Design Patterns

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Big questions

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What are the key ideas of those patterns?

Design challenges

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Can designs be described, codified or standardised?

- this would short circuit the trial and error phase;
- produce "better" software faster.

Design Patterns

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Example: Iterator pattern!

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Example: Iterator pattern! The Iterator pattern defines an interface that declares methods for sequentially accessing the objects in a collection.

History of patterns

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In 1995 book *Design Patterns: Elements of Reusable Object-Oriented Software*, which is a classic of the field, is published.

Benefits of using patterns

Patterns are a common design vocabulary.

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Improve documentation (less is needed) and **understandability** (patterns are described well once).

Gang of Four (GoF) patterns

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Behavioral Patterns: communication between objects.

- Command, Interpreter, Iterator, Mediator, Observer, State, Strategy, Chain of Responsibility, Visitor, Template Method.

Factory Method

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- it impossible to change the instantiation independently from (without having to change) the class.

The Factory Method design pattern describes how to solve such problems:

- Define a separate operation (factory method) for creating an object.
- Create an object by calling a factory method.

Factory Method

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- abstract the creation process.

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Problem to solve: handle the process creation process

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- provide information not accessible to the composing object;
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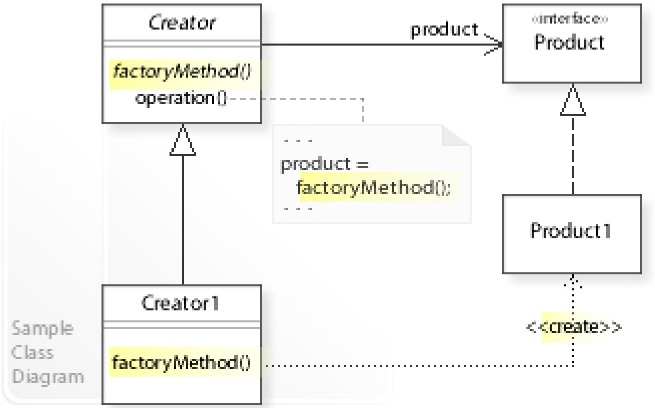
The factory method pattern relies on inheritance, as object creation is delegated to subclasses that implement the factory method to create objects.

Factory Method



Abstract Factory

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- How can a class be independent of how the objects it requires are created?
- How can families of related or dependent objects be created?

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This pattern:

- Encapsulate object creation in a separate (factory) object defined via an interface (AbstractFactory);
- A class delegates object creation to a factory object instead of creating objects directly.

Abstract Factory

Definition: Provide an interface for creating families of related or dependent objects without specifying their concrete classes.

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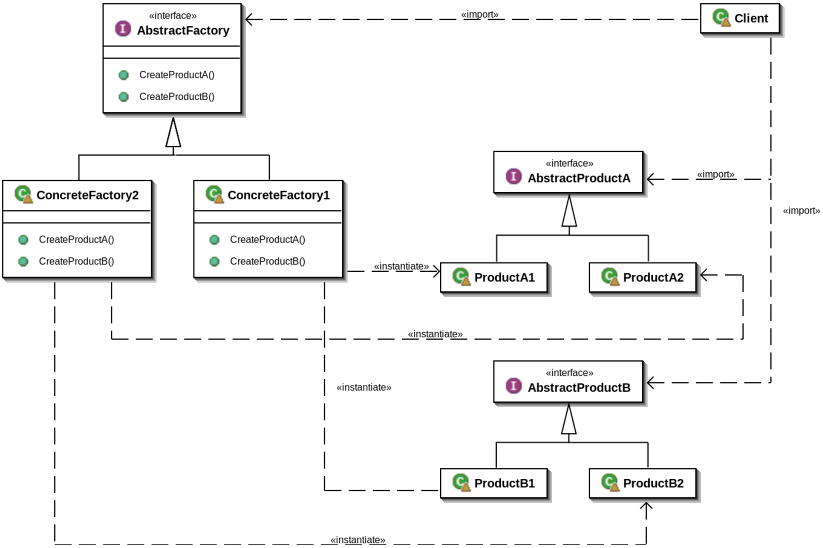
Usage: The factory determines the actual concrete type of object to be created, and it is here that the object is actually created.

However, the factory only returns an abstract pointer to the created concrete object.

This insulates client code from object creation by having clients ask a factory object to create an object of the desired abstract type and to return an abstract pointer to the object.

Abstract Factory



Singleton Pattern

The singleton design pattern solves problems like:

- How can it be ensured that a class has only one instance?
- How can the sole instance of a class be accessed easily?
- How can a class control its instantiation?
- How can the number of instances of a class be restricted?

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The singleton design pattern describes how to solve such problems:

- Hide the constructor of the class.
- Define a public static operation (getInstance()) that returns the sole instance of the class.

Singleton Pattern

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The hidden constructor (declared private) ensures that the class can never be instantiated from outside the class.

The public static operation can be accessed easily by using the class name and operation name (`Singleton.getInstance()`).

Singleton Pattern

```
public final class Singleton {
    private static final Singleton INSTANCE = new Singleton()
    ;

    private Singleton() {
      //If needed, parameters can be read from local context!
    }

    public static Singleton getInstance() {
        return INSTANCE;
    }

    ....
}
```

Composite pattern

What problems can the Composite design pattern solve?

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- A part-whole hierarchy should be represented as tree structure.

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- A part-whole hierarchy should be represented so that clients can treat part and whole objects uniformly.
- A part-whole hierarchy should be represented as tree structure.

What solution does the Composite design pattern describe?

- Define a unified Component interface for both part (Leaf) objects and whole (Composite) objects.
- Individual Leaf objects implement the Component interface directly
- Composite objects forward requests to their child components.

Composite Pattern

Composite enables clients to work through the Component interface to treat Leaf and Composite objects uniformly:

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- Leaf objects perform a request directly;
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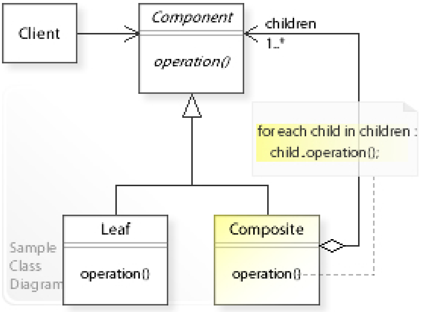
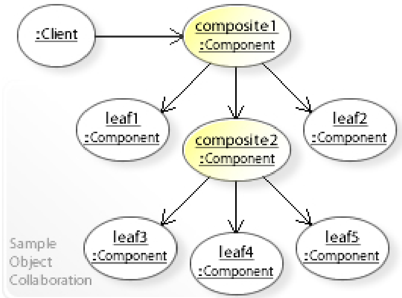
This makes client classes easier to implement, change, test, and reuse.

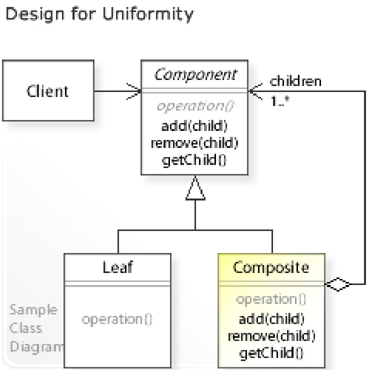
Composite Pattern

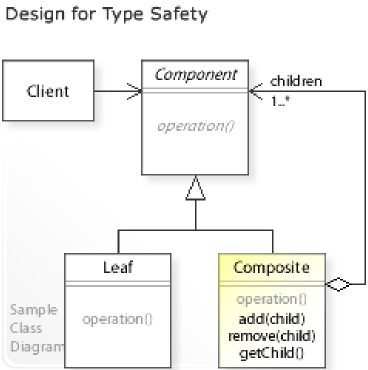




Composite Pattern

Two variants. . .





Composite Pattern
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Each figure can be:

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Each figure can be:

- a basic figure: Rectangle, Ellipse, Triangle.
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Operation is:

- `draw( Graphics g , int x , int y )`

Composite Pattern

Java code. . .

Decorator Pattern

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- Responsibilities should be added to (and removed from) an object dynamically at run-time.
- A flexible alternative to subclassing for extending functionality should be provided.
- When using subclassing, different subclasses extend a class in different ways. But an extension is bound to the class at compile-time and can't be changed at run-time.

Decorator Pattern

What solution does the Decorator design pattern describe?

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What solution does the Decorator design pattern describe? Define Decorator objects that:

- implement the interface of the extended (decorated) object (Component) transparently by forwarding all requests to it and perform additional functionality before/after forwarding a request.
- This enables to work through different Decorator objects to extend the functionality of an object dynamically at run-time.

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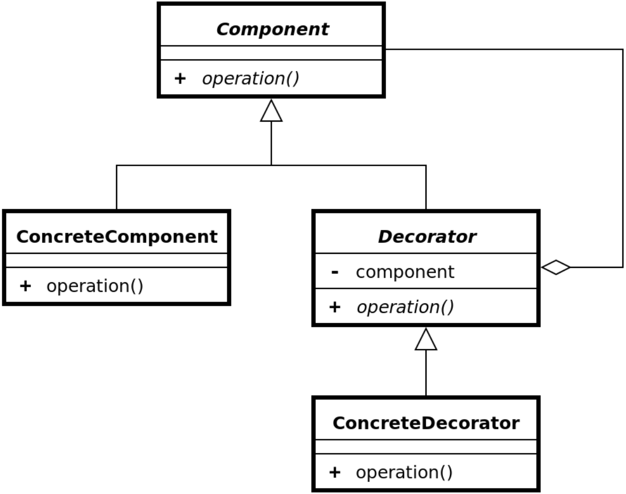
- In the Decorator class, pass a Component to the Decorator constructor to initialise the Component pointer;
- In the Decorator class, forward all Component methods to the Component pointer;
- and In the Decorator class, override any Component method(s) whose behaviour needs to be modified.

Decorator Pattern



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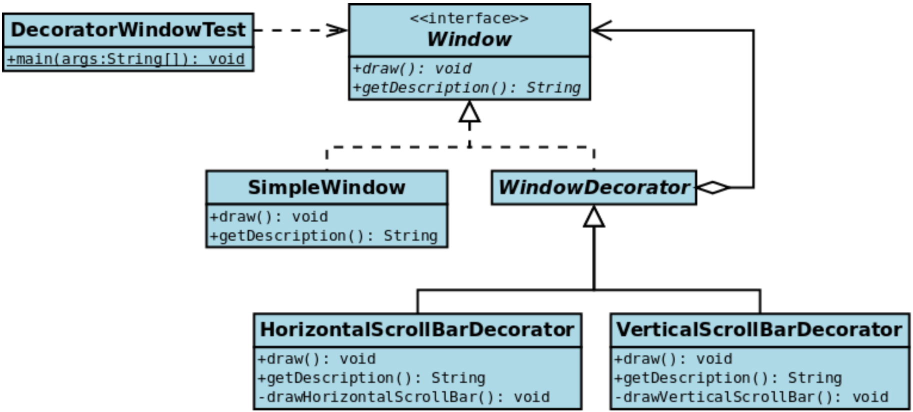


Command

What solution does the Command design pattern describe?

- Define separate (command) objects that encapsulate a request.

This enables one to configure a class with a command object that is used to perform a request. The class is no longer coupled to a particular request and has no knowledge (is independent) of how the request is carried out.

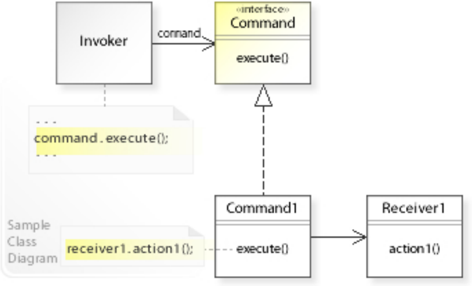
Command

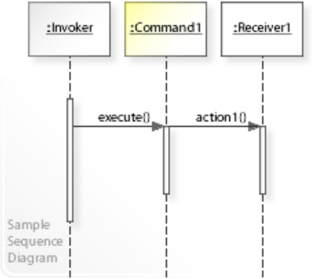
What solution does the Command design pattern describe?

- Define separate (command) objects that encapsulate a request.
- A class delegates a request to a command object instead of implementing a particular request directly.

This enables one to configure a class with a command object that is used to perform a request. The class is no longer coupled to a particular request and has no knowledge (is independent) of how the request is carried out.

Command


Invoker
comnand
«interface»
Command
execute()
...
command.execute();
...
Command1
execute()
Receiver1
action1()
Sample
Class
Diagram
receiver1.action1();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Observer

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- A one-to-many dependency between objects should be defined without making the objects tightly coupled.
- It should be ensured that when one object changes state an open-ended number of dependent objects are updated automatically.
- It should be possible that one object can notify an open-ended number of other objects.

Observer

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- Define `Observable` and Observer objects.
- When a subject changes state, all registered observers are notified and updated automatically.

Observable

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After an observable instance changes, an application calling the Observable's `notifyObservers` method causes all of its observers to be notified of the change by a call to their update method.

Observable

Methods. . .

```
void addObserver(Observer o)

protected void clearChanged()

int countObservers()

void deleteObserver(Observer o)

void deleteObservers()

boolean hasChanged()

void notifyObservers()

void notifyObservers(Object arg)

protected void setChanged()
```

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This method is called whenever the observed object is changed. An application calls an Observable object's notifyObservers method to have all the object's observers notified of the change.

MVC: Model View Controller

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The MVC design pattern decouples these major components allowing for efficient code reuse and parallel development.

MVC: Model View Controller

Components:

- The model, is the central component of the pattern. It directly manages the data, logic and rules of the application.
- A view can be any output representation of information, such as a chart or a diagram. Multiple views of the same information are possible.
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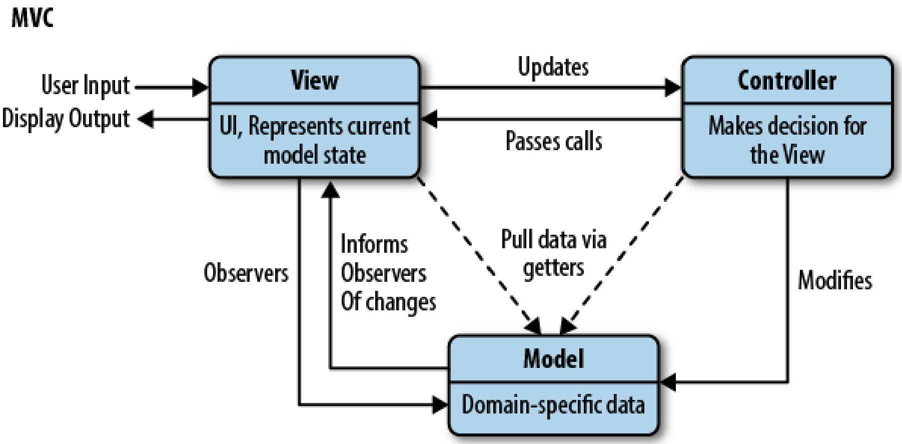
Interactions:

- The model is responsible for managing the data of the application. It receives user input from the controller.
- The view means presentation of the model in a particular format.
- The controller responds to the user input and performs interactions on the data model objects.

MVC: Model View Controller



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- Multiple views for a model, Models can have multiple views

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- Multi-artifact consistency, Decomposing a feature into three artifacts causes scattering. Thus, requiring developers to maintain the consistency of multiple representations at once.
- Pronounced learning curve, Knowledge on multiple technologies becomes the norm. Developers using MVC need to be skilled in multiple technologies.

To be continued. . .