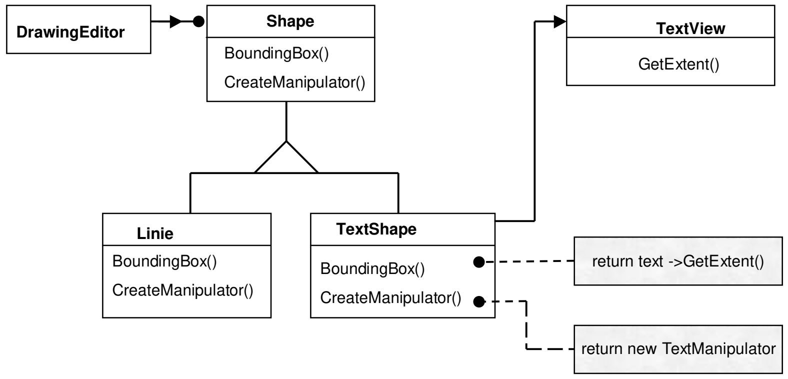
Structural Patterns

- Describe how classes and objects are composed to form larger structures
- Structural **class** patterns use inheritance to compose interfaces or implementations
- Structural **object** patterns describe ways to compose objects to realize new functionality

ADAPTER (Class, Object Structural)

- Intent:
  - Convert the interface of a class into another interface clients expect.
  - Adapter lets classes work together that could not otherwise because of incompatible interfaces.
- Motivation:
  - Sometimes a toolkit class that‘s designed for reuse is not reusable because ist interface does not match the domain-specific interface an application requires

ADAPTER - Motivation



DrawingEditor

Shape

BoundingBox()

CreateManipulator()

TextView

GetExtent()

Linie

BoundingBox()

CreateManipulator()

TextShape

BoundingBox()

CreateManipulator()

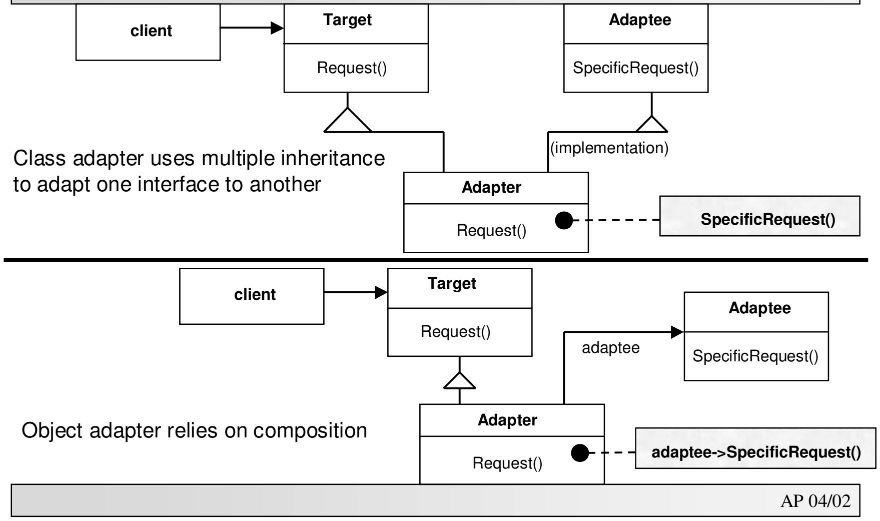
return text ->GetExtent()

return new TextManipulator

Applicability

- Use the Adapter pattern when
  - you want to use an existing class, and its interface does not match the one you need.
  - you want to create a reusable class that cooperates with unrelated or unforeseen classes, that is, classes that don´t necessarily have compatible interfaces.
- (object adapter only)
  - you need to use several existing subclasses, but it´s impractical to adapt their interface by subclassing every one. An object adapter can adapt the interface of its parent class.

ADAPTER - Structure



Class adapter uses multiple inheritance to adapt one interface to another

Object adapter relies on composition

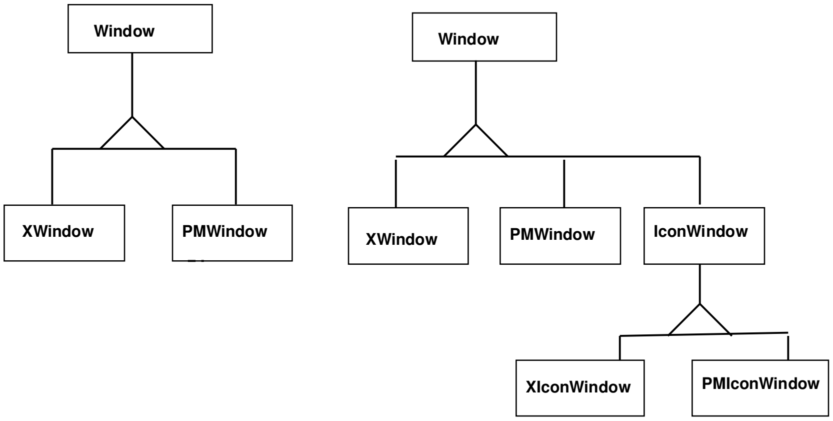
Participants and Collaborations

- Participants:
- Target (Shape)
  - Defines the domain-specific interface that client uses
- Client (DrawingEditor)
  - Collaborates with objects conforming to the Target interface
- Adaptee (TextView)
  - Defines existing interface that needs adapting
- Adapter (TextShape)
  - Adapts the interface of Adaptee to the Target interface
- Collaborations:
  - Clients call operations on an Adapter instance. In turn, the adapter calls Adapter operations that carry out the request.

BRIDGE (Object Structural)

- Intent:
  - Decouple an abstraction from its implementation so that the two can vary independently
- Motivation:
  - Inheritance helps when an abstraction can have multiple possible implementations but is sometimes not flexible enough
  - The bridge patterns puts an abstraction and its implementation in separate class hierarchies
  - Example: There is one class hierarchy for Window interfaces (Window, IconWindow, TransientWindow) and a separate hierarchy for platform-specific windows implementations (with WindowImp as root)

BRIDGE - Motivation



Window

XWindow

PMWindow

Window

XWindow

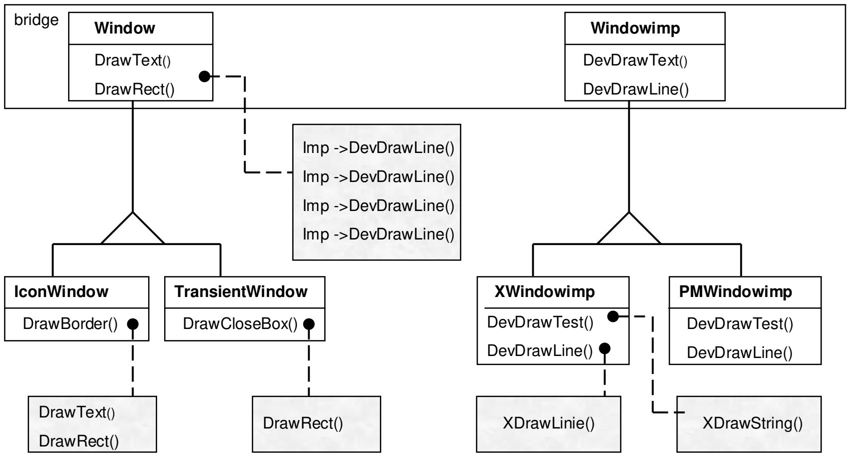
PMWindow

IconWindow

XIconWindow

PMIconWindow

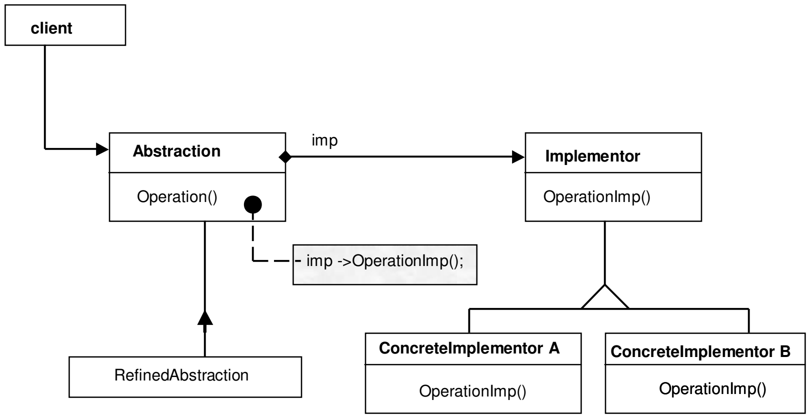
BRIDGE - Motivation



Applicability

- Use the Bridge pattern when:
  - you want to avoid a permanent binding between an abstraction and its implementation. (when the implementation must be selected or switched at run-time)
  - both the abstractions and their implementations should be extensible by subclassing.
    Bridge pattern lets you combine the different abstractions and implementations and extend them independently.
  - (C++) you want to hide the implementation of an abstraction completely from clients. In C++ the representation of a class is visible in the class interface.
  - You want to share an implementation among multiple objects (perhaps using reference counting), and this fact should bi hidden from the client.

BRIDGE - Structure



Participants and Collaborations

Participants:

- Abstraction (Window)
  - Defines the abstraction’s interface
  - Maintains a reference to an object of type implementor
- RefinedAbstraction (IconWindow)
  - Extends the interface defined by Abstraction
- Implementor (WindowImp)
  - Defines interface for implementation class
  - Not necessarily identical to Abstraction’s interface
  - Typically provides primitive operations, Abstraction defines higher-level ops.
- ConcreteImplementor (XWindowImp, PMWindowImp)
  - Implements the Implementor interface, defines concrete implementation

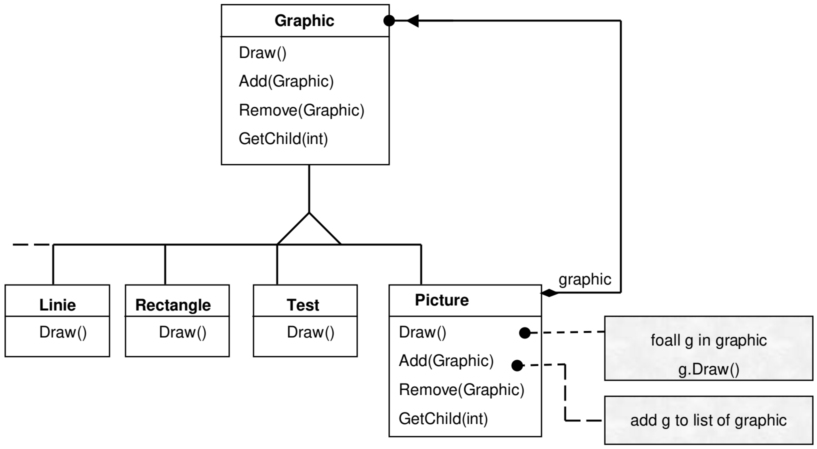
Collaborations:

- Abstraction forwards client requests to its Implementor object.

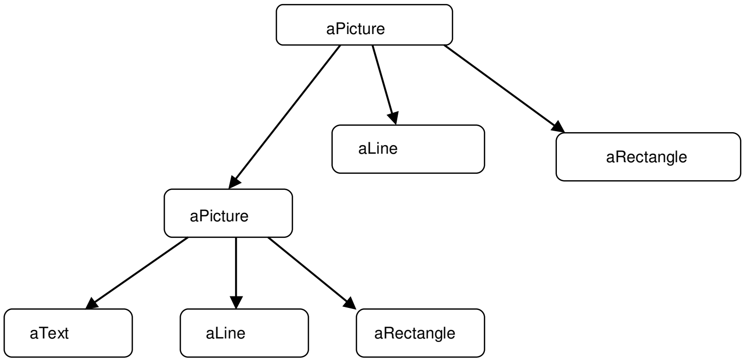
COMPOSITE
(Object Structural)

- Intent:
  - Compose objects into tree structures to represent part-whole hierarchies.
  - Composite lets clients treat individual objects and compositions of objects uniformly.
- Motivation:
  - Apps often allow grouping of objects into more complex structures
  - Single implementation could define classes for graphical primitives (Text, Lines) plus other classes that act as containers for primitives
  - But: code that uses these classes must treat primitive objects and containers differently (even if user treats them identically)

COMPOSITE - Motivation



COMPOSITE - Motivation

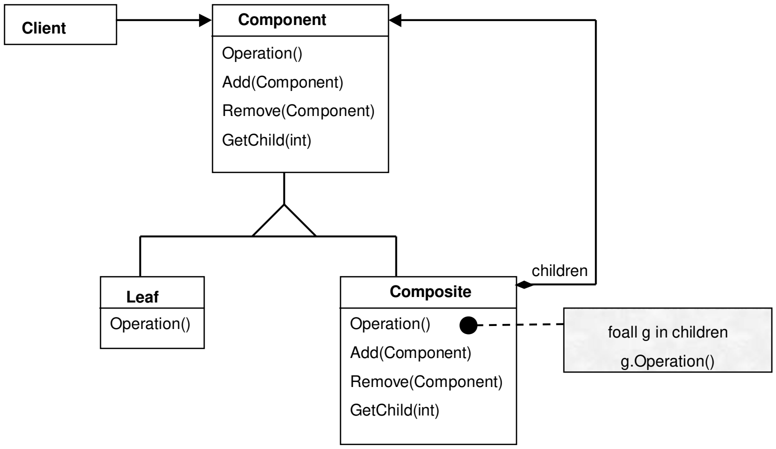


A typical composite object structure of recursively composed Graphic objects.

Applicability

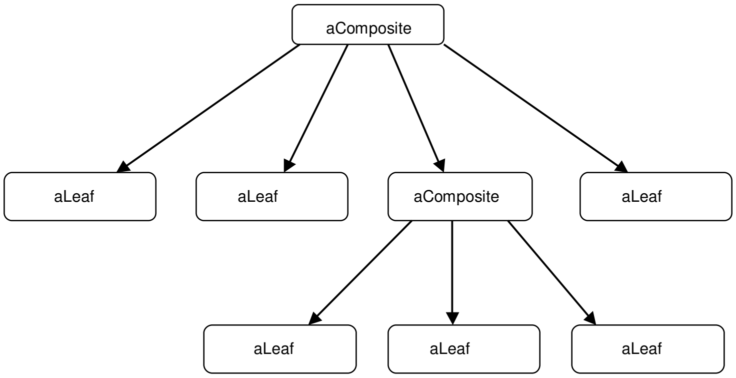
- Use the Composite pattern when
  - You want to represent part-whole hierarchies of objects.
  - You wants clients to be able to ignore the difference between compositions of objects and individual objects.
  - Clients will treat all objects in the composite structure uniformly.

COMPOSITE - Structure



COMPOSITE - Structure

A typical Composite object structure might look like this:



Participants

- Component (Graphic)
  - Declares interface for objects in the composition
  - Implements default behavior for the interface common to all classes
  - Declares interface for accessing and managing child components
  - (optional) defines interface for accessing component's parent
- Leaf (rectangle, Line, Text, etc.)
  - Represents leaf objects in the composition - has no children
  - Defines behavior for primitive objects in the composition
- Composite (Picture)
  - Defines behavior for components having children
  - Stores child components
  - Implements child-relate operations in the Component interface
- Client
  - Manipulates objects through Component interface

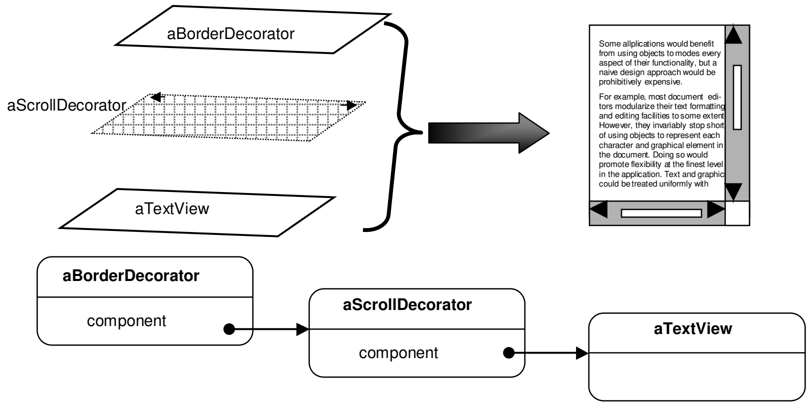
Collaborations

- Clients use the Component class interface to interact with objects in the composite structure.
- If the recipient is a Leaf, then the request is handled directly.
- If the recipient is a Composite, then it usually forwards requests to its child components, possibly performing additional operations before and/or after forwarding.

DECORATOR
(Object Structural)

- Intent:
  - Attach additional responsibilities to an object dynamically.
  - Decorators provide a flexible alternative to subclassing for extending functionality.
- Motivation:
  - Sometimes we want to add responsibilities to individual objects, not an entire class
  - Inheritance is an inflexible (static) solution to the problem. Clients cannot control the way how an object‘s functionality is extended
  - Enclosing the object into another object that adds the functionality is the more flexible approach - the **decorator**

DECORATOR - Motivation

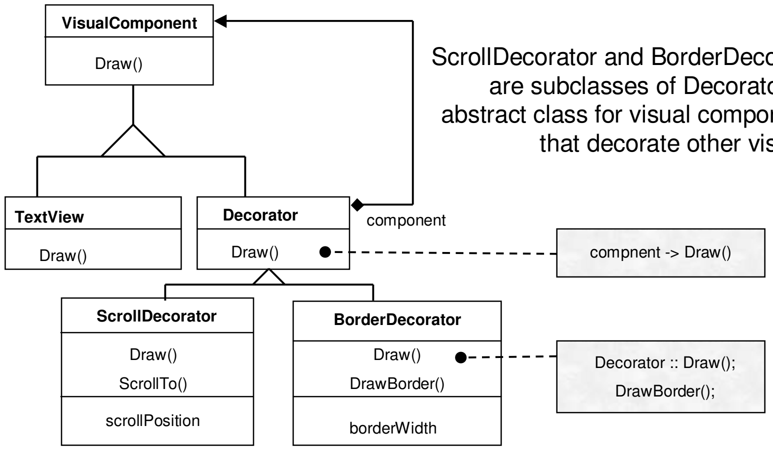


Some allplications would benefit from using objects to modes every aspect of their functionality, but a naive design approach would be prohibitively expensive.

For example, most document editors modularize their text formatting and editing facilities to some extent However, they invariably stop short of using objects to represent each character and graphical element in the document. Doing so would promote flexibility at the finest level in the application. Text and graphic could be treated uniformly with

Use composition to create a boredered, scrollable text view

DECORATOR - Motivation



VisualComponent

Draw()

TextView

Draw()

Decorator

Draw()

component

compnent -> Draw()

ScrollDecorator

Draw()

ScrollTo()

scrollPosition

BorderDecorator

Draw()

DrawBorder()

borderWidth

Decorator :: Draw();

DrawBorder();

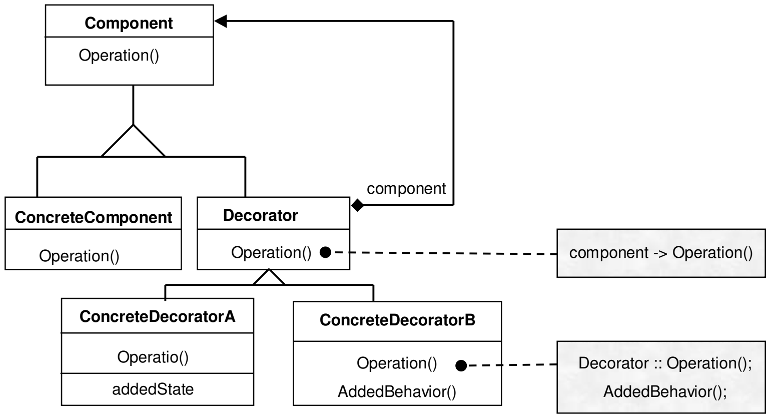
ScrollDecorator and BorderDecorator are subclasses of Decorator, an abstract class for visual components that decorate other visuals.

Applicability

- Use Decorator
  - To add responsibilities to individual objects dynamically and transparently, that is, without affecting other objects.
  - For responsibilities that can be withdrawn.
  - When extension by subclassing is impractical.

    Sometimes a large number of independent extensions are possible and would produce an explosion of subclasses to support every combination. Or a class definition may be hidden or otherwise unavailable for subclassing.

DECORATOR - Structure



Participants and Collaborations

Participants:

- Component (VisualComponent)
  - Defines interface for objects that can have responsibilities added to them dynamically
- ConcreteComponent (TextView)
  - Defines an object to which additional responsibilities can be attached
- Decorator
  - Maintains a reference to a Component object and defines interface that conforms to Component’s interface
- ConcreteDecorator (BorderDecorator, ScrollDecorator)
  - Adds responsibilities to the component

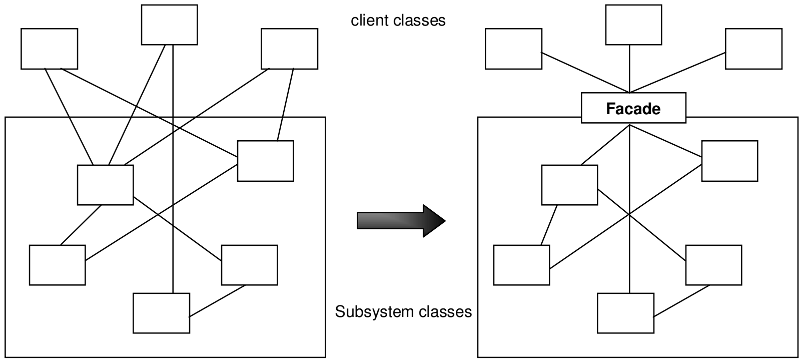
Collaborations:

- Decorator forwards requests to its Component object.
- It may optionally perform additional operations before and after forwarding the request.

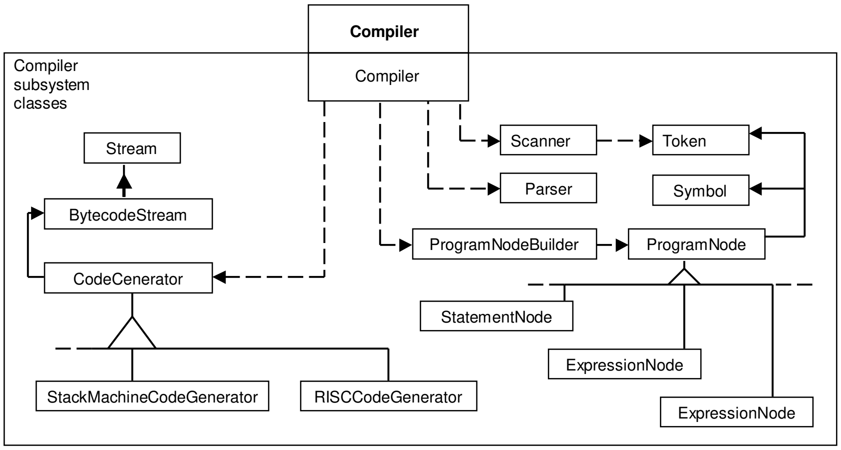
FACADE
(Object Structural)

- Intent:
  - Provide a unified interface to a set of interfaces in a subsystem.
  - Facade defines a higher-level interface that makes the subsystem easier to use.
- Motivation:
  - Structuring a system into subsystems helps reduce complexity.
  - Minimize communication and dependencies between subsystems.
  - Facade may provide a single, simplified interface to the more general facilities of a subsystem.

FACADE - Motivation



FACADE - Motivation

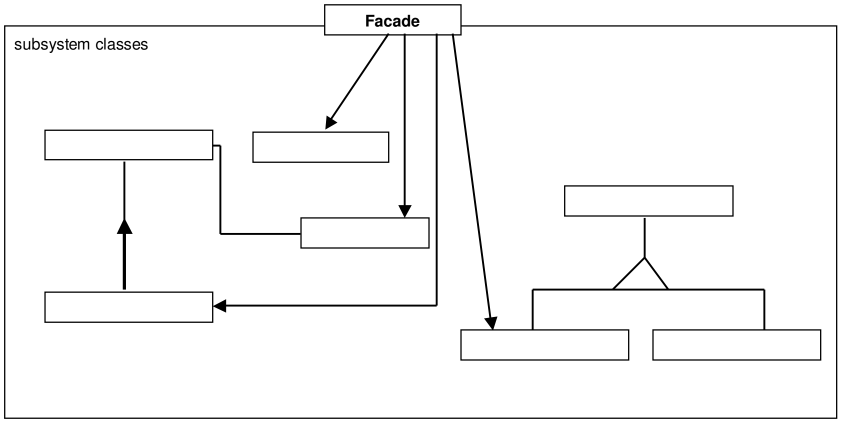


Applicability

Use the Facade pattern:

- to provide a simple interface to a complex subsystem.
  - Subsystems often get more complex as they evolve.
- when there are many dependencies between clients and the implementation classes of an abstraction.
  - Introduce a facade to decouple the subsystems from clients and other subsystems, thereby promoting subsystem independence and portability.
- to layer subsystems.
  - Use facade to define an entry point to each subsystem level.
  - Minimize subsystem inter-dependencies

FACADE - Structure



Participants and Collaborations

Participants:

- Facade (Compiler)
  - Knows which subsystem classes may handle a request
  - Delegates client requests to appropriate subsystem objects
- Subsystem classes (Scanner, Parser, ProgramNode)
  - Implement subsystem functionality
  - Have no knowledge of the facade (i.e.; keep no references to it)

Collaborations:

- Clients communicate with the subsystem by sending requests to Facade, which forwards them to the appropriate subsystem object(s).
- The facade may have to translate its interface to subsystem interfaces.
- Clients do not have to access subsystem objects directly.

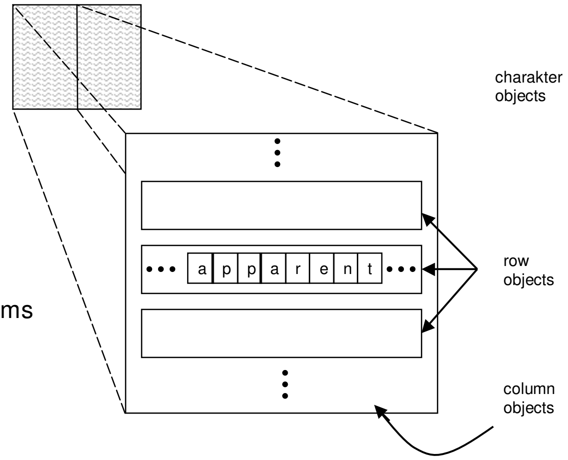
FLYWEIGHT
(Object Structural)

- Intent:
  - Use sharing to support large numbers of small objects efficiently.
- Motivation:
  - Some applications could benefit from using objects throughout their design, but a naïve implementation would be prohibitevly expensive

FLYWEIGHT - Motivation

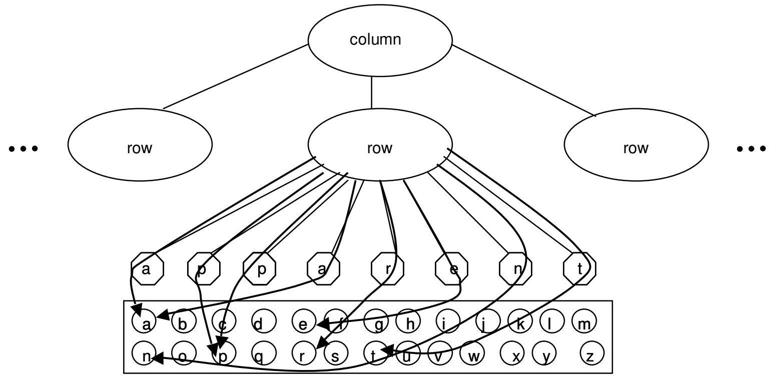
OO editors use objects to represent embedded elements like tables and figures

But treating characters uniquely (as objects) seems to be too expensive



FLYWEIGHT - Motivation

Logically - one object per character in the document



Physically - one shared flyweight object per character

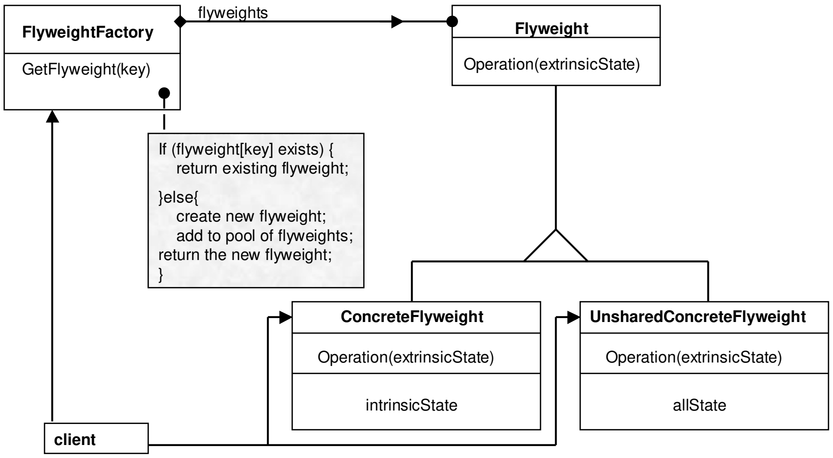
Applicability

The Flyweight pattern‘s effectiveness depends heavily on how and where it‘s used.

Apply the Flyweight pattern when all of the following are true:

- An application uses a large number of objects.
- Storage costs are high because of the sheer quantity of objects.
- Most object state can be made extrinsic.
- Many groups of objects may be replaced by relatively few shared objects once extrinsic state is removed.
- The application doesn't depend on object identity. Since flyweight objects may be shared, identity tests will return true for conceptually distinct objects.

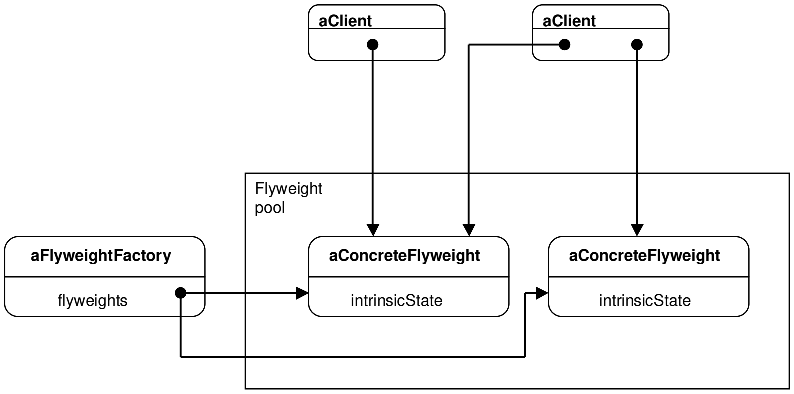
FLYWEIGHT - Structure


FlyweightFactory
GetFlyweight(key)
flyweights
Flyweight
Operation(extrinsicState)
ConcreteFlyweight
Operation(extrinsicState)
intrinsicState
UnsharedConcreteFlyweight
Operation(extrinsicState)
allState
client

```
If (flyweight[key] exists) {
   return existing flyweight;
}else{
   create new flyweight;
   add to pool of flyweights;
return the new flyweight;
}
```

AP 04/02

FLYWEIGHT - Structure



AP 04/02

Participants

- Flyweight (Glyph)
  - Declares an interface through which flyweights can receive and act on extrinsic state
- ConcreteFlyweight (Character)
  - Implements Flyweight interface and adds storage for intrinsic state
  - Must be sharable
  - Any state it stores must be independent of concrete object‘s context
- FlyweightFactory
  - Creates and manages flyweight objects
  - Ensures that flyweights are shared properly
- Client
  - Maintains reference to flyweight(s)
  - Computes or stores the extrinsic state of flyweight(s)

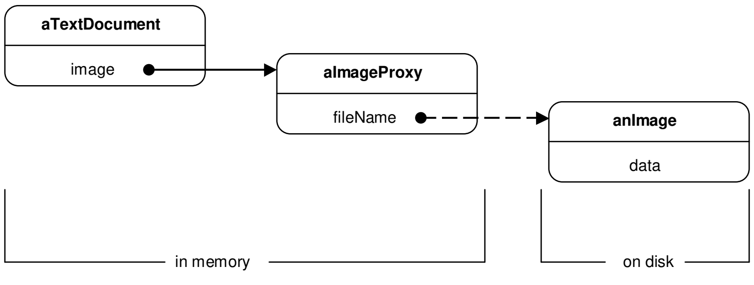
Collaborations

- State that a flyweight needs to function must be characterized as either intrinsic or extrinsic.
  - Intrinsic state is stored in the ConcreteFlyweight object;
  - extrinsic state is stored or computed by Client objects.
  - Clients pass this state to the flyweight when they invoke its operation.
- Clients should not instantiate ConcreteFlyweights directly.
  - Clients must obtain ConcreteFlyweights objects exclusively from the FlyweightFactory object to ensure they are shared properly.

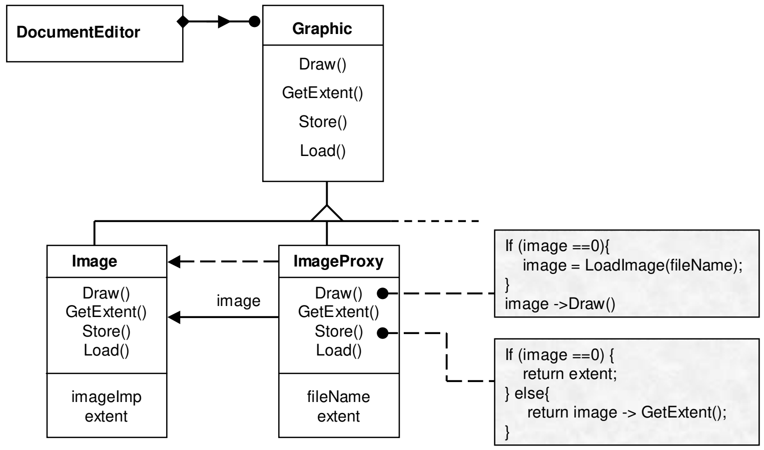
PROXY
(Object Structural)

- Intent:
  - Provide a surrogate or placeholder to control access another object.
- Motivation:
  - One reason for controlling access to an object is defer the full cost of its creation and initialization until we actually need to use it.
  - Consider a document editor that can embed graphical objects into an document - creation of those objects (raster images) can be expensive but opening the document should still be fast.
  - An image proxy might act as stand-in for the real image.

PROXY - Motivation



PROXY - Motivation



```
If (image ==0){
   image = LoadImage(fileName);
}
image ->Draw()
```

```
If (image ==0) {
   return extent;
} else{
    return image -> GetExtent();
}
```

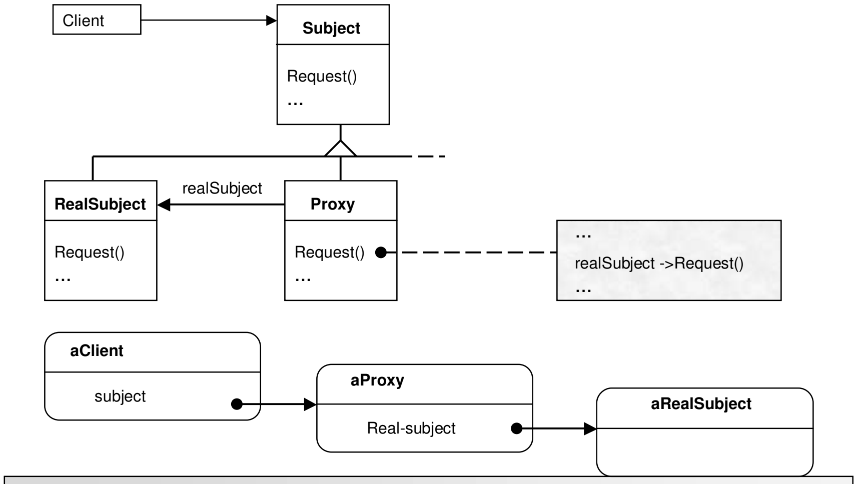
Applicability

Proxy is applicable whenever there is a need for a more versatile or sophisticated reference to an object than a simple pointer.

Common situations in which the Proxy pattern is applicable:

1. A remote proxy provides a local representative for an object in a different address space. NeXTSTEP uses the class NXProxy for this purpose.
2. A virtual proxy creates expensive objects on demand. The ImageProxy described in the Motivation is an example of such a proxy.
3. A protection proxy controls access to the original object. Protection proxies are useful when objects should have different access rights.
(KernelProxies in the Choices OS)
4. A smart reference is a replacement for a bare pointer that performs additional actions when an object is a accessed.

PROXY - Structure



Client

Subject

Request()
...

realSubject

RealSubject

Request()
...

Proxy

Request()
...

...
realSubject ->Request()
...

aClient

subject

aProxy

Real-subject

aRealSubject

Participants and Collaborations

Participants:

- Proxy (ImageProxy)
  - Maintains reference to the real subject
  - Provides interface identical to the real subject
  - Controls access to subject; manages creation and deletion
- Subject (Graphic)
  - Defines common interface for RealSubject and Proxy
- RealSubject (Image)
  - Defines the real object that the proxy represents

Collaborations:

- Proxy forwards requests to RealSubject when appropriate, depending on the kind of proxy.