Database Management Systems

Module 22: Relational Database Design/2

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Module Recap

- Identified the features of good relational design
- Familiarized with the First Normal Form

Module Objectives

- To Introduce Functional Dependencies

Module Outline

- Functional Dependencies

Functional Dependencies

Goal: Devise a Theory for Good Relations

- Decide whether a particular relation R is in "good" form.
- In the case that a relation R is not in "good" form, decompose it into a set of relations $\{R_1, R_2, \ldots, R_n\}$ such that
  - each relation is in good form
  - the decomposition is a lossless-join decomposition
- The theory is based on:
  - Functional dependencies
  - Multivalued dependencies
  - Other dependencies

Functional Dependencies

- Constraints on the set of legal relations
- Require that the value for a certain set of attributes determines uniquely the value for another set of attributes
- A functional dependency is a generalization of the notion of a *key*

Functional Dependencies (2)

- Let R be a relation schema
  $\alpha \subseteq R$ and $\beta \subseteq R$
- The functional dependency or FD
  $\alpha \rightarrow \beta$
  holds on R if and only if for any legal relations $r(R)$, whenever any two tuples t_1 and t_2 of r agree on the attributes α, they also agree on the attributes β. That is,

$$t_1[\alpha] = t_2[\alpha] \Rightarrow t_1[\beta] = t_2[\beta]$$

- Example: Consider $r(A, B)$ with the following instance of r.

A	B
1	4
1	5
3	7

- On this instance, $A \rightarrow B$ does **NOT** hold, but $B \rightarrow A$ does hold. So we cannot have tuples like (2, 4), or (3, 5), or (4, 7) added to the current instance.

Functional Dependencies (3)

- K is a superkey for relation schema R if and only if $K \rightarrow R$
- K is a candidate key for R if and only if
  - $K \rightarrow R$ and
  - for no $\alpha \subset K$, $\alpha \rightarrow R$
- Functional dependencies allow us to express constraints that cannot be expressed using superkeys. Consider the schema:

  inst_dept(ID, name, salary, dept_name, building, budget)
- We expect these functional dependencies to hold:

  dept_name $\rightarrow$ *building*

  dept_name $\rightarrow$ *budget*

  ID $\rightarrow$ *budget*

  but would not expect the following to hold:

  dept_name $\rightarrow$ *salary*

Functional Dependencies (4)

- We use functional dependencies to:
  - test relations to see if they are legal under a given set of functional dependencies.
    - If a relation r is legal under a set F of functional dependencies, we say that r **satisfies** F
  - specify constraints on the set of legal relations
    - We say that F **holds on** R if all legal relations on R satisfy the set of functional dependencies F
- **Note**: A specific instance of a relation schema may satisfy a functional dependency even if the functional dependency does not hold on all legal instances
  - For example, a specific instance of instructor may, by chance, satisfy
    $$name \rightarrow ID$$
  - In such cases we do not say that F holds on R

Functional Dependencies (5)

- A functional dependency is trivial if it is satisfied by all instances of a relation
  - Example:
    - $ID, name \rightarrow ID$
    - $name \rightarrow name$
- In general, $\alpha \rightarrow \beta$ is trivial if $\beta \subseteq \alpha$.

Functional Dependencies (6)

- Functional dependencies are:

StudentID	Semester	Lecture	TA
1234	6	Numerical Methods	John
1221	4	Numerical Methods	Smith
1234	6	Visual Computing	Bob
1201	2	Numerical Methods	Peter
1201	2	Physics II	Simon

  - $StudentID \rightarrow Semester$
    $StudentID, Lecture \rightarrow TA$
    $\{StudentID, Lecture\} \rightarrow \{TA, Semester\}$

Functional Dependencies (7)

- Functional dependencies are:

Employee ID	Employee Name	Department ID	Department Name
0001	John Doe	1	Human Resources
0002	Jane Doe	2	Marketing
0003	John Smith	1	Human Resources
0004	Jane Goodall	3	Sales

  - $EmployeeID \rightarrow EmployeeName$
    $EmployeeID \rightarrow DepartmentID$
    $DepartmentID \rightarrow DepartmentName$

Functional Dependencies (9): Closure of a Set of FDs

- $F = \{A \rightarrow B, B \rightarrow C\}$
- $F^+ = \{A \rightarrow B, B \rightarrow C, A \rightarrow C\}$

Module Summary

- Introduced the notion of Functional Dependencies

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