Announcement

Project 1 Milestone 2 due date: 10/06/2017
The ER (Entity-Relationship) Model
1. High-level motivation for the E/R model

2. Entities

3. Relations

4. E/R Model
• Database design: Why do we need it?
  – Agree on structure of the database before deciding on a particular implementation

• Consider issues such as:
  – What entities to model
  – How entities are related
  – What constraints exist in the domain
  – How to achieve good designs

• Several formalisms exist
  – We discuss one flavor of E/R diagrams
1. **Requirements analysis**
   - What is going to be stored?
   - How is it going to be used?
   - What are we going to do with the data?
   - Who should access the data?

Technical and non-technical people are involved
2. Conceptual Design

- A high-level description of the database

- Sufficiently precise that technical people can understand it

- But, not so precise that non-technical people can’t participate

This is where E/R fits in.
Database Design Process

3. Implementation:

- Logical Database Design
- Physical Database Design
- Security Design
Database Design Process

1. Requirements Analysis
2. Conceptual Design
3. Logical, Physical, Security, etc.

E/R Model & Diagrams used

This process is iterated many times

E/R is a visual syntax for DB design which is precise enough for technical people, but abstracted enough for non-technical people.
The Requirements Analysis Stage

• Sources of requirements
  – User Interviews
  – Forms
  – Reports
  – Queries
  – Use Cases
  – Observation

Understanding the data Problem
Requirements Become the E-R Data Model

• After the requirements have been gathered, they are transformed into an Entity Relationship (E-R) Data Model

• E-R Models consist of
  1. Entities
  2. Attributes
     a) Identifiers (Keys)
     b) Non-key attributes
  3. Relationships
1. E/R BASICS: ENTITIES & RELATIONS
Interlude: Impact of the ER model

- The E/R model is one of the most cited articles in Computer Science
  - Author: Peter Pin-Shan Chen

The entity-relationship model—toward a unified view of data
PPS Chen - ACM Transactions on Database Systems (TODS), 1976 - dl.acm.org
Abstract A data model, called the entity-relationship model, is proposed. This model incorporates some of the important semantic information about the real world. A special diagrammatic technique is introduced as a tool for database design. An example of
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From Google Scholar
Entities and Entity Sets

- **Entities & entity sets** are the primitive unit of the E/R model
  - **Entities** or (entity instances) are the individual objects, which are members of entity sets
    - Ex: A specific person or Item
  - **Entity sets** or (entity classes) are the classes or types of objects in our model
    - Ex: Person, Item
    - *These are what is shown in E/R diagrams - as rectangles*
    - *Entity sets represent the sets of all possible entities*
Entities vs. Entity Sets

Example:

<table>
<thead>
<tr>
<th>Entity Set</th>
<th>Entity Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Name: Xbox</td>
</tr>
<tr>
<td></td>
<td>Category: Total</td>
</tr>
<tr>
<td></td>
<td>Multimedia System</td>
</tr>
<tr>
<td></td>
<td>Price: $250</td>
</tr>
<tr>
<td>My Little Pony</td>
<td>Name: My Little</td>
</tr>
<tr>
<td>Doll</td>
<td>Pony Doll</td>
</tr>
<tr>
<td></td>
<td>Category: Toy</td>
</tr>
<tr>
<td></td>
<td>Price: $25</td>
</tr>
</tbody>
</table>

Entities are **not** explicitly represented in E/R diagrams!

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• An entity set has attributes
  – Represented by ovals attached to an entity set

Shapes are important. Colors are not.
• A **key** is a **minimal** set of attributes that uniquely identifies an entity.

Here, \{name, category\} is **not** a key (it is not **minimal**).

The E/R model forces us to designate a single **primary** key, though there may be multiple candidate keys.
A relationship connects two or more entity sets. It is represented by a diamond, with lines to each of the entity sets involved. The degree of the relationship defines the number of entity classes that participate in the relationship:
- Degree 1 is a unary relationship
- Degree 2 is a binary relationship
- Degree 3 is a ternary relationship
Conceptual Unary Relationship

Person \(\rightarrow\) Marries
Conceptual Binary Relationship

Person -- Owns --> Cars
Conceptual Ternary Relationship

Doctor

Patient

Prescription

Drug

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• E, R and A together:
What is a Relationship?

- **A mathematical definition:**
  - Let $A$, $B$ be sets
    - $A = \{1,2,3\}$, $B = \{a,b,c,d\}$
What is a Relationship?

• A mathematical definition:
  
  – Let A, B be sets
    • A={1,2,3}, B={a,b,c,d}

  – A x B (the cross-product) is the set of all pairs (a,b)
    • A x B = {(1,a), (1,b), (1,c), (1,d), (2,a), (2,b), (2,c), (2,d), (3,a), (3,b), (3,c), (3,d)}
What is a Relationship?

- **A mathematical definition:**
  - Let $A$, $B$ be sets
    - $A = \{1,2,3\}$, $B = \{a,b,c,d\}$,
  - $A \times B$ (the **cross-product**) is the set of all pairs $(a,b)$
    - $A \times B = \{(1,a), (1,b), (1,c), (2,a), (2,b), (2,c), (2,d), (3,a), (3,b), (3,c), (3,d)\}$
  - We define a **relationship** to be a subset of $A \times B$
    - $R = \{(1,a), (2,c), (2,d), (3,b)\}$
What is a Relationship?

• **A mathematical definition:**
  – Let $A, B$ be sets
  – $A \times B$ (the *cross-product*) is the set of all pairs
  – A *relationship* is a subset of $A \times B$

• **Makes is relationship-** it is a *subset* of Product $\times$ Company:
What is a Relationship?

A relationship between entity sets $P$ and $C$ is a subset of all possible pairs of entities in $P$ and $C$, with tuples uniquely identified by $P$ and $C$'s keys.
What is a Relationship?

A relationship between entity sets P and C is a subset of all possible pairs of entities in P and C, with tuples uniquely identified by P and C’s keys.
What is a Relationship?

A **relationship** between entity sets $P$ and $C$ is a *subset of all possible pairs of entities in $P$ and $C*, with tuples uniquely identified by *$P$ and $C$'s keys*.
What is a Relationship?

A **relationship** between entity sets **P** and **C** is a **subset of all possible pairs of entities in P and C**, with tuples uniquely identified by **P and C’s keys**.
• Relationships may have attributes as well.

For example: “since” records when company started making a product

Note: “since” is implicitly unique per pair here! Why?
Types of Relationships
Conceptual Crow’s Foot Relationship Symbols

One  ----  Many
Many-Many Relationships

• Focus: binary relationships, such as Sells between Seller and Buyer.
• In a many-many relationship, an entity of either set can be connected to many entities of the other set.
  – E.g., a seller sells many items; a buyer can buy many items too.
many-many
Many-One Relationships

• Some binary relationships are *many-one* from one entity set to another.
• Each entity of the first set is connected to at most one entity of the second set.
• But an entity of the second set can be connected to zero, one, or many entities of the first set.
• E.g.: One buyer can have multiple order numbers, but one order can be bought by only one buyer.
In Pictures:

many-one
One-One Relationships

• In a one-one relationship, each entity of either entity set is related to at most one entity of the other set.

• **Example:** Relationship *president* between entity *country* and *person*.
  
  – A person can be the president of only one country. One country can have only one president.
In Pictures
Maximum Cardinality

- Relationships are named and classified by their cardinalities, which is a word that means count (as in the number of items in a set).
- Each of the three types of binary relationship shown previously has a different maximum cardinality.
- Maximum cardinality is the maximum number of entity instances that can participate in a relationship instance:
  - One, many, or some other positive fixed number.
Minimum Cardinarity

- Minimum cardinality is the minimum number of entity instances that must participate in a relationship instance
- These values typically assume a value of zero (optional) or one (mandatory)
Crow’s Foot Symbols with Cardinalities

- One-and-Only-One
- One-to-Many
- Zero-to-One
- Zero-to-Many
Cardinality Example

- Maximum cardinality is many for Order and one for Customer
- Minimum cardinality is one for both Customer and Order
  - Each customer can place one or more orders
  - Each order is associated with one and only one customer
The diagrams in previous slides are called entity-relationship diagrams:
- Entities represented by rectangles
- Relationships represented by lines
- Cardinalities represented by Crow’s Foot symbols
HAS-A Relationships

• The relationships in the previous slides are called HAS-A relationships
• The term is used because each entity instance has a relationship to a second entity instance
  – An employee has a locker
  – A locker has an employee
• There are also IS-A relationships
DRAW AN E/R DIAGRAM FOR FOOTBALL

Use the following simplified model of a football season
(concepts to include are underlined):

Teams play each other in Games. Each pair of teams can play each other multiple times

Players belong to Teams

A Game is made up of Plays that result in a yardage gain/loss, and potentially a touchdown

A Play will contain either a Pass from one player to another, or a Run by one player

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