Singleton Pattern

Singleton Pattern: Problem

- Ensure that a class has only one instance.
- Provide a global point of access to it.

Singleton Pattern: Example 1

- **Problem: An object needs to maintain an application's configuration.**
- Many objects may wish to read and update the configuration:
  - **How to restrict only one instantiation?**
  - **A singleton class will ensure that all objects of the application can get the same copy of configuration…**

Singleton Pattern: Example 2

- **Problem:**
  - **How to control access to resources such as database connections or sockets?**
- **Example:** You have a license for only one connection for your database:
  - **A Singleton makes sure that only one connection is made.**
  - **If you buy more licenses or use a JDBC driver that allows multithreading, the Singleton can be easily adjusted to allow more connections.**

Stateful Singleton: Example 3

- Suppose you need a **counter** that gives out unique numbers (e.g. token numbers in a restaurant):
  - First, the counter needs to be unique.
  - A Singleton can generate the numbers and synchronize access.

More Singleton Examples

- One session manager per user session
- One file system
- One shopping basket per customer
- One logger
- One configuration object
- One account per user,
- Abstract factory and factory method, etc.

Singleton Pattern

- A Singleton is accessed by many objects:
  - Therefore should be easily and globally accessible --- Provide a global point of access to the object.
  - Ensure that only one instance of a class is created ---Allow multiple instances when required.

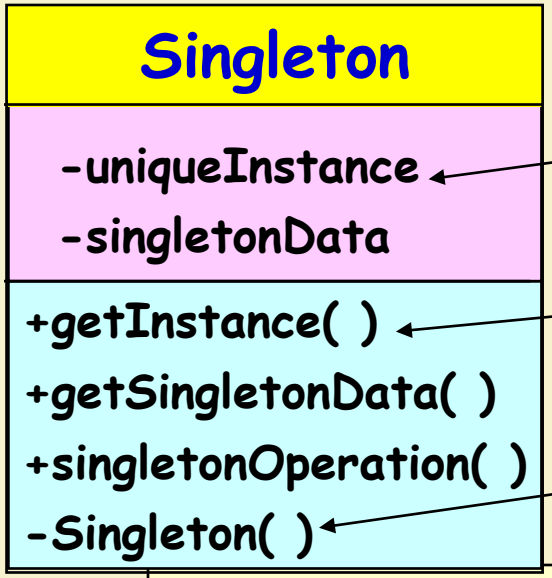
Singleton Solution: Main Idea

- Create an object with operation:
  - **getInstance()**
- On first call to **getInstance():**
  - Relevant object instance is created and object identity is returned.
- On subsequent calls to **getInstance():**
  - No new instance is created,
  - Id of existing object is returned.

Singleton Pattern

- A Singleton class itself is responsible for keeping track of its sole instance.
  - **How?** --- intercept all requests to create new objects.
- **Singletons maintain a static reference to the sole singleton instance:**
  - Return a reference to that instance from a static instance() method.

Singleton Structure



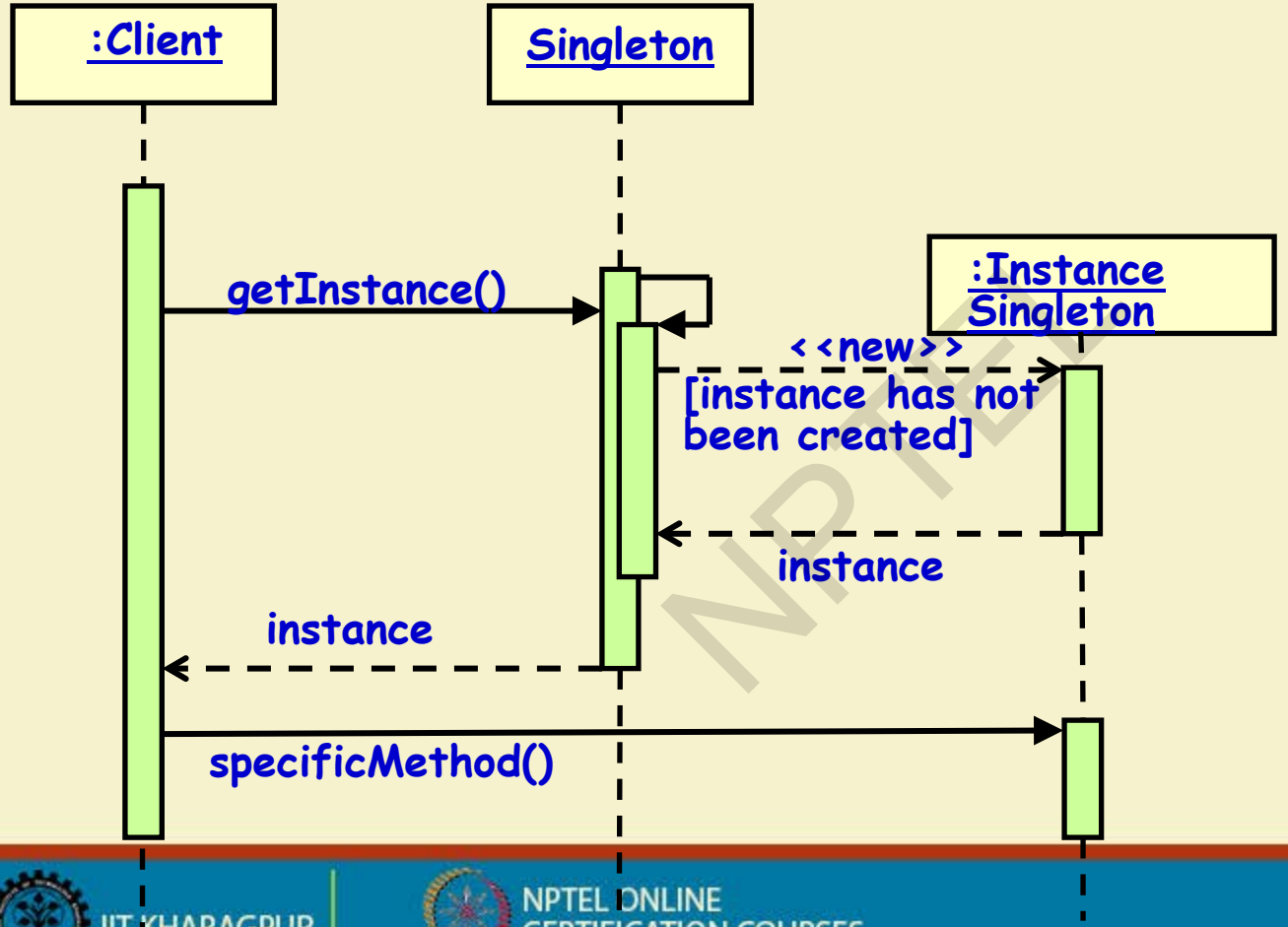
Object identifier for singleton instance, class scope i.e. static

Returns object identifier for unique instance

Private constructor only accessible via getInstance()

```
getInstance( ) {
        if ( uniqueInstance == null )
        { uniqueInstance = new Singleton( ); }
        return uniqueInstance;
    }
```

Singleton: Sequence Diagram



Example Code

```
Public Class Singleton {
    private static Singleton uniqueInstance = null;
    // Why is uniqueInstance static?
   private Singleton( ) { .. } // private constructor
   public static Singleton getInstance( ) {
          if (uniqueInstance == null)
                uniqueInstance = new Singleton();
          return uniqueInstance;
    }
}
```

Exercise 1

- In a certain application, various classes get a Database Manager using the call:

  DBMgr.getDBMgr();

- It needs to be ensured that:
  - There is only one Database Manager object.
    - Need to disallow creation of more than one object of this class.

Exercise 1
Solution

```
class DBMgr {
        private static DBMgr pMgr=null;
        private DBMgr() { } // No way to create outside of this Class
        public static DBMgr getDBMgr() { // Only way to create.
                if (pMgr == NULL)  pMgr = new DBMgr();
                return pMgr;          }
       public Connection getConnection();   }
}
```

Usage:

```
DBMgr dbmgr =  DBMgr.getDBMgr();
//Created first time called
```

- Why have all the complexity of Singleton?
  - **Is a static method not enough?**

Why not just use a static method?

```
public class DBMgr{
  public static getConnection(){};
}
```

- **Problem 1: lacks flexibility**
  - Static methods can't be passed as an argument to a method, nor returned
- **Problem 2: cannot be extended**
  - Static methods can't be subclassed and overridden like a singleton's could be.

Exercise 2: Random Number Generator

```
public class RandomGenerator {
  private static RandomGenerator gen = new
  RandomGenerator();
  public static RandomGenerator getInstance() {
    return gen;
  }
  private RandomGenerator() {}
  public double nextNumber() {
    return Math.random();
  }
}
```

Fill Code Here…

Any problems?

Always creates the instance, even if it isn't used…

Singleton Pattern: Insights

- **Singleton with lazy instantiation:**
  - The singleton instance is not created until the instance() method is called for the first time.
  - Ensures that singleton instance is created only when needed.
- **If subclassing is required: Singleton needs to implement a protected constructor:**
  - Clients cannot directly instantiate Singleton instances through new.
  - Protected constructors can be called by subclasses.

Multiple Singletons?

- In certain situations, two or more Singletons can mysteriously materialize:
  - **Disrupting the very guarantees that the Singleton is meant to provide.**
- Consider a web application being executed in a browser.
  - Each servlet uses its own class loader.
  - Static blocks are executed during the loading of class and even before the constructor is called.

Concurrent Executions…

```
// error as no synchronization on method


public static MySingleton getInstance() {
        if (instance==null) {
                instance = new MySingleton();
        }
        return  instance;
}
```

Concurrency

```
// Correct solution
   public static synchronized MySingleton getInstance(){
                  if (instance==null) {
                        instance = new MySingleton();
                  }
        return  instance;
   }
```

Singleton Pattern: Variations

- **Multiton:**
  - We can easily change a Singleton to allow a small number of instances where this is allowable and meaningful.
  - **Of course, the operation that grants access to the Singleton instance needs to change.**

State Pattern

Introduction

- An object is behaving differently to the same message. What could be the reason?

- **Example:** consider the responses to the "renew" request for the same book:
  - Successfully renewed
  - Reserved, cannot be renewed
  - Book needed for stock taking, cannot be renewed
  - Already renewed five times, cannot be renewed …

State of an Object

- One or more attributes of a class acts as state variable.
- Depending on the values of the state variables.

  -- Some methods exhibit different behavior.

- An example:

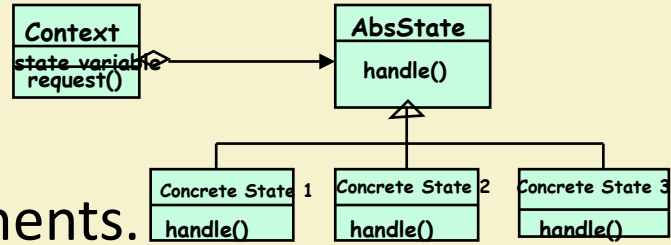
  – A person may behave differently depending on his mood.

State Pattern

- A Behavioral pattern.
- Allows an object to alter its behavior when its state changes.
  - **The object will appear to change its class.**
- To realize different behavior for different states of an object.
  - **Polymorphism is used.**

Why Use A State Pattern?

- **The state pattern creates a separate class for each conditional branch.**
  - –This eliminates if/else or switch/case statements.



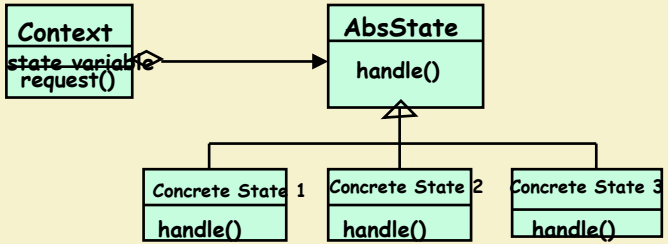
- **Code is modular:**
  - –Allows to easily change state behavior.

The State Design Pattern

- **Idea: Value of an internal state variable determines Object behavior.**
- **Intent:**
  - –Allow an object to alter its behaviour when value the internal state variable changes.
  - **–The object will appear to change its class.**

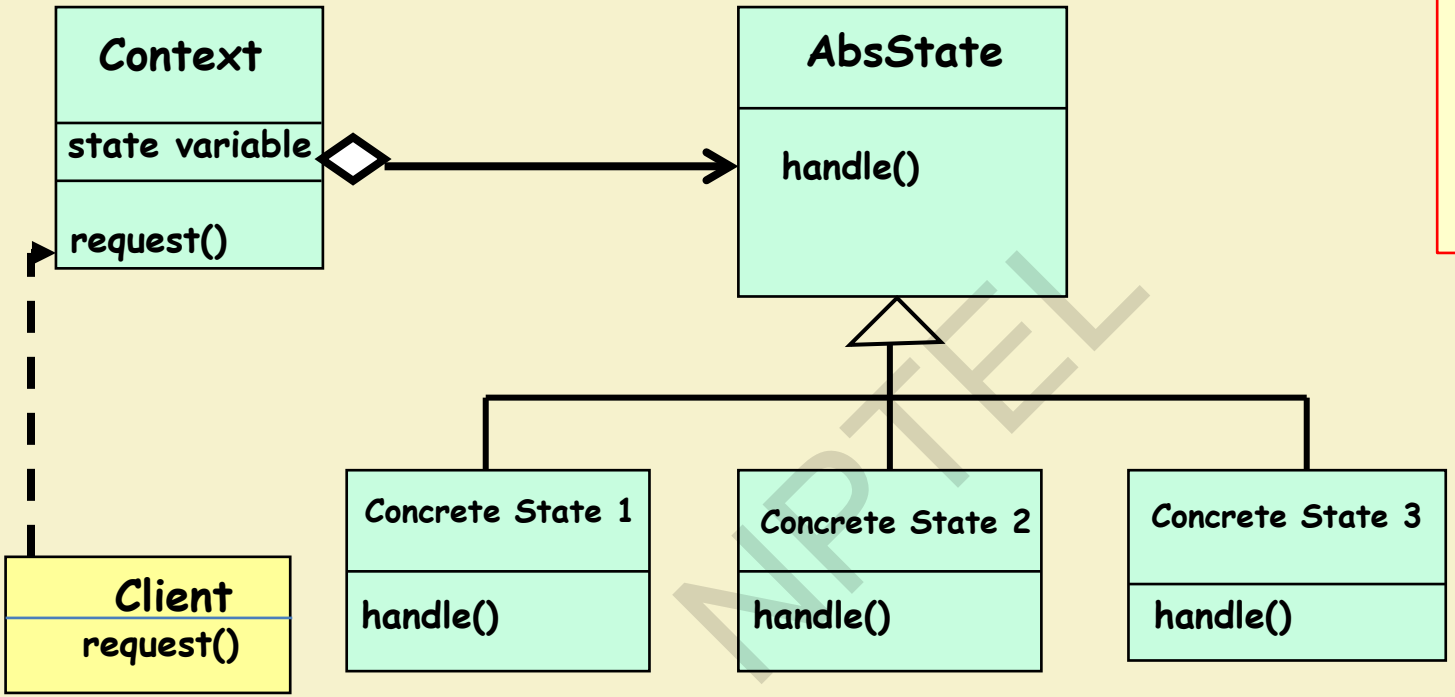
- **Context class:**
  - It is the class which changes state.
  - Context class maintains a reference to the current state object.
  - To change the state,
    - The referenced object needs to be changed.

How is State pattern implemented?

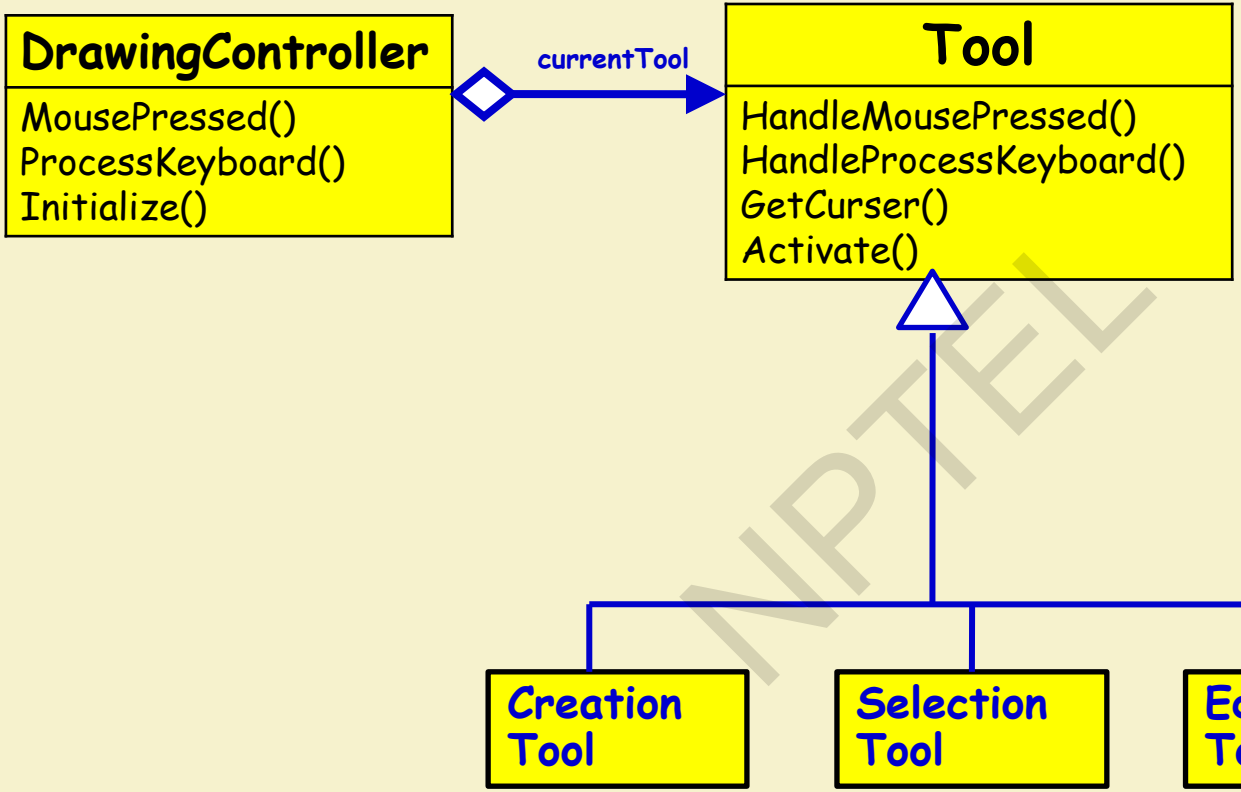


- **Abstract State class**
- **Derived classes:**
  - Define the changed behavior in states.

State Pattern: Structure

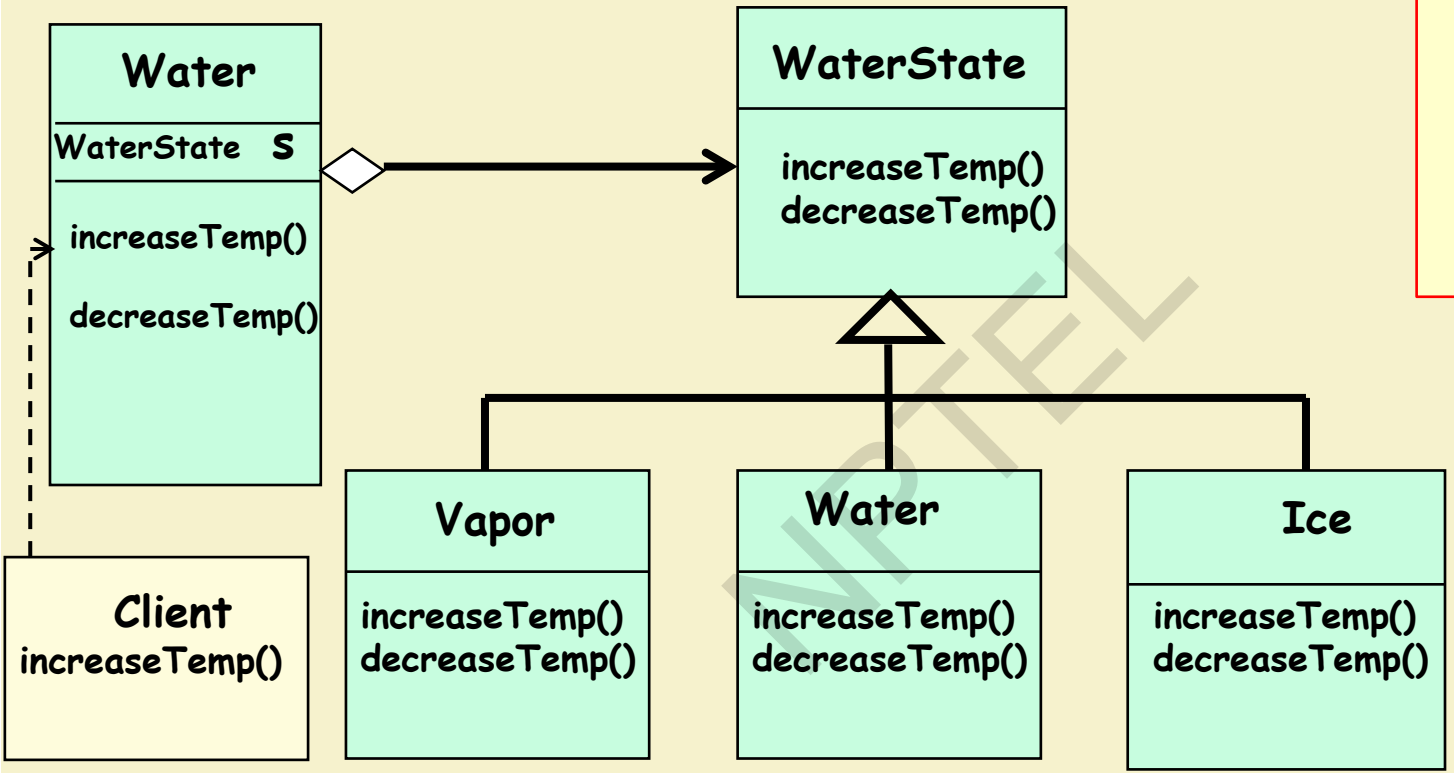


Allow an object to alter its behavior (bind to a different method) when its internal state changes.



Example 1: For a Drawing Package, based on the current tool selection, the behavior of mouse press, key board press, etc. vary…

Example 2: Behavior of Water Depends on Its State

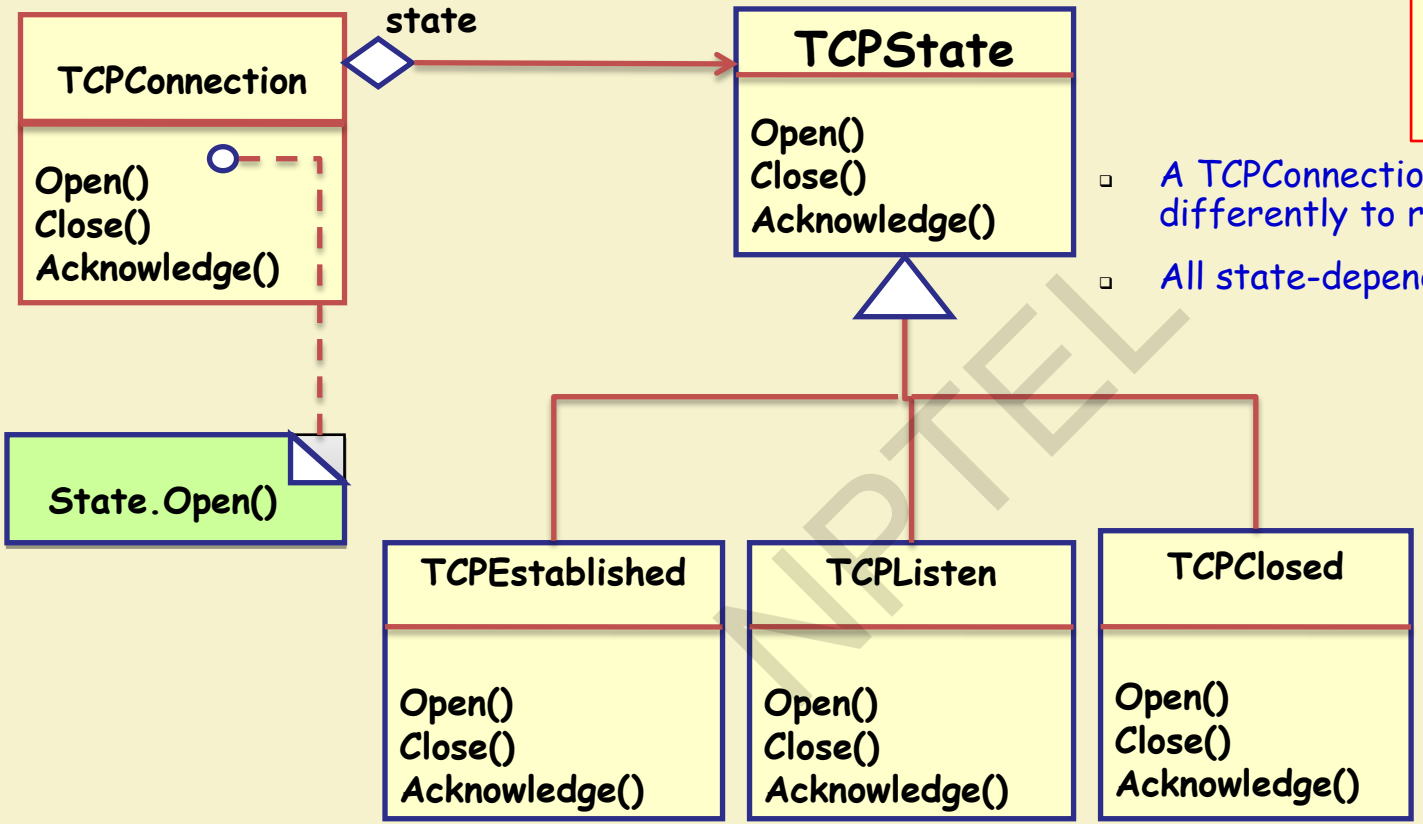


Exercise 1

- A TCP connection may be in any one of the following states:
  - Connection established
  - Listen
  - Close

- A TCPConnection object responds differently to requests at different states.
  - Open
  - Close

Exercise 1: Solution

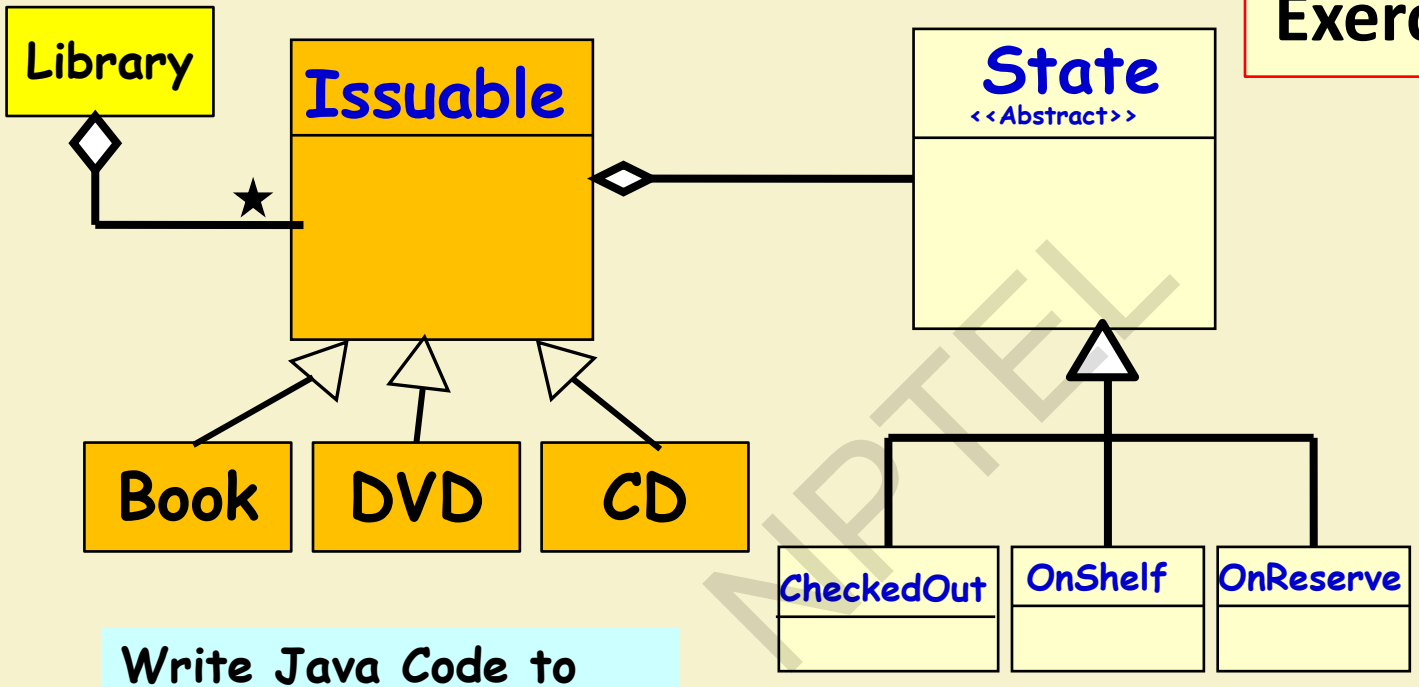


- A TCPConnection object responds differently to requests at different states.
- All state-dependent actions are delegated.

State Pattern: Exercise 2

- A Library has a large number of Issuables.
  - An issuable is either a book, a DVD, or Music CD.
- Each issuable can either be on shelf, issued out, or on reserve.
  - Response to request for issue and renew an issuable is different in different states.

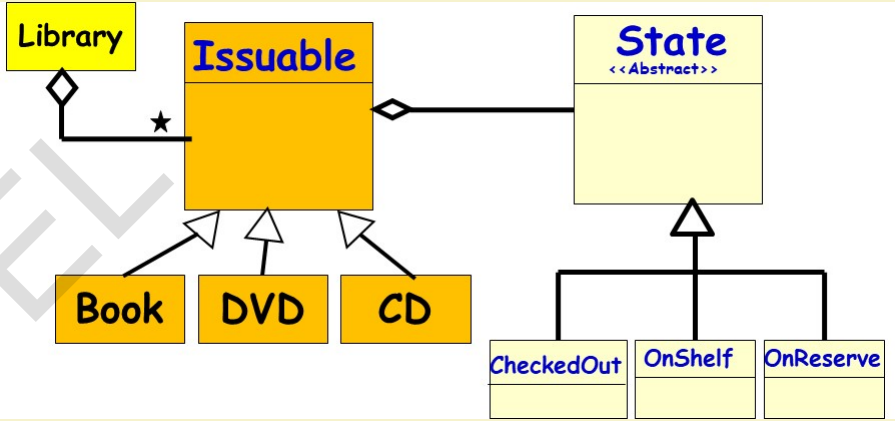
Exercise 2: Solution



Write Java Code to Implement the State Pattern.

Exercise 2: Code

```
abstract public class State {
        protected boolean checkOut() { return false; }
        protected boolean putOnShelf() { return false; }
        protected boolean putOnReserve() { return false; }
}
public class CheckedOut extends State{
        private boolean putOnShelf() { return true; }
}
public class OnShelf extends State {
        private boolean checkOut() { return true; }
        private boolean putOnReserve() { return true; }
}
public class onReserve extends State {
        private boolean checkOut() { return true; }
}
```



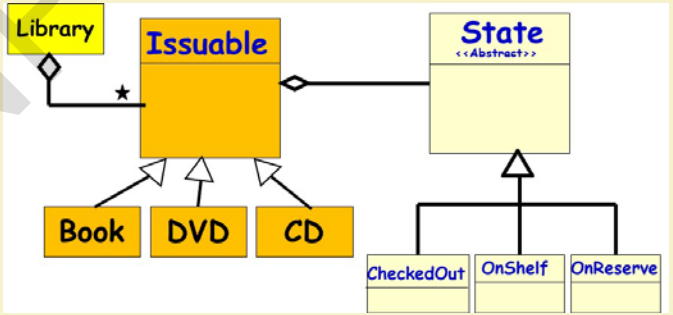
```
abstract public class Issuable{
State state=new onShelf();

Public boolean checkOut(){
if(state.checkOut() == true) {
changeState(new CheckedOut());
  return true;}
 else  return false;
}
```

Exercise 2: State Pattern Code

```
Public boolean putOnShelf() { … }
public boolean  putOnReserve() { … }

public void changeState(State newState){
        state = newState;
  }
}
```



Advantages

- Encapsulates behavior of a state into an object
- Eliminates long lines of code involving if/else or switch/case statements with state transition logic
- State changes occur using one object, therefore avoids inconsistent states.

Disadvantages

- Increased number of objects.

Trade-offs

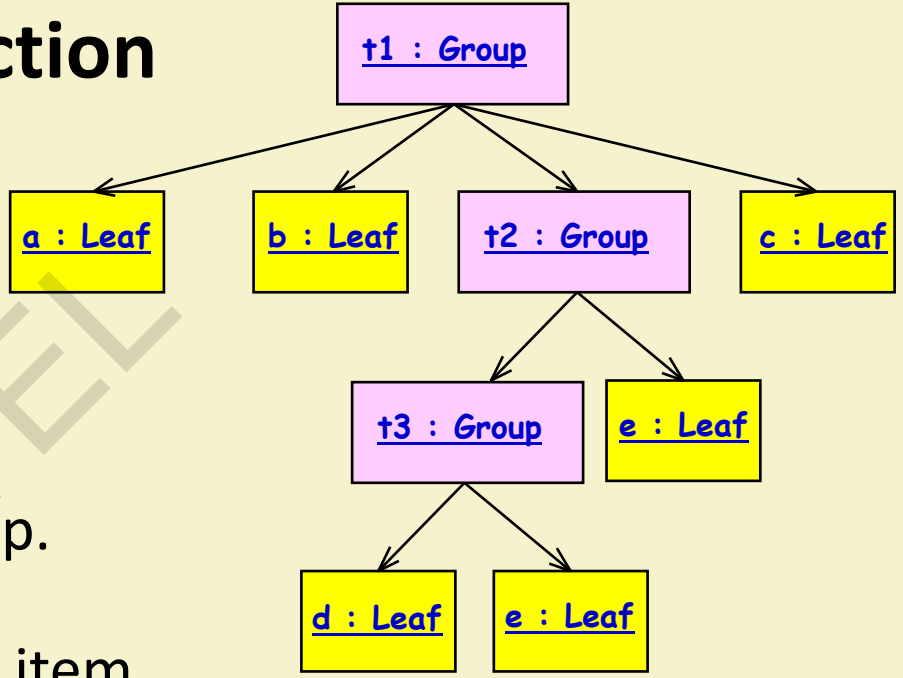
- **Advantages**
  - Switch-case statement is not efficient.
    On the average, half of the options need to be examined.
  - Code becomes modular:
    - Otherwise, behavior for all states get handled in one place (switch-case):
    - **Any changes to state logic would need recompilation and retesting.**

Food for thought…

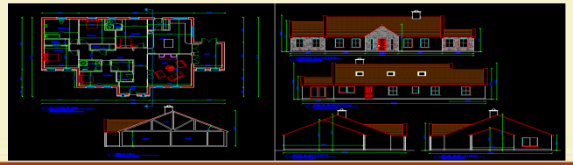
- **Where to define the state transitions ?**
  - For simple cases, transition can be defined in the context.
  - More usable if transition is specified in the State subclass.
- **Whether to create State objects as and when required or to create-them-once-and-use-many-times ?**
  - First one is desirable if state changes are infrequent.
  - Later one is desirable if the state changes are frequent.

Composite Pattern

Composite: Introduction

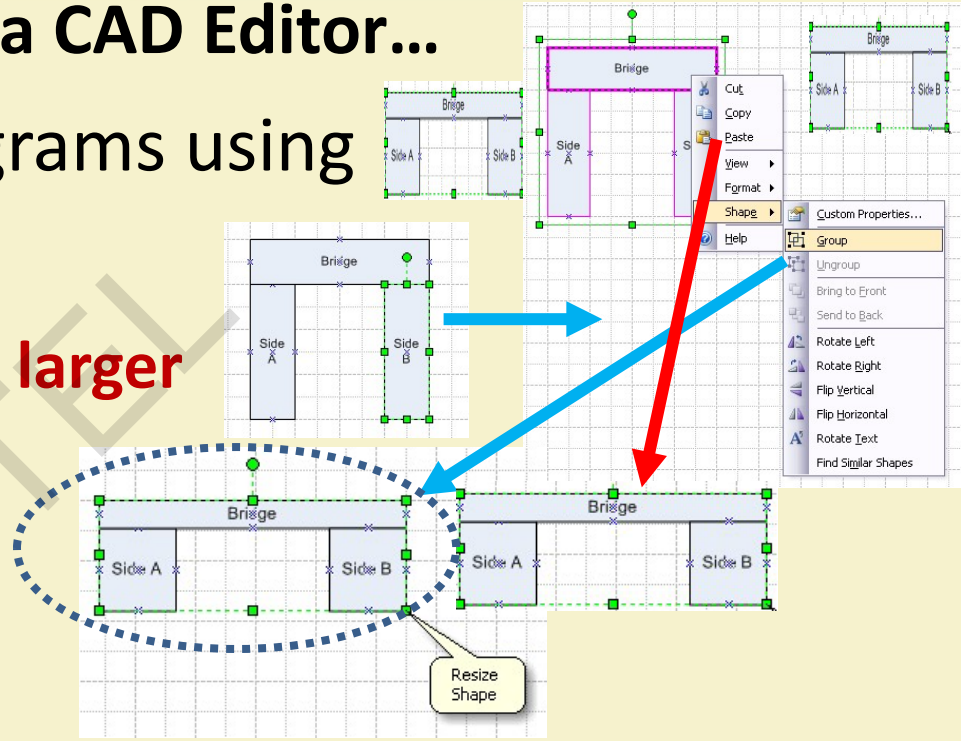


- A composite is a group of objects in which some objects contain others:
  - An object may represent a group.
  - Or may represent an individual item.
  - Example: A CAD Design ---

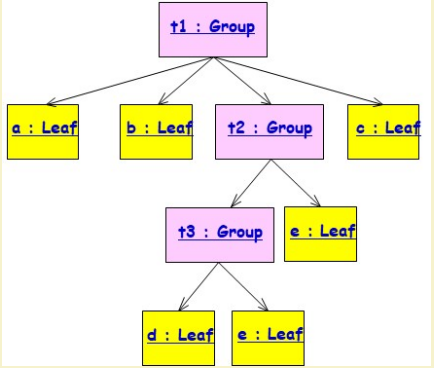


Example: Consider a CAD Editor…

- You can build complex diagrams using simple components
  - **Group components to form larger components…**
  - **…which in turn can be grouped to form still larger components**



Composite Pattern: Intent

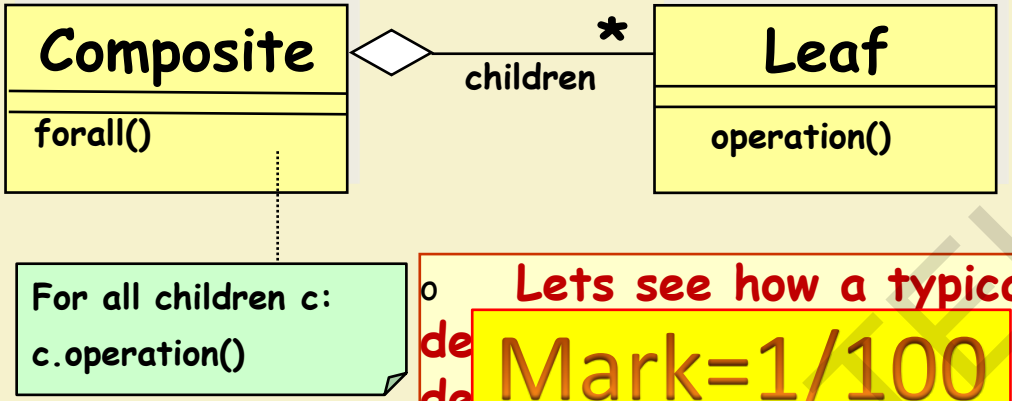


- Compose nested groups of objects into a tree structure to represent part-whole hierarchies.
  - **Clients should be able to treat individual objects and composites in the same way.**

Why Composite Pattern? (Motivation)

- What problems would occur if composite pattern is not used?
  - **Client code might have to treat primitive and container classes differently…**
  - **Makes the application more complex.**
  - **Additions of new types of components becomes troublesome…**

Problem: handling nested group of objects



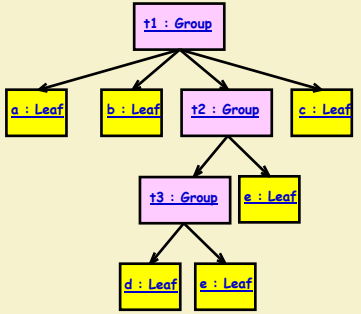
- Lets see how a typical
de
de
from scratch…

Mark=1/100

Client Code:

```
…
if X is
Composite
then
      X.forall()
else
X.operation();
…
```

Composite Solution: First Attempt

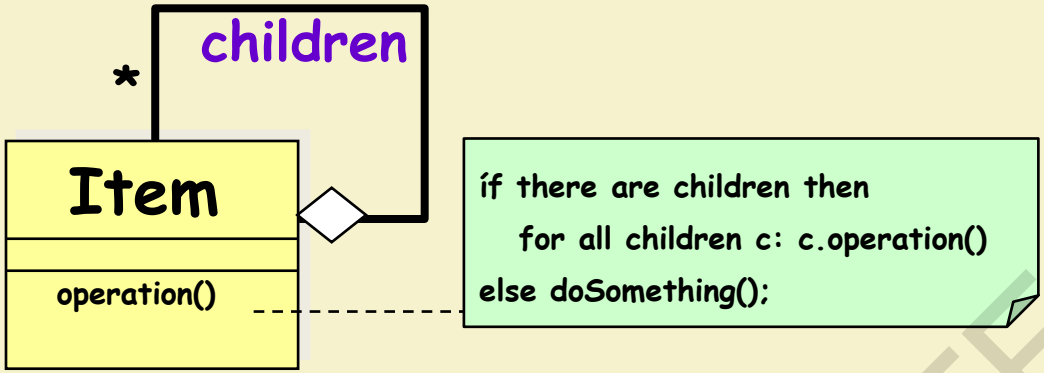


Analysis of Solution: Naive solution…

What are the problems?

-Only single nesting level (depth =1)

-Composite and leafs always treated differently, Difficult to extend.



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Composite: Attempt 2

Surely there are improvements…

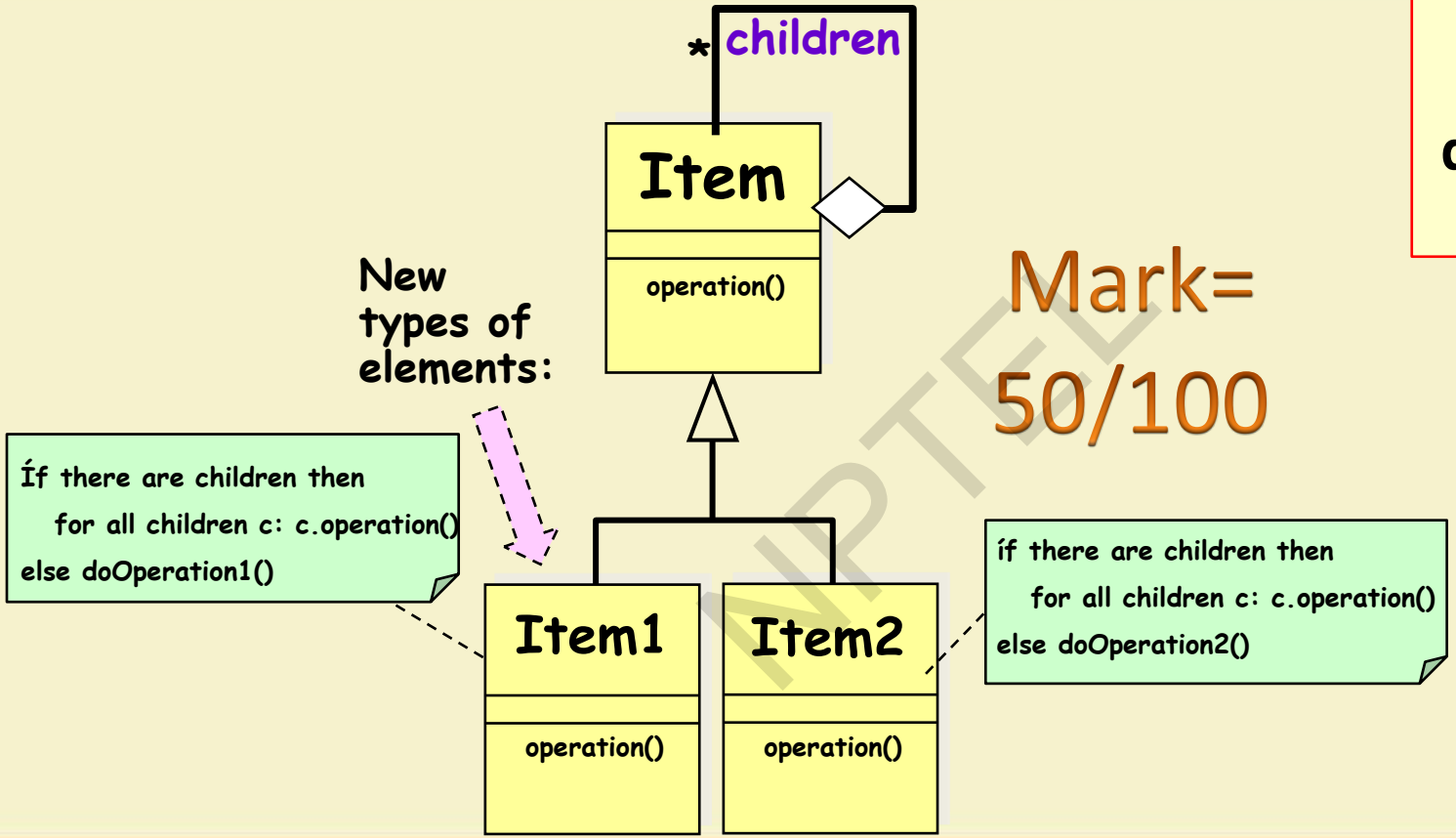
Unified treatment in client **and** unrestricted depth of parts…

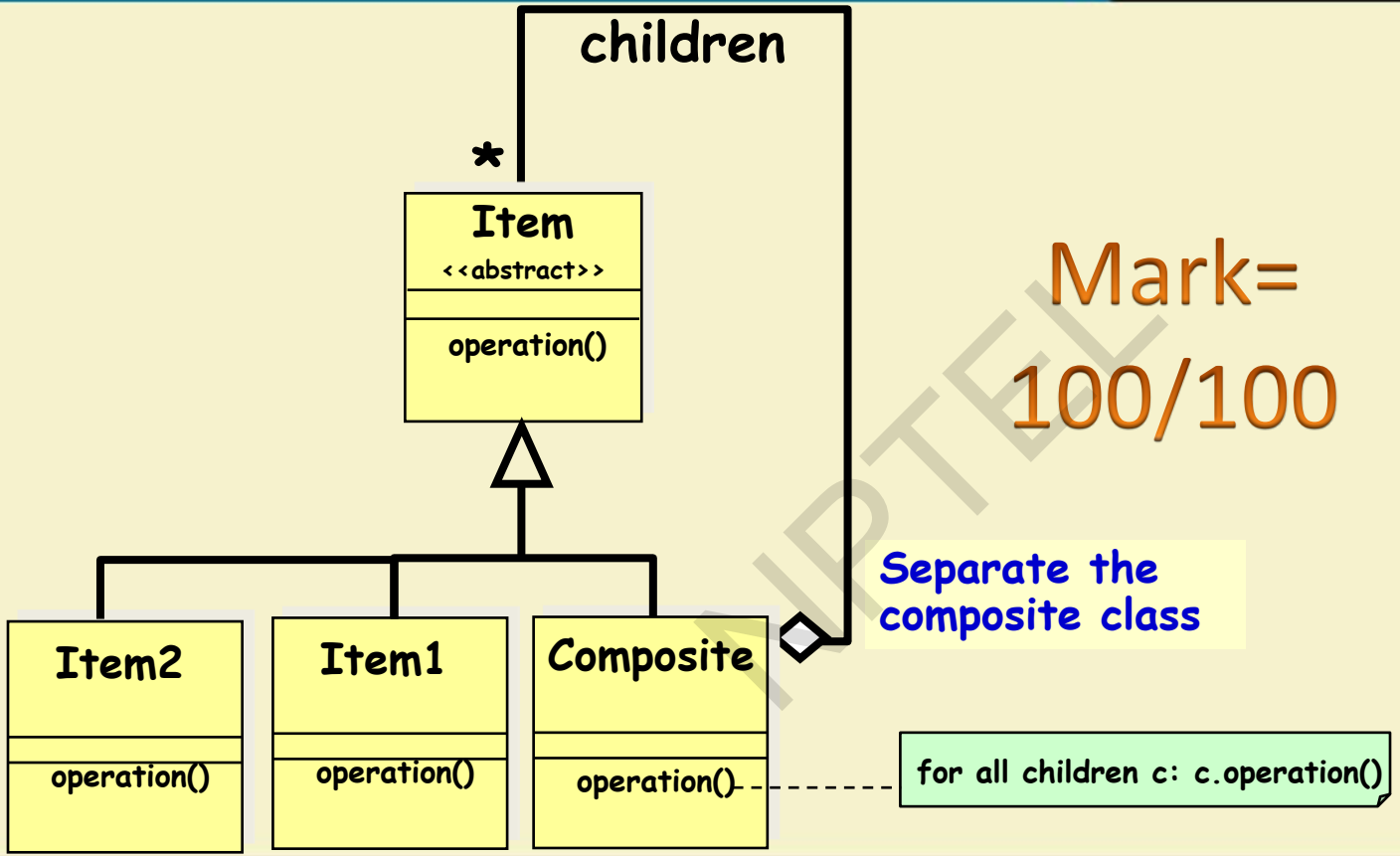
What are the problems?

-Does not handle different item types: primitive and composite

-Difficult to extend with new kinds of leafs or composites.

Attempt 3: Handling different Types of Items





Separate the composite class

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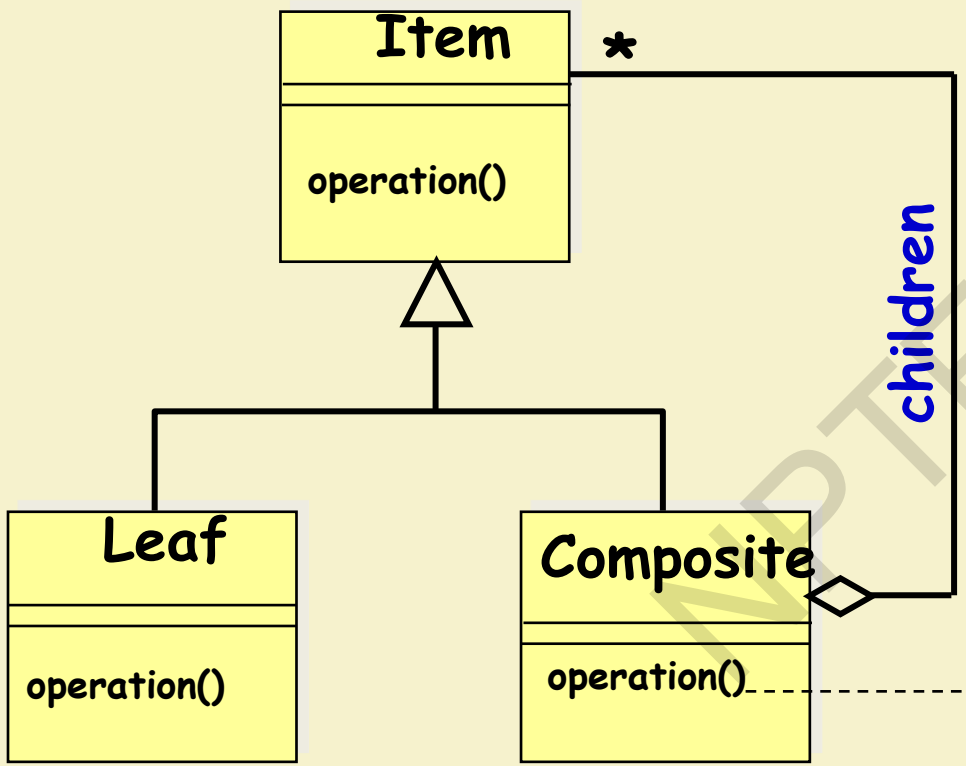
Finally: Composite Pattern

Composite Design Pattern

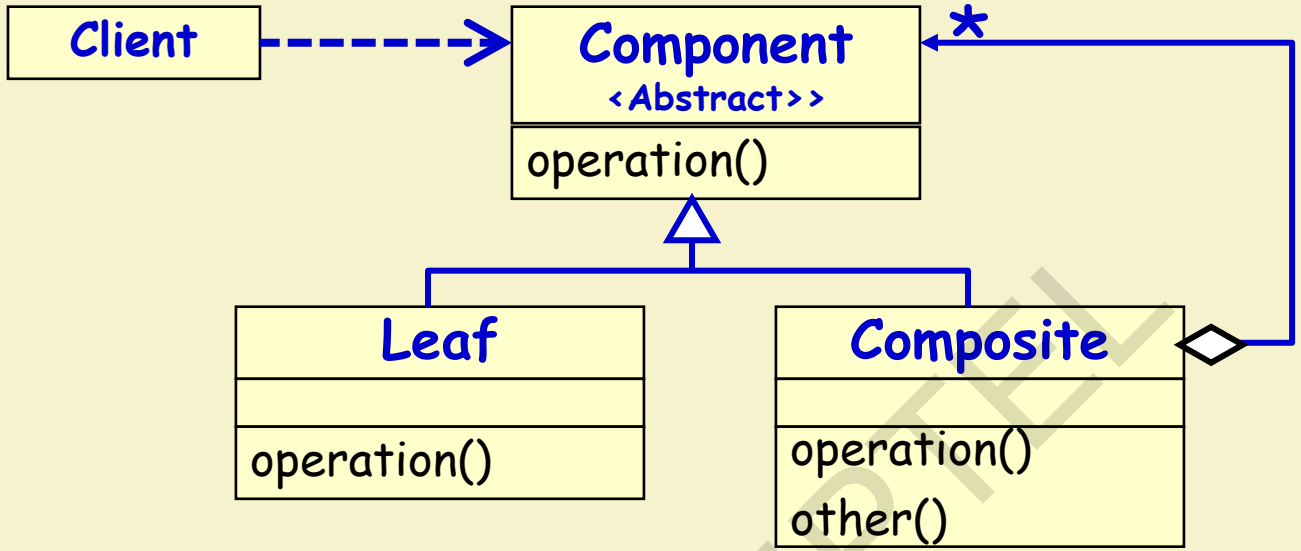


Problem: How to organize a hierarchical object structure so that the clients are not required to be aware of the hierarchy?

Composite Pattern: Issues

- What is the class diagram?
- How does the client interact?
- What operations are defined for:
  - The component, the composite, and the leaf?
  - How are they carried out?
- How is the design implemented?

Composite Pattern

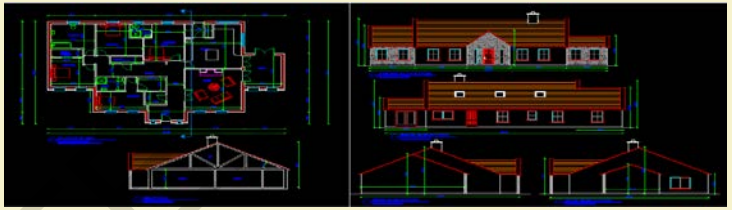


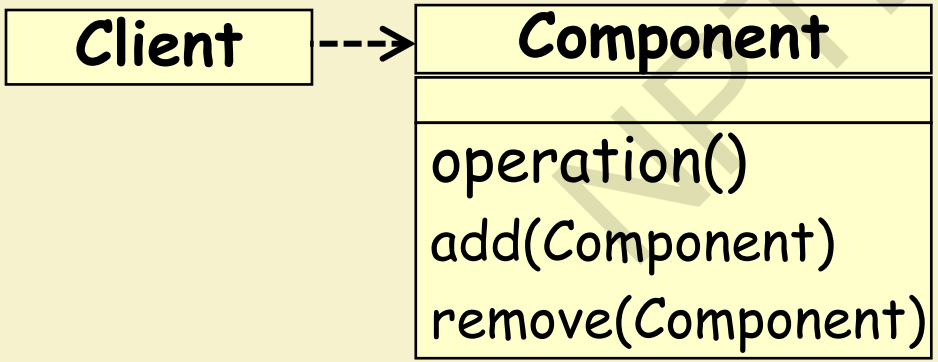
·Each node of the Component structure should respond to some common operation(s).

·The client can call operation of the Component and the structure responds "appropriately".

- The client is a class invokes composite:
  - Manipulates objects in the composition through the Component's interface
- Example: A CAD Drawing

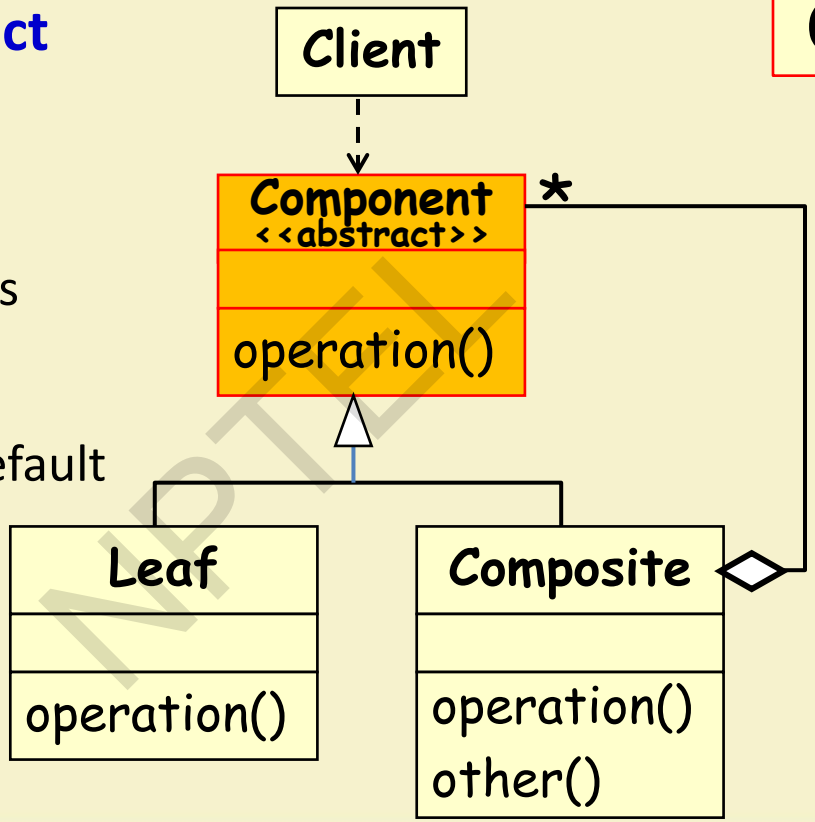
Client





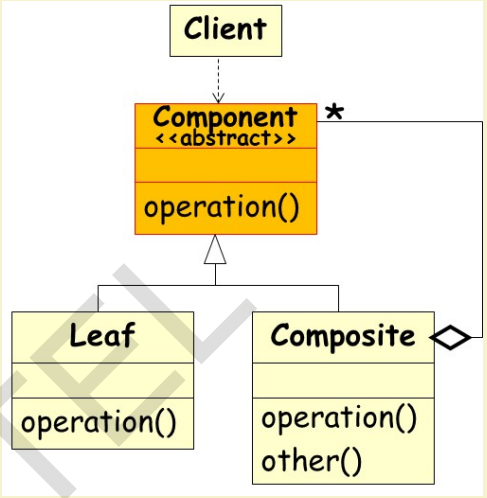
Component

- **Component is an abstract class:**
  - Declares the interface for accessing and managing its child components
  - Defines an interface for default behavior.
  - Optionally provides access to the parent component



Other Participants

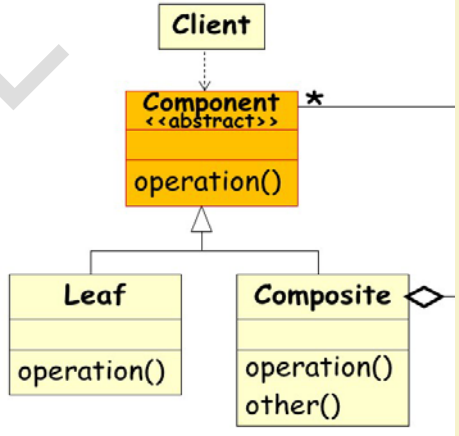
- **Leaf**
  - A leaf has no children.
  - Defines behavior for primitive objects in the composition.



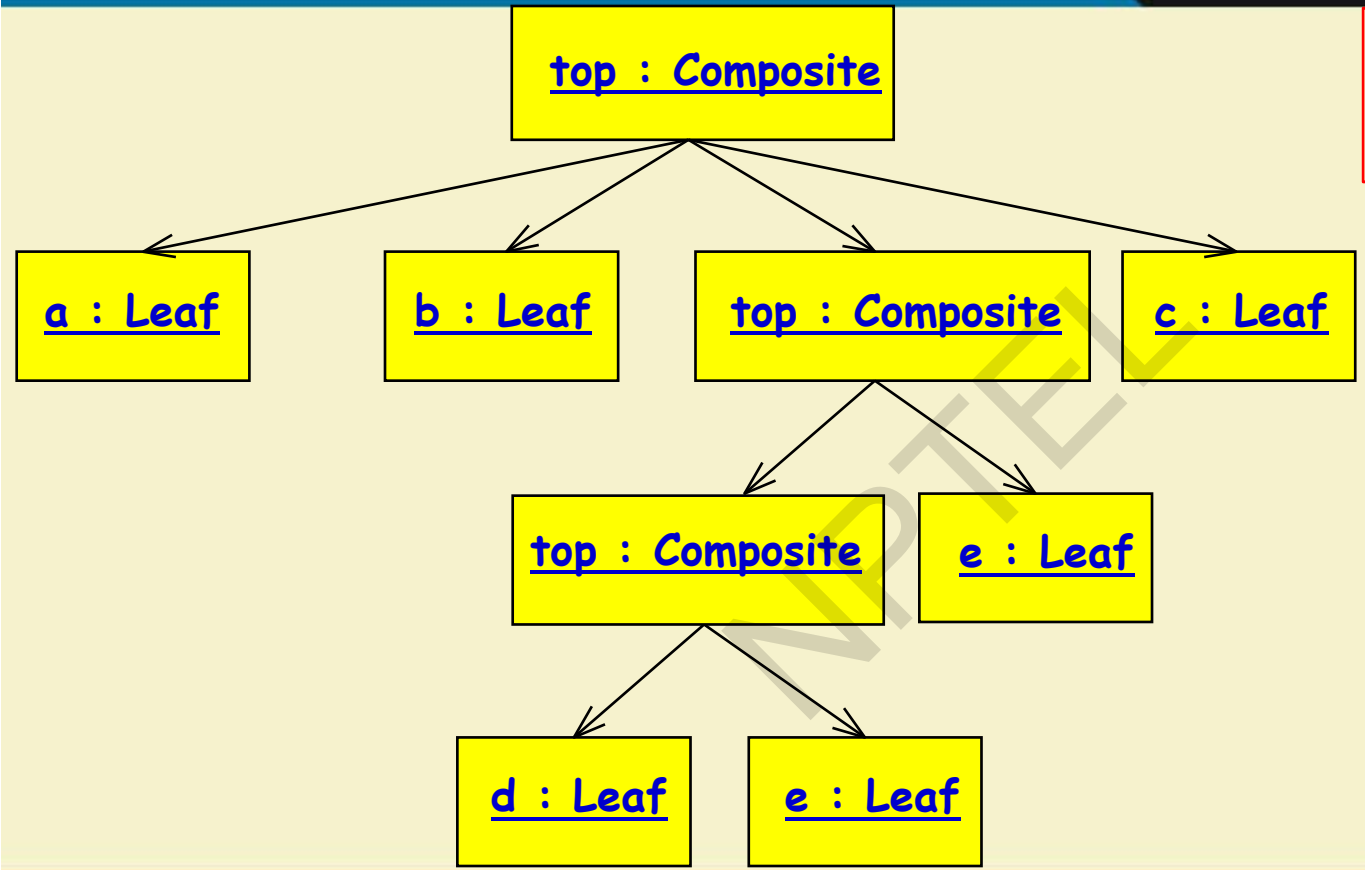
- **Composite**
  - Defines behavior for components having children.
  - Stores child components.
  - Implements child-related operations in the Component interface.

Collaborations

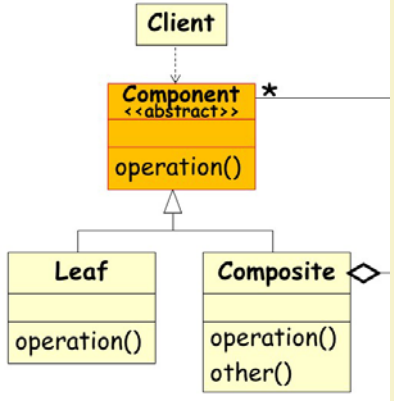
- Clients use the Component class interface, which in turn interacts with objects.
- If the recipient is a Leaf:
  - **Handles the request directly…**
- If the recipient is a Composite:
  - **Forwards the request to its child components…**



Composite: Object Diagram



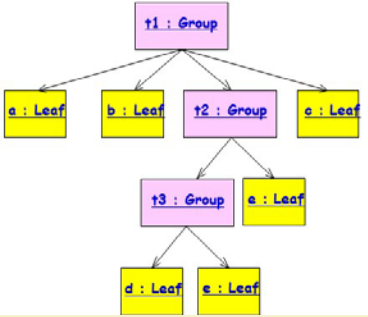
Consequences



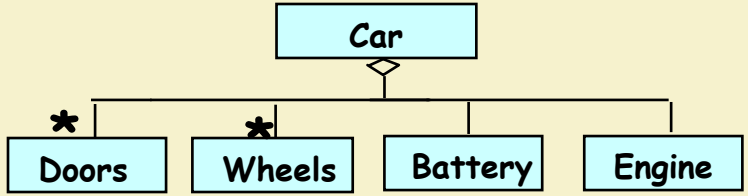
- **Makes it possible to define recursive composition of primitive and composite objects.**
- Makes invocations by client simpler.
  - Client doesn't need to know whether it is dealing with leaves or composites.
- Makes it easier to add new kinds of components.

Applicability

- Use the Composite pattern when:
  - You need to represent part-whole hierarchies of objects
  - You want clients to ignore the differences between parts and wholes
  - **The parts should be created dynamically – at run time:**
    - Example: to build a complex system from primitive components and previously defined subsystems.
    - **This is especially important when the construction process will reuse subsystems defined earlier.**



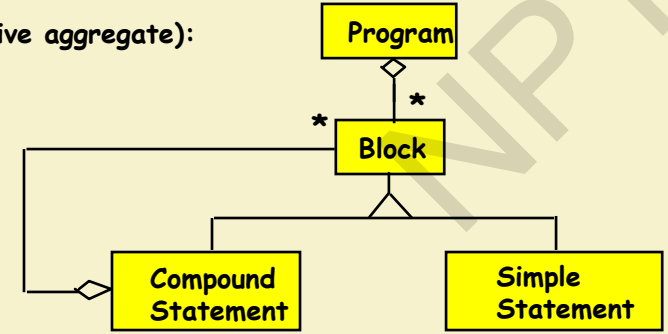
Fixed Structure:



The Composite Patterns model dynamic aggregates

Organization Chart (variable aggregate):

Dynamic tree (recursive aggregate):



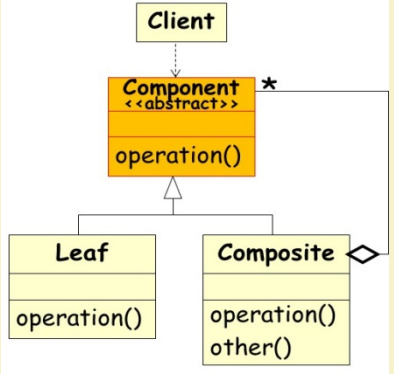
```
Container north = new JPanel(new FlowLayout());
north.add(new JButton("Button 1"));
north.add(new JButton("Button 2"));
Container south = new JPanel(new BorderLayout());
south.add(new JLabel("Southwest"), BorderLayout.WEST);
south.add(new JLabel("Southeast"), BorderLayout.EAST);


// overall panel contains the smaller panels (composite)
JPanel overall = new JPanel(new BorderLayout());
overall.add(north, BorderLayout.NORTH);
overall.add(new JButton("Center Button"), BorderLayout.CENTER);
overall.add(south, BorderLayout.SOUTH);
frame.add(overall);
```

Composite example: Jpanel

JPanel, a part of Java **Swing** package. It is a container that can store a group of components. The main task of **JPanel** is to organize components

Some Insights

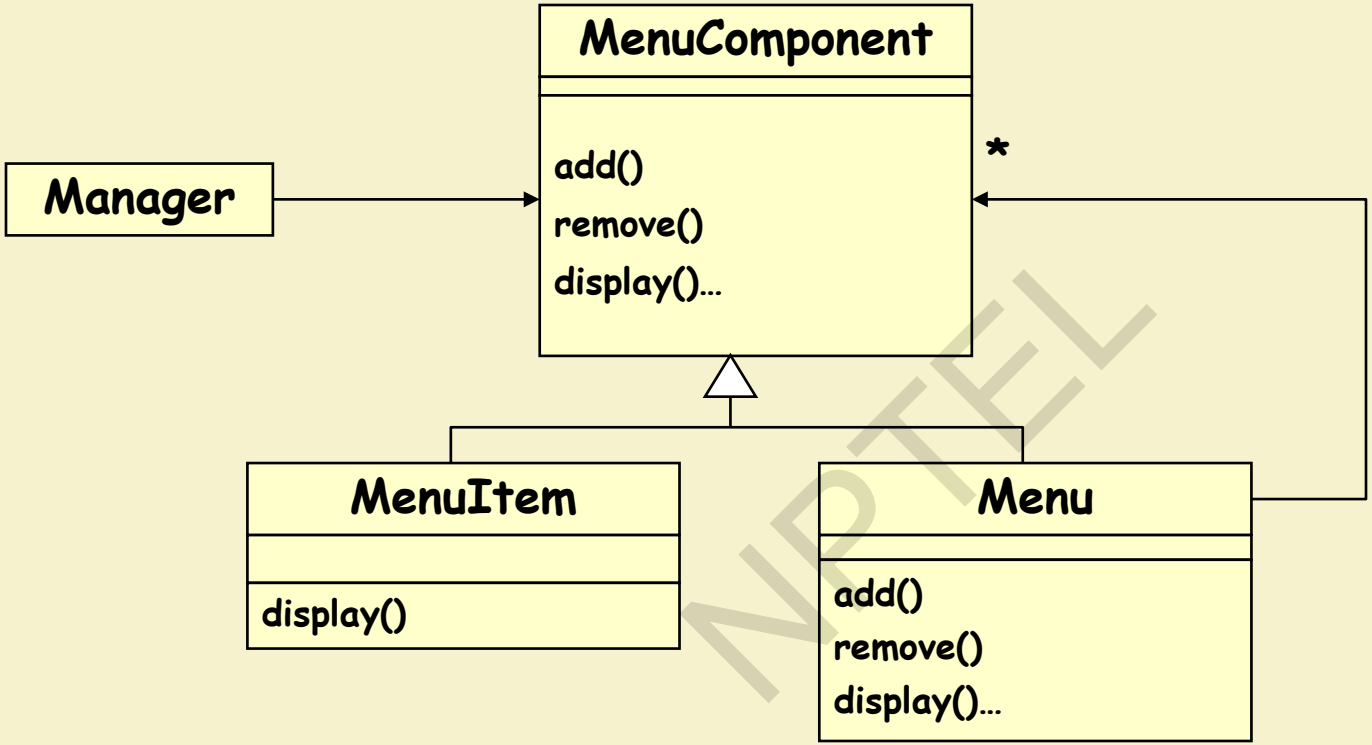
- Why do you declare the methods to handle children in the abstract class?
  - Only the composite class has any use for them?
  - Is it not poor programming practice to have these methods inherited by primitive classes, which have no use for them?
- **There is a tradeoff here between safety and transparency**



Elegance

- If the child management methods are moved from the abstract class to the composite:
  - The client can no longer call these methods on primitive objects, improving elegance.
- However, this gives primitive and composite objects different interfaces:
  - Which is what the design patterns attempt to avoid

Composite Pattern: Example 1



Class Structure to store Restaurant Menu

How can the entire menu be displayed?

Example 1

Menu
menuComponents: ArrayList
add() remove() display()…

1. Menu to MenuComponents association implemented with an array list data type.

2. Let us examine the implementation of print() in Menu and in MenuItem classes…

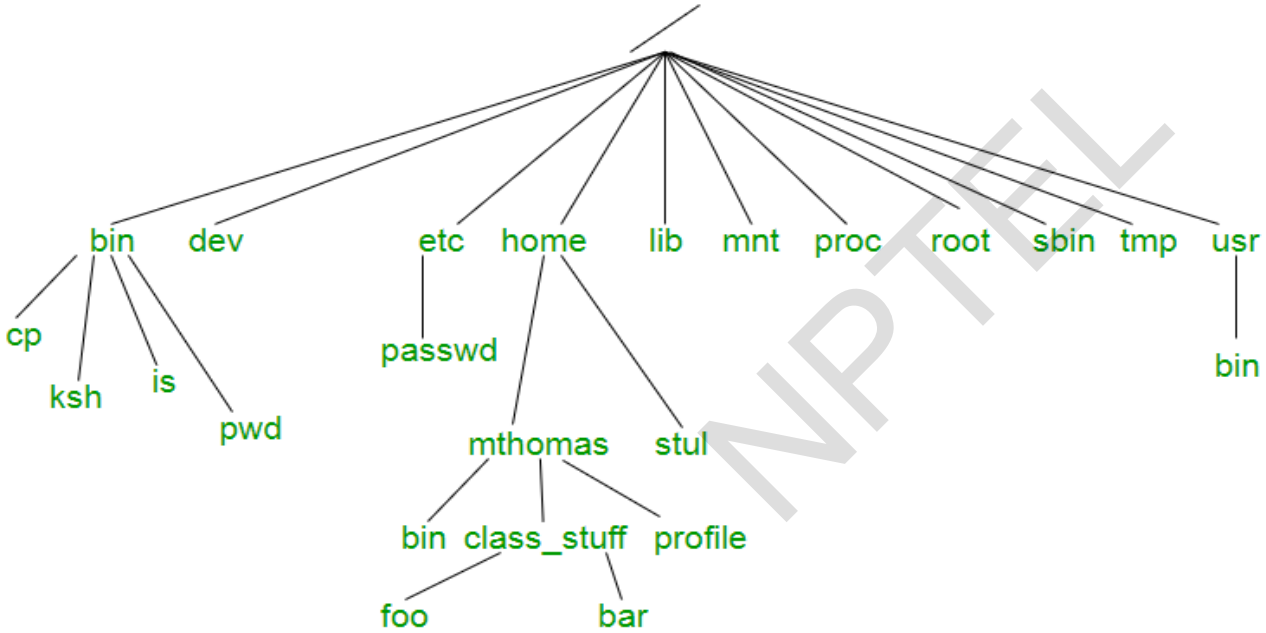
Example 1: Code

```
Class Menu implements MenuComponent{… … …
public void display() {
        System.out.print("\n" + getName());
        System.out.println(", " + getDescription());
        System.out.println("----------------");
        Iterator iterator= menuComponent.iterator();
        while (iterator.hasNext()) {
                MenuComponent menuComponent =
                        (MenuComponent)iterator.next();
                menuComponent.print();
        }
}
```

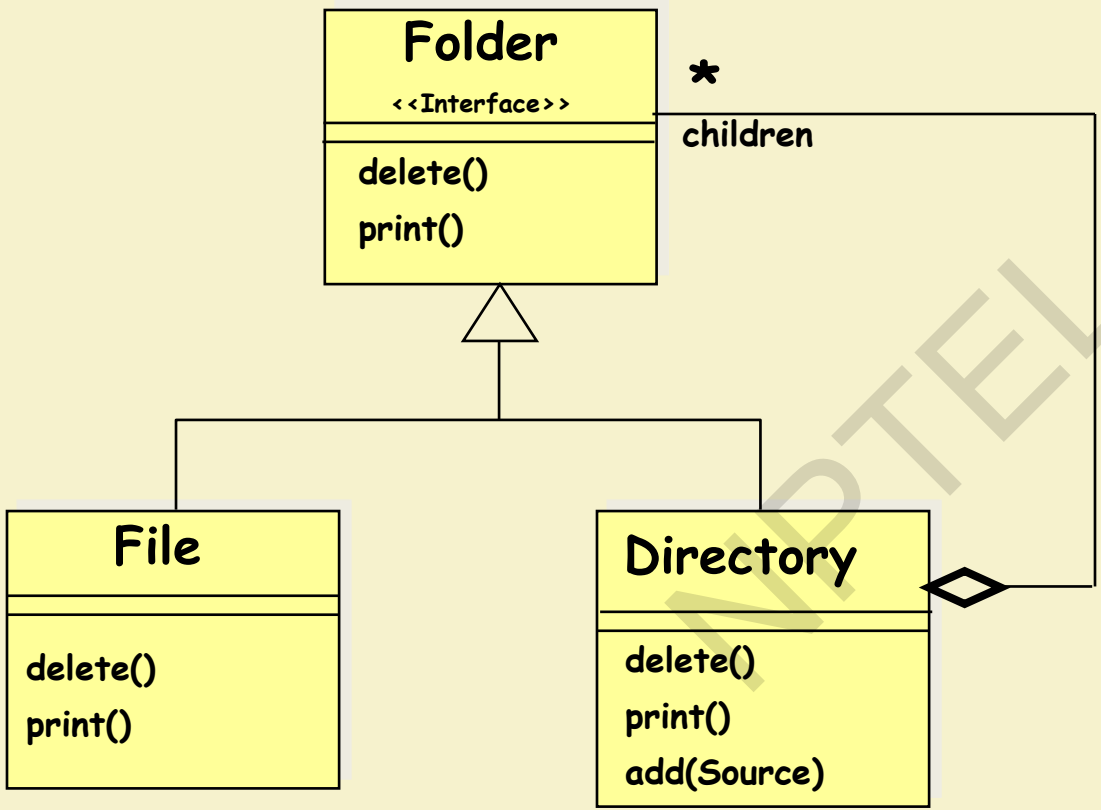
```
class MenuItem implements MenuComponent{ … …

public void display() {

        System.out.print("  " + getName());

        if (isVegetarian())    System.out.print("(v)");

        System.out.println(", " + getPrice());

        System.out.println("--" + getDescription());

    }
```

Exercise 1

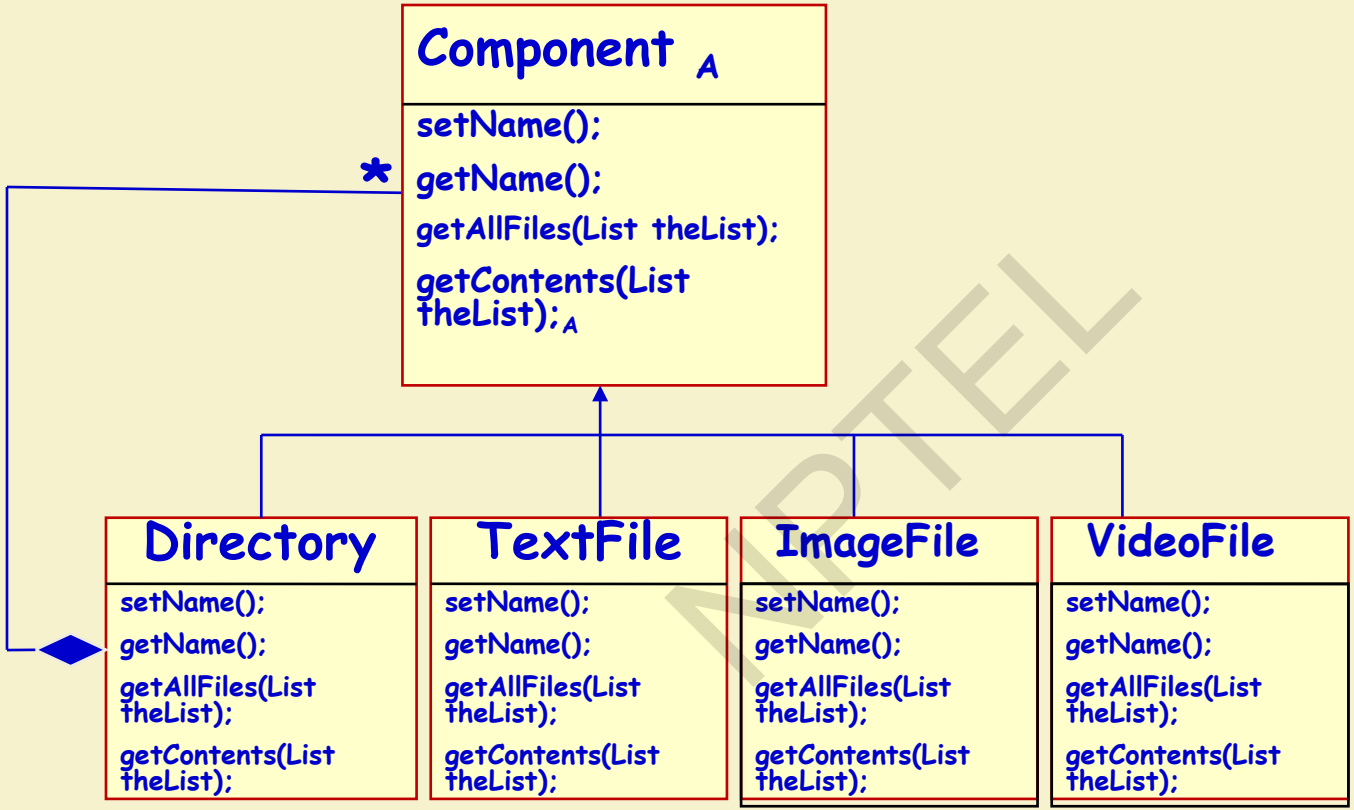
- Design a class structure to model a Unix type file hierarchy …



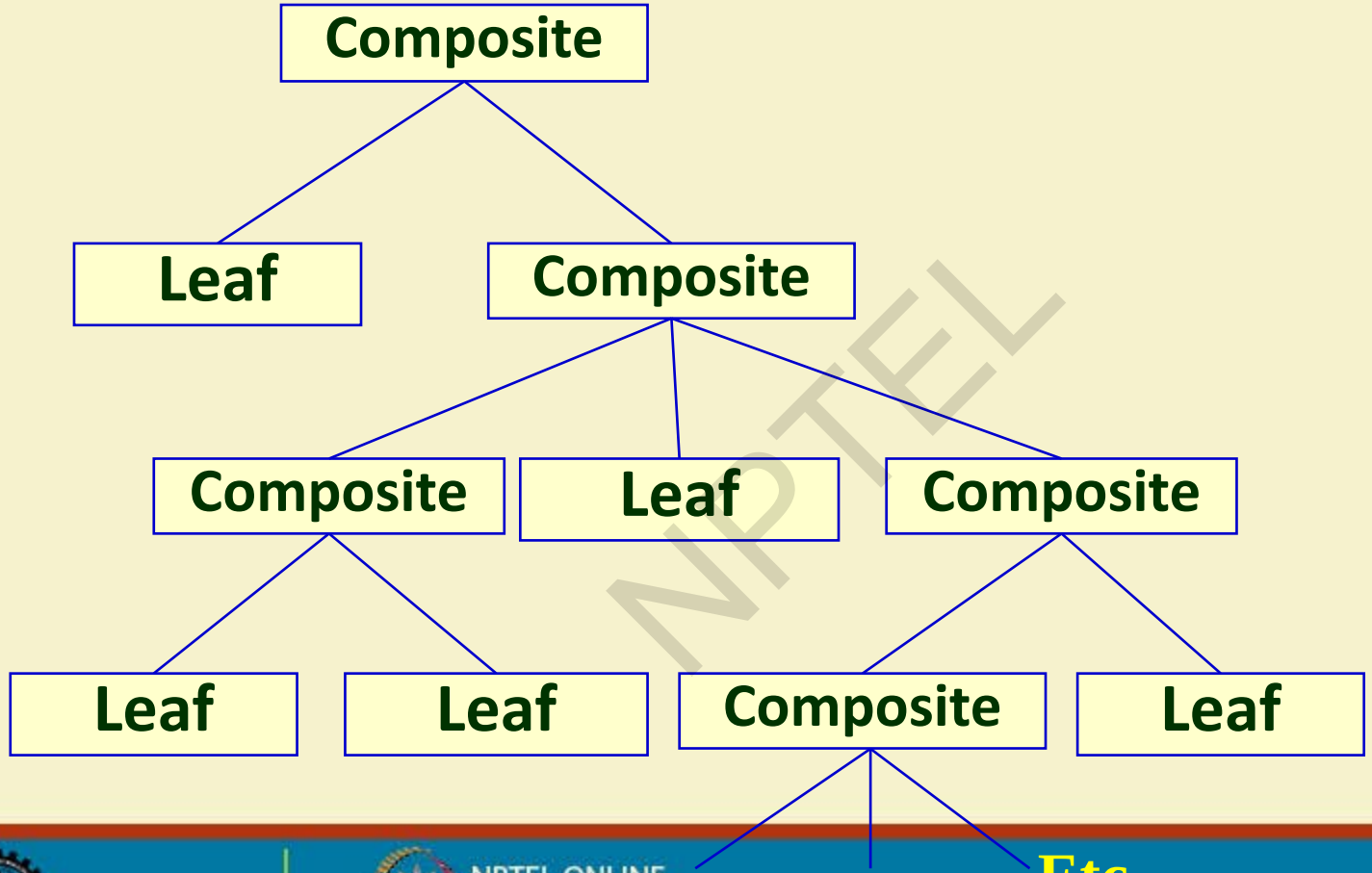
Exercise 1: Solution

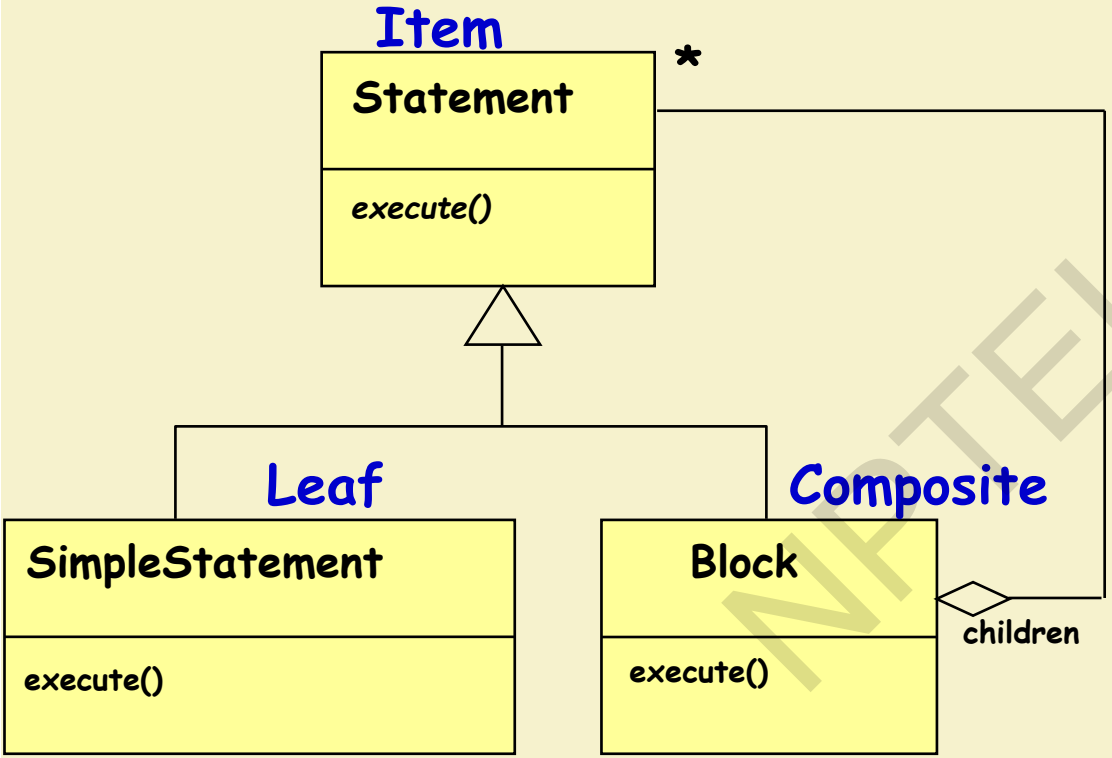


Now Suppose file types are text, image, Video…



Object Model

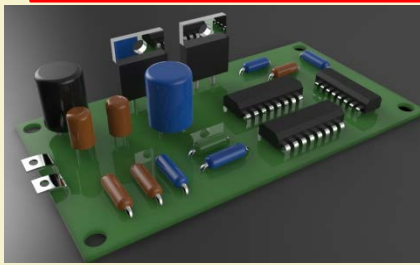




Exercise 2: Programs

A program block can contain simple statements or other program blocks…

Exercise 3



- Develop class design of components to be handled by an Electronic Circuit Diagram editor:

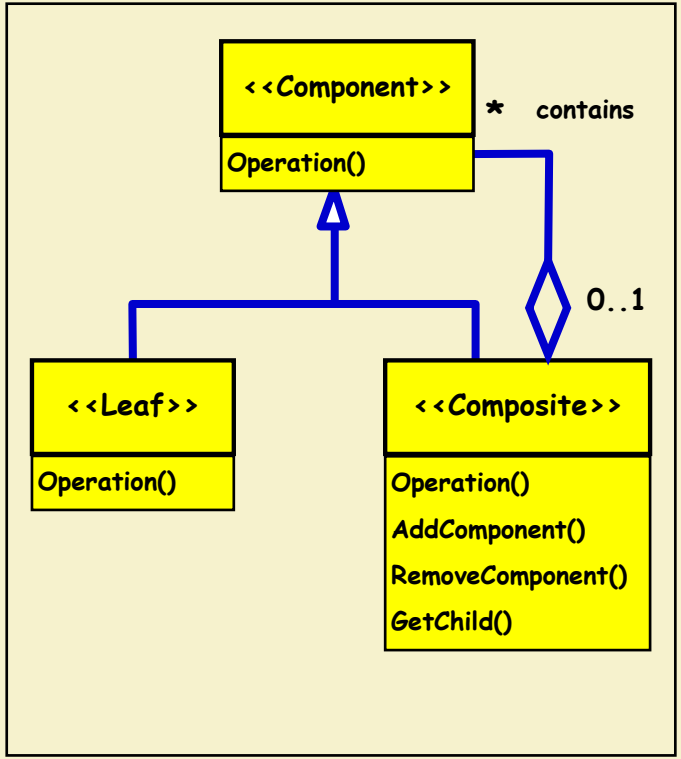
  –Should let users group simple components into larger components.

  - Which in turn can be grouped to form still larger components.
  - Larger components should behave similarly w.r.t. select, copy, paste, move,delete, resize, ...

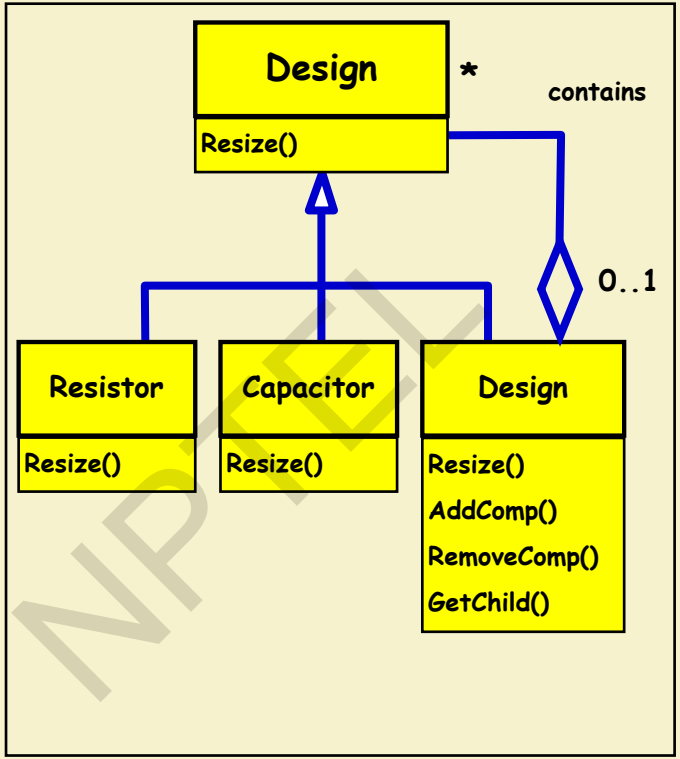
Solution

- The key to the Composite pattern:
  - An abstract class that represents both primitives and their containers.
  - The abstract class Design declares operations like Copy, Move, Delete, resize, etc. that are specific to graphical objects.
  - It also declares operations that all composite objects share, such as
    - Operations for accessing and managing its children, like Add, UnGroup.

Composite Pattern: Solution



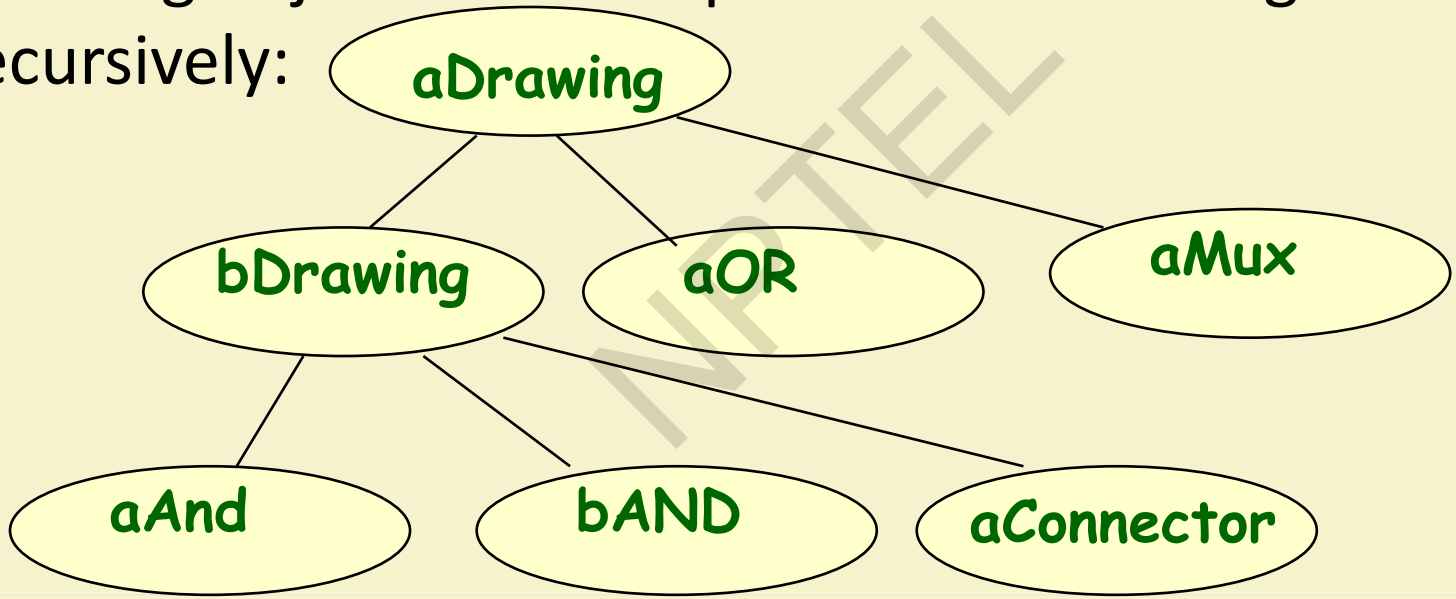
General Idea



Applied to the designing example

Object Structure

- Because the Drawing interface conforms to Design interface,
- Drawing objects can compose other Drawing recursively:



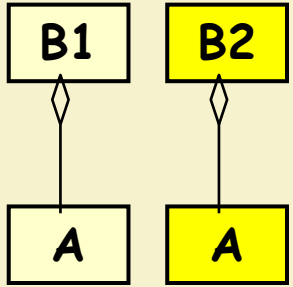
- Component does not know what it is a part of:
  - Component can be in many composites
  - Component can be accessed only through composite

Alternatives…

- Component knows what it is a part of
  - Component can be in only one composite
  - Component can be accessed directly

Composite: Some Issues

- When components are part of a single composite:
  - A is a part of B if and only if B is the composite of A
  - However, duplicating information can be dangerous!



- **Problem: How to ensure that references of components to composite and composite to components are consistent?**

Ensuring consistency

- The public operations on components and composites are:
  - Composite can enumerate components
  - Component knows its container
  - Add/remove a component to/from the composite
    - **The operation to add a component to a composite updates the container of the component**
    - There should be no other way to change the container of a component

addChild() in Composite

```
public void addChild(Component child) {
        childArray.add(child);
        child.setParent(this);
}
```

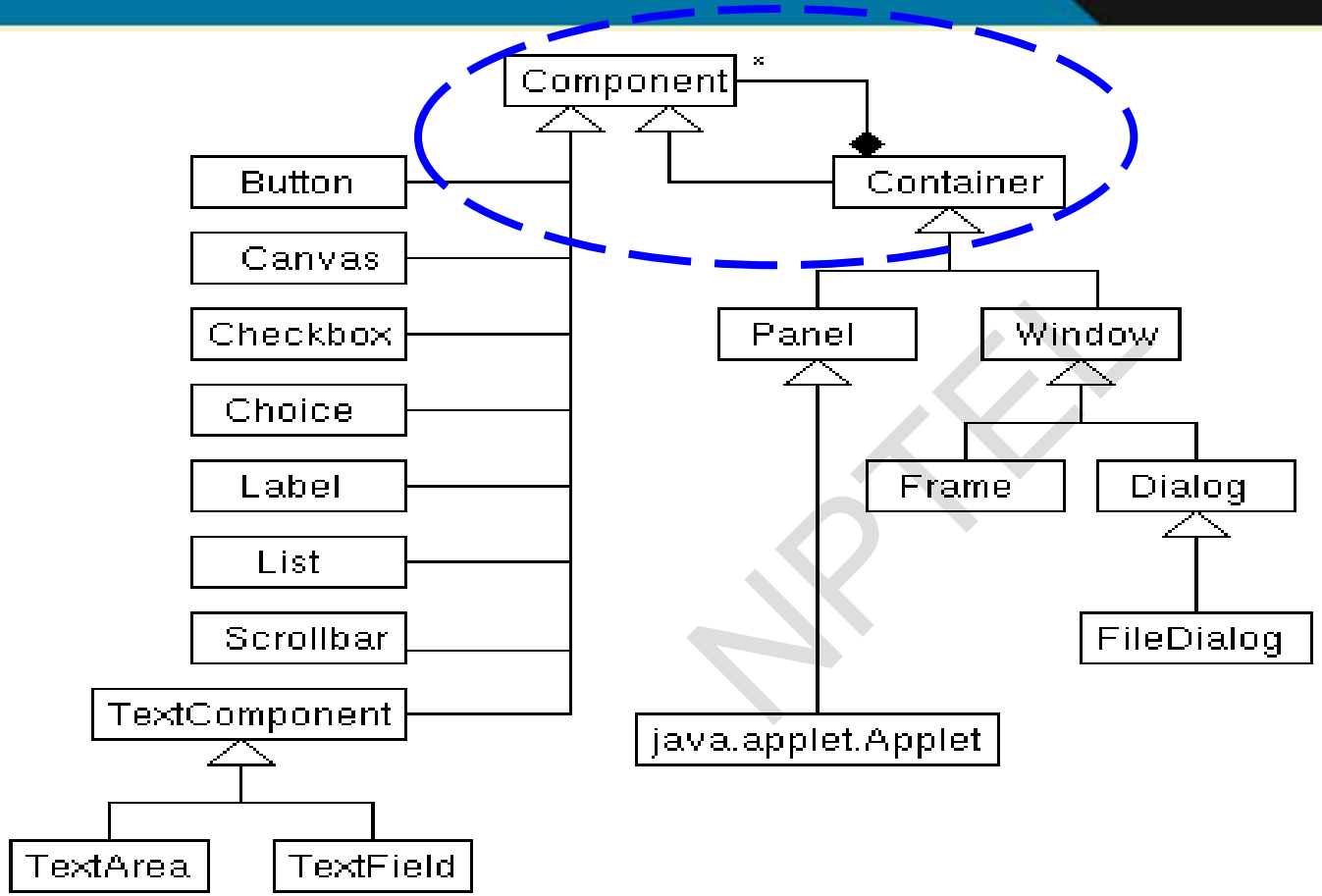
Exercise 4: Java GUI

Q: How can we add any widget to another, for example panels to an applet?

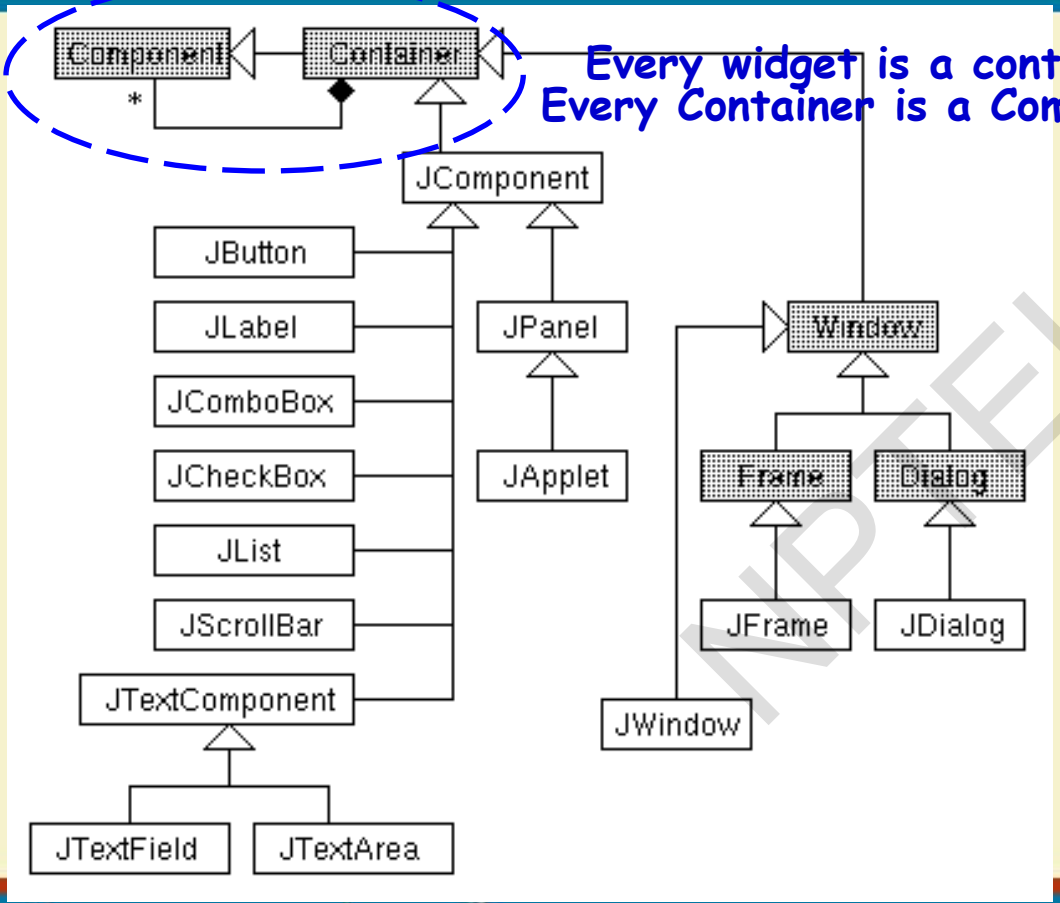
```
public class MyApplet extends java.applet.Applet {
   public MyApplet() {
      add(new Label("My label"));
      add(new Button("My button"));
      Panel myPanel = new Panel();
      myPanel.add(new Label("Sublabel"));
      myPanel.add(new Button("Subbutton"));
      add(myPanel);
   }
```

Solution:
Composing GUI

AWT Components



Swing Components



Adapter Pattern

Adapter Pattern

Intent:

- **Convert the interface of a class to the interface expected by the users of the class.**
- Allows classes to work together even when they have incompatible interfaces.

Also universal adapters?

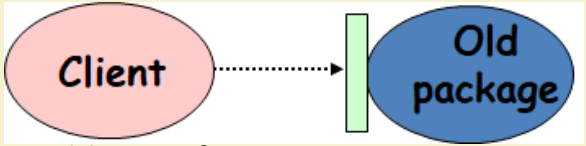
Example (non-software):

- You went to U.S.
- Had an Indian electrical appliance?

- How can you use it in U.S.?
- **Use Adapters!**

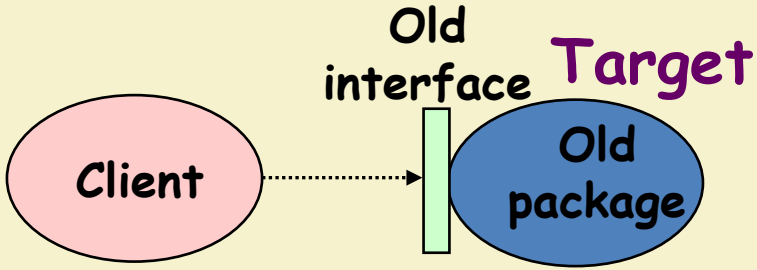
Adapter Pattern

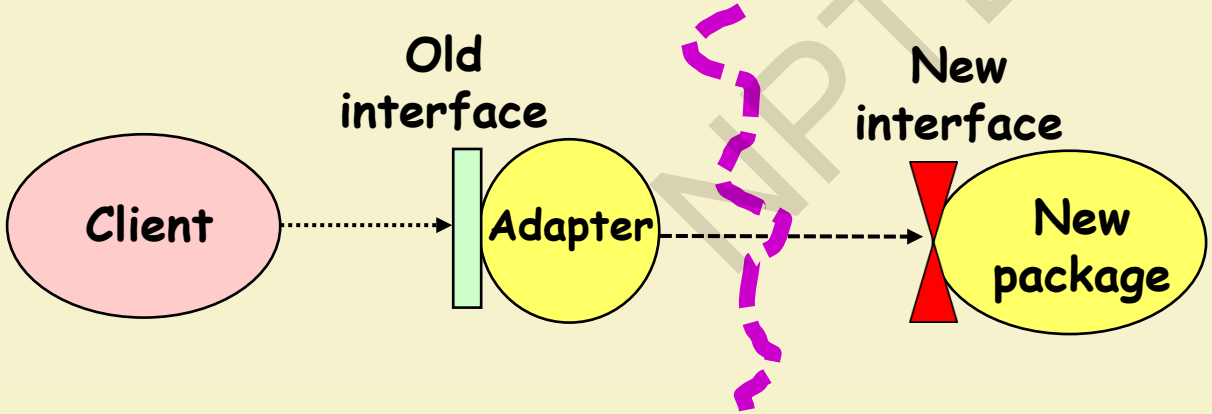
- A **wrapper pattern**
- **Problem: Convert the interface of a class into one that a client expects.**
  - Lets classes work together --- that couldn't otherwise --- because of incompatible interfaces
  - Used to provide a new interface to existing legacy components.



- Two main adapter variants:
  - **Class adapter:**
    - Uses interface implementation and inheritance mechanisms
  - **Object adapter:**
    - Uses delegation to adapt one interface to another
- **Object adapters are much more common.**

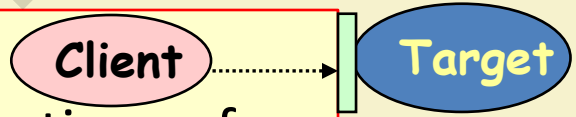
Essential Idea Behind Adapter Pattern





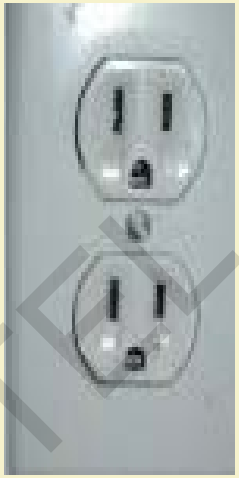
Adapter Pattern

- **Helps two incompatible types to communicate.**
  - When a client class expects an interface ---but that is not supported by a server class,
  - The adapter acts as a translator between the two types.
- 3 essential classes involved:
  - **Target** – Interface that client uses.
  - **Adapter** - class that wraps the operations of the Adaptee in interfaces familiar to client.
  - **Adaptee** - class with operations that the client class desires to use.



Recap: Terminology

Adapter

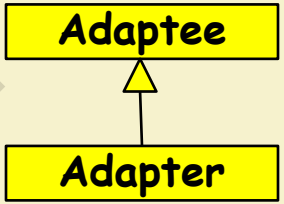


Adaptee

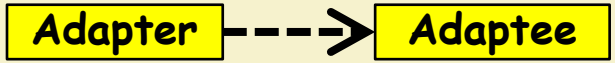
Target

An adaptee may be given a new interface by an adapter in two ways:

- **Inheritance**
  - Known as **Class Adapter pattern**
  - The adapter is a sub-class of adaptee;

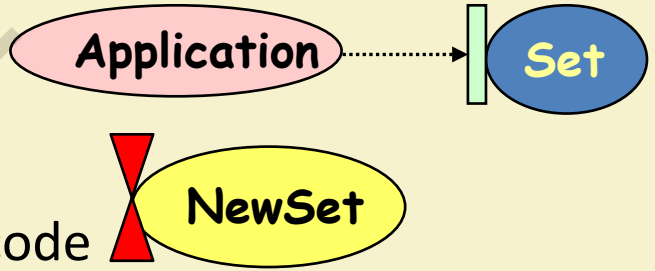


- **Delegation**
  - Known as **Object Adapter pattern**
  - The adapter holds a reference to an adaptee object and delegates work to it.

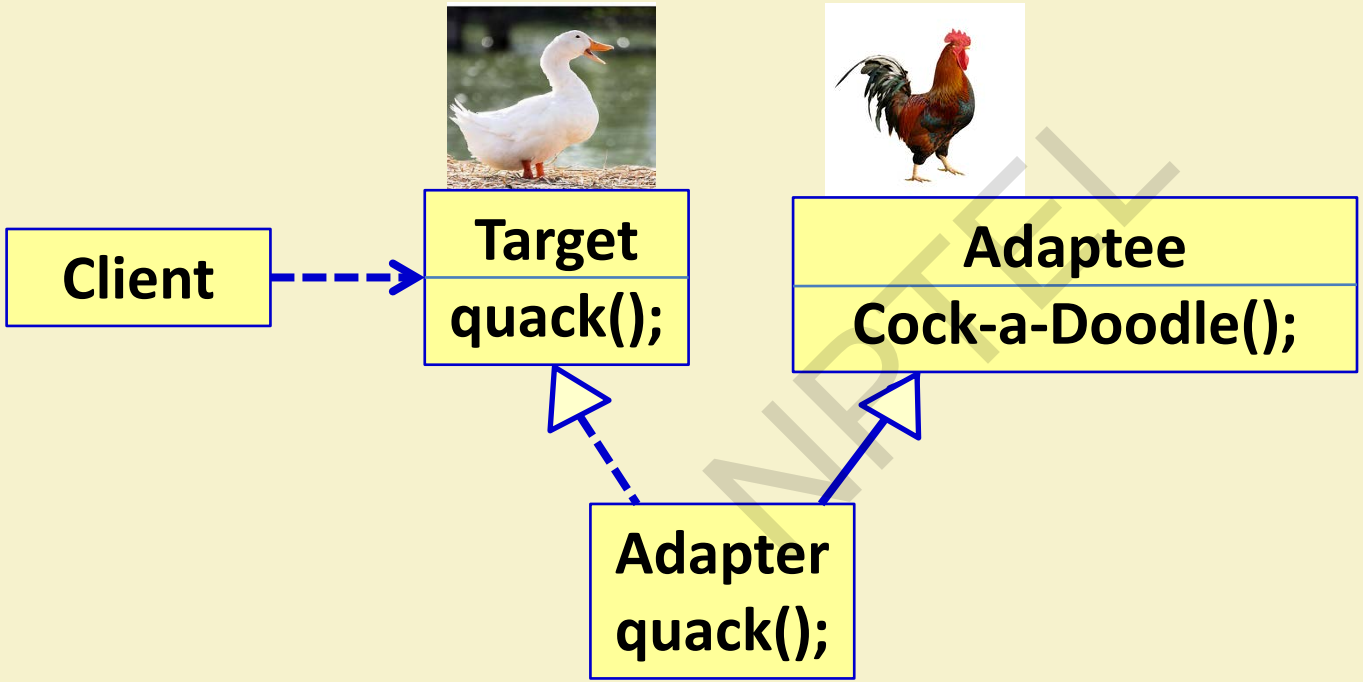


Example 1 – Sets

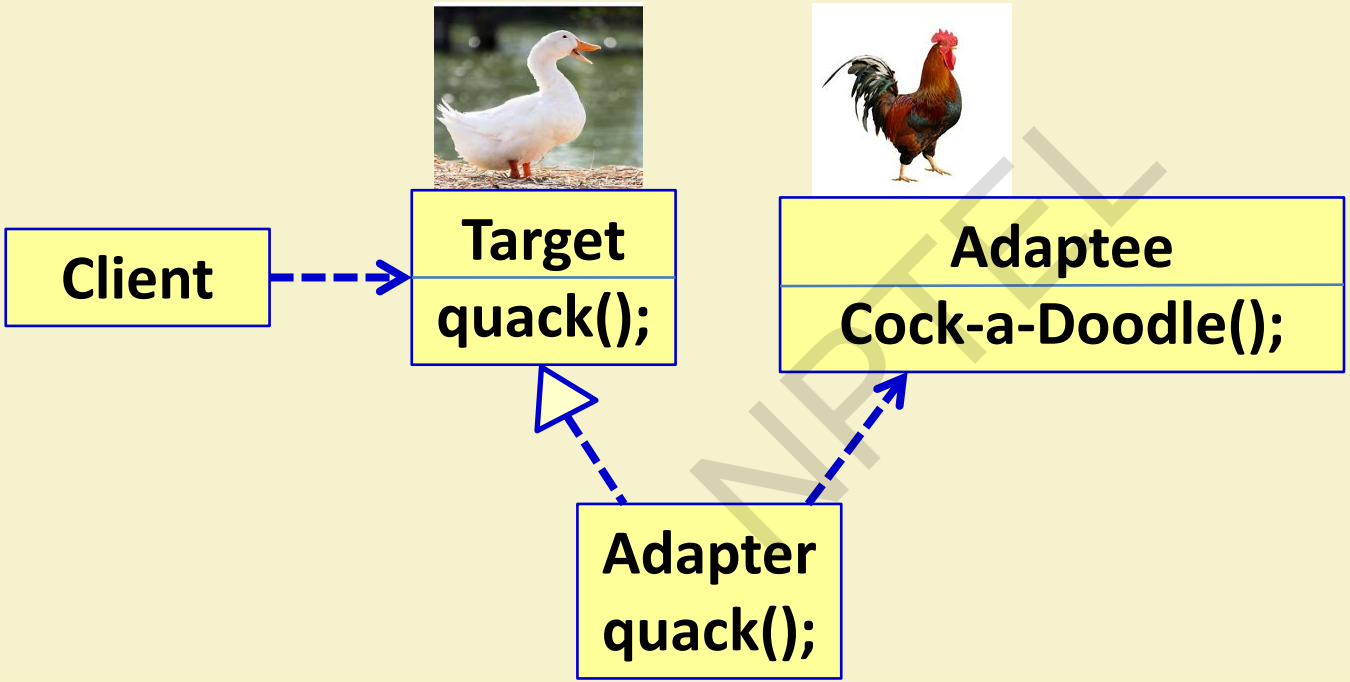
- There are many ways to implement a set
- Assume:
  - Your existing set implementation has poor performance.
- You got hold of a more efficient set class,
  - BUT: The new set has a different interface.
  - Do not want to change voluminous client code
- **Solution: Design a setAdapter class :**
  - Same interface as the existing set..
  - Simply translates to the new set's interface.



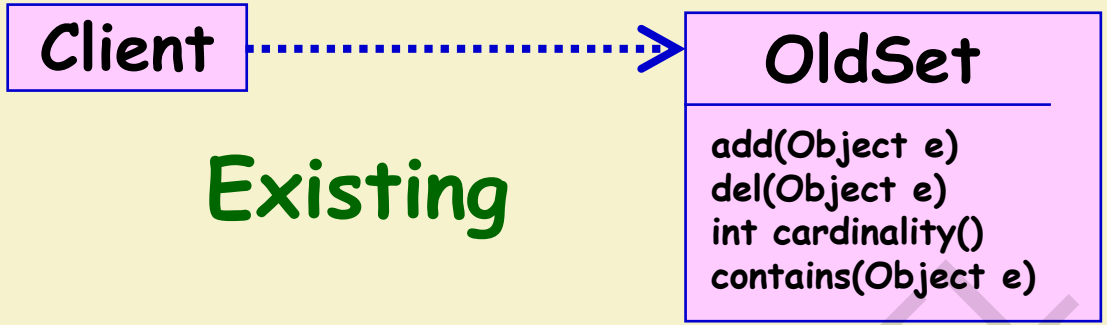
Class Adapter: Main Idea



Object Adapter: Main Idea



Example: Problem



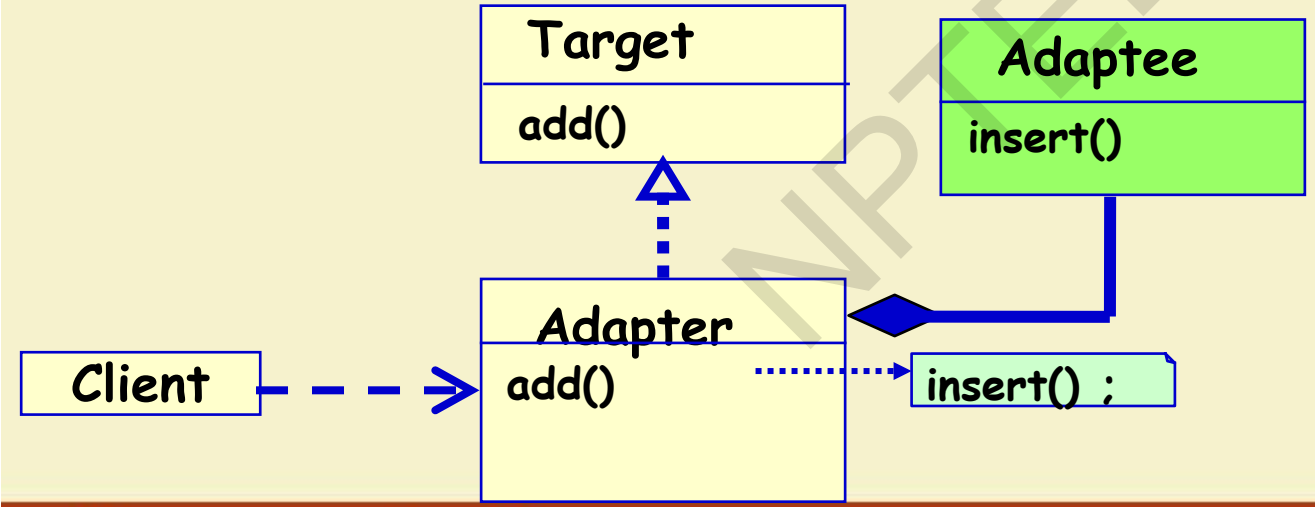
Want use this with client…

But, do not want to change Client code…

Object Adapter --- main idea delegation

- Adapter internally holds an instance of the Adaptee
- Uses it to call Adaptee operations from within operations supported by the Target.

Object Adapter Pattern



Object Adapter - Code

Client Code:

```
Adaptee a =new Adaptee(); Target t = new Adapter(a);
  public void test() {  t.add();  }
```

Target Code:

```
interface Target {
 public void  add(){}
}
```

Adaptee Code:

```
class Adaptee {
  public void insert(){}
}
```

Adapter Code:

```
class Adapter implements Target {
  private Adaptee adaptee;
  public Adapter(Adaptee a) { adaptee = a;}
  public void add() { adaptee.insert();}
}
```