COMP353 Databases

Relational Data Model

Conceptual Database Design

Relational Data Model:

Introduction

The Relational Data Model

- **Relational database**
  - A set of **relations**
- **Relation**
  - A two-dimensional table in which data is arranged

Example: Relation

Attribute **Names**

Title	Year	Length	FilmType
Star Wars	1997	124	color
Mighty Ducks	1991	104	color
Wayne’s World	1992	95	color
. . .	. . .	. . .	. . .

Each row is a tuple

Components of the tuple

Attributes (type) are atomic (1NF)

Relational Data Model

- Relation schema (or structure): $\mathbf{R_i=\{A_1,\ldots,A_m\}}$
  - Relation name + a set of attribute names (+ attribute types)
- Relation instance:
  - The set of "current" tuples
- Database schema:
  - A set of relation schemas $\mathbf{D=\{R_1,\ldots,R_n\}}$
- Database instance:
  - A collection of relation instances -- one for each relation in the database schema

Relational Query Languages

- A major strength of the relational model is that it supports a powerful, high-level programming language – the Structured Query Language (SQL)

Logical Database Design

From E/R to Relational Model

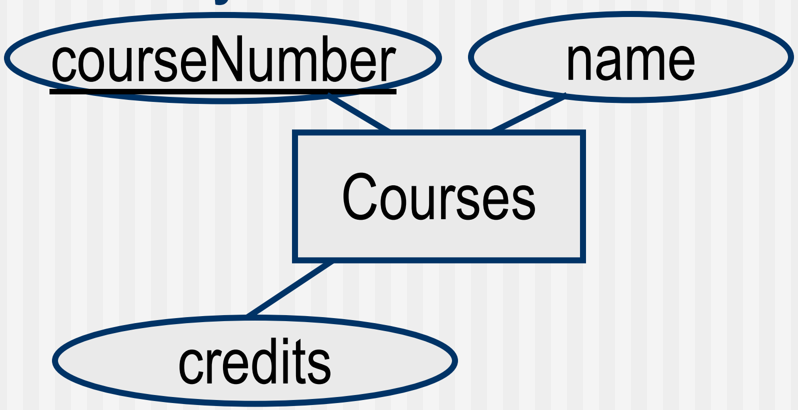
Converting E/R to Relational Model

- Input:
  - An E/R diagram
- Output:
  - A relational database schema -- a collection of relations

Converting Entity Sets to Relations

- For each entity set **E,** create a corresponding relation with the same attributes as in **E**

Entity Set:



Relation Instance:

courseNumber	name	credits
Comp248	C++ Prog.	3
Comp352	Data Structures	4
Comp353	Databases	4

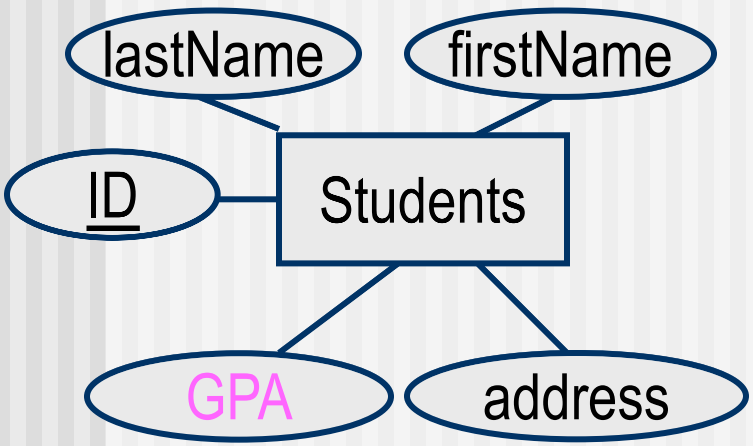
Relation Schema:

In theory, **Courses =** {courseNumber, name, credits}

In practice, **Courses**(courseNumber, name, credits)

Converting Entity Sets to Relations

Entity Set:



Relation Instance:

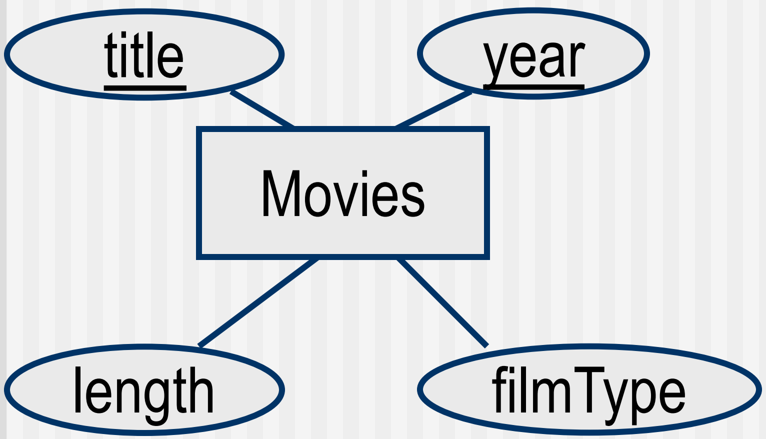
ID	firstName	lastName	GPA	address
111	Joe	Smith	4.0	45 Pine av.
222	Sue	Brown	3.1	71 Main St.
333	Ann	John	3.7	39 Bay St.

Relation Schema:

Students(<u>ID</u>, firstName, lastName, GPA, address)

Converting Entity Sets to Relations

Entity Set:



Relation Instance:

title	year	length	filmType
Star Wars	1997	124	color
Mighty Ducks	1991	104	color
Wayne’s World	1992	95	b&w

Relation Schema:

Movies(title, year, length, filmType)

Converting Entity Sets to Relations

Entity Set:

Relation Instance:

name	address
Fox	Hollywood
Disney	Hollywood
Paramount	Hollywood

Relation Schema:

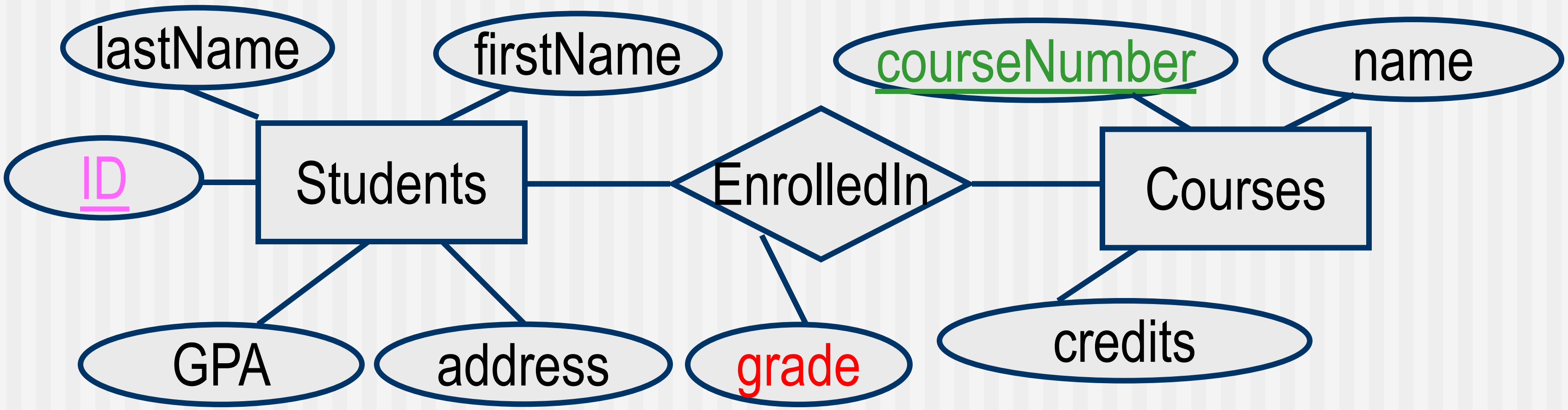
Studios(name, address)

Converting Relationships to Tables

- For each relationship set **R,** create the corresponding table (relation) and determine its attributes.
- The set of attributes of this table includes:
  - “Implicitly”: Key attribute(s) of the entity sets involved in the relationship **R**
  - “Explicitly”: every attribute used ”explicitly” in **R**

From Relationships to Tables

Relationship Set:



Relation Instance:

ID	courseNumber	grade
123	Comp248	A-
456	Comp248	B
123	Comp353	A+

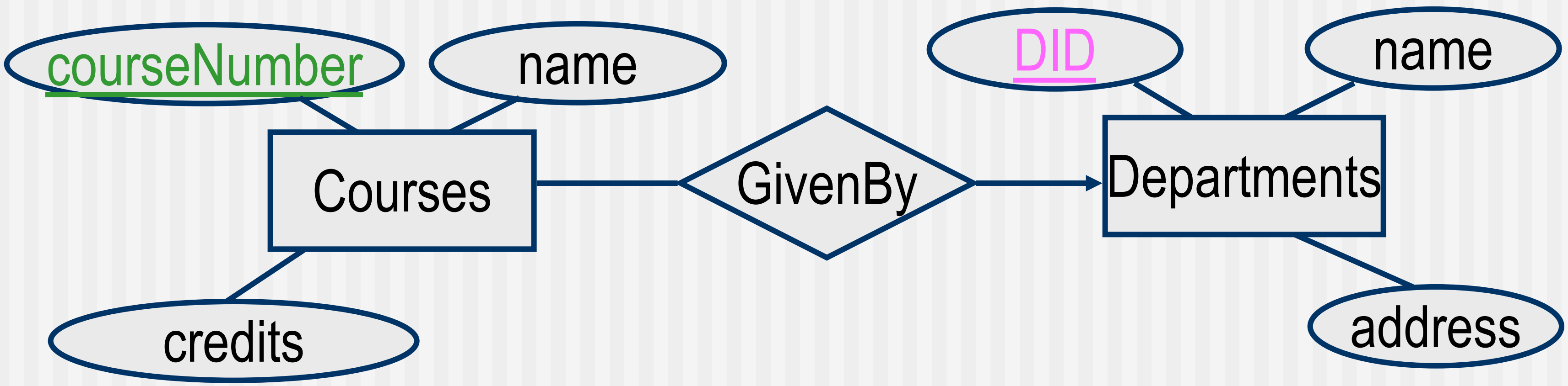
Relation Schema:

EnrolledIn (ID, courseNumber, grade)

What is the primary key of this relation?

From Relationships to Tables

Relationship Set:



Relation Instance:

courseNumber	DID
Comp248	1
Comp352	1
Math207	9

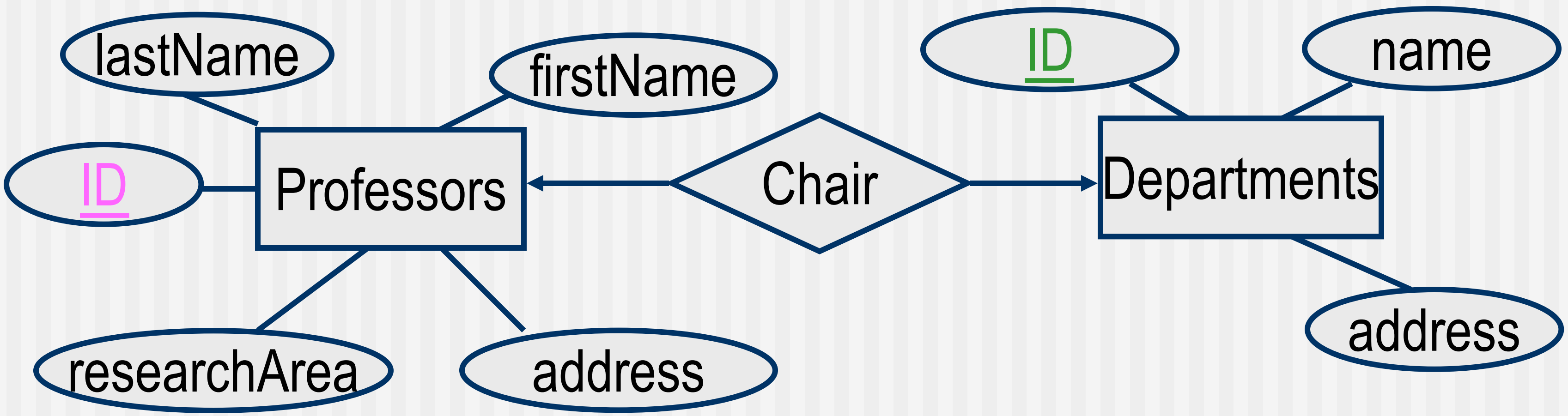
Relation Schema:

GivenBy(courseNumber, DID)

What is the primary key of this relation?

From Relationships to Tables

Relationship Set:



Relation Schema:

Chair(PID, DID)

What is the primary key of this relation?

Relation Instance:

PID	DID
234	1
451	2
778	9

Identifying Key of Relationship R

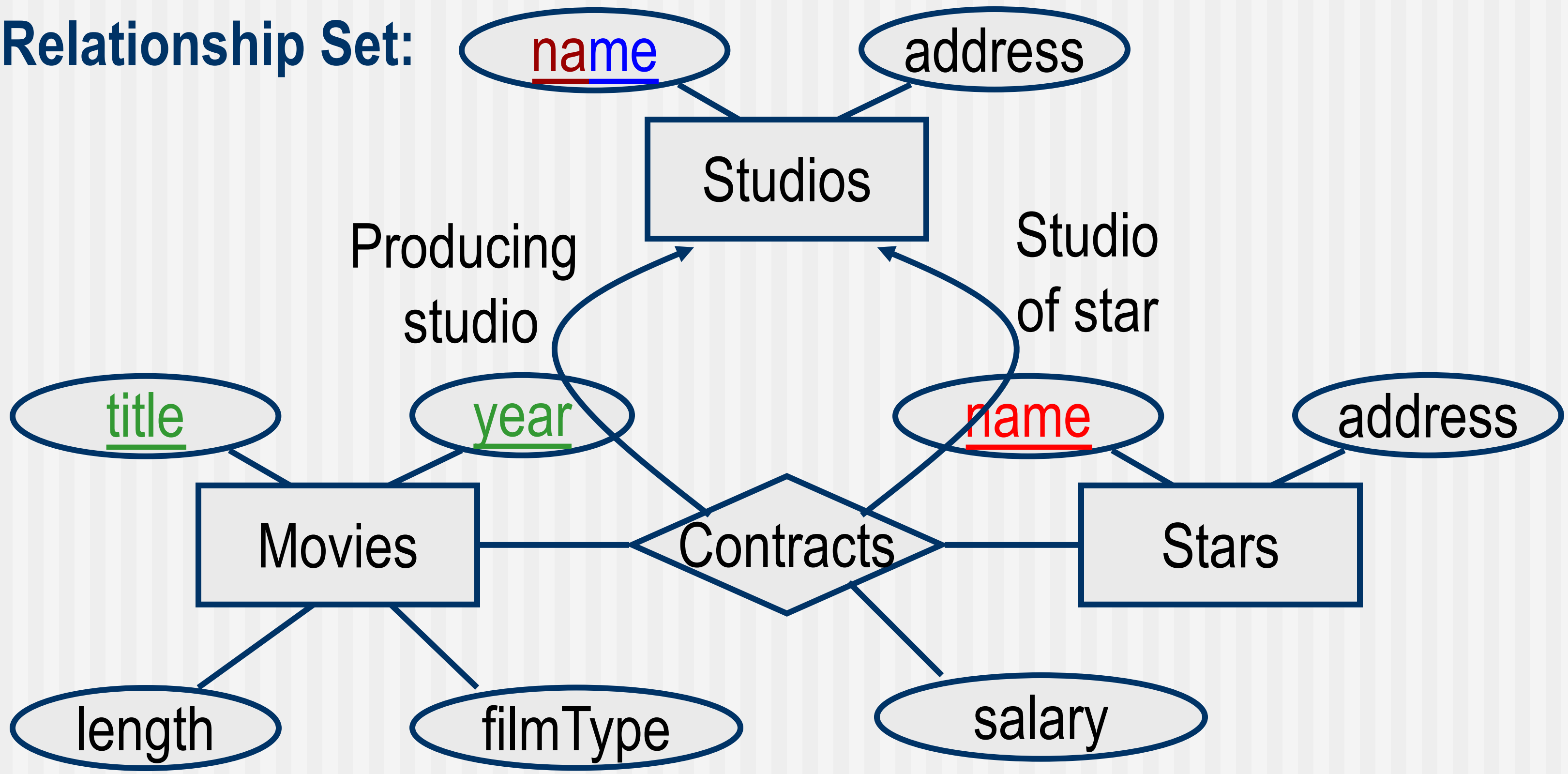
- We are already familiar with the concept of key
- If **R** is a **binary** relationship between entity sets **E1** and **E2**, then the multiplicity of this relationship determines the key of **R**
  - If **R** is M-N, then the keys of **E1** and **E2** together are "part of" the key of **R**
  - If **R** is M-1 from **E1** to **E2**, then the key of **E1** is part of the key of **R**
  - If **R** is 1-1, then either **E1** or **E2** (but not both) is part of the key of **R**
- Do the above rules regarding the formation of keys apply to:
  - **Multi-way relationships?**
- How to determine keys for:
  - **Week entity sets?**
  - **Entity sets *and* relationship *sets in isa* hierarchies?**

Converting Relationships to Tables

- We should **rename** the attributes in the relations created when:
  - An entity set is involved in a relationship more than once
  - The **same attribute name** appears in the keys of different entity sets involved in the relationship (e.g., ID in previous example)
  - This is to avoid **ambiguity** in the schema and to be more clear in meanings

Relationship Sets to Relations

Relationship Set:



What is the primary key for Contracts?

Relation Schema:

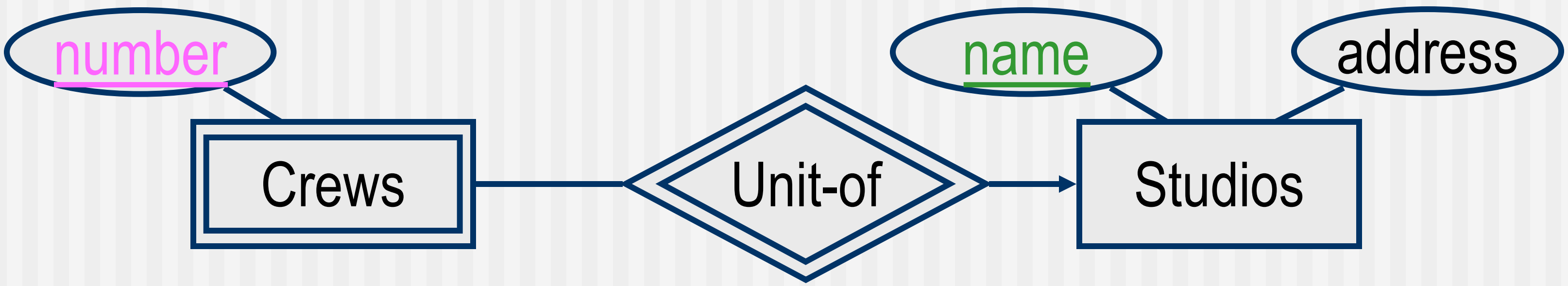
Contracts(starName, title, year, studioOfStar, producingStudio, salary)

Weak Entity Sets to Relations

- The relation/table **W** for the weak entity set $\mathcal{W}$, must include all the attributes of $\mathcal{W}$ as well as the key attributes of the strong entity sets to which $\mathcal{W}$ is associated.
- Any relationship R to which the weak entity set $\mathcal{W}$ contributes, must include **all** the key attributes of $\mathcal{W}$, i.e., the key attributes of *every* entity set that contributes to $\mathcal{W}$'s key
- The weak relationships, from the weak entity set $\mathcal{W}$ to other entity sets that provide the key for $\mathcal{W}$, need not be converted into a separate table, i.e., double diamonds connecting a weak entity set need not become a separate table.

Weak Entity Sets to Relations

Weak Entity Set:



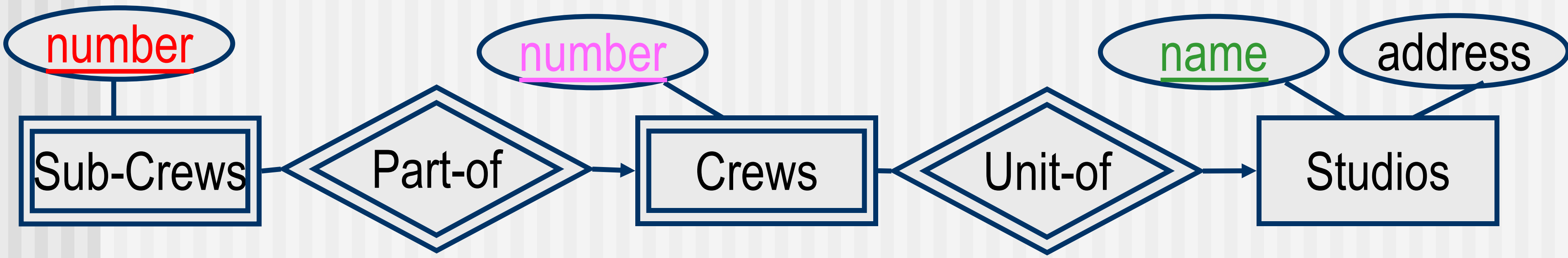
Relation Schema:

Crews (number, name)
Unit-of (number, studioName, name)
Studios (name, address)

Do we need to keep the relation Unit-of?

Weak Entity Sets to Relations

Weak Entity Set:



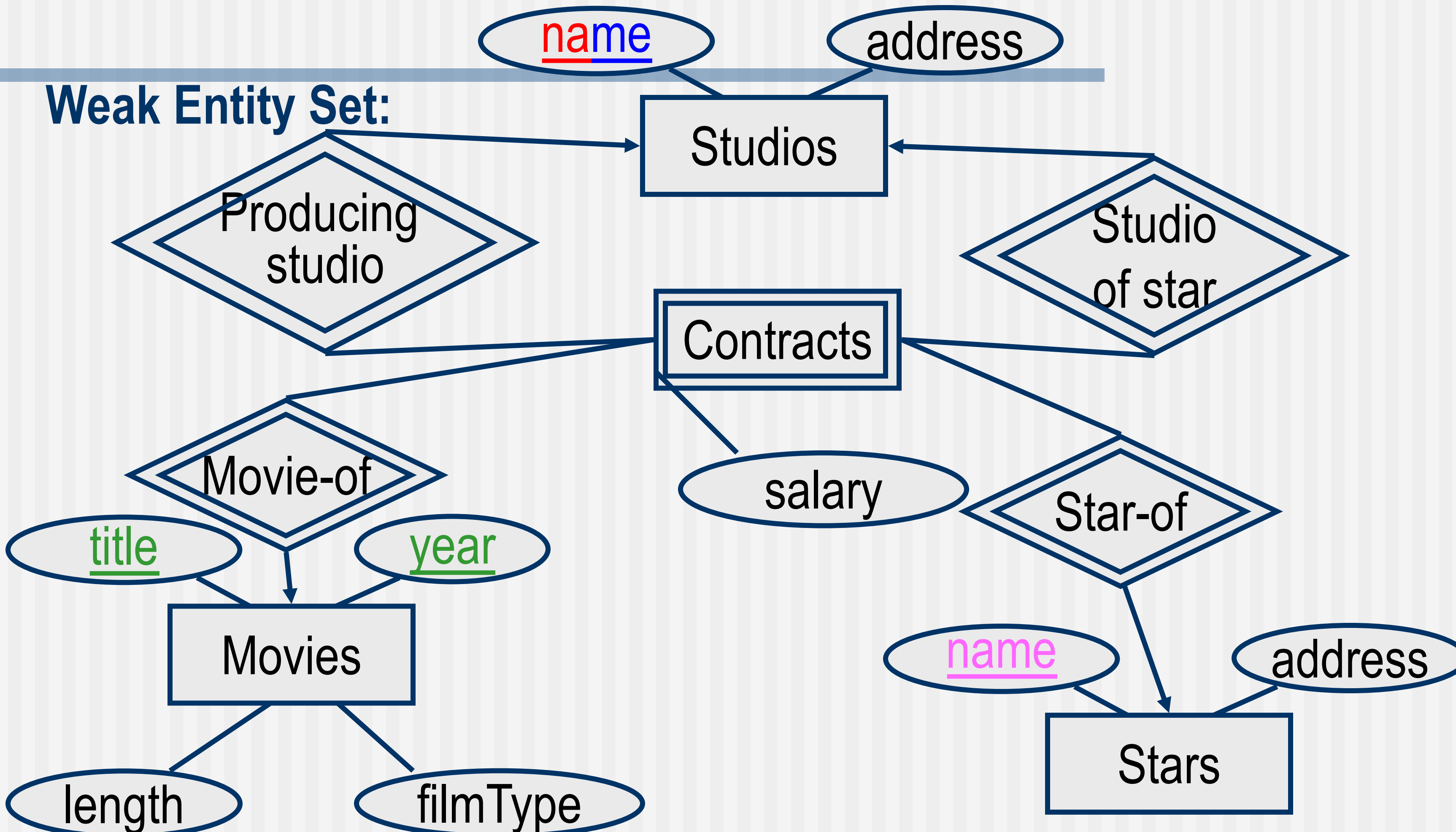
Relation Schemas:

Sub-Crews (number,crewNumber, name)

Studios (name, address)

Weak Entity Sets to Relations

Weak Entity Set:



What is the key for Contracts?

Relation Schema:

Contracts(starName, title, year, studioOfStar, producingStudio,salary)

Converting *isa*-Hierarchies to Relations

There are 3 approaches:

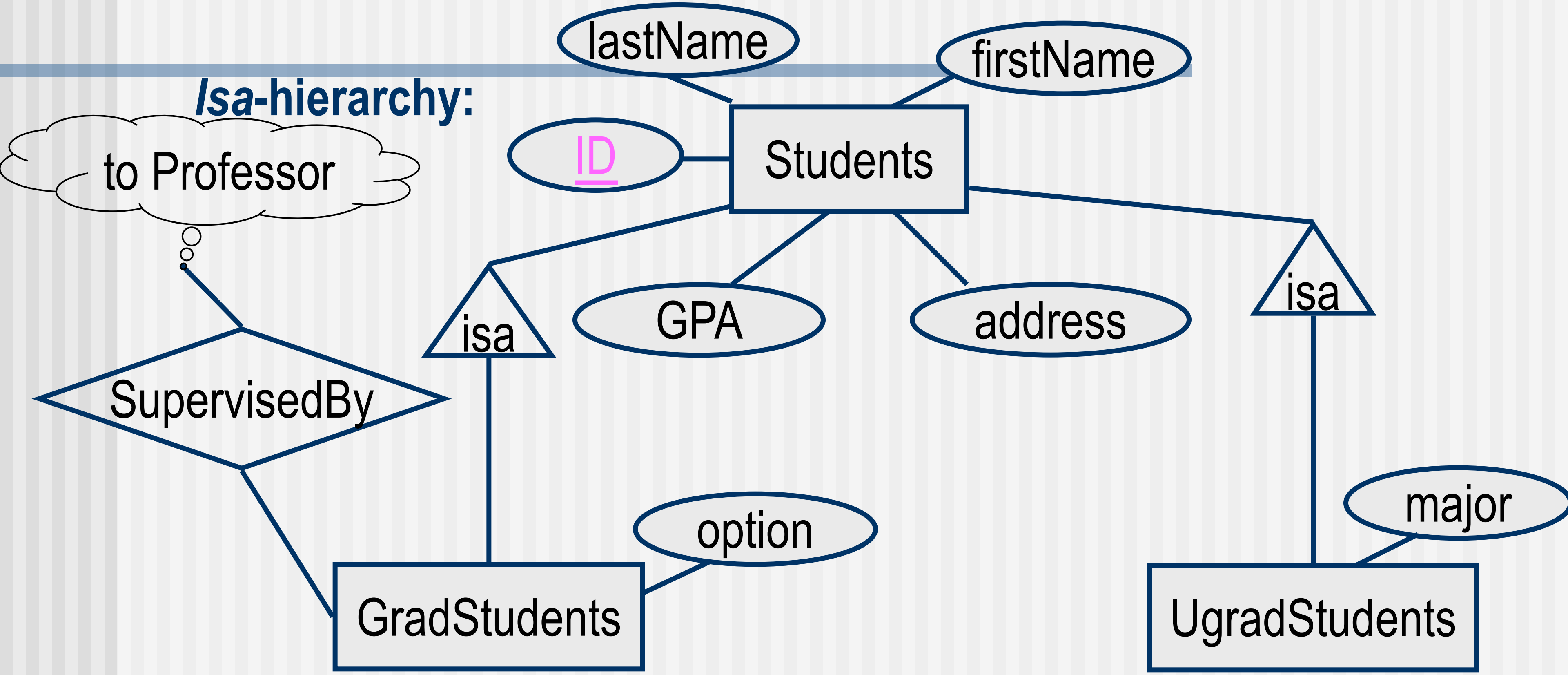
- Straight-E/R style method
  - In the E/R model, an entity (object) can be represented by entities that may belong to several entity sets, which are connected and related via ***isa*** hierarchies
  - The “connected” entities together represent the object and also determine the object’s properties (e.g., attributes and relationships)
- The object-oriented method
- The nulls method

Converting *isa*-Hierarchy to Relations

- For each entity set **E**, create a relation (table) **e**, and give it attribute(s) **A**, whenever:
  - **A** belongs to **E**
  - **A** is the key attribute of the parent(s) relation
- No relation is created for the ***isa***-relationship

Isa-Hierarchy to Relations

***Isa*-hierarchy:**



Relation Schemas:

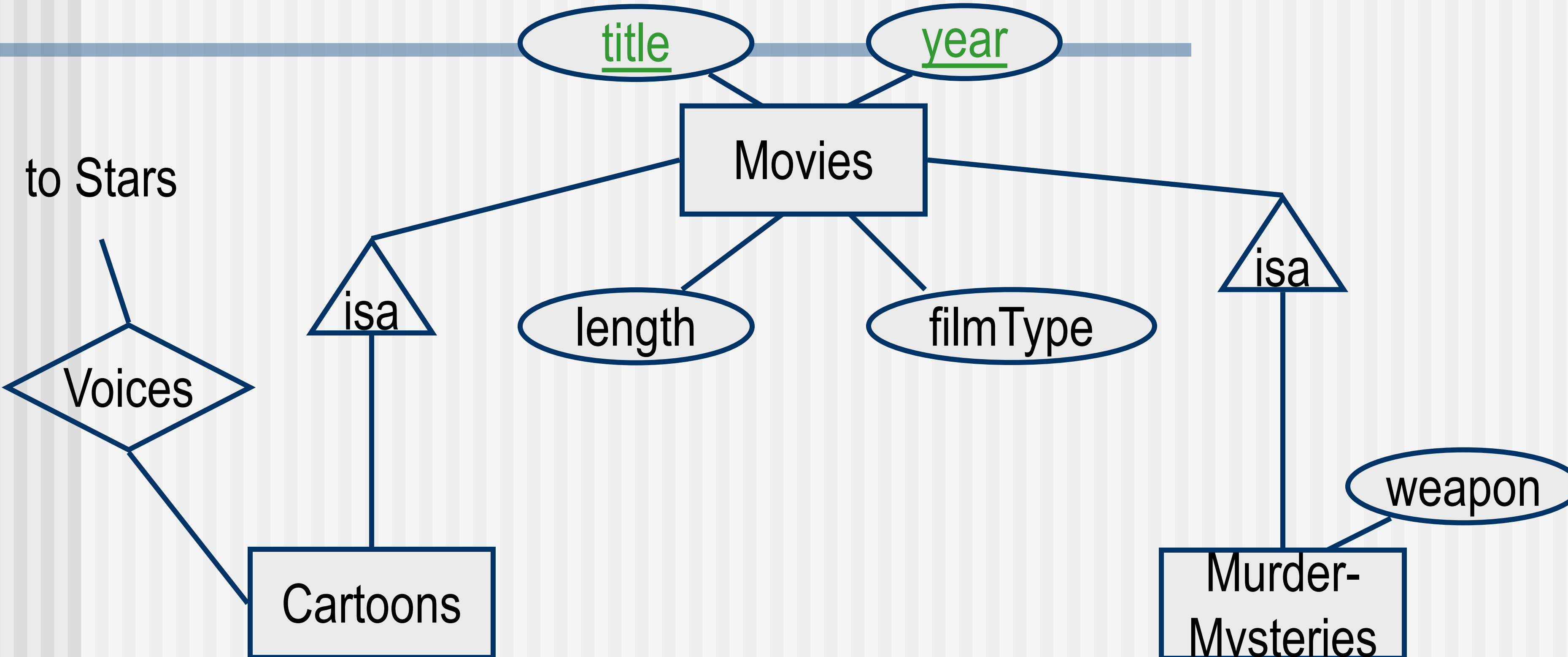
Students (<u>ID</u>, lastName, firstName, GPA, address)

GradStudents (<u>ID</u>, option)

UgradStudents (<u>ID</u>, major)

SupervisedBy (<u>StudentID, professorID</u>)

Isa-Hierarchy to Relations



Relation Schemas:

Movies (title, year, length, film Type)

Cartoons (title, year) 🡐 **Do we really need this?**

Murder-Mysteries (title, year, weapon)

Voices (starName, title, year)

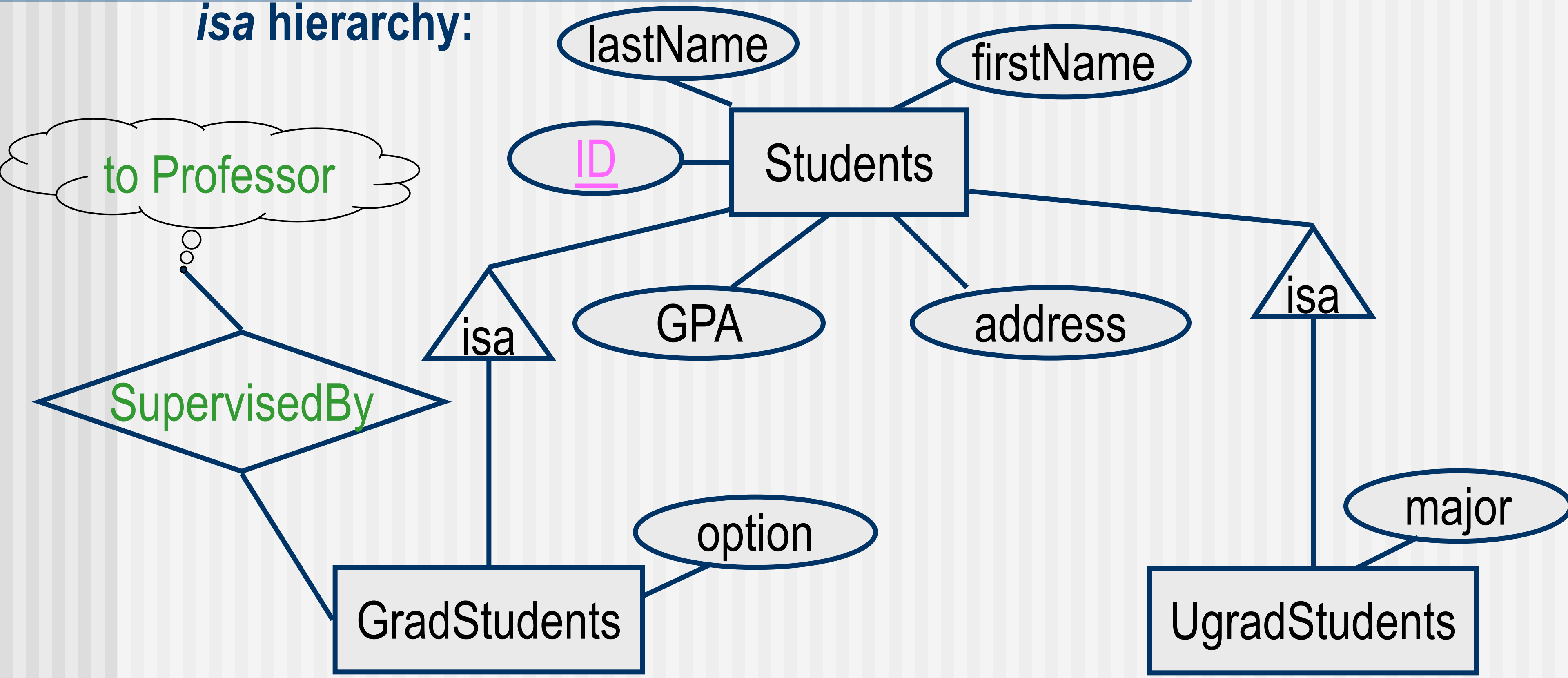
What about Cartoon-Murder-Mysteries?

The NULL Values Approach

- If we are **allowed** to use **NULL** as a value in tuples, we can handle a hierarchy of entity sets (classes) with a single relation
  - This relation has all the attributes belonging to any entity set (class) of the hierarchy.
  - An entity/object is represented by a single tuple that has NULL in each attribute that is not defined for that entity/object.

Converting isa Hierarchy to Relations: The Null Approach

***isa* hierarchy:**



Relation Schemas:

SupervisedBy (<u>ID</u>, <u>professorID</u>)

Student (<u>ID</u>, lastName, firstName, GPA, address, option, major)

NULL Approach

- The null approach**: supports efficient query processing but is inefficient in space utilization. Why?**
  - Answering queries: the nulls approach allows us to find, *in a **single** relation **R***, every tuple/object from any set involved in the hierarchy
  - Allows us to find **all** the information about **an entity**/**object** in a single tuple in **R**
  - The down side is its *space utilization which is too costly for having* repeated and redundant information:
  - **Note:** Nulls are not allowed in the relational model theory, but practically, it is supported by commercial DBMS

A quick test!

- Suppose R is a M-1 relationship from entity set E1={a1,a2} to E2={b1,b2}. Which of the following is NOT a ***valid instance*** of R?
  - R = {(a1, b1), (a1, b2)}.
  - R = {(a1, b1)}.
  - R = {(a2, b1)}.
  - R = {(a1, b1), (a2, b1)}.
  - R = { }