COMP160: Software Engineering

3: Design Patterns

Learning Outcomes

Today's lecture will introduce the basics of object-orientated software design and design patterns, focusing on the following patterns:

- Singleton
- Typesafe Enum
- Factory
- Prototype
- Builder
- Adapter
- Bridge
- Proxy
- Facade
- Decorator
- Template
- State
- Observer
- Visitor
- Strategy

There are many other design patterns that you will be able to discover through independent study.

Further Reading

- Alexander, C. (1977) *A Pattern Language*. Oxford University Press.
- Alexander, C. (1979) *The Timeless Way of Building*. Oxford University Press.
- Coad, P. (1992) *Object-orientated Patterns.*Communications of the ACM, vol. 35, no. 9, pp. 152—159.

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Further Reading

- Johnson, R.E. (1992) `Documenting frameworks using patterns'. In: *Proceedings of the 1992 Conference on Object-oriented Programming Systems, Languages, and Applications* (OOPSLA '92). ACM, New York, pp. 63-76.
- Gamma, E., Helm, R., Johnson, R., and Vlissides, J. (1993) `Design Patterns: Abstraction and Reusage of Object-Orientated Design'. In: *Proceedings of the 7th European Conference on Object-Orientated Programming* (ECOOP `93). Springer, New York, pp. 406-431.

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Further Reading

- Gamma, E., Helm, R., Johnson, R., and Vlissides, J. (1995). Design patterns: elements of reusable object-oriented software. Addison-Wesley.
- Fowler, M. (2002) *Patterns of enterprise application architecture*. Addison-Wesley.

OO Design Basics

Learning Outcomes

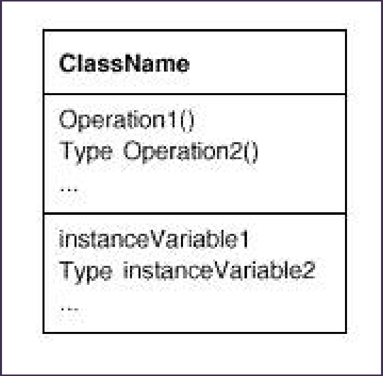
In this section you will learn how to...

- **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

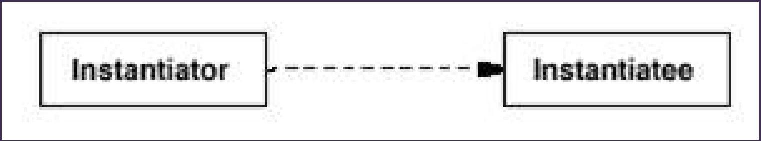
Object Modelling Techniques

- 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

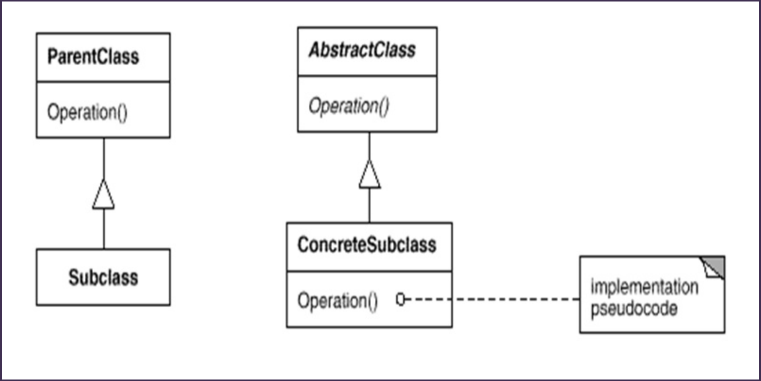
Classes


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

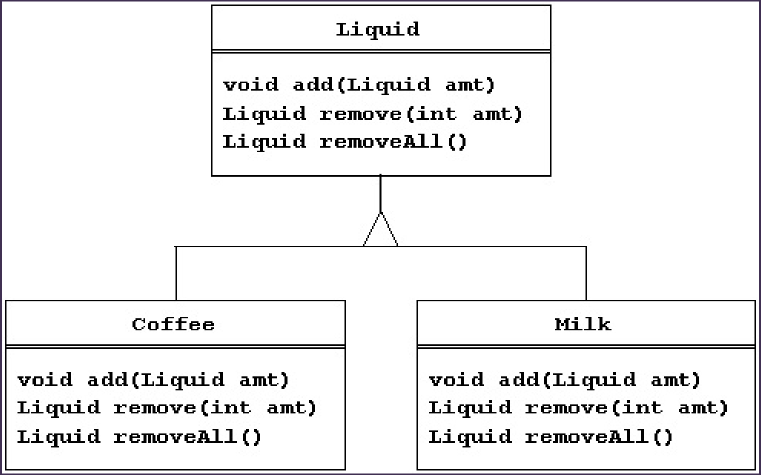
Object Instantiation



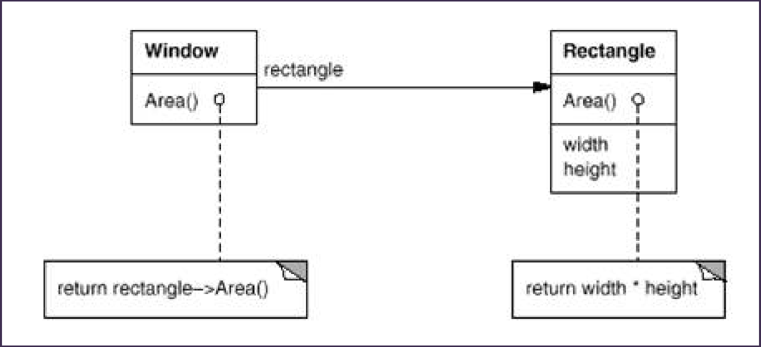
Subclassing and Abstract Classes



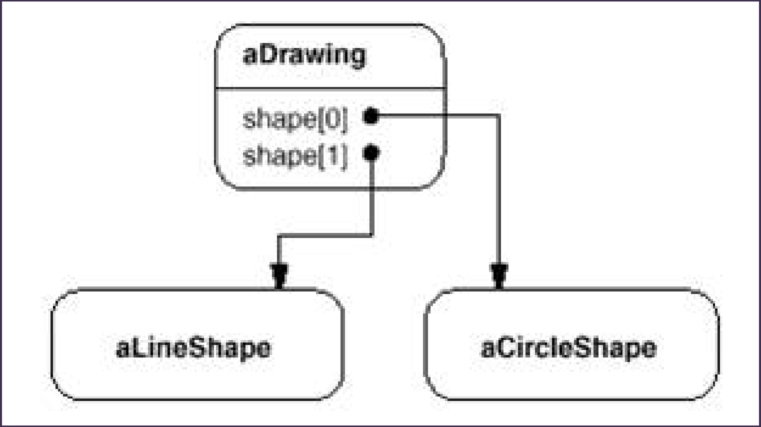
Abstraction and Polymorphism



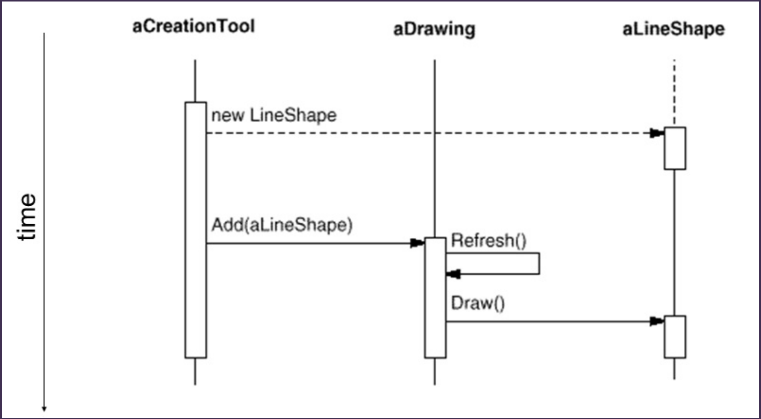
Pseudo-code and Containing



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.

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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

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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

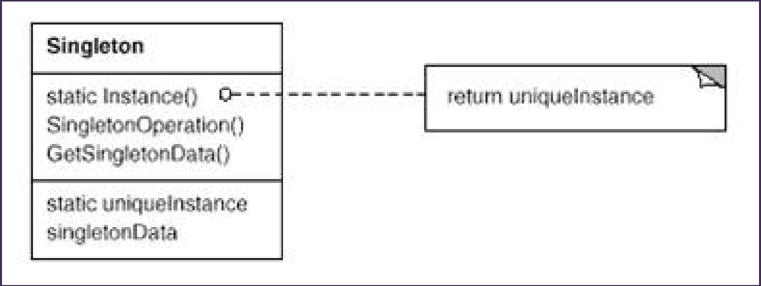
- **Behavioural**
- Template
- State
- Observer
- Visitor
- Strategy

Design Patterns

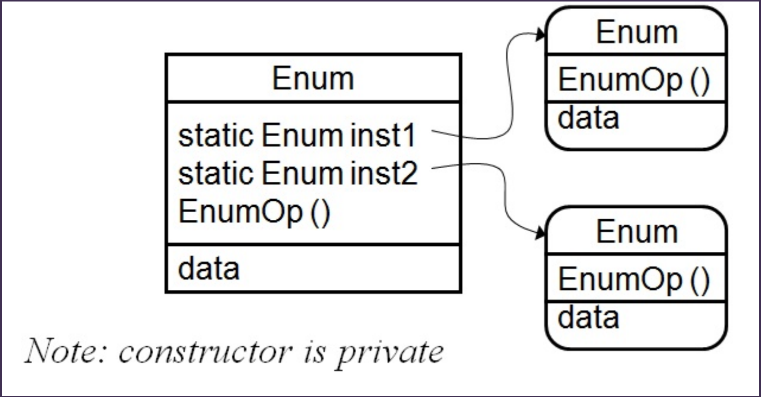
We will now briefly examine these patterns. Throughout this section...

- **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

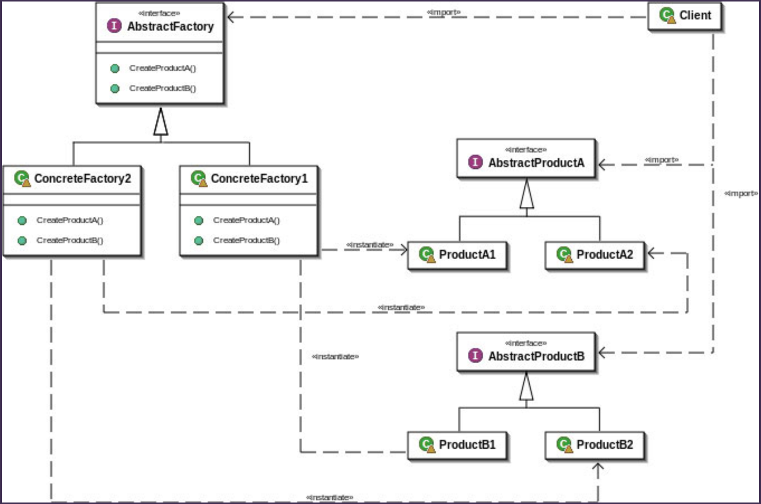
Singleton


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

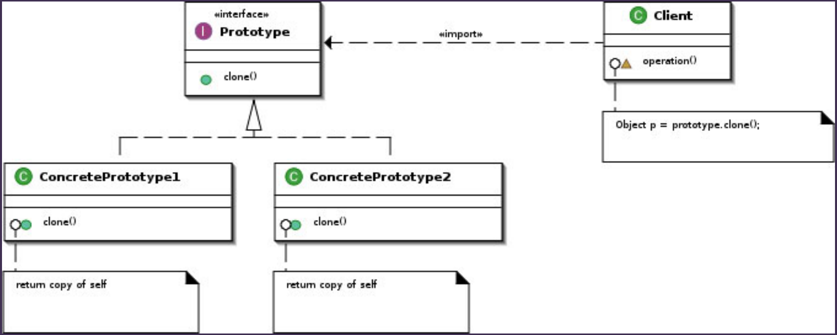
Typesafe Enum



Abstract Factory

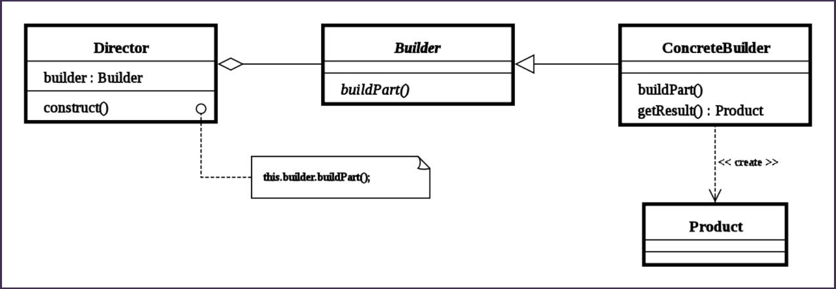


Prototype

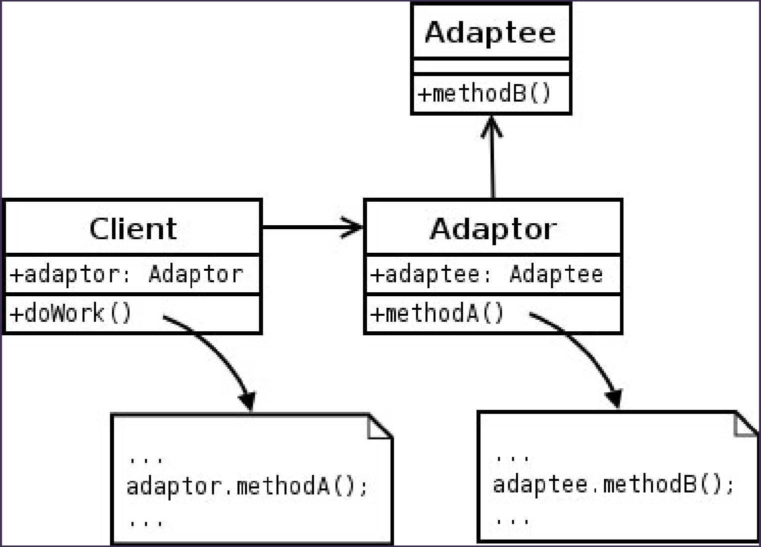


«interface»
Prototype
clone()
«import»
Client
operation()
Object p = prototype.clone();
ConcretePrototype1
clone()
return copy of self
ConcretePrototype2
clone()
return copy of self

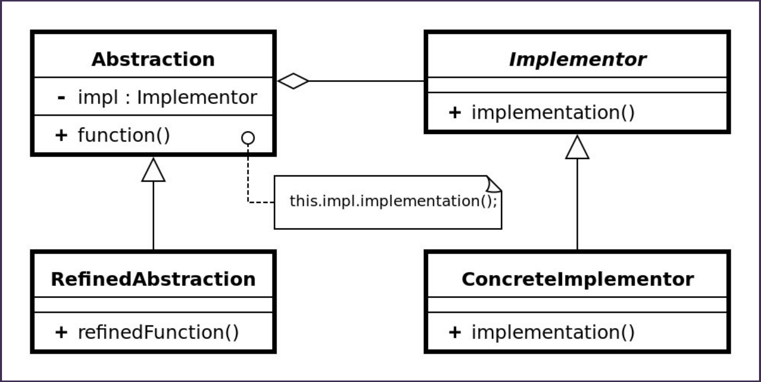
Builder


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

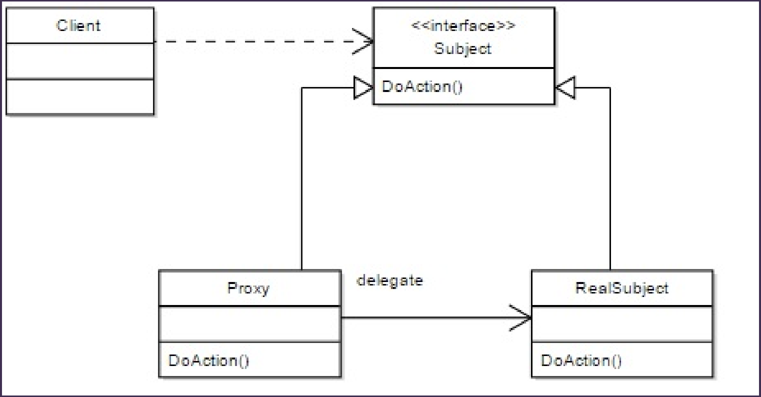
Adapter


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

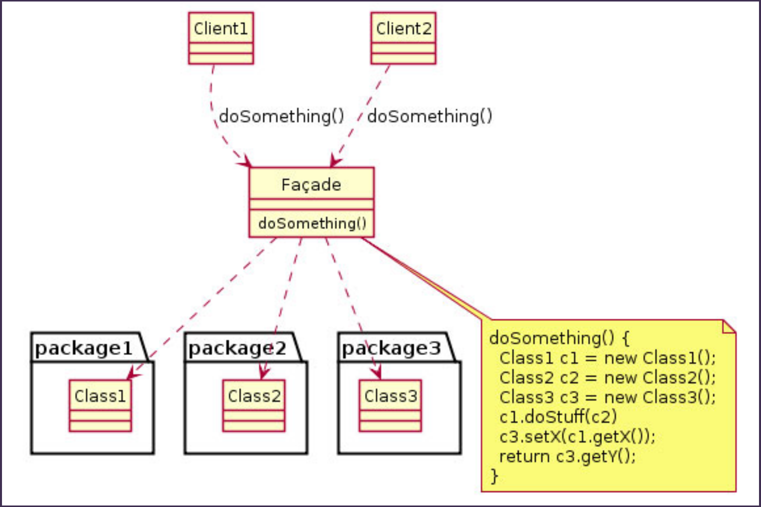
Bridge


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

Proxy

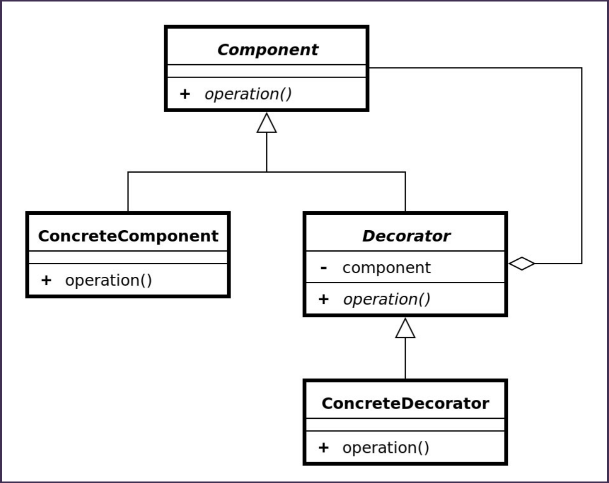

Client
<<interface>>
Subject
DoAction()
Proxy
DoAction()
delegate
RealSubject
DoAction()

Facade

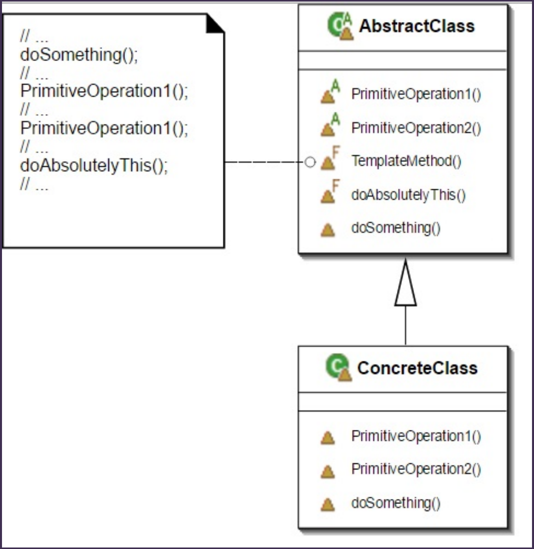


```
doSomething() {
  Class1 c1 = new Class1();
  Class2 c2 = new Class2();
  Class3 c3 = new Class3();
  c1.doStuff(c2)
  c3.setX(c1.getX());
  return c3.getY();
}
```

Decorator

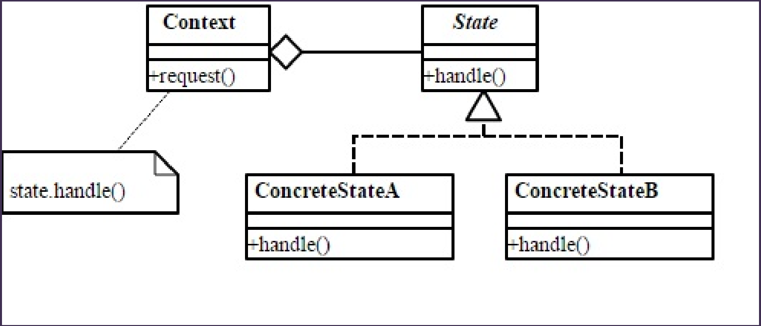

Component
+ operation()
ConcreteComponent
+ operation()
Decorator
- component
+ operation()
ConcreteDecorator
+ operation()

Template



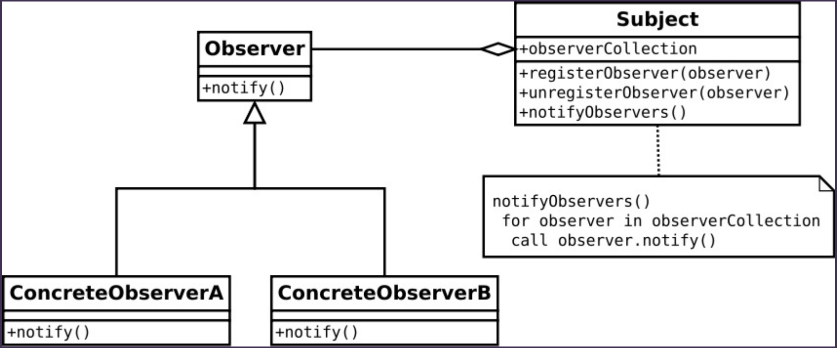
// ...
doSomething();
// ...
PrimitiveOperation1();
// ...
PrimitiveOperation1();
// ...
doAbsolutelyThis();
// ...
AbstractClass
PrimitiveOperation1()
PrimitiveOperation2()
TemplateMethod()
doAbsolutelyThis()
doSomething()
ConcreteClass
PrimitiveOperation1()
PrimitiveOperation2()
doSomething()

State



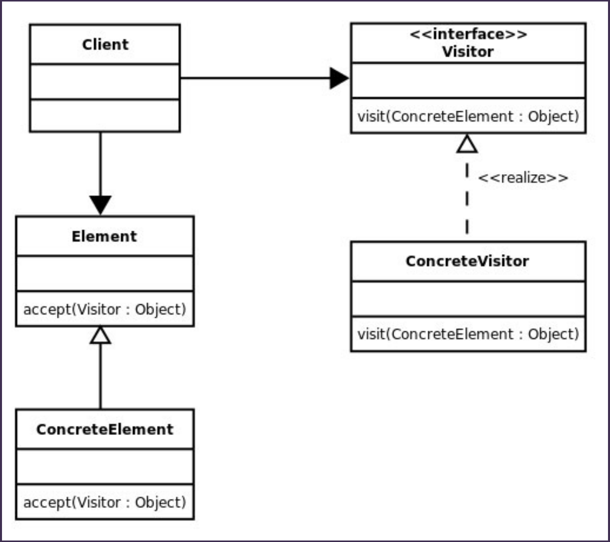
Context
+request()
State
+handle()
state.handle()
ConcreteStateA
+handle()
ConcreteStateB
+handle()

Observer

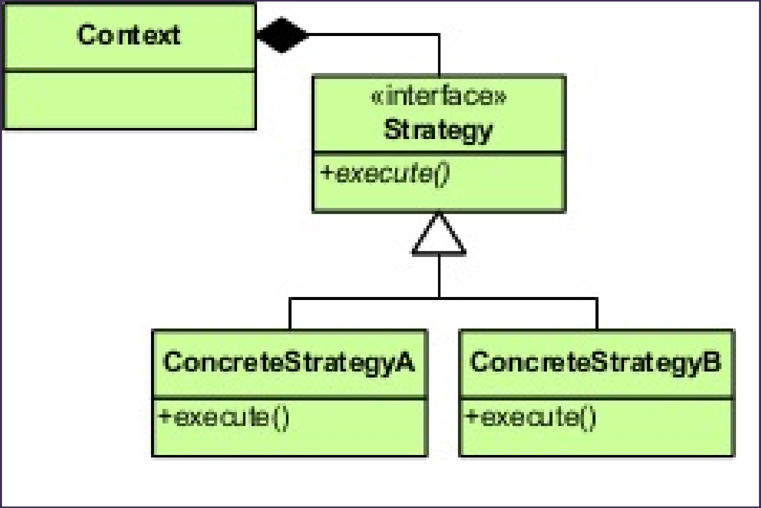


```
notifyObservers()
 for observer in observerCollection
  call observer.notify()
```

Visitor


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

Strategy


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

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Practical Activity

Design Patterns

- **Self-organise** into your project teams.
- **Review** the design of your game's architecture.
- If you have not yet done so, **draw** a UML class diagram that illustrates the game's architecture.
- **Identify** existing patterns **and** opportunities to apply pattern.
- **Refactor** the design accordingly.

(45 minutes)

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Projects

Research Essay

- There is no session in Week 4 — you are to focus on your 200-word research essay proposal.
- Make a pull-request by 5pm on Tuesday 14th February.
- The themes your essay may focus upon include:
  - Engineering Software for Accessibility
  - Engineering Software for Portability
  - Engineering Software for Localisation
  - Incorporating Specialist Algorithms and Systems into Software
- You will need to coordinate your selection with your team, as each team member must focus on a different theme.

Unreal Projects

- You **must** attend product owner meetings. Not only are they **compulsory**, they are also **mark bearing**.
- You need to evidence your individual contributions for COMP130/GAM130. Product owners are tracking this.
- You need to prioritise the user stories and components to maximise your contributions. You cannot spend weeks making things that are not being used. You must deliver something every single sprint.
- You **must** engage with and communicate with your team **on a daily basis**. Even if you can't make the daily stand-up meeting because of classes, you are still expected to check in with your team.