SULEYMAN DEMIREL UNIVERSITY

Database Management System I

Entity Relational Diagram Model

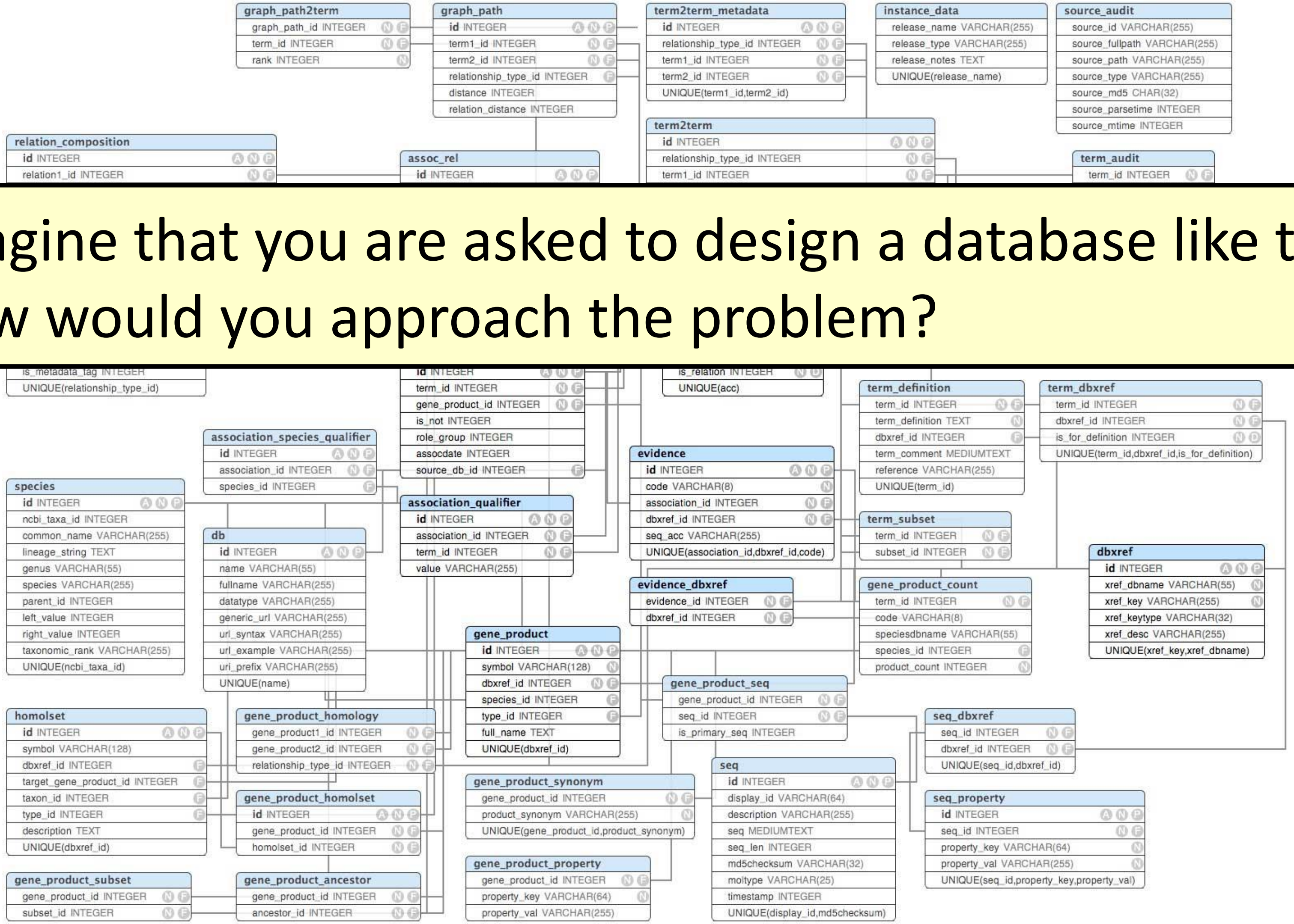
Week #2

The Road Ahead

E/R Diagram

- Introduction to Entity-Relationship (ER) Diagrams
- Entity
- Relationship
- Constraints
- Subclasses
- Weak Entity Sets
- ER Design Principle
- Translating an ER Diagram into a Relational Scheme Design

A real database may have a large number of tables…

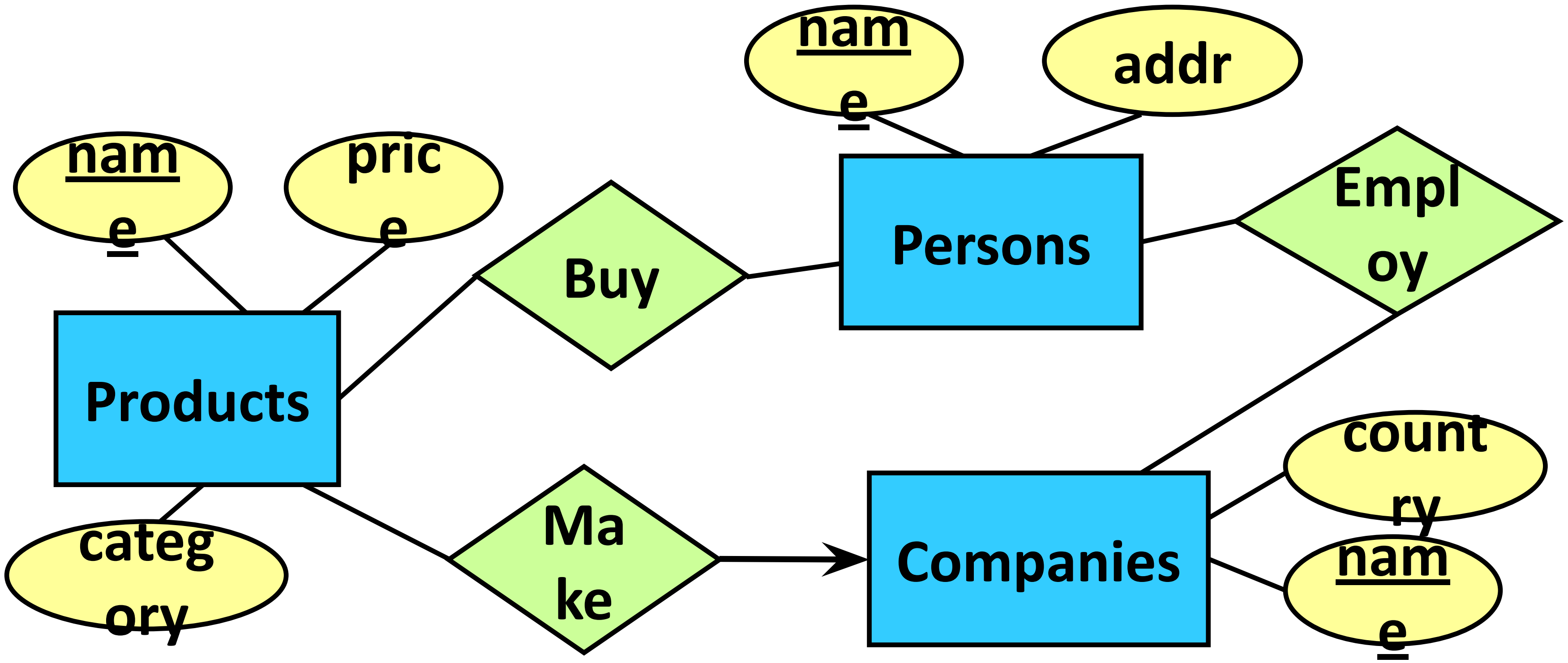


- Imagine that you are asked to design a database like this….
- How would you approach the problem?

Designing a Database for an Application

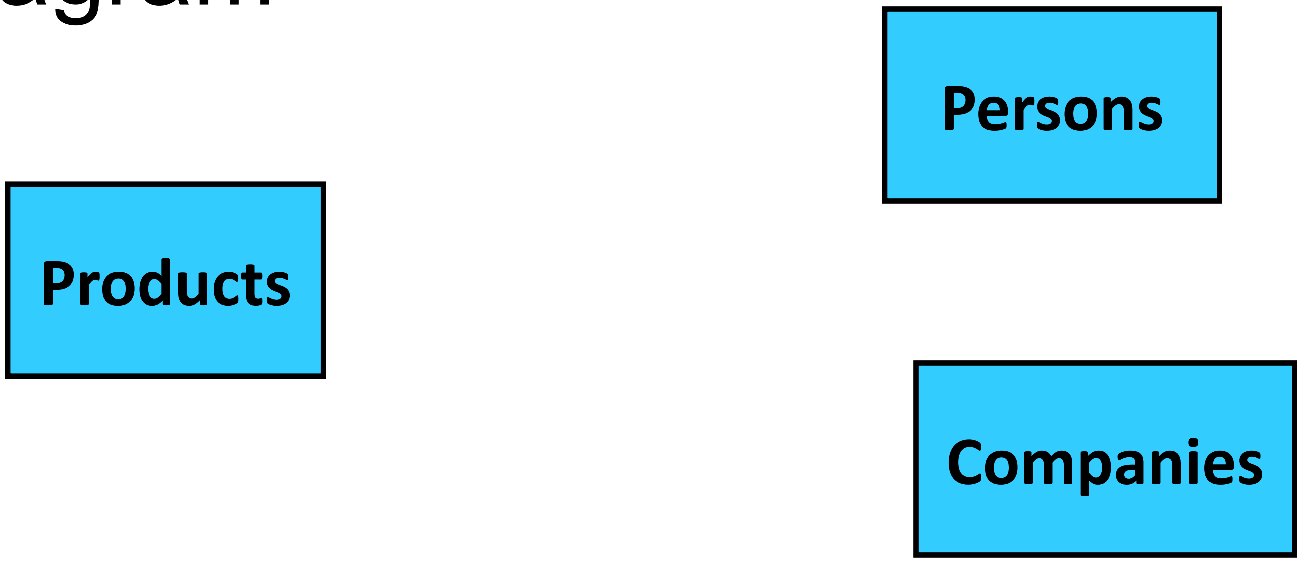
- Conceptually model the requirements of the application
  - What are the things that need to be stored?
  - How do they interact with each other?
- Tool to use: Entity-Relationship (ER) Diagrams
  - for modelling
- Translate the conceptual model into a set of tables
- Create the tables with a DBMS

ER Diagram



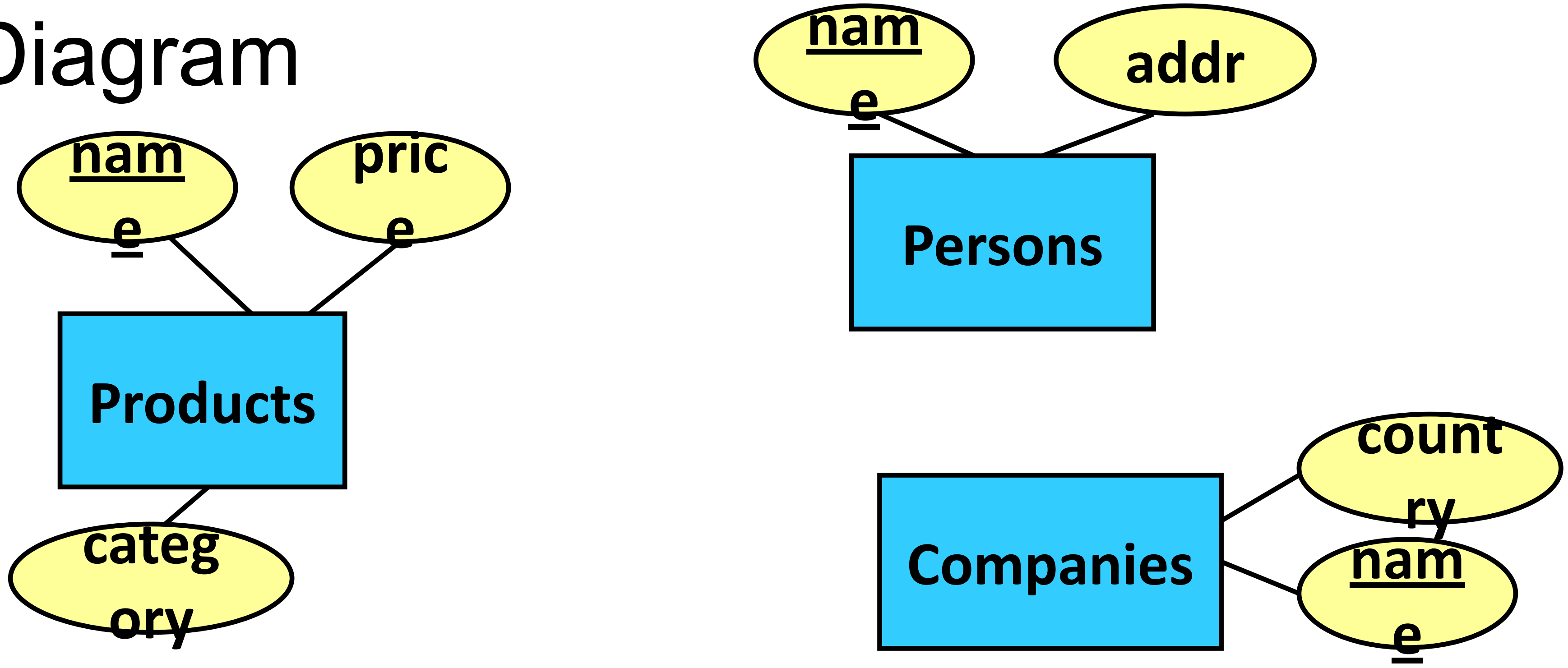
name
price
Products
category
Buy
Make
name
addr
Persons
Employ
Companies
country
name

ER Diagram



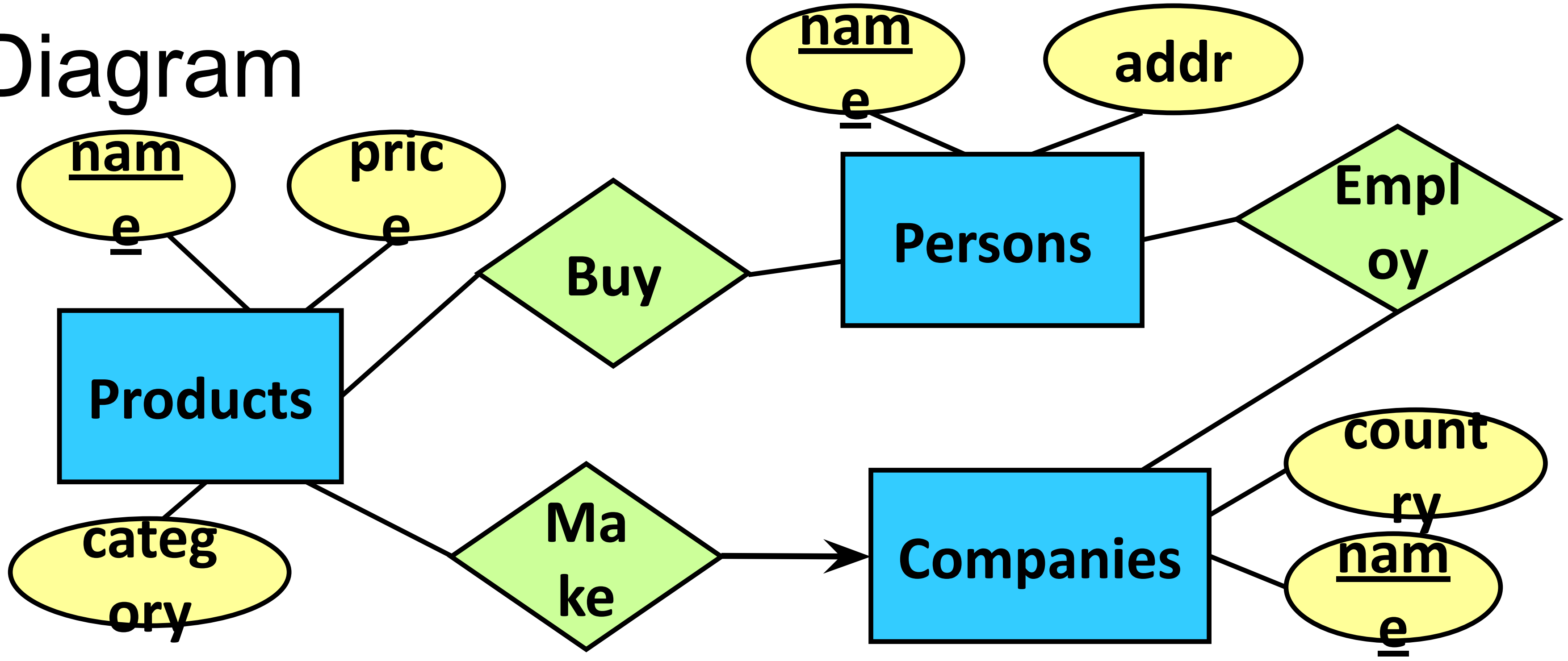
- Rectangle = Entity
- Entity = Real-world object (e.g., a bar)
- Entity Set = Collection of similar objects (e.g., a set of bars)

ER Diagram



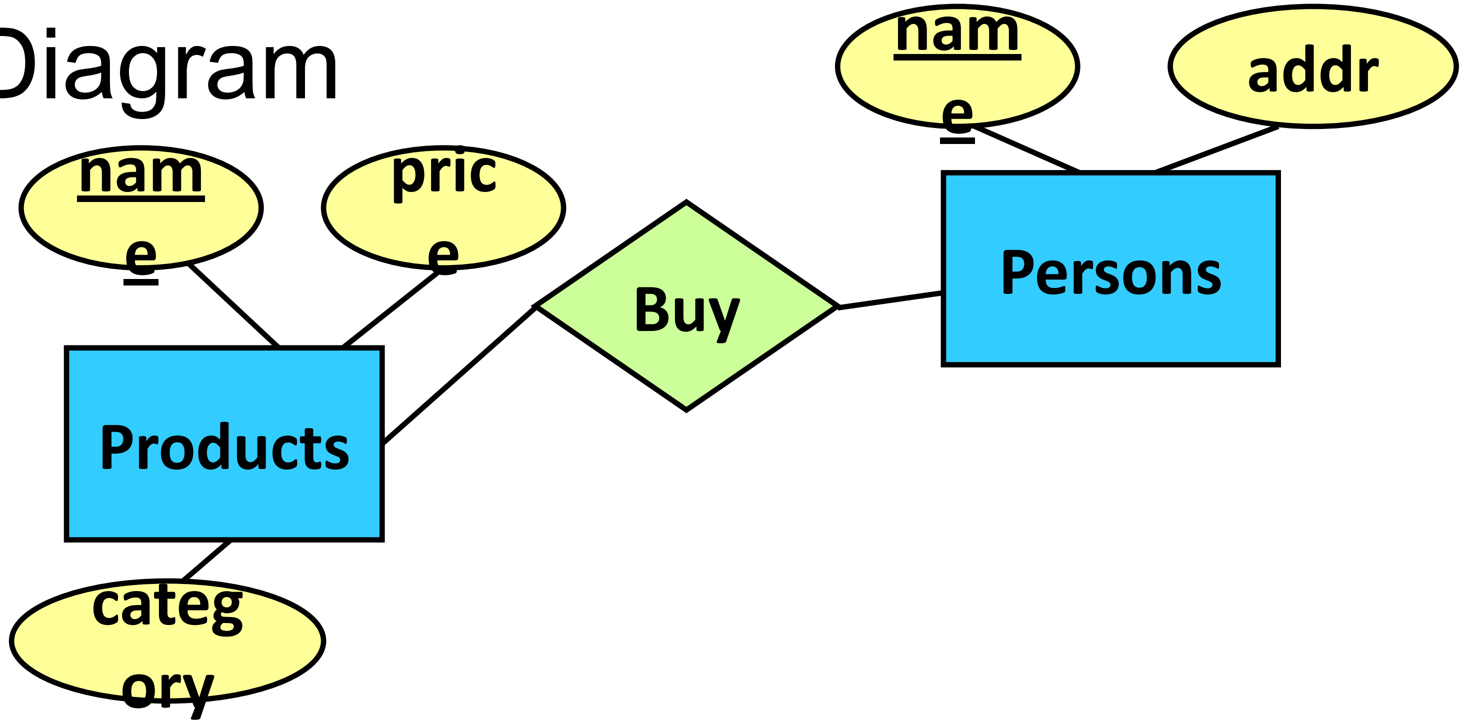
- Oval = Attribute = Property of an entity set

ER Diagram



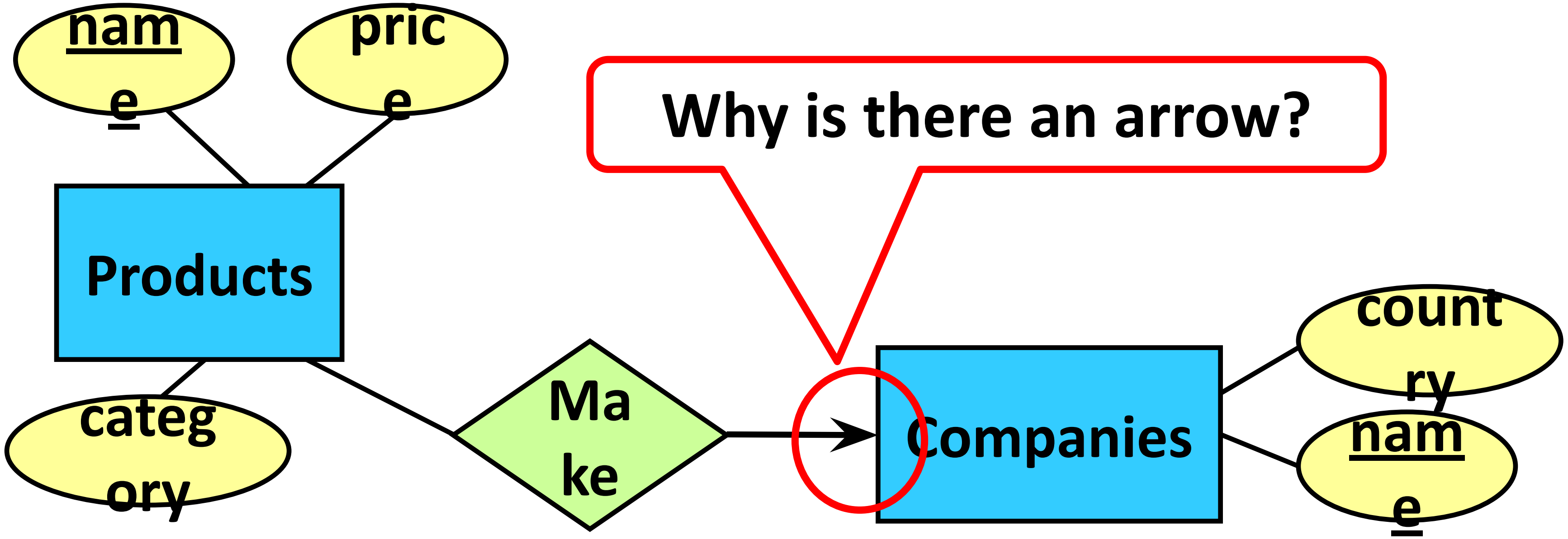
- Diamond = Relationship = Connection between two entity sets

ER Diagram



- Diamond = Relationship = Connection between two entity sets
- Persons buy products

ER Diagram

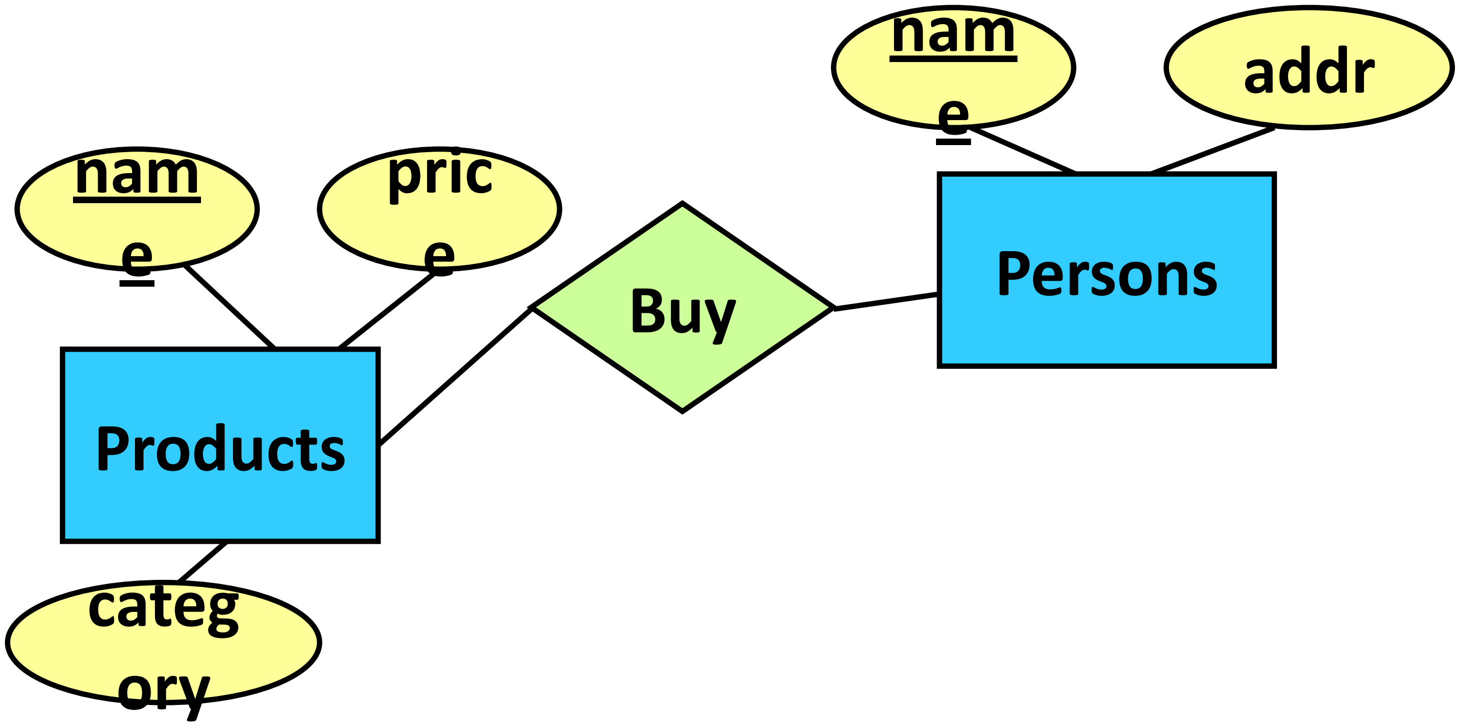


- Diamond = Relationship = Connection between two entity sets
- Companies make products

Types of Relationships

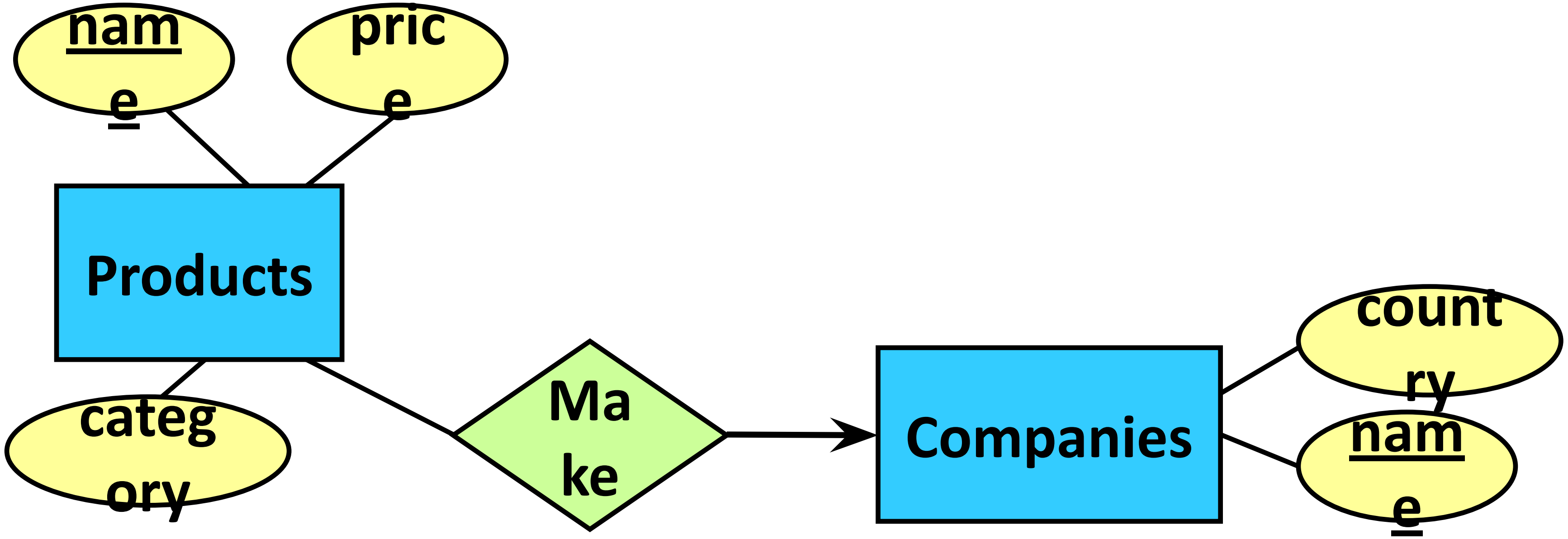
- Many-to-Many Relationships
- Many-to-One Relationships
- One-to-One Relationships

Many-to-Many Relationship



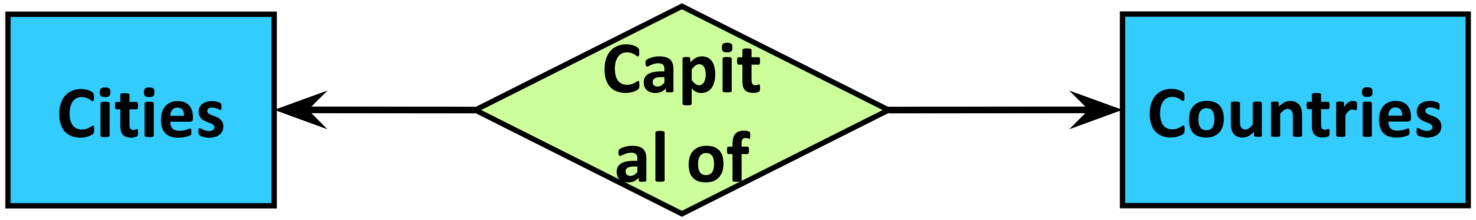
- One person can buy multiple products
- One product can be bought by multiple persons

Many-to-One Relationship



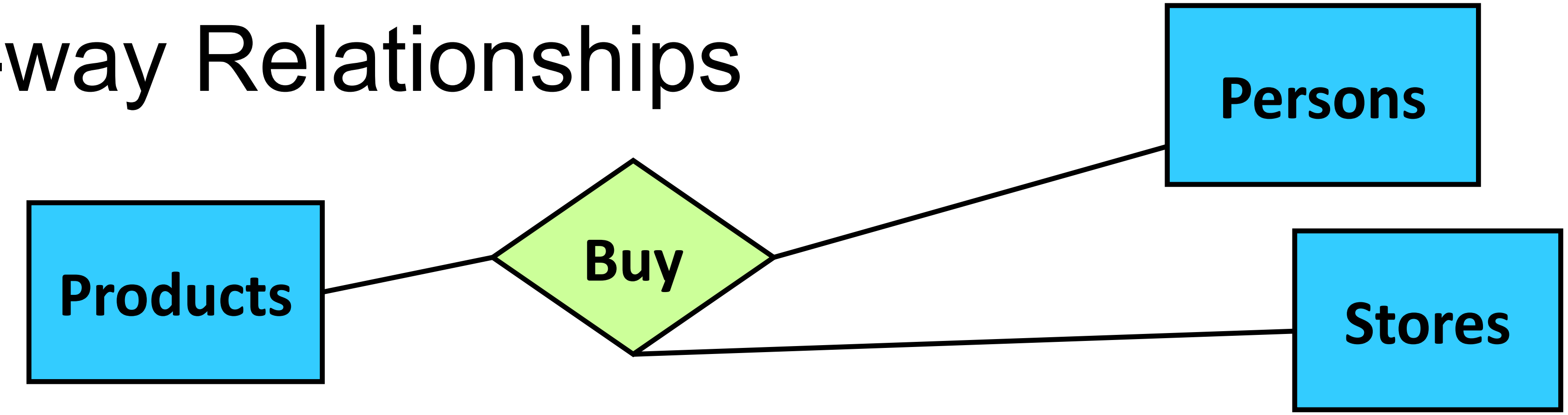
- One company can make multiple products
- But one product can only be made by one company (at most)

One-to-One Relationship



- A city can be the capital of only one country
- A country can have only one capital city

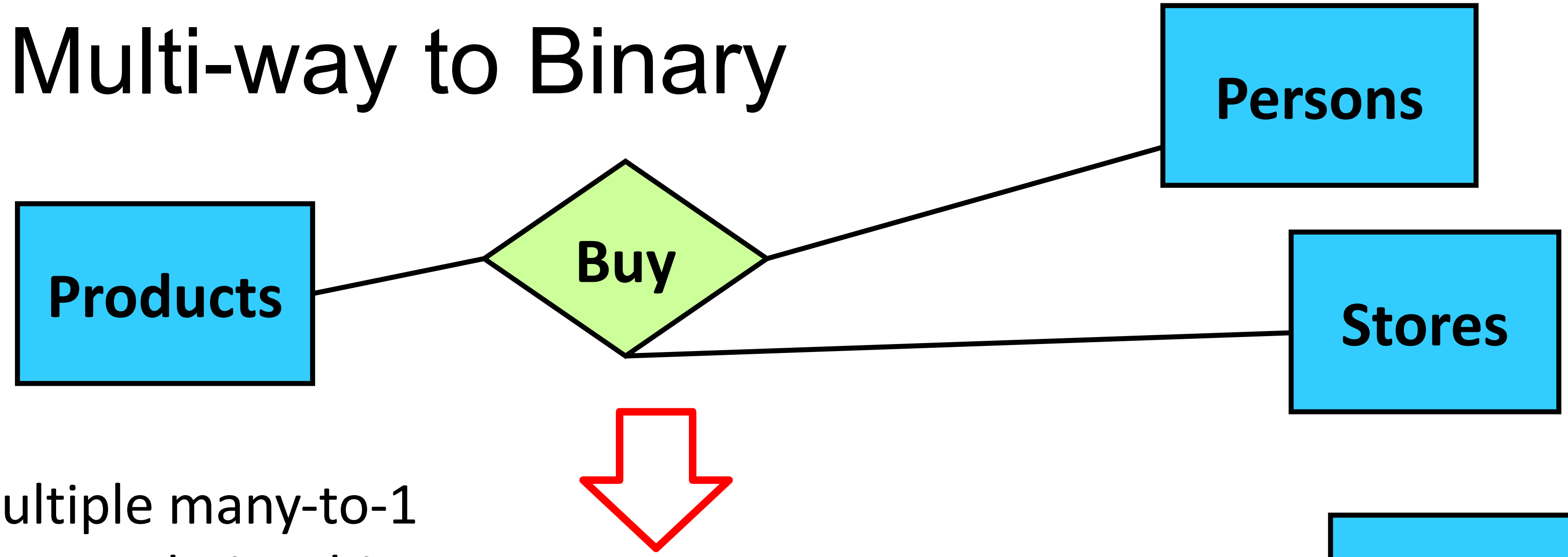
Multi-way Relationships



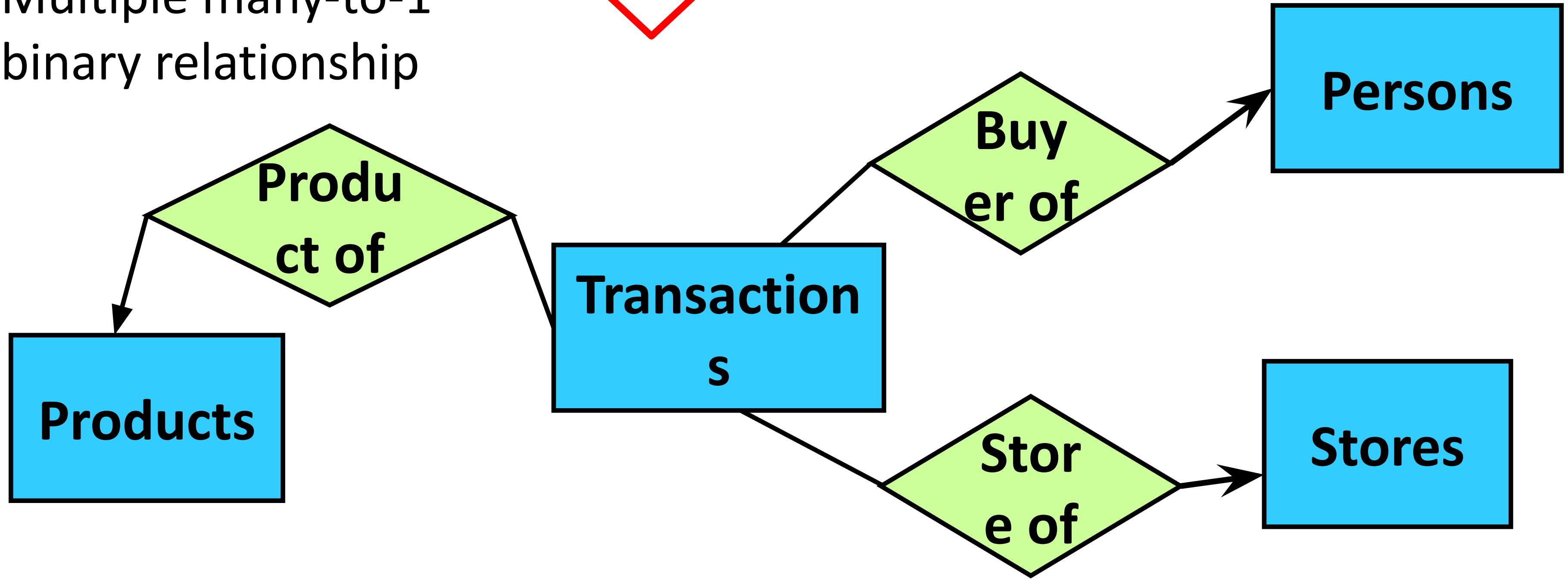
- What if we want to record the store from which the person buys the product?
- We can use a 3-way relationship

person	product	store
Ray	Milk Skim	S&S NTU
Ray	Milk Chocolate	S&S NTU
Ray	Milk Chocolate	NUS co-op
Peter	Milk Skim	S&S NTU

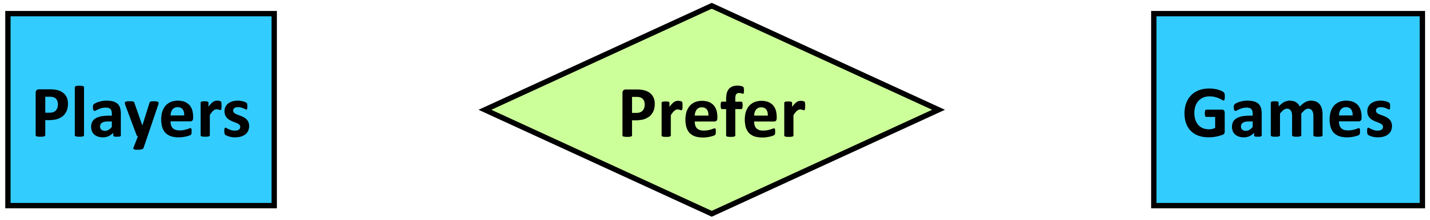
From Multi-way to Binary



Multiple many-to-1
binary relationship



Exercise

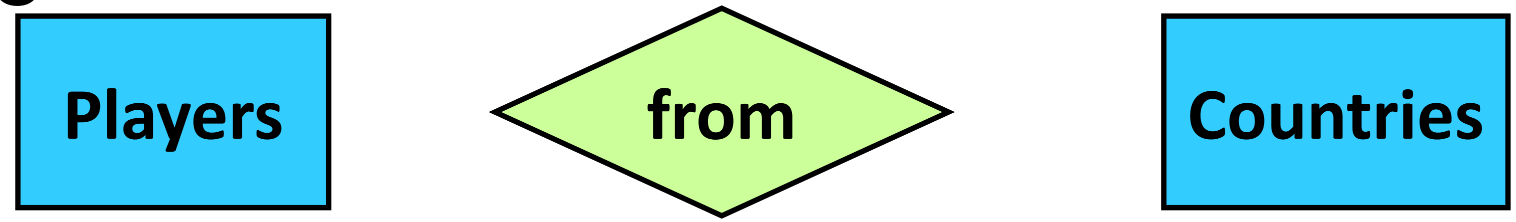


- Each player prefers only one game
  - One player can prefer one game
  - One game can be preferred by many players
  - P-G Many-to-One
- Many-to-many?
- Many-to-one?
- One-to-one?

Exercise

- No two shops sell the same product
  - One product can be sold by one shop
  - One shop can sell many products
  - P-G One-to-One
- Many-to-many?
- Many-to-one?
- One-to-one?

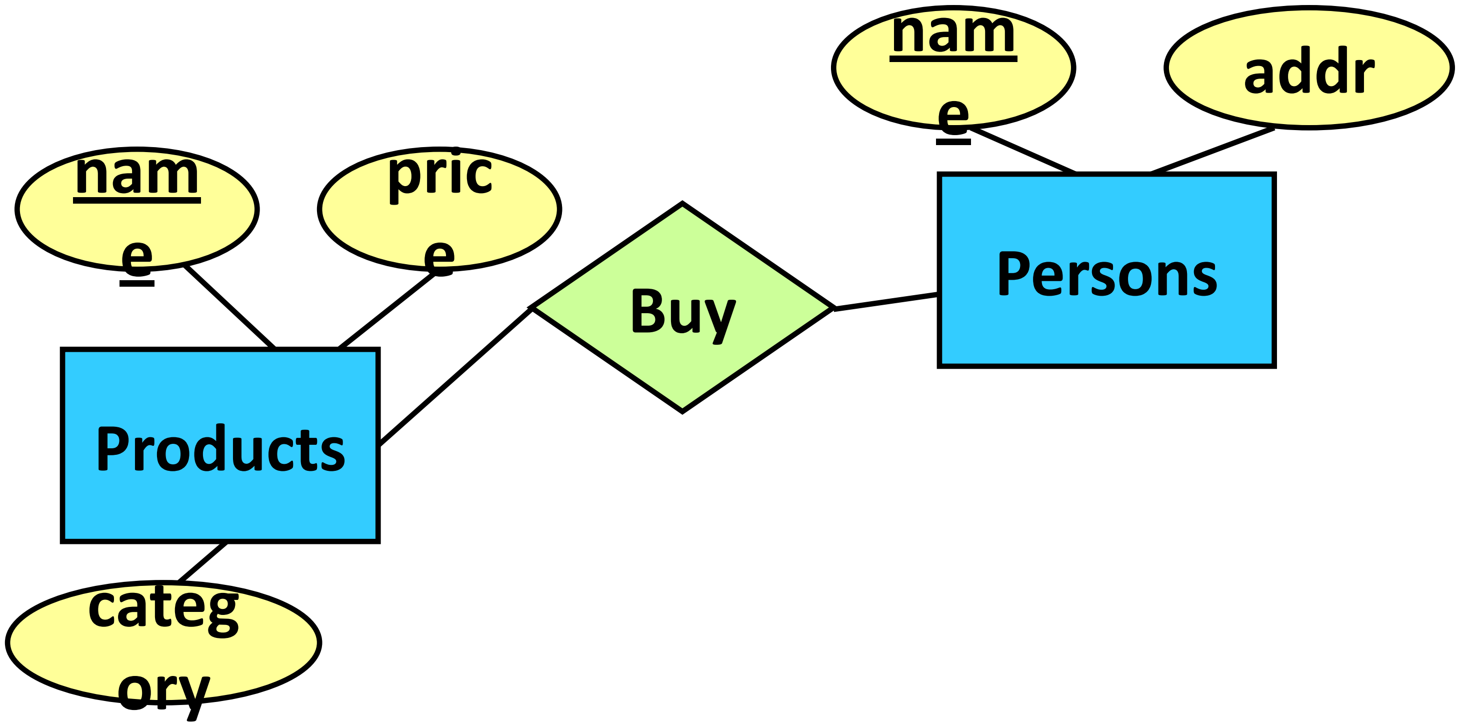
Exercise



- Any two players are from two different countries
  - One player can be from one country
  - One country can have one player only
  - P-G One-to-One
- Many-to-many?
- Many-to-one?
- One-to-one?

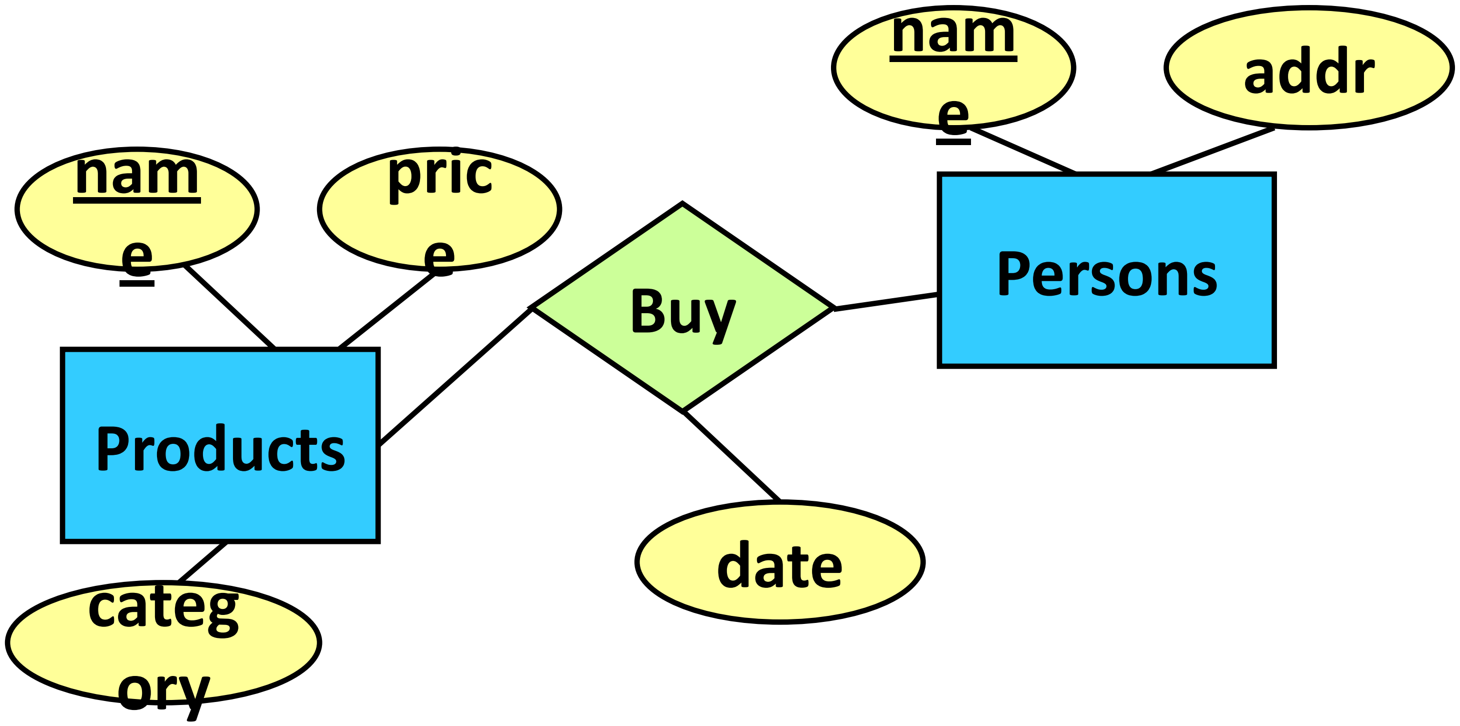
One More Thing about Relationships

- A relationship can have its own attribute

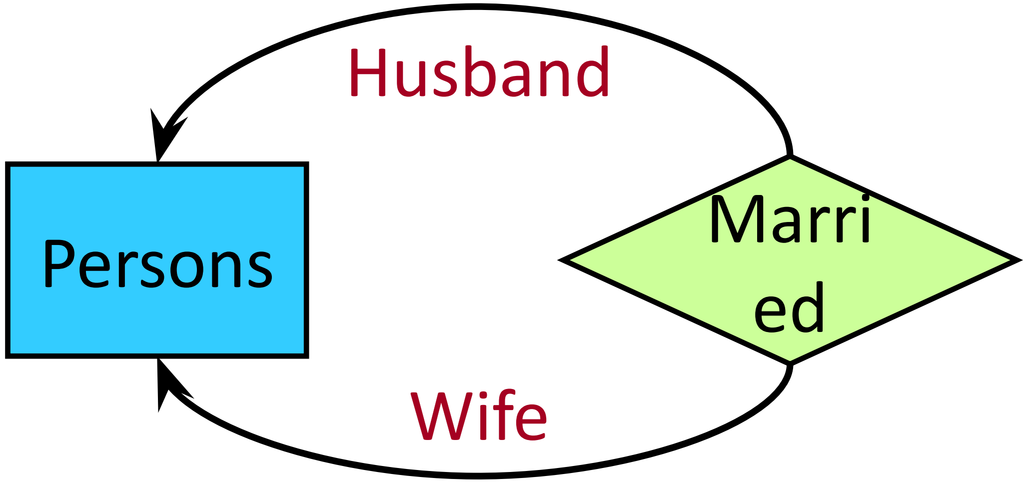


One More Thing about Relationships

- A relationship can have its own attribute
- If we want to record the date of the purchase



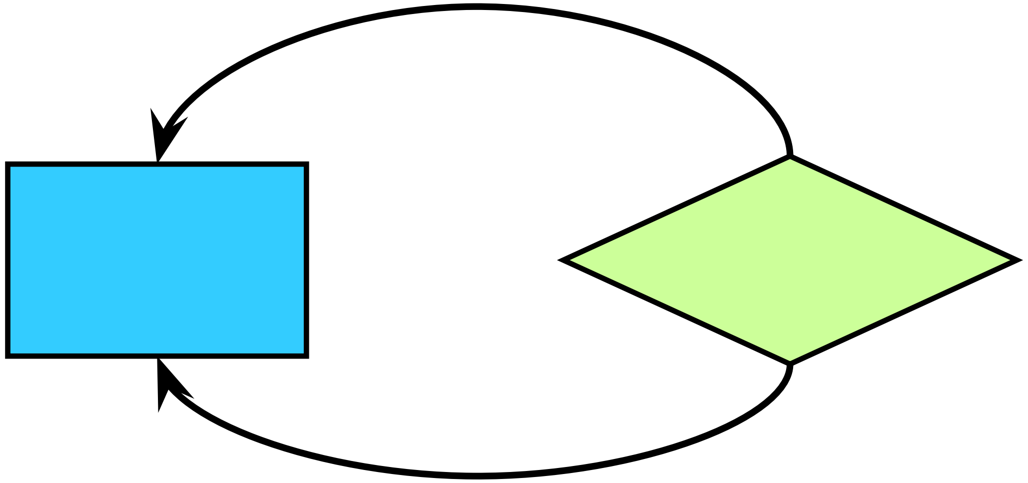
Roles



- Sometimes an entity set may appear more than once in a relationship
- Example: some persons are married to each other
- The role of the person is specified on the edge connecting the entity set to the relationship

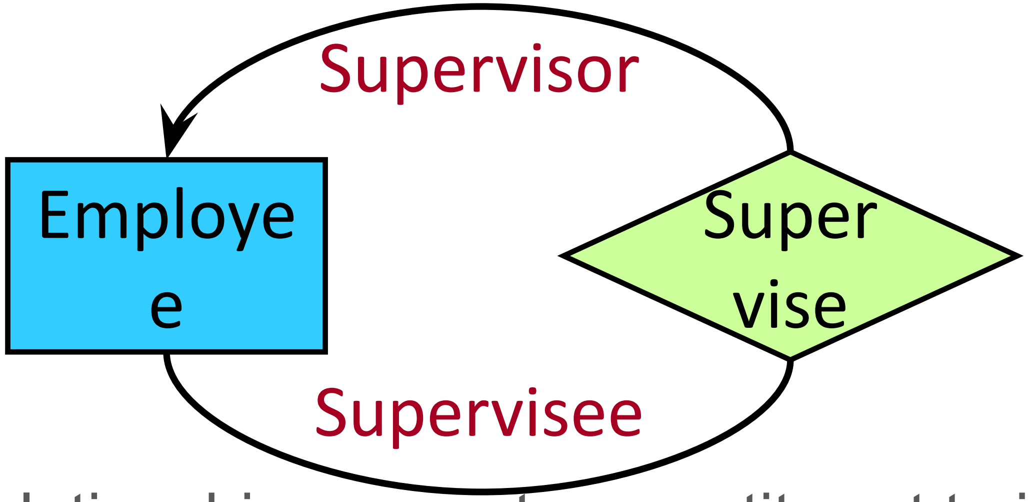
Husband	Wife
Bob	Alice
David	Cathy
…	…

Roles



- Question: A relationship connects an entity set to itself, does it have to be one-to-one?
- Answer: No

Roles



- Question: A relationship connects an entity set to itself, does it have to be one-to-one?
- Answer: No
- Example above:
    - One employee has only one supervisor, but may have many supervisee

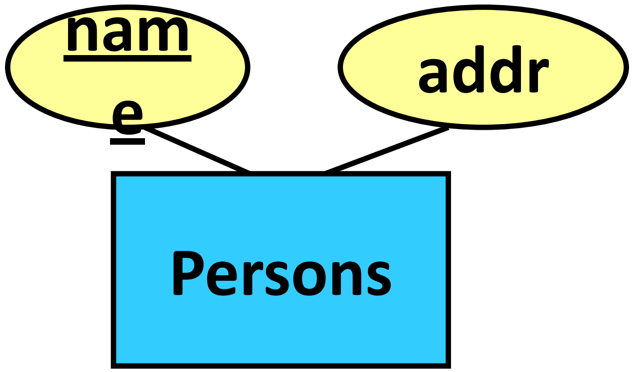
Roadmap

- Constraints
- Subclasses
- Weak Entity Sets
- ER Design Principle
- Translating an ER Diagram into a Relational Scheme Design

Constraints

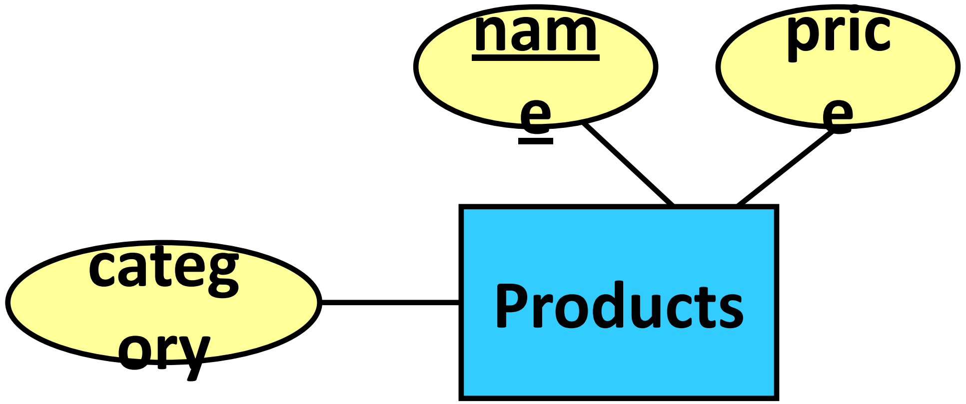
- Some conditions that entity sets and relationships should satisfy
- We will focus on three types of constraints
  - Key constraints
  - Referential integrity constraints
  - Degree constraints

Key



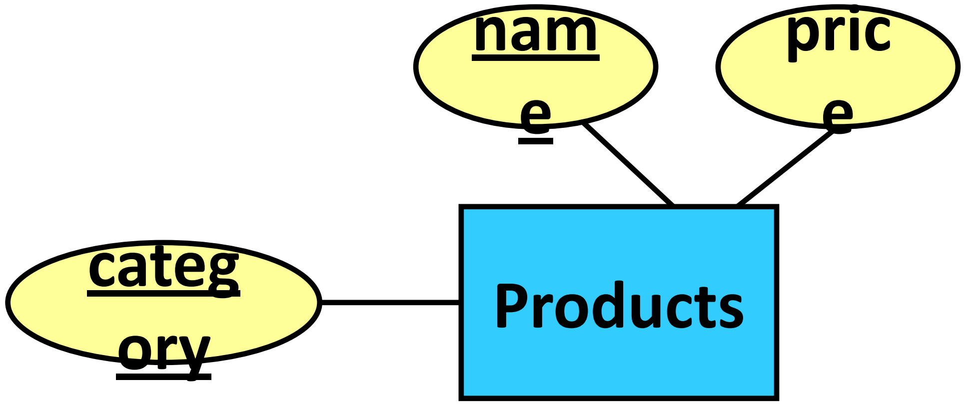
- One or more attributes that are underlined
- Meaning: They uniquely represent each entity in the entity set
- Example: The names uniquely represent the persons
- i.e., each person must have a unique name

Key



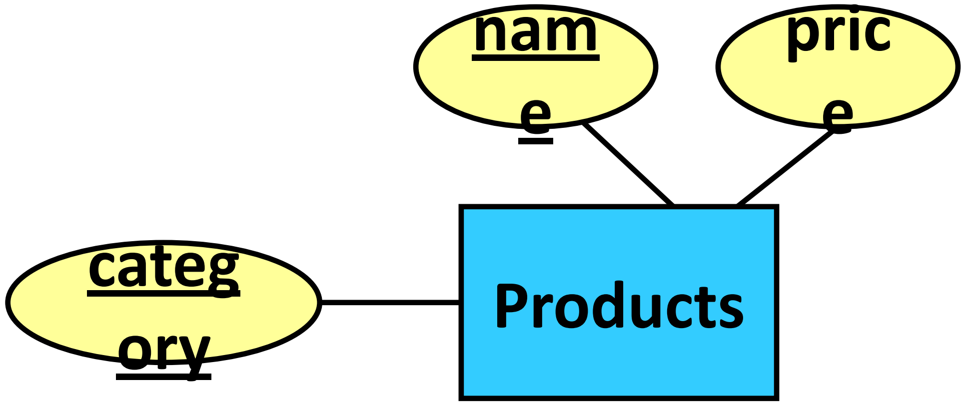
- One or more attributes that are underlined
- Meaning: They uniquely represent each entity in the entity set
- Example: Each product has a unique name

Key



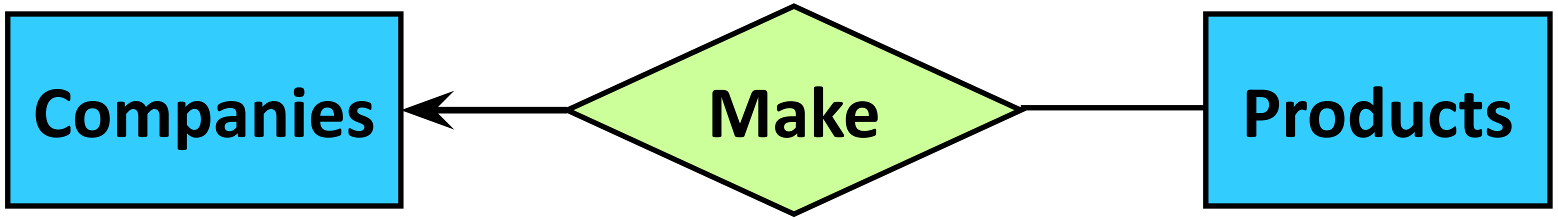
- One or more attributes that are underlined
- What now?
- Each product has a unique <name, category> combination
- But there can be products with the same name, or the same category, but not both
- Example
  - Name = “Apple”, Category = “Fruit”, Price = “1”
  - Name = “Apple”, Category = “Phone”, Price = “888”

Key



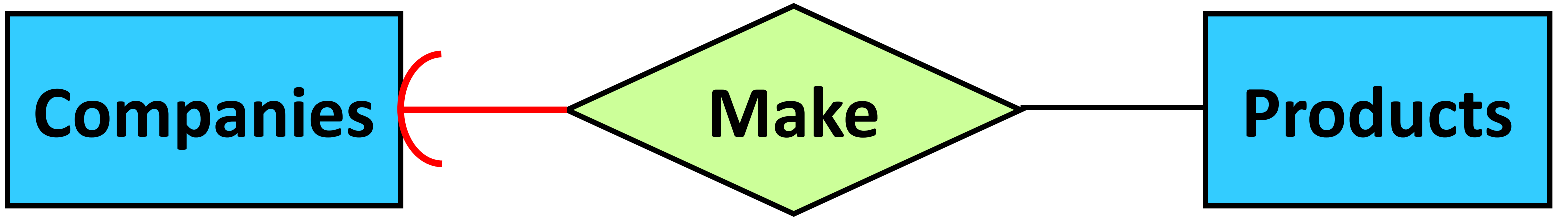
- Rule: Every entity set should have a key
    - So that we can uniquely refer to each entity in the entity set

Referential Integrity



- One company may make multiple products
- One product is made by one company
- Can there be a product that is not made by any company?
- No.
- i.e., every product must be involved in the Make relationship
- This is called a referential integrity constraint.
- How do we specify this in an ER diagram?
- Use a rounded arrow instead of a pointed arrow

Referential Integrity



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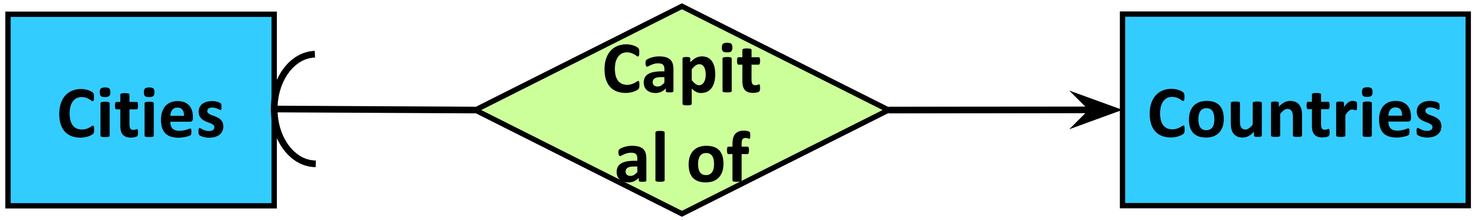
- How do we specify this in an ER diagram?

Referential Integrity: Exercise

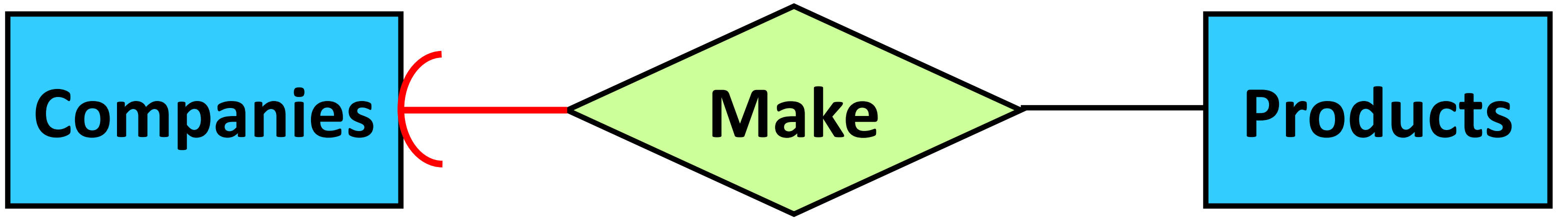


- A city can be the capital of only one country
- A country must have a capital

Referential Integrity: Exercise

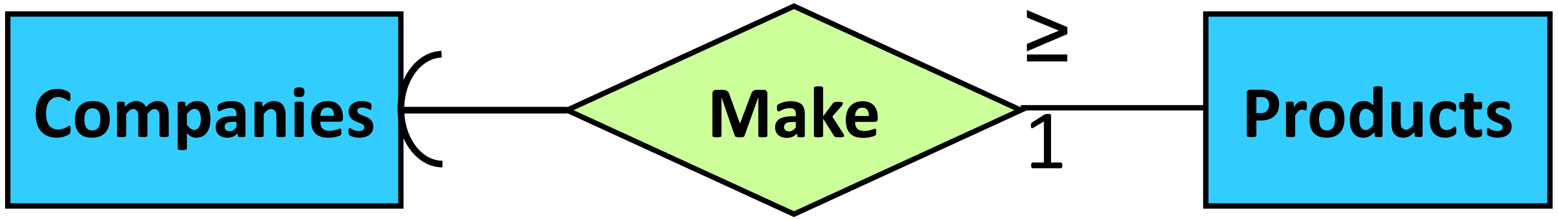
- A company must hire at least one person
- A person must be hired by exactly one company

Referential Integrity



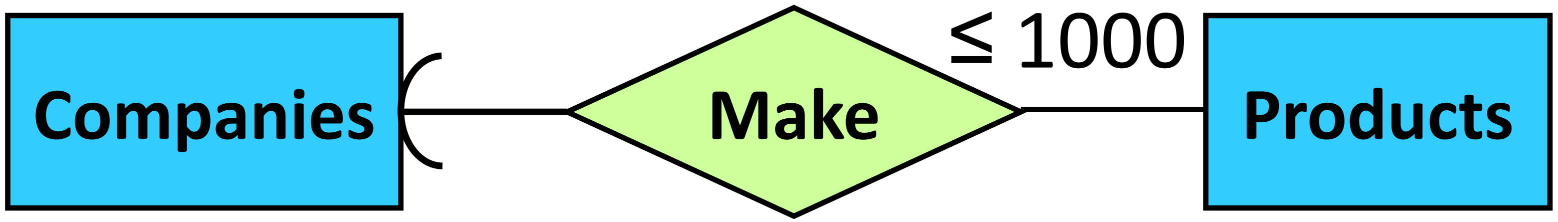
- What if every company should make at least one product?
- In general, a referential integrity constraint can only apply to the "one" side of
  - A many-to-one relationship, or
  - A one-to-one relationship
- For the "many" side, there is another type of constraints to use

Degree Constraint



- Each company should make at least 1 product

Degree Constraint

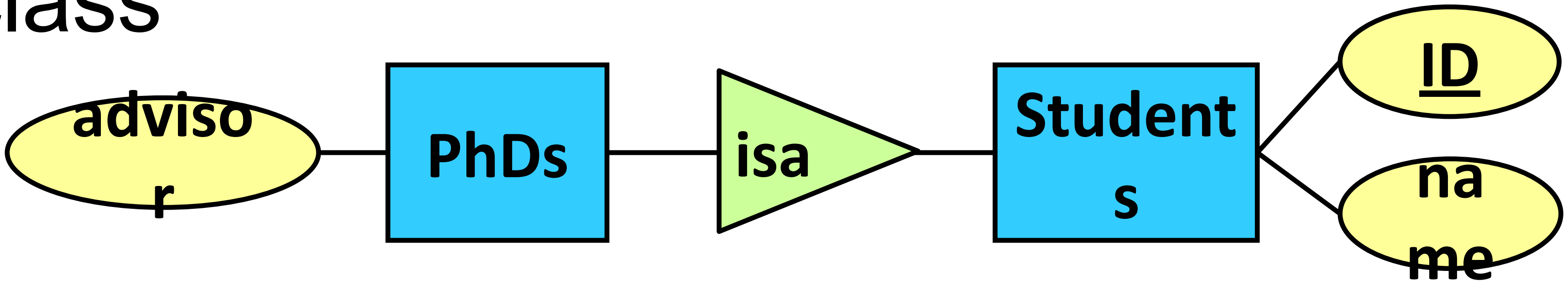


- Each company can make at most 1000 product
- Note
  - Not required in the exam
  - Key and referential integrity constraints can be easily enforced in a DBMS
  - Degree constraints are not easy to enforce

Roadmap

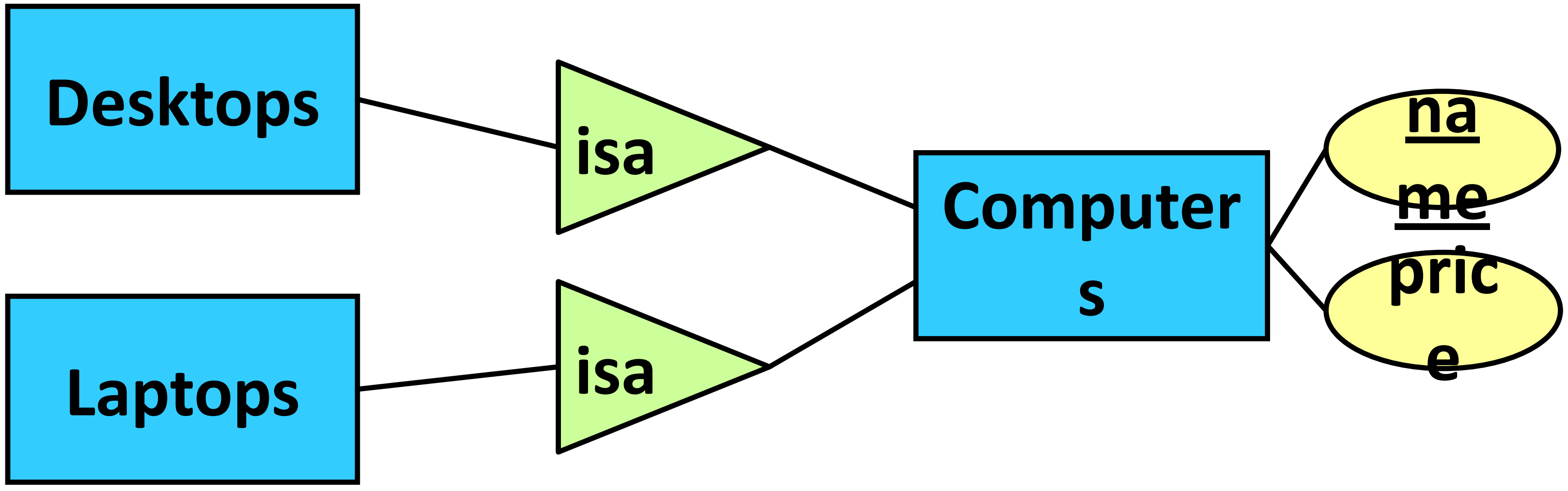
- Constraints
- Subclasses
- Weak Entity Sets
- ER Design Principle
- Translating an ER Diagram into a Relational Scheme Design

Subclass



- PhDs are a special type of Students
- Subclass = Special type
- The connection between a subclass and its superclass is captured by the isa relationship, which is represented using a triangle
- Key of a subclass = key of its superclass
- Example: Key of Phds = Students.ID
- Students is referred to as the superclass of PhDs

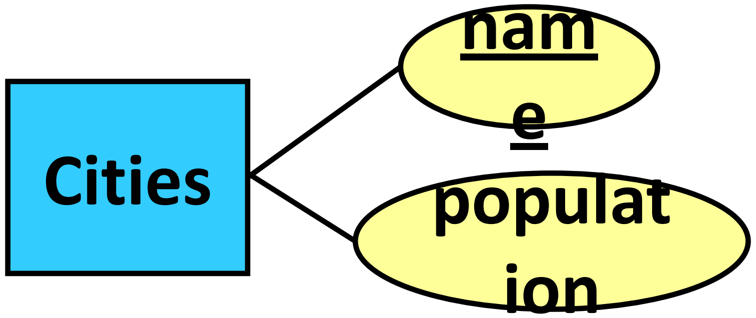
Subclass



- An entity set can have multiple subclasses
- Example
  - Superclass: Computers
  - Subclass 1: Desktop
  - Subclass 2: Laptop

Weak Entity Sets

- Weak entity sets are a special type of entity sets that
  - cannot be uniquely identified by their own attributes
  - needs attributes from other entities to identify themselves
- Example: Cities in USA
- Problem: there are cities with identical names



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Slovenčina
Suomi
Svenska
Volapük

Madison

From Wikipedia, the free encyclopedia

Madison may refer to:

People

- Madison (name), a given name and a surname

Place names

- Madison, Wisconsin, the largest city by the name and the state capital of Wisconsin
- Madison, Alabama
- Madison, Arkansas
- Madison, California
- Madison, Connecticut
- Madison, Florida
- Madison, Georgia
- Madison, Illinois
- Madison, Indiana
- Madison, Kansas
- Madison, Maine
  - Madison (CDP), Maine, census-designated place within the town of Madison
- Madison, Minnesota
- Madison, Mississippi
- Madison, Missouri
- Madison, Nebraska
- Madison, New Hampshire
- Madison, New Jersey
- Madison (town), New York
  - Madison (village), New York, within the town of Madison
- Madison, North Carolina
- Madison, Ohio
- Madison, Pennsylvania
- Madison, South Dakota
- Madison, Tennessee
- Madison, Virginia
- Madison, West Virginia
- Madison (town), Wisconsin, adjacent to the city of Madison
- Madison Lake, Minnesota
- Madison Park, Seattle, Washington State

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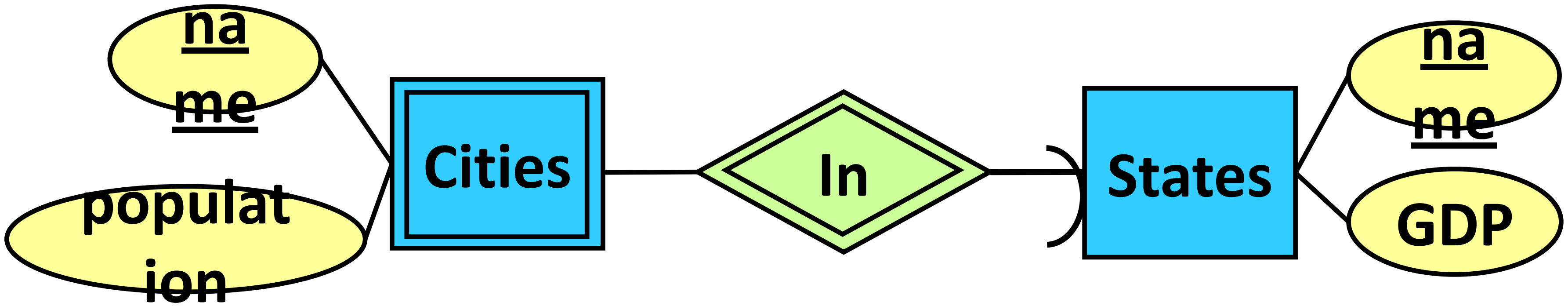
Weak Entity Sets



- Problem: there are cities with identical names
- Observation: cities in the same state would have different names
- Solution: make Cities a weak entity set associated with the entity set States : Double-lined rectangle
- The relationship In is called the supporting relationship of Cities : Double-lined diamond
- The key of Cities = (State.name, Cities.name)
  - Zero or more of its own attributes
  - Key attributes from entity sets that are reached by supporting relationships to other entity sets

Exercise

- Consider two entity sets: Players and Teams
- Each player has a name and a number
- Each team has a name and a manager
- Each player plays for exactly one team, and is uniquely identified within the team by his/her number
- Each team is uniquely identified by its name
- Different players may have the same name
- Draw a ER diagram that captures the above statements
- What is the key of Players?

Road Map

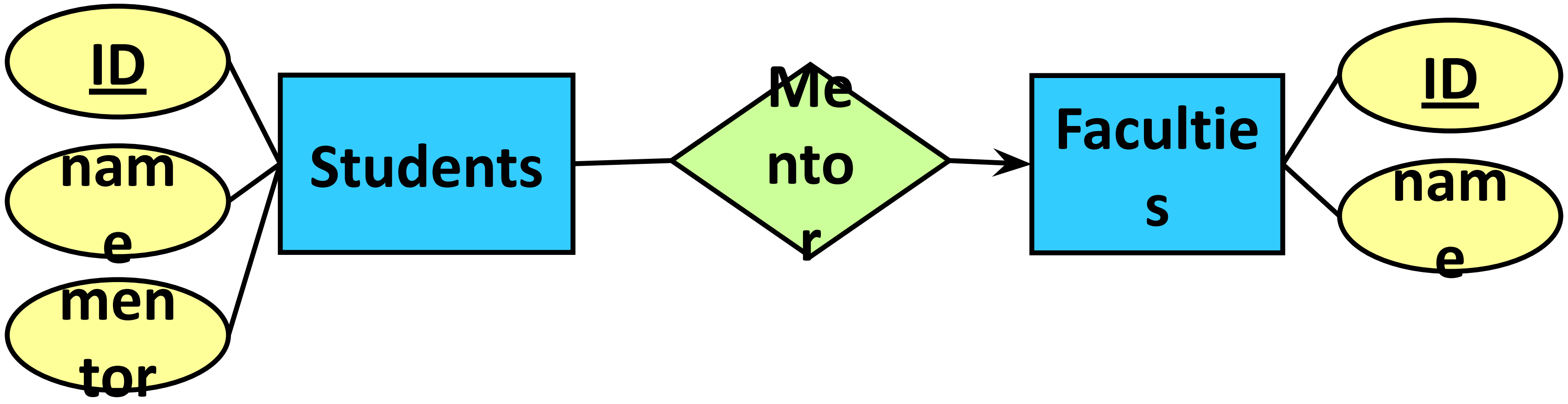
- Design Principle of ER Diagrams
- Translating an ER Diagram into a Relational Scheme Design

Design Principle 1: Be Faithful

- Be faithful to the specifications of the application
- Capture the requirements as much as possible

Design Principle 2: Avoid Redundancy

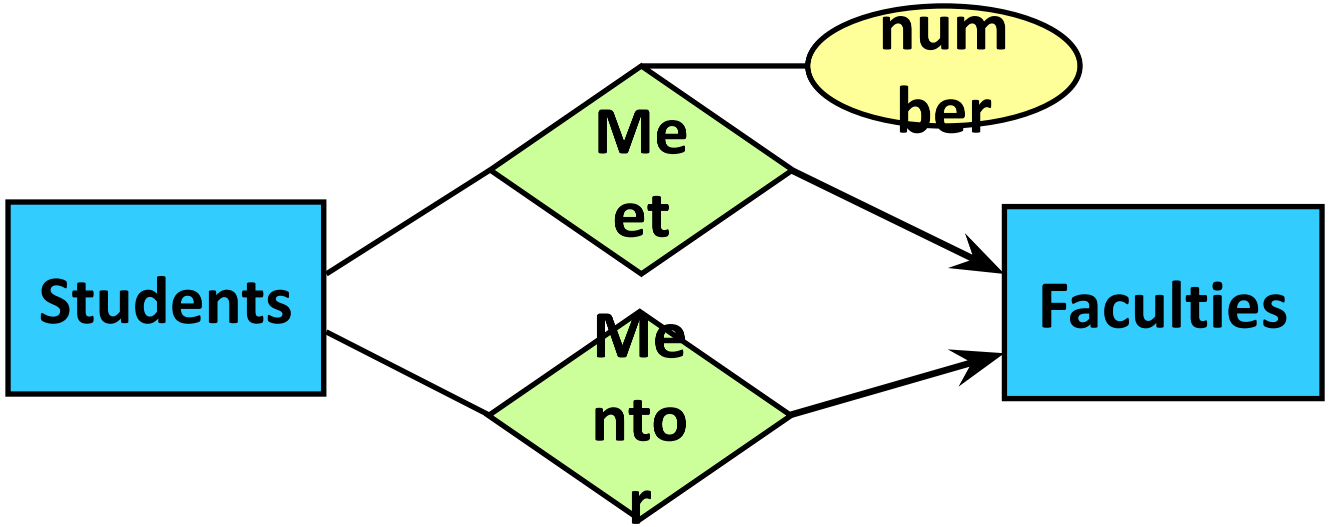
- Avoid repetition of information
- Example



- Problems that can be caused by redundancy
  - Waste of space
  - Possible inconsistency

Design Principle 3: Keep It Simple

- Each student is mentored by one faculty
- One faculty can mentor multiple students
- We also record the number of times that a mentee meets with his/her mentor
- Design below: Not wrong, but can be simplified



Design Principle 3: Keep It Simple

- Each student is mentored by one faculty
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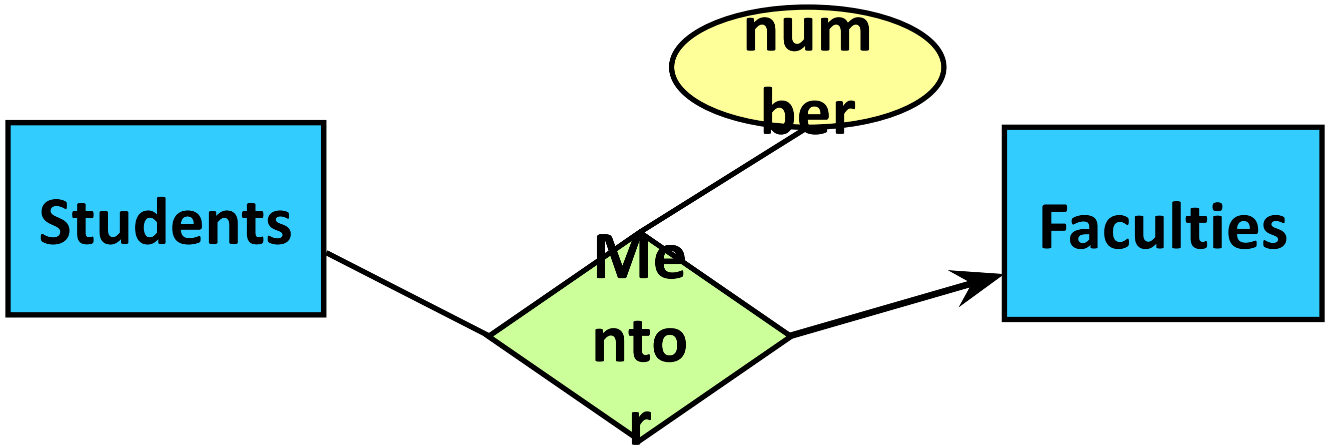
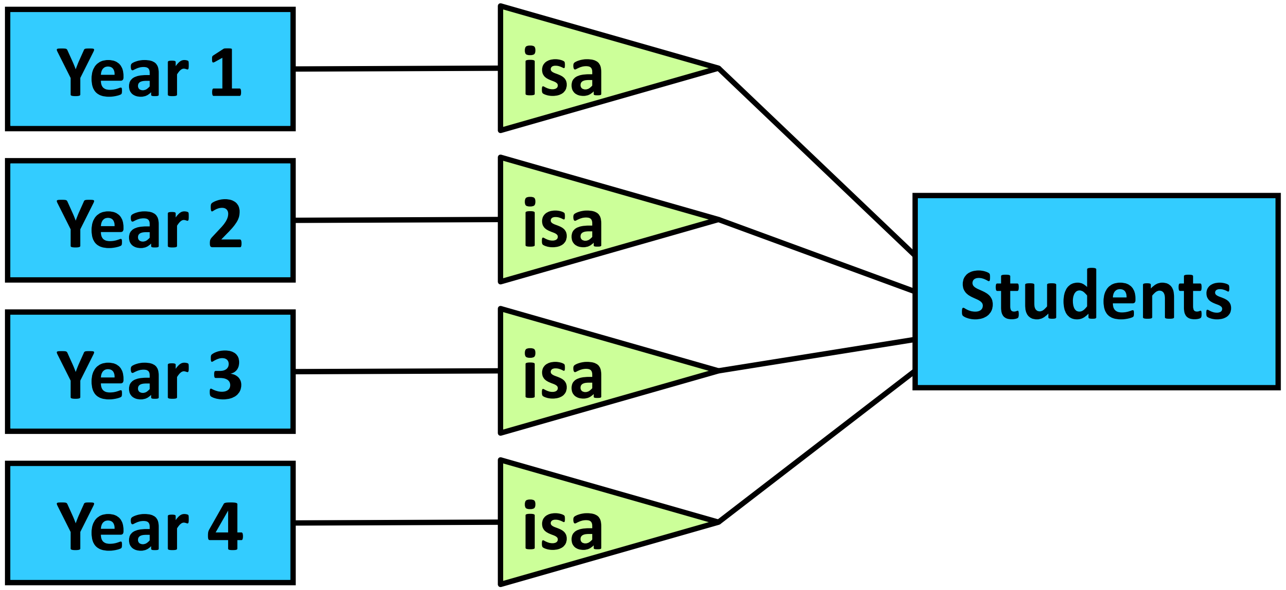
- We also record the number of times that a mentee meets with his/her mentor
- Better Design:



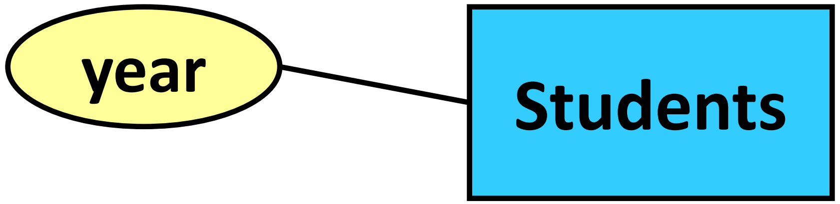
Design Principle 3: Keep It Simple

- There are four types of students: Year 1, Year 2, Year 3, Year 4
- Design below: Not wrong, but can be simplified



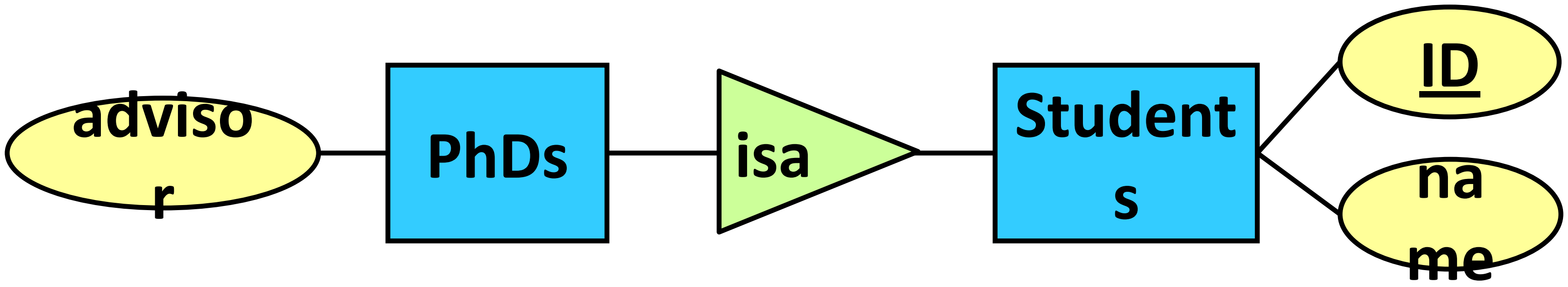
Design Principle 3: Keep It Simple

- There are four types of students: Year 1, Year 2, Year 3, Year 4
- Better Design

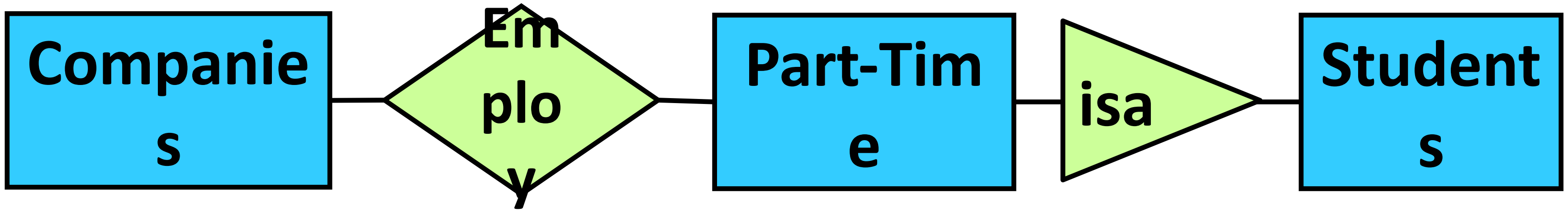


Tips: When to Use Subclasses

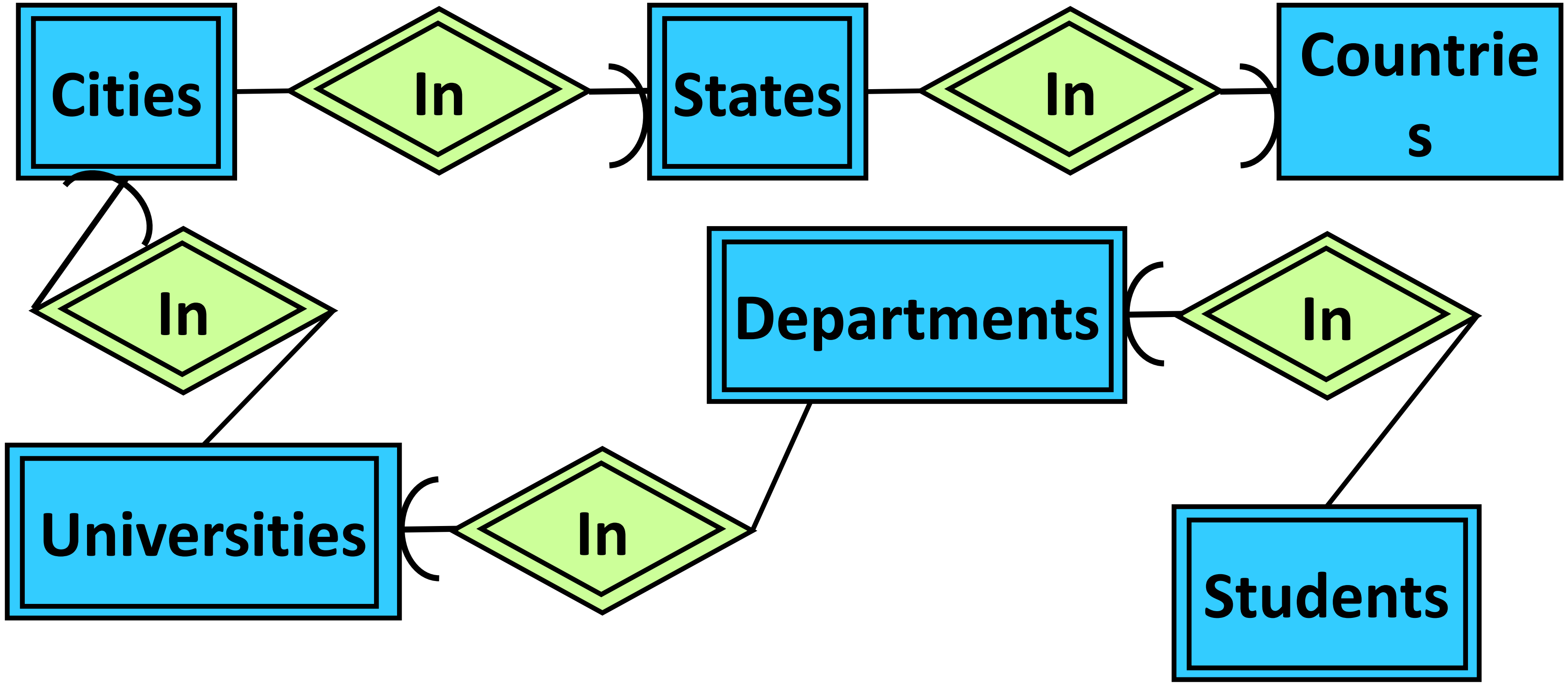
- Case 1: When a subclass has some attribute that is absent from the superclass



- Case 2: When a subclass has its own relationship with some other entity sets



Design Principle 4: Don’t Over-use Weak Entity Sets



- Too many entity sets that should not be “weak”

Road Map

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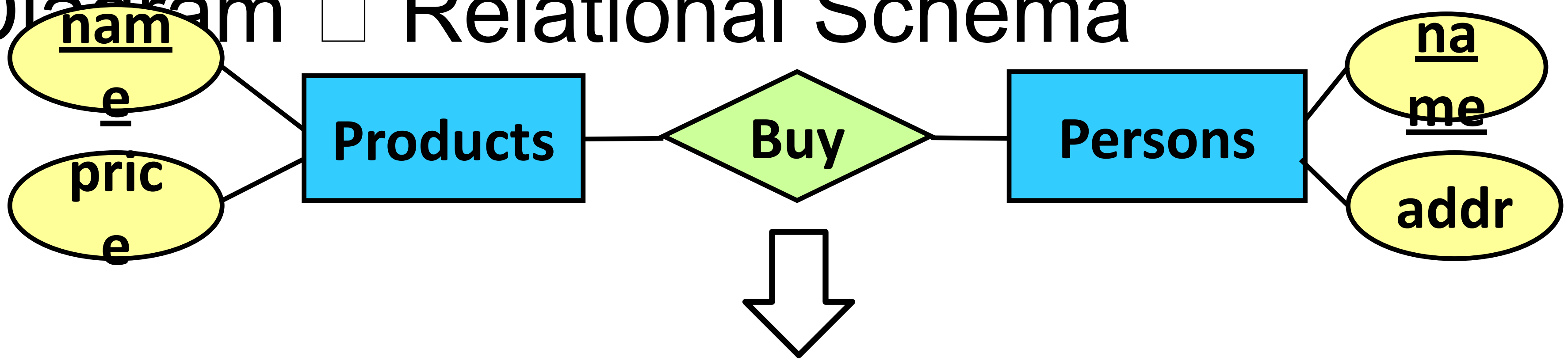
- Design Principle of ER Diagrams
- Translating an ER Diagram into a Relational Scheme Design

ER Diagram □ Relational Schema

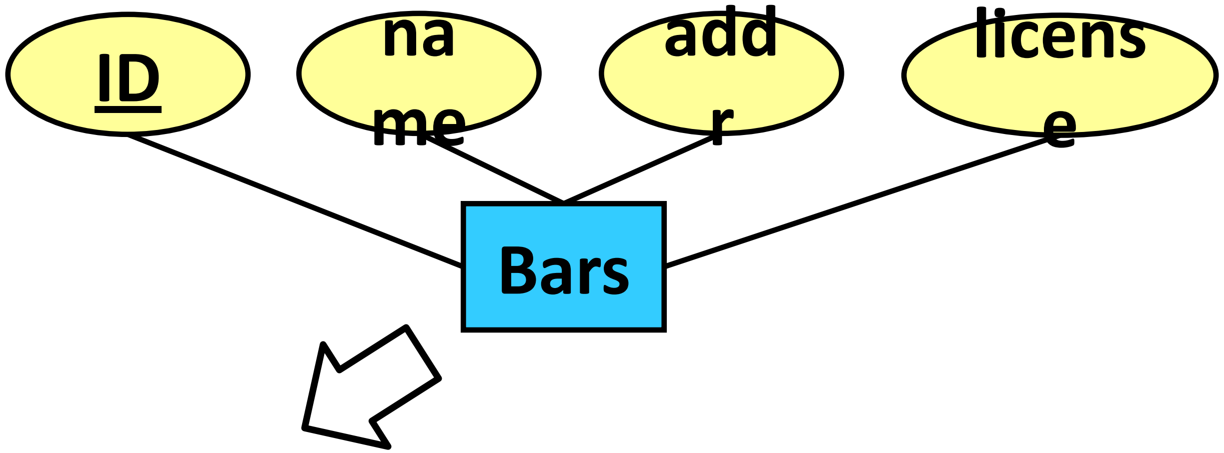


- Products (name, price)
- Persons (name, addr)
- Buy (product_name, person_name)
- Terminology
  - A relation schema = the name of a table + names of its attributes
  - A database schema = a set of relation schemas

ER Diagram Relational Schema

- General rules:
  - Each entity set becomes a relation
  - Each many-to-many relationship becomes a relation
- Special treatment needed for:
  - Weak entity sets
  - Subclasses
  - Many-to-one and one-to-one relationships

Entity Set □ Relation

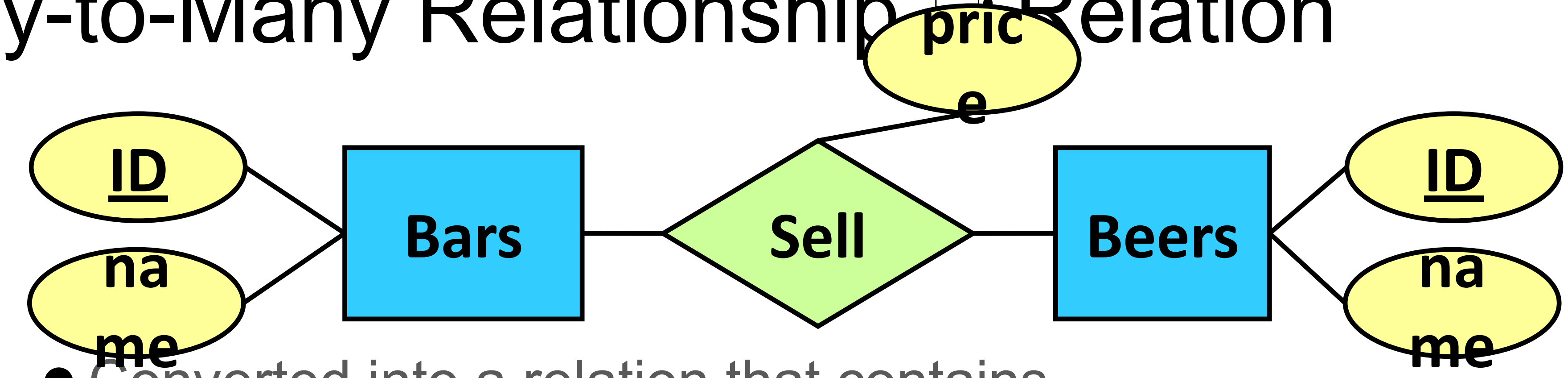


Bars

ID	name	addr	license
…	…	…	…

- Each entity set is converted into a relation that contains all its attributes
- The key of the relation = the key of the entity set

Many-to-Many Relationship → Relation

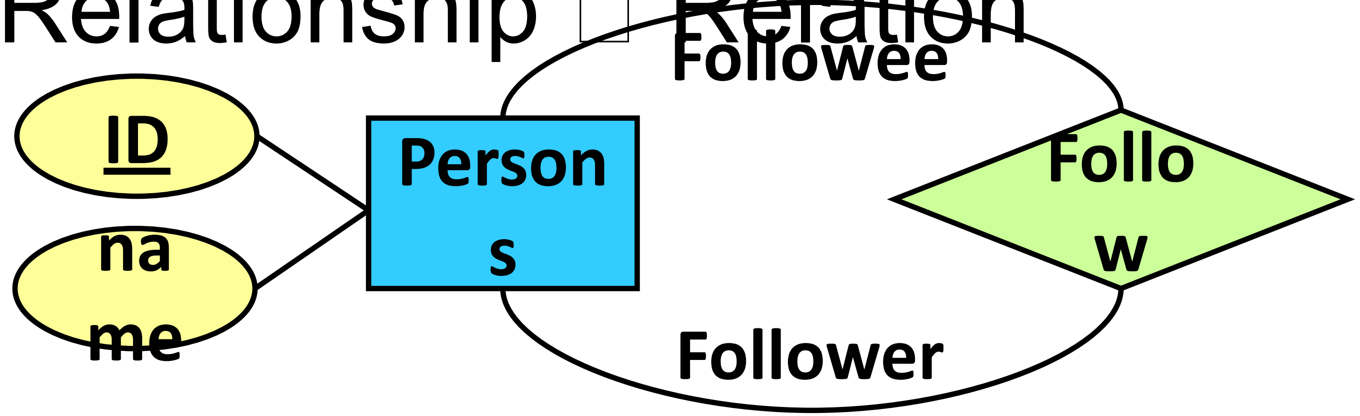


- Converted into a relation that contains
  - all keys of the participating entity sets, and
  - the attributes of the relationship (if any)
- Normally, Key of relation = Keys of the participating entity sets

Sell

Bars-ID	Beers-ID	price
…	…	…

Many-to-Many Relationship Relation

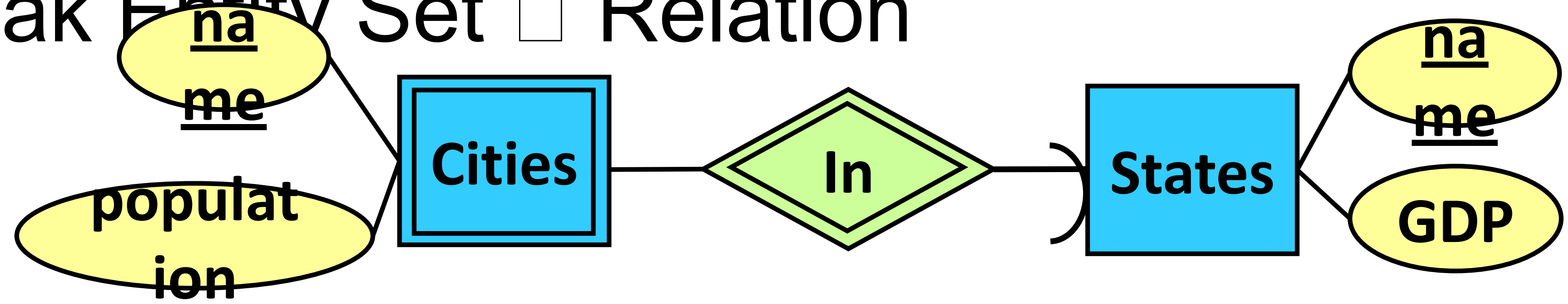


- If an entity is involved multiple times in a relationship
  - Its key will appear in the corresponding relation multiple times
  - The key is re-named according to the corresponding role

Follow

Follower-ID	Followee-ID
…	…

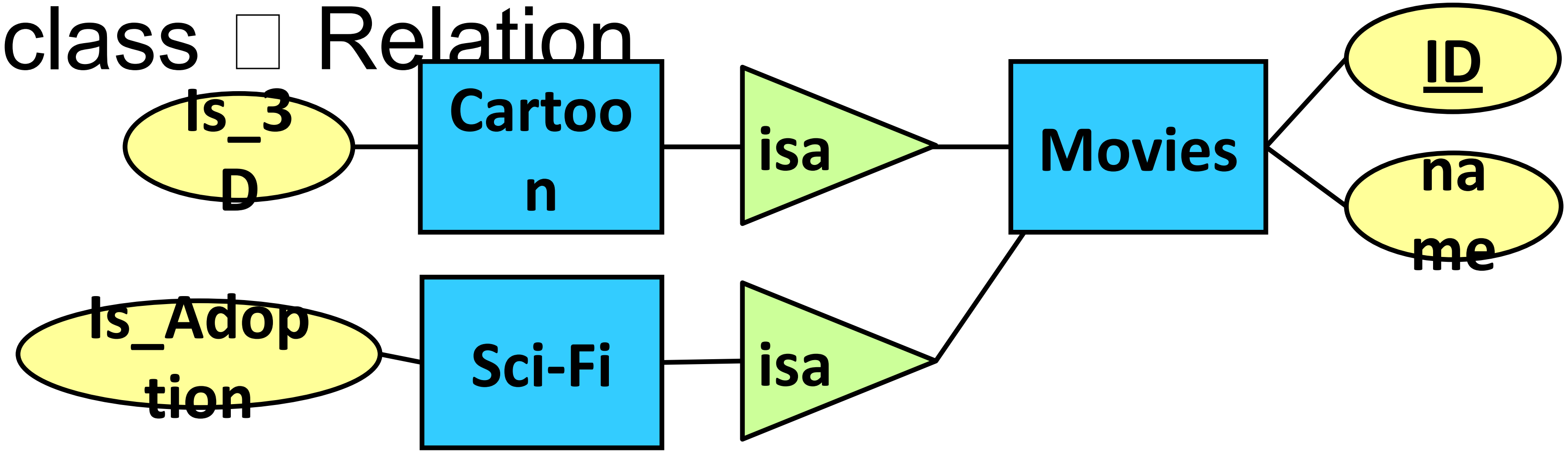
Weak Entity Set □ Relation



- Each weak entity set is converted to a relation that contains
  - all of its attributes, and
  - the key attributes of the supporting entity set
- The supporting relationship is ignored

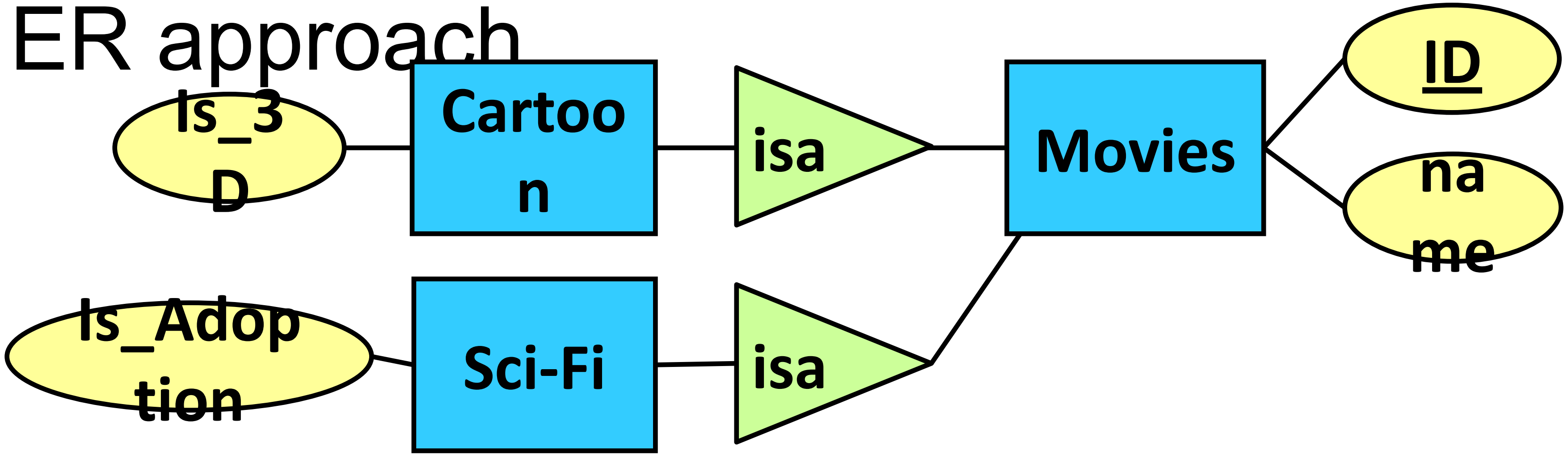
Cities	state-name	city-name	population
	...	...	...

Subclass Relation



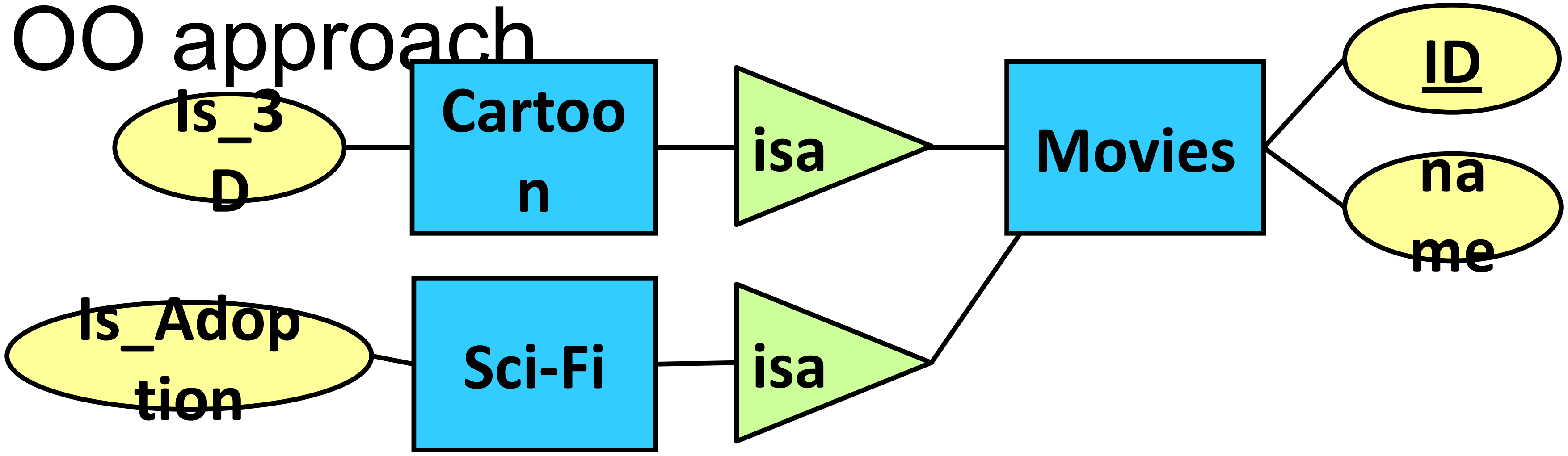
- There are three different ways
  - The ER approach
  - The OO approach
  - The NULL approach

The ER approach



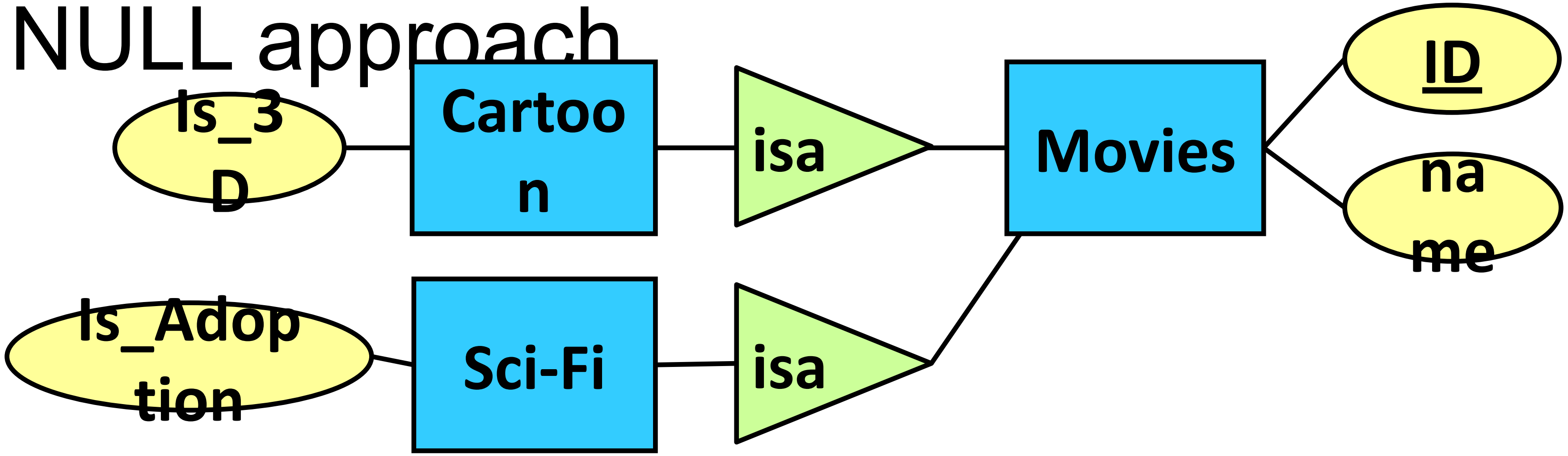
- One relation for each entity set
  - Movies(ID, name)
  - Cartoon(ID, Is_3D)
  - Sci-Fi(ID, Is_Adoption)
- A record may appear in multiple relations

The OO approach



- One relation for each entity set and each possible subclass combination
  - Movies(ID, name)
  - Cartoon(ID, name, Is_3D)
  - Sci-Fi(ID, name, Is_Adoption)
  - Sci-Fi-Cartoon(ID, name, Is_3D, Is_Adoption)
- Each record appears in only one relation

The NULL approach



- One relation that includes everything
  - Movies(ID, name, Is_3D, Is_Adoption)
- For non-cartoon movies, its “Is_3D” is set to NULL
- For non-sci-fi movies, its “Is_Adoption” is set to NULL

Which Approach is the Best?

- It depends
- The NULL approach
  - Advantage: Needs only one relation
  - Disadvantage: May have many NULL values
- The OO approach
  - Advantage: Good for searching subclass combinations
  - Disadvantage: May have too many tables
- The ER approach
  - A middle ground between OO and NULL

ER Diagram Relational Schema

- General rules:
  - Each entity set becomes a relation
  - Each many-to-many relationship becomes a relation
- Special treatment needed for:
  - Weak entity sets
  - Subclasses
  - Many-to-one and one-to-one relationships

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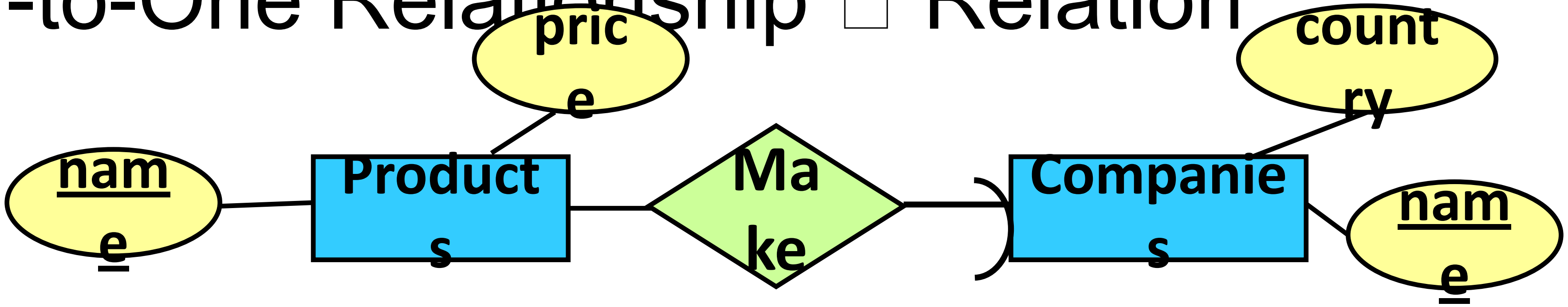
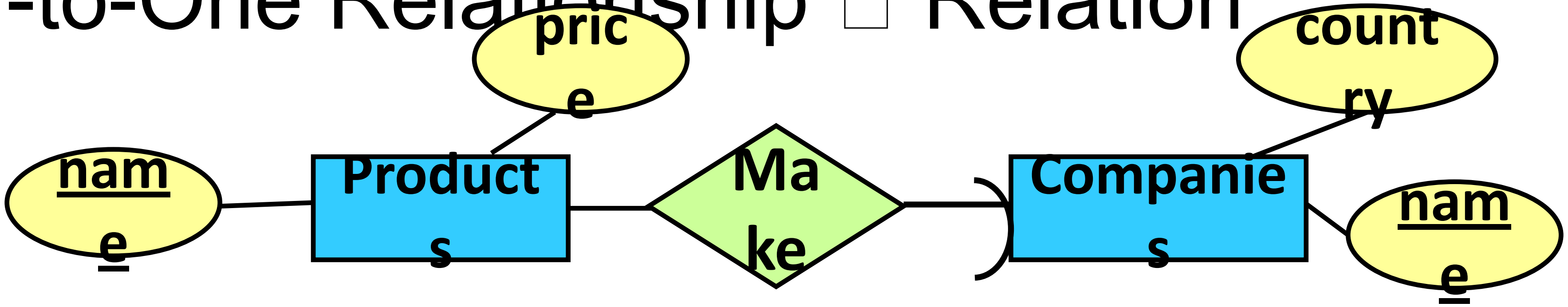
Many-to-One Relationship □ Relation



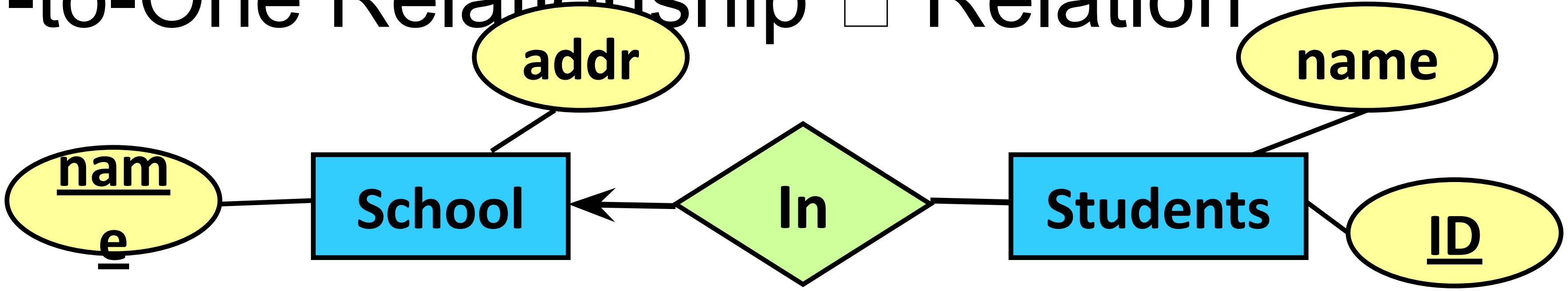
- Intuitive translation:
  - Products(<u>Pname</u>, price)
  - Companies(<u>Cname</u>, country)
  - Make(<u>Pname</u>, Cname)
- Observation: in “Make”, each Pname has only one Cname
- Simplification: Merge “Make” and “Products”
- Results:
  - Products(<u>Pname</u>, price, Cname)
  - Companies(<u>Cname</u>, country)

Many-to-One Relationship Relation



- In general, we do not need to create a relation for a many-to-one relationship
- Instead, we only need to put the key of the "one" side into the relation of the "many" side

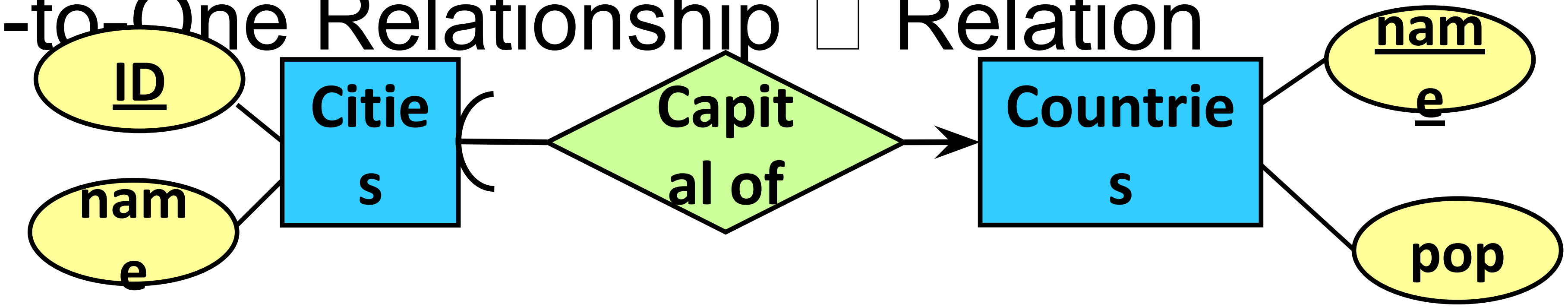
Many-to-One Relationship □ Relation



- Translation:
  - School(<u>Hname</u>, addr)
  - Students(<u>ID</u>, Sname, Hname)

- Only need to put the key of the “one” side into the relation of the “many” side

One-to-One Relationship □ Relation



- No need to create a relation for a one-to-one relationship
- Only need to put the key of one side into the relation of the other
- Solution 1
  - Cities(<u>TID</u>, Tname)
  - Countries(<u>Cname</u>, pop, TID)
- Solution 2
  - Cities(<u>TID</u>, Tname, Cname)
  - Countries(<u>Cname</u>, pop)

Summary

- Entity
- Relationship
- Constraints (Key, FK)
- Subclasses
- Weak Entity Sets
- Translating an ER Diagram into a Relational Scheme Design