CS105.3
Database Management Systems

ER Diagrams

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Revising last week's lesson….

- Data model building blocks
  - Entity
  - Attributes
  - Relationships
  - Constraints
- Translating Business Rules into data models

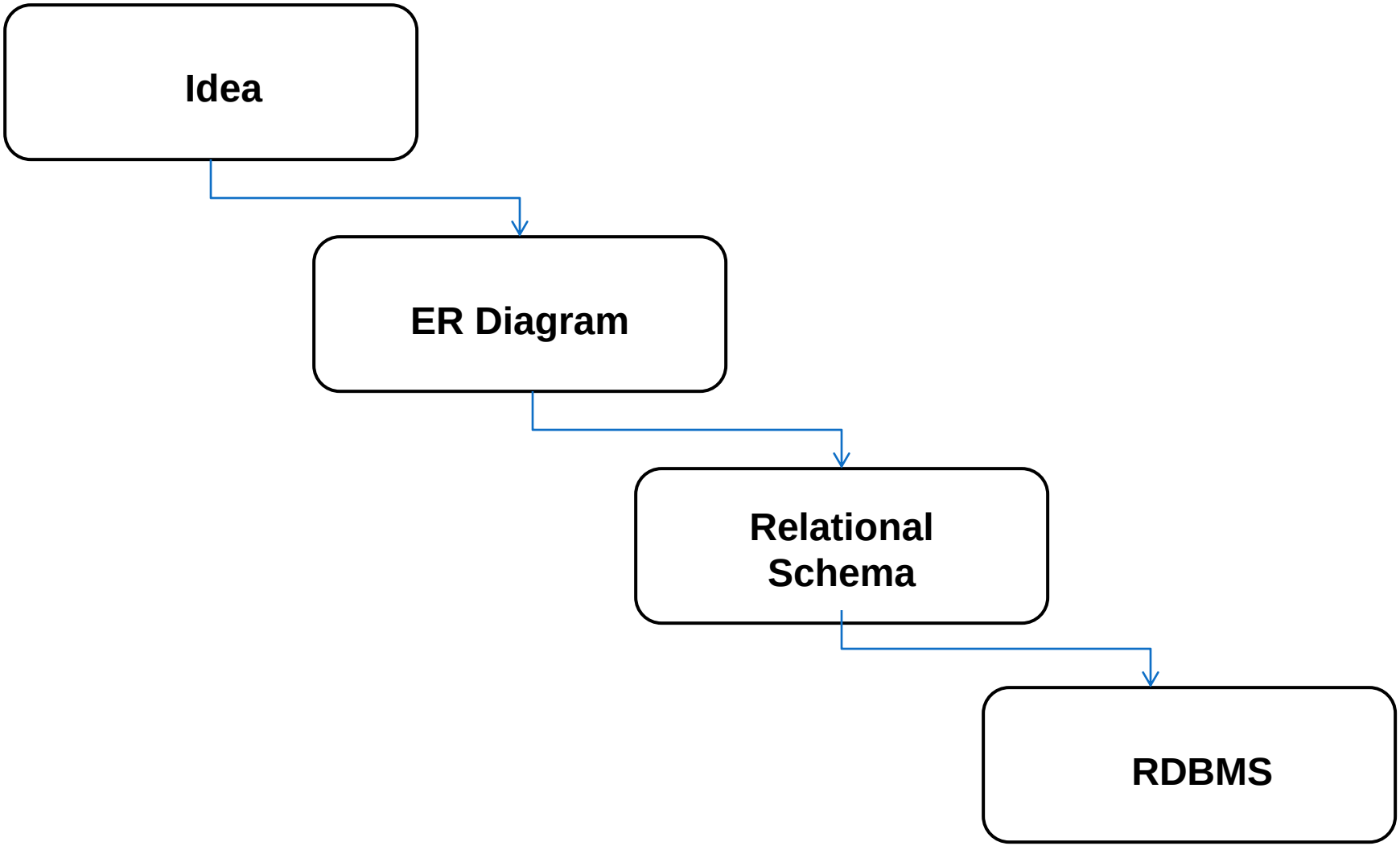
Revision Exercise

- Consider following business rules and identify the entities, relationships, and relationship types described in each. List down possible attributes for each entity.

A University contains many Faculties. The Faculties in turn are divided into several Schools. Each School offers numerous programs and each program contains many courses. Lecturers can teach many different courses and even the same course numerous times. Courses can also be taught by many lecturers. A student is enrolled in only one program but a program can contain many students. Students can be enrolled in many courses at the same time and the courses have many students enrolled.

Database designing using ER diagrams

Steps…

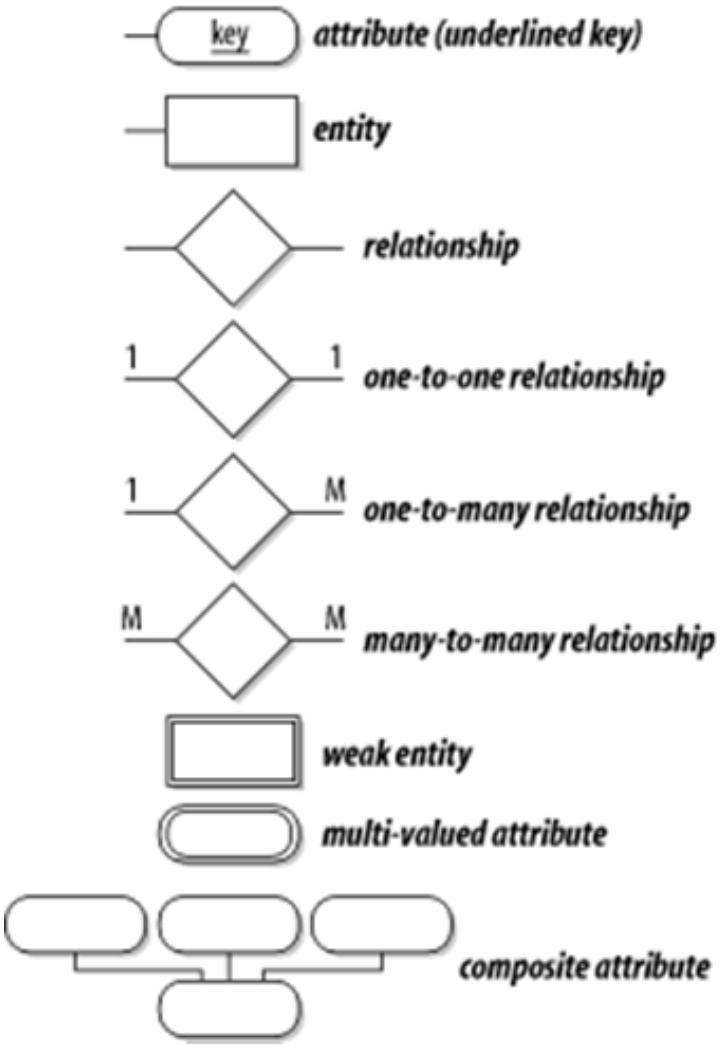


In a university, a Student enrolls in Courses. A student must be assigned to at least one or more Courses. Each course is taught by a single Professor. To maintain instruction quality, a Professor can deliver only one course.

ERD

- The major activity of this phase is identifying entities, attributes, and their relationships to construct model using the Entity Relationship Diagram.
  - Entity → table
  - Attribute → column
  - Relationship → line

Chen Notation



Classes of attributes

- Simple attribute
- Composite attribute
- Derived attributes
- Single-valued attribute
- Multi-valued attribute

Simple/Composite attribute

- A simple attribute cannot be subdivided.
  - Examples: Age, Gender, and Marital status
- A composite attribute can be further subdivided to yield additional attributes.
  - Examples:
    - ADDRESS --→ Street, City, State, Zip
    - PHONE NUMBER --→ Area code, Exchange number

Derived attribute

- is not physically stored within the database
- instead, it is derived by using an algorithm.
  - Example 1: Late Charge of 2%
    - MS Access: InvoiceAmt * 0.02
  - Example 2: AGE can be derived from the date of birth and the current date.
    - MS Access: int(Date() – Emp_Dob)/365)

Single-valued attribute

- can have only a single (atomic) value.
  - Examples:
    - A person can have only one social security number.
    - A manufactured part can have only one serial number.
  - **A single-valued attribute is not necessarily a simple attribute.**
    - Part No: CA-08-02-189935
    - Location: CA, Factory#:08, shift#: 02, part#: 189935

Multi-valued attributes

- can have many values.
  - Examples:
    - A person may have several college degrees.
    - A household may have several phones with different numbers
    - A car color

Exercise - "Movie Database"

- Identify the types of attributes of the Movie Star Entity
  - Entity:
    - Movie Star
  - Attributes:
    - SS# : "123-45-6789"
    - Cell Phone : "(661)123-4567, (661)234-5678"
    - Name : "Harrison Ford"
    - Address : "123, Main Str., LA, CA"
    - Gender : "Female"
    - Birth date : "02-05-1990"
    - Age : "24"

Key Attributes

- An attribute of an entity type for which each entity must have a unique value is called a **key attribute** of the entity type.

E.g. SSN of EMPLOYEE.

- A key attribute may be composite.

E.g. VehicleTagNumber is a key of the CAR entity type with components (Number, State).

- An entity type may have more than one key. For example, the CAR entity type may have two keys:
  - VehicleIdentificationNumber (popularly called VIN) and
  - VehicleTagNumber (Number, State), also known as license_plate number.

Concepts of Keys

- Candidate key
- Primary key
- Super Key
- Alternate key/Secondary Keys
- Composite key
- Foreign key

Candidate key

- A candidate key is a **minimal set** of attributes necessary to identify a tuple.

E.g. employeeID is a candidate key

- Each table may have one or more candidate keys. One of these candidate keys is selected as the table primary key.

S ID	SName	Marks
S1	A	40
S2	A	40
S3	B	50
S2	B	50

Primary key

- One of the candidate keys that has no NULL values.
  - Null = Unknown

- An attribute (or combination of attributes) that uniquely identifies each row in a relation.

–Employee(Emp_No, Emp_Name, Department)

Primary key-Example

Employee

E-No	E-Name	D-No
179	Silva	7
857	Perera	4
342	Dias	7

Primary Key

Salary

E-No	Eff-Date	Amt
179	1/1/98	8000
857	3/7/94	9000
179	1/6/97	7000
342	28/1/97	7500

←—Primary Key—→

Composite Key

- A primary key that consists of more than one attribute

–Salary(Emp_No, Eff_Date, Amount)

Alternate key

- An alternate key is any candidate key that is not the primary key. Alternate keys are sometimes referred to as secondary keys.
  - Null values are allowed
  - More that one alternate keys are allowed

S ID	Bank ACC	Name	Votee ID
1	Acc1	A	V1
2	Acc2	B	V2
3	Acc3	A	V3
4	Acc4	B	V4
5	Acc5	A	null

Super key

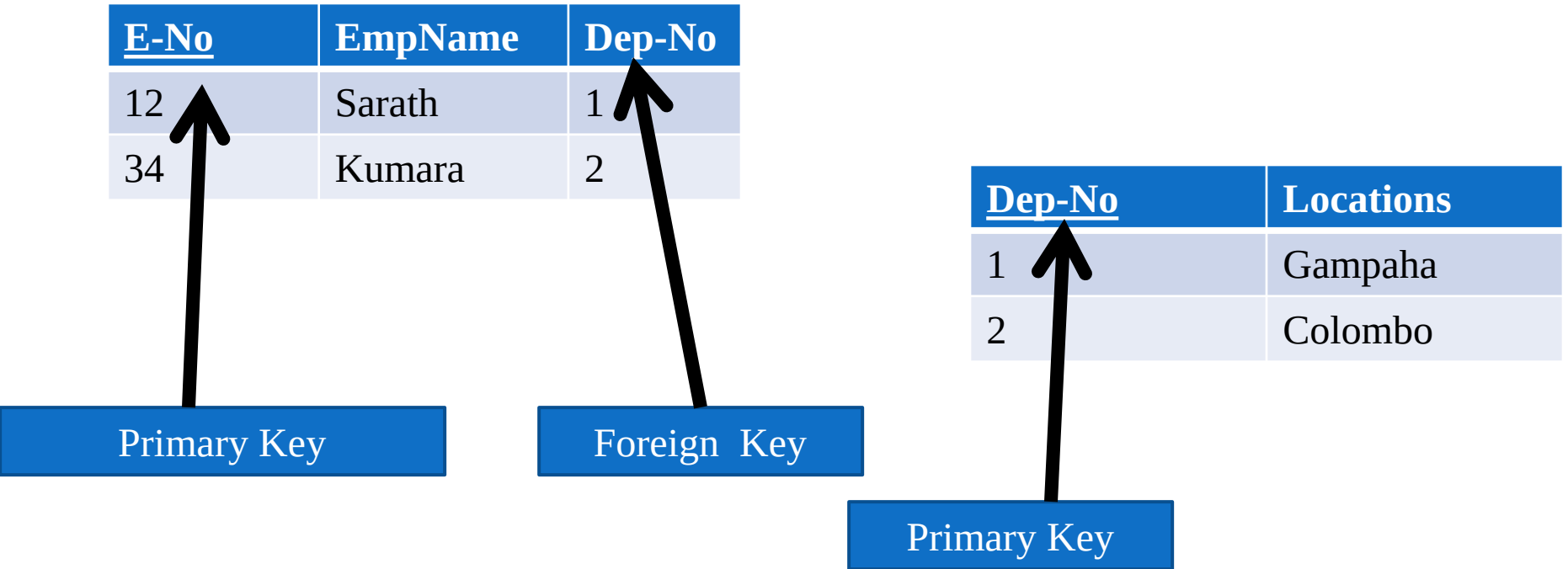
- Super key = candidate key + 0 or more attributes
  - Every candidate key is a super key
  - Every super key cannot be a candidate key

Minimal super key becomes the candidate key

E ID	Salary	E Name
1	400	A
2	500	B
3	400	A
4	500	C

Foreign Key

An attribute in a relation of a database that serves as the primary key of another relation in the same database



Exercise

Database name: Ch03_Theater

Table name: DIRECTOR

DIR_NUM	DIR_LNAME	DIR_DOB
100	Broadway	12-Jan-65
101	Hollywoody	18-Nov-53
102	Goofy	21-Jun-62

Table name: PLAY

PLAY_CODE	PLAY_NAME	DIR_NUM
1001	Cat On a Cold, Bare Roof	102
1002	Hold the Mayo, Pass the Bread	101
1003	I Never Promised You Coffee	102
1004	Silly Putty Goes To Washington	100
1005	See No Sound, Hear No Sight	101
1006	Starstruck in Biloxi	102
1007	Stranger In Parrot Ice	101

- Using the above tables identify
  - Candidate keys, primary keys for each relation.
  - alternate keys, and super keys for one relation.

Exercise

- Below tables are extracted from employee database of an organization. Identify the primary keys and the foreign keys of each table.

Table name: EMPLOYEE

EMP_CODE	EMP_LNAME	JOB_CODE
14	Rudell	2
15	McDade	1
16	Ruellardo	1
17	Smith	3
20	Smith	2

Table name: BENEFIT

EMP_CODE	PLAN_CODE
15	2
15	3
16	1
17	1
17	3
17	4
20	3

Table name: JOB

JOB_CODE	JOB_DESCRIPTION
1	Clerical
2	Technical
3	Managerial

Table name: PLAN

PLAN_CODE	PLAN_DESCRIPTION
1	Term life
2	Stock purchase
3	Long-term disability
4	Dental

Relational Integrity Constraints

- Entity integrity constraints
  - All primary key entries are unique, and no part of a primary key may be null.
- Domain integrity constraints
  - All the values of an attribute must bound to a specific range.
- Referential integrity constraints
  - Referencing attribute should be a subset of referred attribute.

Exercise

- For each table, identify the primary key and the foreign key(s).
- Do the tables exhibit entity integrity? Answer yes or no, and then explain your answer.
- Do the tables exhibit referential integrity? Answer yes or no, and then explain your answer

Table name: EMPLOYEE **Database name:**

EMP_CODE	EMP_TITLE	EMP_LNAME	EMP_FNAME	EMP_INITIAL	EMP_DOB	STORE_CODE
1	Mr.	Williamson	John	W	21-May-64	3
2	Ms.	Ratula	Nancy		09-Feb-69	2
3	Ms.	Greenboro	Lottie	R	02-Oct-61	4
4	Mrs.	Rumpersfro	Jennie	S	01-Jun-71	5
5	Mr.	Smith	Robert	L	23-Nov-59	3
6	Mr.	Renselaer	Cary	A	25-Dec-65	1
7	Mr.	Ogallo	Roberto	S	31-Jul-62	3
8	Ms.	Johnsson	Elizabeth	I	10-Sep-68	1
9	Mr.	Eindsmar	Jack	W	19-Apr-55	2
10	Mrs.	Jones	Rose	R	06-Mar-66	4
11	Mr.	Broderick	Tom		21-Oct-72	3
12	Mr.	Washington	Alan	Y	08-Sep-74	2
13	Mr.	Smith	Peter	N	25-Aug-64	3
14	Ms.	Smith	Sherry	H	25-May-66	4
15	Mr.	Olenko	Howard	U	24-May-64	5
16	Mr.	Archialo	Barry	V	03-Sep-60	5
17	Ms.	Grimaldo	Jeanine	K	12-Nov-70	4
18	Mr.	Rosenberg	Andrew	D	24-Jan-71	4
19	Mr.	Rosten	Peter	F	03-Oct-68	4
20	Mr.	Mckee	Robert	S	06-Mar-70	1
21	Ms.	Baumann	Jennifer	A	11-Dec-74	3

Table name: STORE

STORE_CODE	STORE_NAME	STORE_YTD_SALES	REGION_CODE	EMP_CODE
1	Access Junction	1003455.76	2	8
2	Database Corner	1421987.39	2	12
3	Tuple Charge	986783.22	1	7
4	Attribute Alley	944568.56	2	3
5	Primary Key Point	2930098.45	1	15

Table name: REGION

REGION_CODE	REGION_DESCRIPT
1	East
2	West

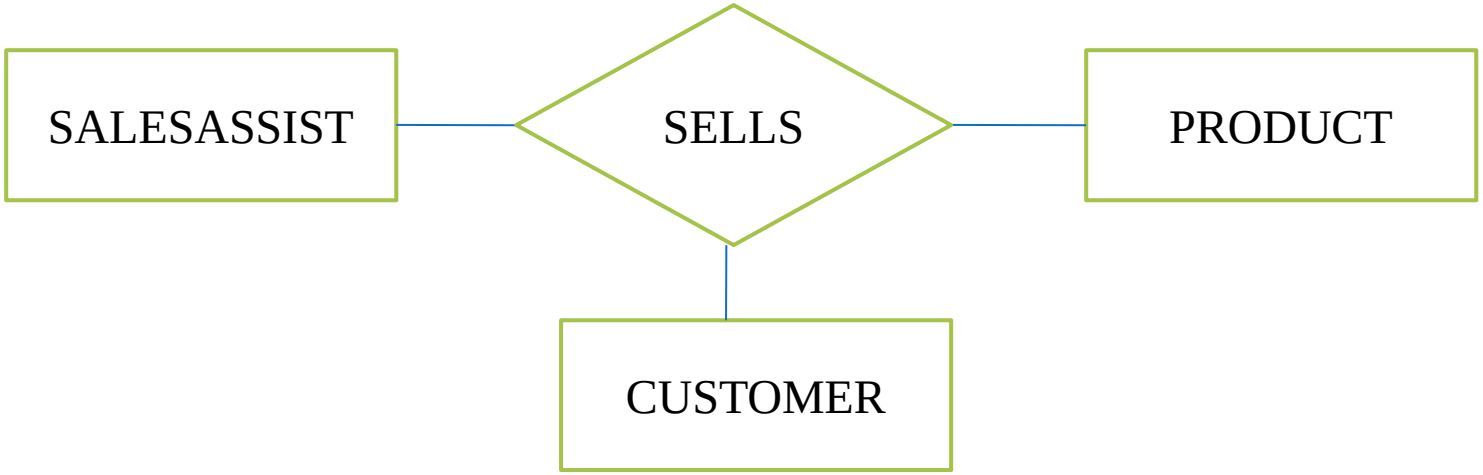
How to find relationships?

- Relationship:
  - Relationships are associations between entities.
  - Typically, a relationship is indicated by a verb connecting two or more entities.
  - Employees are assigned to projects
  - Relationships should be classified in terms of cardinality.
    - One-to-one, one-to-many, etc.

DEGREE OF A RELATIONSHIP

It is the number of entity types that participate in a relationship

- If there are two entity types involved it is a ***binary*** relationship type
- If there are three entity types involved it is a ***ternary*** relationship type
- It is possible to have a n-array relationship

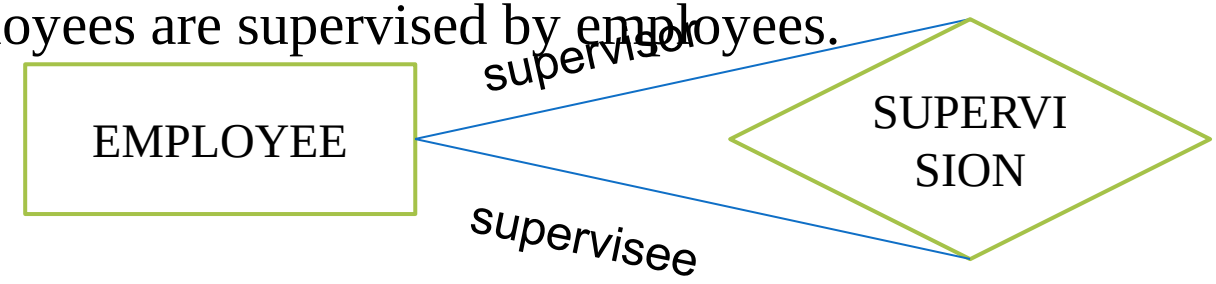


- ***Unary relationships*** are also known as a ***recursive relationship.***

- It is a relationship where the same entity participates more than once in different roles.

- In ER diagram, need to display role names to distinguish participations.

E.g. employees are supervised by employees.



CARDINALITY CONSTRAINTS

CARDINALITY: The number of instances of one entity that can or must be associated with each instance of another entity.

- If we have two entity types A and B, the cardinality constraint specifies the number of instances of entity B that can (or must) be associated with entity A.

- Four possible categories are

  One to one (1:1) relationship

  One to many (1:m) relationship

  Many to one (m:1) relationship

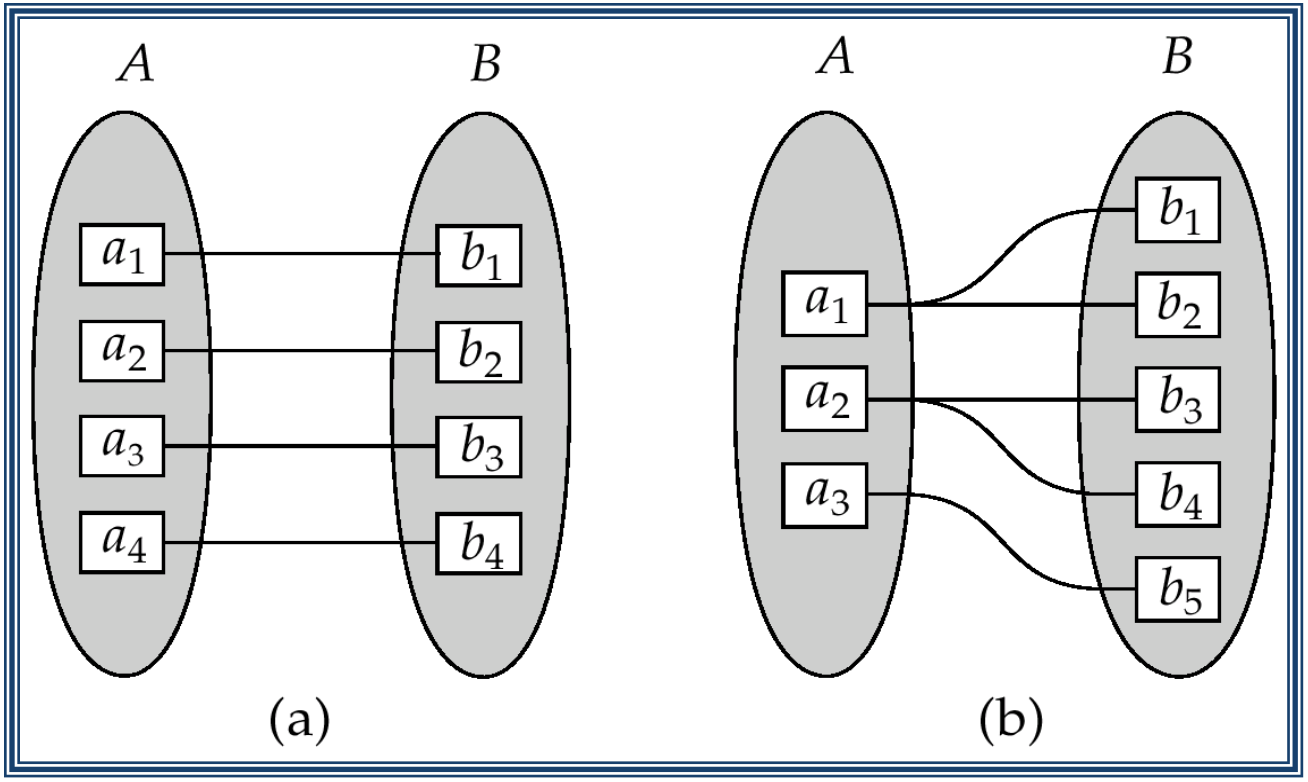
  Many to many (m:n) relationship

- one-to-one

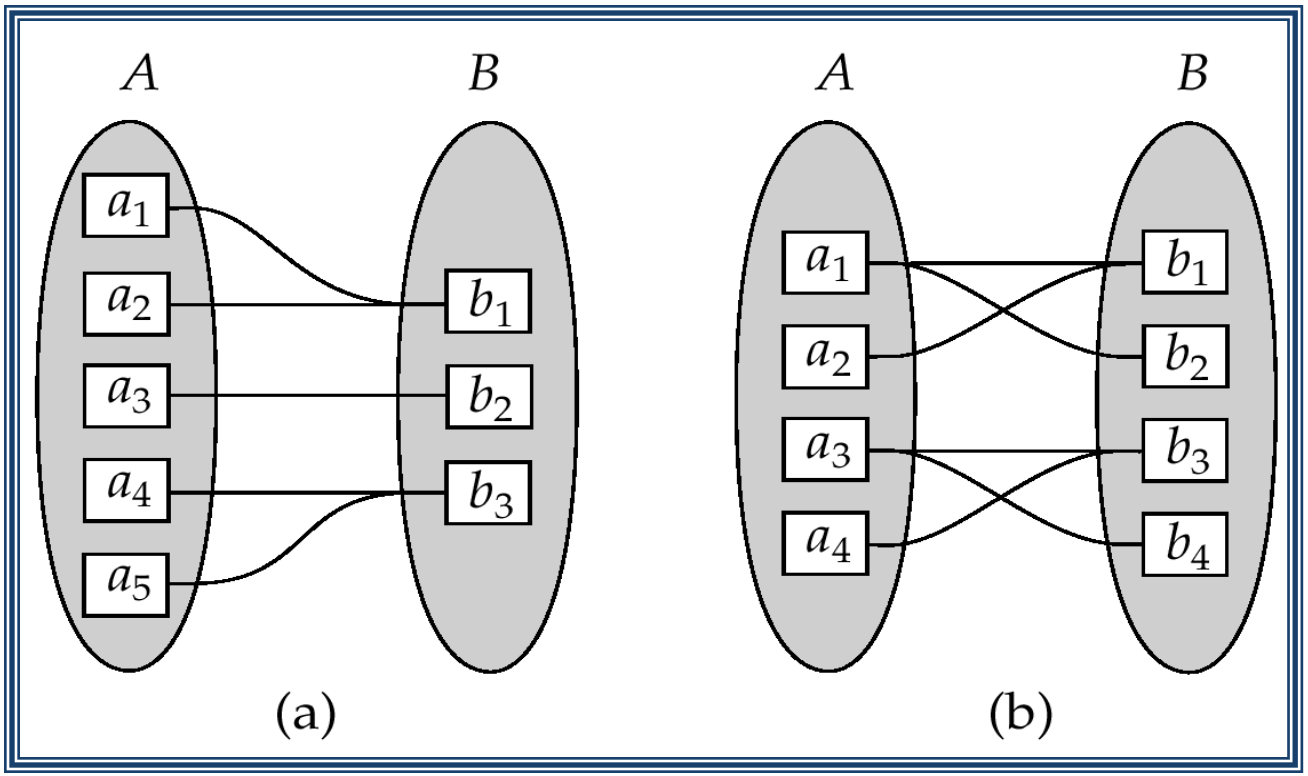
- Many to one

- many-to-many

One-One and One-Many



Many-one and many-many



Exercise

- Using the STUDENT and PROFESSOR tables given below create an ERD.

Database name: Ch03_CollegeQue

Table name: STUDENT

STU_CODE	PROF_CODE
100278	
128569	2
512272	4
531235	2
531268	
553427	1

Table name: PROFESSOR

PROF_CODE	DEPT_CODE
1	2
2	6
3	6
4	4

Weak Entity Types

* An entity that does not have a key attribute
* A weak entity must participate in an identifying relationship type with an owner or identifying entity type
* Entities are identified by the combination of:
  * A partial key of the weak entity type
  * The particular entity they are related to in the identifying entity type

- Ex: if company policy says that every employee must work for the department then participation of employee in work-for is total.

- Total participation is also called ***existence dependencies***.

- But we can't say that every employee must MANAGE a department .

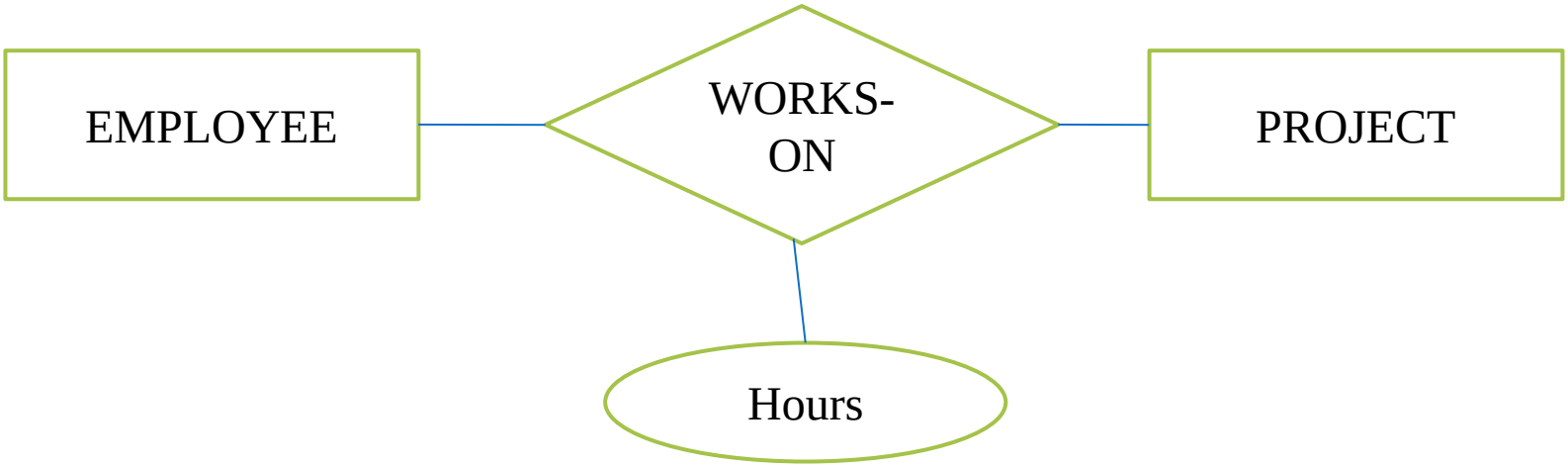
  Hence relationship is ***partial***.

- Total participation is indicated by double line and partial participation by single line.

ATTRIBUTE OF RELATIONSHIP TYPE

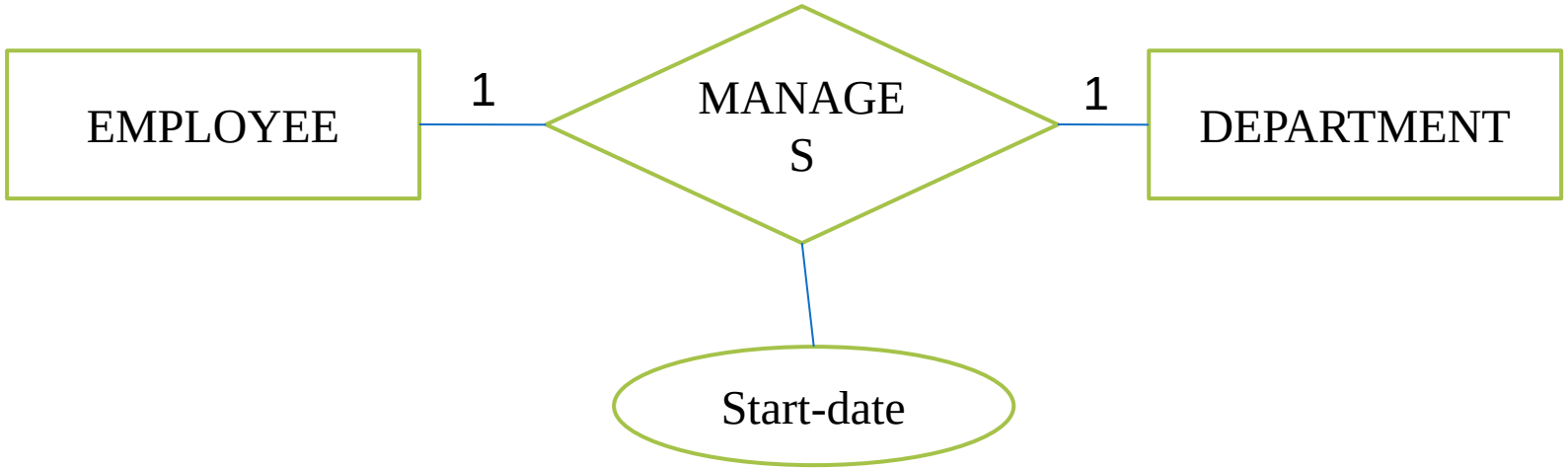
- Relationship can also have attributes

Ex: Hours for WORKS-ON relationship between EMPLOYEE and PROJECT



- Attributes of 1:1 or 1:N relationship ***can be migrated to one of the participating entity types***.

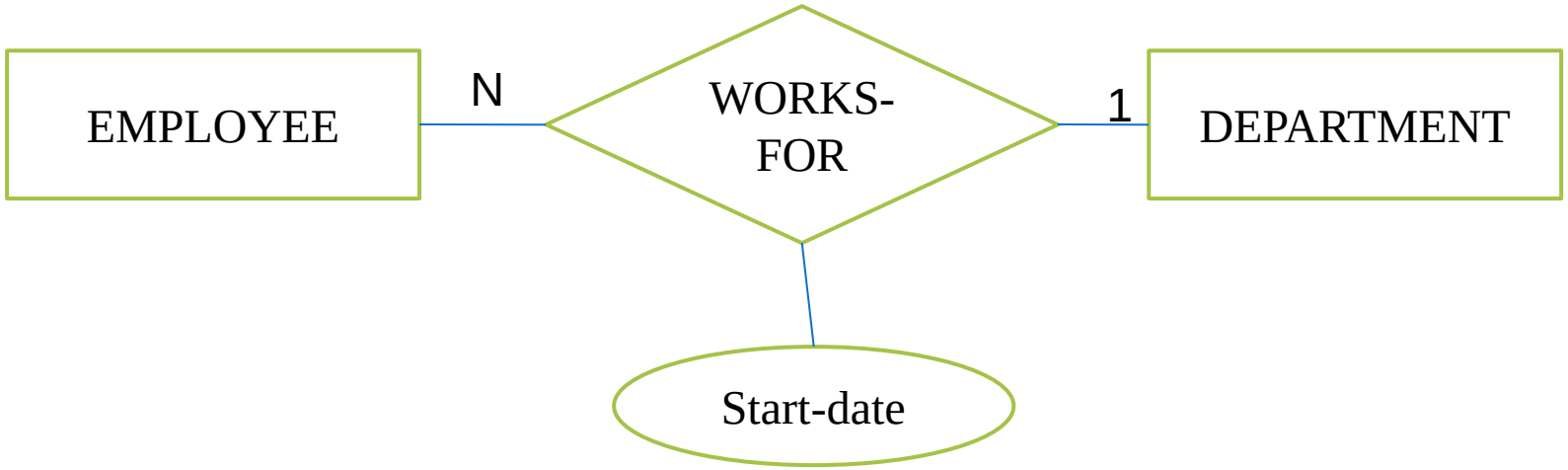
- Ex: Start-date attributes of MANAGES can be attribute of either DEPARTMENT or EMPLOYEE though conceptually it belongs to manages.



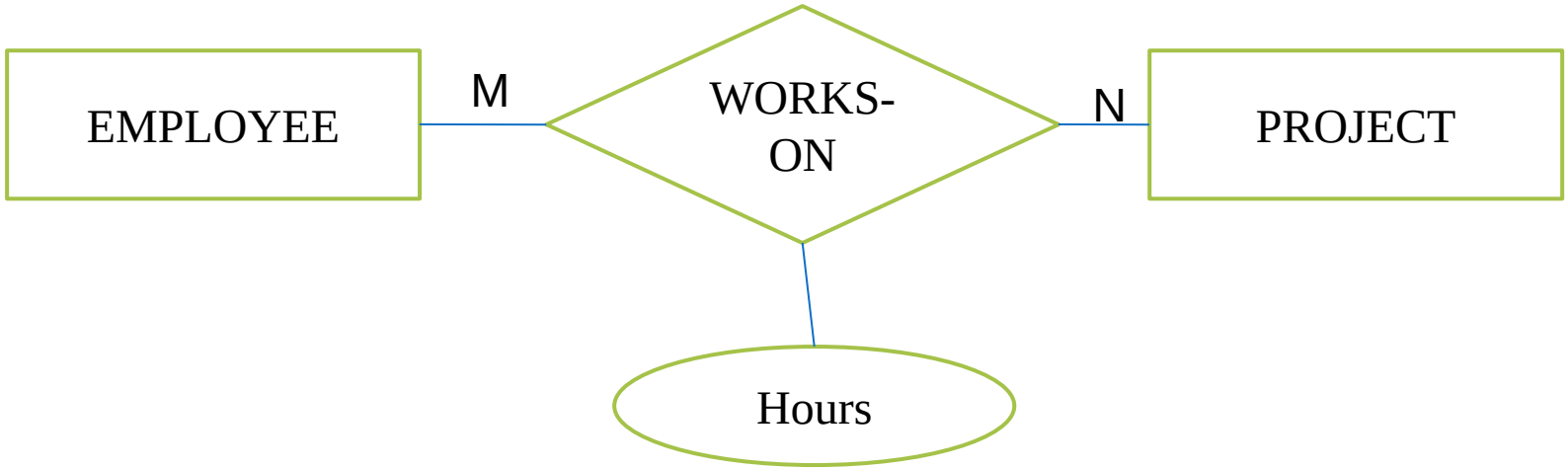
- Because each EMPLOYEE MANAGES is a 1:1 relationship.
- So every DEPARTMENT /EMPLOYEE entity participate in atmost one relationship instance.
- So value of the Start-date can be determined separately either by participating DEPARTMENT entity or participating EMPLOYEE entity.

- For 1:N relationship a relationship attribute can be migrated **only to entity type on N-side of relationship**

- Start-date attribute here can added only to employee.



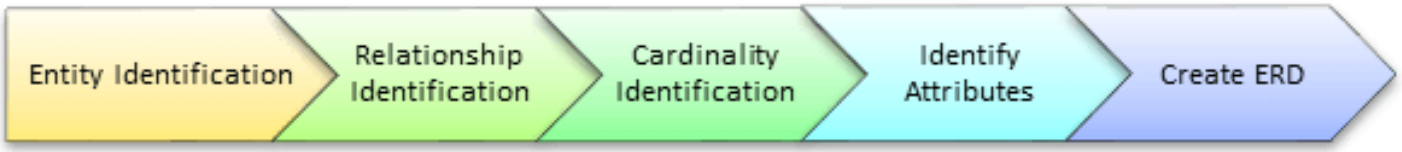
- For M:N relationship types some attribute are determined by the combination of the participating entities, not by a single enity.
- Such attribute ***must be*** specified as the relationship attributes
- Ex: No.of hours an employee works on is department is determent is determined by the EMPLOYEE-PROJECT combination.



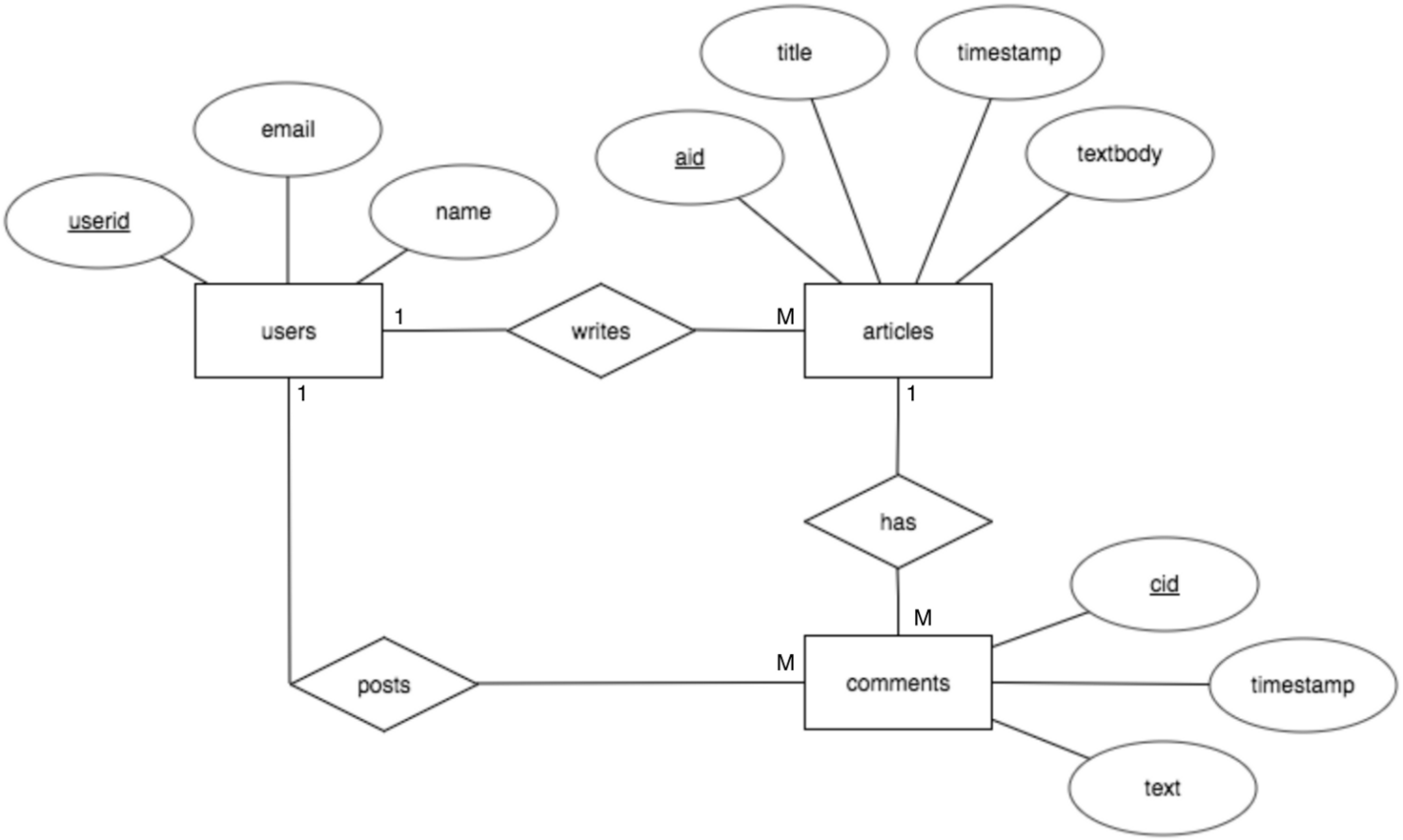
Procedure of ERD

- Data modeling is iterative process.
- “complete” and “100% error free” model is not possible!
- Only “Optimized” model is possible….

Steps to create an ERD



Sample ERD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Exercise

Identify entities, relationships, and cardinalities in the below scenario of a university and create an ER diagram.

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.

Exercise

Create an ERD for the following scenario

The company is organized into DEPARTMENTs. Each department has a name, number and an employee who *manages* the department. We keep track of the start date of the department manager. Each department *controls* a number of PROJECTs. Each project has a name, number and is located at a single location. We store each EMPLOYEE's social security number, address, salary, sex, and birthdate. Each employee *works for* one department but may *work on* several projects. We keep track of the number of hours per week that an employee currently works on each project. We also keep track of the *direct supervisor* of each employee. Each employee may *have* a number of DEPENDENTs who are depending on the employees. For each dependent, we keep track of their name, sex, birthdate, and relationship to employee.

End of the Session