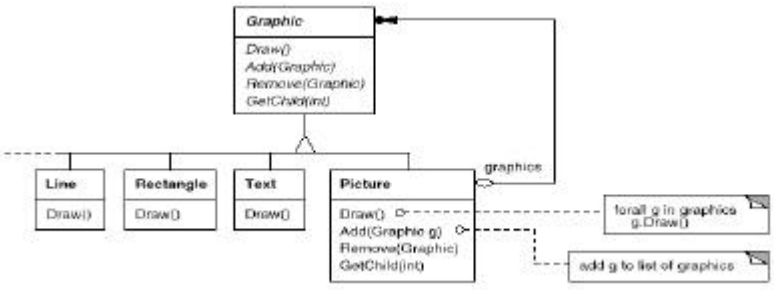
The Composite Pattern

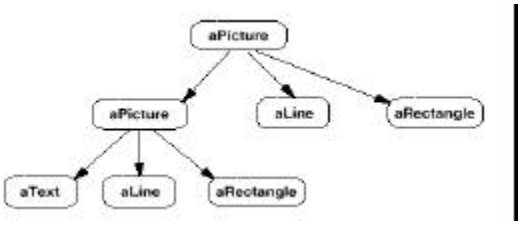
The Composite Pattern

- Intent
  - ⇨ Compose objects into tree structures to represent part-whole hierarchies. Composite lets clients treat individual objects and compositions of objects uniformly. This is called *recursive composition*.
- Motivation



The Composite Pattern

- Motivation



- Applicability

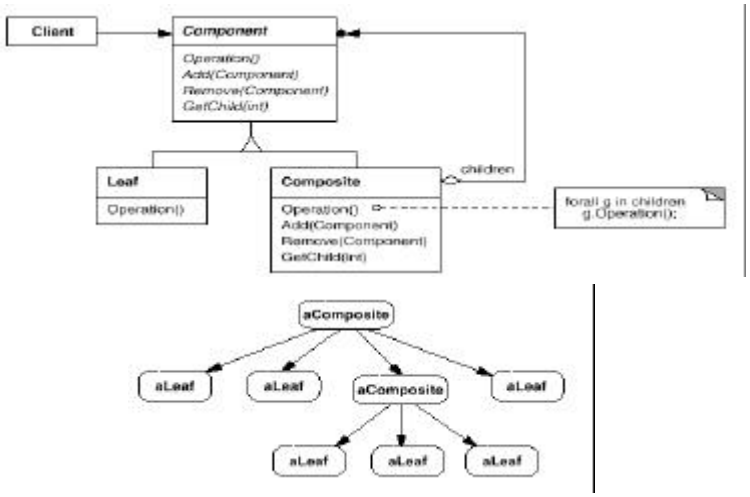
  Use the Composite pattern when

  ⇨ You want to represent part-whole hierarchies of objects

  ⇨ You want clients to be able to ignore the difference between compositions of objects and individual objects. Clients will treat all objects in the composite structure uniformly.

The Composite Pattern

- Structure



The Composite Pattern

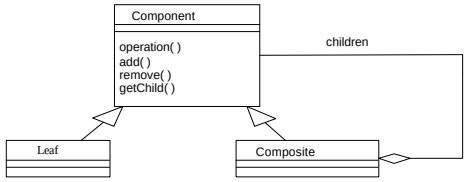
- Consequences
  - ⇨ Benefits
    - ➡ It makes it easy to add new kinds of components
    - ➡ It makes clients simpler, since they do not have to know if they are dealing with a leaf or a composite component
  - ⇨ Liabilities
    - ➡ It makes it harder to restrict the type of components of a composite

The Composite Pattern

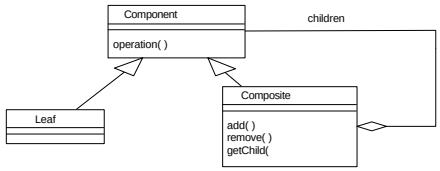
- Implementation Issues
  - ⇨ A composite object knows its contained components, that is, its children. Should components maintain a reference to their parent component?
    - ➡ Depends on application, but having these references supports the Chain of Responsibility pattern
  - ⇨ Where should the child management methods (add(), remove(), getChild()) be declared?
    - ➡ In the Component class: Gives transparency, since all components can be treated the same. But it's not safe, since clients can try to do meaningless things to leaf components at run-time.
    - ➡ In the Composite class: Gives safety, since any attempt to perform a child operation on a leaf component will be caught at compile-time. But we lose transparency, since now leaf and composite components have different interfaces.

The Composite Pattern

- Transparent vs. Safe



TRANSPARENT



SAFE

The Composite Pattern

- Implementation Issues
  - ⇨ Should Component maintain the list of components that will be used by a composite object? That is, should this list be an instance variable of Component rather than Composite?
    - ➥ Better to keep this part of Composite and avoid wasting the space in every leaf object
  - ⇨ Is child ordering important?
    - ➥ Depends on application
  - ⇨ Who should delete components?
    - ➥ Not a problem in Java! The garbage collector will come to the rescue!
  - ⇨ What's the best data structure to store components?
    - ➥ Depends on application

Composite Pattern Example 1

- Situation: A GUI system has window objects which can contain various GUI components (widgets) such as, buttons and text areas. A window can also contain widget container objects which can hold other widgets.
- Solution 1: What if we designed all the widgets with different interfaces for "updating" the screen? We would then have to write a Window update() method as follows:

```
public class Window {

  Button[] buttons;
  Menu[] menus;
  TextArea[] textAreas;
  WidgetContainer[] containers;
```


Composite Pattern Example 1 (Continued)

```
  public void update() {
    if (buttons != null)
      for (int k = 0; k < buttons.length; k++)
        buttons[k].draw();
    if (menus != null)
      for (int k = 0; k < menus.length; k++)
        menus[k].refresh();
    // Other widgets handled similarly.
    if (containers != null)
      for (int k = 0; k < containers.length; k++ )
        containers[k].updateWidgets();
  }
  ...
}
```

- Well, that looks particularly bad. It violates the Open-Closed Principle. If we want to add a new kind of widget, we have to modify the update() method of Window to handle it.

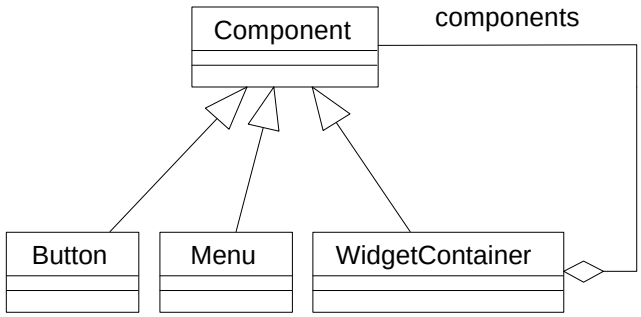
Composite Pattern Example 1 (Continued)

- Solution 2: We should always try to program to an interface, right? So, let's make all widgets support the Widget interface, either by being subclasses of a Widget class or implementing a Java Widget interface. Now our update() method becomes:

```
public class Window {
  Widget[] widgets;
  WidgetContainer[] containers;
  public void update() {
    if (widgets != null)
      for (int k = 0; k < widgets.length; k++)
        widgets[k].update();
    if (containers != null)
      for (int k = 0; k < containers.length; k++ )
        containers[k].updateWidgets();
  }
}
```


Composite Pattern Example 1 (Continued)

- That looks better, but we are still distinguishing between widgets and widget containers
- Solution 3: The Composite Pattern!



Composite Pattern Example 1 (Continued)

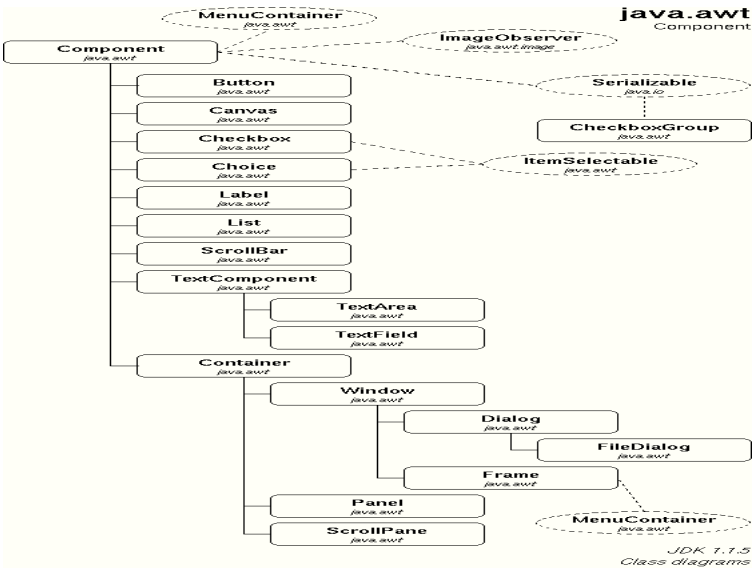
- Now the update method looks like:

```
public class Window {
  Component[] components;

  public void update() {
    if (components != null)
      for (int k = 0; k < components.length; k++)
        components[k].update();
  }

}
```


Composite Pattern Example 2 - The Java AWT



Composite Pattern Example 3

- Situation: Many types of manufactured systems, such as computer systems and stereo systems, are composed of individual components and sub-systems that contain components. For example, a computer system can have various chassis that contain components (hard-drive chassis, power-supply chassis) and busses that contain cards. The entire system is composed of individual components (floppy drives, cd-rom drives), busses and chassis.

Composite Pattern Example 3 (Continued)

- Solution: Use the Composite pattern!