

CST 204 Database Management Systems

MODULE 1

PREPARED BY
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Syllabus

- **Introduction & Entity Relationship (ER) Model**
 - Concept & Overview of Database Management Systems (DBMS). Characteristics of Database system,
 - Database Users, structured, semi-structured and unstructured data. Data Models and Schema - Three Schema architecture. Database Languages, Database architectures and classification.
 - ER model - Basic concepts, entity set & attributes, notations, Relationships and constraints,
 - cardinality, participation, notations, weak entities, relationships of degree 3.

Data, Database & DBMS

- Data
 - Known facts that can be recorded and have implicit meaning
- Database
 - The collection of data
- Database-management system (DBMS)
 - is a collection of interrelated data and a set of programs to access those data.
 - General purpose software system that facilitates process of defining, constructing, manipulating, and sharing database

The primary goal of a DBMS is to provide a way to store and retrieve database information that is both *convenient* and *efficient*.

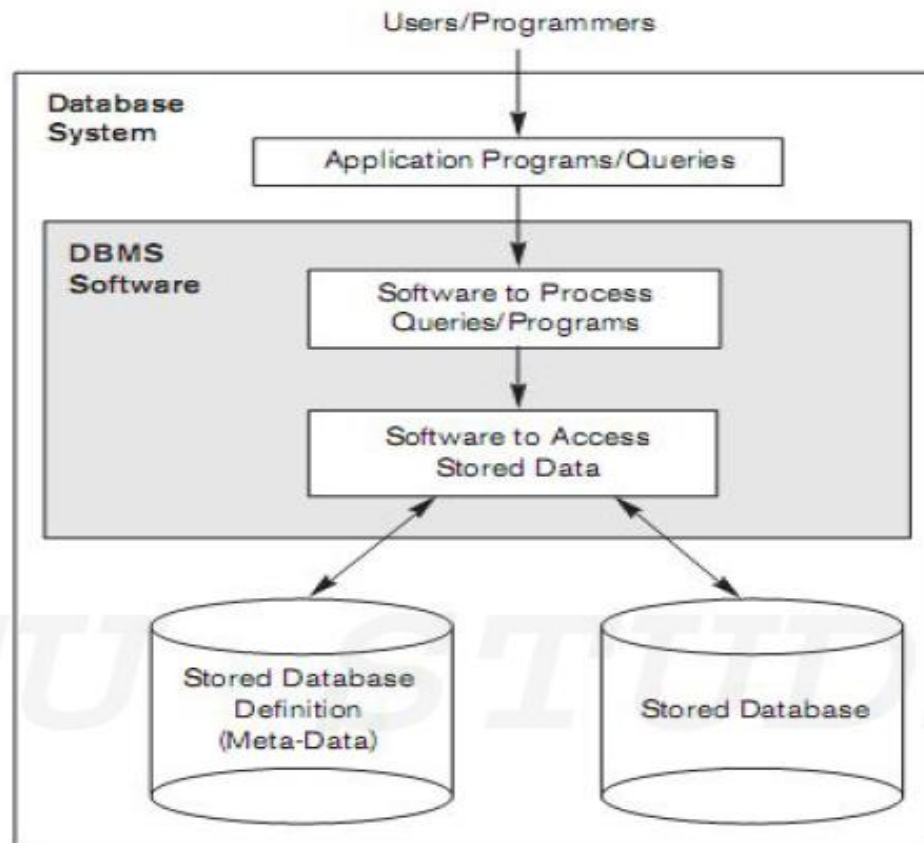
- Database systems are designed to manage large bodies of information.
- Management of data involves both storage of information and mechanisms for manipulation of information.
- The database system must ensure the safety of the information stored
- If data are to be shared among several users, the system must avoid possible anomalous results.

Database implicit properties

- Universe of discourse(UoD) or Miniworld
 - Database represent some aspects of real world
 - Changes to miniworld affects database
- A database is a logically coherent collection of data with some inherent meaning
- A database is designed, built and populated with data for specific purpose

DBMS is a general purpose software system that facilitates process of defining, constructing, manipulating, and sharing database

Database System Environment



Characteristics of the Database Approach

1. Self describing nature of a database system
2. Insulation between programs and data, and data abstraction
3. Support of multiple views of the data

Self-Describing Nature of a Database System

- database system contains not only the database itself but also a complete definition or description of the database structure and constraints.
- This definition is stored in the DBMS catalog
- information stored in the catalog is called meta-data and it describes the structure of the primary database.

Insulation between Programs and Data, and Data Abstraction

- The structure of data files is stored in the DBMS catalog separately from the access programs.
- This property is called program-data independence
- An operation (also called a function or method) is specified in two parts.
- Interface
 - The interface (or signature) of an operation includes the operation name and the data types of its arguments (or parameters).
- Implementation
 - The implementation (or method) of the operation is specified separately and can be changed without affecting the interface.

- The characteristic that allows program-data independence and program operation independence is called data abstraction.

Support of Multiple Views of the Data

- A database has many users, each user may require a different perspective or view of the database.
- A view may be a subset of the database or it may contain virtual data that is derived from the database files but is not explicitly stored.

Sharing of Data and Multiuser Transaction Processing

- DBMS must include *concurrency control* software
 - to ensure that several users trying to update the same data do so in a controlled manner so that the result of the updates is correct
- DBMS must enforce several transaction properties
 - Isolation property
 - Atomicity property

Isolation Property

- ensures that each transaction appears to execute in isolation from other transactions
- even though hundreds of transactions may be executing concurrently.

Atomicity Property

- ensures that either all the database operations in a transaction are executed or none are.
- Any mechanical or electrical device is subject to failure, and so is the computer system.
- In this case we have to ensure that data should be restored to a consistent state.
- For example an amount of Rs 50 has to be transferred from Account A to Account B.
- Let the amount has been debited from account A but have not been credited to Account B and in the meantime, some failure occurred.
 - So, it will lead to an inconsistent state.
 - So, we have to adopt a mechanism which ensures that either full transaction should be executed or no transaction should be executed i.e. the fund transfer should be atomic.

Concurrent access Problems

- Many systems allows multiple users to update the data simultaneously.
- It can also lead the data in an inconsistent state.
- Suppose a bank account contains a balance of Rs 500 & two customers want to withdraw Rs100 & Rs 50 simultaneously.
- Both the transaction reads the old balance & withdraw from that old balance which will result in Rs 450 , Rs 400 which is incorrect.

Security Problems

- All the user of database should not be able to access all the data.
- For example a payroll Personnel needs to access only that part of data which has information about various employees & are not needed to access information about customer accounts.

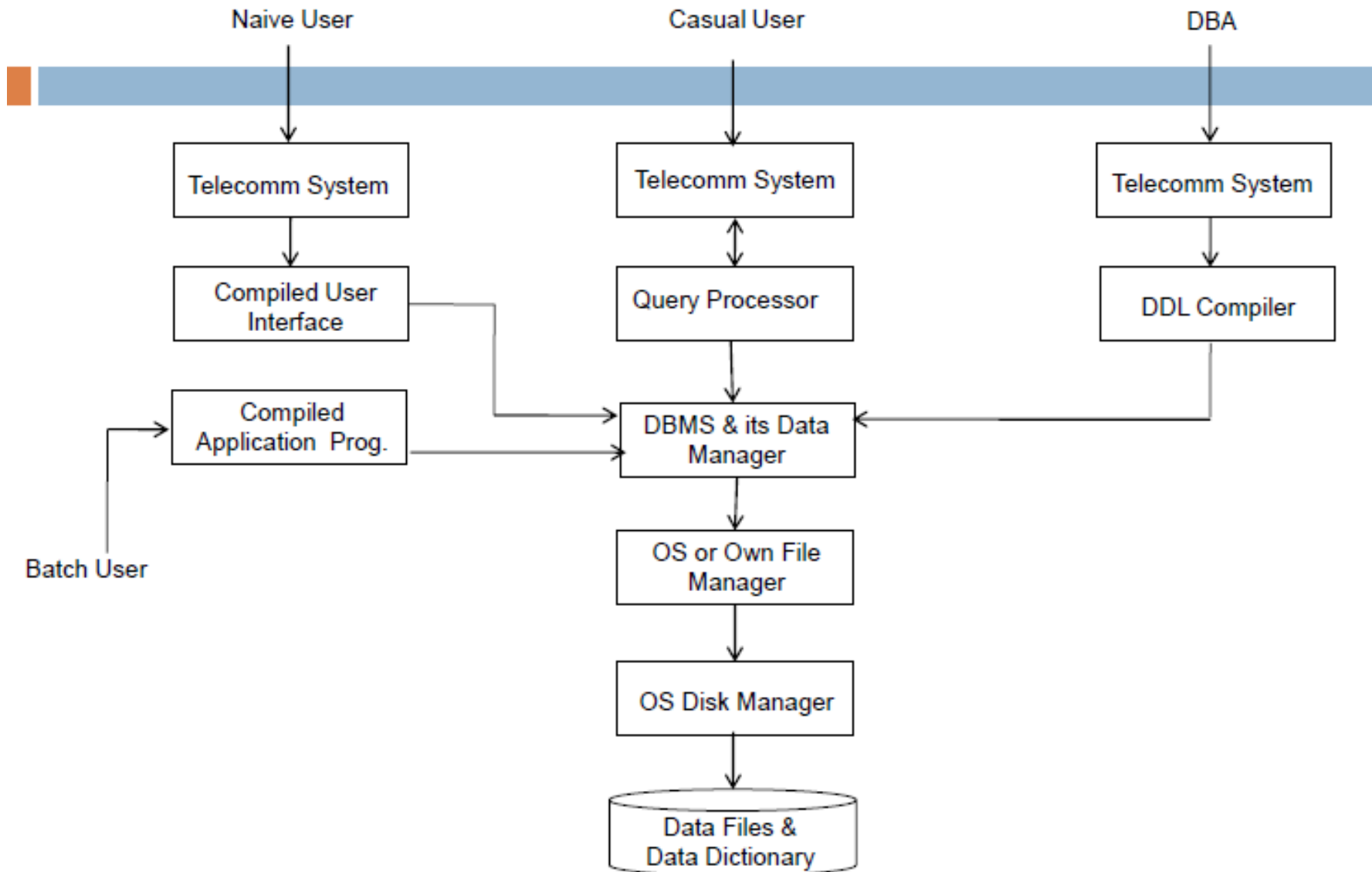
Advantages of DBMS

- Controlling Redundancy
- Restricting Unauthorized Access
- Providing Storage Structures for Efficient
- Query Processing
- Providing Backup and Recovery
- Providing Multiple User Interfaces
- Representing Complex Relationship among Data
- Enforcing Integrity Constraints
- Permitting Inferencing and Actions using Rules

Disadvantages of DBMS

- Cost of Hardware & Software
- Cost of Data Conversion
- Cost of Staff Training
- Appointing Technical Staff
- Database Damage

DBMS Structure



Database Users and Administrators

- A primary goal of a database system is to retrieve information from and store new information in the database.
- People who work with a database can be categorized as database users or database administrators.

Different types of users

- Naïve users
- Application programmers
- Sophisticated users

1. Naïve Users

- unsophisticated users who interact with the system by using predefined user interfaces, such as web or mobile applications
- typical user interface is a forms interface, where the user can fill in appropriate fields of the form
- may also view read *reports* generated from the database.

2. Application programmers

- Are computer professionals who write application programs
- they can choose from many tools to develop user interfaces

3. Sophisticated users

- interact with the system without writing programs.
- Instead they form their requests either using a database query language or by using tools such as data analysis software.
- Analysts who submit queries to explore data in the database fall in this category

Database Administrator

- A person who has such central control over the system is called a database administrator (DBA).
- The functions of a DBA include:
 - **Schema definition.**
 - The DBA creates the original database schema by executing a set of data definition statements in the DDL.
 - **Storage structure and access-method definition.**
 - The DBA may specify some parameters pertaining to the physical organization of the data and the indices to be created.

- Schema and physical-organization modification
 - The DBA carries out changes to the schema and physical organization to reflect the changing needs of the organization
 - or to alter the physical organization to improve performance
- Granting of authorization for data access.
 - The authorization information is kept in a special system structure that the database system consults whenever a user tries to access the data in the system.

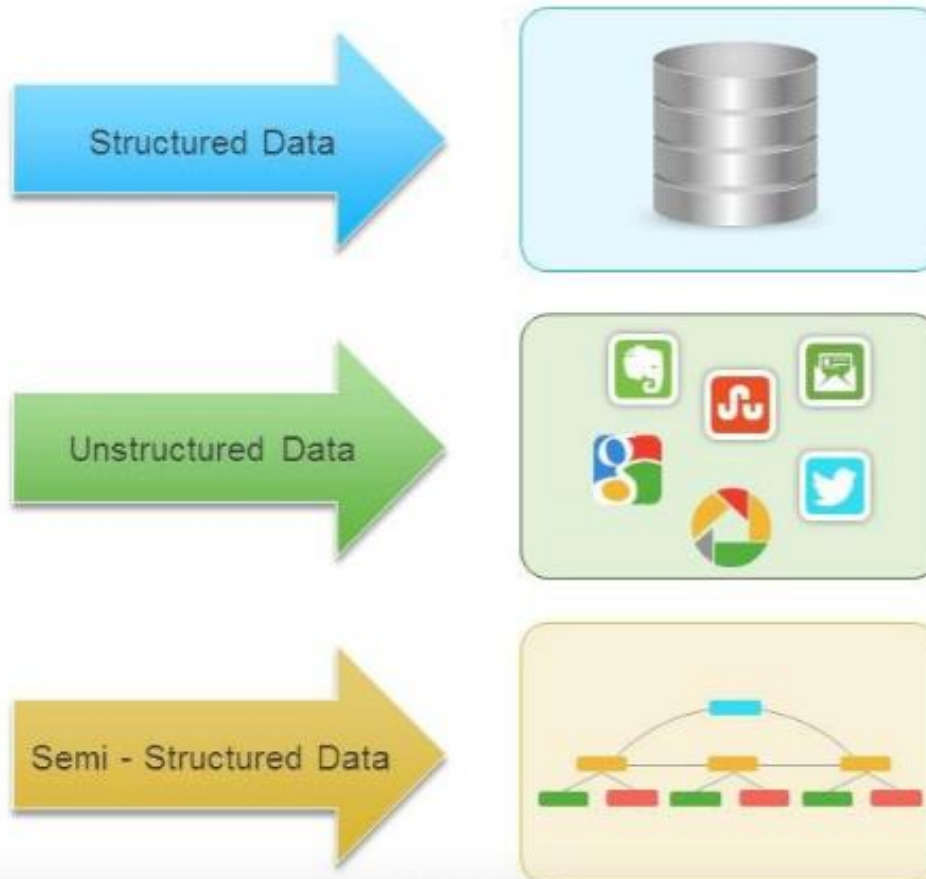
ACTORS ON THE SCENE

- The people whose jobs involve the day-to-day use of a large database are called as the actors on the scene.
 1. Database Administrators
 2. Database Designers
 3. End Users
 4. System Analyst and Application Programmers(Software engineers)

WORKERS BEHIND THE SCENE

- The people who work to maintain the database system environment but who are not actively interested in the database contents as part of their daily job are called as the workers behind the scene
 1. DBMS system designers and implementers
 2. Tool developers
 3. Operators and maintenance personnel (system administration personnel)

Structured, Semi-structured and Unstructured data



Structured data

- Represented in a strict format
- It has been organized into a formatted repository that is typically a database.
- It concerns all data which can be stored in database SQL in a table with rows and columns
- . *Example*: Relational data

Semi-Structured data

- information that does not reside in a relational database but that have some organizational properties that make it easier to analyze
- With some process, you can store them in the relation database
- but Semi-structured exist to ease space.
- *Example: XML data*

Unstructured data

- data which is not organized in a predefined manner or does not have a predefined data model,
- thus it is not a good fit for a mainstream relational database
- there are alternative platforms for storing and managing, it is increasingly prevalent in IT systems and is used by organizations in a variety of business intelligence and analytics applications.
- *Example:* Word, PDF, Text, Media logs.

FEATURES	STRUCTURED	SEMI STRUCTURED	UNSTRUCTURED
Format Type	Relational Database	HTML, XML, JSON	Binary, Character
Version Management	Rows, columns, tuples	Not as common – graph is possible	Whole data
Implementation	SQL	Anonymous nodes	-
Robustness	Robust	Limited robustness	-
Storage Requirement	Less	Significant	Large
Applications	DBMS, RDF, ERP system, Data Warehouse, Apache Parquet, Financial Data, Relational Table	Server Logs, Sensor Output	No SQL, Video, Audio, Social Media, Online Forums, MRI, Ultrasound

Data Models

- a collection of concepts that can be used to describe the structure of a database
- *structure of a database* we mean the data types, relationships, and constraints that should hold on the data.
- Most data models also include a set of **basic operations** for specifying retrievals and updates on the database.

Categories of Data Models

- High-level or conceptual data models
- Low-level or physical data models
- Representational (or implementation) data models

High-level or conceptual data models

- provide concepts that are close to the way many users perceive data
- use concepts such as entities, attributes, and relationships
- An **entity** represents a real-world object or concept
- An **attribute** represents some property of interest that further describes an entity,
- A **relationship** among two or more entities represents an interaction among the entities

Low-level or physical data models

- Provide concepts that describe the details of how data is stored in the computer.
- Concepts provided by low-level data models are generally meant for computer specialists, not for typical end users.
- Describe how data is stored in the computer by representing information such as record formats, record orderings, and access paths.
- An **access path** is a structure that makes the search for particular database records efficient.

Representational (or implementation) data models

- Which provide concepts that may be understood by end users but that are not too far removed from the way data is organized within the computer.
- It hides some details of data storage but can be implemented on a computer system in a direct way.
- used most frequently in traditional commercial DBMSs, and they include the widely-used **relational data model**
- the **network** and **hierarchical models**
- sometimes called **record-based data models**

Schemas, Instances, and Database State

- The description of a database is called the **database schema**, which is specified during database design and is not expected to change frequently
- A displayed schema is called a **schema diagram**. We call each object in the schema a **schema construct**.
- The data in database at particular instant or moment of time is called **database state** or **snapshot**

STUDENT

Name	Student_number	Class	Major
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COURSE

Course_name	Course_number	Credit_hours	Department
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PREREQUISITE

Course_number	Prerequisite_number
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SECTION

Section_identifier	Course_number	Semester	Year	Instructor
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GRADE_REPORT

Student_number	Section_identifier	Grade
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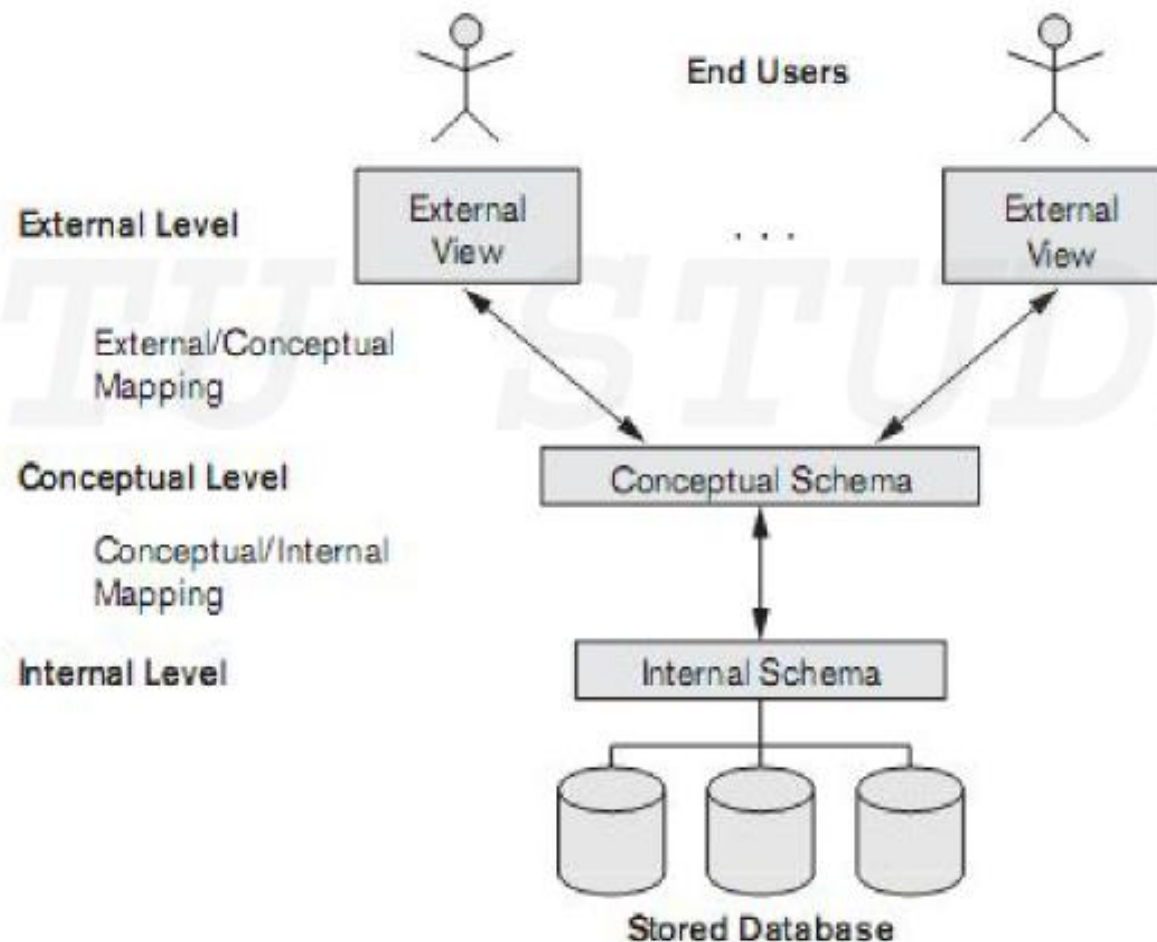
Database schema

Name	Student_number	Class	Major
Ram	CS001	R4	CSE
Shyam	CS002	R4	CSE

Database state

- The schema is not supposed to change frequently, but it is not uncommon that changes occasionally need to be applied to the schema as the application requirements change. It is called **schema evolution**.

The Three-Schema Architecture



Internal level

- The **internal level** has an **internal schema**, which describes the **physical storage** structure of the database.
- The internal schema uses a physical data model and describes the complete details of data storage and access paths for the database.

Conceptual level

- Describes the structure of the whole database for a community of users.
- The conceptual schema hides the details of physical storage structures and concentrates on describing entities, data types, relationships, user operations, and constraints.
- A high-level data model or an implementation data model can be used at this level.

External or view level

- The **external** or **view level** includes a number of **external schemas** or **user views**.
- Each external schema describes the part of the database that a particular user group is interested in and hides the rest of the database from that user group.
- A high-level data model or an implementation data model can be used at this level.

- In a DBMS based on the three-schema architecture, each user group refers only to its own external schema.
- Hence, the DBMS must transform a request specified on an external schema into a request against the conceptual schema, and then into a request on the internal schema for processing over the stored database.
- If the request is a database retrieval, the data extracted from the stored database must be reformatted to match the user's external view.

Mappings

- The processes of transforming requests and results between levels are called **mappings**.
- These mappings may be time-consuming, so some DBMSs—especially those that are meant to support small databases—do not support external views.
- a certain amount of mapping is necessary to transform requests between the conceptual and internal levels.

Data Independence

- The capacity to change the schema at one level of a database system without having to change the schema at the next higher level.
- Two types of data independence:
 1. Logical data independence
 2. Physical data independence

Logical data independence

- Logical data independence is the capacity to change the conceptual schema without having to change external schemas or application programs.

Physical data independence

- Physical data independence is the capacity to change the internal schema without having to change the conceptual schema.
- Data independence occurs because when the schema is changed at some level, the schema at the next higher level remains unchanged; only the mapping between the two levels is changed.

Database Languages and Interfaces

DBMS Languages

- **Data definition language (DDL)**, is used by the DBA and by database designers to define conceptual and internal schemas schemas.
- **Storage definition language (SDL)**, is used to specify the internal schema.
- **View definition language (VDL)**, to specify user views and their mappings to conceptual schema
- **Data Manipulation Language(DML)** is used for retrieval, insertion, deletion, and modification of the data

- There are two main types of DMLs.
- **High-level or nonprocedural DML** can be used on its own to specify complex database operations concisely.
- **Low-level or procedural DML** must be embedded in a general-purpose programming language. This type of DML typically retrieves individual records or objects from the database and processes each separately. Therefore, it needs to use programming language constructs, such as looping, to retrieve and process each record from a set of records. Low-level DMLs are also called record-at-a-time DMLs

DBMS Interfaces

- User-friendly interfaces provided by a DBMS may include the following:
 1. Menu-Based Interfaces for Web Clients or Browsing.
 2. Forms-Based Interfaces.
 3. Graphical User Interfaces (GUI)
 4. Natural Language Interfaces
 5. Speech Input and Output
 6. Interfaces for Parametric Users.

DATABASE MODELING USING ENTITY-RELATIONSHIP

ER MODEL

ER Diagram

- It is not a technical method
- High level conceptual data model
- It is used for conceptual data design of database applications
- Collection of **entities** and their properties called **attributes** and relationship between them
- Diagrammatic representation and easy to understand for non technical users

Entity

- The basic object that the ER model represents
- A thing in real world with existence
- Entity is distinguished from other objects on basis of attributes
- Entities can be tangible and intangible

Entity Type

- The entity type is a collection of the entity having similar attributes.
- an entity type in an ER diagram is defined by a name and a set of attributes
- *We use a rectangle to represent an entity type in the E-R diagram, not entity.*

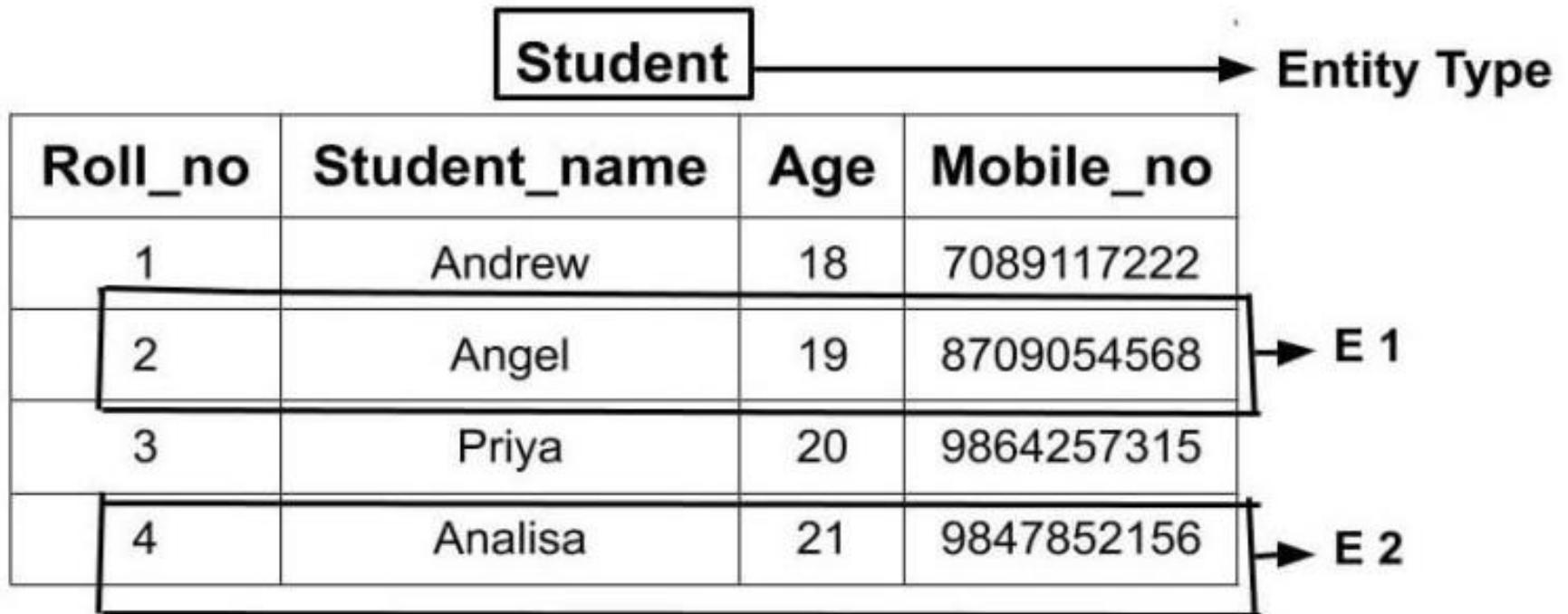
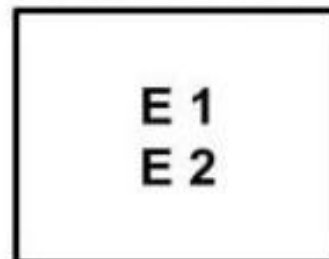
Ex: STUDENT, UNIVERSITY

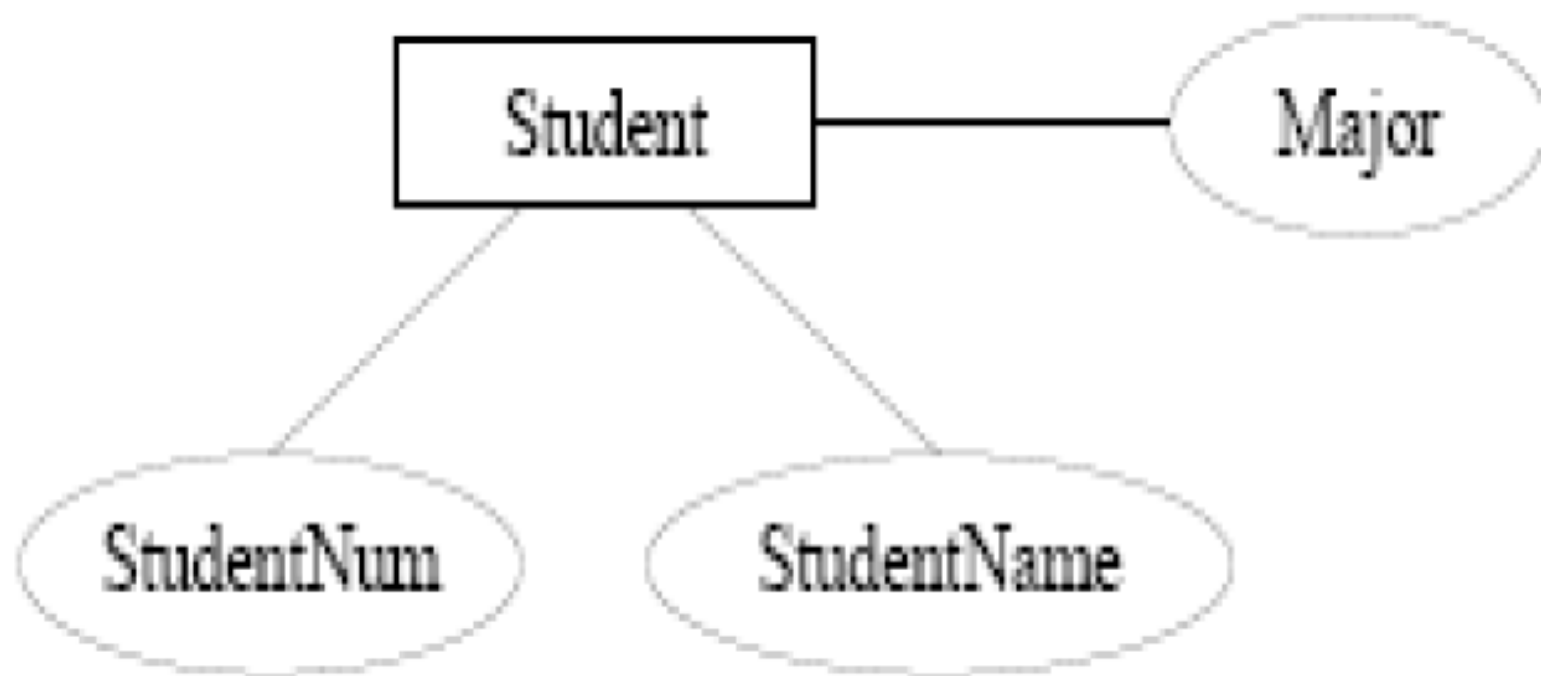
STUDENT

Name	Age	Rollno
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Entity set

- The collection of same type of entities that is their attributes are same is called entity set
- We can say that entity type is a superset of the entity set as all the entities are included in the entity type

**ENTITY SET**



Attributes

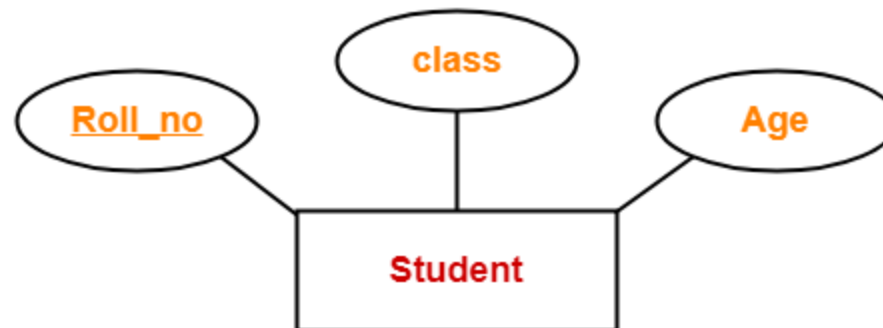
- The properties of entity that basically describes it
- Attributes describes characteristics of entity
- Suppose we have a entity EMPLOYEE and its attributes are ENO, ESAL, ENAME etc..
- Attributes have some set of allowed or permitted values called Domain
- Attributes are represented by OVAL
- Each attribute of an entity set is associated with domain that means the set of values that can be assigned to that attribute for an entity

Types of attribute

- Simple attribute vs Composite attribute
- Single valued vs Multivalued attributes
- Stored vs Derived attributes

Simple attribute vs Composite attribute

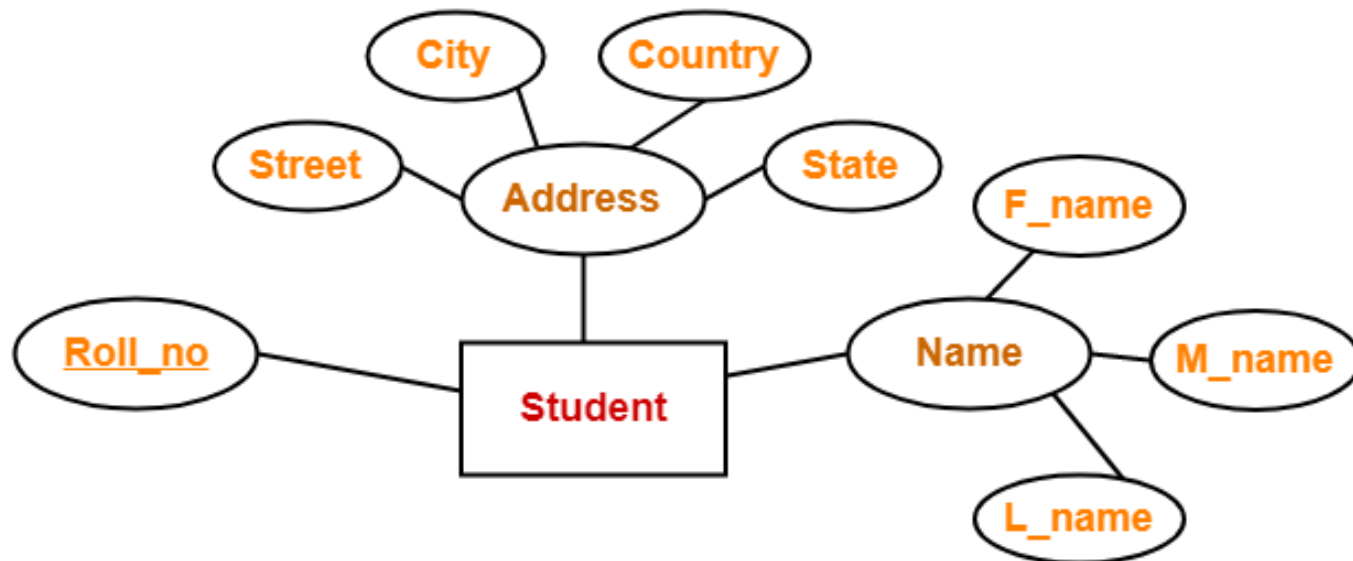
- Simple attributes
 - Attributes which are not divisible that is they cannot be divided
 - Eg: City, State, etc.,



Here, all the attributes are simple attributes as they can not be divided further.

- Composite Attribute

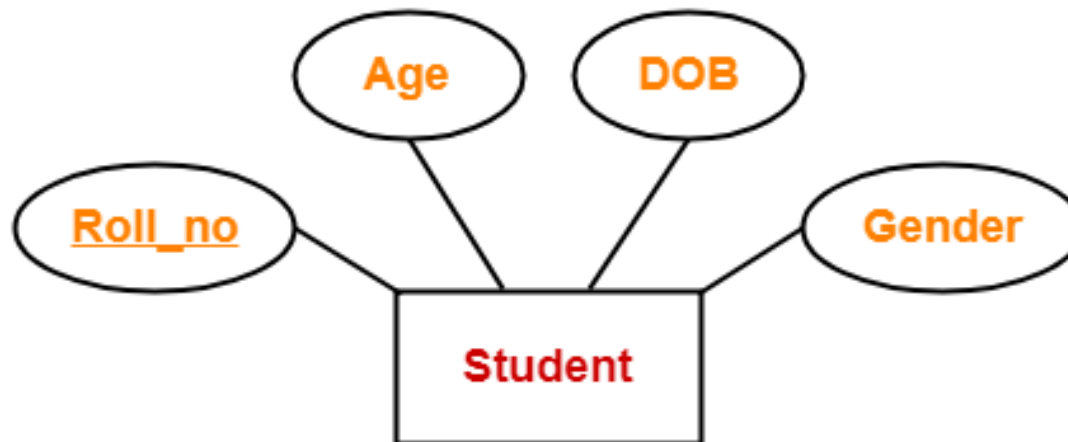
- Attributes that can be divided into smaller sub parts
- Example: Name attribute can be divided into FirstName, MiddleName, LastName



Here, the attributes "Name" and "Address" are composite attributes as they are composed of many other simple attributes.

Single valued vs Multivalued Attributea

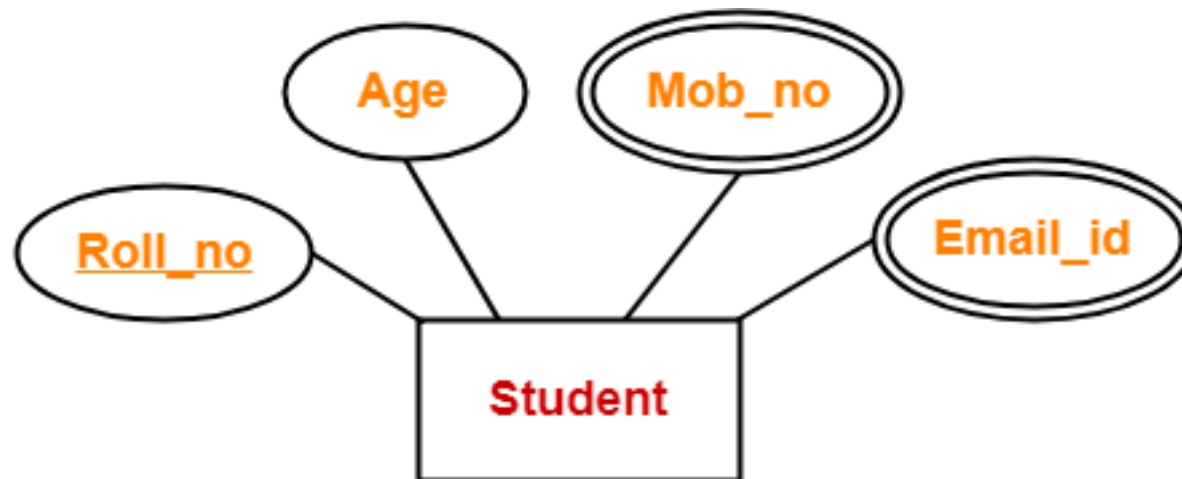
- Single Valued
 - Attributes which are having single values
 - Example: Age



Here, all the attributes are single valued attributes as they can take only one specific value for each entity.

- Multi Valued Attributes

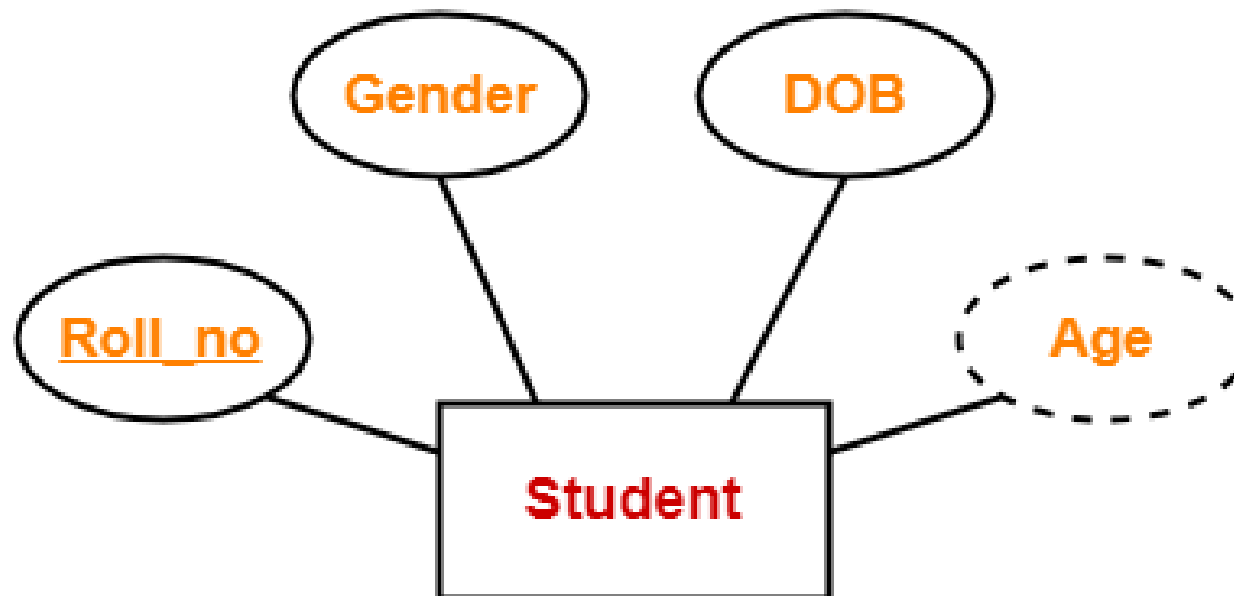
- Multi valued attributes are those attributes which can take more than one value for a given entity from an entity set.
- Represented by double oval



Here, the attributes "Mob_no" and "Email_id" are multi valued attributes as they can take more than one values for a given entity.

Stored Vs Derived Attribute

- In some cases, two (or more) attribute values are related ,for example, the Age and Birthdate attributes of a person.
- For a particular person entity, the value of Age can be determined from the current (today's) date and the value of that person's birthdate.
- The Age attribute is hence called a derived attribute and is said to be derivable from the birthdate attribute, which is called a stored attribute .



Here, the attribute “Age” is a derived attribute as it can be derived from the attribute “DOB”.

Complex Attribute

- Complex attribute is a combination of composite and multi-valued attributes.
- Complex attributes are represented by { } and composite attributes are represented by ().
- Example: Address_phone attribute will hold both the address and phone_no of any person.
- Example: {(2-A, St-5, Sec-4, Bhilai), 2398124}

Null Valued Attributes

- Null value is a value which is not inserted but it does not hold zero value.
- The attributes which can have a null value called null valued attributes.
- Example: Mobile_no attributes of a person may not be having mobile phones.

Key attribute in an entity type

- Key attributes will be having a unique value for each entity of that attribute.
- It identifies every entity in the entity set.
- Key attribute will never be a null valued attribute.
- Any composite attribute can also be a key attribute.
- There could be more than one key attributes for an entity type.
- Example: roll_no, enrollment_no

Domain of value set of an attribute

- Domain of an attribute is the allowed set of values of that attribute.
- Example: if attribute is 'grade', then its allowed values are A,B,C,F.
- $\text{Grade} = \{A, B, C, F\}$

Relationship

- Relates two or more distinct entities with a specific meaning.
- It is an association between two or more entities of same or different entity set
 - For example, EMPLOYEE John works on the ProductX PROJECT or
 - EMPLOYEE Franklin manages the Research DEPARTMENT.
- **Terms used:**
 - Relationship type,
 - Relationship set,
 - Relationship instances.

Relationship type

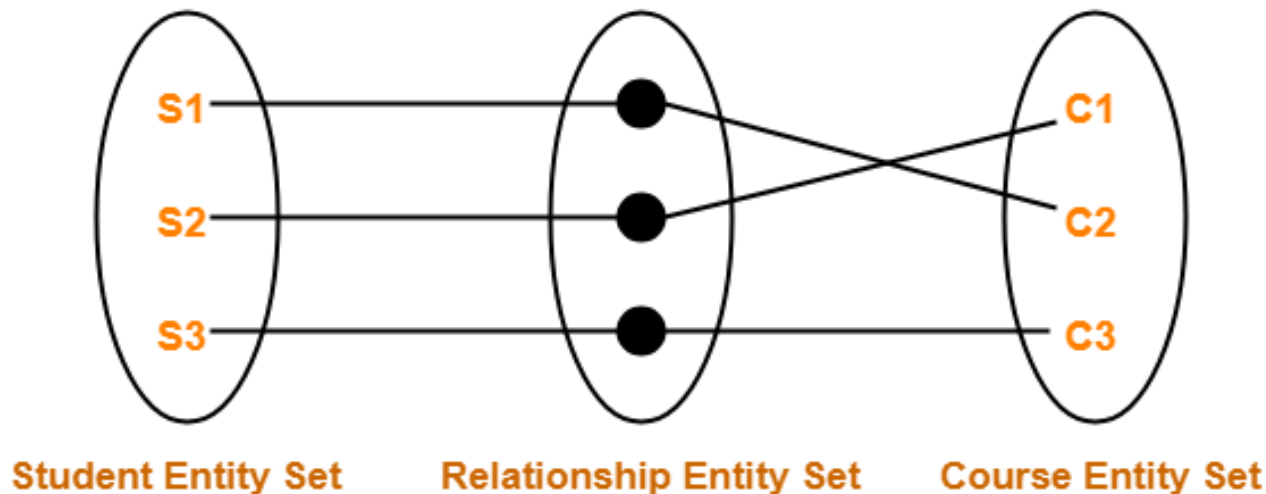
- A set of similar types of relationship

'Enrolled in' is a relationship that exists between entities **Student** and **Course**.



Relationship Set

- A **relationship set** is a set of relationships of the same type.

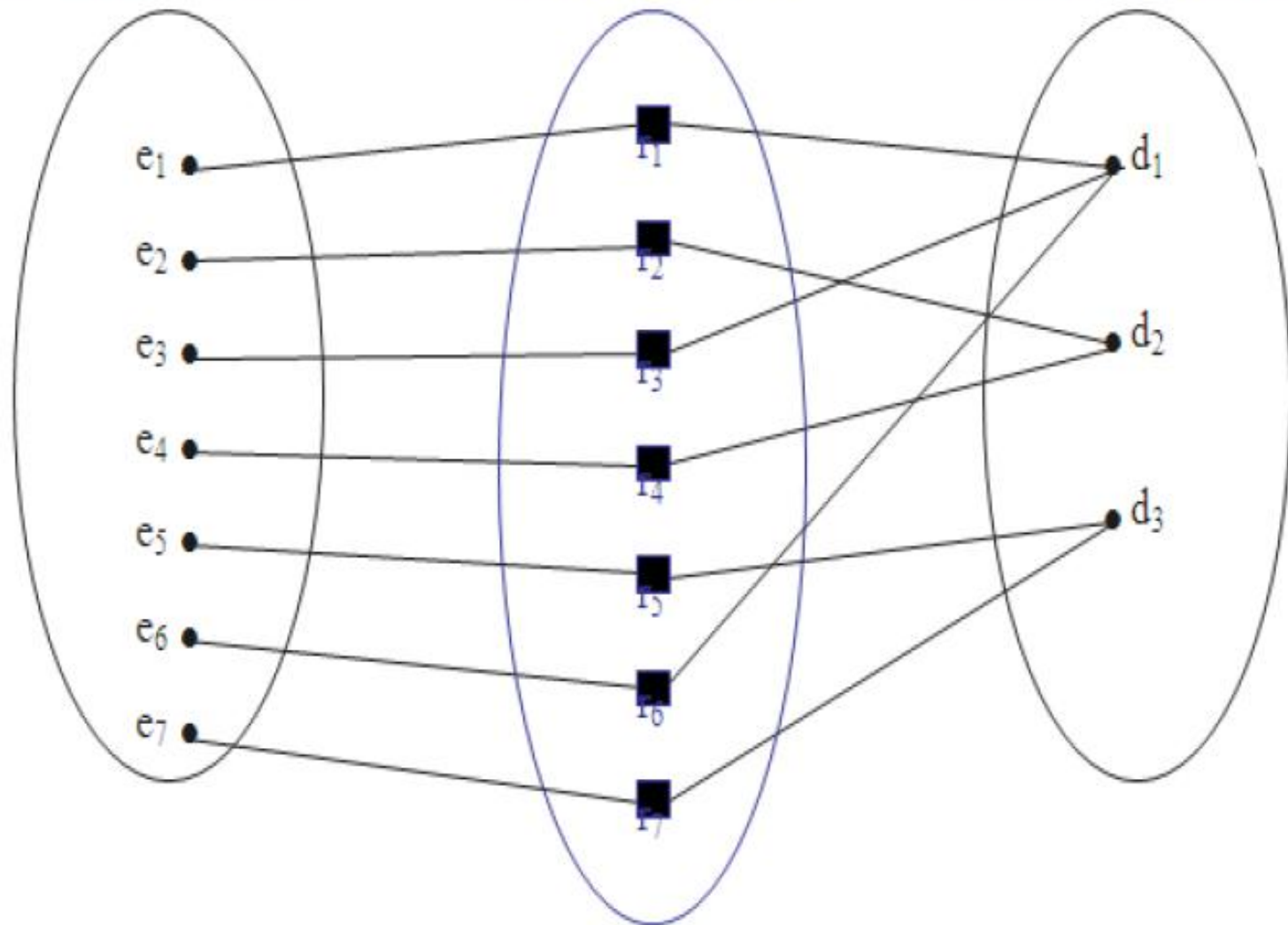


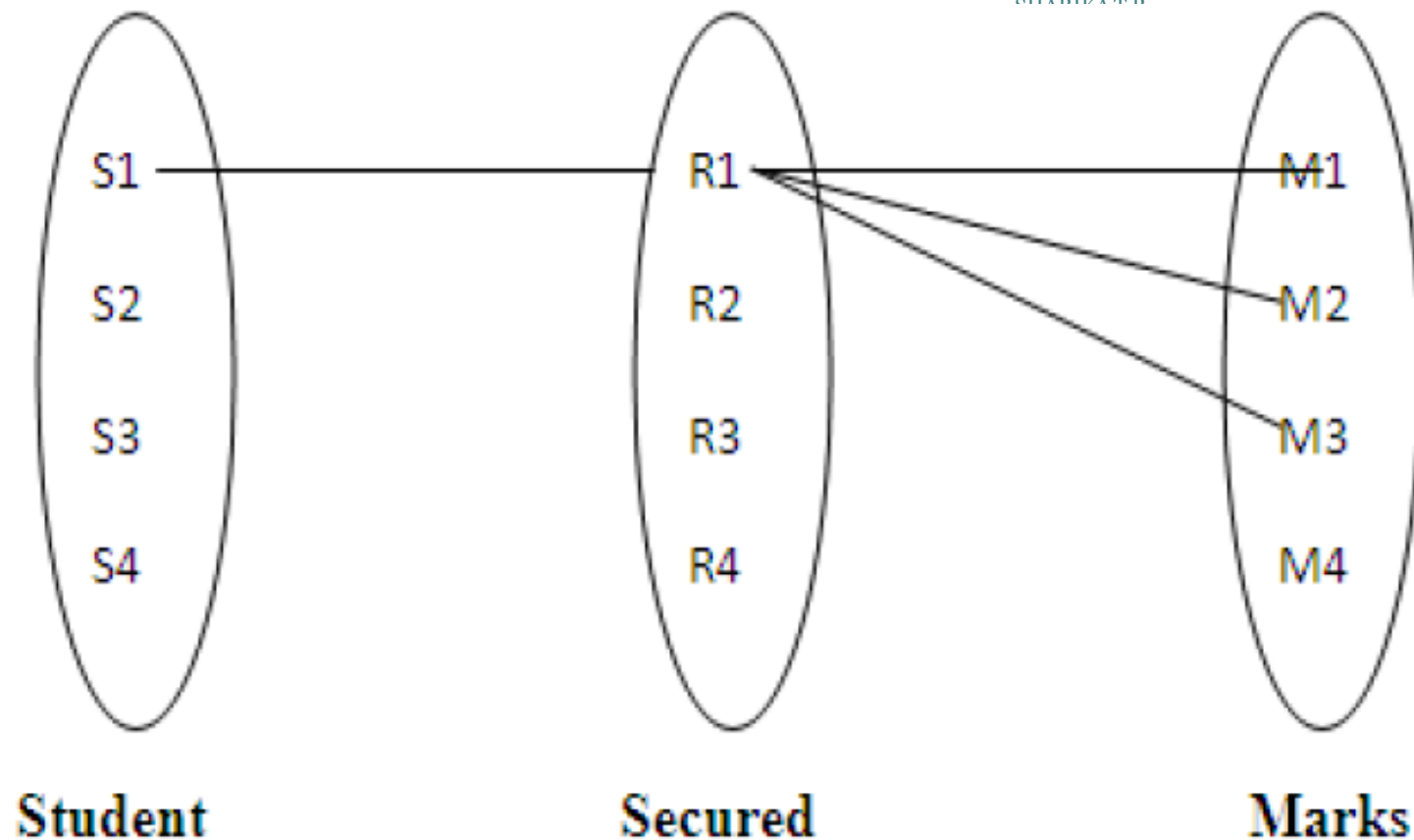
Set Representation of ER Diagram

EMPLOYEE

WORKS_FOR

DEPARTMENT



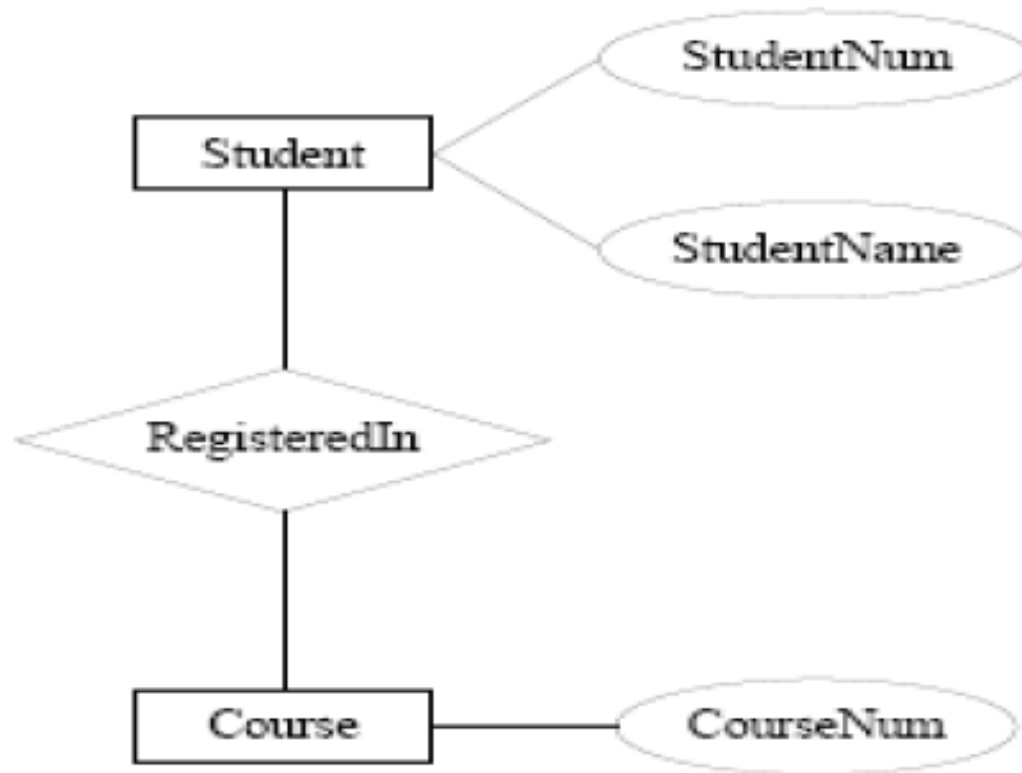


Relationship type: secured

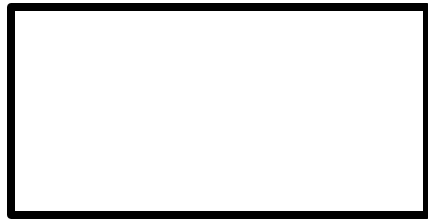
Relationship set: {R1, R2, R3, R4}

Relationship instances: R1

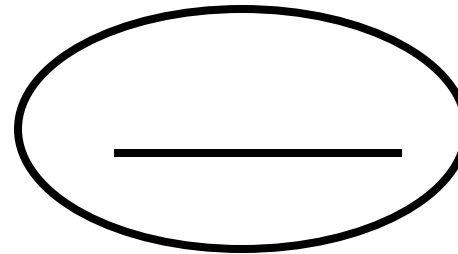
Graphical Representation of Relationship Sets



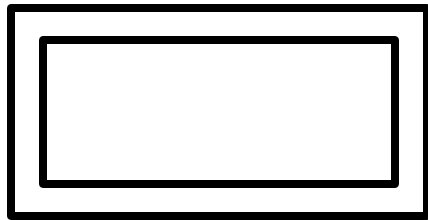
NOTATIONS USED IN E-R DIAGRAM



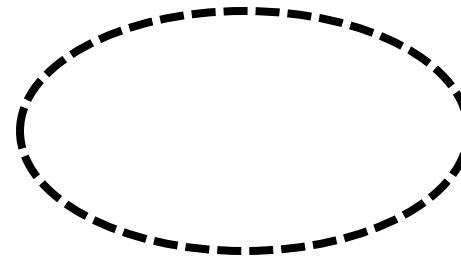
Entity



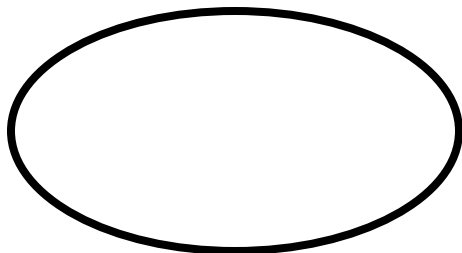
Key
attribute



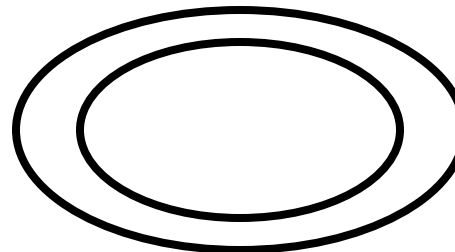
Weak Entity



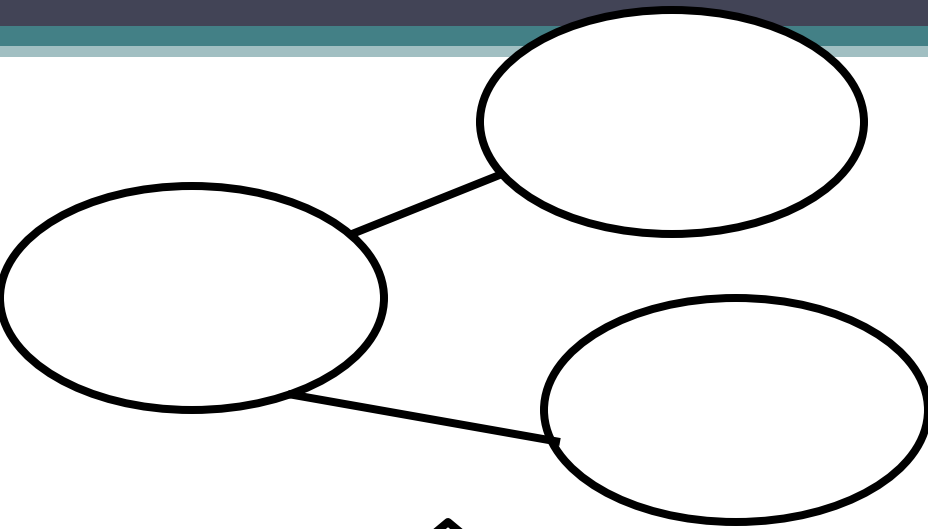
Derived
attribute



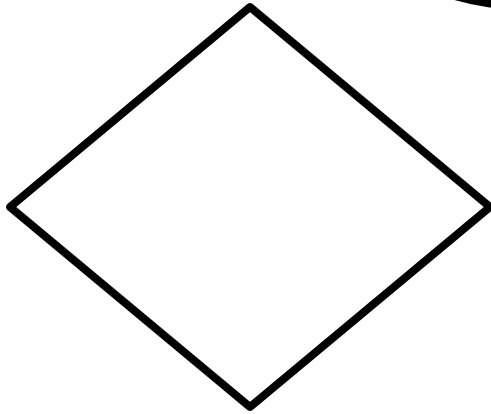
Attribute



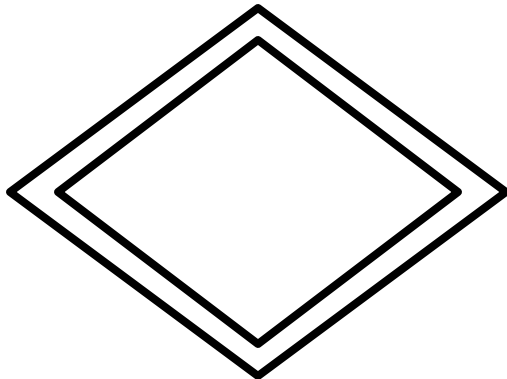
Multivalued
Attribute



Composite Attribute



Relationship type



Identifying Relationship

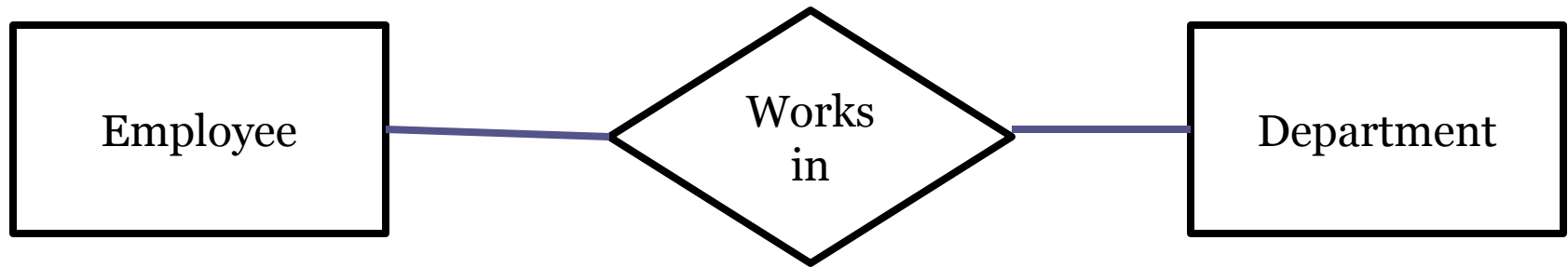
Constraints

- Relationship types usually have certain constraints. Two main types of relationship constraints:
 1. Mapping cardinalities
 2. Participation constraints

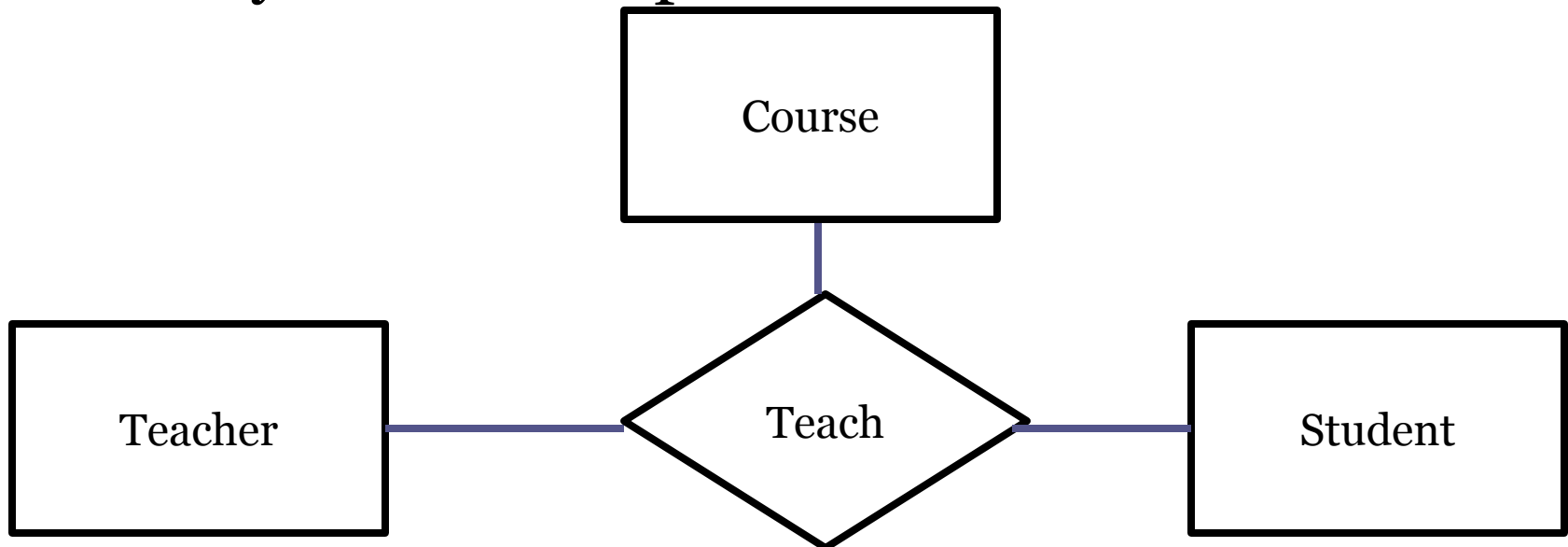
Degree of a relationship

- It is the number of entity set which are participating in a relationship
 - Unary relationship
 - Binary Relationship
 - Ternary Relationship

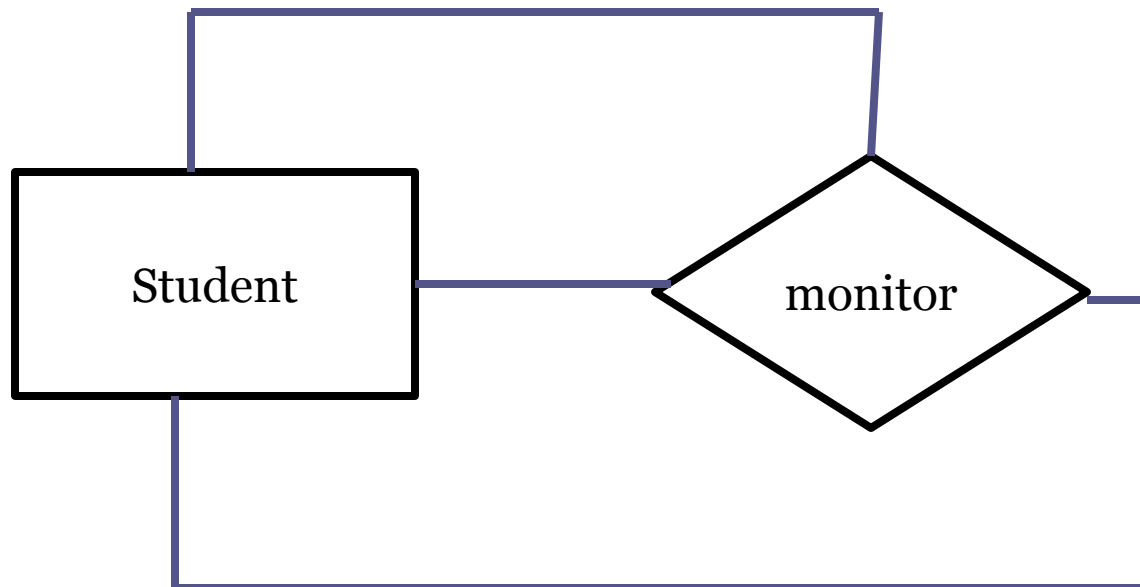
- Binary Relationship



- Ternary Relationship



- Unary Relationship



- Each relationship has
 - Name
 - Degree
 - Cardinality ratio

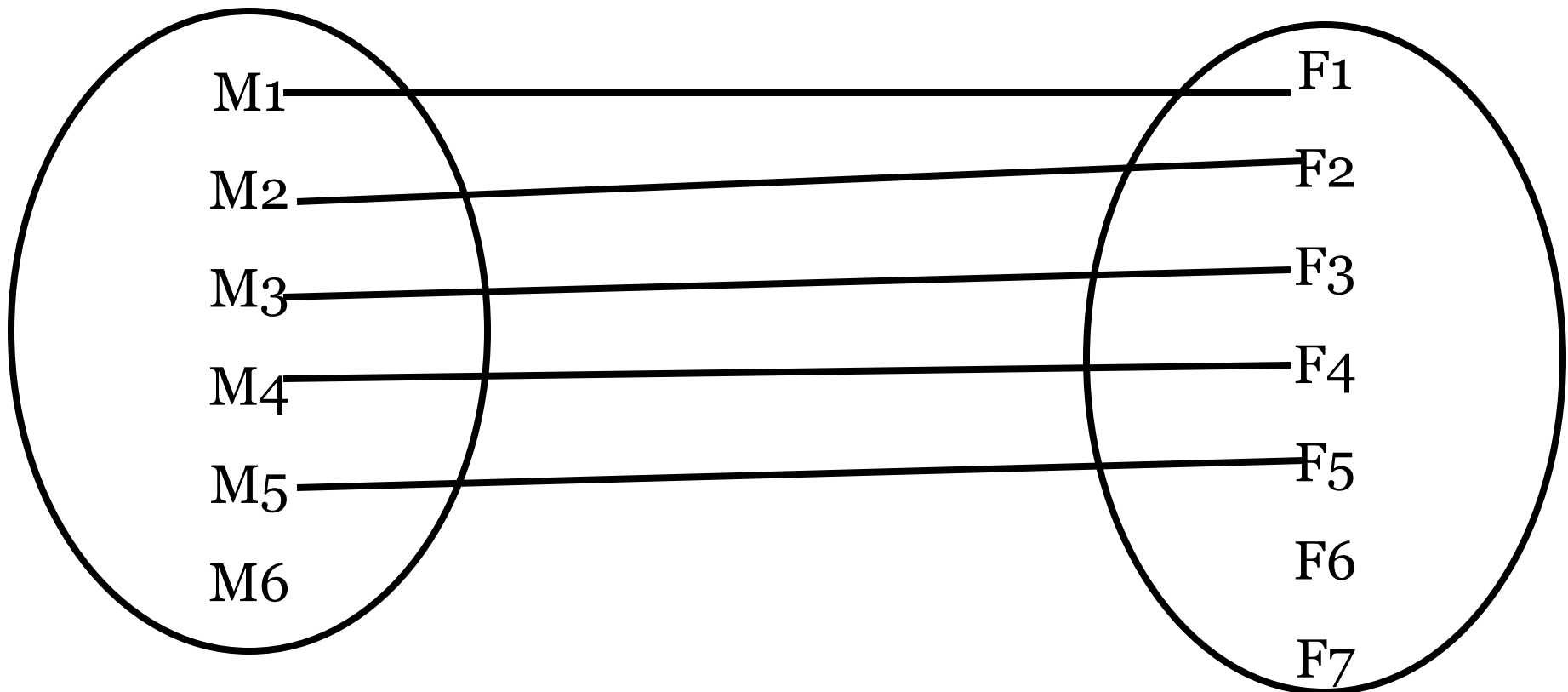
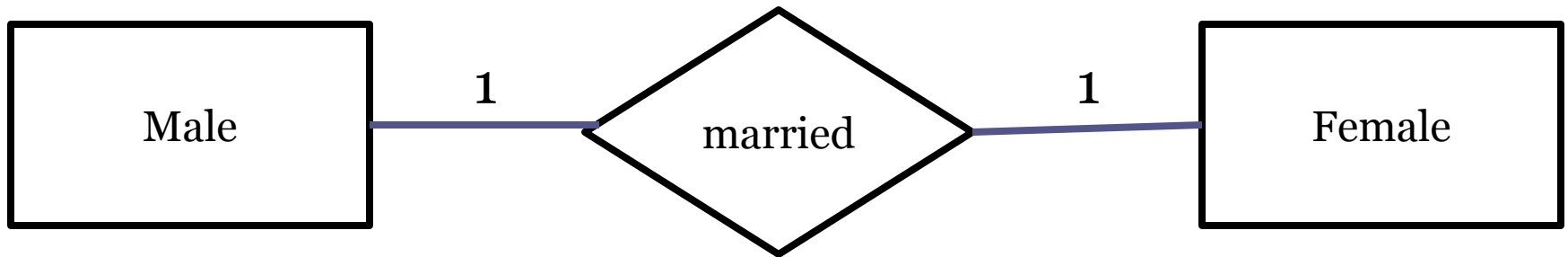
Cardinality Ratio

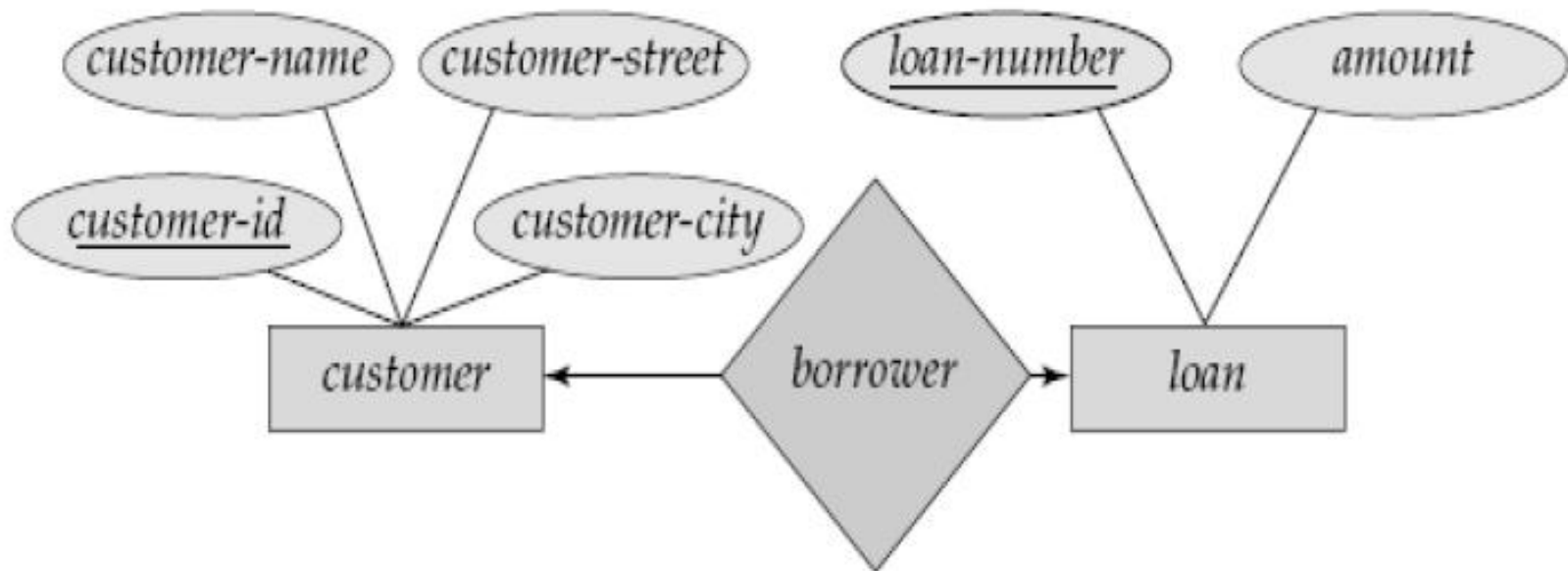
- The cardinality ratio for a binary relationship specifies the maximum number of relationship instances to which an entity can take part in it
- It also specifies number of entities to which other entity can be related by a relationship
- Types
 - **One-to-one (1:1)**
 - **One-to-many (1: N)**
 - **Many-to-one (N: 1)**
 - **Many-to-many (M: N)**

- We express cardinality ratio by drawing
- directed line (\rightarrow), signifying “one,” or an
- undirected line ($-$), signifying “many,”

One to One(1:1)

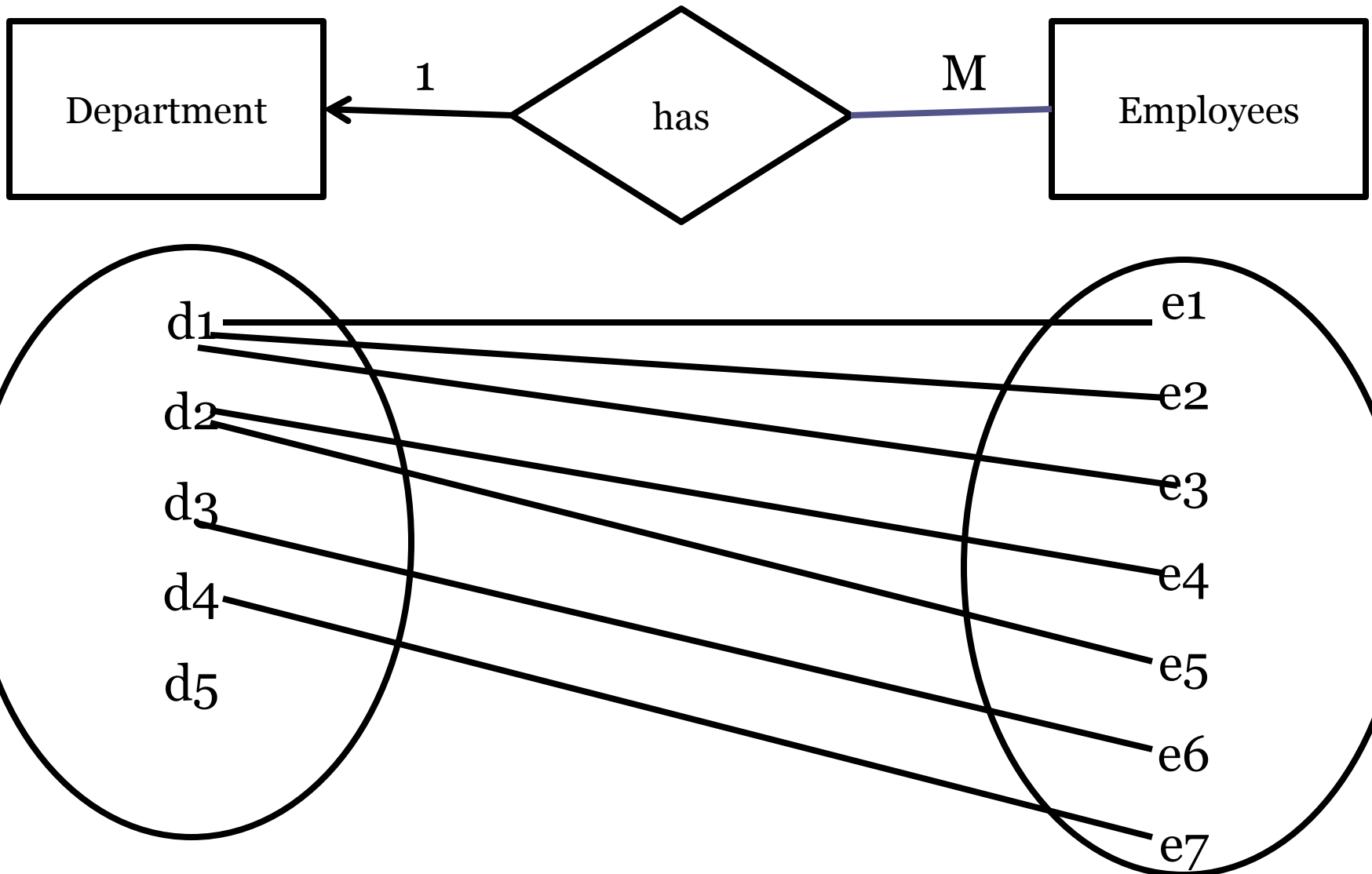
- When only a single instance of an entity is associated with single instance of other entity by a relationship
- When every entity of one entity set is related to maximum one entity of other entity set



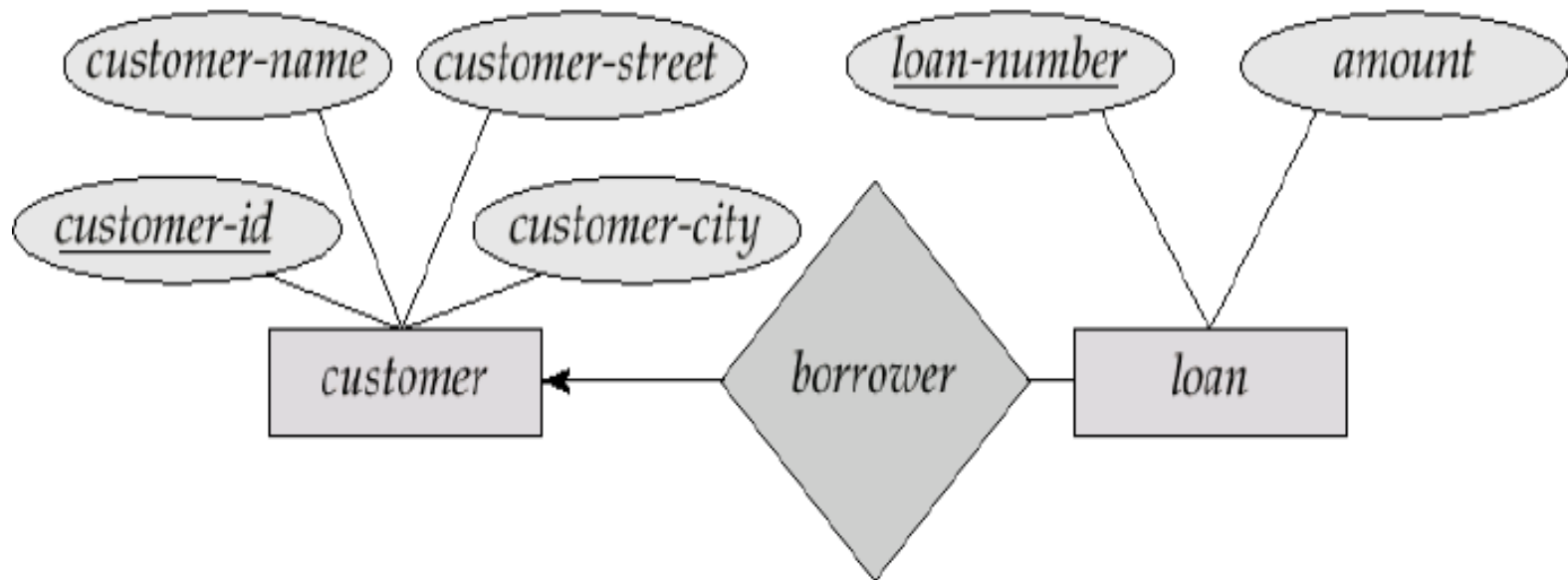


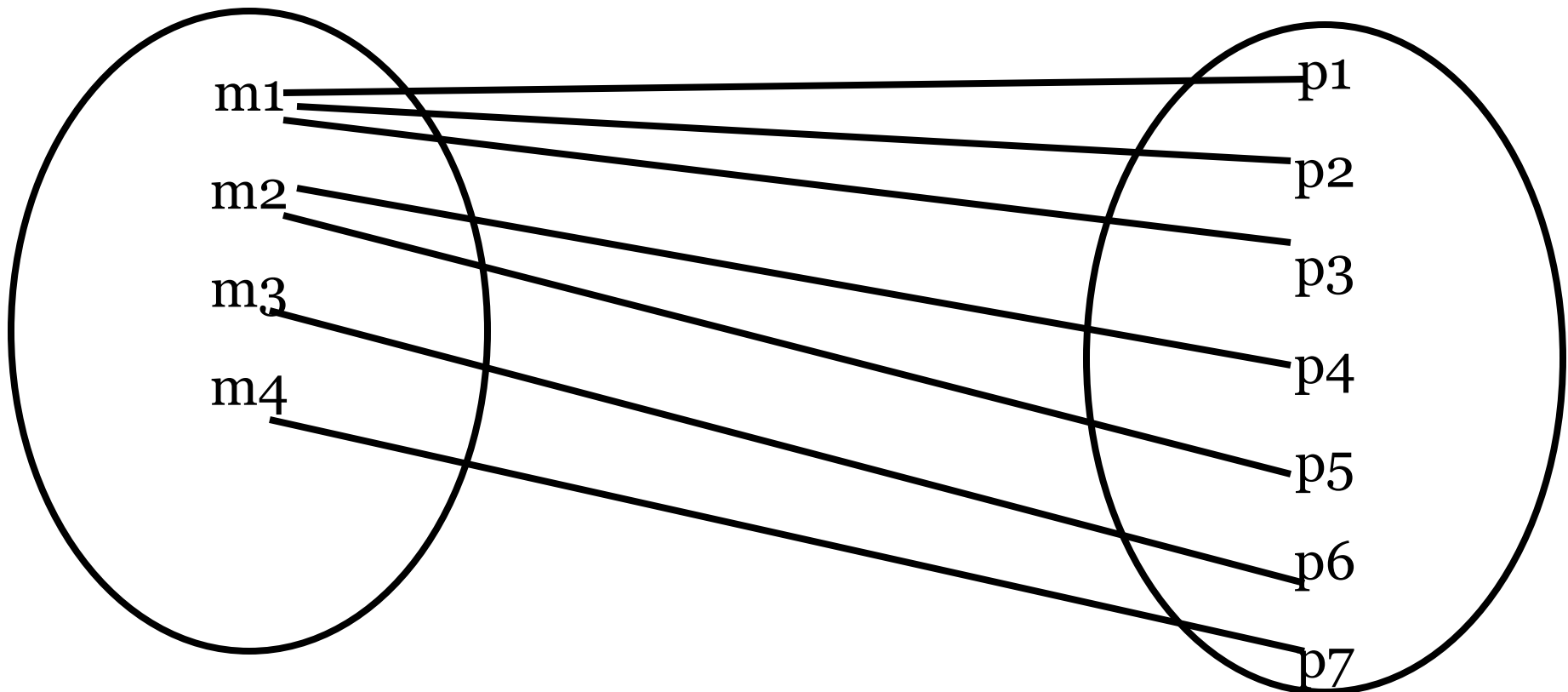
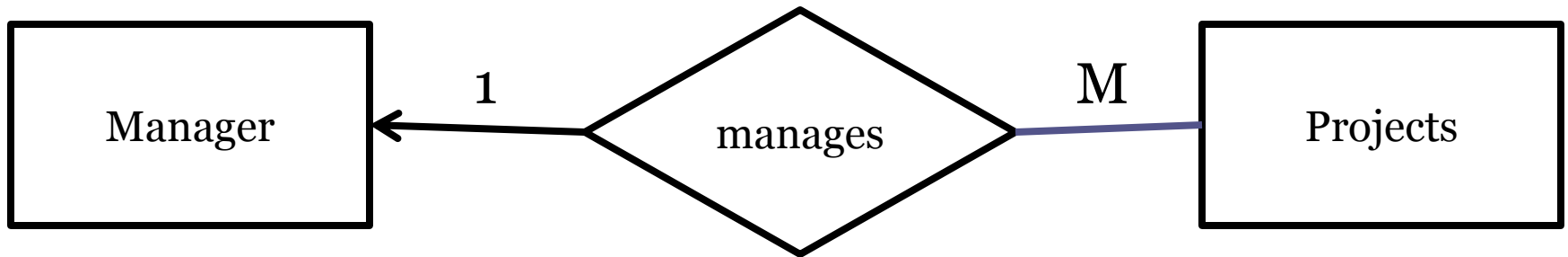
One to Many (1:M)

- When every entity of first entity set is related to at most (max) n entities of other entity set then it is one to many



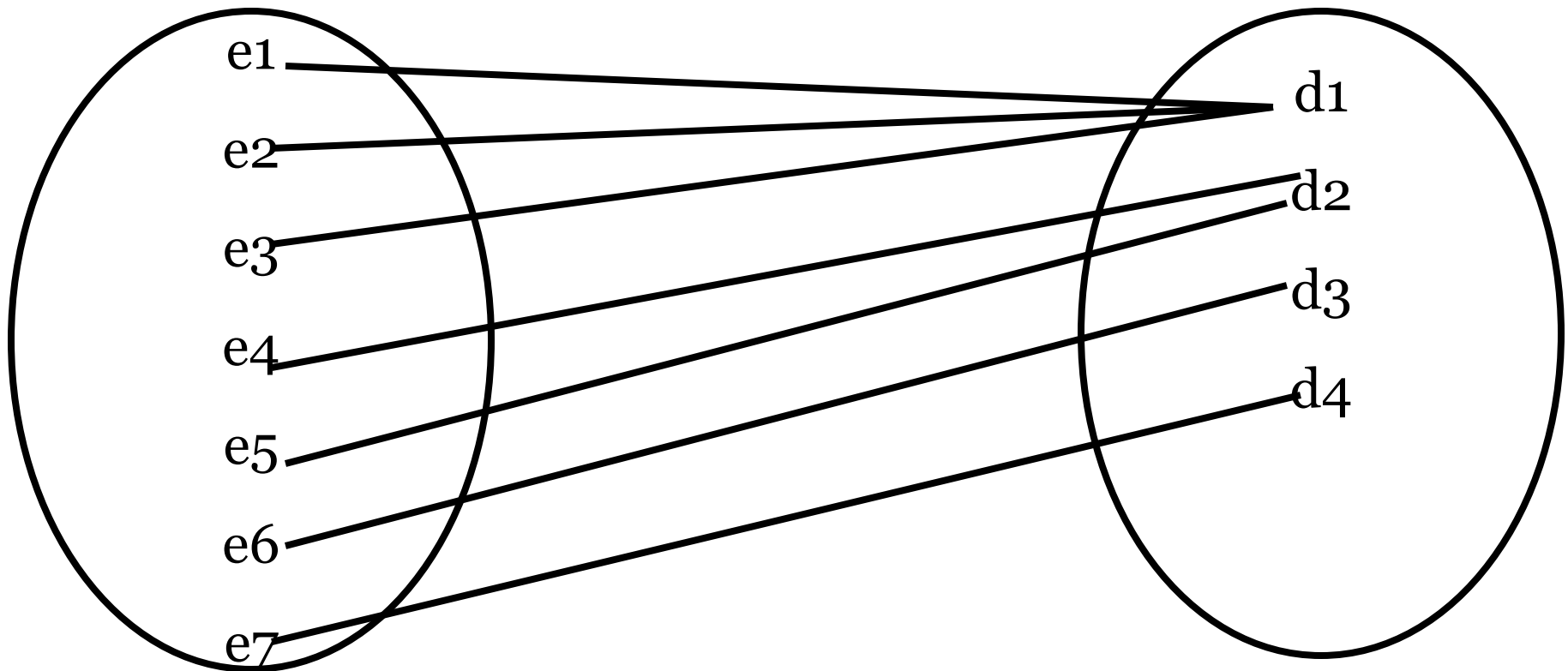
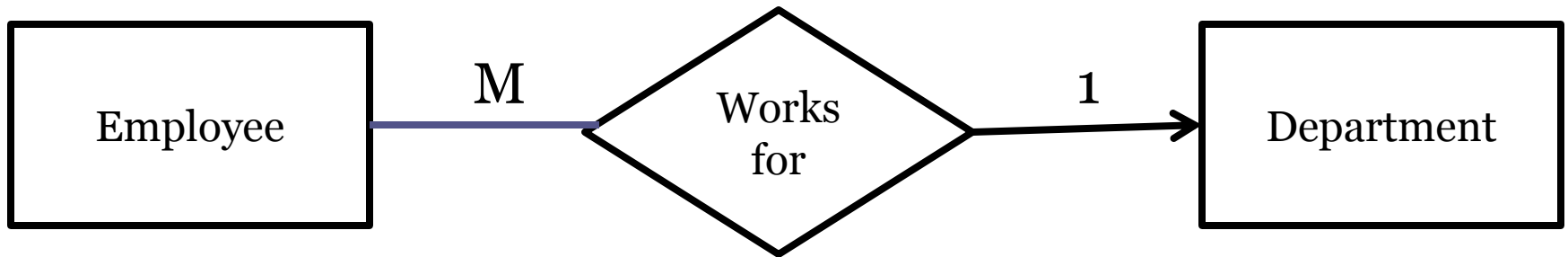
- In the one-to-many relationship a customer is associated with several loans via *borrower*



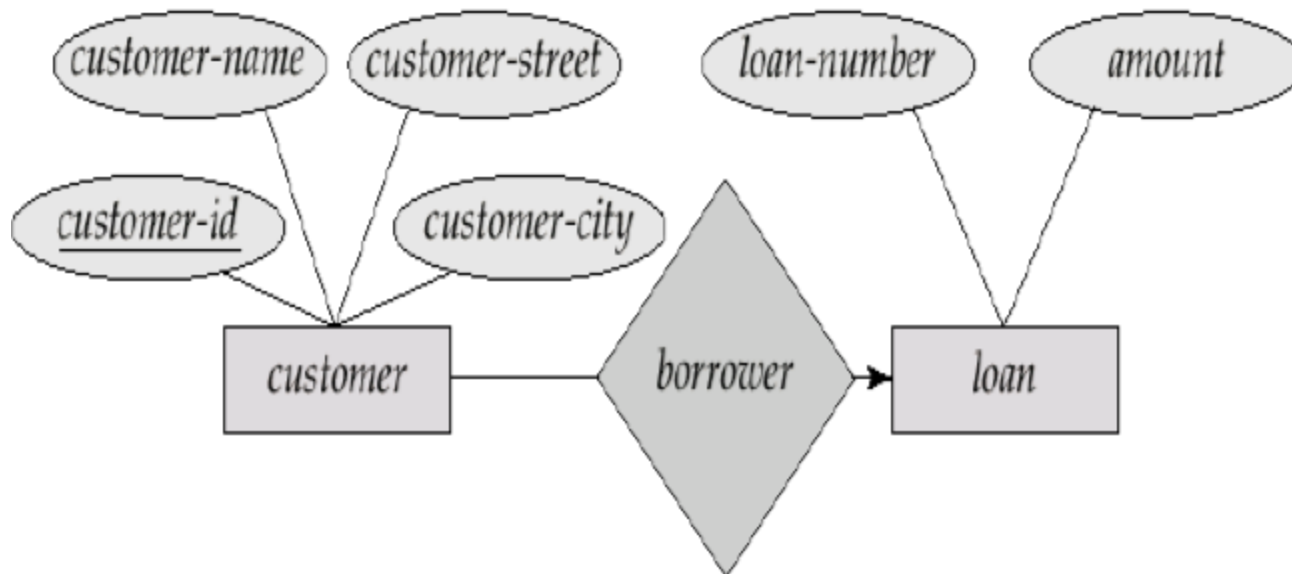


Many to One (M:1)

- When many entities of first entity set is related to 1 entity of other entity set then it is many to one

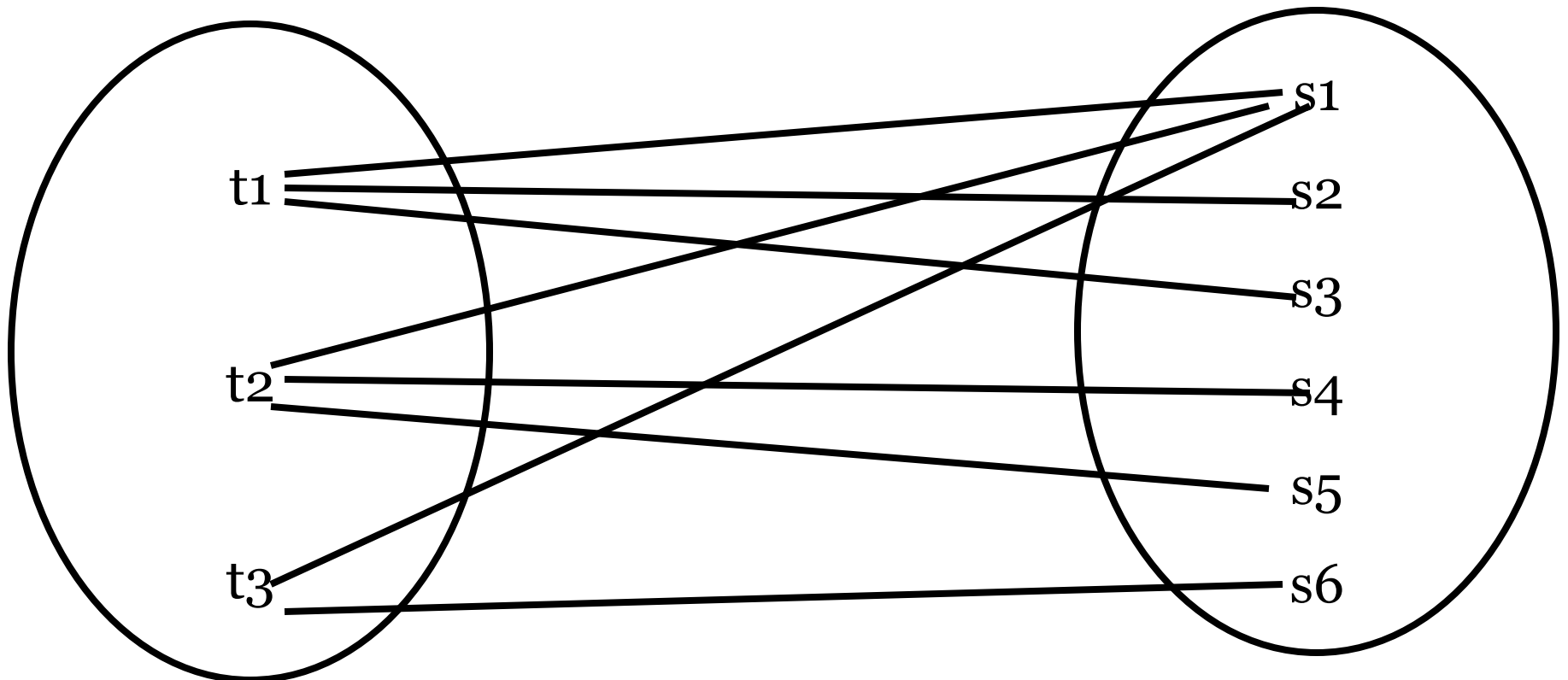
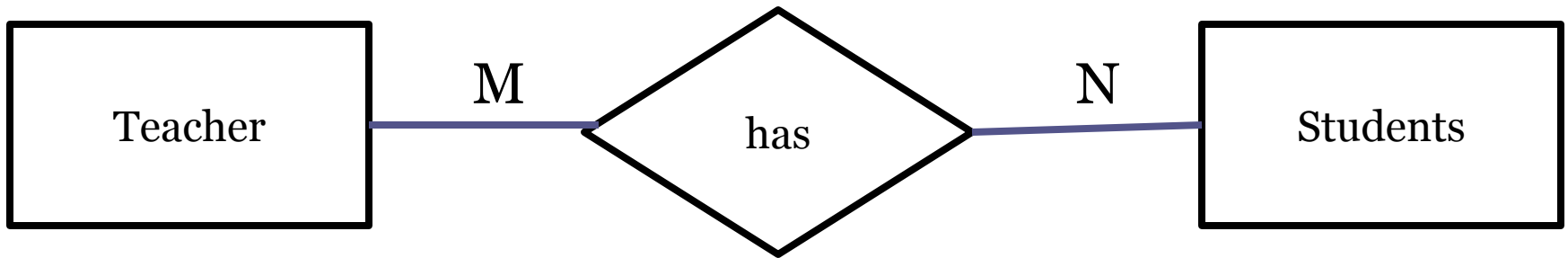


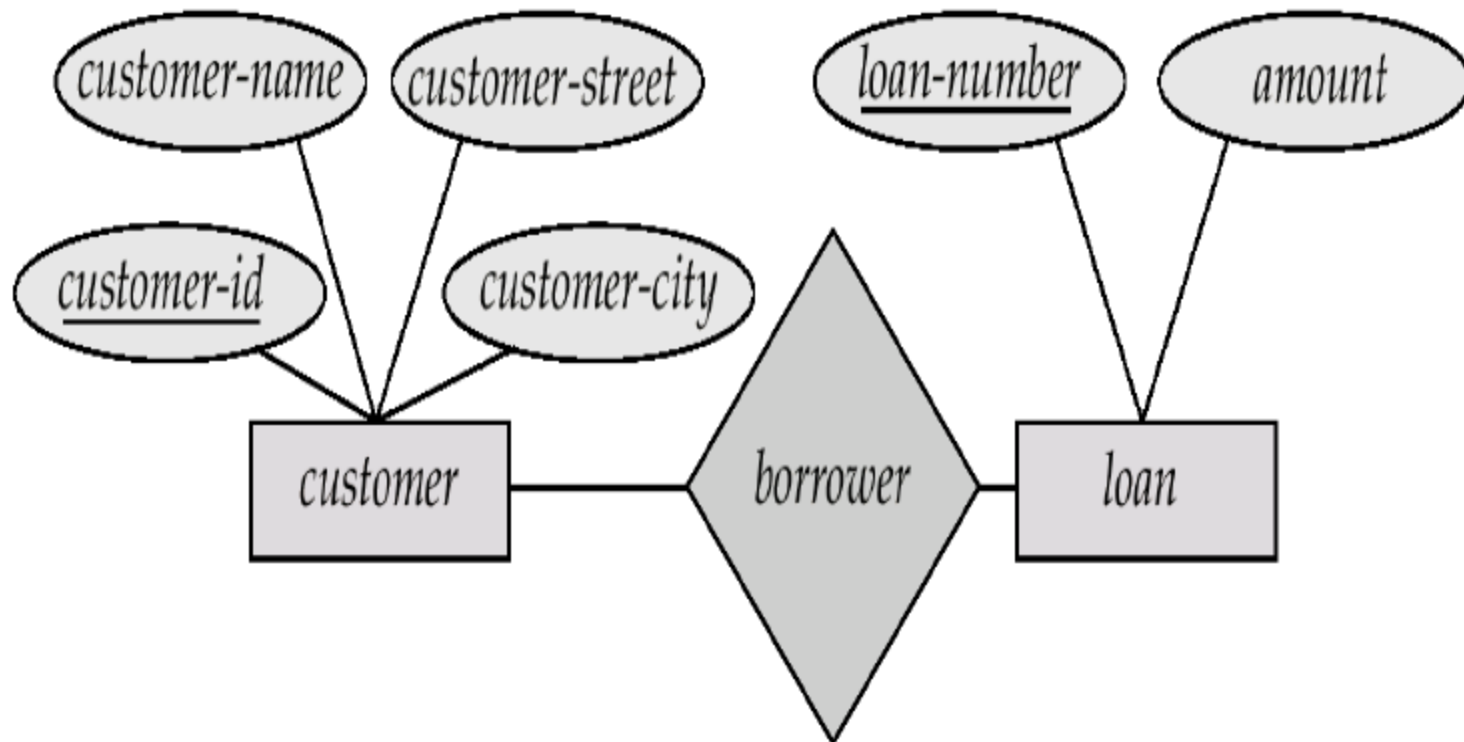
- In a many-to-one relationship a loan is associated with several customers via *borrower*.



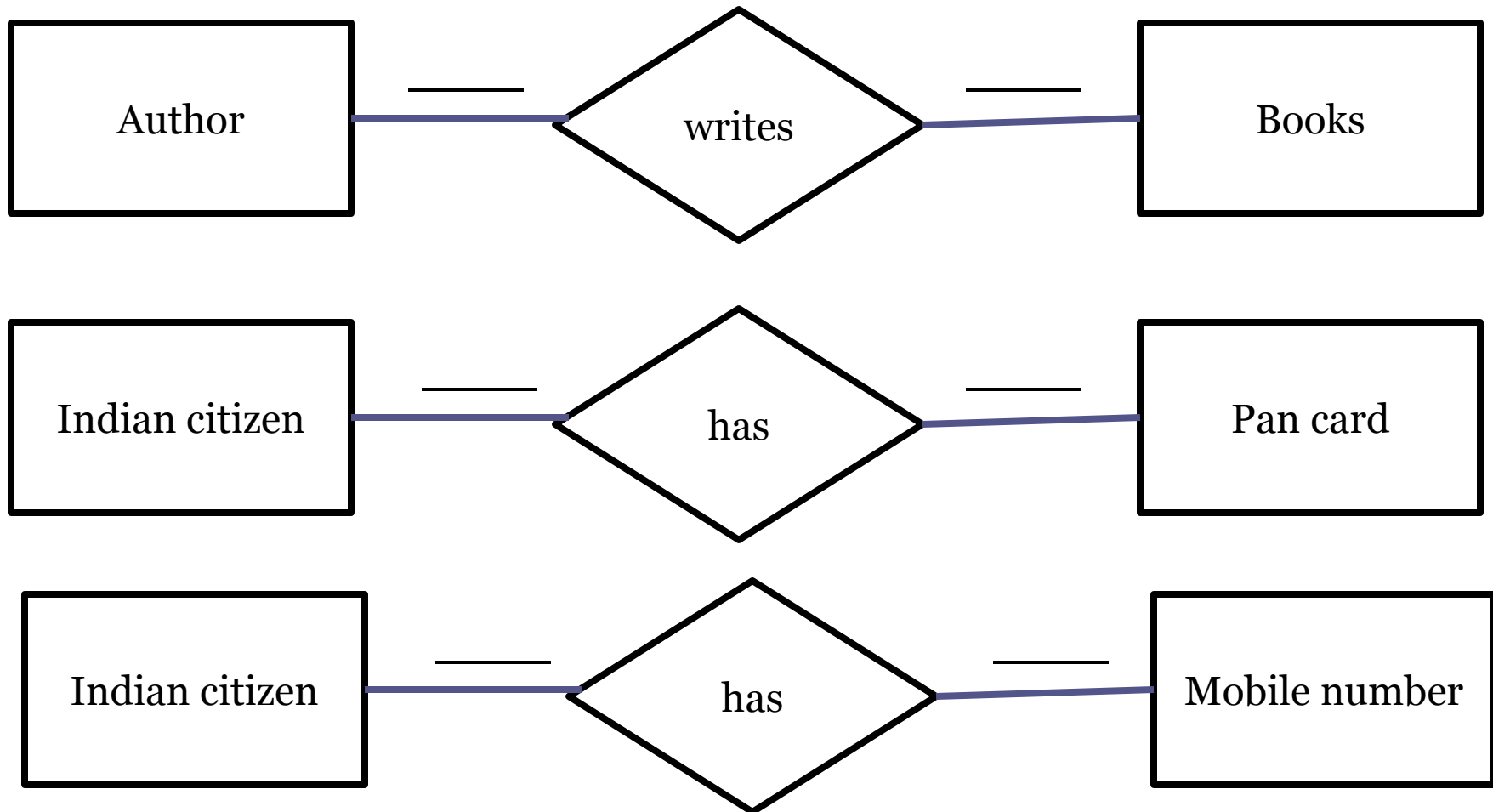
Many to Many(M:N)

- When many occurrences of one entity is related to many occurrences of another entity





Exercise



Homework

- Prime minister-country
- classroom –students
- students –classroom
- customer -loan

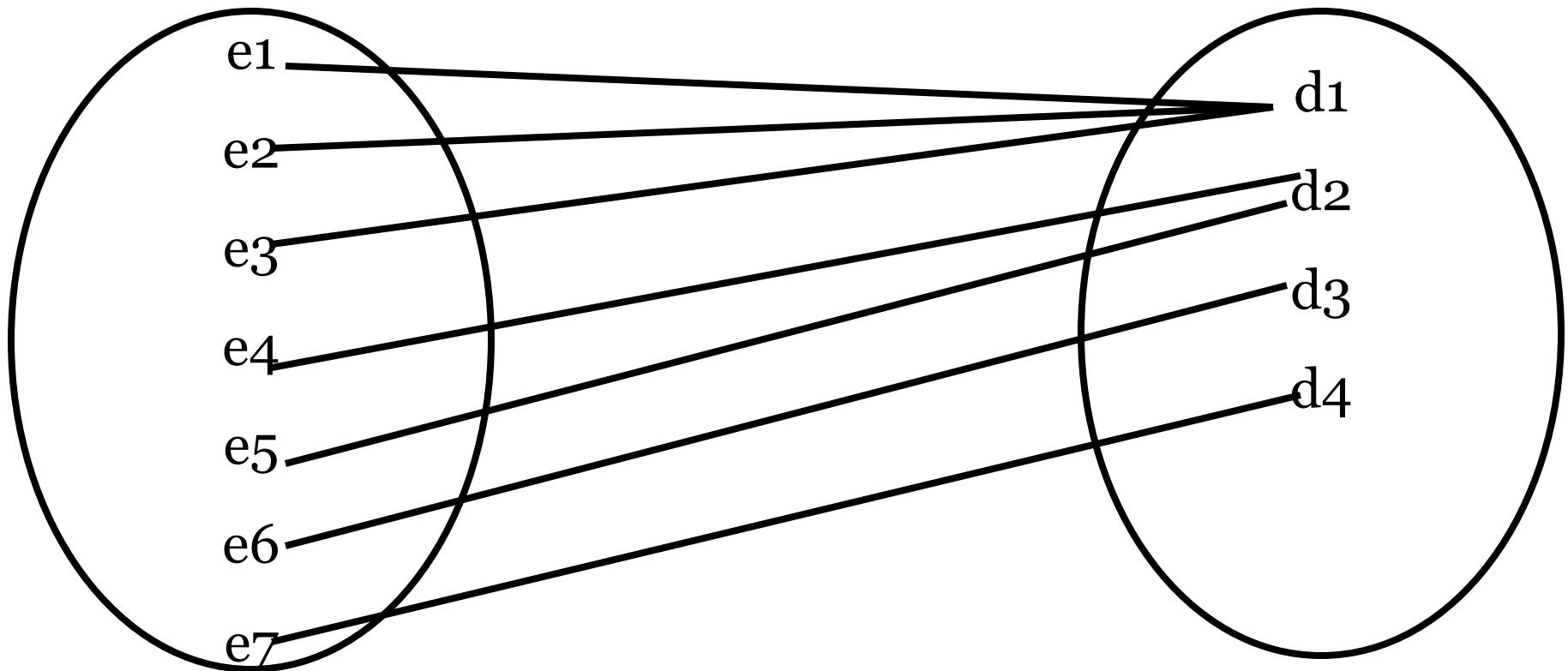
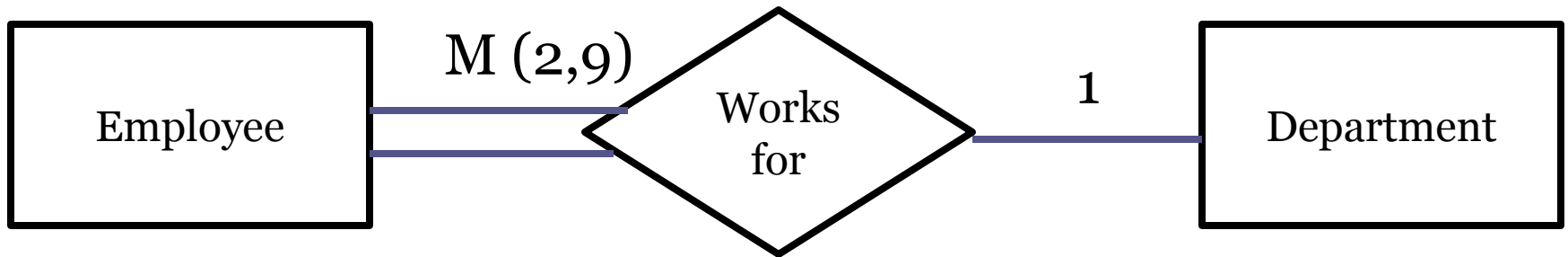
Participation constraints

- It specifies whether the existence of an entity depends on being related to another entity through relationship types
- These constraints defines max and min number of relationship instance that each entity can participate in
- Maximum cardinality
 - It defines maximum number of times an entity can participate in a relationship
- Minimum Cardinality
 - It defines minimum number of times an entity can participate in a relationship

- There are two types of participation constraints
 1. Total Participation
 2. Partial Participation

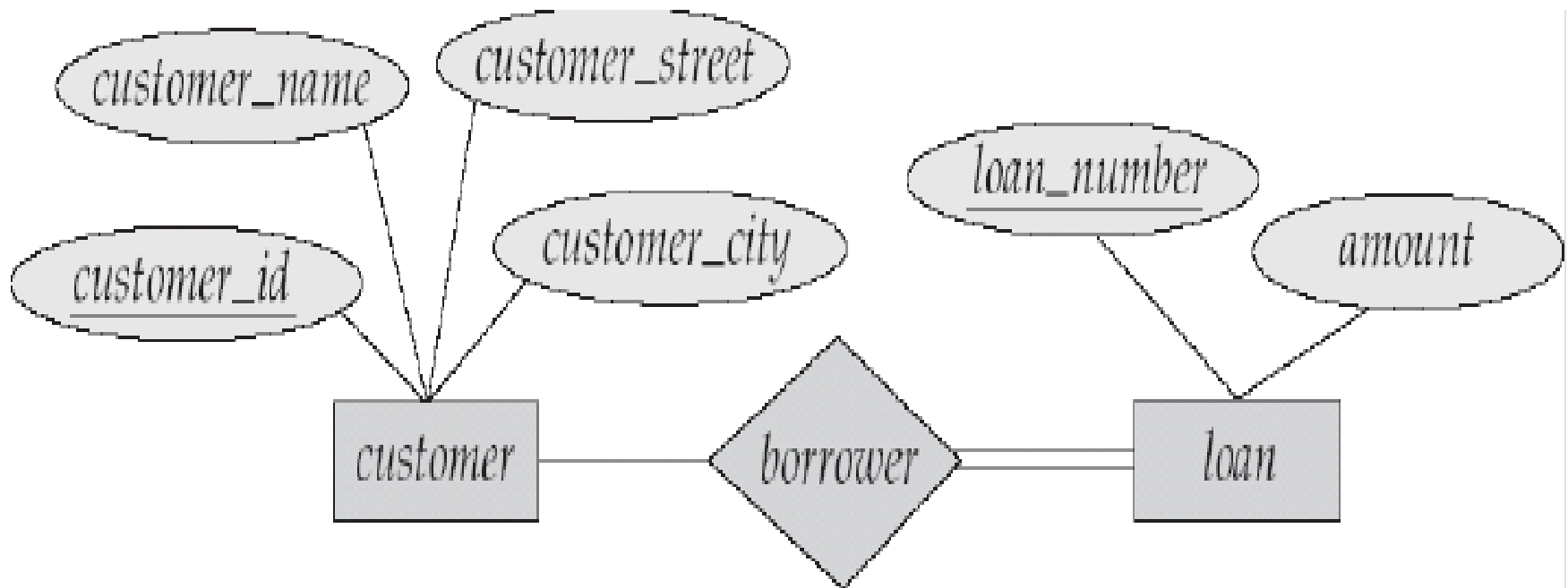
Total participation

- every entity in the entity type participates in at least one relationship in the relationship type
 - E.g. participation of loan in borrower is total every loan must have a customer associated to it via borrower
- Represented by double lines
- Minimum and maximum cardinality represented inside parentheses(m,n)



Partial participation

- Some entities may not participate in any relationship in the relationship type
 - Example: participation of customer in borrower is partial
- Represented by single line



TYPES OF ENTITY TYPES

- **Strong entity type**

- Entity types that have at least one key attribute.
- A strong entity is not dependent of any other entity in the schema.
- A strong entity will always have a primary key.
- Strong entities are represented by a single rectangle.
- The relationship of two strong entities is represented by a single diamond.
- Various strong entities, when combined together, create a strong entity set.

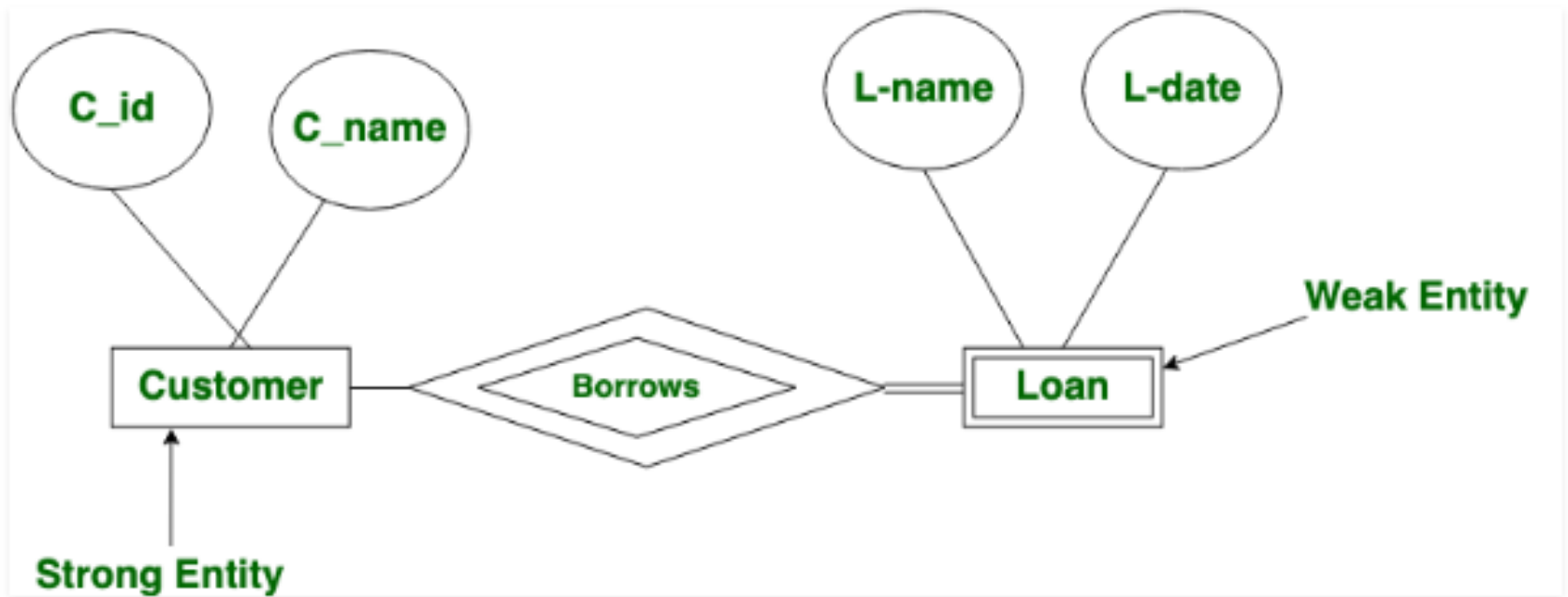
- **Weak entity type**

- Entity type that does not have any key attribute.
- A weak entity is dependent on a strong entity to ensure the its existence.
- Unlike a strong entity, a weak entity does not have any primary key.
- It instead has a partial discriminator key.
- A weak entity is represented by a double rectangle. The relation between one strong and one weak entity is represented by a **double diamond**.



Difference between Strong and Weak Entity:

S.NO	Strong Entity	Weak Entity
1.	Strong entity always has primary key.	While weak entity has partial discriminator key.
2.	Strong entity is not dependent of any other entity.	Weak entity is depend on strong entity.
3.	Strong entity is represented by single rectangle.	Weak entity is represented by double rectangle.
4.	Two strong entity's relationship is represented by single diamond.	While the relation between one strong and one weak entity is represented by double diamond.
5.	Strong entity have either total participation or not.	While weak entity always has total participation.



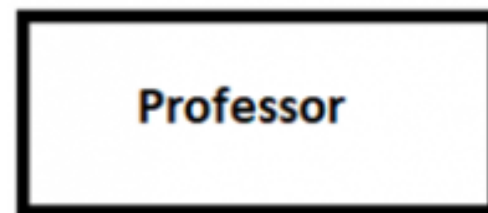
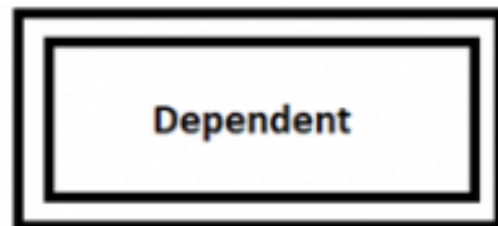
- let us take an example of **Professor** entity, which is our **Strong Entity**, with **Professor_ID** as a **Primary Key**

Professor_ID	Professor_Name	Professor_City	Professor_Salary
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- The weak entity is **Professor_Dependents** entity:

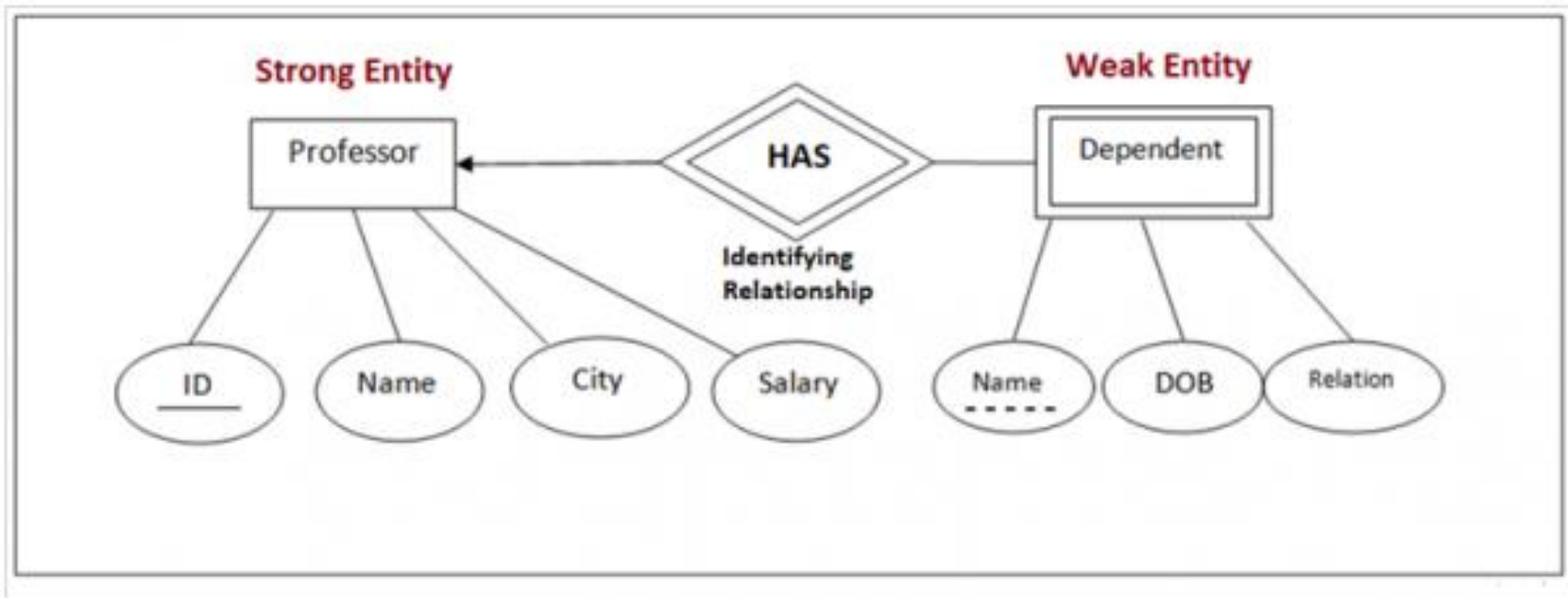
Name	DOB	Relation
------	-----	----------

- Here Dependent is a weak entity and has no primary key
- Professor has a primary key so is the strong entity



Identifying Relationship

- It links the strong and weak entity and is represented by a double diamond sign.
- Let us see with an example to link both the entities using Identifying Relationships:

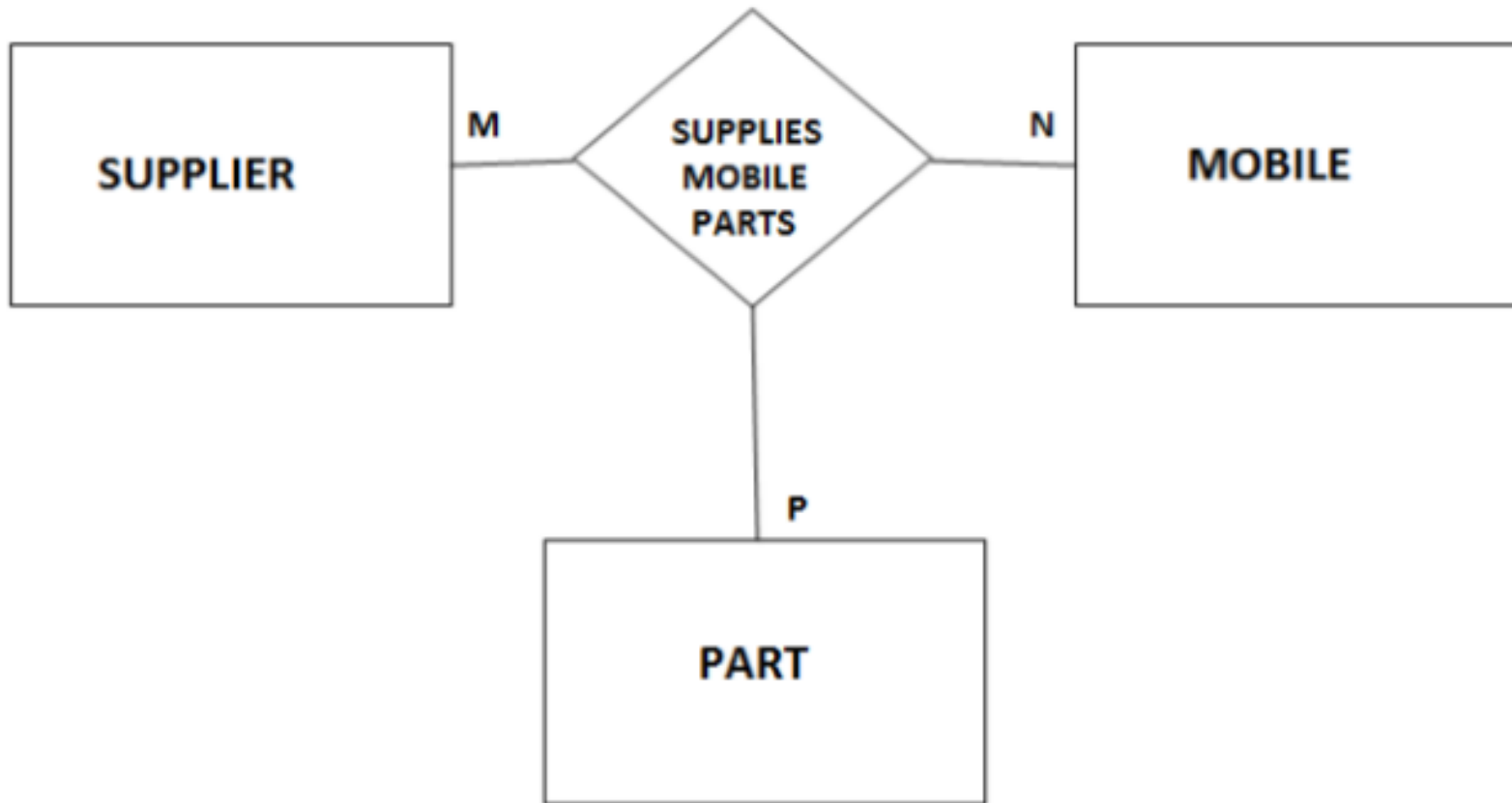


Above we saw that, Dependent Name could not exist on its own but in relationship to a Professor.

Professor	Strong Entity
Dependent	Weak Entity
Partial Key (Weak Entity)	Name
Primary Key (Strong Entity)	ID

Relationship of degree 3

- In Ternary relationship three different Entities takes part in a Relationship.
- Relationship Degree = 3
- For Example: Consider a Mobile manufacture company. Three different entities involved:
 - Mobile - Manufactured by company.
 - Part - Mobile Part which company get from Supplier.
 - Supplier - Supplier supplies Mobile parts to Company.
- Mobile, Part and Supplier will participate simultaneously in a relationship. because of this fact when we consider cardinality we need to consider it in the context of two entities simultaneously relative to third entity.



Cardinality in Ternary Relationship

- Say for a given instance of Supplier and an Instance of Part, can that supplier supply that particular part for multiple Mobile models.

Example – Consider a Supplier S1 that supplies a Processor P1 to the company and the uses the Processor P1 supplied by Supplier S1 in its multiple Models in that case the cardinality of Mobile relative to Supplier and Part is N (many).

- In case of Supplier's cardinality we can say for a given instance of Mobile one of its Part can be supplied by multiple Suppliers.

Example – Consider a Mobile M1 that has a Part P1 and it is being supplied by multiple Suppliers in that case the cardinality of Supplier relative to Mobile and Part is M (many).

- Similarly, for a given instance of Supplier and an instance for Mobile does the Supplier supply multiple Parts.

Example – Consider a Supplier S1 supplying parts for Mobile M1 like screen, Processor etc. in that case the cardinality of Part relative to Supplier and Mobile is P (many).

- Construct an E-R diagram for a car-insurance company whose customers own one or more cars each. Each car has associated with it zero to any number of recorded accidents

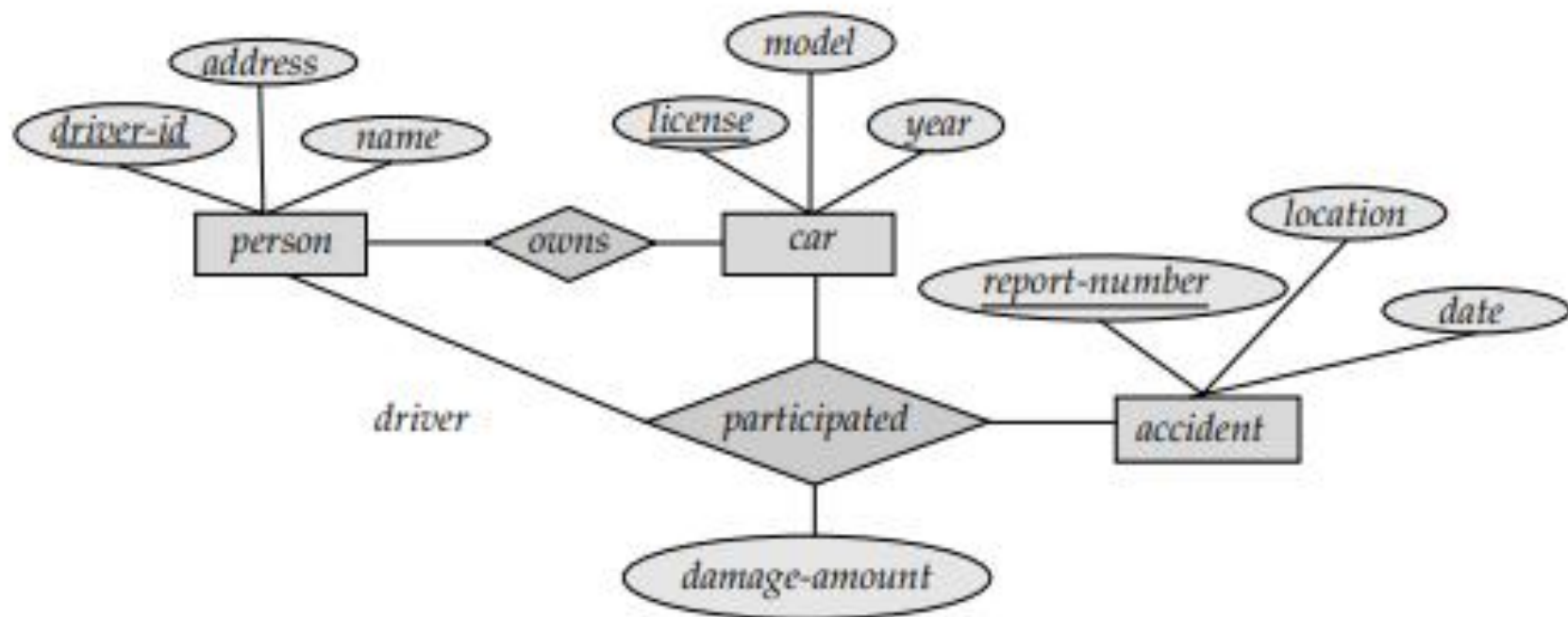


Figure 2.1 E-R diagram for a Car-insurance company.

- Construct an E-R diagram for a hospital with a set of patients and a set of medical doctors. Associate with each patient a log of the various tests and examinations conducted

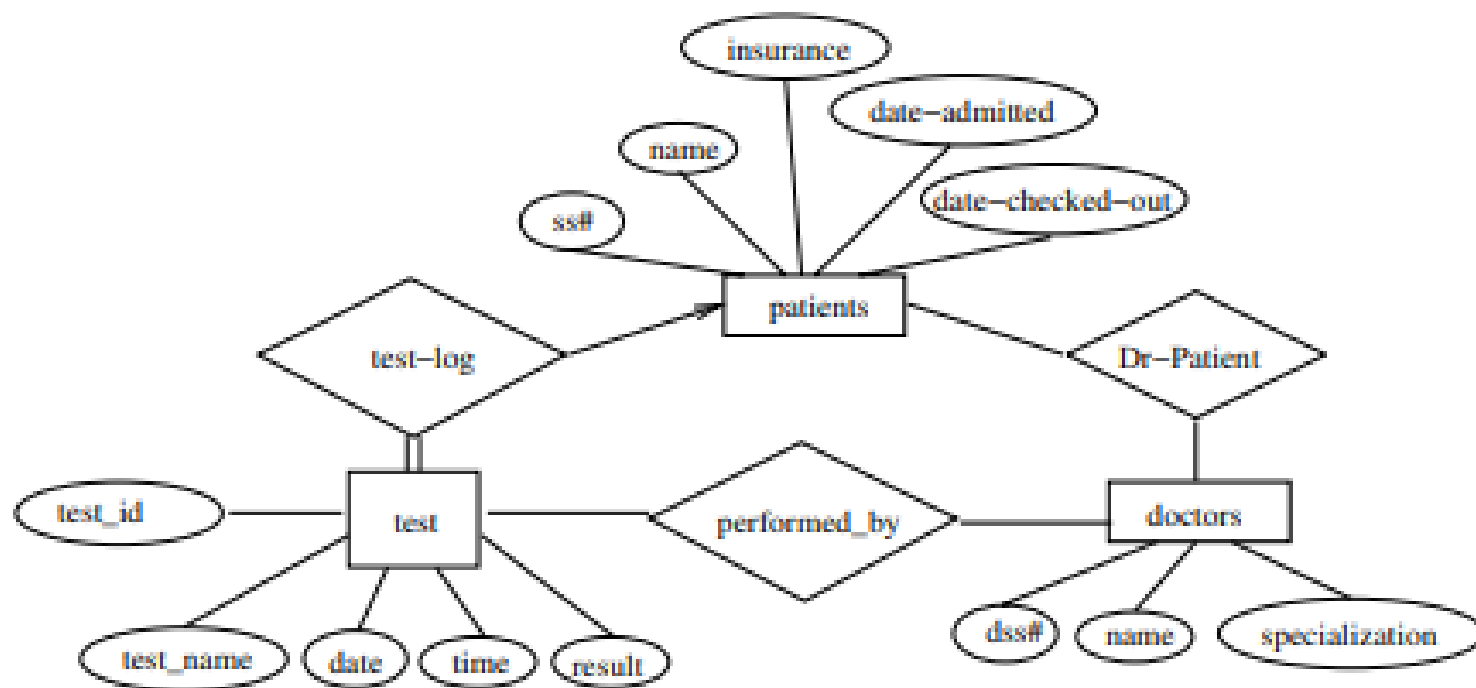


Figure 2.2 E-R diagram for a hospital.

A university registrar's office maintains data about the following entities: (a) courses, including number, title, credits, syllabus, and prerequisites; (b) course offerings, including course number, year, semester, section number, instructor(s), timings, and classroom; (c) students, including student-id, name, and program; and (d) instructors, including identification number, name, department, and title. Further, the enrollment of students in courses and grades awarded to students in each course they are enrolled for must be appropriately modeled. Construct an E-R diagram for the registrar's office. Document all assumptions that you make about the mapping constraints.

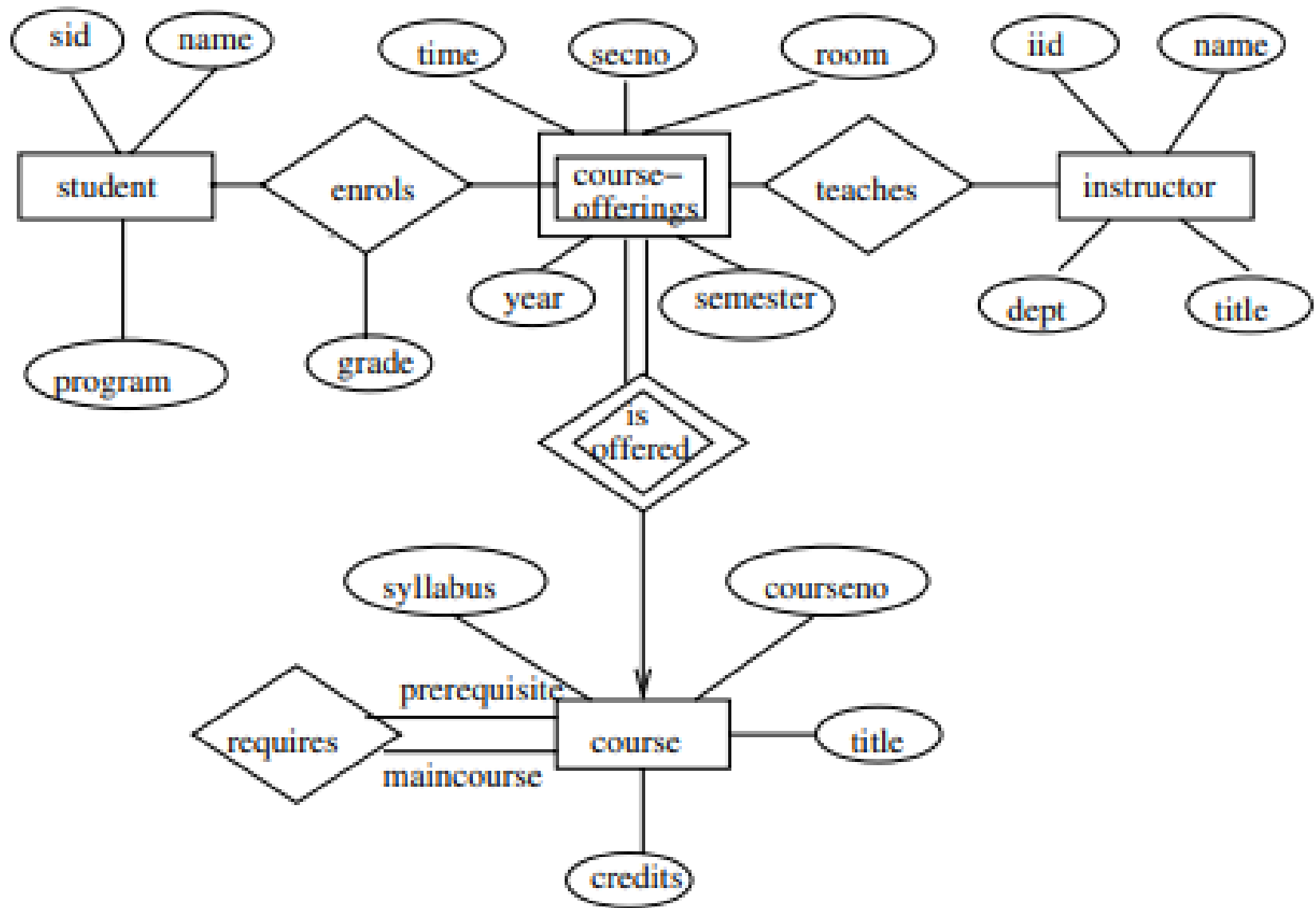


Figure 2.3 E-R diagram for a university.

- Consider a database used to record the marks that students get in different exams of different course offerings.
- Construct an E-R diagram that models exams as entities, and uses a ternary relationship, for the above database.

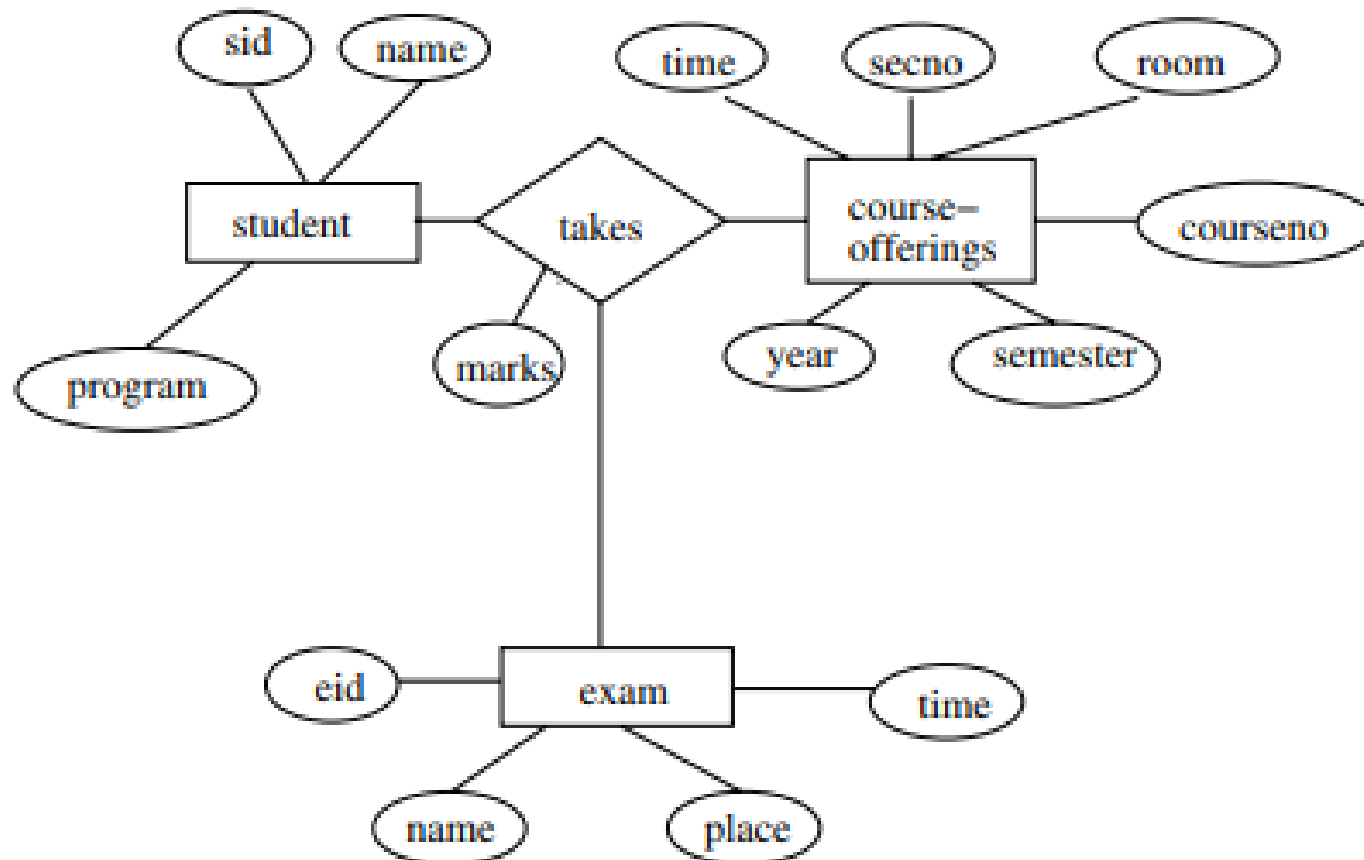


Figure 2.4 E-R diagram for marks database.