



Module 18

Partha Pratim
Das

Objectives &
Outline

Design Process

Abstraction

Models

Design Approach

ER Model

Attributes

Entity Sets

Relationship

Cardinality

Constraints

Weak Entity Sets

Module Summary

Database Management Systems

Module 18: Entity-Relationship Model/1

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Module Summary

- Predicate Calculus
- Tuple Relational and Domain Relational Calculus
- Equivalence of Relational Algebra and Relational Calculus



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Module Summary

- To understand the Design Process for Database Systems
- To study the E-R Model for real world representation



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Module Summary

- Design Process
- E-R Model
 - Entity and Entity Set
 - Relationship
 - ▷ Cardinality
 - Attributes
 - Weak Entity Sets



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Design Process



What is Design?

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A Design:

- Satisfies a given (perhaps informal) **functional specification**
- Conforms to **limitations of the target medium**
- Meets implicit or explicit **requirements on performance and resource usage**
- Satisfies implicit or explicit **design criteria on the form of the artifact**
- Satisfies **restrictions on the design process** itself, such as its length or cost, or the tools available for doing the design



Role of Abstraction

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- *Disorganized Complexity* results from
 - *Storage (STM) limitations* of human brain – an individual can simultaneously comprehend of the order of seven, plus or minus two chunks of information
 - *Speed limitations* of human brain – it takes the mind about five seconds to accept a new chunk of information
- **Abstraction** provides the major tool to handle Disorganized Complexity by *chunking information*
- Ignore inessential details, deal only with the generalized, idealized model of the world

Consider: A binary number 110010101001

Hard to remember. Right?

Try the octal form: (110)(010)(101)(001) \Rightarrow 6251

Or the hex form: (1100)(1010)(1001) \Rightarrow CA9



Model Building

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Module Summary

- Physics
 - Time-Distance Equation
 - Quantum Mechanics
 - Chemistry
 - Valency-Bond Structures
 - Geography
 - Maps
 - Projections
 - Electrical Circuits
 - Kirchoff's Loop Equations
 - Time Series Signals and FFT
 - Transistor Models
 - Schematic Diagram
 - Interconnect Routing
 - Building & Bridges
 - Drawings – Plan, Elevation, Side view
 - Finite Element Models
- Models are common in all engineering disciplines
 - Model building follows principles of decomposition, abstraction, and hierarchy
 - Each model describes a specific aspect of the system
 - Build new models upon old proven models



Design Approach

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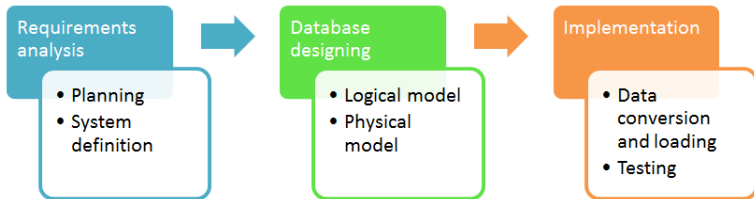
Cardinality

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Module Summary

- **Requirement Analysis:** Analyse the data needs of the prospective database users
 - Planning
 - System Definition
- **Database Designing:** Use a modeling framework to create abstraction of the real world
 - Logical Model
 - Physical Model
- **Implementation**
 - Data Conversion and Loading
 - Testing



Design Approach (2): Database Designing

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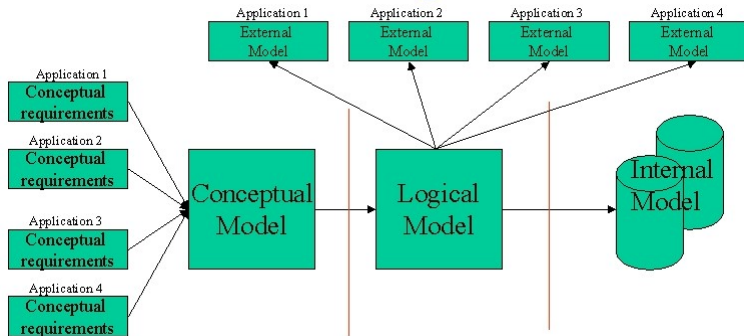
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Module Summary

- **Logical Model:** Deciding on a **good** database schema
 - *Business Decision:* What attributes should we record in the database?
 - *Computer Science Decision:* What relation schema should we have and how should the attributes be distributed among the various relation schema?
- **Physical Model:** Deciding on the physical layout of the database





Design Approach (3): Database Designing: Logical Model

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Module Summary

- **Entity Relationship Model**

- Models an enterprise as a collection of entities and relationships
 - ▷ *Entity*: A distinguishable “thing” or “object” in the enterprise
 - Described by a set of attributes
 - ▷ *Relationship*: An association among multiple entities
- Represented by an *Entity-Relationship or ER Diagram*

- **Database Normalization (Chapter 8)**

- Formalize what designs are bad, and test for them



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Entity Relationship (ER) Model



ER Model: Database Modeling

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Module Summary

- The ER data model was developed to facilitate database design by allowing specification of an **enterprise schema** that represents the overall logical structure of a database
- The ER model is useful in mapping the meanings and interactions of real-world enterprises onto a conceptual schema
- The ER data model employs three basic concepts:
 - Attributes
 - Entity sets
 - Relationship sets
- The ER model also has an associated diagrammatic representation, the ER diagram, which can express the overall logical structure of a database graphically



Attributes

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Module Summary

- An **Attribute** is a property associated with an entity / entity set. Based on the values of certain attributes, an entity can be identified uniquely
- Attribute types:
 - **Simple** and **Composite** attributes
 - **Single-valued** and **Multivalued** attributes
 - ▷ Example: Multivalued attribute: *phone_numbers*
 - **Derived** attributes
 - ▷ Can be computed from other attributes
 - ▷ Example: age, given date_of_birth
- **Domain**: Set of permitted values for each attribute



Attributes (2): Composite

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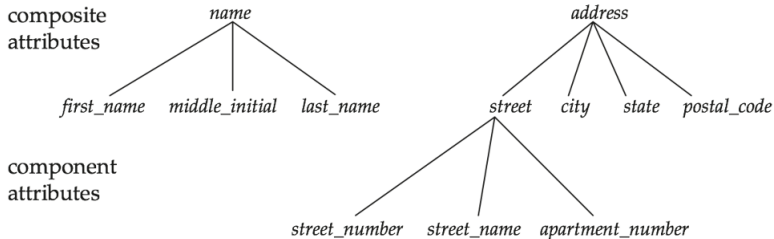
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Entity Sets

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Module Summary

- An **entity** is an object that exists and is distinguishable from other objects.
 - Example: specific person, company, event, plant
- An **entity set** is a set of entities of the same type that share the same properties.
 - Example: set of all persons, companies, trees, holidays
- An entity is represented by a set of attributes; i.e., descriptive properties possessed by all members of an entity set.
 - Example:
 $instructor = (\underline{ID}, name, street, city, salary)$
 $course = (\underline{course_id}, title, credits)$
- A subset of the attributes form a **primary key** of the entity set; that is, uniquely identifying each member of the set.
 - Primary key of an entity set is represented by underlining it



Entity Sets – *instructor* and *student*

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instructor_ID instructor_name

76766	Crick
45565	Katz
10101	Srinivasan
98345	Kim
76543	Singh
22222	Einstein

instructor

student-ID student_name

98988	Tanaka
12345	Shankar
00128	Zhang
76543	Brown
76653	Aoi
23121	Chavez
44553	Peltier

student



Relationship Sets

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Weak Entity Sets

Module Summary

- A **relationship** is an association among several entities

Example:

44553 (Peltier) advisor 22222 (Einstein)
student entity relationship set *instructor* entity

- A **relationship set** is a mathematical relation among $n \geq 2$ entities, each taken from entity sets

$$\{(e_1, e_2, \dots, e_n) \mid e_1 \in E_1, e_2 \in E_2, \dots, e_n \in E_n\}$$

where (e_1, e_2, \dots, e_n) is a relationship.

- Example: $(44553, 22222) \in \text{advisor}$



Relationship Set (2) *advisor*

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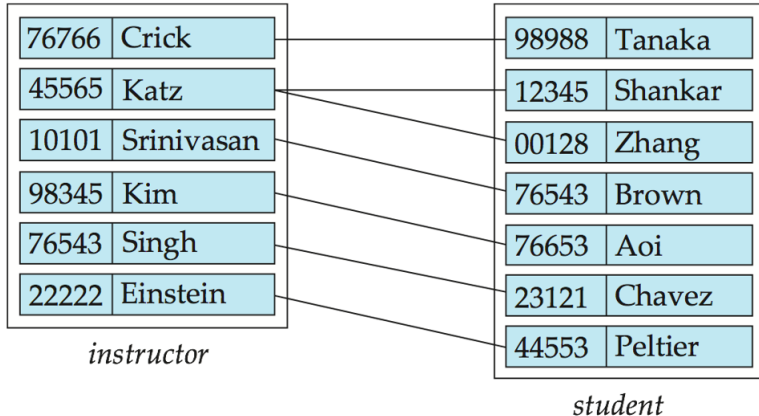
Relationship

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Relationship Sets (3)

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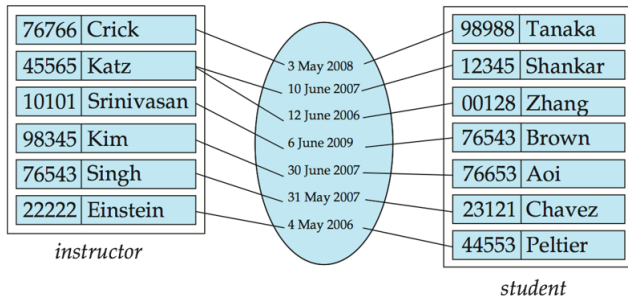
Cardinality

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Weak Entity Sets

Module Summary

- An attribute can also be associated with a relationship set.
- For instance, the *advisor* relationship set between entity sets *instructor* and *student* may have the attribute *date* which tracks when the student started being associated with the advisor





Relationship Set (4): Degree

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Weak Entity Sets

Module Summary

- Binary relationship
 - involves two entity sets (or degree two).
 - most relationship sets in a database system are binary.
- Relationships between more than two entity sets are rare. Most relationships are binary
 - Example: *students* work on research projects under the guidance of an *instructor*.
 - relationship *proj_guide* is a ternary relationship between *instructor*, *student*, and *project*



Attributes (3): Redundant

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Module Summary

- Suppose we have entity sets:
 - *instructor*, with attributes: *ID*, *name*, *dept_name*, *salary*
 - *department*, with attributes: *dept_name*, *building*, *budget*
- We model the fact that each instructor has an associated department using a relationship set *inst_dept*
- The attribute *dept_name* appears in both entity sets. Since it is the primary key for the entity set *department*, it replicates information present in the relationship and is therefore redundant in the entity set *instructor* and needs to be removed
- BUT: When converting back to tables, in some cases the attribute gets reintroduced, as we will see later



Mapping Cardinality Constraints

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**Cardinality
Constraints**

Weak Entity Sets

Module Summary

- Express the number of entities to which another entity can be associated via a relationship set.
- Most useful in describing binary relationship sets.
- For a binary relationship set the mapping cardinality must be one of the following types:
 - One to one
 - One to many
 - Many to one
 - Many to many



Mapping Cardinalities

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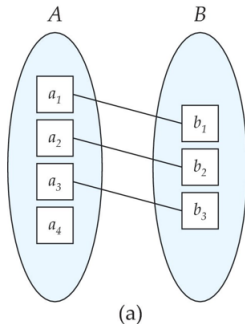
Entity Sets

Relationship

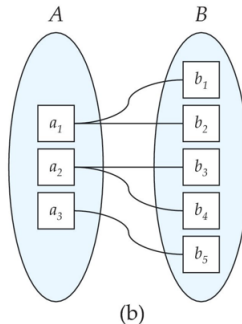
**Cardinality
Constraints**

Weak Entity Sets

Module Summary



One to one



One to many

Note: Some elements in A and B may not be mapped to any elements in the other set



Mapping Cardinalities

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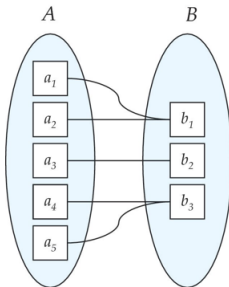
Relationship

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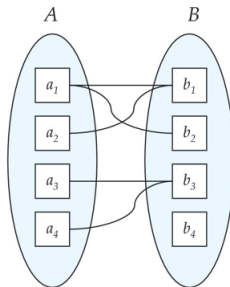
Weak Entity Sets

Module Summary



(a)

Many to
one



(b)

Many to
many

Note: Some elements in A and B may not be mapped to any elements in the other set



Weak Entity Sets

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Weak Entity Sets

Module Summary

An entity set may be of two types:

- Strong entity set
 - A strong entity set is an entity set that contains sufficient attributes to uniquely identify all its entities
 - In other words, *a primary key exists for a strong entity set*
 - Primary key of a strong entity set is represented by underlining it
- Weak entity set
 - A weak entity set is an entity set that does not contain sufficient attributes to uniquely identify its entities
 - In other words, *a primary key does not exist for a weak entity set*
 - However, it contains a partial key called as a **discriminator**
 - Discriminator can identify a group of entities from the entity set
 - Discriminator is represented by underlining with a dashed line



Weak Entity Sets (2)

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Weak Entity Sets

Module Summary

- Since a weak entity set does not have primary key, it cannot independently exist in the ER Model
- It features in the model in relationship with a strong entity set. This is called the **identifying relationship**
- Primary Key of Weak Entity Set
 - The combination of discriminator and primary key of the strong entity set makes it possible to uniquely identify all entities of the weak entity set
 - Thus, this combination serves as a primary key for the weak entity set.
 - Clearly, this primary key is not formed by the weak entity set completely.
 - **Primary Key of Weak Entity Set = Its own discriminator + Primary Key of Strong Entity Set**
- Weak entity set must have **total participation** in the identifying relationship. That is all its entities must feature in the relationship



Weak Entity Sets (3): Example

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Weak Entity Sets

Module Summary

- **Strong Entity Set:** *Building*(building_no, building_name, address). building_no is its primary key
- **Weak Entity Set:** *Apartment*(door_no, floor). door_no is its discriminator as door_no alone can not identify an apartment uniquely. There may be several other buildings having the same door number
- **Relationship:** *BA* between *Building* and *Apartment*
- By **total participation** in *BA*, each apartment must be present in at least one building
- In contrast, *Building* has **partial participation** in *BA* only as there might exist some buildings which has no apartment
- **Primary Key:** To uniquely identify any apartment
 - First, building_no is required to identify the particular building
 - Second, door_no of the apartment is required to uniquely identify the apartment
- Primary key of Apartment = Primary key of Building + Its own discriminator
= building_no + door_no



Weak Entity Sets (4): Example

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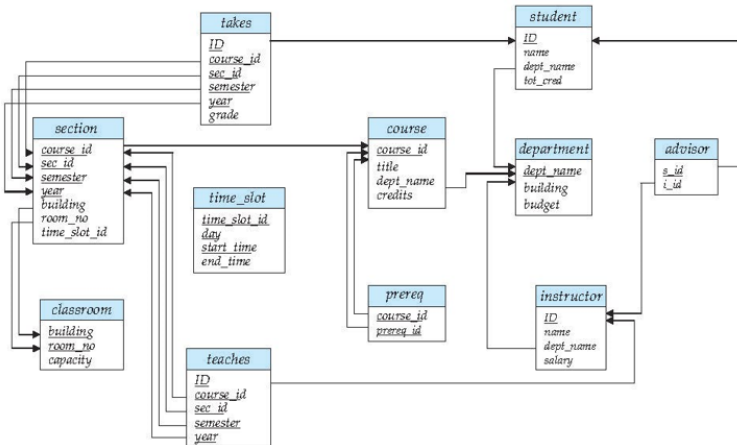
Cardinality

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Weak Entity Sets

Module Summary

- Consider a section entity, which is uniquely identified by a *course_id*, *semester*, *year*, and *sec_id*.
- Clearly, section entities are related to course entities. Suppose we create a relationship set *sec_course* between entity sets *section* and *course*.
- Note that the information in *sec_course* is redundant, since section already has an attribute *course_id*, which identifies the course with which the section is related.





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Module Summary

- Introduced the Design Process for Database Systems
- Elucidated the E-R Model for real world representation with entities, entity sets, attributes, and relationships

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