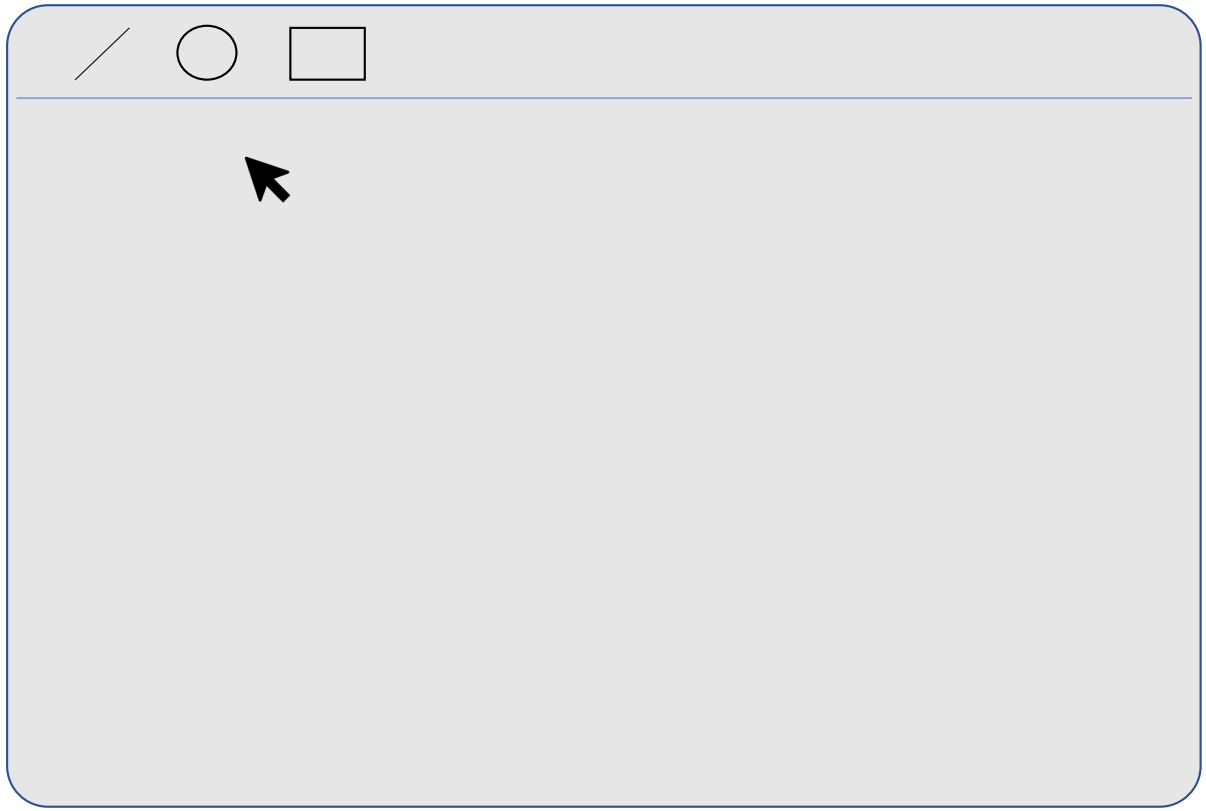
M6 (a) - Composition

Jin L.C. Guo

Image source: https://cdn.pixabay.com/photo/2017/11/05/21/21/container-2921882_960_720.jpg

Design Problem – Drawing Editor



Objective

- Design Principle:

Divide and Conquer

- Programming mechanism:

Aggregation and Delegation

- Design Techniques:

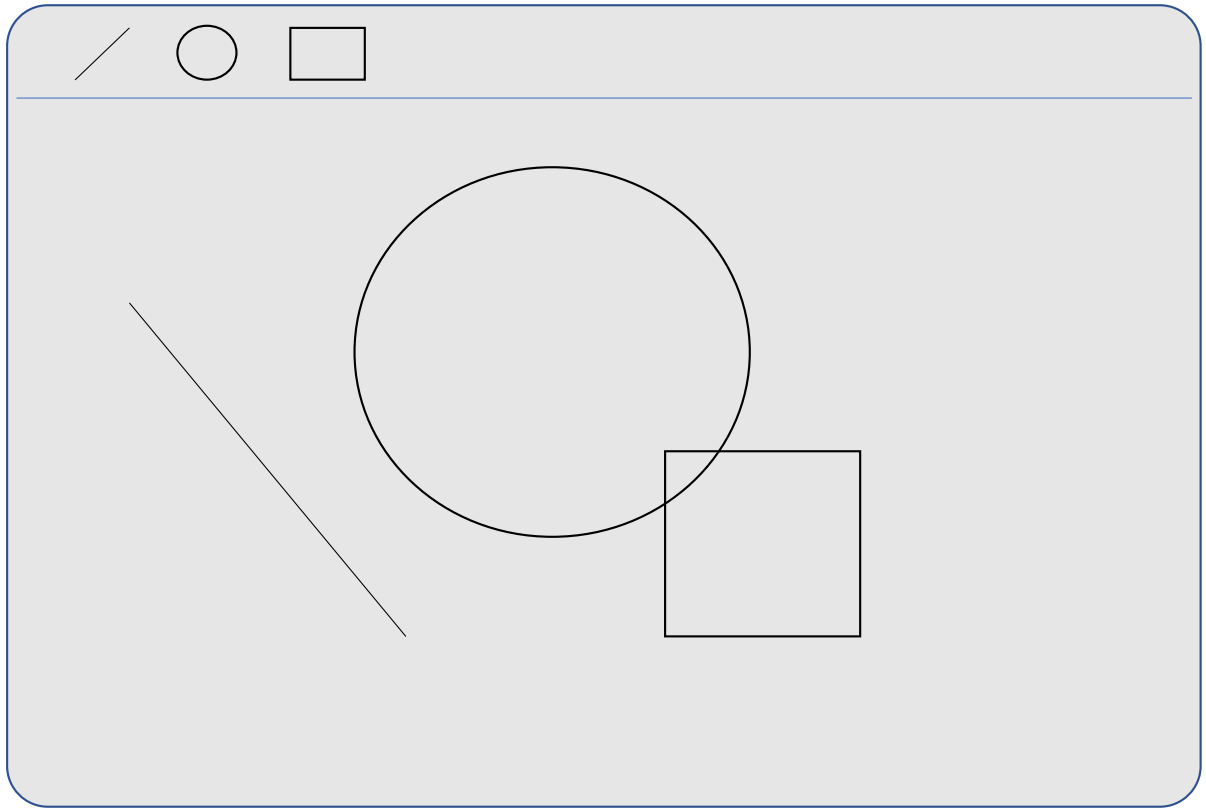
Sequence Diagram

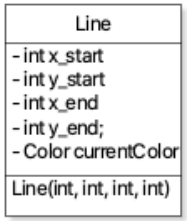
- Patterns and Anti-patterns:

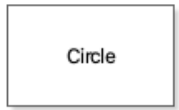
Composite Pattern, Decorator Pattern, God class 

Design Problem

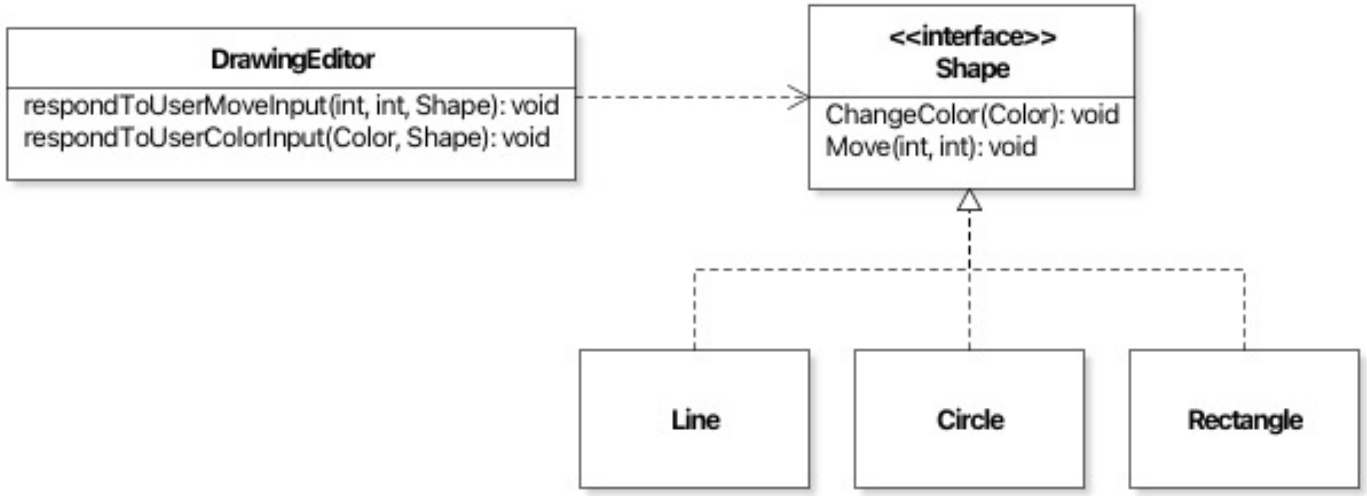
The users need to be able to change the color of the lines, circles and rectangles, as well as their position.



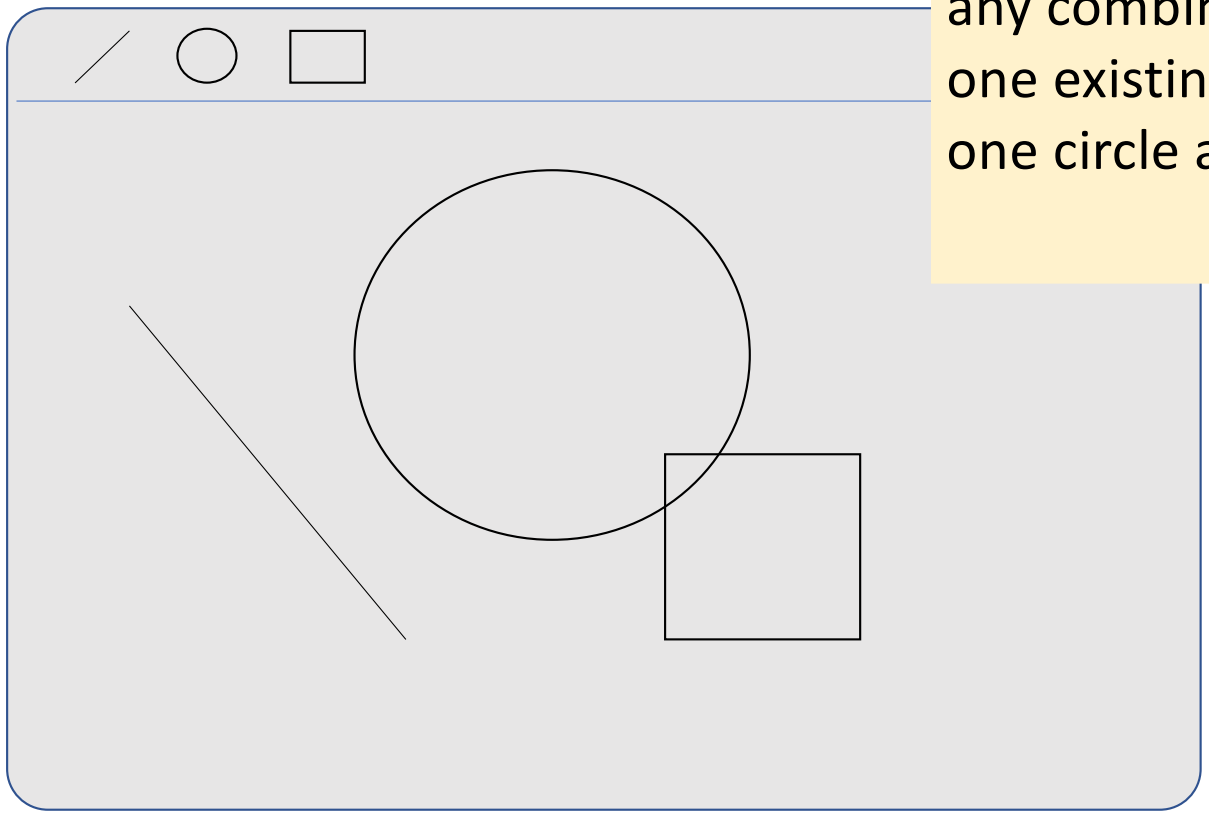




```
void respondUserMoveInput(int x, int y, Shape pShape) {
    pShape.move(x, y);
}
```

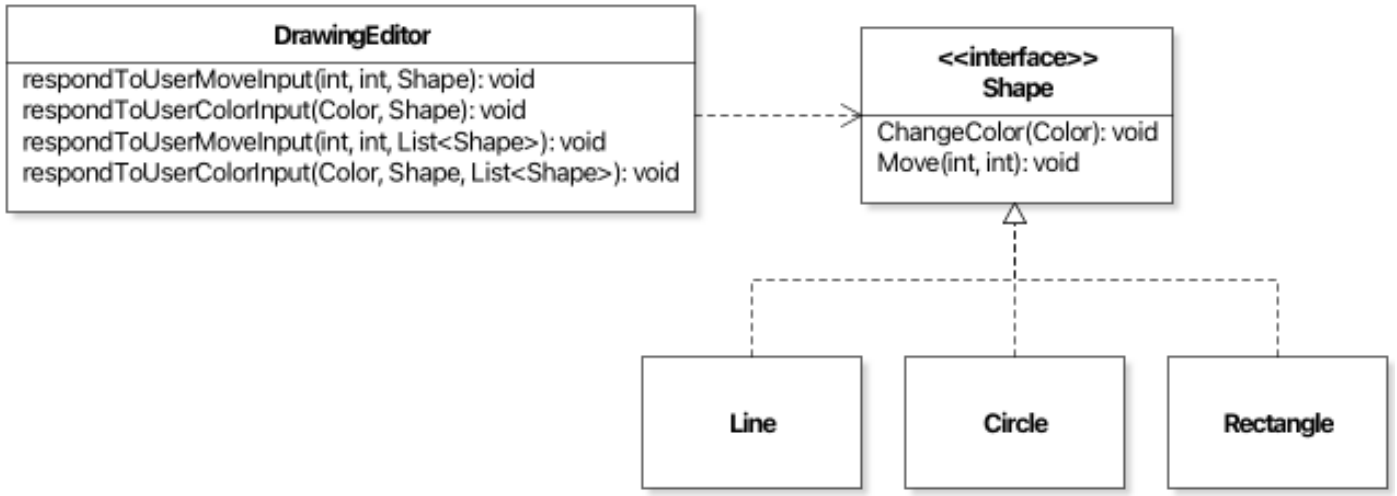


Activity 1: Design Problem



Add the function of grouping shapes so that the users can move or change the color for any combination of more than one existing element, e.g., one circle and rectangle.

Solution 1:




```
void respondUserMoveInput(int x, int y, List<Shape> pShapes) {
    for(Shape aShape: pShapes) {
        aShape.move(x, y);
    }
}
```

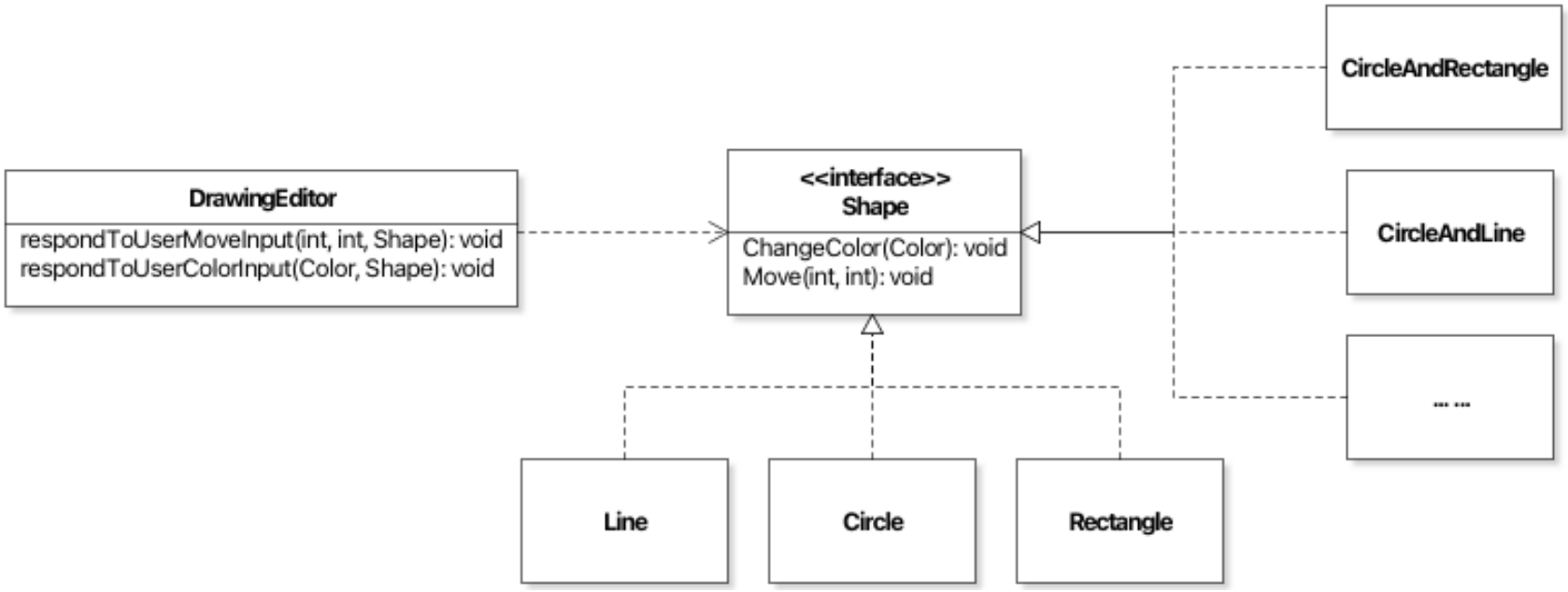
Client code has to treat a single shape and a group of shapes differently.

Solution 2:

Large number of possible structures.

Each option requires a class definition, even rare cases.

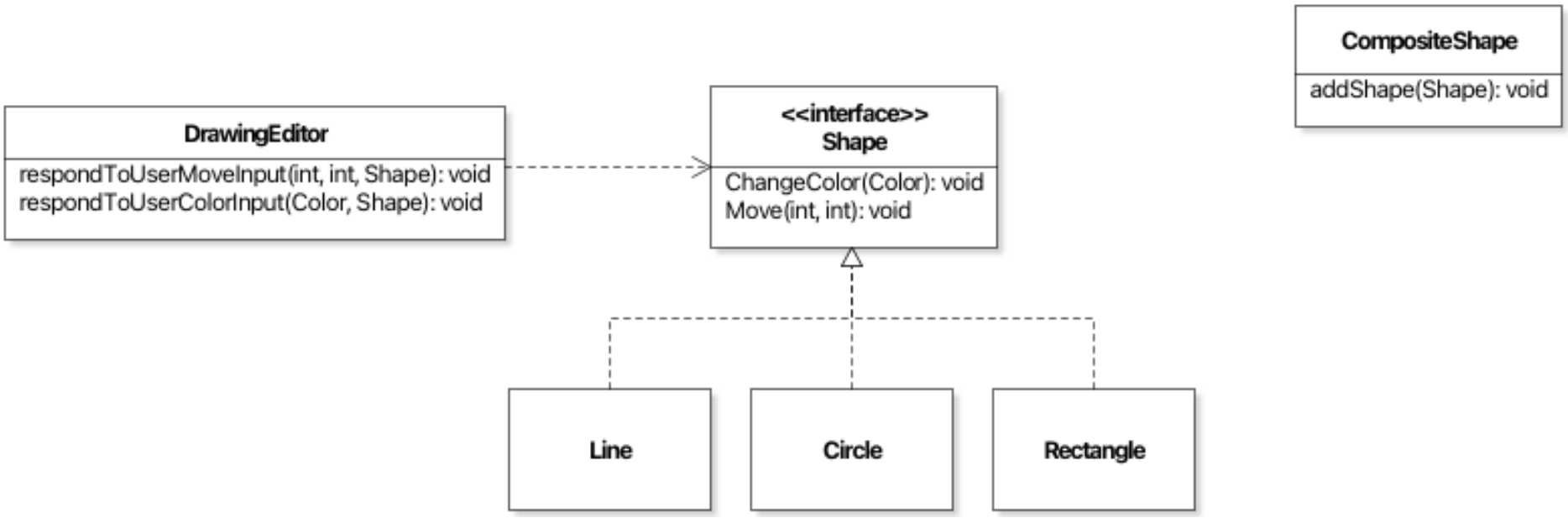
Impossible to accommodate all situations.



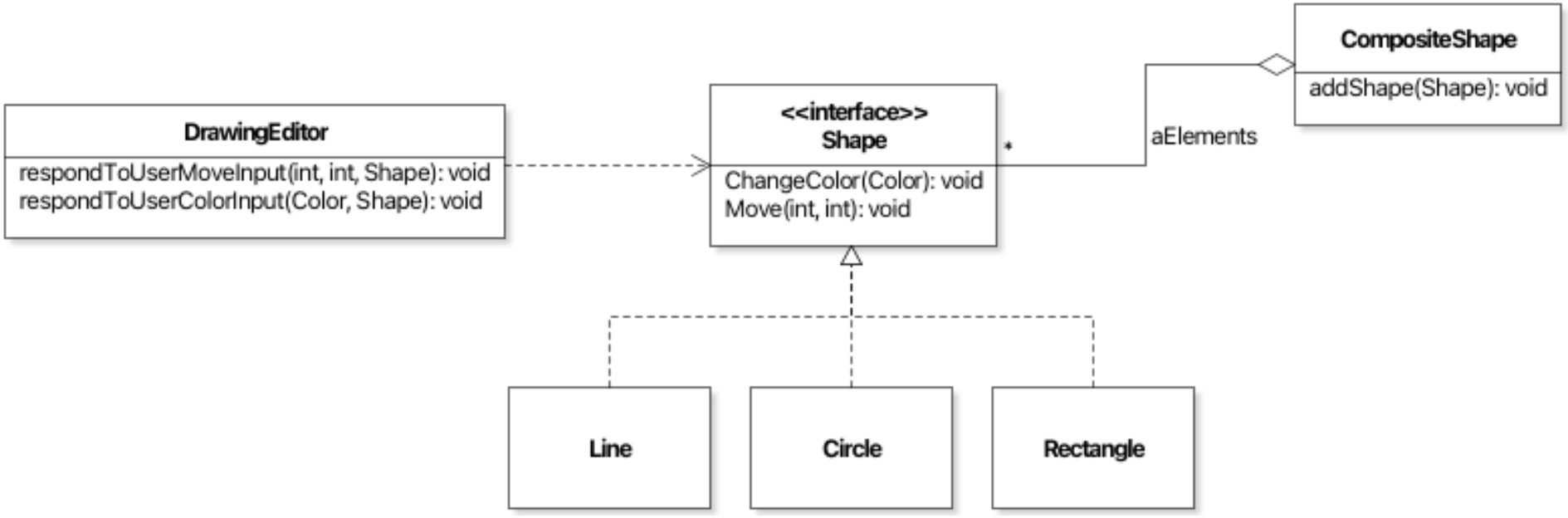
Another Solution

Image Source: https://upload.wikimedia.org/wikipedia/commons/6/61/Lego_blocks.jpg

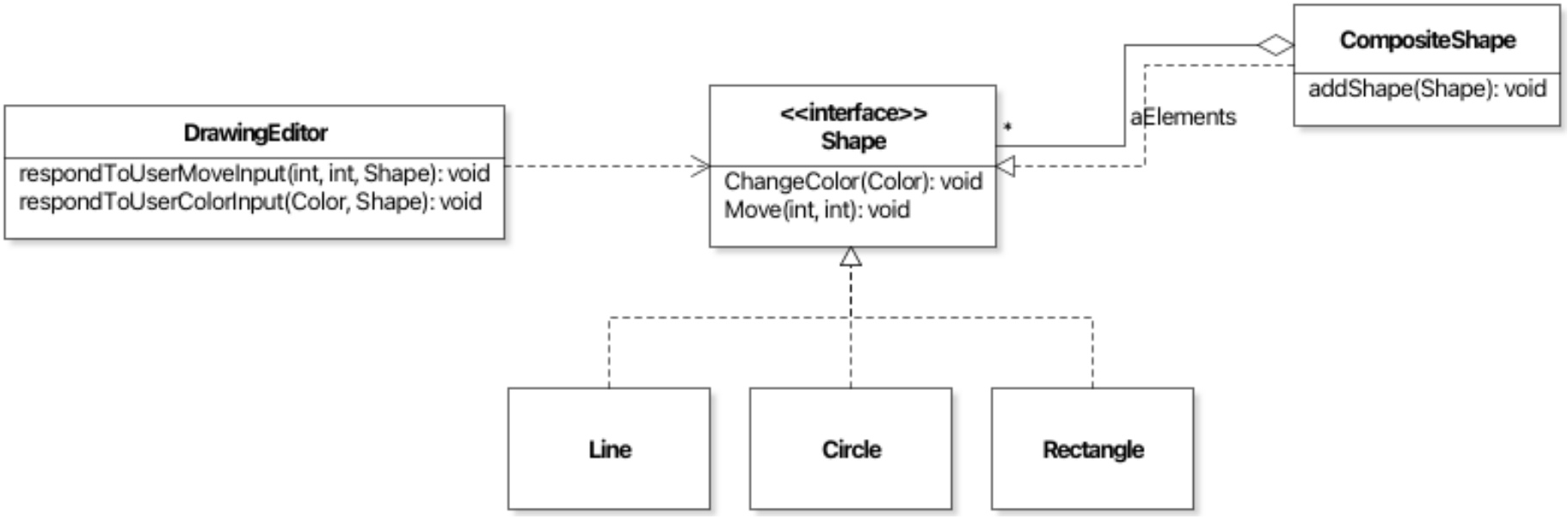
Another Solution:

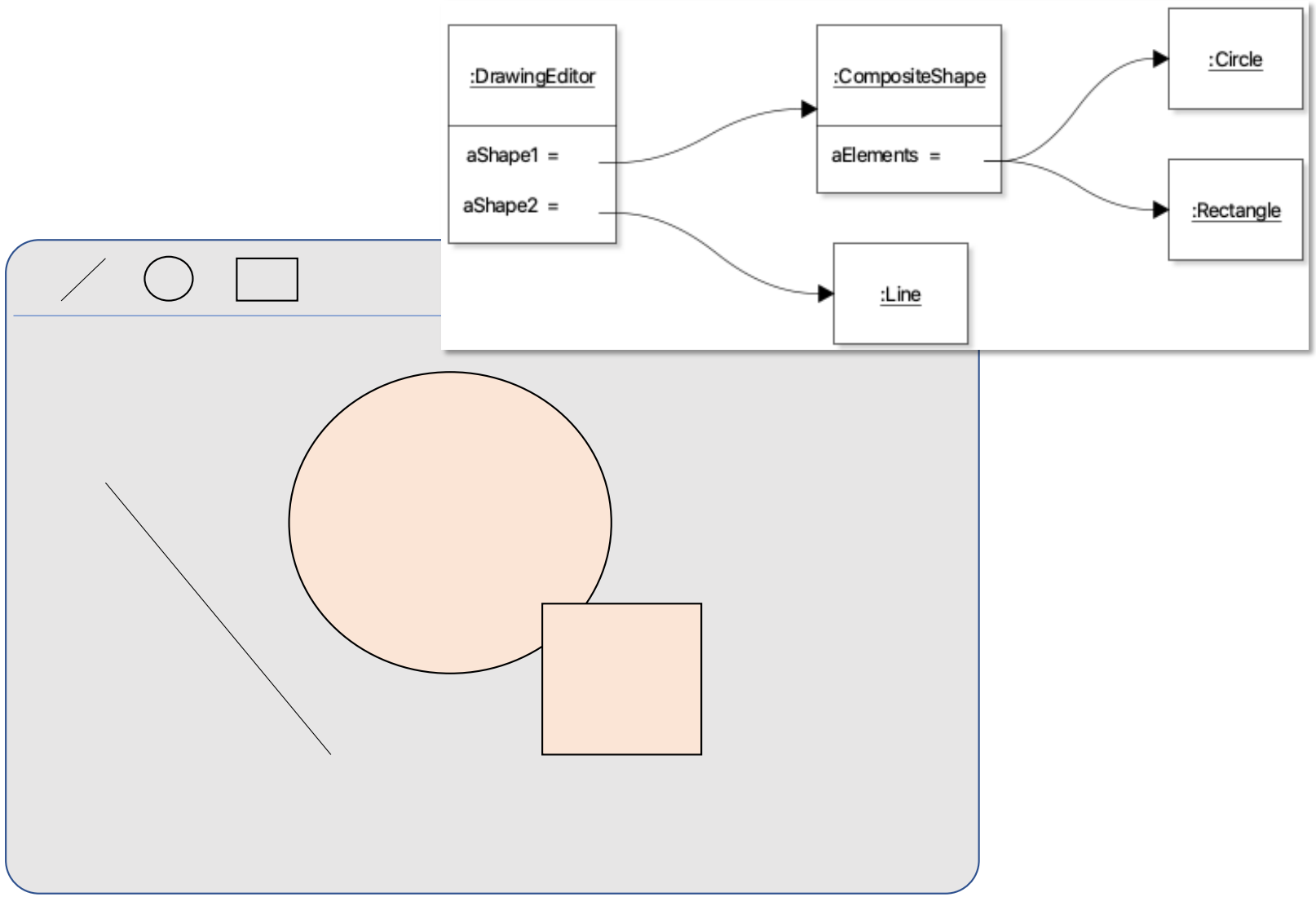


Another Solution:



Another Solution:




:DrawingEditor
aShape1 =
aShape2 =
:CompositeShape
aElements =
:Circle
:Rectangle
:Line

Objective

- Design Principle:

Divide and Conquer

- Programming mechanism:

Aggregation and Delegation

- Design Techniques:

Sequence Diagram

- Patterns and Anti-patterns:

Composite Pattern, Decorator Pattern, God class 

Composite Pattern

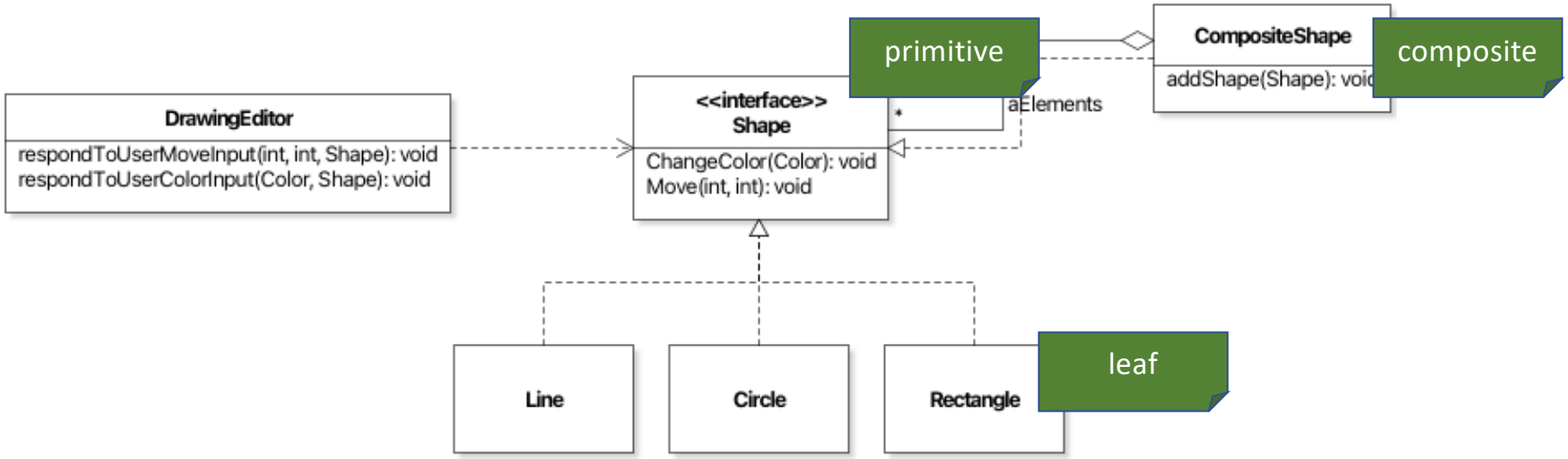
- Intent
  - Compose objects into tree structures to represent part-whole hierarchies. Composite lets clients treat individual objects and compositions of objects uniformly
- Participants:
  - Primitive (Component)

    Declares the interface for objects in the composition.
  - Leaf

    Defines behaviour for primitives
  - Composite

    Defines behaviour for primitives to have children

Composite Pattern



Implement Composite Pattern

```
public class CompositeShape implements Shape
{
    private List<Shape> aElements = new ArrayList<>();


    @Override
    public void changeColor(Color pColor){/* … */}


    @Override
    public void move(int pX, int pY) {/* … */}


}
```

Activity2: how to add Primitive instances to Composite?

```
public class CompositeShape implements Shape
{
    … …


    public void add(Shape pShape)
    {
        aElements.add(pShape);
    }


}
```

What are other options?
What are their tradeoffs?

Other considerations

- Is the order of accessing the children important?
- Should the references to the parent be maintained from the children?
- Should a child be allowed to be added to more than one component?

Object Collaboration

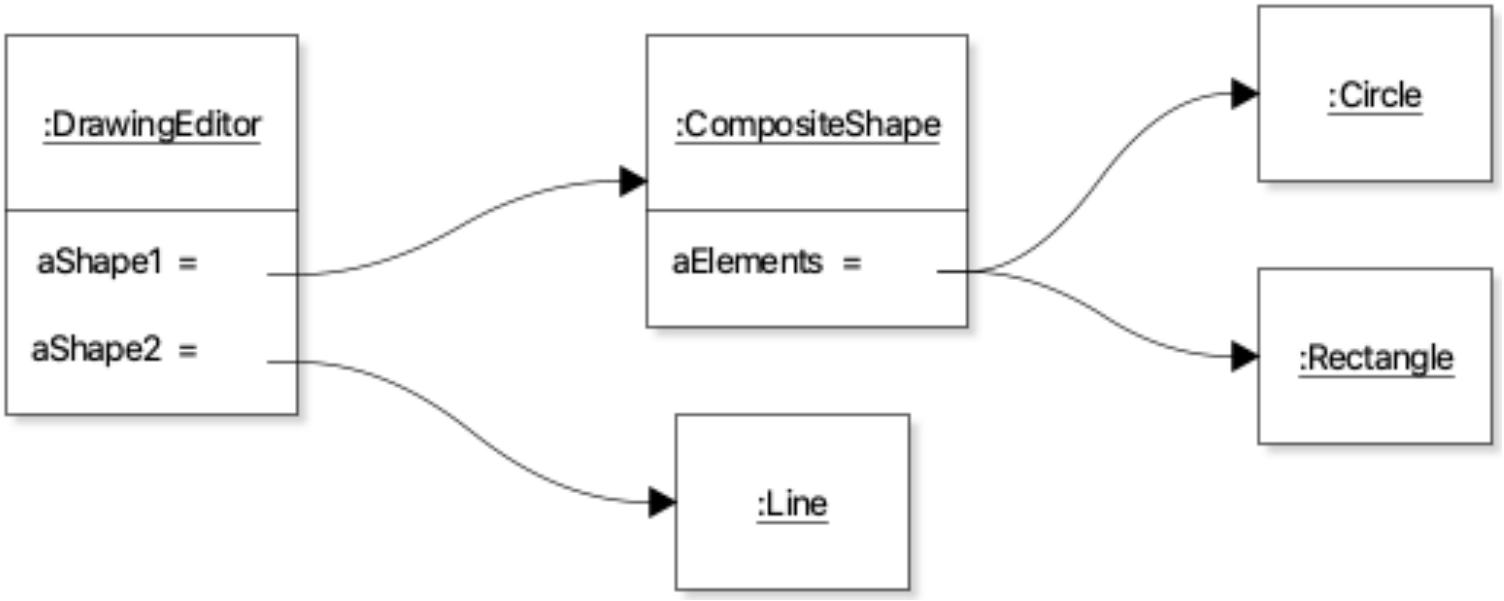
```
public class CompositeShape implements Shape
{
    private List<Shape> aElements = new ArrayList<>();


    @Override
    public void changeColor(Color pColor){
         for(Shape shape : aElements)
         {
             shape.changeColor(pColor);
         }
    }

}
```

The use of composition implies that we are designing how objects collaborate with each other, through methods calls.

Modeling object call sequences?



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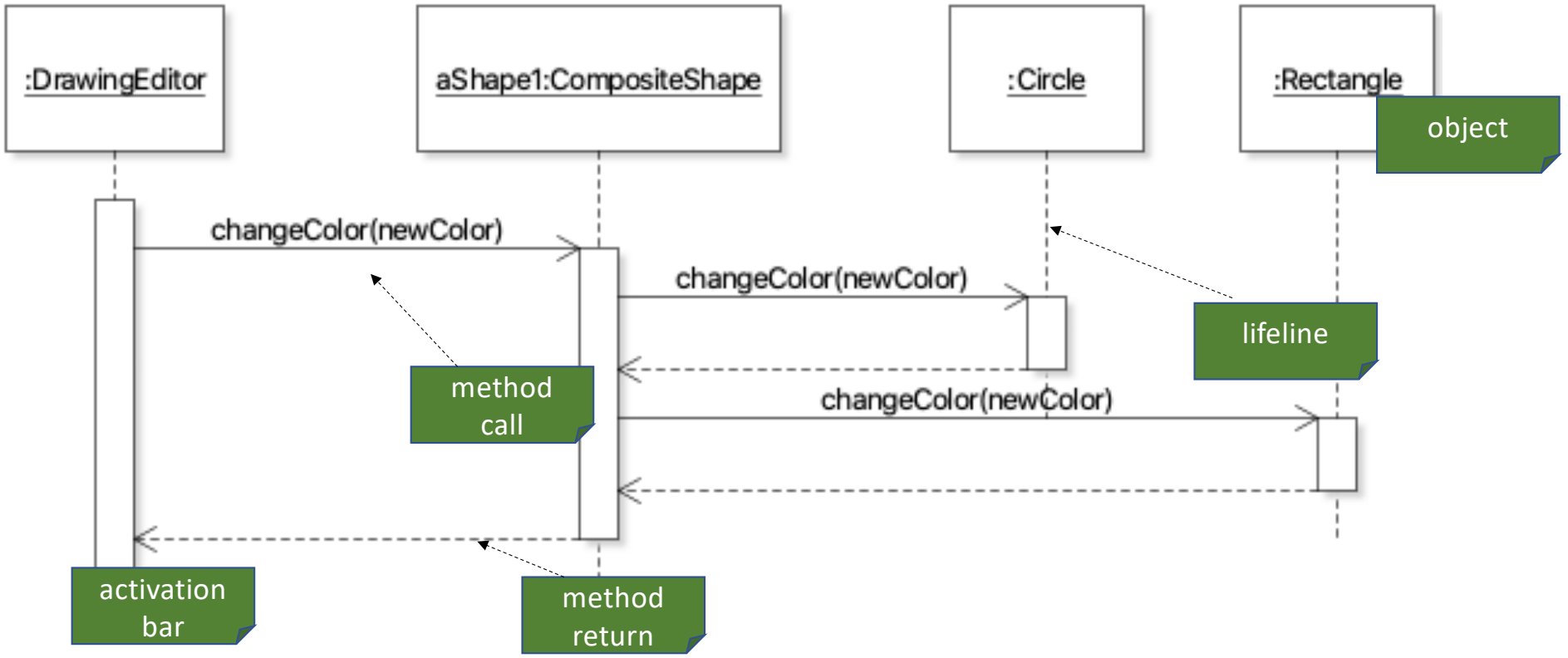
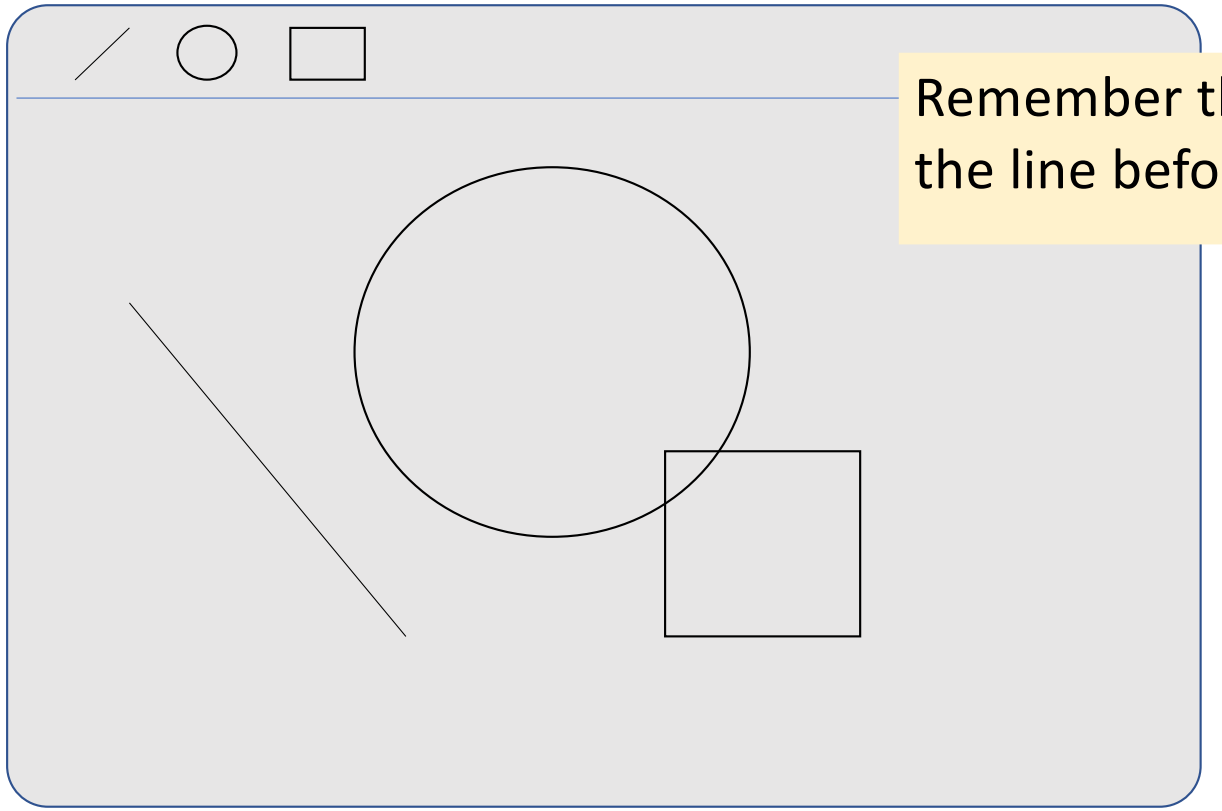
Sequence Diagram



Activity 3: Attach additional responsibility dynamically to `changeColor` of `Line`?



Remember the previous color of the line before changing.

```
public class MemoryLine implements Shape
{
   private int x_start;
   private int y_start;
   private int x_end;
   private int y_end;
   private Color aColor;
   private Color aPreviousColor;


   @Override
   public void changeColor(Color pColor)
   {
      aPreviousColor = aColor;
      aColor = pColor;
   }
}
```

Specialized Class, hard to extend

Cannot turn responsibility on and off at runtime

Other design options?

Separate the essential and additional state and behavior

```
public class MemoryLine implements Shape
{
   private int x_start;
   private int y_start;
   private int x_end;
   private int y_end;
   private Color aColor;
   private Color aPreviousColor;




}
```

Skin Versus Gut

Separate the essential and additional state and behavior

```
public class MemoryLine implements Shape
{


   private Line aLine;


   private Color aPreviousColor;
   @Override
   public void changeColor(Color pColor)
   {
      aPreviousColor = aLine.getColor();
      aLine.chageColor(pColor);
   }

}
```

1. Delegate the original request
2. Implement additional feature

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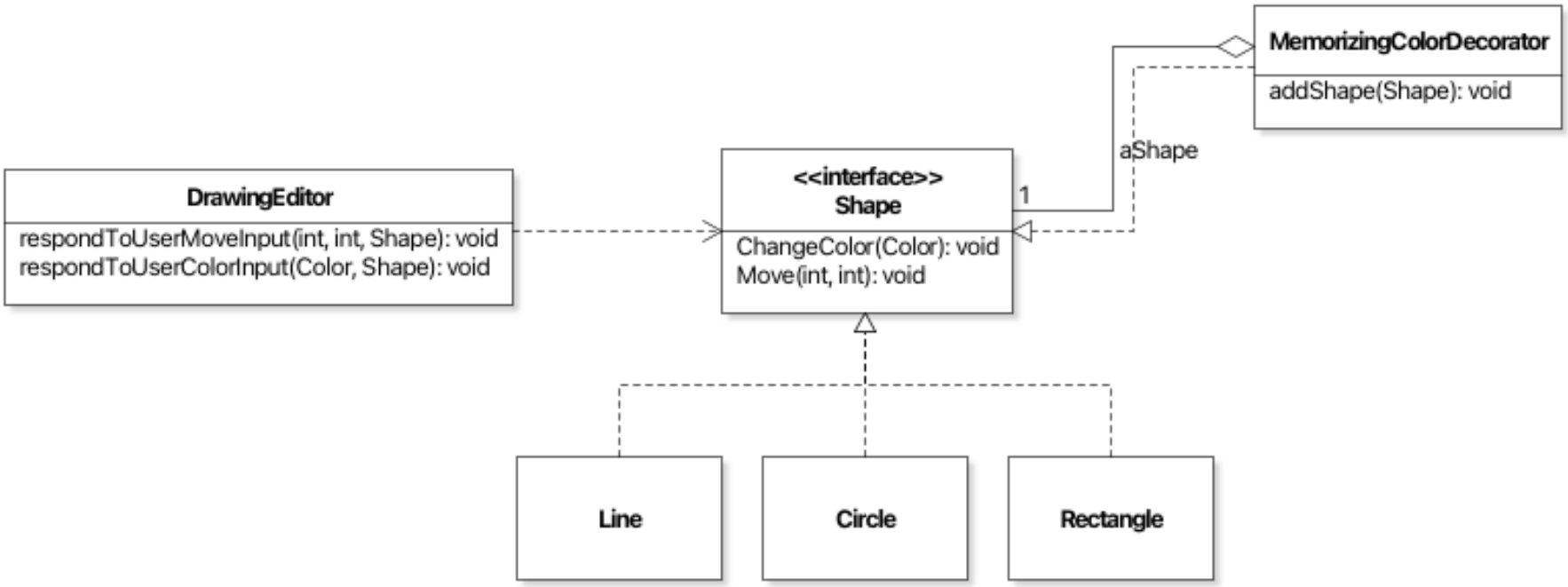
Decorator Pattern

- Intent:
  - Attach additional responsibilities to an object dynamically. Decorators provide a flexible alternative to subclassing for extending functionality.
- Participants:
  - Primitive

    Declares the interface for objects that can have responsibilities added to them dynamically
  - Leaf

    Defines the class to which additional responsibilities can be attached.
  - Decorator

    Maintains a reference to the primitive and defines the interface that confirms the primitive's interface

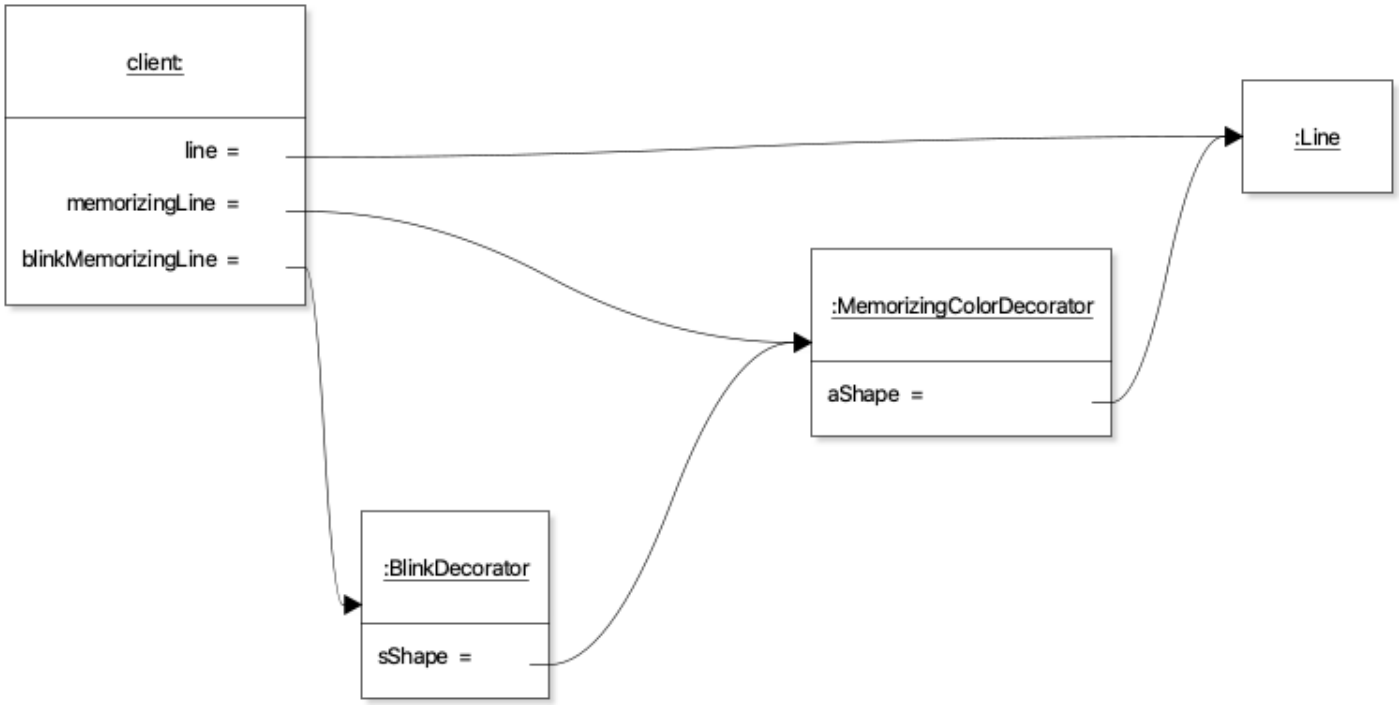

MemorizingColorDecorator
addShape(Shape): void
aShape
1
DrawingEditor
respondToUserMoveInput(int, int, Shape): void
respondToUserColorInput(Color, Shape): void
<<interface>>
Shape
ChangeColor(Color): void
Move(int, int): void
Line
Circle
Rectangle

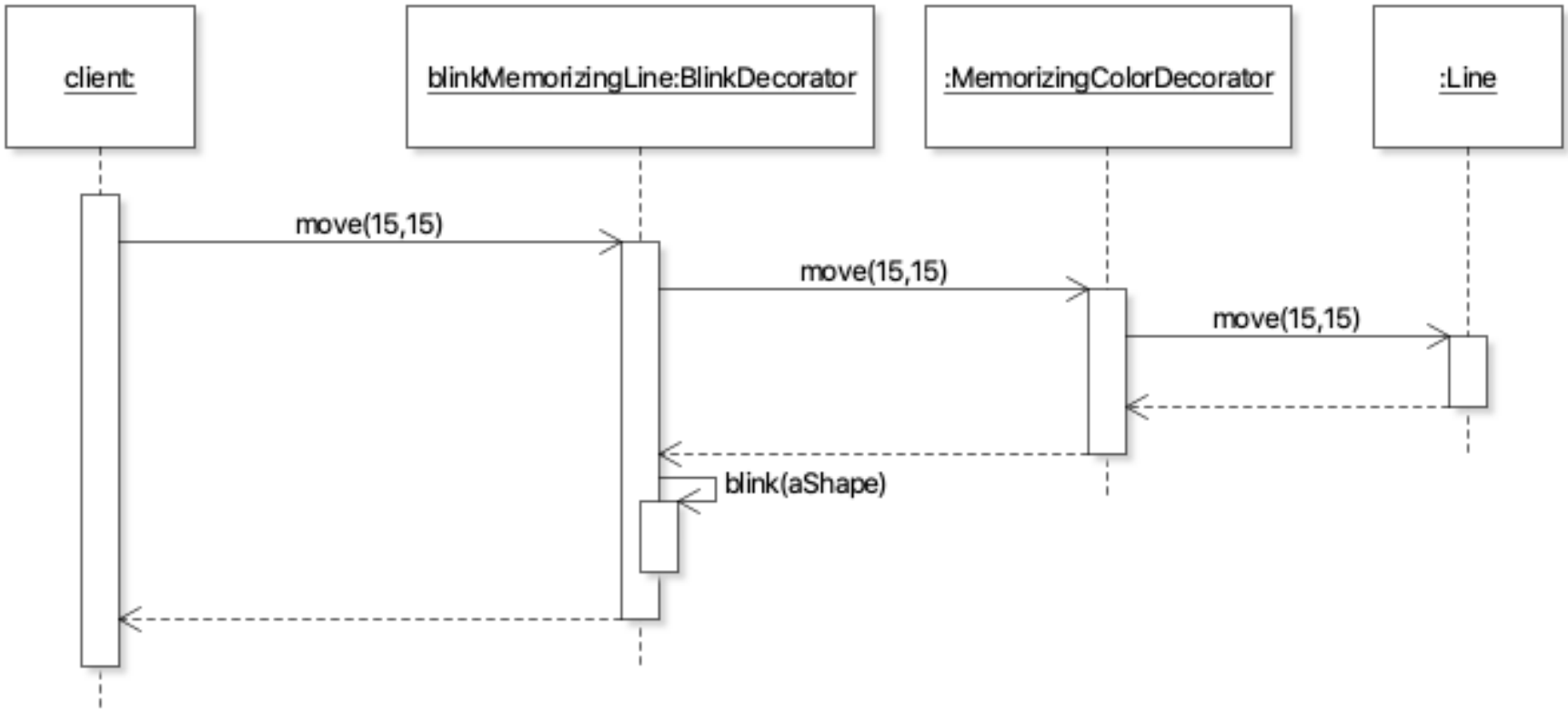
```
public class BlinkDecorator implements Shape
{
   ……
   @Override
   public void move(int pX, int pY)
   {
      aShape.move(pX, pY);
      this.bink(aShape);
   }
}
```

Activity 4

- Draw the object and sequence diagram when executing the last line of the following client code.

```
Shape line = new Line(3,3,10,10);//start x, start y, end x, end y
Shape memorizingLine = new MemorizingColorDecorator(line);
Shape blinkMemorizingLine = new BlinkDecorator(memorizingLine);
blinkMemorizingLine.move(15, 15);
```


client:
line =
memorizingLine =
blinkMemorizingLine =
:Line
:MemorizingColorDecorator
aShape =
:BlinkDecorator
sShape =


client:
blinkMemorizingLine:BlinkDecorator
:MemorizingColorDecorator
:Line
move(15,15)
move(15,15)
move(15,15)
blink(aShape)

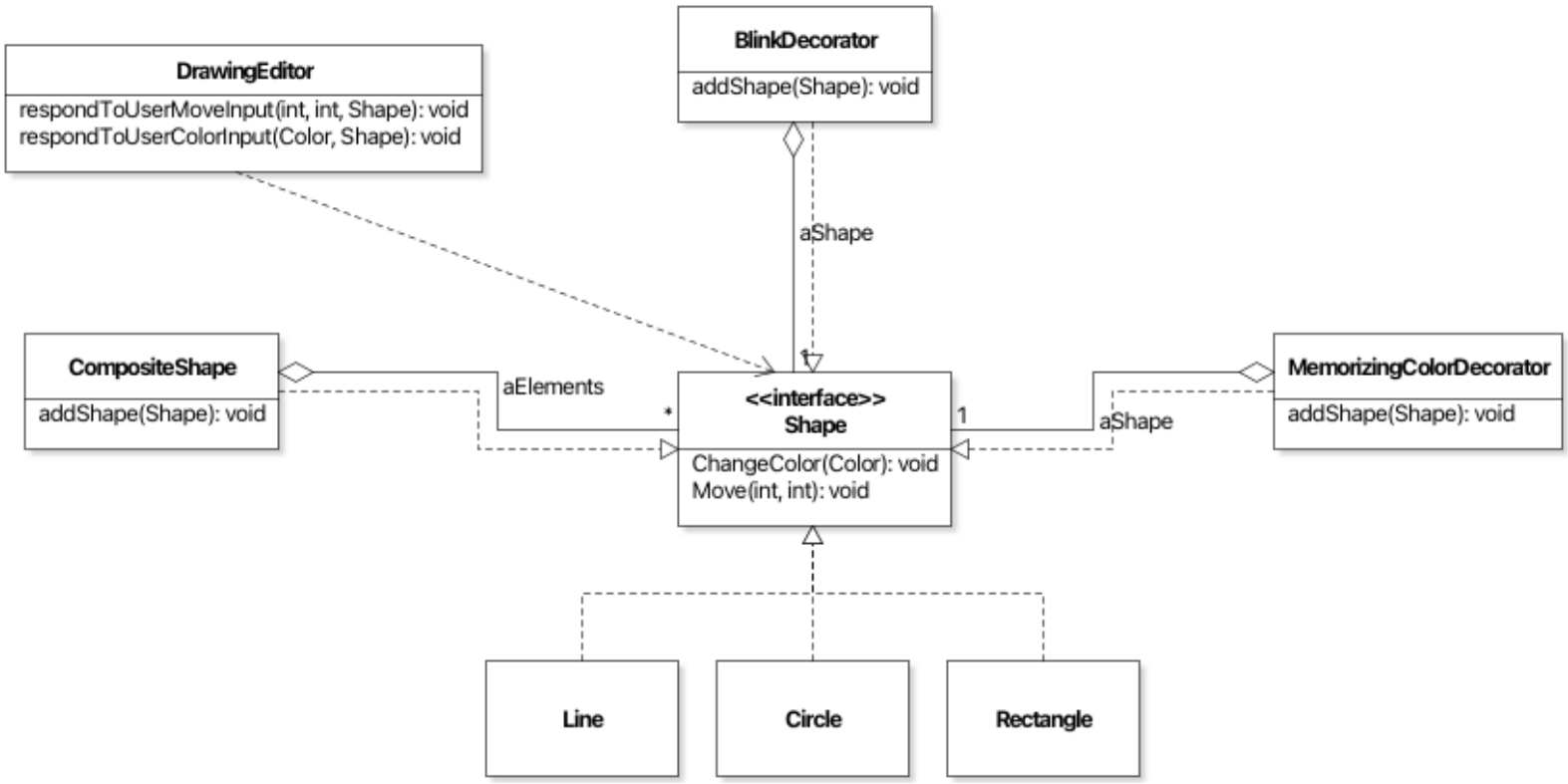
Identity of decorator and decorated object

```
Shape line = new Line(3,3,10,10);//start x, start y, end x, end y
Shape memorizingLine = new MemorizingColorDecorator(line);
Shape blinkMemorizingLine = new BlinkDecorator(memorizingLine);
blinkMemorizingLine.move(15, 15);
```

```
System.out.println(line == blinkMemorizingLine); // true or false?
```

Decorated object identity lost

Combining Decorator and Composite?



Combining Decorator and Composite

- Allow decorating behaviors of the composite, e.g., blinking the group of shapes.

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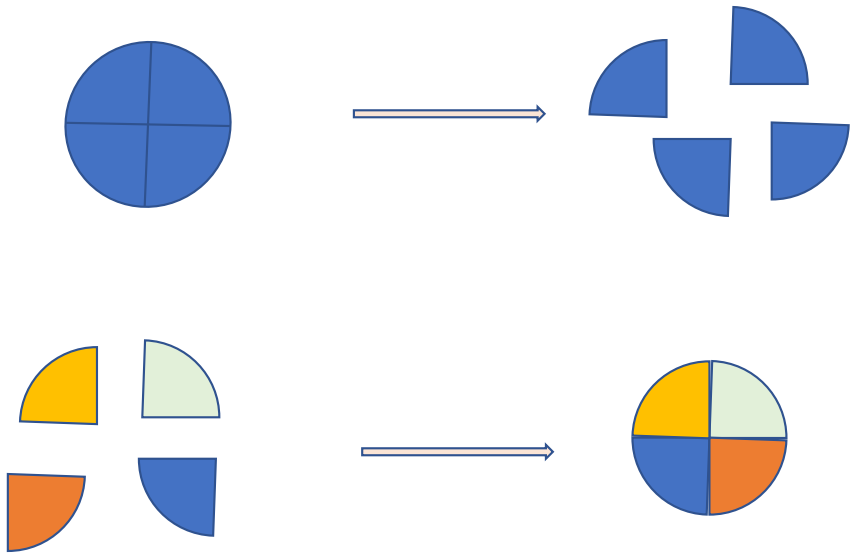
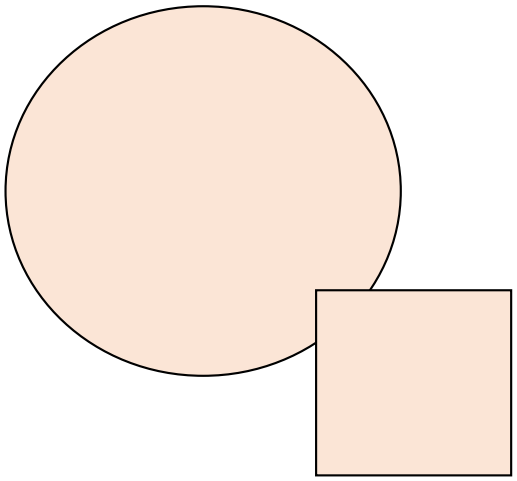
Manage Complexity -- Divide and conquer

- Modularization
  - Decomposable
  - Composable



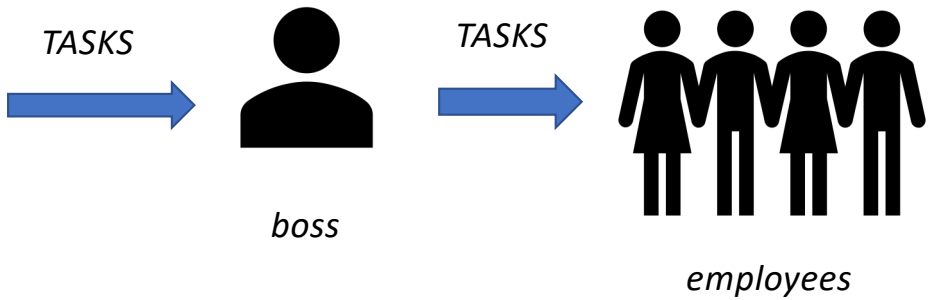
Purpose 1

- Aggregation: Representation of collections



Purpose 2

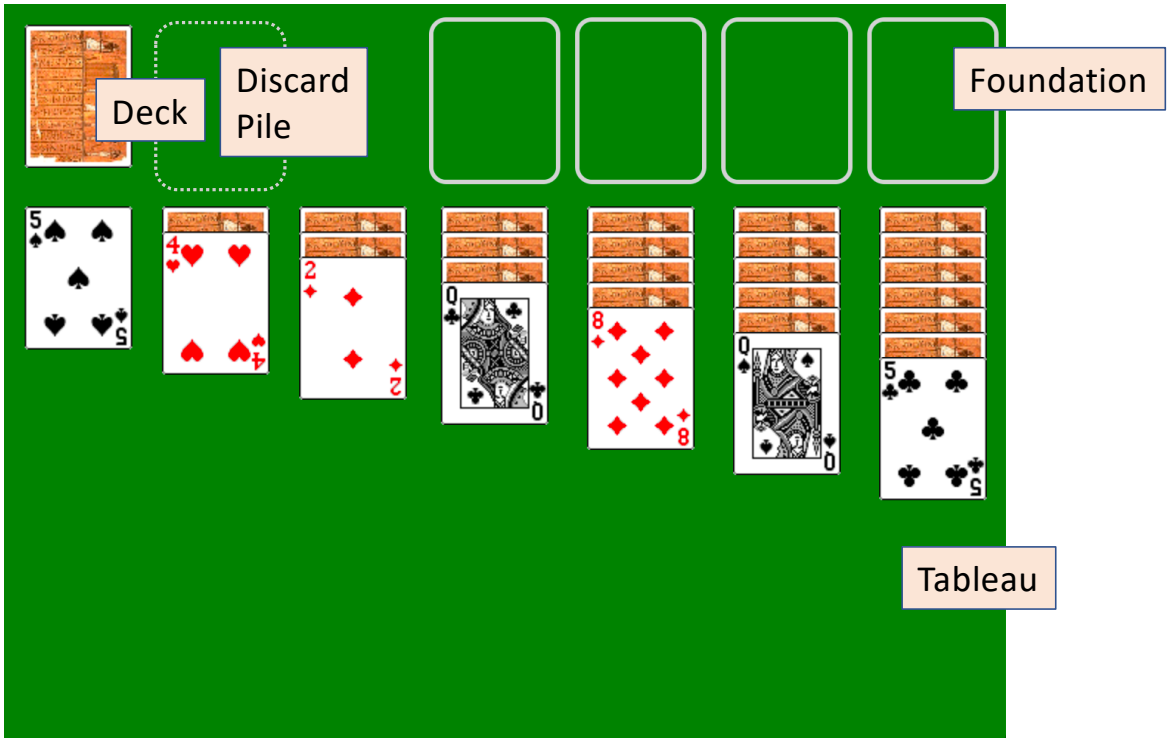
- Delegation: Redirect duties



GameModel in Solitaire

13 piles of cards?

God Class



The elements are both the component, and also entities providing services.

Class Diagram