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Entity-Relationship Modelling

- 1. Entities
- 2. Attributes
- 3. Relationships
- 4. Constraints
 - Keys
 - Mapping Cardinality
- 5. ER Notations
- 6. Roles
- 7. Participation
- 8. Strong & Weak Entity Sets

Entity-Relationship (ER) Modeling

- 1976 proposed by Peter Chen
- ER diagram is widely used in database design
 - Represent conceptual level of a database system
 - Describe things/entities and their relationships in high level

ER Modeling

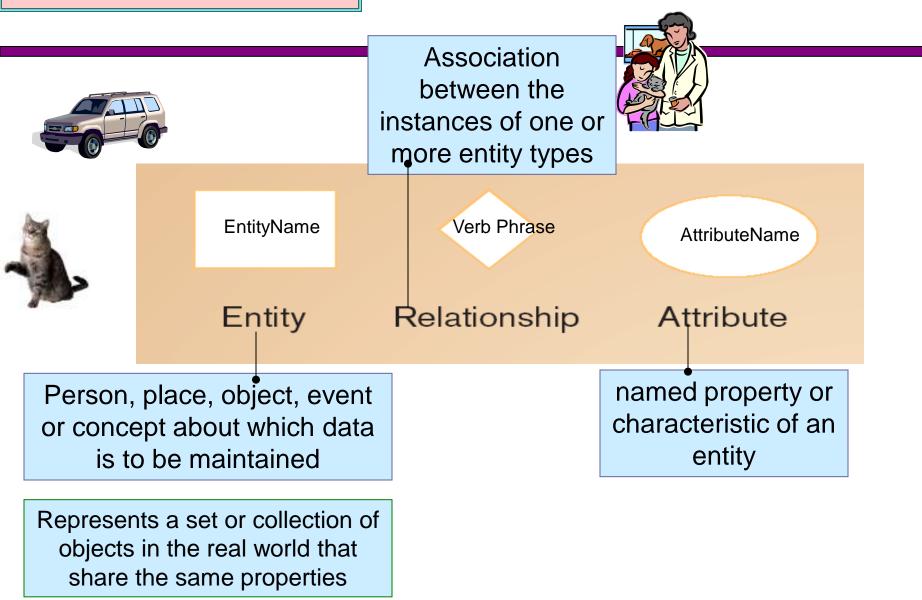
- **ER Modeling** is a *top-down* approach to database design.
- Entity Relationship (ER) Diagram
 - A detailed, logical representation of the entities, associations and data elements for an organization or business
- Notation uses three main constructs
 - Data entities
 - > Relationships
 - Attributes

Chen Model & Crow's Foot Model

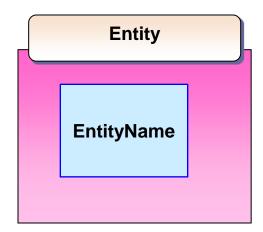
ER Diagrams

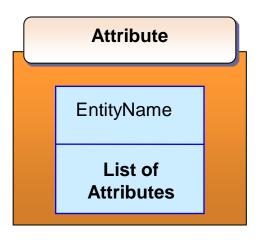
- Several ER diagramming techniques have been proposed over the years:
 - Chen's notation 1976
 - > IDEF1X (NIST) 1993
 - Crow's feet (Barker, Palmer, Ellis, et al.) 1981
 - UML (Booch, Jacobson and Rumbaugh) 1990's
 - Others...
- The authors current version is somewhat UML-like, but previously used Chen's notation.

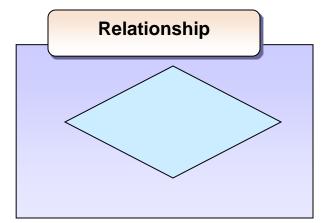
Chen Notation



Crow's Foot Notation







1. Entities

Examples of entities:

- > Person: EMPLOYEE, STUDENT, PATIENT
- Place: STORE, WAREHOUSE
- Object: MACHINE, PRODUCT, CAR
- > Event: SALE, REGISTRATION, RENEWAL
- Concept: ACCOUNT, COURSE



Guidelines for naming and defining entity types:

- An entity type name is a singular noun
- An entity type should be descriptive and specific
- An entity name should be concise
- > Event entity types should be named for the result of the event, not the activity or process of the event.

2. Attributes

Example of entity types and associated attributes:

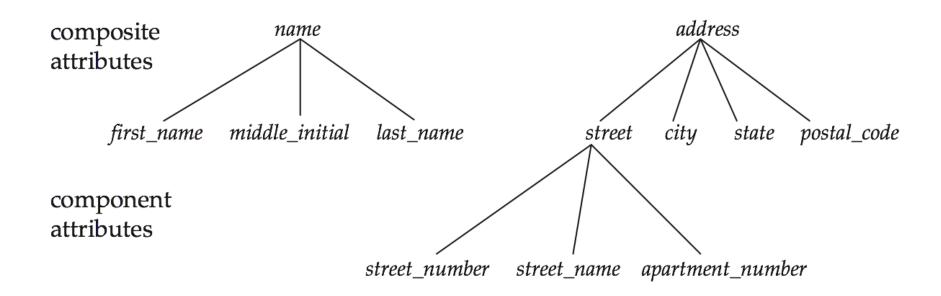
STUDENT: Student_ID, Student_Name, Home_Address, Phone_Number, Major

- Guidelines for naming attributes:
 - An attribute name is a noun.
 - An attribute name should be unique
 - To make an attribute name unique and clear, each attribute name should follow a standard format
 - Similar attributes of different entity types should use similar but distinguishing names.

Attributes

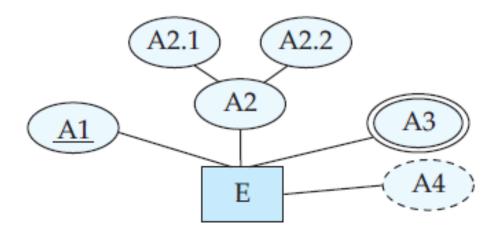
- The set of permitted values for an attribute is call the <u>domain</u> of that attribute.
- Attributes can be one of several types:
 - Simple (i.e., atomic) height in inches, weight in ounces, last-name
 - Composite name, address
 - Single-valued date of birth, name
 - Multi-valued phone-numbers, dependents, hobbies
 - Derived "age" is derived, or rather, computed from "date-of-birth"

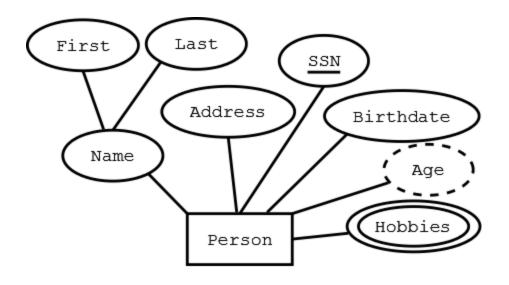
Composite Attributes

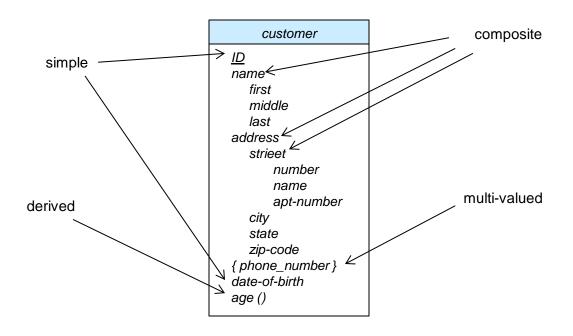


Attributes - Chenn

entity set E with simple attribute A1, composite attribute A2, multivalued attribute A3, derived attribute A4, and primary key A1





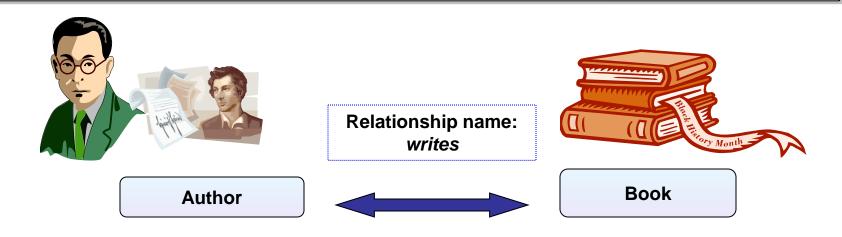


Notes:

- In many applications the terms are much more ambiguous (e.g., function designators)
- An ER diagram is typically accompanied by a document that defines all the terms
- Much harder to do than it appears (e.g., what is an "orbit" for a satellite?)

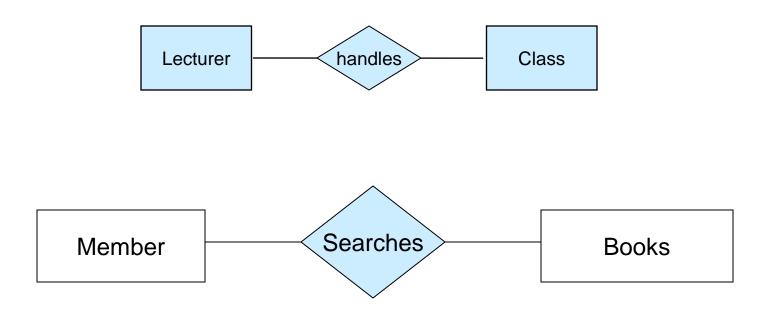
3. Relationships

- → Associations between instances of one or more entity types that is of interest
 - → Given a name that describes its function.
 - relationship name is an <u>active</u> or a <u>passive</u> verb.

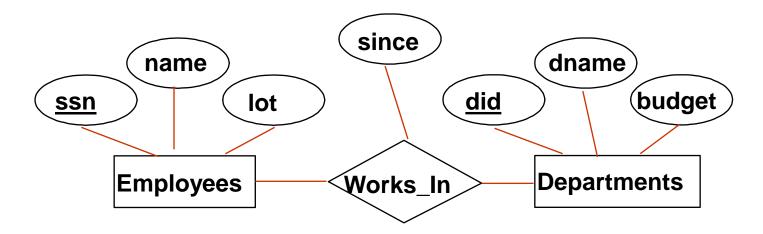


An author writes one or more books A book can be written by one or more authors.

Relationships



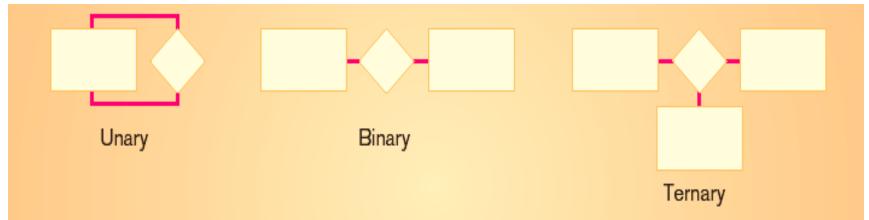
Relationships



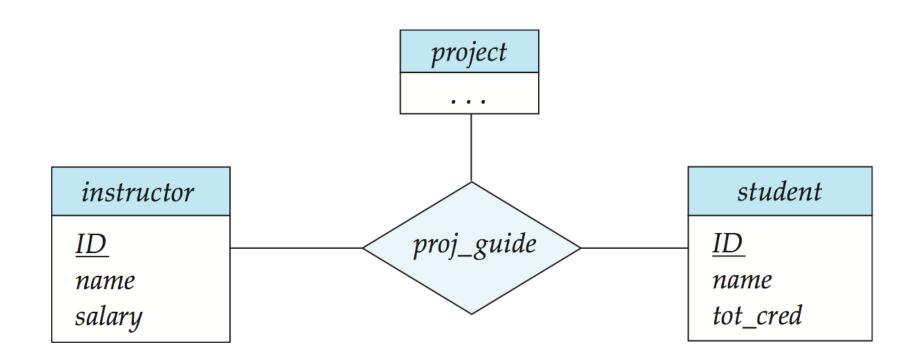
- Relationship: Association among two or more entities. E.g., Bob Smith works in Pharmacy department.
 - relationships can have their own attributes.
 - Verb or Verb phrases (e.g., works_at, enrolled_in, etc)
- Relationship Set: Collection of similar relationships.
 - An *n*-ary relationship set R relates n entity sets $E_1 ... E_n$; each relationship in R involves entities $e_1 \in E_1, ..., e_n \in E_n$

Degree of Relationships

- Degree: number of entity types that participate in a relationship
- Three cases
 - Unary: between two instances of one entities
 - > Binary: between the instances of two entities
 - > Ternary: among the instances of three entities
 - > N-nary: among the instances of more than three entities

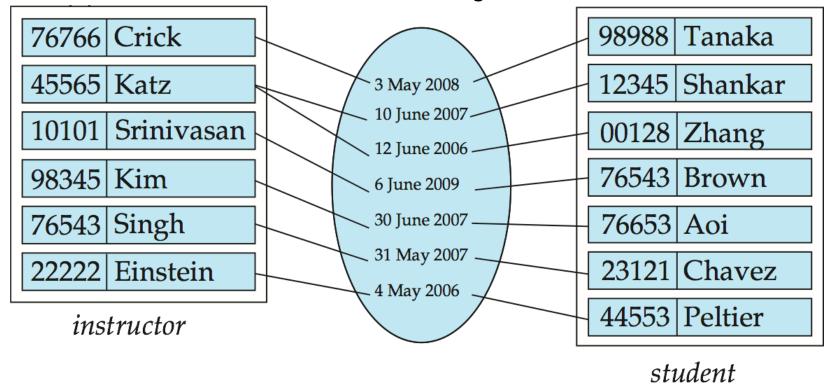


E-R Diagram with a Ternary Relationship

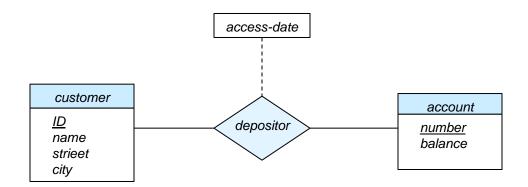


Relationship

- An attribute can also be property of 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



Relationship Sets with Attributes

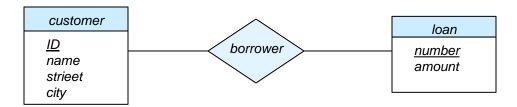


4. Constraints

- Keys
- Cardinalities

Keys

- ☐ Entities and relationships are distinguishable using various keys
- A *key* is a combination of one or more attributes, e.g., social-security number, combination of name and social-security number.
- □ A primary key of an entity set is specified in an ER diagram by underlining the key attributes.



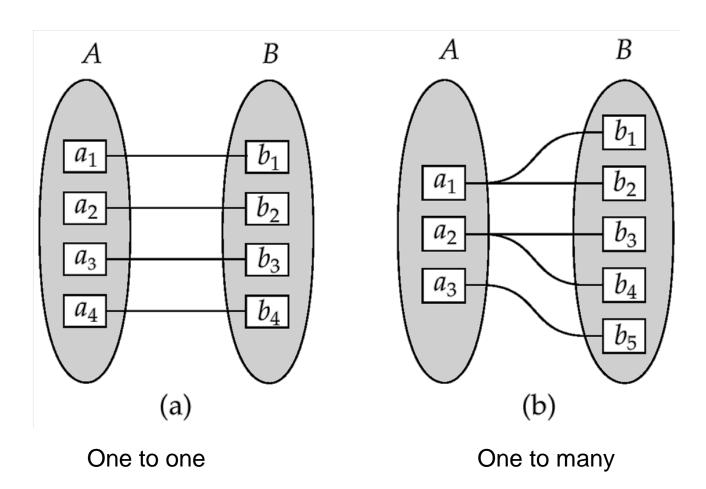
Mapping Cardinalities

- The <u>mapping cardinality</u> of a relationship set expresses the number of entities to which one entity can be associated via the relationship set.
- Most useful in describing binary relationship sets.
- For a binary relationship there are four types:
 - One to one
 - One to many
 - Many to one
 - Many to many

Cardinalities Examples

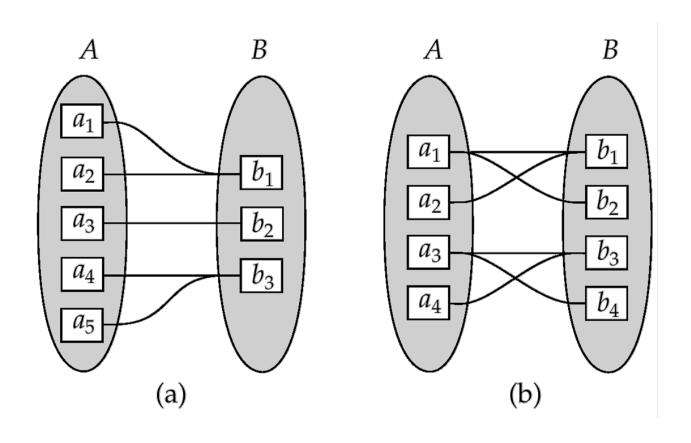
- 1:1 Departments having Chairpersons
- N:1 Children having Mothers
- 1:N Mothers having children (inverse of N:1)
 - M:N Students enrolling in Class Sections

Mapping Cardinalities



Note: Some elements in A and B may not be mapped to any elements in the other set. L.M. Jenila Livingston

Mapping Cardinalities



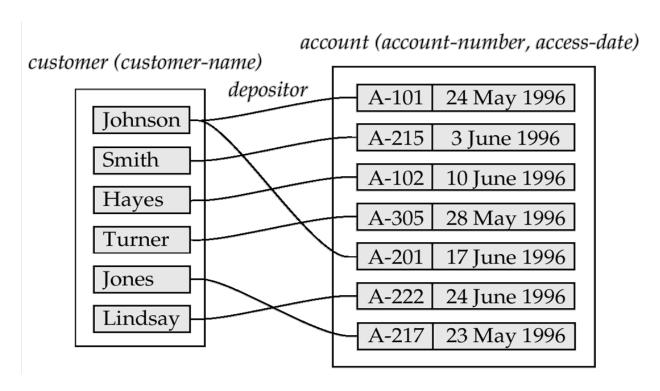
Many to one

Many to many

Note: Some elements in A and B may not be mapped to any elements in the other set, L.M. Jenila Livingston

Mapping Cardinalities affect Attribute Placement

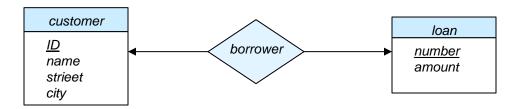
In the banking enterprise, access-date could be an attribute of account instead of a relationship attribute if each account can have only one customer, i.e., if the relationship is one-to-many.



Dr. L.M. Jenila Livingston

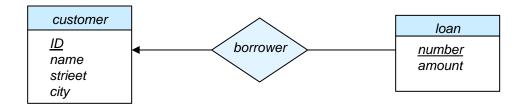
Cardinality Constraints

- Cardinality constraints are indicated by drawing a directed line (→), signifying "one," or an undirected line (—), signifying "many," between the relationship and the entity.
- If borrower were a one-to-one relationship:
 - A customer would be associated with at most one loan.
 - n loan would be associated with at most one customer



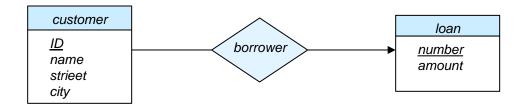
One-To-Many Relationship

If borrower were a one-to-many relationship from customer to loan, then a customer would be associated with <u>zero or more</u> one loans, and a loan would be associated with <u>at most</u> one customer.



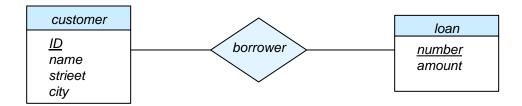
Many-To-One Relationships

■ If *borrower* were a many-to-one relationship from customer to loan, then a loan would be associated with <u>zero or more</u> customers, and a customer would be associated with <u>at most</u> one loan.

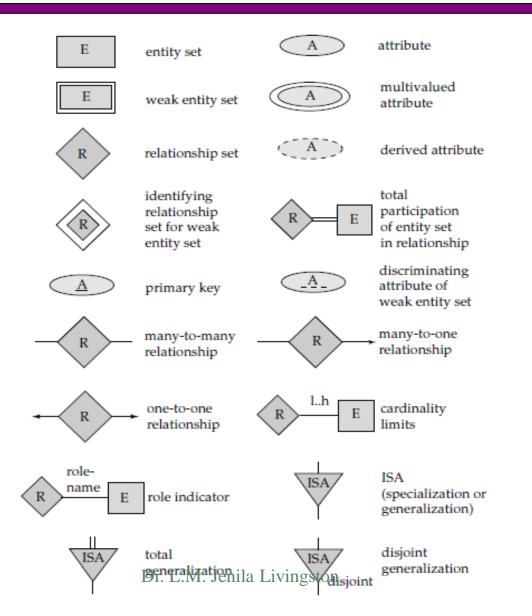


Many-To-Many Relationship

If borrower were a many-to-many relationship then a customer would be associated with <u>zero or more</u> loans, and a loan would be associated with <u>zero of more</u> customers.



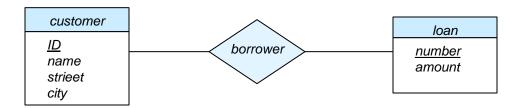
5. ER NOTATIONS – Chenn Model



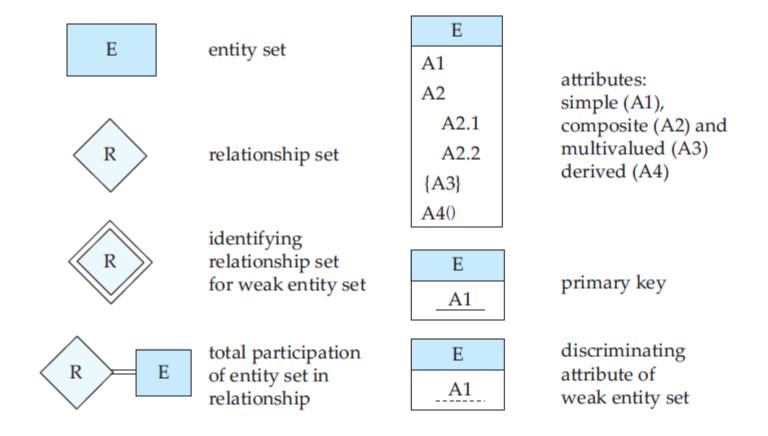
- 1. Rectangles divided into two parts represent entity sets. The first part, contains the name of the entity set. The second part contains the names of all the attributes of the entity set.
- 2. Diamonds represent relationship sets.
- **3. Undivided rectangles** represent the attributes of a relationship set.
 - **Attributes** that are part of the primary key are underlined.
- 4. Lines link entity sets to relationship sets.
- **5. Dashed lines link** attributes of a relationship set to the relationship set.
- **6. Double lines indicate total participation** of an entity in a relationship set.
- 7. Double diamonds represent identifying relationship sets linked to weak entity sets linked to weak e

ER Notations - Revised

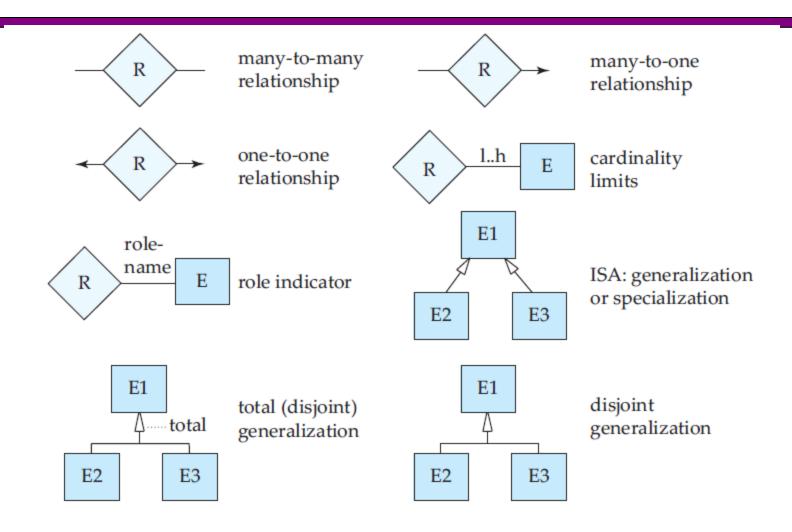
- Rectangles entity sets
- Diamonds relationship sets
- Lines connect attributes to entity sets, and entity sets to relationship sets.
- Underlined Attributes primary key attributes



ER Notations

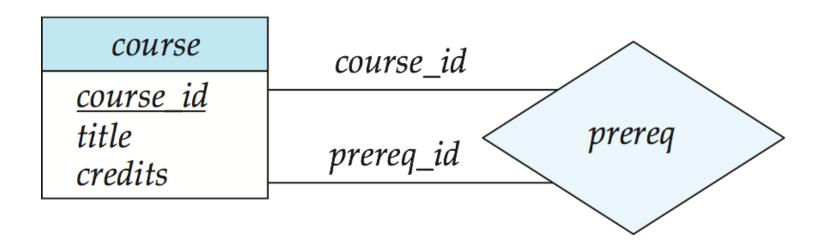


ER Notations



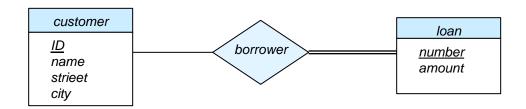
6. Roles

- The function that an entity plays in a relationship is called its role.
- Entity sets of a relationship need not be distinct
 - > Each occurrence of an entity set plays a "role" in the relationship
- The labels "course_id" and "prereq_id" are called roles.



7. Participation of an Entity Set in a Relationship Set

If every entity in an entity set must participate in a relationship set, then that entity set is said to have <u>total participation</u> in the relationship; indicated by a double-line and a double-diamond.



- If participation in a relationship is optional for some entities then that entity set is said to have *partial participation* in the relationship.
- All elements of loan participate in customer

8. Strong Entity Sets

- For most entity sets, a primary key is specified in terms of its immediate attributes.
- Such an entity set is referred to as a <u>strong entity set</u>.

Weak Entity Sets

- An entity set that does not have a primary key is referred to as a weak entity set.
- They are dependent on another entity
- The existence of a weak entity set depends on the existence of a identifying entity set
 - It must relate to the identifying entity set via a total, one-to-many relationship set from the identifying to the weak entity set
 - Identifying relationship depicted using a double diamond
- The **discriminator** (or partial key) of a weak entity set is the set of attributes that distinguishes among all the entities of a weak entity set.

Weak Entity Sets, Cont.

- In such a case, the (weak) entity typically has a subset of attributes, called a <u>discriminator</u> (or partial key), that distinguishes among all entities of the weak entity set associated with one identifying entity.
- In such a case, a primary key for the weak entity set can be constructed with two parts:
 - primary key of the strong entity set on which the weak entity set is existence dependent
 - > The weak entity set's discriminator
- A weak entity set is typically associated with an <u>identifying entity</u> <u>set</u> (which is usually strong) via a total, <u>one-to-many relationship</u>.

Weak Entity Sets (Cont.)

- A weak entity set is represented by double rectangles.
- The discriminator is underlined with a dashed line.
- Primary key for payment is (loan-number)



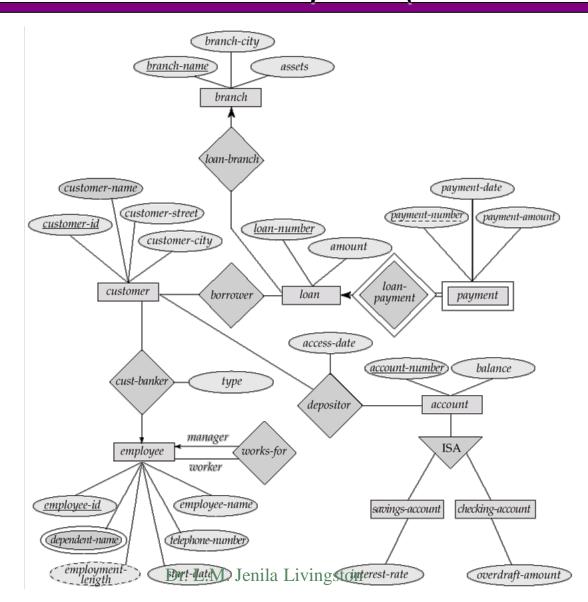
More Weak Entity Set Examples

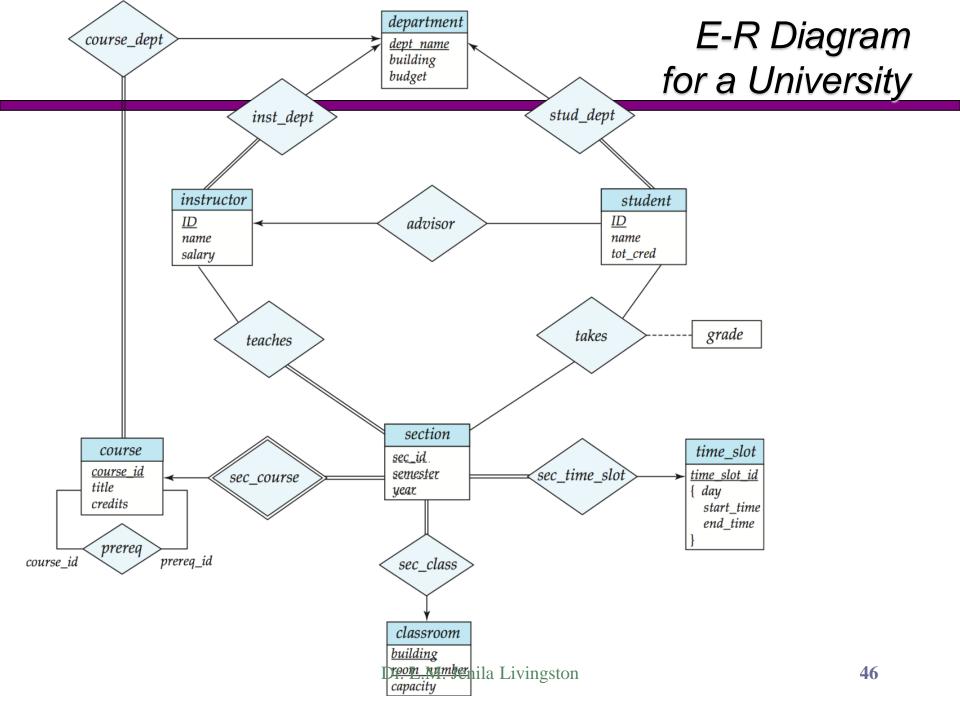
In a university, a course is a strong entity and a section can be modeled as a weak entity.



- The discriminator of section would be sec-id, semester and year.
- If section were modeled as a strong entity then it would have id as an attribute; the relationship with course would be implicit in the id attribute.

E-R Diagram for a Banking Enterprise (Chen's Notation)





Exercise -1

Draw an ER diagram that best represents the following situation. There are three types of accounts in a bank, with these attributes:

- Checking: Acct-no, Date-opened, Balance, Service-charge
- Savings: Acct-no, Date-opened, Balance, Interest-rate
- Loan: Acct-no, Date-opened, Balance, Acct-limit

Exercise 2

A company database needs to store information about employees (identified by ssn, with salary and phone as attributes), departments (identified by dno, with dname and budget as attributes), and children of employees (with name and age as attributes). Employees work in departments; each department is managed by an employee

Draw an ER diagram that captures this information and the following.

- Identify the primary keys and foreign keys
- Apply all types of attributes wherever it can be used.
- Apply mapping cardinalities and participation constraints

Thank You!