Object-Oriented Software Engineering

Practical Software Development using UML and Java

Chapter 6:

Using Design Patterns

6.1 Introduction to Patterns

The recurring aspects of designs are called *design patterns.*

- A *pattern* is the outline of a reusable solution to a general problem encountered in a particular context
- Many of them have been systematically documented for all software developers to use
- A good pattern should
  - —Be as general as possible
  - —Contain a solution that has been proven to effectively solve the problem in the indicated context.

Studying patterns is an effective way to learn from the experience of others

Pattern description

Context:

- The general situation in which the pattern applies

Problem:

—A short sentence or two raising the main difficulty.

Forces:

- The issues or concerns to consider when solving the problem

Solution:

- The recommended way to solve the problem in the given context.
  - —'to balance the forces'

Antipatterns: (Optional)

- Solutions that are inferior or do not work in this context.

Related patterns: (Optional)

- Patterns that are similar to this pattern.

References:

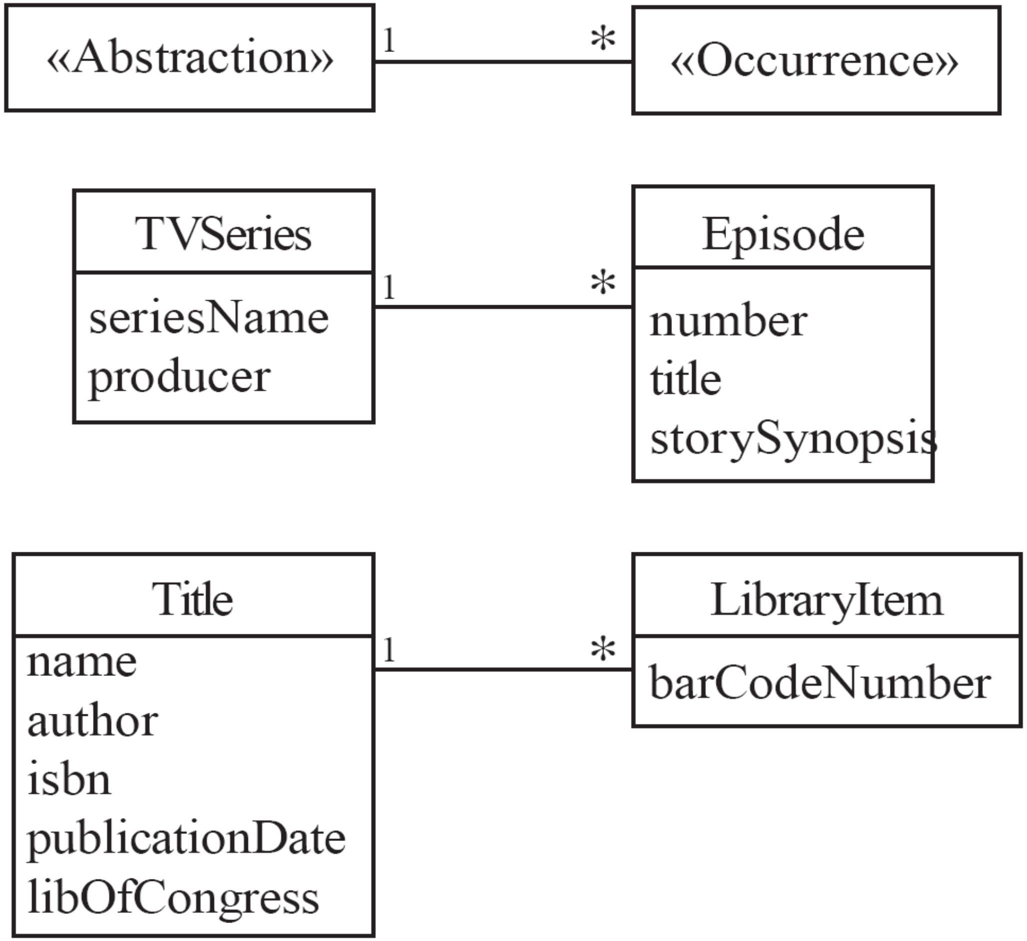
- Who developed or inspired the pattern.

6.2 The Abstraction-Occurrence Pattern

- ***Context***:
  - —Often in a domain model you find a set of related objects (*occurrences)*.
  - —The members of such a set share common information
    - but also differ from each other in important ways.
- ***Problem***:
  - —What is the best way to represent such sets of occurrences in a class diagram?
- ***Forces***:
  - —You want to represent the members of each set of occurrences without duplicating the common information

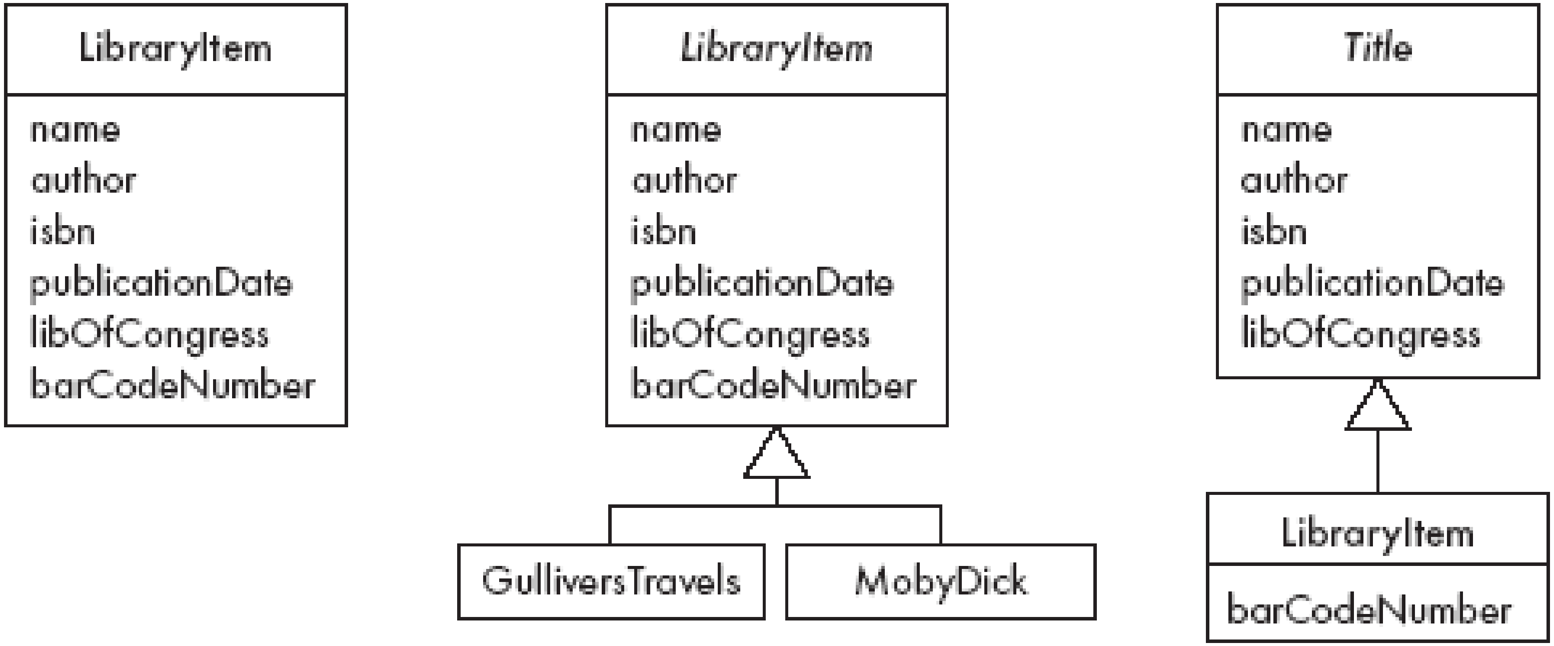
Abstraction-Occurrence

- ***Solution:***



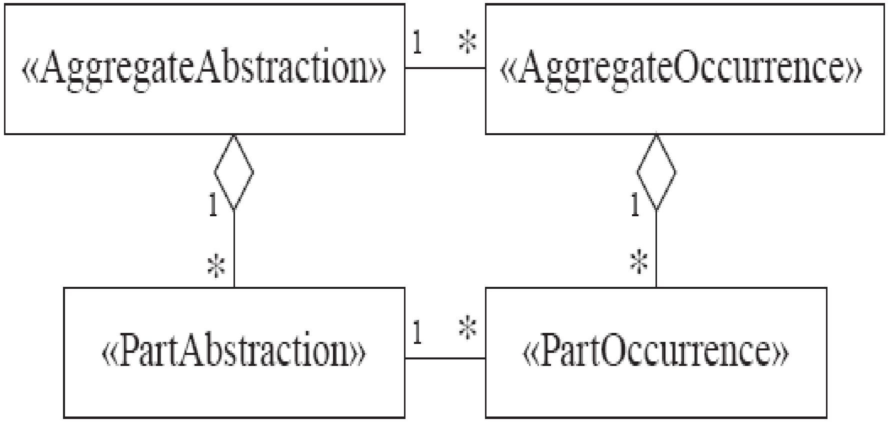
Abstraction-Occurrence

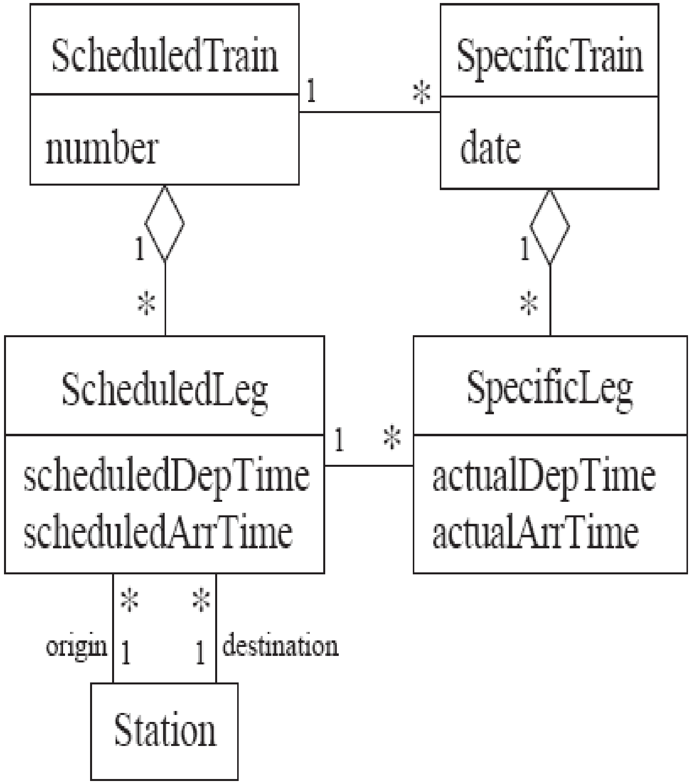
Antipatterns:



Abstraction-Occurrence

Square variant



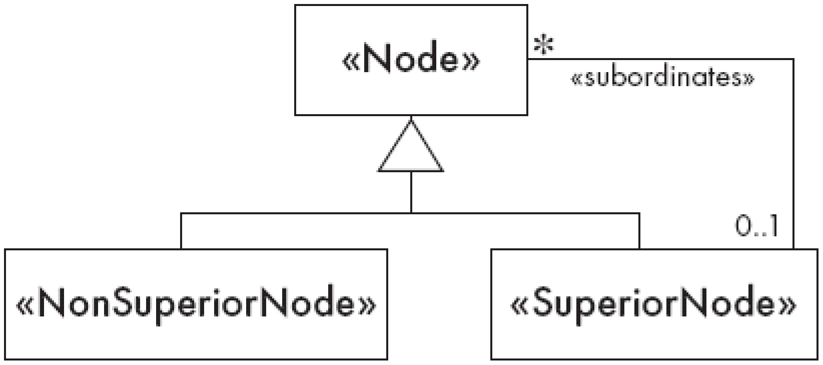


6.3 The General Hierarchy Pattern

- ***Context***:
  - —Objects in a hierarchy can have one or more objects above them (superiors),
    - and one or more objects below them (subordinates).
  - —Some objects cannot have any subordinates
- ***Problem***:
  - —How do you represent a hierarchy of objects, in which some objects cannot have subordinates?
- ***Forces***:
  - —You want a flexible way of representing the hierarchy
    - that prevents certain objects from having subordinates
  - —All the objects have many common properties and operations

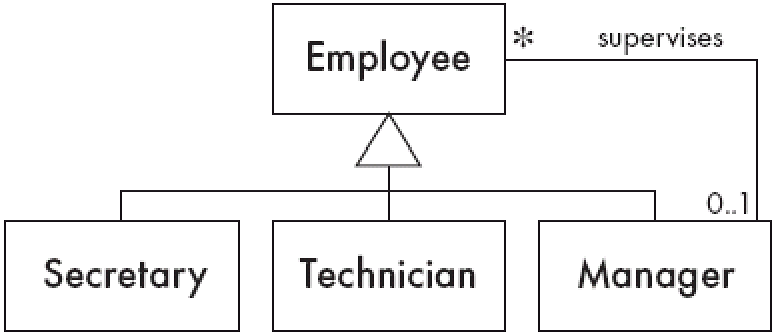
General Hierarchy

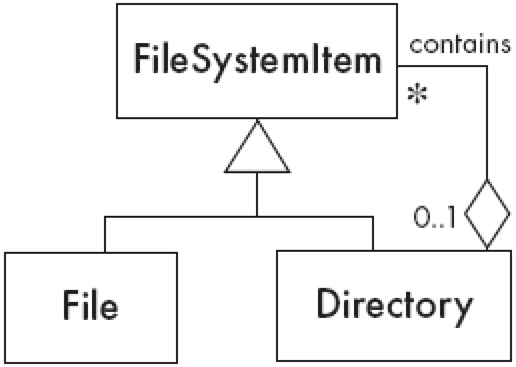
- ***Solution:***

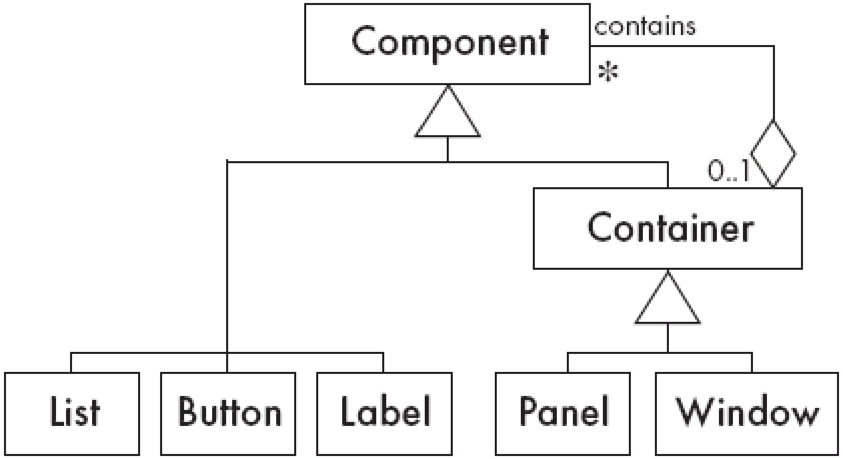


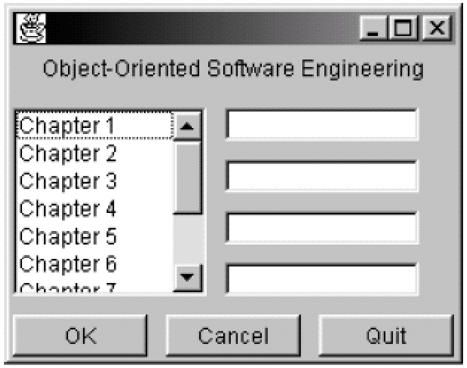
General Hierarchy

- ***Solution:***



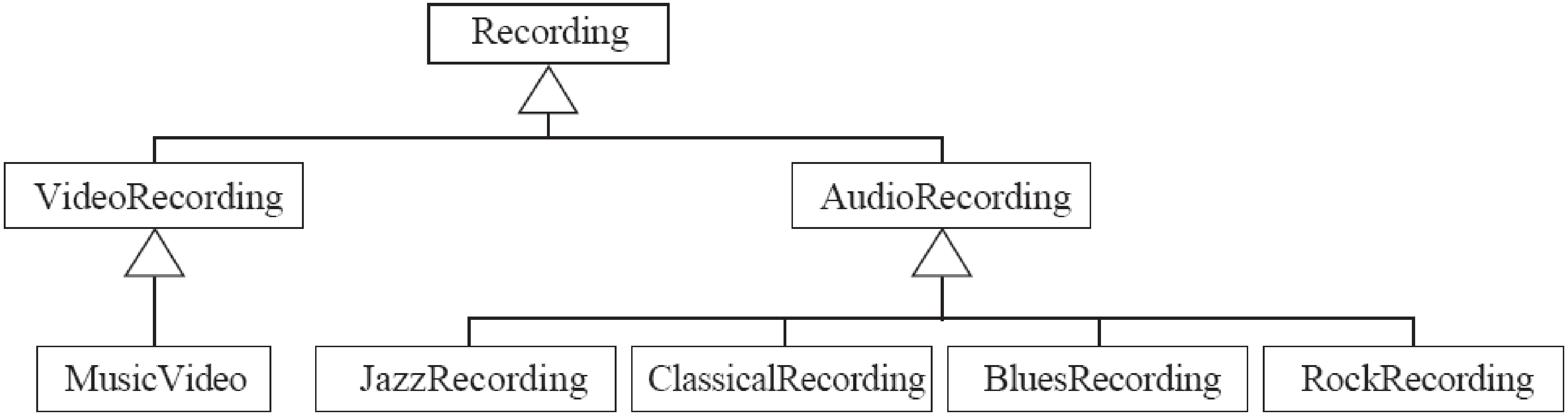






General Hierarchy

Antipattern:

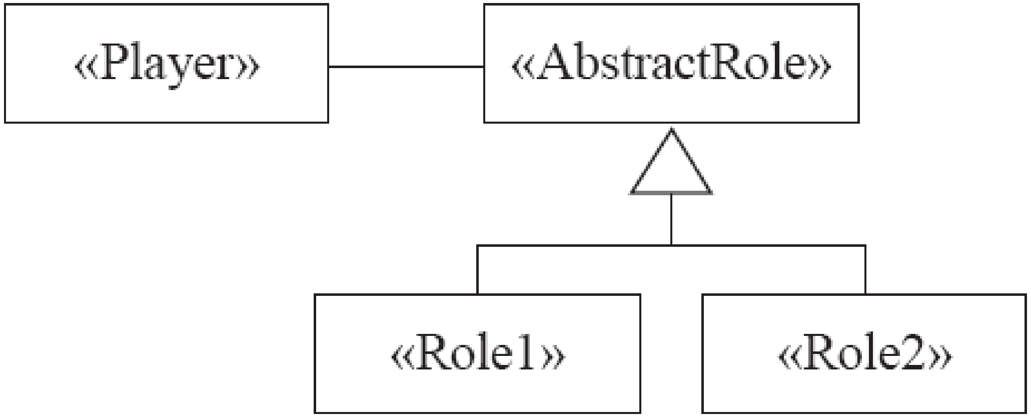


6.4 The Player-Role Pattern

- ***Context***:
  - —A *role* is a particular set of properties associated with an object in a particular context.
  - —An object may *play* different roles in different contexts.
- ***Problem***:
  - —How do you best model players and roles so that a player can change roles or possess multiple roles?

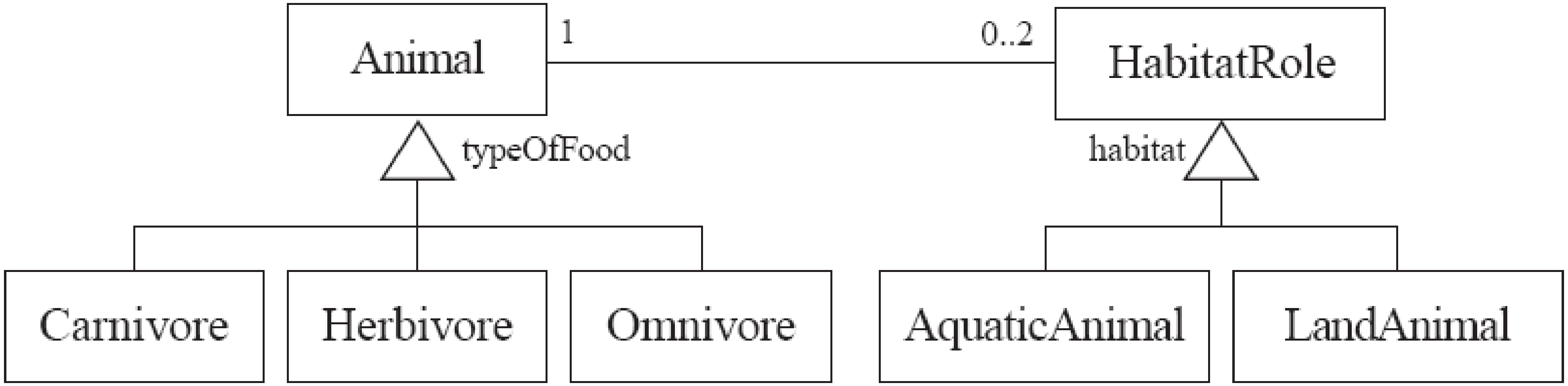
Player-Role

- ***Forces***:
  - —It is desirable to improve encapsulation by capturing the information associated with each separate role in a class.
  - —You want to avoid multiple inheritance.
  - —You cannot allow an instance to change class
- ***Solution***:



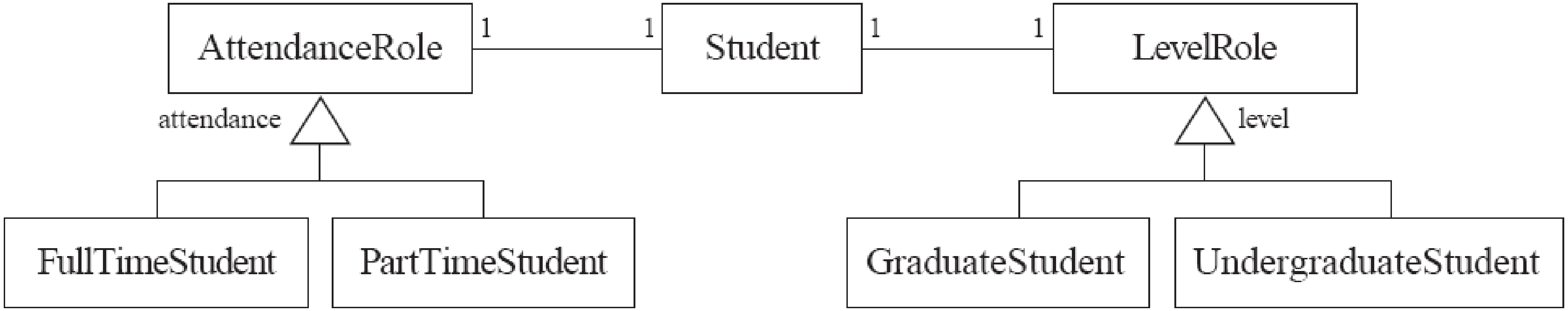
Player-Role

Example 1:



Player-Role

Example 2:



Player-Role

Antipatterns:

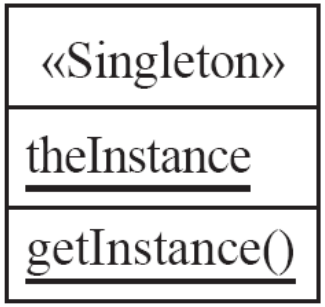
- Merge all the properties and behaviours into a single «Player» class and not have «Role» classes at all.
- Create roles as subclasses of the «Player» class.

6.5 The Singleton Pattern

- ***Context***:
  - —It is very common to find classes for which only one instance should exist (*singleton)*
- ***Problem***:
  - —How do you ensure that it is never possible to create more than one instance of a singleton class?
- ***Forces***:
  - —The use of a public constructor cannot guarantee that no more than one instance will be created.
  - —The singleton instance must also be accessible to all classes that require it

Singleton

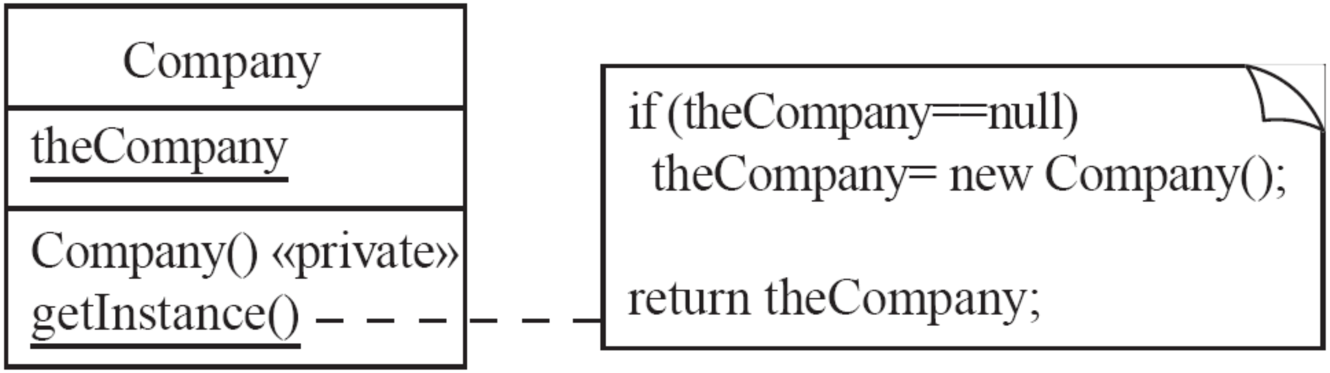
- ***Solution:***



«Singleton»

theInstance

getInstance()



Company

theCompany

Company() «private»
getInstance()

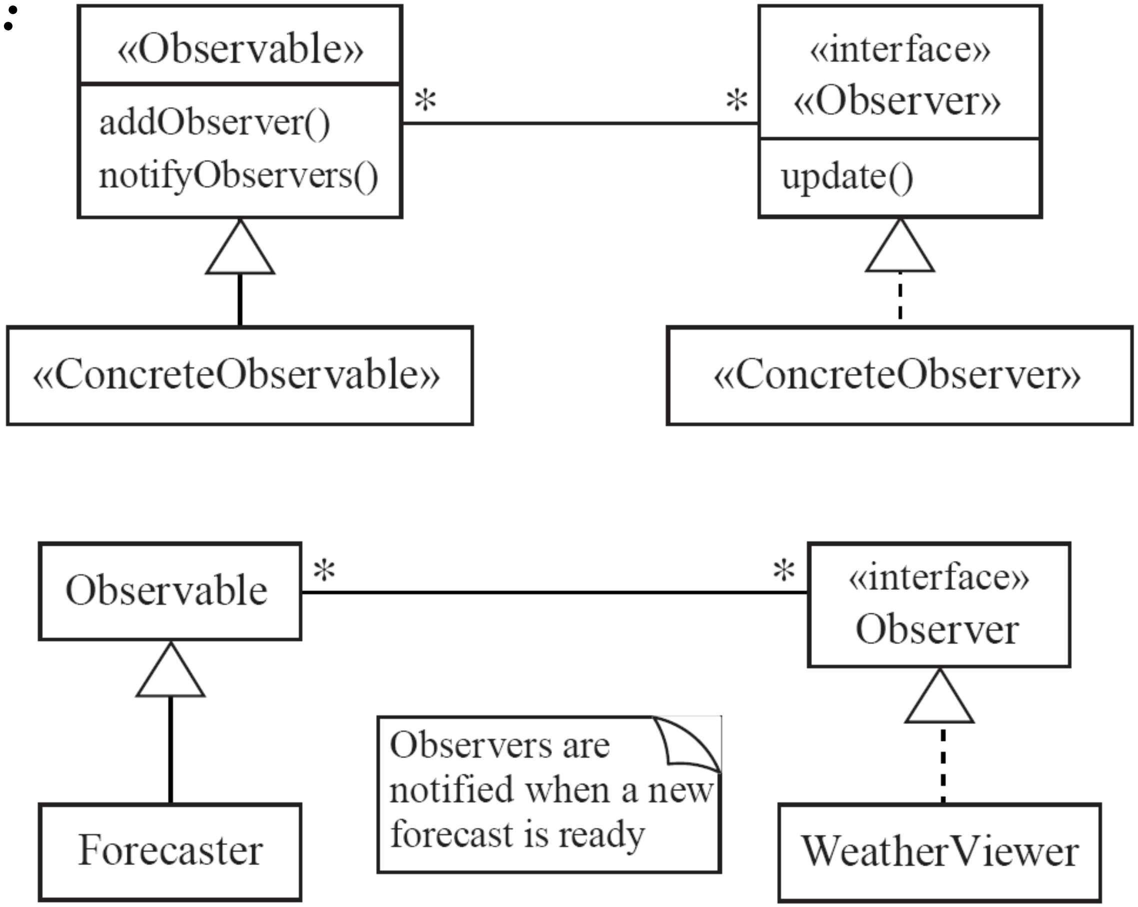
```
if (theCompany==null)
  theCompany= new Company();

return theCompany;
```

6.6 The Observer Pattern

- ***Context***:
  - —When an association is created between two classes, the code for the classes becomes inseparable.
  - —If you want to reuse one class, then you also have to reuse the other.
- ***Problem***:
  - —How do you reduce the interconnection between classes, especially between classes that belong to different modules or subsystems?
- ***Forces***:
  - —You want to maximize the flexibility of the system to the greatest extent possible

Observer

- ***Solution:***



Observer

Antipatterns:

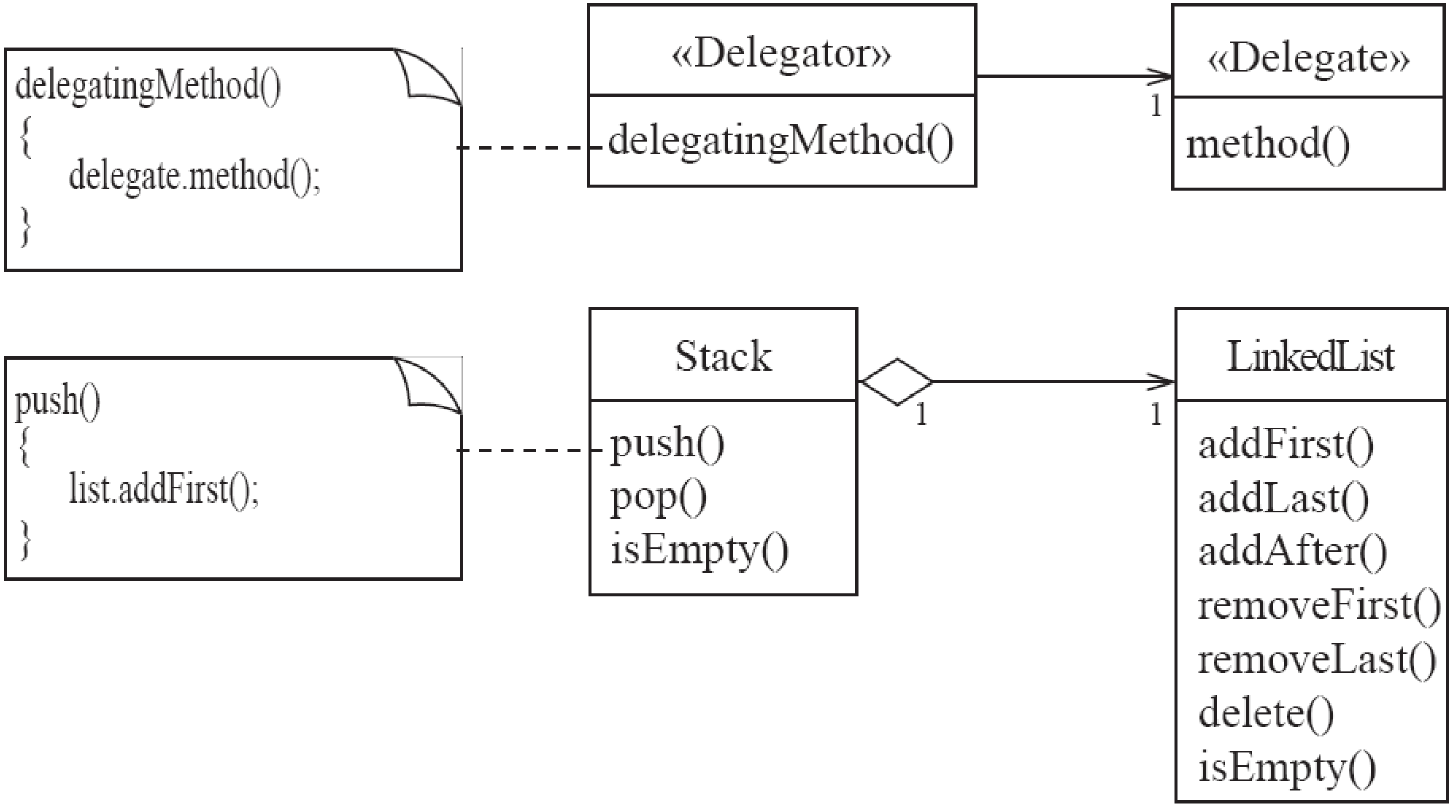
- Connect an observer directly to an observable so that they both have references to each other.
- Make the observers *subclasses* of the observable.

6.7 The Delegation Pattern

- ***Context***:
  - —You are designing a method in a class
  - —You realize that another class has a method which provides the required service
  - —Inheritance is not appropriate
    - E.g. because the isa rule does not apply
- ***Problem***:
  - —How can you most effectively make use of a method that already exists in the other class?
- ***Forces***:
  - —You want to minimize development cost by reusing methods

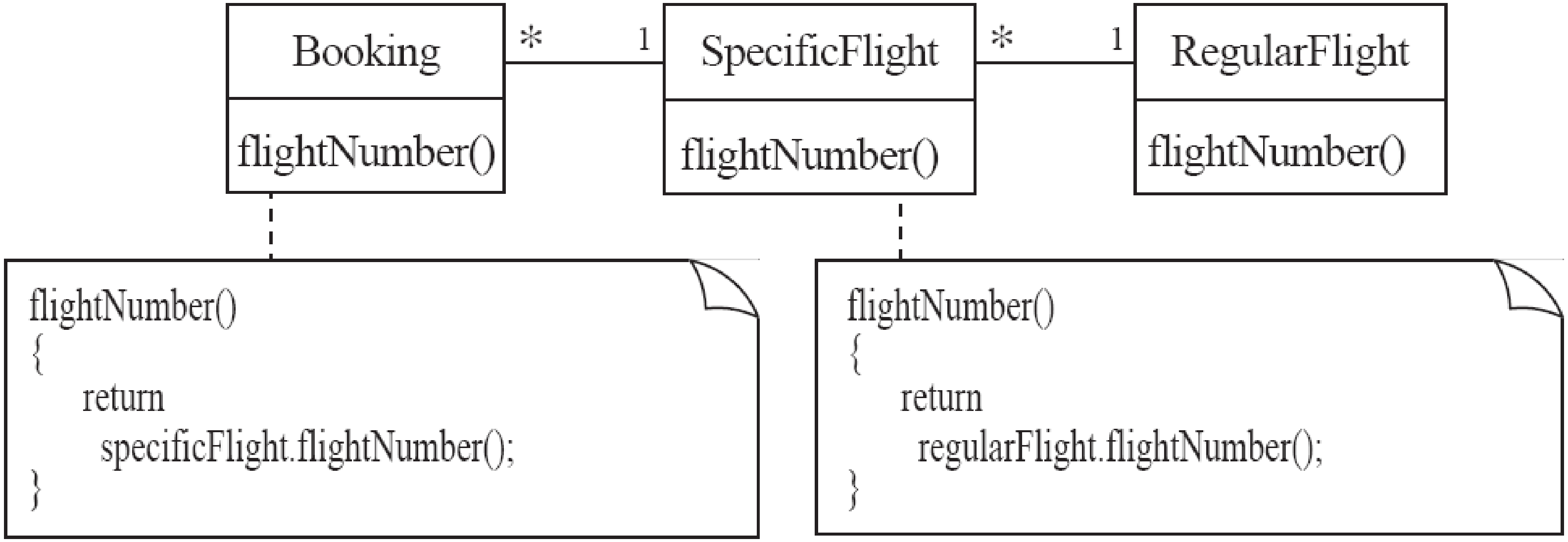
Delegation

- ***Solution:***



Delegation

Example:



Booking * — 1 SpecificFlight * — 1 RegularFlight

Booking: flightNumber()

SpecificFlight: flightNumber()

RegularFlight: flightNumber()

```
flightNumber()
{
    return
      specificFlight.flightNumber();
}
```

```
flightNumber()
{
    return
      regularFlight.flightNumber();
}
```

Delegation

Antipatterns

- Overuse generalization and *inherit* the method that is to be reused
- Instead of creating a *single* method in the «Delegator» that does nothing other than call a method in the «Delegate
  - —consider having many different methods in the «Delegator» call the delegate's method
- Access non-neighboring classes

```
return specificFlight.regularFlight.flightNumber();

return getRegularFlight().flightNumber();
```

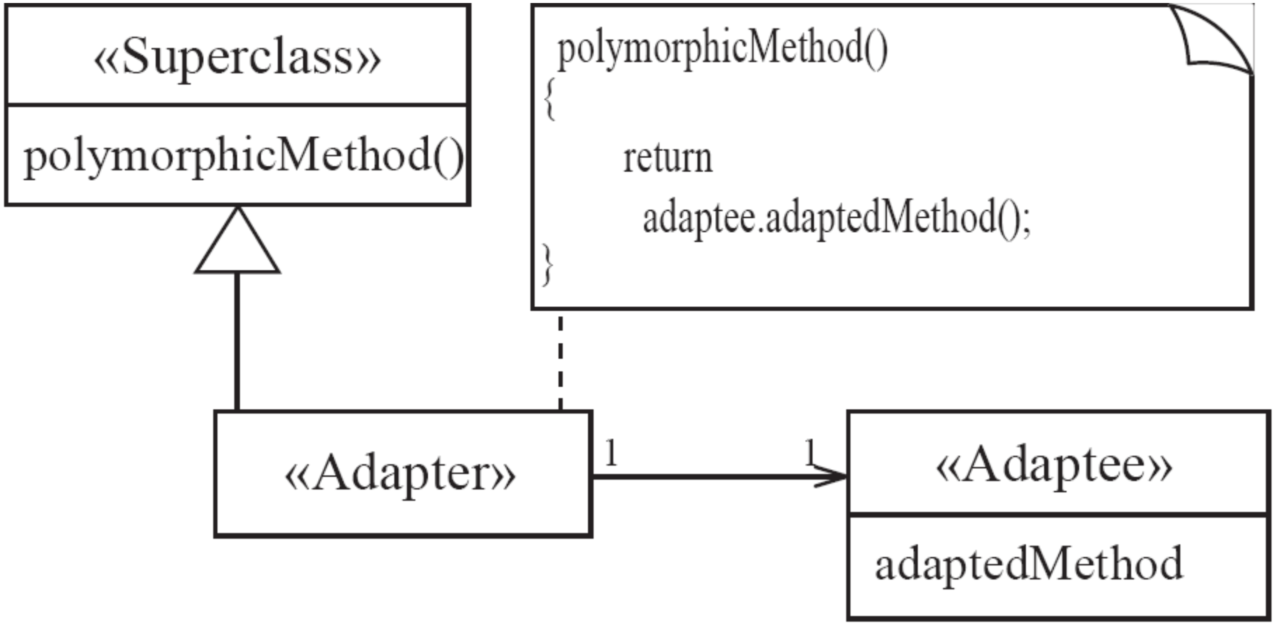
6.8 The Adapter Pattern

- ***Context***:
  - —You are building an inheritance hierarchy and want to incorporate it into an existing class.
  - —The reused class is also often already part of its own inheritance hierarchy.
- ***Problem***:
  - —How to obtain the power of polymorphism when reusing a class whose methods
    - have the same function
    - but *not* the same signature

    as the other methods in the hierarchy?
- ***Forces***:
  - —You do not have access to multiple inheritance or you do not want to use it.

Adapter

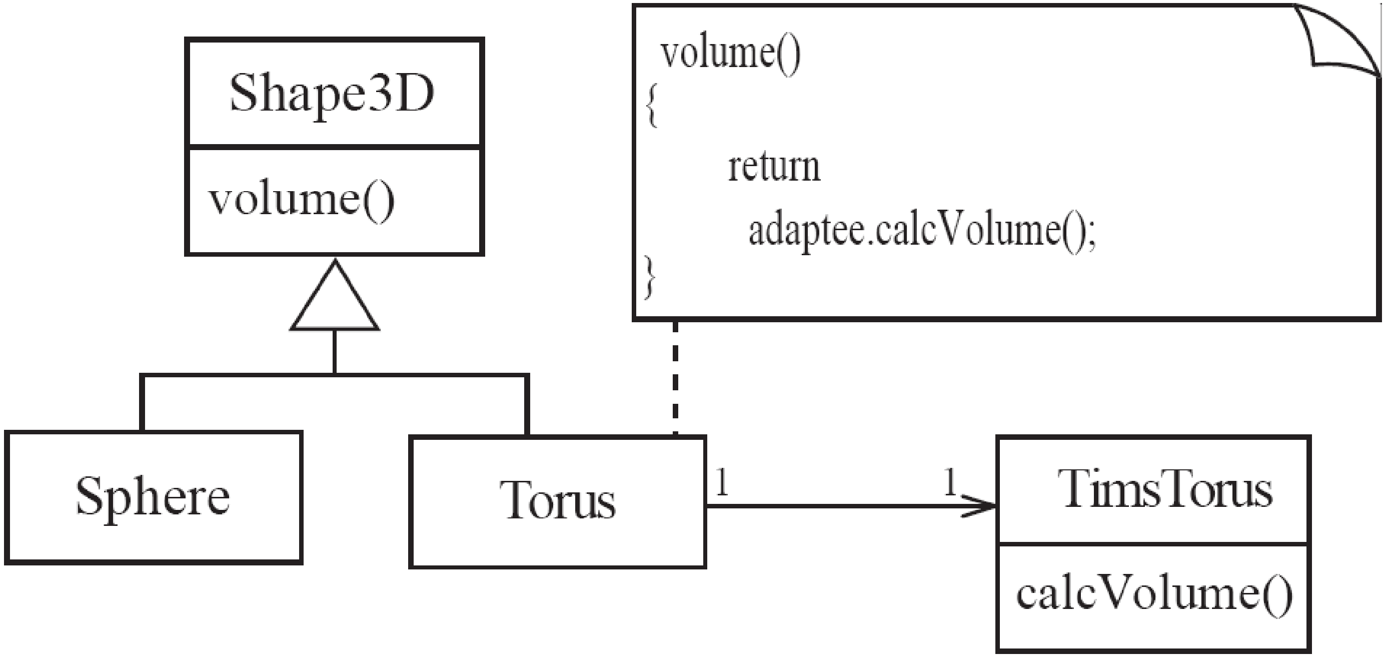
- ***Solution:***



```
polymorphicMethod()
{
        return
          adaptee.adaptedMethod();
}
```

Adapter

Example:



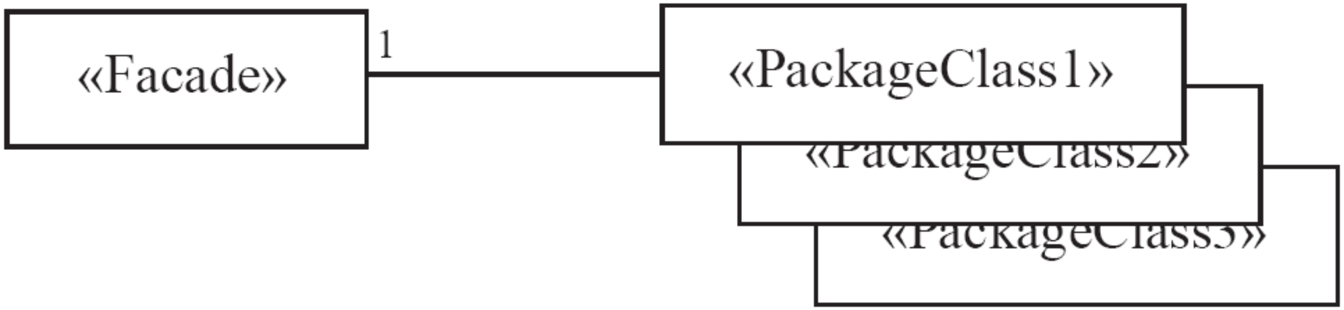
```
volume()
{
      return
        adaptee.calcVolume();
}
```

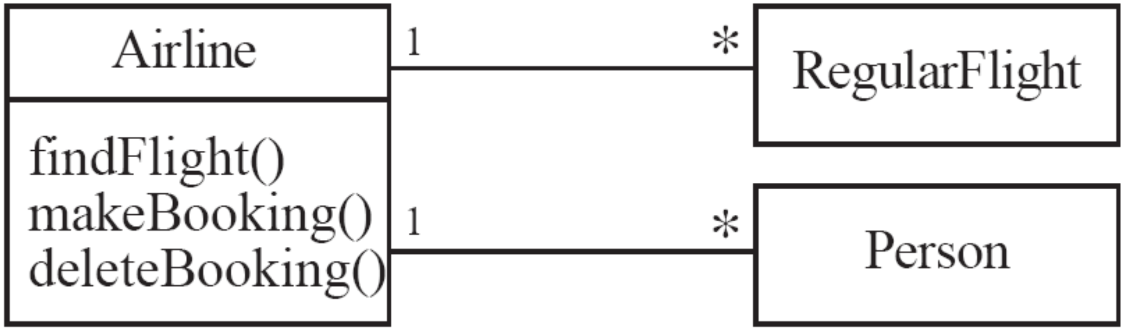
6.9 The Façade Pattern

- ***Context***:
  - —Often, an application contains several complex packages.
  - —A programmer working with such packages has to manipulate many different classes
- ***Problem***:
  - —How do you simplify the view that programmers have of a complex package?
- ***Forces***:
  - —It is hard for a programmer to understand and use an entire subsystem
  - —If several different application classes call methods of the complex package, then any modifications made to the package will necessitate a complete review of all these classes.

Façade

- ***Solution:***





6.10 The Immutable Pattern

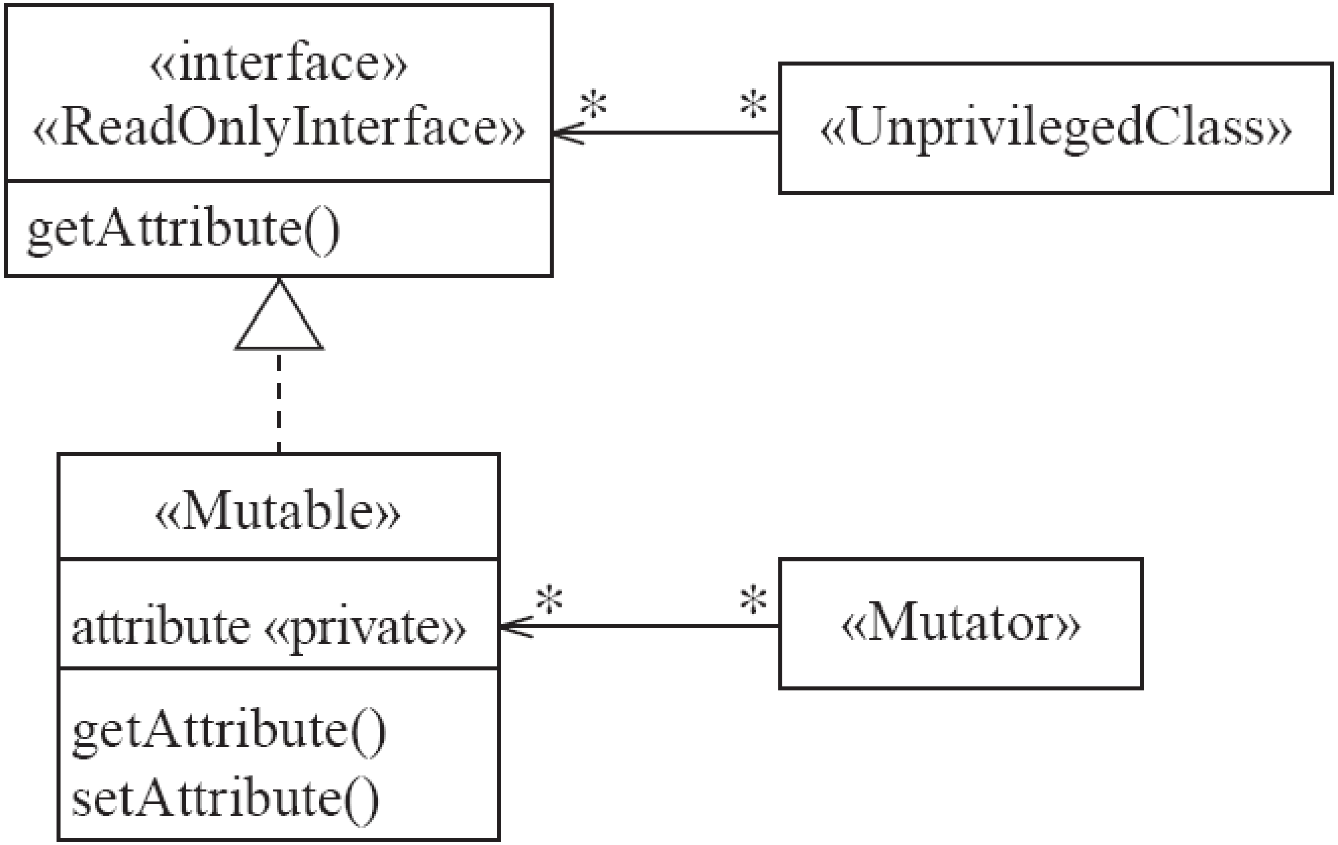
- ***Context***:
  - —An immutable object is an object that has a state that never changes after creation
- ***Problem***:
  - —How do you create a class whose instances are immutable?
- ***Forces***:
  - —There must be no loopholes that would allow ‘illegal’ modification of an immutable object
- ***Solution***:
  - —Ensure that the constructor of the immutable class is the *only* place where the values of instance variables are set or modified.
  - —Instance methods which access properties must not have side effects.
  - —If a method that would otherwise modify an instance variable is required, then it has to return a *new* instance of the class.

6.11 The Read-only Interface Pattern

- ***Context***:
  - —You sometimes want certain privileged classes to be able to modify attributes of objects that are otherwise immutable
- ***Problem***:
  - —How do you create a situation where some classes see a class as read-only whereas others are able to make modifications?
- ***Forces***:
  - —Restricting access by using the **`public`**, **`protected`** and **`private`** keywords is not adequately selective.
  - —Making access **`public`** makes it public for both reading and writing

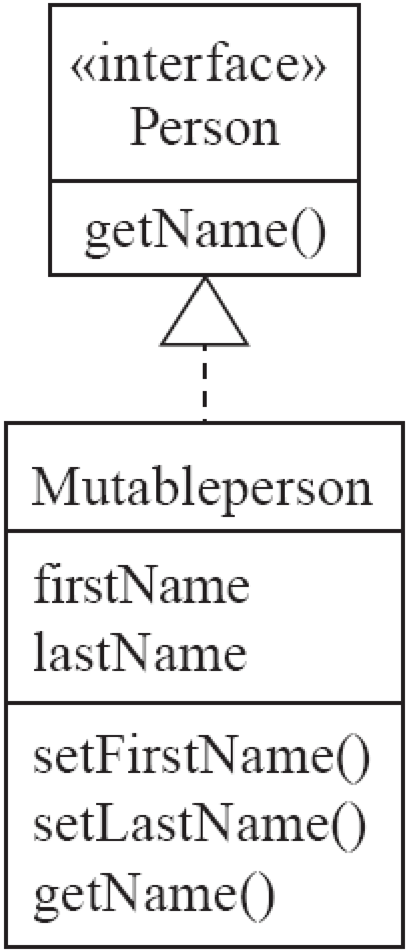
Read-only Interface

- ***Solution:***



Read-only Interface

Example:



Read-only Interface

Antipatterns:

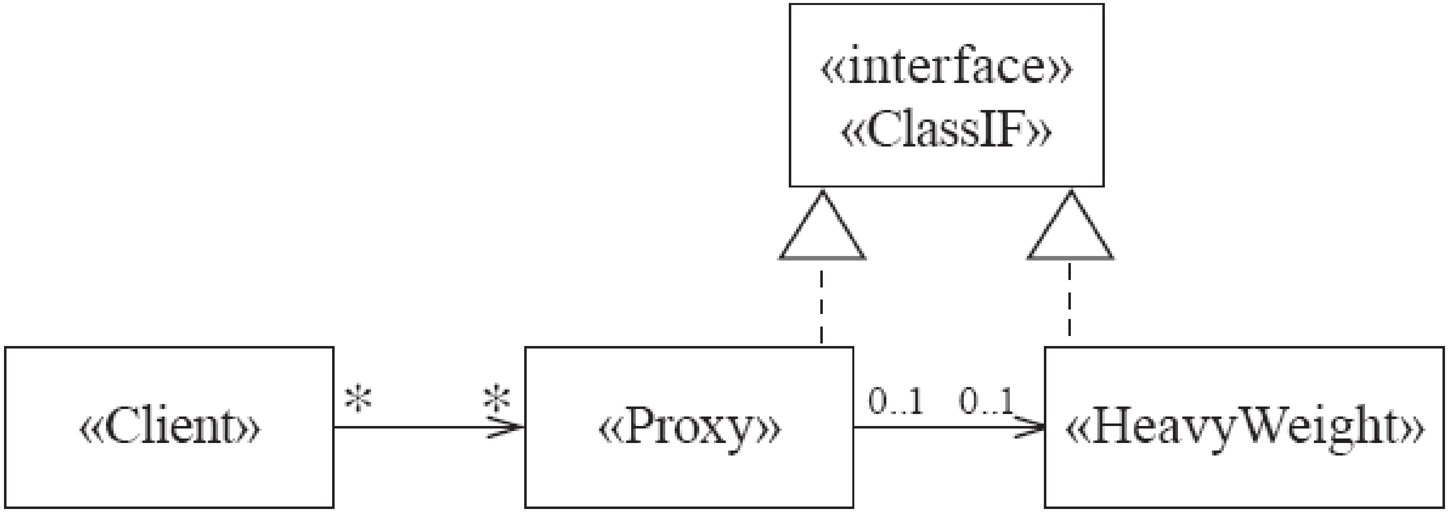
- Make the read-only class a *subclass* of the «Mutable» class
- Override all methods that modify properties
  —such that they throw an exception

6.12 The Proxy Pattern

- ***Context***:
  - —Often, it is time-consuming and complicated to create instances of a class (*heavyweight* classes).
  - —There is a time delay and a complex mechanism involved in creating the object in memory
- ***Problem***:
  - —How to reduce the need to create instances of a heavyweight class?
- ***Forces***:
  - —We want all the objects in a domain model to be available for programs to use when they execute a system’s various responsibilities.
  - —It is also important for many objects to persist from run to run of the same program

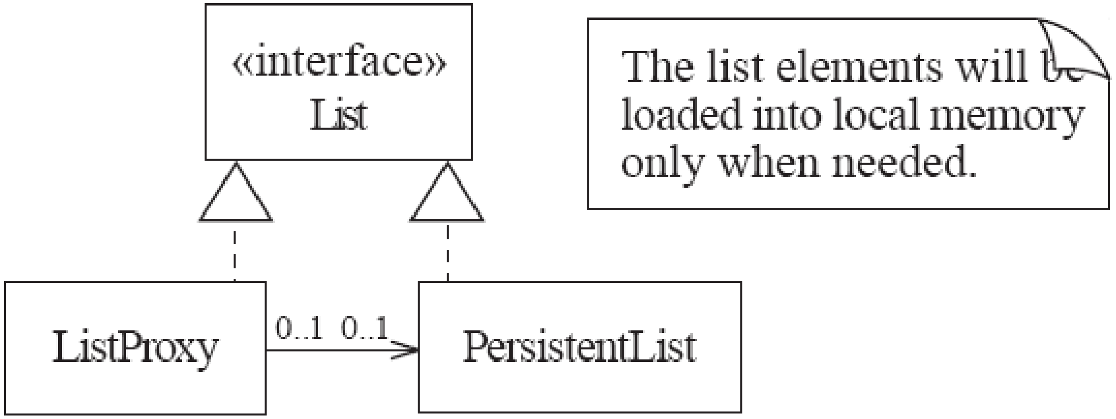
Proxy

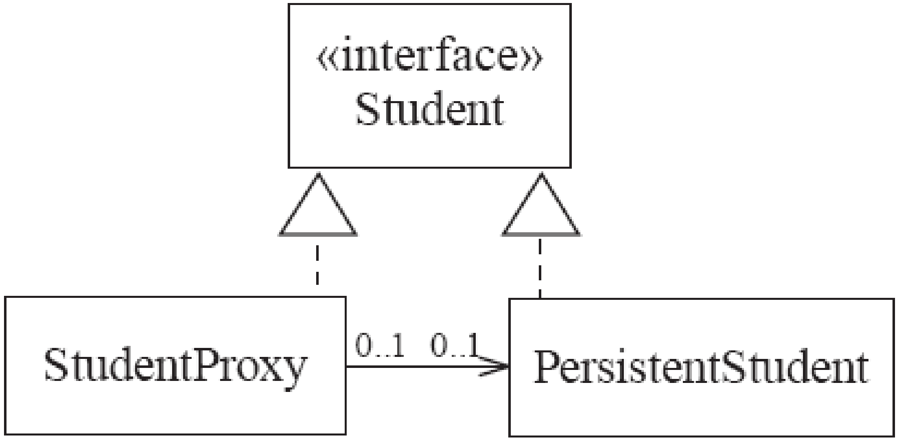
- ***Solution:***



Proxy

Examples:


«interface»
List
ListProxy
0..1
0..1
PersistentList
The list elements will be loaded into local memory only when needed.

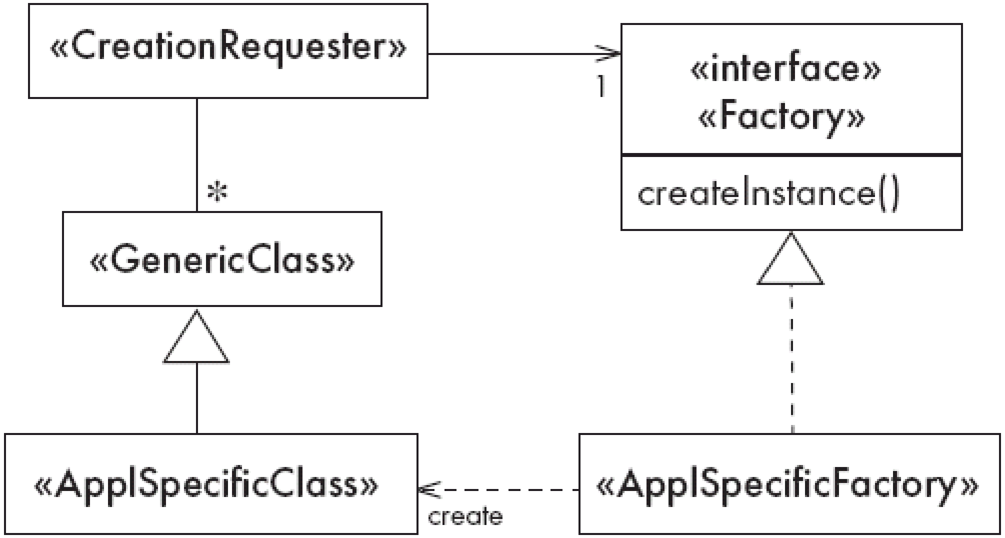


6.13 The Factory Pattern

- ***Context***:
  - —A reusable framework needs to create objecs; however the class of the created objects depends on the application.
- ***Problem***:
  - —How do you enable a programmer to add new application-specific class into a system built on such a framework?
- ***Forces***:
  - —We want to have the framework create and work with application-specific classes that the framework does not yet know about.
- ***Solution***:
  - —The framework delegates the creation of application-specific classes to a specialized class, the Factory.
  - —The Factory is a generic interface defined in the framework.
  - —The factory interface declares a method whose purpose is to create some subclass of a generic class.

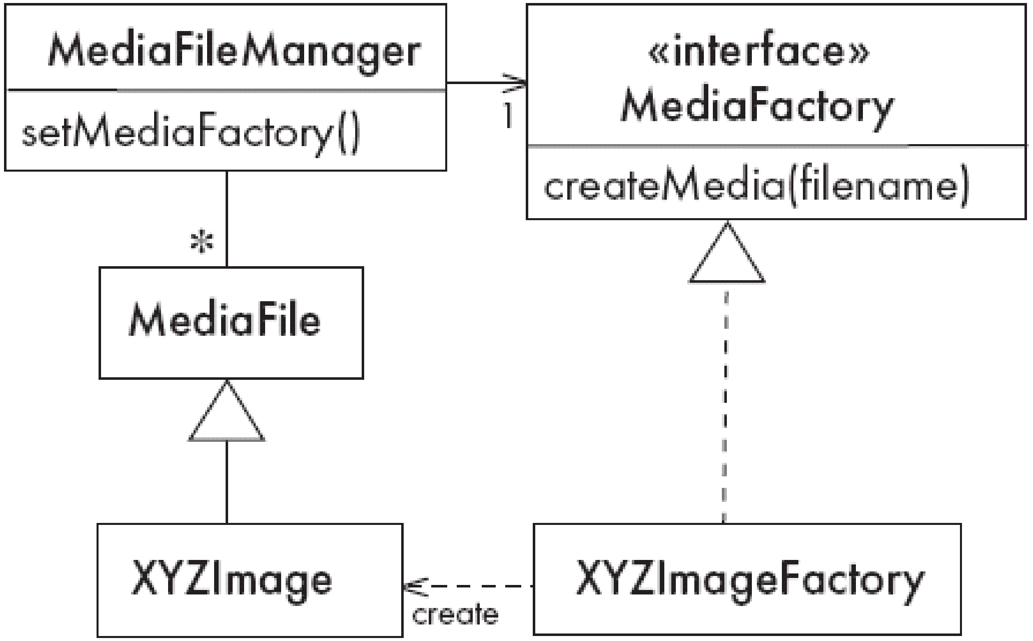
The Factory Pattern

Solution

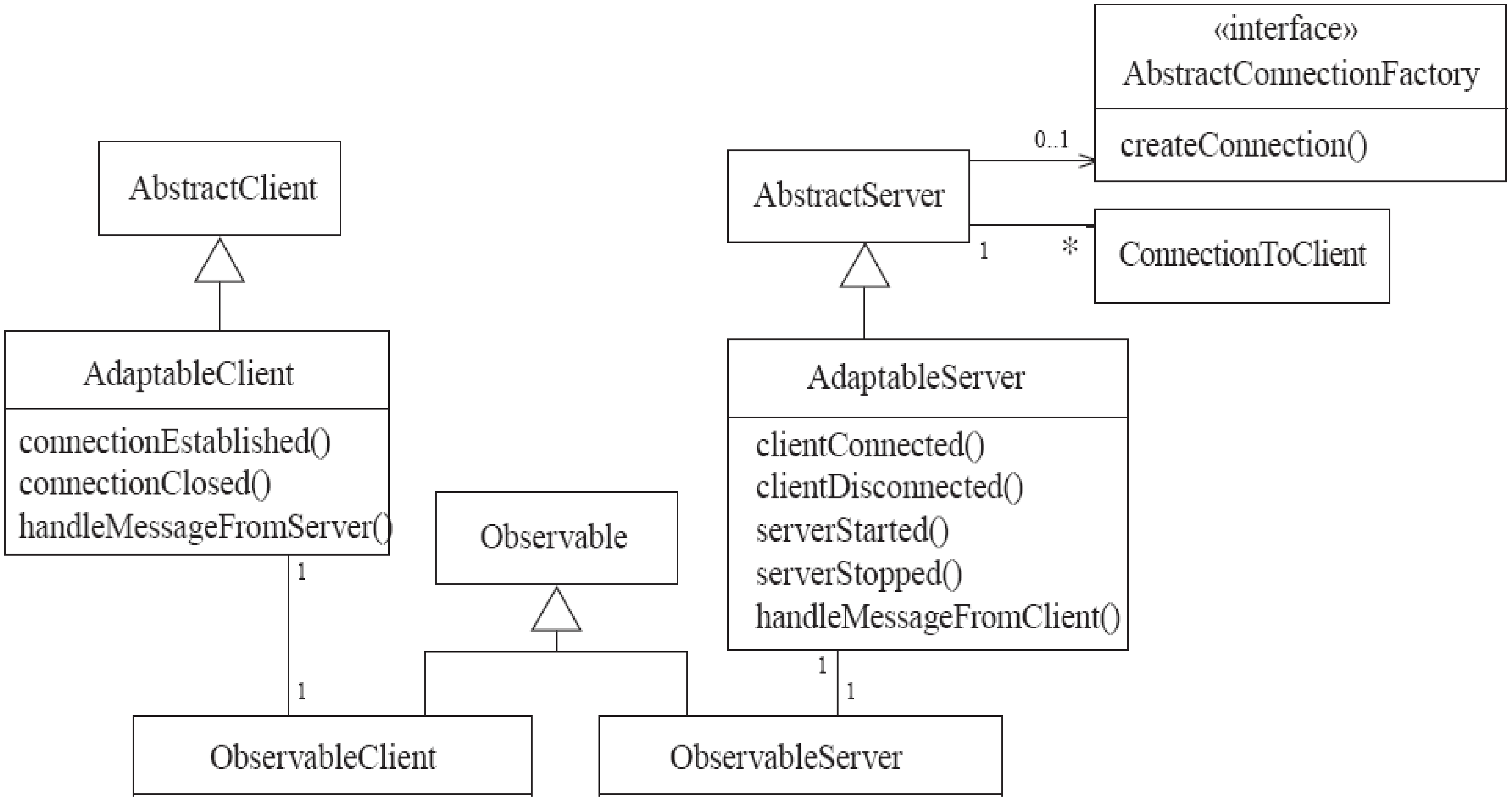


The Factory Pattern

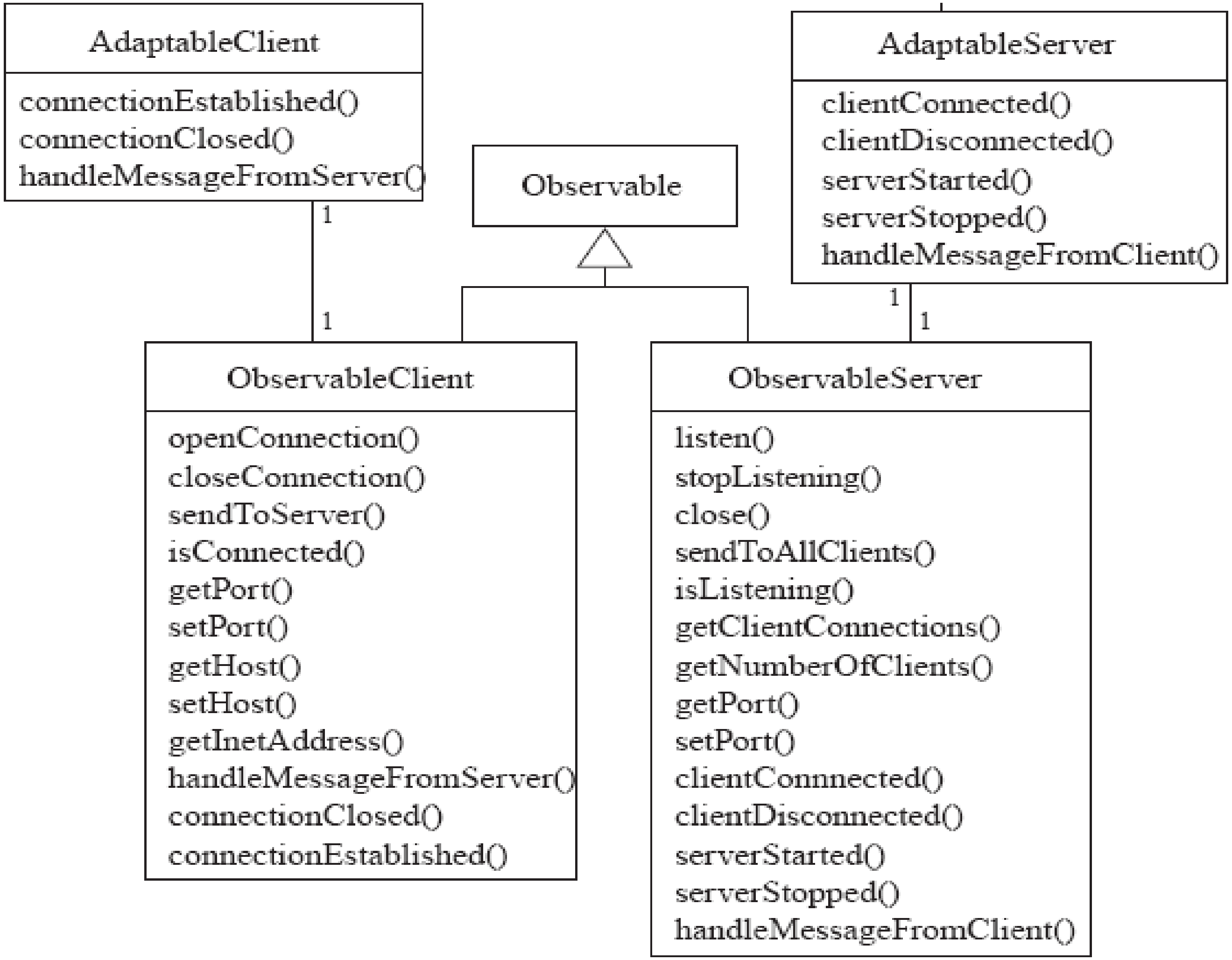
Example



6.14 Detailed Example: enhancing OCSF with some design patterns



The Observable layer of OCSF (continued)



Using the observable layer

1. Create a class that implements the **Observer** interface.
2. Register it as an observer of the **Observable**:

```
public MessageHandler(Observable client)
{
      client.addObserver(this);
      ...
}
```

3. Define the **update** method in the new class:

```
public void update(Observable obs, Object message)
{
        if (message instanceOf SomeClass)
        {
            // process the message
        }
}
```

6.15 Difficulties and Risks When Creating Class Diagrams

- **Patterns are not a panacea:**
  - —Whenever you see an indication that a pattern should be applied, you might be tempted to blindly apply the pattern.
  - —This can lead to unwise design decisions .
- *Resolution:*
  - — *Always understand in depth the forces that need to be balanced, and when other patterns better balance the forces.*
  - —*Make sure you justify each design decision carefully.*

Difficulties and Risks When Creating Class Diagrams

- **Developing patterns is hard**
  - —Writing a good pattern takes considerable work.
  - —A poor pattern can be hard to apply correctly
- *Resolution:*
  - —*Do not write patterns for others to use until you have considerable experience both in software design and in the use of patterns.*
  - —*Take an in-depth course on patterns.*
  - —*Iteratively refine your patterns, and have them peer reviewed at each iteration.*