Database Management Systems

Module 18: Entity-Relationship Model/1

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Module Recap

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

Module Objectives

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

Module Outline

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

Design Process

What is Design?

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

- *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 remembers. Right?

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

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

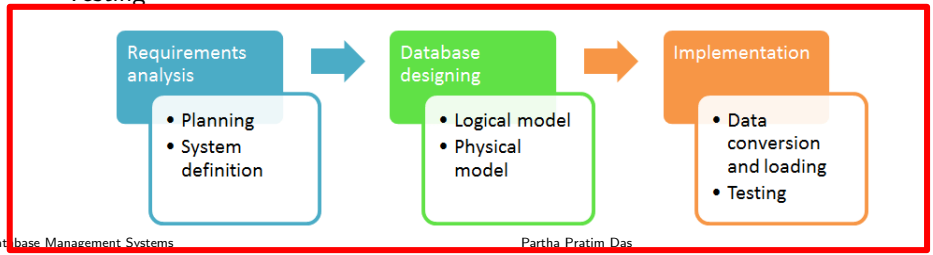
Model Building

- 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

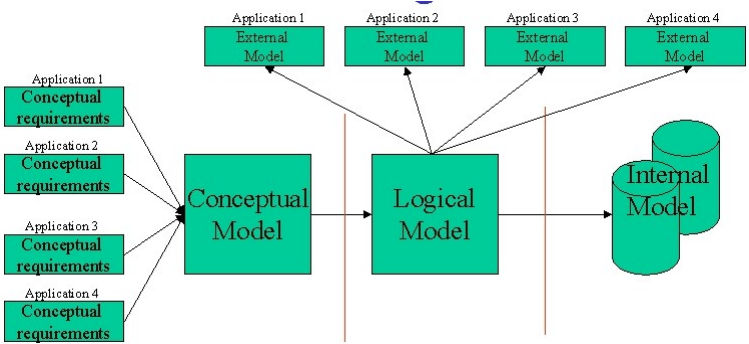
Design Approach

- **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

- **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

- **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

Entity Relationship (ER) Model

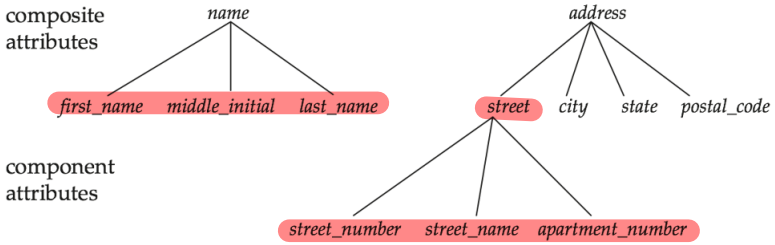
ER Model: Database Modeling

- 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

- An **Attribute** is a property associated with and 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



Entity Sets

- 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 = (*ID*, *name*, *street*, *city*, *salary*)
    course= (*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*

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

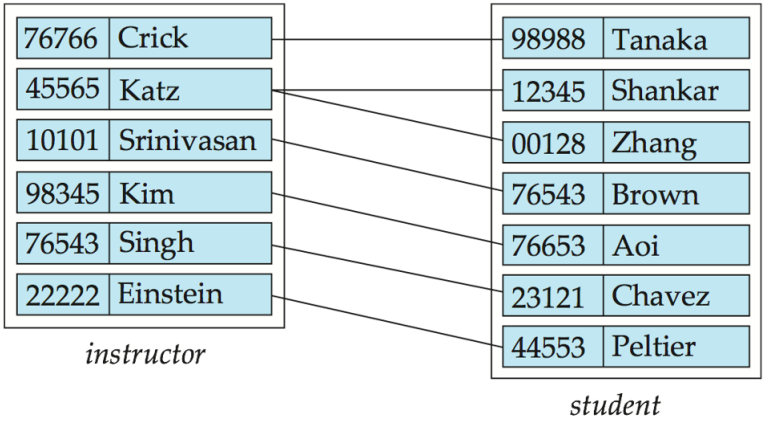
Relationship Sets

- 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

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

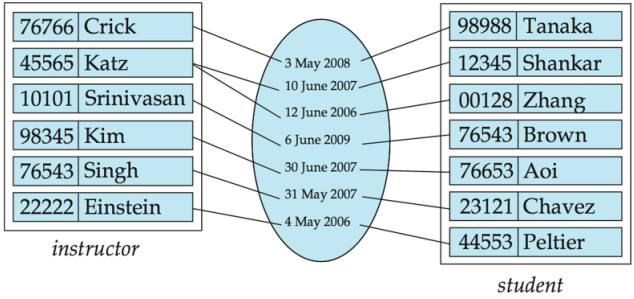
  where $(e_1, e_2, \ldots e_n)$ is a relationship.
  - Example: $(44553, 22222) \in advisor$

Relationship Set (2) *advisor*



Relationship Sets (3)

- 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

- 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*

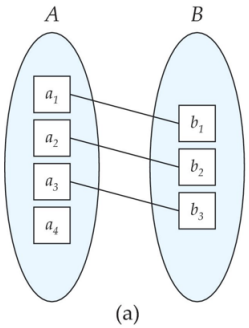
Attributes (3): Redundant

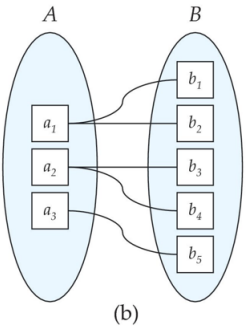
- Suppose we have entity sets:
  - *instructor*, with attributes: *ID, name, dept_name, salary*
  - *department*, with attributes: *dept_name, building, budget*
- We model the fact that each instructor has an associated department using a relationship set *inst_dept*
- The attribute *dept_name* appears 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

- 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

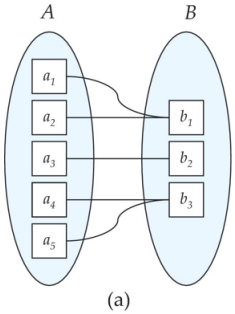
Mapping Cardinalities

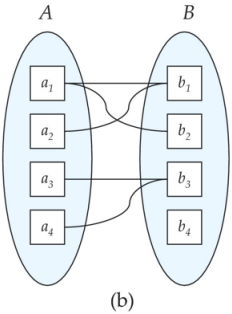




Note: Some elements in A and B may not be mapped to any elements in the other set

Mapping Cardinalities





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

Weak Entity Sets

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)

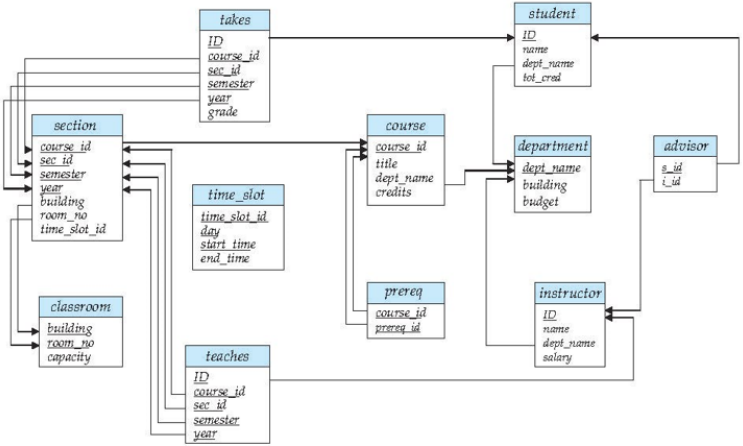
- Since a weak entity set does not have primary key, it cannot independently exist in the ER Model
- It features in the model in relationship with a strong entity set. This is called the **identifying relationship**
- Primary Key of Weak Entity Set
  - The combination of discriminator and primary key 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

- **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

- 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.



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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