ENSF 608:
Entity-Relationship (ER) Modelling and Enhanced Entity-Relationship Modelling

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Lesson Content (1 of 2)

- Overview of Database Design Process
- Example Database Application (COMPANY)
- ER Model Concepts
  - Entities and Attributes
  - Entity Types, Value Sets, and Key Attributes
  - Relationships and Relationship Types
  - Weak Entity Types
  - Roles and Attributes in Relationship Types

Lesson Content (2 of 2)

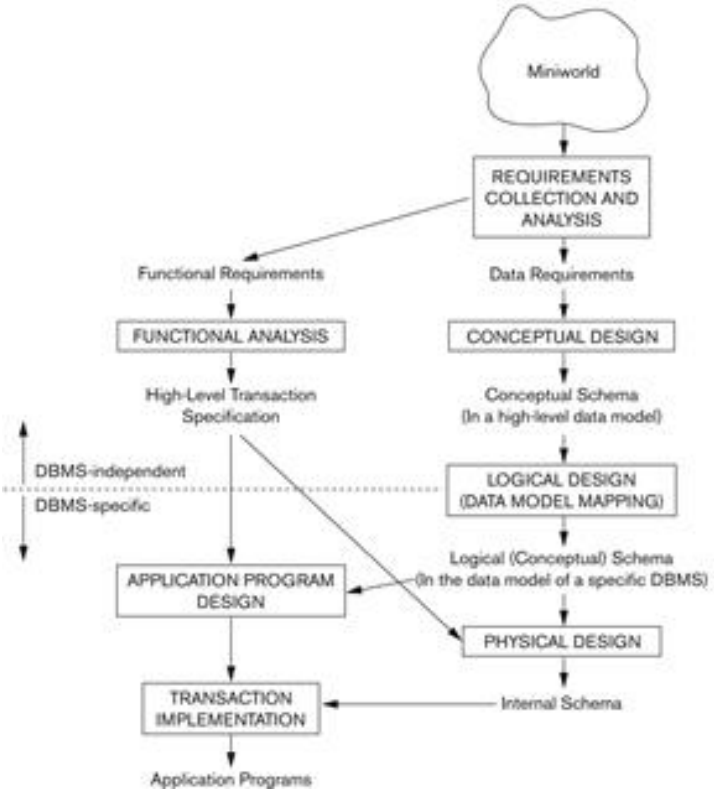
- Relationships of Higher Degree
- ER Diagrams - Notation
- ER Diagram for COMPANY Schema
- Alternative Notations – UML class diagrams, others
- EER Model Concepts
  - Subclasses/Superclasses
  - Specialization/Generalization
  - Categories (UNION types)
  - Attribute and Relationship Inheritance
  - Constraints

Overview of Database Design Process (1 of 2)

- Two main activities:
  - Database design
  - Applications design
- Focus in this topic on **conceptual database design**
  - To design the conceptual schema for a database application
- Applications design focuses on the programs and interfaces that access the database
  - Generally considered part of software engineering

Overview of Database Design Process (2 of 2)

Figure 3.1 A simplified diagram to illustrate the main phases of database design.



Example COMPANY Database (1 of 2)

- We need to create a database schema design based on the following (simplified) **requirements** of the COMPANY Database:
  - The company is organized into DEPARTMENTs. Each department has a name, number and an employee who **manages** the department. We keep track of the start date of the department manager. A department may have several locations.
  - Each department **controls** a number of PROJECTs. Each project has a unique name, unique number and is located at a single location.

Example COMPANY Database (2 of 2)

- The database will store each EMPLOYEE's social security number, address, salary, sex, and birthdate.
  - Each employee **works for** one department but may **work on** several projects.
  - The DB will keep track of the number of hours per week that an employee currently works on each project.
  - It is required to keep track of the **direct supervisor** of each employee.
- Each employee may **have** a number of DEPENDENTs.
  - For each dependent, the DB keeps a record of name, sex, birthdate, and relationship to the employee.

ER Model Concepts (1 of 2)

- Entities and Attributes
  - Entity is a basic concept for the ER model. Entities are specific things or objects in the mini-world that are represented in the database.
    - For example the EMPLOYEE John Smith, the Research DEPARTMENT, the ProductX PROJECT
  - Attributes are properties used to describe an entity.
    - For example an EMPLOYEE entity may have the attributes Name, SSN, Address, Sex, BirthDate

ER Model Concepts (2 of 2)

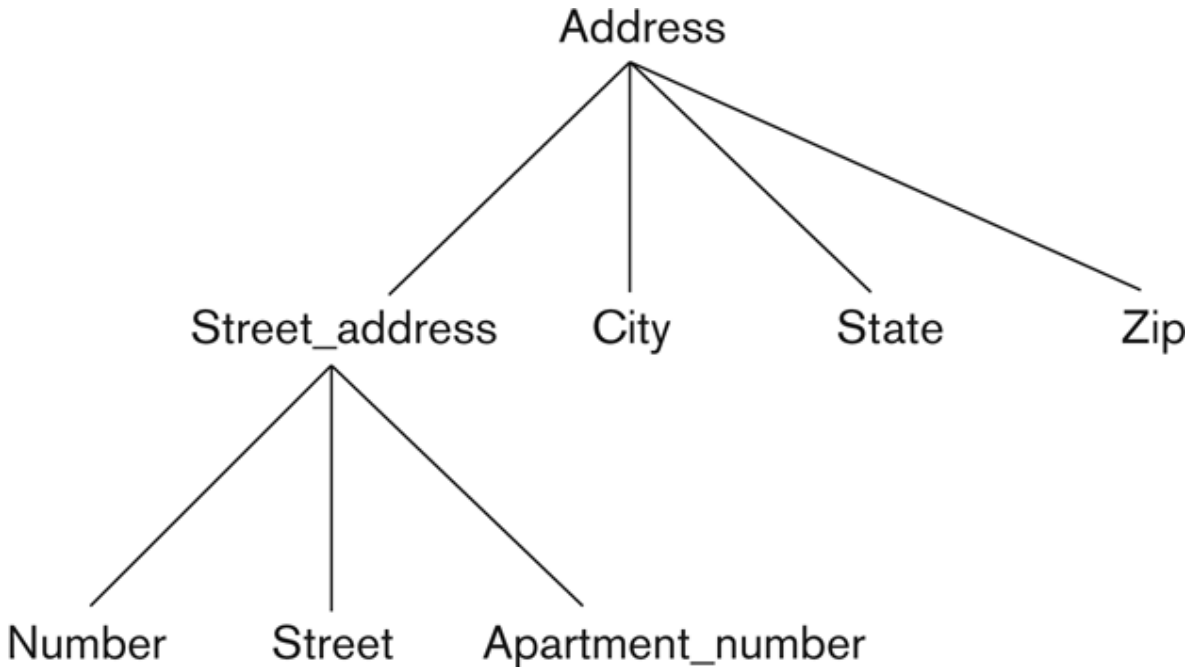
- A specific entity will have a value for each of its attributes.
  - For example a specific employee entity may have Name='John Smith', SSN='123456789', Address ='731, Fondren, Houston, TX', Sex='M', BirthDate='09-JAN-55'
- Each attribute has a **value set** (or data type) associated with it – e.g. integer, string, date, enumerated type, …

Types of Attributes (1 of 3)

- Simple
  - Each entity has a single atomic value for the attribute. For example, SSN or Sex.
- Composite
  - The attribute may be composed of several components. For example:
    - Address(Apt#, House#, Street, City, Province, PostalCode, Country), or
    - Name(FirstName, MiddleName, LastName).
    - Composition may form a hierarchy where some components are themselves composite.

Example of a Composite Attribute

Figure 3.4 A hierarchy of composite attributes.



Types of Attributes (2 of 3)

- Multi-valued
  - An entity may have multiple values for that attribute. For example, Color of a CAR or PreviousDegrees of a STUDENT.
    - Denoted as {Color} or {PreviousDegrees}.
- In general, composite and multi-valued attributes may be nested arbitrarily to any number of levels, although this is rare.
  - For example, PreviousDegrees of a STUDENT is a composite multi-valued attribute denoted by {PreviousDegrees (College, Year, Degree, Field)}

Types of Attributes (3 of 3)

  - Multiple PreviousDegrees values can exist
  - Each has four subcomponent attributes:
    - College, Year, Degree, Field

- Derived
  - Attribute whose value is derived from other attributes
  - May not be physically stored within the database

Entity Types and Key Attributes (1 of 2)

- Entities with the same basic attributes are grouped or typed into an entity type.
  - For example, the entity type EMPLOYEE and PROJECT.
- An attribute of an entity type for which each entity must have a unique value is called a key attribute of the entity type.
  - For example, SSN of EMPLOYEE.

Entity Types and Key Attributes (2 of 2)

- A key attribute may be composite.
  - VehicleTagNumber is a key of the CAR entity type with components (Number, State).
- An entity type may have more than one key.
  - The CAR entity type may have two keys:
    - VehicleIdentificationNumber (popularly called VIN)
    - VehicleTagNumber (Number, State), aka license plate number.
- **Each key** is **underlined** (Note: this is different from the relational schema where only one "primary key is underlined).

Entity Set

- Each entity type will have a collection of entities stored in the database
  - Called the **entity set** or sometimes **entity collection**
- Previous slide shows three CAR entity instances in the entity set for CAR
- Same name (CAR) used to refer to both the entity type and the entity set
- However, entity type and entity set may be given different names
- Entity set is the current **state** of the entities of that type that are stored in the database

Value Sets (Domains) of Attributes

- Each simple attribute is associated with a value set
  - E.g., Lastname has a value which is a character string of upto 15 characters, say
  - Date has a value consisting of MM-DD-YYYY where each letter is an integer
- A **value set** specifies the set of values associated with an attribute

Attributes and Value Sets

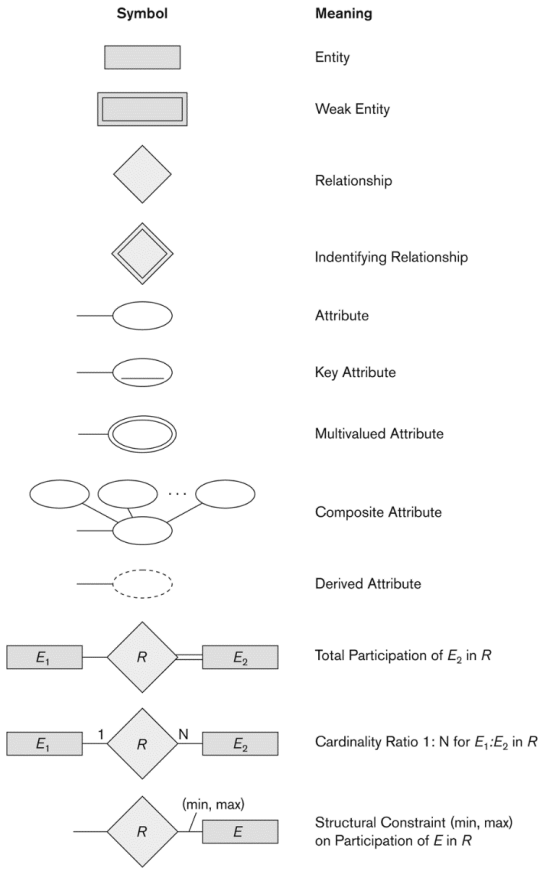
- Value sets are similar to data types in most programming languages – e.g., integer, character (n), real, bit
- Mathematically, an attribute A for an entity type E whose value set is V is defined as a function
- $A : E \rightarrow P(V)$
- Where $P(V)$ indicates a power set (which means all possible subsets) of V. The above definition covers simple and multivalued attributes.
- We refer to the value of attribute A for entity e as $A(e)$.

Displaying An Entity Type

- In ER diagrams, an entity type is displayed in a rectangular box
- Attributes are displayed in ovals
  - Each attribute is connected to its entity type
  - Components of a composite attribute are connected to the oval representing the composite attribute
  - Each key attribute is underlined
  - Multivalued attributes displayed in double ovals
- See the full ER notation in advance on the next slide

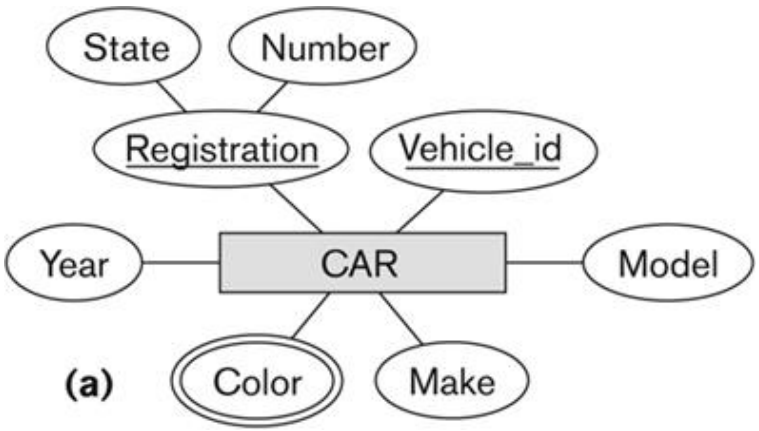
Notation for ER Diagrams

Figure 3.14 Summary of the notation for ER diagrams.



Entity Type CAR with Two Keys and a Corresponding Entity Set

Figure 3.7 The CAR entity type with two key attributes, Registration and Vehicle_id. (a) ER diagram notation. (b) Entity set with three entities.



(b)

CAR

Registration (Number, State), Vehicle_id, Make, Model, Year, {Color}

CAR_1
((ABC 123, TEXAS), TK629, Ford Mustang, convertible, 2004 {red, black})

CAR_2
((ABC 123, NEW YORK), WP9872, Nissan Maxima, 4-door, 2005, {blue})

CAR_3
((VSY 720, TEXAS), TD729, Chrysler LeBaron, 4-door, 2002, {white, blue})

Initial Conceptual Design of Entity Types for the COMPANY Database Schema

- Based on the requirements, we can identify four initial entity types in the COMPANY database:
  - DEPARTMENT
  - PROJECT
  - EMPLOYEE
  - DEPENDENT
- Their initial conceptual design is shown on the following slide
- The initial attributes shown are derived from the requirements description

Initial Design of Entity Types: EMPLOYEE, DEPARTMENT, PROJECT, DEPENDENT

Figure 3.8 Preliminary design of entity types for the COMPANY database. Some of the shown attributes will be refined into relationships.