Lecture 4

Entity-Relationship Model
(part 1)

ER模型

(第1部分)
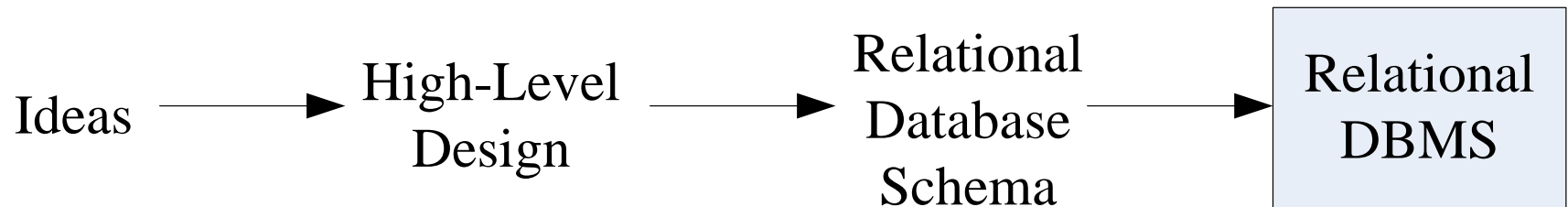
Outline

- The Entity/Relationship Model

- Design Principles

- Constraints in the E/R Model

- Weak Entity Sets

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Database Design Phase

- The database modeling and implementation process

Ideas → High-Level Design → Relational Database Schema → Relational DBMS

The Entity/Relationship Model

Dr. Peter Chen
陈品山 博士
1976年发明了E/R模型

- The Entity/Relationship Model 实体/联系 模型
    E/R Model   E/R 模型
    E/R Diagram   E/R 图
  - Entity sets   实体集
  - Attributes   属性
  - Relationships   联系

[P.P.S. Chen. The Entity Relationship Model – Towards a Unified View of Data.
 ACM Transactions on Database Systems, 1(1):9–36, 1976]

Entity Sets

- Entity
    - An abstract object of some sort
- Entity set
    - A collection of similar entities forms an entity set

E/R Model	OO Programming
Entity	Object
Entity set	Class

Entity Sets

- Example   (Movie-database)
  - Entity
    - A movie
    - A star
    - A studio
  - Entity set
    - The set of all movies
    - The set of all stars
    - The set of studios

Attributes

- Attributes　　　属性
  - Entity sets have associated attributes, which are properties of the entities in that set.
- Example
  - The entity set Movies
    - Might be given attributes such as title and length
- Assume
  - Attributes are of primitive types, such as strings, integers, or reals

Relationships

- Relationships   联系
  - Connections among two or more entity sets
- Example
  - Two entity sets: ***Movies*** and ***Stars***
  - Relationship: ***Stars-in***
    that connects movies and stars
  - The intent
    - A movie entity m is related to a star entity s by the relationship *Stars-in* if s appears in movie m

Entity-Relationship Diagrams

- E/R Diagram   E/R图
  - An E/R diagram is a graph representing entity sets, attributes, and relationships

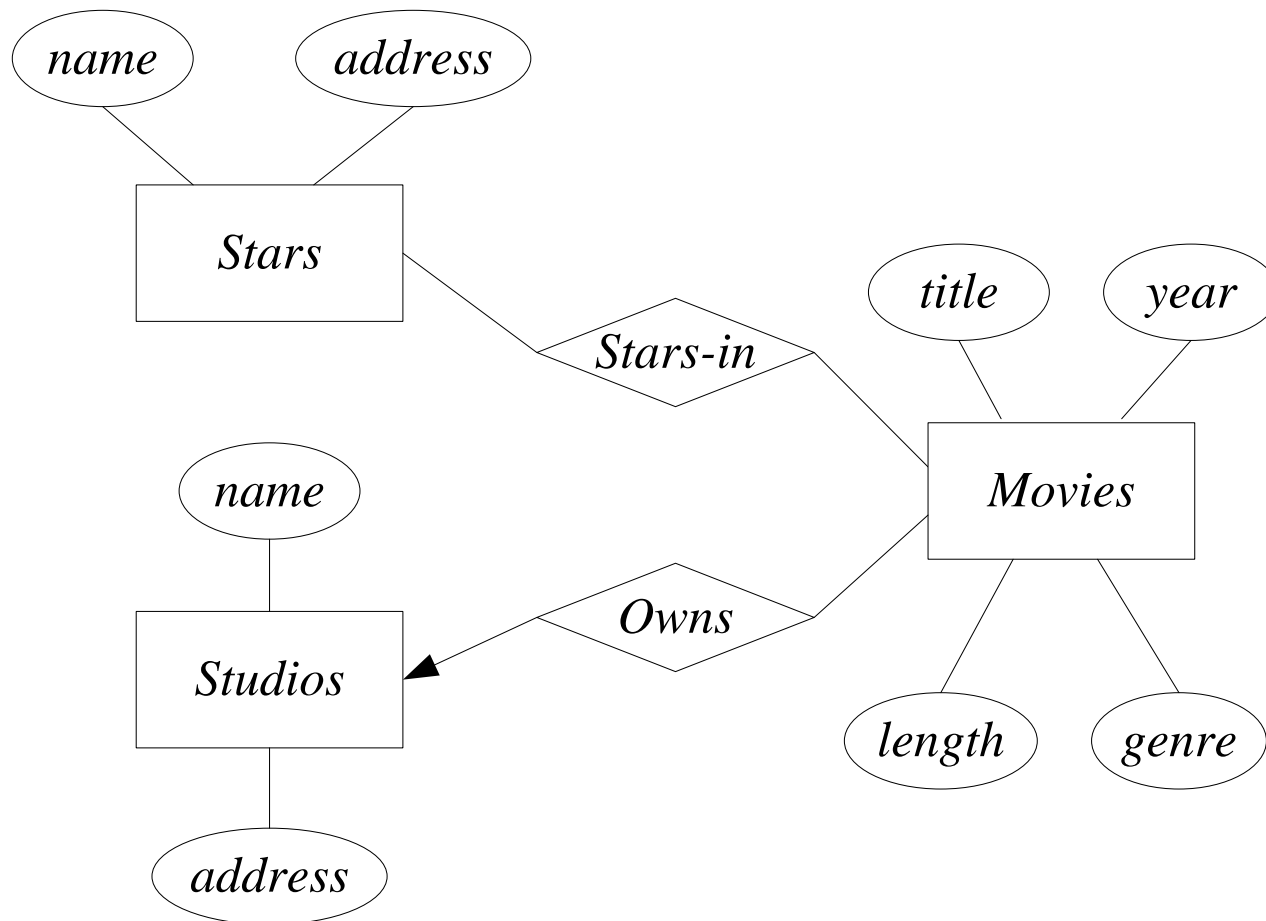 | Elements | Nodes | |
  |---|---|---|
  | Entity sets | Rectangles | 矩形 |
  | Attributes | Ovals | 椭圆 |
  | Relationships | Diamonds | 菱形 |

  - Edges
    - Connect an entity set to its attributes and also connect a relationship to its entity sets.

Entity-Relationship Diagrams

- Example 4.2

Instances of an E/R Diagram

- Entity set E
  - A particular finite set of entities
- Relationship R
  - Relationship set of R 联系集
  - Connects n entity sets $E_1, E_2, \ldots, E_n$
  - "Instance": a finite set of tuples $(e_1, e_2, \ldots, e_n)$

  $e_i \in E_i$

Instances of an E/R Diagram

- Example
  - An instance of the *Stars-in* relationship

| *Movies*	*Stars*
Basic Instinct	Sharon Stone
Total Recall	Arnold Schwarzenegger
Total Recall	Sharon Stone

Multiplicity of Binary E/R Relationships

- Multiplicity of Binary Relationships
  - *R* is a relationship connecting entity sets *E* and *F*

  - ***many-one***   多对一
    - If each member of *E* can be connected by *R* to at most one member of *F*, then we say that *R* is *many-one* from *E* to *F*.
      (Note that in a many-one relationship from *E* to *F*, each entity in *F* can be connected to many members of *E*.)
    - If each member of *F* can be connected by *R* to at most one member of *E*, then we say that *R* is *many-one* from *F* to *E*.
      (or equivalently, ***one-many*** from *E* to *F*). 一对多

Multiplicity of Binary E/R Relationships

- Multiplicity of Binary Relationships
  - *R* is a relationship connecting entity sets *E* and *F*

  - ***many-one***   多对一

实体集*E*   实体集*F*

  - ***one-many***   一对多

实体集*E*   实体集*F*
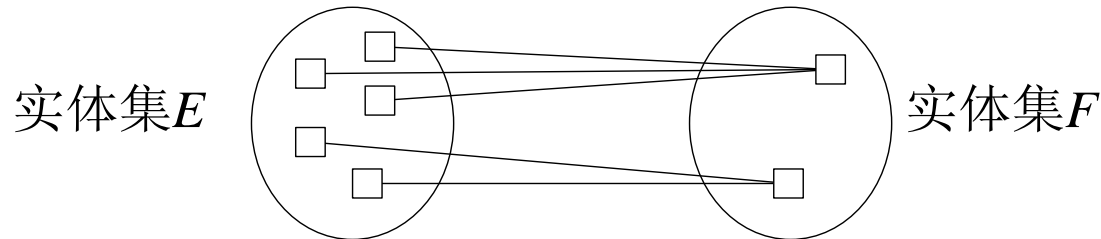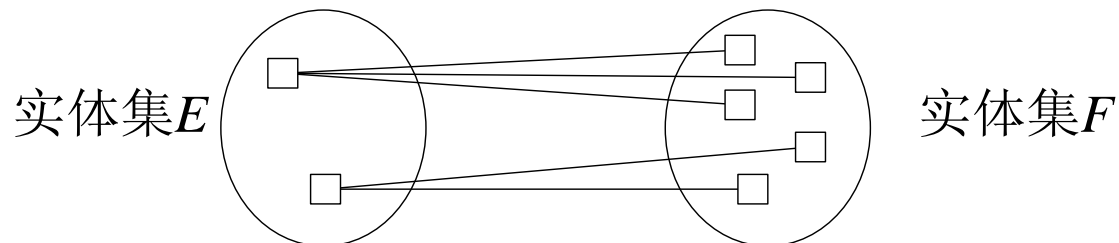
Multiplicity of Binary E/R Relationships

- Multiplicity of Binary Relationships
  - R is a relationship connecting entity sets E and F

  - ***one-one***   一对一
    - If R is both many-one from E to F and many-one from F to E, then we say that R is *one-one*.
      (In a one-one relationship an entity of either entity set can be connected to at most one entity of the other set.)
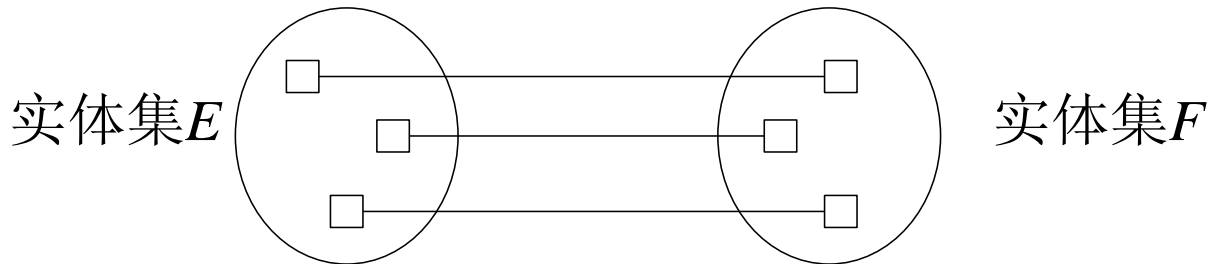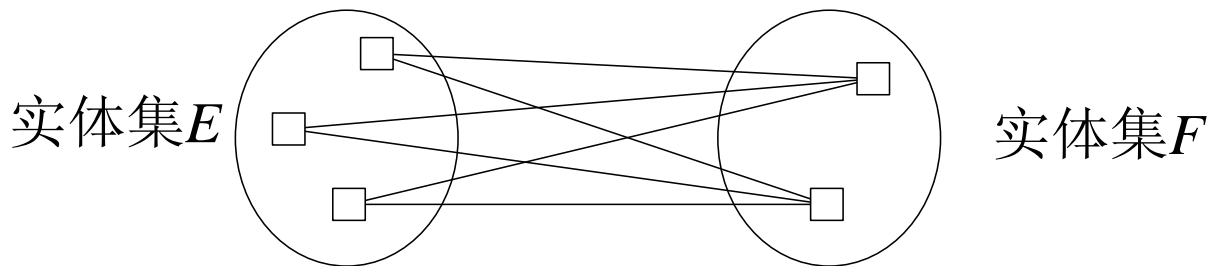
实体集E 实体集F

Multiplicity of Binary E/R Relationships

- ## Multiplicity of Binary Relationships
  - *R* is a relationship connecting entity sets *E* and *F*
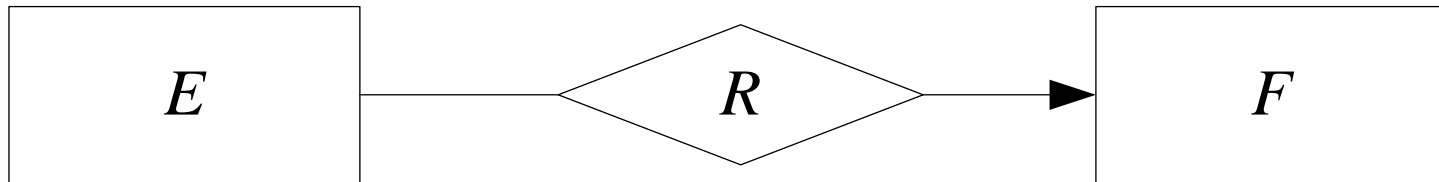
  - ***many-many***　　　　　多对多
    - If *R* is neither many-one from *E* to *F* or from *F* to *E*, then we say that *R* is *many-many*.

实体集*E*　　　　　　　　　　　　　　　实体集*F*

Multiplicity of Binary E/R Relationships

- **Multiplicity of Binary Relationships**
  - *R* is a relationship connecting entity sets *E* and *F*

 - If a relationship is many-one from *E* to *F*, then we place an arrow entering *F*

$$E \longrightarrow R \longrightarrow F$$

Multiplicity of Binary E/R Relationships

- Example
  - A one-one relationship

$$\boxed{\textit{Studios}} \longleftarrow \Diamond\ \textit{Runs}\ \Diamond \longrightarrow \boxed{\textit{Presidents}}$$
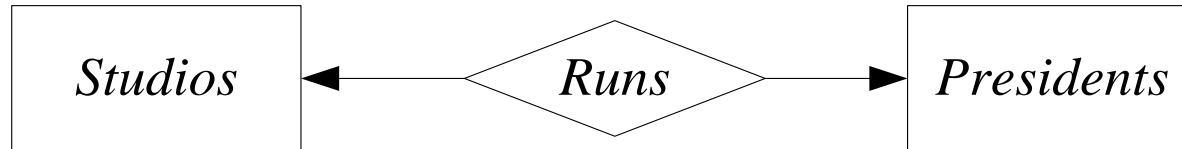
Multiway Relationship

- ## Multiway Relationship　多路联系
  - In practice, ternary or higher-degree relationships are rare, but they occasionally are necessary to reflect the true state of affairs.

- ## Example
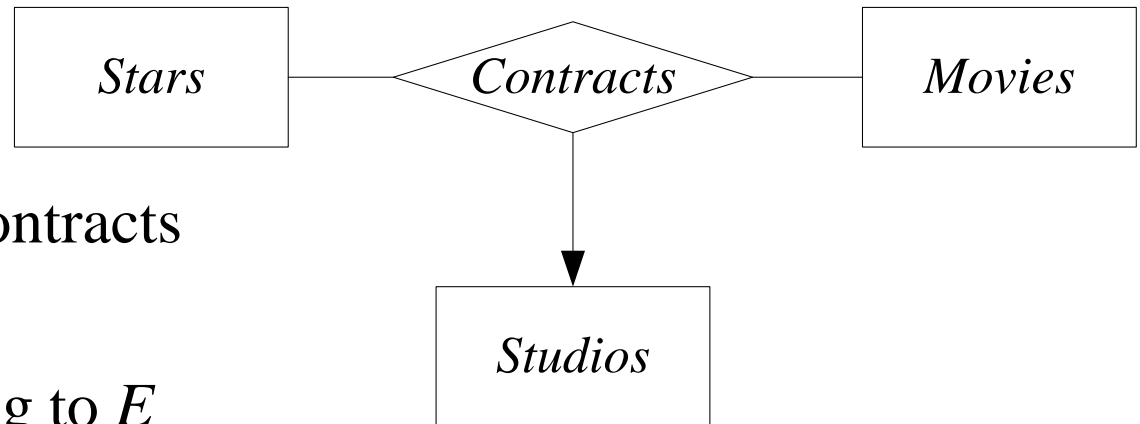 - A relationship Contracts
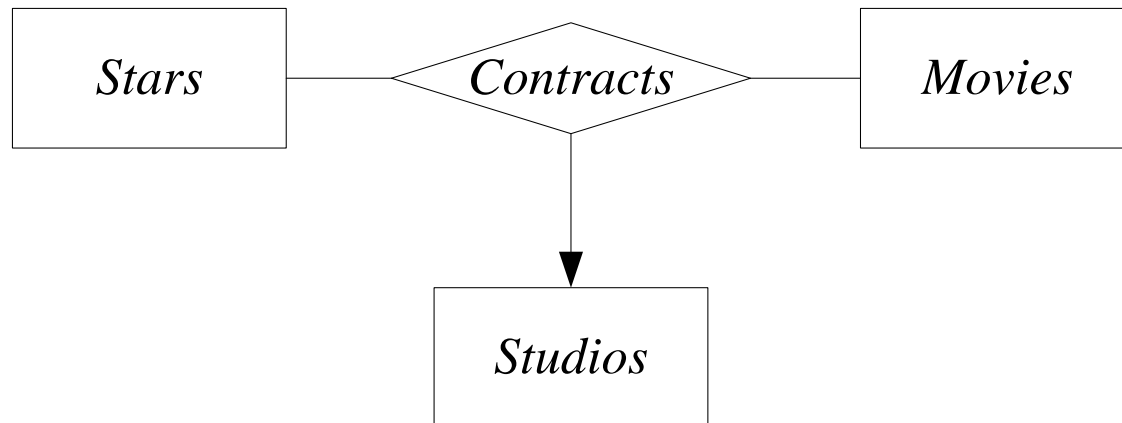
Multiway Relationship

- Example
  - A relationship Contracts

  - An arrow pointing to E
    - If we select one entity from each of the other entity sets in the relationship, those entities are related to at most one entity in E.
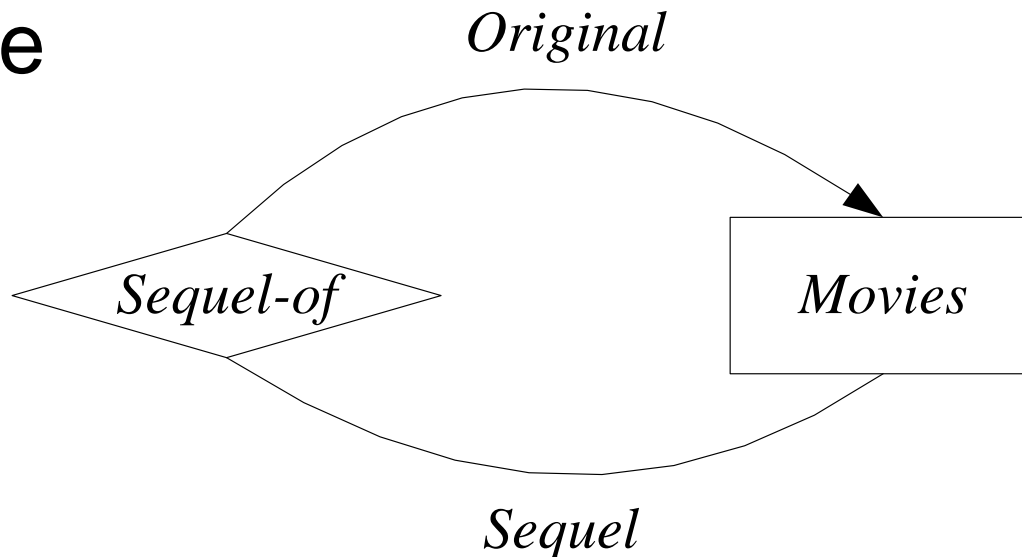   - Functional Dependency

      All the other entity sets $\rightarrow E$

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Roles in Relationships

- Roles in Relationships 联系中的角色
  - Each line to the entity set represents a different *role* that the entity set plays in the relationship
    - Label the edges by names, "roles"

- Example

Original
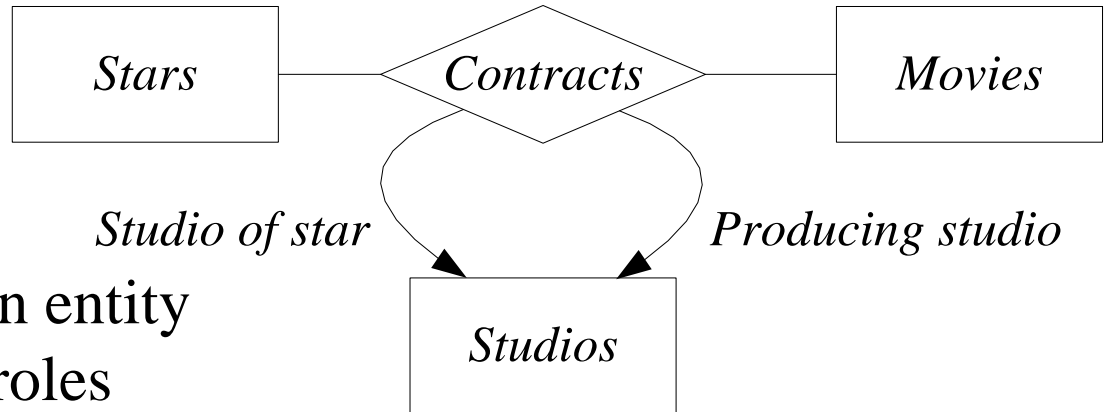
Sequel-of

Movies

Sequel

Roles in Relationships

- Example
  - Both a multiway relationship and an entity set with multiple roles
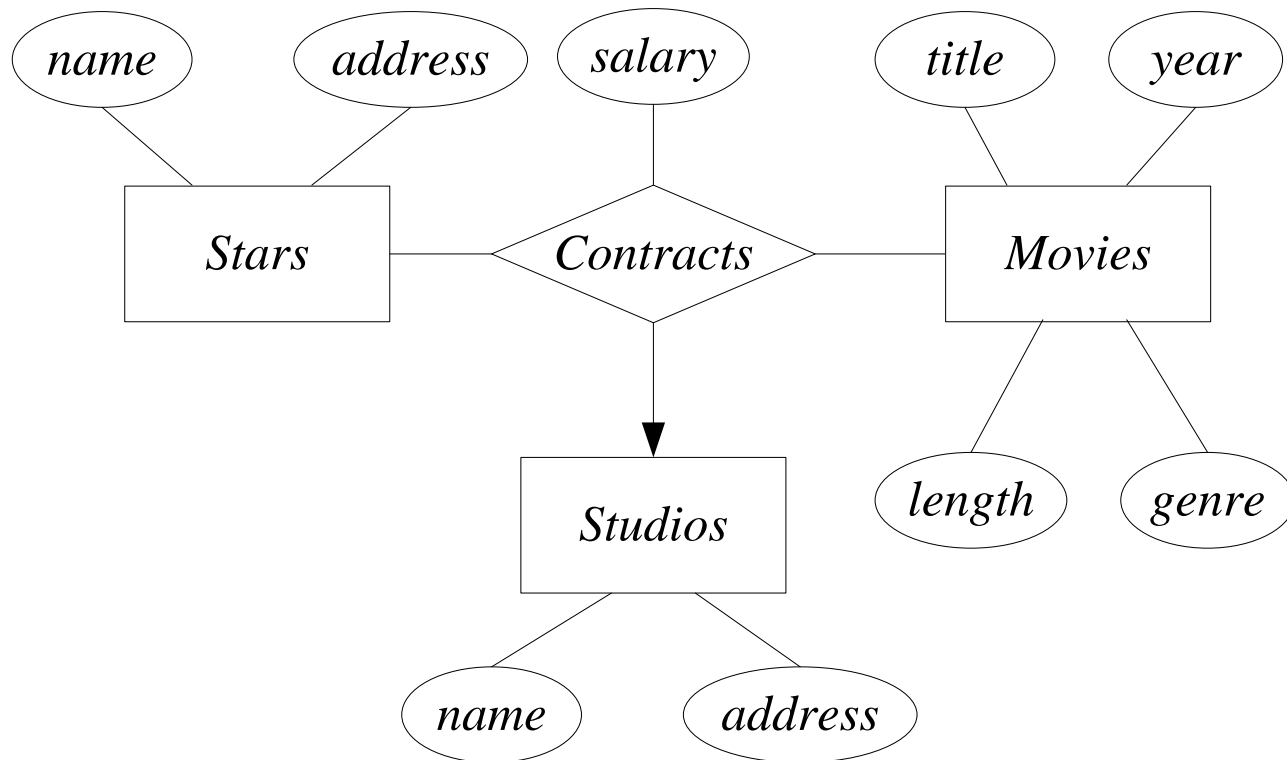
(studio1, studio2, star, movie)

  - studio2 contracts with studio1 for the use of studio1's star by studio2 for the movie

| Stars | Contracts | Movies |

Studio of star   *Producing studio*
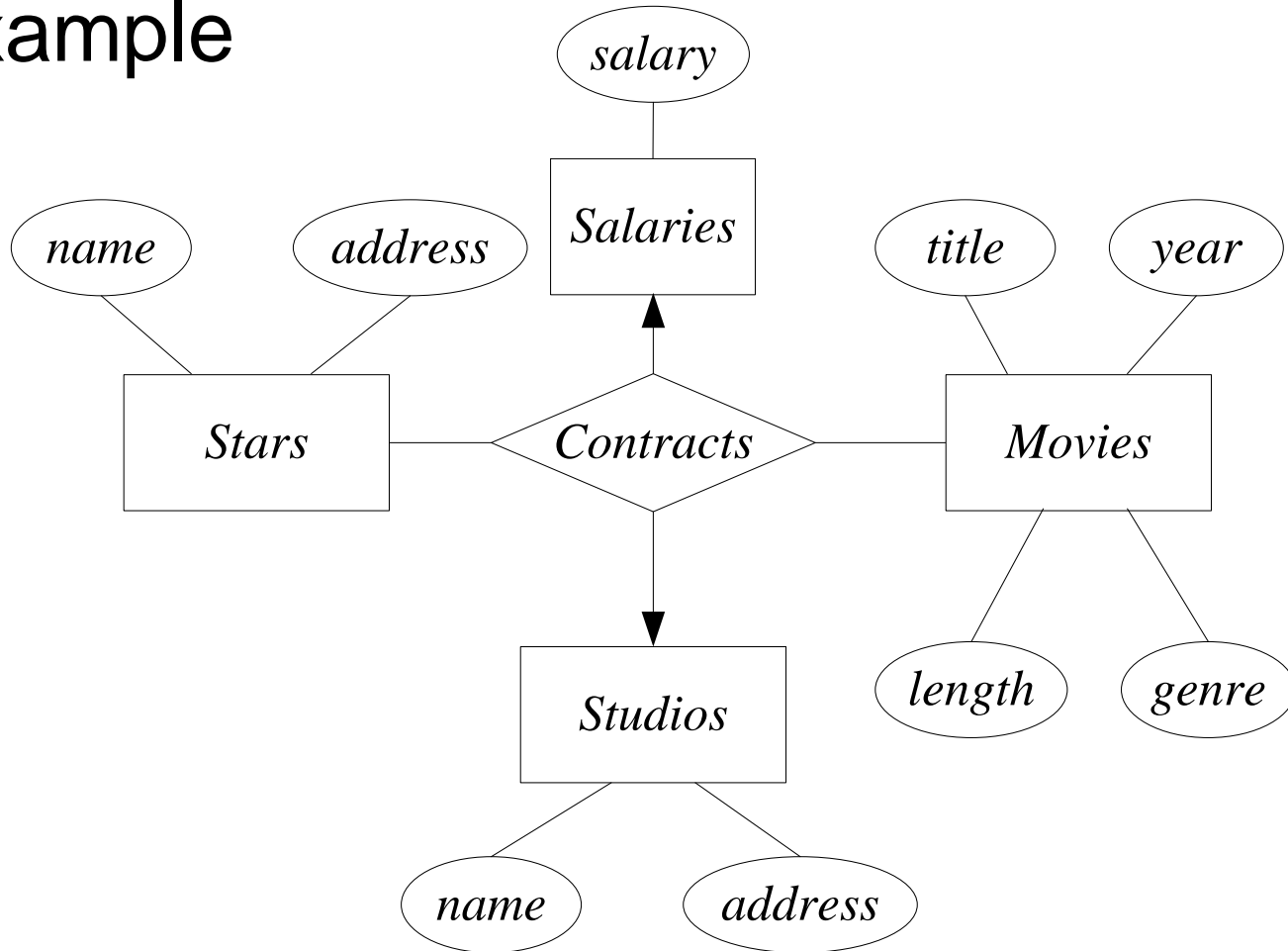
Studios

Attributes on Relationships

- Example
  - Sometimes it is convenient, or even essential, to associate attributes with a relationship
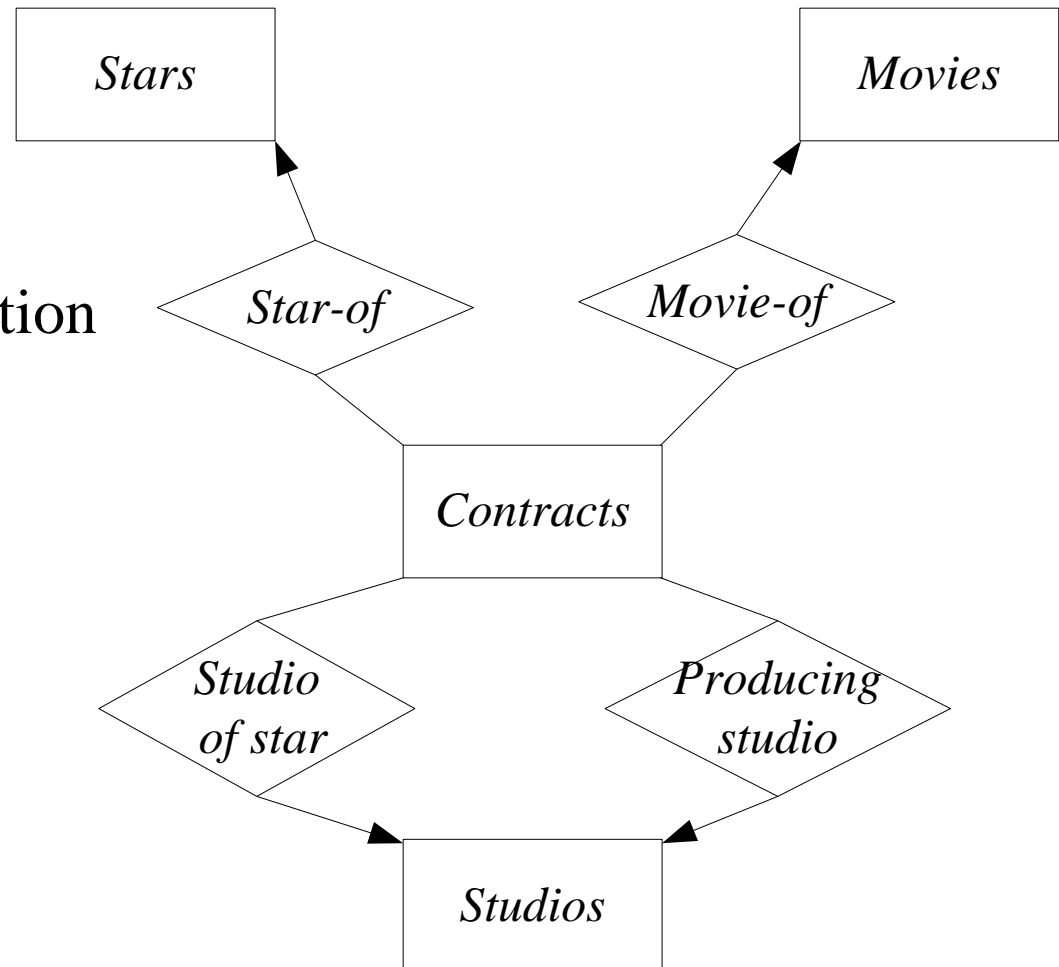
Attributes on Relationships

- Example

# Converting Multiway Relationships to Binary

- ## Example
  - Any multiway relationship can be converted to a collection of binary, many-one relationships

Subclasses in the E/R Model

- Subclasses   子类
  - Special-case entity sets, or subclasses, each with its own special attributes and/or relationships
  - *isa* relationship
    - A one-one relationship
    - Although not draw the two arrows
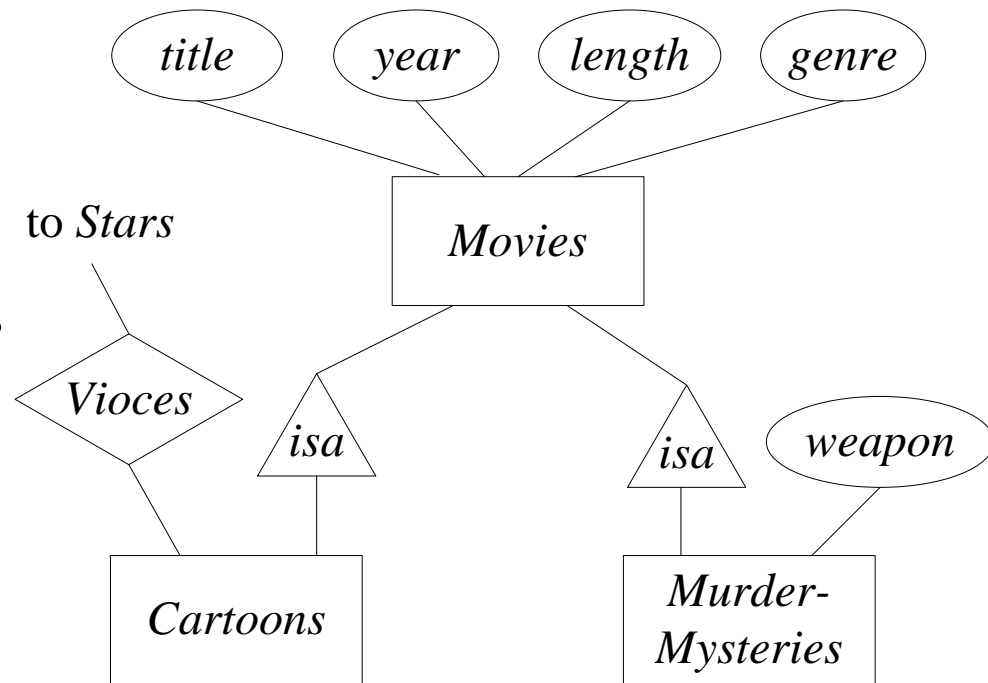
Outline

- The Entity/Relationship Model

- Design Principles

- Constraints in the E/R Model

- Weak Entity Sets

Design Principles

- Faithfulness   忠实性
  - The design should be faithful to the specifications of the application

Design Principles

- Avoiding Redundancy　避免冗余
  - We should be careful to say everything once only

  - For instance
    - We have used a relationship *Owns* between movies and studios
    - We might also choose to have an attribute *studioName* of entity set *Movies*
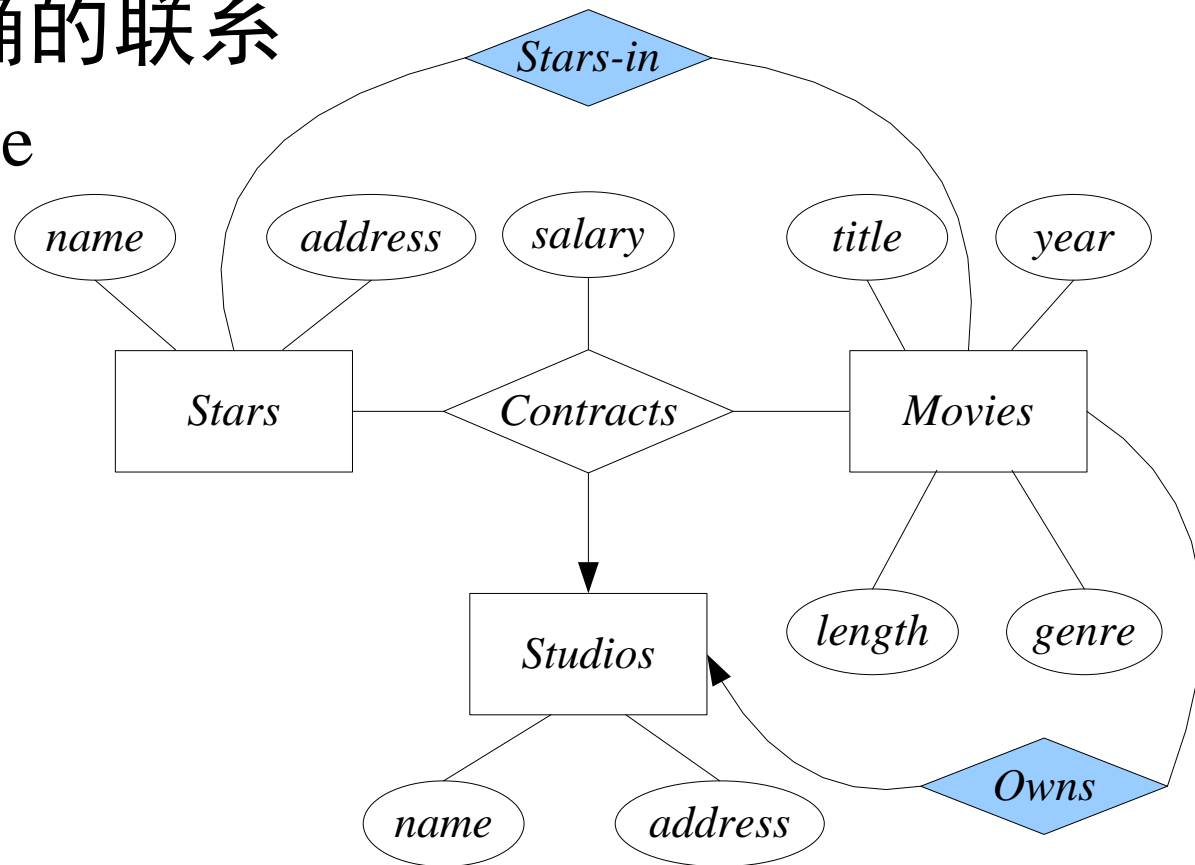
Design Principles

- Simplicity Counts　　简单性
  - Avoid introducing more elements into your design than is absolutely necessary

- Example
  - A poor design with an unnecessary entity set

```
┌──────────┐      ◇─────────────◇      ┌──────────┐      ◇──────────◇      ┌──────────┐
│  Movies  │◀────   Represents    ────▶│ Holdings │        Owns       ────▶│  Studios │
└──────────┘      ◇─────────────◇      └──────────┘      ◇──────────◇      └──────────┘
```
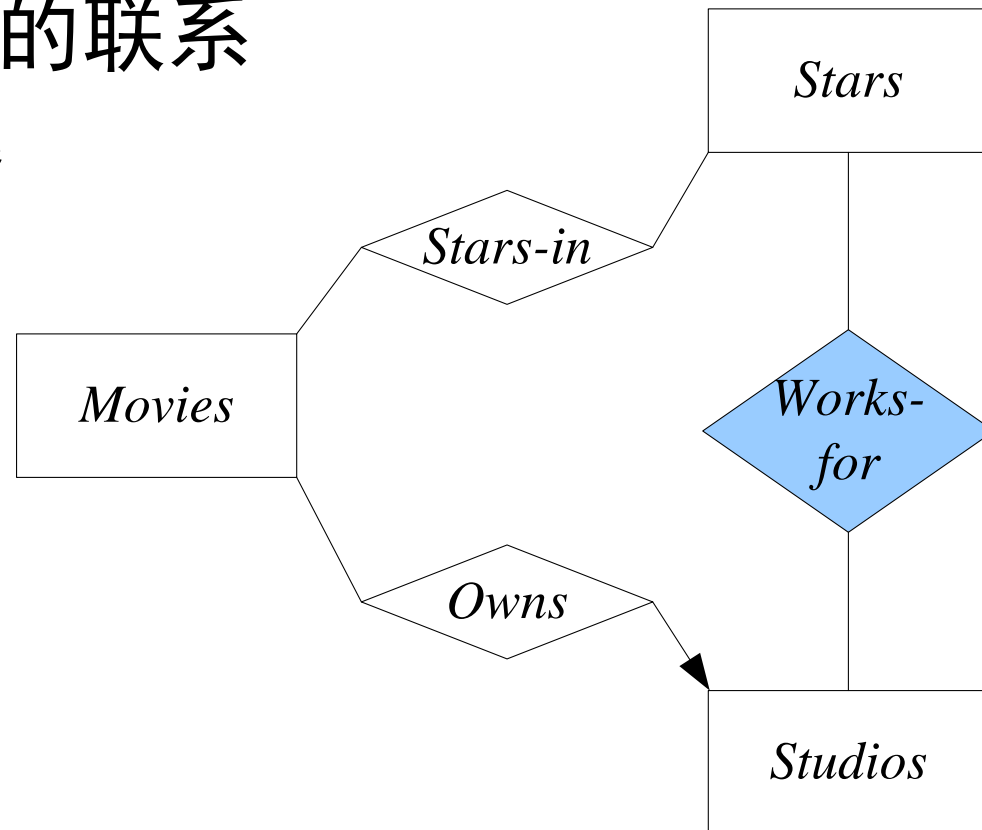
Design Principles

- Choosing the Right Relationship
  选择正确的联系
  - Example

Design Principles

- Choosing the Right Relationship 选择正确的联系
  - Example

Stars

Stars-in

Movies

Works-for

Owns

Studios

Design Principles

- Picking the Right Kind of Element
  选择正确的元素种类
  - Many of these choices are between
    - using attributes
    - using entity set / relationship combinations
  - In general
    - an attribute is simpler to implement
  - However,
    - making everything an attribute will usually get us into trouble

Design Principles

- Picking the Right Kind of Element
  选择正确的元素种类
  - Conditions under which
    we prefer to use an attribute instead of an entity set
    Suppose E is an entity set
    1. E must be the "one" is many-one relationships
    2. The only key for E is all its attributes
    3. No relationship involves E more than once

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Constraints in the E/R Model

- Constraints

  – Keys   键

  – Functional dependencies   函数依赖

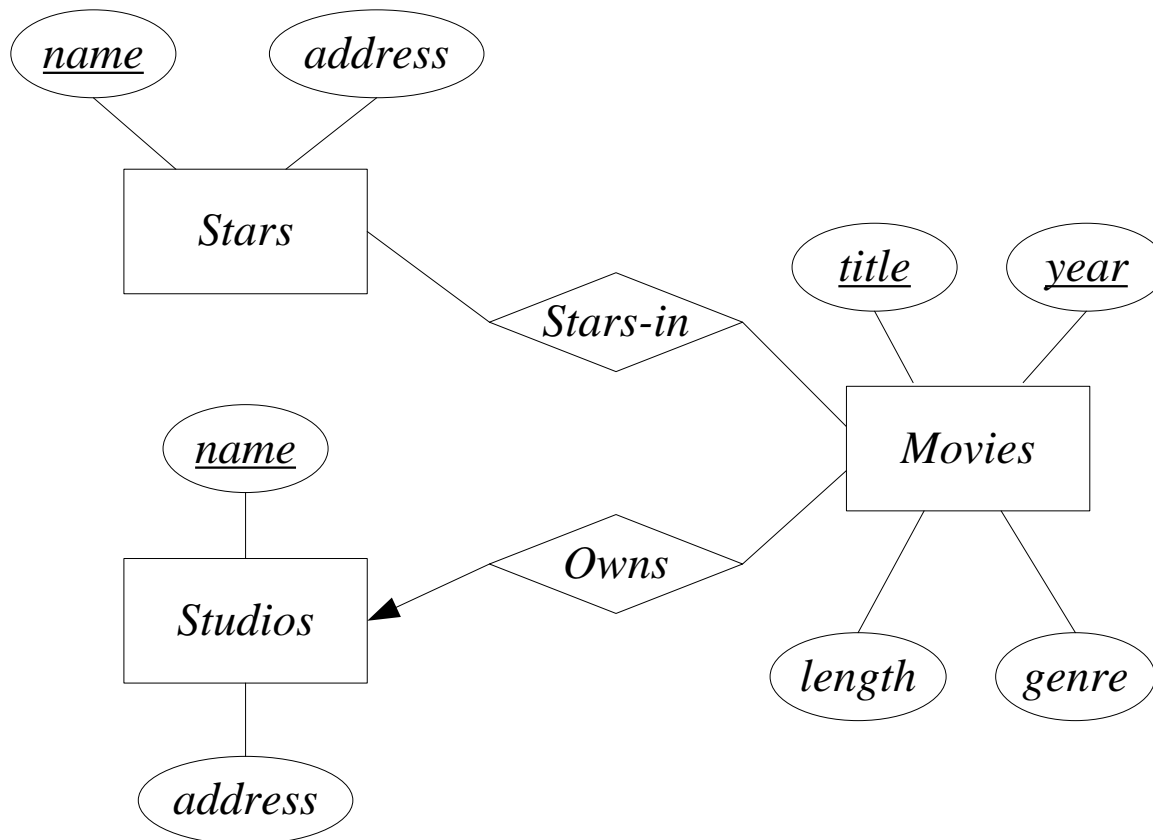 – Referential-integrity   参照完整性

Keys in the E/R Model

- Key
  - Every entity set must have a key

  - There can be more than one possible key for an entity set. It is customary to pick one key as the "primary key"

  - When an entity set is involved in an isa-hierarchy, we require that the root entity set have all the attributes needed for a key

Representing Keys in the E/R Model

- Example
 - Underline the attributes belonging to a key

Referential Integrity

- Notation
  - Suppose R is a relationship from E to F
  - A rounded arrow-head pointing to F indicates
    - not only that the relationship is many-one from E to F,
    - but that the entity of set F related to a given entity of set E is required to exist

| Movies | — Owns — | Studios | — Runs — | Presidents |

Degree Constraints

- Notation
  - Attach a bounding number to the edges

- Example
  - A movie entity cannot be connected by relationship Stars-in to more than 10 star entities
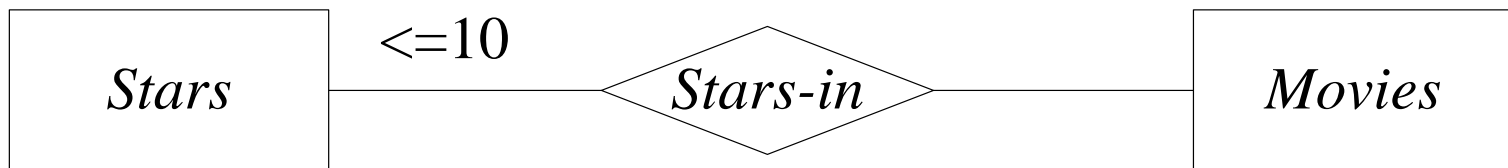
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Weak Entity Sets

- Weak entity set 弱实体集
  - An entity set's key is composed of attributes, some or all of which belong to another entity set
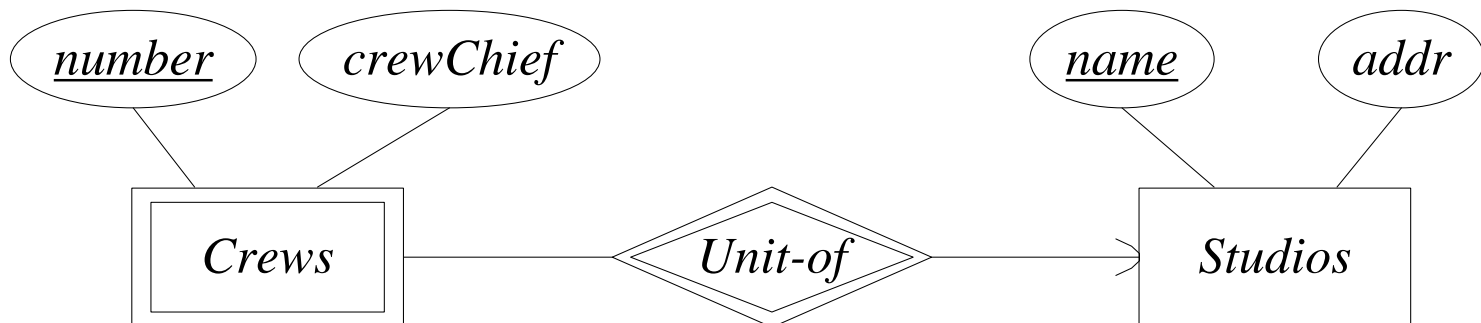
Causes of Weak Entity Sets

- Two principal reasons
  - First

    If entities of set E are subunits of entities in set F, then it is possible that the names of E-entities are not unique until we take into account the name of the F-entity to which the E entity is subordinate.
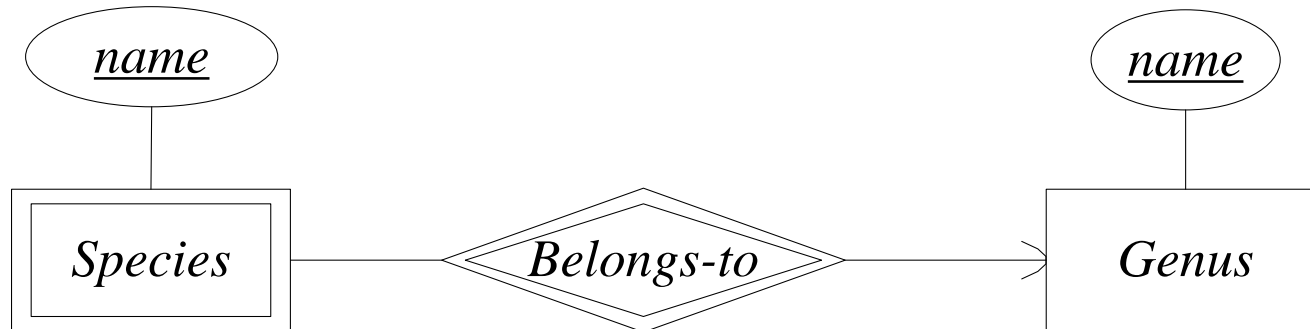
  - Example

Causes of Weak Entity Sets

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  - Example

Causes of Weak Entity Sets

- Two principal reasons
  - Second

    The connecting entity sets that are introduced as a way to eliminate a multiway relationship. These entity sets often have no attributes of their own. Their key is formed from the attributes that are the key attributes for the entity sets they connect.
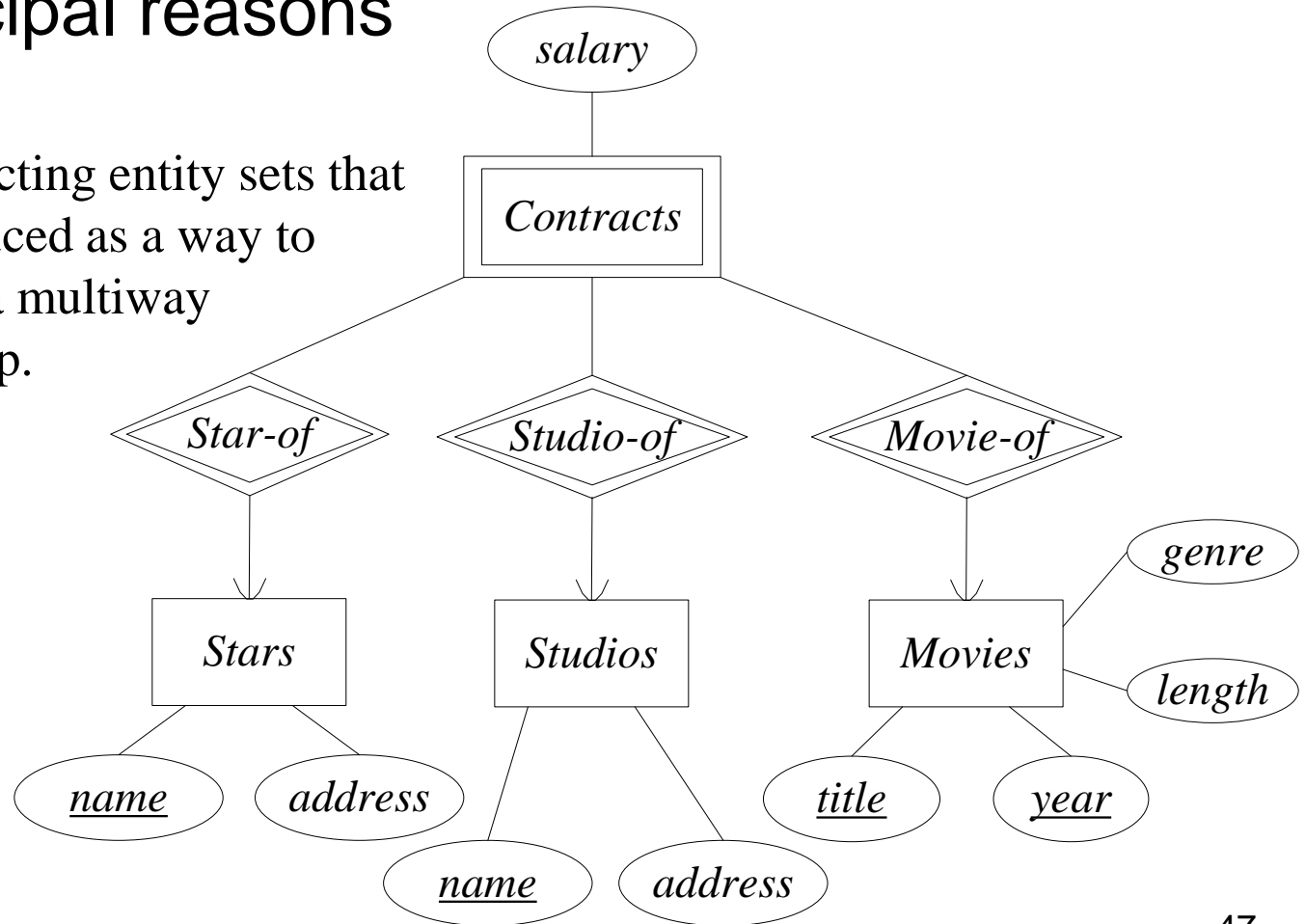
Causes of Weak Entity Sets

- ## Two principal reasons
  - Second

    The connecting entity sets that are introduced as a way to eliminate a multiway relationship.

  - Example

Requirements for Weak Entity Sets

- Key attributes for a weak entity set E

    1. Zero or more of its own attributes, and

    2. Key attributes from entity sets that are reached by certain many-one relationships from E to other entity sets

        - These many-one relationships are called *supporting relationships* for E, and　　支持联系
        - the entity sets reached from E are *supporting entity sets*
            　　　　　　　　支持实体集

Requirements for Weak Entity Sets

- *R* to be a supporting relationship for *E*

  The following conditions must be obeyed:

  a) *R* must be a binary, many-one relationship from *E* to *F*

  b) *R* must have referential integrity from *E* to *F*

  c) The attributes that *F* supplies for the key of *E* must be key attributes of *F*

  d) If *F* is itself weak, then some of the key attributes of *F* supplied to *E* will be key attributes of the entity set *G* to which *F* is connected by a supporting relationship (Recursively)

Requirements for Weak Entity Sets

- *R* to be a supporting relationship for *E*

  The following conditions must be obeyed:

  e) If there are several different supporting relationships from E to the same entity set F, then each relationship is used to supply a copy of the key attributes of F to help form the key of E.

  Note that an entity e from E may be related to different entities in F through different supporting relationships from F. Thus, the keys of several different entities from F may appear in the key values identifying a particular entity e from E.

Weak Entity Sets Notation

- Notations

  1. If an entity set is weak, it will be shown as a rectangle with a double border

  2. Its supporting many-one relationship will be shown as diamonds with a double border

  3. If an entity set supplies any attributes for its own key, then those attributes will be underlined

Weak Entity Sets Notation

- The following rule

Whenever we use an entity set E with a double border, it is weak. The key for E is whatever attributes of E are underlined plus the key attributes of those entity sets to which E is connected by many-one relationships with a double border.