Database Analysis and Design

Lesson 5: Entity Relationship Diagram

Plan

- Introduction and Review
- Features
- Diversity of The Graphical Representation
  1. Chen’s convention
  2. Min-Max
  3. Crown’s Foot

Introduction

- Entity Relationship Diagram (ERD) - by Chen in 1976.
  - Graphical representation of data model or data structure.
  - The conceptual data modeling which facilitate database design.
  - Graph representing entity sets, attributes, and relationship set, rather than individual record.
  - Edges of the graph
    - Connect entity sets to its attributes
    - Connect a relationship set to its entity sets.
  - In Chen's Notation, entities are represented by rectangles, attributes by ovals, relationships are represented by diamonds.

ER Model - Entity

- Entity: is a real-world object or concept that is distinguishable from other objects.
- An entity might be:
  - An object with physical existence (e.g., a lecturer, a student, a car).
  - An object with conceptual existence (e.g., a course, a job, a position).
- It is usually represented as a rectangle in ER diagrams.
- Example: entity Student

ER Model - Attributes

- Attributes are the properties which define the entity type.
- Ex: Id, Name, DOB, Age, Tel

Attribute

Key Attribute

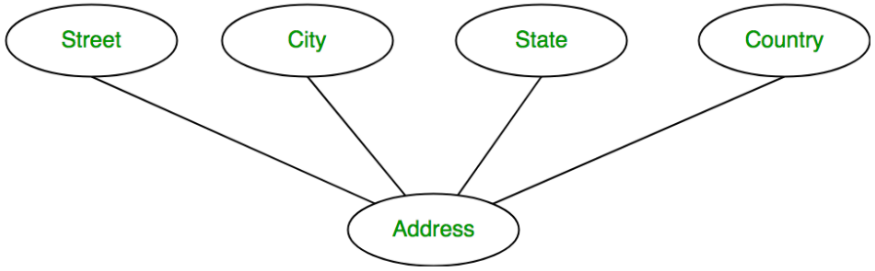
The attribute which **uniquely identifies each entity** in the entity set

Derived Attribute

An attribute which can be **derived from other attributes** of the entity type

Multivalued Attribute

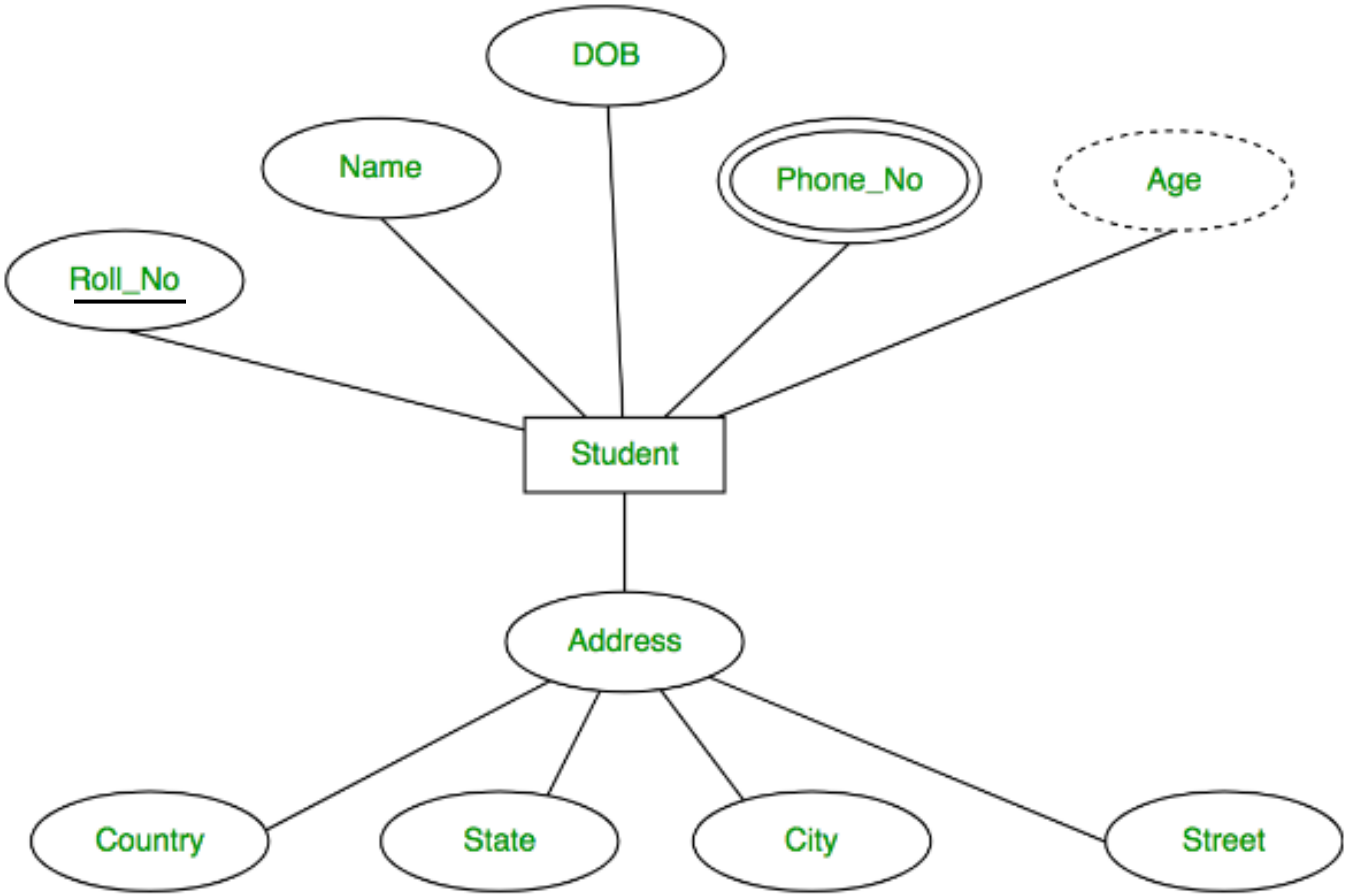
An attribute consisting **more than one value** for a given entity



Composite Attribute

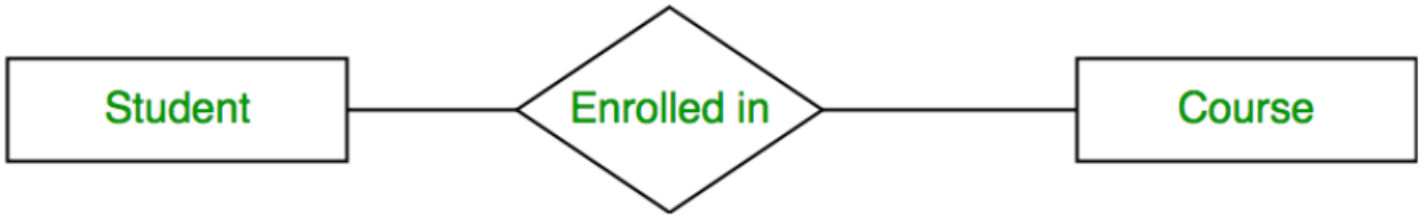
An attribute **composed of many other attribute**

Example of Entity Type **Student**



Relationship type

- A relationship type represents the association between entity types. (verb phrase)
- It is usually represented as a diamond shape in ER diagrams.
- Ex: “Enrolled in” is a relationship type that exists between entity type Student and Course.



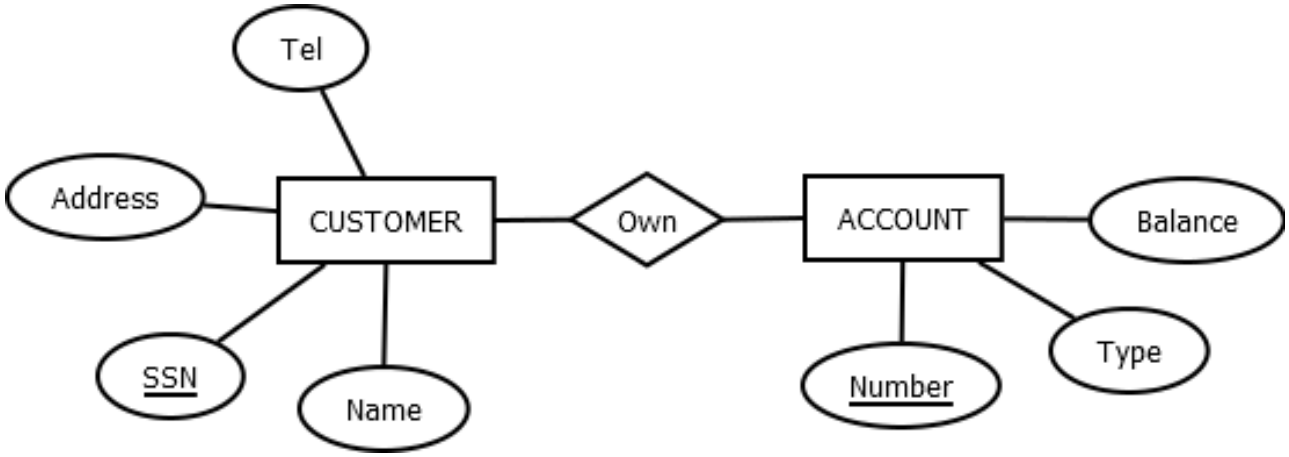
Exercise

Design a database for a bank, including information about **customers** and their **accounts**. Information about a customer includes their name, address, phone, and Social Security number. Accounts have numbers, types (e.g., savings, checking) and balances. Also record the customer(s) who *own* an account. Draw the E /R diagram for this database.

- Workflow
  1. Find entity sets according to the declaration of the exercise. Represent them in the right form of graphical representation.
  2. Find attributes for each entity set. . Represent them in the right form of graphical representation.
  3. For each entity set, find the relationship set between other entity sets and itself. Represent them in the right form of graphical representation.

Exercise

- Answer
  - Entity sets: CUSTOMER, ACCOUNT
  - Attributes:
    - CUSTOMER: Name, Address, Tel, SSN, SSN is the key of the entity set because it has unique value for each customer
    - ACCOUNT: Number, Balance, Type, Number is the key of the entity set for the same reason.



Degree of Relationship Type

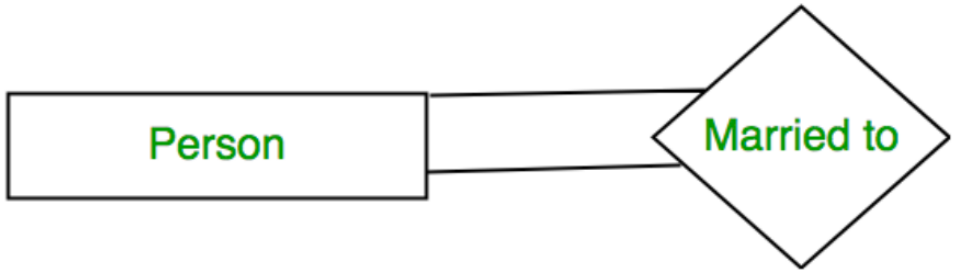
- Degree of relationship type:
  - Refers to the Nary relationship
  - The number of participating entities in a relationship
    - N=1, unary relationship or reflection
    - N=2, binary relationship
    - N=3, ternary relationship, …
  - Binary relationship is the most practical.

Degree of Relationship Type

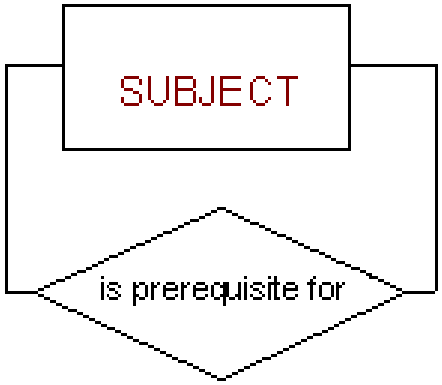
1. Unary Relationship

when both participants in the relationship are the same entity.

Ex: one person is married to only one person.



Ex: Subjects may be prerequisites for other subjects.

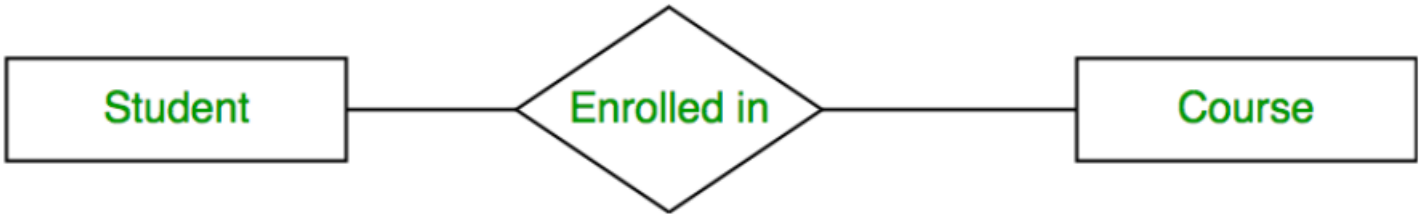


Degree of Relationship Type

2. Binary Relationship

TWO entities set participating in a relation.

Ex: Student is enrolled in Course



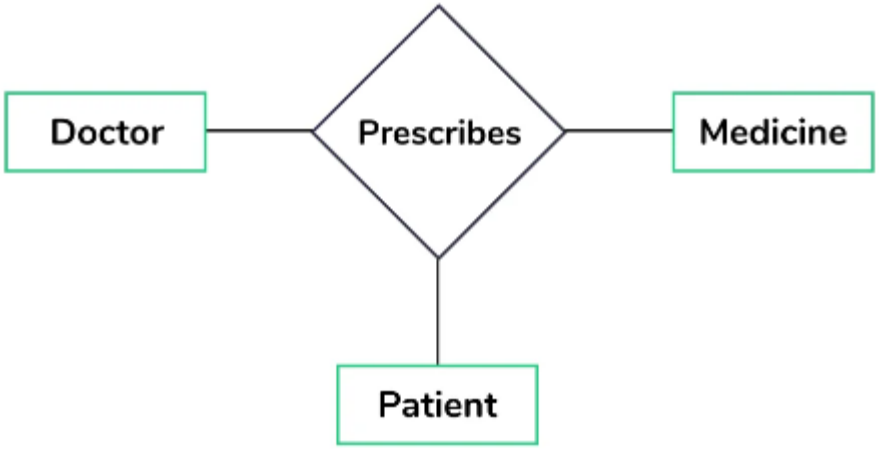
Degree of Relationship Type

3. Ternary Relationship

N entities set participating in a relation.

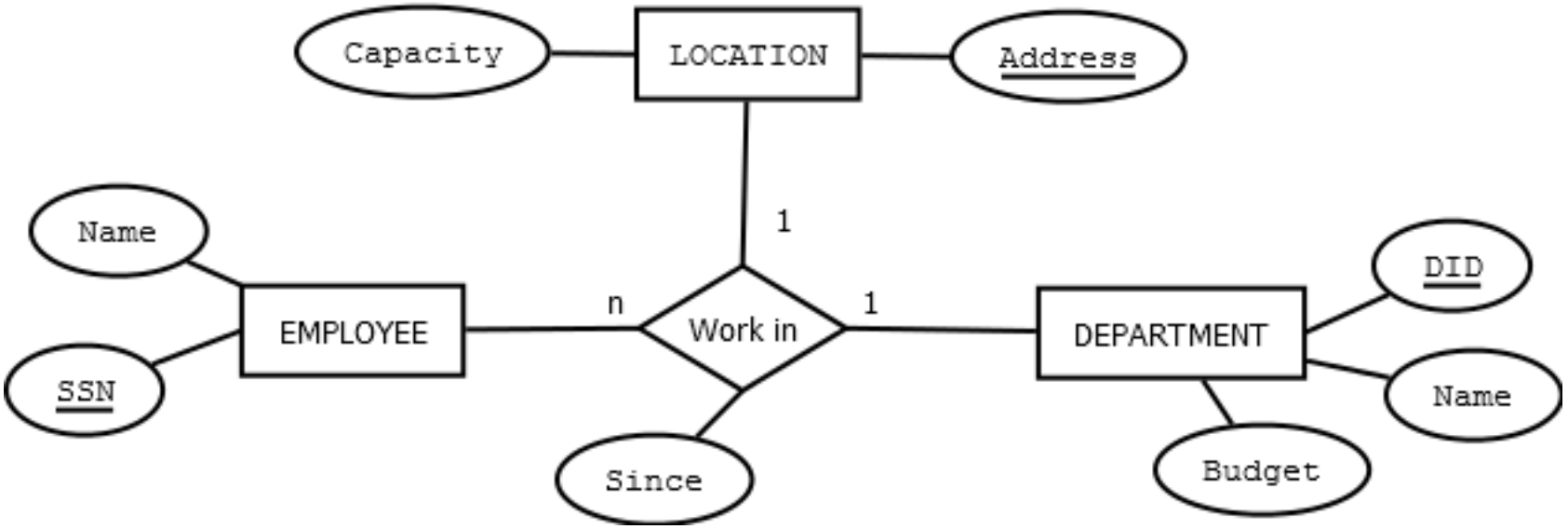
For Example:

a patient goes to a doctor and doctor prescribes the medicine to the patient.



Degree of Relationship Type

Example of Ternary Relationship: the relationship Work in is participated by 3 different entity sets, EMPLOYEE, LOCATION, and DEPARTMENT.



- An employee can work in at most a department and a location in a given time.
- A location belong to a department, and many employees can work in the same location.
- A department has many employees who work in and is located in a location.

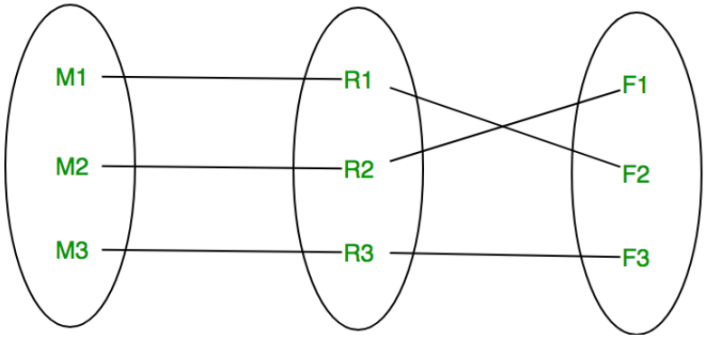
Cardinality of Relationship

- Cardinality of relationship defines the maximum number of possible relationship for every entity.
- It is used to restrict the relationship between entity according to business rule of a company.
- 3 different types of cardinality of relationship:
  - One-to-one (1:1)
  - One-to-many (1:n)
  - Many-to-many (m:n)

Cardinality of Relationship

- **One-to-one (1:1)**: One instance of an entity is related to one instance of another entity.

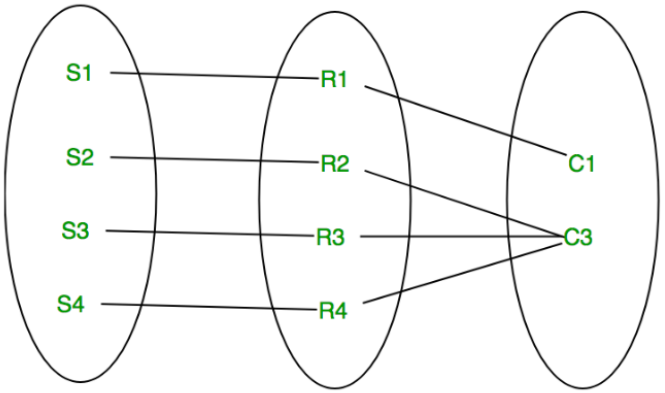
Ex: An employee can manage at most a department.
A department can have at most a manager.

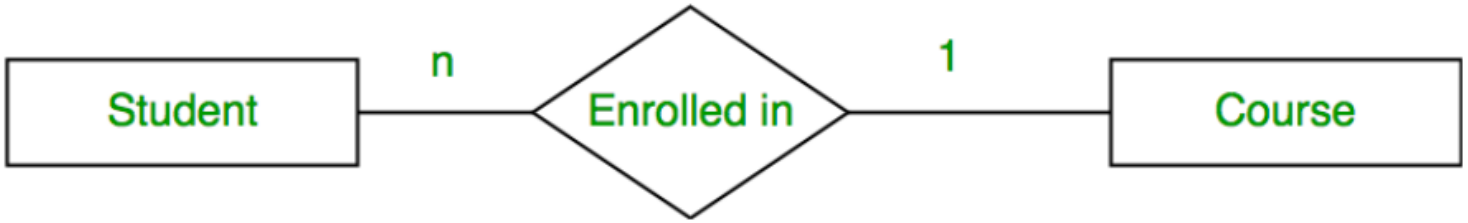


Cardinality of Relationship

- **One-to-many (1:n)**: One instance of an entity is related to multiple instances of another entity. It can be applied in both directions.

Ex: A course can be attended by many students. A student can attend at most one course.

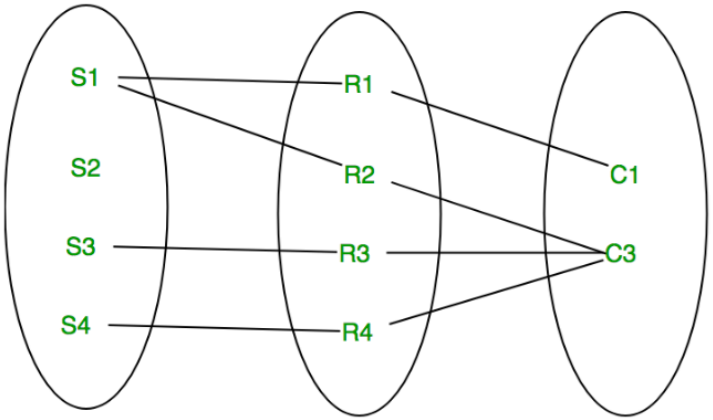


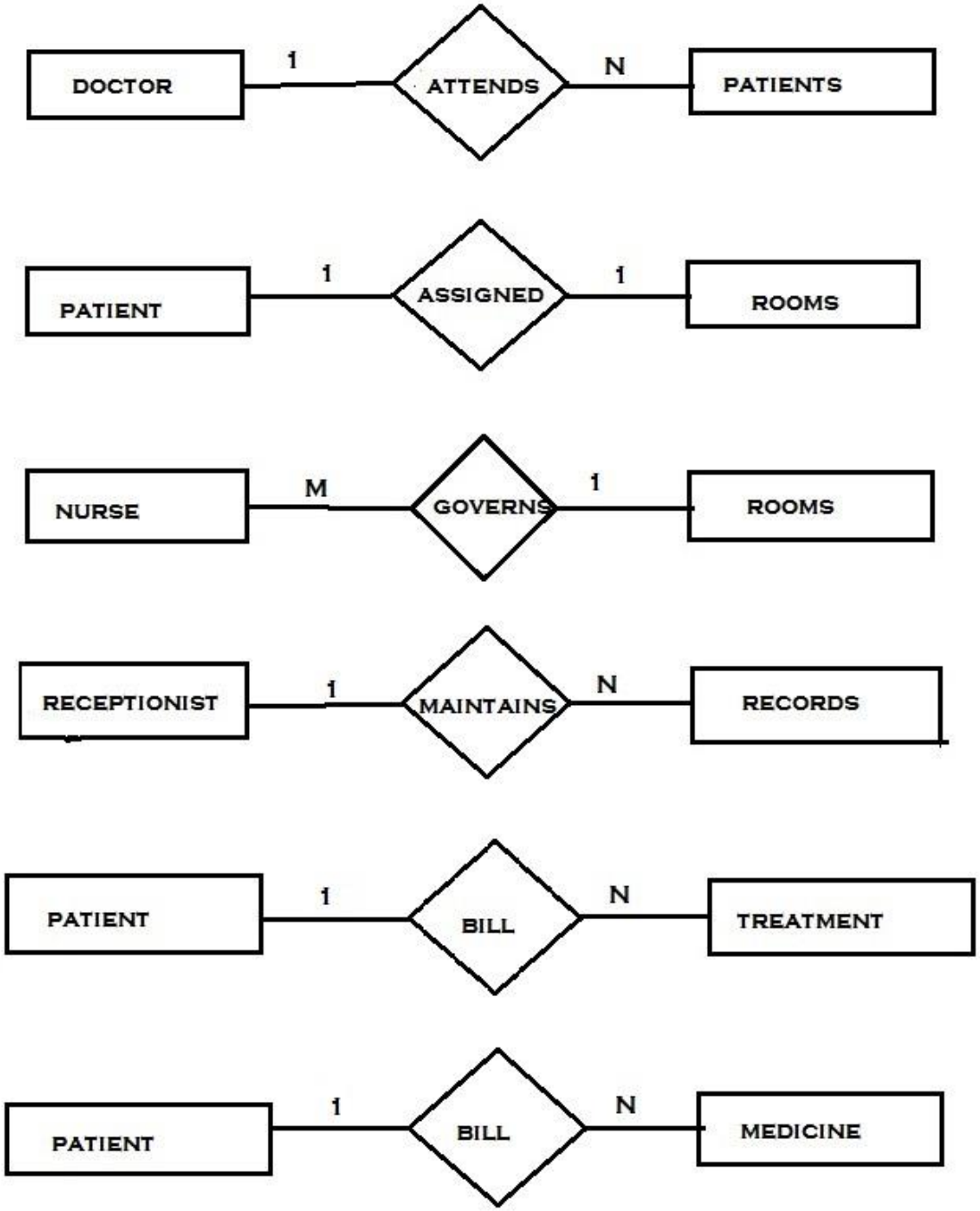


Cardinality of Relationship

- **Many-to-many (m:n)**: Multiple instances of an entity are related to multiple instances of another entity.

Ex: A course can be attended by many students. A student can attend many course.

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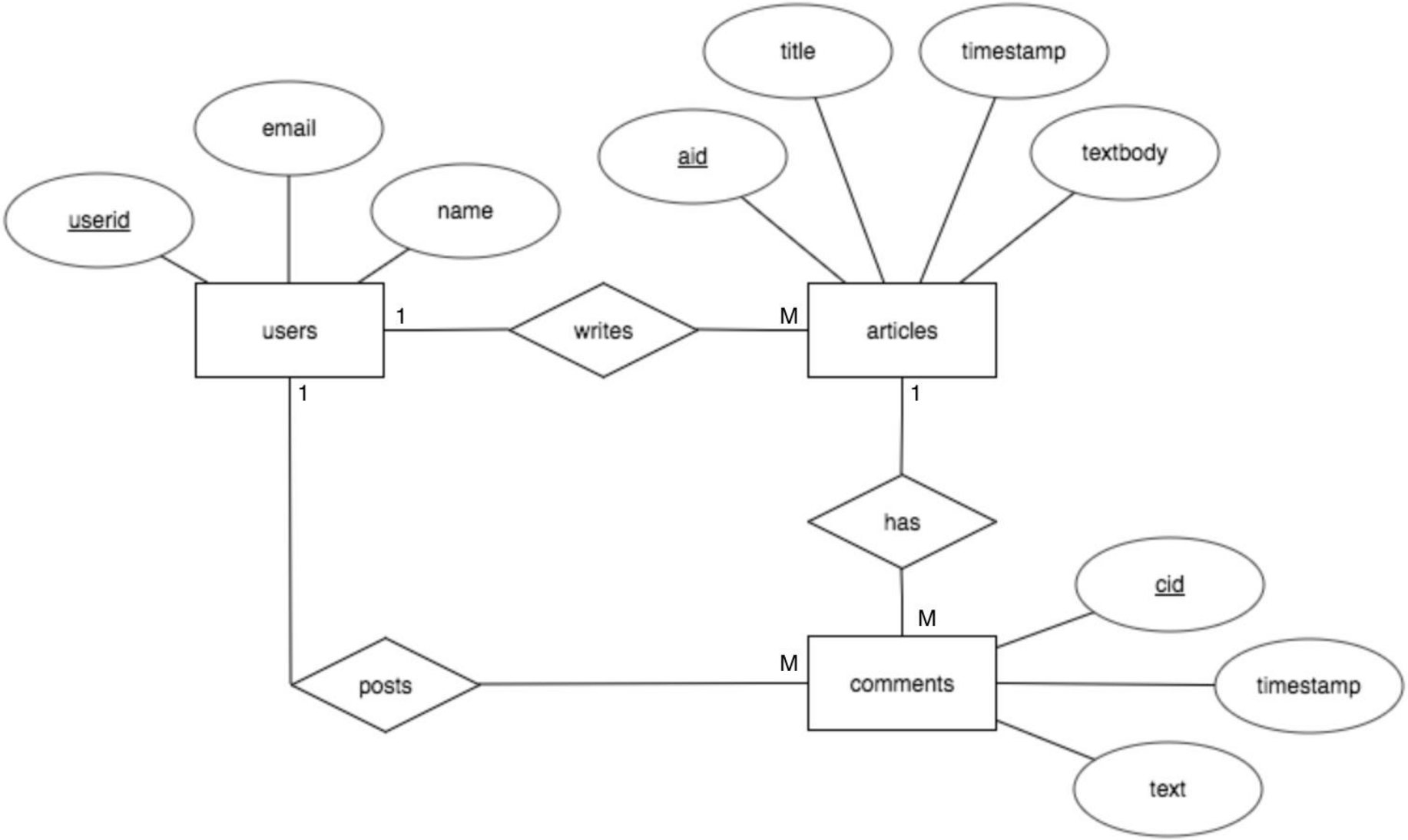
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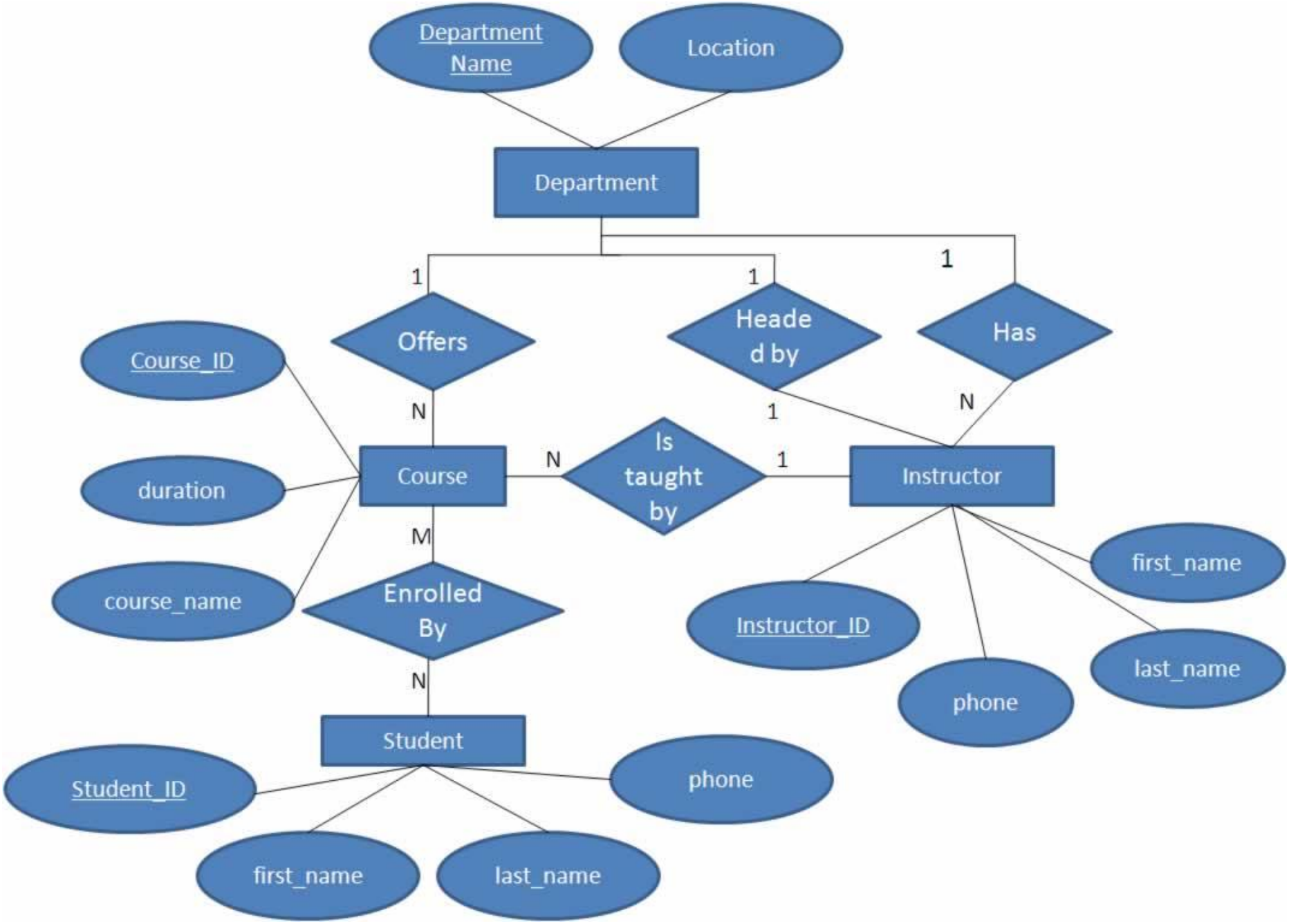
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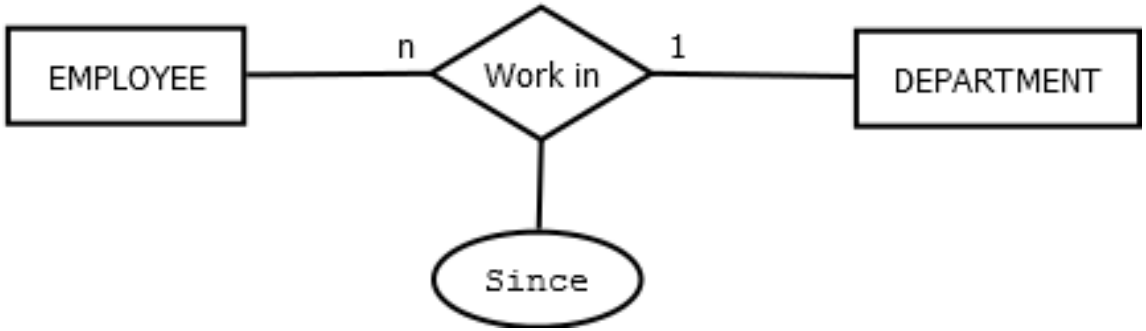
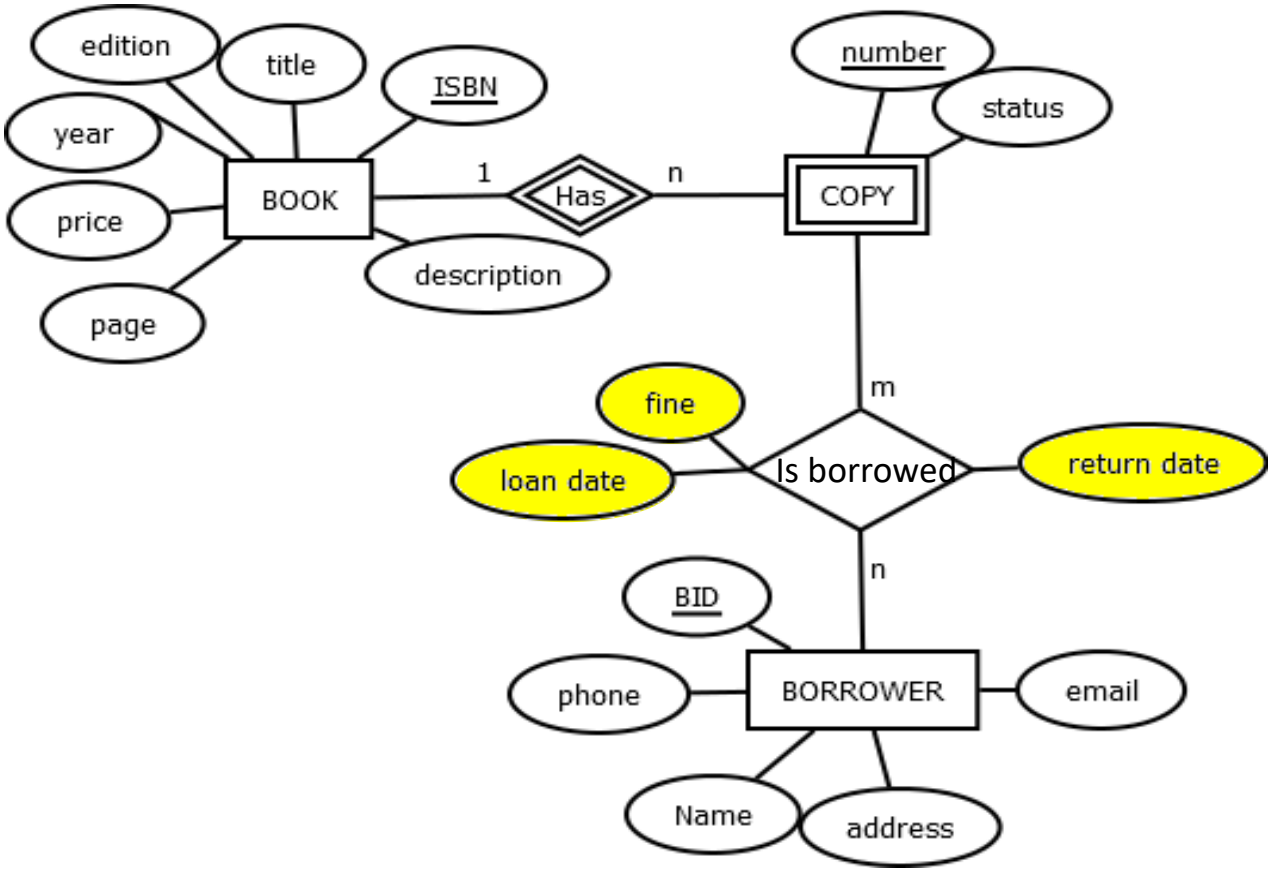
Attribute of Relationship Set

- Attribute of relationship set
  - A relationship can also have **descriptive attributes.** Descriptive attribute used to *record information about relationship*, not about participating entities.
  - Can be an attribute or a set of attributes.
  - Ex: we may wish to record that Sok works in the pharmacy department since January 1991.



Attribute of Relationship Set

- Example: BOOK and BORROWER

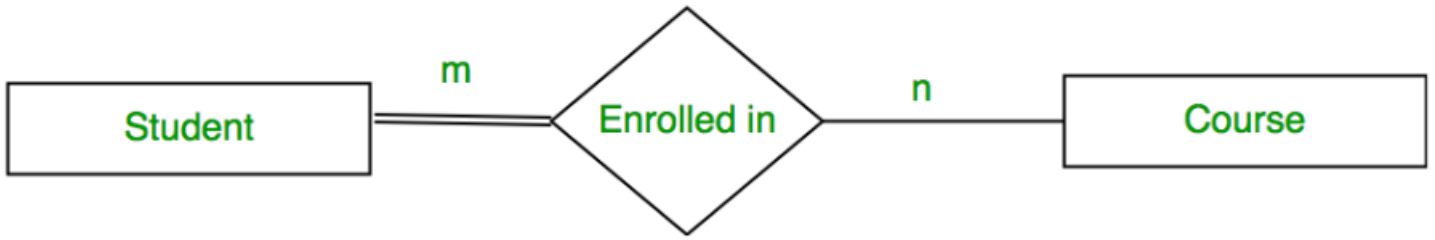


Participation Constraint

1. Total Participation

- It specifies that each entity in the entity set must compulsorily participate in at least one relationship instance in that relationship set.
- This is also called mandatory participation
- Total participation is represented using a double line or thick line between the entity set and relationship set.

Ex: If each student must enroll in a course, the participation of student will be total.

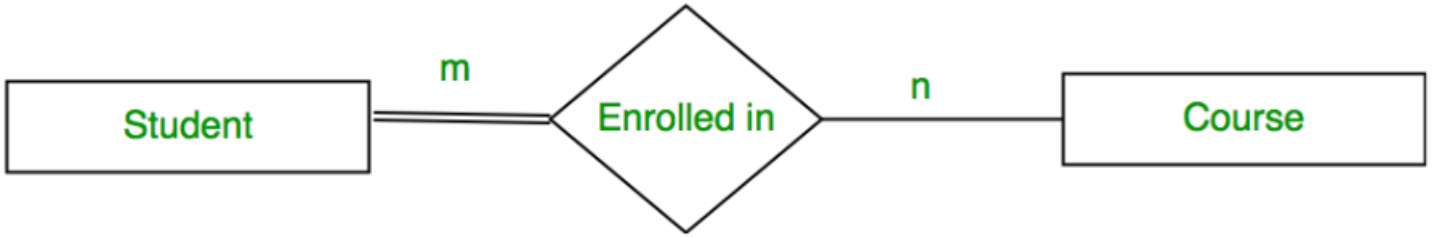


Participation Constraint

2. Partial Participation

- It specifies that each entity in the entity set may or may not participate in the relationship instance in that relationship set.
- It is also called as *optional participation*.
- Partial participation is represented using a single line between the entity set and relationship set.

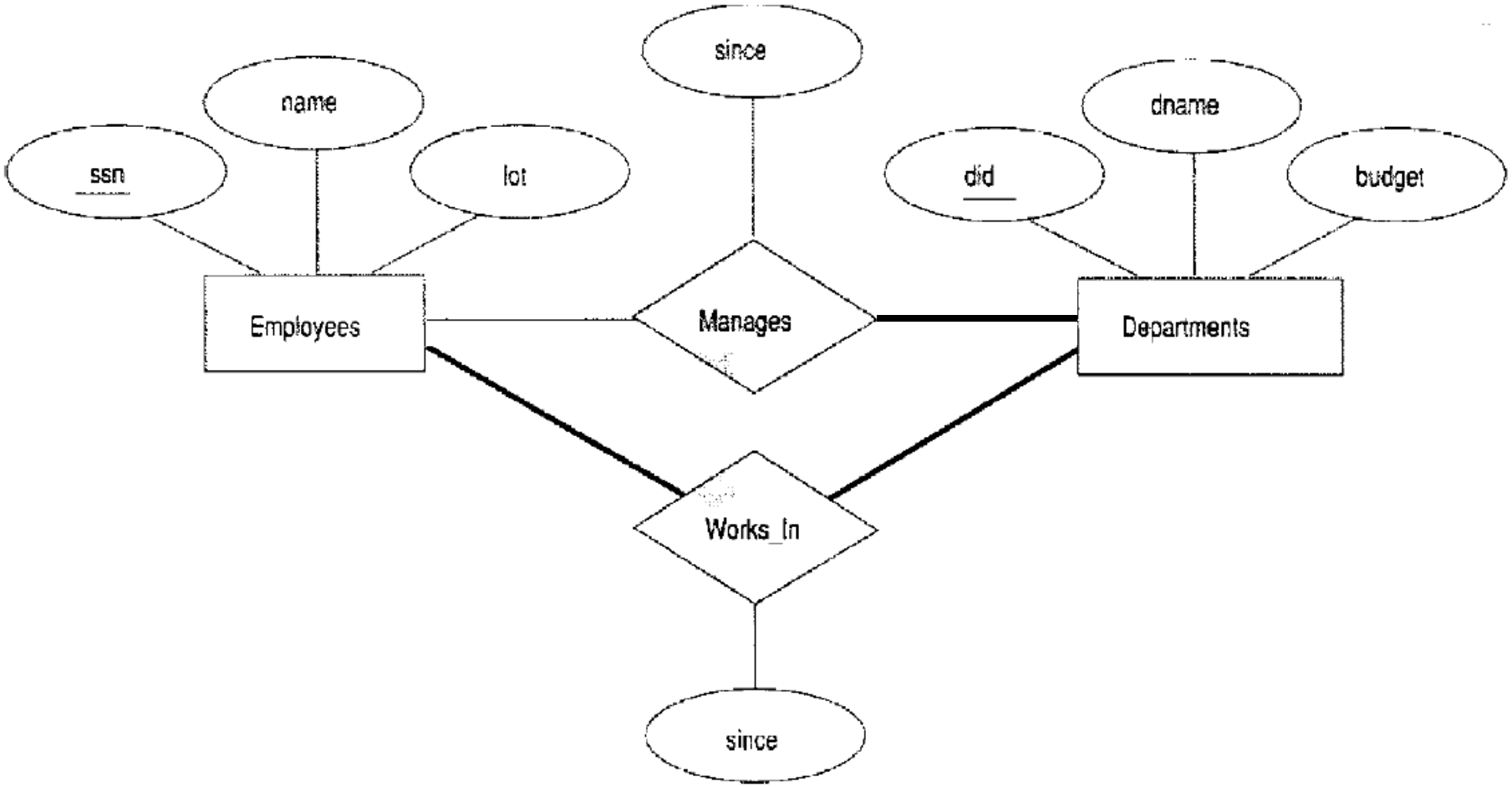
Ex: If some courses are not enrolled by any of the student, the participation of course will be partial.



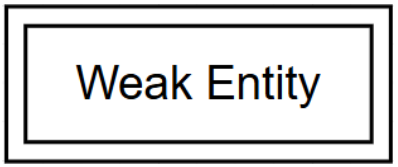
Participation Constraints

- Example: Relationship set:
  - EMPLOYEES <**work in**> DEPARTMENTS.
  - EMPLOYEES <**Manages** > DEPARTMENTS.
- Every department is required to have a manager. This requirement is an example of a *participation constraint*;
- The participation of the entity set Departments in the relationship set **<Manages>** is said to be *total*.
- The participation of the entity set Employees in **<Manages>** is *partial*, since not every employee gets to manage a department.
- On the **<Works_In>** relationship set, it is natural to expect that each employee works in at least one department and that each department has at least one employee. This means that the participation of both Employees and Departments in <**Works_In**> is *total*.

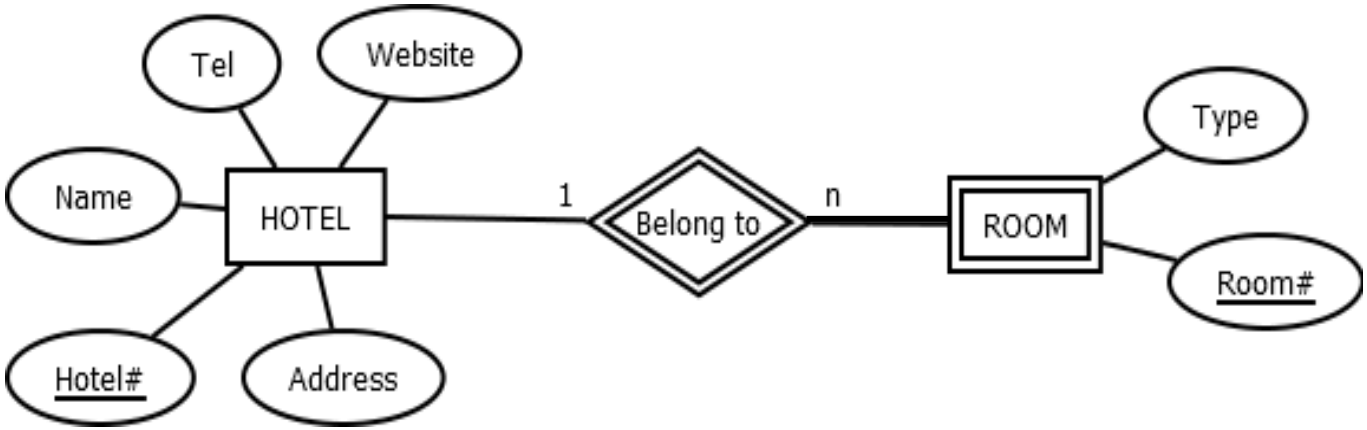
Participation Constraints



Weak Entity



- Weak entity set is graphically represented by double border rectangle (or with dark lines).
- Weak entity set is required to support at least a 1:M relationship with the owner entity set which helps to identify the weak entity.
- This relationship set is presented in double border diamond (or with dark lines).

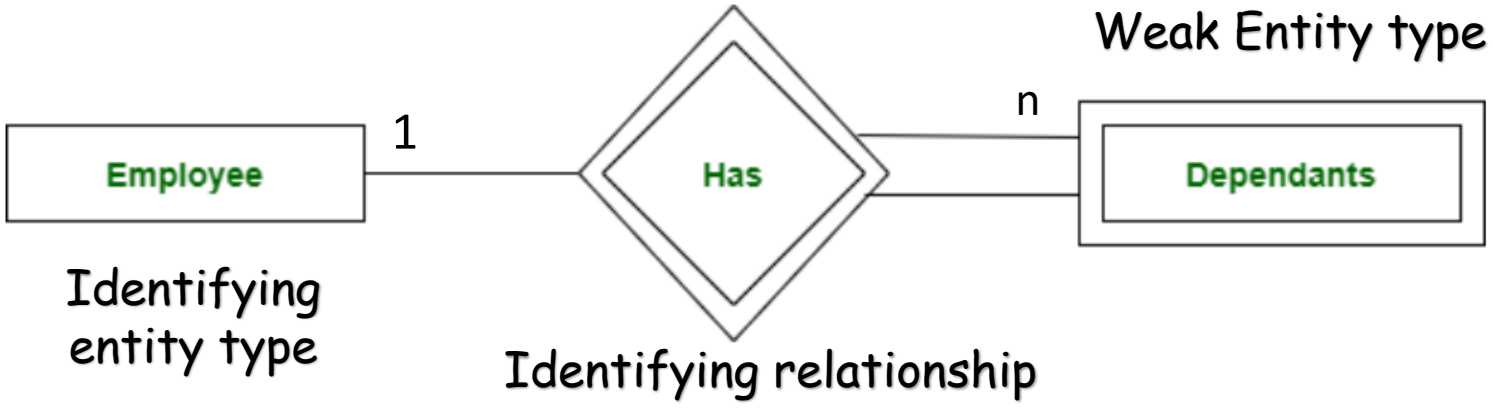


Weak Entity

Ex: A company may store the information of dependents (Parents, Children, Spouse) of an Employee. But the dependents don't have existence without the employee.

Dependents : weak entity type

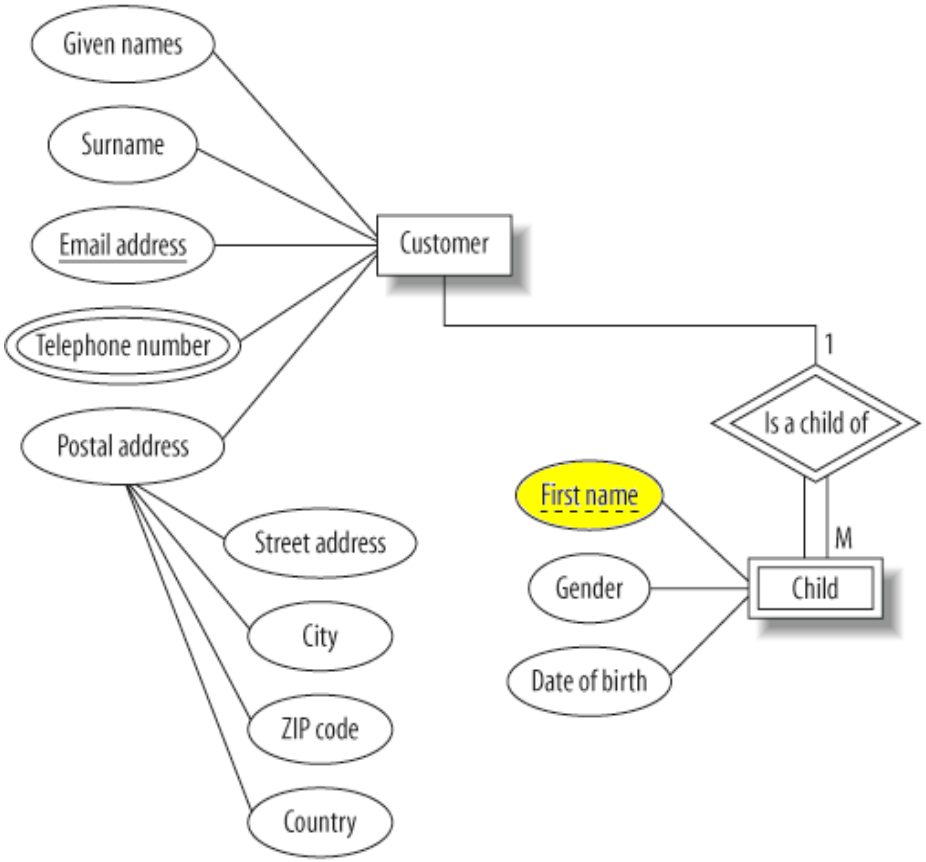
Employee: Identifying Entity type for dependent



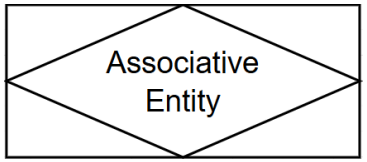
Weak Entity

Attributes of weak entity set also participate in identifying the weak entity set for a given owner entity is called a *partial key* for a weak entity.

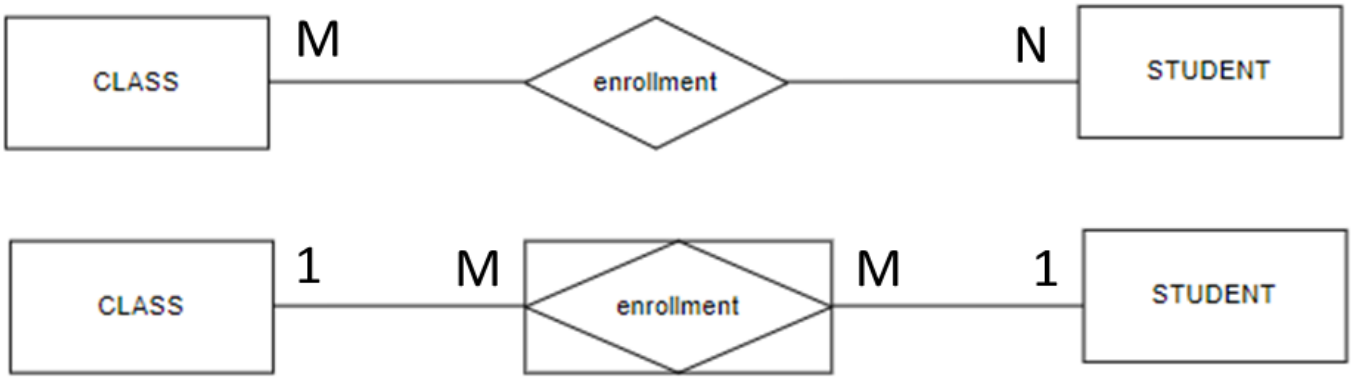
To indicate a partial key, we underline it.



Associative Entity



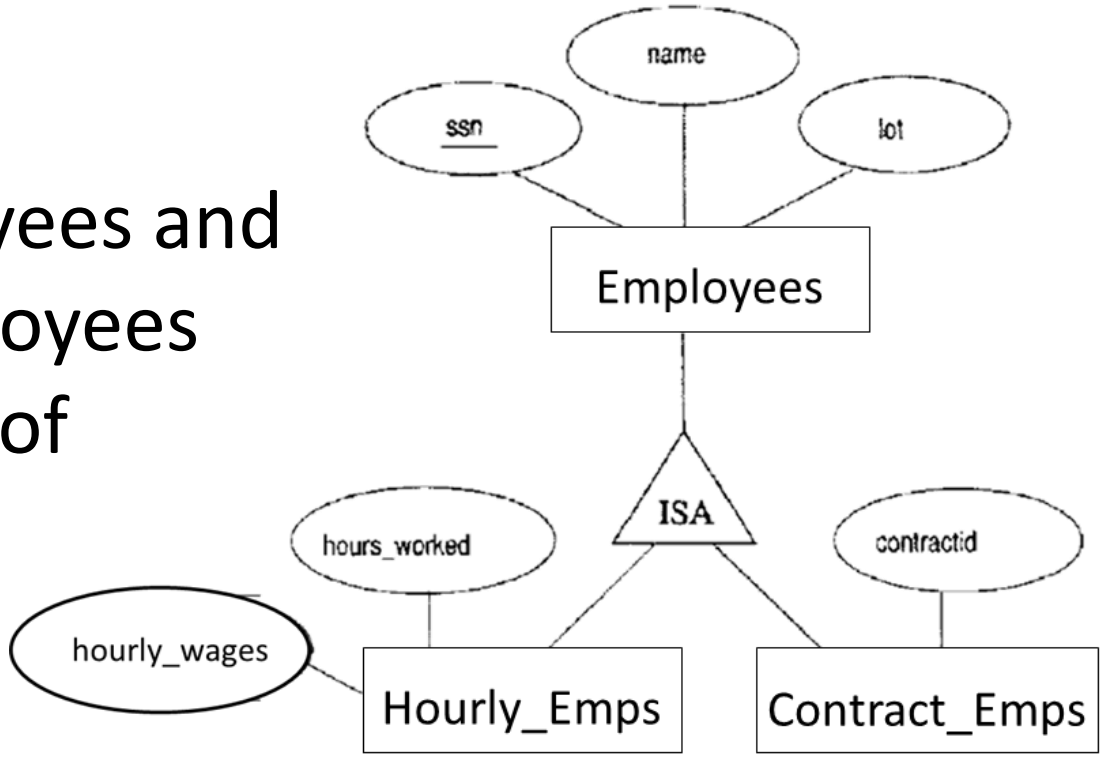
- An associative entity is used to model M:M relationships by breaking them down into two 1:M relationships. It often has its own attributes.
- Example: Consider the M:M relationship between Student and Class



Supertype and Subtype

- The relationship between Subtype and supertype is represented by triangle (with the ISA label), linking to supertype and subtypes.
- Example:

Hourly_Employees and Contract_Employees are subclasses of Employees.



DIVERSITY OF THE GRAPHICAL REPRESENTATION

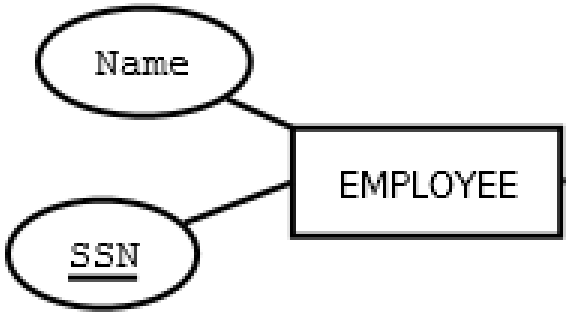
Entity set and Attribute, cardinality

Chen’s convention, Min-max, Crow’s foot

Diversity of The Graphical Representation

- In ER modeling, there are different graphical notations to represent entities relationships, and constraints.
- The three popular notations:
  a. Chen's Notation
  b. Min-Max Notation
  c. Crow's Foot Notation
- Each has its distinct way of depicting entities, attributes, relationships and cardinality and participation constraints.

Diversity Representation of Entity set and Attribute



DESK
*desk_id desk_colour desk_size

CUSTOMER	
PK	CustomerID
	CustomerName EmailAddress Address

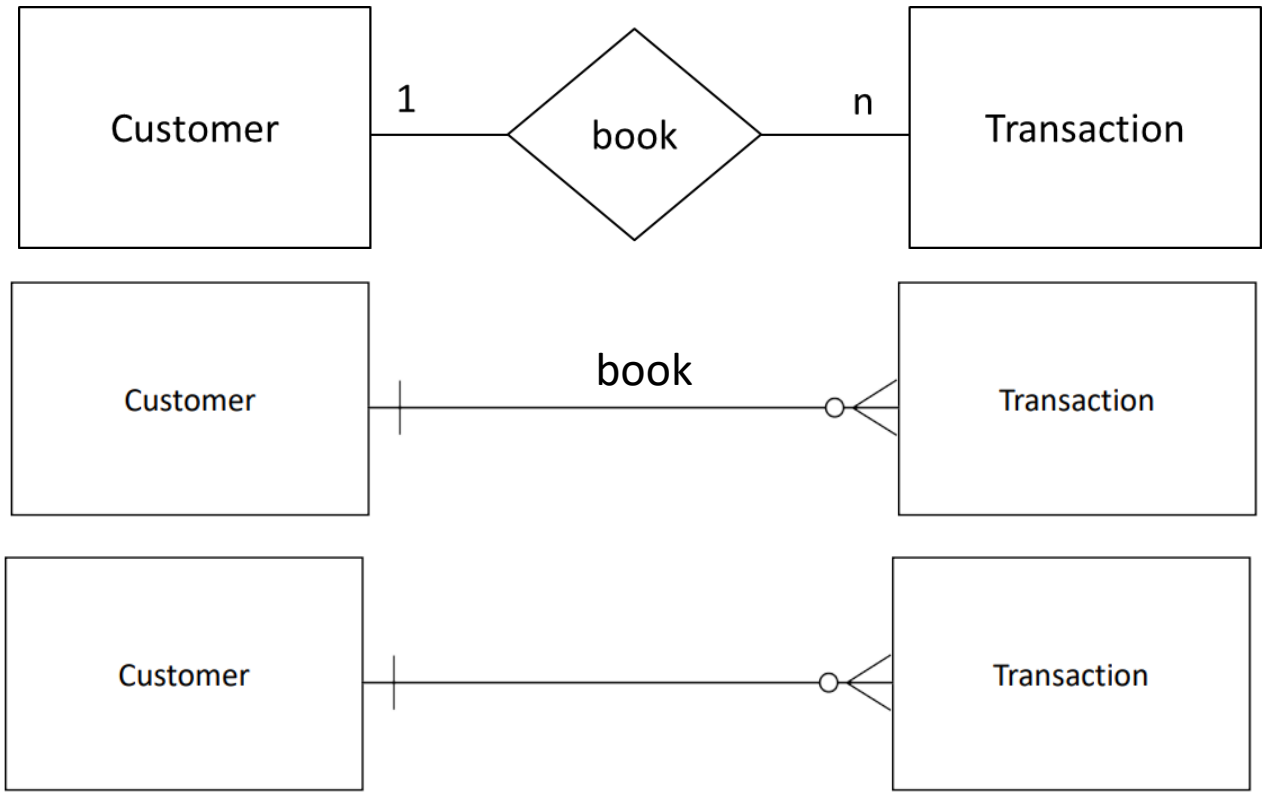
User	
id	varchar
username	varchar
password	varchar
gender	varchar
role	enum
image	varchar

Marks	
mark id	integer
student id	integer
subject id	integer
date	date/time
mark	integer

capital		
id	int	PK
name	varchar(128)	
country_id	int	FK

Diversity Representation of Relationship

- Relationship can be represented by a diamond or a line directly connecting entities.



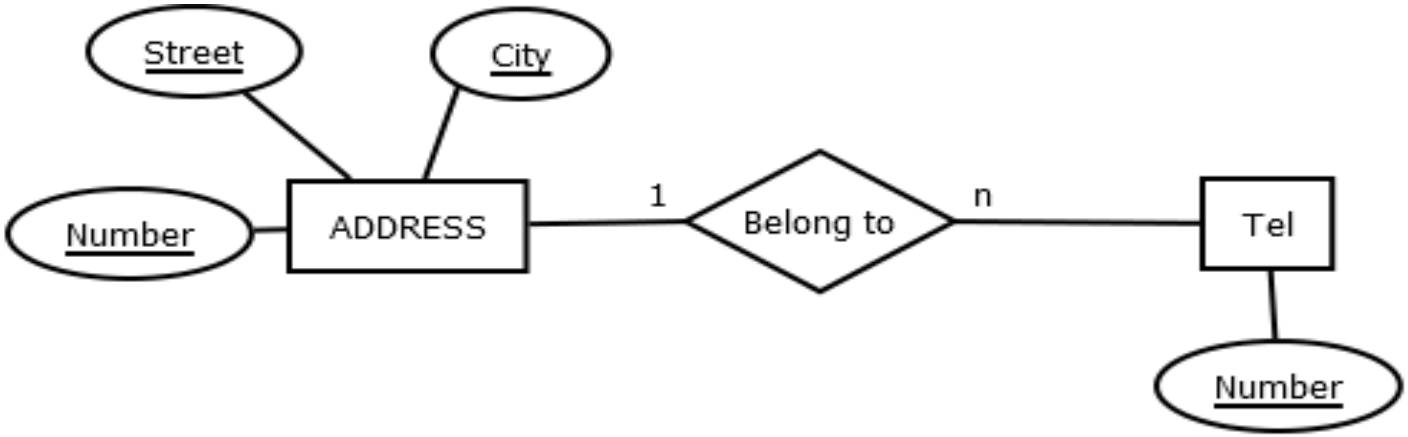
Diversity Representation of Cardinality and Optionality

1. Chen's convention

- Cardinality constraints are represented using number "1" for max one, labels "N" or "M" or "∞" for many next to the lines that connect entities to relationships.
- Total participation is represented using a double line or thick line, and partial participation is represented using a single line between the entity set and relationship set.
- No line style (unspecified) = Generally interpreted as Total Participation by default.

Diversity Representation of Cardinality and Optionality

1. Chen's convention
   - Ex: An entity in ADDRESS can be mapped to many entities in TEL (An address can have many phone number). An entity in TEL can be mapped to only an entity in ADDRESS (A phone number belong to an address.).

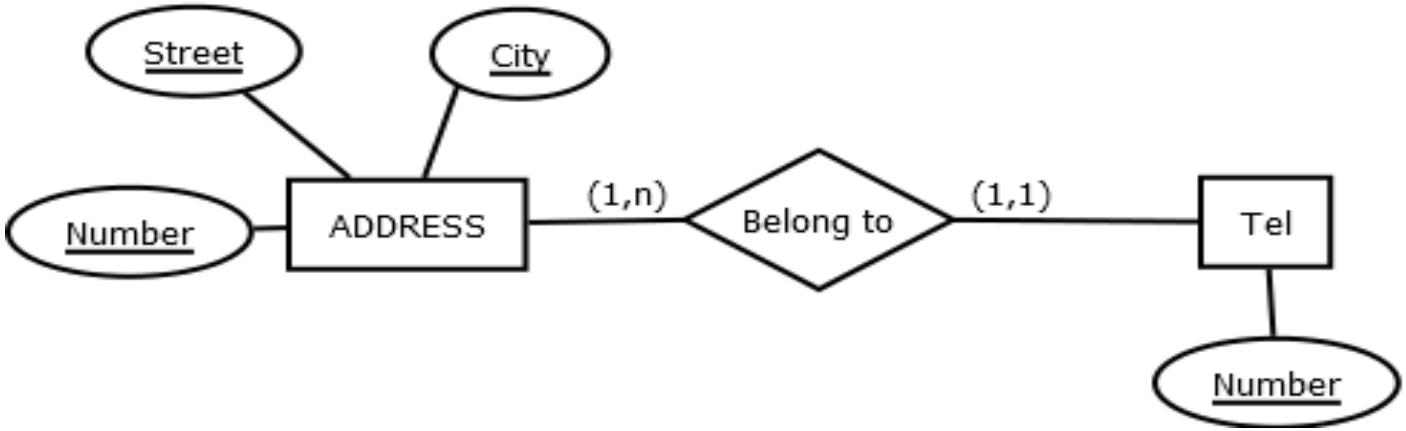


Diversity Representation of Cardinality and Optionality

2. Min-Max convention
   - Cardinality and Participation are represented in couple (min, max).
   - For a given cardinality (x, y), it respect some constraints
     - X can be 1 (mandatory) or 0 (optional)
     - Y can be 1 (one) or n (many) or "*" (many)
     - (1,1) or 1 : Exactly one
     - (1,n) or (1,*) : One or more
     - (0,1) : Zero or one (optional one)
     - (0,n) or (0,*) : Zero or more (optional many)
   - Opposite from Chen's convention in term of position

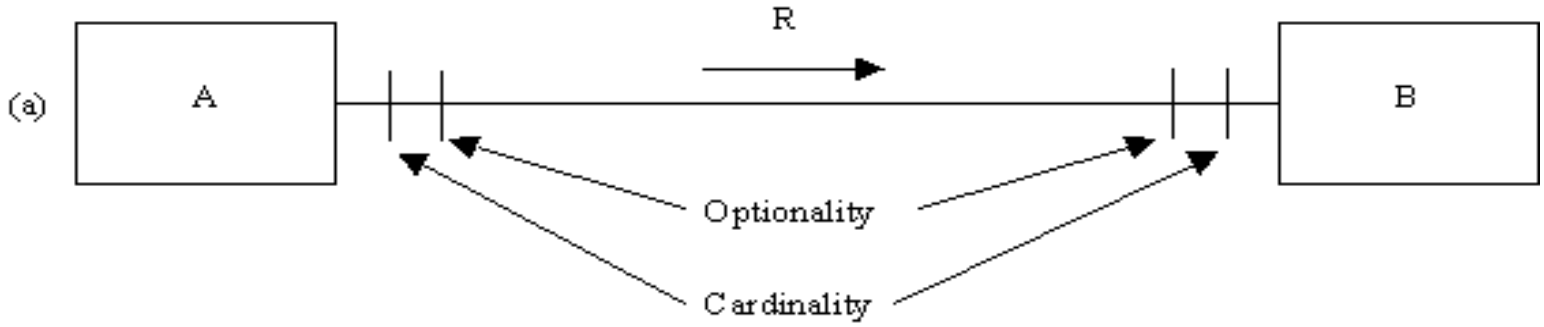
Diversity Representation of Cardinality and Optionality

2. Min-Max convention
   - Ex: An address may contain at least a phone number and at most n phone number. A phone number belongs to at least an address and at most an address too.



Diversity Representation of Cardinality and Optionality

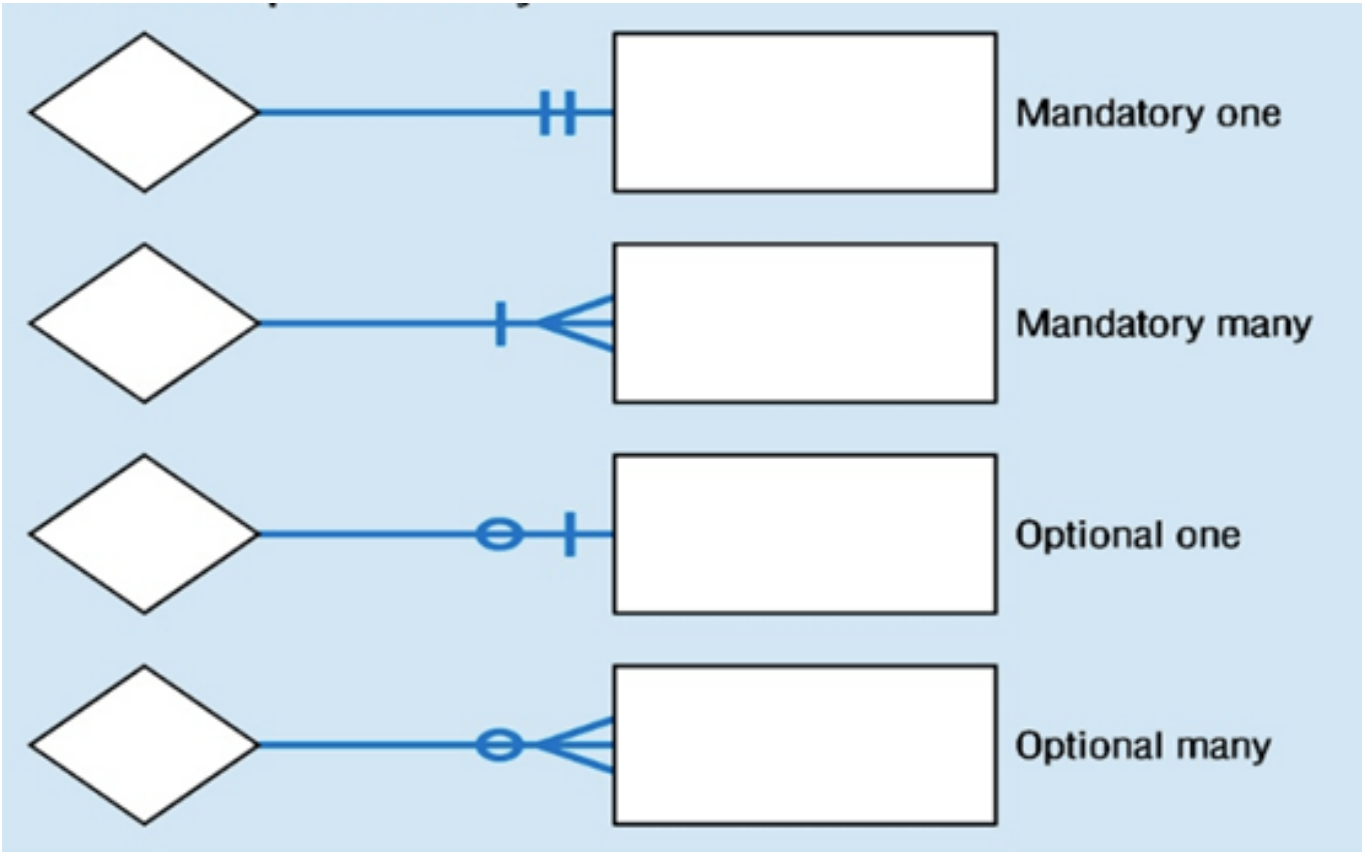
3. Crow's foot convention



- **Optionality** refers to the minimum possible participation
  - A circle refers to zero (0), an optional participation
  - A line refers to one (1), represents a total participation
- **Cardinality** refers to the maximum possible participation
  - A crow's foot refers to many, A line refers to one.
- Similar to Chen's convention in term of position
- If optionality isn't indicated (only cardinality alone), it generally means that the relationship is mandatory.

Diversity Representation of Cardinality and Optionality

3. Crow's foot convention



1 or only 1

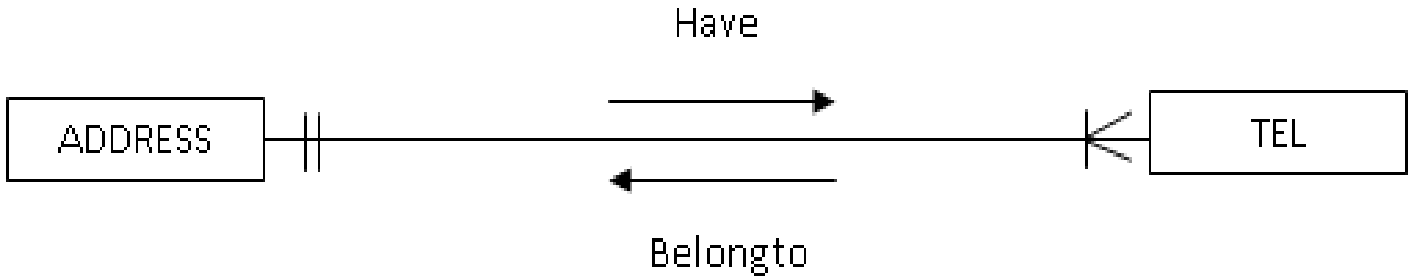
1 or many

zero or one

zero or many

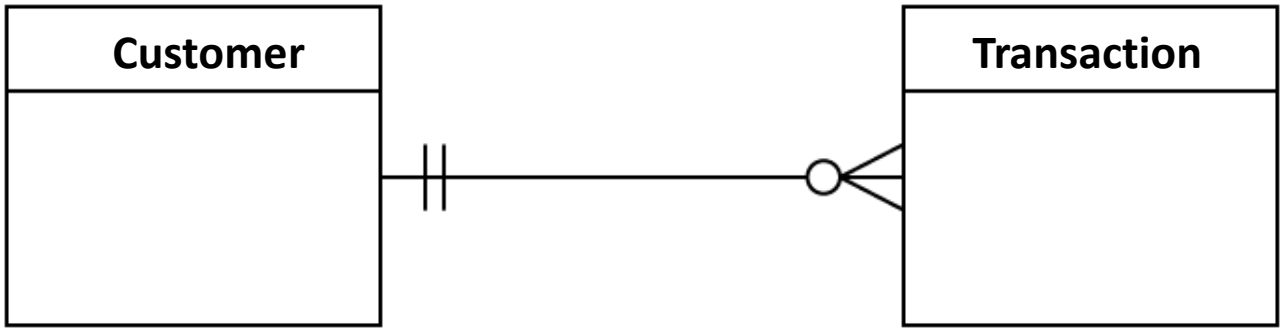
Diversity Representation of Cardinality and Optionality

3. Crow's foot convention
   - Ex1: Relationship Have between ADDRESS and TEL is the 1:n relationship. Every entity in ADDRESS can be mapped to at least one and at most many entities in TEL. Every entity in TEL is mapped to one and only one entity in ADDRESS.



Diversity Representation of Cardinality and Optionality

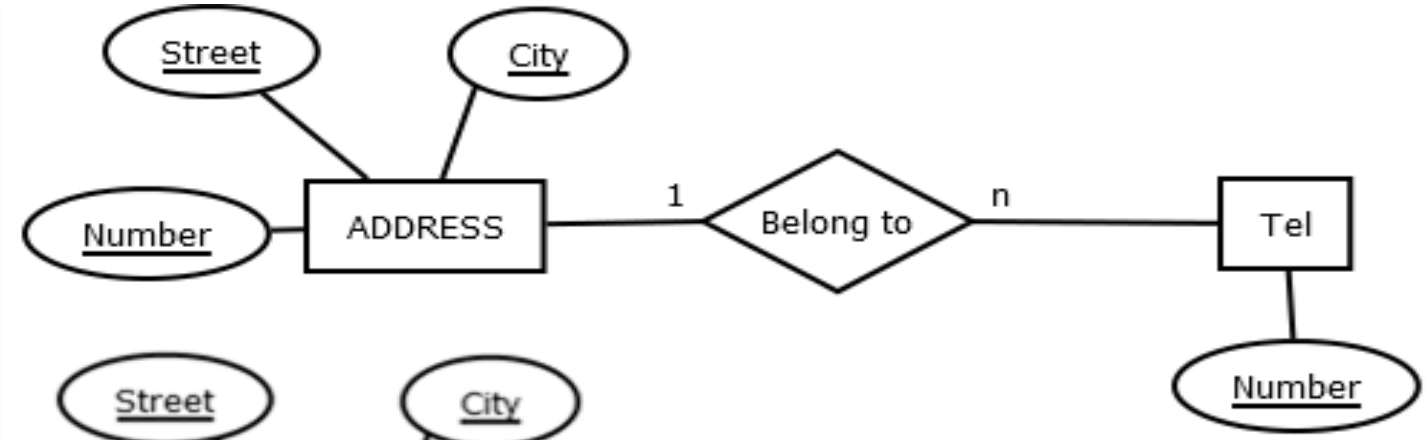
3. Crow's foot convention
   - Ex2: relationship between customer and transaction. These entities now have a 1:0m relationship because a customer can book one, many, or zero transactions, but a transaction still belongs to one and only one customer.



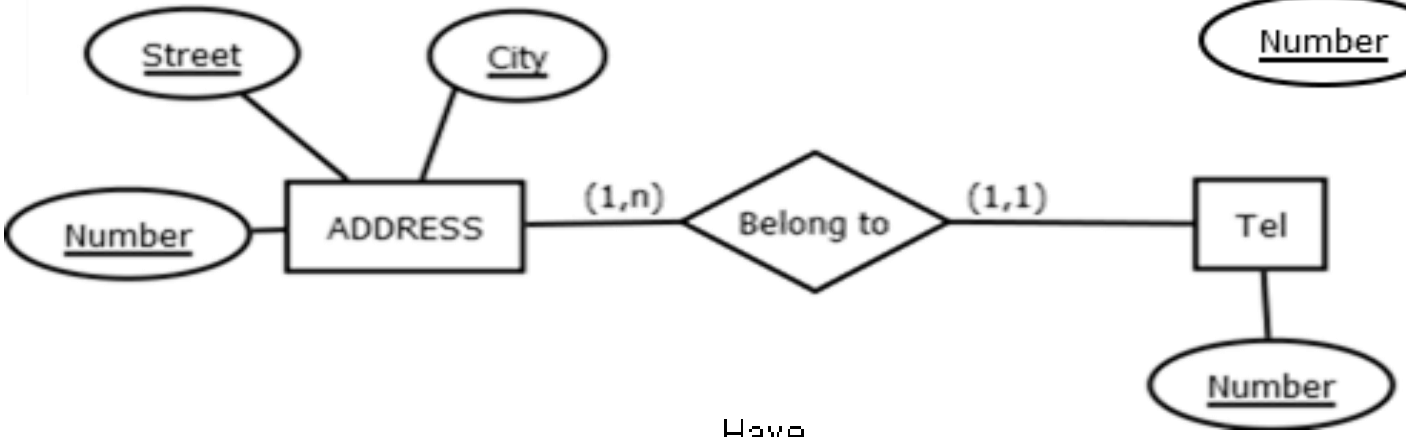
A customer could exist in the database but could have zero transactions.

Diversity Representation of Cardinality and Optionality

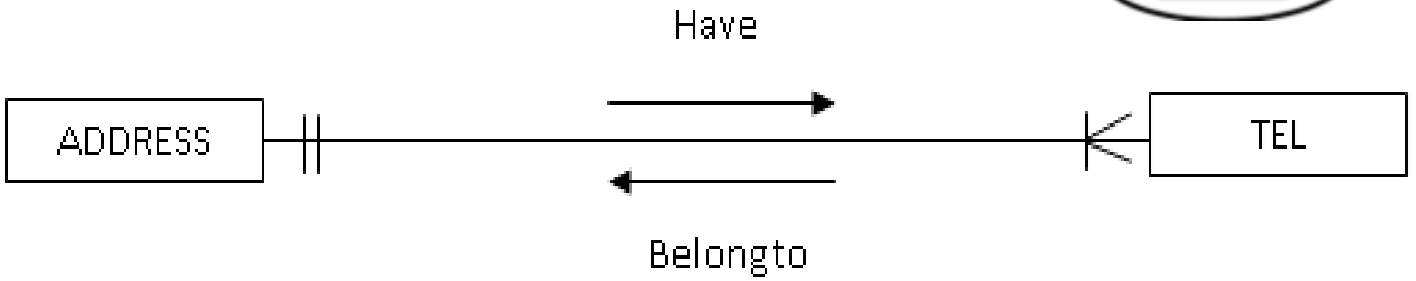
Chen



Max-Min



Crow's foot



Assignment

- Designing an ER (Entity-Relationship) diagram for a basic e-commerce system

Scenario

- An online e-commerce platform allows users to place orders, and store the orders, ordered items, the payments and the invoices. Your task is to create an ERD that accurately represents the entities and relationships in a basic ecommerce database.

Exampled e-commerce database

1. Users Table

UserID	Name	Email	Phone	Address
1	John Smith	john@example.com	555-1234	123 Eln
2	Jane Doe	jane@example.com	555-5678	456 Oa
3	Mike Johnson	mike@example.com	555-8765	789 Pir

2. Categories Table

CategoryID	CategoryName	Description
1	Electronics	Devices and gadgets
2	Clothing	Apparel and accessori
3	Home & Kitchen	Furniture and utensils

3. Products Table

ProductID	Name	Description	Price	StockQuantity	CategoryID
1	Laptop	15-inch laptop with 16GB RAM	899.99	50	1
2	Smartphone	Latest model smartphone	699.99	100	1
3	T-Shirt	Cotton t-shirt in various sizes	19.99	200	2
4	Coffee Maker	Automatic drip coffee maker	49.99	30	
5	Microwave Oven	Compact microwave oven	79.99	20	

4. Orders Table

OrderID	OrderDate	UserID	TotalAmount	PaymentStatus
1	2024-10-01 10:00:00	1	919.98	Paid
2	2024-10-05 14:30:00	2	19.99	Paid
3	2024-10-10 09:15:00	1	119.98	Pending

5. OrderItems Table

OrderItemID	OrderID	ProductID	Quantity	Price
1	1	1	1	899.99
2	1	2	1	699.99
3	2	3	1	19.99
4	3	4	1	49.99
5	3	5	1	79.99

6. Payments Table

PaymentID	OrderID	PaymentDate	Amount	PaymentMethod	Status
1	1	2024-10-01 10:05:00	59.97	Credit Card	Completed
2	2	NULL	29.99	PayPal	Pending
3	3	2024-10-03 14:20:00	39.99	Credit Card	Completed

7. Invoices Table

InvoiceID	OrderID	InvoiceDate	TotalAmount	PaymentStatus
1	1	2024-10-01 10:10:00	59.97	Paid
2	2	NULL	29.99	Unpaid
3	3	2024-10-03 14:25:00	39.99	Paid

Assignment

Instructions

1. Identify Entities and Attributes: Based on the scenario, define each entity and its attributes, ensuring each entity has a primary key.
2. Define Relationships: Establish the relationships between entities, including the cardinality and participation constraints.
3. Choose a Notation: Use Chen's or Crow's Foot notation to create your ERD. Ensure it clearly shows entities, attributes, primary keys, and relationships.
4. Include Descriptive Attributes: Add descriptive attributes as necessary

Submission Requirements

- Submit a single-page ERD as a PDF or image file.

Assignment

- Specify the entities and their basic attributes:
  - User: UserID, Username, Email, Address, PhoneNumber
  - Product: ProductID, ProductName, Description, Price, StockQuantity
  - Order: OrderID, OrderDate, TotalAmount, Status
  - Payment: PaymentID , PaymentDate, Amount, PaymentMethod, Status
  - Category: CategoryID , CategoryName, Description
  - Invoice: InvoiceID, InvoiceDate, TotalAmount, PaymentStatus
- Define relationships and specify the cardinality

Assignment

1. Users and Orders
   - Relationship: A User can place multiple Orders, but an Order is placed by one User.
   - Cardinality: (1:M)
   - Participation:
   - User: Total participation (each User must be able to place at least one Order).
   - Order: Total participation (each Order must be associated with one User).

Assignment

2. Orders and Products
   - Relationship: An Order can contain multiple Products, and a Product can appear in multiple Orders.
   - Cardinality: M:M
   - Participation:
   - Order: Total participation (each Order must contain at least one Product).
   - Product: Partial participation (not all Products need to be in an Order; they can exist without being ordered).

Assignment

3. Categories and Products
   - Relationship: A Product belongs to one Category, but a Category can have multiple Products.
   - Cardinality: 1:M
   - Participation:
   - Category: Total participation (every Product must belong to a Category).
   - Product: Total participation (each Product must reference a Category).

Assignment

4. Orders and Payments
   - Relationship: An Order has one Payment, but a Payment is associated with one Order.
   - Cardinality: 1:1
   - Participation:
   - Order: Total participation (each Order must have one associated Payment).
   - Payment: Total participation (each Payment must be linked to one Order)

Assignment

5. Orders and Invoices
   - Relationship: An Order can have one Invoice, but an Invoice is associated with one Order.
   - Cardinality: 1:1
   - Participation:
   - Order: Total participation (each Order must have an Invoice).
   - Invoice: Total participation (each Invoice must be linked to one Order)