

# Entity-Relationship (ER) Model

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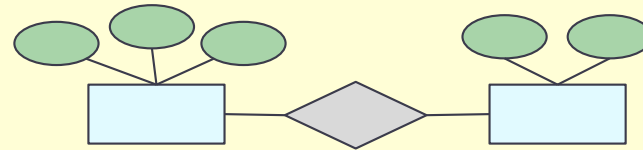
## CS 4750 Database Systems

[A. Silberschatz, H. F. Korth, S. Sudarshan, Database System Concepts, Ch.6]  
[C.M. Ricardo and S.D. Urban, Database Illuminated, Ch.3]

# Database Design Process

Interact with users and domain experts to characterize the data

Translate requirements into **conceptual model** (E-R diagrams)



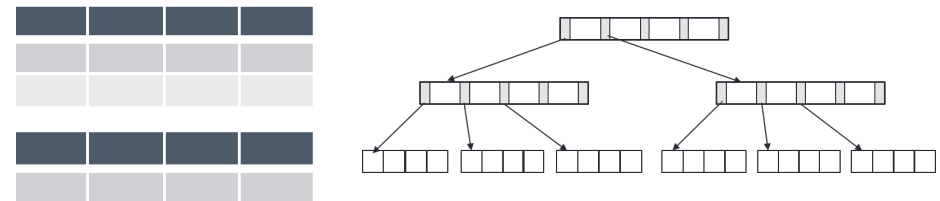
Convert the model to **relational model** (schema and constraints)



Normalize and develop **conceptual (logical) schema** of the database

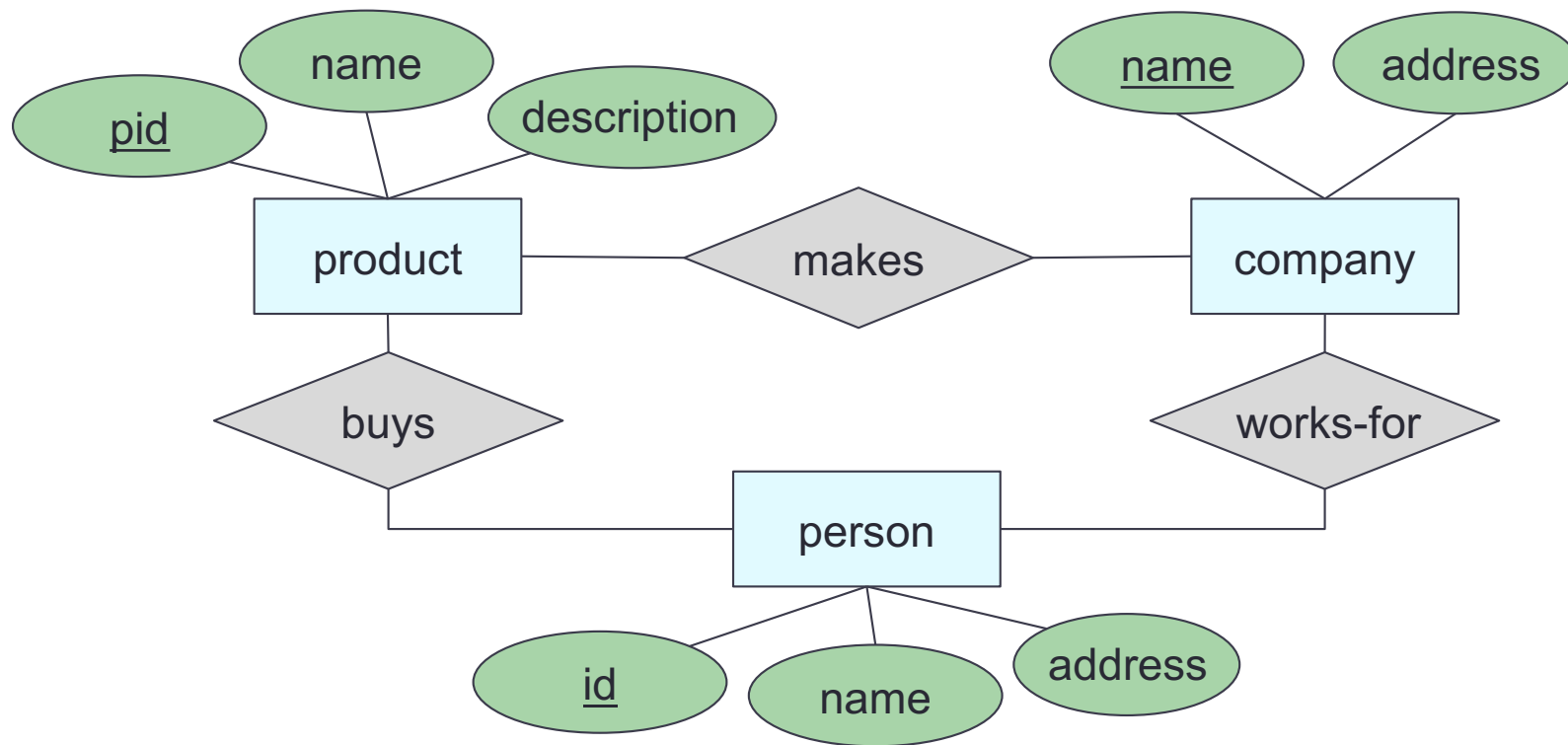


Develop **physical schema** (partitioning and indexing)



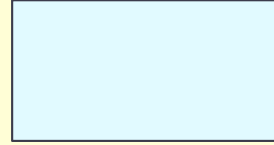
# Entity-Relationship Model

- **E-R diagram** – high-level design model representing a database as a collection of entities and relationships among entities

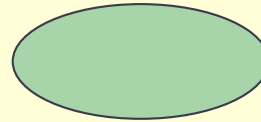


# E-R Diagram: Building Blocks

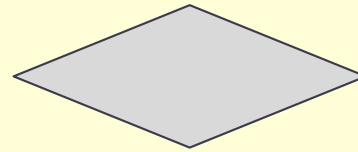
(strong) Entity set



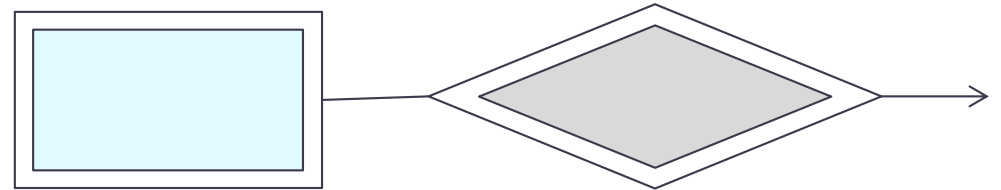
Attribute



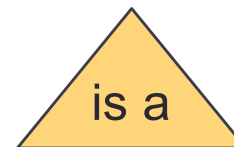
Relationship



Weak entity



Subclass

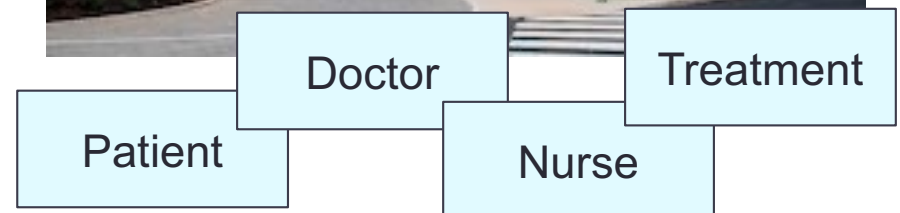
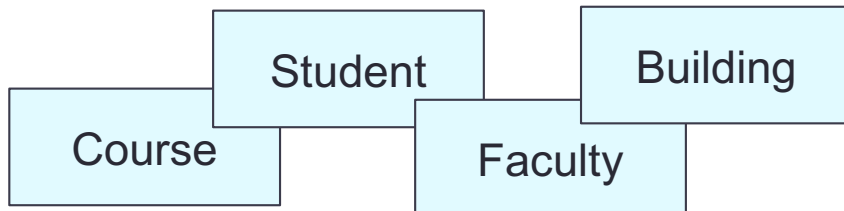


Note: colors are not part of E-R Diagram. They simply are used to increase readability.

# Entity and Entity Sets

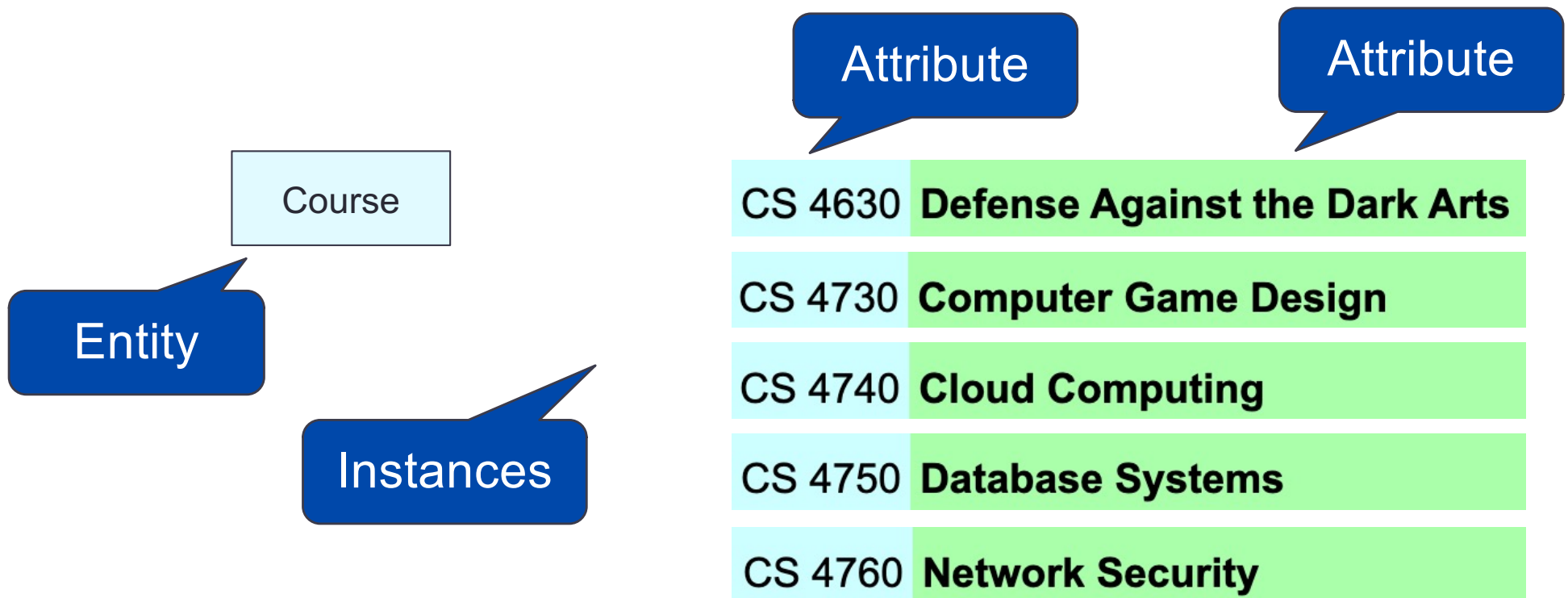
- **Entity** ~an object (thing to keep track to run the business)
- **Entity set** ~a class (~table, a collection of things of the same kind)

Some entity set examples



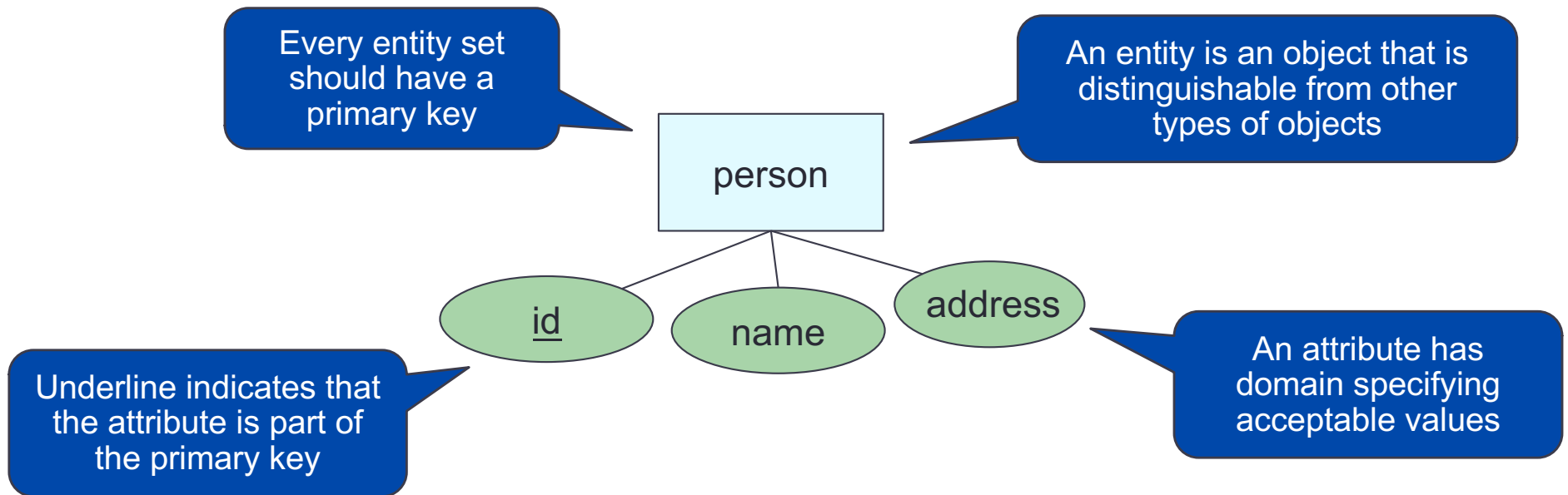
# Entity – Instance – Attributes

- **Entity** ~an object (thing to keep track to run the business)
- **Instance** ~actual occurrence of the entity (~row in a table)
- **Attribute** ~ a field (property of the entities in that set)



Note: instances do not exist in E-R. The term is mentioned here for completeness. It will be revisited when we discuss data model.

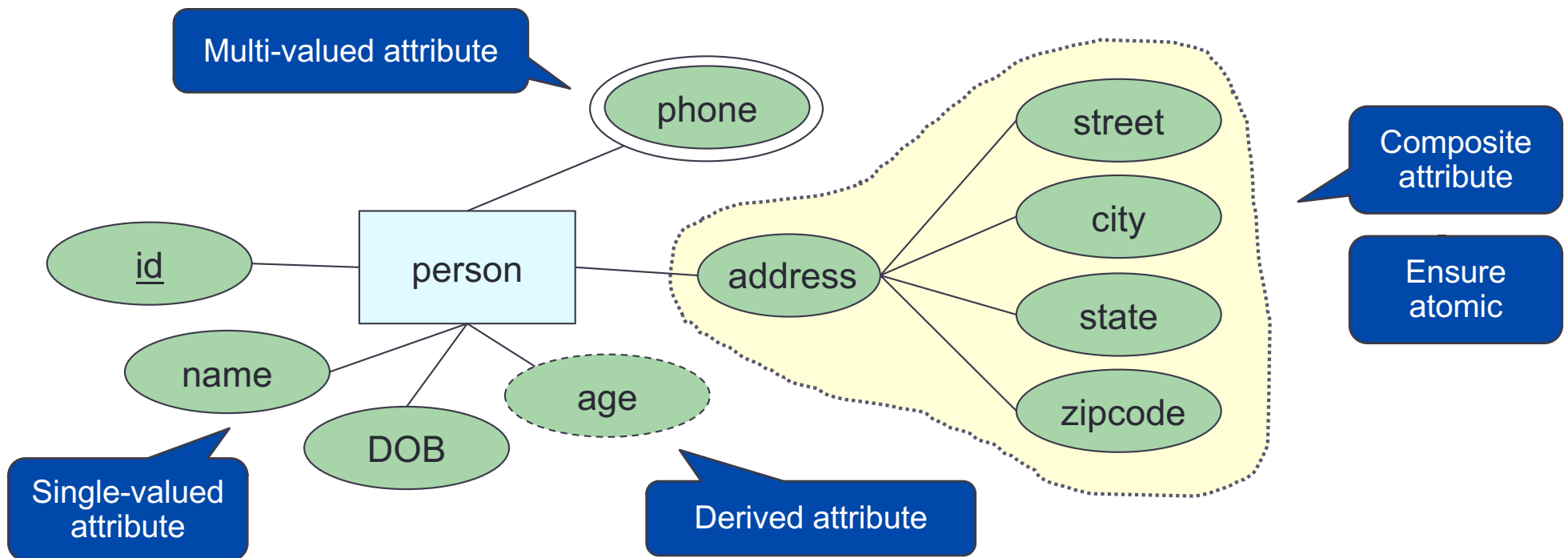
# Entity Sets and Attributes



E-R model is a static concept, involving the structure of data and not the operations on data.  
Thus, no methods associated with an entity set

# Attributes

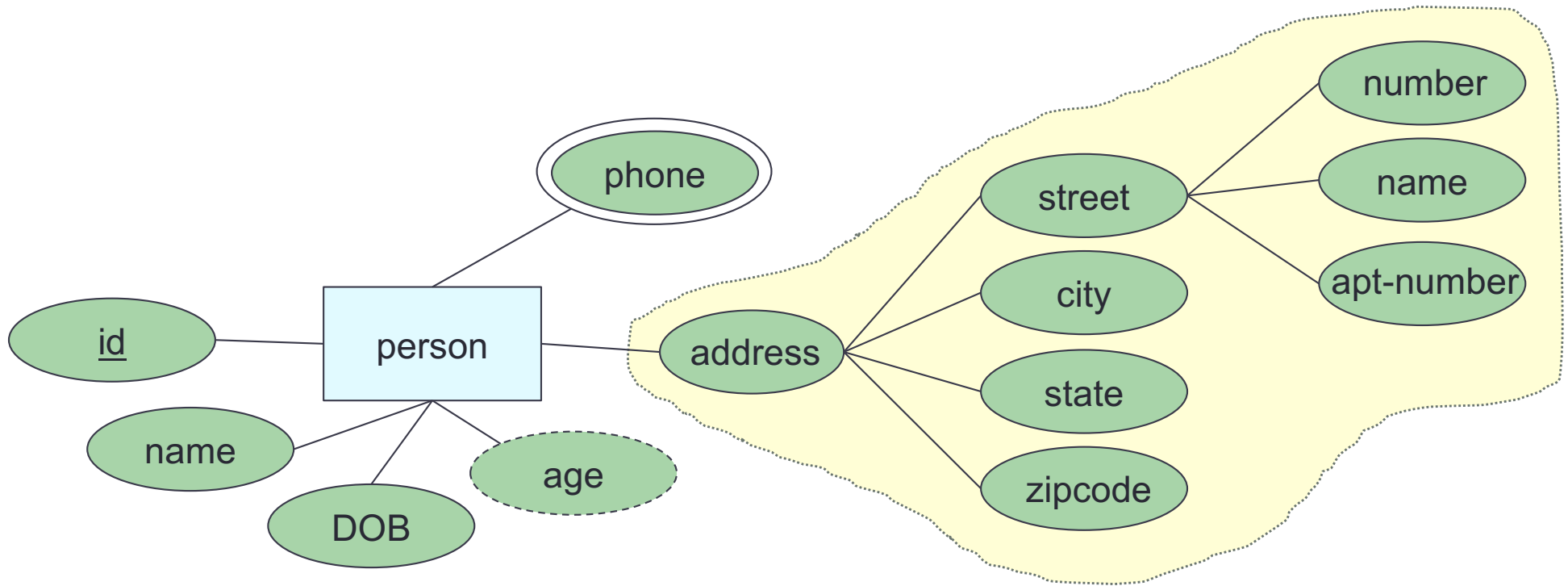
- **Single-valued attribute** – allows a single value
- **Multi-valued attribute** – allows multiple values at the same time
- **Derived attribute** – can be calculated from one or more attributes
- **Composite attribute** – consists of multiple values





# Attributes

- **Composite attribute** – can have as many levels as needed



# Note: Instances of E-R Diagram

E-R model is used to design a database. The database is not implemented. Therefore, the instance of E-R diagram never exists in the sense that a relation's instances exist in a relational model.

However, it is often useful to visualize the database being designed as if it existed.

# Relationships

- Connections among two or more entity sets
- **Binary relationships** – connections between two entity sets
- **Multi-way relationships (u-ary)** – connections involving more than two entity sets

# Binary Relationships

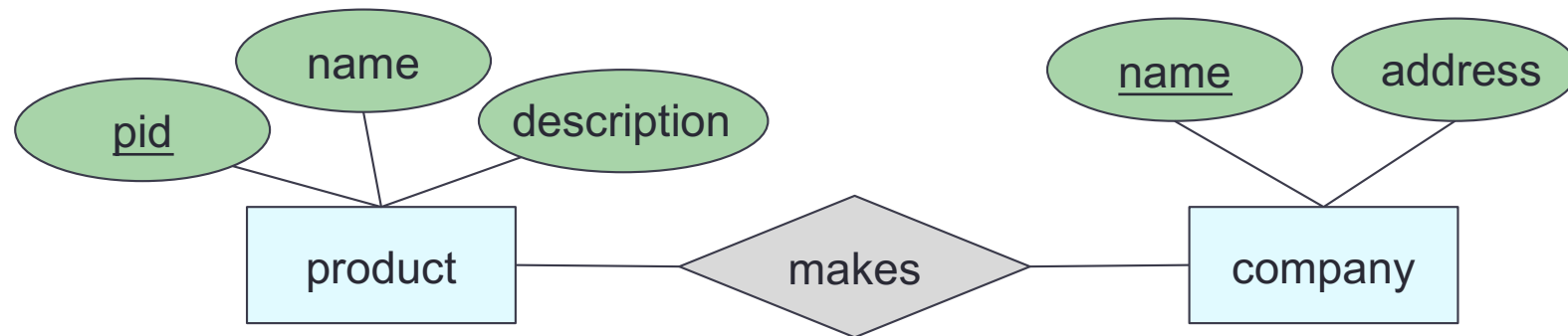
If  $A$  and  $B$  are sets, a relationship  $R$  is a subset of  $A \times B$

product

pid	name	description
11	Beyblade	...
22	Trolls	...
...	...	...

company

name	address
Dreamwork	...
Hashbro	...
Nyform	...

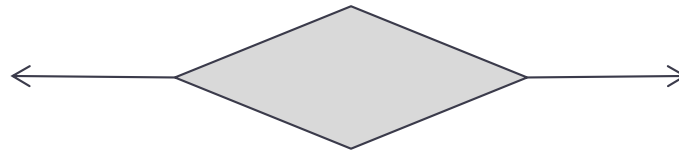


Note: instances do not exist in E-R. These tables are only to help visualize the database being designed.

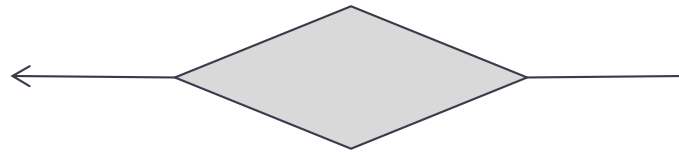
# Cardinality (or Multiplicity)

A binary relationship can connect any member of one of its entity sets to any number of members of the other entity set

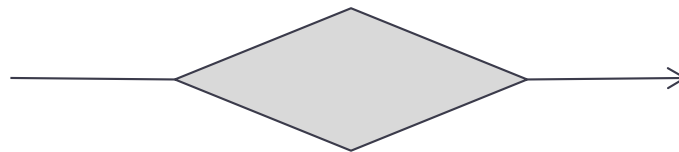
- One-to-one



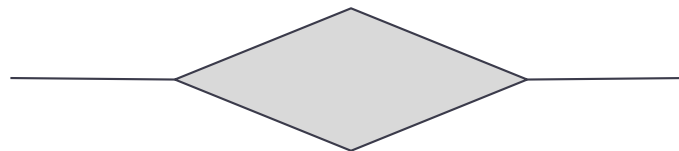
- One-to-many



- Many-to-one



- Many-to-many



# Cardinality: One-to-One

product

pid	name	description
11	Beyblade	...
22	Trolls	...
...	...	...

company

name	address
Dreamwork	...
Hashbro	...
Nyform	...



Arrow pointing to the entity that is constrained to one

Arrow pointing to the entity that is constrained to one

Each product can be made by **at most one** company.  
Each company can make **at most one** product.

“at most one” – Guarantee existence?

Note: instances do not exist in E-R. These tables are only to help visualize the database being designed.

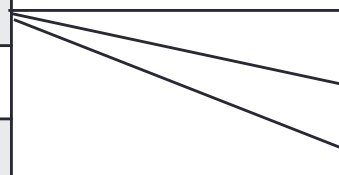
# Cardinality: One-to-Many

product

pid	name	description
11	Beyblade	...
22	Trolls	...
...	...	...

company

name	address
Dreamwork	...
Hashbro	...
Nyform	...



Arrow pointing to the entity that is constrained to one

Each product can be made by **many** companies.  
Each company can make **at most one** product.

“at most one” and “many” – Guarantee existence?

Note: instances do not exist in E-R. These tables are only to help visualize the database being designed.

# Cardinality: Many-to-One

product

pid	name	description
11	Beyblade	...
22	Trolls	...
...	...	...

company

name	address
Dreamwork	...
Hashbro	...
Nyform	...



Arrow pointing to the entity that is constrained to one

Each product can be made by **at most one** company.  
Each company can make **many** products.

“at most one” and “many” – Guarantee existence?

Note: instances do not exist in E-R. These tables are only to help visualize the database being designed.



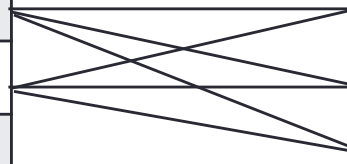
# Cardinality: Many-to-Many

product

pid	name	description
11	Beyblade	...
22	Trolls	...
...	...	...

company

name	address
Dreamwork	...
Hashbro	...
Nyform	...



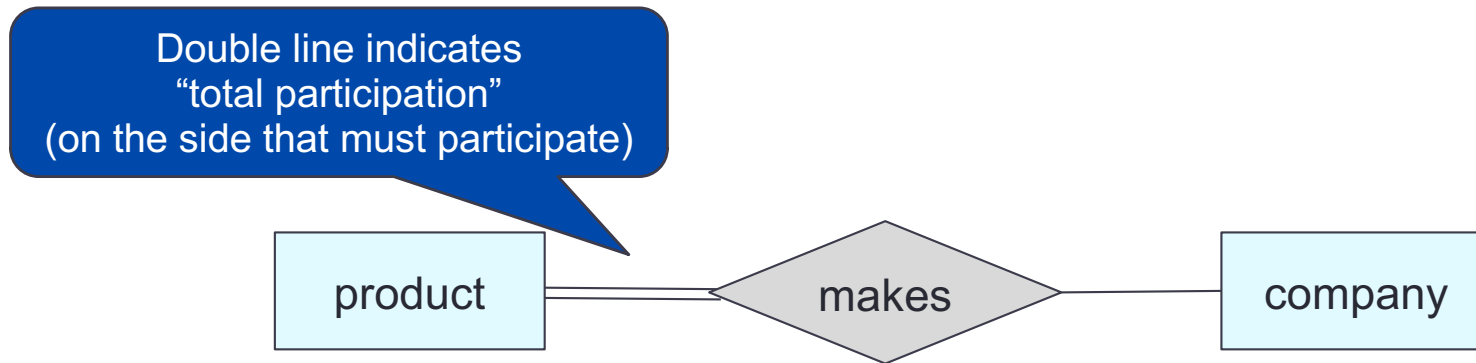
Each product can be made by **many** companies.  
Each company can make **many** products.

“many” – Guarantee existence?

Note: instances do not exist in E-R. These tables are only to help visualize the database being designed.

# Total Participation

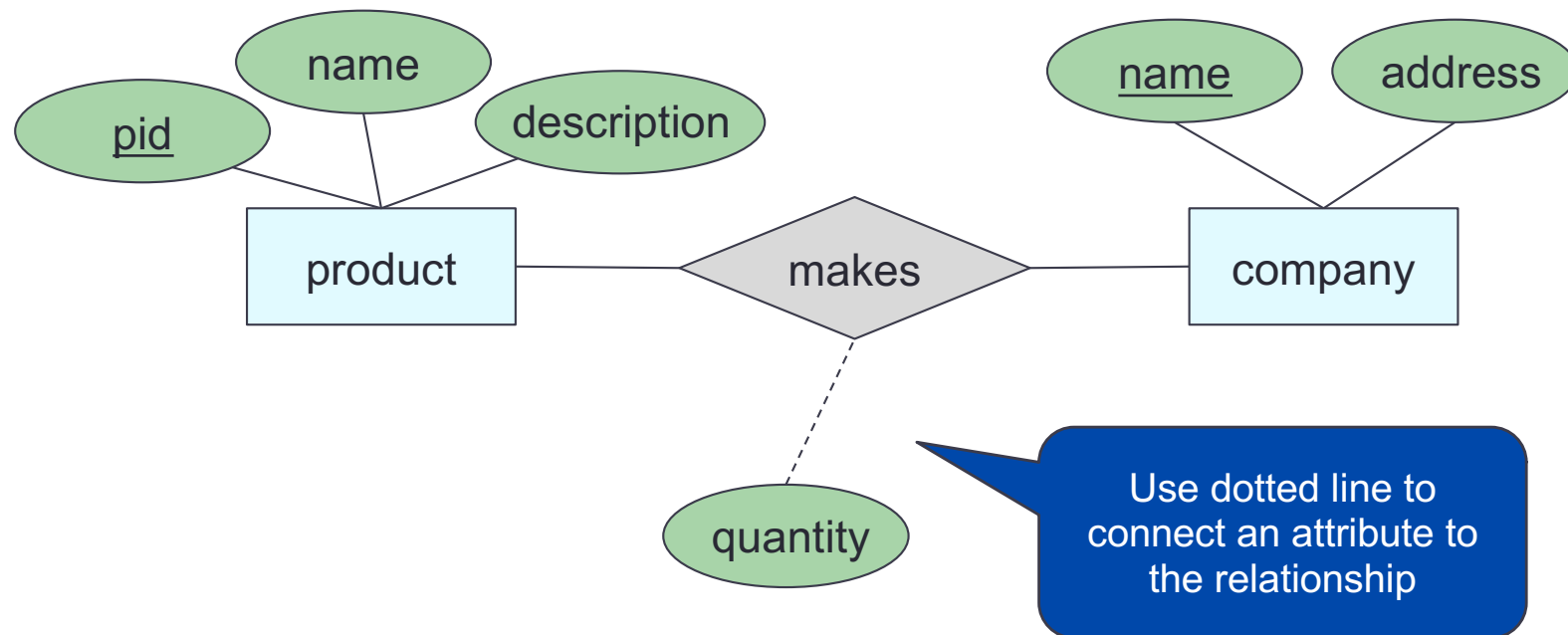
**Total participation** – all entities in an entity set **must** participate in the relationship



**Every** product **must** be made by **at least one** company.  
Each product can be made by many companies.  
Each company can make many products.  
Some companies may not make any product.

# Attributes on Relationships

- Relationships can have attributes
- The attributes have values only when the relationship occurs



# Wrap-Up

- Database design process
- Intro to E-R model
- Entities and entity sets
- Attributes: single-valued, multi-valued, derived, composite
- Cardinality and participation

## What's next?

- Roles in relationships
- Relationships: binary, multi-way
- Weak entity