CONCEPTUAL DESIGN:
UML CLASS DIAGRAM
RELATIONSHIPS

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A Simplified Object-Oriented Systems Analysis & Conceptual Design Methodology

Activities

1. Identify the information system's purpose
2. Identify the information system's actors and features
3. Identify Use Cases and create a Use Case Diagram
4. Identify Objects and their Classes and create a Class Diagram
5. Create Interaction/Scenario Diagrams
6. Create Detail Logic for Operations
7. Repeat activities 1-6 as required to refine the "blueprints"

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Objects

- ***Objects have three responsibilities:***
  - ***What they know about themselves** – (e.g., Attributes)*
  - ***What they do** – (e.g., Operations)*
  - ***What they know about other objects** – (e.g., Relationships)*

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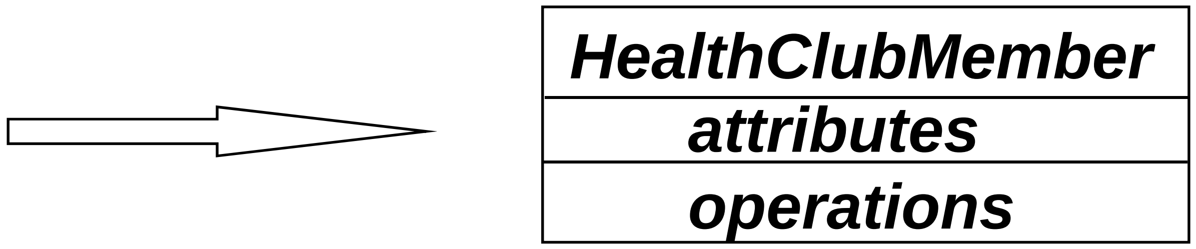
Defining Class

A CLASS is a template (specification, blueprint) for a collection of objects that share a common set of attributes and operations.

Class



Objects

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• Relationships

A RELATIONSHIP is what a class or an object knows about another class or object.

Four Types

- **Generalization (Class-to-Class)** *(Superclass/Subclass)*
  - *Inheritance*
  - *Ex: Person - FacultyPerson, StudentPerson, Staff...*
  - *Ex: ModesOfTravel - Airplane, Train, Auto, Cycle, Boat...*
- ***[Object] Associations***
  - *FacultyInformation - CourseInformation*
  - *StudentInformation - CourseInformation*
- ***[Object] Aggregations & Composition*** *(Whole-Part)*
  - *Assembly - Parts*
  - *Group - Members*
  - *Container - Contents*

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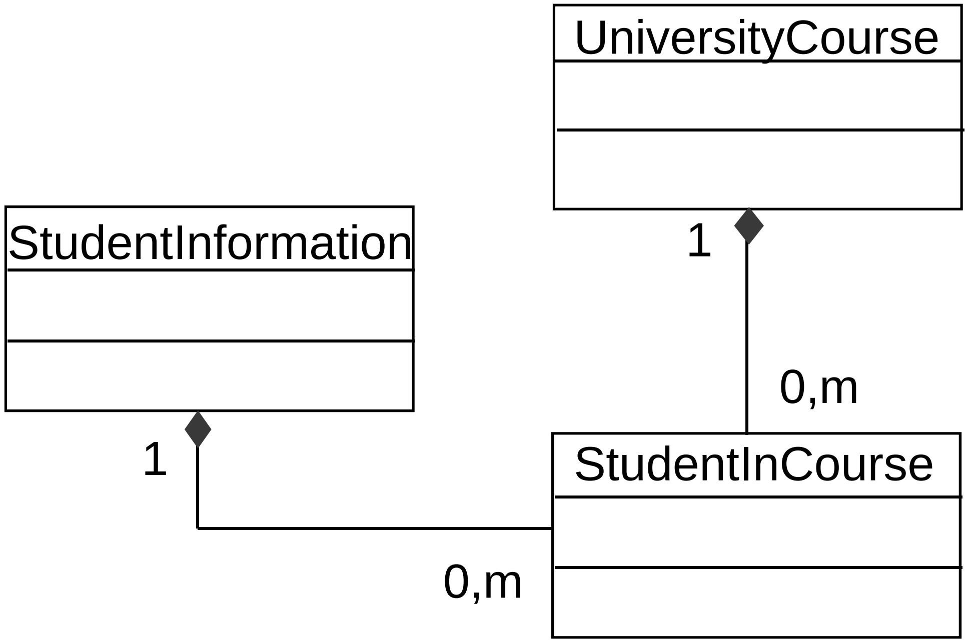
• Relationships

Exist to:

1) show relationships 2) enforce integrity 3) help produce results



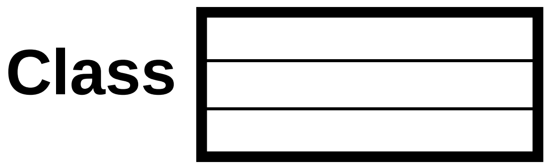
In this example:

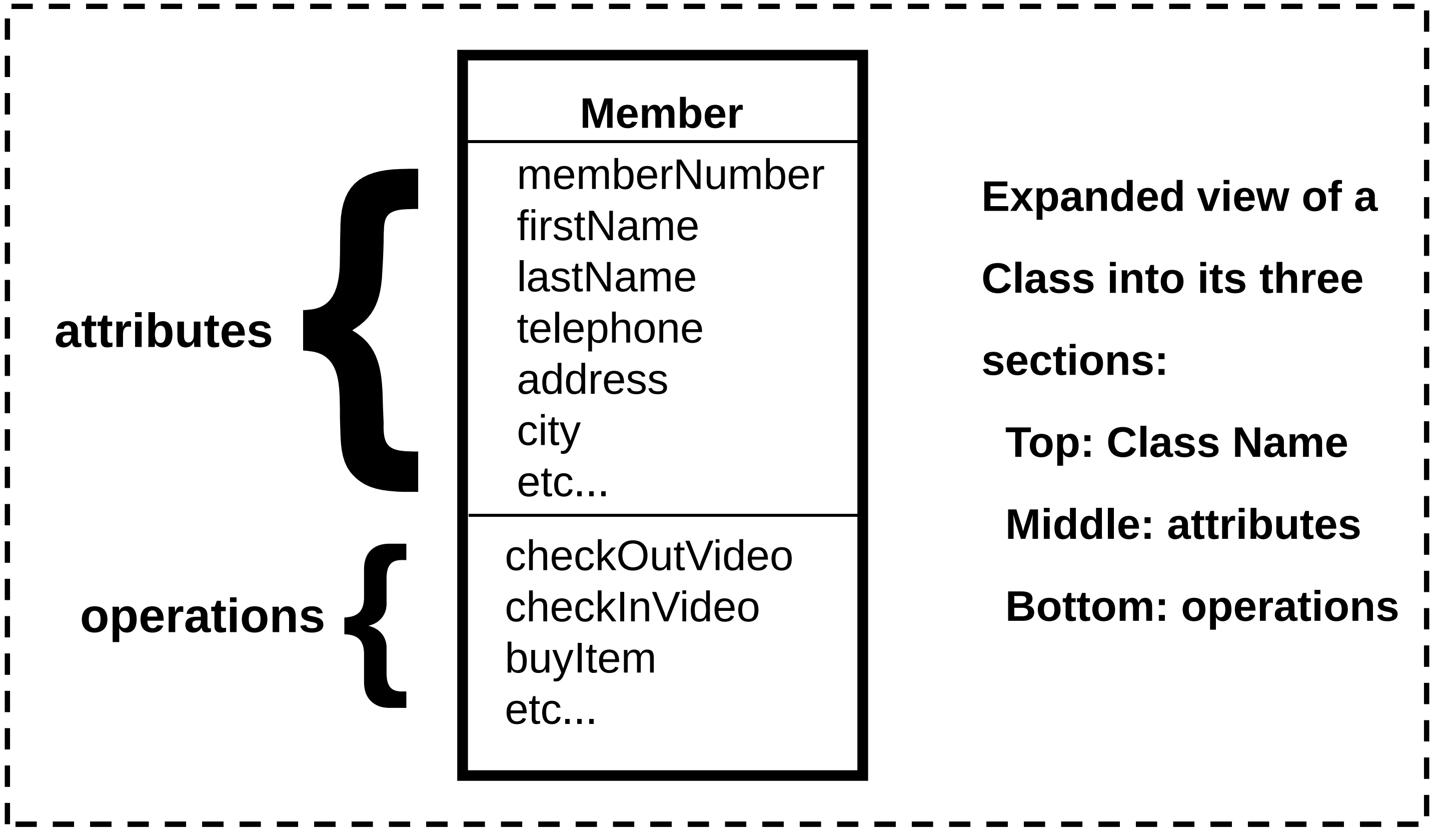
- ***Removal of a University Course should also remove Students that are in the Course but not Student Information.***

- ***Removal of a Student should also remove the Courses that the Student is in but not the University Course.***

- ***Removal of a Student in a Course should not affect either University Course or Student Information.***

UML Class Diagram Notation





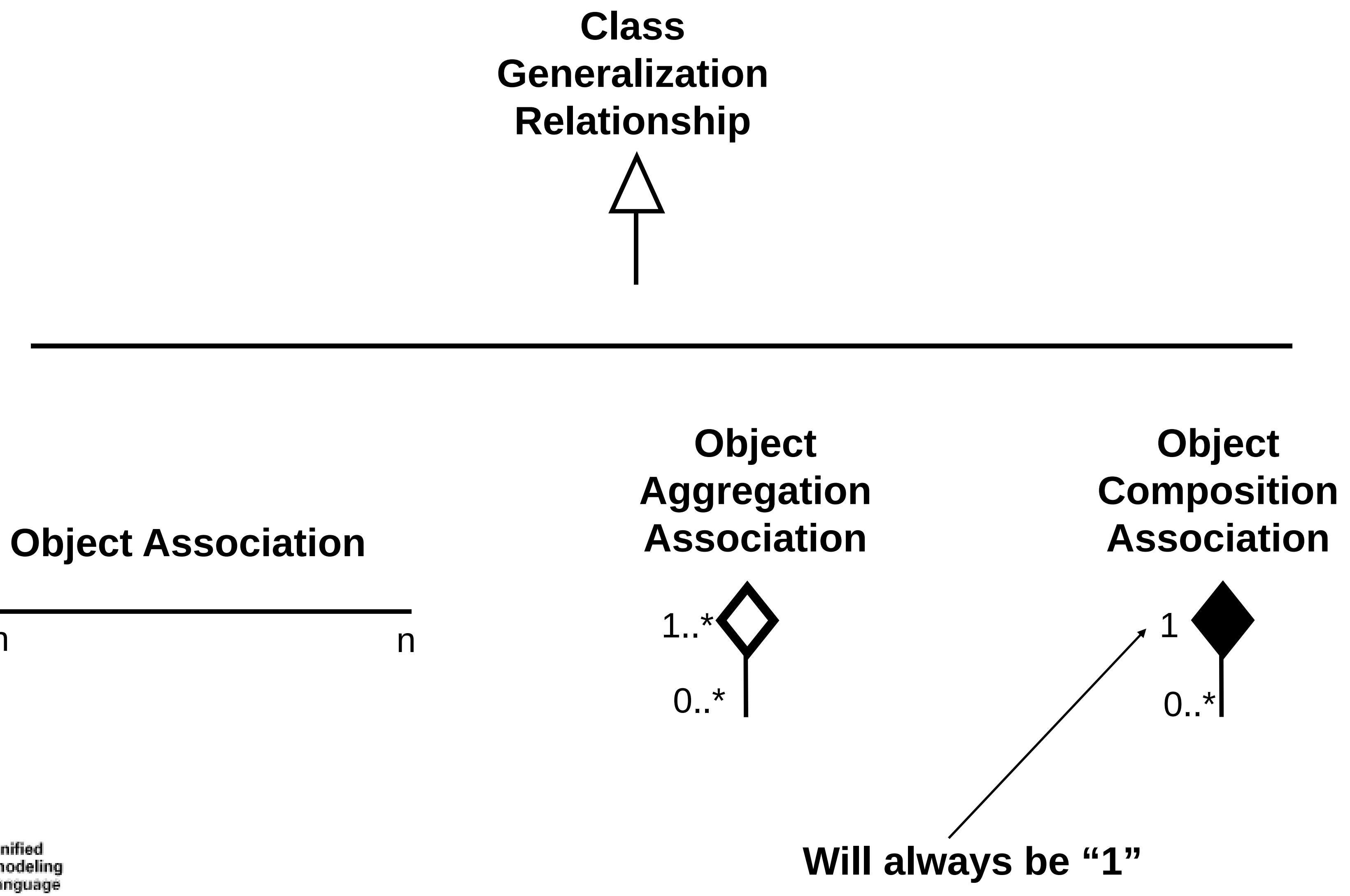
Expanded view of a Class into its three sections:

Top: Class Name

Middle: attributes

Bottom: operations

UML Class Diagram Notation


Class Generalization Relationship
Object Association
n
n
Object Aggregation Association
1..*
0..*
Object Composition Association
1
0..*
Will always be "1"

Class Diagram Relationships

- ***Class***
  - ***Generalization***
- ***Object***
  - ***Association***
  - ***Aggregation***
  - ***Composition***

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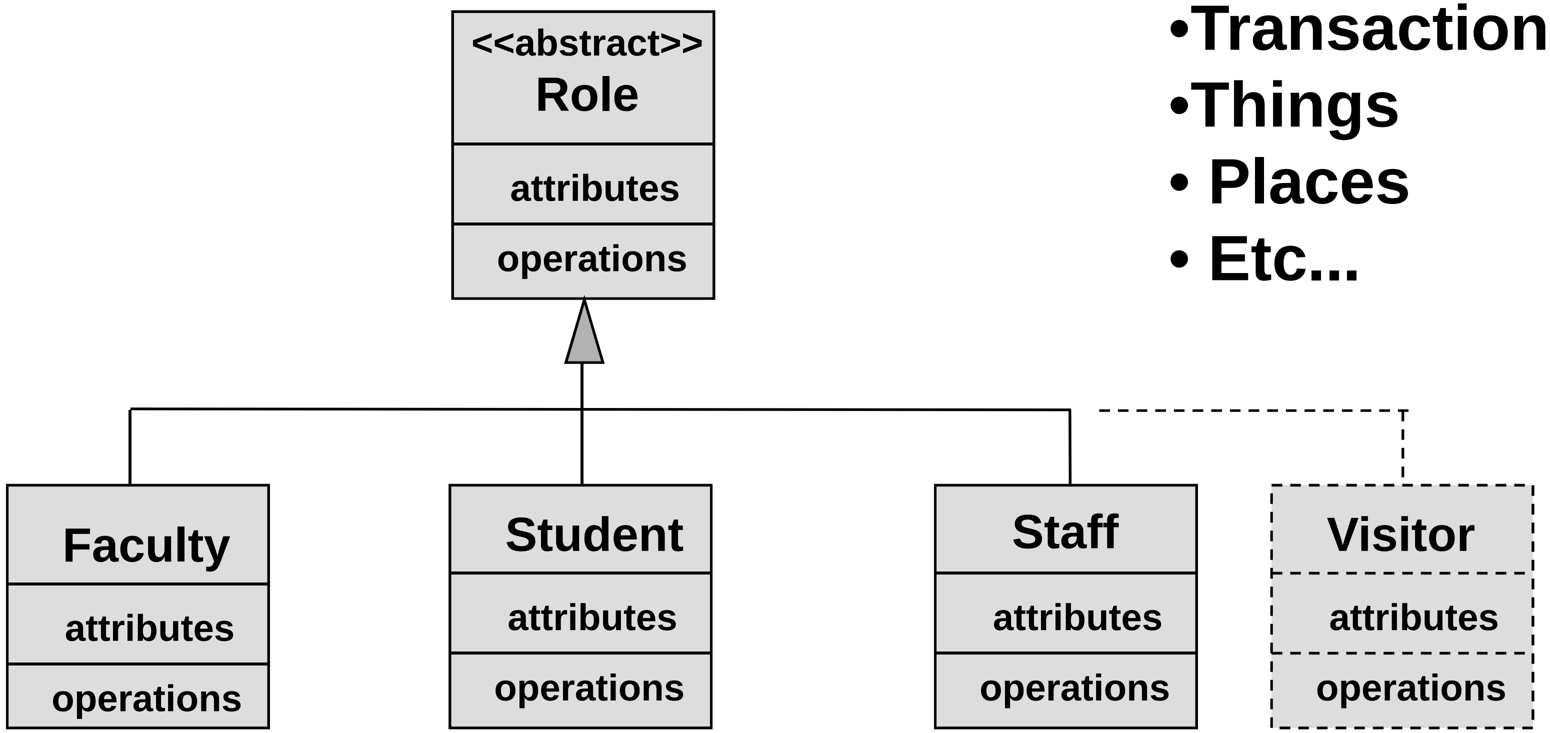
Generalization (Class-to-Class) (superclass – subclass; supertype – subtype)

- **A Generalization follows a “is a” or “is a kind of” heuristic from a specialization class to the generalization class. (e.g., student “is a” person, video “is a kind of” inventory).**
- **Common attributes, operations and relationships are located in the generalization class and are inherited by the specialization classes**
- **Unique attributes, operations and relationships are located in the specialization classes.**
- **Inherited attributes and operations may be overridden or enhanced in the specialization class depending on programming language support.**
- **Inherited operations in the specialization classes may be polymorphic.**
- **Only use when objects do NOT “transmute” (add, copy, delete)**
- **Multiple inheritance is allowed in the UML but can complicate the class model’s understanding and implementation (e.g., C++ supports but Java and Smalltalk do not).**

Generalization Example

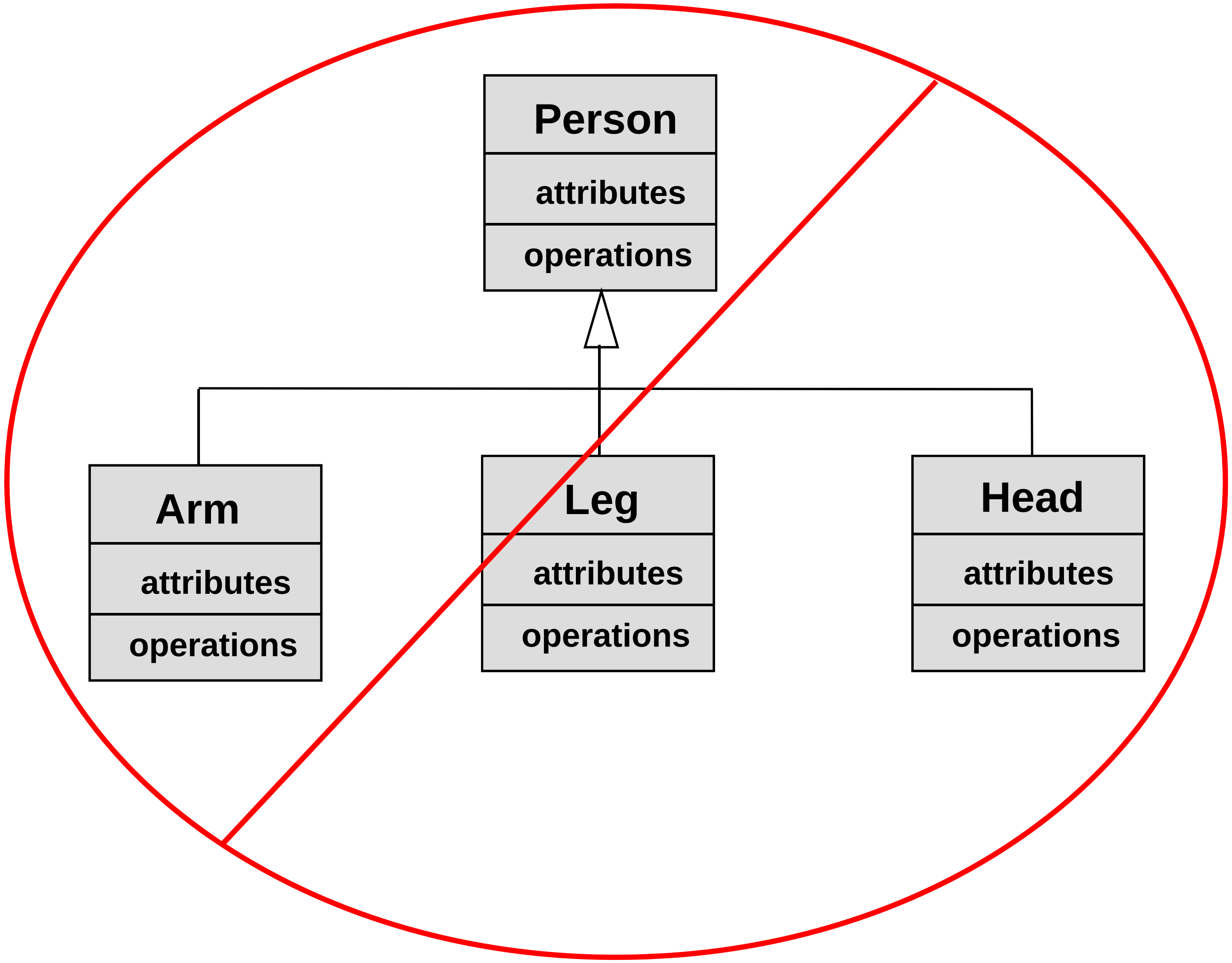


Others:

- Transactions
- Things
- Places
- Etc...

Note: <<abstract>> = no objects

Poor Generalization Example
(violates the “is a” or “is a kind of” heuristic)



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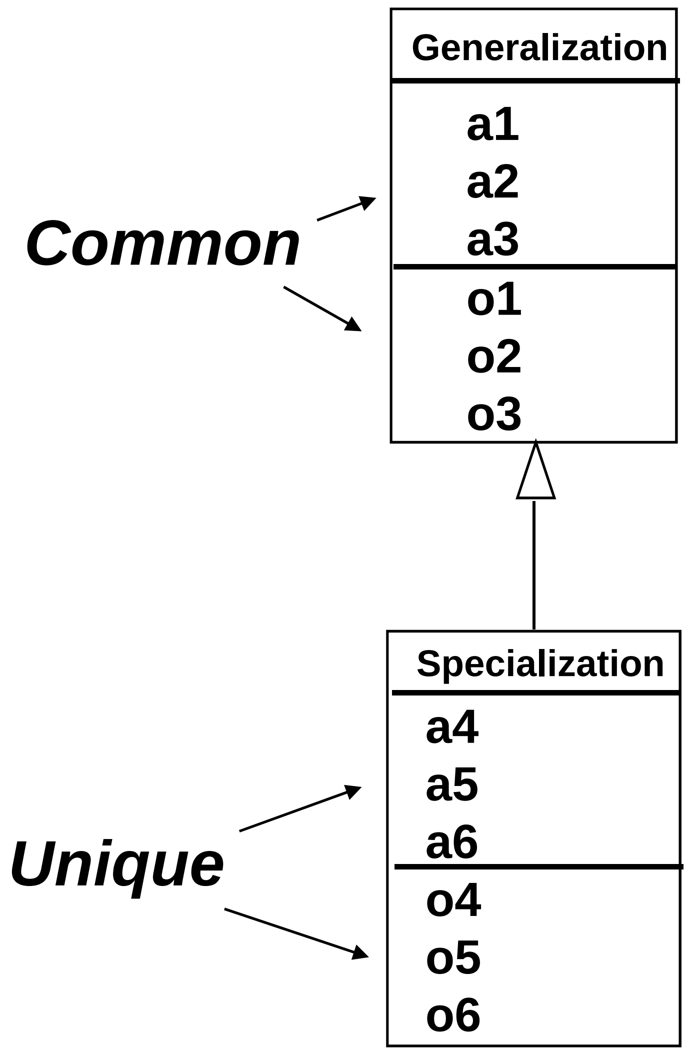
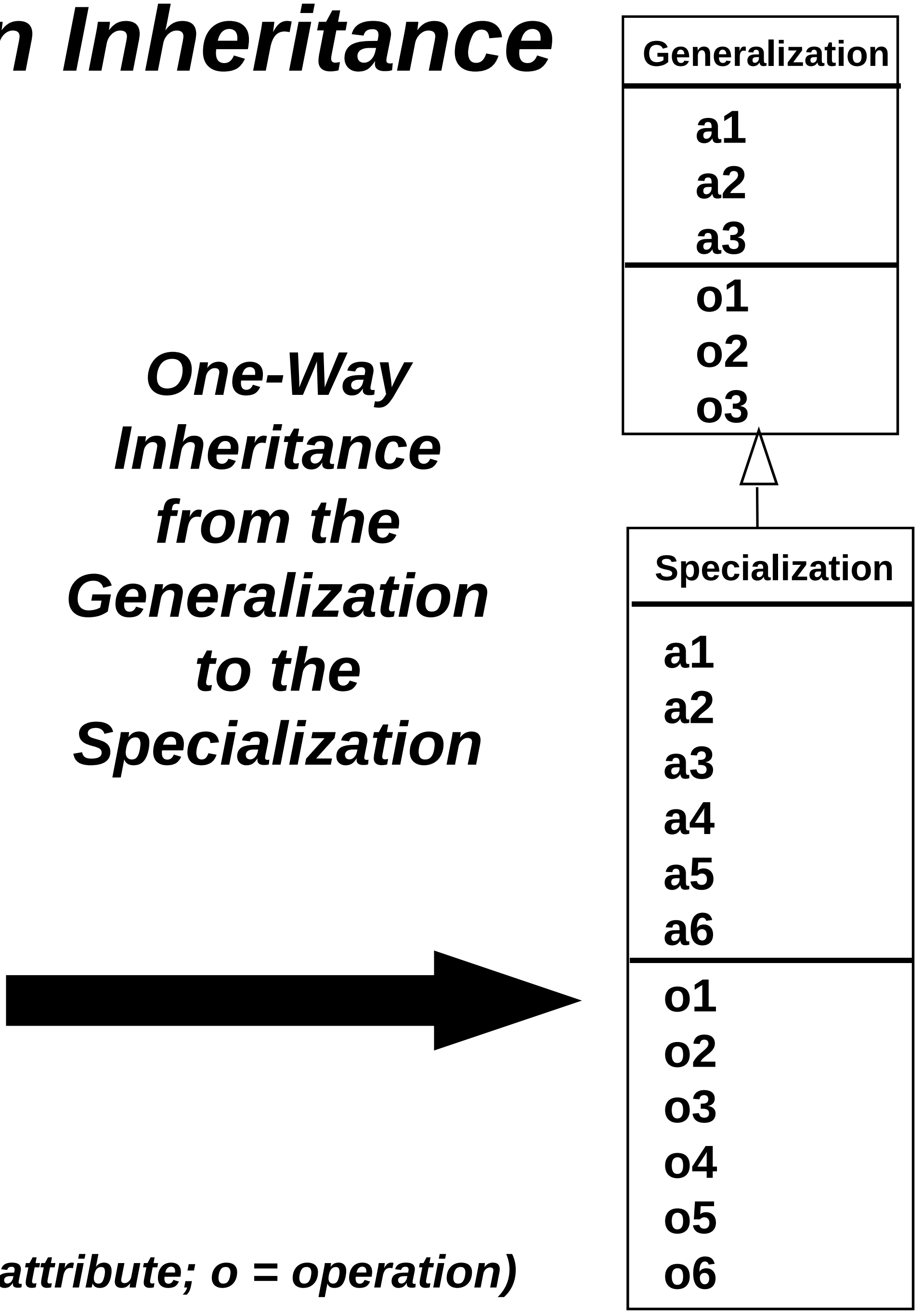
Generalization Inheritance

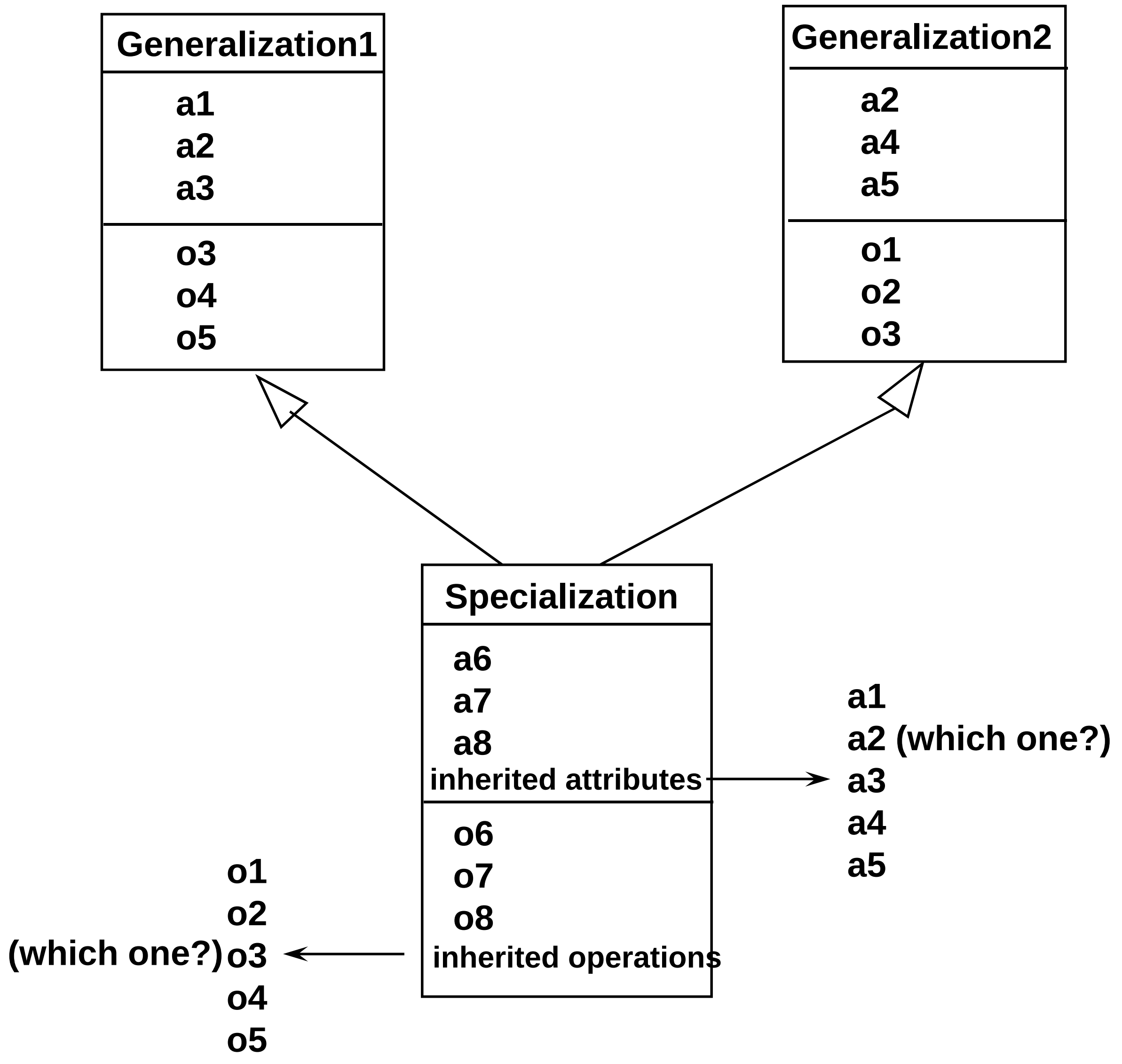


One-Way Inheritance from the Generalization to the Specialization



(a = attribute; o = operation)

Generalization - Multiple Inheritance



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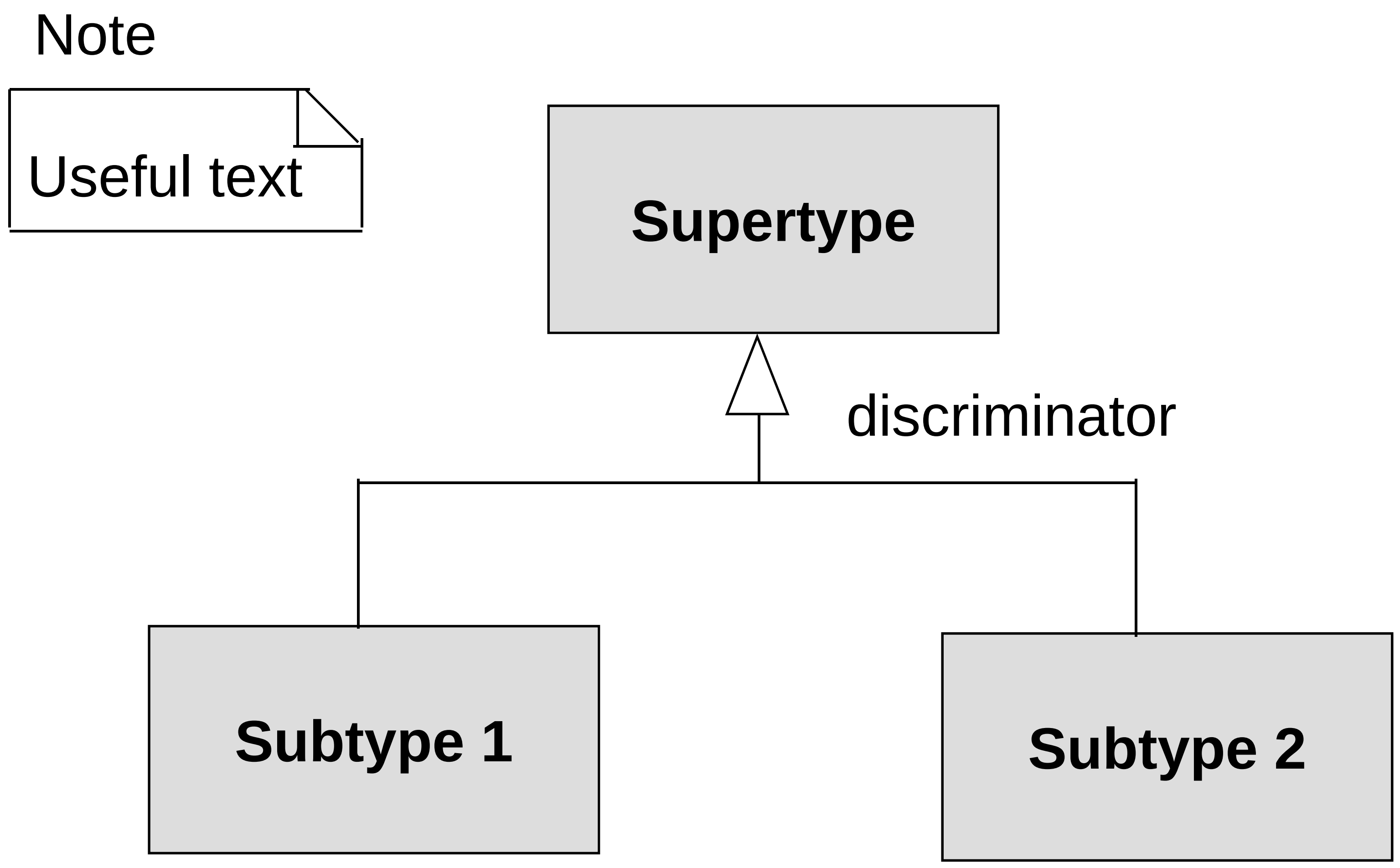
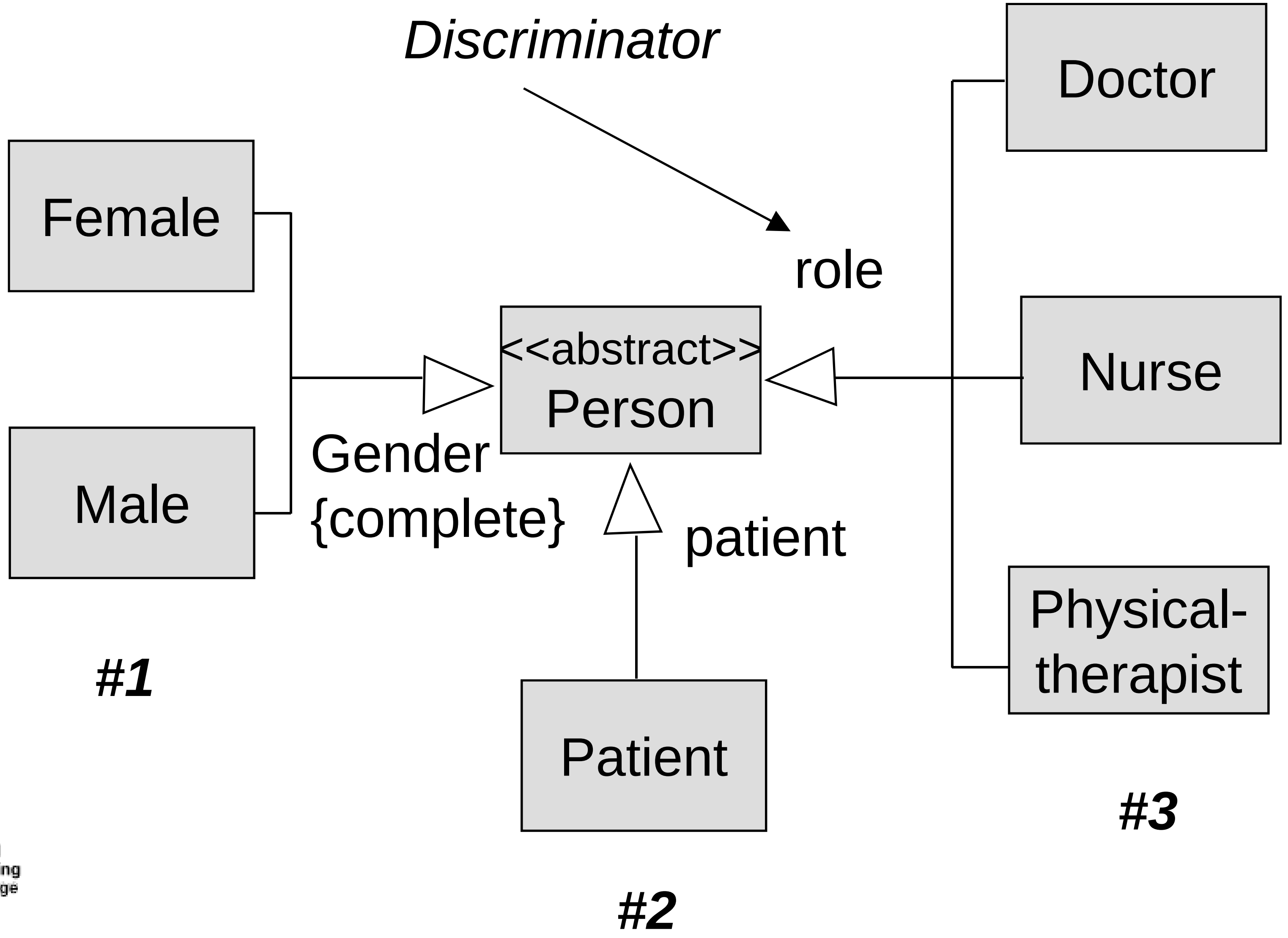
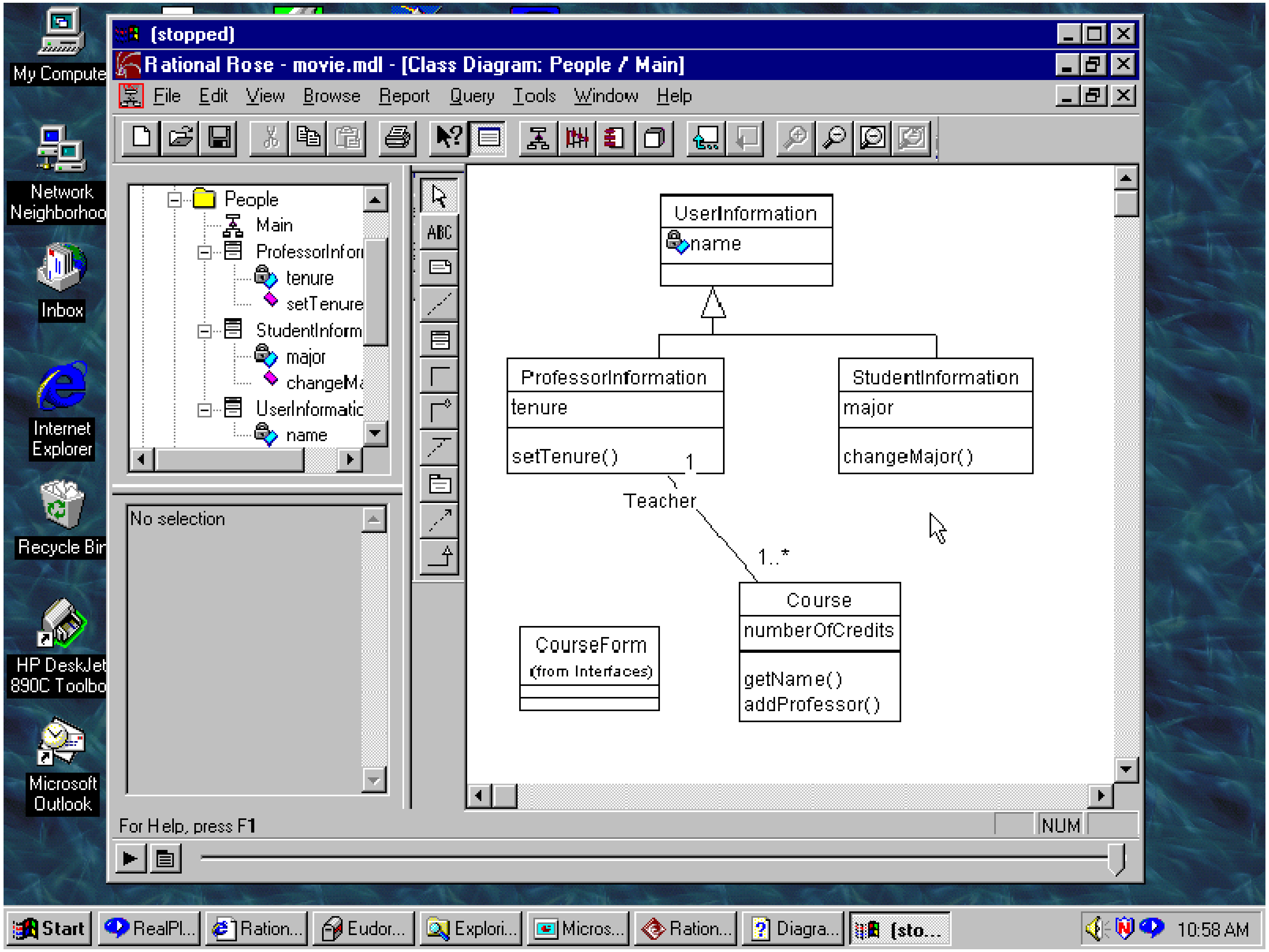
UML Generalization Notation



Note: Supertype = Superclass; Subtype = Subclass

Generalization - Multiple Classification



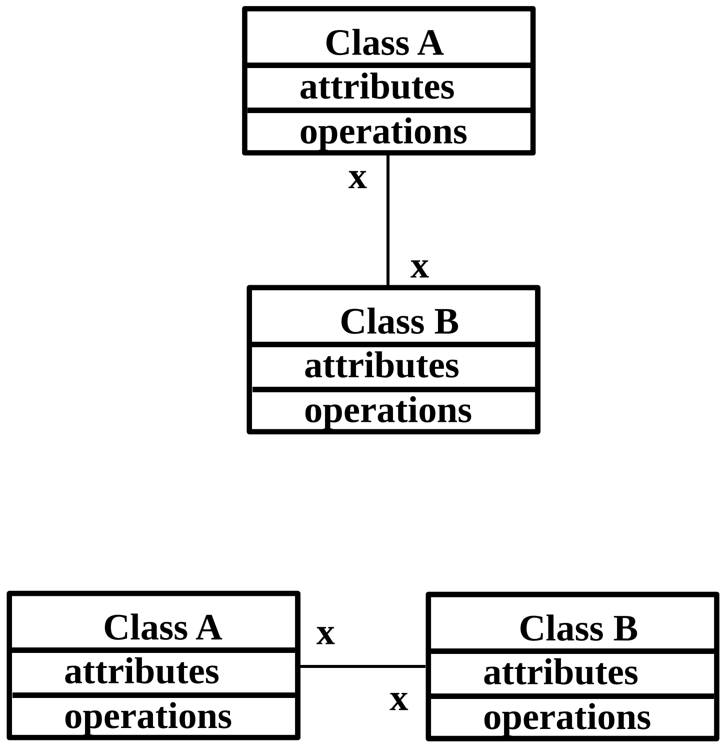


Rational Rose Class Diagram Example

Associations

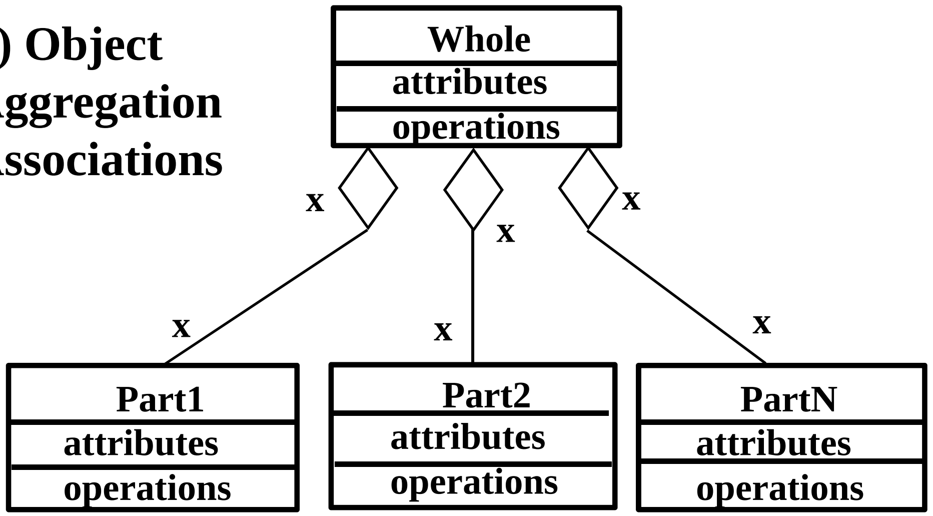
- Relationships between instances (objects) of classes
- Conceptual:
  - associations can have two roles (bi-directional):
    - source --> target
    - target --> source
  - roles have multiplicity (e.g., cardinality, constraints)
  - To restrict navigation to one direction only, an arrowhead is used to indicate the navigation direction
- No inheritance as in generalizations

Object Association Relationship Patterns

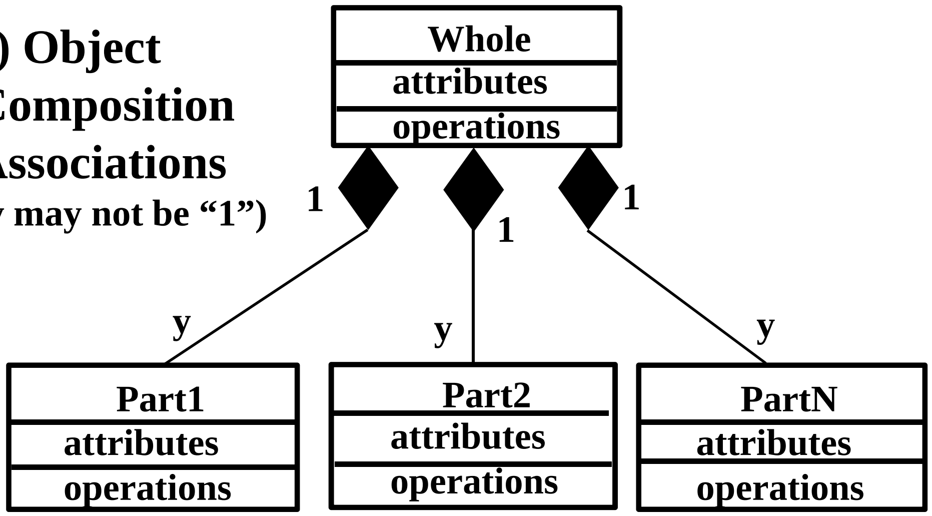


a) Object Associations

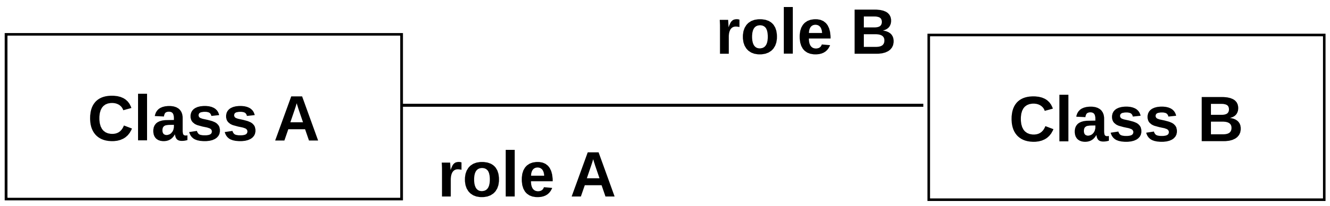
b) Object Aggregation Associations



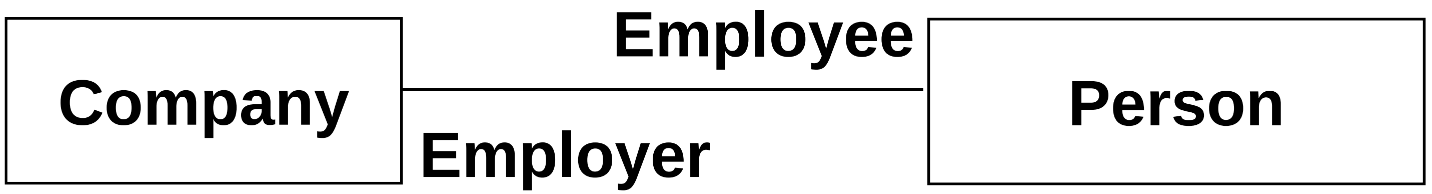
c) Object Composition Associations
(y may not be "1")



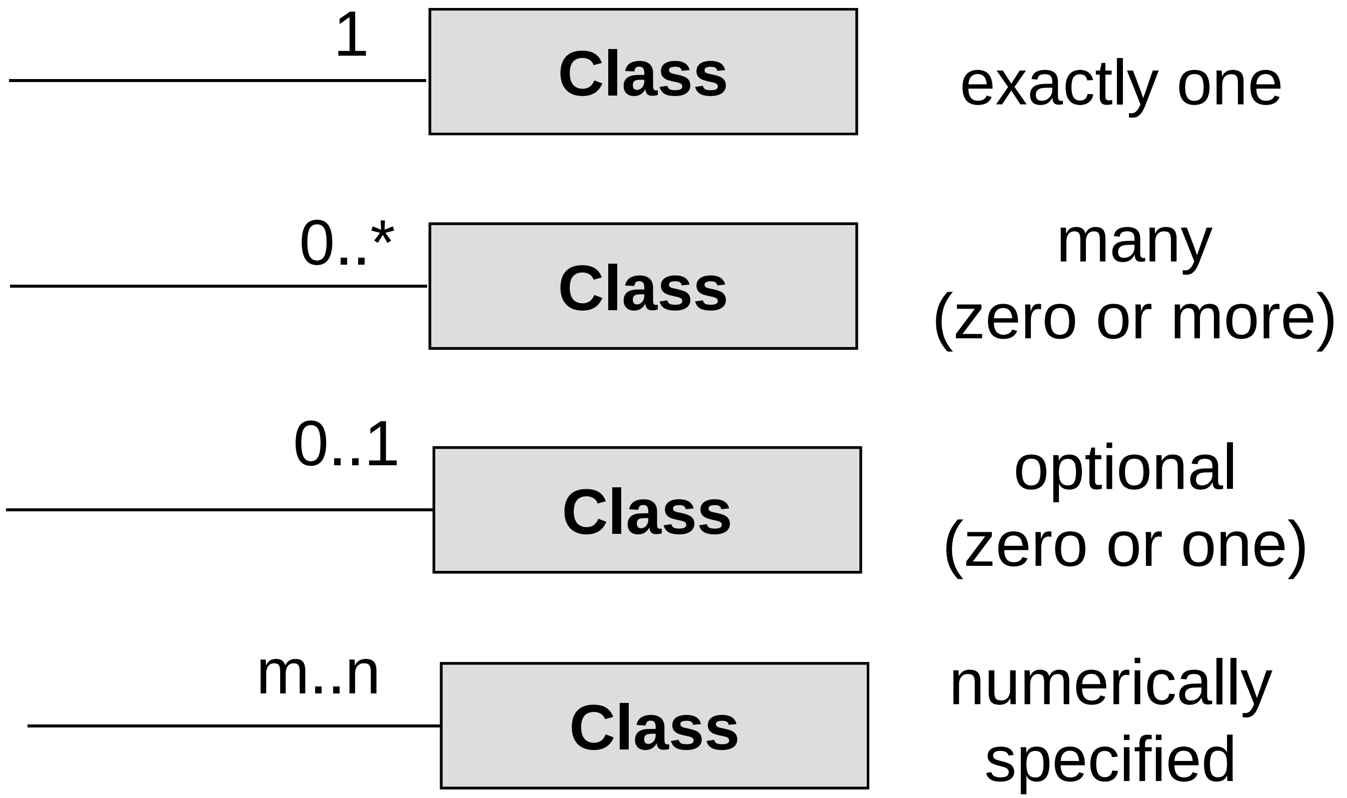
Associations



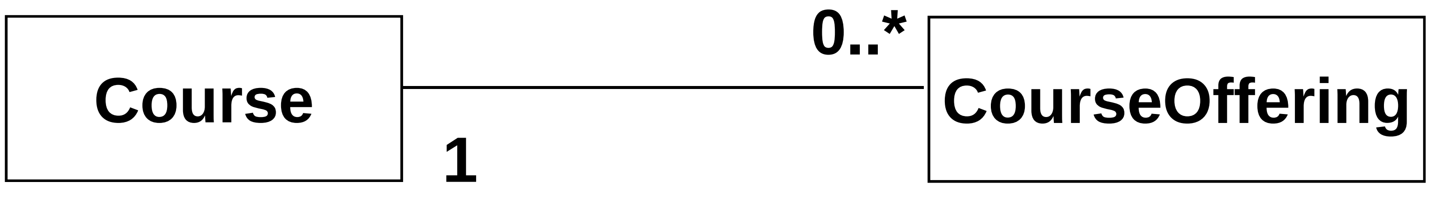
Example:



Multiplicities



Example:



Aggregation & Composition

- ***Aggregation (shared aggregation):***
  - ***is a specialized form of ASSOCIATION in which a whole is related to its part(s).***
  - ***is known as a “part of” or containment relationship and follows the “has a” heuristic***
  - ***three ways to think about aggregations:***
    - ***whole-parts***
    - ***container-contents***
    - ***group-members***
- ***Composition (composite aggregation):***
  - ***is a stronger version of AGGREGATION***
  - ***the “part(s)” may belong to only ONE whole***
  - ***the part(s) are usually expected to “live” and “die” with the whole (“cascading delete”)***
- ***Aggregation vs. Composition vs. Association???***

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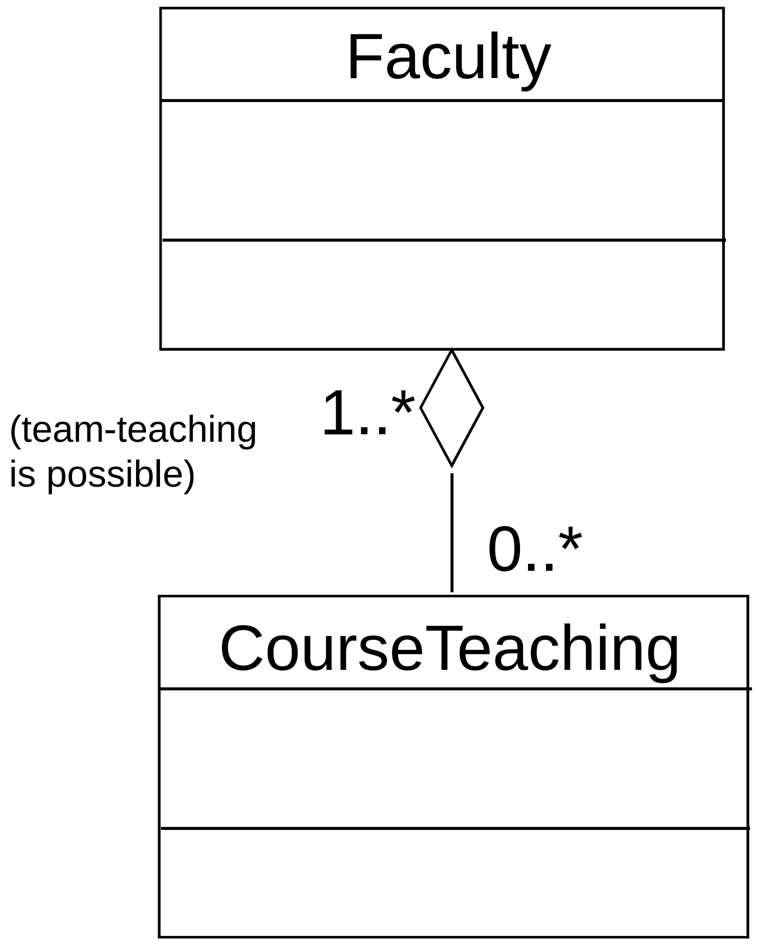
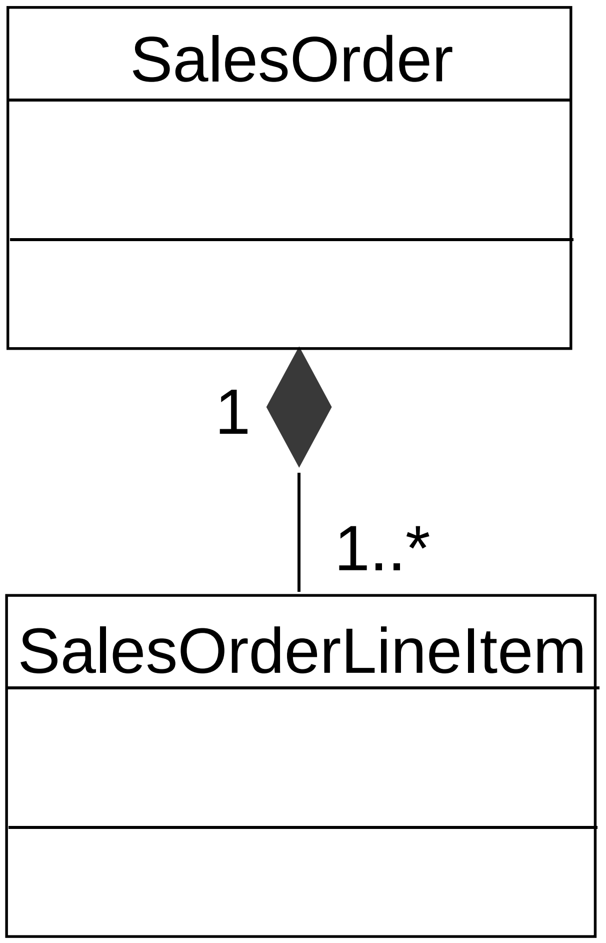
Aggregation



(another: assembly --> part)

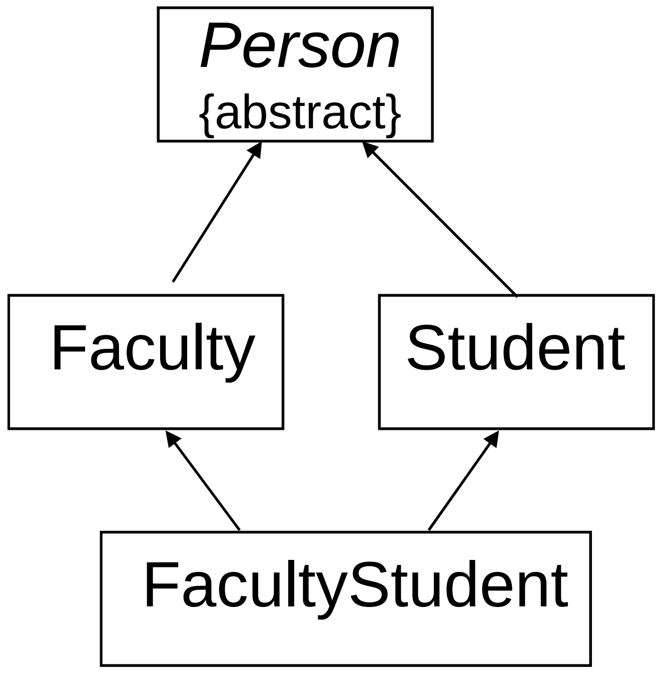
Composition

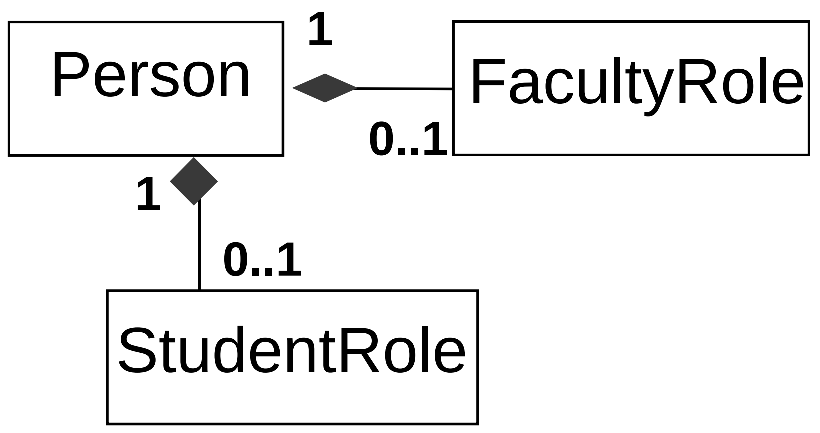


(another: hand --> finger)

Composition

- ***Composition is often used in place of Generalization (inheritance) to avoid "transmuting" (adding, copying, and deleting of objects)***

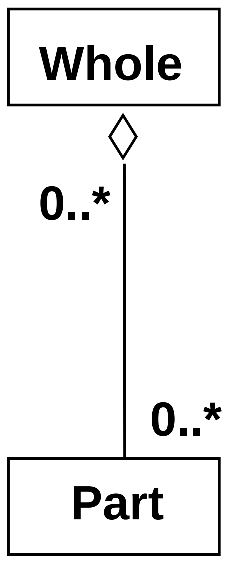




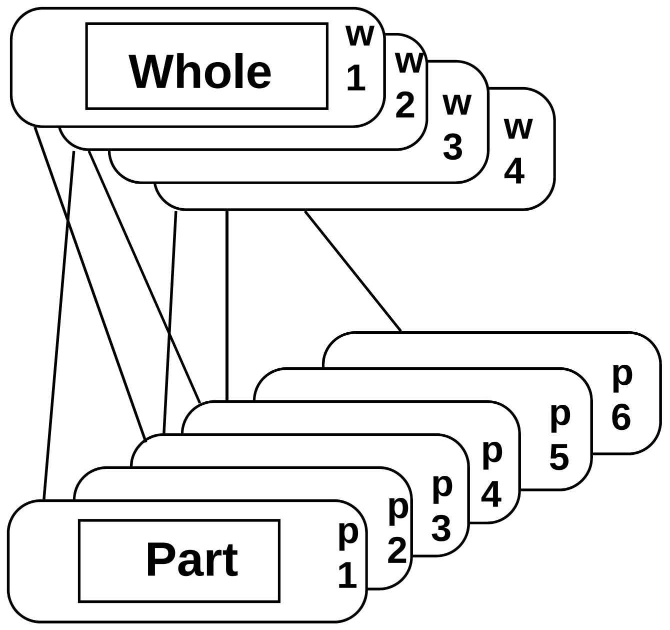
Note: Attributes may need to be considered to more-fully understand

Association, Aggregation and Composition

Template/Pattern

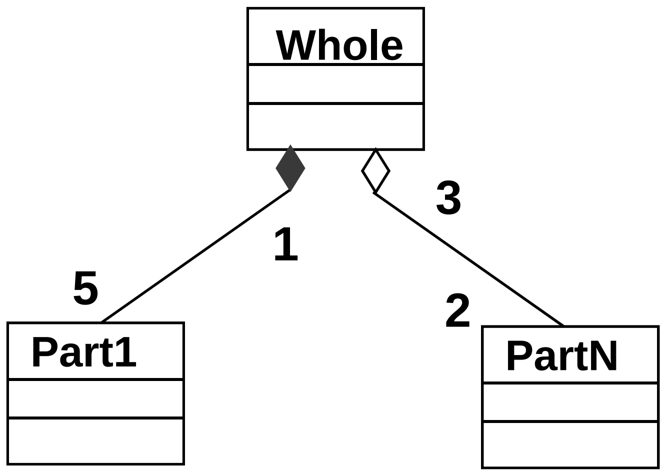


Example



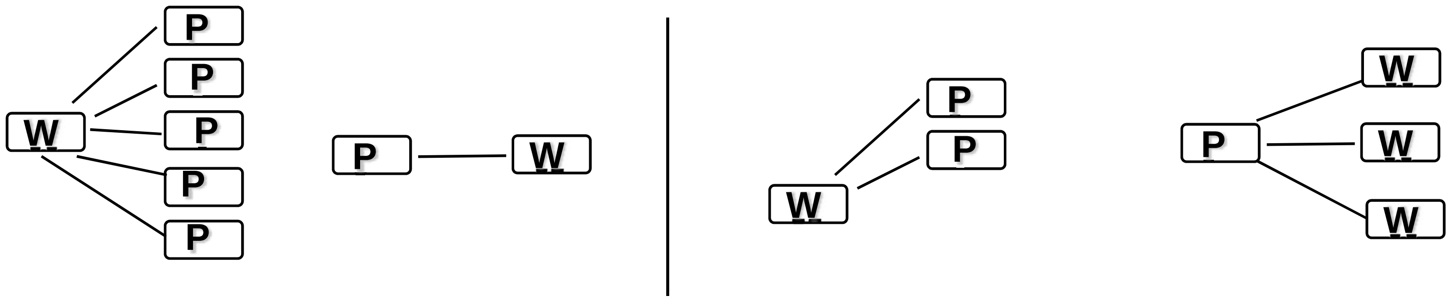
(association, aggregation & composition look the same)

Multiplicity Example #1

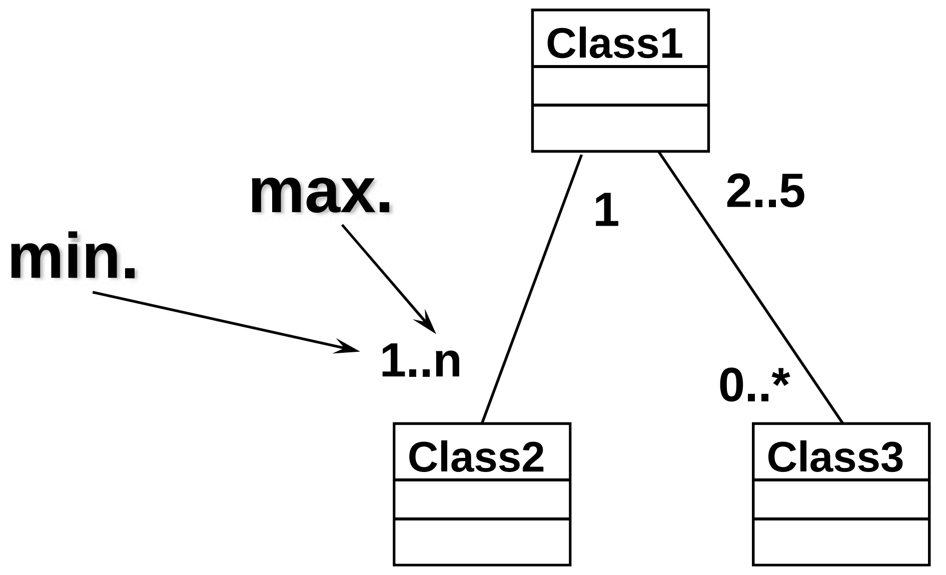


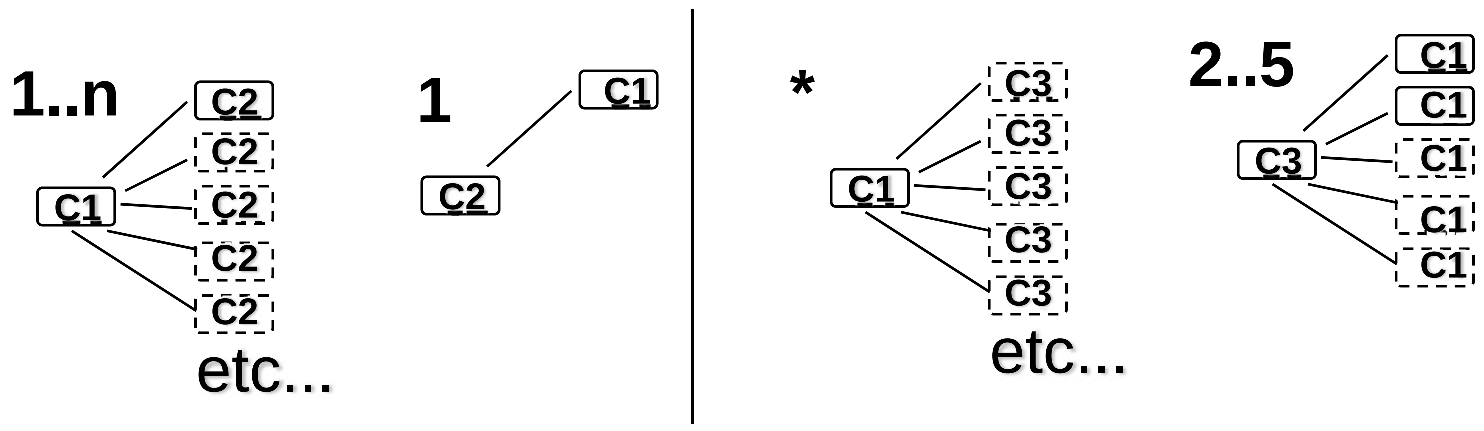
- One Whole is associated with 5 Part1
- One Part1 is associated with 1 Whole

- One Whole is associated with 2 PartN
- One PartN is associated with 3 Whole

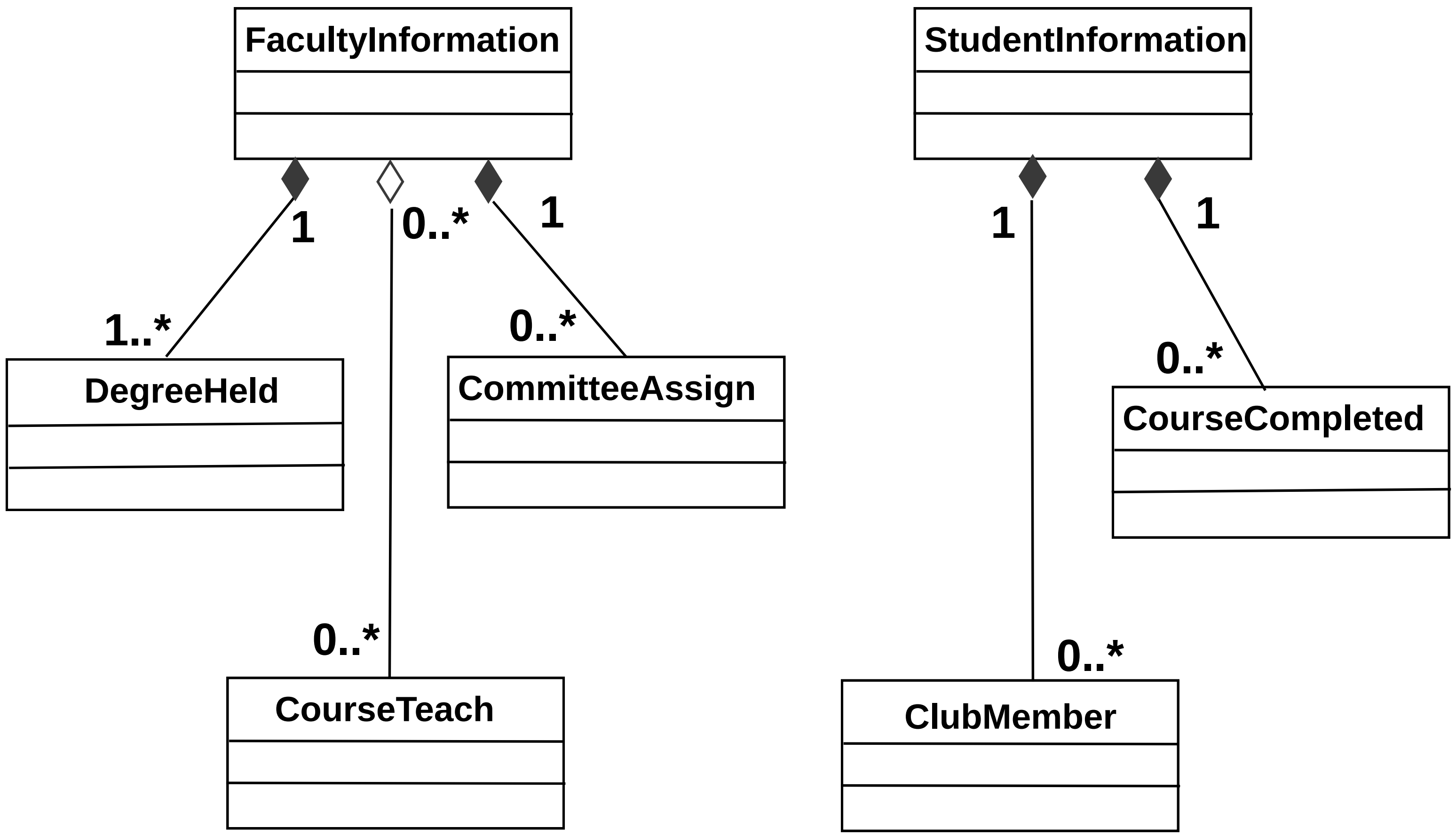


Multiplicity Example #2

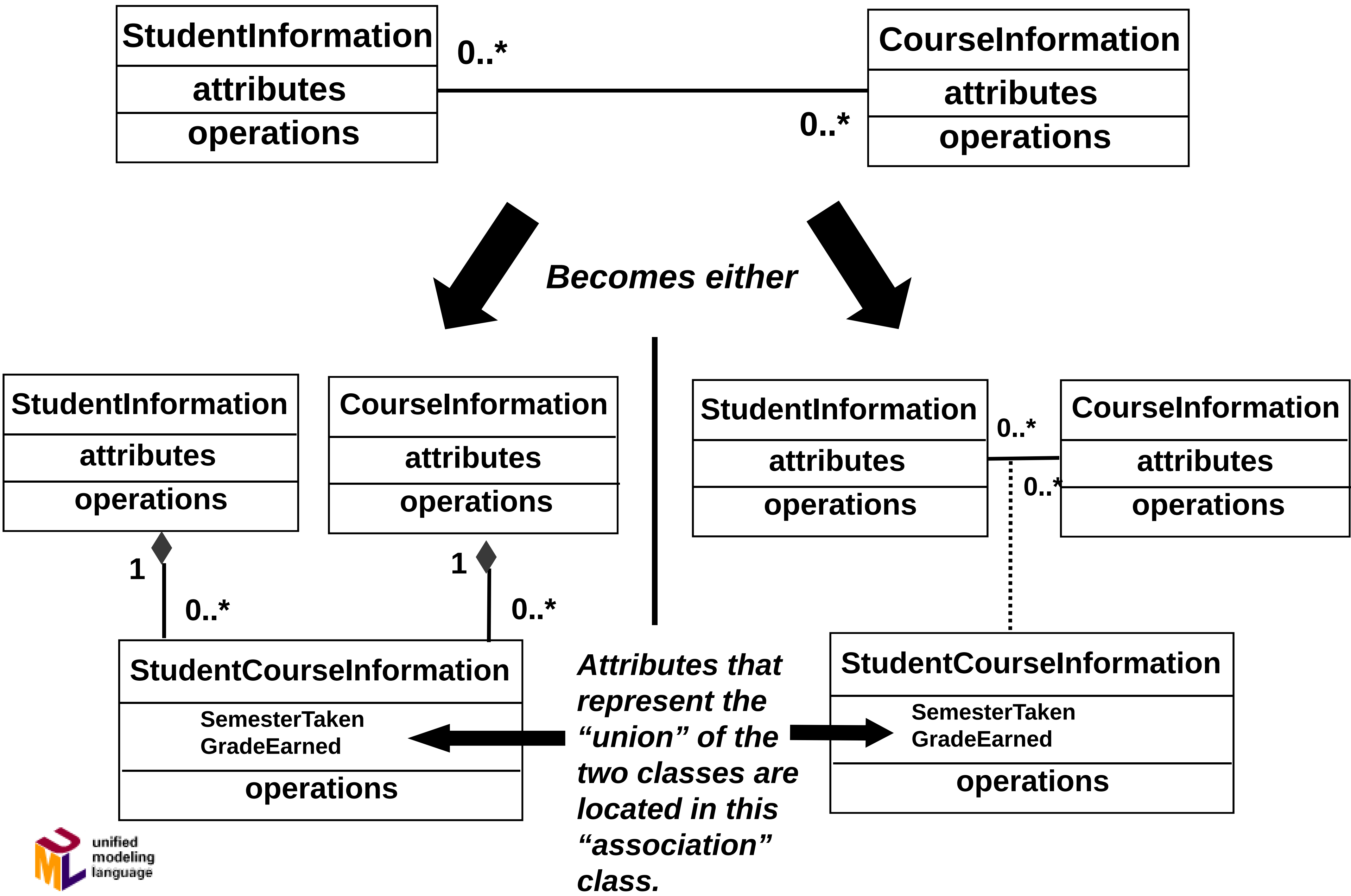




Multiplicity Example #3



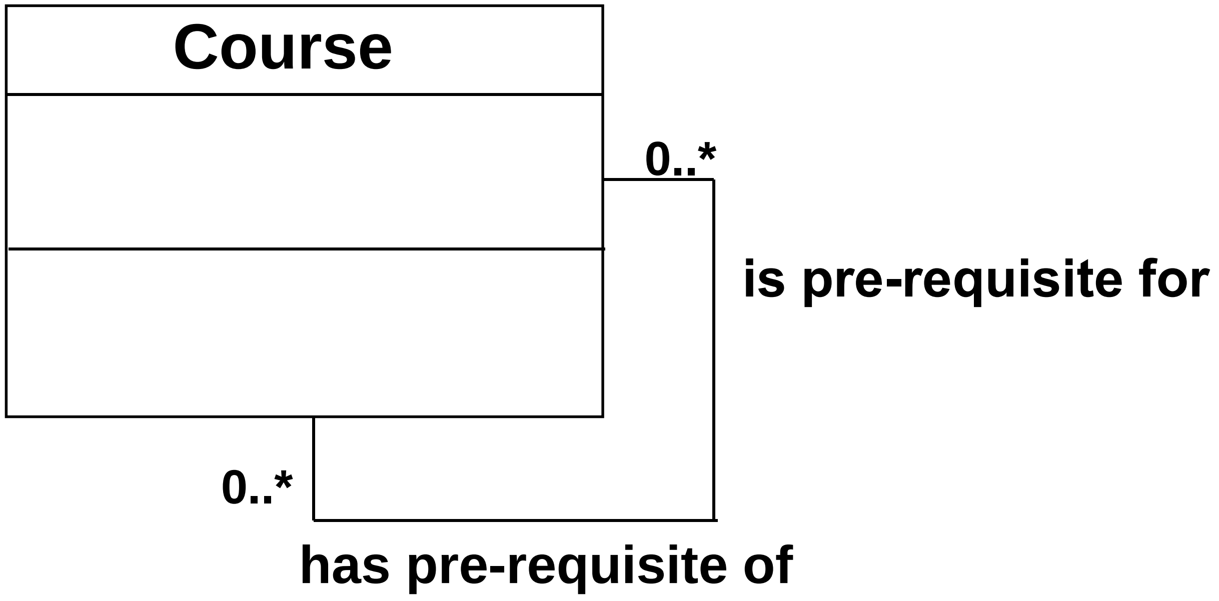
"many-to-many" multiplicity



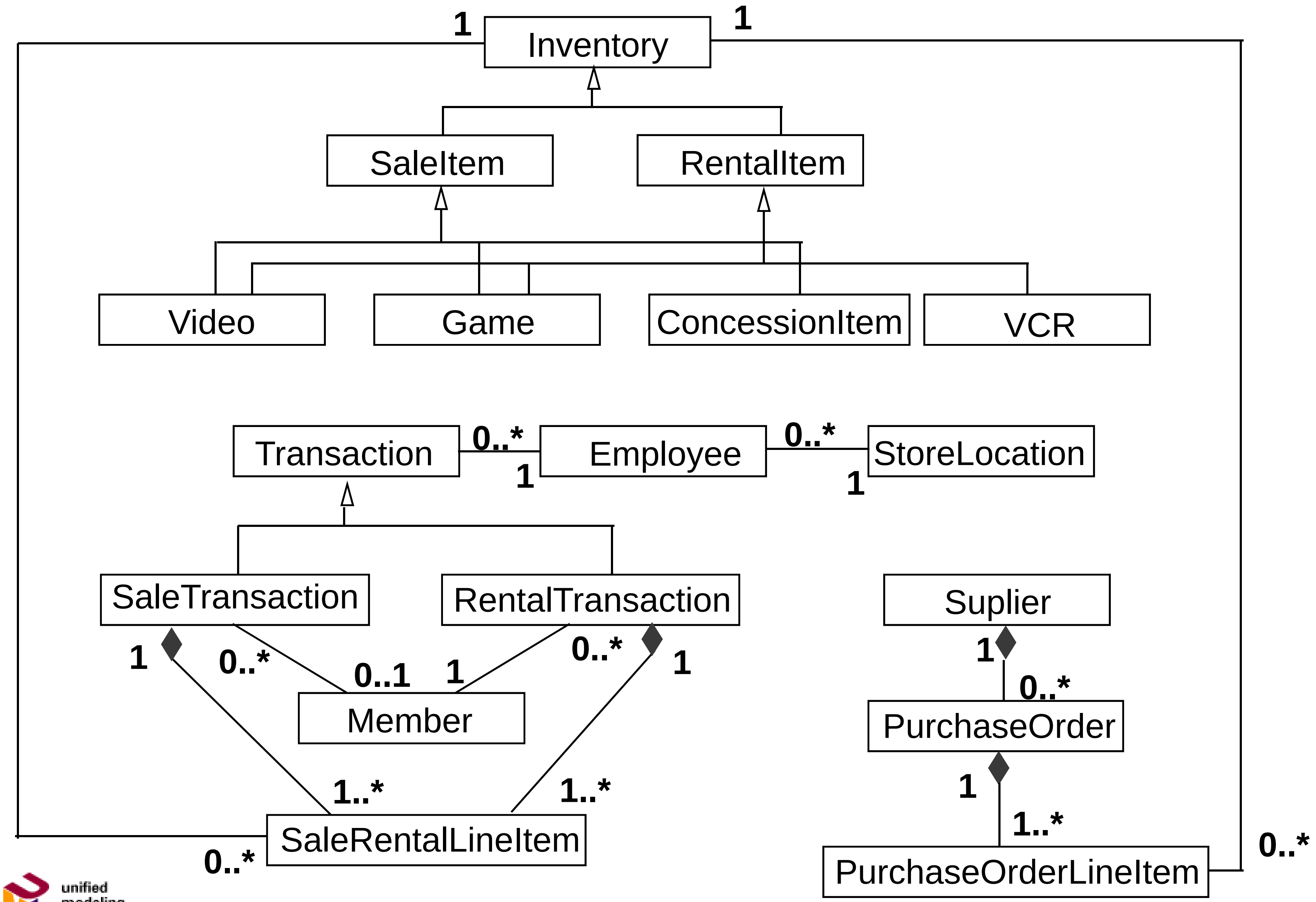
Attributes that represent the "union" of the two classes are located in this "association" class.

Reflexive Association Relationships

Objects within the same class have a relationship with each other.



Video Store – UML Class Diagram



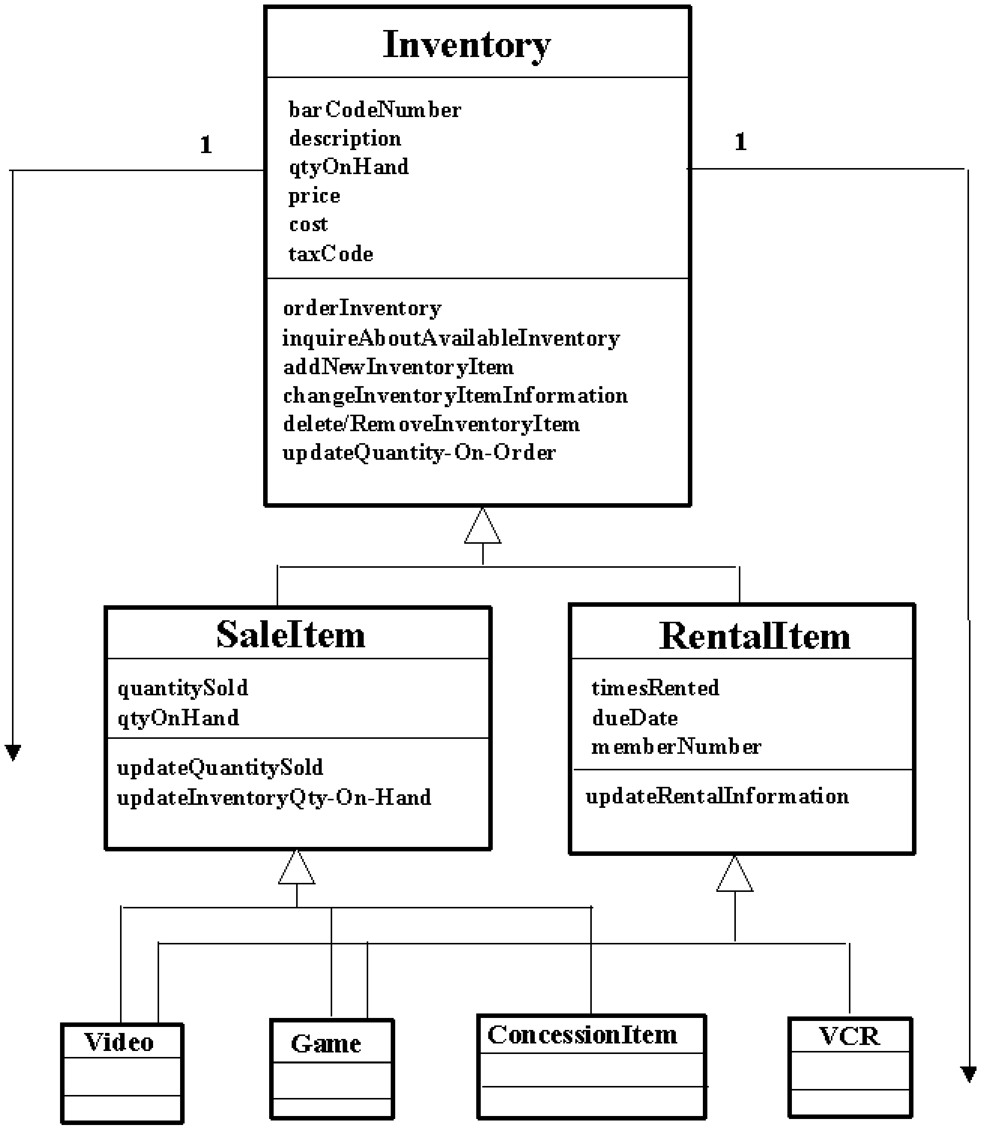


Figure 3.10a Video Store UML Class Diagram with Attributes & Operations

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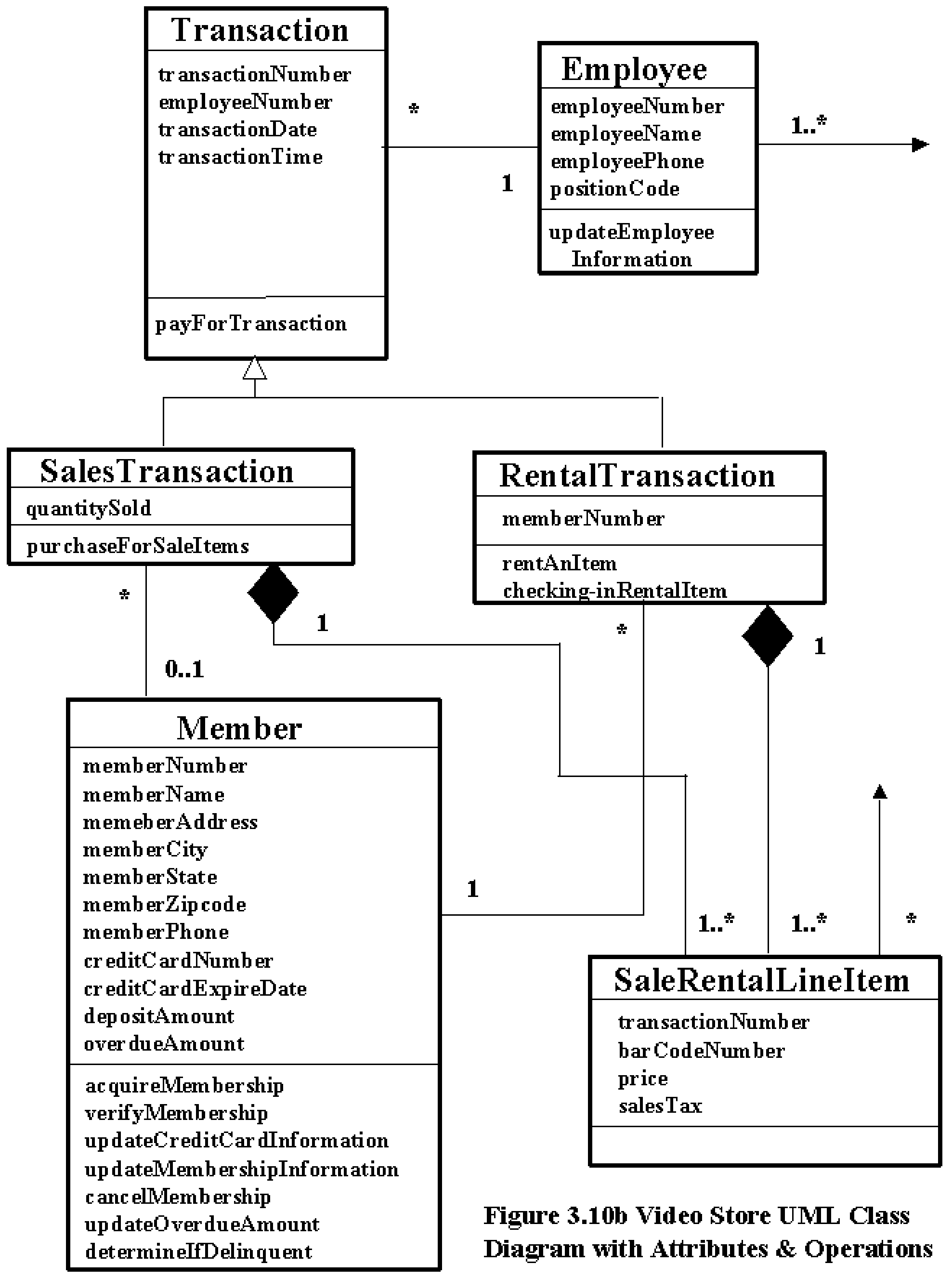

Figure 3.10b Video Store UML Class Diagram with Attributes & Operations

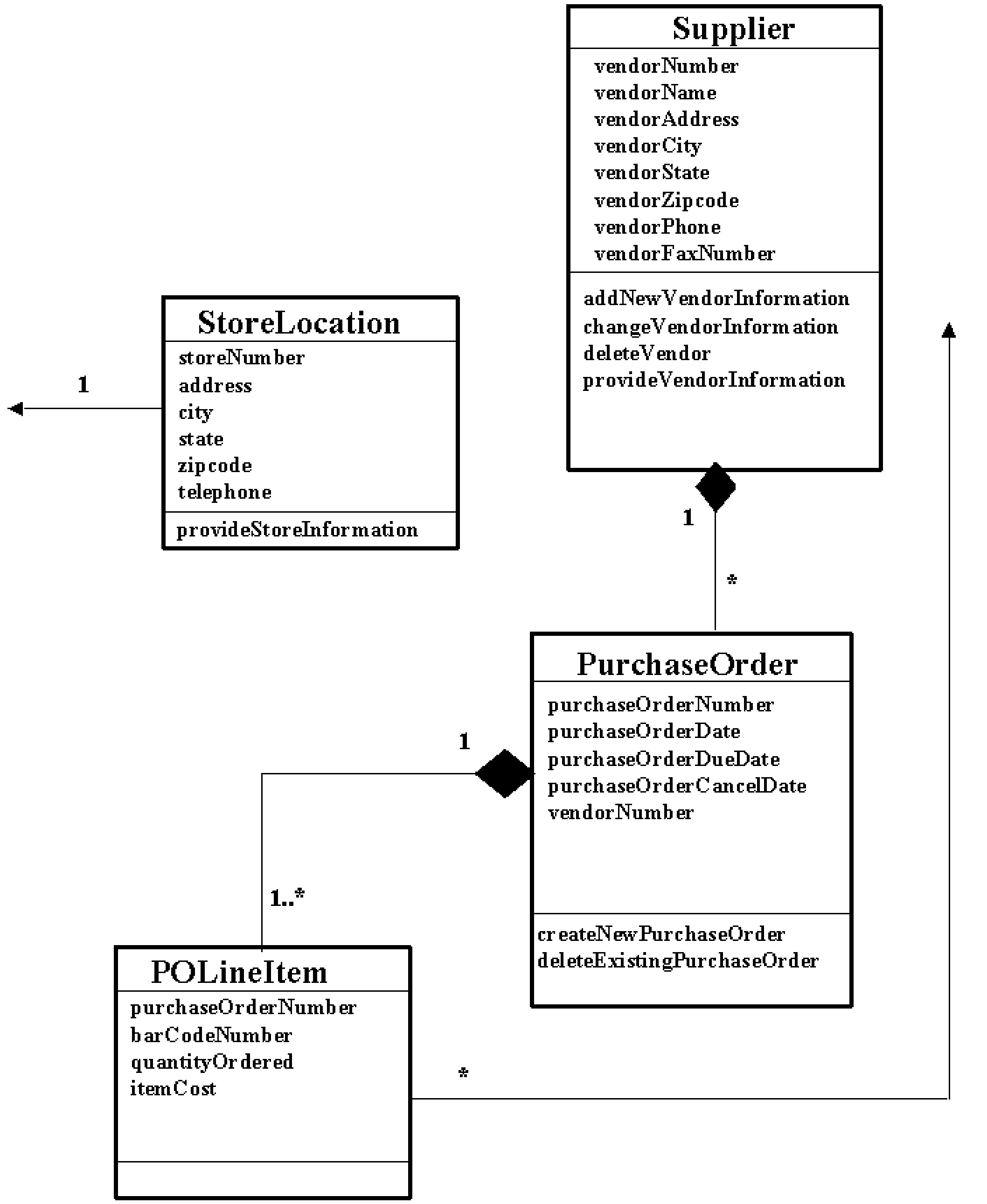

Figure 3.10c Video Store UML Class Diagram with Attributes & Operations

Now, apply the concepts in Java

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