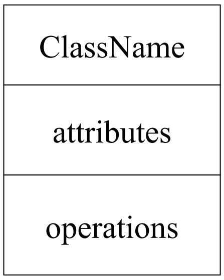
Software Design

Static Modeling using the Unified Modeling Language (UML)

Material based on
[Booch99, Rambaugh99, Jacobson99, Fowler97, Brown99]

Classes


ClassName

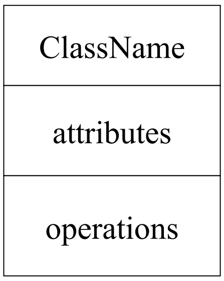
attributes

operations

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

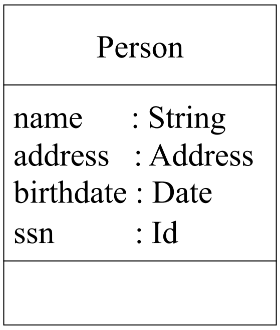
Graphically, a class is rendered as a rectangle, usually including its name, attributes, and operations in separate, designated compartments.

Class Names



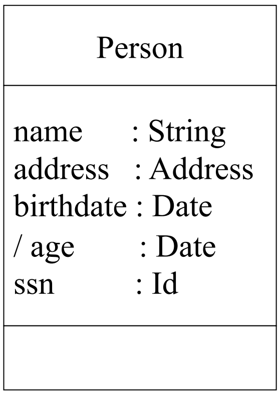
The name of the class is the only required tag in the graphical representation of a class. It always appears in the top-most compartment.

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)



Person

name : String
address : Address
birthdate : Date
/ age : Date
ssn : Id

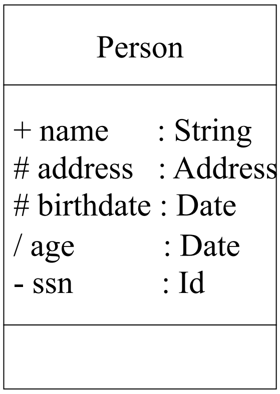
Attributes are usually listed in the form:

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)



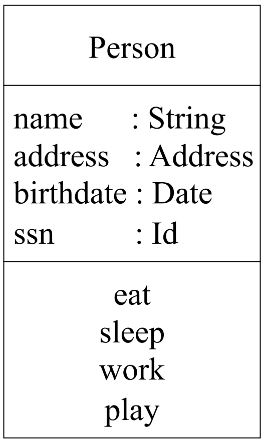
Person

+ name : String
# address : Address
# birthdate : Date
/ age : Date
- ssn : Id

Attributes can be:

+ public
# protected
- private
/ derived

Class Operations



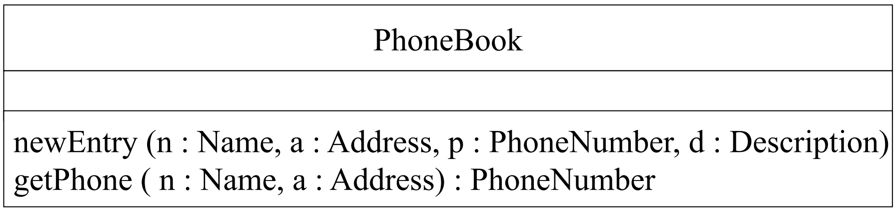
Person

name : String
address : Address
birthdate : Date
ssn : Id

eat
sleep
work
play

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

Class Operations (Cont'd)



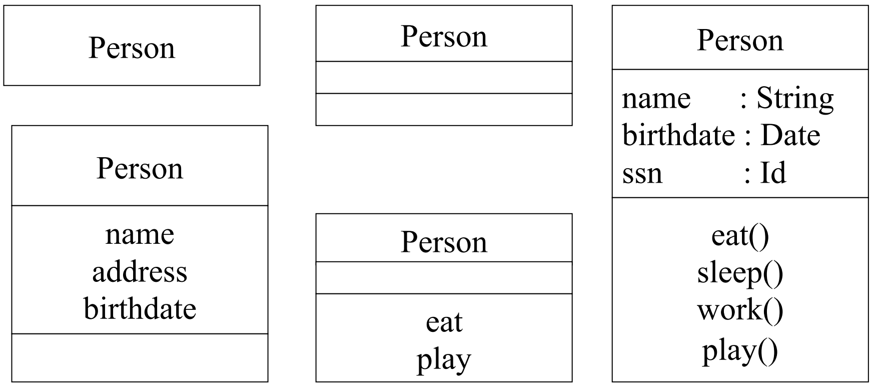
PhoneBook

newEntry (n : Name, a : Address, p : PhoneNumber, d : Description)
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.

Depicting Classes

When drawing a class, you needn't show attributes and operation in every diagram.



Person

Person

Person

name : String
birthdate : Date
ssn : Id

eat()
sleep()
work()
play()

Person

name
address
birthdate

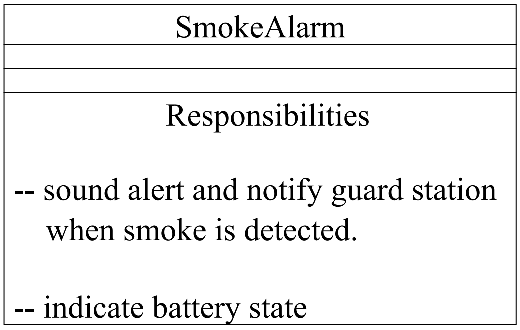
Person

eat
play

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.



SmokeAlarm

Responsibilities

-- sound alert and notify guard station when smoke is detected.

-- indicate battery state

Relationships

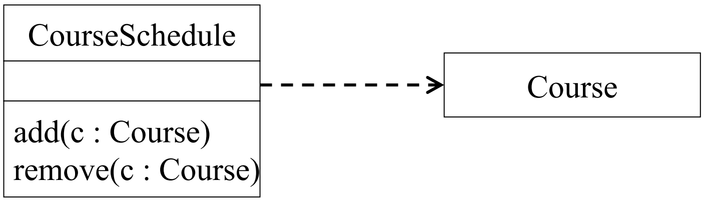
In UML, object interconnections (logical or physical), are modeled as relationships.

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*.

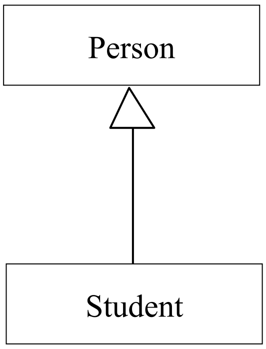


CourseSchedule

add(c : Course)
remove(c : Course)

Course

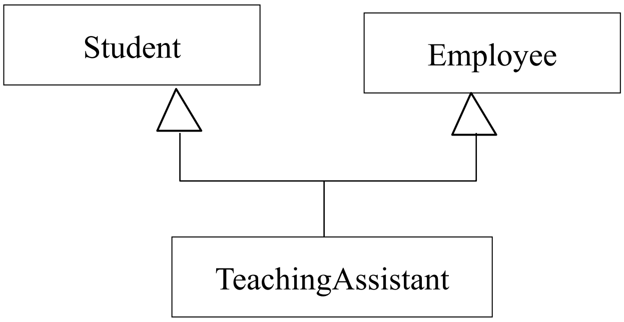
Generalization Relationships



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 (Cont'd)

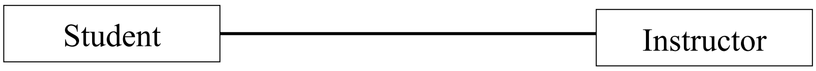
UML permits a class to inherit from multiple superclasses, although some programming languages do not permit multiple inheritance.



Association Relationships

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

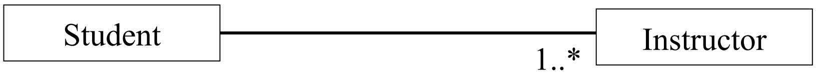
An *association* denotes that link.



Association Relationships (Cont'd)

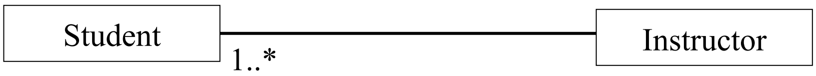
We can indicate the *multiplicity* of an association by adding *multiplicity adornments* to the line denoting the association.

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



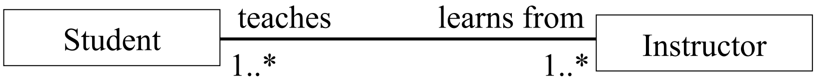
Association Relationships (Cont'd)

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



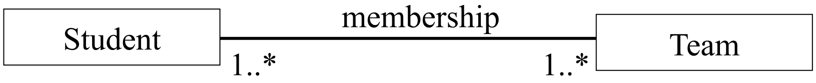
Association Relationships (Cont'd)

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



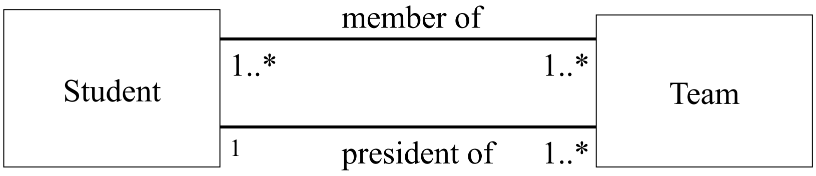
Association Relationships (Cont'd)

We can also name the association.



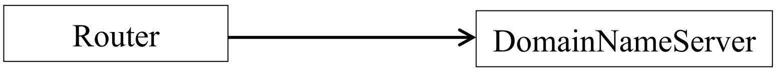
Association Relationships (Cont'd)

We can specify dual associations.



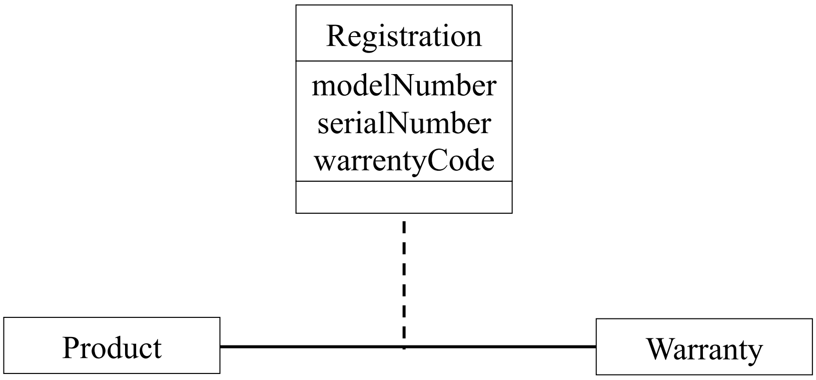
Association Relationships (Cont'd)

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*.



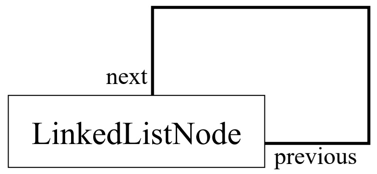
Association Relationships (Cont'd)

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



Association Relationships (Cont’d)

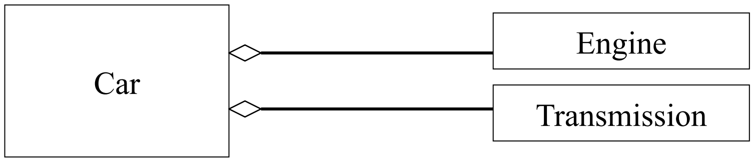
A class can have a *self association*.



Association Relationships (Cont’d)

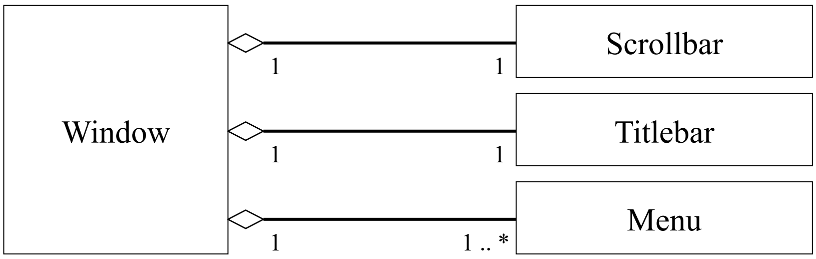
We can model objects that contain other objects by way of special associations called *aggregations* and *compositions.*

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.

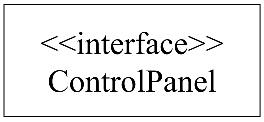


Association Relationships (Cont'd)

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.

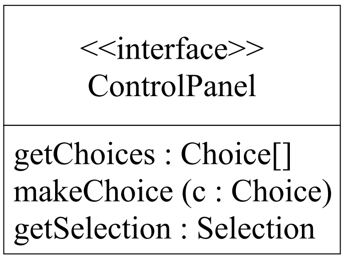


Interfaces



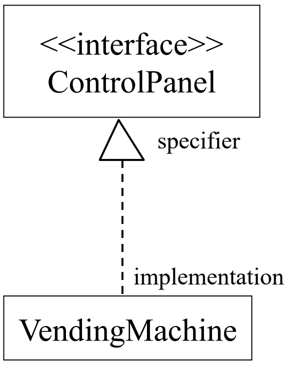
An *interface* is a named set of operations that specifies the behavior of objects without showing their inner structure. It can be rendered in the model by a one- or two-compartment rectangle, with the *stereotype* <<interface>> above the interface name.

Interface Services



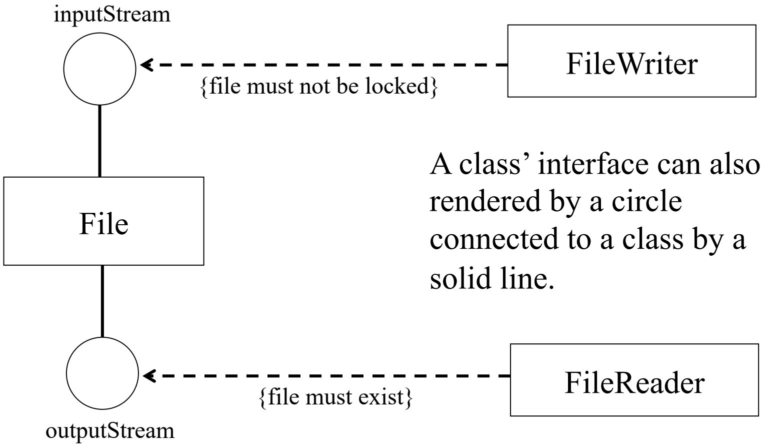
Interfaces do not get instantiated. They have no attributes or state. Rather, they specify the services offered by a related class.

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.

Interfaces



inputStream

FileWriter

{file must not be locked}

File

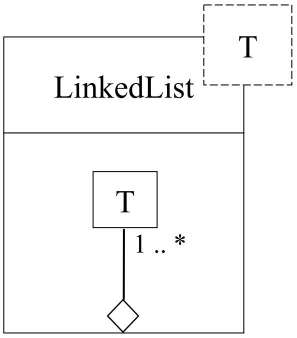
FileReader

{file must exist}

outputStream

A class' interface can also be rendered by a circle connected to a class by a solid line.

Parameterized Class



T

LinkedList

T

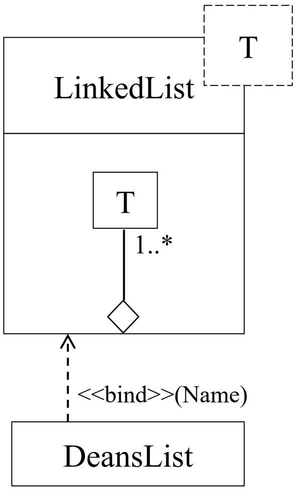
1 .. *

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.

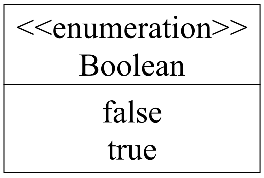
Parameterized Class (Cont'd)



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.

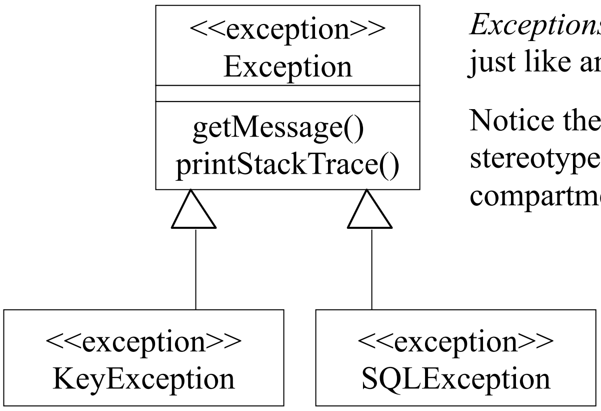
Here we create a linked-list of names for the Dean's List.

Enumeration



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

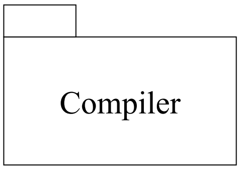
Exceptions



Exceptions can be modeled just like any other class.

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

Packages



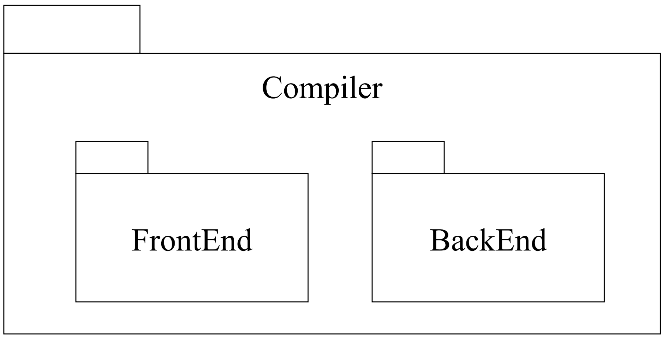
A *package* is a container-like element for organizing other elements into groups.

A package can contain classes and other packages and diagrams.

Packages can be used to provide controlled access between classes in different packages.

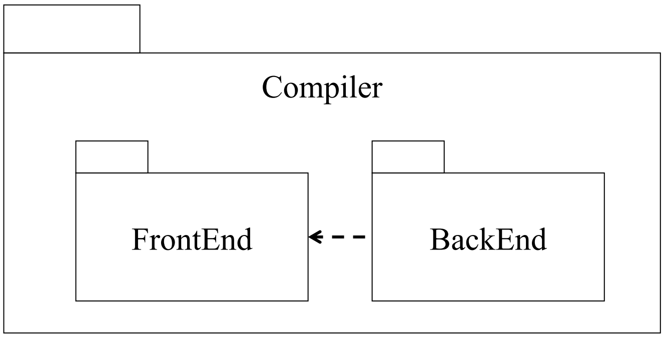
Packages (Cont'd)

Classes in the *FrontEnd* package and classes in the *BackEnd* package cannot access each other in this diagram.

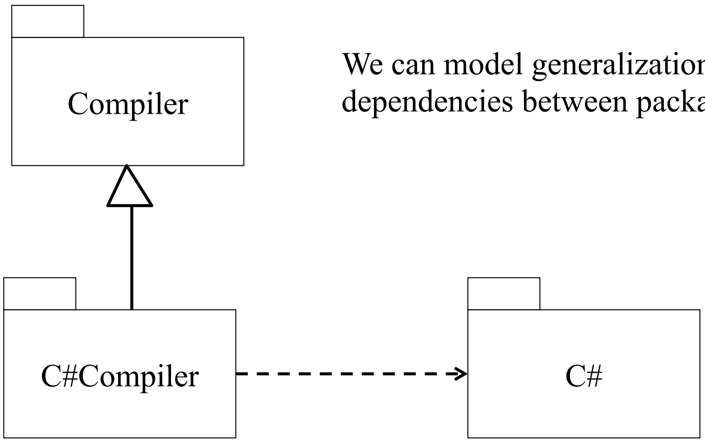


Packages (Cont'd)

Classes in the *BackEnd* package now have access to the classes in the *FrontEnd* package.



Packages (Cont'd)



We can model generalizations and dependencies between packages.