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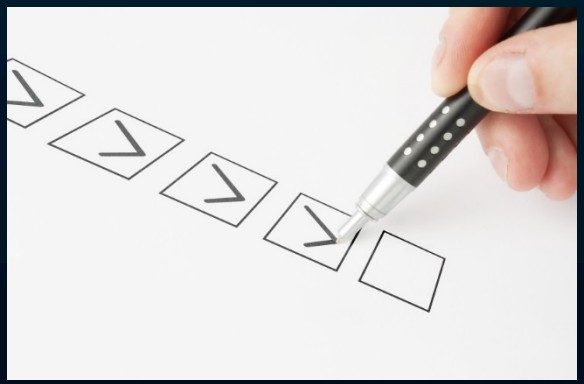
# Introduction to Relational Databases

## Introduction to Database Design

# Enabling Objectives

After completing this chapter, in the next 30 minutes you will be able to :

- Define with an example at least 1 data model
- List and define at least 1 Database Normalization with an example
- List different Data Types used in a table creation



# Key Topics

- The need of RDBMS
- Types of Data Models
- Different Levels of Database Normalization
- The purpose of SQL

# Database and Data Models

# Need of Database

- To manage large chunks of data
- Accuracy
- Ease of updating data
- Security of data

# What is a Database

- A database is a collection of logically related data
- It is used to search data to answer queries
- A database may be designed for batch processing, real time processing, or online processing

# Database Management System

- Is a set of software or programs
  - Enables storing, modifying, and extracting information from a database
- Data can be accessed by using
  - query and reporting tools
  - application programs

# The Relational Database

## The Relational Databse

Relational Databases are primarily defined by a colelction of tables.  The tables (more formally called relations) are made up of:

- A list of attributes (fields, or columns)
- A set of records (tuples, or rows) containing paticular data for some or all of the attributes

## Relationships

These tables have relationships among them represented by shared attributes.

Consider the following example of two tables in a database about dogs.

## Relationship Example

Dog: {dog_id, name, sex, weight, height, color, d_o_b, breed_id}

Breed: {breed_id, name, temperament, coat}

Using breed_id, we can find the likely temperament of a particular dog or get a list of all of the dogs we have of a given breed.

# Normalization

- Normalization is a process for determining how to organize our data.
  - Normalizing reduces various troublesome data anomalies.
  - There are six normal forms that have universally accepted definitions.  We'll only look at the first four.
    - These focus on the elimination of data redundancy.
    - The other two are quite rare and hard to even think of reasonable examples for.

## Functional Dependencies and Key Fields

In order to go any further we need to understand a couple of central topics.

- Functional Dependencies
- Key Fields

Consider the following fields in an Employee table

{EID, EName, Email, Phone, WorkAddress, HomeAddress, TaxJurisdiciton, ManagerID, DependentNames}

## Functional Dependencies

A functional dependency is a relationship between two attributes where y is functionally dependant on x if by knowing x I can find y, but not necessarily the other way around. In our table there are the following FDs:

- EID -> {<The entire table>}
- Email -> {<The entire table>}
- WorkAddress -> {TaxJurisdiction}

## Keys

- A superkey is a field or set of fields on which all other fields in the table are functionally dependant. (That is, they can uniquely identify rows in the table.)
  - EID and Email are superkeys
  - {EID, EName} is also a superkey, because it is a superset of EID
- A candidate key is a superkey that has no proper subset which is also a superkey
  - Thus EID and Email, but not {EID, EName} are candidate keys.

## Primary Keys

- The primary key is the designated identifying field of a table is chosen by the developer from among the candidate keys.
- Some guidelines:
  - Choose attributes under your organization's control – values such as passport numbers or government ID numbers may change outside of your control
  - Choose meaningless fields over ones with a purpose.
  - EID is a better choice than email address, as, while unique, an email address may change as well.
  - Prefer smaller attribute sets to larger ones

# Normal Forms

## First Normal Form (1NF)

- 1NF states that a relational database table can have no "repeating groups".
- This applies to two things:
  - Collections of items im one field
  - Composite items in a field

Collections are simply any field intended to hold more than one entry.

Composite fields are dependent on the context of the data.  Fields should not have data that's intended to be broken down to be used.

## 1NF Example

Consider our Employee table:

{EID, EName, Email, Phone, WorkAddress, HomeAddress, TaxJurisdiciton, ManagerID, DependentNames}

- Here, WorkAddress and HomeAddress are likely composite fields and should be broken into nultiple fields each.
- Dependents here is intended as a list of the employee's dependents (not a count) and is thus a collection.

## Breaking out a collection

- Collections are resolved by breaking them out into another table (likely named Dependent):
  - {EID, DependentName}
  - Thus, if we want to represent a given employee's 5 dependents, we create five rows in this new table with the same EID and each, different dependent name.

## 1NF is required

For a database to be strictly; a relational database, 1NF is required.  Relational databases do not have collections or composite objects in them.

In practice, most commecially used relational databases do support list and object types for fields due to their rusefulness.

# Second Normal Form ($2^{NF}$)

- A table is in 2NF if
  - it is in 1NF and
  - all non-key fields are functionally dependent on the entire Primary Key. (More simply, no partial dependencies.) Consider this table:

| Project Code | Project Name | Project Manager | Project Budget | Employee No. | Employee Name | Department No. | Department Name | Hourly Rate |
|---|---|---|---|---|---|---|---|---|
| PC010 | Reservation System | Mr. Ajay | 120500 | S100 | Mohan | D03 | Database | 21.00 |
| PC010 | Reservation System | Mr. Ajay | 120500 | S101 | Vipul | D02 | Testing | 16.50 |
| PC010 | Reservation System | Mr. Ajay | 120500 | S102 | Riyaz | D01 | IT | 22.00 |
| PC011 | HR System | Mrs. Charu | 500500 | S103 | Pavan | D03 | Database | 18.50 |
| PC011 | HR System | Mrs. Charu | 500500 | S104 | Jitendra | D02 | Testing | 17.00 |
| PC011 | HR System | Mrs. Charu | 500500 | S315 | Pooja | D01 | IT | 23.50 |
| PC012 | Attendance System | Mr. Rajesh | 710700 | S137 | Rahul | D03 | Database | 21.50 |
| PC012 | Attendance System | Mr. Rajesh | 710700 | S218 | Avneesh | D02 | Testing | 15.50 |
| PC012 | Attendance System | Mr. Rajesh | 710700 | S109 | Vikas | D01 | IT | 20.50 |

- Let's look at the functional dependencies:
  - Project name, manager, and budget are dependent on ProjectCode
  - EmployeeName, DepartmentNo, and DepartmentName are dependent on EmployeeNo
  - DepartmentName is dependent on DepartmentNo
  - HourlyRate is dependent on EmployeeNo and ProjectCode

## 2NF cont.

- Thus, the only candidate key (and thus the primary key) is {ProjectCode, EmployeeNo}. This is called a composite key
- Only HourlyRate is dependent upon the entire primary key
- To fix this, we put ProjectCode and it's dependencies and EmployeeNo and its dependencies into separate tables, leaving only Hourly Rate in the original.

# Second Normal Form (2NF)

Example :

Primary Key

| Employee No. | Employee Name | Department No. | Department Name |
|---|---|---|---|
| S100 | Mohan | D03 | Database |
| S101 | Vipul | D02 | Testing |
| S102 | Riyaz | D01 | IT |
| S103 | Pavan | D03 | Database |
| S104 | Jitendra | D02 | Testing |
| S315 | Pooja | D01 | IT |
| S137 | Rahul | D03 | Database |
| S218 | Avneesh | D02 | Testing |
| S109 | Vikas | D01 | IT |

Composite Key

| Project Code | Employee No. | Hourly Rate |
|---|---|---|
| PC010 | S100 | 21.00 |
| PC010 | S101 | 16.50 |
| PC010 | S102 | 22.00 |
| PC011 | S103 | 18.50 |
| PC011 | S104 | 17.00 |
| PC011 | S315 | 23.50 |
| PC012 | S137 | 21.50 |
| PC012 | S218 | 15.50 |
| PC012 | S109 | 20.50 |

Primary Key

| Project Code | Project Name | Project Manager | Project Budget |
|---|---|---|---|
| PC010 | Reservation System | Mr. Ajay | 120500 |
| PC011 | HR System | Mrs. Charu | 500500 |
| PC012 | Attendance System | Mr. Rajesh | 710700 |

# Third Normal Form (3NF)

- A database table is said to be in 3NF if
  - it is in 2NF and
  - No non-key fields are functionally dependent upon any other non-key fields
  - That is, we have no transitive dependencies
- The process of converting a table into 3NF is to remove the transitive dependencies into a new table along with their (now key) field.
- In our example, DepartmentName is functionally dependent upon DepartmentNo, a non-key field.

# Third Normal Form (3NF)

## Example :

Primary Key

| Project Code | Project Name | Project Manager | Project Budget |
|---|---|---|---|
| PC010 | Reservation System | Mr. Ajay | 120500 |
| PC011 | HR System | Mrs. Charu | 500500 |
| PC012 | Attendance System | Mr. Rajesh | 710700 |

Composite Key

| Project Code | Employee No. | Hourly Rate |
|---|---|---|
| PC010 | S100 | 21.00 |
| PC010 | S101 | 16.50 |
| PC010 | S102 | 22.00 |
| PC011 | S103 | 18.50 |
| PC011 | S104 | 17.00 |
| PC011 | S315 | 23.50 |
| PC012 | S137 | 21.50 |
| PC012 | S218 | 15.50 |
| PC012 | S109 | 20.50 |

Primary Key

| Employee No. | Employee Name | Department No. |
|---|---|---|
| S100 | Mohan | D03 |
| S101 | Vipul | D02 |
| S102 | Riyaz | D01 |
| S103 | Pavan | D03 |
| S104 | Jitendra | D02 |
| S315 | Pooja | D01 |
| S137 | Rahul | D03 |
| S218 | Avneesh | D02 |
| S109 | Vikas | D01 |

Primary Key FK_Relationship

| Department No. | Department Name |
|---|---|
| D01 | IT |
| D02 | Testing |
| D03 | Database |

# Boyce Codd Normal Form (BCNF)

- BCNF is one of the more commonly misrepresented forms on the Internet.
- A table is in BCNF iff
  - It is in 3NF and
  - No component of the primary key is dependent on a non-key field
- This can only occur if there are multiple, composite candidate keys.
- Consider this in the abstract:
- We have a table {A, B, C, D}
- Dependencies are
  - {A,B} -> C, D
  - C -> B
- {A,B} is chosen as primary key.
- We are in 3NF, as both C and D are directly dependent on {A, B}
- We are not in BCNF, as B is dependent on C

## Resolving BCNF

- What we missed in our analysis is that if C -> B, and {A, B} -> D then {A, C} -> B, D as well.
- If we were to have chosen {A,C} as our primary key, we'd now fail to be in 2NF.
- Resolving this to  tables {A, C, D} and {C, B} leaves us in BCNF.
- Note that the FDs reflect our data. Our tables conform to our data.  And so if we know A and B, we'll still have a single C and D that correspond to both of them, thus {A,B} – C, D will still hold.

You have successfully completed the session on Introduction to database