Module 02: Entity Relationship Model(ER), Relational Model and Extended ER Model

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1.1 Data Model

Data model is the conceptual tools which describe data, data semantics, and consistency constraints. It defines how data is connected to each other and how it will be processed and stored inside the system. Following are the four data models:

1. Hierarchical data model
2. Network data model
3. Entity Relationship model
4. Relational Model

1. **Hierarchical Data Model**: In this model, data is represented in the form of hierarchical structure or parent child or tree like structure. In this model, each record is having one parent record and many children. Following is the example of hierarchical data model where student record is represented by this model. For example, hierarchical model for project in the company is :
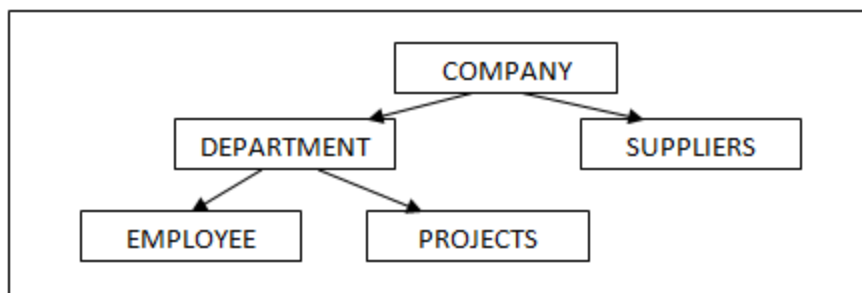
Data inconsistency is more in this model. Also, data retrieval is very complex.

2. **Network Data Model:** In this model data is represented in the form of graph. In this model each parents can have multiple children and children can also have multiple parents. Data inconsistency is less than Hierarchical model. Data retrieval is faster than Hierarchical model.
For example, network model for project in the company is :
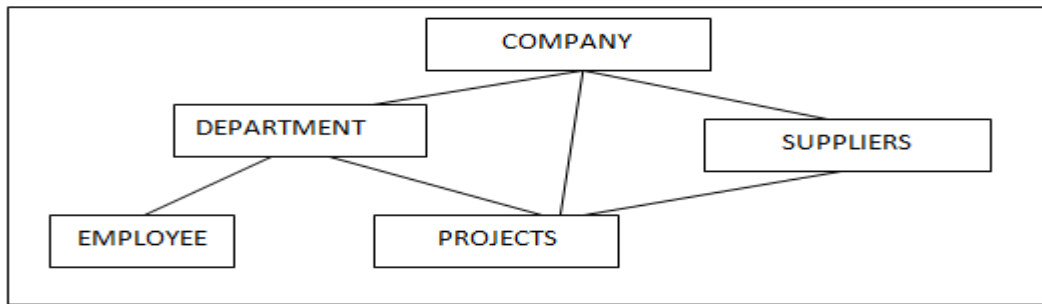
3. Entity Relationship Model (ER model)
4. Relational Model

1.2 Entity Relationship Model (ER Model)

Entity-Relationship or ER model is a data model used to represent the data elements and their relationship to each other. It is collection of real world entities and their association or relationship. It is used as tool for requirements gathering and verification. Following are the elements of ER diagram.

1. **Entity and Entity Sets:** An entity is any real-world object whose data is going to store in the database. Set of entity is known as Entity set. For example, if a student is an entity, then the complete dataset of all the students will be the entity set. **Examples of entities:**

- **Person:** Employee, Student, Patient
- **Place:** Store, Building
- **Object:** Machine, product, and Car
- **Event:** Sale, Registration, Renewal
- **Concept:** Account, Course

There two types of entity: Strong entity and Weak Entity.

a. **Strong Entity:** It is entity which is having sufficient attributes for identification. Example of strong entity is student in college database. Student entity is having key attribute for identification. It is represented by rectangle notation.

b. **Weak Entity:** It is entity which does not have sufficient attributes for identification. It is depends on weak other entity. For example parent of student in college database is weak entity because to identify the particular parent, it is required to refer student first. It is represented by double rectangle notation.

2. **Attribute:** Attribute is the property of entity. All attributes of entity have values. For example, a student entity may have name, class, and age as attributes. It is denoted by following oval.


Following are different types of attributes:

a. **Key attribute:** It is attribute which **uniquely identifies each entity** .For example, Roll_No of student will be unique for each student. It is represented by an oval with underlying lines.

b. **Composite Attribute: It is a**n attribute **composed of many other attribute.** For example, Address attribute of student Entity consists of street, city, state, and country. It is represented by an oval comprising of ovals.
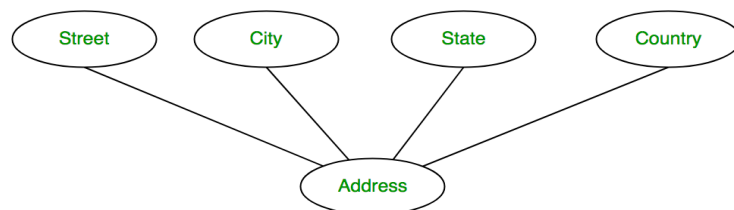
c. **Multi valued Attribute: It is an** attribute consisting **more than one values**. For example, students can have more than one phone numbers.it is represented by double oval.

d. **Derived Attribute: The** attribute which can be **derived from other attributes is called as the** derived attribute. For example age can be derived from date of birth of student.It is represented by dashed oval.

3. **Relationship: It** represents the **association between entities**. It shows the natural relationship between entities. For example relationship between student and course is **enrolled in**. It is represented by a diamond.

```
┌─────────┐       ╱╲                ┌─────────┐
│ Student │──────╱    ╲─────────────│ Course  │
└─────────┘      ╲ Enrolled in ╱    └─────────┘
                  ╲  ╱
```

Number of different entity sets **participating in a relationship** set is called as degree of a relationship set. There are three types of relationship: unary, binary and n-ary.

a. **Unary Relationship:** In this type , **only one entity set participate in a relation**, For example, one person is married to only one person.

```
┌──────────────────┐    ╱╲
│     Person       │───╱    ╲
└──────────────────┘   ╲ Married to ╱
                        ╲  ╱
```
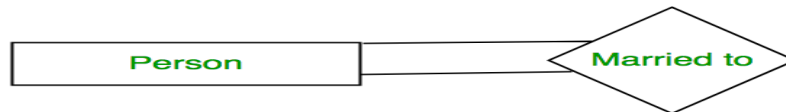
b. **Binary Relationship: When two entities set participating in a relation is the binary relationship.** For example, student is enrolled in course.

```
┌─────────┐     ╱╲              ┌─────────┐
│ Student │────╱    ╲───────────│ Course  │
└─────────┘    ╲ Enrolled in ╱  └─────────┘
                ╲  ╱
```

c. **N-ary Relationship –**
When there are n entities set participating in a relation is called N-ary relationship.

4. **Cardinality:** Number of times an entity of an entity set participates in a relationship is called cardinality. There are four types of cardinality :
   a. **One to one:** In this, each entity in each entity set can take part **only once in the relationship.** For example, male can marry to one female and a female can marry to one male.

```
┌────────┐  1   ╱╲  1   ┌────────┐
│  Male  │─────╱    ╲──│ Female │
└────────┘     ╲Married to╱   └────────┘
                ╲  ╱
```

   b. **Many to one :** When entities in one entity set **can take part only once in the relationship set and entities in other entity set can take part more than once in the relationship set then it is** many to one. For example student can take only one course but one course can be taken by many students.

```
┌─────────┐  n   ╱╲  1   ┌─────────┐
│ Student │─────╱    ╲──│ Course  │
└─────────┘     ╲Enrolled in╱  └─────────┘
                 ╲  ╱
```

1. **Many to many:** When entities in all entity sets can **take part more than once in the relationship** this cardinality is many to many. For example, student can take more than one course and one course can be taken by many students.
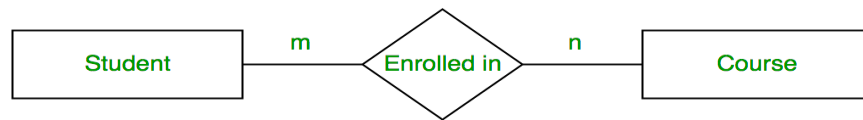
5. **Participation Constraint: It is** constraint applied on the entity participating in the relationship set. There are two types of constraints :

    a. **Total Participation –** Each entity in the entity set **must participate** in the relationship. For example if each student must enroll in a course. It shown by double line.
    b. **Partial Participation –** The entity in the entity set **may or may NOT participate** in the relationship. For example if some courses are not enrolled by any of the student.
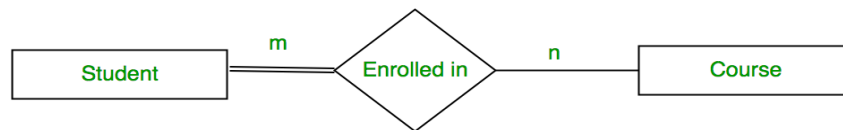
6. **Steps to draw ER diagram :** Following are steps to draw ER diagram :
    a. Identify Entities in the system
    b. Identify the attributes of entity
    c. Identify relationships between entities
    d. Identify cardinality of relationship
    e. Create ER diagram

7. Examples of ER Diagram

Q1. Draw ER diagram for university database where Student enrolls in Courses. A student must be assigned to at least one or more Courses. Each course is taught by a single Professor. To maintain instruction quality, a Professor can deliver only one course

Answer:

    1. Identify entities in the university database.

We have three entities

- Student
- Course
- Professor

    2. Identify the attributes of each entity.

We have identified following attributes of three entities

Entity	Primary Key	Attribute
Student	Student_ID	StudentName
Professor	Employee_ID	ProfessorName
Course	Course_ID	CourseName

3. Identity relationship of between entities

We have the following two relationships

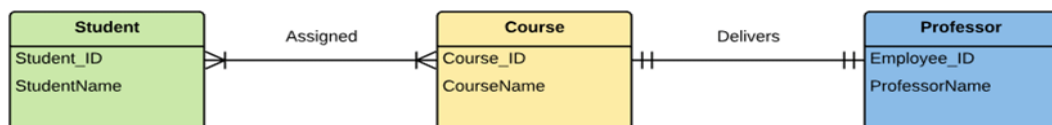- The student is **assigned** a course
- Professor **delivers** a course

4. Identify cardinality of relationship

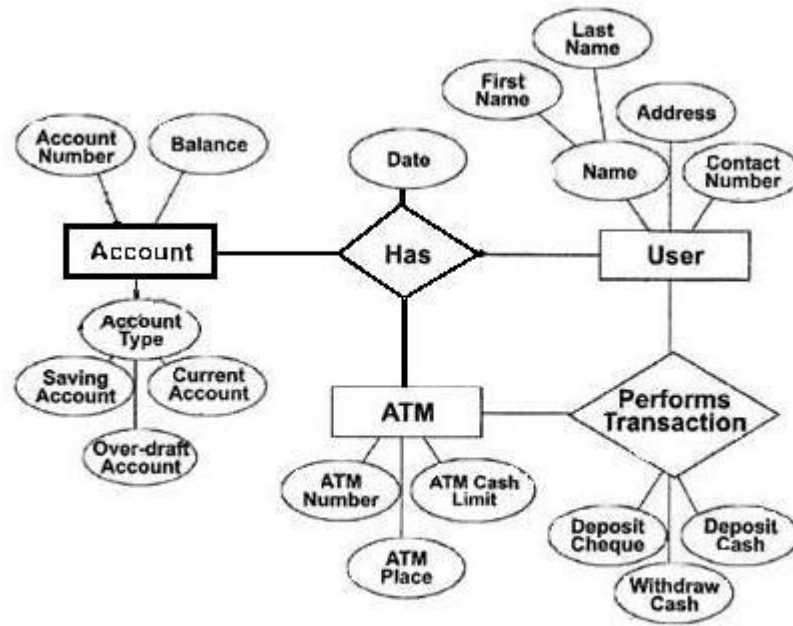For them problem statement we know that,

- A student can be assigned **multiple** courses
- A Professor can deliver only **one** course

5. Create ER diagram
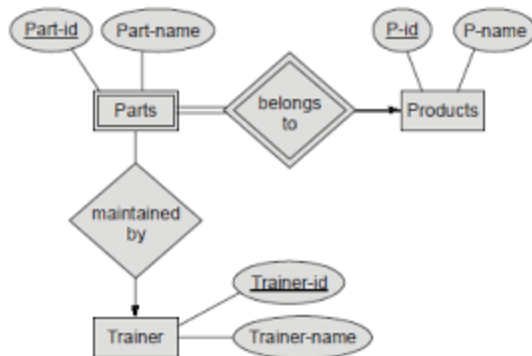
ER diagram for above entities is as follows:

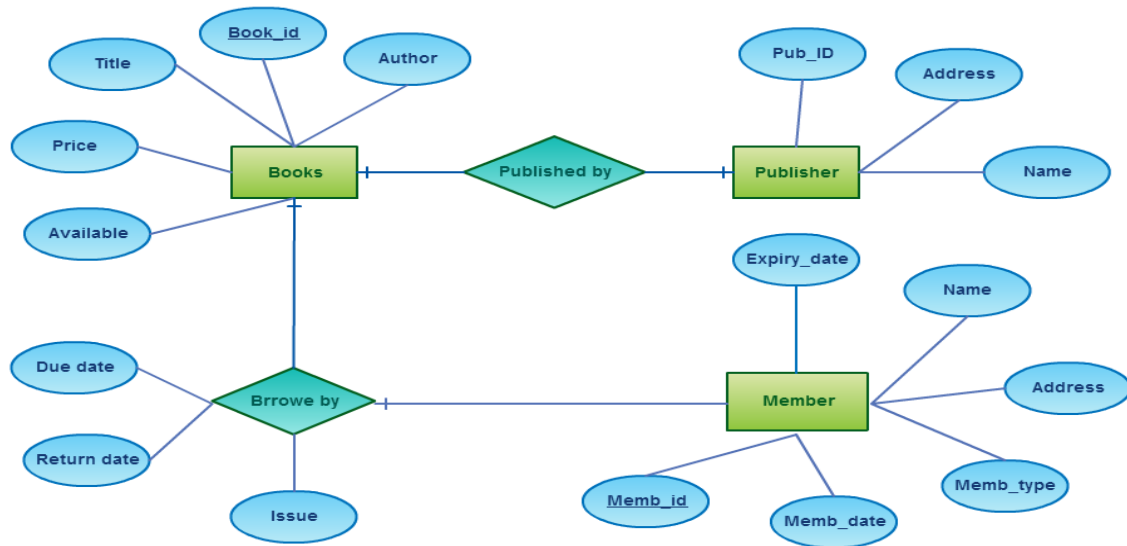Q2 Draw ER diagram for banking system

ER Diagram of Banking System

Q3. ER diagram for Products in the company with Weak entity

Q4 ER diagram for library System

E-R Diagram of Library Management System

1.3 Relational Model:

In this model, data is represented in the form of columns and rows (Tables /Relations). A relation is nothing but a table of values. The row is called as a tuple and column is the attribute. Following is the example of relational model for student data.

Roll Number	Name of student	Address of student
1	anand	Kandivali
2	ajay	Malad

Following are some of the important terminologies of relational model:

1. **Domain:** It is set of atomic values of attribute.
2. **Attribute:** It is column in a particular table.
3. **Relational schema:** A relational schema contains the name of the relation and name of attributes. For example in student relational schema is student (Roll Number, Name of student, Address of student)
4. **Key:** It is the attribute in the relational which will identify the row in the relation uniquely. For example.
5. **Tuple** – It is single row in the table.

1.4 keys in Relational model:

The key is an attribute or set of an attribute which will uniquely identify the records in the table. Key helps to establish a relationship between and identify the relation between tables. It also used to enforce identity and integrity in the relationship. There are various types of keys :

- Primary Key
- Candidate Key
- Super Key
- Foreign Key

- Compound Key
- Composite Key
- Surrogate Key

1. **Primary key:** It is single attribute which will uniquely identify the records in the relation. Example is roll number in student table is primary key.
2. **Candidate key:** It is set of attributes that uniquely identify the records in the relation. Example is < roll number and name > can be candidate key.
3. **Super key:** It is super set of candidate key which will uniquely identify the records in the relation. <roll number, name, Address> is super key.
4. **Foreign Key:** It is **KEY** that creates a relationship between two tables. Key of first table is to be matched with key of second table for performing transaction on it. Then key of first table is foreign key of second table. Consider two tables, Department and library. If student wants to issue the books from library then librarian will check whether this student is part of any department. If yes then only books will be issued. In this, student id of department and library will be matched. Hence student id of library table is foreign key for department table.
5. **Surrogate key :** It is system generated key which will uniquely identify each record

1.5 Extended ER Model (EER) : It improvements or enhancements in the existing ER Model to make it able to handle the complex applications better. Following are the three concepts added to the existing ER Model:

1. Generalization
2. Specialization
3. Aggregation

1. Specialization and Generalization: **Specialization** is a top-down approach where higher level entity can be broken down into two or more lower level entities. It the process of identifying subsets of an entity that share some different characteristic. **Generalization** is the bottom-up approach where lower level entities combine to form a higher level entity. It is the process of generalizing an entity which contains generalized attributes or properties. Following is the the example of **specialization and generalization.**
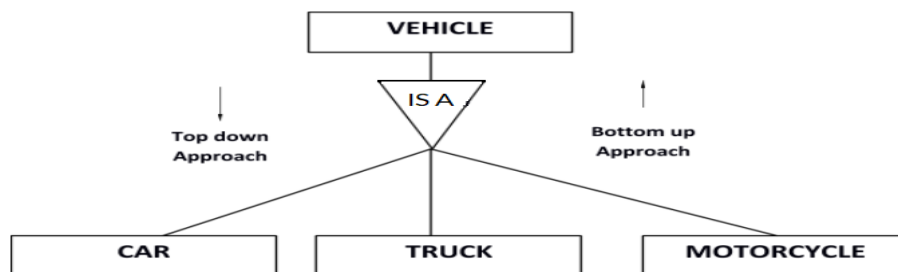
In specialization, vehicle entity is divided into three entities such as car, truck and motorcycle. In generalization, three sub entities car, truck and motorcycle are generalized into one super class named as vehicle.

2. Aggregation: Aggregation is a process where relation between two entities is considered as the entity. Following is the example of aggregation :
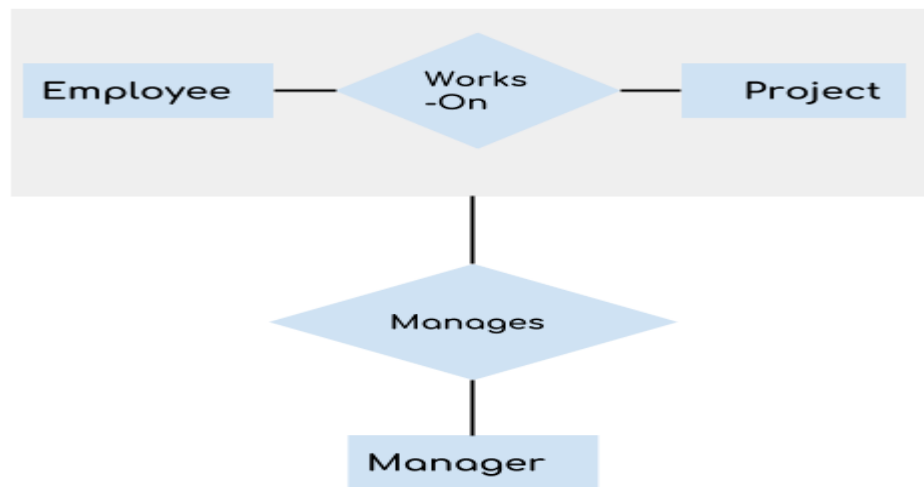
In this example, relationship Works-On between entities Employee & Project acts as one entity that has a relationship manages with the entity Manager.

1.5 Mapping of ER and EER to Relational Model :
Following are rules to map the ER model into relational model.
1. Create table for each entity. Attributes of entity will become column of tables.
2. Create table for a relationship. Primary keys of all participating Entities will become column of table.
3. Create table for weak entity set. All the simple and primary attributes of entity become column field.
4. In case of specialization and generalization, create tables for all higher-level and lower-level entities. Add primary keys of higher-level entities in the table of lower-level entities. In lower-level tables, add all other attributes of lower-level entities.

Example of converting ER and EER into relational model.

Questions

MCQ on ER diagram :

1. Entity is a _____
   a) Object of relation
   b) Present working model

c) Thing in real world
d) Model of relation

Ans : C

2. The descriptive property possessed by each entity set is _____
   a) Entity
   b) Attribute
   c) Relation
   d) Model

   Ans : b

3. The attribute *name* could be structured as an attribute consisting of first name, middle initial, and last name. This type of attribute is called
   a) Simple attribute
   b) Composite attribute
   c) Multivalued attribute
   d) Derived attribute

   Ans : b

4. Which one of the following attribute can be taken as a primary key?
   a) Name
   b) Street
   c) Id
   d) Department

   Ans : Id

5. Course(course_id,sec_id,semester)
   Here the course id,sec_id and semester are _____ and course is a _____
   a) Relations, Attribute
   b) Attributes, Relation
   c) Tuple, Relation
   d) Tuple, Attributes

   Ans : b

Subjective Questions:

1. What is a Data Model? What are its types
2. What is ER model? Explain its components and notations used.
3. What is relational model? How it is differ from ER model
4. Explain with examples various keys in relational model.
5. Explain rules to convert ER model into relational model
6. Draw ER diagram for hospital management system.
7. Draw ER diagram for Banking system
8. What is Extended ER? Explain its features with examples.