# Object Oriented Analysis & Design


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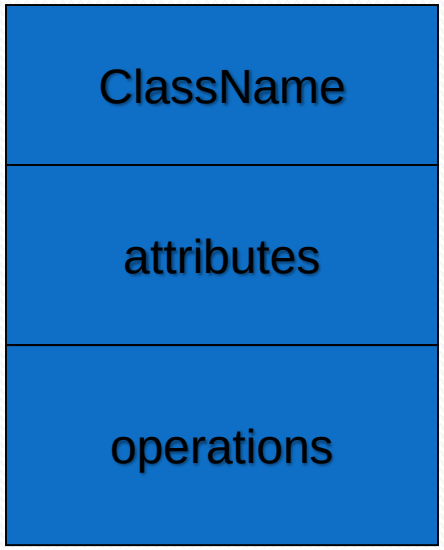
# Class Diagrams

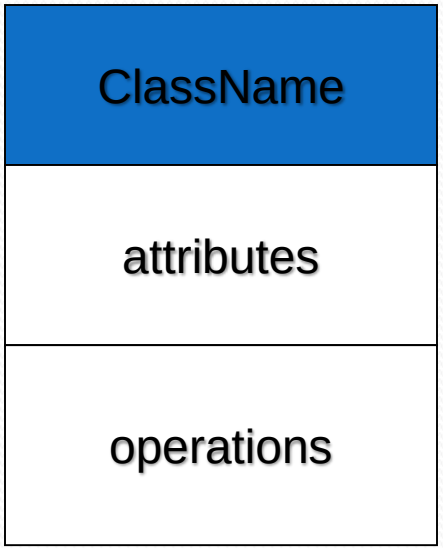
# Classes




A *class* is a description of a set of objects that share the same attributes, operations, relationships, and semantics.

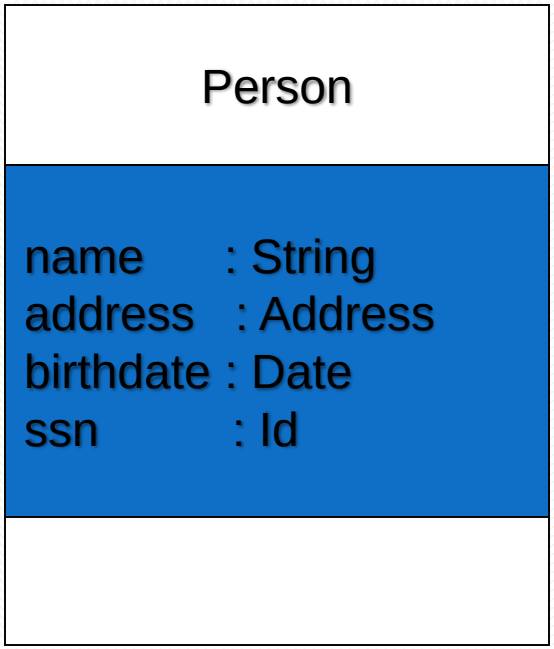
Graphically, a class is rendered as a rectangle, usually including its name, attributes, and operations in separate, designated compartments.

# Class Names



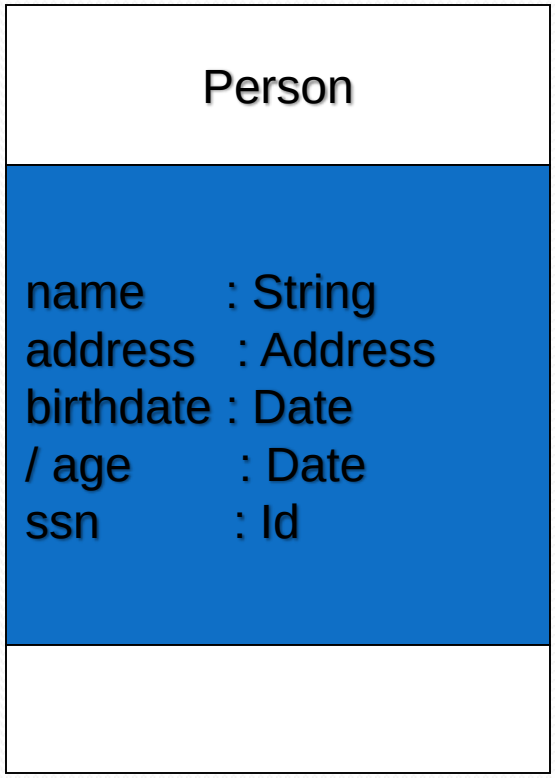

The name of the class is the only required tag in the graphical representation of a class. It always appears in the top-most compartment.

# Class Attributes




An *attribute* is a named property of a class that describes the object being modeled. In the class diagram, attributes appear in the second compartment just below the name-compartment.

# Class Attributes (Cont'd)



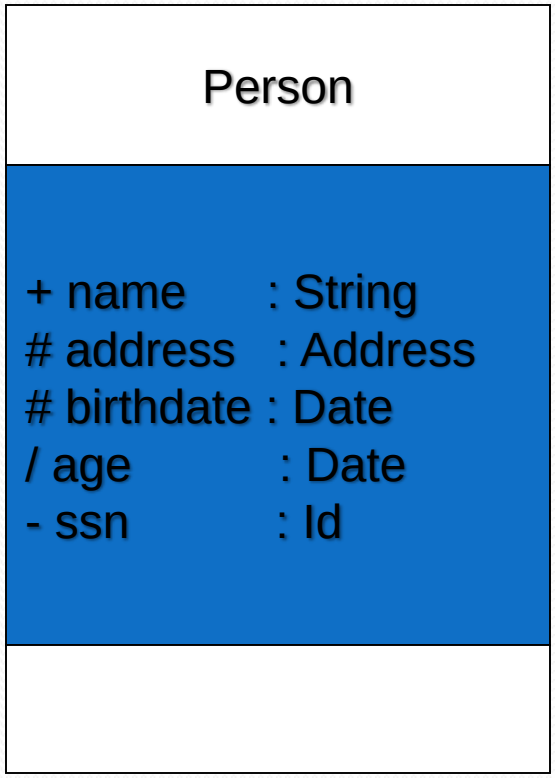

Attributes are usually listed in the form:

attributeName : Type

A *derived* attribute is one that can be computed from other attributes, but doesn't actually exist. For example, a Person's age can be computed from his birth date. A derived attribute is designated by a preceding '/' as in:

/ age : Date

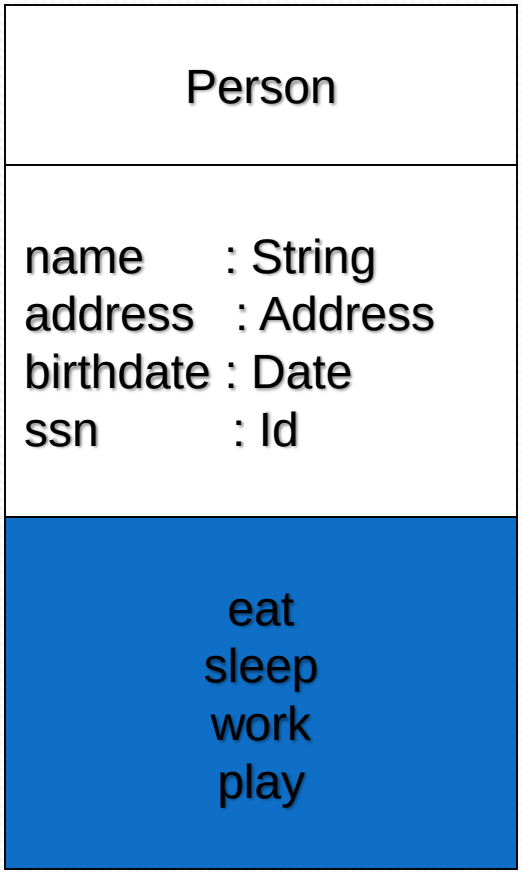
# Class Attributes (Cont'd)




Attributes can be:

+ public
# protected
- private
/ derived

# Class Operations




*Operations* describe the class behavior and appear in the third compartment.

# Class Operations (Cont'd)

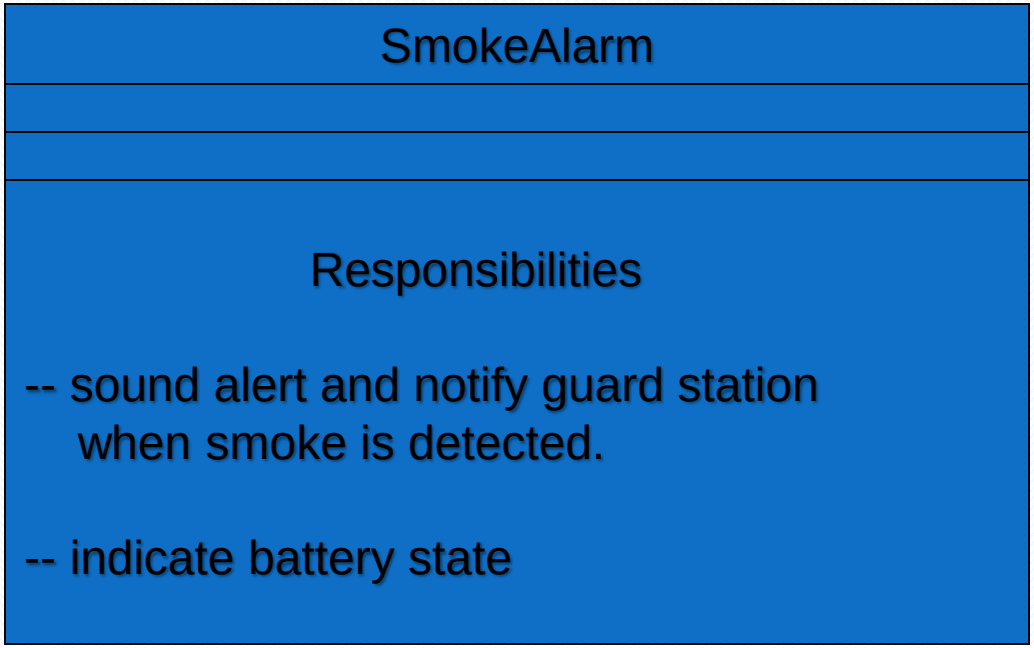
| PhoneBook |
| --- |
| |
| newEntry (n : Name, a : Address, p : PhoneNumber, d : Description)<br>getPhone ( n : Name, a : Address) : PhoneNumber |

You can specify an operation by stating its signature: listing the name, type, and default value of all parameters, and, in the case of functions, a return type.

# Class Responsibilities

A class may also include its responsibilities in a class diagram.

A responsibility is a contract or obligation of a class to perform a particular service.



# Relationships

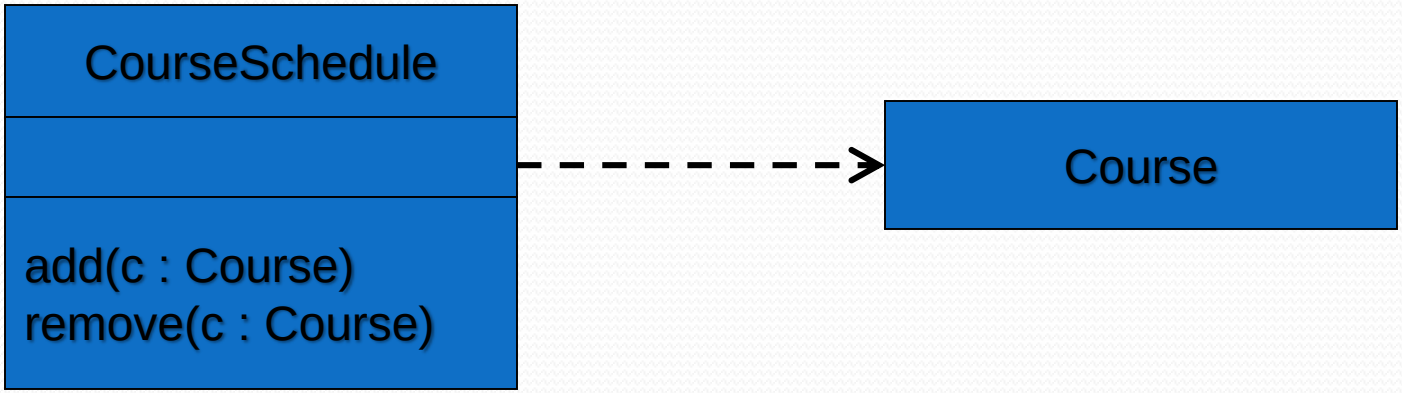
In UML, object interconnections (logical or physical), are modeled as relationships.

There are three kinds of relationships in UML:

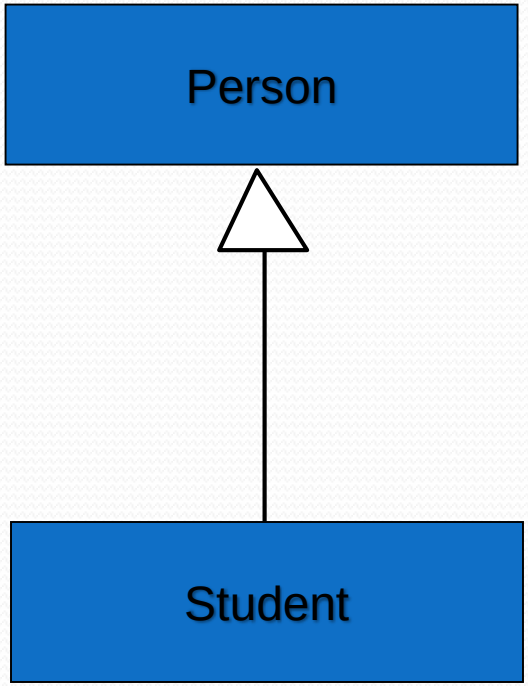
- dependencies
- generalizations
- associations

# Dependency Relationships

A *dependency* indicates a semantic relationship between two or more elements. The dependency from *CourseSchedule* to *Course* exists because *Course* is used in both the **add** and **remove** operations of *CourseSchedule*.



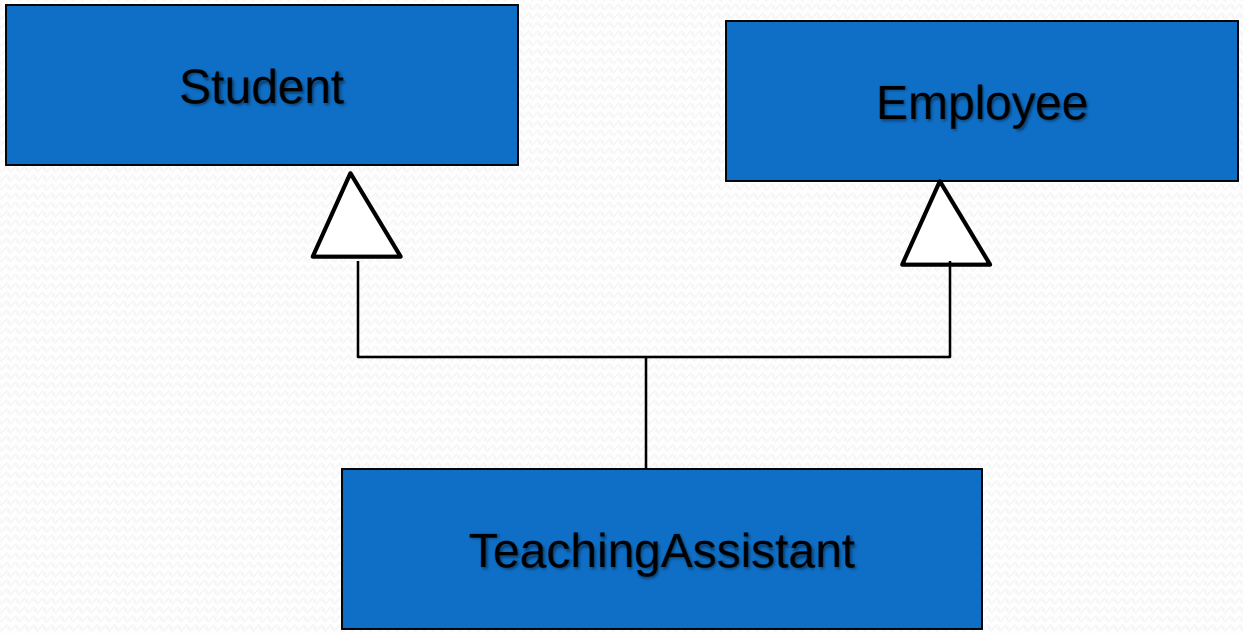
# Generalization Relationships




A *generalization* connects a subclass to its superclass. It denotes an inheritance of attributes and behavior from the superclass to the subclass and indicates a specialization in the subclass of the more general superclass.

# Generalization Relationships

UML permits a class to inherit from multiple superclasses, although some programming languages (*e.g.*, Java) do not permit multiple inheritance.



# Association Relationships

If two classes in a model need to communicate with each other, there must be link between them.

An *association* denotes that link.

# Association Relationships

We can indicate the ***multiplicity*** of an association by adding *multiplicity adornments* to the line denoting the association.

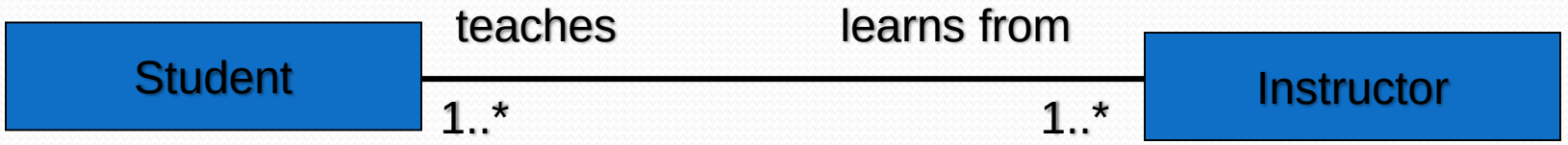
The example indicates that a *Student* has one or more *Instructors*:

# Association Relationships

The example indicates that every *Instructor* has one or more *Students*:

# Association Relationships

We can also indicate the behavior of an object in an association (*i.e.*, the *role* of an object)

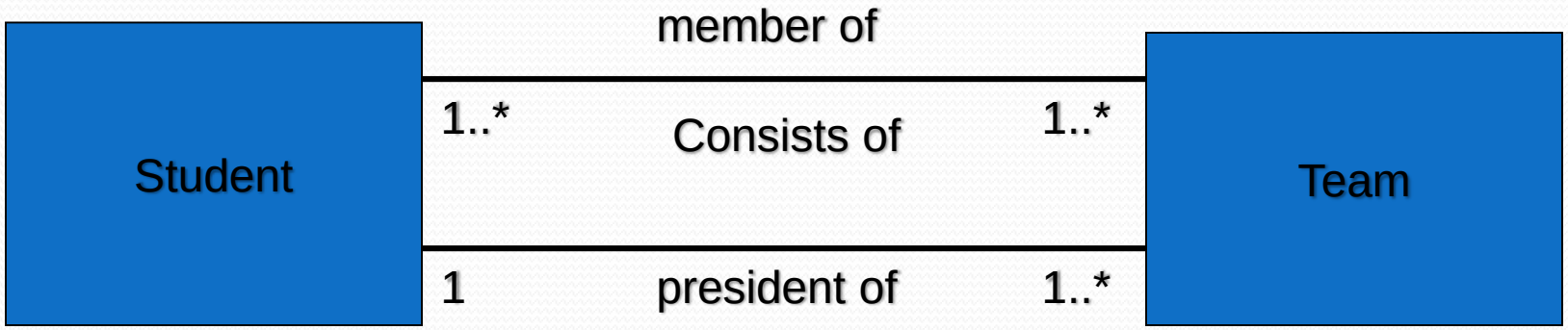


# Association Relationships

We can also name the association.

# Association Relationships

We can specify dual associations.

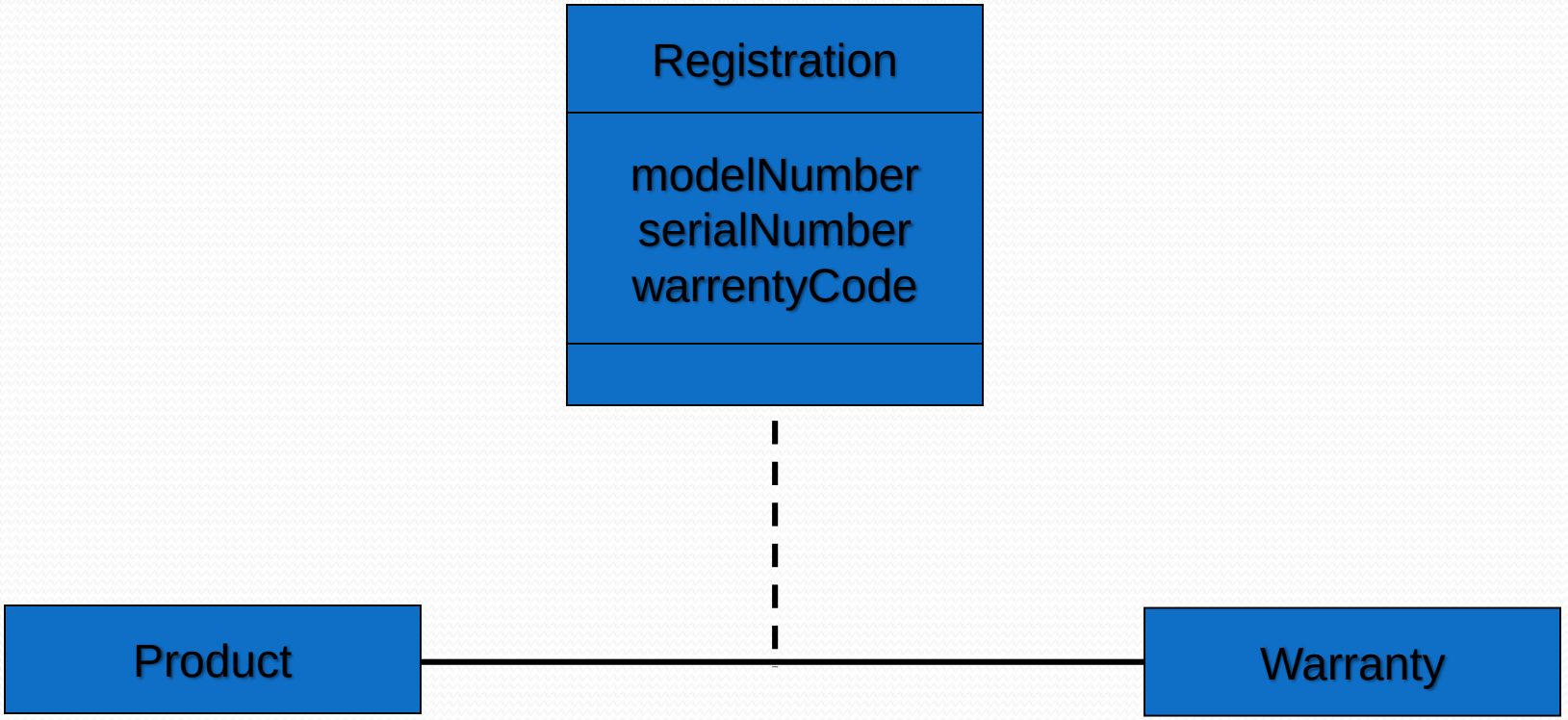


# Association Relationships

We can constrain the association relationship by defining the *navigability* of the association. Here, a *Router* object requests services from a *DNS* object by sending messages to (invoking the operations of) the server. The direction of the association indicates that the server has no knowledge of the *Router*.

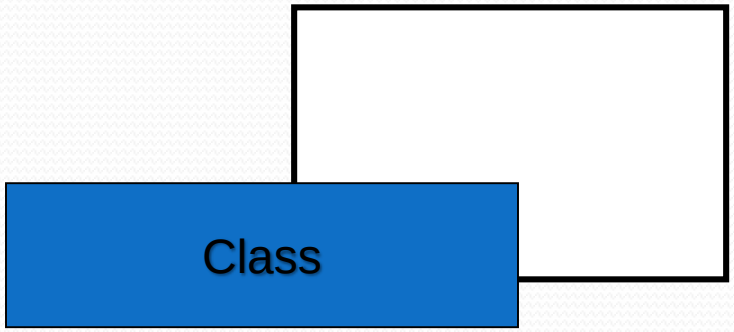
# Association Relationships

Associations can also be objects themselves, called *link classes* or an *association classes*.



# Association Relationships

A class can have a *self association*.

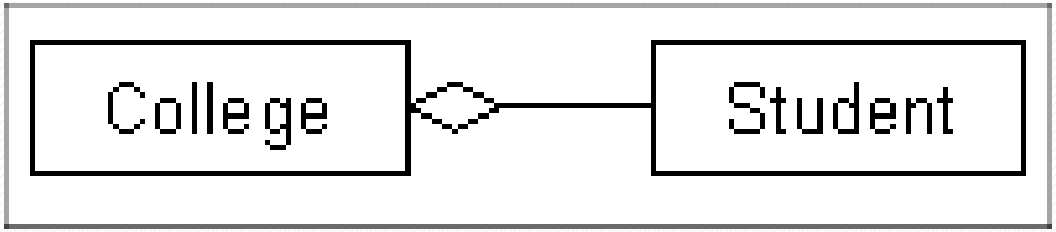


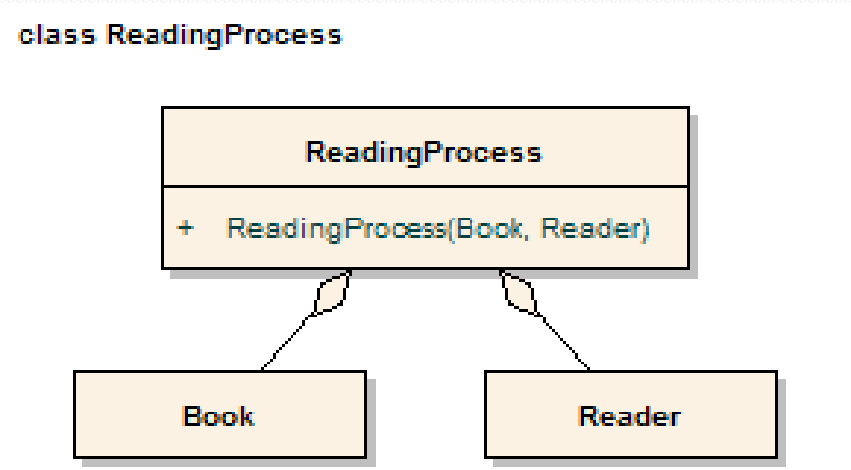

Two instances of the same class:
Pilot
Aviation engineer

# Association Relationships

We can model objects that contain other objects by way of special associations called *aggregations* and *compositions*.

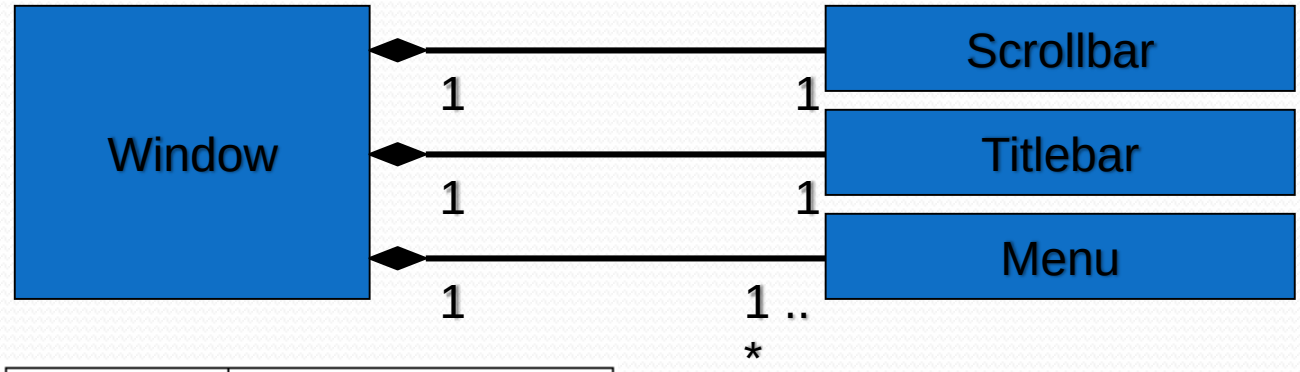
An *aggregation* specifies a whole-part relationship between an aggregate (a whole) and a constituent part, where the part can exist independently from the aggregate. Aggregations are denoted by a hollow-diamond adornment on the association.

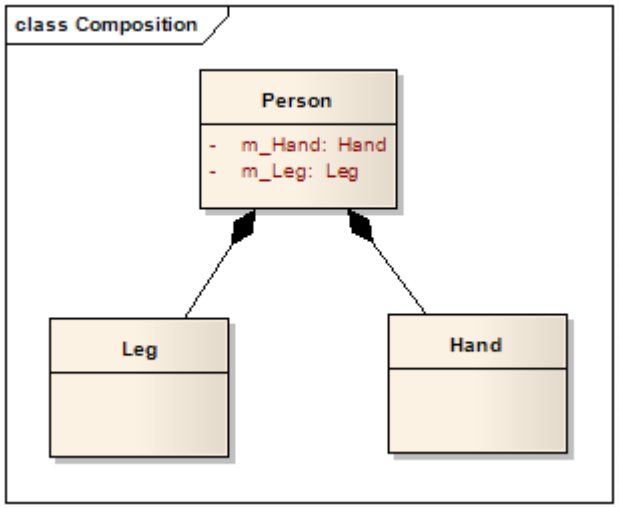


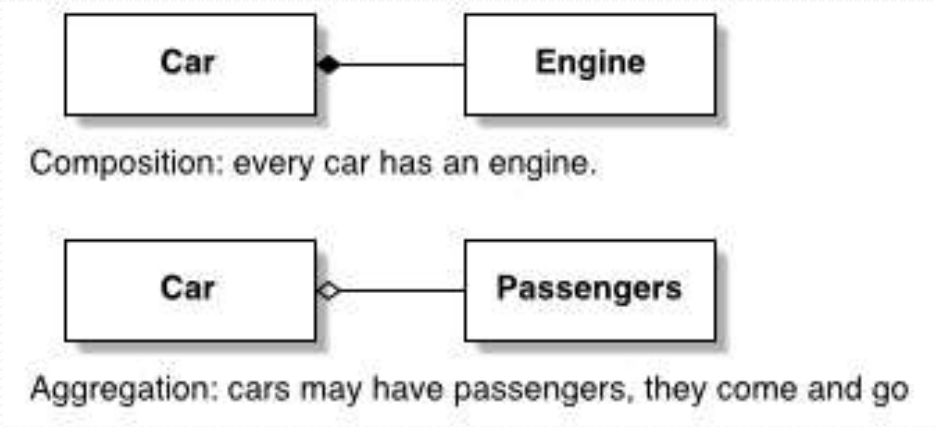



# Association Relationships

A *composition* indicates a strong ownership and coincident lifetime of parts by the whole (*i.e.*, they live and die as a whole). Compositions are denoted by a filled-diamond adornment on the association.



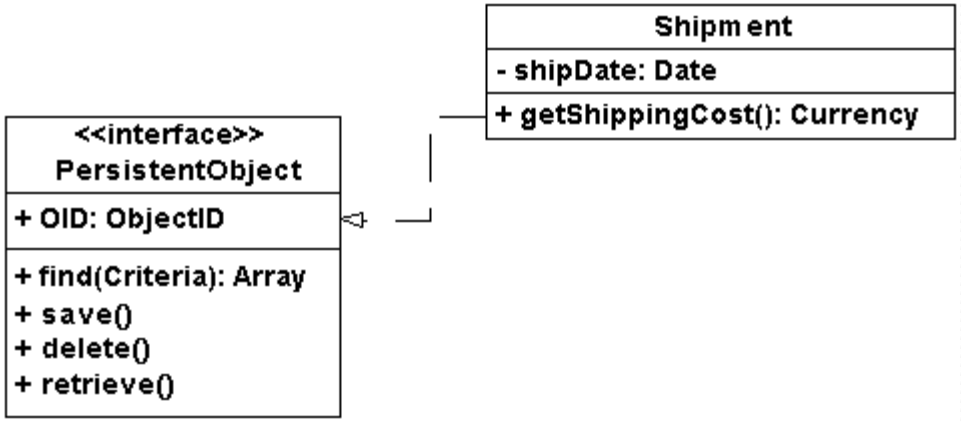



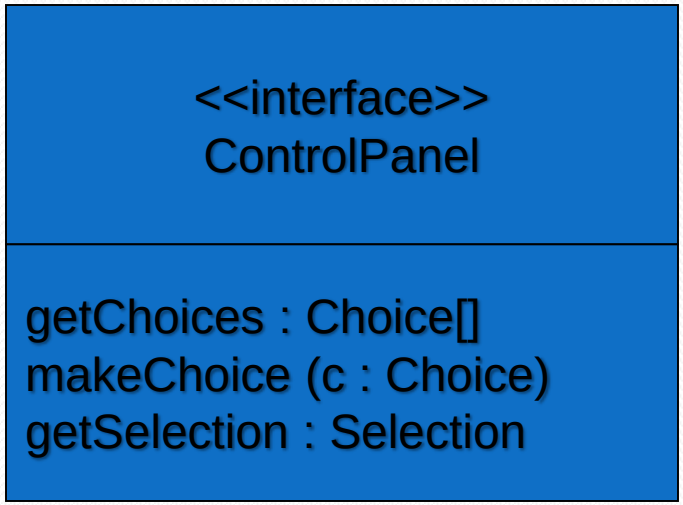
# Interfaces

<<interface>>
ControlPanel

An *interface* is a named set of operations that specifies the behavior of objects without showing their inner structure. It can be rendered in the model by a one- or two-compartment rectangle, with the *stereotype* <<interface>> above the interface name.

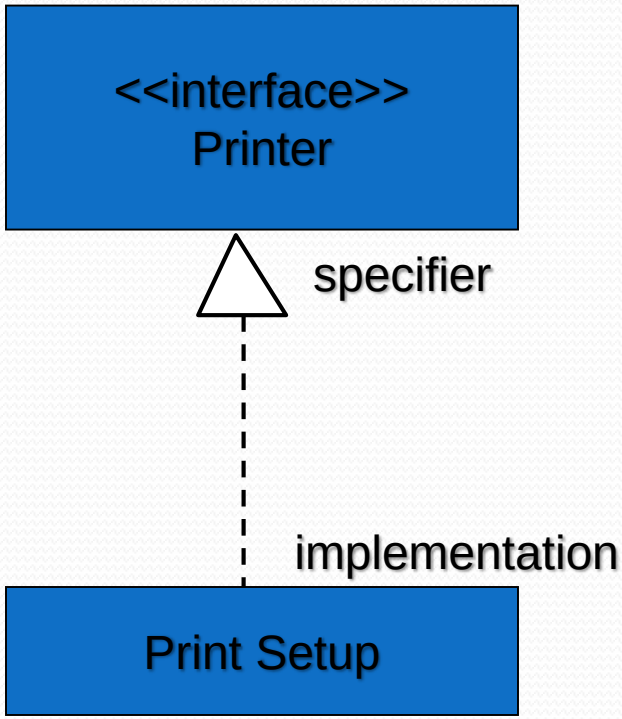


# Interface Services

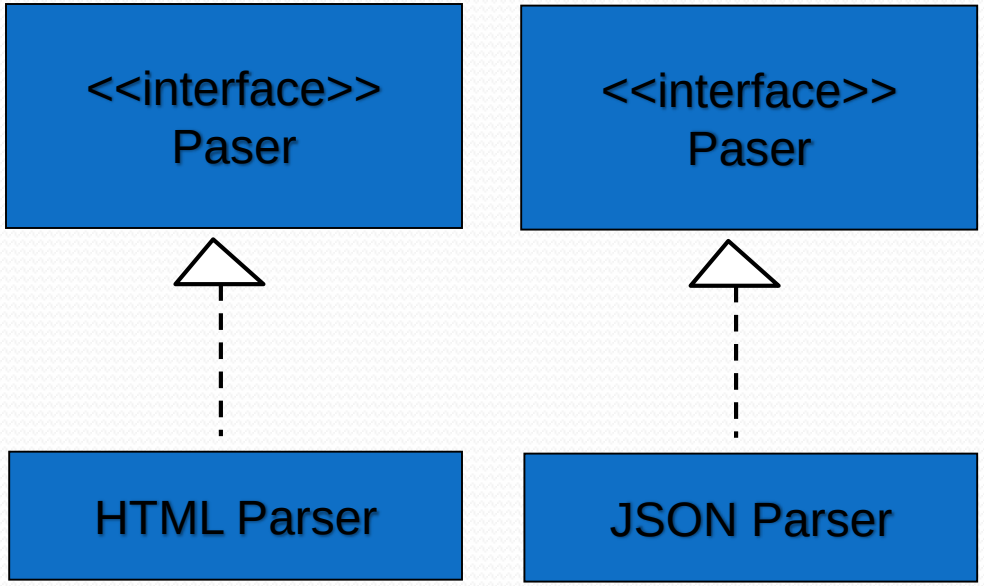



Interfaces do not get instantiated. They have no attributes or state. Rather, they specify the services offered by a related class.

# Interface Realization Relationship

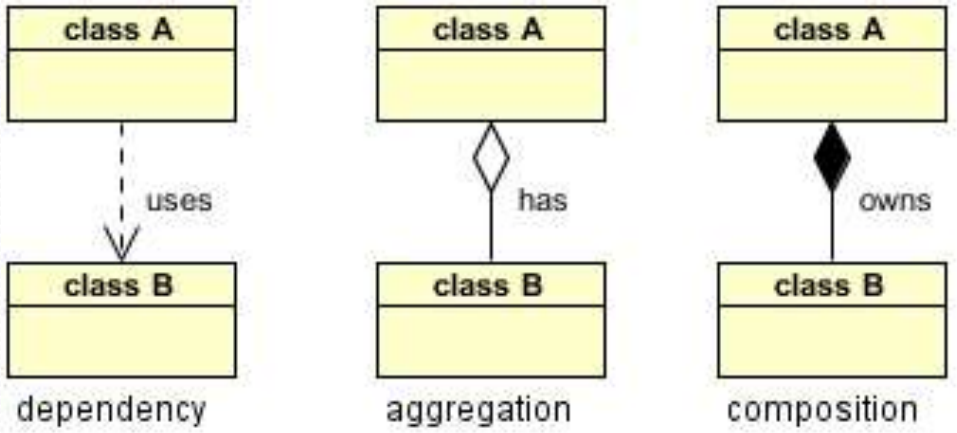


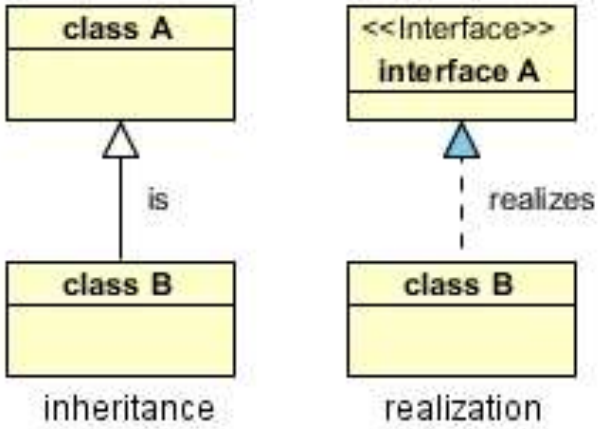

A *realization* relationship connects a class with an interface that supplies its behavioral specification. It is rendered by a dashed line with a hollow triangle towards the specifier.



# Relationships in Nutshell

- **Dependency** : class A uses class B
- **Aggregation** : class A has a class B
- **Composition** : class A owns a class B
- **Inheritance** : class B is a Class A (or class A is extended by class B)
- **Realization** : class B realizes Class A (or class A is realized by class B)



# Dependency

- **Dependency** is represented when a reference to one class is passed in as a method parameter to another class. For example, an instance of class B is passed in to a method of class A:

```
1public class A {
2
3    public void doSomething(B b) {
```

# Aggregation

- Now, if class A stored the reference to class B for later use we would have a different relationship called **Aggregation**. A more common and more obvious example of Aggregation would be via setter injection:

```
1public class A {
2
3    private B _b;
4
5    public void setB(B b) { _b = b; }
```

# Composition

- Aggregation is the weaker form of object containment (one object contains other objects). The stronger form is called **Composition**. In Composition the containing object is responsible for the creation and life cycle of the contained object (either directly or indirectly). Following are a few examples of Composition. First, via member initialization:

```
1public class A {
2
3    private B _b = new B();
```

```
1public class A {
2
3    private B _b;
4
5    public A() {
6        _b = new B();
7    } // default constructor
```

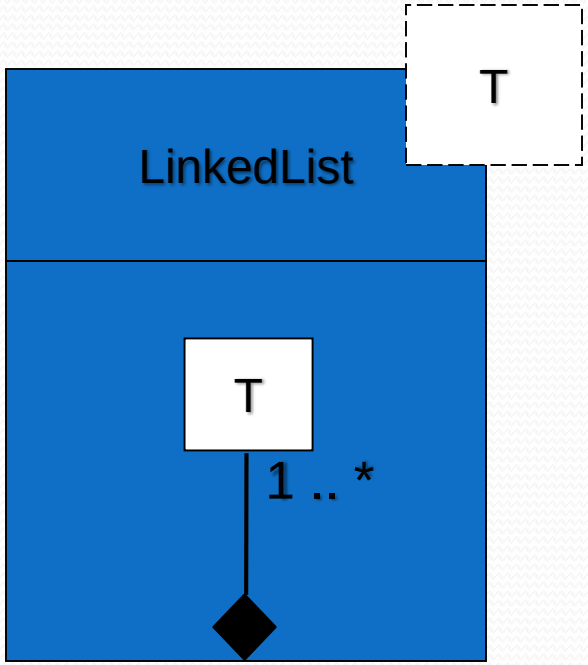
# Inheritance

```
 1public class A {
 2
 3    ...
 4
 5} // class A
 6
 7public class B extends A {
 8
 9    ....
10
11} // class B
```

# Realization

```
 1public interface A {
 2
 3    ...
 4
 5} // interface A
 6
 7public class B implements A {
 8
 9    ...
10
11} // class B
```

# Parameterized Class

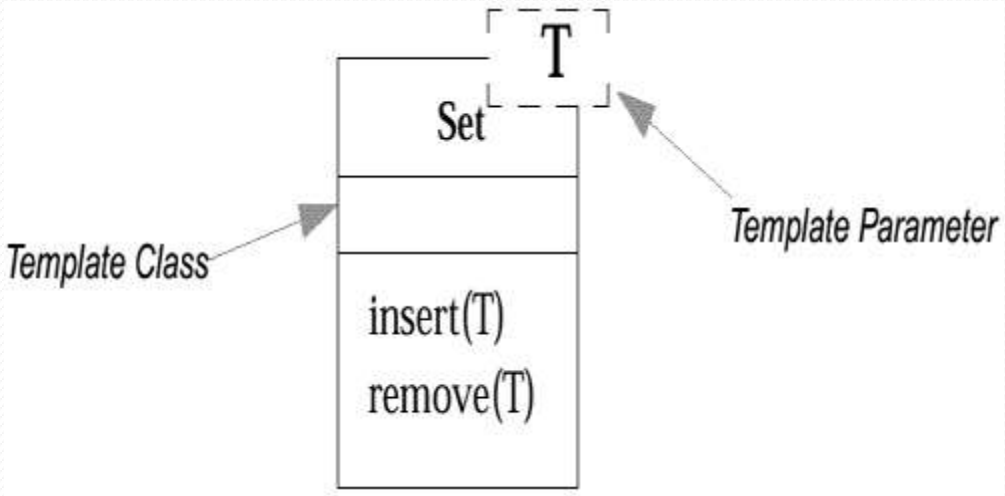



A *parameterized class* or *template* defines a family of potential elements.

To use it, the parameter must be bound.

A *template* is rendered by a small dashed rectangle superimposed on the upper-right corner of the class rectangle. The dashed rectangle contains a list of formal parameters for the class.

# Example : Parameterized Class



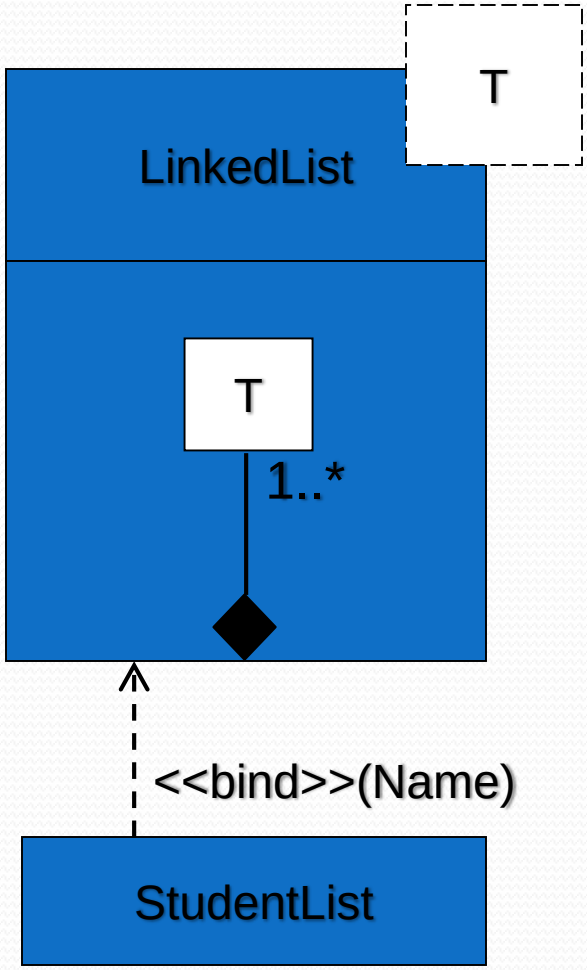

```
class Set <T> {
        void insert (T newElement);
        void remove (T anElement);
```

# Parameterized Class (Cont'd)

- Some object-oriented languages such as C++ and Ada support the concept of parametrized classes.
- They are most commonly used for the element type of collection classes, such as the elements of lists.
- For example, in Java, suppose that a *Board* software object holds a *List* of many *Squares*. And, the concrete class that implements the *List* interface is an *ArrayList*:

```
public class Board
{
private List<Square> squares = new ArrayList<Square>();
// …
}
```

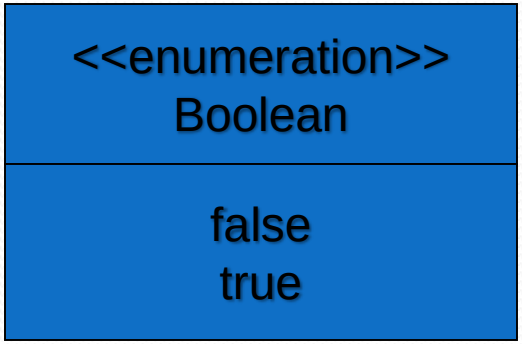
# Parameterized Class (Cont'd)




*Binding* is done with the <<bind>> stereotype and a parameter to supply to the template. These are adornments to the dashed arrow denoting the realization relationship.

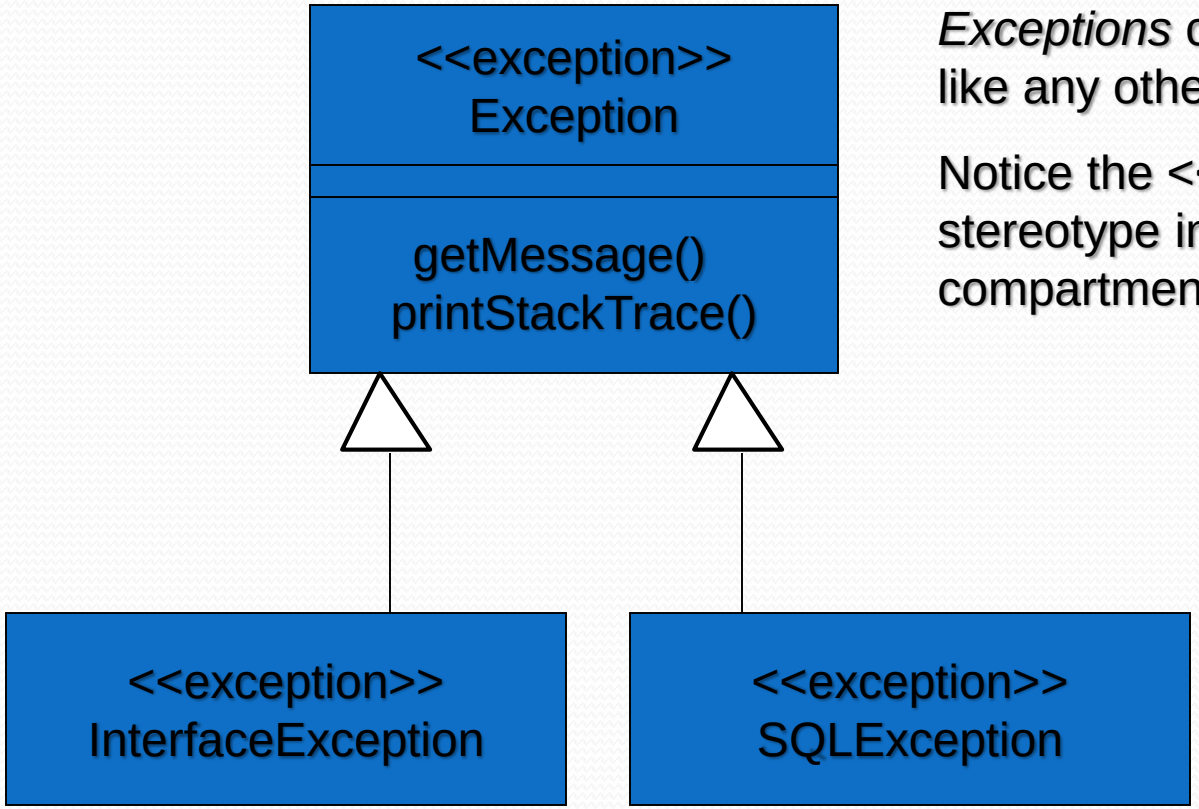
Here we create a linked-list of names for the Students List.

# Enumeration




An *enumeration* is a user-defined data type that consists of a name and an ordered list of enumeration literals.

# Exceptions

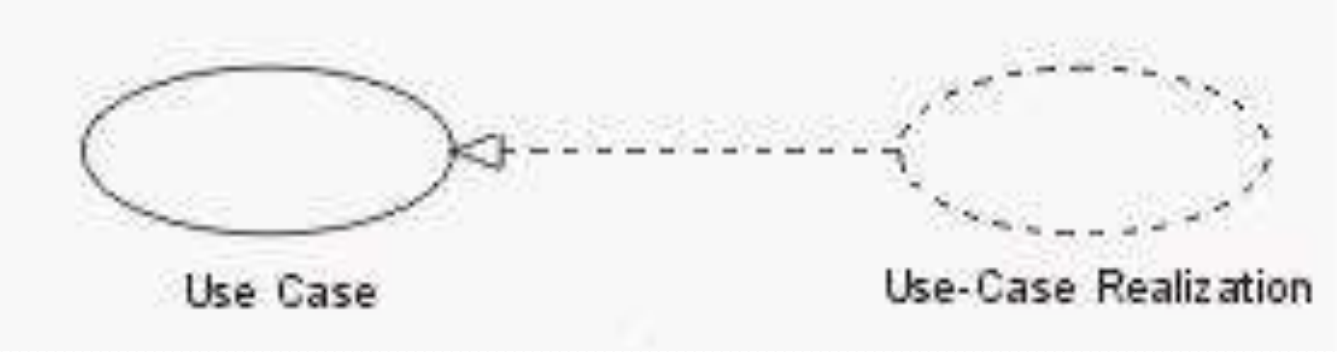



*Exceptions* can be modeled just like any other class.

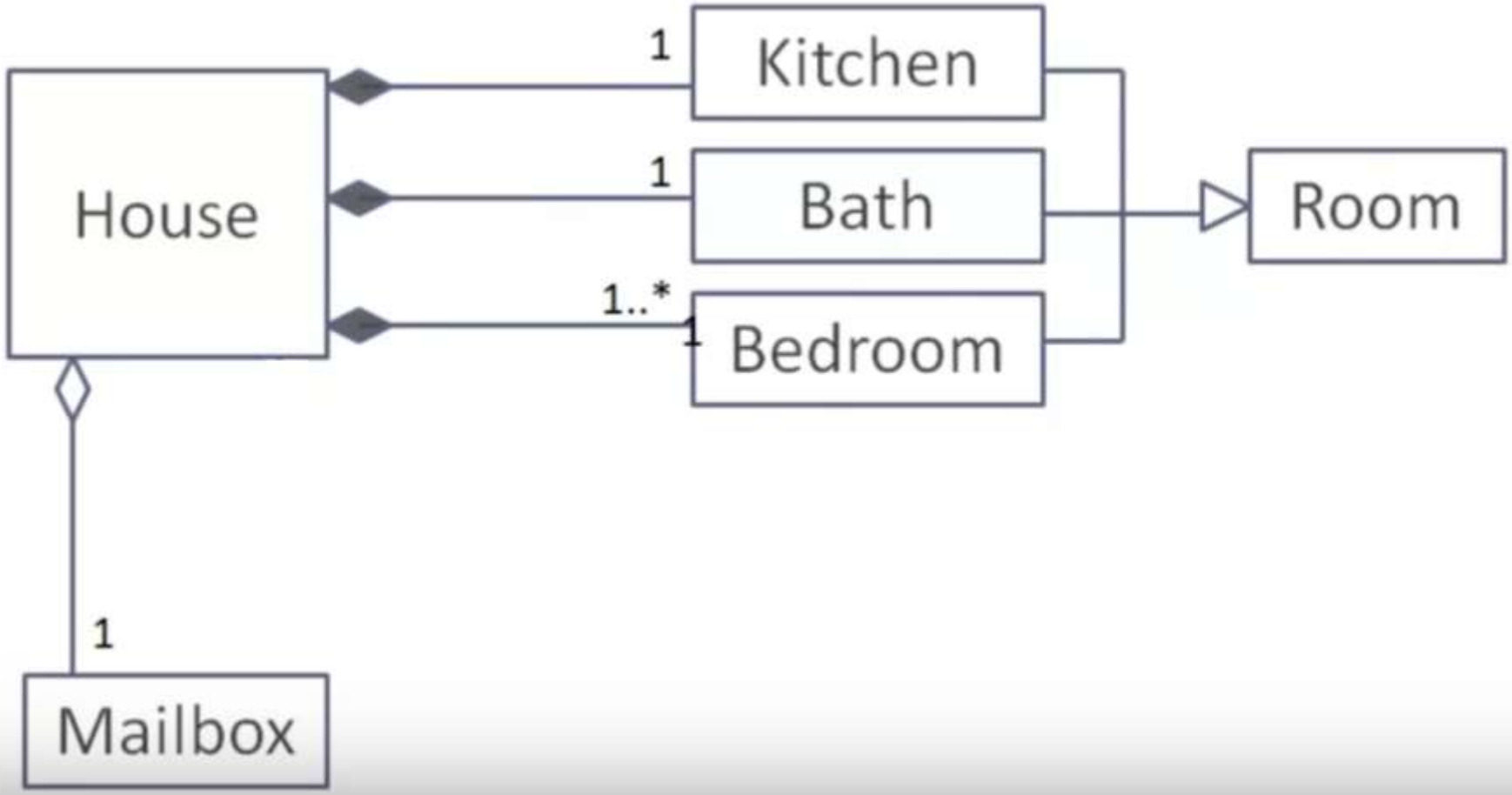
Notice the <<exception>> stereotype in the name compartment.

# Use Case Realization?

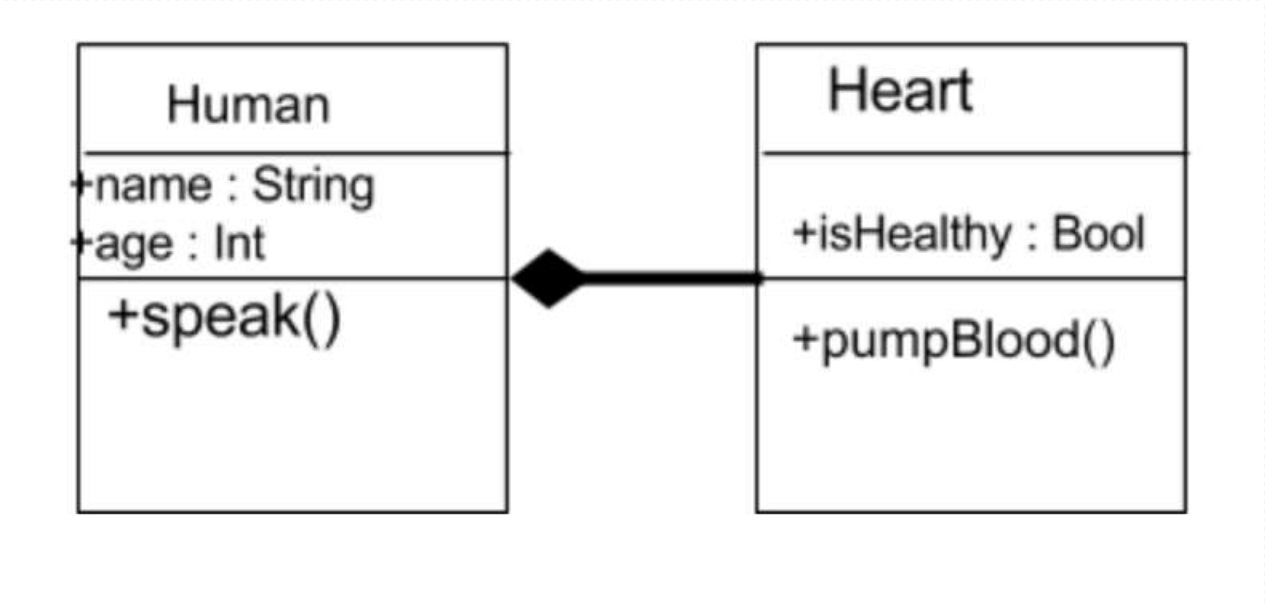
- Each use case realization will define the physical design in terms of classes and collaborating objects which support the use case. Therefore, each use case realization typically is made up of a class diagram and a number of interaction diagrams, most commonly sequence diagrams, showing the collaboration or interaction between physical objects.

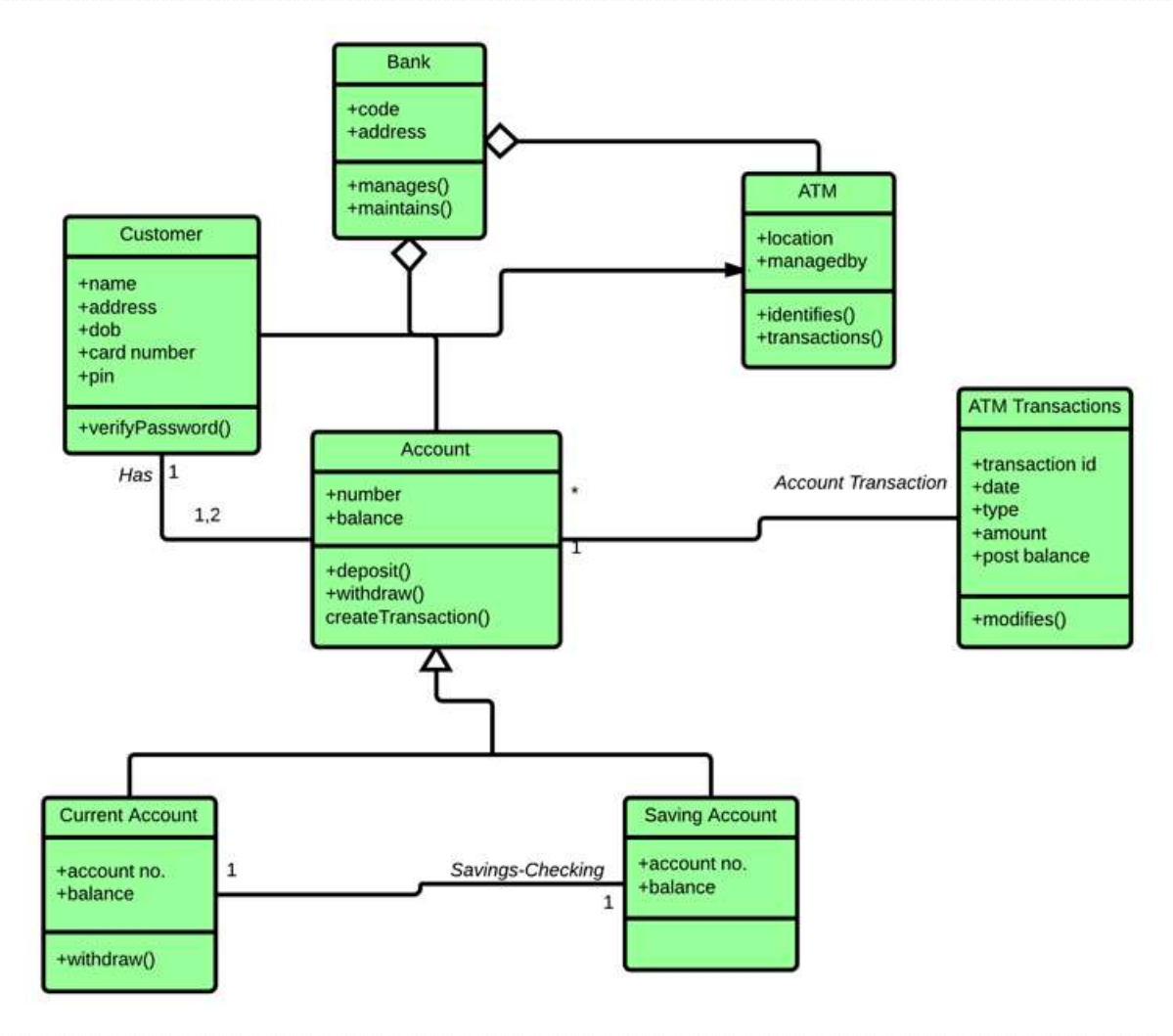


# Class discussion



# Class discussion



# Homework:

- Write java code for this class diagram