

CSEN 501 – CSEN501 - Databases I

Lecture 1: The Entity-Relationship Model

Prof. Dr. Slim Abdennadher

`slim.abdennadher@guc.edu.eg`

German University Cairo, Faculty of Media Engineering and Technology

Data Model

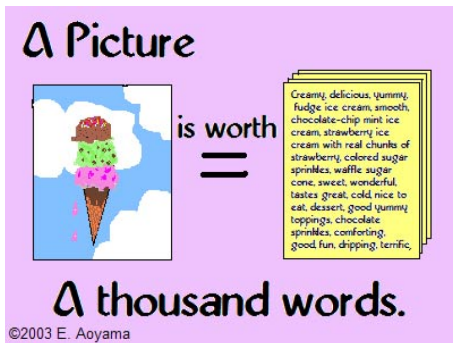
- A **data model** describes conceptual structuring of data stored in database.
 - **Example**: Data is set of records, each with ID, name, address, and courses.
 - **Example**: Data is a graph where nodes represent proteins and edges represent chemical bonds between proteins.
- Data model provides a description of the database structure including:
 - The data
 - The relationships within the data
 - The constraints on the data
- Different representation methods:
 - **Entity-Relationship Model**
 - Relational Model
 - Object-Oriented Model
 - Object Relational Model

Database Schema and Database instance

- **Database Schema** describes how data is to be structured
 - defined during creation of the database
 - rarely change
- **Database instance**: The data stored in the database at a given moment.
 - rapidly change
 - updated continuously

What is the Entity-Relationship Model?

A Picture Is Worth a Thousand Words



Entity-Relationship Model

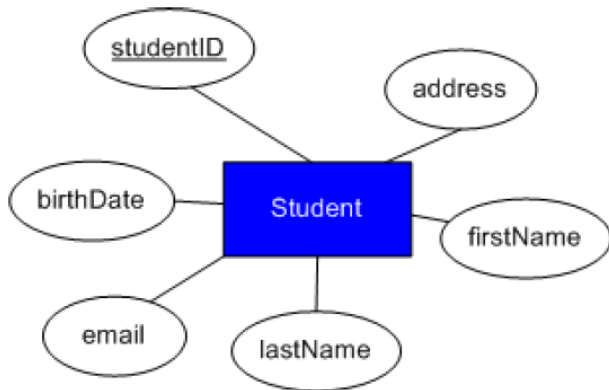
- First introduced in the mid 1970's by Chen as an improvement to the relational model.
- The **Entity-Relationship** (E/R) model allows us to draw diagrams of database designs.
 - Represent different types of data and how they relate to each other.
- The design is a drawing called the **entity-relationship** diagram.
- The **Entity-Relationship** model is an example of what is called a **semantic** model
 - Description of conceptual and external levels of data
 - Independent of the internal and physical aspects
- We will learn later how to convert an E/R diagram to a relational schema (database design)

Ideas \Rightarrow E/R Design \Rightarrow Relational Schema \Rightarrow Relational DBMS

Entity - Entity Set - Attributes

- An **Entity** is an abstract object of some sort.
 - **Banking system**: Customer, Account, Loan.
 - **Airline system** : Aircraft, Passenger, Flight, Airport.
- An **Entity set** is a collection of similar entities.
- Entities have attributes.
 - An **attribute** is a property of the entities in an entity set.
- In an **E/R diagram**:
 - A **rectangle** represents an entity set
 - An **oval** represents an attribute
 - A **line** connects an entity set (rectangle) to an attribute (oval)

Attributes: An Example



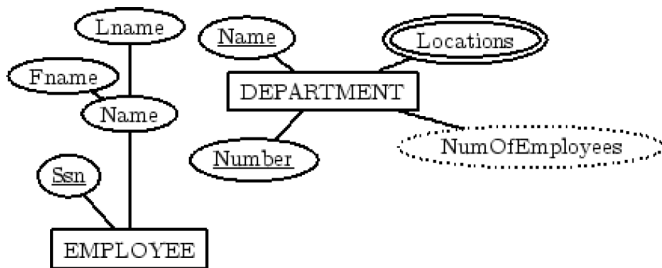
What appears to be an attribute to one designer may be an entity to another

Attributes: Domain and Values

- Attributes have a **value** set or **domain** (set of possible values).
- **Null values**: Sometimes the value of an attribute is unknown at the present time or undefined for a particular instance.
- **Composite Attributes**: can be decomposed into smaller elements.
Example: Address can be broken down into street, city, state, and zip.
- **Multivalued Attributes**: have multiple values for an entity instance, e.g. student with more than one e-mail address.
- **Derived Attributes**: whose value can be calculated when needed.
Example: Age may be determined from the current date and the date of birth.

Attributes in ER-Diagram

- **Multivalued Attribute:** Double oval around the attribute's name
- **Composite Attribute:** Writing the name in an oval and then drawing ovals for the individual components which are connected by lines to the composite attribute's oval
- **Derived Attribute:** Dashed oval around the attribute's name



Entity Identification

The process of identifying entities is one of the most important steps in developing a data model.

Some guidelines:

- An **informal questioning approach**: the analyst asks targeted questions to determine what information is necessary and whether or not that information is recorded within the system.
- **Face to face discussions with user**: the nouns should be recorded.
- The **existing documentation** often contains clues.
- Every fact that is required to support the business is almost certainly an attribute. In turn each of these attributes will belong to an entity. If no “parent” entity can be found for one or more of these low level facts, then this indicates that your entity search is incomplete.

Entity identification can continue once the drawing of the data model diagram has begun

Keys I

- Each entity occurrence can be uniquely identified, by using an attribute or a combination of attributes as a **key**.
- A **Super Key** is the attribute (or group of attributes) that serve to uniquely identify each entity occurrence.
 - Consider the following **problem**: the name and address of an individual were used as the super key for identifying the patients within a hospital.
 - Take the example of a patient called Mohammed Mohammed living in New Cairo City. He has a son also called Mohammed Mohammed living at the same address.
 - Name and Address would not necessarily provide a unique identifier and confusion could easily arise.
 - In a hospital system patients each have a *PatientNumber* as their super key.

Keys II

- If two or more data items are used as the unique identifier, then this represents a **Compound Key**.
 - **Example**: a compound key used to identify a book could be “Title” together with “Author”.
- A **Candidate Key** is a super key such that no proper subset of its attributes is itself a super key.
- An entity set might have several candidate keys.
 - **Example**: A book could be identified, either by “Title” together with “Author” or by the widely used unique identifier for books - the ISBN number.
- The **Primary Key** is the candidate key actually chosen.

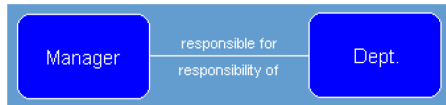
Relationships

- Entities are often linked by associations or relationships.
- A **Relationship** is a connection between two or more entity sets.
- In an **E/R diagram**
 - a diamond represents a relationship
 - a line connects the relationship to each entity set.



Relationship Link Phrase

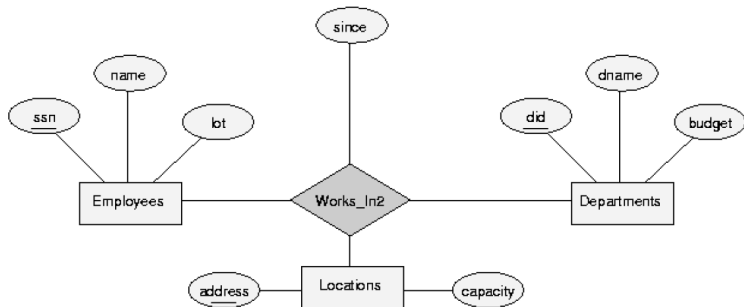
Alternative representation of relationships:



- **Relationship link phrase** should be a short description of the nature of the relationship.
- It is always read **clockwise** with respect to the entities that it links.
- **Example**: “Manager is responsible for department” and “Department is responsibility of manager”.

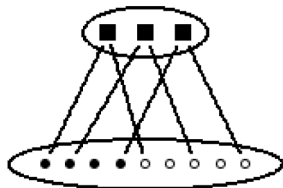
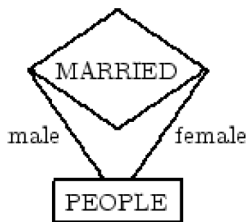
Ternary Relationships

- A relationship set need not be an association of precisely two entities; it can involve three or more when applicable.
- A relationship that involves three entities is called **ternary relationship**.
- **Example**: A store having multiple locations



Recursive Relationships

- A **Recursive Relationship** is a relationship that associate an entity type with itself.



Relationship Cardinality

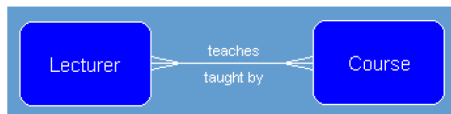
- **One-to-one relationship:** Each manager is responsible for only one department and each department is the responsibility of only one manager.



- **One-to-many relationship (crow's foot symbol):** Each company employs one or more employees, but each employee is employed by only one company.



- **Many-to-many relationship:** Each lecturer teaches one or more courses and each course is taught by one or more lecturers.



Identifying Relationships

- In order to identify the **degree** of the relationship between the entities X and Y the following two questions need to be asked.
 - **Question 1**: Can an occurrence of X be associated with more than one occurrence of Y?
 - **Question 2**: Can an occurrence of Y be associated with more than one occurrence of X?
- **Four possible outcomes**:

| Question 1 | Question 2 |
|------------|------------|
| YES | NO |
| No | Yes |
| YES | YES |
| NO | NO |

- **Option 1 and Option 2**: A one-to-many relationship has been identified.
- **Option 3**: A many-to-many relationship has been identified.
- **Option 4**: A one-to-one link has been identified.

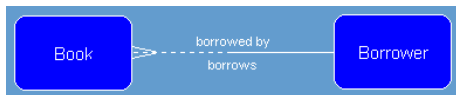
Relationship Participation

The final property of the relationship statement is the **total and partial participation**.

- A solid line shows that an entity occurrence must be associated with each occurrence of the other entity.
- **Example:** Each passenger must possess a ticket, and each ticket must belong to a passenger.

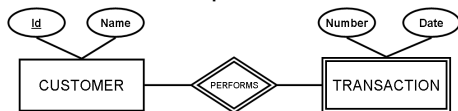


- A dotted line shows that an entity occurrence may be associated with each occurrence of the other entity.
- **Example:** Each book may be borrowed by a borrower, and each borrower must borrow one or more books.



Weak Entities

- A **Weak Entity** is an entity that cannot be uniquely identified by its own attributes alone.
- A weak entity can be identified uniquely only by considering another entity.
- **Example:** Each book has several editions, and certainly it is nonsense to speak about an edition if this does not happen in the context of a specific book.

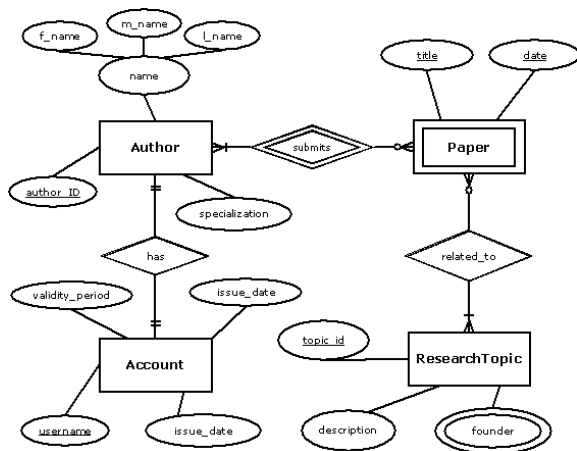


- A weak entity is depicted in the ERD by drawing a double rectangle around the entity and making the relationship diamond a double diamond.

ERD Example - Small Conference

- We need to keep track of **authors** that submit papers to the conference. An author should be identified uniquely and information such as his **name** (first, middle and last name) and **research specialization** should be recorded.
- We need to keep track of the **papers** submitted to the conference. A research paper is identified by its **author, title, and date**. One author can submit one or more papers to the conference and some papers are submitted by more than one author.
- Each paper is related to one or more **research topics**. We need to keep track of the research topics that the conference has covered. A research topic should be uniquely identified. The **founder(s)** and **description** of each topic should also be recorded.
- Each author participating in the conference has an **account** through which he can access all conference-related material. An account is identified by a unique **username**. The **password, issue date and validity period** of an account should also be recorded.

ERD Example - Small Conference



Objectives

In this lecture, you learned

- The meaning of entity and entity set
- How to represent entities on the entity relationship (E/R) diagram
- The meaning of an attribute
- How attributes are associated with entities
- The meaning of an attribute domain
- The meaning of multi-valued, composite, and derived attributes
- The meaning of different kinds of keys
- The meaning of relationship
- How to represent relationship sets and their attributes on an E/R diagram
- The meaning and representation of the cardinality of a relationship
- The meaning of existence dependency