# Database Modeling and Database Systems — Units 3 & 4

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TOPIC OUTLINE

UNIT 3

# CONCEPTION AND MODELING OF RELATIONAL DATABASES

# Study goals

- Design a database using an Entity Relationship Model (ERD).
- Model relationships among tables within an ERD.
- Normalize the tables in a database.

# EXPLAIN SIMPLY

1. Why is it necessary to design a database before starting implementation?
2. Is data redundancy a desired or undesired feature in a relational database?
3. Must a Primary Key be defined in each table in a relational database?

# Introduction

Before a relational database can be created, a model of the data to be stored is created and then optimized for efficient use as a relational data schema. This lesson introduces the **Entity Relationship Model**—a standard data modeling structure—and teaches which relationship types to consider. We will also discuss the concept of normal forms.

# The Entity Relationship Model

The Entity Relationship Model (ERM) is an iterative process of creating a structure for a relational database. This process involves:

- Creating a technical data model from a business data model.
- Determining how data are structured in a Database Management System (DBMS).
- Using graphical modeling languages for design and documentation.

# Elements of an ER Model

- **Entities**: Represented as rectangles in diagrams.
- **Attributes**: Shown as ovals connected to their entities.
- **Keys**: Attributes that uniquely identify an entity instance, often underlined.
- **Relationships**: Illustrated as lines connecting entities; can have attributes too.

**TIP:** Relationships in ER models are akin to those in UML class diagrams.

# Graphical Notation of Entities and Attributes in ER Models

Different notations for ER diagrams:

- **Chen notation**: Uses rectangles for entities and ovals for attributes.
- **Martin notation** (Crow's foot): Displays entities in rectangles with attributes listed inside.
- **UML class diagram**: Models entities as classes with attributes inside.

# Relationships and Cardinalities in ER Models

Three main relationship types:

1. **1:1 Relationships**: One entity is related to one other entity.
2. **1:N Relationships**: One entity is associated with many other entities.
3. **N:M Relationships**: Many entities are associated with many other entities.

# 1:1 Relationships

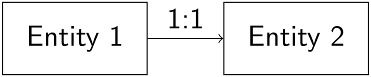



Figure: Schematic representation of a 1:1 relationship.

- Bijective: Each element in one entity set is associated with exactly one element in another entity set.
- Variants with optionality (1:C, C:C) cannot be represented with Chen notation.

# 1:N Relationships

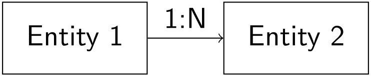



Figure: Schematic representation of a 1:N relationship.

- One entity is related to several others.
- Variants include 1:CN, C:CN, and C:N, reflecting the optionality and number of connections.

# N:M Relationships

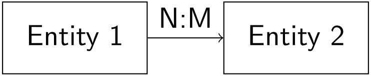
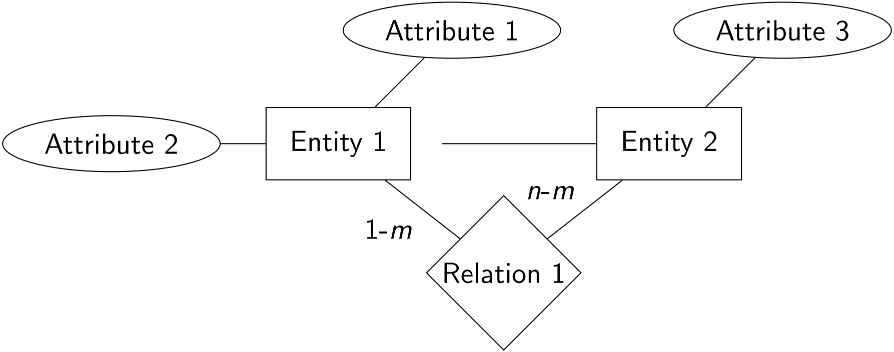



Figure: Schematic representation of an N:M relationship.

- Several entities on both sides are related to each other.
- Variants such as N:CM and CN:CM reflect optionality and numbers of connections.

# ERM example


Attribute 1
Attribute 3
Attribute 2
Entity 1
Entity 2
n-m
1-m
Relation 1

# ER - Model for the hospital db

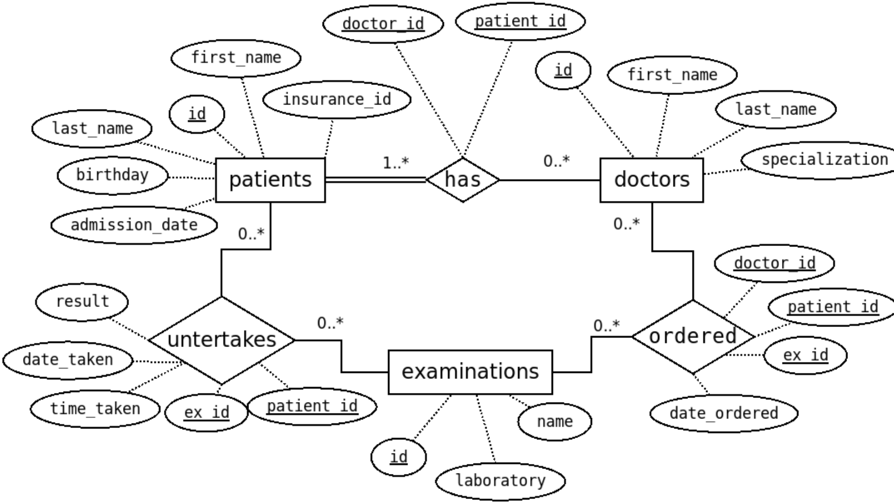



Figure: ER - Model for the hospital db on Chen notation

# ER Model - Hospital Database Overview

The hospital database consists of **three entities**:

- **Patients**: Identified by **id**, including personal details and **admission_date**.
- **Doctors**: Identified by **id**, including names and **specialization**.
- **Examinations**: Identified by **id**, with **name** and the **laboratory**.

# ER Model - Relationships Overview

The database also includes **three relationships**:

- **has**: Between **patients** and **doctors**.
- **undertakes**: Between **patients** and **examinations**.
- **ordered**: Between **doctors** and **examinations**.

# Patients-Doctors Relationship (has)

- Connects patients to doctors with **patient_id** and **doctor_id**.
- Each patient must have at least one doctor (**full participation**).
- A doctor may have zero or more patients (**partial participation**).

# Patients-Examinations Relationship (undertakes)

- Associates tests with patients through **patient_id** and **ex_id**.
- Not all patients are required to take tests (**partial participation**).
- Tests can be taken by multiple patients.
- Includes **results**, **date_taken**, and **tim_taken**.

# Doctors-Examinations Relationship (ordered)

- Links doctors to tests they order using **doctor_id** and **ex_id**.
- Doctors can order any number of tests (**partial participation**).
- Each test can be ordered by one doctor (**one-to-one cardinality**).
- Includes **date_ordered** for tracking.

# Recap

Up to now, we've covered:

- The importance of data modeling for relational databases.
- The Entity Relationship Model and its elements.
- Graphical notations and relationship types in ER models.

**Next steps:** Practice modeling with ER diagrams and understand the implications of different relationship types on database design.

# Normal Forms of Databases

Database Normalization

# What is Database Normalization?

- A process for organizing data in a database.
- It involves creating tables and establishing relationships between those tables according to rules designed to protect the data and to make the database more flexible by eliminating redundancy and inconsistent dependency.
- Normalization is used to minimize the duplication of information and to ensure that only related data is stored in each table.

# The Goals of Normalization

- To free the database from unwanted insertions, updates, and deletion dependencies.
- To reduce the need for restructuring the collection of relations, as new types of data are introduced, and thus increase the life span of application programs.
- To make the relational model more informative to users and to ensure that the data is represented accurately and consistently.
- To make the database neutral to the query statistics, where it performs equally well regardless of the types of data retrieval queries that are issued.

# Overview of Normal Forms

- Normal forms are defined as the standards for the organization of data in databases.
- There are several normal forms, each with more strict rules than the previous one: First Normal Form (1NF), Second Normal Form (2NF), Third Normal Form (3NF), and Boyce-Codd Normal Form (BCNF).
- Higher normal forms (4NF and 5NF) deal with more complex scenarios and are not as commonly applied as the first three forms.
- The aim is to achieve the desired form of normalization suitable for the use case and to balance the trade-offs between data redundancy and query performance.

# Dependencies and Normal Forms

**Table 26: Table for Article Delivery Example**

**Article Delivery**

| **Vendor** | **Customer** | **Articles** |
|---|---|---|
| MediaService, Hattstadt | Sophie Weber, 182932 | Edge Of Tomorrow; EAN 838883 |
| MovieGroup, Hamburg | Sophie Weber, 182932 | Cry Baby; EAN 1222233 |
| MovieGroup, Hamburg | Ralf Fischer, 488389 | In the Morning; ISBU XX-NHN-223 |
| FilmService, Berlin | Maria Bolz, 299376 | Edge Of Tomorrow; EAN 838883 |

Source: Jörg Dreikauss, 2022.

# Normal Forms

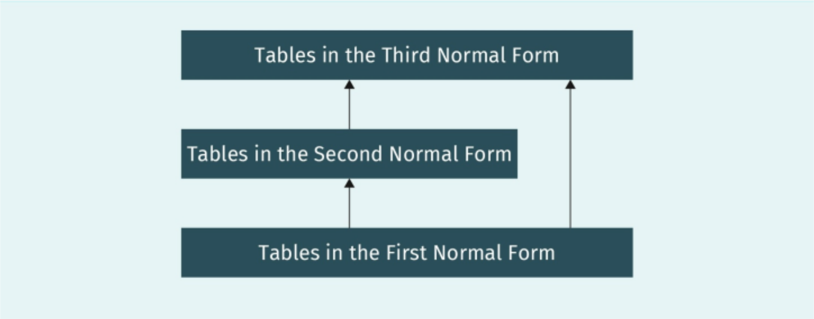



Figure: Dependencies of the normal forms. Adapted from Steiner, 2014, p. 78.

# First Normal Form (1NF)

- Attributes must contain single, atomic values.
- Records are uniquely identifiable by a primary key.

**Normalization to 1NF:**

- Split composite attributes into individual columns.
- Define a primary key to uniquely identify records.

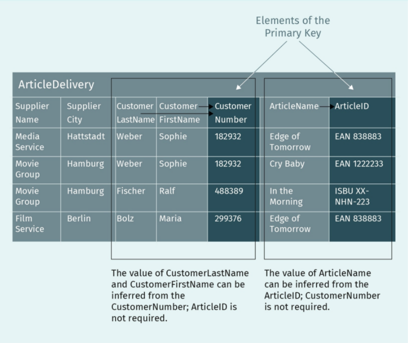



Figure: Dependencies in First Normal Form. Source: Jörg Dreikauss, 2022.

# Normalization to 1NF:

Table 27: First Normal Form with Compound Primary Key

**ArticleDelivery**

| Supplier-Name | Suppli-erCity | Cus-tomer Last-Name | Customer First-Name | Customer Number | ArticleName | ArticleID |
|---|---|---|---|---|---|---|
| MediaSer-vice | Hatt-stadt | Weber | Sophie | 182932 | Edge of Tomor-row | EAN 838883 |
| Movie Group | Ham-burg | Weber | Sophie | 182932 | Cry Baby | EAN 1222233 |
| Movie Group | Ham-burg | Fischer | Ralf | 488389 | In the Morning | ISBU XX-NHN-223 |
| FilmService | Berlin | Bolz | Maria | 299376 | Edge of Tomor-row | EAN 838883 |

# Normalization to 1NF:s

**Table 28: First Normal Form with Transformed Table Including Simple Primary Key. Part 1**

**ArticleDelivery**

| ArticleDeliveryID | SupplierName | SupplierCity | CustomerLastName |
|---|---|---|---|
| L01 | MediaService | Hattstadt | Weber |
| L02 | Movie Group | Hamburg | Weber |
| L03 | Movie Group | Hamburg | Fischer |
| L04 | FilmService | Berlin | Bolz |

Source: Jörg Dreikauss, 2022.

# Normalization to 1NF:s

**Table 29: First Normal Form with Transformed Table Including Simple Primary Key. Part 2**

**ArticleDelivery**

| ArticleDeliveryID | CustomerFirst | CustomerNum-ber | ArticleName | ArticleID |
|---|---|---|---|---|
| L01 | Sophie | 182932 | Edge of Tomorrow | EAN 838883 |
| L02 | Sophie | 182932 | Cry Baby | EAN 1222233 |
| L03 | Ralf | 488389 | In the Morning | ISBU XX-NHN-223 |
| L04 | Maria | 299376 | Edge of Tomorrow | EAN 838883 |

Source: Jörg Dreikauss, 2022.

# Second Normal Form (2NF)

- Achieved by further decomposing 1NF tables with composite primary keys.
- Each attribute must depend on the *entire* primary key.

**Transition to 2NF:**

- Remove partial dependencies of attributes on the primary key.
- Create separate tables for entities with independent attributes.

# Normalization to 2NF:s

**Table 30: ArticleDelivery, Second Normal Form**

**ArticleDelivery**

| SupplierName | SupplierCity | CustomerNumber | ArticleID |
|---|---|---|---|
| MediaService | Hattstadt | 182932 | EAN 838883 |
| MovieGroup | Hamburg | 182932 | EAN 1222233 |
| MovieGroup | Hamburg | 488389 | ISBU XX-NHN-223 |
| FilmService | Berlin | 299376 | EAN 838883 |

Source: Jörg Dreikauss, 2022.

# Normalization to 2NF:s

**Table 31: Customer, Second Normal Form**

**Client**

| CustomerLastName | CustomerFirstName | CustomerNumber |
|---|---|---|
| Weber | Sophie | 182932 |
| Fischer | Ralf | 488389 |
| Bolz | Maria | 299376 |

Source: Jörg Dreikauss, 2022.

# Normalization to 2NF:s

**Table 32: ArticleDelivery, Second Normal Form**

**Articles**

| ArticleName | ArticleID |
|---|---|
| Edge of Tomorrow | EAN 838883 |
| Cry Baby | EAN 1222233 |
| In the Morning | ISBU XX-NHN-233 |

Source: Jörg Dreikauss, 2022.

# Third Normal Form (3NF)

- Based on 1NF and 2NF criteria.
- Non-key attributes must depend only on the primary key.
- No transitive dependencies between non-key attributes.

**Achieving 3NF:**

- Eliminate transitive dependencies by further decomposition.
- Ensure all non-key attributes depend directly on the key.

# Normalization to 2NF:s

**Figure 20: Third Normal Form with a Simple Primary Key**

**ArticleDelivery**

| ArticleDeliveryID | SupplierName | CustomerNumber | ArticleID |
|---|---|---|---|
| L01 | MediaService | 182932 | EAN 838883 |
| L02 | MovieGroup | 182932 | EAN 1222233 |
| L03 | MovieGroup | 488389 | ISBU XX-NHN-223 |
| L04 | FilmService | 299376 | EAN 838883 |

**Supplier**

| SupplierName | SupplierCity |
|---|---|
| MediaService | Hattstadt |
| MovieGroup | Hamburg |
| FilmService | Berlin |

**Articles**

| ArticleName | ArticleID |
|---|---|
| Edge of Tomorrow | EAN 838883 |
| Cry Baby | EAN 1222233 |
| In the Morning | ISBU XX-NHN-223 |

**Client**

| Customer LastName | Customer FirstName | CustomerNumber |
|---|---|---|

# First Normal Form (1NF) Example

Table **Orders** is in 1NF, which requires that there are no repeating groups or arrays, and all values are atomic.

| OrderID | CName | OrderDate | PID | PName | PQuantity |
|---|---|---|---|---|---|
| 1 | John Doe | 2023-01-01 | 101 | Apples | 3 |
| 2 | Jane Smith | 2023-01-02 | 102 | Oranges | 5 |

Table: Example of an Orders table in First Normal Form (C: Costumer, P: Product)

# First Normal Form (1NF) Explanation

- The table ‘Orders‘ is in 1NF because:
  - Each cell contains a single value.
  - Each record is unique and can be identified by ‘OrderID‘.
  - There are no repeating groups or arrays.
- This is the base requirement for a table to be considered normalized.
- The atomicity of values ensures that each piece of data is in its own domain.

# Second Normal Form (2NF) Example

Tables **Orders** and **Order Details** are in 2NF, which requires no partial dependency of any column on the primary key.

| OrderID | CName | OrderDate |
|---|---|---|
| 1 | John Doe | 2023-01-01 |
| 2 | Jane Smith | 2023-01-02 |

Table: Orders Table

| OrderID | PID | PName | PQuantity |
|---|---|---|---|
| 1 | 101 | Apples | 3 |
| 2 | 102 | Oranges | 5 |

Table: Order Details Table

# Second Normal Form (2NF) Explanation

- The ‘Orders‘ and ‘Order Details‘ tables are in 2NF because:
  - They were already in 1NF.
  - All non-key attributes are fully functional-dependent on the primary key.
  - We’ve removed partial dependencies by separating the ‘Order Details‘ from the ‘Orders‘ table.
- 2NF is about eliminating redundancy that occurs when a table has composite primary keys.

# Third Normal Form (3NF) Example

Tables **Orders** and **Customers** are in 3NF, which requires that there are no transitive dependencies of non-key attributes.

| OrderID | CustID | OrderDate |
|---|---|---|
| 1 | 1 | 2023-01-01 |
| 2 | 2 | 2023-01-02 |

Table: Orders Table

| CustID | CName | CAddress |
|---|---|---|
| 1 | John Doe | 123 Elm St. |
| 2 | Jane Smith | 456 Oak St. |

Table: Customers Table

**Note:** CustID is the abbreviation for CustomerID, CName for CustomerName, and CAddress for CustomerAddress.

# Third Normal Form (3NF) Explanation

- The ‘Orders‘ and ‘Customers‘ tables are in 3NF because:
  - They meet all the requirements of 2NF.
  - No non-key attribute depends on another non-key attribute.
  - This eliminates transitive dependencies, ensuring that non-key attributes are only dependent on primary keys.
- 3NF tables are more efficient for updates and maintain data integrity.

# Boyce-Codd Normal Form (BCNF) Explanation

Table: Orders Table in BCNF

| **OrderID** (PK) | **OrderDetails** |
|---|---|
| 1 | Details for Order 1 |
| 2 | Details for Order 2 |

Table: Customers Table in BCNF

| **CustomerID** (PK) | **Name** | **Address** |
|---|---|---|
| C001 | John Doe | 123 Apple St. |
| C002 | Jane Smith | 456 Berry Ave. |

- Both tables satisfy 3NF conditions.
- In BCNF, every determinant (a column that can determine other columns) is a candidate key.
- BCNF handles anomalies that 3NF does not, making it useful for complex schemas with overlapping candidate keys.

# Why Design a Database Before Implementation?

## Foundation for Efficiency

Designing a database before implementation is akin to architectural planning before building a house. It ensures that:

- All necessary data relationships and structures are thoughtfully laid out.
- The database can scale efficiently without significant rework.
- Data integrity and security are maintained from the start.

# Is Data Redundancy Desired in a Relational Database?

## Minimizing Data Redundancy

In relational databases, data redundancy is generally undesired because:

- It can lead to inconsistencies and inaccuracies.
- It consumes unnecessary storage space.
- It complicates data management and increases maintenance workload.

The goal is to design the database to ensure data is stored only once and referenced elsewhere as needed.

# Is a Primary Key Required in Every Table?

## The Role of Primary Keys

Yes, a primary key is required in each table because:

- It uniquely identifies each record in the table, which is essential for data integrity.
- It enables efficient data retrieval and relationships between tables.
- Without a primary key, it becomes difficult to ensure that each row represents a unique piece of information.

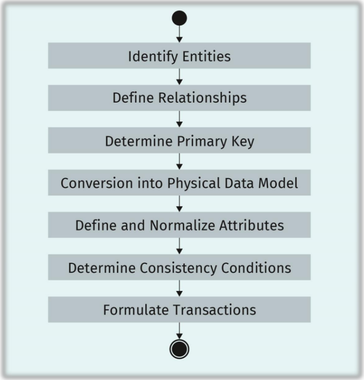
UNIT 4

# CREATING RELATIONAL DATABASES

# Study goals

- Design a database through standard processes.
- Convert a conceptual design model into a physical model.
- Use SQL to define database tables.

## GRAPHICAL NOTATION OF ENTITIES AND ATTRIBUTES IN ER MODELS




Source of the graphic: Steiner, 2014, p. 83.

# Introduction to Unit 4

- From Conceptual Models to Physical Databases
- Key Design Activities in Database Creation
- Relationship Mapping: Theory to Practice
- Introduction to SQL and Table Generation

# Overview of Database Design Process

- **Requirements Analysis:** Gathering data requirements from stakeholders.
- **Conceptual Design:** Creating an ER diagram or other high-level data models.
- **Logical Design:** Translating the conceptual model into a logical model for a specific DBMS.
- **Schema Refinement:** Normalizing and optimizing to remove redundancy and improve performance.
- **Physical Design:** Deciding on storage details, indexing strategies.
- **Implementation:** Using DDL to create the database schema.
- **Maintenance:** Making ongoing adjustments and improvements.

# Iterations and Feedback Loops in Database Design

- **Iterative Nature:** Database design often requires revisiting and refining earlier stages based on new feedback.
- **Stakeholder Communication:** Regularly checking in with stakeholders to ensure the database aligns with their needs.
- **Testing and Validation:** Confirming that the database design supports all required data operations and maintains data integrity.

# From Requirements to Data Models

- **Translating Business Rules:** Converting business processes into data structures within the model.
- **Identifying Key Components:** Pinpointing crucial entities, relationships, and constraints in the data model.
- **Supporting Data Operations:** Ensuring the model can handle all necessary operations, including CRUD and complex transactions.
- **Prototyping and Validation:** Using prototypes and conceptual models to confirm requirements and design decisions with end-users.

# What Constitutes an Entity?

- **Definition:** An entity represents a real-world object or concept with an independent existence in the database context.
- **Characteristics:** Entities have attributes that give them specific properties and identity.
- **Identification:** Entities are uniquely identifiable by a primary key within the database.
- **Examples:** In a university database, entities could be Students, Professors, Courses, etc.

# Technical vs. Business Entities

- **Business Entities:** Reflect the organization's operational elements, like Customers, Orders, and Products.
- **Technical Entities:** Used for database functionalities and may not have a direct business context, like UserAccounts or LogRecords.
- **Importance of Distinction:** Recognizing the difference is crucial for effective database design and aligning with business objectives.

# Refinement of Entity Characteristics

- **Process:** Refining entity characteristics involves detailing out the attributes and relationships of the entity.
- **Normalization:** This step often includes normalization to ensure efficient data structure and avoid redundancy.
- **Evolution:** Entities may evolve as the understanding of the system deepens or as business requirements change.
- **Collaboration:** Refinement is usually a collaborative process involving feedback from stakeholders.

# Refinement of Entity Characteristics

- **Process:** Refining entity characteristics involves detailing out the attributes and relationships of the entity.
- **Normalization:** This step often includes normalization to ensure efficient data structure and avoid redundancy.
- **Evolution:** Entities may evolve as the understanding of the system deepens or as business requirements change.
- **Collaboration:** Refinement is usually a collaborative process involving feedback from stakeholders.

# Understanding Cardinalities

- **Defining Quantities:** Cardinalities define the numerical aspects of relationships between entities (one-to-one, one-to-many, many-to-many).
- **Constraints and Rules:** They help establish constraints and rules that govern the associations between data sets.
- **Design Decisions:** Cardinalities affect database normalization and table structures, influencing design decisions.
- **Optimization:** Correct cardinalities are essential for database performance and optimization.

# Real-world vs. Data Model Relationships

- **Mimicking Reality:** Data model relationships strive to accurately represent the complex relationships found in the real world.
- **Simplification:** However, they may simplify or abstract certain aspects to fit the constraints and purposes of the database.
- **Business Logic:** Relationships in data models must enforce the business logic of the application, sometimes going beyond the direct real-world analogs.
- **Flexibility and Scalability:** They must be flexible enough to accommodate changes in business processes and scalable to handle growth.

# What are Primary Keys?

- **Unique Identifiers:** Primary keys are unique identifiers for records within a database table.
- **Uniqueness Guarantee:** They guarantee that each record can be uniquely distinguished from all others.
- **Indexing:** Primary keys are typically indexed, improving search performance within the database.
- **Referential Integrity:** They are crucial for establishing relationships between tables, maintaining referential integrity.

# Simple vs. Compound Primary Keys

- **Simple Primary Keys:** A single attribute that uniquely identifies a record. Ideal for straightforward scenarios.
- **Compound Primary Keys:** A combination of two or more attributes that together create a unique identifier. Used when no single attribute is unique on its own.
- **Design Considerations:** The choice between simple and compound keys affects database normalization, schema complexity, and query simplicity.
- **Performance Impacts:** Compound keys can impact database performance and should be used judiciously.

# Use of Artificial/Surrogate Keys

- **Artificial Keys:** These are system-generated keys, often a sequence or auto-increment number, that have no inherent meaning outside of their role as an identifier.
- **Surrogate Keys:** A type of artificial key used when natural keys (real-world meaning) are not suitable, often due to complexity or lack of uniqueness.
- **Advantages:** They can simplify database design, especially when natural keys are changeable or cumbersome.
- **Considerations:** While they add simplicity, they may also introduce an additional layer of abstraction, requiring careful consideration in system design.

# Translating Conceptual to Physical Models

- **Detailing the Design:** Transitioning from high-level conceptual models to detailed physical models suitable for implementation.
- **Mapping Entities to Tables:** Converting entities into tables, attributes into columns, and relationships into foreign keys.
- **Defining Data Types:** Assigning appropriate SQL data types to each attribute based on the nature of the data it will hold.
- **Performance Considerations:** Indexing strategies, partitioning, and physical storage decisions are made to optimize performance and storage efficiency.

# The Role of Relational DBMS in Physical Modeling

- **DBMS-Specific Features:** Understanding the features and limitations of the target DBMS to effectively design the physical model.
- **SQL Script Generation:** Automated tools can generate SQL scripts for table creation, which are then fine-tuned by database developers.
- **Physical Data Integrity:** Defining constraints and triggers to maintain data integrity in line with business rules.
- **Database Administration:** Planning for backup, recovery, and security policies within the physical model.

# Case Study: UML to Relational Model Conversion

- **Case Study Overview:** Presenting a real-world example of converting a UML class diagram into a relational database schema.
- **Mapping Strategies:** Discussing various approaches to map inheritance, associations, and aggregation in UML to relational tables.
- **Lessons Learned:** Sharing insights on common challenges and best practices observed during the conversion process.
- **Q&A:** Allowing the audience to ask questions specific to the case study, fostering a deeper understanding of the practical aspects of the conversion.

# Defining Attributes for Entities

- **Identifying Attributes:** Determining the necessary information to be stored about each entity within the database.
- **Attribute Characteristics:** Establishing attribute properties including uniqueness, nullability, and default values.
- **Keys and Indexes:** Selecting primary keys to uniquely identify entity instances and indexes to enhance query performance.
- **Data Integrity Rules:** Applying constraints to ensure the accuracy and consistency of data across related entities.

# Data Types and Their Significance

- **Data Type Selection:** Matching the nature of data to the appropriate SQL data types, such as INTEGER, VARCHAR, DATE, etc.
- **Data Type Implications:** Understanding how data type choices affect storage, performance, and data integrity.
- **Type Safety:** Ensuring that operations on data are type-safe to prevent errors and data corruption.
- **Advanced Data Types:** Exploring the use of specialized data types like ENUM, SET, or custom types for specific use cases.

# Normalization: Theory and Practice

- **Fundamentals of Normalization:** Introducing the concept of normalization and its role in reducing redundancy and dependency.
- **Normal Forms:** Describing the various normal forms from 1NF to BCNF, including their rules and objectives.
- **Normalization in Design:** Applying normalization during database design to create a scalable and maintainable schema.
- **Denormalization Considerations:** Discussing scenarios where denormalization may be beneficial for performance optimization.

# SQL Data Types Overview

- Understanding SQL Data Types
- Text, Numeric, and Date Data Types
- Binary and Boolean Data Types

# SQL Data Types and Examples

**DATA TYPES**

| Form | SQL Data Type | Examples |
|---|---|---|
| Character strings with always exactly n characters | CHAR(n)alternative: CHARACTER(n) | Country codes: DE, CN, FR, NL etc.: CHAR(2) ISBN 13 numbers: 9783836216999<br>CHAR(13)<br>UUIDs: 21EC2020–3AEA-1069-A2DD-08002B30309DCHAR(36)(German)<br>Postal codes: 45147CHAR(5) |
| Character strings with variable but limited length (max. n characters) | VARCHAR (n)alternative: CHARACTER VARYING(20) | proper names, designations, short descriptions: VARCHAR(55), VARCHAR(160),VARCHAR(500) |
| Very long character strings; the actual allowed size is limited by technical parameters within the DBMS. | TEXT | Texts, blog entries, detailed descriptions: TEXT |

Source of the table: Course Book DLBCSDMD01, p. 95

# SQL Data Types and Examples

**DATA TYPES**

| Form | SQL Data Type | Examples |
|---|---|---|
| Integers; 32 bits, value range from –2,147,483,648 to 2,147,483,647 | INTEGER alternative: INT | Number, index, numbering: INTEGER |
| Decimal numbers with a maximum of n digits in total and exactly m digits after the decimal point. | DECIMAL(n,m) | Amounts of money: DECI-MAL(9,2), Key figures: DECIMAL(4,2), |
| Floating point numbers, 32bit | REAL | Measured values: REAL |

Source of the graphic: Course Book DLBCSDMD01, p. 96

# SQL Data Types and Examples

**DATA TYPES**

| Form | SQL Data Type | Examples |
| --- | --- | --- |
| Calendar data accurate to the day, from year 1000 to year 9999 in YYYY-MM-DD format | DATE | Date, calendar days: 2014–06–14 |
| Time data in the format HH:MM:SS | TIME | Time, to the second: 13:43:56 |
| Exact determination of a time, exact to the second, often in the format YYYY-MM-DD HH:MM:SS | TIMESTAMP | Selected times: 2014–06–14 14:00:02; Automatic saving of creation or modification times |

Source of the table: Course Book DLBCSDMD01, pp. 96-97

# SQL Data Types and Examples

**DATA TYPES**

| Form | SQL Data Type | Examples |
| --- | --- | --- |
| Binary types with variable length, but not more than n characters (n bits) | VARBINARY(n) | Store binary data such as images, audio, video, and other binary files;<br>BINARY VARYING(50000);<br>often also called BLOB in DBMS |
| Boolean Values | BOOLEAN | Boolean Values |

Source of the table: Course Book DLBCSDMD01, p. 97

# Ensuring Data Consistency

- **Consistency Conditions**: Rules that ensure the reliability of database transactions and maintain the validity of data.
- **Unique ID Constraints**: Mechanisms that guarantee each record can be uniquely identified within a table.
- **Data Integrity**: The accuracy and consistency of data over its lifecycle, including constraints like foreign keys to maintain referential integrity.

# Defining Database Transactions

- **ACID Properties**: The set of properties—Atomicity, Consistency, Isolation, Durability—that ensure reliable processing of database transactions.
- **CRUD Operations**: The four basic functions of persistent storage: Create, Read, Update, Delete.
- **Transaction Processing**: Ensuring that all database transactions are processed reliably and that the database remains in a consistent state.

# Conceptual vs. Physical Data Models

- **Conceptual Data Models**: High-level models that define entities, relationships, and constraints without considering DBMS specifics.
- **Physical Data Models**: Detailed models that include specific tables, columns, data types, and database constraints tailored to a particular DBMS.
- **Model Bridging**: The process of transforming a conceptual model into a physical model, considering performance and storage requirements.

# Creating Tables: The SQL Way

- **CREATE TABLE Command**: SQL syntax used to define a new table structure in the database.
- **Column Definitions and Data Types**: Specific columns and SQL data types that describe the shape and kind of data each table will store.
- **Primary and Foreign Keys**: The use of keys to enforce data integrity and define relationships between tables.

# Maintaining Referential Integrity

- **Referential Integrity**: A database concept that ensures relationships between tables remain consistent.
- **CASCADE, SET NULL, RESTRICT Options**: Different strategies for managing updates and deletions in related tables.
- **Data Integrity Design**: Creating a database schema that robustly enforces data integrity through appropriate constraints.

# Database Integrity with CHECK

- **CHECK Constraint**: A condition that the data must meet before being accepted into the database table.
- **Defining Data Entry Conditions**: Using CHECK constraints to validate data upon insertion or update.
- **Practical Examples**: Scenarios where CHECK constraints prevent invalid data from corrupting the database.

# Recap of the Database Creation Process

- The database creation process is a multi-stage endeavor that begins with understanding user requirements and culminates in the deployment of a fully functional database system.
- Key stages include requirements gathering, conceptual modeling, logical and physical design, implementation, and maintenance.
- Effective database creation requires meticulous planning, iterative design, and ongoing collaboration with stakeholders to ensure the database meets all functional requirements and performance criteria.

# The Critical Role of Accurate Modeling

- Accurate modeling is essential for translating real-world scenarios into a structured database schema that accurately represents data relationships and constraints.
- It involves using standard modeling techniques like Entity-Relationship diagrams or UML to visualize and test the database structure before implementation.
- Proper modeling can prevent future issues such as data redundancy, integrity problems, and scalability concerns, making it a critical step in the database design process.

# Best Practices for SQL Table Definition

- Defining SQL tables is more than just a technical exercise; it requires a deep understanding of the data, its interrelationships, and how it will be accessed and manipulated.
- Best practices include normalizing data to reduce redundancy, carefully selecting data types to balance performance with precision, and enforcing data integrity with appropriate key constraints.
- Regularly reviewing and updating table definitions as application requirements evolve is crucial to maintain optimal performance and data integrity.

SESSION 2

# TRANSFER TASK

## TRANSFER TASKS

Given the following branch table:

| Branch ID | Branch address | Branch phone number | Department ID | Department name | Employee ID | Employee Name |
|---|---|---|---|---|---|---|

1. Normalize the above table by putting it in the third normal form.
2. Draw the ERD of the normalized tables.
3. Write the SQL code that creates the normalized tables.

# Normalization to Third Normal Form (3NF)

- Separate the data into three tables to remove dependencies.
- Ensure that each table contains only data related to the primary key.

# Normalization to Third Normal Form (3NF)

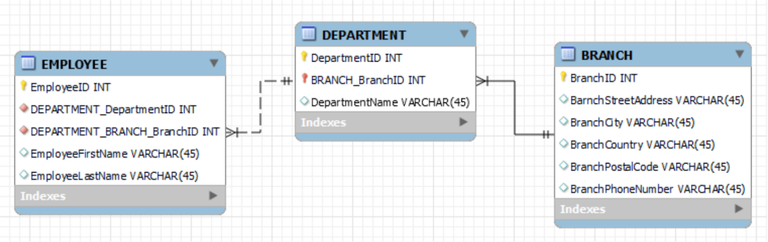
- Ensure the table is already in 2NF.
- Remove transitive dependencies to achieve 3NF.

**Normalization Steps:**

1. Create **Branch** table with:
    - Branch ID (Primary Key)
    - Branch Address
    - Branch Phone
2. Create **Department** table with:
    - Department Number (Primary Key)
    - Department Name
    - Branch ID (Foreign Key)
3. Create **Employee** table with:
    - Employee ID (Primary Key)
    - Employee Name
    - Department Number (Foreign Key)

The resulting structure eliminates partial and transitive dependencies, placing the database in 3NF.

**TRANSFER TASKS**




Source of the image: Aljiendi, 2022

# SQL Code for Normalized Tables

```
CREATE TABLE Branch (
  BranchID VARCHAR(255) PRIMARY KEY,
  BranchAddress VARCHAR(255),
  BranchPhone VARCHAR(255)
);

CREATE TABLE Department (
  DepartmentNumber VARCHAR(255) PRIMARY KEY,
  DepartmentName VARCHAR(255),
  BranchID VARCHAR(255),
  FOREIGN KEY (BranchID) REFERENCES Branch(BranchID)
);
```

# SQL Code for Normalized Tables

```
CREATE TABLE Employee (
  EmployeeID VARCHAR(255) PRIMARY KEY,
  EmployeeName VARCHAR(255),
  DepartmentNumber VARCHAR(255),
  FOREIGN KEY (DepartmentNumber) REFERENCES
                                 Department(DepartmentNumber)
);
```