Normalization of Database Tables

ISM 602

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Normalization of Database Tables

- **Objectives**
- ✓ **The idea of Dependencies of Attributes**
- ✓ **Normalization and Database Design**
- ✓ **Understand concepts of normalization (Higher-Level Normal Forms)**
- ✓ **Learn how to normalize tables**
- ✓ **Understand normalization and database design issues**
- ✓ **Denomalization**

Functional Dependency

- A **Functional Dependency** Is A Relationship Between Or Among Attributes Such That The Values Of One Attribute Depend On, Or Are Determined By, The Values Of The Other Attribute(s).
- **Partial Dependency:** Is A Relationship Between Attributes Such That The Values Of One Attribute Is Dependent On, Or Determined By, The Values Of Another Attribute Which Is Part Of The Composite Key.
- Partial Dependencies Are Not Good Due To duplication Of Data And Update Anomalies;

Examples of Functional Dependencies:

- If we know an ISBN, then we know the Book Title and the author(s)
  - ISBN ➔ Book Title
  - ISBN ➔ Author(s)
- If we know the VIN, then we know who is the Auto owner
  - VIN ➔ Auto_Owner
- If we know Student-ID (SID), then we can uniquely determine his/her Name
  - SID ➔ S_Name

Transitive Dependencies

- Is A Relationship Between Attributes Such That The Values Of One Attribute Is Dependent On, Or Determined By, The Values Of Another Attribute Which Is Not A Part Of The Key.
- Exist when a nonkey attribute value is functionally dependent upon another nonkey value in the record. For example:
  - **EMPLOYEE_ID --> JOB_CATEGORY**
  - **JOB_CATEGORY --> HOURLY_RATE**
- An employee data table that includes the “hourly pay rate” would require searching every employee record to properly update an hourly rate for a particular job category.

So Now what is Normalization?

- GOLDEN RULE OF NORMALIZATION: Enter The Minimum Data Necessary, Avoiding Duplicate Entry Of Information, With Minimum Risks To Data Integrity.
- Goals Of Normalization:
  - ◆ **Eliminate Redundancies Caused By:**
    - **Fields Repeated Within A File**
    - **Fields Not Directly Describing The Key Entity**
    - **Fields Derived From Other Fields**
  - ◆ **Avoid Anomalies In Updating (Adding, Editing, Deleting)**
  - ◆ **Represent Accurately The Items Being Modeled**
  - ◆ **Simplify Maintenance And Retrieval Of Info**

Database Tables and Normalization

Introduction to Normalization of Database Tables

- **Normalization** is a process for assigning attributes to entities. It reduces data redundancies and helps eliminate the data anomalies.
- Normalization works through a series of stages called normal forms:
  - First normal form (1NF)
  - Second normal form (2NF)
  - Third normal form (3NF)
- The highest level of normalization is not always desirable.

Basic Rule for Normalization

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- **The attribute values in a relational table should be functionally dependent (FD) on the primary key value.**
  - A relationship is functionally dependent when one attribute value implies or determines the attribute value for the other attribute.
    - EM_SS_NUM --> EM_NAME
- **Corollaries**
  - **Corollary 1:** No repeating groups allowed in relational tables.
  - **Corollary 2:** A relational table should not have attributes involved in a transitive dependency relationship with the primary key.

Normalization Benefits

Introduction to Normalization of Database Tables

- **Facilitates data integration.**
- **Reduces data redundancy.**
- **Provides a robust architecture for retrieving and maintaining data.**
- **Compliments data modeling.**
- **Reduces the chances of data anomalies occurring.**

Database Tables and Normalization

Introduction to Normalization of Database Tables

- **The Need for Normalization**
  - Case of a Construction Company
    - Building project -- Project number, Name, Employees assigned to the project.
    - Employee -- Employee number, Name, Job classification
    - The company charges its clients by billing the hours spent on each project. The hourly billing rate is dependent on the employee’s position.

Database Tables and Normalization

Introduction to Normalization of Database Tables

- **Problems with the Table 5.1**
  - The project number is intended to be a primary key, but it contains nulls.
  - The table displays data redundancies.
  - The table entries invite data inconsistencies.
  - The data redundancies yield the following anomalies:
    - Update anomalies.
    - Addition anomalies.
    - Deletion anomalies.

Deletion Anomaly

Introduction to Normalization of Database Tables

- **Occurs when the removal of a record results in a loss of important information about an entity.**
- **Example:**
  - All the information about a customer is contained in an order file, if the order is canceled, all the customer information could be lost when the order record is deleted
- **Solution:**
  - Create two tables--one table contains order information and the other table contains customer information.

Update Anomaly

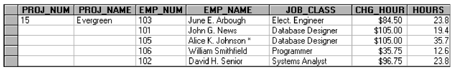
- **Occurs when a change of a single attribute in one record requires changes in multiple records**
- **Example:**
  - A staff person changes their telephone number and every potential customer that person ever worked with has to have the corrected number inserted.
- **Solution:**
  - Put the employees telephone number in one location--as an attribute in the employee table.

Insertion Anomaly

- **Occurs when there does not appear to be any reasonable place to assign attribute values to records in the database. Probably have overlooked a critical entity.**
- **Example:**
  - Adding new attributes or entire records when they are not needed. Where do you place information on new Evaluator's? Do you create a dummy Lead.
- **Solution:**
  - Create a new table with a primary key that contains the relevant or functional dependent attributes.

Database Tables and Normalization

- **Conversion to First Normal Form**
  - A relational table must not contain repeating groups.
  - Repeating groups can be eliminated by adding the appropriate entry in at least the primary key column(s). (See Database Table 5.3)



PROJ_NUM	PROJ_NAME	EMP_NUM	EMP_NAME	JOB_CLASS	CHG_HOUR	HOURS
15	Evergreen	103	June E. Arbough	Elect. Engineer	$84.50	23.8
		101	John G. News	Database Designer	$105.00	19.4
		105	Alice K. Johnson *	Database Designer	$105.00	35.7
		106	William Smithfield	Programmer	$35.75	12.6
		102	David H. Senior	Systems Analyst	$96.75	23.8

Database Table 5.2 The Evergreen Data

Database Tables and Normalization

- **Dependency Diagram**
  - The arrows above the entity indicate that the entity's attributes are dependent on the combination of PROJ_NUM and EMP_NUM.
  - The arrows below the dependency diagram indicate less desirable dependencies based on only a part of the primary key -- partial dependencies.

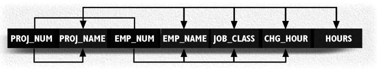


Figure 5.1 A Dependency Diagram: First Normal Form

Database Tables and Normalization

- **1NF Definition**
  - The term first normal form (1NF) describes the tabular format in which:
    - All the key attributes are defined.
    - There are no repeating groups in the table.
    - All attributes are dependent on the primary key.

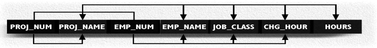
Database Tables and Normalization

- **Conversion to Second Normal Form**
  - Starting with the 1NF format, the database can be converted into the 2NF format by
    - Writing each key component on a separate line, and then writing the original key on the last line and
    - Writing the dependent attributes after each new key.

PROJECT (PROJ_NUM, PROJ_NAME)

EMPLOYEE (EMP_NUM, EMP_NAME, JOB_CLASS, CHG_HOUR)

ASSIGN (PROJ_NUM, EMP_NUM, HOURS)



Database Tables and Normalization

- **2NF Definition**
  - A table is in 2NF if:
    - It is in 1NF and
    - It includes no partial dependencies; that is, no attribute is dependent on only a portion of the primary key.
  - Note:

    It is still possible for a table in 2NF to exhibit transitive dependency; that is, one or more attributes may be functionally dependent on nonkey attributes.
  - See figure 5.2 page 290.

Database Tables and Normalization

- **Conversion to Third Normal Form**
  - Create a separate table with attributes in a transitive functional dependence relationship.

PROJECT (PROJ_NUM, PROJ_NAME)
ASSIGN (PROJ_NUM, EMP_NUM, HOURS)
EMPLOYEE (EMP_NUM, EMP_NAME, JOB_CLASS)
JOB (JOB_CLASS, CHG_HOUR)

Database Tables and Normalization

- **3NF Definition**
  - A table is in 3NF if:
    - It is in 2NF and
    - It contains no transitive dependencies.

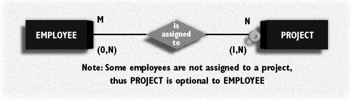
Normalization and Database Design

- **Database Design and Normalization Example: (Construction Company)**
  - Summary of Operations:
    - The company manages many projects.
    - Each project requires the services of many employees.
    - An employee may be assigned to several different projects.
    - Some employees are not assigned to a project and perform duties not specifically related to a project. Some employees are part of a labor pool, to be shared by all project teams.
    - Each employee has a (single) primary job classification. This job classification determines the hourly billing rate.
    - Many employees can have the same job classification.

Normalization and Database Design

- **Two Initial Entities:**

PROJECT (PROJ_NUM, PROJ_NAME)
EMPLOYEE (EMP_NUM, EMP_LNAME, EMP_FNAME, EMP_INITIAL, JOB_DESCRIPTION, JOB_CHG_HOUR)



Note: Some employees are not assigned to a project, thus PROJECT is optional to EMPLOYEE

Figure 5.7 The Initial E-R Diagram for a Contracting Company

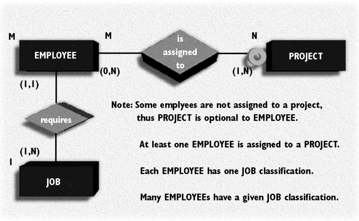
Normalization and Database Design

- **Three Entities After Transitive Dependency Removed**

PROJECT (PROJ_NUM, PROJ_NAME)
EMPLOYEE (EMP_NUM, EMP_LNAME, EMP_FNAME, EMP_INITIAL, JOB_CODE)
JOB (JOB_CODE, JOB_DESCRIPTION, JOB_CHG_HOUR)

Normalization and Database Design

Introduction to Normalization of Database Tables



Note: Some emplyees are not assigned to a project, thus PROJECT is optional to EMPLOYEE.

At least one EMPLOYEE is assigned to a PROJECT.

Each EMPLOYEE has one JOB classification.

Many EMPLOYEEs have a given JOB classification.

Figure 5.8 The Modified E-R Diagram for a Contacting Company

Normalization and Database Design

Introduction to Normalization of Database Tables

- **Creation of the Composite Entity ASSIGN**

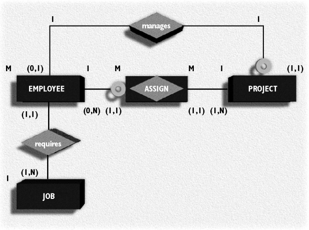


Figure 5.9 The Final (Implementable) E-R Diagram for the Contracting Company

Normalization and Database Design

Introduction to Normalization of Database Tables

- **Attribute ASSIGN_HOUR is assigned to the composite entity ASSIGN.**
- **"Manages" relationship is created between EMPLOYEE and PROJECT.**

PROJECT (<u>PROJ_NUM</u>, PROJ_NAME, EMP_NUM)

EMPLOYEE (<u>EMP_NUM</u>, EMP_LNAME, EMP_FNAME, EMP_INITIAL, EMP_HIREDATE, JOB_CODE)

JOB (<u>JOB_CODE</u>, JOB_DESCRIPTION, JOB_CHG_HOUR)

ASSIGN (<u>ASSIGN_NUM</u>, ASSIGN_DATE, PROJ_NUM, EMP_NUM, ASSIGN_HOURS)

Normalization and Database Design

Introduction to Normalization of Database Tables

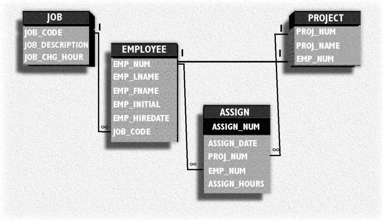
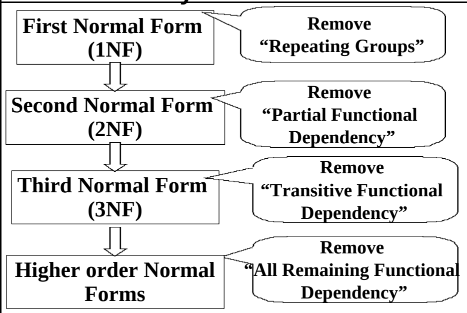


Figure 5.10 The Relational Schema for the Contracting Company

Summary
A Journey of Normalization

Introduction to Normalization of Database Tables



First Normal Form (1NF) — **Remove "Repeating Groups"**

Second Normal Form (2NF) — **Remove "Partial Functional Dependency"**

Third Normal Form (3NF) — **Remove "Transitive Functional Dependency"**

Higher order Normal Forms — **Remove "All Remaining Functional Dependency"**

Denormalization

Introduction to Normalization of Database Tables

- Normalization is only one of many database design goals.
- Normalized (decomposed) tables require additional processing, reducing system speed.
- Normalization purity is often difficult to sustain in the modern database environment. The conflict between design efficiency, information requirements, and processing speed are often resolved through compromises that include denormalization.