Database Design

- Goal: specification of database schema
- Methodology:
  - Use E-R model to get a high-level graphical view of essential components of the model and how they are related
  - Convert E-R diagram to DDL
- E-R Model is viewed as a set of
  - Entities
  - Relationships among entities

Entities

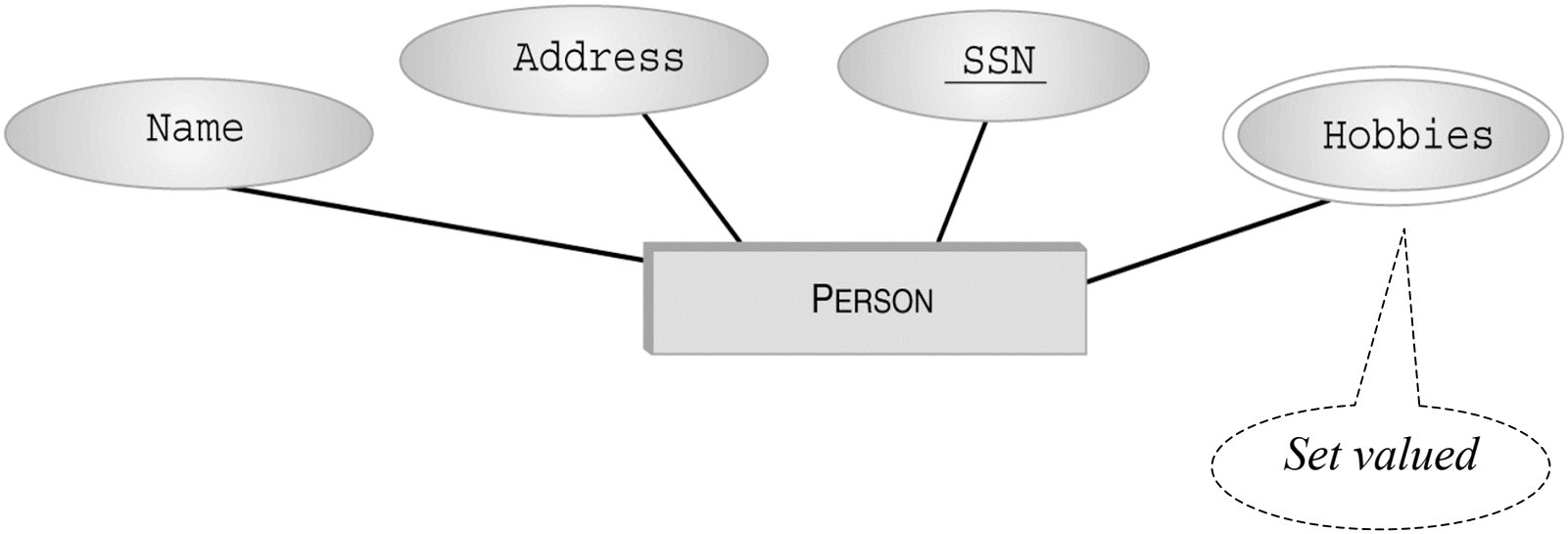
- *Entity*: an object that is involved in the enterprise
  - Ex: Mike, DBS
- *Entity Type*: set of similar objects
  - Ex: students, courses, professors
- *Attribute*: describes one aspect of an entity type
  - Ex: *name, maximum enrollment, cno, etc.*

Entity Type

- Entity type described by set of attributes
  - Person: *Id*, *Name*, *Address*, *Hobbies*
- *Domain*: possible values of an attribute
  - Value can be a set (in contrast to relational model)
    - (123456789, Mike, 123 College, {stamps, coins})
- *Key*: minimum set of attributes that uniquely identifies an entity
- *Entity Schema*: entity type name, attributes (and associated domain), key constraints

Entity Type cont'd

- Graphical Representation in E-R diagram:



Relationships

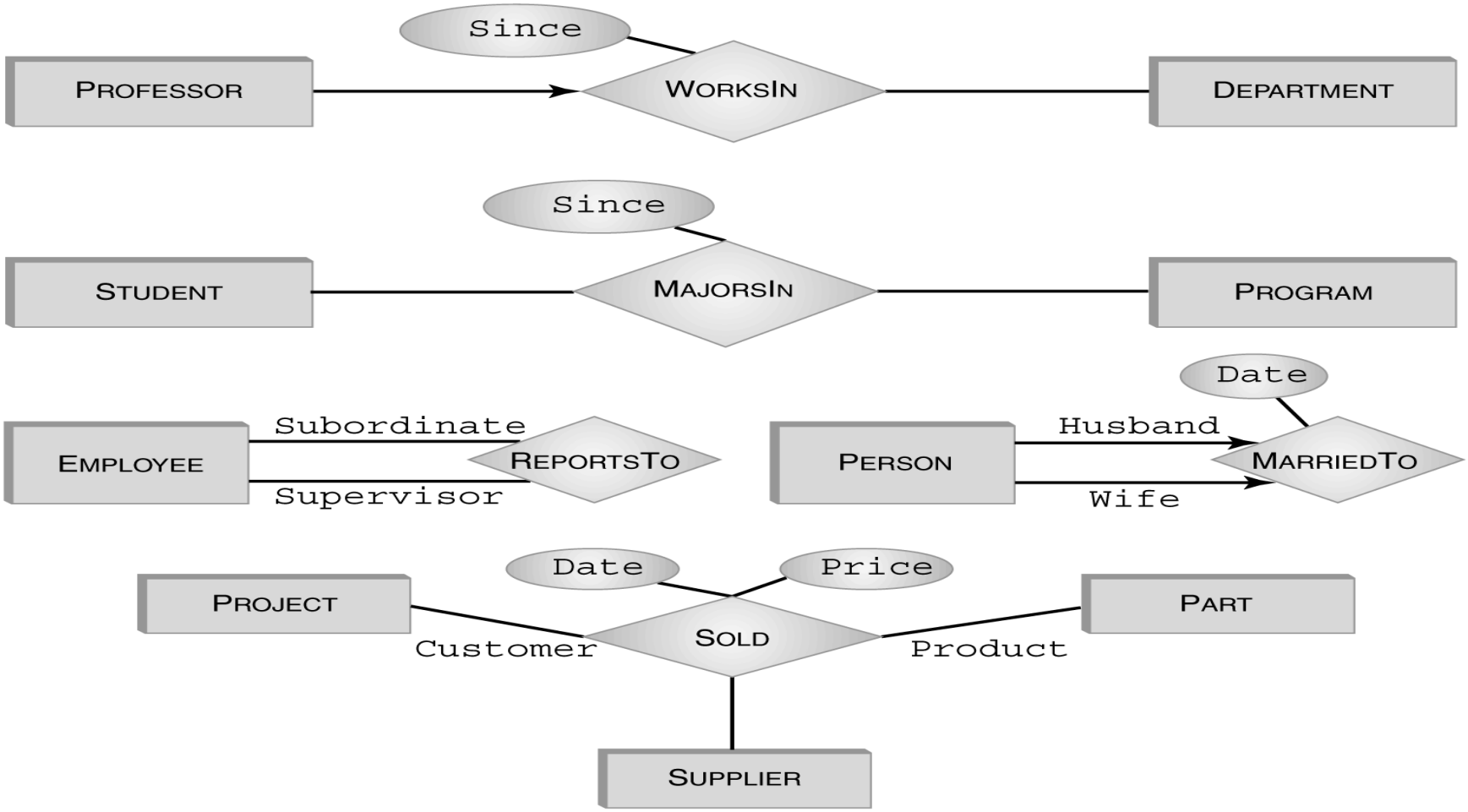
- *Relationship*: relates two or more entities
  - John *majors in* Computer Science
- *Relationship Type*: set of similar relationships
  - Student (entity type) related to Department (entity type) by MajorsIn (relationship type).
- Distinction:
  - *relation* (relational model) - set of tuples
  - *relationship* (E-R Model) – describes relationship between entities Both entity types and relationship types (E-R model) may be represented as relations (in the relational model)

Attributes and Roles

- *Attribute* of a relationship type describes the relationship
  - e.g., Mike majors in CS *since* 2004
    - Mike and CS are related
    - 2004 describes relationship - value of SINCE attribute of MajorsIn relationship type
- *Role* of a relationship type names one of the related entities
  - e.g., Mike is value of *Student* role, CS value of *Department* role of MajorsIn relationship type
  - (Mike, CS; 2004) describes a relationship

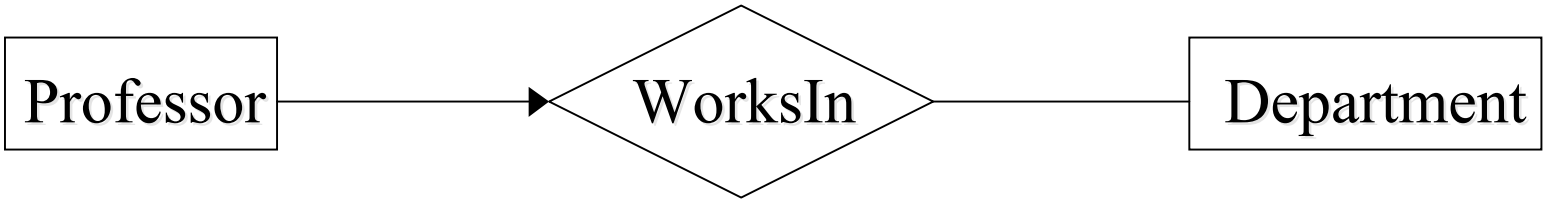
Graphical Representation

- Roles are edges labeled with role names (omitted if role name = name of entity set). Most attributes have been omitted.



Single-role Key Constraint

- If, for a particular participant entity type, each entity participates in *at most* one relationship, corresponding role is a key of relationship type
  - E.g., *Professor* role is unique in WorksIn
- Representation in E-R diagram: arrow



Entity Type Hierarchies

- One entity type might be subtype of another
  - Freshman is a subtype of Student
- A relationship exists between a Freshman entity and the corresponding Student entity
  - e.g., Freshman John is related to Student John
- This relationship is called *IsA*
  - Freshman IsA Student
  - The two entities related by IsA are always descriptions of the same real-world object

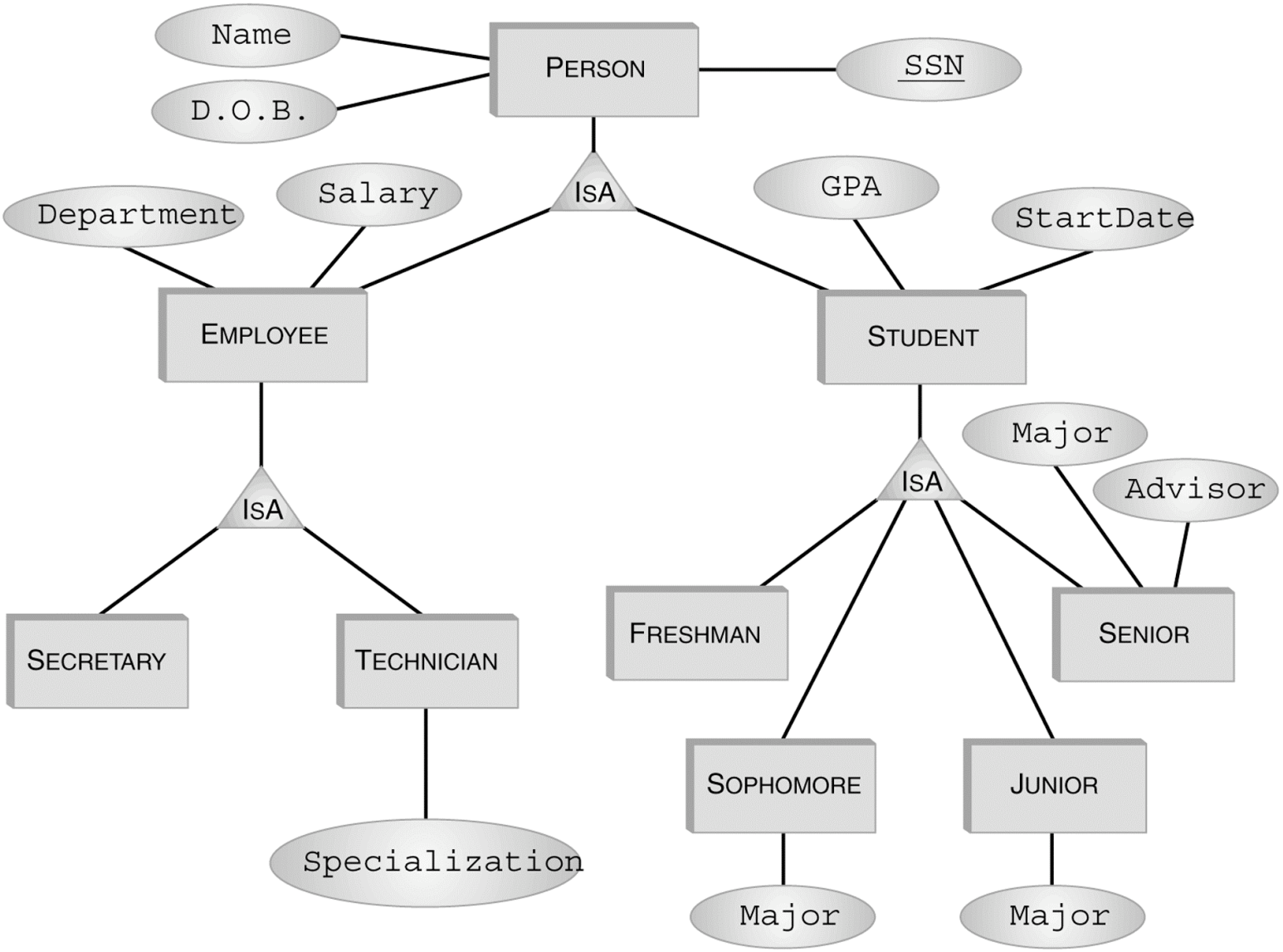
Properties of IsA

- *Inheritance* - Attributes of supertype apply to subtype.
  - E.g., *GPA* attribute of Student applies to Freshman
  - Subtype *inherits* all attributes of supertype.
  - Key of supertype is key of subtype
- *Transitivity* - Hierarchy of IsA
  - Student is subtype of Person, Freshman is subtype of Student, so Freshman is also a subtype of Student

Advantages of IsA

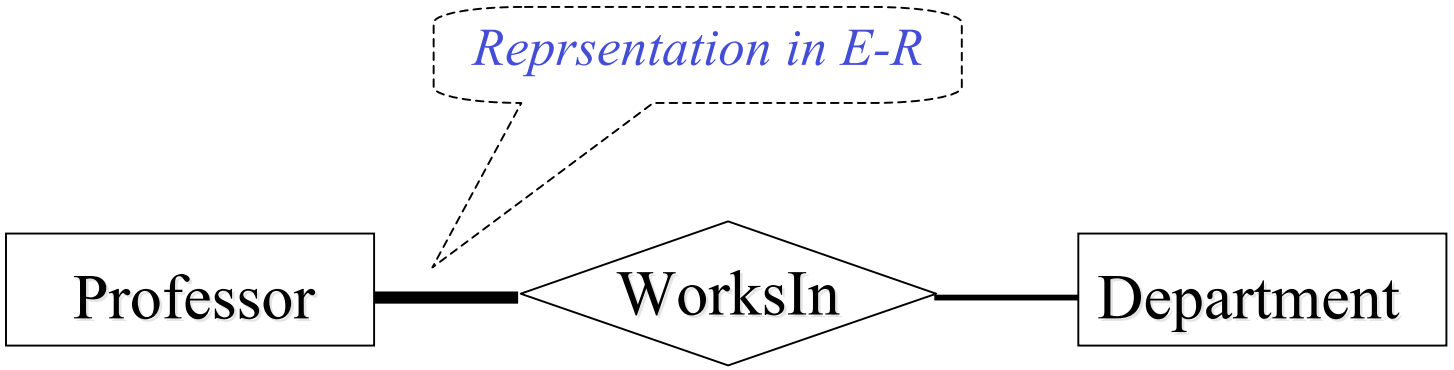
- Can create a more concise and readable E-R diagram
  - Attributes common to different entity sets need not be repeated
  - They can be grouped in one place as attributes of supertype
  - Attributes of (sibling) subtypes can be different

IsA Hierarchy - Example



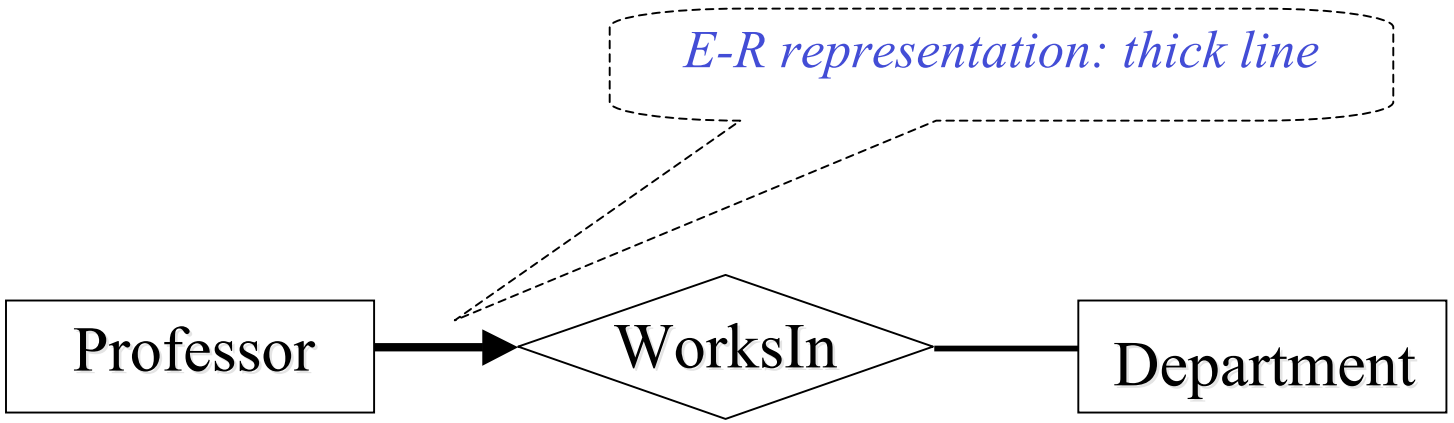
Participation Constraint

- If every entity participates in *at least* one relationship, a *participation constraint* holds:
  - e.g., every professor works in *at least* one department



Participation *and* Key Constraint

- If every entity participates in *exactly* one relationship, both a participation and a key constraint hold:
  - e.g., every professor works in *exactly one* department



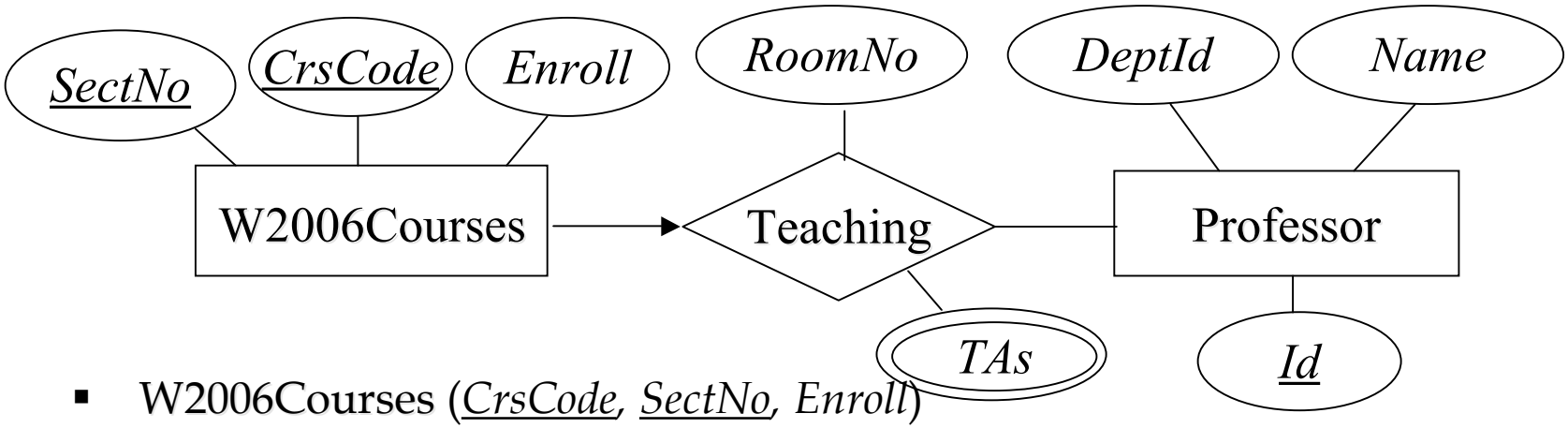
Representation of Entity Types in the Relational Model

- An entity type corresponds to a relation
- Relation's attributes = entity type's attributes
  - *Problem*: entity type can have set valued attributes, e.g.,

    Person: *Id*, *Name*, *Address*, *Hobbies*
  - *Solution*: Use several rows to represent a single entity
    - (123456789, Mike, 123 College St, stamps)
    - (123456789, Mike, 123 College St, coins)
  - Problems with this solution:
    - Redundancy
    - Key of entity type (Id) not key of relation
    - Hence, the resulting relation must be further transformed (we'll see how later)

Representation of Relationship Types in the Relational Model

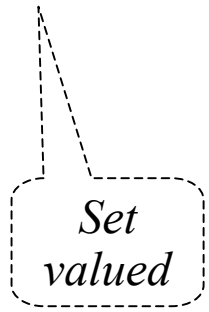
- Typically, a relationship becomes a relation in the relational model
- Attributes of the corresponding relation are
  - Attributes of relationship type
  - For each role, the primary key of the entity type associated with that role
- *Example*:



  - W2006Courses (*CrsCode*, *SectNo*, *Enroll*)
  - Professor (*Id*, *DeptId*, *Name*)
  - Teaching (*CrsCode*, *SecNo*, *Id*, *RoomNo*, *TAs*)

Representation of Relationship Types in the Relational Model

- Key of corresponding table = key of relation
  - Except when there are set valued attributes
  - Example: Teaching (*CrsCode, SectNo, Id, RoomNo, TAs*)
    - Key of relationship type = (*CrsCode, SectNo*)
    - Key of relation = (*CrsCode, SectNo, TAs*)

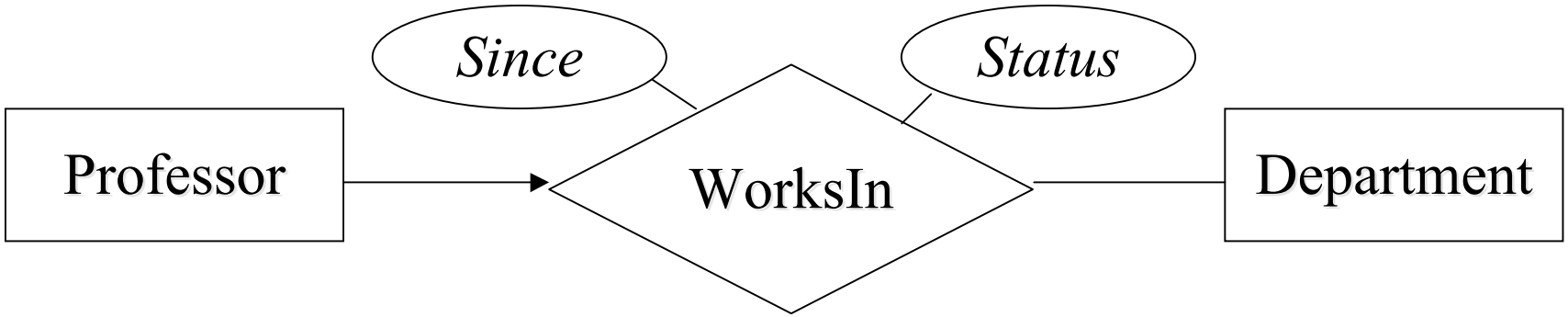


CrsCode	*SectNo*	*Id*	*RoomNo*	*TAs*
CSC343	1	1234	BA1180	Joe
CSC343	2	1234	GB119	Mary

Representation in SQL

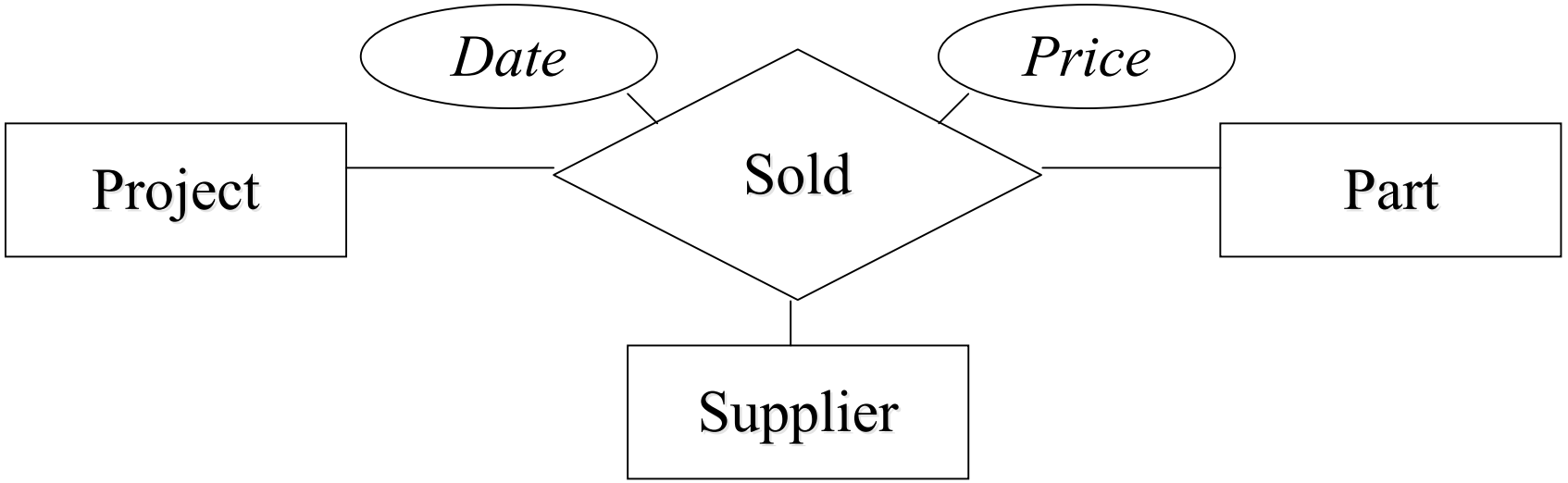
- Each role of relationship type produces a foreign key in corresponding relation
  - Foreign key references table corresponding to entity type from which role values are drawn

Example 1




```
CREATE TABLE WorksIn  (
    Since DATE,              -- attribute
    Status  CHAR (10),       -- attribute
    ProfId  INTEGER,         -- role (key of  Professor)
    DeptId  CHAR (4),        -- role (key of  Department)
    PRIMARY KEY (ProfId),  -- since a professor works in at most one department
    FOREIGN KEY (ProfId) REFERENCES Professor (Id),
    FOREIGN KEY (DeptId) REFERENCES Department )
```

Example 2




```
CREATE TABLE  Sold  (
   Price  INTEGER,                -- attribute
   Date  DATE,                    -- attribute
   ProjId  INTEGER,               -- role
   SupplierId  INTEGER,           -- role
   PartNumber  INTEGER,           -- role
   PRIMARY KEY (ProjId, SupplierId, PartNumber, Date),
   FOREIGN KEY (ProjId) REFERENCES Project,
   FOREIGN KEY (SupplierId) REFERENCES Supplier (Id),
   FOREIGN KEY (PartNumber) REFERENCES Part (Number)  )
```

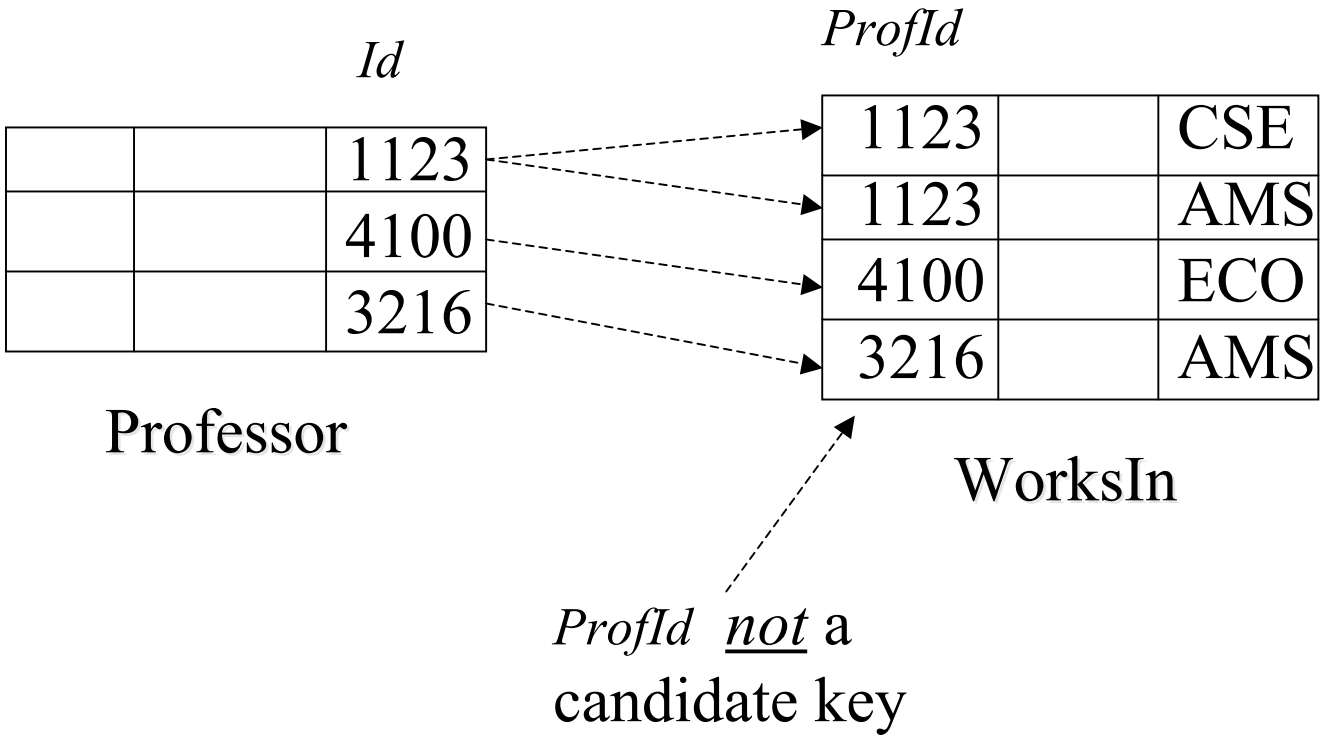
Representing Participation Constraints in the Relational Model

- *Inclusion dependency*: Every professor works in *at least* one dep't.
  - in the relational model: (easy)
    - Professor (*Id*) references WorksIn (*ProfId*)
  - in SQL:
    - Simple case: *If ProfId is a key in* **WorksIn** (i.e., every professor works in *exactly one* department) then it is easy:
      - FOREIGN KEY *Id* REFERENCES WorksIn (*ProfId*)
    - General case – *ProfId* is *not* a key in **WorksIn**, so can't use foreign key constraint (not so easy):

```
CREATE ASSERTION ProfsInDepts
  CHECK ( NOT EXISTS (
    SELECT * FROM Professor P
    WHERE NOT EXISTS (
      SELECT * FROM WorksIn W
      WHERE P.Id = W.ProfId ) ) )
```

Representing Participation Constraint in the Relational Model

- Example (can't use foreign key in Professor if ProfId is not a candidate key in WorksIn)



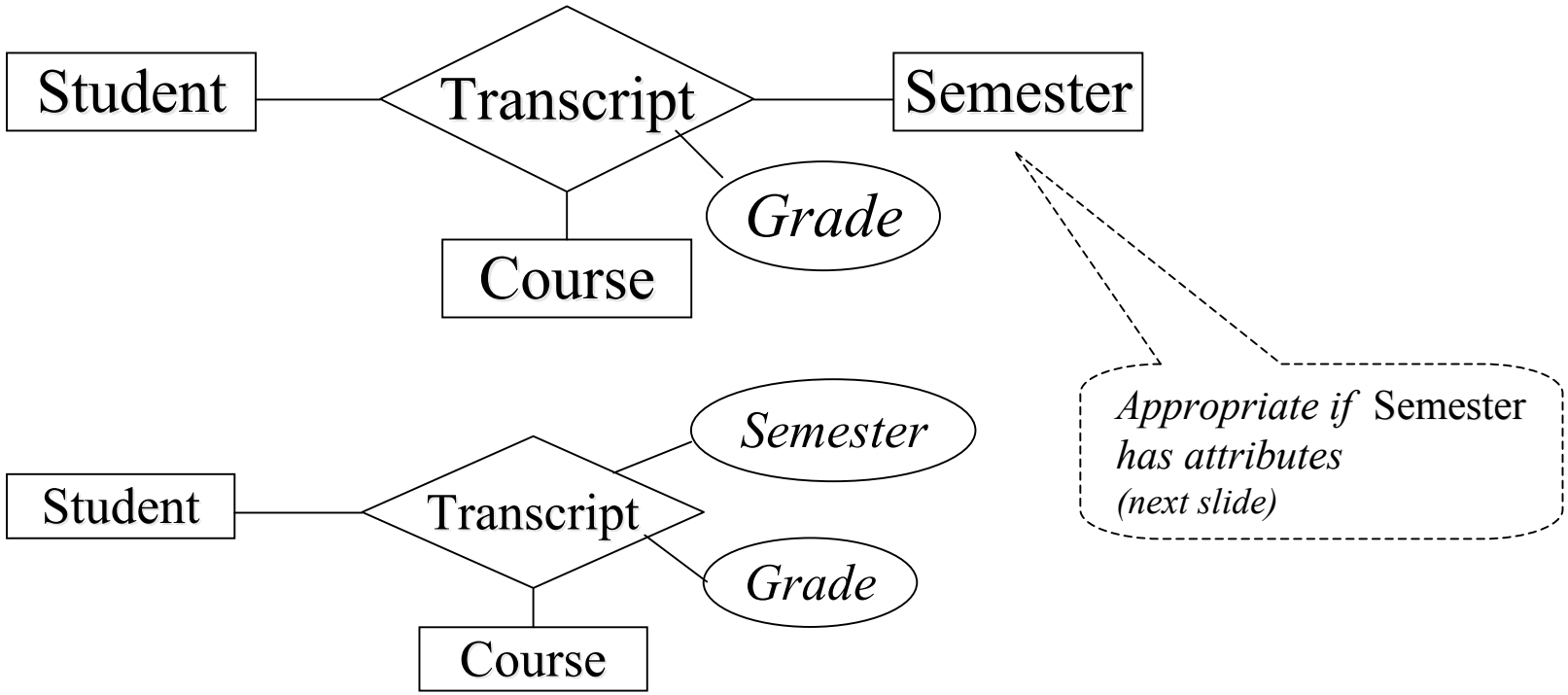
Representing Participation *and* Key Constraint in SQL

- If both participation and key constraints apply, use foreign key constraint in entity table (but beware: if candidate key in entity table is not primary, presence of nulls violates participation constraint).

```
CREATE TABLE Professor  (
   Id   INTEGER,
        ……
   PRIMARY KEY (Id),      -- Id can't be null
   FOREIGN KEY (Id) REFERENCES WorksIn  (ProfId)
                                --all professors participate
)
```

Entity or Attribute?

- Sometimes information can be represented as either an entity or an attribute.



Entity or Relationship?