**ITEC 630**

*Information Systems Analysis, Modeling, and Design*

***Lecture Notes***

**An Example of Database Normalization**

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Consider a project management system in which each employee is assigned to a specific department and employees from several departments often are assigned to special project teams, however, when a new product is launched or for major marketing events. Note that the project hours are the number of hours that employees charge to their assigned projects. The following is an example of an un-normalized PROJECT-DATA table for two projects.

**PROJECT-DATA**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Project Number** | **Project Name** | **Start Date** | **Employee Number** | **Employee Name** | **Job Title** | **Department Number** | **Department Name** | **Project Hours** |
| 1 | ACORN | 04/10/2015 | 2489 | Smith | Manager | 1 | Web Design | 450 |
|  |  |  | 1887 | Jones | Engineer | 1 | Web Design | 400 |
|  |  |  | 9540 | Mike | Technician | 5 | Desktop | 450 |
| 2 | IMPPOAS | 12/15/2015 | 3436 | Catherine | Programmer | 2 | Software | 1500 |
|  |  |  | 2489 | Smith | Manager | 1 | Web Design | 100 |

Perform the normalization process to convert the above un-normalized table to:

1. First normal form (1NF)

2. Second normal form (2NF)

3. Third normal form (3NF)

**SOLUTION**

**UNNORMALIZED  
PROJECT-DATA (Figure 1)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Project Number | Project Name | Start Date | Employee Number | Employee Name | Job Title | Department Number | Department Name | Project Hours |
| 1 | ACORN | 04/10/2015 | 2489 | Smith | Manager | 1 | Web Design | 450 |
|  |  |  | 1887 | Jones | Engineer | 1 | Web Design | 400 |
|  |  |  | 9540 | Mike | Technician | 5 | Network | 450 |
| 2 | IMPPOAS | 12/15/2015 | 3436 | Catherine | Programmer | 2 | Software | 1500 |
|  |  |  | 2489 | Smith | Manager | 1 | Web Design | 100 |

This PROJECT-DATA table shown in Fig. 1 is un-normalized because it contains a repeating group (enclosed within a pair of square brackets. The PROJECT-DATA table design can be written as:

**PROJECT-DATA (Project Number, Project Name, Start Date,  
[Employee Number, Employee Name, Job Title, Department Number,  
Department Name, Project Hours])**

**1NF  
PROJECT-DATA (Figure 2A)**

|  |  |  |
| --- | --- | --- |
| Project Number | Project Name | Start Date |
| 1 | ACORN | 04/10/2015 |
| 2 | IMPPOAS | 12/15/2015 |

**EMPLOYEE-INFORMATION (Figure 2B)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Project Number | Employee  Number | Employee Name | Job Title | Department Number | Department Name | Project Hours |
| 1 | 2489 | Smith | Manager | 1 | Web Design | 450 |
| 1 | 1887 | Jones | Engineer | 1 | Web Design | 400 |
| 1 | 9540 | Mike | Technician | 5 | Network | 450 |
| 2 | 3436 | Catherine | Programmer | 2 | Software | 1500 |
| 2 | 2489 | Smith | Manager | 1 | Web Design | 100 |

**PROJECT-DATA (Project Number, Project Name, Start Date)**

**EMPLOYEE-INFORMATION (Project Number, Employee Number, Employee Name, Job Title, Department Number, Department Name, Project Hours)**

As shown in each record of the 1NF **EMPLOYEE-INFORMATION** table, (1) the field Employee Name, Job Tile, Department Number, and Department Name depend on the Employee Number key, and (2) the field Project Hours is the only one that depends on the combined primary key “Project Number and Employee Number).

**2NF  
PROJECT-DATA (Figure 3A)**

|  |  |  |
| --- | --- | --- |
| Project Number | Project Name | Start Date |
| 1 | ACORN | 04/10/2015 |
| 2 | IMPPOAS | 12/15/2015 |

**EMPLOYEE-DEPARTMENT (Figure 3B)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Employee Number | Employee Name | Job Title | Department Number | Department Name |
| 2489 | Smith | Manager | 1 | Web Design |
| 1887 | Jones | Engineer | 1 | Web Design |
| 9540 | Mike | Technician | 5 | Network |
| 3436 | Catherine | Programmer | 2 | Software |
| 2489 | Smith | Manager | 1 | Web Design |

**EMPLOYEE-PROJECT-HOURS (Figure 3C)**

|  |  |  |
| --- | --- | --- |
| Project Number | Employee Number | Project Hours |
| 1 | 2489 | 450 |
| 1 | 1887 | 400 |
| 1 | 9540 | 450 |
| 2 | 3436 | 1500 |
| 2 | 2489 | 100 |

Based on the above analysis of field dependencies to the primary key, we will keep the **PROJECT-DATA** table (Fig. 3A) unchanged but we should break the **EMPLOYEE-INFORMATION** table into two tables **EMPLOYEE-DEPARTMENT** (Fig. 3B) and **EMPLOYEE-PROJECT-HOURS** (Fig. 3C).

The 2NF **PROJECT-DATA** table design can be written as:

**PROJECT-DATA (Project Number, Project Name, Start Date)**

The 2NF **EMPLOYEE-DEPARTMENT** table design can be written as:

**EMPLOYEE-DEPARTMENT (Employee Number, Employee Name, Job Title, Department Number, Department Name)**

The 2NF **EMPLOYEE-PROJECT-HOURS** table design can be written as:

**EMPLOYEE-PROJECT-HOURS (Project Number, Employee Number,  
Project Hours)**

In each of these three tables, every non-key field depends on their entire primary key. Are these three tables in 3NF? The **PROJECT-DATA** and **EMPLOYEE-PROJECT-HOURS** tables are in 3NF but the **EMPLOYEE-DEPARTMENT** table is not in 3NF because the non-key field **Department Name** depends on the non-key field **Department Number**. In 3NF, no non-key field should be dependent on another non-key field so the **EMPLOYEE-DEPARTMENT** table should be broken into two tables called **EMPLOYEE and DEPARTMENT.** The **DEPARTMENT** table consists of two fields **Department**-Number and **Department**-Name where the **Department**-Number acts as the primary key. The entire set of 3NF tables are shown in Fig. 4A, 4B, 4C, and 4D below.

**3NF  
PROJECT-DATA (Figure 4A)**

|  |  |  |
| --- | --- | --- |
| Project Number | Project Name | Start Date |
| 1 | ACORN | 04/10/2015 |
| 2 | IMPPOAS | 12/15/2015 |

**EMPLOYEE (Figure 4B)**

|  |  |  |  |
| --- | --- | --- | --- |
| Employee Number | Employee Name | Job Title | Department Number |
| 2489 | Smith | Manager | 1 |
| 1887 | Jones | Engineer | 1 |
| 9540 | Mike | Technician | 5 |
| 3436 | Catherine | Programmer | 2 |
| 2489 | Smith | Manager | 1 |

**DEPARTMENT (Figure 4C)**

|  |  |
| --- | --- |
| Department Number | Department Name |
| 1 | Web Design |
| 5 | Network |
| 2 | Software |

**EMPLOYEE-PROJECT-HOURS (Figure 4D)**

|  |  |  |
| --- | --- | --- |
| Project Number | Employee Number | Project Hours |
| 1 | 2489 | 450 |
| 1 | 1887 | 400 |
| 1 | 9540 | 450 |
| 2 | 3436 | 1500 |
| 2 | 2489 | 100 |

The final 3NF design is as follows:

The 3NF **PROJECT-DATA** table design can be written as:

**PROJECT-DATA (Project Number, Project Name, Start Date)**

The 3NF **EMPLOYEE** table design can be written as:

**EMPLOYEE (Employee Number, Employee Name, Job Title, Department Number)**

The 3NF **DEPARTMENT** table design can be written as:

**DEPARTMENT (Department Number, Department Name)**

The 3NF **EMPLOYEE-PROJECT-HOURS** table design can be written as:

**EMPLOYEE-PROJECT-HOURS (Project Number, Employee Number,  
Project Hours)**