GAM250: Advanced Games Programming

2: Design Patterns

Learning outcomes

- **Describe** the concept of Design Patterns
- **Understand** some of the classic ’Gang of Four’ Design Patterns
- **Implement** some of the most commmon design patterns

OO Design Basics

Learning Outcomes

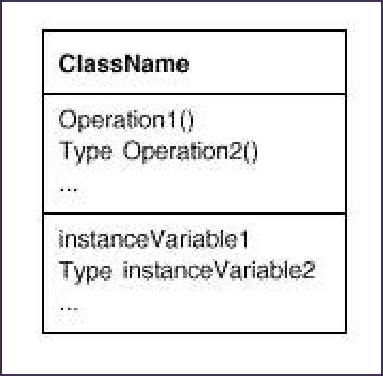
In this section you will learn how to...

- **Illustrate** the role of UML in communicating software design
- **Explain** basic OO design principles, including abstraction and polymorphism
- **Explain** the role of design patterns in object-orientated software design
- **Identify** the key components of a pattern

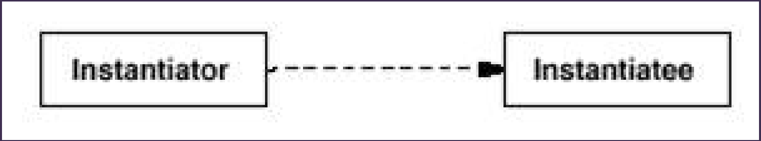
Object Modelling Techniques

- Used to describe patterns in the GO4 book
- Uses UML to graphical represent different OO relationships:
  - **class diagrams**: show the static relationship between classes
  - **object diagrams**: show the state of a program as a series of related objects
  - **interaction diagrams**: illustrate execution of the program as an interaction among related objects

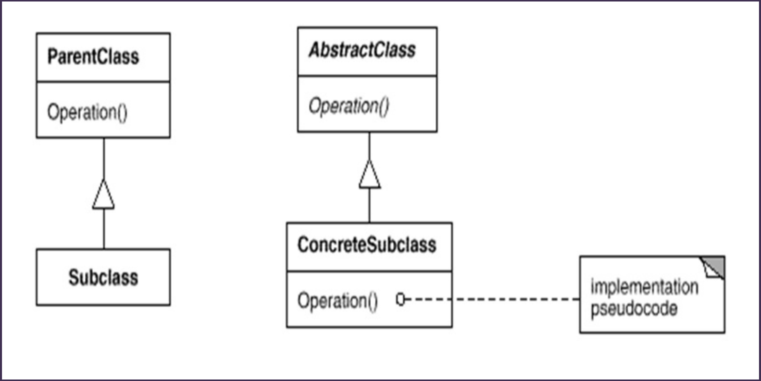
Classes


ClassName
Operation1()
Type Operation2()
...
instanceVariable1
Type instanceVariable2
...

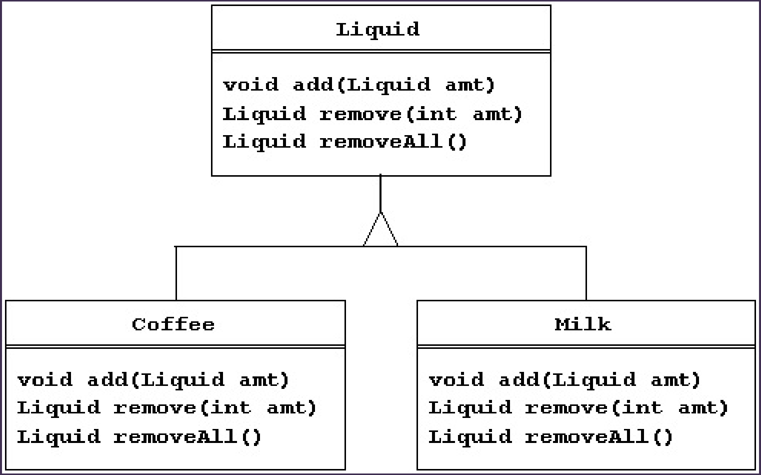
Object Instantiation



Subclassing and Abstract Classes



Abstraction and Polymorphism



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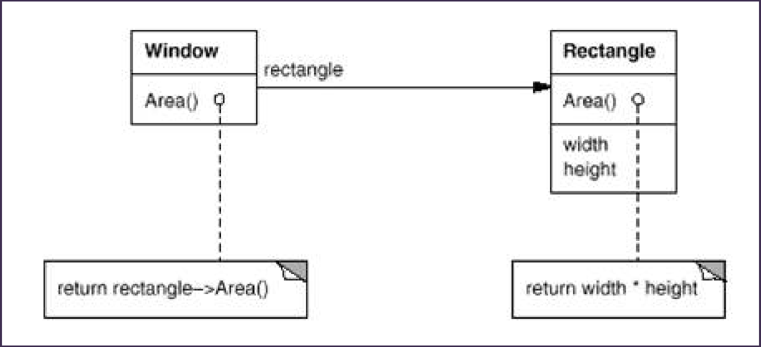
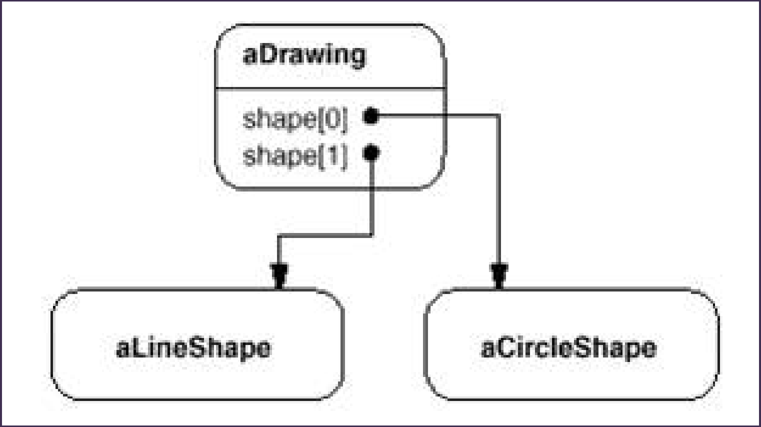
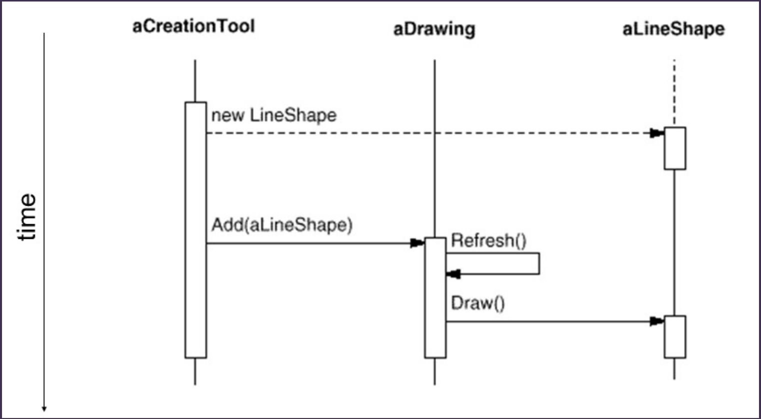
Pseudo-code and Containing



Object Diagrams



Interaction Diagrams



Role of Design Patterns

- OO design is more than just drawing diagrams, it is craftsmanship
- Good drafters are good designers
- OO design skill comes with deliberate practice and project experience
- A powerful form of abstraction and resuse is *design* abstraction and re-use

Role of Design Patterns

Object orientated systems tend to exhibit recurring structures that promote:

- Abstraction
- Flexibility
- Modularity
- Elegance

Role of Design Patterns

- Therein lies valuable design knowledge.
- The challenge, of course, is to...
  - capture
  - communicate
  - and apply
- ...this knowledge.

Role of Design Patterns

A design pattern...

- Abstracts a recurring design structure
- Comprises class and/or object
  - dependencies
  - structures
  - interactions
  - conventions
- names and specifies the design structure explicitly
- and thereby distils design experience

Components of a Design Pattern

A design pattern is comprised of:

- A name
- Common aliases — *also known as...*
- Real-world examples
- Contexts
- Common problems solved
- Solution
- Structure
- Diagrams
- Consequences

Components of a Design Pattern

- Design patterns are often tacit knowledge made explicit.
- You will develop tacit knowledge of patterns through regular design practice.
- You are expected to engage in constant research and reflection when designing software to learn all of these different patterns.
- They will help you communicate and design in the future.
- Additional research will be required as the number of patterns greatly exceeds those that can be covered in workshops.

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Design Patterns

Learning Outcomes

In this section you will learn how to...

- **Distinguish** between creational, structural, and behavoral design patterns
- **Compare and contrast** different design patterns
- **Suggest** the most appropriate design pattern for a given context

Types of Design Pattern

Design patterns come in three main flavours:

- **creational**: concerned with the process of creating and managing the creation of objects.
- **structural**: dealing with the composition of objects.
- **behavioural**: characterizing the different means by which objects can interact with others.

Types of Design Pattern

- **Creational**
- Singleton
- Typesafe Enum
- Factory
- Prototype
- Builder

- **Structural**
- Adapter
- Bridge
- Proxy
- Facade
- Decorator

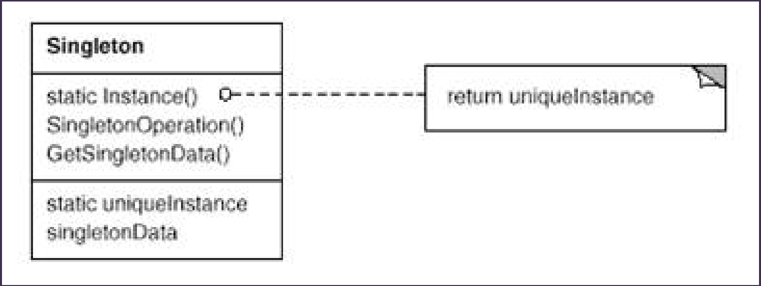
- **Behavioural**
- Template
- State
- Observer
- Visitor
- Strategy

Design Patterns

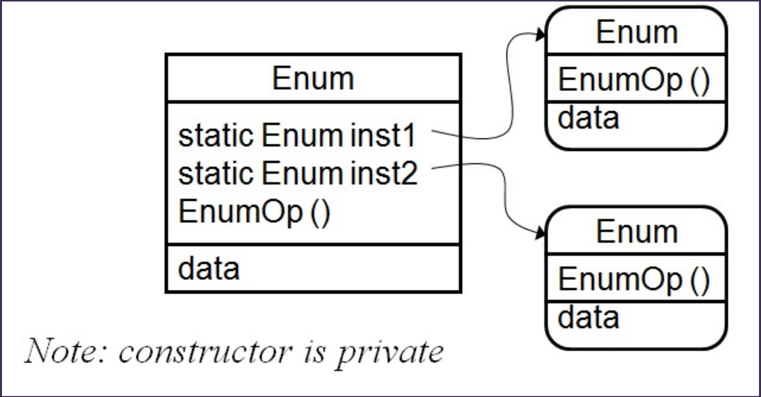
We will now briefly examine these patterns. Throughout this section...

- **Please** make notes on Slack
- **Link** to on-line resources
- **Ask** questions
- **Think** about how the patterns may apply to your own projects
- **Conduct** further research

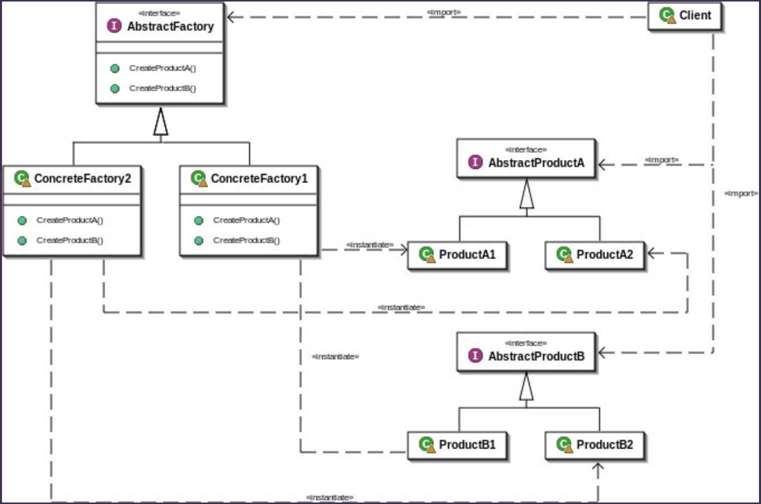
Singleton


Singleton
static Instance()
SingletonOperation()
GetSingletonData()
static uniqueInstance
singletonData
return uniqueInstance

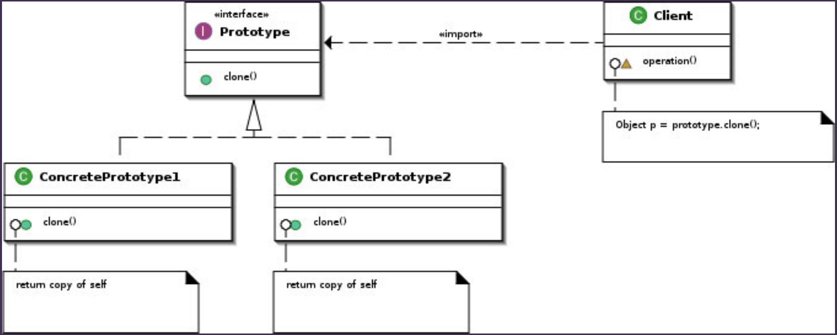
Typesafe Enum



Abstract Factory

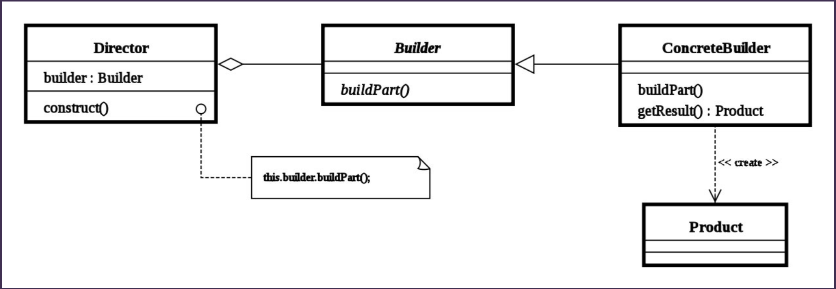


Prototype

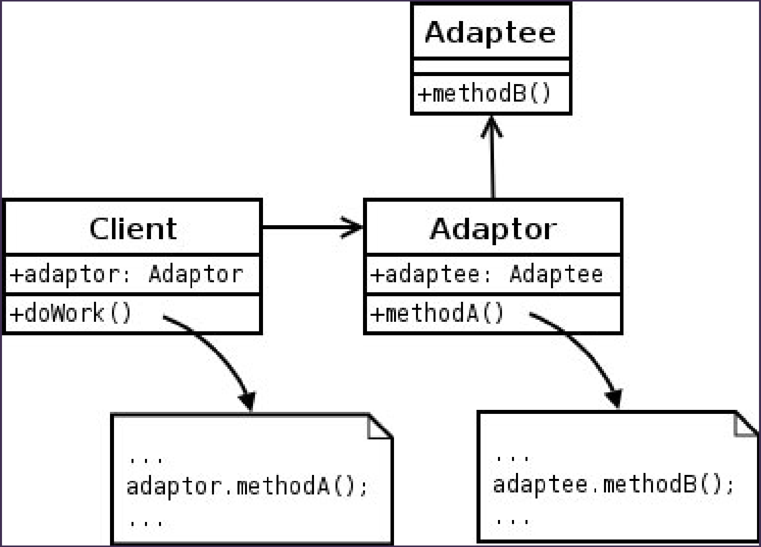


«interface»
Prototype
clone()
«import»
Client
operation()
Object p = prototype.clone();
ConcretePrototype1
clone()
return copy of self
ConcretePrototype2
clone()
return copy of self

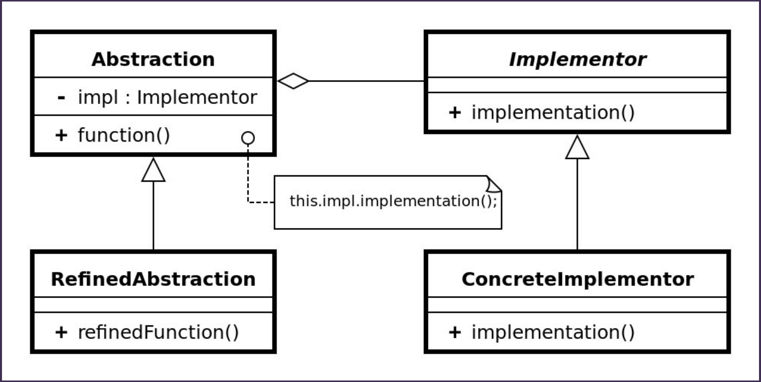
Builder


Director
builder : Builder
construct()
Builder
buildPart()
ConcreteBuilder
buildPart()
getResult() : Product
this.builder.buildPart();
<< create >>
Product

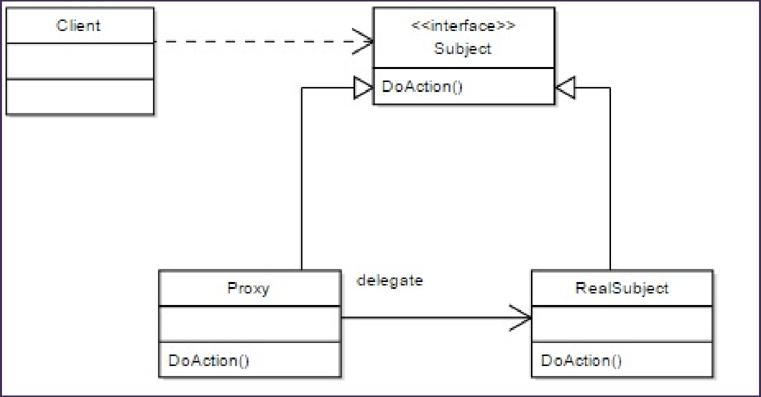
Adapter


Adaptee
+methodB()
Client
+adaptor: Adaptor
+doWork()
Adaptor
+adaptee: Adaptee
+methodA()
...
adaptor.methodA();
...
...
adaptee.methodB();
...

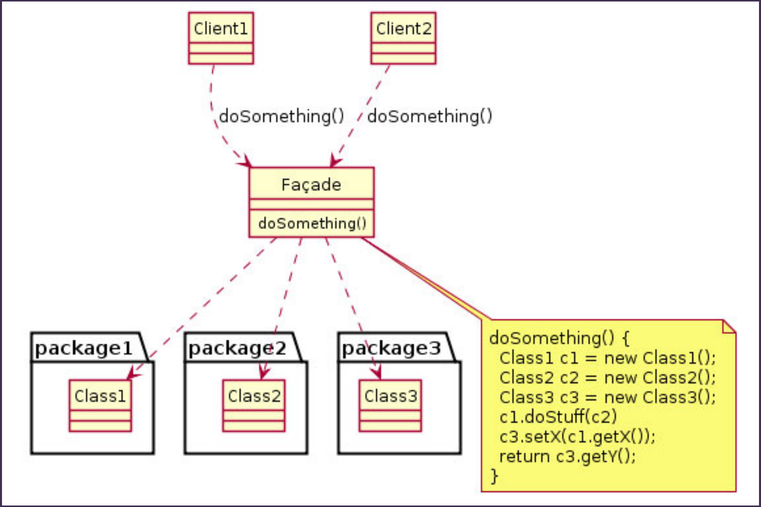
Bridge


Abstraction
- impl : Implementor
+ function()
Implementor
+ implementation()
this.impl.implementation();
RefinedAbstraction
+ refinedFunction()
ConcreteImplementor
+ implementation()

Proxy

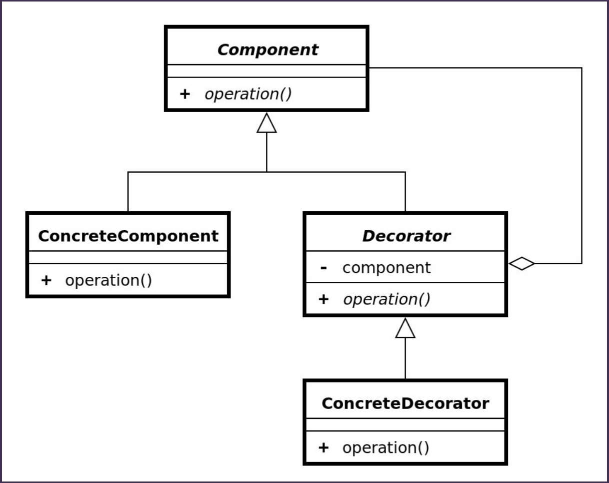

Client
<<interface>>
Subject
DoAction()
Proxy
DoAction()
delegate
RealSubject
DoAction()

Facade



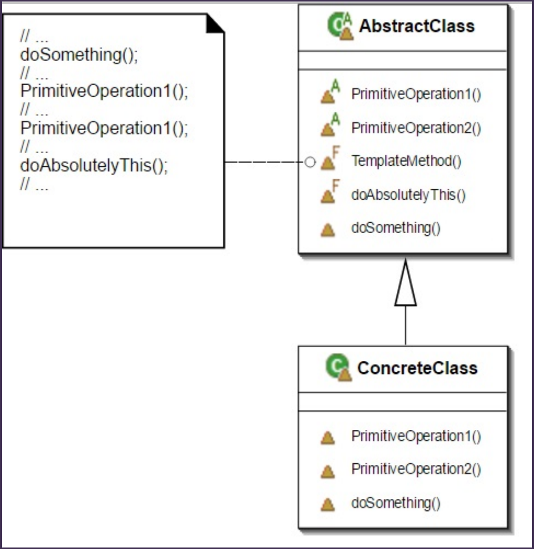
```
doSomething() {
  Class1 c1 = new Class1();
  Class2 c2 = new Class2();
  Class3 c3 = new Class3();
  c1.doStuff(c2)
  c3.setX(c1.getX());
  return c3.getY();
}
```

Decorator

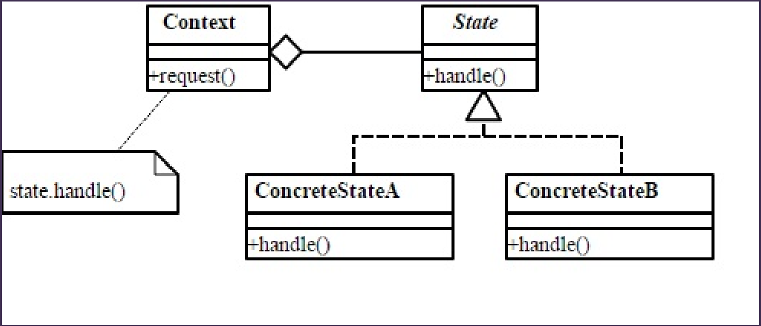


Component
+ *operation()*
ConcreteComponent
+ operation()
Decorator
- component
+ *operation()*
ConcreteDecorator
+ operation()

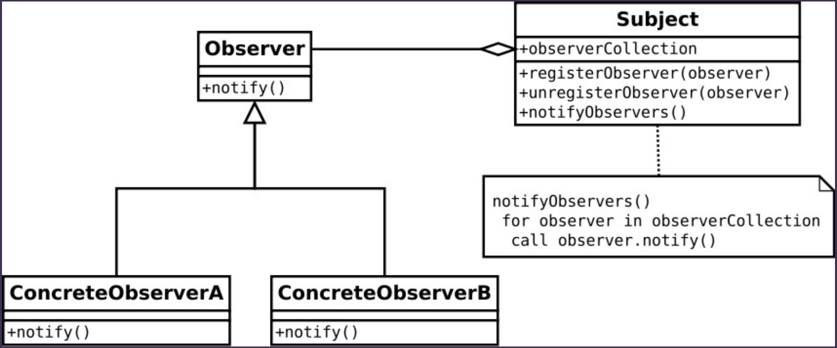
Template


```
// ...
doSomething();
// ...
PrimitiveOperation1();
// ...
PrimitiveOperation1();
// ...
doAbsolutelyThis();
// ...
```

State

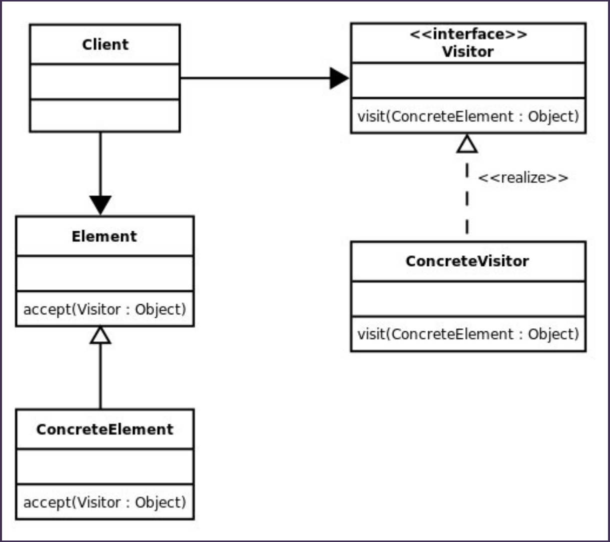

Context
+request()
State
+handle()
state.handle()
ConcreteStateA
+handle()
ConcreteStateB
+handle()

Observer



```
notifyObservers()
 for observer in observerCollection
  call observer.notify()
```

Visitor



Client
<<interface>>
Visitor
visit(ConcreteElement : Object)
<<realize>>
ConcreteVisitor
visit(ConcreteElement : Object)
Element
accept(Visitor : Object)
ConcreteElement
accept(Visitor : Object)

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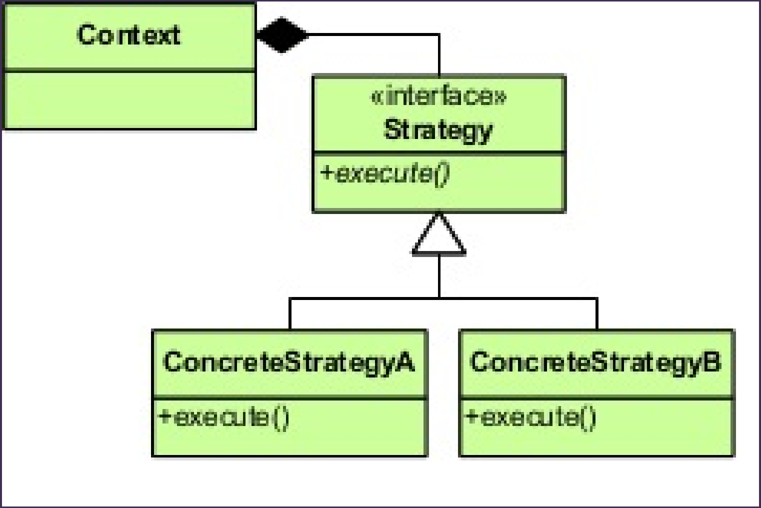
Strategy


Context
«interface»
Strategy
+execute()
ConcreteStrategyA
+execute()
ConcreteStrategyB
+execute()