Lecture 14: Entity Relationship Modelling

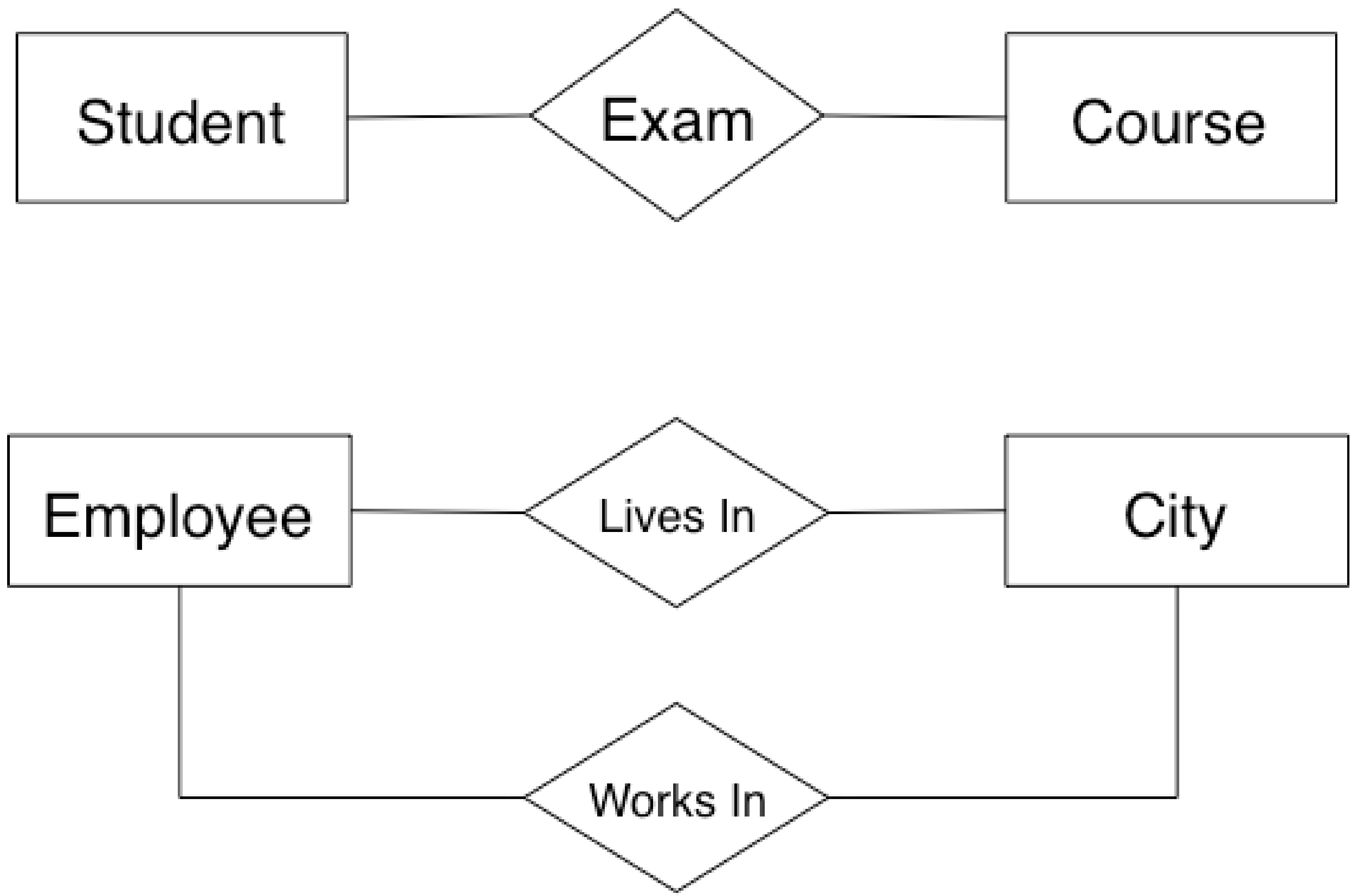
- The Entity-Relationship Model
  - Entities
  - Relationships
  - Attributes
- Constraining the instances
  - Cardinalities
  - Identifiers
  - Generalization

The Entity Relationship Model

- Entity-Relationship Schema
  - Describes data requirements for a new information system
  - Direct, easy-to-understand graphical notation
  - Translates readily to relational schema for database design
    - But more abstract than relational schema
    - E.g. can represent an entity without knowing its properties
  - comparable to UML class diagrams
- Entities:
  - classes of objects with properties in common and an autonomous existence
    - E.g. City, Department, Employee, Purchase and Sale
  - An instance of an entity is an object in the class represented by the entity
    - E.g. Stockholm, Helsinki, are examples of instances of the entity City
- Relationships:
  - logical links between two or more entities.
    - E.g. Residence is a relationship that can exist between the City and Employee
  - An instance of a relationship is an n-tuple of instances of entities
    - E.g. the pair (Johanssen,Stockholm), is an instance in the relationship Residence.

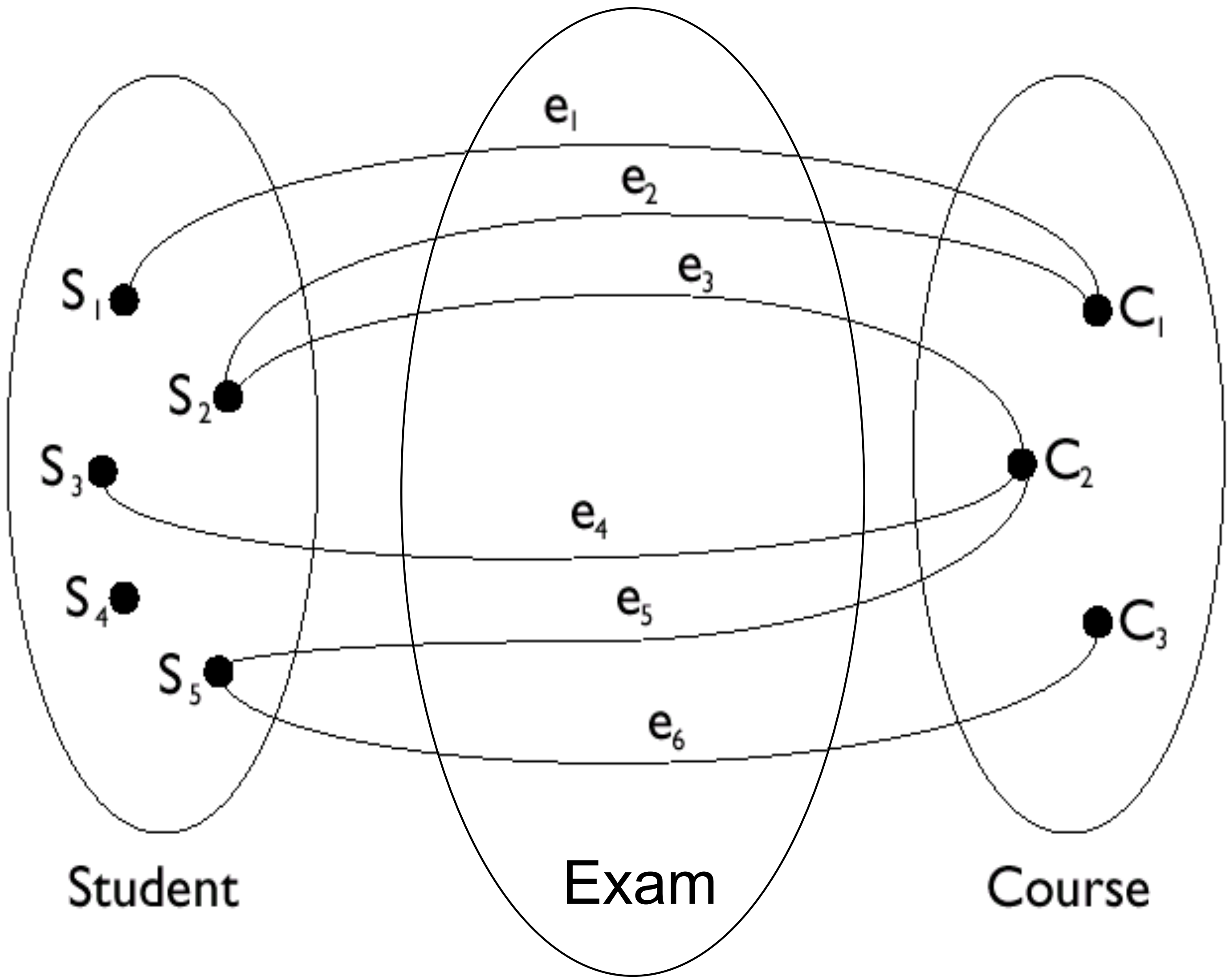
Examples

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999



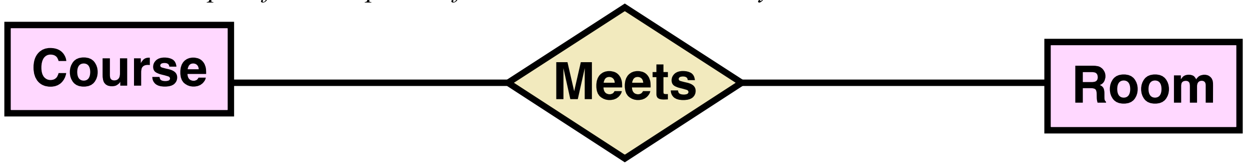
Example Instances for Exam

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

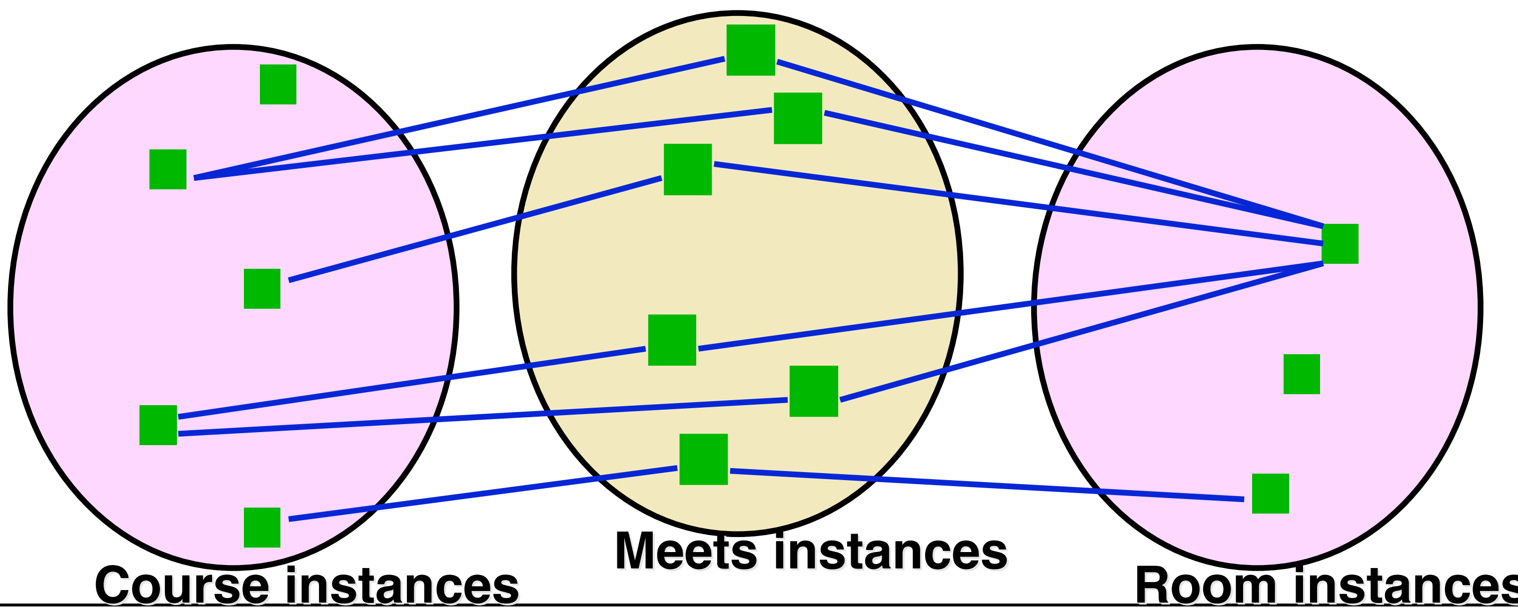


What Does An ER Diagram Really Mean?

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999



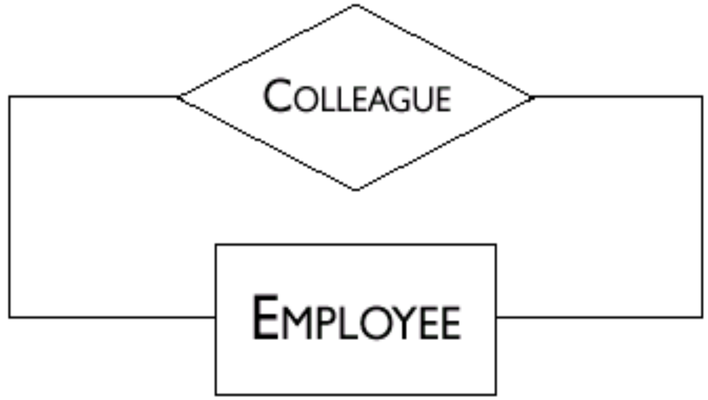
- **Course** and **Room** are entities.
  - Their instances are particular courses (eg CSC340F) and rooms (eg MS2172)
- **Meets** is a relationship.
  - Its instances describe particular meetings.
  - Each meeting has exactly one associated course and room



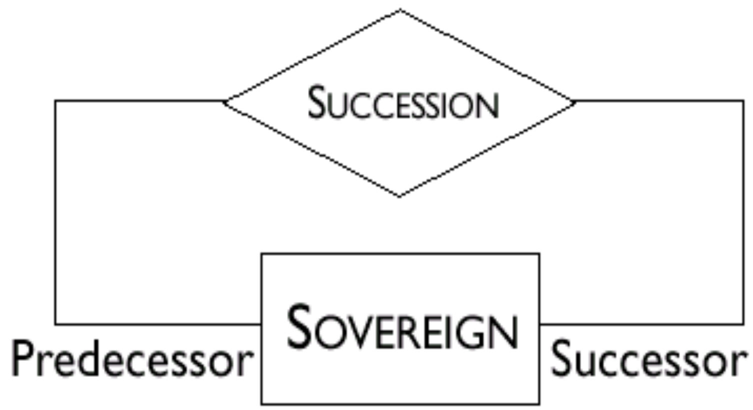
Recursive Relationships

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

- An entity can have relationships with itself…

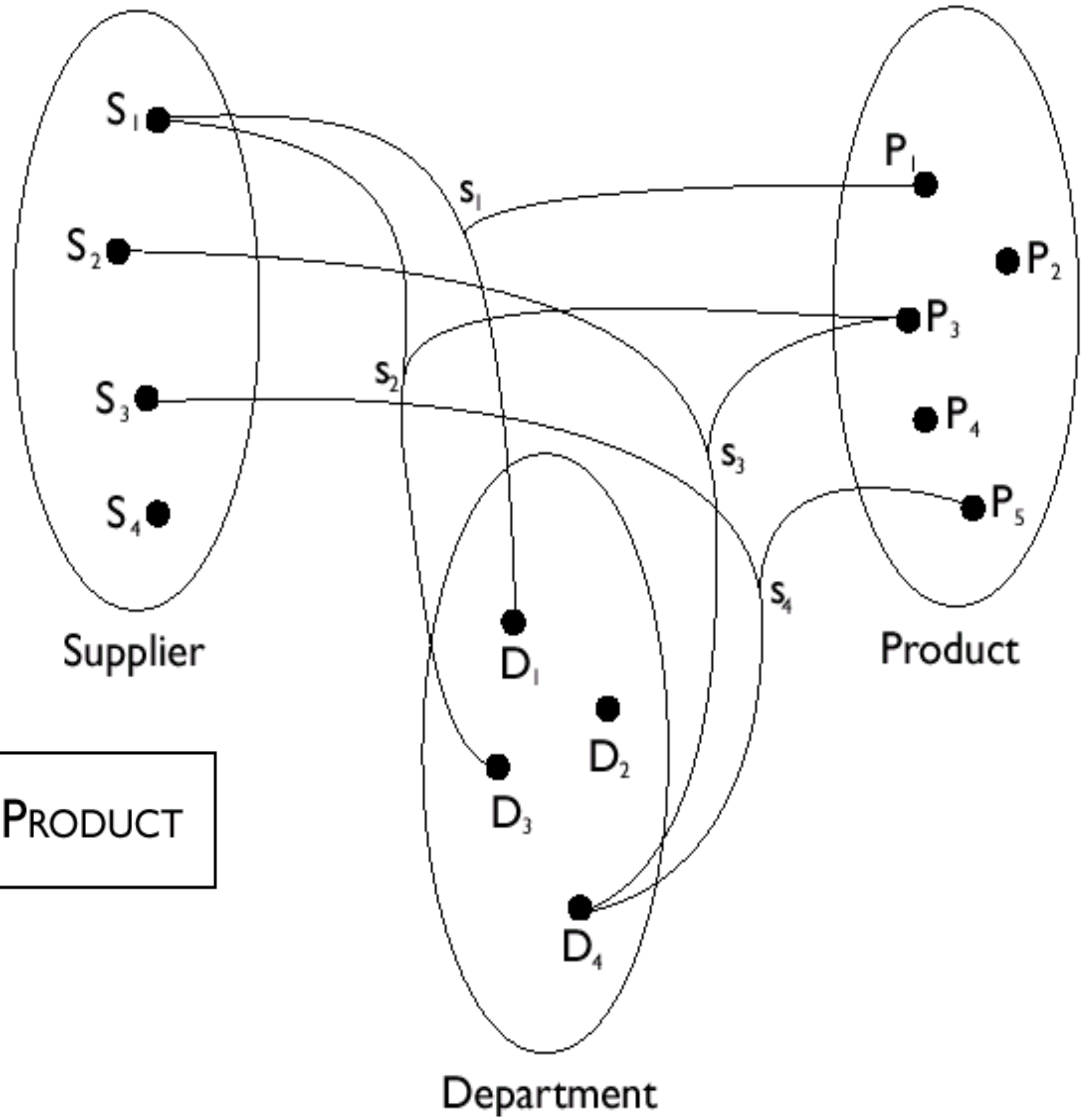


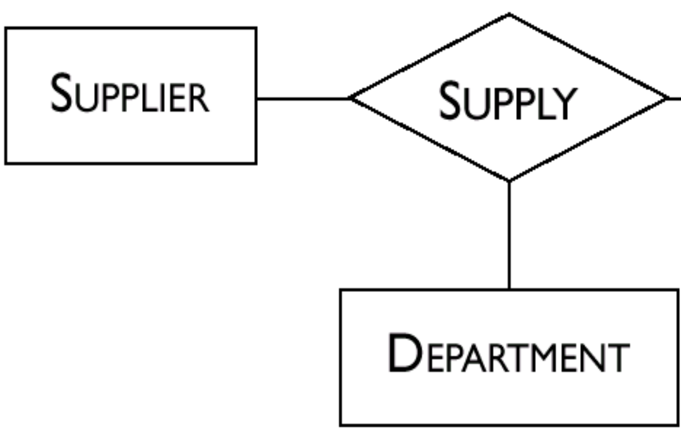
- If the relationship is not symmetric…
  - …need to indicate the two roles that the entity plays in the relationship.



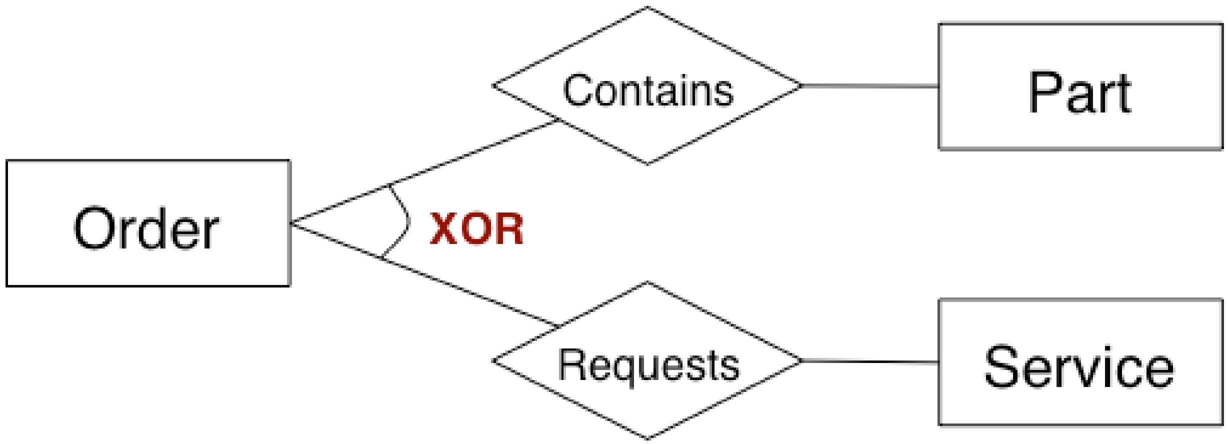
Ternary Relationships

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

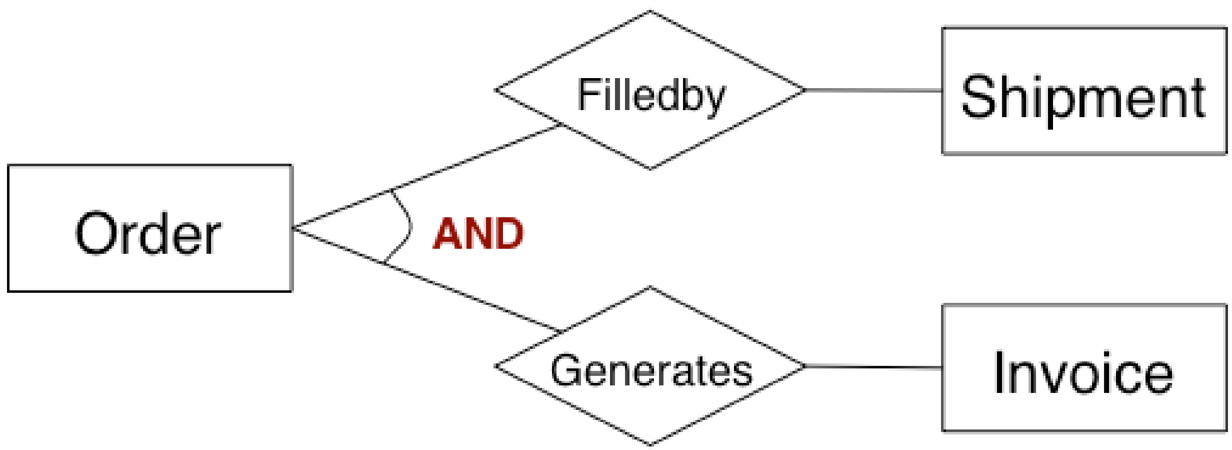




AND/XOR Relationships



"Each Order either contains a part or requests a service, but not both"

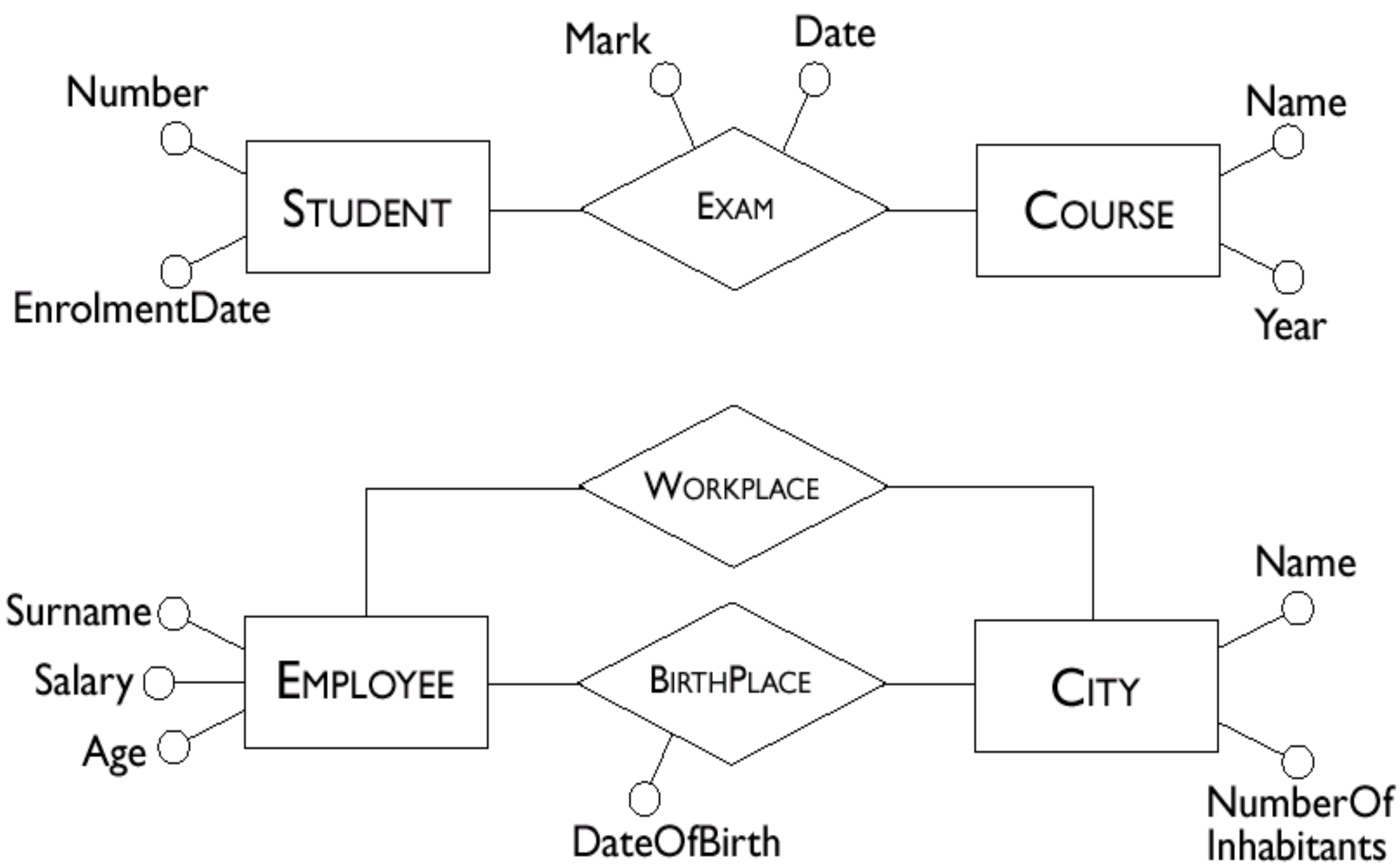


"For any given order, whenever there is at least one invoice there is also at least one shipment and vice versa"

Attributes

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

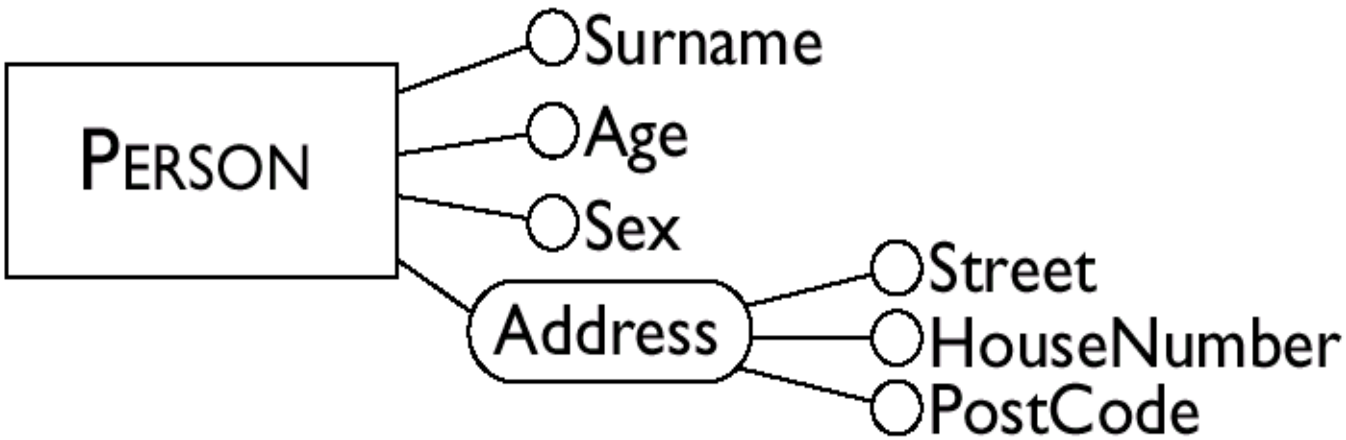
- associates with each instance of an entity (or relationship) a value belonging to a set (the domain of the attribute).
  - The domain determines the admissible values for the attribute.



Composite Attributes

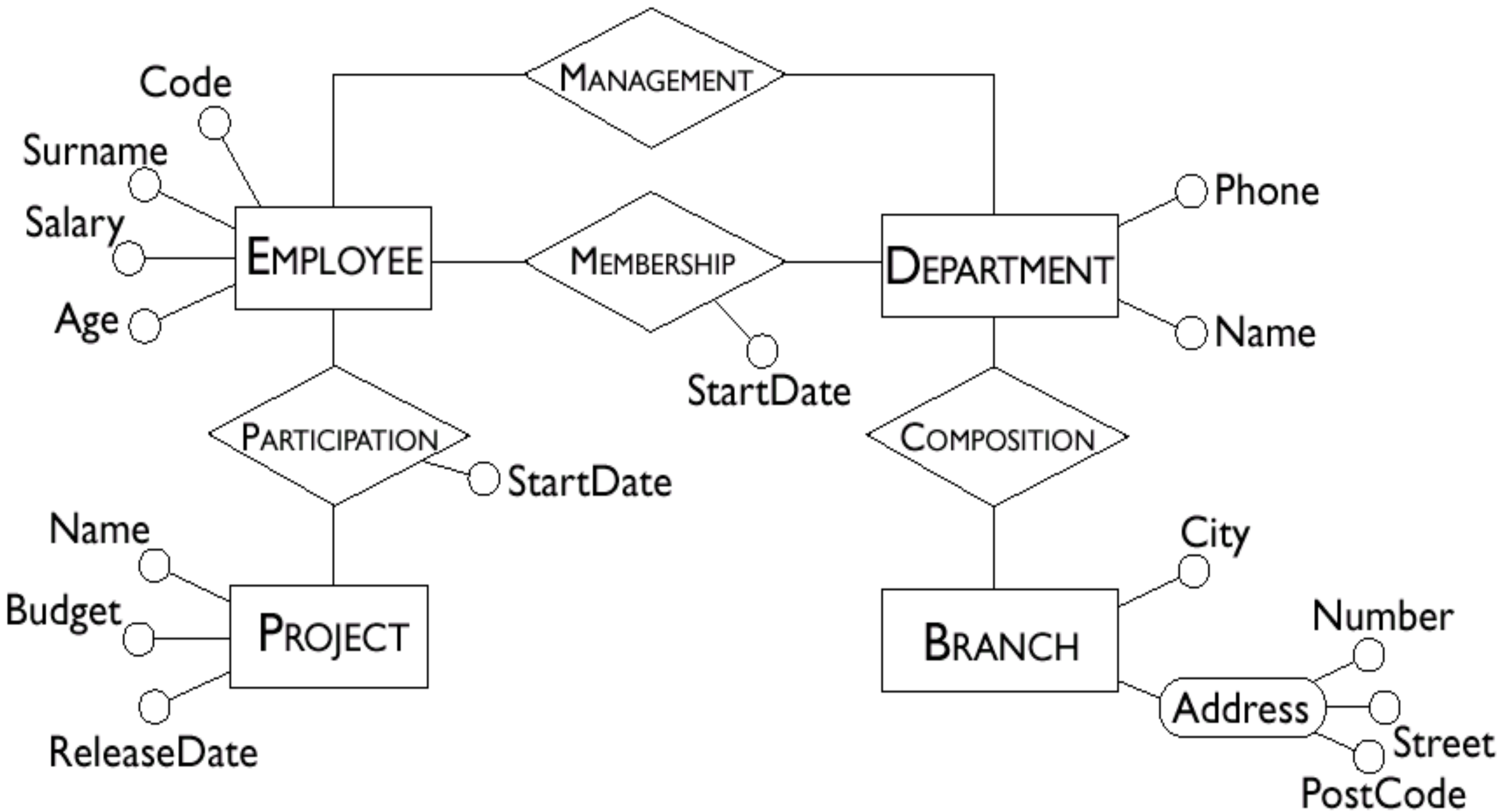
Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

- These group attributes of the same entity or relationship that have closely connected meanings or uses.



Schema with Attributes

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999



Cardinalities

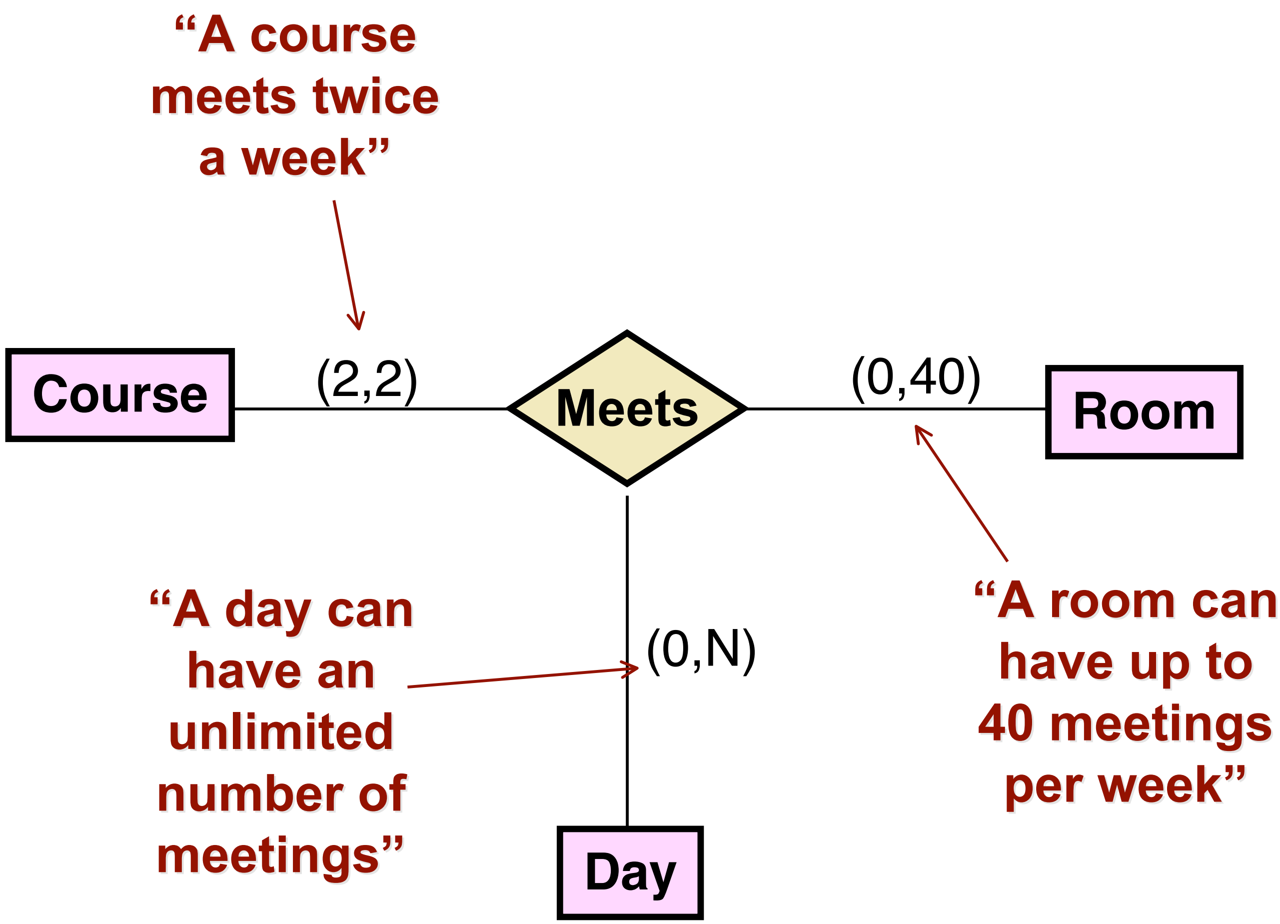
Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

- Cardinalities constrain participation in relationships
  - maximum and minimum number of relationship instances in which an entity instance can participate.
  - E.g.

- cardinality is any pair of non-negative integers (a,b)
  - such that a≤b.
  - If a=0 then entity participation in a relationship is optional
  - If a=1 then entity participation in a relationship is mandatory.
  - If b=1 each instance of the entity is associated at most with a single instance of the relationship
  - If b="N" then each instance of the entity is associated with an arbitrary number of instances of the relationship.

Cardinality Example

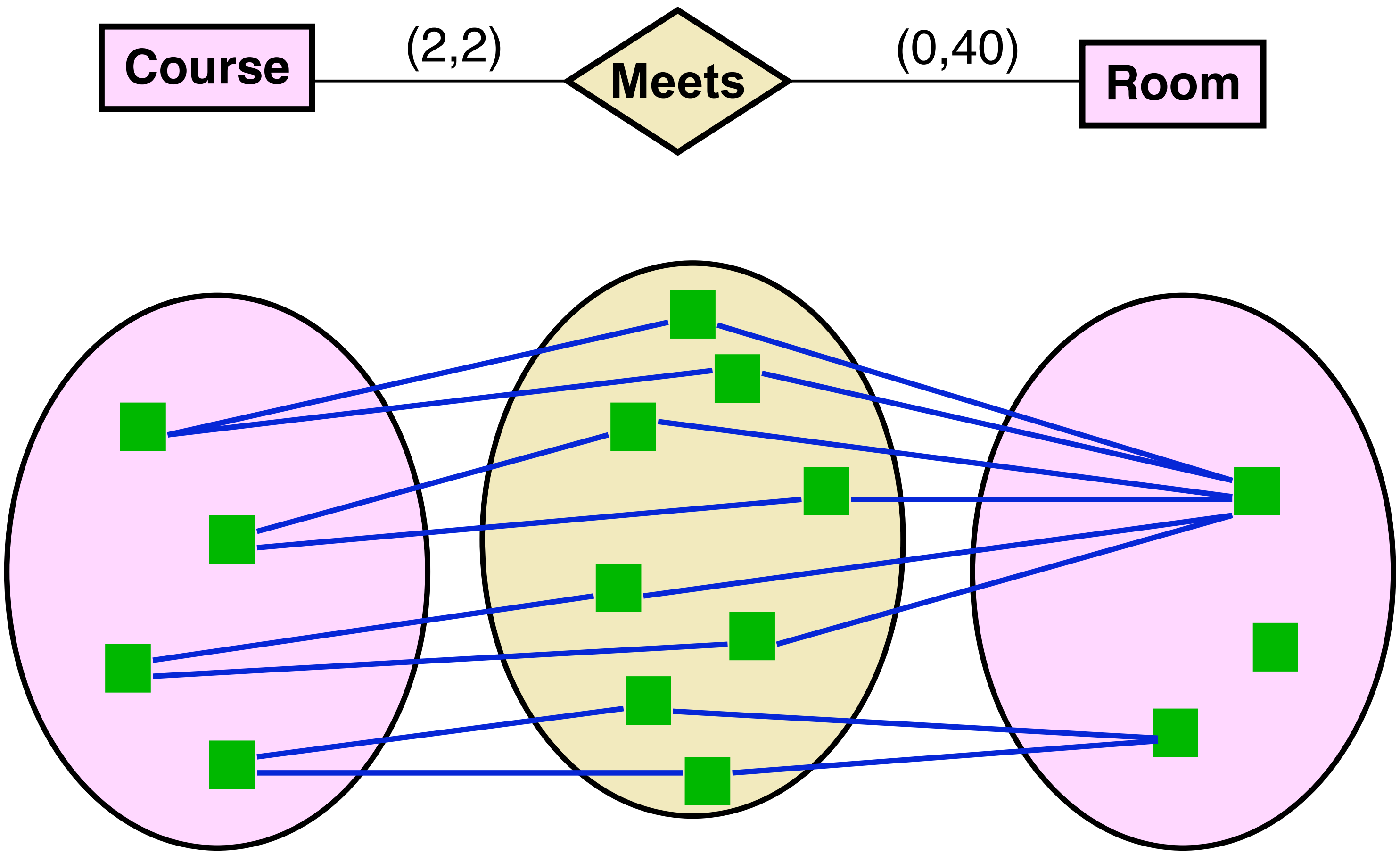
Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999



Instantiating ER diagrams

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

→ An ER diagram specifies what states are possible in the world being modeled



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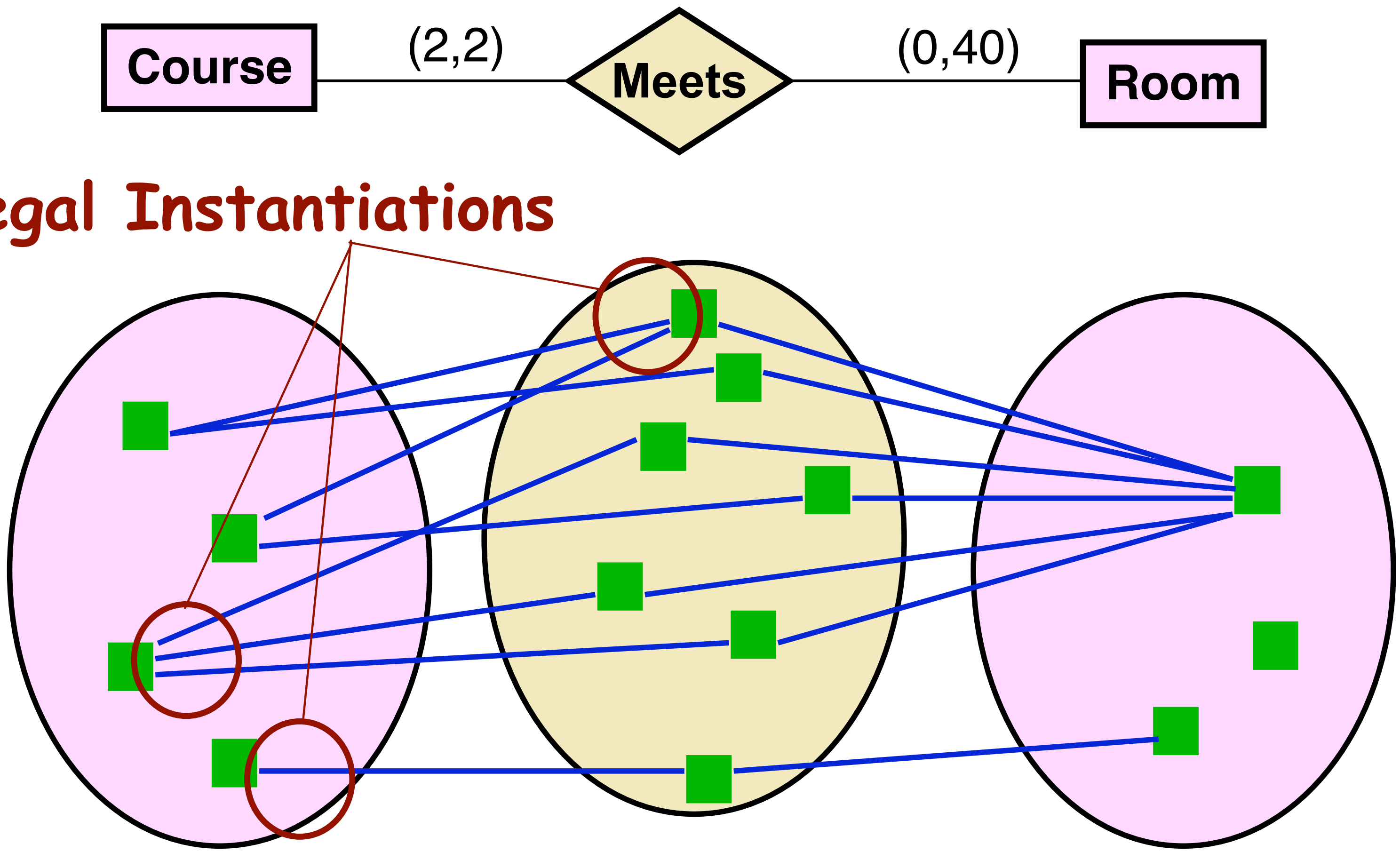
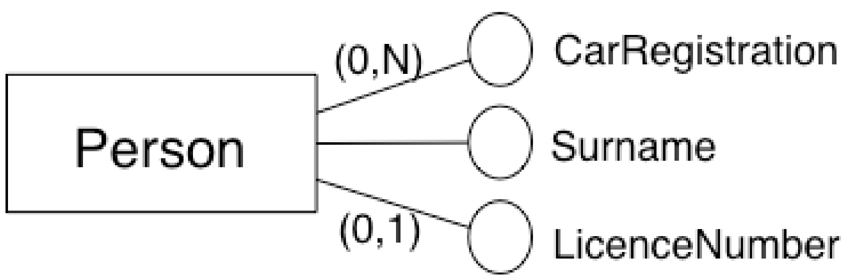


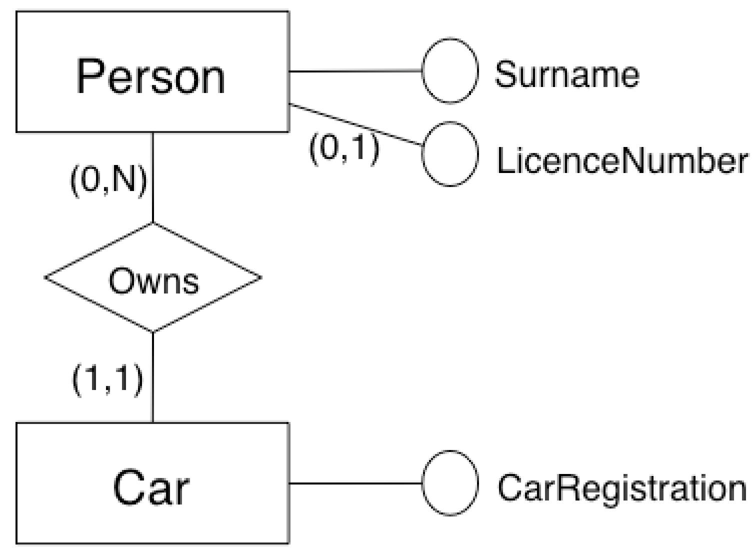
Cardinalities of Attributes

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

- **Attributes can also have cardinalities**
  - To describe the minimum and maximum number of values of the attribute associated with each instance of an entity or a relationship.
  - The default is (1,1)
  - Optional attributes have cardinality (0,1)



- **Multi-valued attribute cardinalities are problematic**
  - Usually better modelled with additional entities linked by one-to-many (or many-to-many) relationships

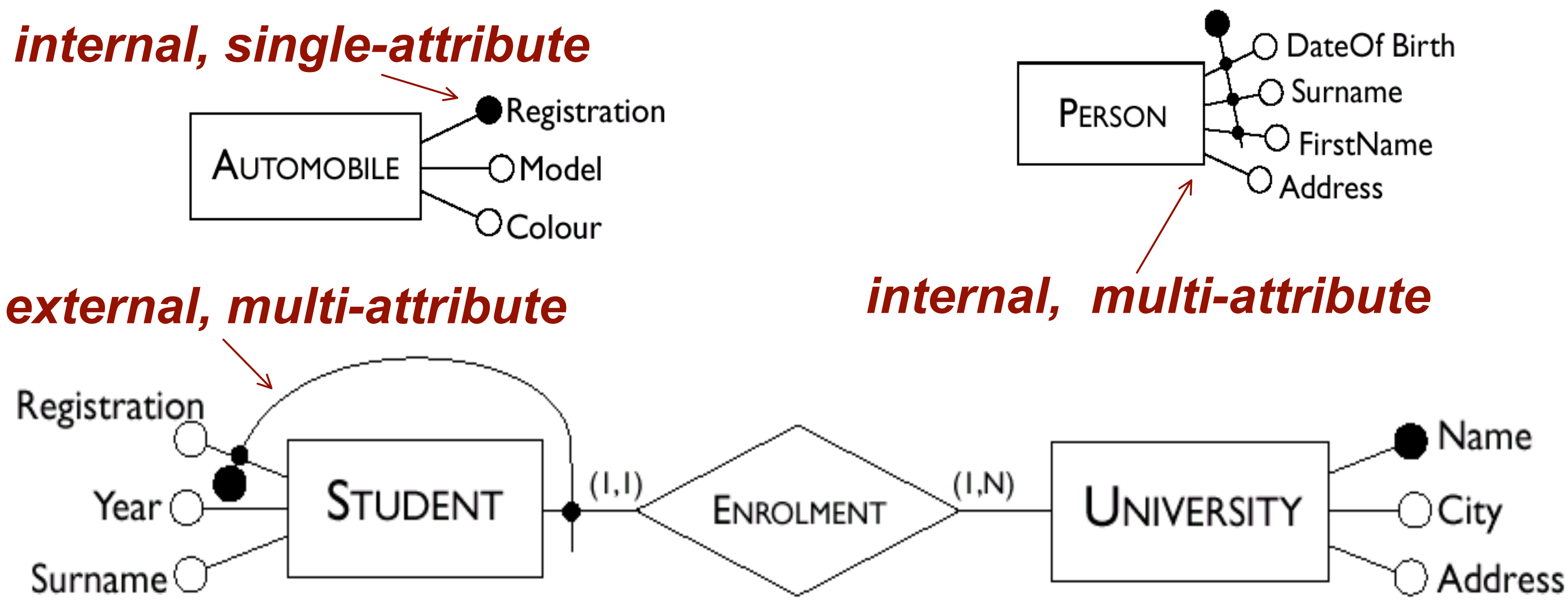


Identifiers (also known as "keys")

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

→ **How to uniquely identify instances of an entity?**

- An identifier may formed by one or more attributes of the entity itself
- If attributes of an entity are not sufficient to identify instances unambiguously, other entities can be involved in the identification
- A relationships is identified using identifiers for all the entities it relates
  - E.g. the identifier for the relationship (Person-) Owns(-Car) is a combination of the Person and Car identifiers.



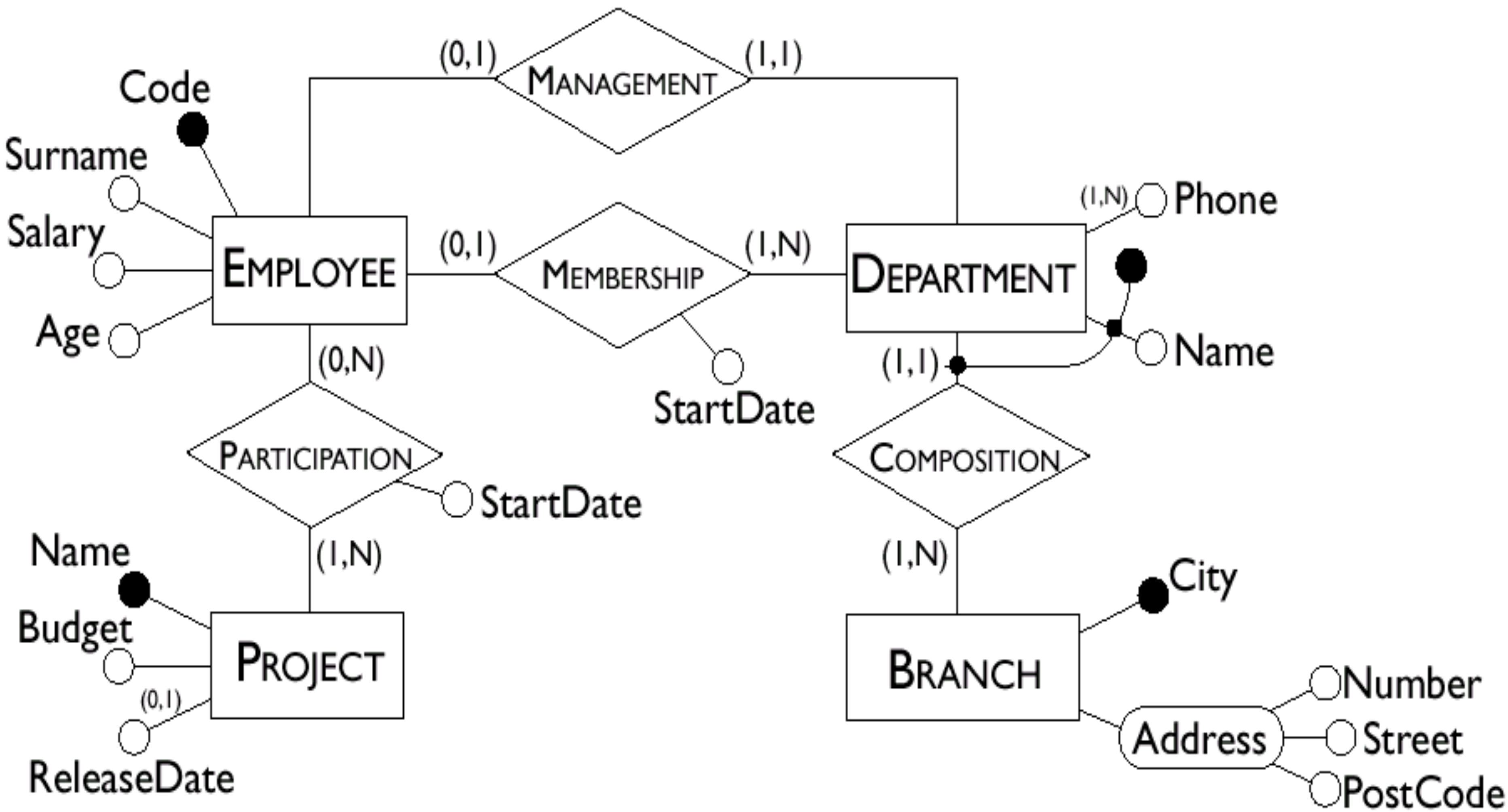
Notes on Identifiers

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

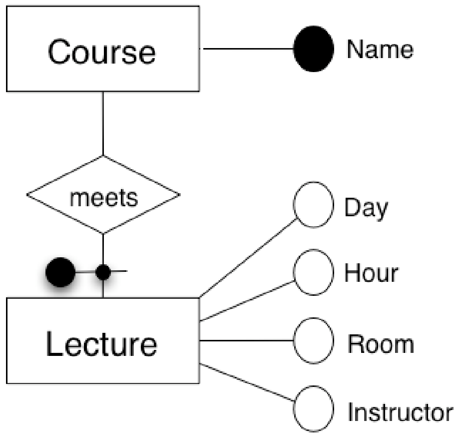
- **Identifiers and cardinality:**
  - An identifier can involve one or more attributes, provided that each has (1,1) cardinality
  - An external identifier can involve one or more entities, provided that each is a member of a relationship to which the entity to identify participates with cardinality (1,1)
- **Cycles**
  - An external identifier can involve an entity that is in its turn identified externally, as long as cycles are not generated;
- **Multiple identifiers**
  - Each entity must have at least one (internal or external) identifier
  - An entity can have more than one identifier
    - Note: if there is more than one identifier, then the attributes and entities involved in an identification can be optional (minimum cardinality equal to 0).

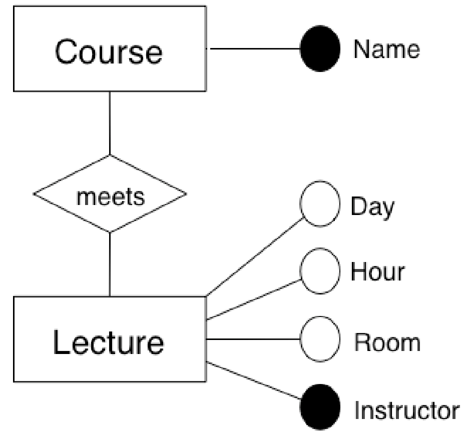
Schema with Identifiers

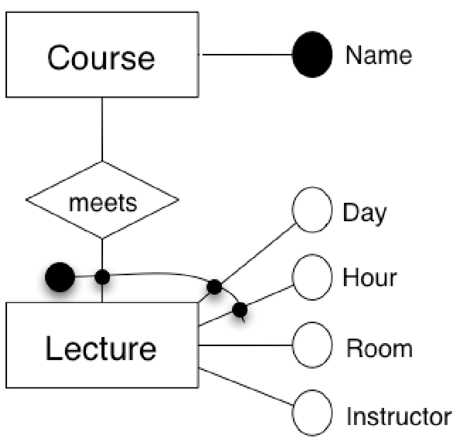
Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

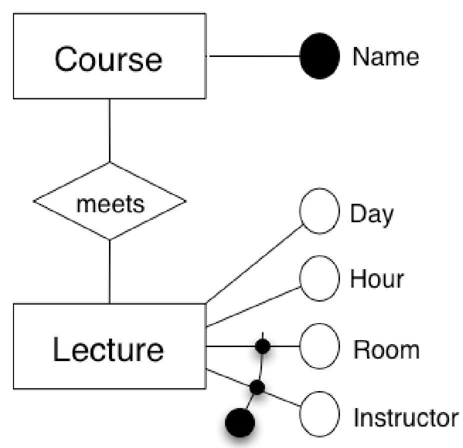


Understanding Identifier Choices





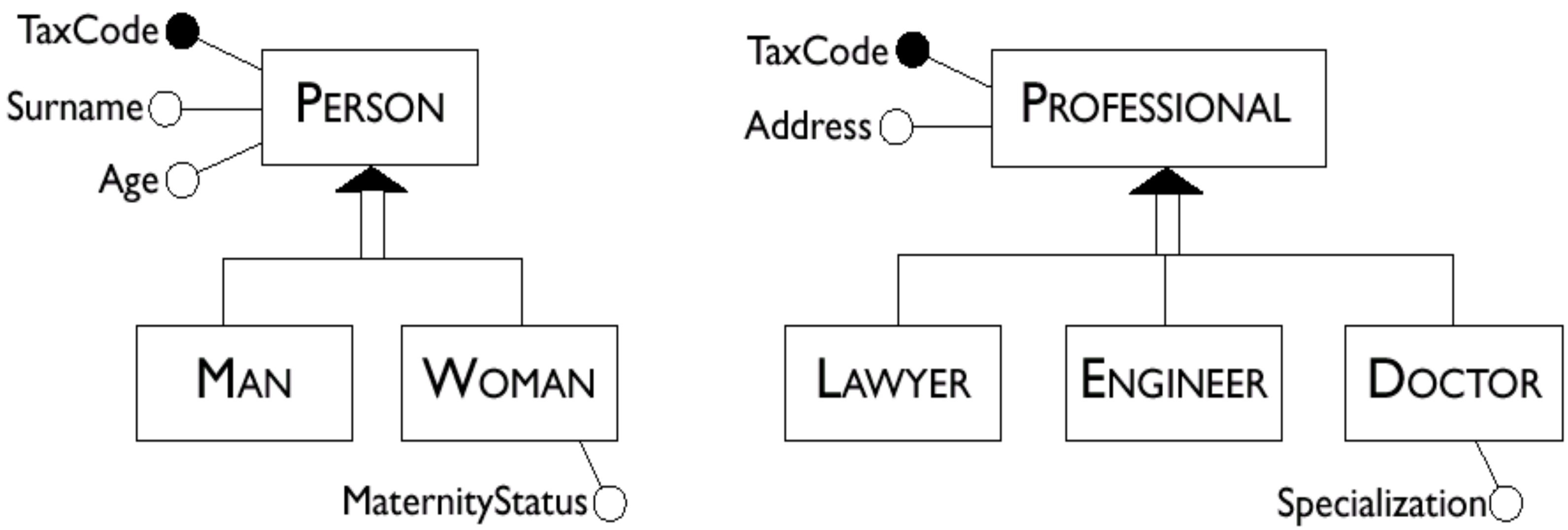




Generalizations

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

- Show "is-a" relationships between entities

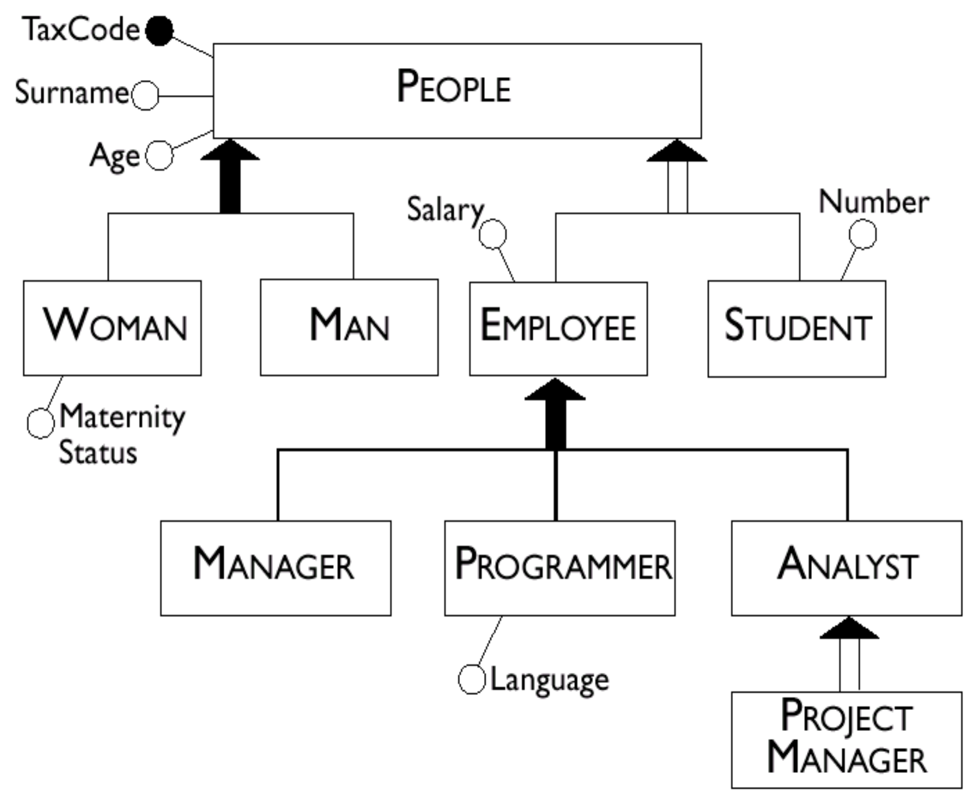


- Inheritance:
  - Every instance of a child entity is also an instance of the parent entity
  - Every property of the parent entity (attribute, identifier, relationship or other generalization) is also a property of a child entity

Types of Generalizations

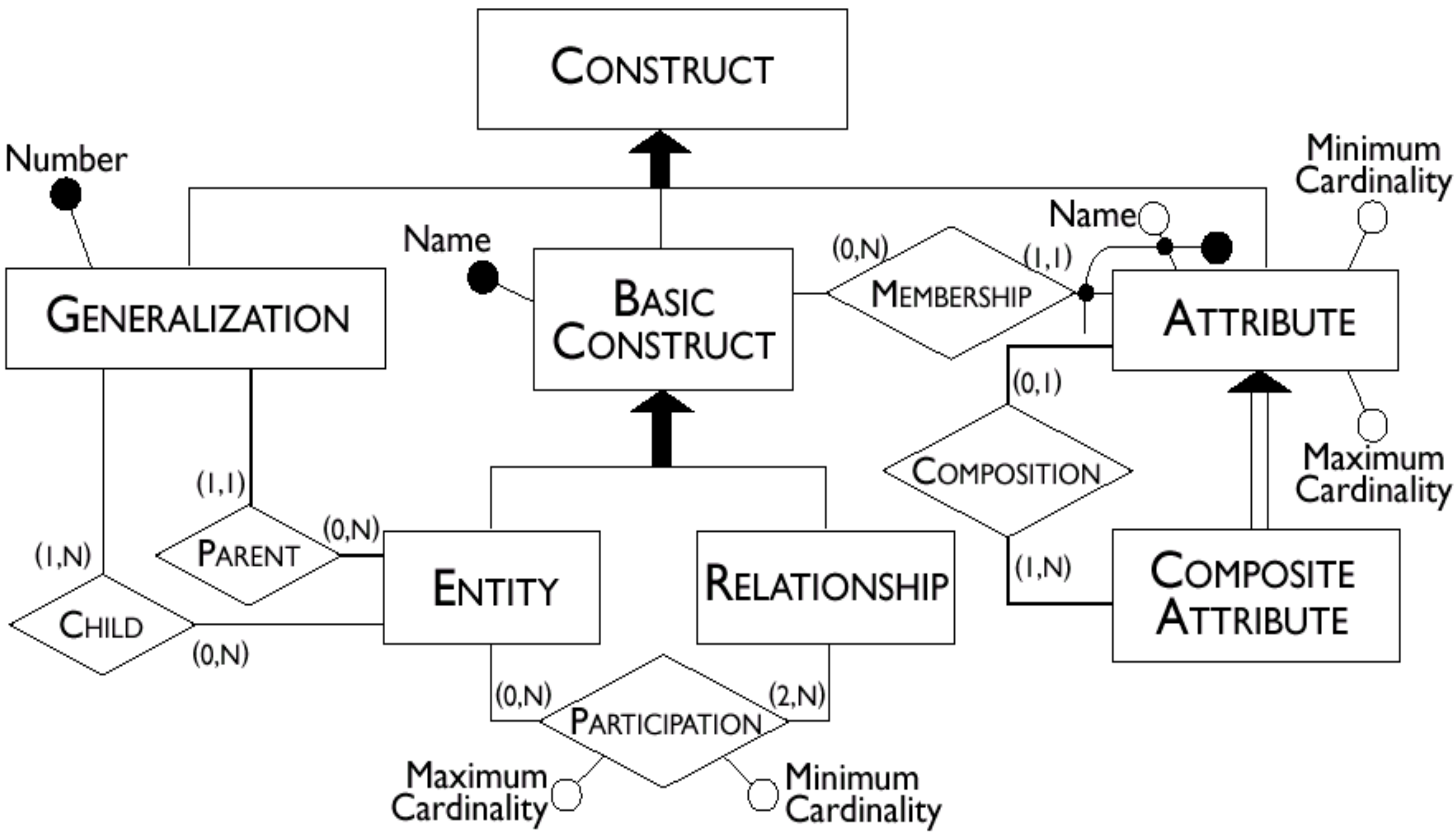
Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999

- **Total generalizations:**
  - …every instance of the parent entity is an instance of one of its children
  - Shown as a solid arrow
  - (otherwise: Partial, shown as an unfilled arrow)
- **Exclusive generalizations:**
  - …every instance of the parent entity is at most an instance of one of its children
  - (otherwise: overlapping)



The E-R Meta-Model (as an E-R Diagram)

Adapted from chapter 5 of Atzeni et al, "Database Systems" McGraw Hill, 1999



Summary: UML vs ERD

- ER diagrams are similar to UML Class diagrams
  - Class diagrams emphasize class hierarchies and operations
  - ER diagrams emphasize relationships and identity

But you only need one for any given problem analysis!

- ER provides richer notation for database concepts:
  - ER diagrams allow N-ary relationships
    - (UML Class diagrams only allow binary relationships)
  - ER diagrams allow multi-valued attributes
  - ER diagrams allow the specification of identifiers
- Choice may depend on implementation target:
  - Class diagrams for Object Oriented Architecture
  - ER diagrams for Relational Databases
  - But this only matters if you are using them for blueprints
    - For sketches, familiarity with notation is more important