Entity Relationship Diagram (ERD): Basics

CIS 3730
Designing and Managing Data

J.G. Zheng
Fall 2010
Overview: 3 Level Database Design

Creating an Entity Relationship Diagram (ERD) and associated data dictionary to represent the reality and capture business data requirements

Transforming ERD to relational model: tables, keys (constraints), etc.

Creating the database and other supporting structures based on a specific DBMS

Conceptual Design

Logical Design

Physical Design
Entity-Relationship Diagram

- Proposed by Dr. Peter Chen in 1970s
  - http://en.wikipedia.org/wiki/Peter_Chen

- ERD is a conceptual model

- Major elements
  - Entity (with attributes and identifier)
  - Relationship
Entity and Attribute

Entity
- Entity class (entity set) is a structural description of things that share common attributes
- Entity instance is the occurrence of a particular entity

Attribute
- Describes an entity class
- All entity instances of a given entity class have the same attributes, but vary in the values of those attributes

Identifier
- Identifies an entity instance
- The value of the identifier attribute is unique for each entity instance
Entity Notations in ERD

Chen’s original style

The style used in my Visio examples

Style used in the textbook

(a) Entity with All Attributes
(b) Entity with Identifier Attribute Only
(c) Entity with No Attributes
Other Attribute Types

- **Composite attribute**
  - An attribute that can be further divided into more attributes
  - Example: Name, Address, etc.

- **Multi-Value Attribute**
  - An attribute that allow multiple values
  - Example: skills, phone numbers, etc.

- **Derived attribute**
  - Attributes that can be calculated (derived) from other attributes
  - Example: age, total, interest, due date, etc.

- Unlike the relational model, these attribute are allowed in conceptual models
Relationship

Relationship describes how entities are related

Relationship features
- Cardinality
  - Entity instance’s participation count
- Degree of relationship
  - How many entities are involved in a relationship?

Books ➔ Publish / Published by ➔ Publishers
Cardinality

- Describes how many entity instance can be in the relationship

Maximum cardinality (type of relationship)
- Describes the maximum number of entity instances that participate in a relationship
  - One-to-one
  - One-to-many
  - Many-to-many

Minimum cardinality
- Describes the minimum number of entity instances that must participate in a relationship
One-to-One Relationship

One-to-One (1:1)
- A single entity instance in one entity class is related to a single entity instance in another entity class

ERD Notation (Crow’s foot)
- A governor governs (only) one state; a state has (only) one governor.
One-to-Many Relationship

One-to-Many (1:N)
- A single entity instance in one entity class (parent) is related to multiple entity instances in another entity class (child)

ERD Notation (Crow’s foot)
- A book is published by (only) one publisher; a publisher can publish many (multiple) books
Many-to-Many Relationship

- Many-to-Many (N:M)
  - Each entity instance in one entity class is related to multiple entity instances in another entity class; and vice versa.

- ERD Notation (Crow’s foot)
  - A book can be written by many (multiple) authors; an author can write many (multiple) books
Minimum Cardinality

Minimum cardinality describes the minimum number of instances that must participate in a relationship for any one instance.

Minimums are generally stated as either zero or one:
- 0 (optional): participation in the relationship by the entity is optional.
- 1 (mandatory): participation in the relationship by the entity is mandatory.

ERD Notation (Crow’s foot)

A certificate is optional in the relationship (optional for a programmer); or a programmer may not have any certificates.

A programmer instance is required in the relationship (a programmer is mandatory for a certificate); or a certificate has to be issued to someone.

Certificates

Has / Issued to

Programmers

One to many maximum cardinality: a programmer can have many certificates; a certificate is issued to only one programmer.
## Crow’s Foot Notation Summary

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>How many instances</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Symbol" /></td>
<td>One—Mandatory</td>
<td>Exactly one</td>
</tr>
<tr>
<td><img src="image2" alt="Symbol" /></td>
<td>Many—Mandatory</td>
<td>From one to many</td>
</tr>
<tr>
<td><img src="image3" alt="Symbol" /></td>
<td>One—Optional</td>
<td>From zero to one</td>
</tr>
<tr>
<td><img src="image4" alt="Symbol" /></td>
<td>Many—Optional</td>
<td>From zero to many</td>
</tr>
</tbody>
</table>
Relationship Modeling Considerations

1. Multiple relationships
2. Transitive relationship
3. Attributes of relationships
4. Promoting relationship to entity
1. Multiple Relationships

Multiple relationships can exist between entities, as long as they are independent or different.
2. Transitive Relationship

Entities can be related indirectly by two relationships.

A relationship is redundant if it can be completely represented by alternate transitive relationships.

Is this relationship redundant?

Can Department and Student be related indirectly through these two relationships?
Redundant Relationship?

(a) Nonredundant relationships

(b) Redundant relationships using transitivity

3. Attributes of a Relationship

A relationship can have attributes
Relationships can be modeled as entities, particularly when they have attributes.

Notice the change of cardinality notations (direction)
Degree of Relationship

- Degree of relationship: describes the number of entities involved in a relationship
  - Unary (one entity)
  - Binary (two entities)
  - Ternary (three entities)
  - N’ary (more than 3)

- Binary (two entities) relationship is most common
Unary Relationship

 Unary (recursive): only 1 entity

Example

- A customer can refer multiple other customers, and it’s optional for them to refer other customers (he/she does not have to refer anyone).
- A customer can be referred by only one other customer, and his/her referee is optional (he/she does not have to be referred by anyone).
**Ternary Relationship**

- **Ternary:** 3 entities are required in this relationship

- **Example**
  - A technician uses a notebook in a project
  - Notebook and project as a combination always stay together
  - Any of these 3 entities has to participate the relationship
N’ary Relationship Example

4 entities

- A physician operates on a patient, with certain nurses and supplies participating in this operation at the same time
Summary

Key concepts

- ERD
- Entity, attribute and identifier
- Relationship
  - Cardinality
  - Maximum cardinality: 1:1, 1:N, N:M
  - Minimum cardinality: optional, mandatory
  - Degree: unary, binary, ternary, etc.

- Crow’s foot

Key skills

- Interpret simple ERDs involving the key concepts above.
- Draw simple ERD using the crow’s foot notation to model entities, attributes, identifiers, relationships, and cardinalities correctly, in simple scenarios involving binary relationships.