ICS 321 Data Storage & Retrieval

High Level Database Models

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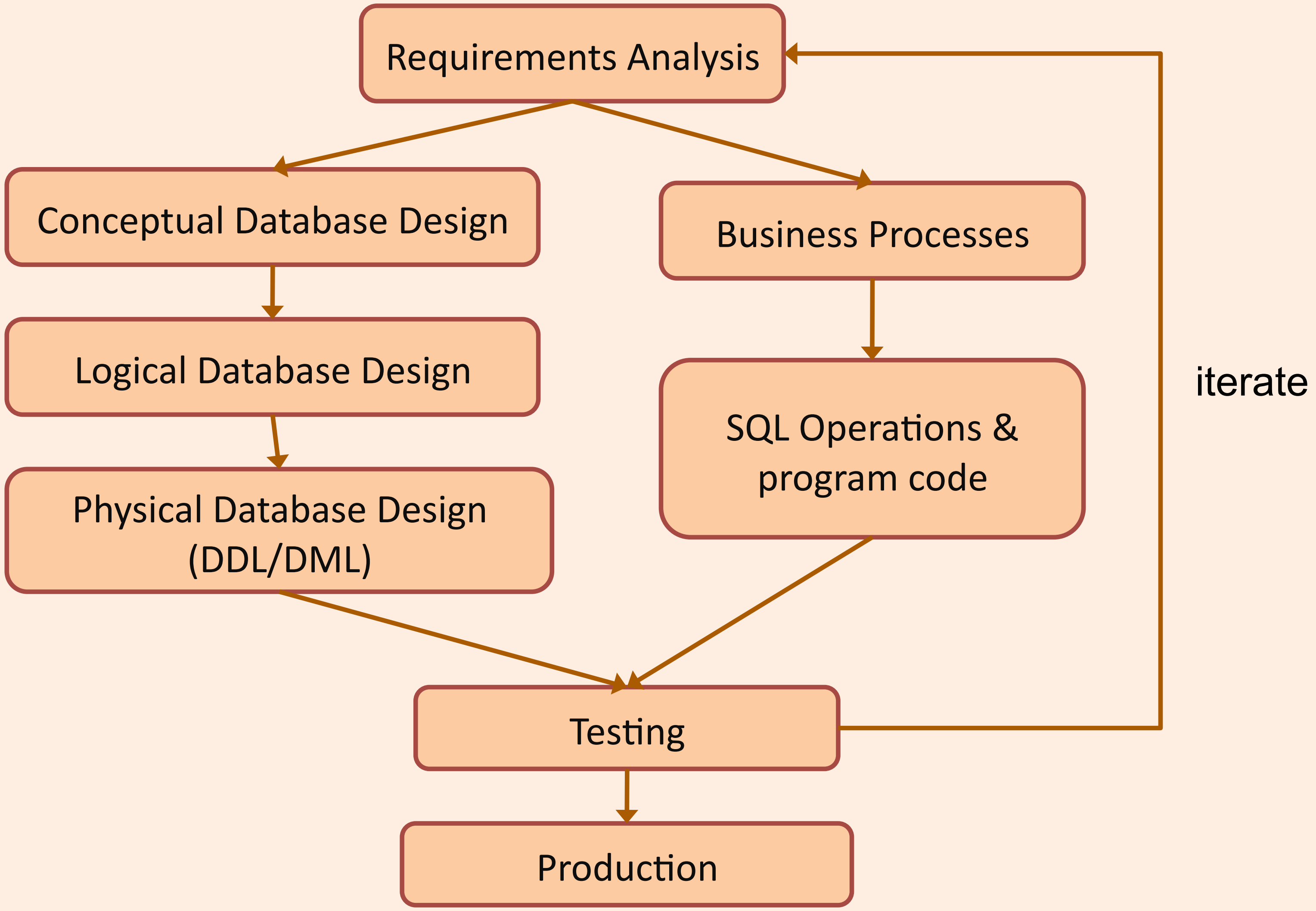
Database Design & Deployment

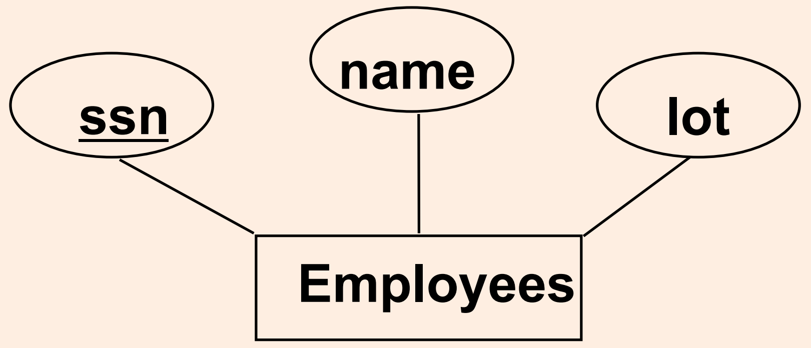


Requirements Analysis
Conceptual Database Design
Business Processes
Logical Database Design
SQL Operations & program code
Physical Database Design (DDL/DML)
iterate
Testing
Production

Overview Database Design

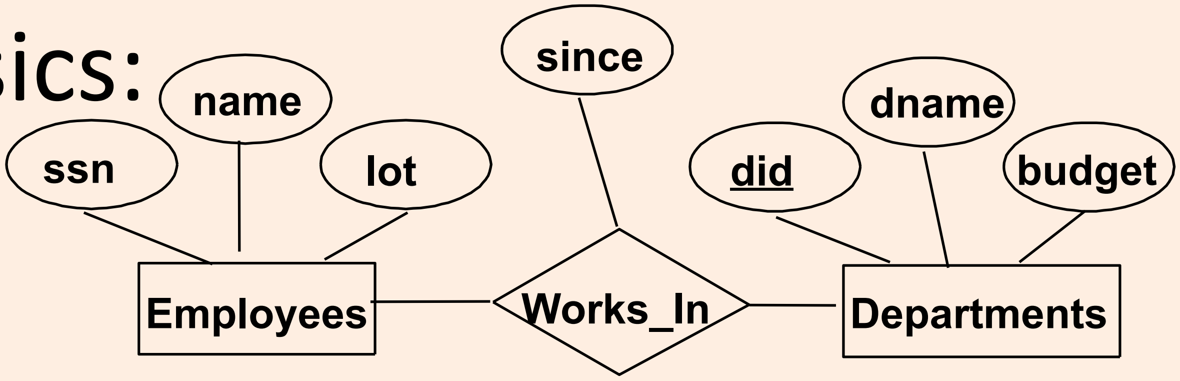
- Conceptual Design
  - Use entity-relationship (aka ER) model represented pictorially as ER diagrams
  - Map ER model to relational schema
- Questions to ask yourself
  - What are the entities and relationships in the application?
  - What information about these entities and relationships should we store in the database?
  - What are the integrity constraints or business rules that hold?

ER Model Basics: Entities



- *Entity:* Real-world object distinguishable from other objects. An entity is described (in DB) using a set of *attributes*.
- *Entity Set*: A collection of similar entities. E.g., all employees.
  - All entities in an entity set have the same set of attributes. (Until we consider ISA hierarchies, anyway!)
  - Each entity set has a *key*.
  - Each attribute has a *domain*.

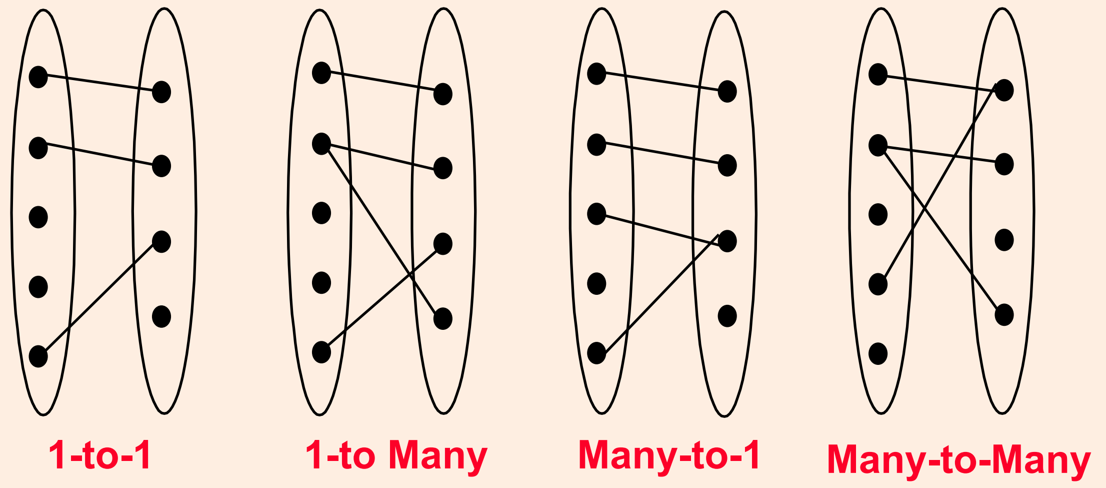
ER Model Basics: Relationships



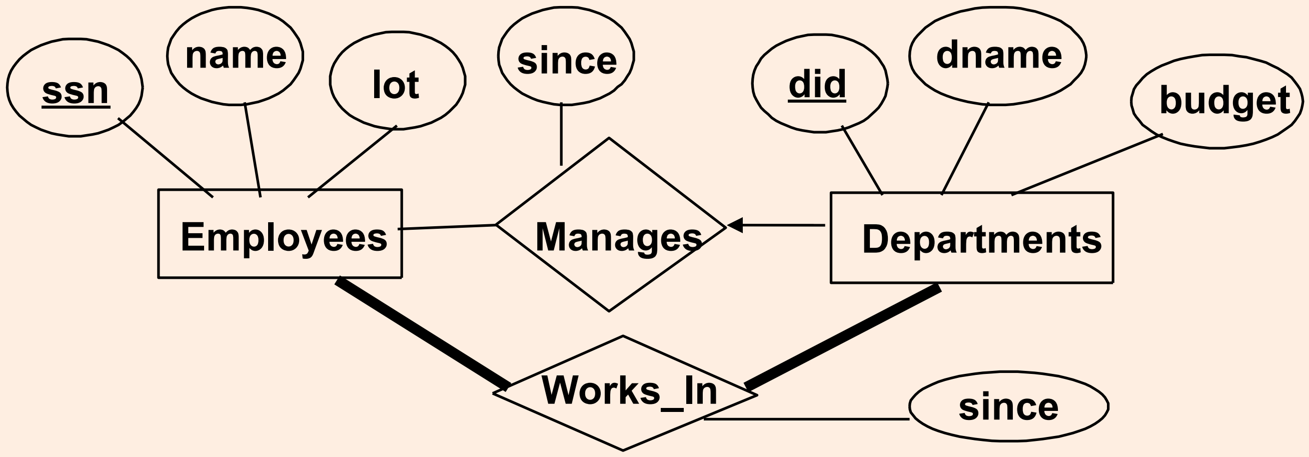
- *Relationship*: Association among two or more entities.
- *Relationship Set*: Collection of similar relationships.
  - An n-ary relationship set R relates n entity sets E1 ... En; each relationship in R involves entities e1 E1, ..., en En
  - Same entity set could participate in different relationship sets, or in different "roles" in same set.

Cardinality Ratios of Relationships

- Consider binary relationships, i.e., between two entity sets
- Alternate notation: 1:1, 1:M, M:1, M:N

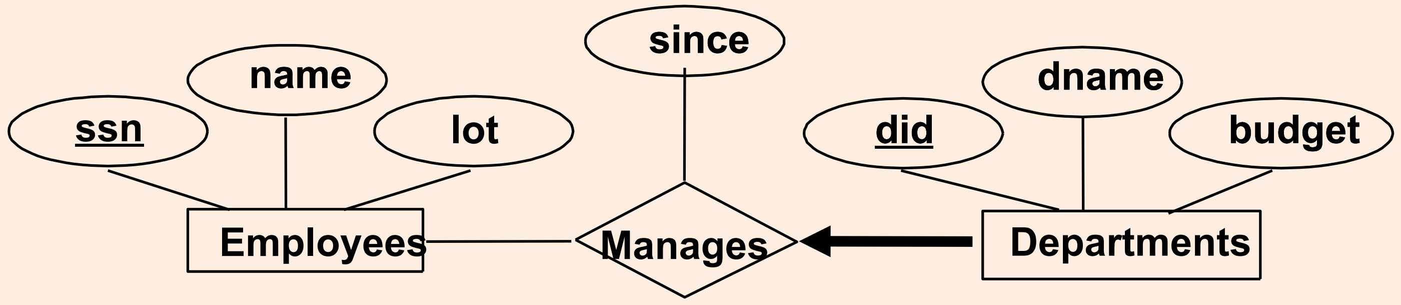


Key Constraints



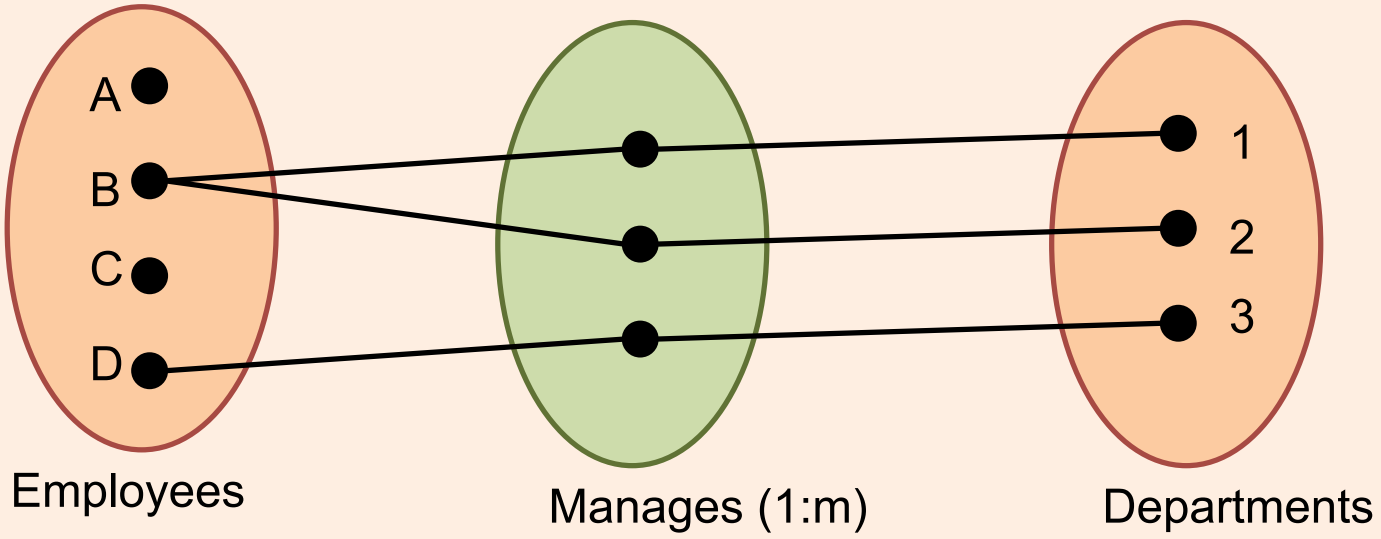
- Consider Works_In: An employee can work in many depts; a dept can have many employees : m-to-m
- Consider Manages: each dept has at most one manager
- Dept has a *key constraint* on Manages: each instance of dept appears in at most one instance of manages
- Denoted by an arrow: given a dept entity we can uniquely identify the manages relationship in which it appears

Participation constraints



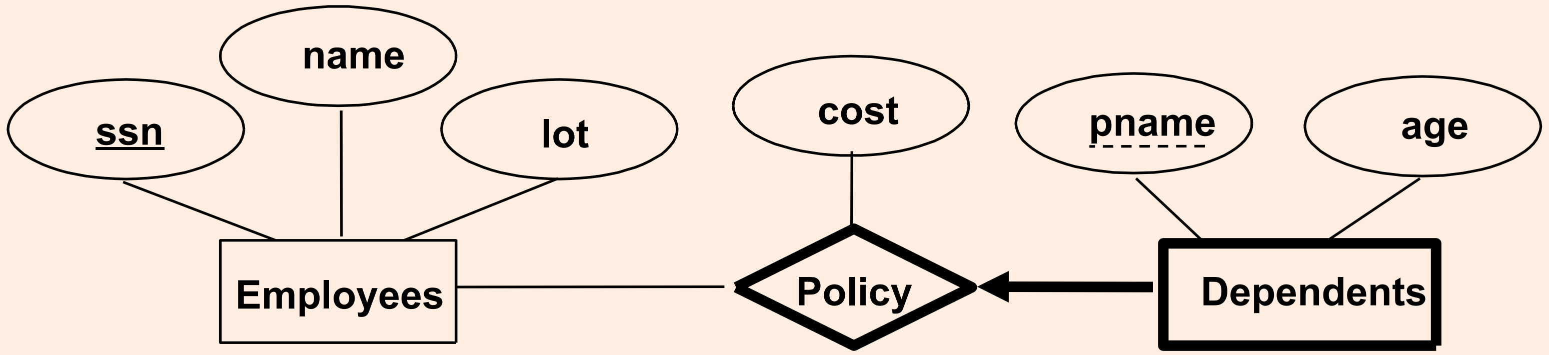
- Does every dept have a manager?
- If so, this is a *participation constraint*: the participation of dept in Manages is said to be *total* (vs. *partial*). Denoted by thick/double line
- Meaning that every Dept entity must appear in an instance of the Manages relationship

Set Theoretic Formulation



- Partial Partiticipation: Not all members of the Employees entity set take part in the manages relations
- Total Partiticipation: All members of the Dept entity set take part in the manages relationship
- Dept has a key constraint on Manages: each member of the dept entity set takes part in at most one member of the manages relationship set

Weak Entities

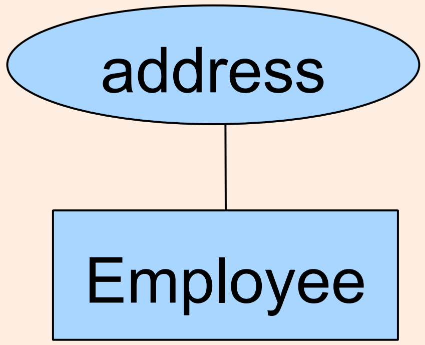


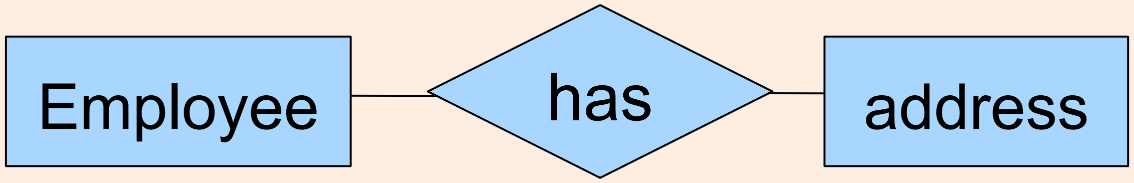
- A *weak entity* can be identified uniquely only by considering the primary key of another (*owner*) entity.
- Owner entity set and weak entity set must participate in a one-to-many relationship set (one owner, many weak entities).
- Weak entity set must have total participation in this *identifying* relationship set.
- Denoted by a box with double or thick lines

Design Choices

- Should a concept be modeled as an entity or an attribute?
- Should a concept be modeled as an entity or a relationship?
- Identifying relationships: Binary or ternary? Aggregation?
- How much semantics to capture in the form of constraints ?

Entity vs. Attribute

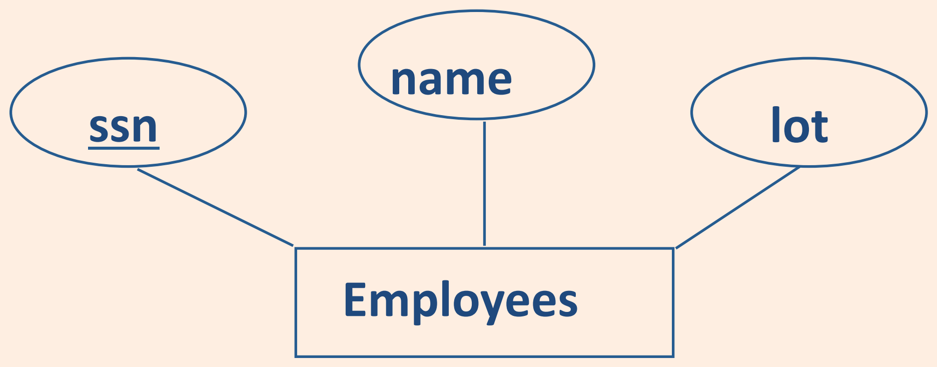




- Depends upon how we want to use the address information, and the semantics of the data:
  - If we have several addresses per employee, *address* must be an entity (since attributes cannot be set-valued).
  - If the structure (city, street, etc.) is important, e.g., we want to retrieve employees in a given city, *address* must be modeled as an entity (since attribute values are atomic).

Logical DB Design: ER to Relational

- Entity sets to tables:

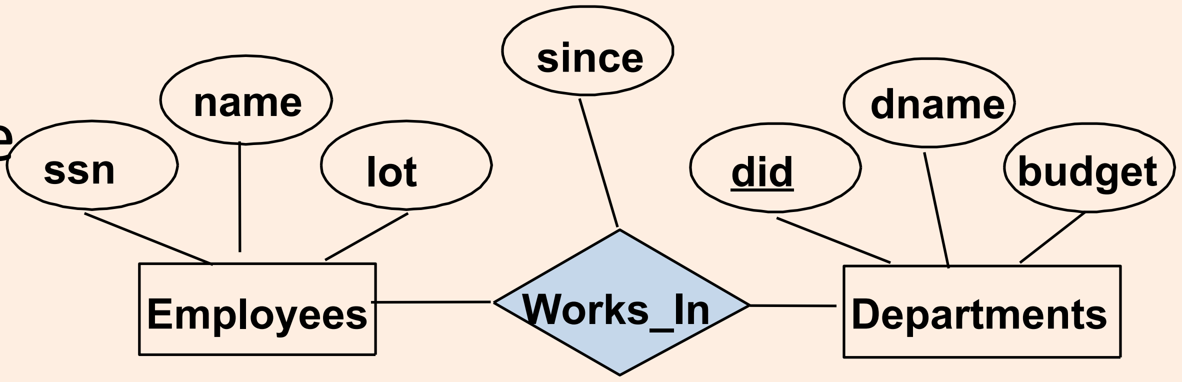


```
CREATE TABLE Employees
   (ssn CHAR(11),
   name CHAR(20),
   lot  INTEGER,
   PRIMARY KEY  (ssn))
```

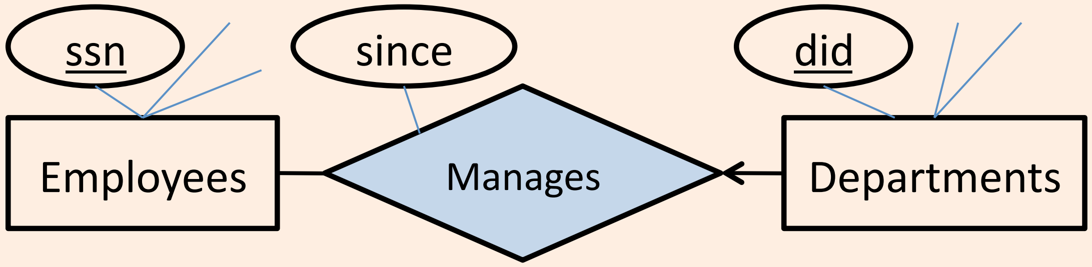
Relationship Sets to Tables

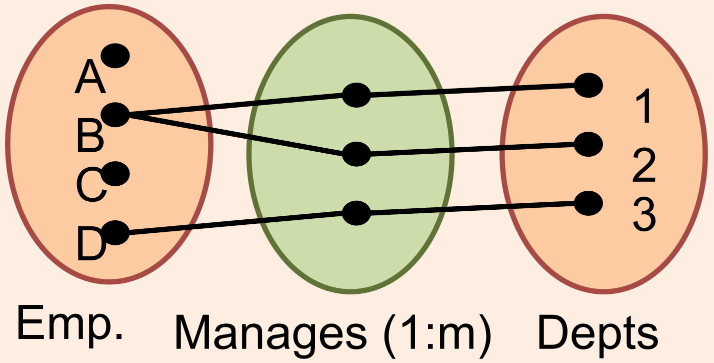
- Attributes of the relation must include:
  - Keys for each participating entity set (as foreign keys).
    - This set of attributes forms a *superkey* for the relation.
  - All descriptive attributes.

```
CREATE TABLE Works_In(
  ssn  CHAR(11),
  did  INTEGER,
  since  DATE,
  PRIMARY KEY (ssn, did),
  FOREIGN KEY (ssn)
       REFERENCES Employees,
  FOREIGN KEY (did)
       REFERENCES Departments)
```



Translating ER Diagrams with Key Constraints





- Map relationship to a table:
  - Note that did is the key now!
- Since each department has a unique manager, we could instead combine Manages and Departments.

```
CREATE TABLE  Manages(
  ssn  CHAR(11), did  INTEGER, since  DATE,
  PRIMARY KEY  (did),
  FOREIGN KEY (ssn) REFERENCES Employees,
  FOREIGN KEY (did) REFERENCES Departments)
```

```
CREATE TABLE  Dept_Mgr(
  did  INTEGER,
  dname  CHAR(20),
  budget  REAL,
  ssn  CHAR(11),  since  DATE,
  PRIMARY KEY  (did),
  FOREIGN KEY (ssn) REFERENCES Employees)
```

Participation Constraints in SQL

- We can capture participation constraints involving one entity set in a binary relationship, but little else (without resorting to CHECK constraints).

```
CREATE TABLE  Dept_Mgr(
  did  INTEGER,
  dname  CHAR(20),
  budget  REAL,
  ssn  CHAR(11) NOT NULL,
  since  DATE,
  PRIMARY KEY  (did),
  FOREIGN KEY  (ssn) REFERENCES Employees,
    ON DELETE NO ACTION)
```

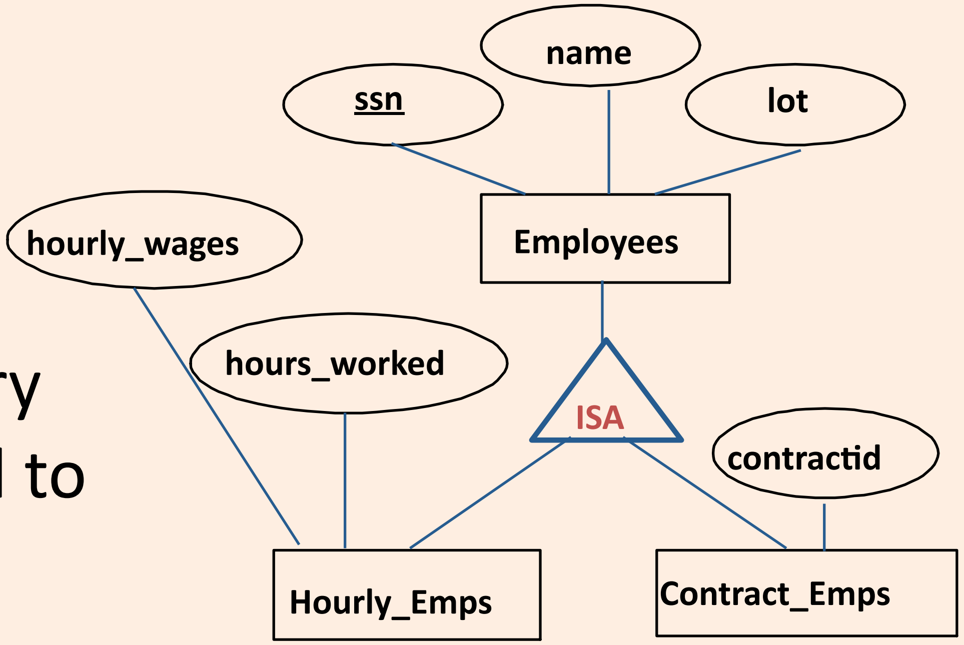
Translating Weak Entity Sets

- Weak entity set and identifying relationship set are translated into a single table.
  - When the owner entity is deleted, all owned weak entities must also be deleted.

```
CREATE TABLE  Dep_Policy (
  pname  CHAR(20),
  age  INTEGER,
  cost  REAL,
  ssn  CHAR(11) NOT NULL,
  PRIMARY KEY  (pname, ssn),
  FOREIGN KEY  (ssn) REFERENCES Employees,
    ON DELETE CASCADE)
```

ISA Hierarchies

- As in C++, or other PLs, attributes are inherited.
- If we declare A **ISA** B, every A entity is also considered to be a B entity.



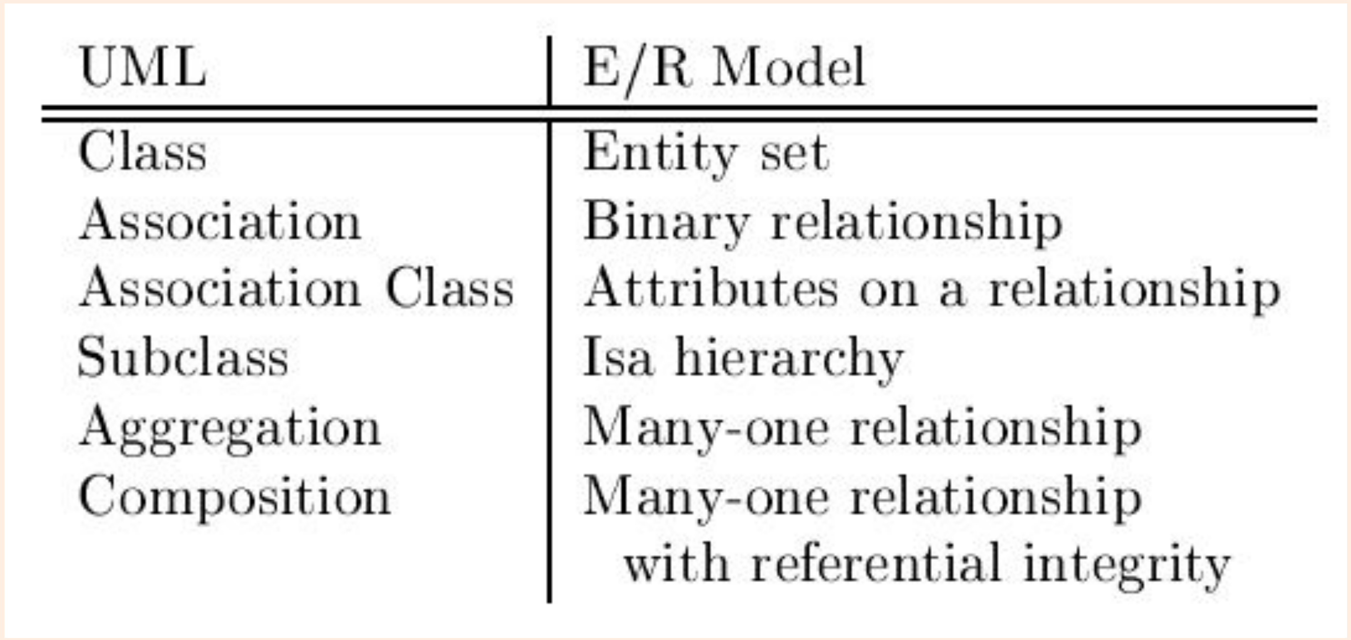
- *Overlap constraints*: Can Joe be an Hourly_Emps as well as a Contract_Emps entity? (*Allowed/disallowed*)
- *Covering constraints*: Does every Employees entity also have to be an Hourly_Emps or a Contract_Emps entity? *(Yes/no)*

Translating ISA Hierarchies to Relations

- ***General approach:***
  - 3 relations: Employees, Hourly_Emps and Contract_Emps.
    - *Hourly_Emps*: Every employee is recorded in Employees. For hourly emps, extra info recorded in Hourly_Emps (*hourly_wages*, *hours_worked*, *ssn)*; must delete Hourly_Emps tuple if referenced Employees tuple is deleted).
    - Queries involving all employees easy, those involving just Hourly_Emps require a join to get some attributes.
- Alternative: Just Hourly_Emps and Contract_Emps.
  - *Hourly_Emps*: *ssn, name, lot, hourly_wages, hours_worked.*
  - Each employee must be in one of these two subclasses.

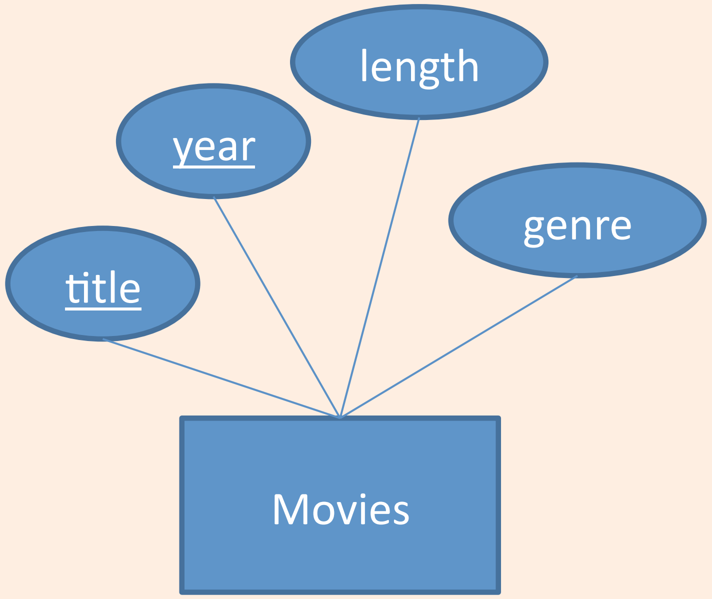
Unified Modeling Language

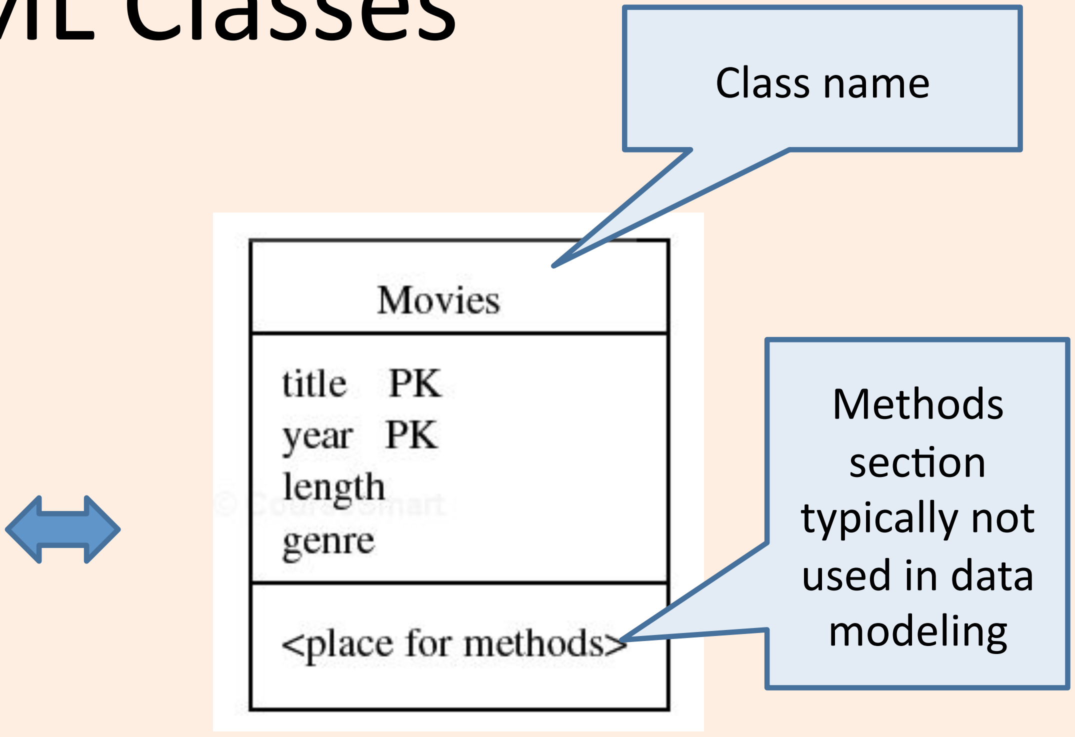
- Standardized general-purpose modeling language for software design
- Based on object-oriented model
- Class diagrams



UML	E/R Model
Class	Entity set
Association	Binary relationship
Association Class	Attributes on a relationship
Subclass	Isa hierarchy
Aggregation	Many-one relationship
Composition	Many-one relationship with referential integrity

UML Classes

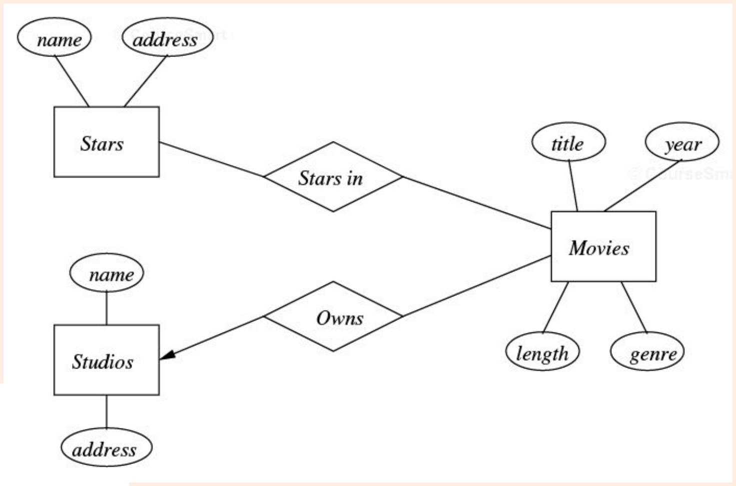


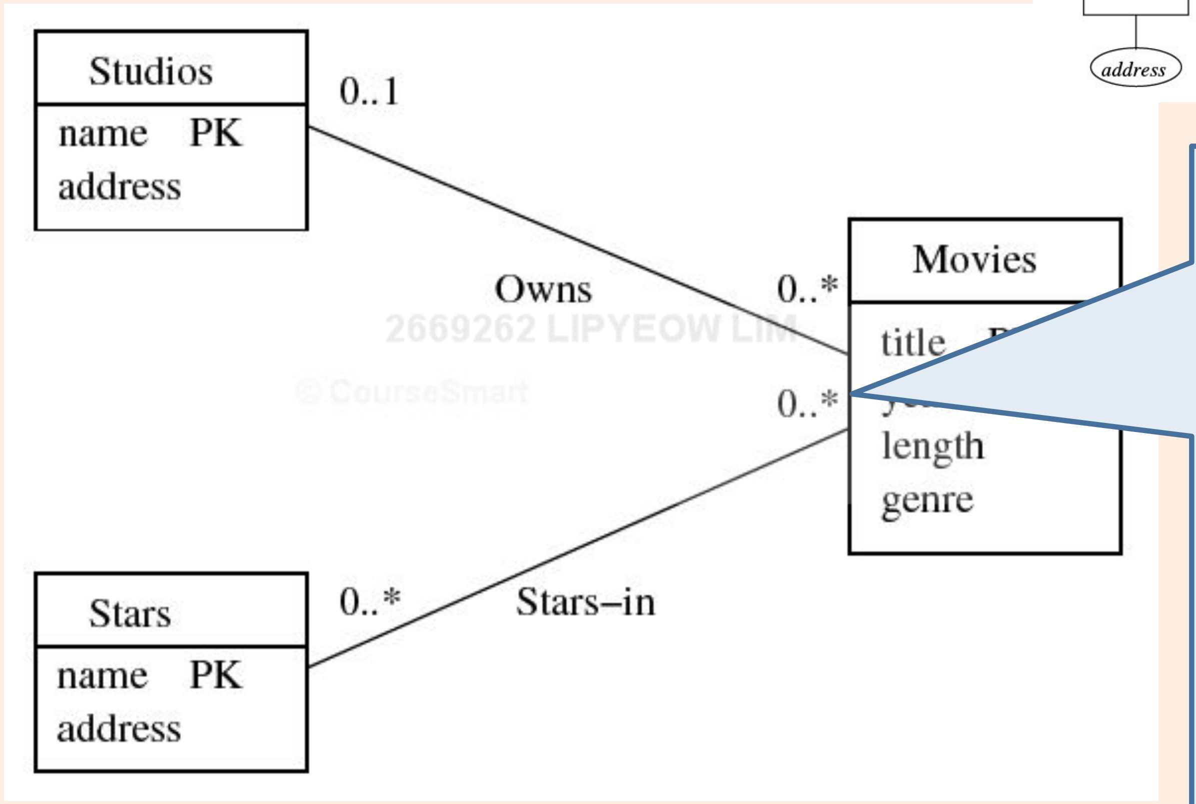


ER Entity Set

UML Class

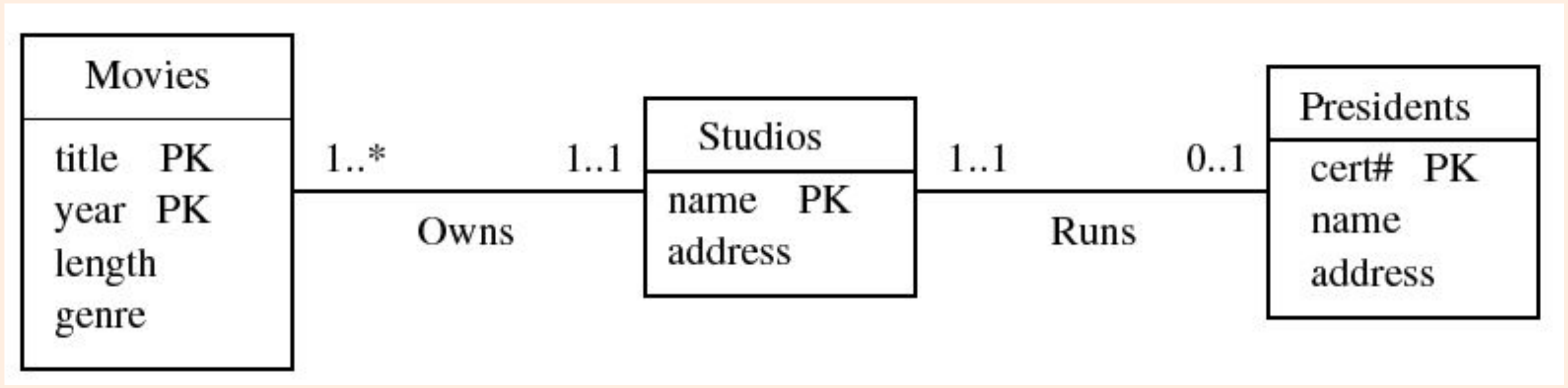
Associations





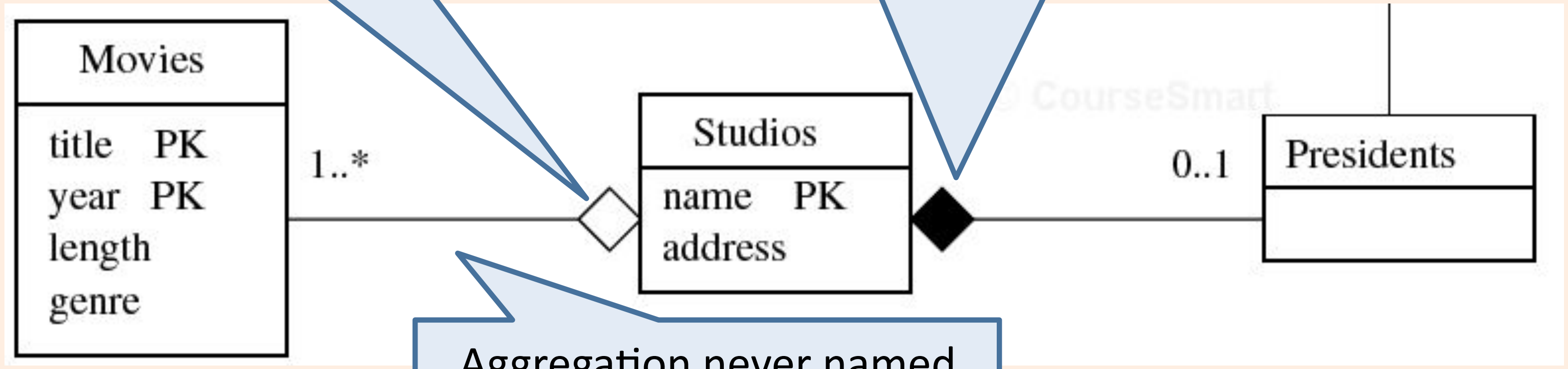
Cardinality constraints : one instance of Stars can be connected to at least 0 instance of movies and at most inifinite instances of movies

Referential Integrity



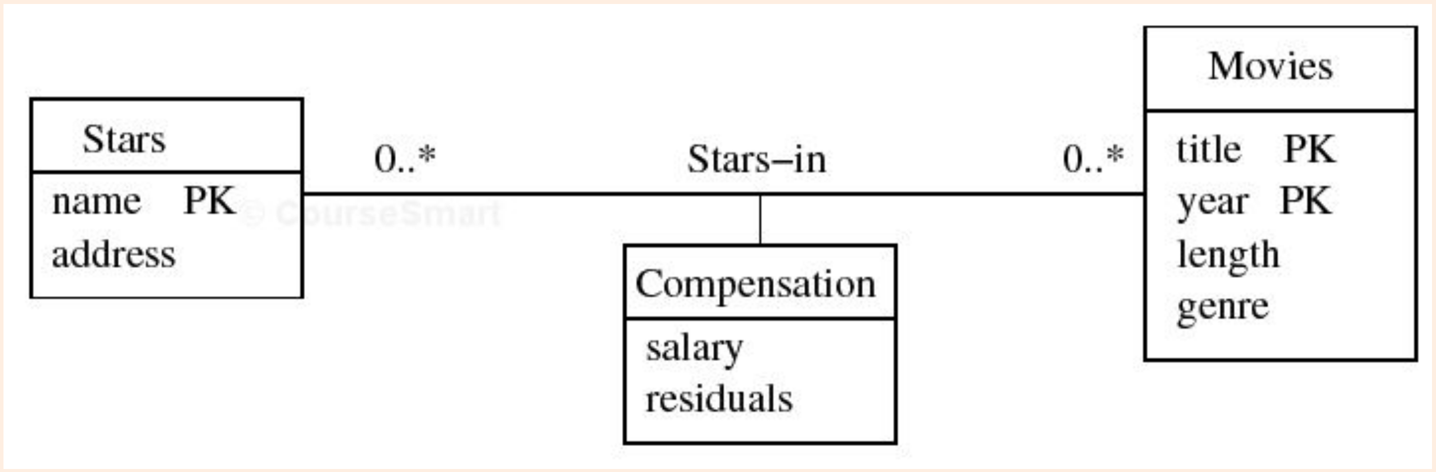
Aggregation: Must be 0..1 (includes 1..1)

Composition : Must be 1..1
Every president runs exactly one studio

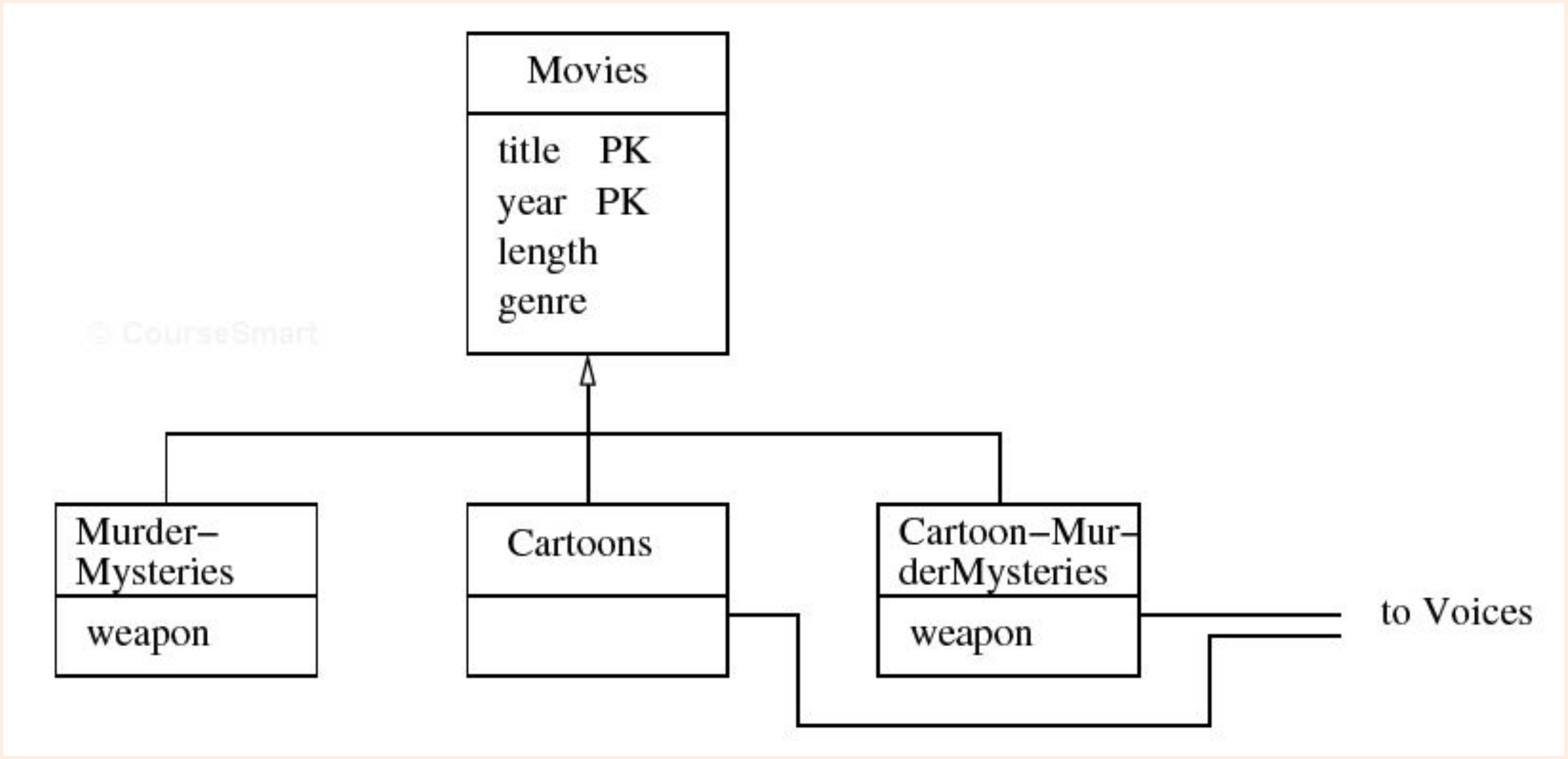


Aggregation never named

Association Classes



Sub-Class Hierarchies



Modeling Tips

- Faithful to the semantics of the application
- Model only what is needed in the application
- Minimize redundancy (why?)
- Simple is good
- If the model is getting too complicated, take a step back and ask
  - Am i conceptualizing the right entities ?
  - Am i thinking of the right relationships ?
  - Should some relationships become entities ? Vice versa ?
  - Should some attributes become entities ? Vice versa ?