Entity Relationship Diagram

An **Entity-Relationship Diagram (ERD)** is a **visual representation of a database's structure** that shows the **entities (objects, things, or concepts of interest)**, their **attributes (properties or details)**, and the **relationships (associations or connections)** between them.

## Basic constructs of the E-R model:

1. Entities:

- Definition: An entity represents a real-world object, person, place, event, or concept that the business needs to track or store information about.

- In Databases: Usually corresponds to a table.

- Examples:

    - Person → Student, Employee, Customer

    - Place → Branch, Warehouse, Country

    - Object → Product, Car, Book

    - Event → Order, Payment, Appointment

    - Concept → Subject, Policy, Course

2. Attributes:

- Definition: An attribute is a property or characteristic that describes an entity.

- In Databases: Usually corresponds to a column (field) in a table.

- Types of Attributes:

    - Simple: Cannot be divided further (Age, Name).

    - Composite: Can be broken down (Full Name → First Name, Last Name).

    - Derived: Calculated from other attributes (Age derived from Date of Birth).

    - Key Attribute: Uniquely identifies each entity (Student_ID).

- Example: For entity Student → Attributes: Student_ID, Name, Age, Email.

3. Relationships

- Definition: A relationship shows how two or more entities are connected to each other.

- In Databases: Implemented through primary key – foreign key links between tables.

- Cardinality (types of relationships):

    - One-to-One (1:1) → Each person has one passport.

    - One-to-Many (1:M) → A customer can place many orders.

    - Many-to-Many (M:N) → Students enroll in many courses, and each course has many students.

- Example: Relationship between Student and Course → "Enrolled In".

- Rectangles: entity sets
- Diamonds: relationship sets
- Ellipses: attributes
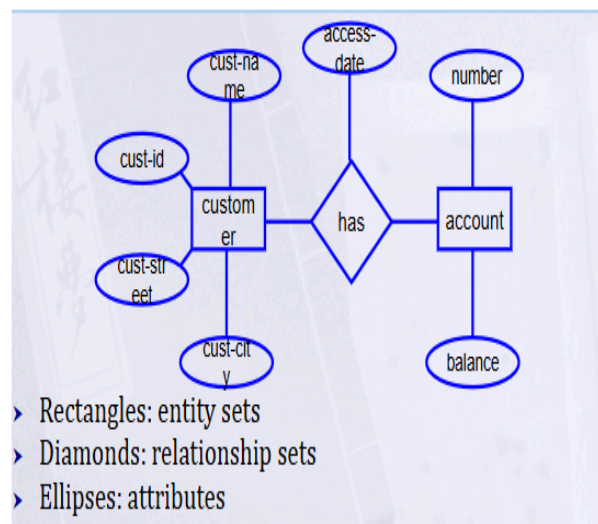
Strong Entity Vs Weak Entity:

1. Strong Entity:

- Definition: An entity that can exist independently in the database and is uniquely identified by its own primary key.

- Key Features:

  - Has a primary key that uniquely identifies each record.

  - Does not depend on any other entity for its identification.

  - Represented by a **single rectangle** in ER diagrams.

- Example:

  - Student(Student_ID, Name, Age, Email)

  - *Student_ID* is the primary key → uniquely identifies each student.

2. Weak Entity:

- Definition: An entity that cannot exist independently and depends on a strong entity for its identification.

- Key Features:

  - Does not have a complete primary key of its own.

  - Identified using a partial key (discriminator) + the primary key of the related strong entity.

  - Existence depends on a strong entity.

  - Represented by a **double rectangle** in ER diagrams.

- Example:

  - Dependent(Dependent_Name, Relation, Student_ID)

  - Here, *Dependent_Name* alone may not uniquely identify a record, but together with *Student_ID* (from Student, a strong entity), it does.

  - A dependent cannot exist in the system without a student.

**Types of Attributes in DBMS:**
1. Simple Attribute:

- Definition: Attributes that cannot be divided into smaller sub-parts.

- Example: Age, Gender, Employee_ID.

- ERD Representation: **ellipse** shape directly linked to the entity.
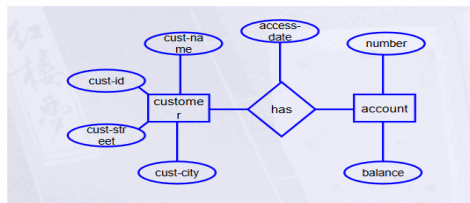
2. Composite Attribute:

- Definition: Attributes that can be broken down into smaller, meaningful parts.

- Example:

  - Full Name → First Name, Middle Name, Last Name

  - Address → Street, City, State, ZIP Code

- ERD Representation: **ellipse** with sub-**ellipse** (parts).
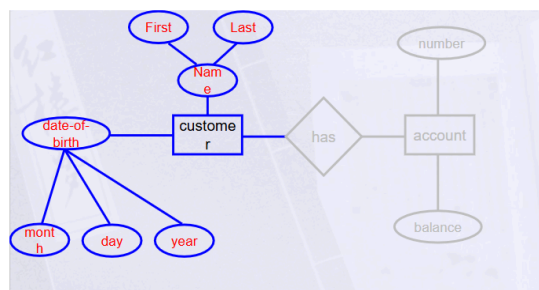
3. Multi-Valued Attribute:

- Definition: Attributes that can hold multiple values for a single entity.

- Example:

    - Phone Numbers (a person can have more than one).

    - Skills (a programmer may have many).

- ERD Representation: **Double ellipse** connected to the entity.
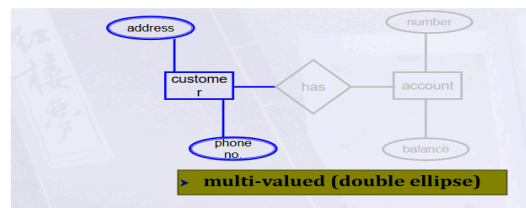
4. Derived Attribute:

- Definition: Attributes whose values can be derived from other attributes.

- Example:

    - Age (derived from Date_of_Birth).

    - Total Price (derived from Quantity × Unit Price).

- ERD Representation: Dashed **ellipse.**

5. Complex Attribute:

- Definition: Attributes formed by combining composite and multi-valued attributes together.

- Example:

    - Address (Composite: Street, City, State) + may also allow multi-values (multiple addresses: Home, Work).

- ERD Representation: Hierarchical nesting of attributes (composite + multi-valued).

Relationship:

- **Definition**:
  A **relationship** represents an **association between two or more entities**.
  It describes how entities are **connected** in the real world and how they interact with each other in the database.

- **In Databases**:
  Relationships are implemented using **Primary Key – Foreign Key** connections between tables.

- **ERD Representation**:
  Represented by a **diamond shape** connecting the related entities.

Types of Relationships (Cardinality):

1. **One-to-One (1:1):**

   - Each entity instance in one set is related to one entity instance in another set.

   - Example: One person → one passport.

2. **One-to-Many (1:M):**

   - One entity instance in a set is related to many in another set.

   - Example: One customer → many orders.

3. **Many-to-Many (M:M):**

   - Many entities in one set can be related to many in another set.

   - Example: Students ↔ Courses (a student enrolls in many courses, each course has many students).
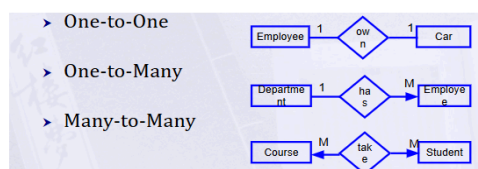
Degree of Relationships

Unary (Recursive) → Relationship within the same entity. Example: Employee "manages" Employee.

Binary → Relationship between two entities (most common). Example: Student "enrolls in" Course.

Ternary → Relationship among three entities. Example: Doctor "prescribes" Medicine to Patient.
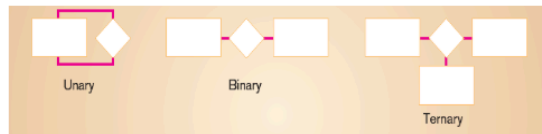
Participation Constraint (in ER Model):

Definition:

The participation constraint specifies whether all or only some entity occurrences participate in a given relationship.
 It defines the minimum number of times an entity must participate in a relationship.

Types of Participation:

1. Total Participation(Mandatory):

- Definition: Every entity in the entity set must participate in the relationship.

- Representation in ERD: **Double line** between entity and relationship.

- Example:

  - Every employee must belong to a department.

  - → All employees are linked to at least one department.

2. Partial Participation(Optional):

- Definition: Only some entities in the entity set participate in the relationship.

- Representation in ERD: **Single line** between entity and relationship.

- Example:

  - Not every student has a scholarship.

  - → Some students participate, others don't.

-An Employee may have a car.
-A Car must be assigned to particular employee
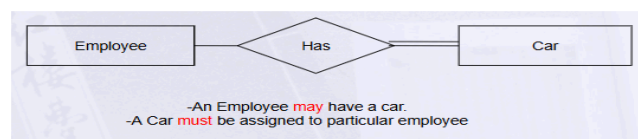
Figure 3.14
Summary of the notation for ER diagrams.

Symbol	Meaning
	Entity
	Weak Entity
	Relationship
	Indentifying Relationship
	Attribute
	Key Attribute
	Multivalued Attribute
	Composite Attribute
	Derived Attribute
E_1 — R — E_2	Total Participation of E_2 in R
E_1 —1— R —N— E_2	Cardinality Ratio 1 : N for E_1:E_2 in R
R —(min, max)— E	Structural Constraint (min, max) on Participation of E in R