Entity-Relationship (ER) Model

CS 4750 Database Systems

[A. Silberschatz, H. F. Korth, S. Sudarshan, Database System Concepts, Ch.6] [C.M. Ricardo and S.D. Urban, Database Illuminated, Ch.3]

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I've Got Great Ideas for An App



- In database design, communication is key
- Many people are involved in the design process

We need a way to communicate our ideas

[modified from image by Janetti, https://www.cleanpng.com/png-project-management-project-manager-architectural-e-5729993/download-png.html]

Creating DB App



Overview: Creating DB App



Database design = process of organizing data into a database model by considering data to be stored and the interrelationship of the data

Database Design Process

Interact with users and domain experts to characterize the data

Translate requirements into conceptual model (E-R diagrams)

Convert the model to relational model (schema and constraints)

Normalize and develop conceptual (logical) schema of the database

Develop physical schema (partitioning and indexing)











Entity-Relationship Model

 E-R diagram – high-level design model representing a database as a collection of entities and relationships among entities



E-R Diagram: Building Blocks



Note: colors are not part of E-R Diagram. They simply are used to increase readability.

Entity and Entity Sets

- Entity ~an object (thing to keep track to run the business)
- Entity set ~a class (~table, a collection of things of the same kind)

Some entity set examples





Entity – Instance – Attributes

- Entity ~an object (thing to keep track to run the business)
- **Instance** ~actual occurrence of the entity (~row in a table)
- Attribute ~ a field (property of the entities in that set)



Note: instances do not exist in E-R. The term is mentioned here for completeness. It will be revisited when we discuss data model.

Entity Sets and Attributes



E-R model is a static concept, involving the structure of data and not the operations on data. Thus, no methods associated with an entity set

Attributes

- **Single-valued attribute** allows a single value
- Multi-valued attribute allows multiple values at the same time
- Derived attribute –can be calculated from one or more attributes
- Composite attribute consists of multiple values



Attributes

• Composite attribute – can have as many levels as needed



Let's try: Movie-Database

Identify entity, entity sets, and attributes

Object **Movies** Each movie has a *title* and *year*; *titl* identify the movie. *Length* and *gent* Each movie is associated with a *stu*

Each movie has a *title* and *year*; *title* and *year* together uniquely identify the movie. *Length* and *genre* are maintained for each movie. Each movie is associated with a *studioName* which tells us the studio that owns the movie, and *producerC#* which is an integer that represents the producer of the movie.

Object

MovieStars²

MovieStars tells us something about stars. It maintains the *name* of the movie star, address, gender, and birthdate. The gender can be a single character (M or F). Birthday is of type "date," which might be a character string of a special form.

Let's try: Movie-Database

Movies



Title	Year	Length	Genre
Mickey's Club House	1939	231	drama
Awesome Minnie	1977	124	sciFi
Most wanted	1992	95	comedy

MovieStars



name	address	gender	birthdate
Mickey	11 Somewhere, Charlottesville, VA, 22903	F	01/01/1911
Minnie	22 Another place, Fairfax, VA, 22030	Μ	02/02/1912
Donald	nald 33 Nowhere, Charlottesville, 22911		03/03/1913

Note: Instances of E-R Diagram

E-R model is used to design a database. The database is not implemented. Therefore, the instance of E-R diagram never exists in the sense that a relation's instances exist in a relational model.

However, it is often useful to visualize the database being designed as if it existed.

Relationships

- Connections among two or more entity sets
- Binary relationships connections between two entity sets
- Multi-way relationships connections involving more than two entity sets

Binary Relationships

If A and B are sets, a relationship R is a subset of A X B

product			company		
pid	name	description	name	address	
11	Beyblade		Dreamwork		
22	Trolls		Hashbro		
			Nyform		



Cardinality (or Multiplicity)

A binary relationship can connect any member of one of its entity sets to any number of members of the other entity set



Cardinality: One-to-One

product			company		
pid	name	description	name	address	
11	Beyblade		 Dreamwork		
22	Trolls		 Hashbro		
			Nyform		



Each product can be made by at most one company. Each company can make at most one product.

"at most one" – Guarantee existence?

Cardinality: One-to-Many

product			company		
pid	name	description		name	address
11	Beyblade			Dreamwork	
22	Trolls			Hashbro	
				Nyform	
Arro	pr w pointing to t	oduct	makes	>com	ipany

Each product can be made by many companies. Each company can make at most one product.

"at most one" and "many" – Guarantee existence?

Cardinality: Many-to-One





Each product can be made by at most one company. Each company can make many products.

"at most one" and "many" – Guarantee existence?

Cardinality: Many-to-Many

product			company		
pid	name	description	name	address	
11	Beyblade		Dreamwork		
22	Trolls		Hashbro		
			Nyform		



Each product can be made by many companies. Each company can make many products.

"many" – Guarantee existence?

Let's try: Cardinality (1)

Draw an E-R diagram to model the given image sample data. Specify the cardinality. Interpret the E-R diagram.



(many-to-one)

Let's try: Cardinality (2)

Draw an E-R diagram to model the given image sample data. Specify the cardinality. Interpret the E-R diagram.



(one-to-one)

Let's try: Cardinality (3)

Draw an E-R diagram to model the given image sample data. Specify the cardinality. Interpret the E-R diagram.



(many-to-many)

Let's try: Cardinality (4)

Draw an E-R diagram to model the given image sample data. Specify the cardinality. Interpret the E-R diagram.



(one-to-many)

Total Participation

Total participation – all entities in an entity set must participate in the relationship



Every product must be made by at least one company. Each product can be made by many companies. Each company can make many products. Some companies may not make any product.

Let's try: Participation (1)

Interpret the E-R diagram.



Every product must be made by exactly one company. Each company can make many products. Some companies may not make any product.

Let's try: Participation (2)

Interpret the E-R diagram.



Every employee must be assigned to at least one department. Each employee can be assigned to many departments. Each department can have many employees. Every department must have at least one employee.

Let's try: Participation (3)

Interpret the E-R diagram.



Each instructor must work for at least 1 department (double lines on the instructor) Each instructor can work for at most 1 department (arrow points to the department). Thus, each instructor works for exactly 1 department.

Each department has 0...many instructors (no arrow points to the instructor).

Let's try: Participation (4)

Interpret the E-R diagram.



Each instructor must work for at least 1 department (double lines on the instructor). Each instructor can work for at most 1 department (arrow points to the department). Thus, each instructor works for exactly 1 department.

Each department has at most 1 instructor (0..1) (arrow points to the instructor).

Let's try: Participation (5)

Interpret the E-R diagram.



Each instructor must work for at least 1 department (double lines on the instructor). Each instructor can work for many departments (no arrow points to the department). Thus, each instructor works for 1...many department.

Each department has at most 1 instructor (0..1) (arrow points to the instructor).

Let's try: Participation (6)

Interpret the E-R diagram.



Each instructor must work for at least 1 department (double lines on the instructor). Each instructor can work for many departments (no arrow points to the department). Thus, each instructor works for 1...many department.

Each department must have at least 1 instructor (double lines on the department). Each department has at most 1 instructor (arrow points to the instructor). Thus, each department has exactly 1 instructor.

Attributes on Relationships

- Relationships can have attributes
- The attributes have values only when the relationship occurs



Let's try: Attributes - Relationships

Interpret the E-R diagram.



Each student can take many courses.

Each course can be taken by many students.

A grade exists only when the student takes a course.

Wrap-Up

- Database design process
- Intro to E-R model
- Entities and entity sets
- Attributes: single-valued, multi-valued, derived, composite
- Cardinality and participation

What's next?

- Roles in relationships
- Relationships: binary, multi-way
- Weak entity