Lecture 2

Entity- Relationship Model

COMP3278A

Introduction to Database Management Systems

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Acknowledgement: **Dr. Chui Chun Kit**

Outcome based learning (OBL)

- Outcome 1. **Information Modeling**
  - Able to understand the modeling of real life information in a database system.
- Outcome 2. **Query Languages**
  - Able to understand and use the languages designed for data access.
- Outcome 3. **System Design**
  - Able to understand the design of an efficient and reliable database system.
- Outcome 4. **Application Development**
  - Able to implement a practical application on a real database.

We are going to learn…

- Introduce the Entity-Relationship (E-R) Diagram
- More examples using the E-R Diagram

Section 2.1

E-R Diagram

E-R Diagram

Four concepts

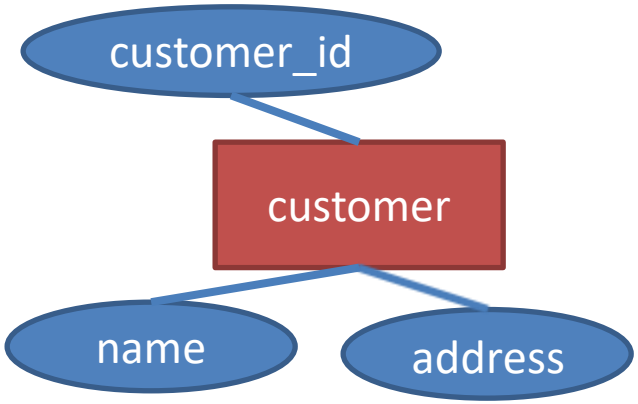
- 1. Entity and Entity set
- 2. Relationship and Relationship set
- 3. Constraints
- 4. Keys

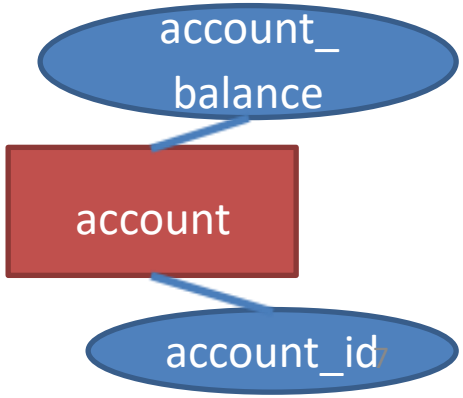
1. Entity and Entity set

- **Entity**
  - An object that exists and is distinguishable from other objects.
  - E.g. A customer, an account, a department, etc.
- **Entities have Attributes**
  - People have names and address.
- **Entity set**
  - A set of entities of the same type that share the same properties (or attributes).
  - E.g., a set of all customers, all saving accounts, all departments in the company, etc.

1. Entity and Entity set

- **In the E-R Diagram**
  - **Rectangles** – entity sets.
  - **Ellipses** – attributes.
  - **Line between a rectangle and an ellipse** – link between an attribute and an entity set.





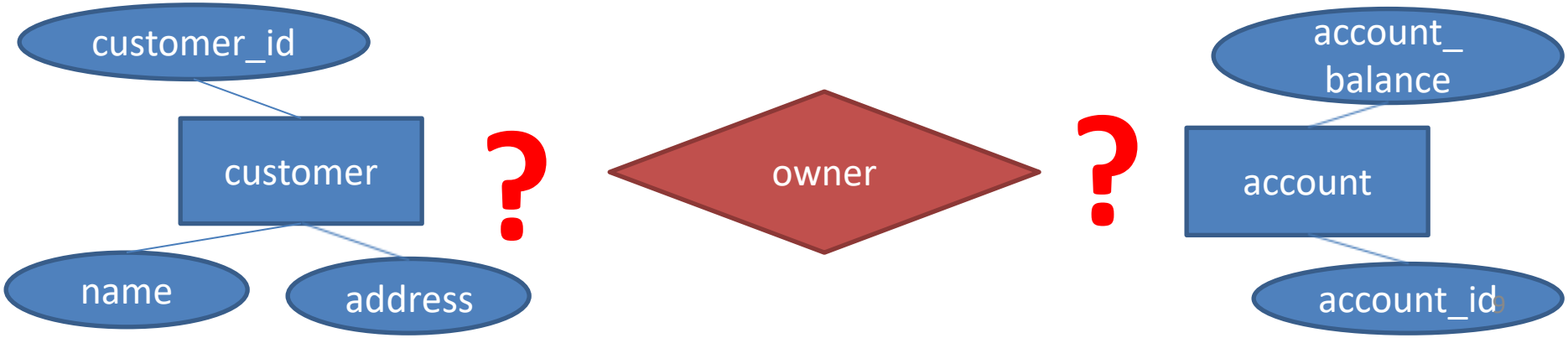
2. Relationship and Relationship set

- **A relationship is an association among entities.**
  - E.g., the relationship between the customers and the accounts.
- **A relationship set is a set of relationships of the same type.**

2. Relationship and Relationship set

- **In the E-R Diagram**
  - **Diamond** – a set of relationships

What are the constraints in specifying the relationship between two entity sets?

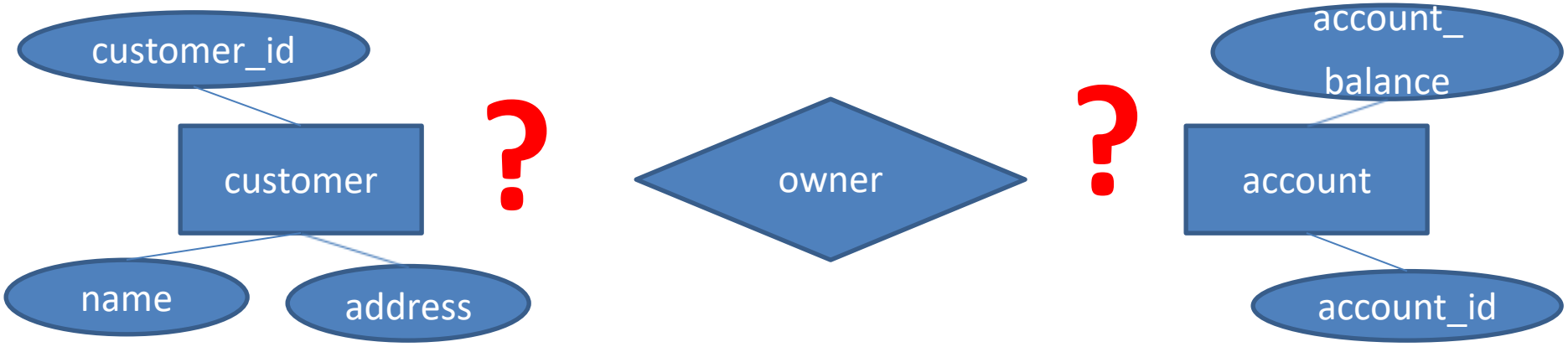


3. Constraints

- **Mapping cardinalities**
  - Concerns the number of entities to which another entity can be associated via a relationship set.
  - E.g. For each customer, how many accounts he/she can have? **One or more than one**?
- **Participation constraints**
  - Concerns whether all entities in the entity set have to participate in the relationship set.
  - E.g. whether a customer **must have** an account record, or there can be some customers **without** any accounts?

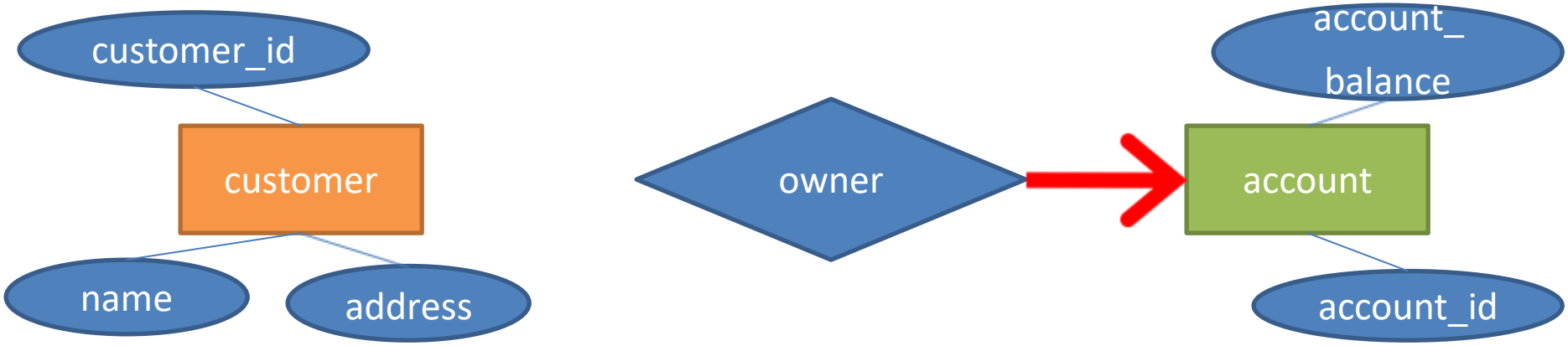
Mapping cardinalities

- We express **cardinality constraints** by drawing either **a directed line (→)**, signifying "**one**," or **an undirected line (—)**, signifying "**many**," between the relationship set and the entity set.



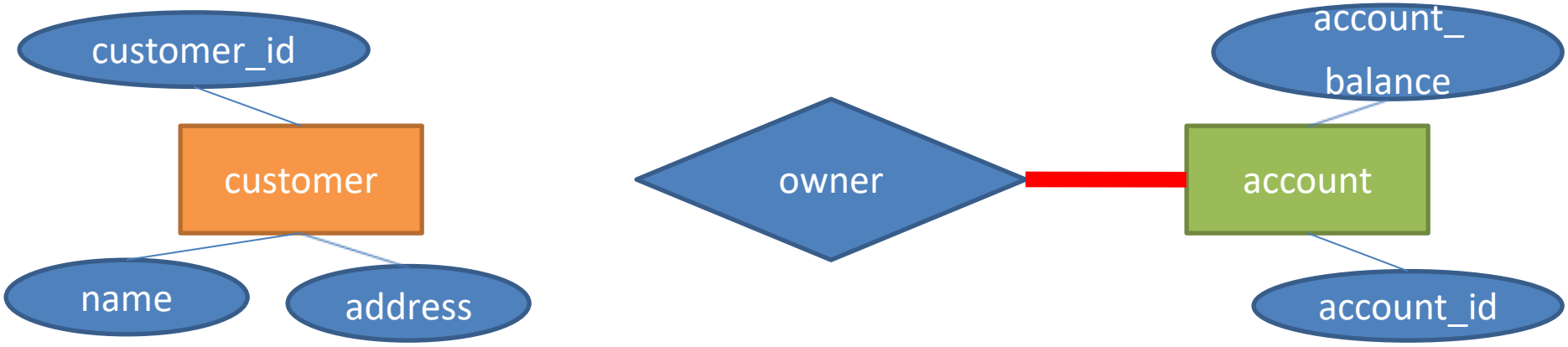
Mapping cardinalities

- A **customer** can have at most **one account**.



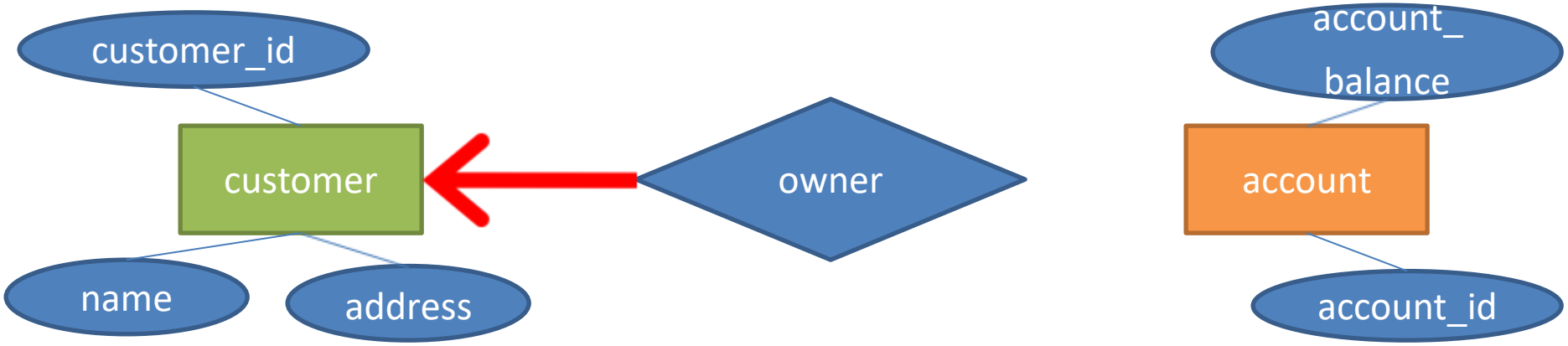
Mapping cardinalities

- A **customer** can have **more than one accounts**.



Mapping cardinalities

- An **account** can be associated with at most **one customer**.



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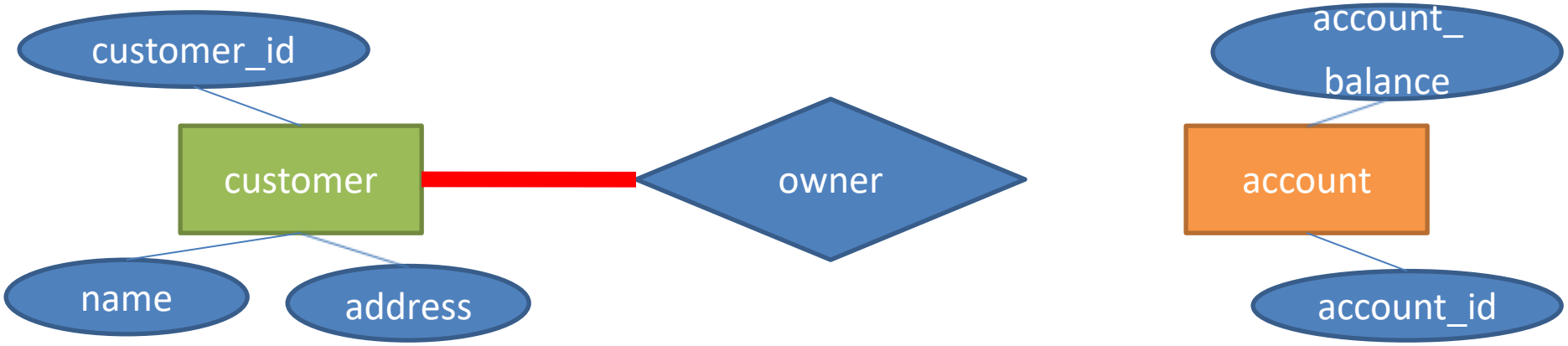
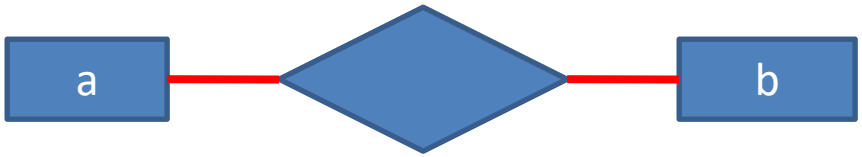
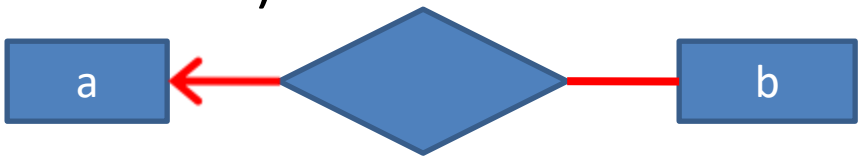


Mapping cardinalities

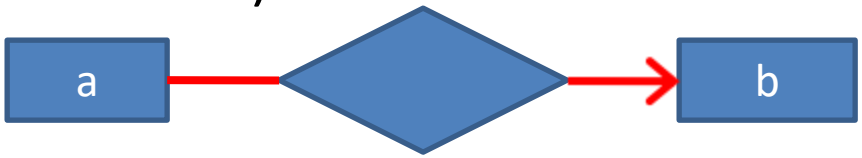
- **Different mapping relationships:**
  - Many to many.



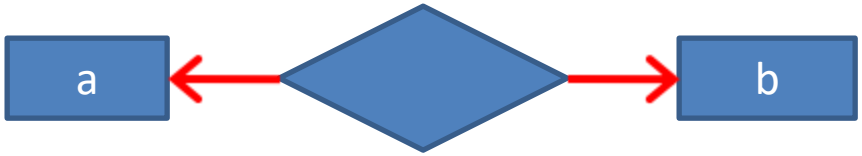
  - One to many (from a to b).



  - Many to one (from a to b).



  - One to one.



Mapping cardinalities

Please build a system to store the **customer** and **account** information of UBank. For each customer, we record his/her **customer ID**, **name** and **address**; for each account, we record its **account ID** and **account balance**. **Each customer can have one or more accounts, and each account has to be owned by only one customer**.

Step1. Identify the Entity sets.

Mapping cardinalities

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account

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Step2. Identify the Relationship sets.

customer

account

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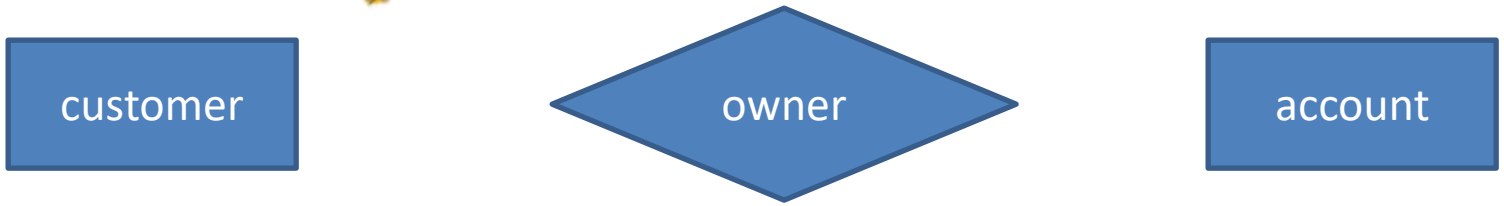
Step3. Identify the attributes.



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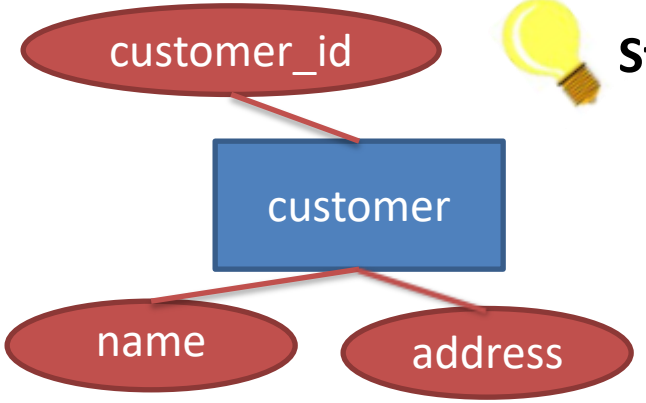

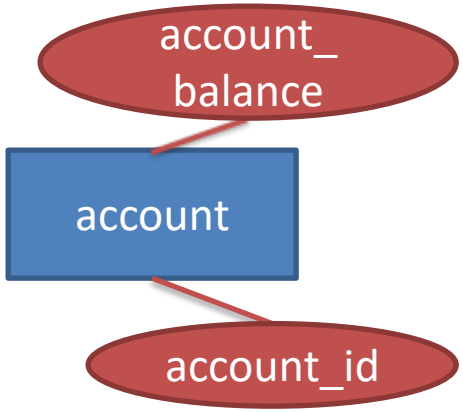

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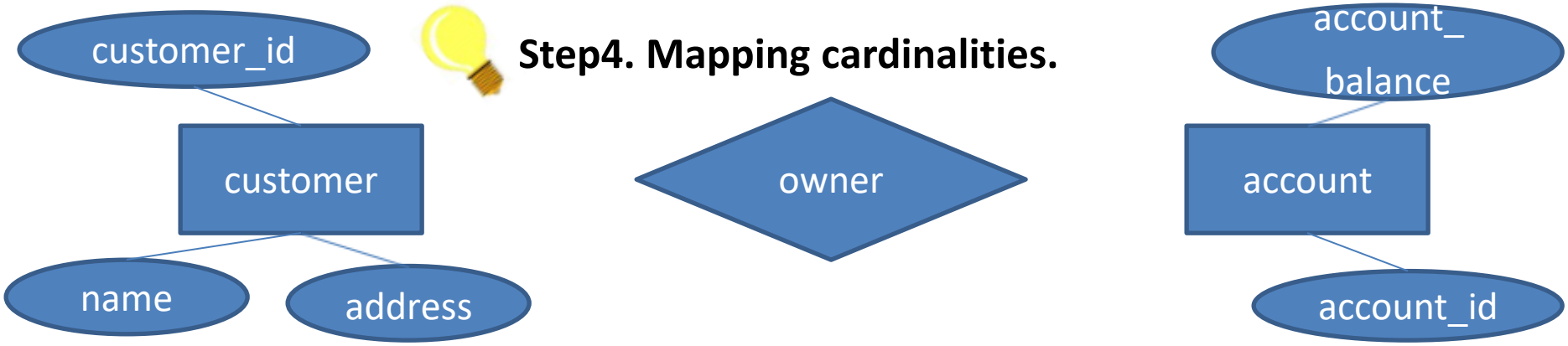
Step4. Mapping cardinalities.



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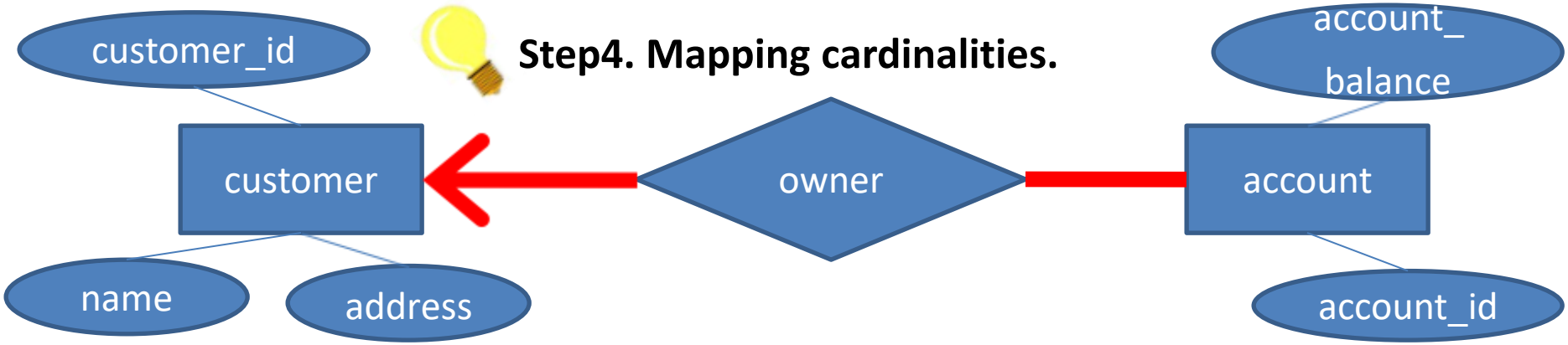


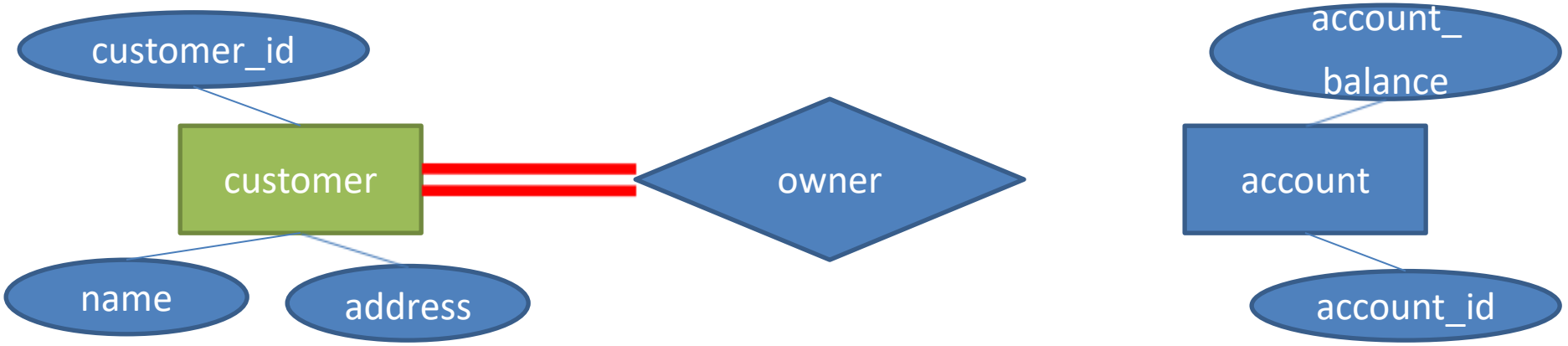
Note: this ER-Diagram is incomplete! Some more steps in the next few slides including the participation, primary keys …etc

Participation constraints

- Concerns whether all entities in the entity set have to participate in the relationship.
  - **Total participation** (indicated by double line): every entity in the entity set participates in at least one relationship in the relationship set.
  - **Partial participation** (indicated by single line): some entity may not participate in any relationship in the relationship set.

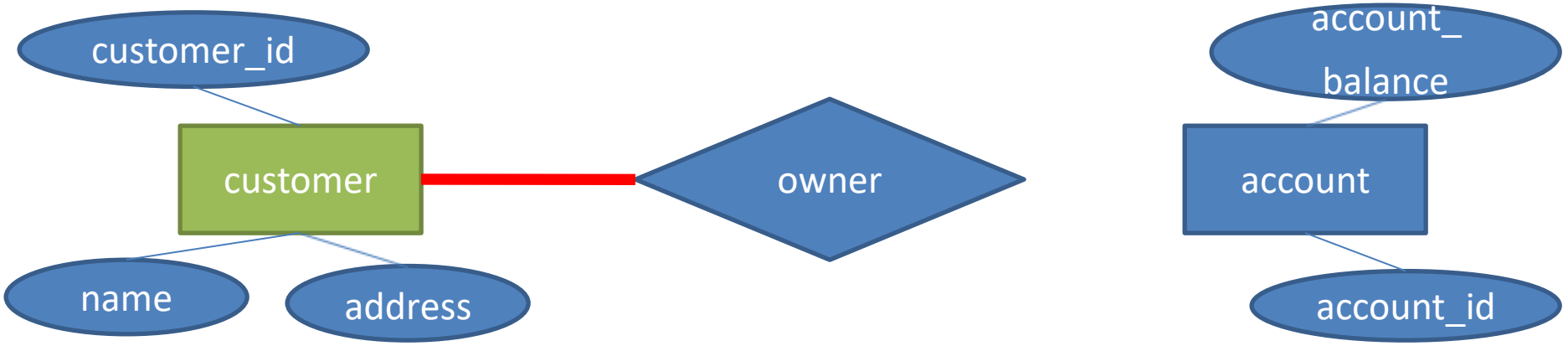
Participation constraints

- Each customer **must have an account**.
  - **Total participation**: All **customers** must participate in the owner relationship.



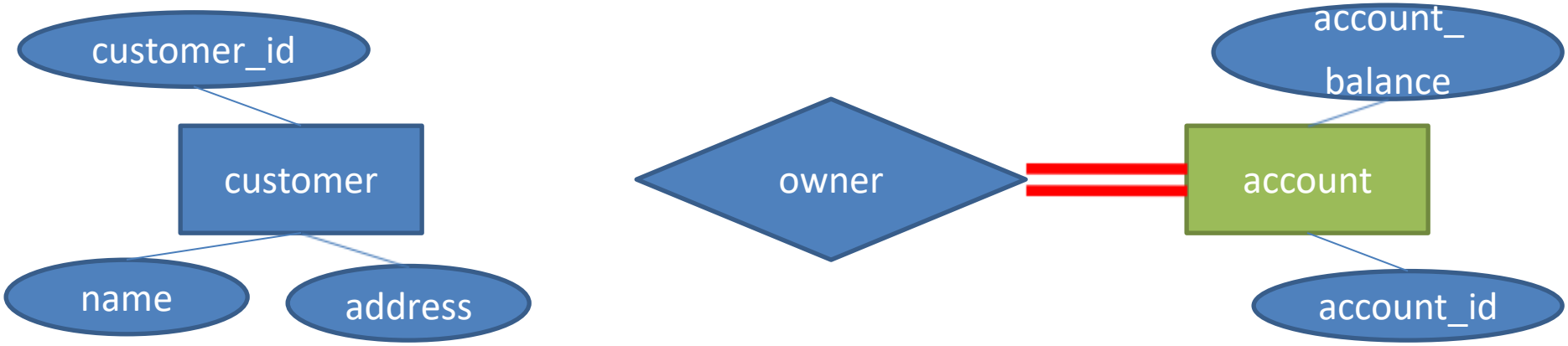
Participation constraints

- Not all customers are required to have an account.
  - **Partial participation**: Not all **customers** participate in the owner relationship.



Participation constraints

- Each account must be owned by customers.
  - **Total participation**: All **accounts** participate in the owner relationship.



Practical issues

- **As a professional DB designer, you have to be able to:**
  - Understand and model the data of an application using a E-R diagram.
  - Interact with the client to work out a clear problem definition.
  - Realize the missing information and ask your client for clarification.
  - Provide professional suggestions to better design the database for the specific application.

Practical issues

Please build a system to store the customer and account information of our bank. For each customer, we record his/her customer ID, name and address; for each account, we record its account ID and account balance.

Do we have enough information to model the data of this application? What questions should I ask?

Practical issues

Please build a system to store the customer and account information of our bank. For each customer, we record his/her customer ID, name and address; for each account, we record its account ID and account balance.

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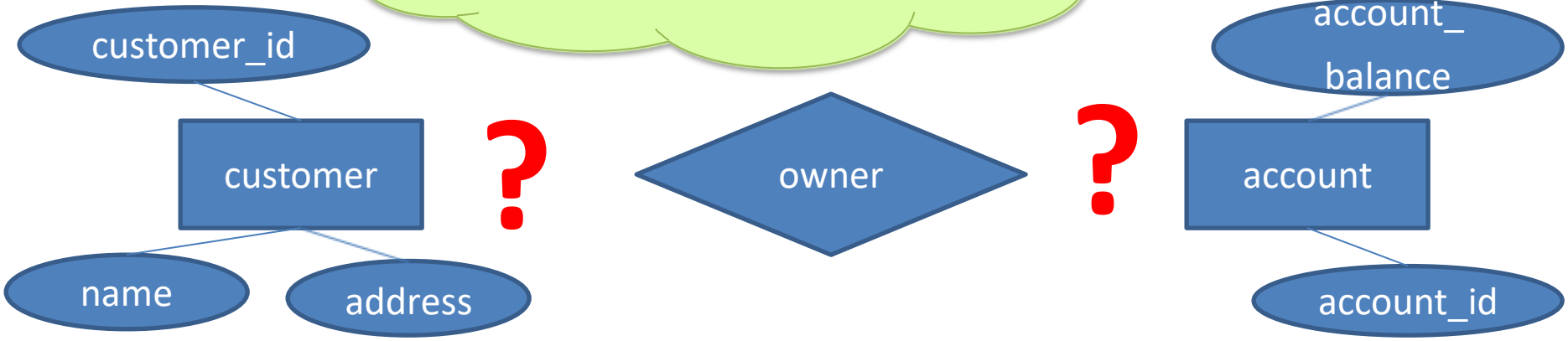


To Recap

- **Entity and entity set, Entities have Attributes**
- **Relationship and relationship set**
- **In the E-R Diagram**
  - **Rectangles** – entity sets.
  - **Ellipses** – attributes.
  - **Line between a rectangle and an ellipse** – link between an attribute and an entity set.

To Recap

- **Mapping cardinalities (many, one)**
  - Concerns the number of entities to which another entity can be associated via a relationship set.
  - E.g. For each customer, how many accounts he/she can have? **One or more than one**?
- **Participation constraints (full, partial)**
  - Concerns whether all entities in the entity set have to participate in the relationship set.
  - E.g. whether a customer **must have** an account record, or there can be some customers **without** any accounts?

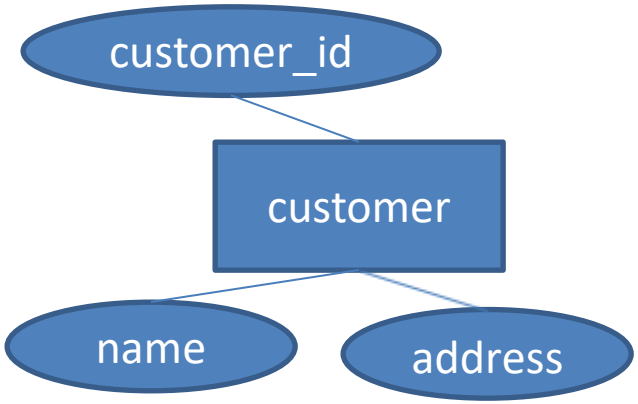
Keys

Attributes

- Super key
- Candidate keys
- Primary key

Super key

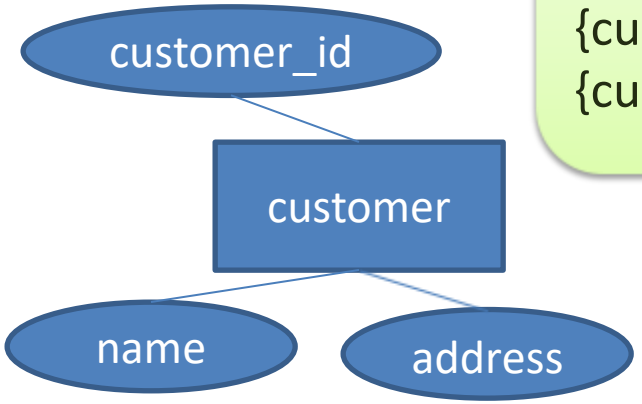
- A **super key** of an entity set is a set of one or more attributes whose values uniquely determine each entity.
  - No two entities have exactly the same values in super key.



Super key

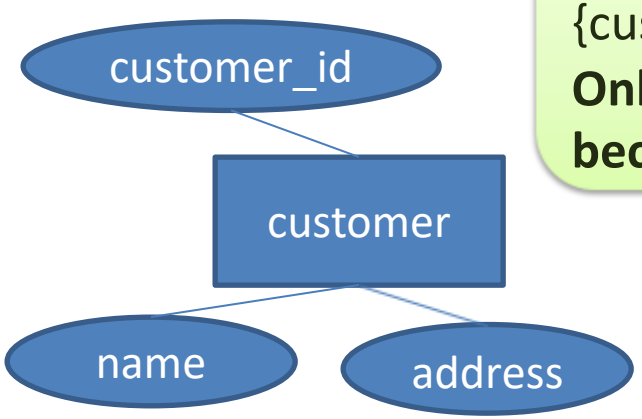
- A **super key** of an entity set is a set of one or more attributes whose values uniquely determine each entity.
  - No two entities have exactly the same values in super key.

In this example, if each customer has his/her **unique customer_id**, then
{customer_id, name} is a super key.
{customer_id, address} is another super key.
{customer_id, name, address} is also a super key.



Candidate key

- A **candidate key** of an entity set is a **minimal** super key.
  - Minimal – no redundant attributes, i.e., no subset of a candidate key is still a key.

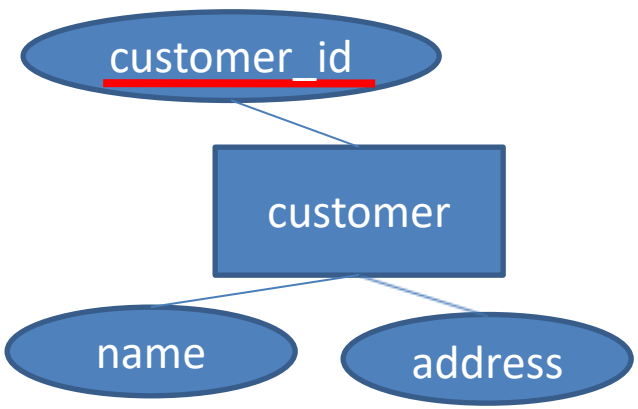


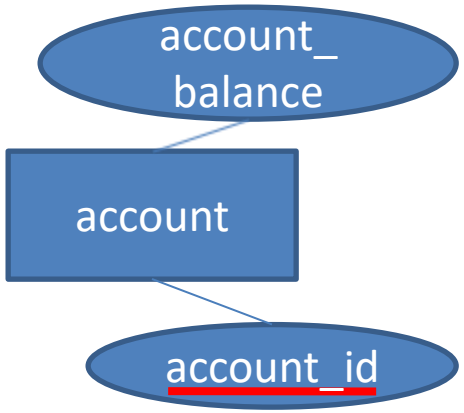
Although the following are super keys:
{ customer_id, name}, {customer_id, address}, {customer_id, name, address}
Only the {customer_id} is a candidate key because it is minimal.

Question:
Can it be more than one candidate key?

Primary key

- Although several candidate keys may exist, one of the candidate keys is selected to be the **primary key**.
- **In the E-R Diagram**
  - **Underline the attribute** – The attribute is a primary key of the entity.





Section 2.2

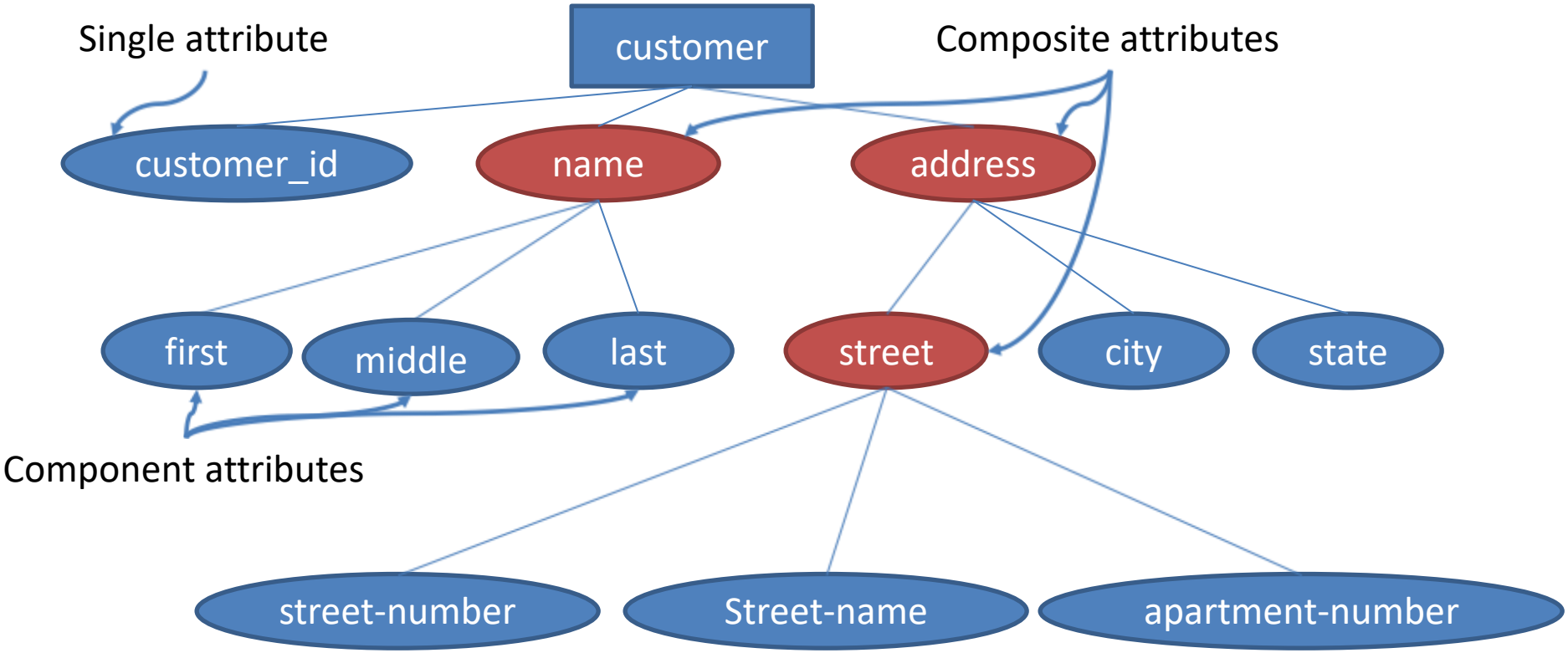
More on E-R Diagram

More on E-R Diagram

- Different attribute types
- Weak entity set
- Role
- Specialization

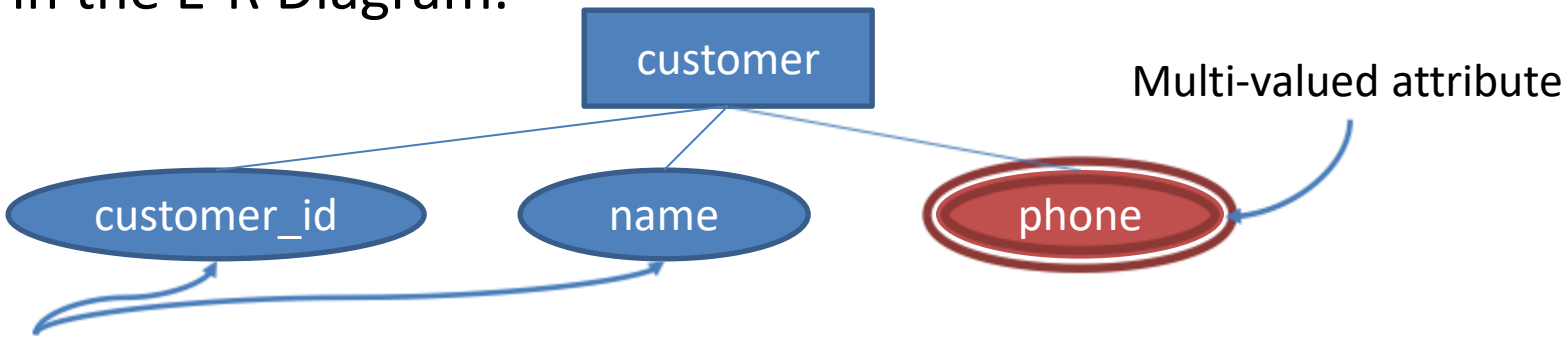
Different attribute types

- **Single v.s. Composite attributes**



Different attribute types

- **Single-valued v.s. Multi-valued attributes**
  - Multi-valued attributes are represented by **double ellipses** in the E-R Diagram.

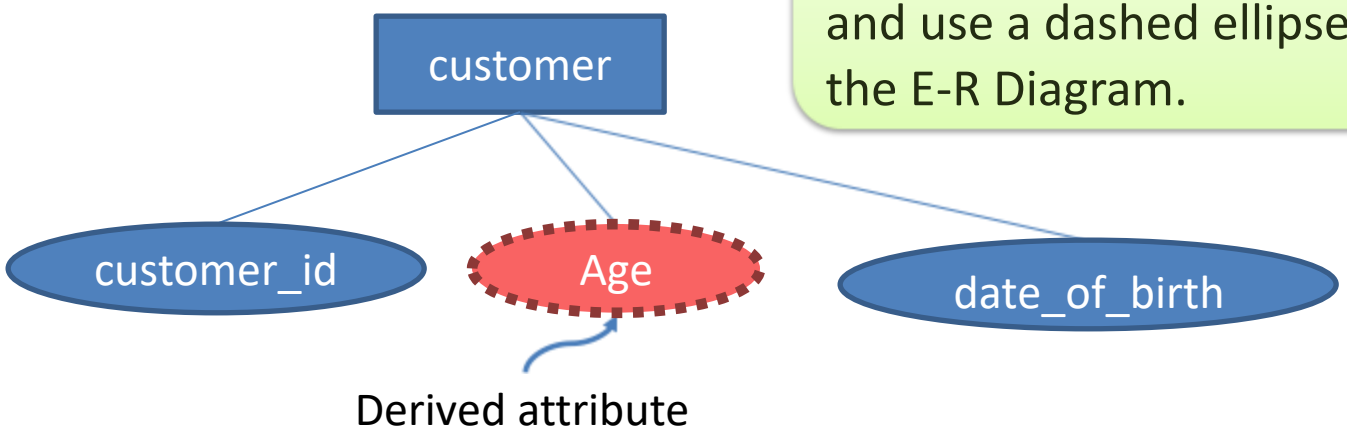


customer_id	name	phone
1	Kit	6012 3456, 9888 8888, 2857 8435
2	Yvonne	6987 6543, 2859 1104
3	Jolly	9876 1234, 2857 8434

Different attribute types

- **Derived attribute**
  - Values in this attribute can be **derived** from other attributes.
  - Derived attributes are represented by **dashed ellipses** in the E-R Diagram.

Since "**age**" can be derived from the "**date of birth**", we treat "age" as a derived attribute, and use a dashed ellipse to represent it in the E-R Diagram.



Weak Entity Set

- **An entity set that does not have a primary key is referred to as a weak entity set.**
- **The existence of a weak entity set depends on the existence of an identifying entity set.**
  - We need the identifying entity set to help to uniquely identify the entities in the weak entity set.

Create a database for storing the NBA teams and the NBA players…

Weak Entity Set

team

player

1. Identify Entity sets:
We have to store the “NBA Teams” and “NBA Players”.

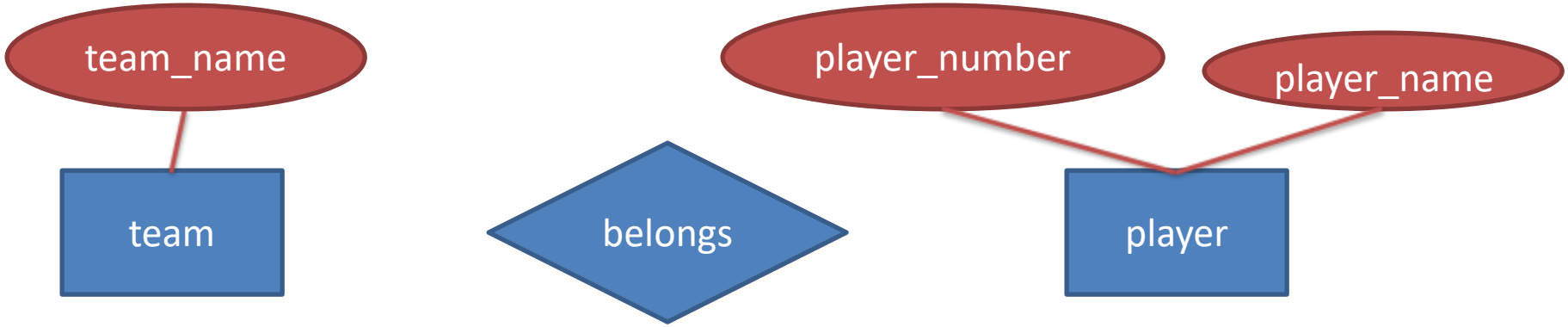
Create a database for storing the NBA teams and the NBA players…

Weak Entity Set

2. Identify relationship set:
Each player **belongs** to a team.

Create a database for storing the NBA teams and the NBA players…

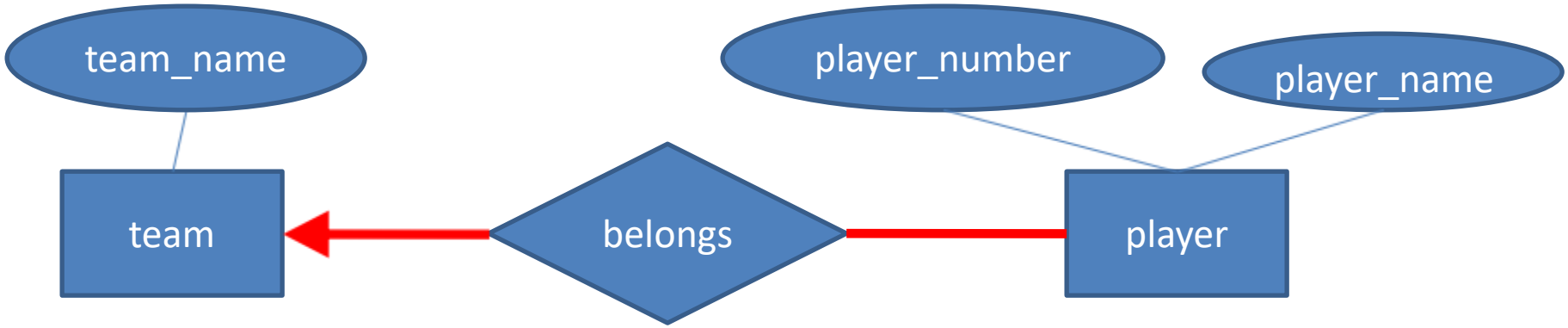
Weak Entity Set



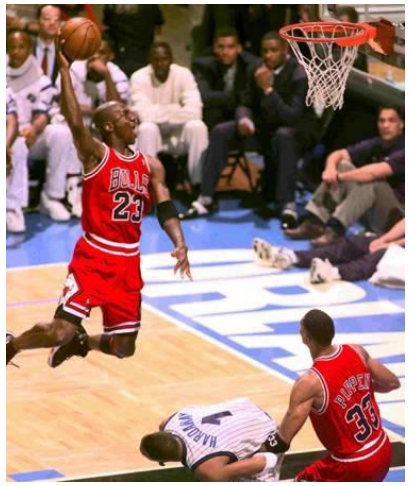
3. Identify the attributes of the entity sets: For each NBA team, we store the team's **name**; for each player, we store his **number** and **name**.

Create a database for storing the NBA teams and the NBA players…

Weak Entity Set

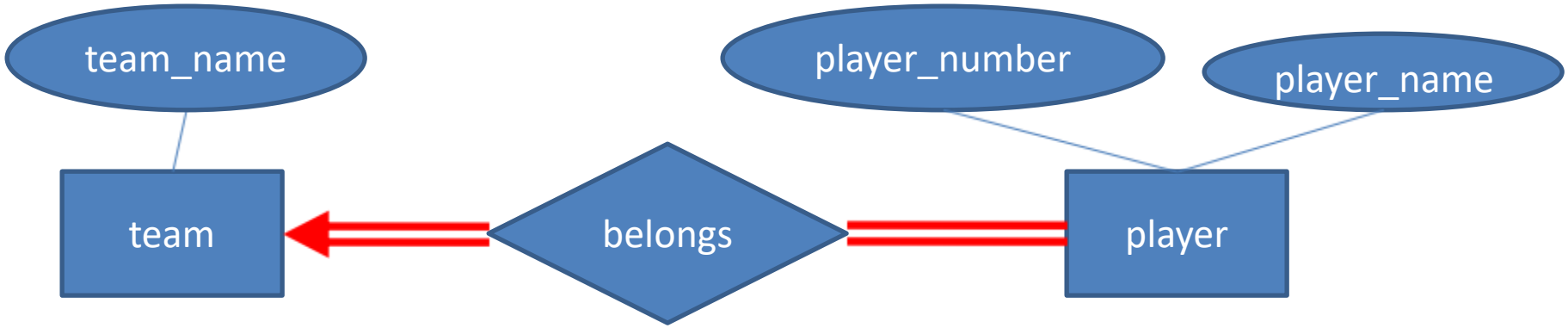


4. Identify the mapping cardinalities:
A team can have more than one players.
A player can belongs to only one team.

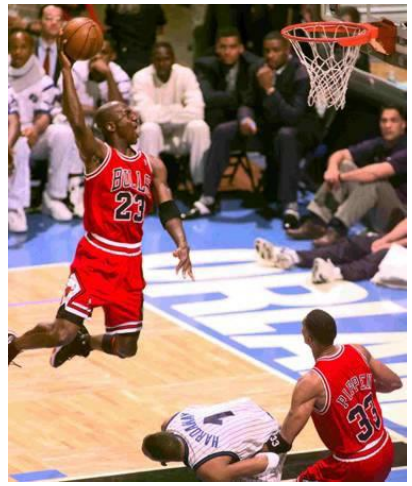


Create a database for storing the NBA teams and the NBA players…

Weak Entity Set



5. Identify the total/ partial participation:
A team must have some players.
A player must belong to a team.



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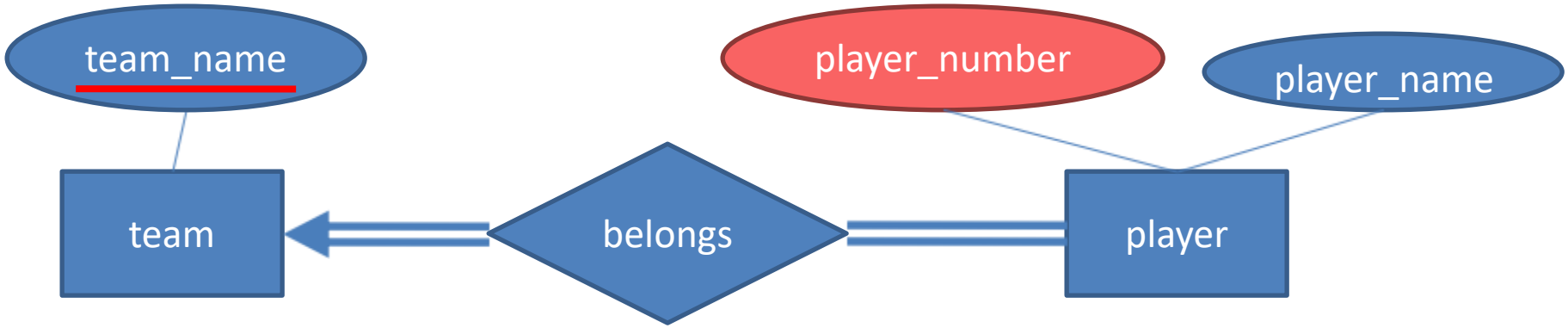
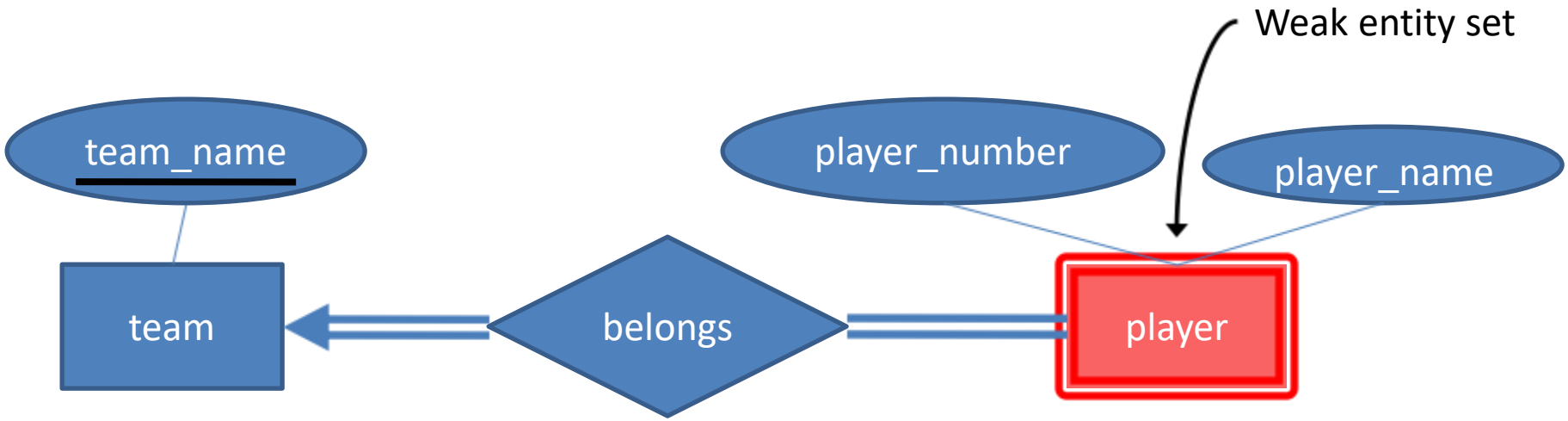
Weak Entity Set



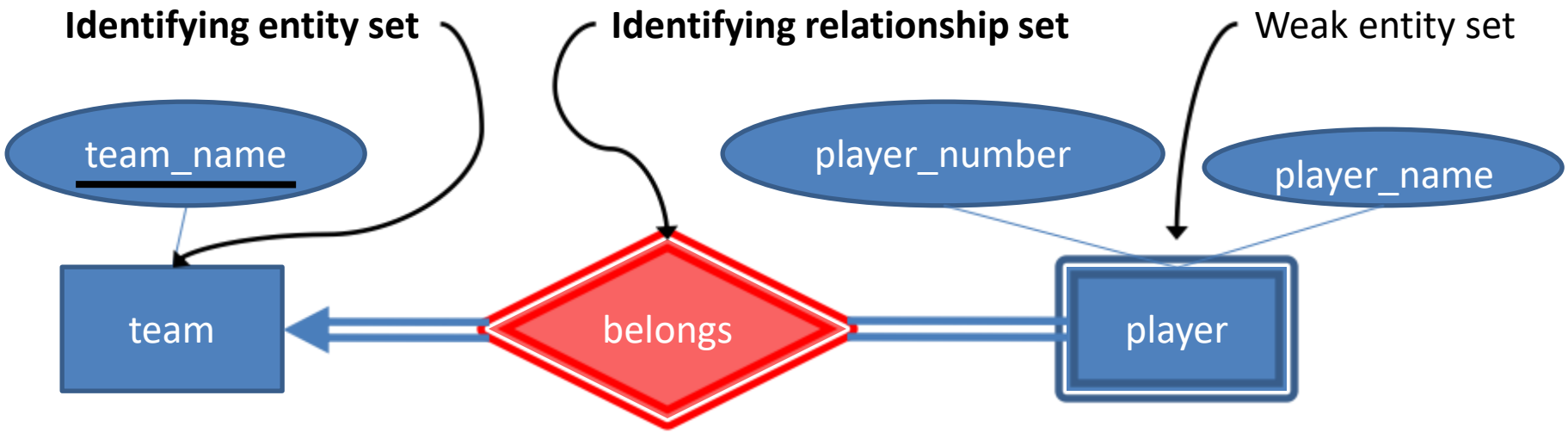
6. Identify the primary key of the entity sets:
The team name can uniquely identify a team.
Problem: The player_number cannot uniquely identify a player!
E.g., Michael Jordan and LeBron James were both #23!

Weak Entity Set



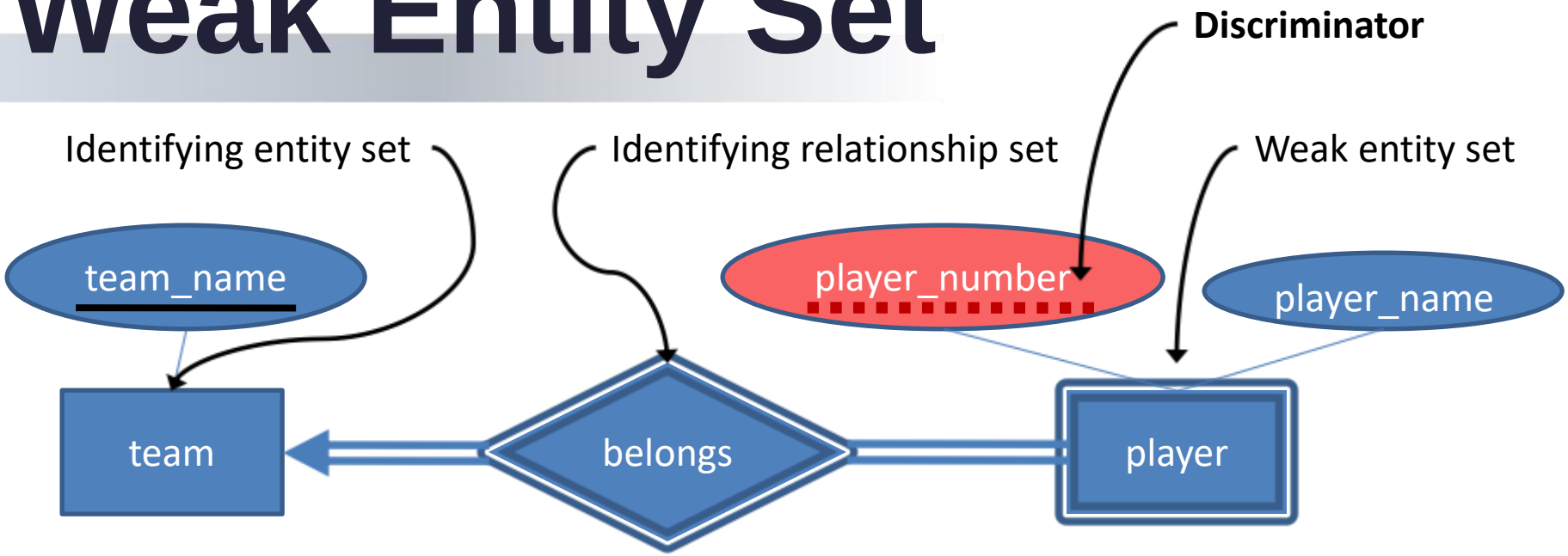
- **An entity set that does not have a primary key is referred to as a weak entity set.**
  - We depict a weak entity set by a **double rectangle**.

Weak Entity Set



- **The existence of a weak entity set depends on the existence of an identifying entity set.**
  - The weak entity set must relate to its identifying entity set via a **total**, **many-to-one** **identifying relationship set** from the weak entity set to the identifying entity set.
  - We depict an identifying relationship set as a **double diamond**.

Weak Entity Set



- The **discriminator** (or, partial key) of a weak entity set is a set of attributes that distinguish among the weak entities that depend on the same identifying entity.
  - The primary key of a weak entity set is formed by the primary key of the identifying entity set plus the weak entity set's discriminator.

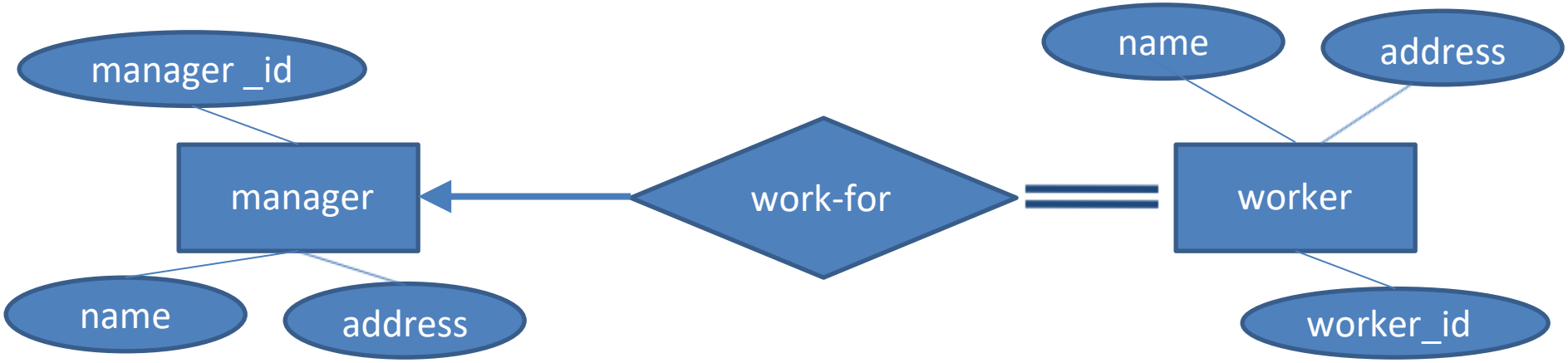
Role

- Entity sets of a relationship need not be distinct.

Role

Entity sets of a relationship need not be distinct.

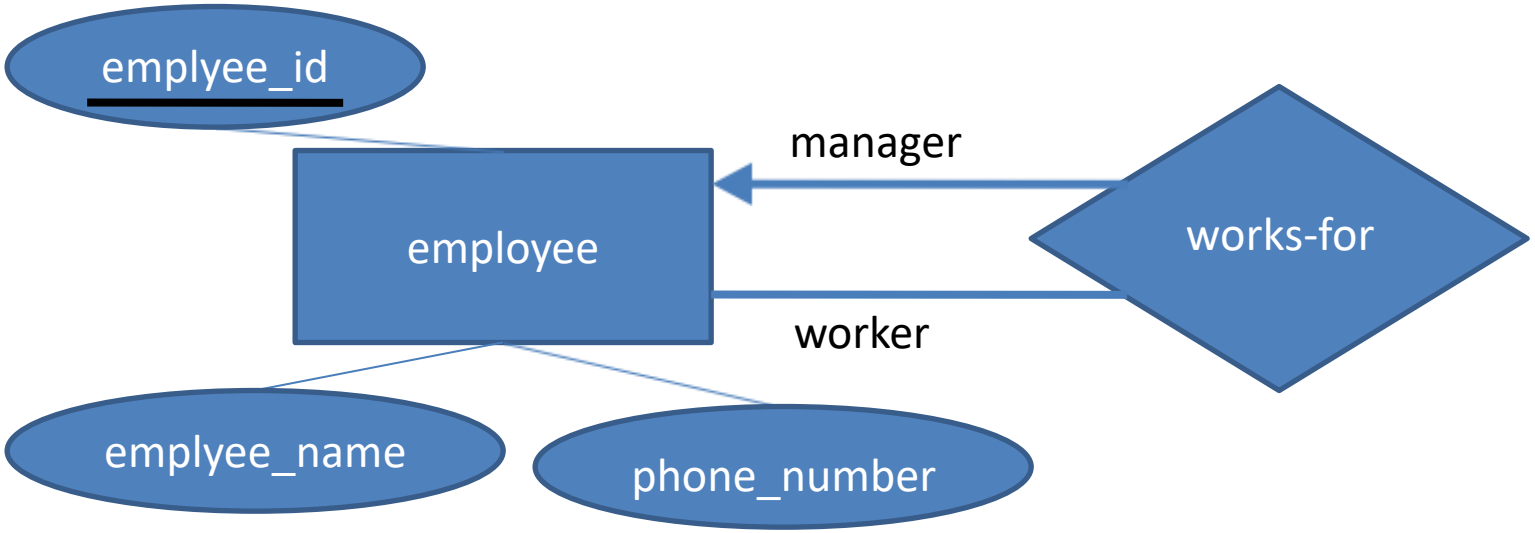
Please build a system to store the **manager** and **worker** information for UBank. For each manager, we record his/her **manager ID**, **name** and **address**; for each worker, we record its **worker ID, name** and **address**. **Each manager can have no, one or more workers, and each worker has to report to only one manager.**



Any problems in the above ER diagram?

Role

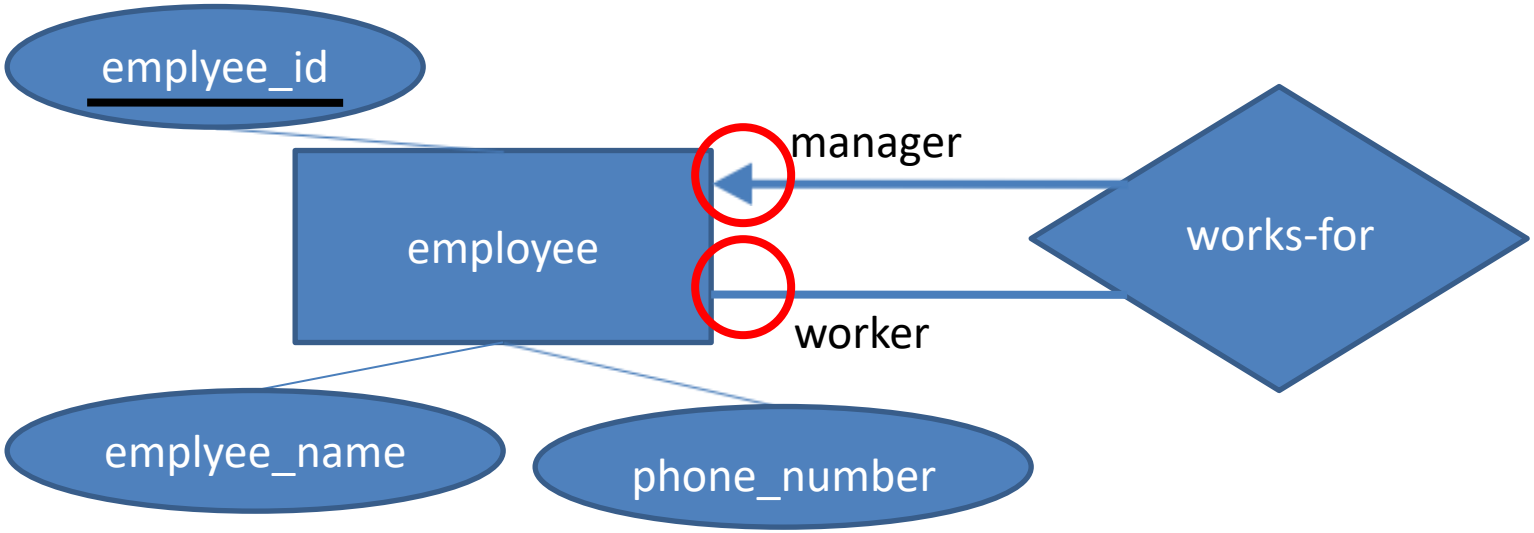
- **Entity sets of a relationship need not be distinct.**



  - The label “manager” and “worker” are called **roles**. They specify how employee entities interact via the “works-for” relationship set.

Role

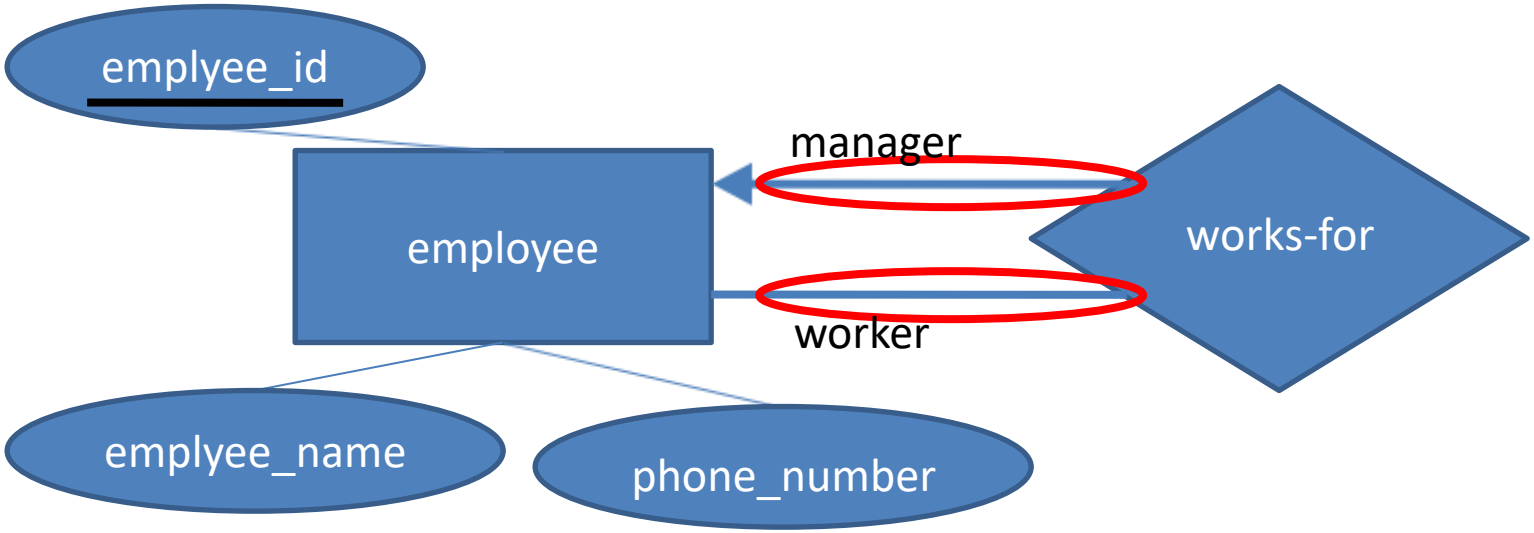
- **Entity sets of a relationship need not be distinct.**



- **Cardinality**
  - An employee (worker) works for one manager.
  - An employee (manager) can have more than one workers work for him/her.

Role

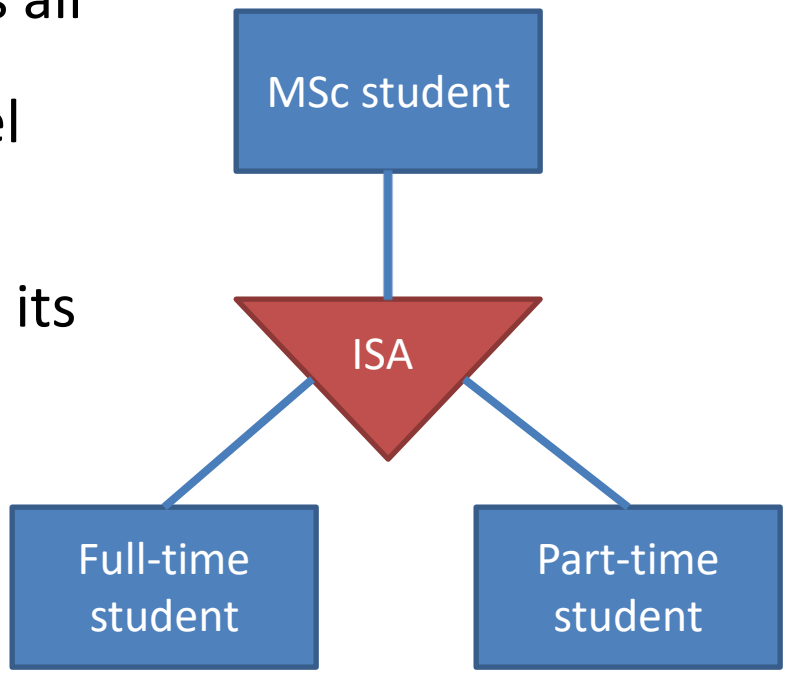
- **Entity sets of a relationship need not be distinct.**



- **Participation**
  - An employee (worker) may not work for any manager.
  - An employee (manager) can have no workers work for him/her.

Specialization

- **Specialization**
  - We designate sub-groupings within an entity set that are distinctive from other entities in the set.
  - A lower-level entity set inherits all attributes and relationship set participation of the higher-level entity set to which it is linked.
  - Lower-level entity set can have its own attributes.

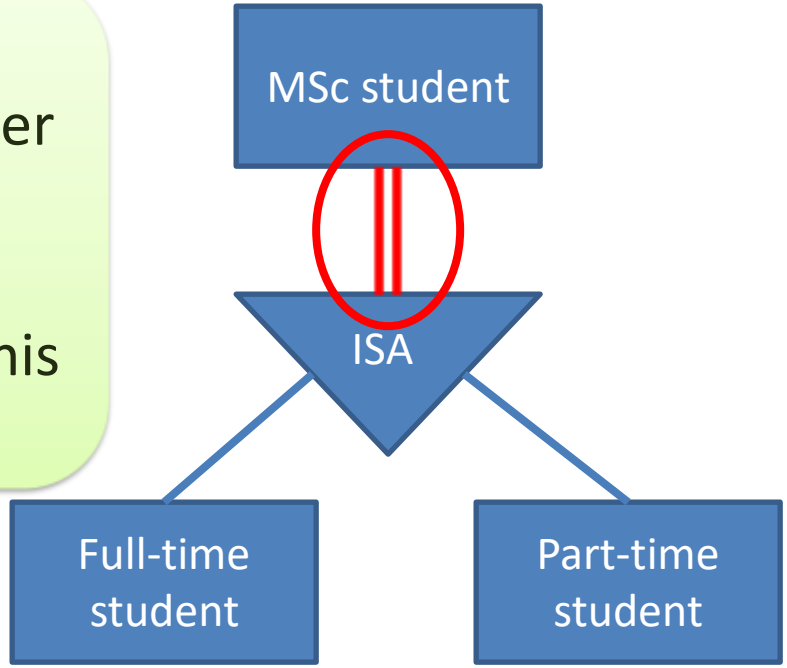


Specialization

Total or partial

- Specifies whether an entity in the higher level-entity set must belong to at least one of the lower-level entity sets within a specialization.

Total specialization:
An MSc student MUST BE either a full-time student or a part-time student, so all MSc students must participate in this specialization.

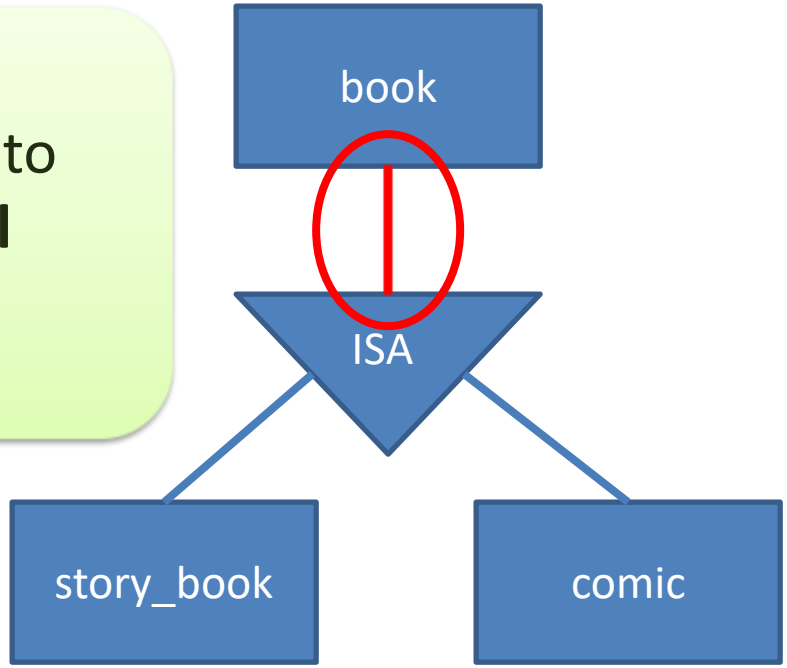


Specialization

Total or partial

- Specifies whether an entity in the higher level-entity set must belong to at least one of the lower-level entity sets within a specialization.

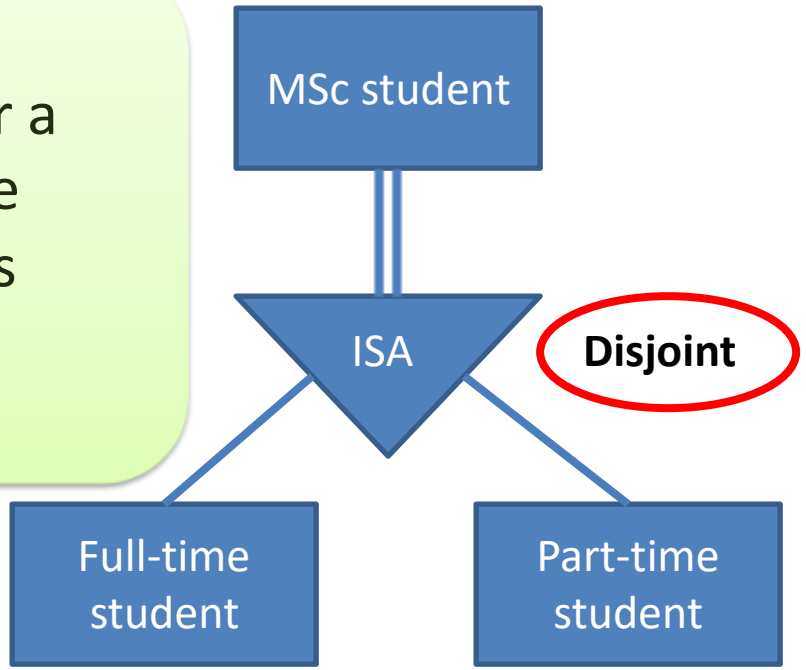
Partial specialization:
A book may not be specialized to story book or comics, so **not all books** are participating in this specialization.



Specialization

- **Disjoint or overlapping**
  - Constraints on whether entities may belong to more than one lower-level entity set within a single specialization.

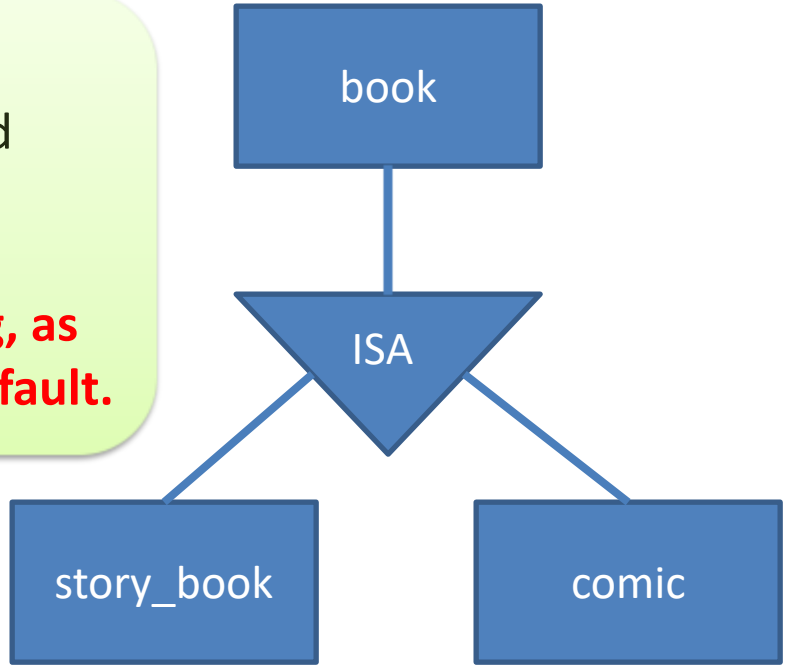
Disjoint specialization:
An MSc student must be either a full-time student or a part-time student, so the specialization is disjoint. **We use a keyword "Disjoint" to indicate it.**



Specialization

- **Disjoint or overlapping**
  - Constraints on whether entities may belong to more than one lower-level entity set within a single specialization.

Overlapping specialization:
A book can be both a story book and comic, so the specialization is overlapping.
We do not need to specify anything, as overlapping specialization is the default.



To Recap

- **Entity and entity set, Entities have Attributes**
- **Relationship and relationship set**
- **In the E-R Diagram**
  - **Rectangles** – entity sets.
  - **Ellipses** – attributes.
  - **Line between a rectangle and an ellipse** – link between an attribute and an entity set.

To Recap

- **Mapping cardinalities (many, one)**
  - Concerns the number of entities to which another entity can be associated via a relationship set.
  - E.g. For each customer, how many accounts he/she can have? **One or more than one**?
- **Participation constraints (full, partial)**
  - Concerns whether all entities in the entity set have to participate in the relationship set.
  - E.g. whether a customer **must have** an account record, or there can be some customers **without** any accounts?

To Recap

- Super key
- Candidate keys
- Primary key
- Different attribute types (Single/Composite/component, single-valued, multi-valued, derived)
- Weak entity set
- Role
- Specialization (ISA, Total/partial, disjoint/overlap)

Consider the HKU Student Information System (SIS)

- We store the users of SIS.
  - Each user has a userID (e.g., h0123456), which is the unique identifier of all users in HKU.
  - Name, and password of the users will also be stored.
- Each user is specialized to Student or Teacher.
  - No user can be both Student and Teacher.
  - For Student user, we store the enrollment date, which consists of day, month and year.
  - For Teacher user, we store the title, salary.
- We store the courses offered in HKU over different academic years.
  - Each course has a courseID (e.g., COMP3278B), which is unique only within an academic year.
  - Course name will also be stored.
- We store the departments in the system.
  - Each department has a unique name.
- Department offer course(s). Each course can be taught by some teachers. Each teacher belongs to a department. A course could be jointly offered by more than one departments.
- Students can enroll in courses. The grade obtained by a student in a course has to be recorded.
- The pre-requisite(s) relations of the courses have to be stored in the system. E.g.,
  - COMP2119 is a pre-requisite course of COMP3278.
  - ENGG1111 is a pre-requisite course of COMP2119.
  - ENGG1111 is a pre-requisite course of COMP3278.

Draw an ER diagram of the HKU Student Information System (SIS).
Please construct the ER diagram base on the information given in the question, do not add extra attributes nor create unnecessary tables.
For the parts that are not mentioned (e.g., participation / cardinality), please decide a reasonable modelling. You could state assumptions.

Lecture 2

END

COMP3278A

Introduction to Database Management Systems

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