IT420: Database Management and Organization

Introduction to Entity-Relationship Model (Chapter 5)

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Last Time

- Why Database Management Systems?
  - High-level abstractions for data access, manipulation, and administration
  - Data integrity and security
  - Performance and scalability
  - Transactions

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Goals of This Lecture

- Database design: Entity-Relationship Model

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Database Design Process

- Requirements analysis
- Conceptual design $\rightarrow$ data model
- Logical design
- Schema refinement: Normalization
- Physical tuning
Problem: University Database

- Divisions (Colleges)
- Departments
- Faculty
- Students

The College Report

<table>
<thead>
<tr>
<th>Department</th>
<th>Chairperson</th>
<th>Phone</th>
<th>Total Majors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accounting</td>
<td>Jackson, Seymour P.</td>
<td>232-1841</td>
<td>318</td>
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<tr>
<td>Finance</td>
<td>Hsu, Teng, Susan</td>
<td>232-1414</td>
<td>211</td>
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<tr>
<td>Info Systems</td>
<td>Brammer, Nathaniel D.</td>
<td>236-0011</td>
<td>247</td>
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<tr>
<td>Management</td>
<td>Tuttle, Christine A.</td>
<td>236-9988</td>
<td>184</td>
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<tr>
<td>Production</td>
<td>Barnes, Jack T.</td>
<td>236-1184</td>
<td>212</td>
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College of Business
Mary B. Jefferson, Dean
Phone: 232-1187
Campus Address: Business Building, Room 100

The Department Report

Information Systems Department
College of Business
Chairperson: Brammer, Nathaniel D
Phone: 236-0011
Campus Address: Social Science Building, Room 213

<table>
<thead>
<tr>
<th>Professor</th>
<th>Office</th>
<th>Phone</th>
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<tbody>
<tr>
<td>Jones, Paul D.</td>
<td>Social Science, 219</td>
<td>232-7713</td>
</tr>
<tr>
<td>Parks, Mary B.</td>
<td>Social Science, 308</td>
<td>232-5791</td>
</tr>
<tr>
<td>Wu, Elizabeth</td>
<td>Social Science, 207</td>
<td>232-9112</td>
</tr>
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</table>

The Department Major Report

Student Major List
Information Systems Department
Chairperson: Brammer, Nathaniel D
Phone: 236-0011

<table>
<thead>
<tr>
<th>Major's Name</th>
<th>Student Number</th>
<th>Phone</th>
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<tr>
<td>Jackson, Robin R.</td>
<td>12345</td>
<td>237-8713</td>
</tr>
<tr>
<td>Lincoln, Fred J.</td>
<td>48127</td>
<td>237-8713</td>
</tr>
<tr>
<td>Madison, Janice A.</td>
<td>37512</td>
<td>237-8713</td>
</tr>
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</table>
The Student Acceptance Letter

Mr. Fred Parks
323 8th Street
Los Angeles, CA 90000

Dear Mr. Parks:

You have been admitted as a major in the Accounting Department at Hightine
University. Registration for the fall semester begins in two weeks. The office of
the Accounting Department is located in the Business Building, room 227. Your
adviser is Professor Elizabeth Johnson, whose telephone number is 123-4567
and whose office is located in the Business Building, room 227. Please
schedule an appointment with your adviser as soon as you arrive on campus.

Congratulations and welcome to Hightine University!

Sincerely,

Jan P. Smathers
President

JPSInc.

Conceptual Design Overview

- Entity-Relationship (ER) Model
- What are the entities and relationships for given problem?
- What information about these entities and relationships should we store?
- What are the integrity constraints or business rules that hold?

Data Model

- A **data model** is a plan, or blueprint, for a database.
- General
- Abstract (no implementation suggested)
- Easy to change

ER Model

- **Entity-Relationship model**: set of concepts and graphical symbols
- Versions
  - Original E-R model
  - Extended E-R model
  - Information Engineering (IE)
  - IDEF1X
  - Unified Modeling Language (UML)

Original E-R model — Peter Chen (1976)
Extended E-R model — Extensions to the Chen model
Information Engineering (IE) — James Martin (1983). It uses "crow’s foot” notation, is easier to understand and we will use it
IDEF1X — A national standard developed by NIST
Unified Modeling Language (UML) — The Object Management Group, it supports object-oriented methodology
**Entities**

- Something that can be identified and the users want to track
  - **Entity class**
  - **Entity instance**
- There are usually many instances of an entity in an entity class.

**Attributes**

- **Attributes**: describe the characteristics of an entity
- **Entity instances**:
  - Same attributes
  - Different values

**Identifiers**

- **Identifiers** = attributes that identify entity instances
- **Composite identifiers**: Identifiers that consist of two or more attributes

**Entity Attributes Display in Data Models**

- (a) Entity with All Attributes
- (b) Entity with Identifier Attribute Only
- (c) Entity with No Attributes
Relationships

Cardinality

- Cardinality means “count” - a number
- Maximum cardinality
- Minimum cardinality

Maximum Cardinality

- Maximum cardinality: maximum number of entity instances that can participate in a relationship
- One-to-One [1:1]
- One-to-Many [1:N]
- Many-to-Many [N:M]

Minimum Cardinality

- Minimum cardinality: minimum number of entity instances that must participate in a relationship.
- zero [0] → optional
- one [1] → mandatory
HAS-A Relationships

- Previous relationships: HAS-A relationships:
  - Each entity instance has a relationship with another entity instance:
    - An EMPLOYEE has one BADGE
    - A BADGE has an assigned EMPLOYEE.

Data Modeling Notation

Data Modeling Notation: ERwin

<table>
<thead>
<tr>
<th>E-R Diagram Symbol Use</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>Oval with hash mark</td>
<td>0 or 1 entities are allowed</td>
</tr>
<tr>
<td>Hash mark alone</td>
<td>Exactly 1 entity is allowed</td>
</tr>
<tr>
<td>Hash mark with one’s foot</td>
<td>1 or more entities are allowed</td>
</tr>
<tr>
<td>Oval, hash mark, and one’s foot</td>
<td>0, 1, or more entities are allowed</td>
</tr>
</tbody>
</table>

Class Exercise

- Give examples of the following relationships:
  - Maximum cardinality:
    - One-to-One
    - One-to-Many
    - Many-to-Many
  - Minimum cardinality:
    - Optional-Optional
    - Mandatory-Optional
    - Mandatory-Mandatory
ID-Dependent Entities

- **ID-dependent entity**: entity (child) whose identifier includes the identifier of another entity (parent)
- Example:
  - BUILDING : APARTMENT
- Minimum cardinality from the ID-dependent entity to the parent is always one

Weak Entities

- A **weak entity** is an entity whose existence depends upon another entity.
- All ID-Dependent entities are considered weak.
- But there are also non-ID-dependent weak entities.
  - The identifier of the parent does not appear in the identifier of the weak child entity.

Weak Entities (Continued)

- Weak entities must be indicated by an accompanying text box in Erwin – There is no specific notation for a nonidentifying but weak entity relationship

ID-Dependent Entities

- A solid line indicates an identifying relationship

Weak Entities

- A dashed line indicates a nonidentifying relationship

Note: AUTO is a weak, but not ID-dependent, entity.
ID-Dependent and Weak Entities

- **ID-Dependent** entity: Identifier depends (includes) another identifier
  - Identifying relationship
  - Ex: BUILDING:APARTMENT
- **Weak** entity: existence depends on another entity
  - Ex: MODEL:CAR
- ID-Dependent → Weak
- Weak does NOT imply ID-Dependent

Subtype Entities

- **Subtype entity**: special case of a supertype entity:
  - STUDENT: UNDERGRADUATE or GRADUATE
- Supertype:
  - all common attributes
  - [discriminator] attribute
- Subtypes:
  - specific attributes

Subtypes: Exclusive or Inclusive

- If subtypes are **exclusive**, one supertype relates to at most one subtype.
- If subtypes are **inclusive**, one supertype can relate to one or more subtypes.
Subtypes: IS-A relationships

- **IS-A relationships**: a subtype IS A supertype.
- Supertype and subtypes identifiers are identical
- Use subtypes if
  - Have attributes that make sense only for subtypes
  - Want to specify a relationship only for subtype or supertype

Class Exercise

- Drugwarehouse.com has offered you a free lifetime supply of prescription drugs (no questions asked) if you design its database schema. Given the rising cost of health care, you agree. Here is the information that you gathered:
  - Patients are identified by their SSN, and we also store their names and age
  - Doctors are identified by their SSN, and we also store their names and specialty
  - Each patient has one primary care physician
  - Each doctor has at least one patient

ER Summary

- Entities, attributes, identifiers
- HAS-A Relationships
  - Degree: binary, ternary
  - Maximum cardinality
  - Minimum cardinality
- Weak entities
  - ID-dependent entities; identifying relationships
- IS-A Relationships
  - Inclusive, Exclusive

For Next Time

- Read Chapter 5