

COSC 304
Introduction to Database Systems

ER to Relational Mapping

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ER Model to Relational Schemas

These notes will describe how to convert an ER diagram (or EER diagram) into a corresponding relational schema.

Conceptual database design produces a conceptual ER model. This conceptual model is then converted into the relational model (which is a logical model).

Note that although it is possible to design using the relational model directly, it is normally more beneficial to perform conceptual design using the ER model first.

ER Model to Relational Schemas (2)

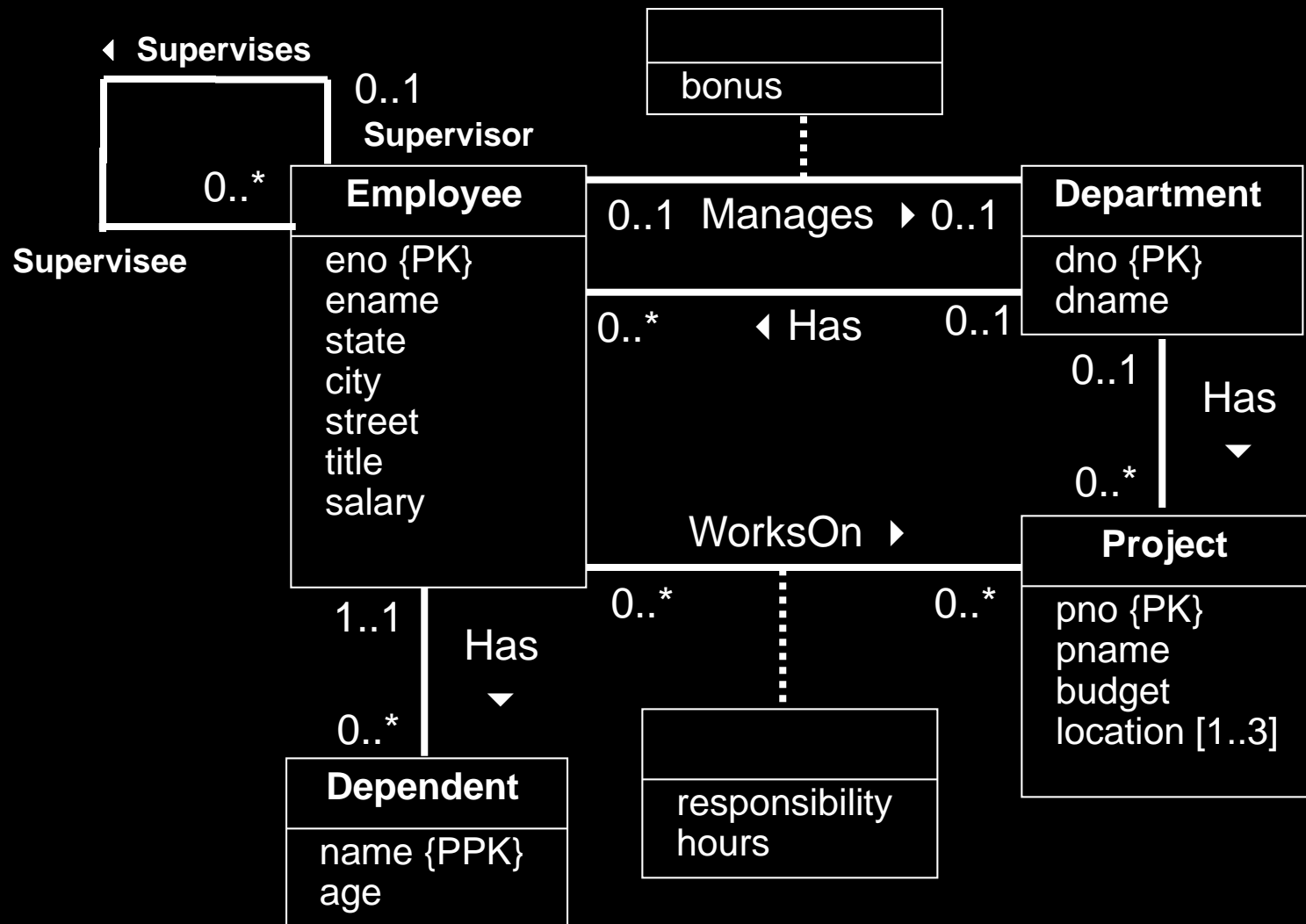
Converting an ER model to a relational database schema involves 7 steps.

In general, these steps convert entities to relations and ER relationships to relations. For 1:1 and 1:N relationships, foreign keys can be used instead of separate relations.

Handling subclasses and superclasses in the EER model requires an extra conversion step.

After conversion is performed, normalization and optimization are often performed to improve the relational schema.

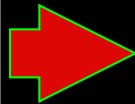
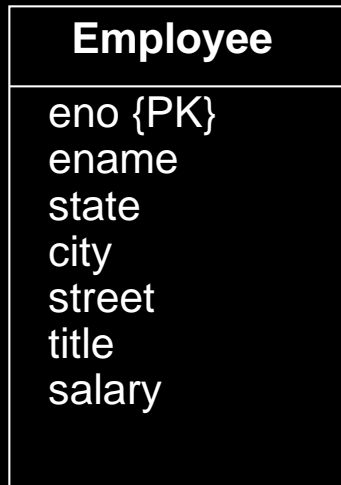
ER Model Example



ER to Relational Mapping

Step #1: Convert Strong Entities

Step #1: Convert each strong entity to a relation.



Employee (eno, ename, state, city, street, title, salary)

◆ Notes:

- ⇒ 1) Attributes of the entity type become attributes of the relation.
- ⇒ 2) Include only simple attributes in relation. For composite attributes, only create attributes in the relation for their simple components.
- ⇒ 3) Multi-valued attributes are handled separately (in step #6).
- ⇒ 4) The primary key of the relation is the key attributes for the entity.

ER to Relational Mapping

Current Relational Schema - Step #1

Employee (eno, ename, state, city, street, title, salary)

Project (pno, pname, budget)

Department (dno, dname)

ER to Relational Mapping

Step #2: Convert Weak Entities

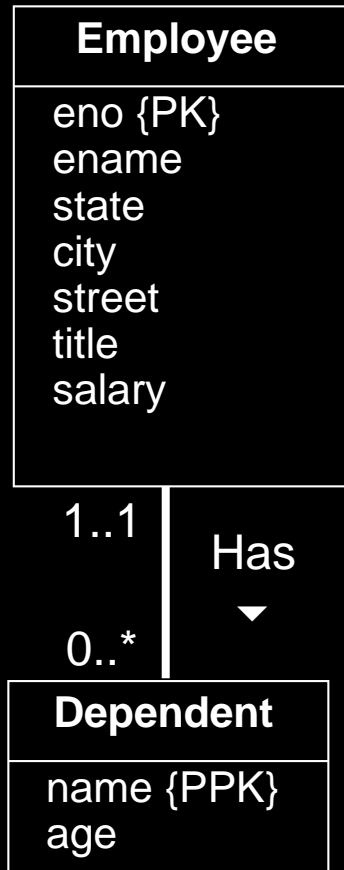
Step #2: Convert each weak entity into a relation with foreign keys to its identifying relations (entities).

For each weak entity W with identifying owners E_1, E_2, \dots, E_n create a relation R :

- ◆ Identify relations R_1, R_2, \dots, R_n for entity types E_1, E_2, \dots, E_n .
- ◆ The primary key of R consists of the primary keys of R_1, R_2, \dots, R_n plus the partial key of the weak entity.
- ◆ Create a foreign key in R to the primary key of each relation R_1, R_2, \dots, R_n .
- ◆ Attributes are converted the same as strong entities.

ER to Relational Mapping

Step #2: Convert Weak Entities (2)



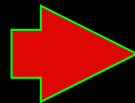
1..1

Has



0..*

Employee (eno, ename, state, city, street, title, salary)



Dependent (eno, name, age)

ER to Relational Mapping

Current Relational Schema - Step #2

Dependent (eno, name, age)



Employee (eno, ename, state, city, street, title, salary)

Project (pno, pname, budget)

Department (dno, dname)

ER to Relational Mapping

Steps #3-5: Convert Relationships

Steps 3 to 5 convert *binary* relationships of cardinality:

- ◆ 1:1 - Step #3
- ◆ 1:N - Step #4
- ◆ M:N - Step #5

Note that M:N relationships are the most general case, and the conversion algorithm for these relationships can be applied to 1:1 and 1:N as well.

- ◆ However, for performance reasons, it is normally more efficient to perform different conversions for each relationship type.
- ◆ In general, each ER relationship can be mapped to a relation. However, for 1:1 and 1:N relationships, it is more efficient to combine the relationship with an existing relation instead of creating a new one.

Relationships that are not binary are handled in step #7. Page 10

ER to Relational Mapping

Step #3: Convert 1:1 Relationships

Step #3: Convert binary 1:1 relationships into a `UNIQUE` foreign key reference from one relation to the other.

Given a binary 1:1 relationship R between two entities E_i and E_j :

- ◆ Identify the corresponding relations R_i and R_j .

- ◆ Chose one of the relations, say R_i , and:

 - ⇒ Add the attributes of R to R_i .

 - ⇒ Add the primary key attributes of R_j to R_i , and create a foreign key reference to R_j from R_i .

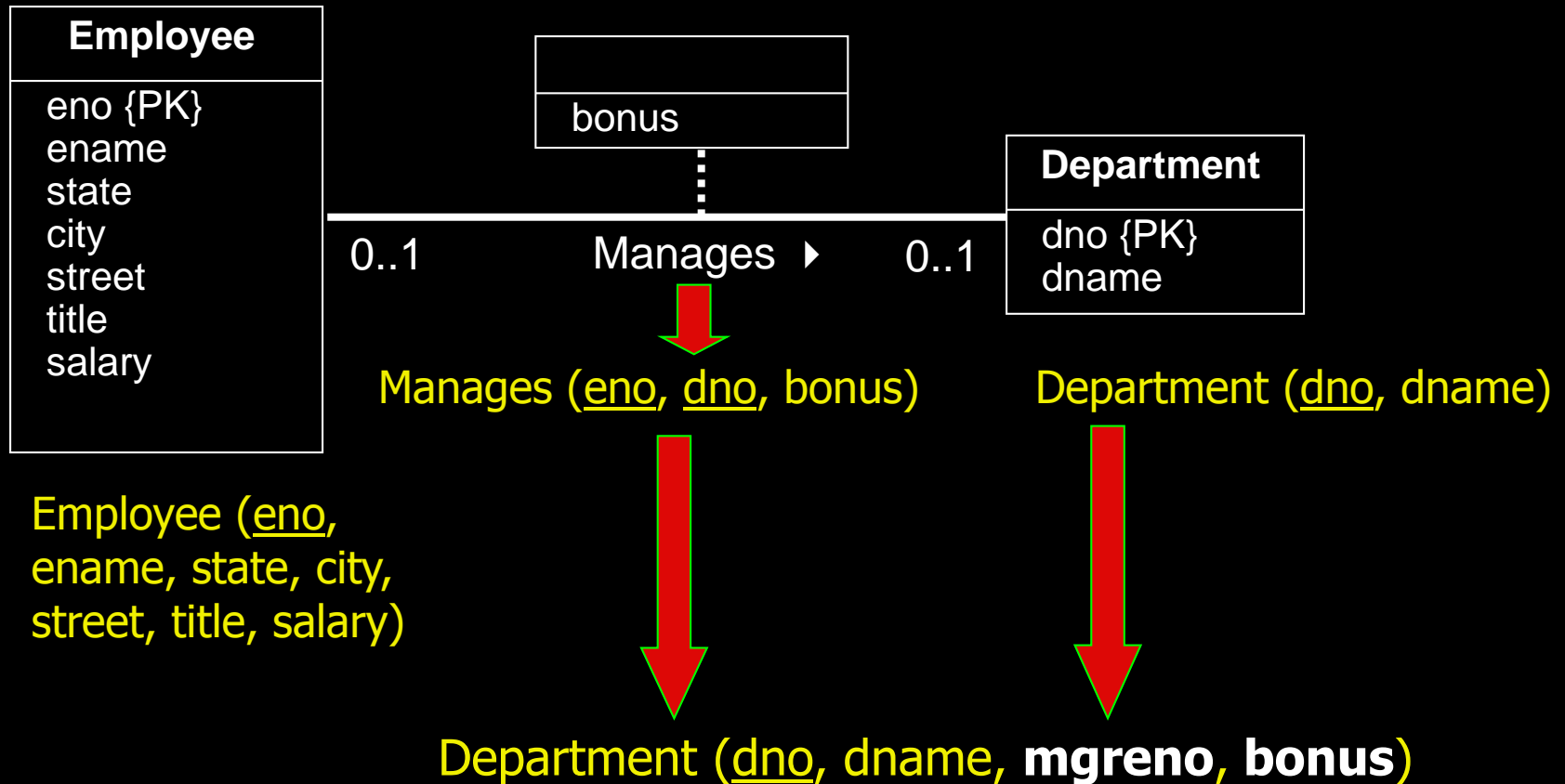
 - ⇒ Declare these primary key attributes of R_j to be `UNIQUE`.

- ◆ Notes:

 - ⇒ You can select either R_i or R_j . Typically, it is best to select the relation that is guaranteed to always participate in the relationship or the one that will participate the most in the relationship.

ER to Relational Mapping

Step #3: Convert 1:1 Relationships (2)



Note: Renamed eno to mgreno for clarity.

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Step #4: Convert 1:N Relationships

Step #4: Convert binary 1:N relationships between into a foreign key reference from the N-side relation to the 1-side relation.

Given a binary 1:N relationship R between two entities E_i and E_j :

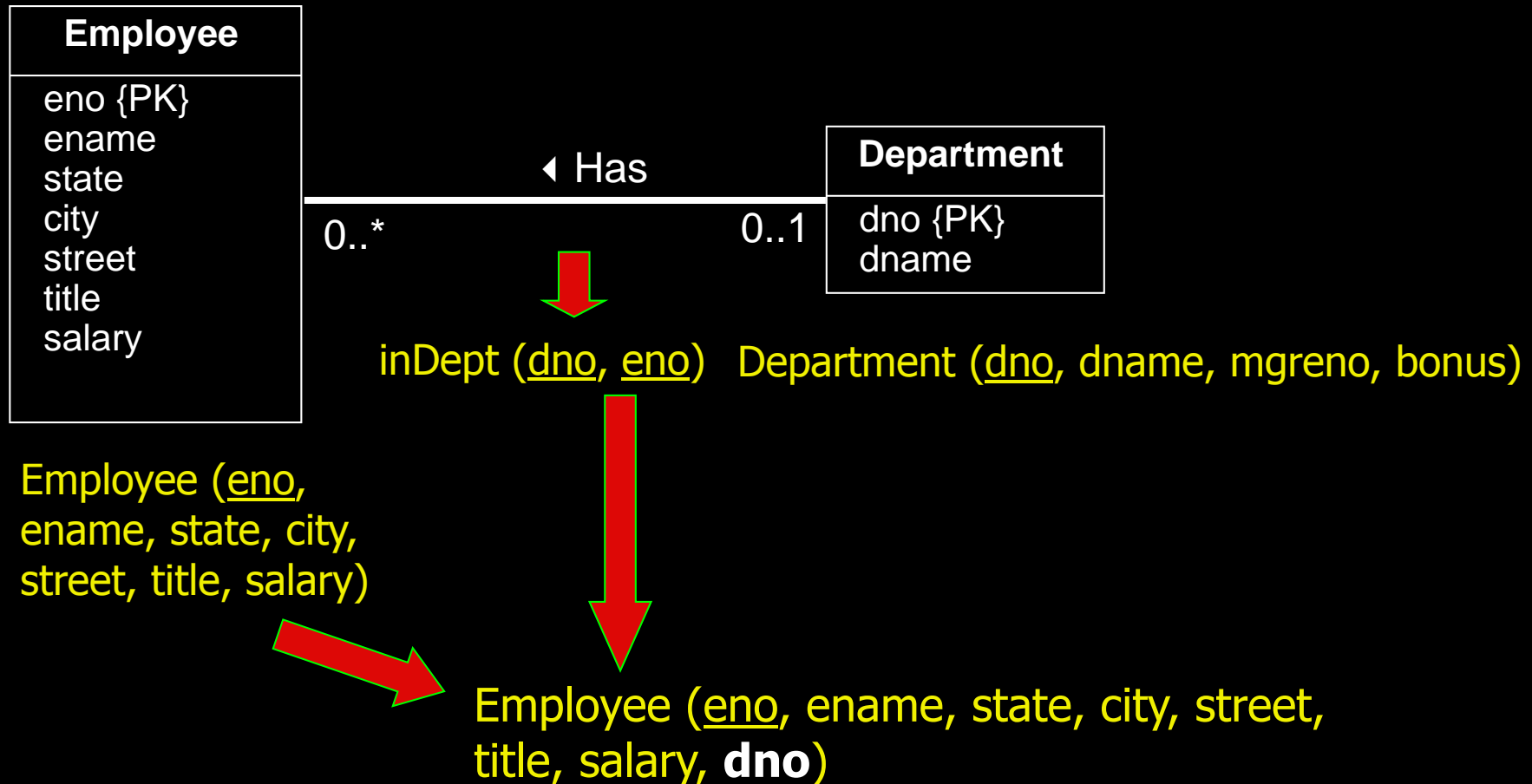
- ◆ Identify the corresponding relations R_i and R_j .
- ◆ Let R_i be the N-side of the relation.
 - ⇒ Add the attributes of R to R_i .
 - ⇒ Add the primary key attributes of R_j to R_i , and create a foreign key reference to R_j from R_i .

Notes:

- ◆ Unlike 1:1 relationships, you must select the N-side of the relationship as the relation containing the foreign key and relationship attributes.

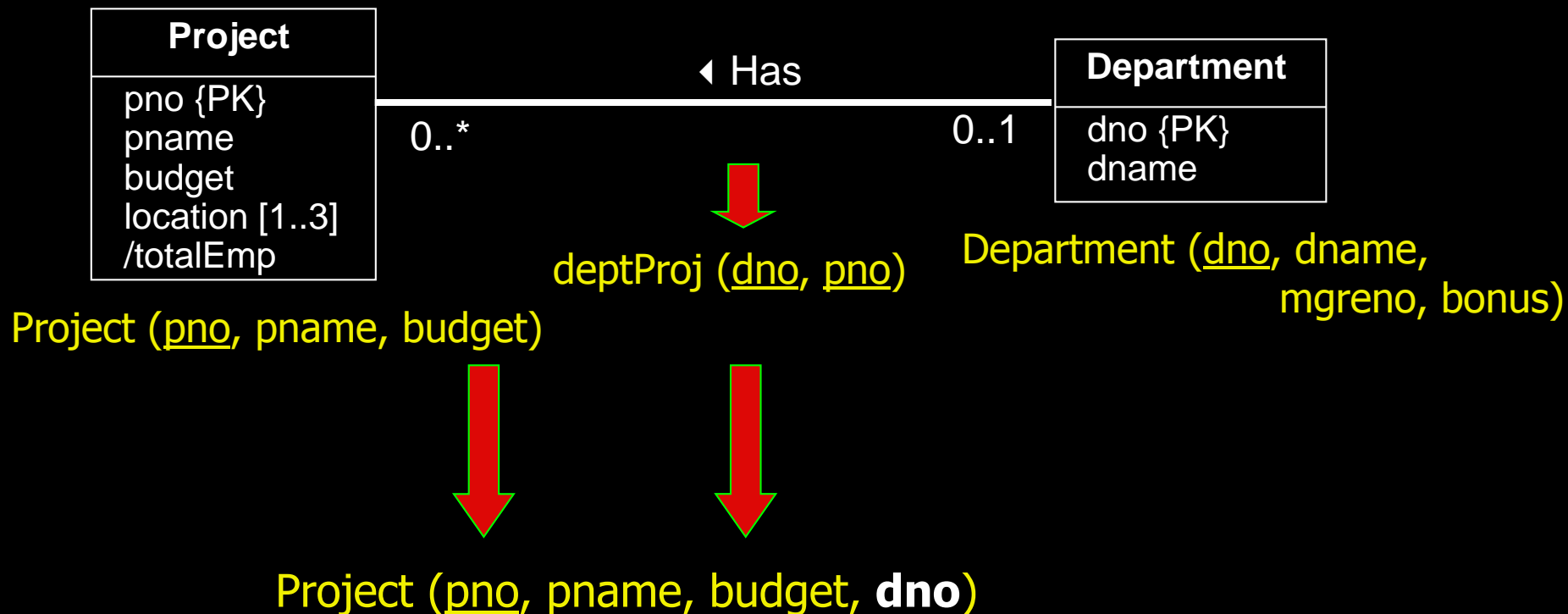
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Step #4: Convert 1:N Relationships



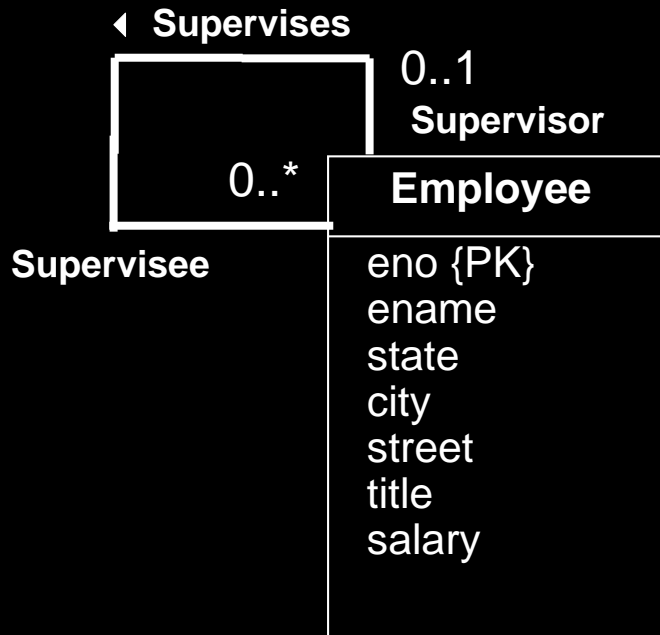
ER to Relational Mapping

Step #4: Convert 1:N Relationships



ER to Relational Mapping

Step #4: Convert 1:N Relationships



→ **Supervises** (supereno, eno)

Employee (eno, ename, state, city, street, title, salary, dno)



Employee (eno, ename, state, city, street, title, salary, dno, **supereno**)

ER to Relational Mapping

Current Relational Schema - Step #4

Dependent (eno, name, age)

Employee (eno, ename, state, city, street, title, salary, **dno**, **supereno**)

Project (pno, pname, budget, **dno**)

Department (dno, dname, **mgreno**, bonus)

ER to Relational Mapping

Step #5: Convert M:N Relationships

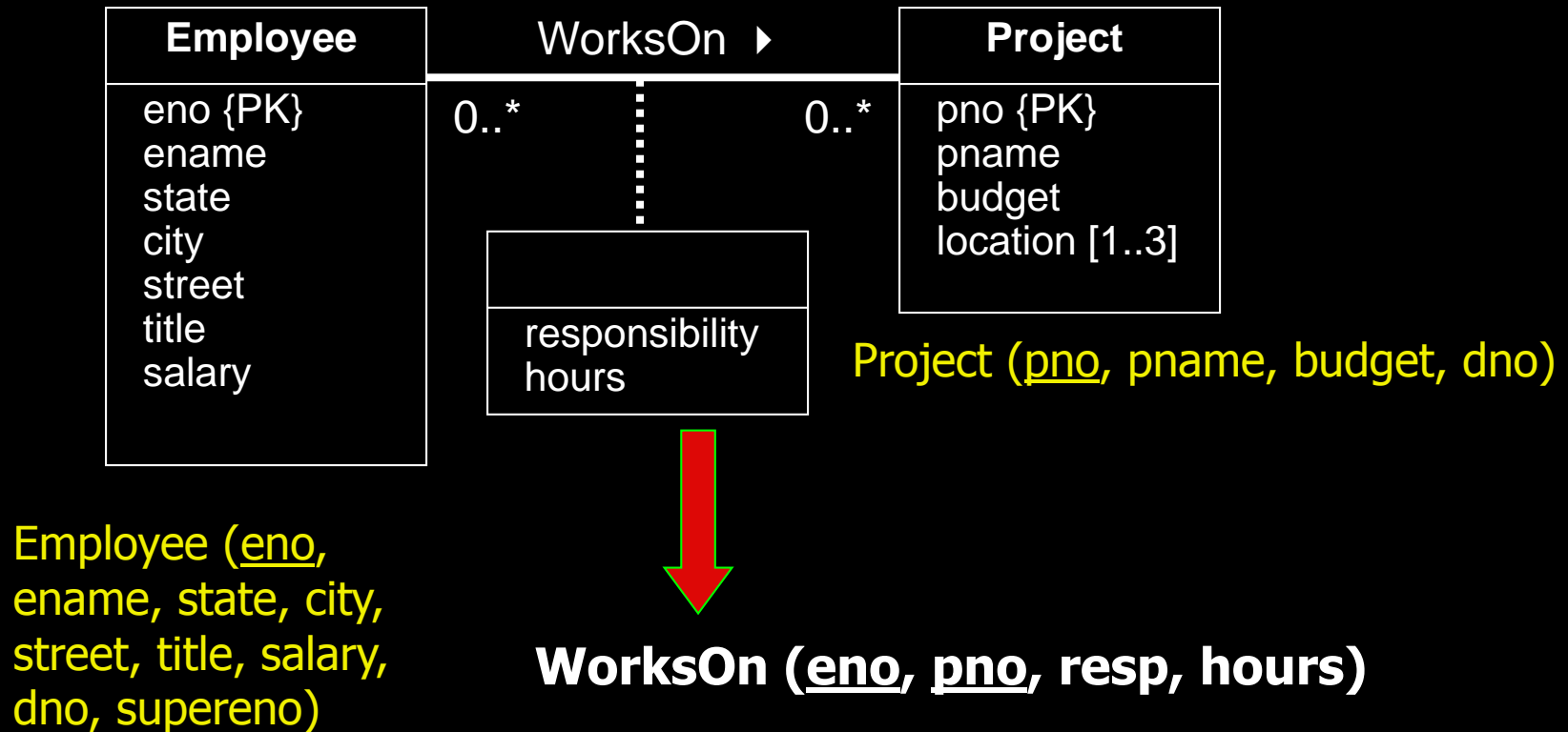
Step #5: Convert binary M:N relationships into a new relation with foreign keys to the two participating entities.

Given a binary M:N relationship between entities E_i and E_j :

- ◆ Identify the corresponding relations R_i and R_j .
- ◆ Create a new relation R representing the relationship where:
 - ⇒ R contains the relationship attributes.
 - ⇒ The primary key of R is a composite key consisting of the primary keys of R_i and R_j .
 - ⇒ Add the primary key attributes of R_i and R_j to R , and create a foreign key reference to R_i from R and to R_j from R .

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Step #5: Convert M:N Relationships



ER to Relational Mapping

Current Relational Schema - Step #5

Dependent (eno, name, age)

Employee (eno, ename, state, city, street, title, salary, dno, supereno)

WorksOn (eno, pno, resp, hours)

Project (pno, pname, budget, dno)

Department (dno, dname, mgreno, bonus)

ER to Relational Mapping

Step #6: Convert Multi-Valued Attributes

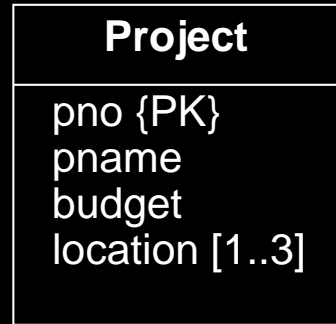
Step #6: Convert a multi-valued attribute into a relation with composite primary key consisting of the attribute value plus the primary key of the attribute's entity.

Given a multi-valued attribute A of entity E_i :

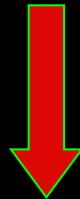
- ◆ Identify the corresponding relation R_i .
- ◆ Create a new relation R representing the attribute where:
 - ⇒ R contains the simple, single-valued attribute A .
 - ⇒ Add the primary key attributes of R_i to R , and create a foreign key reference to R_i from R .
 - ⇒ The primary key of R is a composite key consisting of the primary key of R_i and A .

ER to Relational Mapping

Step #6: Convert Multi-Valued Attributes



Project (pno, pname, budget, dno)



ProjectLocation (pno, location)

Project (pno, pname, budget, dno)

ER to Relational Mapping

Final Relational Schema

Dependent (eno, name, age)

Employee (eno, ename, state, city, street, title, salary, dno, supereno)

WorksOn (eno, pno, resp, hours)

Project (pno, pname, budget, dno)

ProjectLocation (pno, location)

Department (dno, dname, mgreno, bonus)

ER to Relational Mapping

Step #7: Convert n -ary Relationships

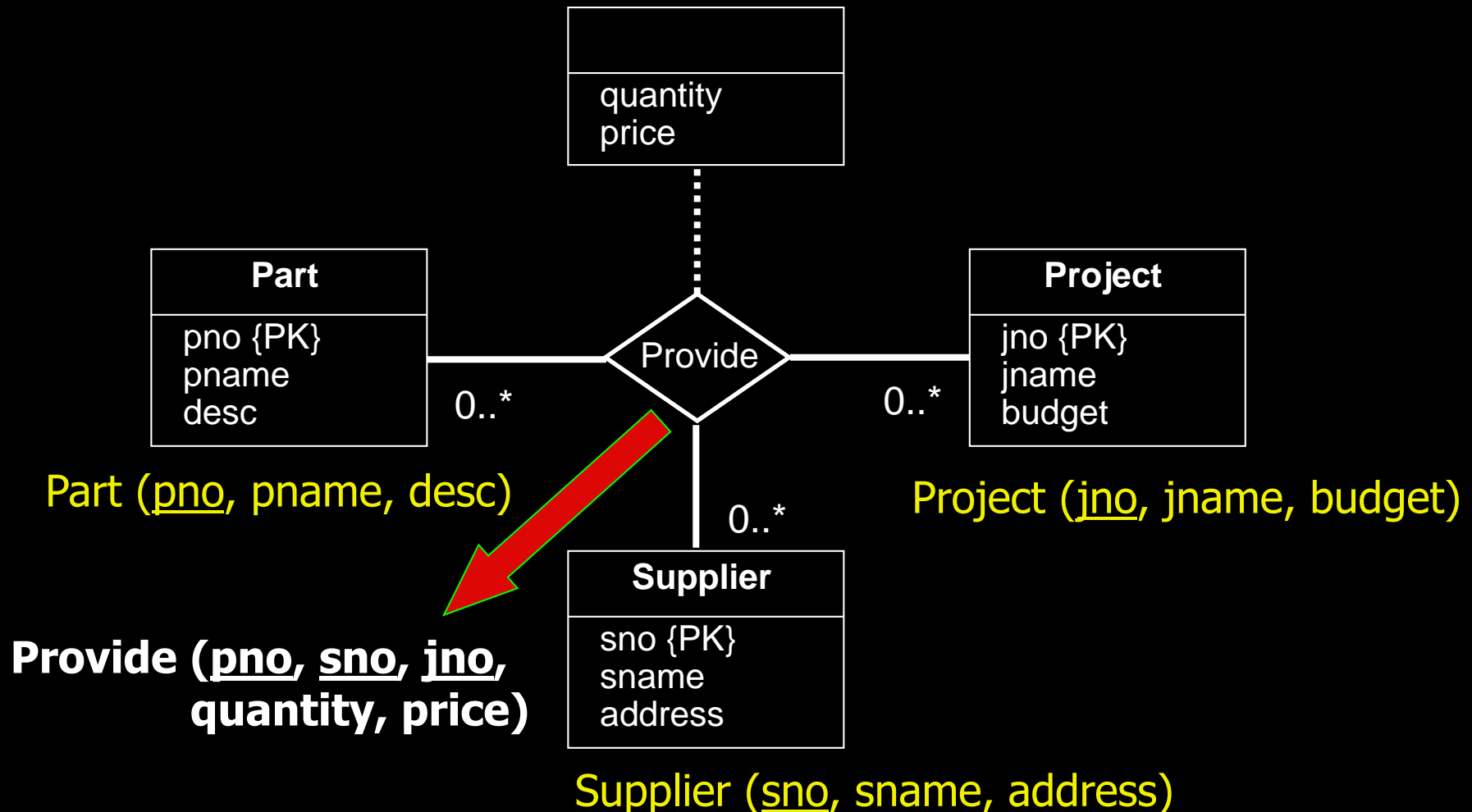
Step #7: Convert n -ary relationships by creating a new relation to represent the relationship and creating foreign keys that reference the related entities.

Given an n -ary relationship between entities E_1, E_2, \dots, E_n :

- ◆ Identify relations R_1, R_2, \dots, R_n for entity types E_1, E_2, \dots, E_n .
- ◆ Create a new relation R to represent the relationship.
- ◆ The primary key of R consists of the primary keys of R_1, R_2, \dots, R_n .
- ◆ Create a foreign key in R to the primary key of each relation R_1, R_2, \dots, R_n .
- ◆ Attributes of the relationship become attributes of R .

ER to Relational Mapping

Step #7: Convert *n*-ary Relationships



EER to Relational Mapping

An additional step is necessary to convert subclasses and superclasses to the relational model.

We have several different approaches:

- ◆ **1) Create a separate relation for each superclass and subclass.**
 - ⇒ Most general technique that we will use.
- ◆ **2) Create relations for subclass only.**
 - ⇒ Only works if superclass has mandatory participation.
- ◆ **3) Create a single relation with one type attribute.**
 - ⇒ Attribute is used to indicate the type of object (subclass) in the row.
 - ⇒ Works only if the subclasses are disjoint.
- ◆ **4) Create a single relation with multiple type attributes.**
 - ⇒ Have a boolean valued attribute for each subclass. True if in subclass.
 - ⇒ Works if subclasses may be overlapping.

ER to Relational Mapping

Step #8: Convert Subclasses

Step #8: Convert subclasses and superclasses by creating a relation for each subclass and superclass. Link the subclasses to the superclass using foreign key references.

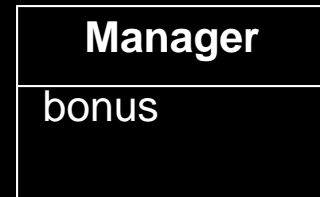
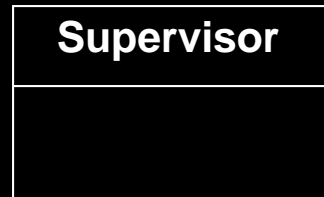
Given a superclass C and set of subclasses S_1, S_2, \dots, S_n :

- ◆ Create a relation R for C .
- ◆ The primary key for R is the primary key of the superclass.
- ◆ Create relations R_1, R_2, \dots, R_n for subclasses S_1, S_2, \dots, S_n .
- ◆ The primary key for each R_i is the primary key of the superclass.
- ◆ For each R_i , create a foreign key to R using the primary key attributes.

ER to Relational Mapping

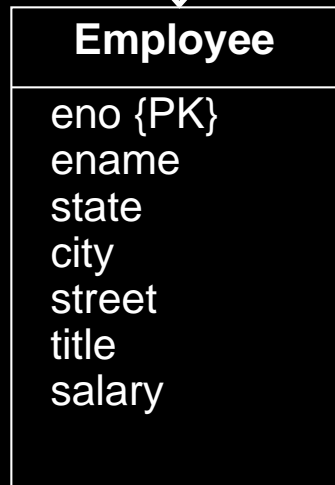
Step #8: Convert Subclasses

Supervisor (eno)



Manager (eno, bonus)

{Optional, AND}



Employee (eno, ename, state, city, street, title, salary, supereno)

Summary of *ER to Relational Mapping*

ER Model

Entity Type

1:1 or 1:N Relationship Type

M:N Relationship Type

n -ary Relationship Type

Simple attribute

Composite attribute

Multi-valued attribute

Key attribute

Relational Model

Relation

Foreign key (from N-side to 1-side)

"Relationship" relation and 2 foreign keys

"Relationship" relation and n foreign keys

Attribute

Set of simple component attributes

Relation and foreign key

Primary key attribute

ER to Relational Mapping Question

Question: How many of the following statements are **true**?

- 1)** The M:N relationship mapping rule could be applied to 1:1 and 1:N relationships, as it is more general.
- 2)** A weak entity will always have primary key attributes from the identifying entity.
- 3)** The designer has a choice on which side to put the foreign key when mapping a 1:N relationship.
- 4)** When mapping a multi-value attribute, the new table containing the multi-value attribute will have a composite key.

A) 0

B) 1

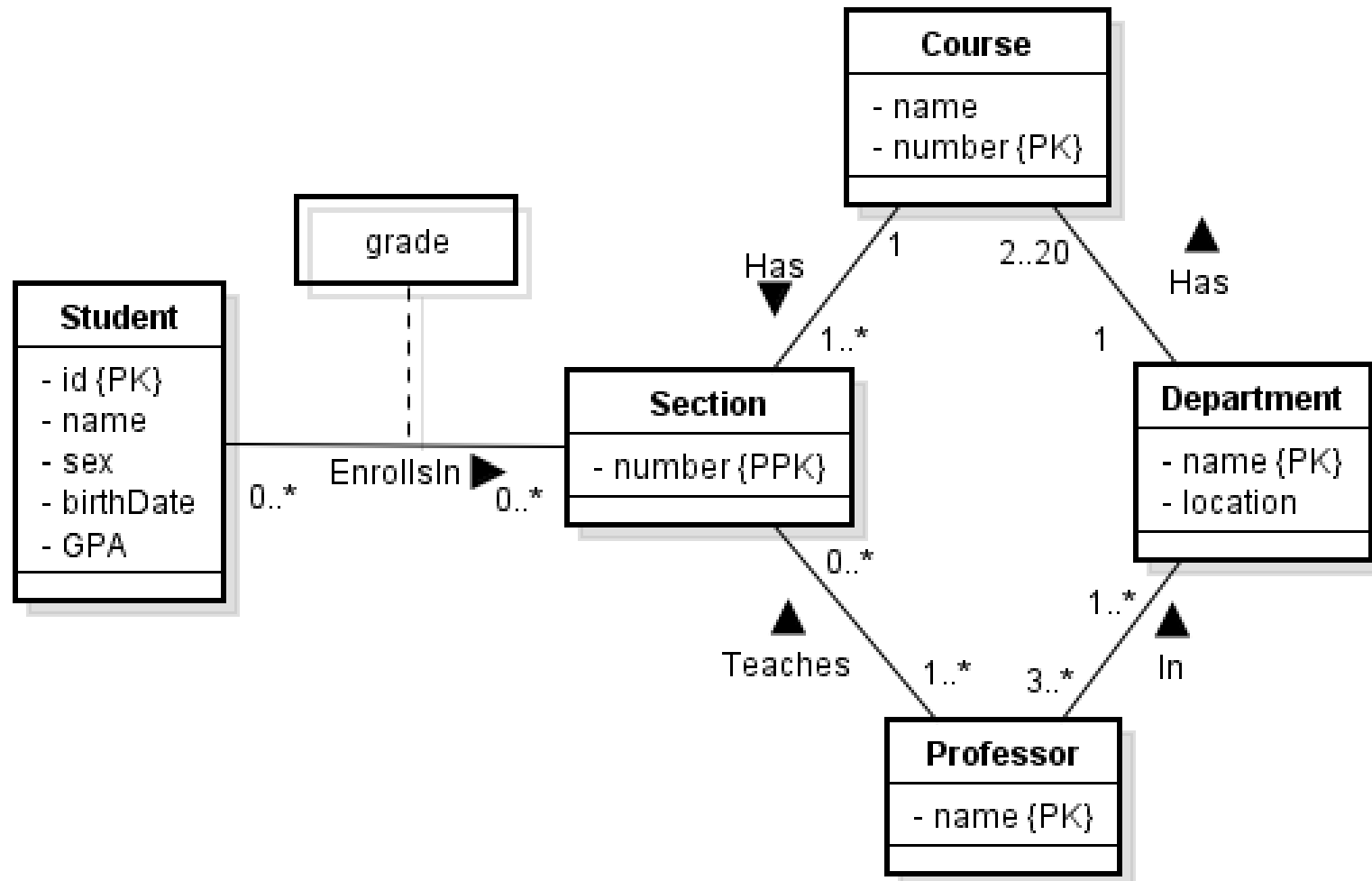
C) 2

D) 3

E) 4

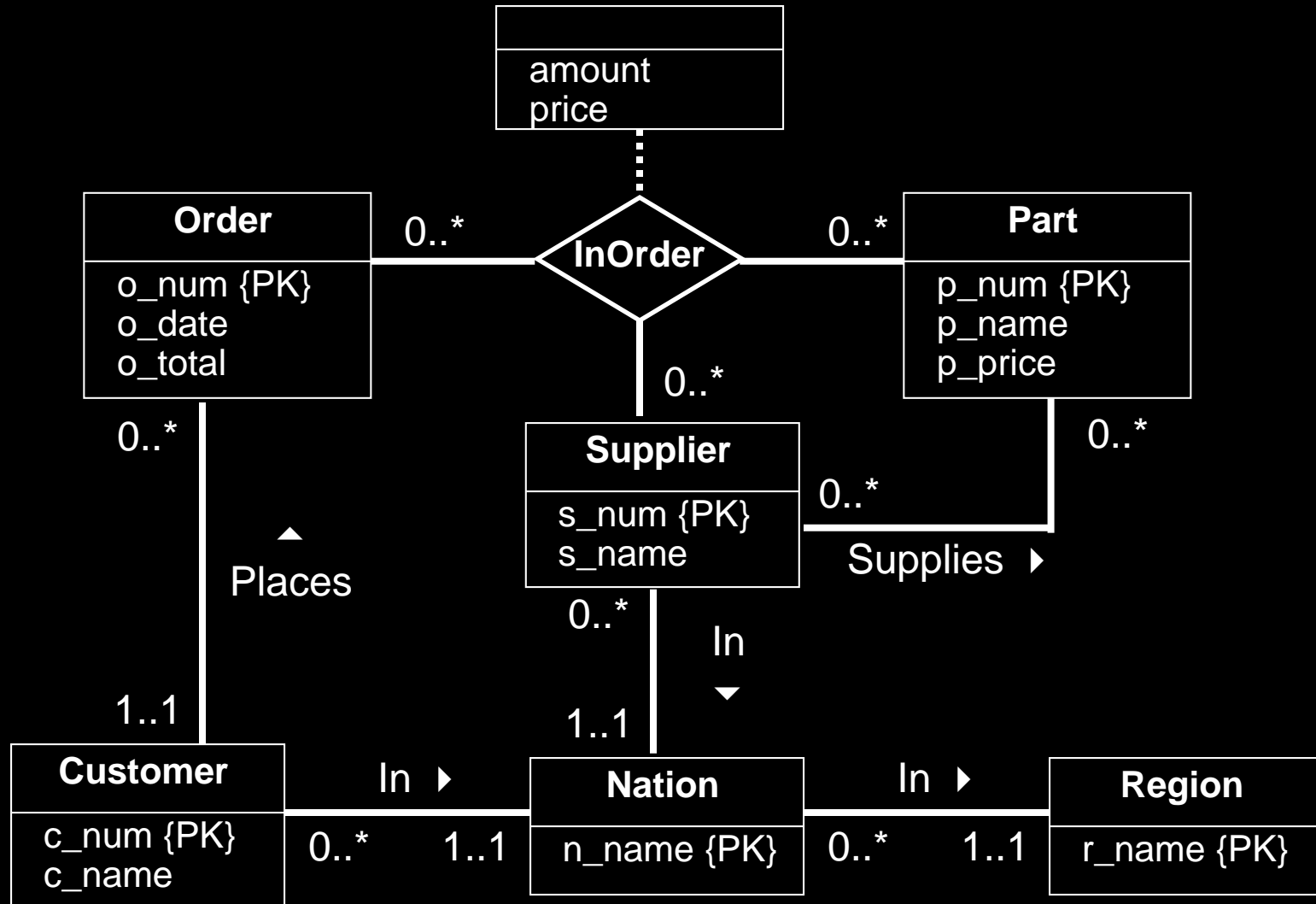
ER to Relational Mapping

University Question



ER to Relational Mapping

TPC-H Standard Question



Conclusion

There is a straightforward algorithm for converting ER models to relational schemas.

The algorithm involves 7 steps for converting regular ER models, and 8 steps for converting EER models.

In general, these steps convert entities to relations and ER relationships to relations. For 1:1 and 1:N relationships, foreign keys can be used instead of separate relations.



Objectives

Given an ER/EER diagram, be able to convert it into a relational schema using the seven/eight steps.

Be able to discuss the different ways of converting subclasses/superclasses into relational schemas.