Entities

- Entity:
  - Is a "thing" in the real world with an independent existence (eg. Department, employee, project, … etc). (This is called Strong Entity)
  - It's ER Diagram notation:

ENTITY

  - Example: Department Entity

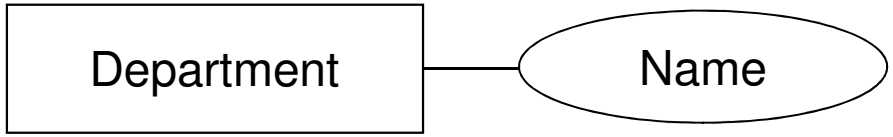
Entity Instance

- An Entity is a general type that includes all instances
- An instance is an example of the entity
- Example:
  - Employee is an entity
  - Ahmad is an instance of entity Employee
- Example:
  - Department is an entity
  - CS Department is an instance of entity Department

Attributes

- Attribute:
  - Properties that describe entities (eg. Employee name, department name, …etc).
  - It's ER Diagram notation

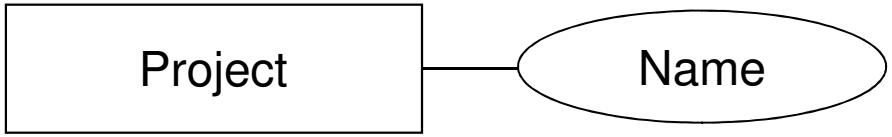
  - Attribute "Value Set" or "Domain"
    - Data type associated with the attribute.
    - Example: EmployeeID is an integer.
    - Example: Grade can take letters "A","B","C","D", and "F".
  - Attribute Example: Name is an attribute of Department



Attribute Types

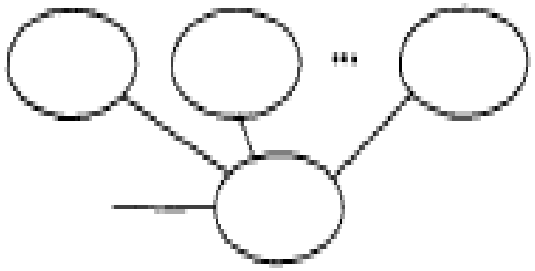
- Simple (Atomic) Attribute
  - Attributes that are not divisible.
  - It's ER Diagram notation is the same as the general attribute you saw in the previous slide.

  - Example: Project Name is a simple attribute of entity Project



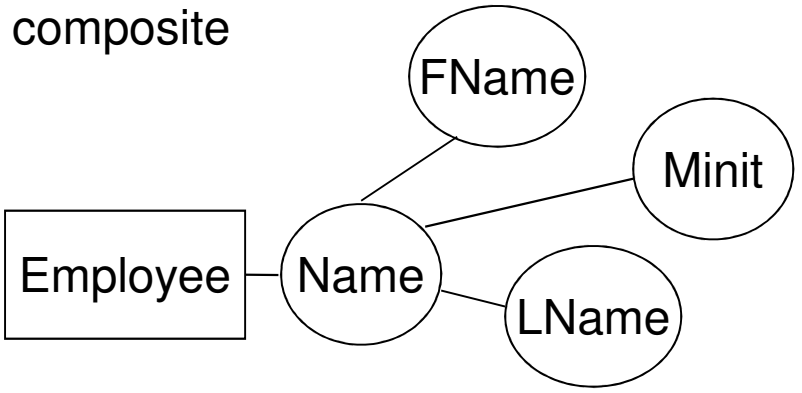
Attribute Types

- Composite Attribute
  - Can be divided into smaller subparts.
  - Example: Address can be derived into “city”, ”street”, ”building number”, and “apartment number”.
  - It’s ER-Diagram notation:



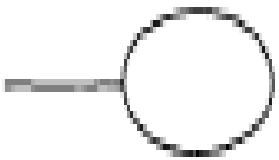
COMPOSITE ATTRIBUTE

Example: Employee Name can be composite



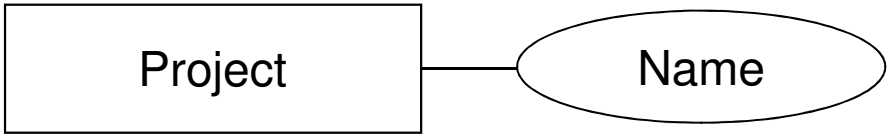
Attribute Types

- Single-Valued Attribute:
  - A **single** entity has a **single** value of that attribute.
  - Example: employee ID. A **single** employee has only one **single** ID.
  - Its ER Diagram notation is the same as a general attribute .



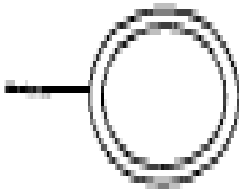
ATTRIBUTE

A **single** project has a **single** name



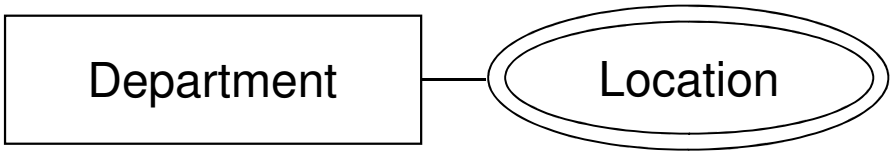
Attribute Types

- Multi-Valued Attribute:
  - A **single** entity has a **multiple** values of that attribute.
  - Example: Employee earned degree. A **single** employee can have **multiple** degrees (B.SC + MS + PhD degrees).
  - Its ER Diagram Notation is **two nested circles**.



MULTIVALUED ATTRIBUTE

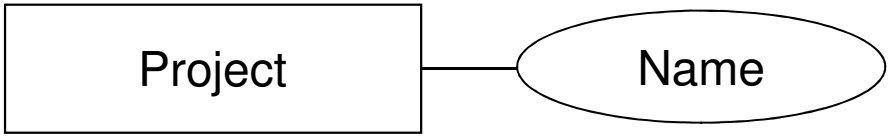
Example: A **single** department can have **multiple** locations



Attribute Types

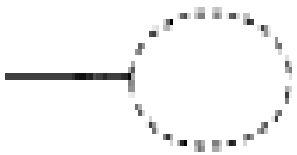
- Stored Attribute
  - Cannot be derived from any other attribute.
  - Example: Birth Date.
  - Its ER-Diagram Notation is the same as the general attribute notation.

Example: Name is a stored attribute of project entity



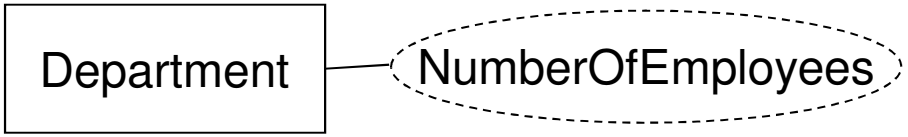
Attribute Types

- Derived Attribute
  - Can be derived from a “Stored Attribute”.
  - Example: employee age can be derived from his birth date and today’s date.
  - Its ER Diagram Notation is **dashed** circle.



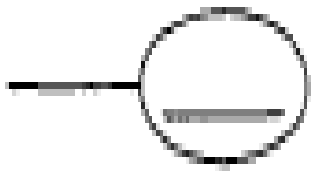
DERIVED ATTRIBUTE

Example: NumberOfEmployees
Is a derived attribute of entity Department.
It is derived from count of records.



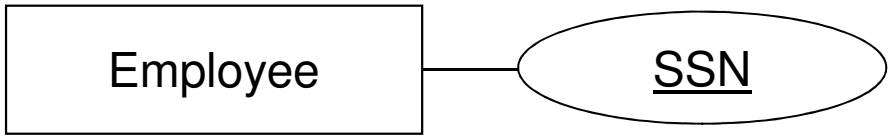
Attribute Types

- Key Attribute:
  - Its value uniquely identifies the entity it belongs to.
  - Example: employee ID uniquely identifies an employee.
  - Its ER Diagram Notation is an **<u>underlined attribute name</u>**.



KEY ATTRIBUTE

Example: SSN is a key attribute of entity Employee



Key Attribute Examples

- What is the key of the following entities?

Entity	Key
Student	Student_id
Employee	Employee_id
Course	Course_number
Section	section_id, course_number, semester,year
Bank branch	bank_id, branch_id
Employee Project	employee_id, project_id

Attribute Types

- Complex Attribute
  - Uses **multi-level of nesting** in a **multi-valued** or **composite** attributes.
  - Example:
    - PreviousDegreesof a STUDENT is a **composite** **multi-valued** attribute denoted by {PreviousDegrees(College, Year, Degree, Field)}.
      - Here we used “Multi-value” and “Composite”.
      - “Multi-value”: A **single** student can have **multiple** degrees.
      - “Composite”: each degree can be specified by several attributes (college, year, degree, field)

Note

- One attribute can have different types at the same time.

- For example: Project Name is:
  - Stored Attribute.
  - Key Attribute.
  - Single-Valued Attribute.
  - Simple Attribute.

Null Values

- Some attribute values could be optional or may be they are not crucial to have.
- For example, if you have an attribute **Hobbies**. It is OK for the value of this attribute to be missing. In this case, we call it “NULL” value.
- Key Attributes **cannot** be NULL because they uniquely identifies an entity, so they have to have a value.

More about “Key” Attributes

- A key uniquely identifies each entity in Entity Set.
- For example: StudentID is a key for student entity because each student has different (Unique) ID.
- Some times key attributes can be **composite** attributes. This happens when a single attribute cannot satisfy the “Uniqueness Requirement”. Example:

  SectionID, courseID, Semester,Year

  1 , 34234, first, 2010

  1 , 34234, first, 2009

  1 , 44478, Sum, 2010

- In this example, Section entity has one key.
- This key consists of combination of 4 attributes.

Keys should be Minimal

- A key is minimal if it cannot be broken into smaller parts that work as a key.

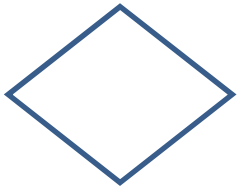
- For example:
  - SectionID, courseID, Semester,Year
  - Is it Minimal?
  - Yes, because non of its smaller parts can work by itself as a key.

- Keys should be minimal.

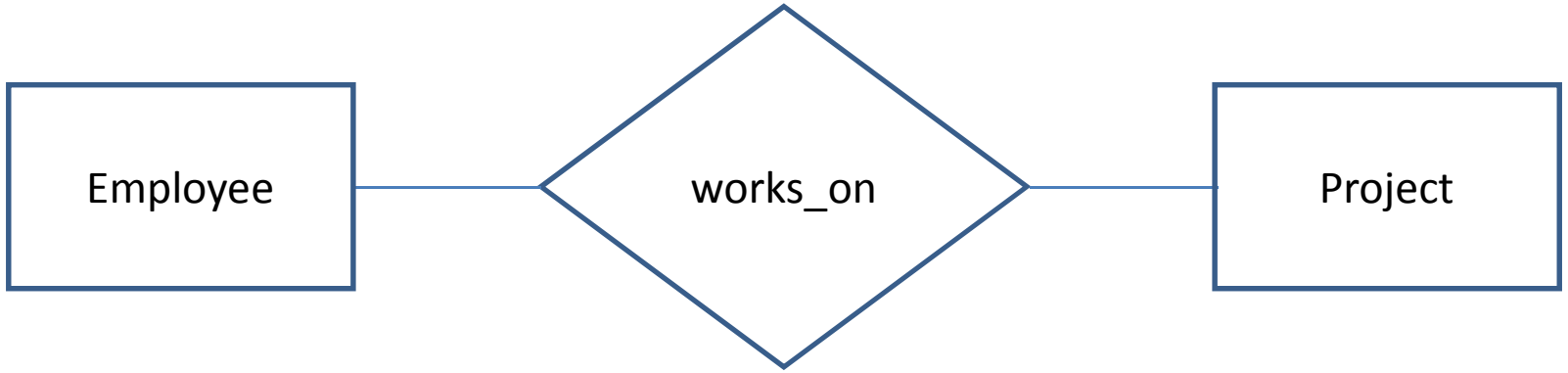
- “studentID+studentAge”, is it minimal key of Student?
  - No, because “studentID” by itself works as a key.

Relationship

- A Relationship is an association between two or more entities.
- It is represented in ER diagram by using the following shape which is connected to participating entities.



- Usually, a “verb” is written inside the relationship shape because verbs can express why the entities are connected with each other.



Relationship Degree

- Relationship **degree** is the number of participating entity types.

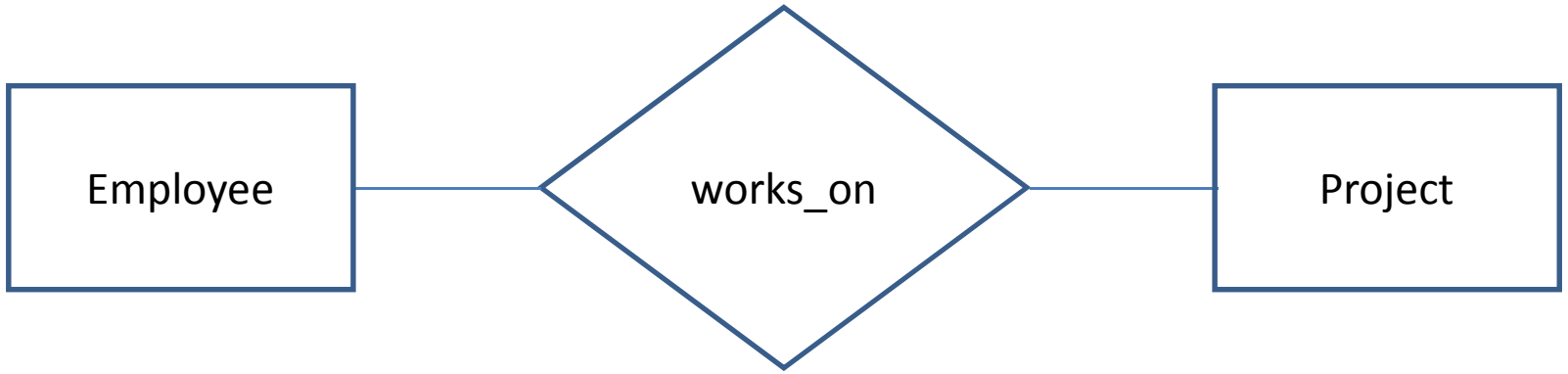
- Possible relationship degrees are
  - Binary Relationship: includes 2 entity types.
  - Ternary Relationship: includes 3 entity types.
  - N-ary Relationship: includes N entity types.

Relationship Degrees

1) Binary Relationship: Includes two entity types.

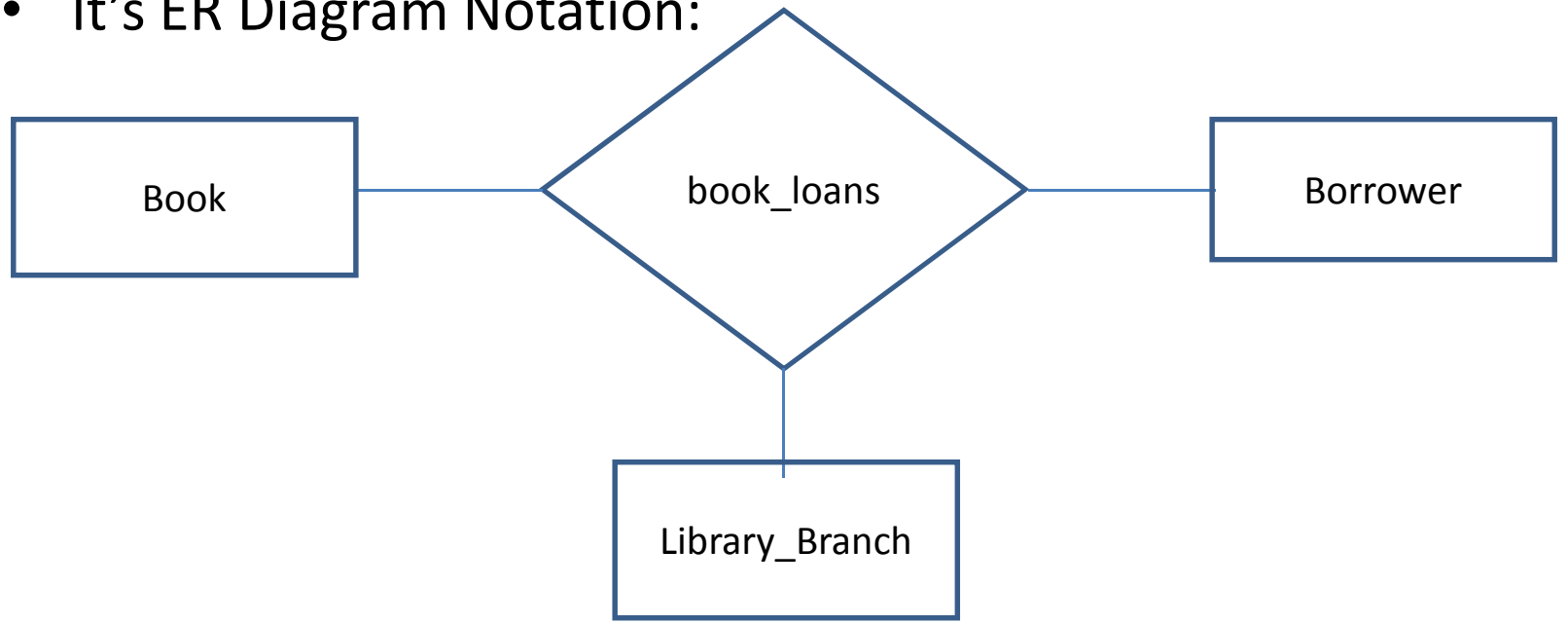
2) Example: Employee “works_on” Project.

3) Its notation in ER Diagram is as follows.



Relationship Degree

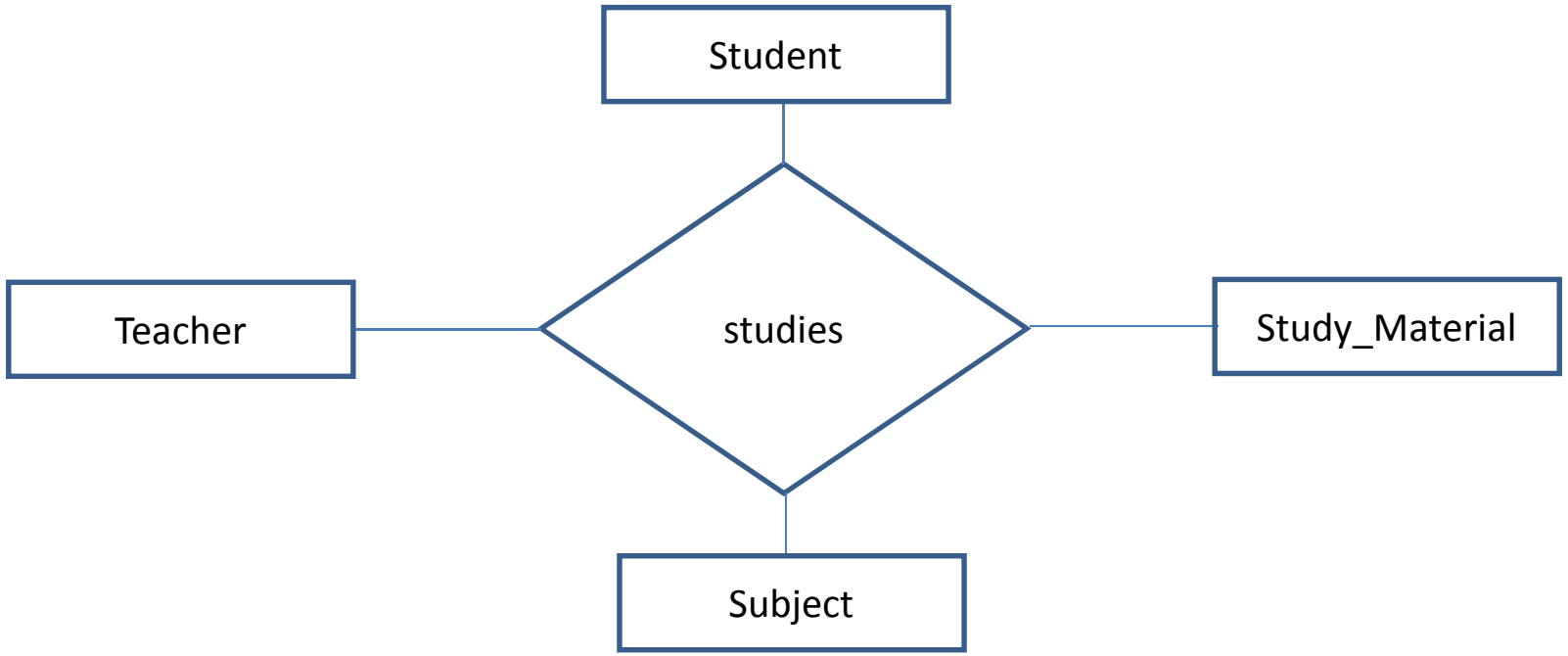
- Ternary relationship: includes 3 entity types
- Example: Book_loans: is a relationship that shows:
  - Each borrowed book (**Book**)
  - Who borrowed it (**Borrower**)
  - Which library branch the book was borrowed from (**Library_Branch**)
- It's ER Diagram Notation:



Relationship Degrees

- N-ary Relationship: includes N entity types.

- Example: studies: is a 4-ary relationship that shows that a "**student**" studies a "**subject**" with a "**teacher**" and the help of "**study_material**".

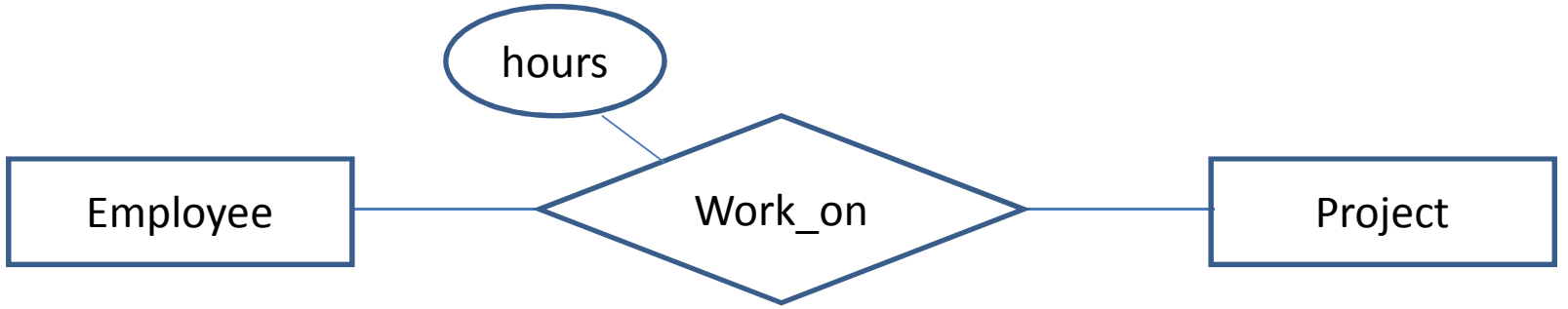


Relationship Attributes

- In some cases, a relationship type can have attributes.
- Usually, in these cases, the attribute does not belong to any of the participating entities (exclusively).
- Because of that, we add the attribute on the relationship.

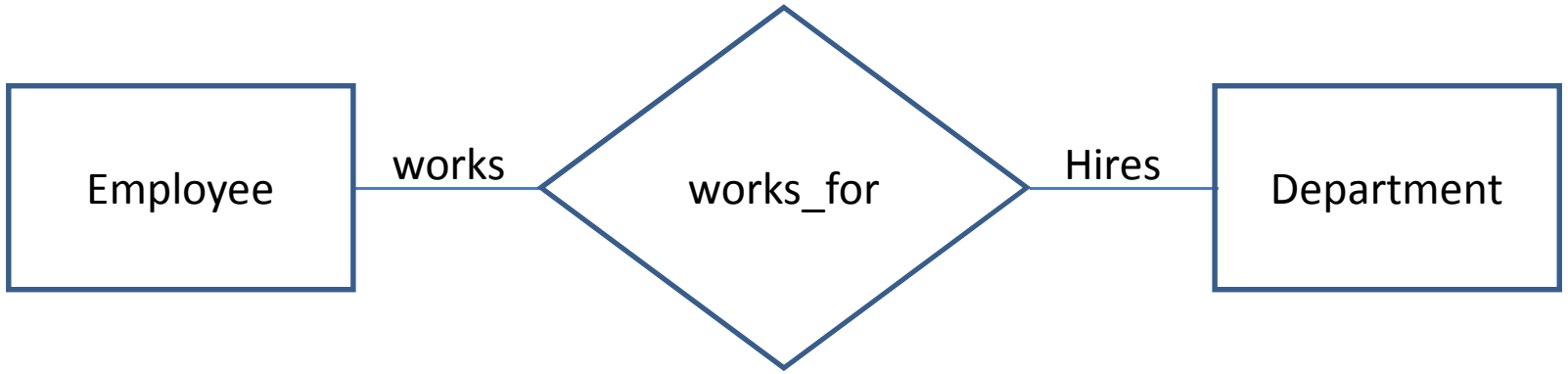
Relationship Attributes

- Examples:
  - start_date: is an attribute that specifies the start date of an employee as a manager of a department. It does not belong to employee or department exclusively. But, it belongs to both of them, therefore we place it on the relationship “manages”.
  - Hours: is an attribute that specifies the number of hours an employee works on a project. It does not belong to employee nor project exclusively. Therefore we place it on relationship “works_on”.



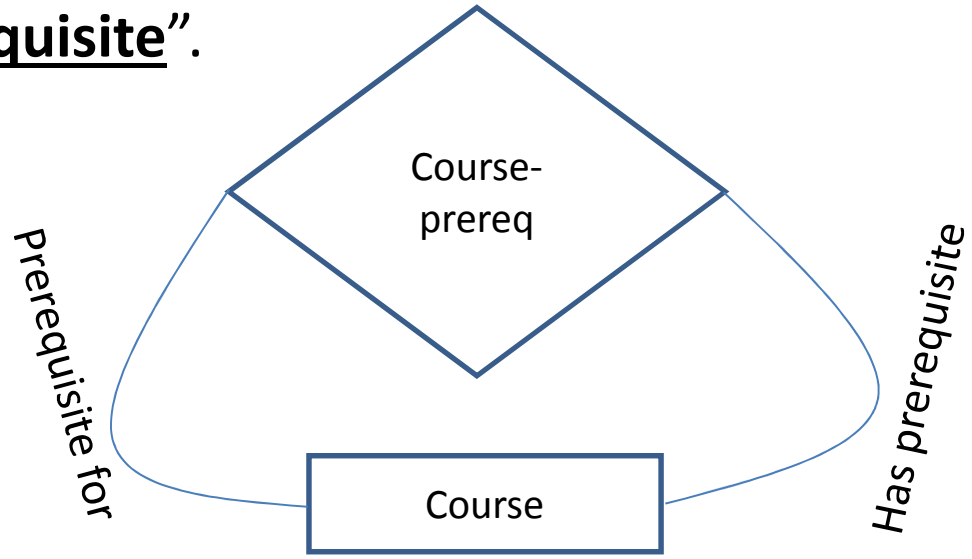
Entity Roles

- In any relationship, entity has a role that specifies what it does in a relationship.
- Example: In Employee “works_for” department relationship:
  - Employee Role: “worker” (works in department)
  - Department Role: “Employer” (employs employee)
- Entity roles can be written on relationship lines in ER Diagram. But they are **implicitly** known, so they are not necessary unless we have a recursive relationship (Look Next Slide).



Recursive Relationship

- Recursive Relationship is a relationship between an entity and itself.
- Example: Course_Prereq is a recursive relationship that shows courses and their prerequisite.
- Notice that entity role is important here because we need to know which course is a "**prerequisite for**" and which course "**has prerequisite**".

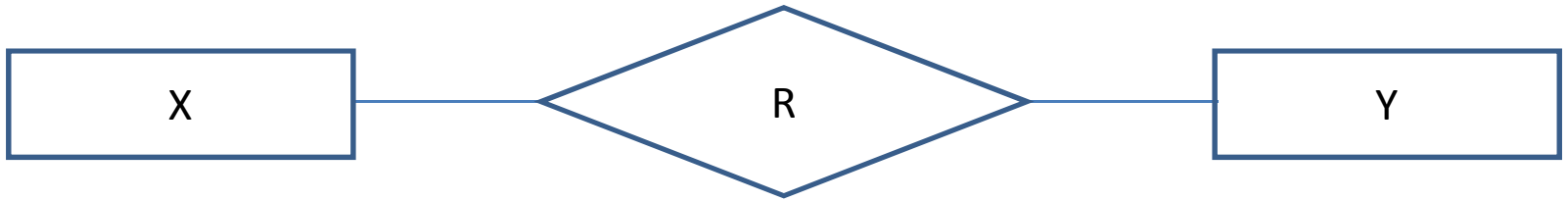


Constraints on Relationships

- Constraints should be reflected in ER diagram.
- They are called **Structural Constraints**.
- For example: Each employee works on “only one project”.
- Types of Structural Constraints:
  - Cardinality Ratio (Maximum Cardinality)
  - Participation (Minimum Cardinality)

Cardinality Ratio (Maximum Cardinality)

- Cardinality Ratio: is the maximum number of “relationship instances” that an entity can participate in. (Maximum Cardinality)
- Types of cardinality ratio :
  - 1:1 --- It is read as (one to one), 1 instance of entity x can be connected to only 1 instance of entity Y via relationship R and vice versa.
  - 1:N --- It is read as (one to many), 1 instance of entity x can be connected to N instances of entity Y via relationship R.
  - M:N --- It is read as (many to many), M instances of entity x can be connected to N instances of entity Y via relationship R and vice versa.



Cardinality Ratio (Maximum Cardinality) (1:1)

Examples:

- **One** department is managed by only **One** employee.
- **One** employee can manage only **One** department.

Employee ---Manage--- Department

Ahmad ——— CS_Dep

Subresult: 1 to 1

Employee ---Manage--- Department

Ahmad ——— CS_Dep

Subresult: 1 to 1

Final Result: (take the max on each column)

1 to 1
1 to 1
---
1 to 1

(Final Result)

Cardinality Ratio (Maximum Cardinality) (1:N)

Examples:

- **One** teacher can teach **Many** sections
- **One** section is only taught by only **One** teacher

Teacher---Teach--- Section

Dr. Ahmad — DB-Sec1
Java-Sec2
Compilers-Sec1

Subresult: 1 to N

Teacher---Teach------ Section

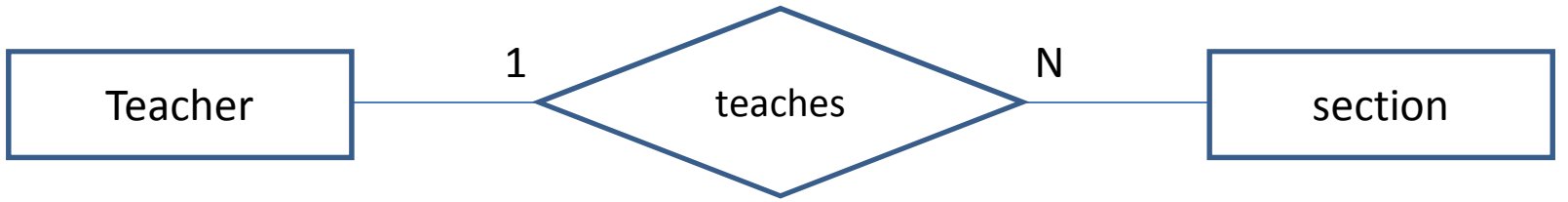
Dr. Ahmad — DB-Sec1

Subresult: 1 to 1

Final Result: (take the max on each column)

1 to N
1 to 1
---
1 to N

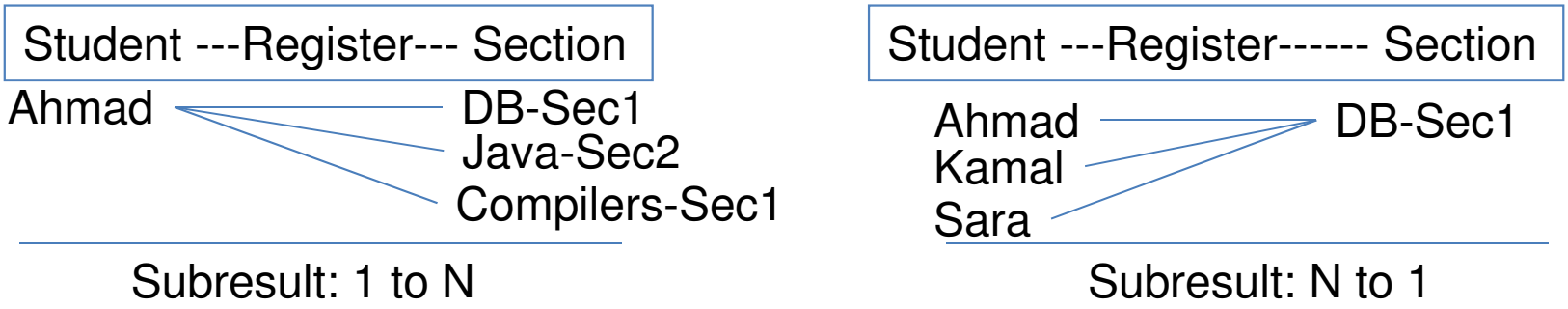
(Final Result)



Cardinality Ratio (Maximum Cardinality) (M:N)

Examples:

- **One** student can register for **Many** sections
- **One** section can be registered for by **Many** students



Final Result: (take the max on each column)

1	to	N
N	to	1
N	to	M

(Final Result) (switch one N to M to fix ambiguity)

Constraints on Relationships

- Types of Structural Constraints:
  - Cardinality Ratio (Maximum Cardinality)
    - We already discussed this one.
  - Participation (Minimum Cardinality)
    - Now, we look into this.

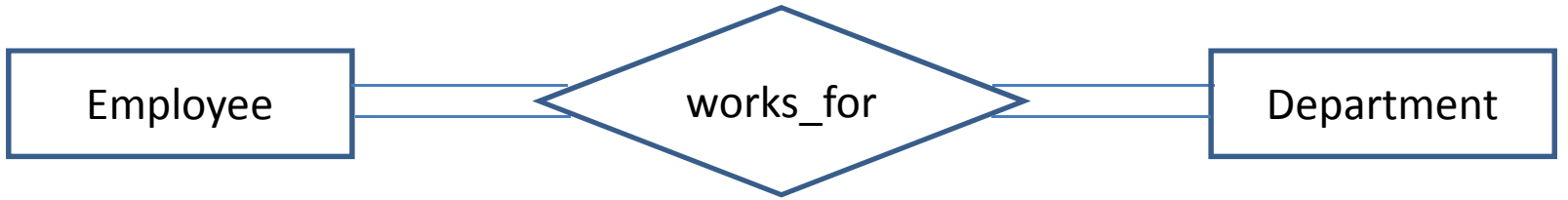
Participation Constraints

- The participation constraint specifies whether the existence of an entity depends on it being related to another entity via the relationship type. This constraint specifies the "**minimum**" number of relationship instances that each entity can participate in.

- Two types of participation constraints:
  - Total Participation (Existence Dependency)
  - Partial Participation

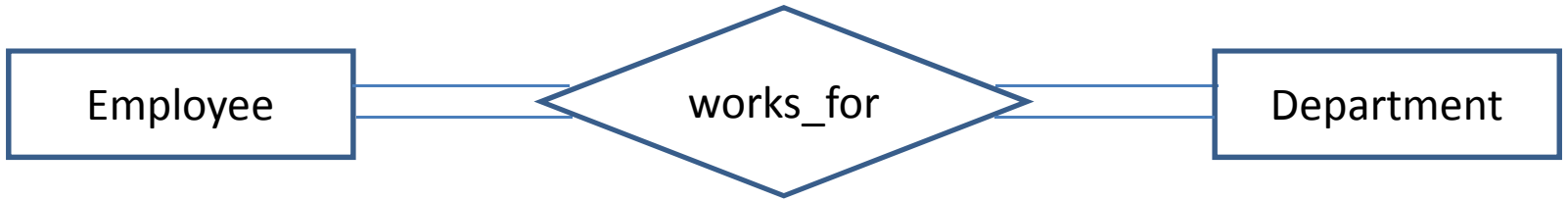
A way to think of participation constraints

- Example 1:
  - Employee “works for” department
  - Total Participation from **Employee side** (how?)
  - Assume that the **company has 3 employees**. Should **all** of the employees belong to at least one department ?
    - If the answer is yes: (Total Participation) (represented by two lines)
    - If the answer is No: (Partial Participation) (represented by one line)
  - In our example, the answer is “yes”



A way to think of participation constraints

- Example 1:
  - Employee “works for” department.
  - Total Participation from **department side** (how?)
  - Assume that the **company** has **3 departments**. Should **all** departments have employees working in them ?
    - If the answer is yes: (Total Participation) (represented by two lines)
    - If the answer is No: (Partial Participation) (represented by one line)
  - In our example, the answer is “yes”



A way to think of participation constraints

- Example 2:
  - Employee “manages” department.
  - Partial Participation from **employee side** (how?)
  - Assume that the **company** has **3 employees**. Should **all** employees manage departments ?
    - If the answer is yes: (Total Participation) (represented by two lines)
    - If the answer is No: (Partial Participation) (represented by one line)
  - In our example, the answer is “No” because some employees are not managers.

A way to think of participation constraints

- Example 2:
  - Employee “manages” department
  - Total Participation from **department side** (how?)
  - Assume that **company** has **3 departments**. Should **all** departments be managed by employees?
    - If the answer is yes: (Total Participation) (represented by two lines)
    - If the answer is No: (Partial Participation) (represented by one line)
  - In our example, the answer is “yes”

Weak Entity

- A weak entity: is an entity with a primary key that does not come from its own attributes.
- Strong entity: is an entity that does have a key attribute “from within its own attributes”.
- Weak entity is only identified by being related to another strong entity.
- This kind of relationship is called **identifying relationship**.
- Weak Entities are identified by a combination of:
  - **Partial Key**: Some attributes of weak entity.
  - **Strong Entity Key**: Key of strong entity that defines weak entity.
- **Weak entity key = partial key of weak entity + key of strong entity**

Weak Entity

- Example: Assume that employees can have dependents.
- By dependents we mean “Son”, “Daughter”, “Wife”, … etc.
- Dependents are only identified through employees they belong to.
- For example: Employee Ahmad has a dependent, his daughter “Sara”. Sara is only identified by being related to Ahmad.
- Dependent can be identified by a combination of:
  - **Partial key**: may be “**First Name**” of dependent, assuming that dependents of the same employee do not have similar first name.
  - **Strong Entity Key**: Key of employee (**employeeID**)
- **Key of dependent is**: dependent name + employee ID

Weak Entity

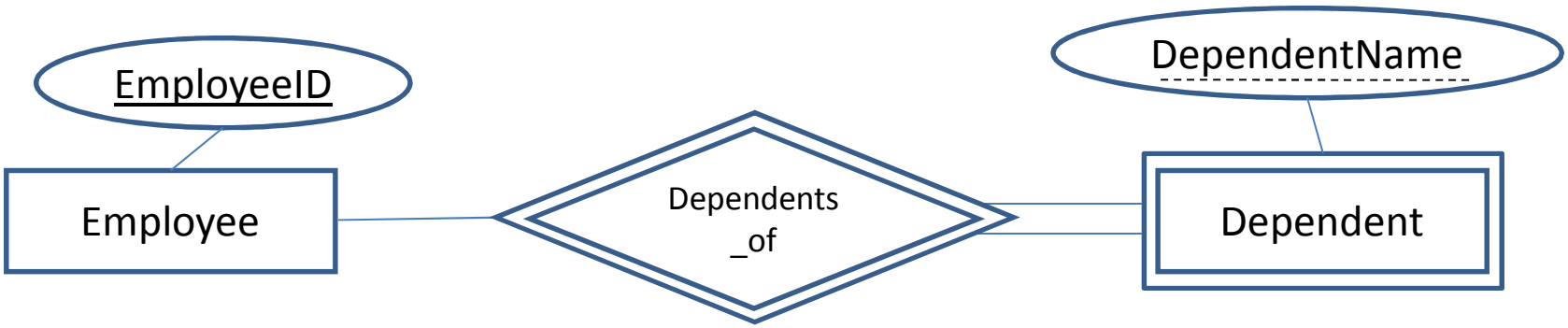
- For example assume employee with ID "**365**" has **two** dependents, his **daughter "Sara"** and his **son "Kamal"**. Also employee with ID 300 has a son "Kamal", then dependents are identified as:

EmployeeID	DependentName	Relationship
365	Sara	Daughter
365	Kamal	Son
300	Kamal	Son

- Notice that partial key cannot work as key by itself.
  - in this example, the two employees have a son named "Kamal". So, "kamal" (dependent name) cannot be a key for dependent. This is why it is called **partial key**.

Weak Entities

- Weak entities are represented in ER Diagram by a double lines in entity and relationship shapes.
- Also, because weak entities depend on a strong entity in order to exist, then weak entities **always** has "**total participation**" in the **identifying relationship**. (represented by double lines).
- In ER diagram, a **partial key** is underlined with a **dashed** line.



More Examples (Registration DB)(Entities)

- **Student**: Each student has an id, a name that is composed of a first name, middle initial, and last name. Each student has an address, gender, major, class, and birth date.
- **Course**: Each course has an id, name, and credit hours.
- **Instructor**: Each instructor has an id, a name, address, major, and degree.
- **Department**: Each department has an id, and name.
- **Section**: Each section has an id which is “not” unique among other sections. Each section has a semester and year in which it was offered.

More Examples (Registration DB) (Relationship)

- Student “registers-for” Section
- Instructor “teaches” Section
- Course “has” Section
- Course is “offered by” Department
- Student “belongs to” a Department
- Course “belongs to” a Department
- Instructor “belongs to” a Department

More Examples (Registration DB) (ERD)