Lecture 3 – Modeling and ER

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A simplified diagram to illustrate the main phases of database design.
Entity-Relationship Data Model

• ER models include:
  – Entities
    • Things in the real world
  – Attributes
    • Properties of entities
  – Relationships
    • Between and among entities
ER: Entities

• Entities are:
  – Things in the real world...
    • with independent existence (EN6 7.3.1)
    • distinguishable from other objects (Ram98, 14.2.1)
    • Ex: this classroom, a particular grocery store, the manager of that grocery store
  – Entities are placed in rectangles in an ER diagram
ER: Attributes

• Attributes are:
  – Properties that describe an entity
    • Ex: room size, number chairs, projector y/n?
    • Ex: employee id #, department, pay rate
ER: Attributes

• Every attribute has a **domain**
  – Specifies the possible values for an attribute
  – All attributes must have a domain defined
  – Examples:
    • Employee id # \(\rightarrow\) *nine digit number*
    • Department \(\rightarrow\) *{produce, bakery, cashier}*
    • Pay rate \(\rightarrow\) *dollars and cents per hour, minimum = minimum wage, maximum = set by management*
Simple vs. Composite Attributes

• Simple (atomic) attributes have one “part”
• Composite attributes have multiple parts

Here, Address is a composite attribute

123 Maple St., Anytown, NC 10012
Use Composite Attributes with Caution

210 Manning
office
building
room
dancing, sailing

vitals
weight
height
b_date
temp
bp

150, 5’10”, 03-23-1962, 97, 130/82
Representing Values

• Suppose you are modeling a T-shirt store
  – T-shirts are available in XS, S, L, XL, XXL.
  – But not in sizes like 8, 10, 12
  – And not in size M

• How do you model this in an ER diagram?
Representing Values

• Suppose you are modeling a T-shirt store
  – T-shirts are available in XS, S, L, XL, XXL.
  – But not in sizes like 8, 10, 12
  – And not in size M

• How do you model this in an ER diagram?
  
  Answer: You don’t!
  
  You have a size attribute
  and implement a constraint on the values later.
ER: Types of Attributes

• Single-valued
  – only one value for an entity
  – Ex:
    • for a person – age, height

• Multivalued
  – multiple values for a single entity
  – Ex:
    • a car may have several colors
    • a person may have more than one college degree
ER: Types of Attributes

• Stored vs. derived
  – Derived
    • can be computed from other attribute(s)
    • Ex: age and birth_date
  – Stored
    • value is stored, not derived from other attributes

• NULL values
  – If a particular entity does not have a value for an attribute
ER: Entities

• Entity type
  – A collection of entities with the same attributes
    • Ex: EMPLOYEES, CLASSROOMS

• Entity set
  – A collection of all entities of a particular entity type at a given point in time in the DB
    • Ex: for a given grocery store, all the employees on a given date
    • Ex: for a given university, all the classrooms on a given date
Entity Types

Entity Type Name: EMPLOYEE
Name, Age, Salary

- $e_1$: (John Smith, 55, 80k)
- $e_2$: (Fred Brown, 40, 30K)
- $e_3$: (Judy Clark, 25, 20K)

Entity Type Name: COMPANY
Name, Headquarters, President

- $c_1$: (Sunco Oil, Houston, John Smith)
- $c_2$: (Fast Computer, Dallas, Bob King)

Entity Set: (Extension)

EN6, Fig 7.6
ER: Keys

• Key attributes
  – For each entity type, typically one or more subsets of attributes form a key that uniquely identifies each individual entity in an entity set:
    • One attribute is the key
      – Ex: SSN, emp_id_num
    • More than one attribute forms a key
      – Ex: \{street_address + zip_code\}
  – Key attributes are underlined in the ER diagram
ER: Relationships

• Types, sets, instances – similar to entities

“A relationship type $R$ among entity types $E_1$, $E_2$, etc. defines a set of associations – or a relationship set – among entities from these entity types.” (EN6, 7.4.1)

– Entities are said to participate in relationships
– Relationships can also have attributes

![ER diagram]

- EMP
- WORK_IN
- DEPT
- years

years
Relationships

• **Degree**
  
  – the number of entities that **participate** in the relationship
  – Binary relationship = 2
  – Ternary relationship = 3
ER Relationships

• An association between entities
  – Will be represented in the DB
  – Usually a verb
  – Represent business rules or practices, laws, policies
  – All entities do not have to be connected to all other entities
  – Each entity is (usually) connected to at least one other entity

• 3 design decisions
  – which entities
  – cardinality
  – participation
Degree

- Unary

- Binary

- Ternary

- N-ary (not shown)
Recursive Relationships

A recursive relationship SUPervision between EMPLOYEE in the supervisor role (1) and EMPLOYEE in the subordinate role (2).

EN6, Fig 7.11
Cardinality

• Cardinality ratios for binary relationships

“Maximum number of relationship instances that an entity can participate in”, (EN6, 7.4.3)

1:1    one-to-one
1:N    one-to-many
N:1    many-to-one
M:N    many-to-many
Cardinality Examples

- Questions to determine cardinality:
  - How many instances of B can be associated with 1 instance of A?
  - How many instances of A can be associated with 1 instance of B?

- Two separate questions for each (binary) relationship:
  - Stand on 1 instance of A; how many Bs can you see?
  - Stand on 1 instance of B; how many As can you see?
• One-to-one
  – 1 instance of A can be associated with 1 instance of B. 1 instance of B can be associated with 1 instance of A.
  – e.g., in a Dr. office, *medical record documents patient*

  – Remember the questions:
    • How many instances of B can be associated with 1 instance of A?
    • How many instances of A can be associated with 1 instance of B?
    • *Stand on 1 instance of A; how many Bs can you see?*
    • *Stand on 1 instance of B; how many As can you see?*
One-to-many

- 1 instance of A can be associated with many instances of B. 1 instance of B can be associated with 1 instance of A.
- e.g., in school, faculty member advises student
- Be careful with the wording!

- Remember the questions:
  - How many instances of B can be associated with 1 instance of A?
  - How many instances of A can be associated with 1 instance of B?
  - Stand on 1 instance of A; how many Bs can you see?
  - Stand on 1 instance of B; how many As can you see?
• Many-to-many
  - 1 instance of A can be associated with many instances of B. 1 instance of B can be associated with many instances of A.
  - e.g., in school, student enroll in class
  - Be careful with the wording!

  – Remember the questions:
    • How many instances of B can be associated with 1 instance of A?
    • How many instances of A can be associated with 1 instance of B?
    • *Stand on 1 instance of A; how many Bs can you see?*
    • *Stand on 1 instance of B; how many As can you see?*
Participation

• Participation constraints
  – The existence of an entity depends on its being related to another entity via the relationship type
  – Is the minimum number of relationship instances an entity can participate in
    • Total participation
      – “Every employee must work for a department”
        » Implies that an EMP does not exist in the DB unless they are in a WORK_FOR relationship with a DEPT
    • Partial participation
      – Some (but not all) employees are managers
        » Participation of EMP in MANAGES relationship is partial
        » Some subset of EMP are related to DEPT by MANAGES, but not necessarily all
Participation

• Question to ask is:
  – Must an instance of A be associated with an instance of B in order to exist (have a record in) the database?

• Two answers:
  1) mandatory or required
     • Use a double-line in the ER diagram
     • e.g. in e-commerce DB, an order must be placed by a customer
  2) optional
     • Use a single line in the ER diagram
     • e.g., in e-commerce DB, an item can be listed even if it is not contained in an order
Confusing differences in notations

- EMP
  - WORKS
    - M
    - 1
    - N
  - LOCATE
    - N
    - BUILDING

- EMP
  - WORKS
    - (1,1)
    - (1,N)
  - LOCATE
    - (1,N)
    - BUILDING

- EMP
  - WORKS
    - (1,N)
    - (0,M)
  - LOCATE
    - (1,N)
    - BUILDING
Figure 3.2
An ER schema diagram for the COMPANY database. The diagrammatic notation is introduced gradually throughout this chapter.