

**COSC 304**

***Introduction to Database Systems  
Enhanced Entity-Relationship (EER)  
Modeling***

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# ***Enhanced Entity-Relationship Modeling***

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**Enhanced Entity-Relationship (EER) modeling** is an extension of ER modeling to include object-oriented concepts such as:

- ◆ superclasses and subclasses
- ◆ specialization and generalization
- ◆ aggregation and composition

These modeling constructs may allow more precise modeling of systems that are object-oriented in nature such as:

- ◆ CAD/CAM systems (Computer-Aided Design/Manufacturing)
- ◆ GIS (Geographical Information Systems)

# ***Review: Superclasses and Subclasses***

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The object-oriented ideas of inheritance and superclasses and subclasses are taught during programming in an OO language such as Java.

A **superclass** is a general class that is extended by one or more subclasses.

A **subclass** is a more specific class that extends a superclass by inheriting its methods and attributes and then adding its own methods and attributes.

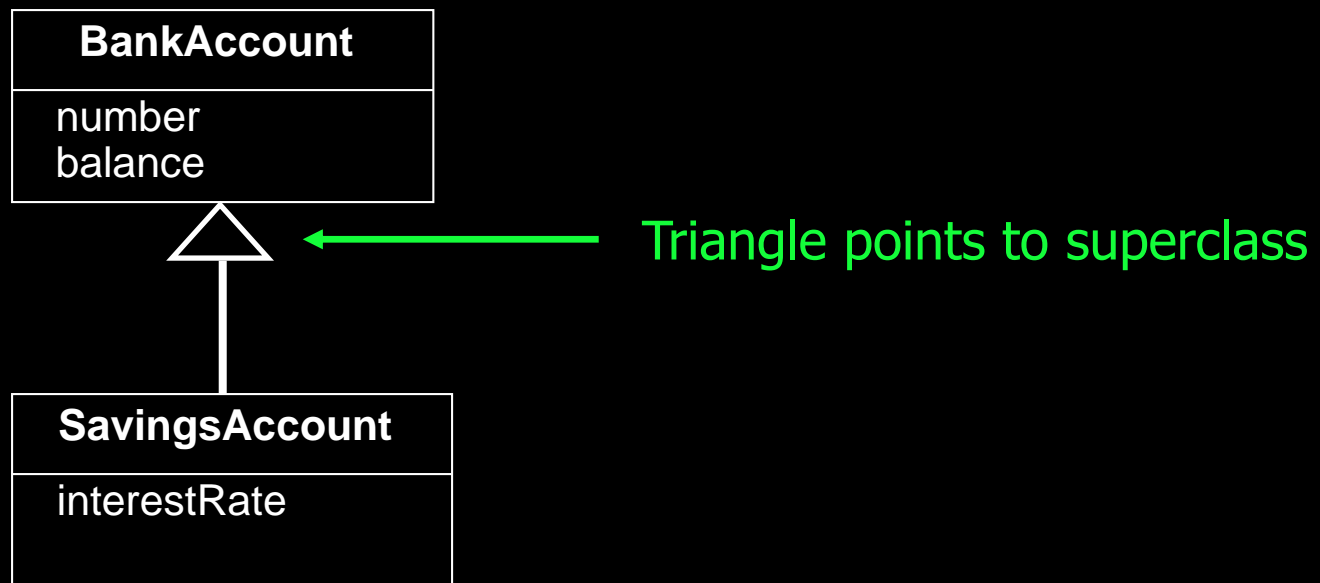
**Inheritance** is the process of a subclass inheriting all the methods and attributes of a superclass.

# ***Superclasses and Subclasses Example***

Java code:

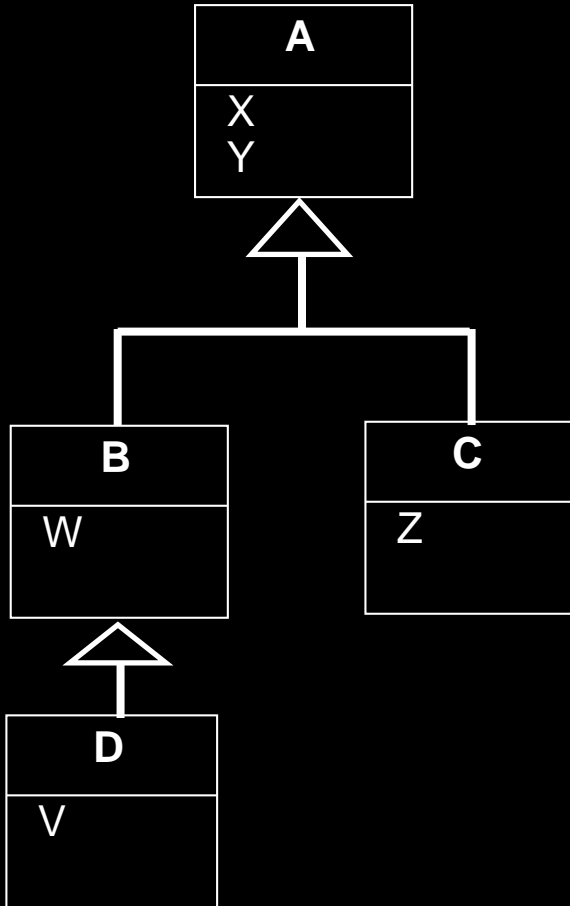
```
public class SavingsAccount extends BankAccount
```

UML class diagram:



# Superclasses and Subclasses Question

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



- 1) D is a superclass.
- 2) D has 1 attribute.
- 3) B and C are subclasses of A.
- 4) B inherits V from D.
- 5) D inherits attribute X.

**A) 0**

**B) 1**

**C) 2**

**D) 3**

**E) 4**

# ***When to use EER Modeling?***

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It is important to emphasize that many database projects do not need the object-oriented modeling features of EER modeling.

Remember the goal of conceptual modeling is to produce a model that is simple and easy to understand.

Do not introduce complicated subclass/superclass relationships if they are not needed.

Only use the EER modeling constructs if they offer a *significant advantage* over regular ER modeling.

# When to use EER Modeling? (2)

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EER modeling is especially useful when the domain being modeled is object-oriented in nature and the use of inheritance reduces the complexity of the design.

There are two common cases where EER modeling is useful instead of basic ER modeling:

- ◆ 1) When using *attribute inheritance* can reduce the use of nulls in a single entity relation (that contains multiple subclasses).
- ◆ 2) Subclasses can be used to explicitly model and name subsets of entity types that participate in their own relationships.

# When to use EER Modeling? Using Attribute Inheritance

## Emp Relation

<u>eno</u>	ename	bdate	title	salary	supereno	dno
E1	J. Doe	01-05-75	EE	30000	E2	null
E2	M. Smith	06-04-66	SA	50000	E5	D3
E3	A. Lee	07-05-66	ME	40000	E7	D2
E4	J. Miller	09-01-50	PR	20000	E6	D3
E5	B. Casey	12-25-71	SA	50000	E8	D3
E6	L. Chu	11-30-65	EE	30000	E7	D2
E7	R. Davis	09-08-77	ME	40000	E8	D1
E8	J. Jones	10-11-72	SA	50000	null	D1

Note that the `title` attribute indicates what job the employee does at the company. Consider if each job title had its own unique information that we would want to record such as:

- ◆ EE, PR - programming language used (`lang`), DB used (`db`)
- ◆ SA, ME - MBA? (`MBA`), `bonus`



# When to use EER Modeling?

## Using Attribute Inheritance (2)

We could represent all these attributes in a single relation:

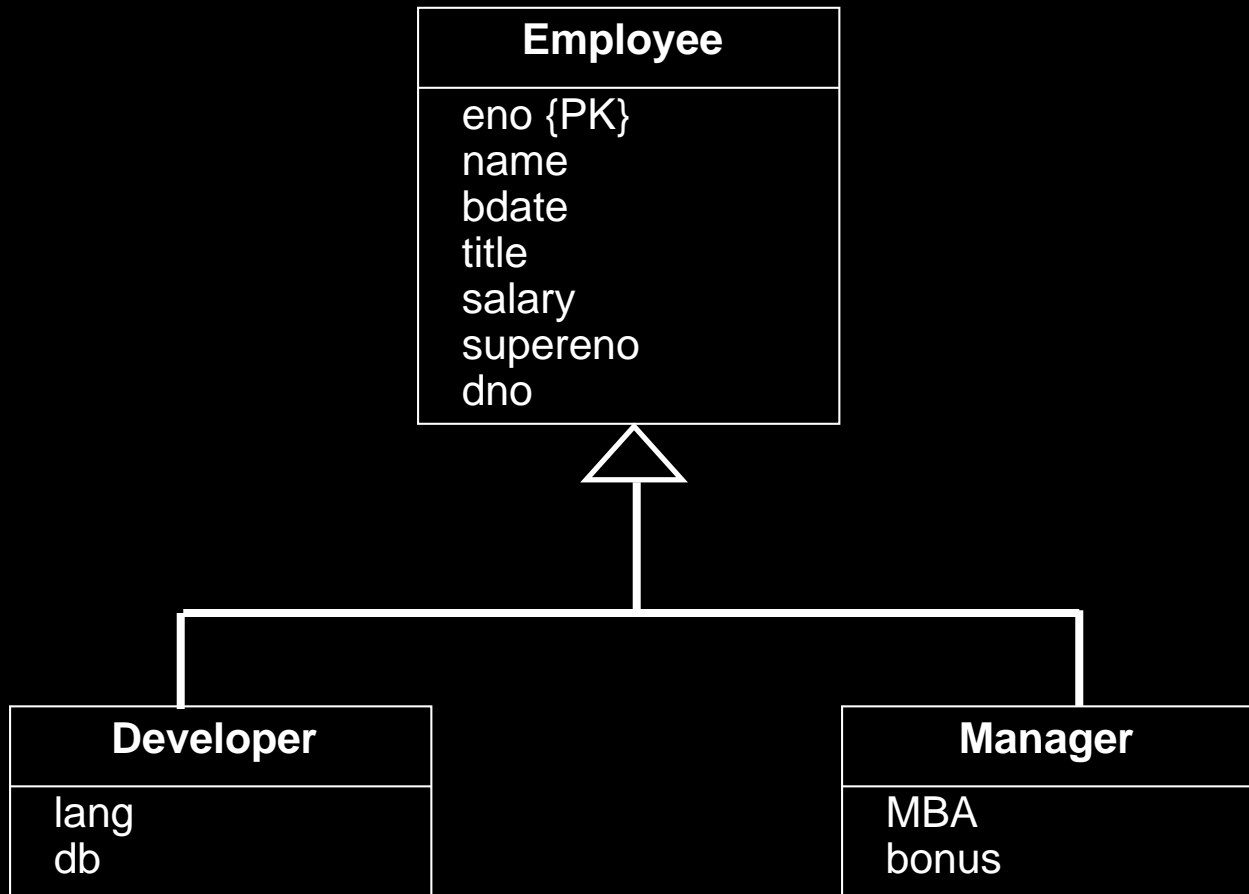
<u>eno</u>	ename	bdate	title	salary	supereno	dno	lang	db	MBA	bonus
E1	J. Doe	01-05-75	EE	30000	E2		C++	MySQL		
E2	M. Smith	06-04-66	SA	50000	E5	D3			N	2000
E3	A. Lee	07-05-66	ME	40000	E7	D2			N	3000
E4	J. Miller	09-01-50	PR	20000	E6	D3	Java	Oracle		
E5	B. Casey	12-25-71	SA	50000	E8	D3			Y	4000
E6	L. Chu	11-30-65	EE	30000	E7	D2	C++	DB2		
E7	R. Davis	09-08-77	ME	40000	E8	D1			N	3000
E8	J. Jones	10-11-72	SA	50000		D1			Y	6000

Note the wasted space as attributes that do not apply to a particular subclass are NULL.

# When to use EER Modeling?

## Using Attribute Inheritance (3)

A better solution would be to make two subclasses of Employee called Developer and Manager:



# When to use EER Modeling?

## Using Attribute Inheritance (4)

Resulting relations:

### Employee Relation

<u>eno</u>	ename	bdate	title	salary	supereno	dno
E1	J. Doe	01-05-75	EE	30000	E2	null
E2	M. Smith	06-04-66	SA	50000	E5	D3
E3	A. Lee	07-05-66	ME	40000	E7	D2
E4	J. Miller	09-01-50	PR	20000	E6	D3
E5	B. Casey	12-25-71	SA	50000	E8	D3
E6	L. Chu	11-30-65	EE	30000	E7	D2
E7	R. Davis	09-08-77	ME	40000	E8	D1
E8	J. Jones	10-11-72	SA	50000	null	D1

### Developer Relation

<u>eno</u>	lang	db
E1	C++	MySQL
E4	Java	Oracle
E6	C++	DB2

### Manager Relation

<u>eno</u>	MBA	bonus
E2	N	2000
E3	N	3000
E5	Y	4000
E7	N	3000
E8	Y	6000

# ***Generalization and Specialization***

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Subclasses and superclasses are created by using either generalization or specialization.

**Specialization** is the process of creating more specialized subclasses of an existing superclass.

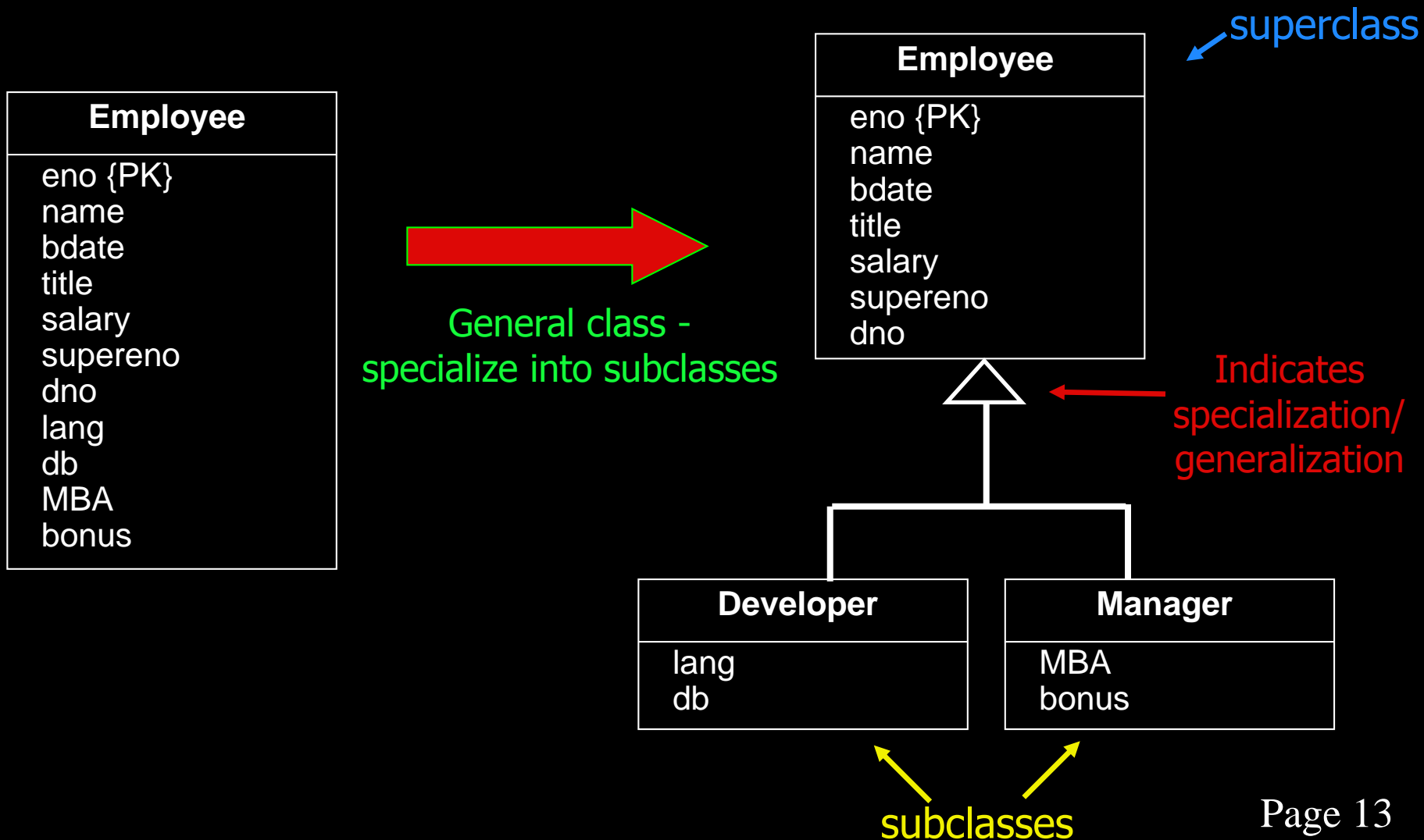
- ◆ **Top-down process: Start with a general class and then subdivide it into more specialized classes.**

- ⇒ The specialized classes may contain their own attributes. Attributes common to all subclasses remain in the superclass.

**Generalization** is the process of creating a more general superclass from existing subclasses.

- ◆ **Bottom-up process: Start with specialized classes and try to determine a general class that contains the attributes common to all of them.**

# Specialization Example

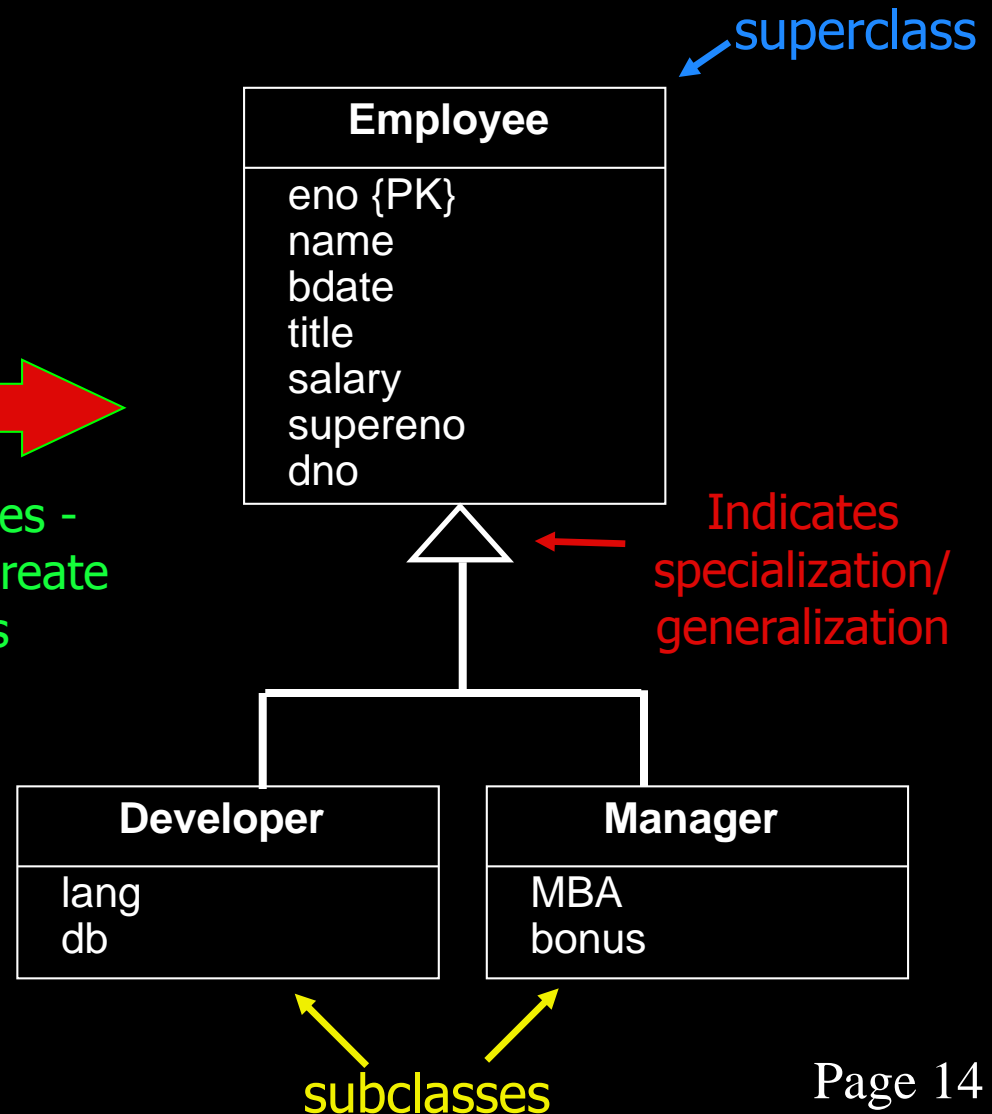


# Generalization Example

Developer
number {PK}
developerName
birthDate
title
salary
supereno
dno
lang
db

Manager
eno {PK}
name
birthDate
title
salary
supereno
dno
MBA
bonus

Specific classes -  
generalize to create  
superclass



# Constraints on Generalization and Specialization

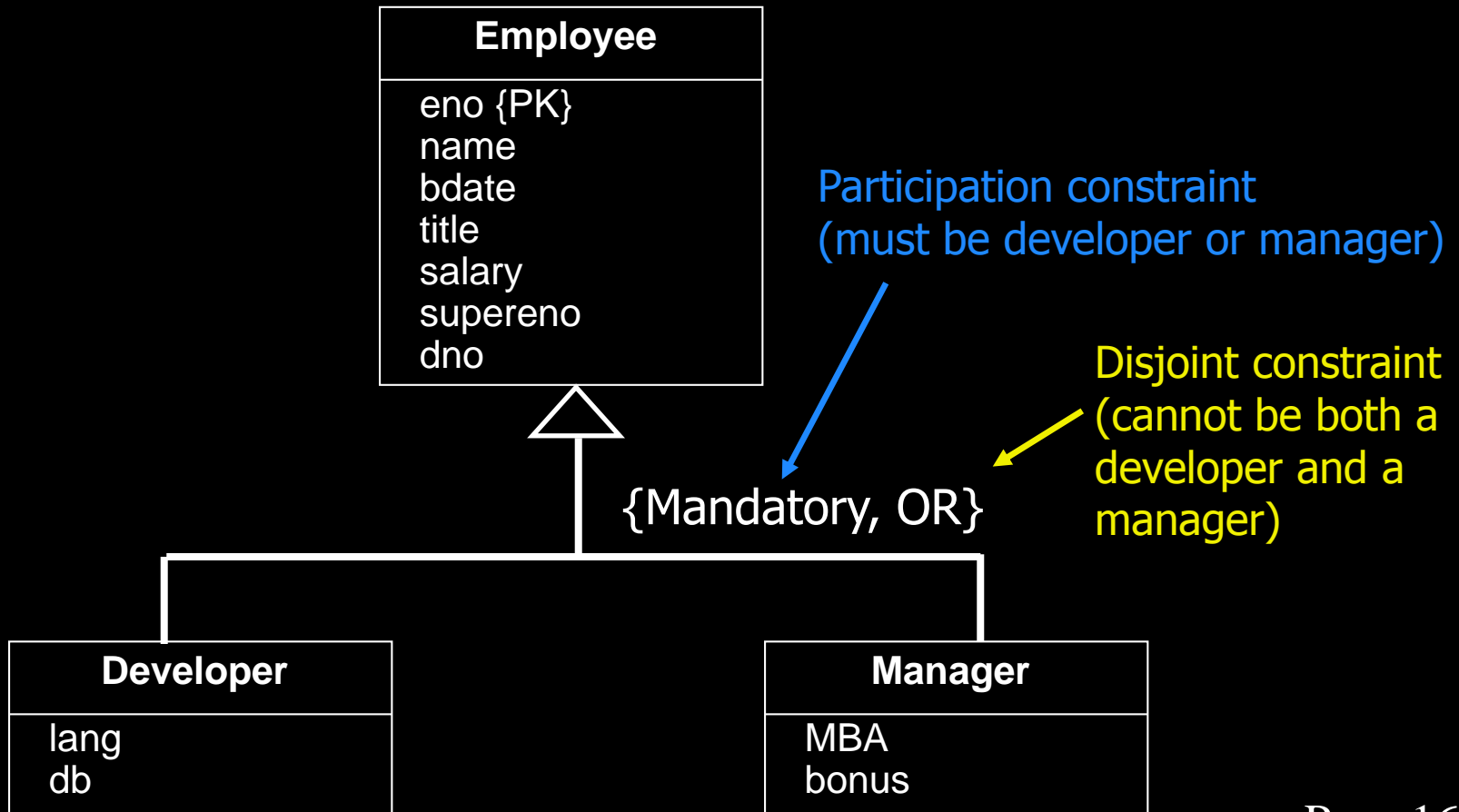


There are two types of constraints associated with generalization and specialization:

- ◆ **Participation constraint** - determines if every member in a superclass must participate as a member of one of its subclasses.
  - ⇒ It may be `optional` for a superclass member to be a member of one of its subclasses, or it may be `mandatory` that a superclass member be a member of one of its subclasses.
- ◆ **Disjoint constraint** - determines if a member of a superclass can be a member of one or more than one of its subclasses.
  - ⇒ If a superclass object may be a member of only one of its subclasses this is denoted by `OR` (subclasses are *disjoint*).
  - ⇒ Otherwise, `AND` is used to indicate that it may be in more than one of its subclasses.

# Constraints Example

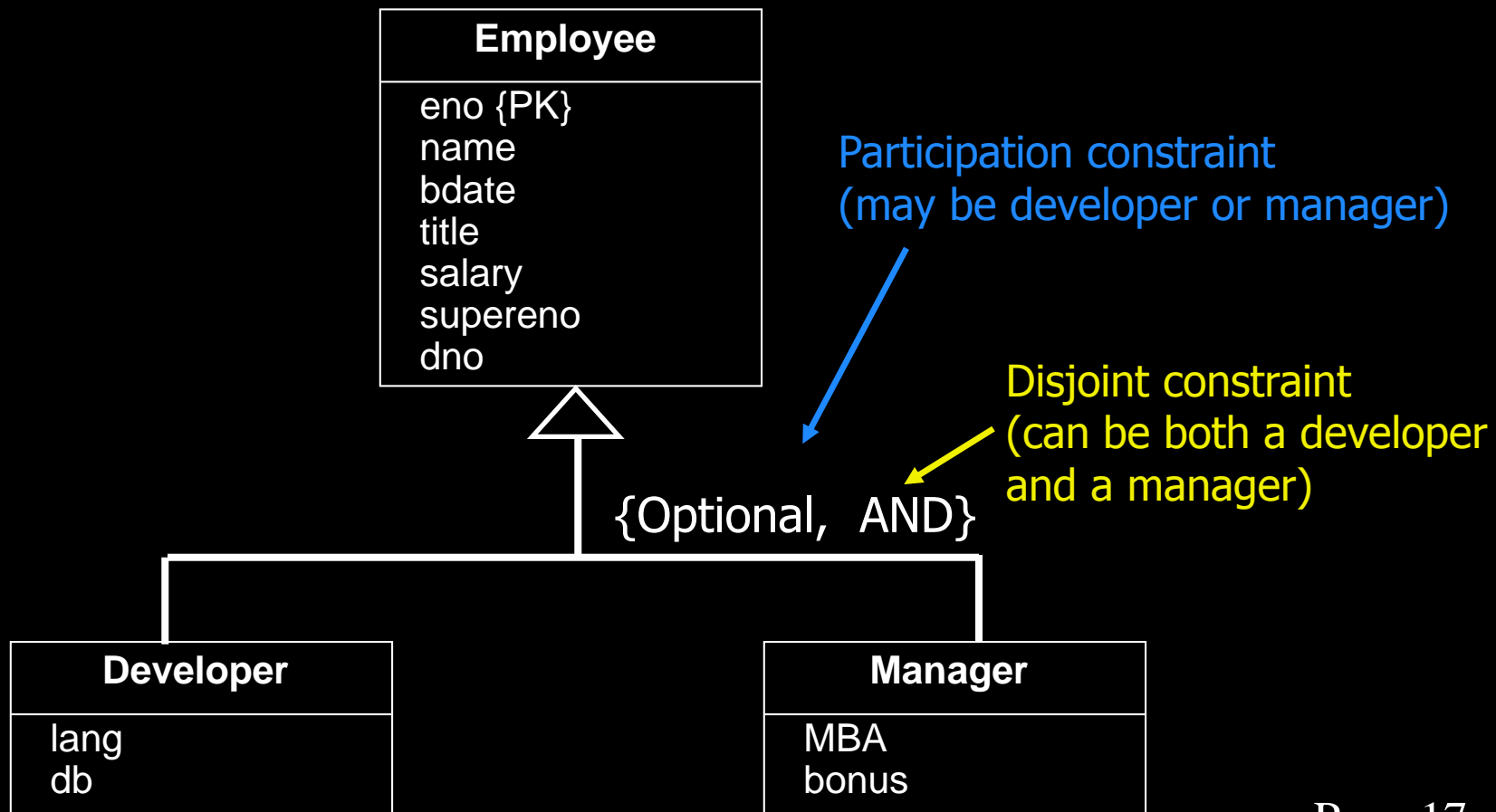
An employee must be either a developer or a manager, but cannot be both.





# Constraints Example (2)

An employee may specialize as a developer or manager. An employee may be both a manager and developer.



# General Predicate Constraints

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**Predicate-defined constraints** specify when an object participates in a subclass using a certain rule.

- ◆ For example, a subclass called `RichEmployees` can be defined with a membership predicate such as `salary > 100000`.

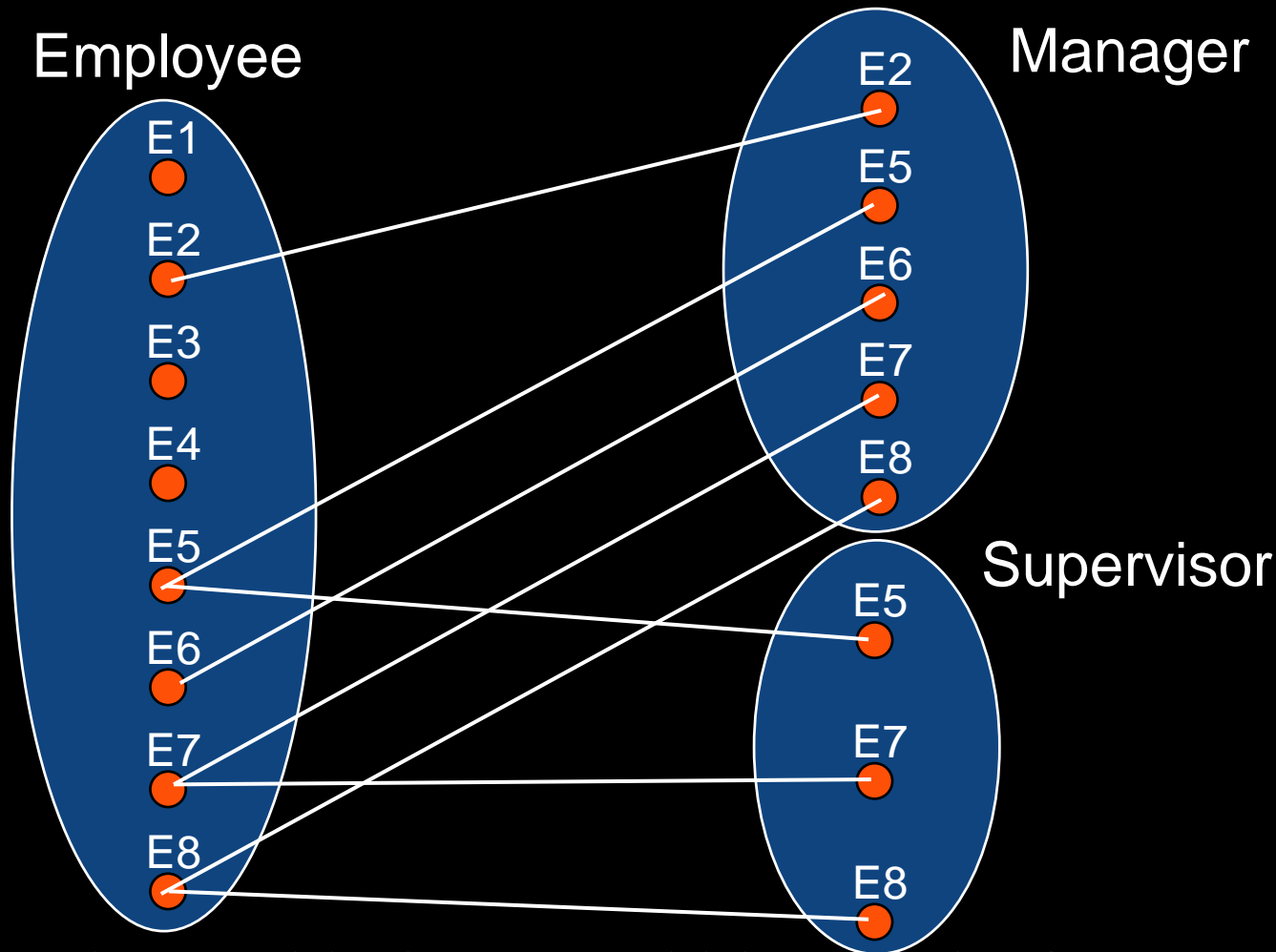
**Attribute-defined subclasses** are a particular type of predicate-defined constraint where the value of an attribute(s) determines if an object is a member of a subclass.

- ◆ For example, the `title` field could be used as a *defining attribute* for the `Developer` and `Manager` subclasses.

⇒ `Emp is in Developer if title = 'EE' or 'PR'`

⇒ `Emp is in Manager if title = 'ME' or 'SA'`

# Constraints Question



Note: What is the participation and the disjoint constraints for superclass Employee (with subclasses Manager and Supervisor) given these instances?

# Relationship Constraints vs. Inheritance Constraints

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There is a parallel between relationship constraints on associations/relationships and inheritance constraints on superclasses and subclasses.

- ◆ Minimum # of occurrences – called participation constraint in both cases
- ◆ Maximum # of occurrences – called cardinality constraint for relationships and disjoint constraint for subclasses

Possible combinations:

<u>Subclass Constraints</u>	<u>Relationship Constraints</u>
Optional, AND	0..*
Optional, OR	0..1
Mandatory, AND	1..*
Mandatory, OR	1..1

# EER Question

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

- 1) Generalization is a bottom-up process.
- 2) In an UML diagram, the inheritance arrow points towards the superclass.
- 3) OPTIONAL and MANDATORY are possible choices for the participation constraint.
- 4) If the disjoint constraint is AND, a given object can be a member of multiple subclasses.
- 5) If the participation constraint is OPTIONAL, the disjoint constraint must be AND.

**A)** 0

**B)** 1

**C)** 2

**D)** 3

**E)** 4

# Multiple Inheritance

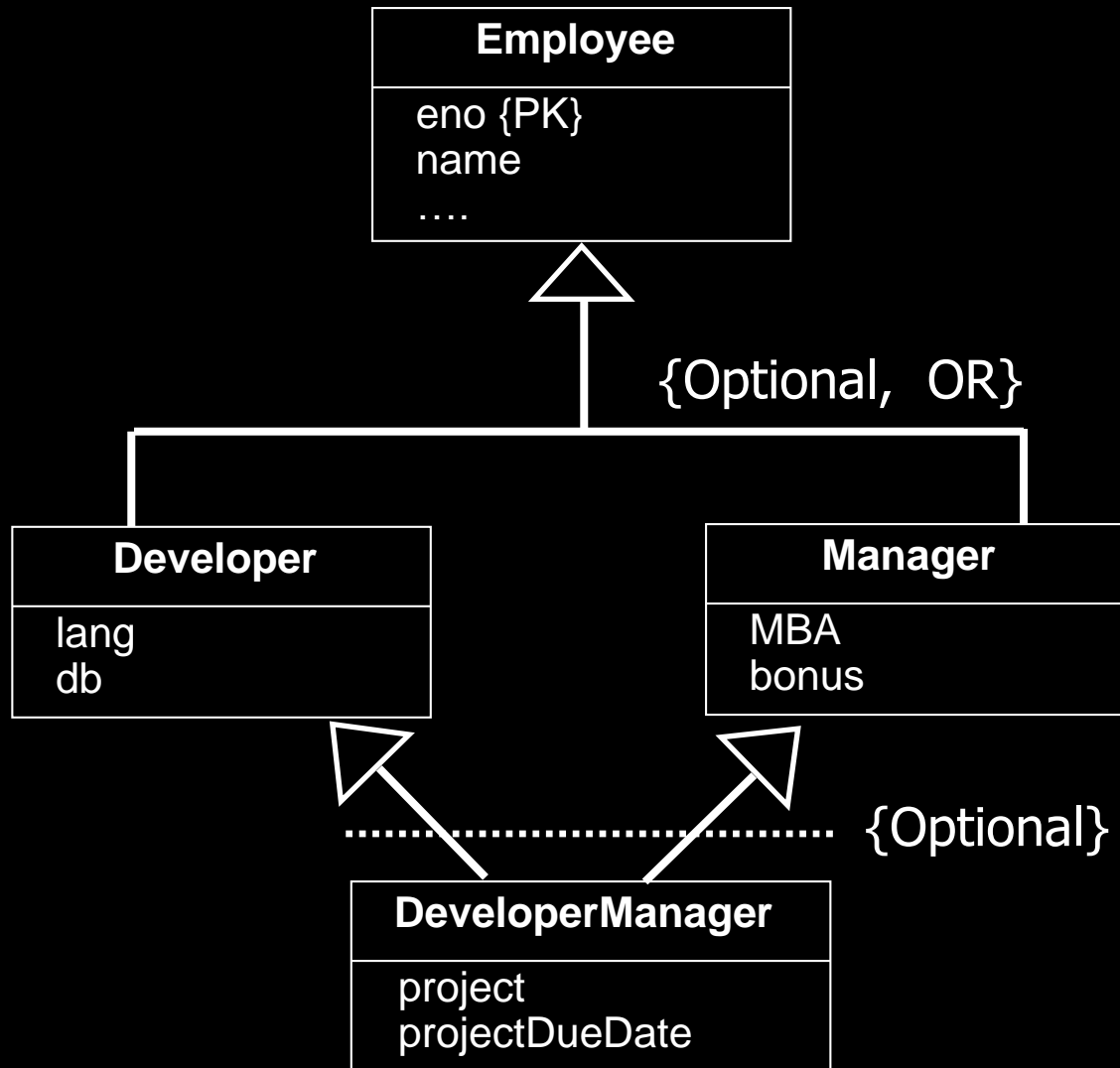
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If each class only has one superclass, then the class diagram is said to be a **specialization** or **type hierarchy**.

If a class may have more than one superclass, then the class diagram is said to be a **specialization** or **type lattice**.

Although multiple inheritance is powerful, it should be avoided if possible.

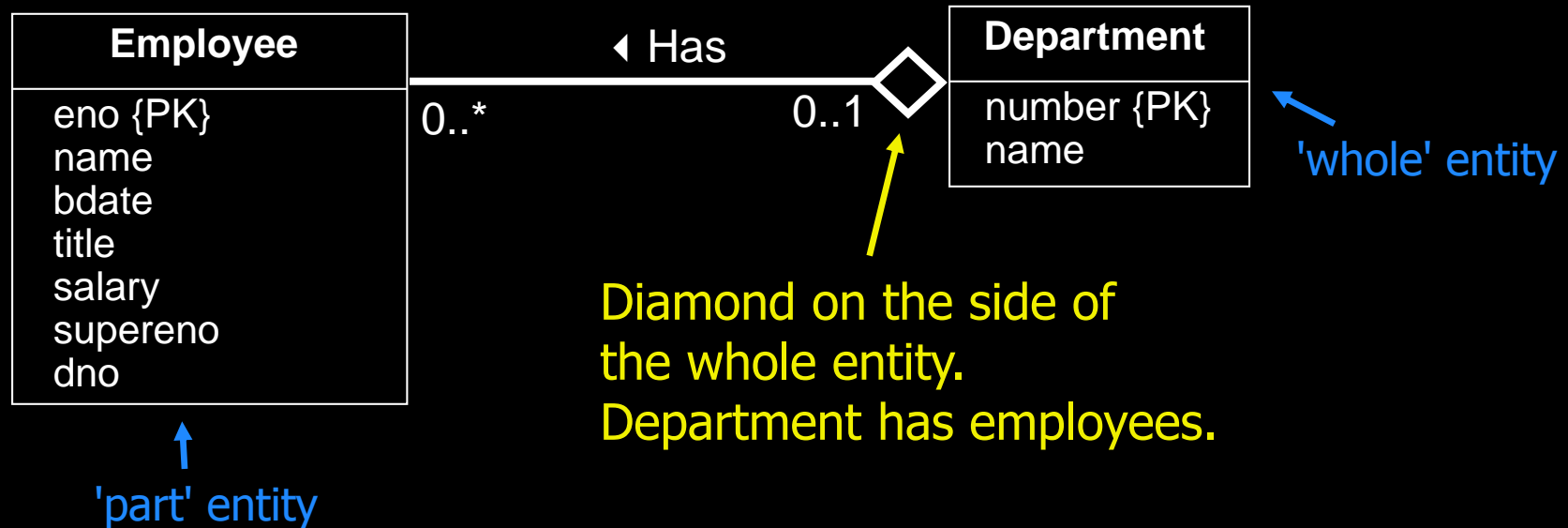
# Multiple Inheritance Example



# Aggregation

**Aggregation** represents a 'HAS-A' or 'IS-PART-OF' relationship between entity types. One entity type is the *whole*, the other is the *part*.

Example:

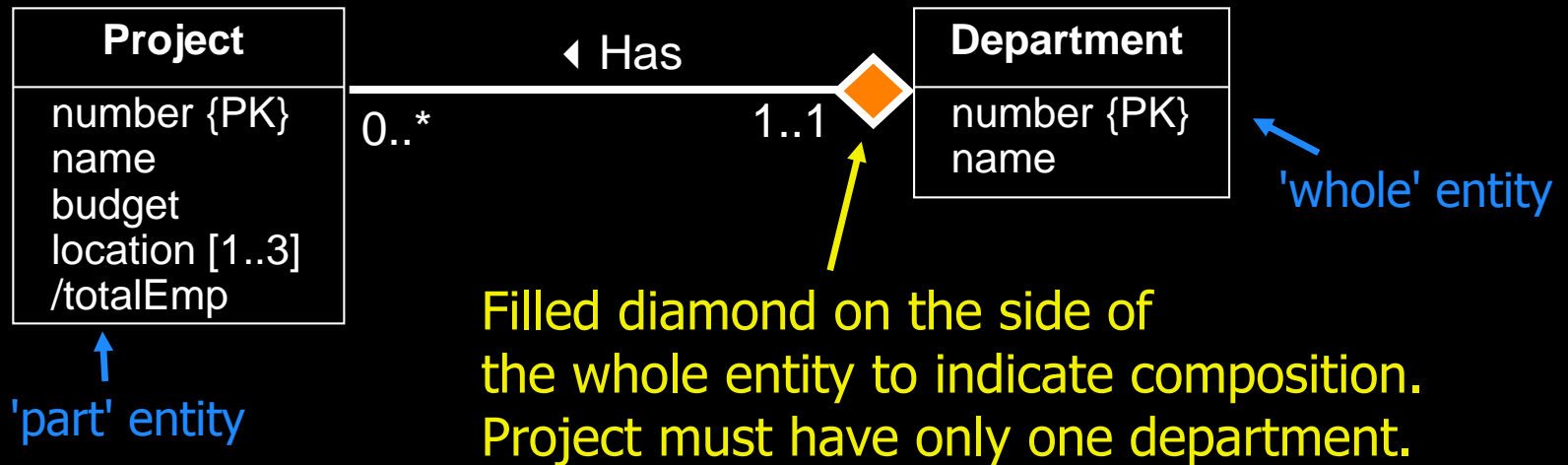




# Composition

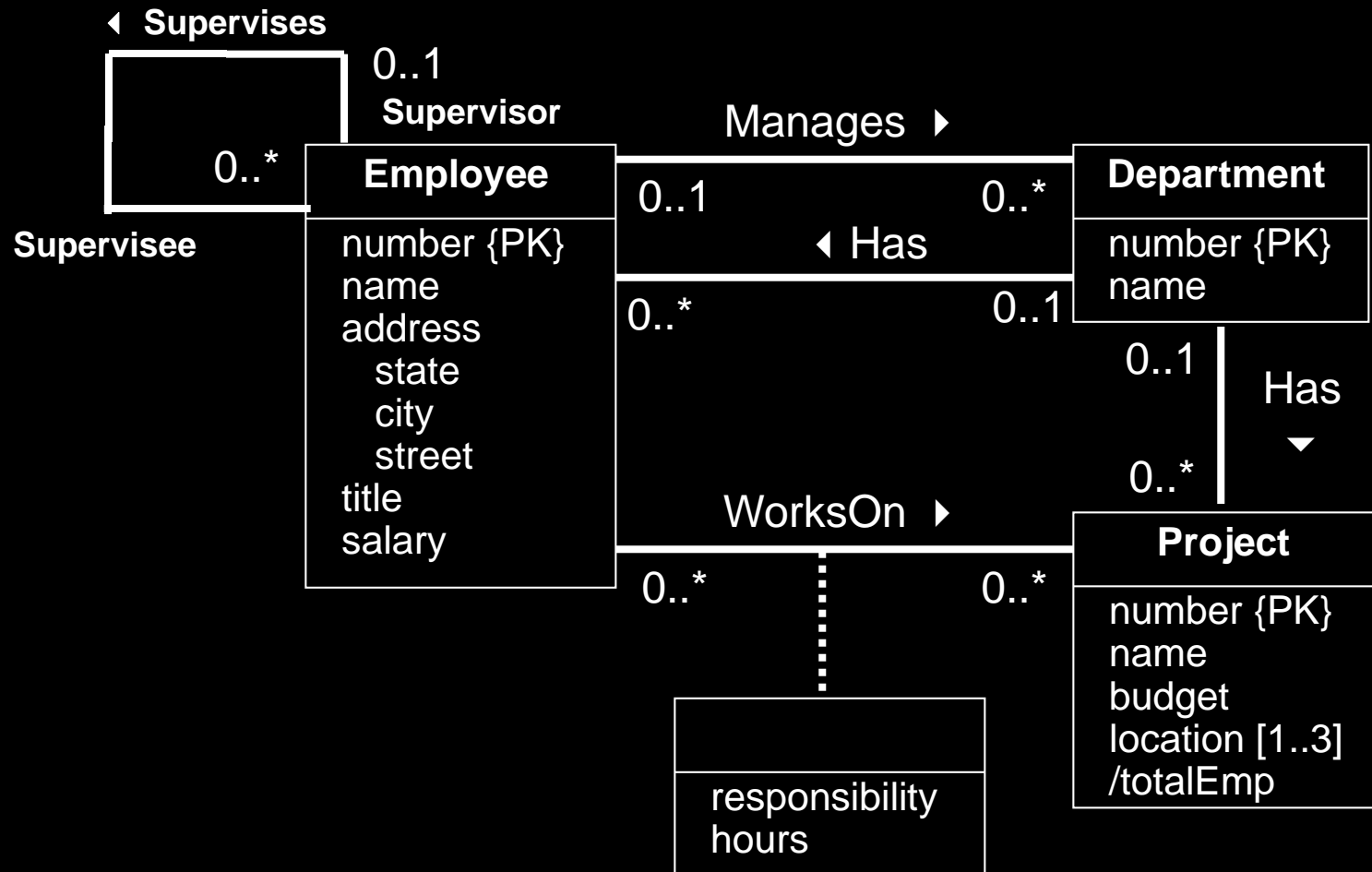
**Composition** is a stronger form of aggregation where the part cannot exist without its containing whole entity type and the part can only be part of one entity type.

Example:

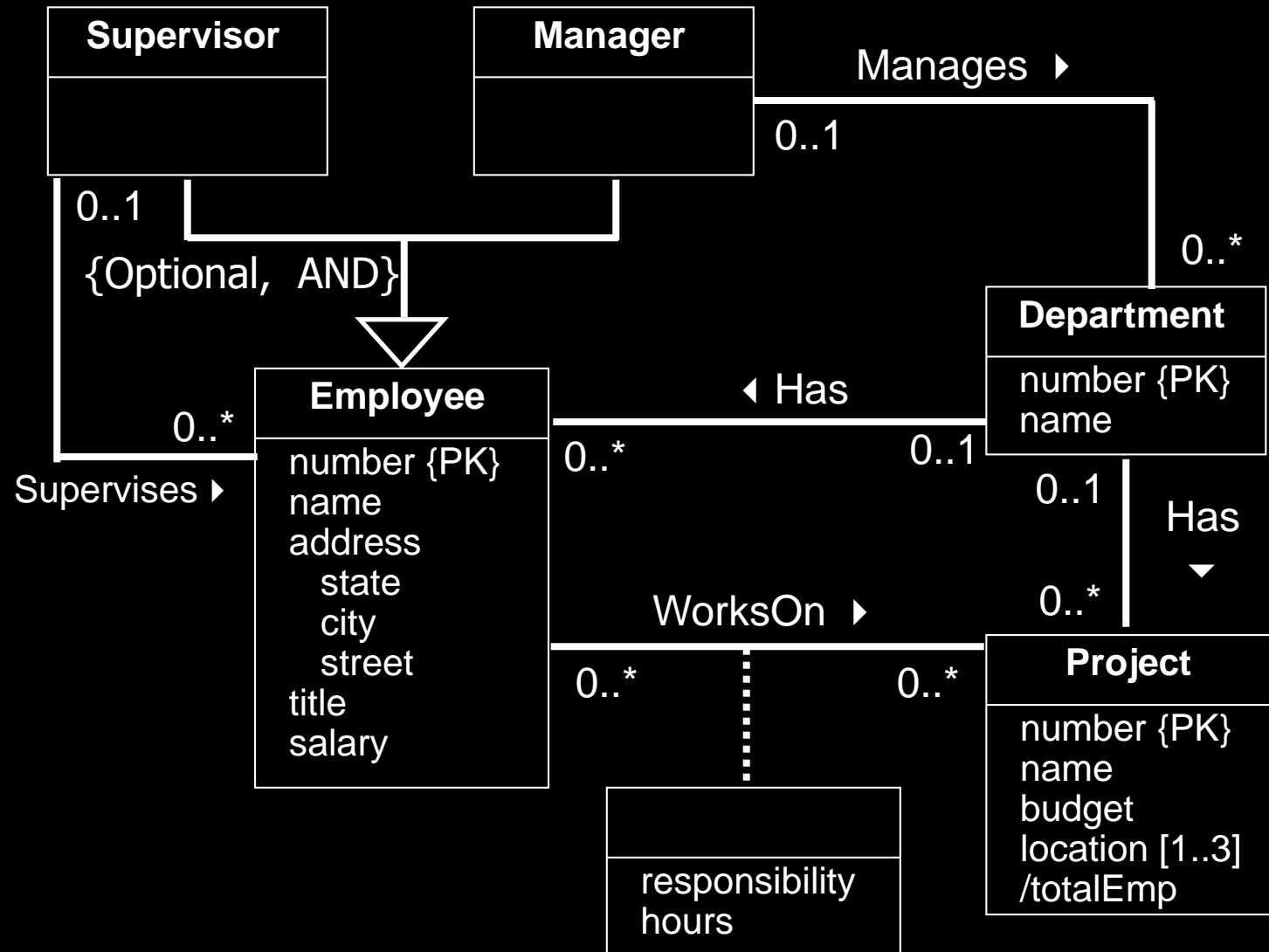


Note: The min-max constraint on the whole side of the relationship (in this case department) must always be 1..1 when modeling composition. Why?

# Original ER Model Example



# EER Model Example



# Conclusion

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The **Enhanced Entity-Relationship** model (**EER**) model allows for object-oriented design features to be captured.

**Generalization** and **specialization** are two complementary processes for constructing superclasses and subclasses.

**Participation** and **disjoint constraints** apply to subclasses.

- ◆ Participation of a superclass may be mandatory or optional in a subclass.
- ◆ A superclass may only be a member of one subclass (disjoint constraint indicated by OR) or multiple (indicated by AND).

Aggregation and composition are used to model HAS-A or PART-OF relationships.

The features of EER modeling are rarely needed in most database design projects.

# Objectives

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Given an EER diagram, recognize the subclasses, superclasses, and constraints using the notation.

Explain the difference between the participation constraint and the disjoint constraint.

Explain the difference between aggregation and composition.

Given an EER diagram, list the attributes of each class including attributes inherited from superclasses.