

```
    REFERENCES Projects(ProjectID)
```

```
)
```

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

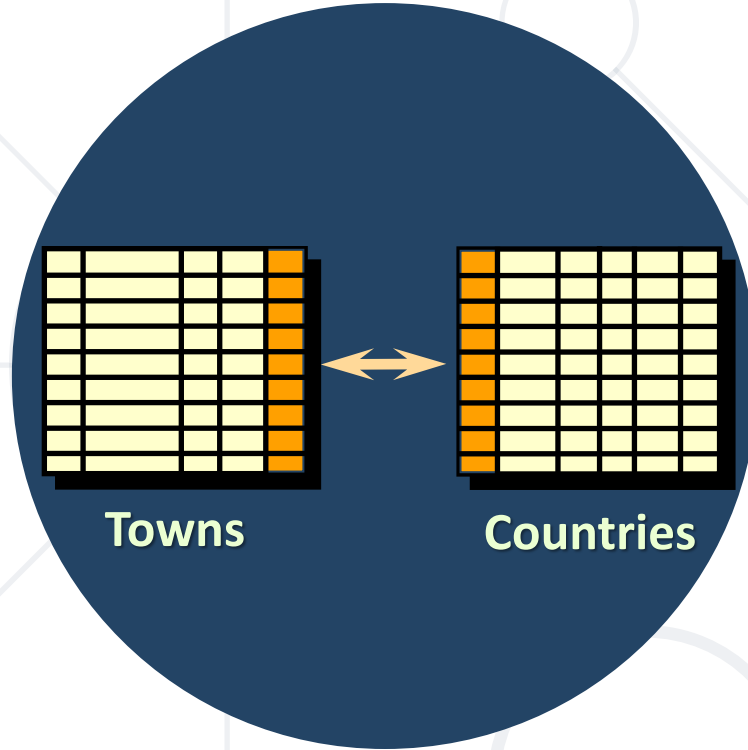
```
CONSTRAINT FK_Cars_Drivers  
FOREIGN KEY (DriverID)  
REFERENCES Drivers(DriverID)
```

Constraint
Name

Foreign Key

Referenced Table

Primary Key



Retrieving Related Data

Using Simple 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

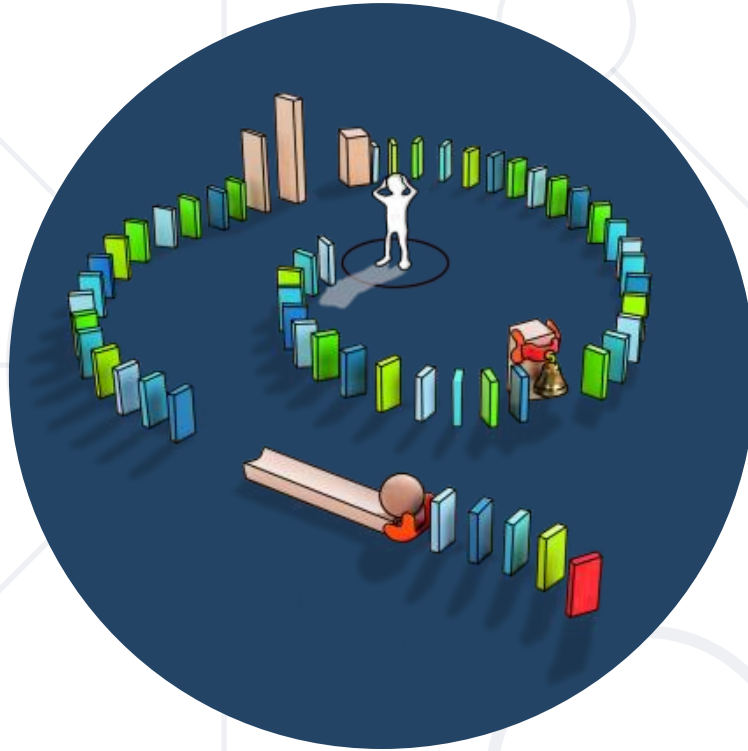
Check your solution here: <https://judge.softuni.org/Contests/Compete/Index/292#6>

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>

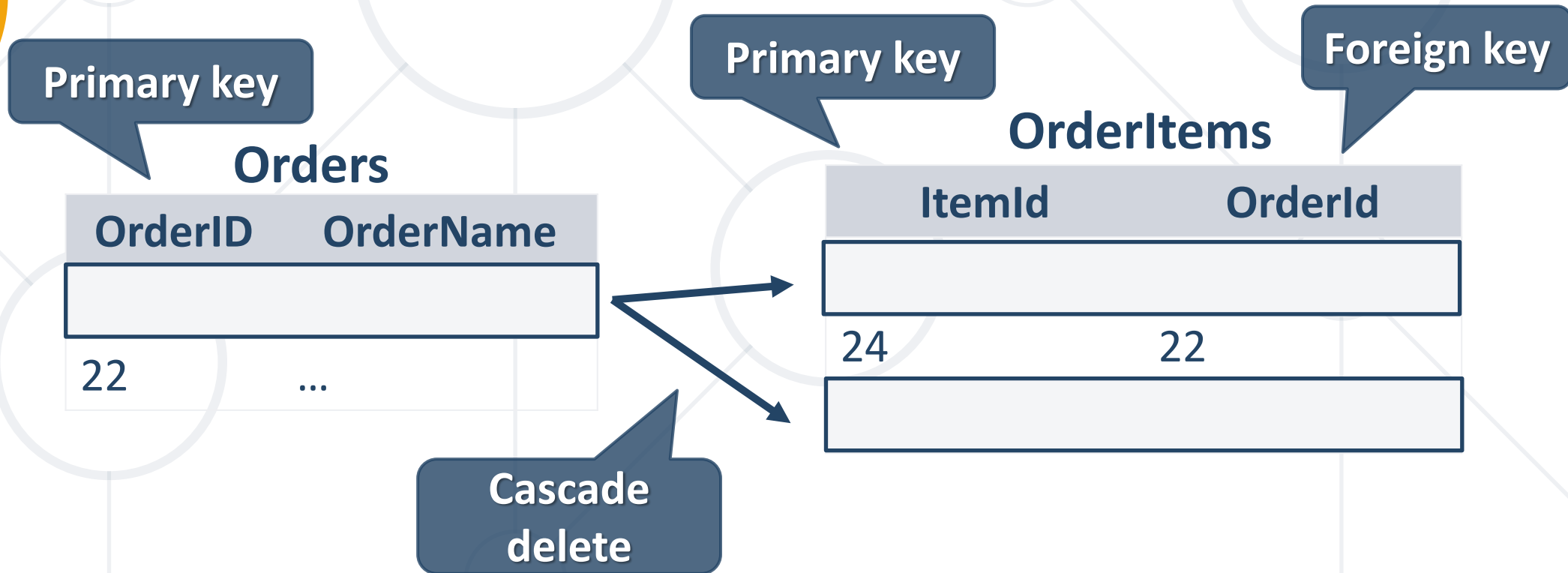


Cascade Operations

Cascade Delete/Update

Definition

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



- **Cascade** 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

- 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

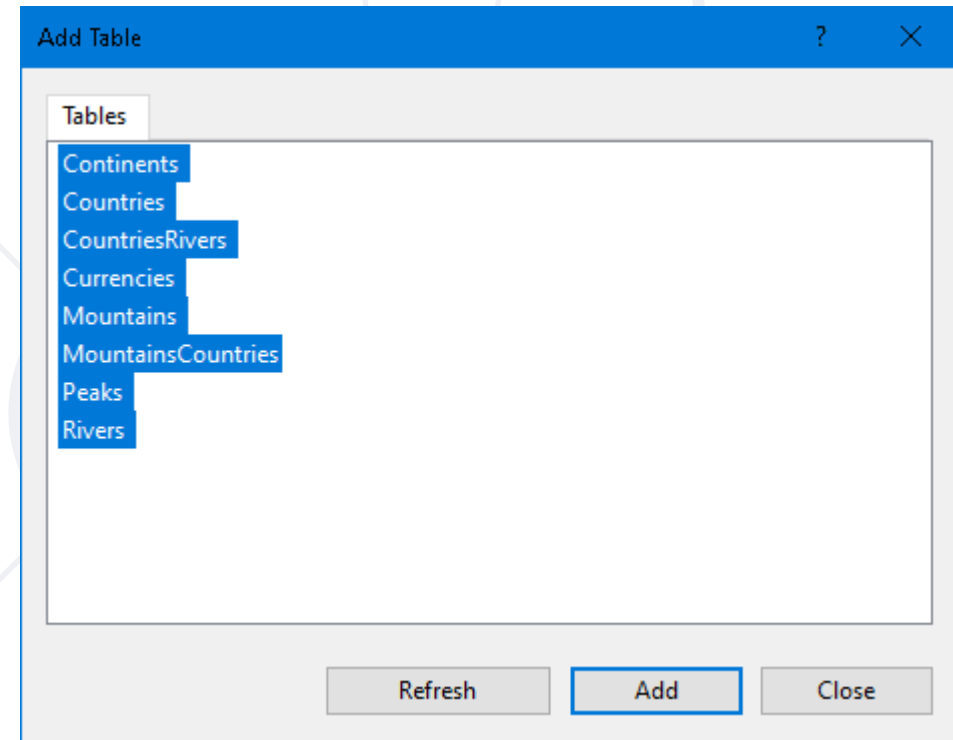
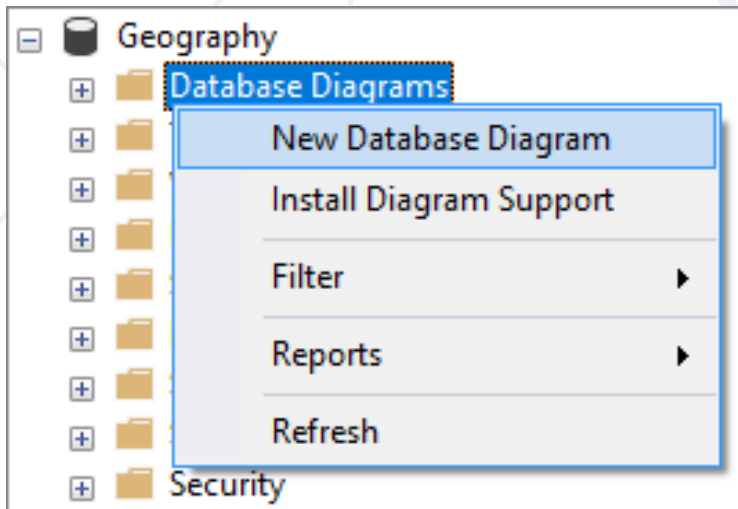
Relational Schema

- **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**)

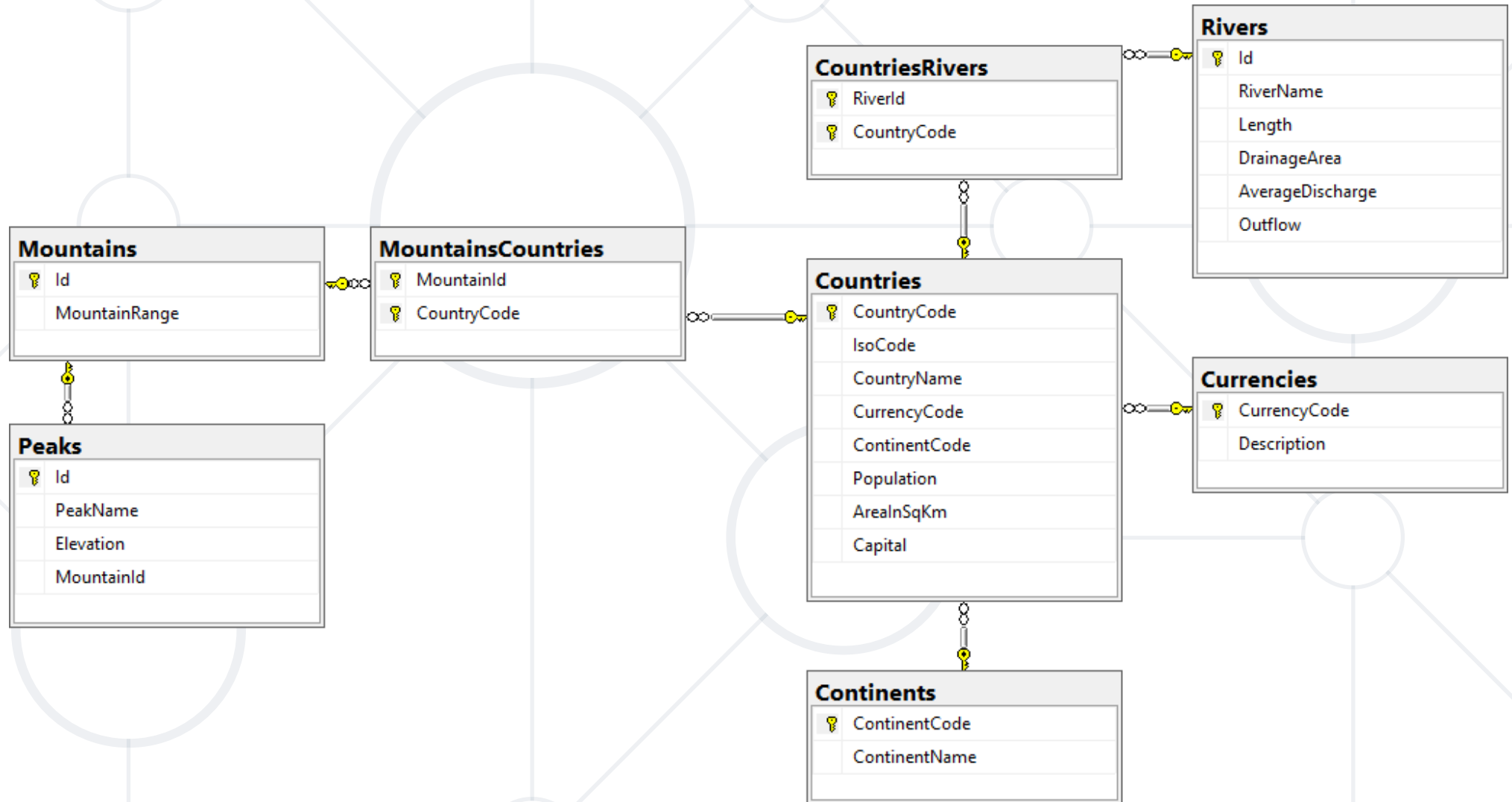


SSMS E/R Diagram: Usage

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



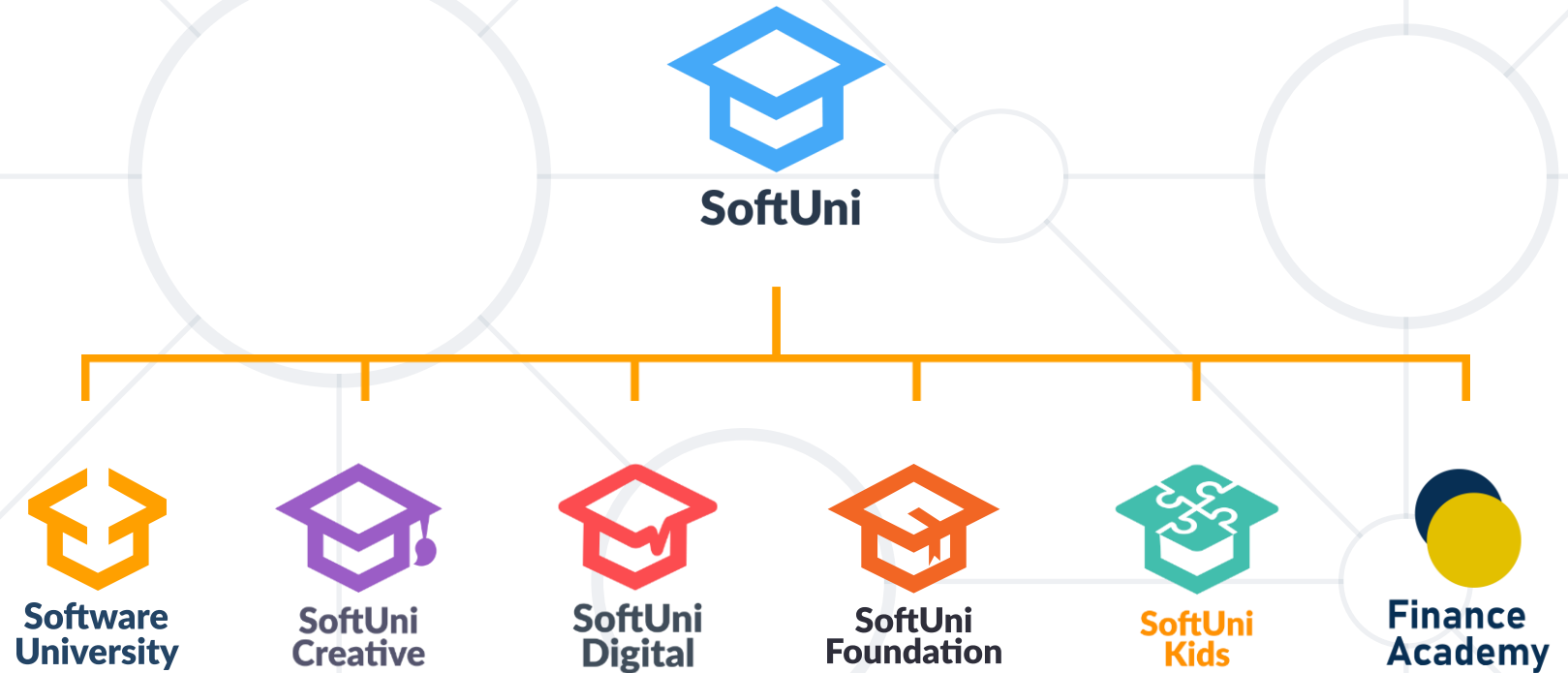
SSMS E/R Diagram



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



Questions?



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