Introduction

A design pattern is a general repeatable solution to a commonly occurring problem in software design. A design pattern isn't a finished design that can be transformed directly into code. It is a description or template for how to solve a problem that can be used in many different situations.

Why keep reinventing the wheel? Why not just write down your solution and refer back to it as needed? That's what design patterns are all about.

A design pattern is a tested solution to a standard programming problem. Once you learn design patterns, if you face a programming issue, a solution will come to you more quickly. What you will probably need is the Factory pattern." Or the Observer pattern. Or the Adapter pattern. Someone has already faced the problem you're facing and has come up with a solution that implements all kinds of good design.

Design patterns can speed up the development process by providing tested, proven development paradigms. Effective software design requires considering issues that may not become visible until later in the implementation. Reusing design patterns helps to prevent subtle issues that can cause major problems and improves code readability for coders and architects familiar with the patterns.

The charm of knowing about design patterns is that it makes your solution easily reusable, extendable, and maintainable. When you're working on a programming problem, the tendency is to program to the problem, not in terms of reuse, extensibility, maintainability, or other good design issues.

Patterns describe common ways of doing things. They are collected by people who spot repeating themes in designs. These people take each theme and describe it so that other people can read the pattern and see how to apply it.

<u>The power of shared pattern vocabulary</u>

Shared pattern vocabulary is powerful: When you communicate with your teams using patterns, you are communicating not just a pattern name but a whole set of qualities, characteristic and constraints that the pattern represents.

Patterns allow you to say more with less: When you use a pattern in a description, other developers quickly know precisely the design you have in mind.

Talking at the pattern level allows you to stay "in the design" longer: Talking about software systems using patterns allows you to keep the discussion at the design level, without having to get into the details of implementing objects and classes.

Inheritance is fundamental to object-oriented programming. A programming language may have objects and messages, but without inheritance it is not object-oriented (merely "object-based", but still polymorphic).

Composition is also fundamental to every language (in terms of parts and components). It would be impossible to break down complex problems into modular solutions without composition. Composition is fairly easy to understand - we can see composition in everyday life: a chair has legs, a wall is composed of bricks and mortar. Computer system has a hard disk, memory. Car has an Engine, chassis, steering wheels.

The set of 23 standard design patterns was published by Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides in their book Design Patterns: Elements of Reusable Object-Oriented Software. They've come to be known in programming circles as the Gang of Four, or, more popularly, GoF. According to these authors design patterns are primarily based on the following principles of object oriented design.

- Program to an interface not an implementation
    - Interface is a contract between an object and its clients. An interface specifies the things that an object can do, and the signatures for accessing those things. Implementations are the actual behaviors. For example you have a method sort(). You can implement QuickSort or MergeSort. That should not matter to the client code calling sort as long as the interface does not change.

      Coding against interface means, the client code always holds an Interface object which is supplied by a factory. Any instance returned by the factory would be of type Interface which any factory candidate class must have implemented. This way the client program is not worried about implementation and the interface signature determines what all operations can be done. This can be used to change the behavior of a program at run-time.

- Favor object composition over inheritance
    - It is a design principle that gives the design higher flexibility. It is more natural to build business-domain classes out of various components than trying to find commonality between them and creating a family tree. For example, a pedal and a wheel share very few common traits, yet are both vital components in a car. What they can do and how they can be used to benefit the car is easily defined. In other words, it is better to compose what an object can do (HAS-A) than extend what it is (IS-A).

      Initial design is simplified by identifying system object behaviors in separate interfaces instead of creating a hierarchical relationship to distribute behaviors among business-domain classes via inheritance. This approach more easily accommodates future requirements changes that would otherwise require a complete restructuring of business-domain classes in the inheritance model. Additionally, it avoids problems often associated with relatively minor changes to an inheritance-based model that includes several generations of classes.

      One common drawback of using composition instead of inheritance is that methods being provided by individual components may have to be implemented in the derived type, even if they are only forwarding methods. In contrast, inheritance does not require all of the base class's methods to be re-implemented within the derived class.

  Inheritance should only be used when:
    - Both classes are in the same logical domain
    - The subclass is a proper subtype of the superclass
    - The superclass's implementation is necessary or appropriate for the subclass
    - The enhancements made by the subclass are primarily additive.

Code listing 1 (interface1.cpp)

```
#include <iostream>
using namespace std;
```

```
#define interface struct

interface IData
{
  virtual void addData() = 0;
  virtual void getData() = 0;
  virtual void deleteData() = 0;
  virtual void updateData() = 0;
};

class fileData : public IData {
  public:
    void addData() {
      cout << "fileData addData invoked " << endl;
    }
    void getData() {
      cout << "fileData getData invoked " << endl;
    }
    void deleteData() {
      cout << "fileData deleteData invoked " << endl;
    }
    void updateData() {
      cout << "fileData updateData invoked " << endl;
    }
};

class dbData : public IData {
  public:
    void addData() {
      cout << "dbData addData invoked " << endl;
    }
    void getData() {
      cout << "dbData getData invoked " << endl;
    }
    void deleteData() {
      cout << "dbData deleteData invoked " << endl;
    }
    void updateData() {
      cout << "dbData updateData invoked " << endl;
    }
};

void main()
{
  IData *obj = new fileData();
  obj->addData();
  obj->getData();
  obj->updateData();
  obj->deleteData();

  delete obj;
  obj = new dbData();
  obj->addData();
  obj->getData();
  obj->updateData();
  obj->deleteData();
}
```

What is Containment?

Containment is the simple approach, in which a class B, that needs access to the members of class A, contains an instance/object of class A, rather then inheriting the class A.

Although controlling access to the members of a class may be the reason why we may not prefer inheritance for code re-usability, there are a few points that may help us to decide whether we should use inheritance or containment.

Point 1: Do we need entire functionality of the base class or just some part of it

```
class livingThings()
{
  public:
    void CanWalk() {}
    void CanTalk() {}
    void CanTalk() {}
};

class mankind : public livingThings
{
  public:
    // All methods of livingThings
    // new methods can be added
};

// Is designing this class correct? If not Why?
class animal : public livingThings
{

};
```

The answer is No, since an animal can walk and run but an animal cannot talk. Inheritance will still expose this method to the derived class. So if we really want to use inheritance with this concept then it will be better to break the LivingThings class into further components (depending on the requirements) and further use them as base classes.

Point 2: Do we need a coupled or decoupled system?

When we inherit from a base class to create a derived class, it increases the coupling between the two classes since the derived class directly uses the base class and its member functions. On the other hand, using containment, via interfaces, promotes loose coupling since we are programming against the interfaces and not the concrete classes. See the following points.

Point 3: Do we need to change the base class at run-time?

If we have multiple base classes, implementing a common interface, then we can switch between the multiple base classes, at run-time, based on some kind of condition

Point 4: Do we need to control access to the public members class?

Which component of a class should be accessible to the other classes. Using inheritance, it will only control restriction to the private members. Protected and public members will be still accessible to the other classes

Point 5: Avoid change in client code due to base class code change.

<u>Code listing 2 (containment1.cpp)</u>

```
#include <iostream>
using namespace std;

#define interface struct

interface IText
{
  virtual char * getText() = 0;
};

class htmlText : public IText {
  public:
    char * getText() {
      return "html text";
    }
    void method1() {}
};

class jsonText : public IText {
  public:
    char * getText() {
      return "json text";
    }
    void method2() {}
};

class report {
  IText *obj;

  public:
  char * getReportText(int type)
  {
    if(type == 1)
    {
      obj = new htmlText();
      return obj->getText();
    }
    else if(type == 2)
    {
      obj = new jsonText();
      return obj->getText();
    }
  }
};

void main()
{
  report obj;
  cout << obj.getReportText(1) << endl;
  cout << obj.getReportText(2) << endl;
}
```

<u>Code listing 3 (inheritance_containment.cpp)</u>

```
#include <iostream>
using namespace std;

class oneI {
  public:
    int add(int x, int y)
    {
      return x + y;
    }
};

class twoI : public oneI {
  public:
    int mult(int x, int y)
    {
      return x * y;
    }
};

class oneC {
  public:
    int add(int x, int y)
    {
      return x + y;
    }
};

class twoC {
  oneC obj;
  public:
    void callbaseMethod()
    {
      cout << obj.add(10, 20) << endl;
    }
    int mult(int x, int y)
    {
      return x * y;
    }
};

void main()
{
  twoI objI;
  int result;
  result = objI.add(3, 4);
  cout << result << endl;
  result = objI.mult(3, 4);
  cout << result << endl;

  twoC objC;
  objC.callbaseMethod();
  result = objC.mult(10, 20);
  cout << result << endl;
}
```

// Make the following changes:
// 1) Add a subtract method in oneI and oneC
// 2) Update the signature of add in oneI and oneC (add third argument)

Design patterns are classified by two criteria.

1. The first criterion, called purpose, reflects what a pattern does, which can be Creational, Structural, or Behavioral.

2. The second criterion, called scope, specifies whether the pattern applies primarily to classes or objects. Class patterns deal with relationships between classes and their subclasses. These relationships are established through inheritance, so they are static - fixed at compile time. Object patterns deal with object relationships, which can be changed at run time and are more dynamic.

Creational patterns
Creational patterns are used to create objects for a suitable class that serves as a solution for a problem. They are particularly useful when you are taking advantage of polymorphism and need to choose between different classes at runtime rather than compile time.

Structural patterns
These patterns are concerned with how classes and objects are composed to form larger structures. These design patterns concern class and object composition. Concept of inheritance is used to compose interfaces and define ways to compose objects to obtain new functionalities.
How do you built a software component?

Behavioral patterns
Behavioral patterns describe interactions between objects and focus on how objects communicate with each other. Behavioral patterns are concerned with algorithms and the assignment of responsibilities between objects.

How do you want to run a behavior in Software?

		Purpose		
		Creational	Structural	Behavioral
Scope	Class	Factory Method	Adapter (class)	Interpreter Template Method
	Object	Abstract factory Builder Prototype Singleton	Adapter (object) Bridge Composite Decorator Façade Flyweight Proxy	Chain of responsibility Command Iterator Mediator Memento Observer State Strategy Visitor

Design pattern space

Purpose	Design Pattern	Aspects that can vary
Creational	Abstract Factory	Provides an interface for creating families of related or dependent objects without specifying their concrete classes.
	Builder	Separate the construction of a complex object from its representation so that the same construction process can create different representation.
	Factory Method	Define an interface for creating an object, but let subclasses decide which class to instantiate. Factory method lets a class defer instantiation to subclasses.
	Prototype	Specify the kinds of objects to create using a prototypical instance, and create new objects by copying their prototype.
	Singleton	Ensure a class only has one instance, and provide a global point of access to it.
Structural	Adapter	Convert the interface of a class into another interface clients expect. Adapter lets classes work together that couldn't otherwise because of incompatible interfaces.
	Bridge	Decouple an abstraction from its implementation so that the two can vary independently.
	Composite	Compose objects into tree structure to represent part-whole hierarchies. Composite lets clients treat individual objects and composition of objects uniformly.
	Decorator	Attach additional responsibilities to an object dynamically. Decorators provide a flexible alternative to sub classing for extending functionality.
	Facade	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.
	Flyweight	Use sharing to support large number of fine grained objects efficiently.
	Proxy	Provide a surrogate or placeholder for another object to control access to it.
Behavioral	Chain of responsibility	Avoid coupling the sender of a request to its receiver by giving more than one object a chance to handle the request. Chain the receiving objects and pass the request along the chain until an object handles it.
	Command	Encapsulate a request as an object, thereby letting you parameterize clients with different requests, queue or log requests, and support undoable operations.
	Interpreter	Given a language, define a representation for its grammar along with an interpreter that uses the representation to interpret sentences in its language,
	Iterator	Provide a way to access the elements of an aggregate object sequentially without exposing its underlying representation.
	Mediator	Define an object that encapsulates how a set of objects interact. Mediator promotes loose coupling by keeping objects from referring to each other explicitly, and it lets you vary their interaction independently.
	Memento	Without violating encapsulation, capture and externalize an object's internal state so that the object can be restored to this state later.
	Observer	Define a one-to-many dependency between objects so that

		when one object changes state, all its dependents are notified and updated automatically.
	State	Allow an object to alter its behavior when its internal state changes. The object will appear to change its class.
	Strategy	Define a family of algorithms, encapsulate each one, and make them interchangeable. Strategy lets the algorithm vary independently from clients that use it.
	Template Method	Define the skeleton of an algorithm in an operation, deferring some steps to subclasses. Template method lets subclasses redefine certain steps of an algorithm without changing the algorithm's structure.
	Visitor	Represent an operation to be performed on the elements of an object structure. Visitors lets you define a new operation without changing the classes of the elements on which it operates.

Design aspects that design patterns let you vary

Creational patterns: Singleton

It is important for some classes to have exactly one instance. Although there can be many printers in a system, there should be only one printer spooler. There should be only one file system and one window manager.

How do we ensure that a class has only one instance and that the instance is easily accessible? A global variable makes an object accessible, but it doesn't keep you from instantiating multiple objects.

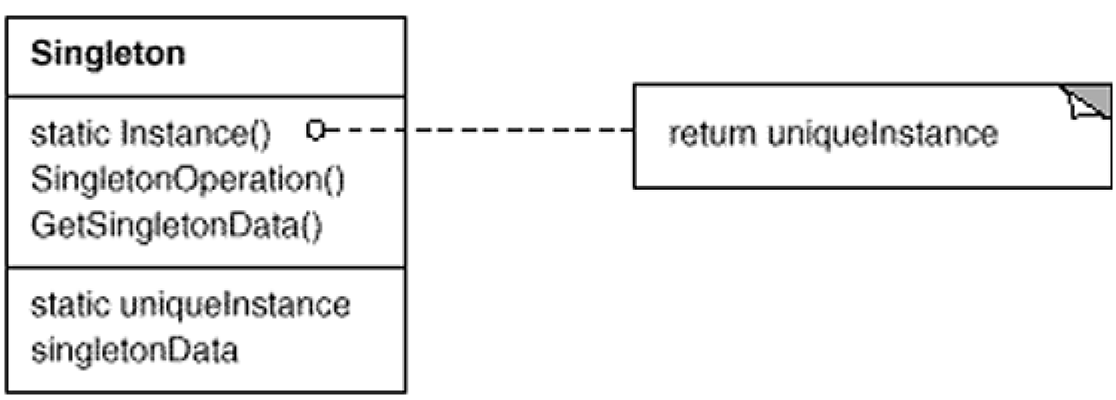
A better solution is to make the class itself responsible for keeping track of its sole instance. The class can ensure that no other instance can be created, and it can provide a way to access the instance. This is the singleton pattern.

Use the singleton pattern when

- There must be exactly one instance of a class, and it must be accessible to clients.

- When the sole instance should be extensible by subclassing, and clients should be able to use extended instance without modifying their code.

Structure



Participants

Singleton

- defines an Instance operation that lets clients access its unique instance. Instance is a class operation (that is a static member function in C++).
- may be responsible for creating its own unique instance.

<u>Code listing 4 (Singleton.cpp)</u>

```
#include <iostream>
using namespace std;

class singleton
{
   private:
      int value;
      singleton();
      static singleton* _instance;
   public:
      int getValue();
      void setValue(int val);
      static singleton* getInstance();
      static void DestroyInstance();
   protected:
      // To disallow copy constructor, assignment operator
      // and destructor to be called from outside the class
      singleton(const singleton&) {};
      singleton& operator=(const singleton&){};
      ~singleton(){};
};

singleton* singleton :: _instance = NULL;

singleton :: singleton() {
   value = 20;
}

int singleton :: getValue() {
   return value;
}

void singleton :: setValue(int val) {
   value = val;
}

singleton * singleton :: getInstance() {
   if (_instance == NULL)  {
      cout << "if block" << endl;
      _instance = new singleton();
   }
   else {
      cout << "else block" << endl;
   }
   return _instance;
```

```
}
void singleton::DestroyInstance() {
  delete _instance;
  _instance = NULL;
}

void main() {
   singleton *s1 = singleton::getInstance();
   s1->setValue(40);
   cout << "Value 1 " << s1->getValue() << endl;

   singleton *s2 = singleton::getInstance();
   cout << "Value 2 " << s2->getValue() << endl;

   s2->setValue(50);
   cout << "Value 1 " << s1->getValue() << endl;
   cout << "Value 2 " << s2->getValue() << endl;

  singleton::DestroyInstance();

  singleton *s3 = singleton::getInstance();
  cout << "Value 1 " << s1->getValue() << endl;
  cout << "Value 2 " << s2->getValue() << endl;

  cout << "Value 3 " << s3->getValue() << endl;

  // *s1 = *s2;
  // singleton s4(*s1);
}
```

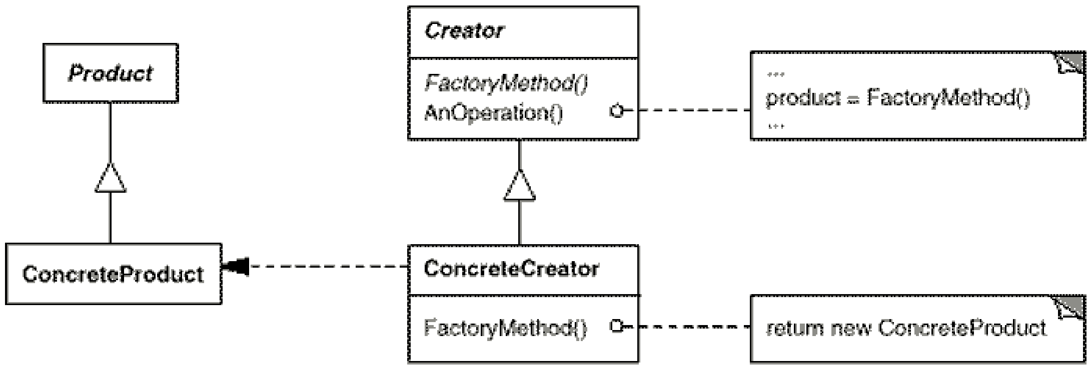
Creational patterns: Factory Method

Defines an interface for creating an object, but let subclasses decide which class to instantiate. Factory method lets a class defer instantiation to subclasses.

Use the Factory Method pattern when

- A Class can't anticipate the class of objects it must create.
- A Class wants its subclasses to specify the objects it creates.
- Classes delegate responsibility to one of several helper subclasses, and you want to localize the knowledge of which helper subclass is the delegate.

Structure



Participants

Product (Shape)
defines the interface of objects the factory method creates.

ConcreteProduct (Square, Circle, Rectangle)
implements the Product interface.

Creator (Factory)

- declares the factory method (getShape), which returns an object of type Product. Creator may also define a default implementation of the factory method that returns a default ConcreteProduct object.

- may call the factory method to create a Product object.

ConcreteCreator (ShapeFactory)
overrides the factory method to return an instance of a ConcreteProduct.

Code listing 5 (FactoryMethod.cpp)

```
#include <iostream>
using namespace std;

#define interface struct

interface Shape
{
  virtual void draw() = 0;
};

class Square : public Shape
{
  public:
    void draw() {
      cout << "Inside Square::draw() method." << endl;
    }
};

class Circle : public Shape
{
  public:
    void draw() {
      cout << "Inside Circle::draw() method." << endl;
    }
```

```
};

class Rectangle : public Shape
{
  public:
    void draw() {
      cout << "Inside Rectangle::draw() method." << endl;
    }
};

Interface Factory
{
  virtual Shape * getShape(char * shapeType) = 0;
};

class ShapeFactory : public Factory
{
  public:
    Shape * getShape(char * shapeType)
    {
      if(shapeType == NULL) {
          return NULL;
      }
      if(stricmp(shapeType, "CIRCLE") == 0)
      {
        return new Circle();
      }
      else if(stricmp(shapeType, "SQUARE") == 0)
      {
        return new Square();
      }
      else if(stricmp(shapeType, "RECTANGLE") == 0)
      {
        return new Rectangle();
      }
      return NULL;
    }
};

void main()
{
  //get shape factory
  Factory * shapeFactory = new ShapeFactory();

  //get an object of Shape Circle
  Shape * shape1 = shapeFactory->getShape("CIRCLE");
  if(shape1 != NULL)
    shape1->draw();

  //get an object of Shape Square
  Shape * shape2 = shapeFactory->getShape("SQUARE");
  if(shape2 != NULL)
    shape2->draw();

  //get an object of Shape Rectangle
  Shape * shape3 = shapeFactory->getShape("RECTANGLE");
  if(shape3 != NULL)
```

```
    shape3->draw();
}
```

Creational patterns: Abstract factory

Provides an interface for creating families of related or dependent objects without specifying their concrete classes. Abstract Factory patterns work around a super-factory which creates other factories. This factory is also called as factory of factories. In Abstract Factory pattern an interface is responsible for creating a factory of related objects without explicitly specifying their classes.
Abstract factory only declares the interface for creating products. It is up to the concrete subclasses to actually create them.

Use the AbstractFactory pattern when

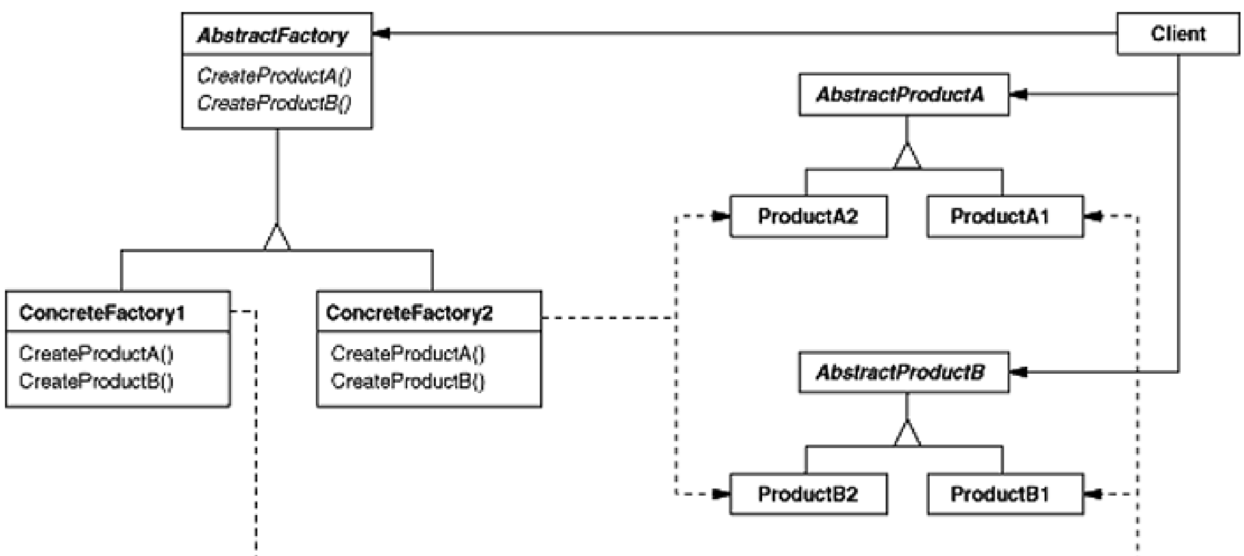
- A system should be configured of how its products are created, composed and represented.

- A system should be configured with one of multiple families of products.

- A family of related product objects is designed to be used together, and you need to enforce this constraint.

- Provide a class library of products, and want to reveal just their interface, not their implementation.

Structure



Participants

AbstractFactory (AbstractFactory)
declares an interface for operations that create abstract product objects.

ConcreteFactory (ShapeFactory)
implements the operations to create concrete product objects.

AbstractProduct (Shape)

declares an interface for a type of product object.

ConcreteProduct (Square, Circle)
defines a product object to be created by the corresponding concrete factory.
implements the AbstractProduct interface.

Client
uses only interfaces declared by AbstractFactory and AbstractProduct classes.

Code listing 6 (AbstractFactory.cpp)

```
#include <iostream>
using namespace std;

#define interface struct

class Shape
{
  public:
    virtual void draw() = 0;
};

class Square : public Shape
{
  public:
    void draw() {
      cout << "Inside Square::draw() method." << endl;
  }
};
class Circle : public Shape
{
  public:
    void draw() {
      cout << "Inside Circle::draw() method." << endl;
  }
};

interface AbstractFactory
{
   virtual Shape * getShape(char * shape) = 0;
};

class ShapeFactory : public AbstractFactory
{
  public:
    Shape * getShape(char * shapeType)
    {
      if(shapeType == NULL) {
        return NULL;
    }
    if(stricmp(shapeType, "CIRCLE") == 0)
    {
      return new Circle();
    }
    else if(stricmp(shapeType, "SQUARE") == 0)
    {
```

```
      return new Square();
    }
    return NULL;
  }
};

class FactoryProducer
{
  public:
    static AbstractFactory * getFactory(char * choice)
    {
      if(stricmp(choice, "SHAPE") == 0)
      {
         return new ShapeFactory();
      }
      return NULL;
   }
};

void main()
{
  //get shape factory
  AbstractFactory * shapeFactory =
      FactoryProducer::getFactory("SHAPE");

  //get an object of Shape Circle
  Shape * shape1 = shapeFactory->getShape("CIRCLE");

  //call draw method of Shape Circle
  shape1->draw();

  //get an object of Shape Square
  Shape * shape2 = shapeFactory->getShape("SQUARE");

  //call draw method of Shape Square
  shape2->draw();
}
```

Structural patterns: Proxy

A proxy, in its most general form, is a class functioning as an interface to something else. The proxy could interface to anything: a network connection, a large object in memory, a file, or some other resource that is expensive or impossible to duplicate. In short, a proxy is a wrapper or agent object that is being called by the client to access the real serving object behind the scenes.

Let’s look at an example. Say you have some objects running in a process on your desktop, and they need to communicate with other objects running in another process. Perhaps this process is also on your desktop; perhaps it resides elsewhere. You don’t want the objects in your system to have to worry about findings other objects on the network or executing remote procedure calls.

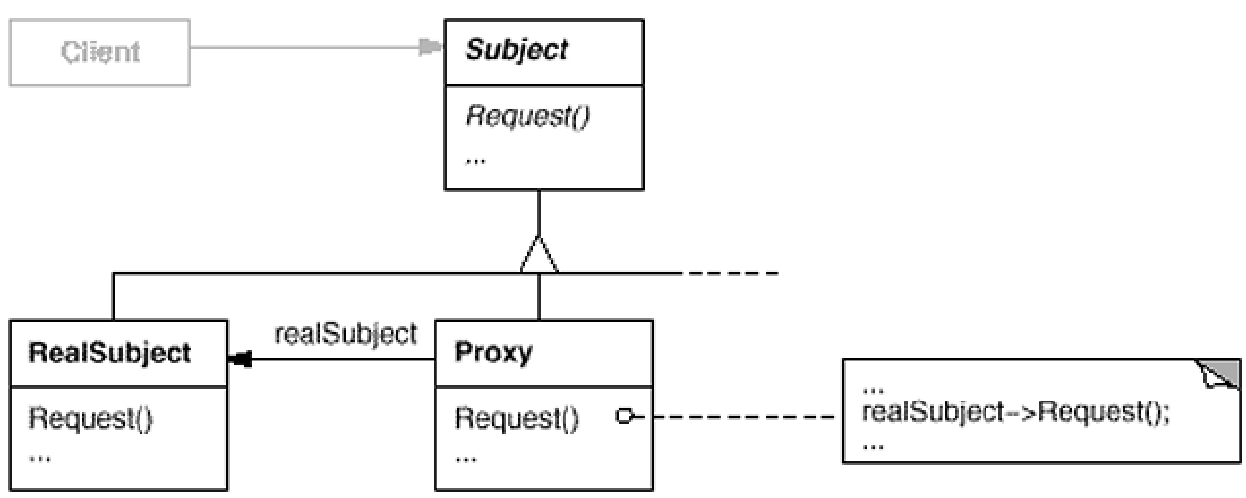
What you can do is create a proxy object within your local process for remote object. The proxy has the same interface as the remote object. Your local objects talk to the proxy using the usual in-process message sends. The proxy then is responsible for passing any messages on to the real object, wherever it might reside.

The proxy design pattern allows you to provide an interface to other objects by creating a wrapper class as the proxy. The wrapper class, which is the proxy, can add additional functionality to the object of interest without changing the object's code. A proxy provides a surrogate or placeholder for another object to control access to it.

Below are some of the common examples in which the proxy pattern is used:

- Adding security access to an existing object. The proxy will determine if the client can access the object of interest.
- Simplifying the API of complex objects. The proxy can provide a simple API so that the client code does not have to deal with the complexity of the object of interest.
- Providing interface for remote resources, such as web service or REST resources.
- Add a wrapper and delegation to protect the real component from undue complexity.
- Adding a thread-safe feature to an existing class without changing the existing class's code.

Structure



Participants

Proxy (ProxyCar)

- maintains a reference that lets the proxy access the real subject. Proxy may refer to a Subject if the RealSubject and Subject interfaces are the same.
- provides an interface identical to Subject's so that a proxy can be substituted for the real subject.
- controls access to the real subject and may be responsible for creating and deleting it.
- other responsibilities depend on the kind of proxy:
  - remote proxies are responsible for encoding a request and its arguments and for sending the encoded request to the real subject in a different address space.

- virtual proxies may cache additional information about the real subject so that they can postpone accessing it.

- protection proxies check that the caller has the access permissions required to perform a request.

Subject (ICar)
defines the common interface for RealSubject and Proxy so that a Proxy can be used anywhere a RealSubject is expected.

RealSubject (Car)
defines the real object that the proxy represents.

Code listing 7 (Proxy.cpp)

```
#include <iostream>
#include <string>
using namespace std;
#define interface struct

interface ICar {
  virtual void DriveCar() = 0;
};

// Real Subject
class Car : public ICar
{
  public:
    void DriveCar()
    {
      cout << "Car has been driven!";
    }
};

class Driver
{
  public:
    int Age;

    Driver(int age = 20)
    {
      this->Age = age;
    }
};

//Proxy Subject
class ProxyCar : public ICar
{
  Driver driver;
  ICar *realCar;

  public:
    ProxyCar(Driver driver)
    {
      this->driver = driver;
      realCar = new Car();
```

```
    }

    void DriveCar()
    {
      if (driver.Age <= 16)
        cout << "Sorry, the driver is too young to drive." << endl;
      else
        realCar->DriveCar();
    }
};

void main()
{
  ICar *car = new ProxyCar(Driver(16));
  car->DriveCar();

  car = new ProxyCar(Driver(25));
  car->DriveCar();
}
```

Code listing 8 (Proxy2.cpp)

```
#include <iostream>
#include <string>
using namespace std;

#define interface struct

// A protection proxy controls access to the original object

interface IAccess {
   virtual bool withdraw(int) = 0;
};
class Person
{
    string Role;
    static string roles[];
    static int next;
  public:
    Person()
    {
      if(next == 4)
        next = 0;
      Role = roles[next++];
    }
    string role()
    {
      return Role;
    }
};

string Person::roles[] =
{
  "Manager", "Finance", "Admin", "CFO"
};

int Person::next = 0;
```

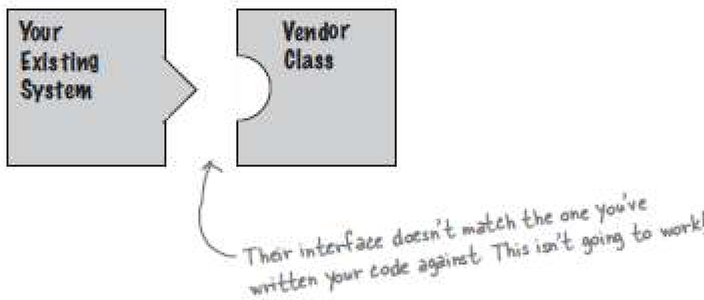
```
class ActualAccess : public IAccess
{
    int balance;
  public:
    ActualAccess()
    {
      balance = 500;
    }
    bool withdraw(int amount)
    {
      if (amount > balance)
        return false;
      balance -= amount;
      return true;
    }
    int getBalance()
    {
      return balance;
    }
};

class ProxyAccess : public IAccess
{
    Person p;
    ActualAccess object;
  public:
    ProxyAccess(Person &obj)
    {
      p = obj;
    }
    bool withdraw(int amount)
    {
      if (p.role() == "Manager" || p.role() == "Director" ||
        p.role() == "CFO")
        return object.withdraw(amount);
      else
        return false;
    }
    int getBalance()
    {
      return object.getBalance();
    }
};

int main()
{
  Person staff[4];
  IAccess *pc;
  for (int i = 0, amount = 100; i < 4; i++, amount += 100)
  {
    pc = new ProxyAccess(staff[i]);
    if (!pc->withdraw(amount))
      cout << "No access for " << staff[i].role() << '\n';
    else
      cout << amount << " dollars for " << staff[i].role() << '\n';
  }
}
```

Structural patterns: Adapter

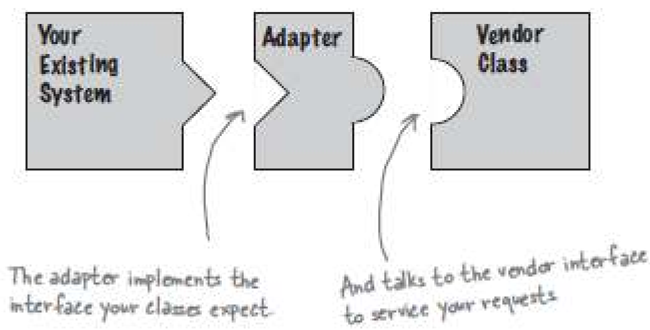
Adapter pattern works as a bridge between two incompatible interfaces. This pattern combines the capability of two independent interfaces.

Convert the interface of a class into another interface clients expect. Adapter lets classes work together that couldn't otherwise because of incompatible interfaces.

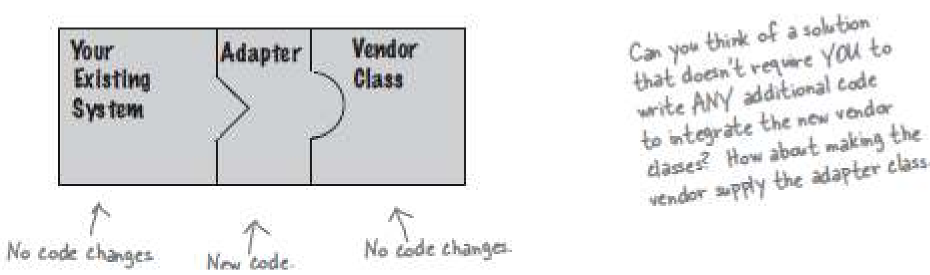
Suppose we have an existing system that you need to work with a new vendor class library, but the new vendor designed their interfaces differently than the last vendor.



We cannot solve the problem by changing the existing code (and we can't change the vendor's code). One solution is to write a class that adapts the new vendor interface into the one you are expecting.



The adapter acts as the middleman by receiving requests from the client and converting them into requests that make sense on the vendor classes.



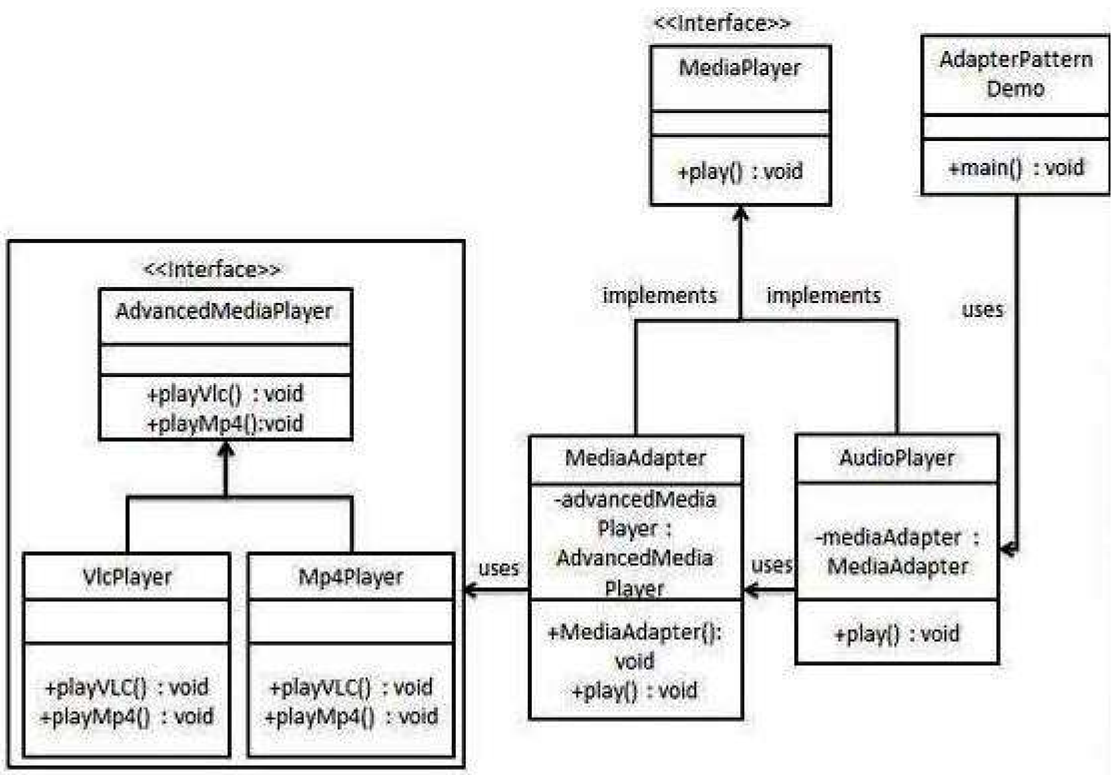
This pattern involves a single class which is responsible to join functionalities of independent or incompatible interfaces. A real life example could be a case of card reader which acts as an adapter between memory card and a laptop. You plugin the memory card into card reader and card reader into the laptop so that memory card can be read via laptop.

We have a MediaPlayer interface and a concrete class AudioPlayer implementing the MediaPlayer interface. AudioPlayer can play mp3 format audio files by default.

We are having another interface AdvancedMediaPlayer and concrete classes implementing the AdvancedMediaPlayer interface. These classes can play vlc and mp4 format files.

We want to make AudioPlayer to play other formats as well. To attain this, we have created an adapter class MediaAdapter which implements the MediaPlayer interface and uses AdvancedMediaPlayer objects to play the required format.

AudioPlayer uses the adapter class MediaAdapter passing it the desired audio type without knowing the actual class which can play the desired various formats.



Code listing 9 (Adapter.cpp)

```
#include <iostream>
#include <string.h>
using namespace std;

#define interface struct

interface MediaPlayer
{
  virtual void play(char * audioType, char * fileName) = 0;
};

interface AdvancedMediaPlayer
{
  virtual void playVlc(char * fileName) = 0;
  virtual void playMp4(char * fileName) = 0;
};

class VlcPlayer : public AdvancedMediaPlayer
{
```

```
  public:
    void playVlc(char * fileName)
    {
      cout << "Playing vlc file. Name: " << fileName << endl;
    }
    void playMp4(char * fileName)
    {
      //do nothing
    }
};


class Mp4Player : public AdvancedMediaPlayer
{
   public:
    void playVlc(char * fileName)
    {
      //do nothing
    }
    void playMp4(char * fileName)
    {
      cout << "Playing mp4 file. Name: " << fileName << endl;
    }
};

class MediaAdapter : public MediaPlayer
{
  private:
    AdvancedMediaPlayer *advancedMusicPlayer;
  public:
    MediaAdapter(char * audioType)
    {
      if(stricmp(audioType, "vlc") == 0)
      {
        advancedMusicPlayer = new VlcPlayer();
      }
      else if(stricmp(audioType, "mp4") == 0)
      {
        advancedMusicPlayer = new Mp4Player();
      }
    }

    void play(char * audioType, char * fileName)
    {
      if(stricmp(audioType, "vlc") == 0)
      {
        advancedMusicPlayer->playVlc(fileName);
      }
      else if(stricmp(audioType, "mp4") == 0)
      {
         advancedMusicPlayer->playMp4(fileName);
      }
    }
};

class AudioPlayer : public MediaPlayer
{
```

```
    MediaAdapter *mediaAdapter;
    public:
     void play(char * audioType, char * fileName)
     {
       // inbuilt support to play mp3 music files
       if(stricmp(audioType, "mp3") == 0)
       {
          cout << "Playing mp3 file. Name: " << fileName << endl;
       }
       // mediaAdapter is providing support to play other file formats
       else if(stricmp(audioType, "vlc") == 0 ||
         stricmp(audioType, "mp4") == 0)
       {
          mediaAdapter = new MediaAdapter(audioType);
          mediaAdapter->play(audioType, fileName);
       }
       else{
          cout << "Invalid media. " << audioType <<
            "format not supported" << endl;
      }
    }
};

void main() {
  MediaPlayer *audioPlayer = new AudioPlayer();

  audioPlayer->play("mp3", "beyond the horizon.mp3");
  audioPlayer->play("mp4", "homealone.mp4");
  audioPlayer->play("vlc", "far far away.vlc");
  audioPlayer->play("avi", "test.avi");
}
```

Structural patterns: Facade

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.

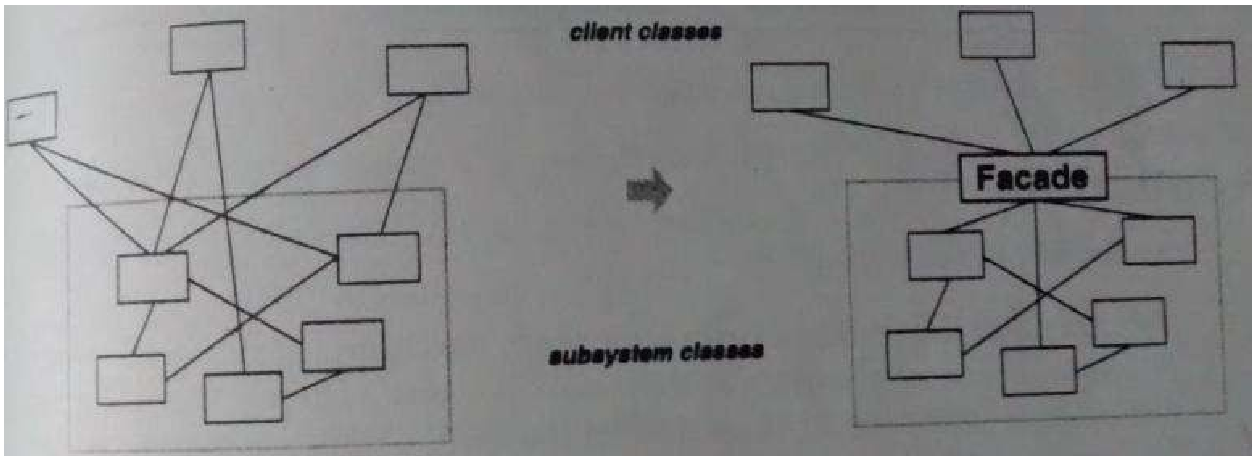
Structuring a system into subsystems helps reduce complexity. A common design goal is to minimize the communication and dependencies between subsystems. One way to achieve this goal is to introduce a facade object that provides a single, simplified interface to the more general facilities of a subsystem.

Use the facade pattern when

- You want to provide a simple interface to a complex subsystem. Subsystems often get more complex as they evolve. Most patterns, when applied, result in more and smaller classes. This makes the subsystem more reusable and easier to customize, but it also becomes harder to use for clients that don't need to customize it. A facade provides a default view of the subsystem that is good enough for most clients. Only clients needing more customizability will need to look beyond the facade.

- There are many dependencies between clients and the implementation classes of an abstraction. Introduce a facade to decouple the subsystem from clients and other subsystems, thereby promoting subsystem independence and portability.

- You want to layer your subsystems. Use a façade to define an entry point to each subsystem level. If subsystems are dependent, then you can simplify the dependencies between them by making them communicate with each other solely through facades.



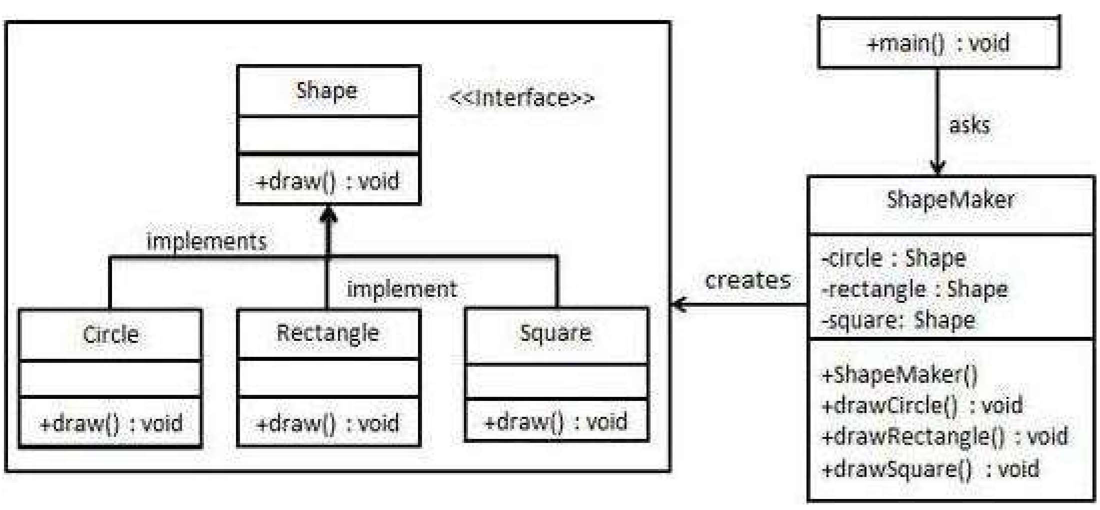
The facade pattern offers the following benefits:

1. It shields clients from subsystem components, thereby reducing the number of objects that clients deal with and making the subsystem easier to use.

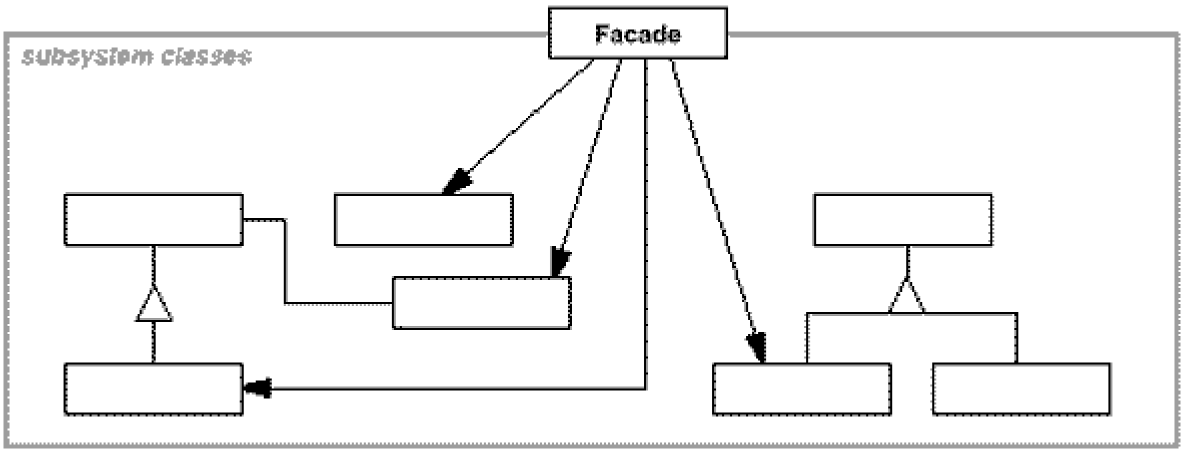
2. It promotes weak coupling between the subsystems and its clients. Often the components in a subsystem are strongly coupled. Weak coupling lets you vary the components of a subsystem without affecting its clients. Facades help layer a system and the dependencies between objects.

3. It doesn't prevent applications from using subsystem classes if they need to. Thus you can choose between ease of use and generality.

We create a Shape interface and concrete classes implementing the Shape interface. A facade class ShapeMaker uses the concrete classes to delegate user calls to these classes.



Structure



Participants

Facade (ShapeMaker)

- knows which subsystem classes are responsible for a request.
- delegates client requests to appropriate subsystem objects.

subsystem classes (Square, Circle, Rectangle)

- implement subsystem functionality.
- handle work assigned by the Facade object.
- have no knowledge of the facade; that is, they keep no references to it.

<u>Code listing 10 (facade.cpp)</u>

```
#include <iostream>
using namespace std;
#define interface struct

interface Shape
{
   virtual void draw() = 0;
};

class Square : public Shape
{
  public:
    void draw() {
      cout << "Inside Square::draw() method." << endl;
  }
};

class Circle : public Shape
{
  public:
    void draw() {
      cout << "Inside Circle::draw() method." << endl;
  }
};
```

```
class Rectangle : public Shape
{
  public:
    void draw() {
      cout << "Inside Rectangle::draw() method." << endl;
  }
};

class ShapeMaker {
  private:
    Shape *circle;
    Shape *rectangle;
    Shape *square;

  public:
    ShapeMaker() {
      circle = new Circle();
      rectangle = new Rectangle();
      square = new Square();
    }

    void drawCircle(){
      circle->draw();
    }

    void drawRectangle(){
      rectangle->draw();
    }

    void drawSquare(){
      square->draw();
    }
};

void main()
{
  ShapeMaker shapeMaker;

  shapeMaker.drawCircle();
  shapeMaker.drawRectangle();
  shapeMaker.drawSquare();
}
```

Structural patterns: Bridge

When an abstraction can have one of several possible implementations, the usual way to accommodate them is to use inheritance. An abstract class defines the interface to the abstraction, and concrete subclasses implement it in different ways. But this approach isn't always flexible enough. Inheritance binds an implementation to the abstraction permanently, which makes it difficult to modify, extend, and reuse abstractions and implementations independently.

Decouple an abstraction from its implementation so that the two can vary independently.

Use the bridge pattern when

- You want to avoid a permanent binding between an abstraction and its implementation. This might be the case, for example, when the implementation must be selected or switched at run time.

- Both the abstraction and their implementation should be extended by subclassing. The bridge pattern lets you combine the different abstractions and implementations and extend them independently.

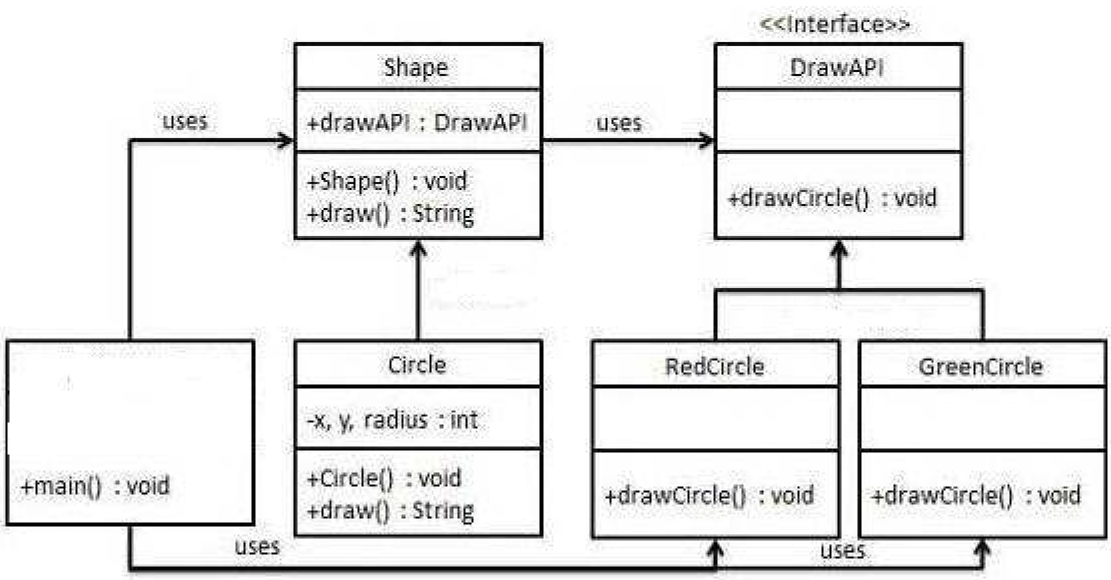
- Changes in the implementation of an abstraction should have no impact on clients; that is, their code should not have to be recompiled.

The bridge pattern has the following consequences:

1. Decoupling interface and implementation. An implementation is not bound permanently to an interface. The implementation of an abstraction can be configured at runtime. It is even possible for an object to change its implementation at runtime.

2. Improved extensibility. You can extend the abstraction and implementation hierarchies independently.

3. Hiding implementation details from clients. You can shield clients from implementation details, like the sharing of implementer objects and the accompanying reference count mechanism.



Code listing 11a (bridge.h)

```
#define interface struct

interface DrawAPI {
  virtual void drawCircle(int, int, int) = 0;
};

struct RedCircle : public DrawAPI {
  void drawCircle(int, int, int);
};
```

```
struct GreenCircle : public DrawAPI {
  void drawCircle(int, int, int);
};

class Shape
{
  protected:
    DrawAPI *drawAPI;
    Shape(DrawAPI *);
  public:
    virtual void draw() = 0;
};

class Circle : public Shape
{
  private:
    int x, y, radius;
  public:
    Circle(int, int, int, DrawAPI *);
    void draw();
};
```

<u>Code listing 11b (bridge.cpp)</u>

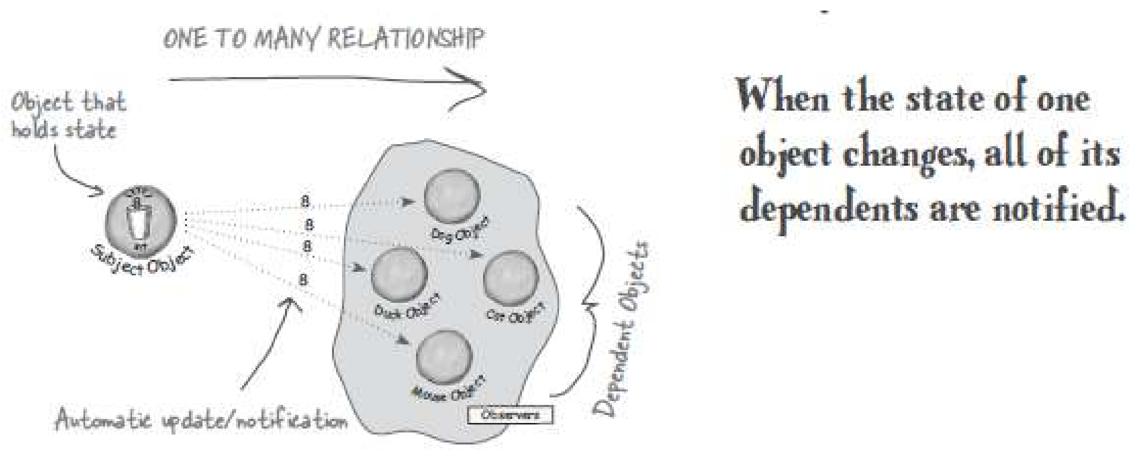
```
#include <iostream>
#include <string.h>
using namespace std;
#include "bridge.h"

void RedCircle::drawCircle(int radius, int x, int y) {
  cout << "Drawing Circle [color: red, radius: " <<  radius
    << ", x: " << x  << ", " << y  << "]" << endl;
}

void GreenCircle::drawCircle(int radius, int x, int y) {
  cout << "Drawing Circle [color: green, radius: " <<  radius
    << ", x: " << x  << ", " << y  << "]" << endl;
}

Shape::Shape(DrawAPI *drawAPI)
{
  this->drawAPI = drawAPI;
}

Circle::Circle(int x, int y, int radius, DrawAPI *drawAPI) :
  Shape(drawAPI)
{
  this->x = x;
  this->y = y;
  this->radius = radius;
}

void Circle::draw()
{
  drawAPI->drawCircle(radius,x,y);
}
```

Code listing 11c (bridge.cpp)

```
#include <iostream>
#include <string.h>
using namespace std;
#include "bridge.h"

void main() {
  Shape *redCircle  = new Circle(100,100, 10, new RedCircle());
  Shape *greenCircle  = new Circle(100,100, 10, new GreenCircle());

  redCircle->draw();
  greenCircle->draw();
}

// cl -c bridge.cpp
// cl -c bridgemain.cpp
// cl bridge bridge.obj bridgemain.obj
```

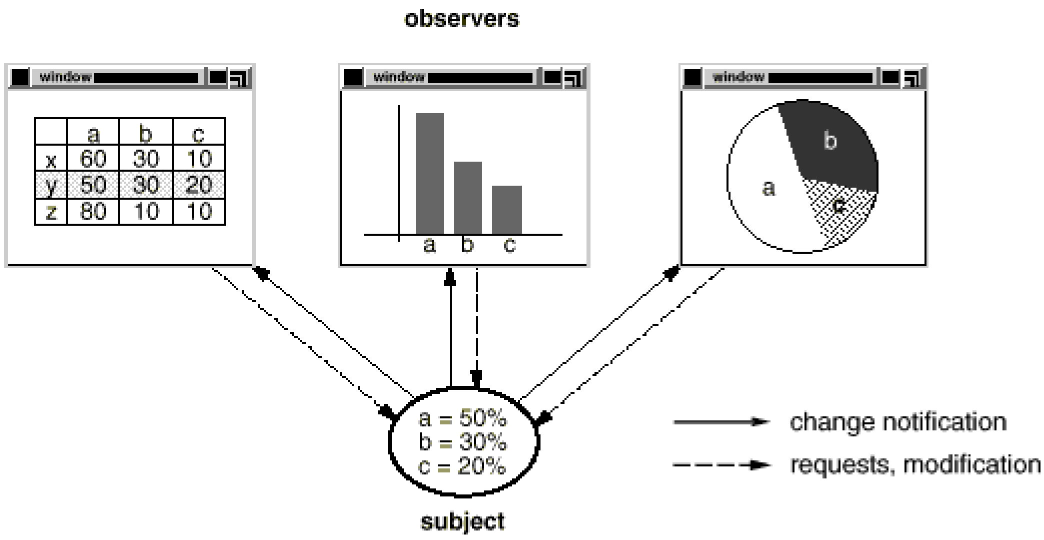
Behavioral patterns: Observer

The Observer Pattern defines a one-to-many dependency between objects so that when one object changes state, all of its dependents are notified and updated automatically. When two objects are loosely coupled, they can interact, but have very little knowledge of each other.



The Observer Pattern provides an object design where subjects and observers are loosely coupled. The only thing the subject knows about an observer is that it implements a certain interface. Observer pattern uses three actor classes - Subject, Observer and Client. Subject is an object having methods to attach and detach observers to a client object.

Many GUIs toolkits separate the presentation aspects of the UI from the underlying application data. Classes defining application data and presentation can be reused independently. For example, a spreadsheet object and chart object can depict information in the same application data object using different presentations. The spreadsheet and chart object don’t know about each other, but they behave as though they do. When the user changes the information in the spreadsheet, the chart object reflects the changes immediately, and vice versa.



This behavior implies that the spreadsheet and the charts objects are dependent on the data object and therefore should be notified of any changes in its state.
The observer pattern describes how to establish these relationships. The key objects in this pattern are subject and observer. A subject can have any number of dependent observers. All the observers are notified when the subject undergoes a change in state. In response, each observer will query the subject to synchronize its state with the subject's state.

<u>Use the observer pattern in any of the following situations:</u>

We can add a new observer at any time.

We never need to modify the subject to add a new type of observers.

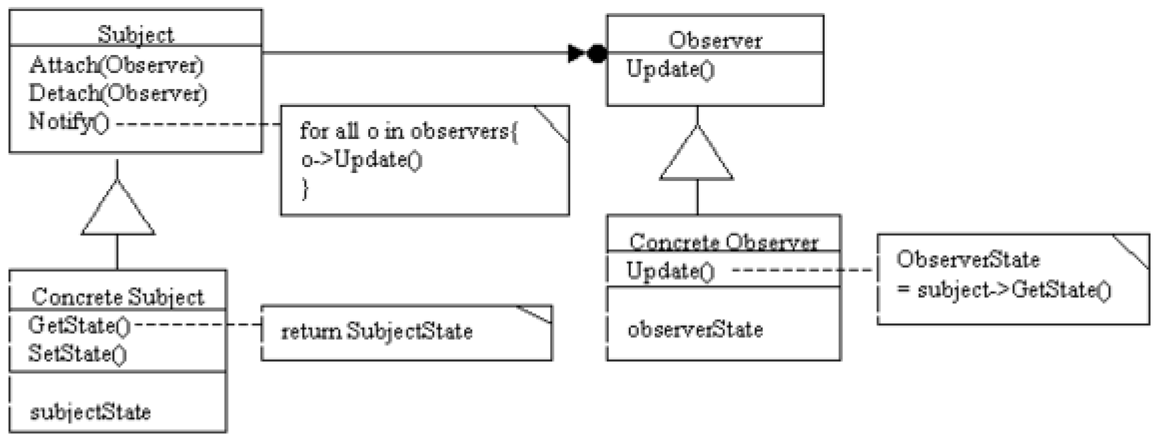
We can reuse subjects or observers independently of each other.

Changes to either the subject or an observer will not affect each other.

<u>UML class diagrams and participants</u>

Subject maintains a list of Observers and provides an interface for attaching and detaching them. Observer defines an abstract Update interface, which is called by the Subject when its state changes. Concrete Subject maintains state of interest for Concrete Observers and notifies them when the state changes. Concrete Observer implements the update interface provided by the Observer. It also maintains a reference to Concrete Subject and updates its state to be in sync with the Concrete Subject.

Structure



Participants

Subject (Subject)
- knows its observers. Any number of Observer objects may observe a subject.
- provides an interface for attaching and detaching Observer objects.

Observer (Observer)
defines an updating interface for objects that should be notified of changes in a subject.

ConcreteSubject (ConcreteSubject)
- stores state of interest to ConcreteObserver objects.
- sends a notification to its observers when its state changes.

ConcreteObserver (HexadecimalObserver, OctalObserver)
- maintains a reference to a ConcreteSubject object.
- stores state that should stay consistent with the subject's.
- implements the Observer updating interface to keep its state consistent with the subject's.

Code listing 12 (observer.cpp)

```
# include <iostream>
# include <list>

using namespace std;

class Subject;

class Observer {
   protected :
     Subject *subject;
   public:
     virtual void update() = 0;
};

class Subject {
  private:
    list <Observer *> observers;

  public:
    void attach(Observer *o){
```

```
      observers.push_back(o);
    }

    void detach (Observer* o) {
      observers.remove(o);
    }

    void notifyAllObservers()
    {
      list <Observer *>::iterator o_Iter;

      for (o_Iter = observers.begin(); o_Iter != observers.end();
        o_Iter++)
      {
        if(*o_Iter != 0)
        {
           (*o_Iter)->update();
        }
      }
    }
};

class ConcreteSubject: public Subject {
  private:
    int state;

  public:
    int getState() {
      return state;
    }

    void setState(int changedData) {
      state = changedData;
      notifyAllObservers();
    }
};

class HexadecimalObserver : public Observer
{
  private:
    ConcreteSubject* _subject;
  public:
    HexadecimalObserver(ConcreteSubject *sub)
    {
      _subject = sub;
      _subject->attach(this);
    }

    HexadecimalObserver()
    {
      this->_subject = NULL;
    }

    void update() {
      cout << "Hexadecimal String: " <<  hex <<  _subject->getState()
        << endl;
    }
```

```
};

class OctalObserver  : public Observer
{
  private:
    ConcreteSubject* _subject;

  public:
    OctalObserver (ConcreteSubject *sub){
      _subject = sub;
      _subject->attach(this);
    }

    OctalObserver()
    {
      this->_subject = NULL;
    }

    void update() {
      cout << "Octal String: " <<  oct <<  _subject->getState() <<
        endl;
    }
};

void main()
{
  ConcreteSubject *subject = new ConcreteSubject();
  OctalObserver *Octobj = new OctalObserver(subject);
  HexadecimalObserver *hexaObj = new HexadecimalObserver(subject);
  subject->setState(25);
  subject->setState(50);
  subject->detach(Octobj);
  subject->setState(100);
  subject->detach(hexaObj);
  subject->setState(200);
}
```

Behavioral patterns: Mediator

Usually a program is made up of a large number of classes. So the logic and computation is distributed among these classes. However, as more classes are developed in a program, especially during maintenance and/or refactoring, the problem of communication between these classes may become more complex. This makes the program harder to read and maintain. Furthermore, it can become difficult to change the program, since any change may affect code in several other classes.

With the mediator pattern, communication between objects is encapsulated with a mediator object. Objects no longer communicate directly with each other, but instead communicate through the mediator. This reduces the dependencies between communicating objects, thereby lowering the coupling.

The problem with monolithic code is that the large number of cross connections between components makes it very hard to change or maintain. Using the mediator design pattern can help reduce class interdependencies, aid componentization, and ultimately help make classes service-oriented.

Define an object that encapsulates how a set of objects interact. Mediator promotes loose coupling by keeping objects from referring to each other explicitly, and it lets you vary their interaction independently.

Use the mediator pattern when

- A set of objects communicate in well defined but complex ways. The resulting interdependencies are unstructured and difficult to understand.

- Reusing an object is difficult because it refers to and communicates with many other objects.

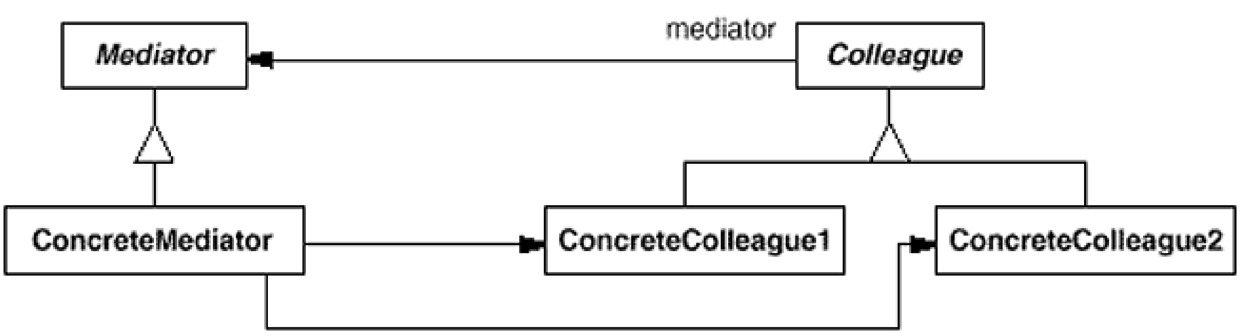
- A behavior that's distributed between several classes should be customizable without a lot of subclassing.

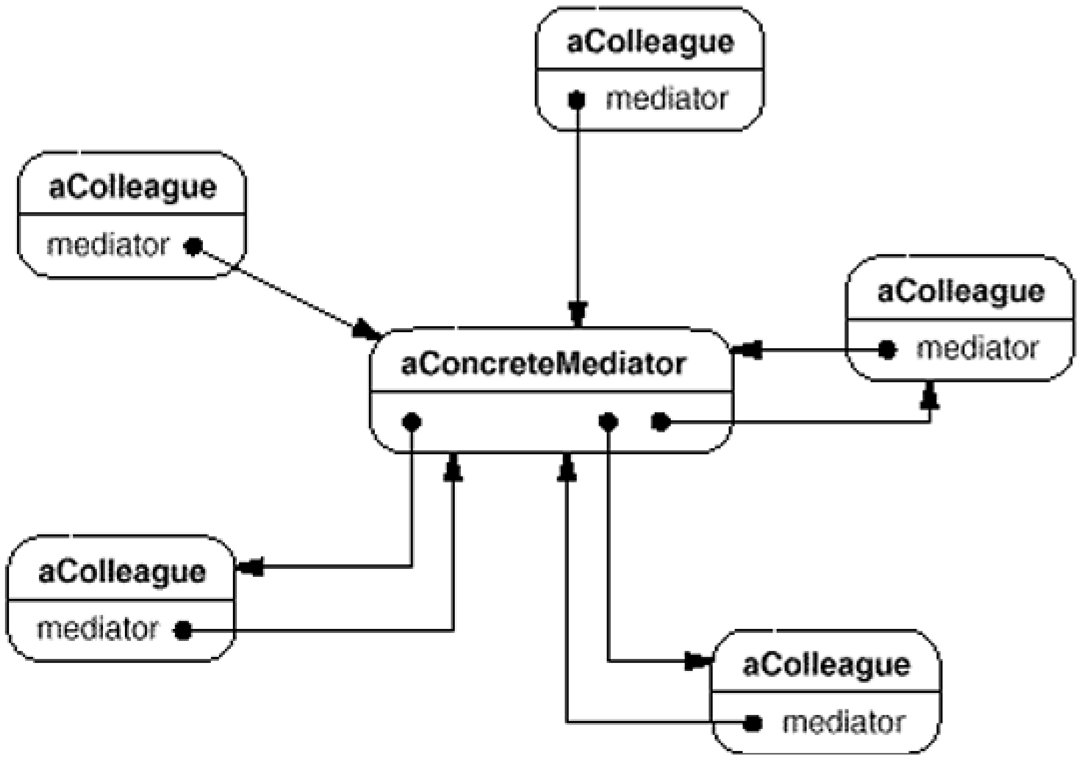
Participants

Mediator - defines an interface for communication with Colleague objects

ConcreteMediator - implements the Mediator interface and coordinates communication between Colleague objects. It is aware of all the Colleagues and their purpose with regards to inter communication.

ConcreteColleague classes - communicates with other Colleagues through its Mediator. Each colleague class knows its mediator object. Each Colleague communicates with its mediator whenever it would have otherwise communicates with another colleague.





Colleagues send and receive requests from a Mediator object. The mediator implements the cooperative behavior by routing requests between the appropriate colleague(s).

Code listing 13 (mediator.cpp)

```
#include <iostream>
#include <string>
# include <list>
using namespace std;

class Mediator;

class Colleague
{
  public:
    virtual ~Colleague() {};
    virtual void SetMediator(Mediator*);
    virtual void SendMsg(string) = 0;
    virtual void GetMsg(string) = 0;
  protected:
    Colleague(Mediator*);
    Mediator* _mediator;
};

class ConcreteColleague1 : public Colleague
{
  public:
    virtual ~ConcreteColleague1() {};
    ConcreteColleague1(Mediator*);
    virtual void SendMsg(string msg);
    virtual void GetMsg(string);
};
```

```
class ConcreteColleague2 : public Colleague
{
  public:
    virtual ~ConcreteColleague2() {};
    ConcreteColleague2(Mediator*);
    virtual void SendMsg(string msg);
    virtual void GetMsg(string);
};

class Mediator
{
  public:
    virtual ~Mediator() {};
    virtual void SendMsg(string, Colleague*) = 0;
  protected:
    Mediator() {};
};

class ConcreteMediator : public Mediator
{
  public:
    ConcreteMediator(Colleague* = NULL);
    virtual ~ConcreteMediator() {};
    void SetColleague(Colleague*);
    virtual void SendMsg(string msg, Colleague*);
  private:
    list <Colleague *> Colleagues;
};

ConcreteMediator::ConcreteMediator(Colleague* o) {
  Colleagues.push_back(o);
}

Colleague::Colleague(Mediator* pMediator)
{
  this->_mediator = pMediator;
}

void Colleague::SetMediator(Mediator* pMediator)
{
  this->_mediator = pMediator;
}

ConcreteColleague1::ConcreteColleague1(Mediator* pMediator) :
  Colleague(pMediator) {}

void ConcreteColleague1::SendMsg(string msg)
{
  this->_mediator->SendMsg(msg, this);
}

void ConcreteColleague1::GetMsg(string msg)
{
   cout <<"ConcreteColleague1 Received:"<<msg << endl;
}

ConcreteColleague2::ConcreteColleague2(Mediator* pMediator) :
```

```
  Colleague(pMediator) {}

void ConcreteColleague2::SendMsg(string msg)
{
  this->_mediator->SendMsg(msg, this);
}

void ConcreteColleague2::GetMsg(string msg)
{
  cout <<"ConcreteColleague2 Received:" <<msg << endl;
}

ConcreteColleague3::ConcreteColleague3(Mediator* pMediator) :
  Colleague(pMediator) {}

void ConcreteColleague3::SendMsg(string msg)
{
  this->_mediator->SendMsg(msg, this);
}

void ConcreteColleague3::GetMsg(string msg)
{
  cout <<"ConcreteColleague3 Received:" <<msg << endl;
}

void ConcreteMediator::SetColleague(Colleague* p)
{
  Colleagues.push_back(p);
}

void ConcreteMediator::SendMsg(string msg, Colleague* p)
{
  list <Colleague *>::iterator o_Iter;

  for (o_Iter = Colleagues.begin(); o_Iter != Colleagues.end();
    o_Iter++)
  {
    if(*o_Iter != 0 && p != *o_Iter)
    {
      (*o_Iter)->GetMsg(msg);
    }
  }
}

int main()
{
  ConcreteMediator* pMediator = new ConcreteMediator();

  Colleague* c1 = new ConcreteColleague1(pMediator);
  Colleague* c2 = new ConcreteColleague2(pMediator);
  Colleague* c3 = new ConcreteColleague3(pMediator);
  pMediator->SetColleague(c1);
  pMediator->SetColleague(c2);
  pMediator->SetColleague(c3);
  c1->SendMsg("Colleague1 sends message");
  c2->SendMsg("Colleague2 sends message");
  c3->SendMsg("Colleague3 sends message");
```

```
  return 0;
}
```

Behavioral patterns: Visitor

The visitor pattern allows generic algorithms to be implemented without modifying the objects on which they operate and supports different actions for each type of object without the need for dynamic casting.

The visitor pattern consists of two parts:

1. a method called Visit() which is implemented by the visitor and is called for every element in the data structure

2. visitable classes providing Accept() methods that accept a visitor

Use the visitor pattern when

- An object structure contains many classes of objects with differing interfaces, and you want to perform operations on these objects that depend on their concrete classes.

- Many distinct and unrelated operations need to be performed on objects in an object structure, and you want to avoid polluting their classes with these operations. And, you don't want to have to query the type of each node and cast the pointer to the correct type before performing the desired operation. Visitor lets you keep related operations together by defining them in one class.

- The classes defining the object structure rarely change, but you often want to define new operations over the structure. Changing the object structure classes require redefining the interfaces to all visitors, which is potentially costly. If the object structure classes change often, then it is probably better to define the operations in those classes.

When a visitor visits an element, two function calls are made (one to accept and one to visit) and the final visit function that is called depends on the type of both the element and the visitor. This process is known as double dispatch.

The visitor pattern is particularly useful when the elements are part of a larger structure, in which case the accept function can call itself recursively down the structure.

The nature of the Visitor makes it an ideal pattern to plug into public APIs thus allowing its clients to perform operations on a class using a “visiting” class without having to modify the source.

The pattern should be used when you have distinct and unrelated operations to perform across a structure of objects. This avoids adding in code throughout your object structure that is better kept separate, so it encourages cleaner code. You may want to run operations against a set of objects with different interfaces. Visitors are also valuable if you have to perform a number of unrelated operations across the classes.

Visitor's primary purpose is to abstract functionality that can be applied to an aggregate hierarchy of "element" objects. The approach encourages designing lightweight Element classes - because processing functionality is removed from their list of responsibilities. New functionality can easily be added to the original inheritance hierarchy by creating a new Visitor subclass.

Visitor implements "double dispatch". OO messages routinely manifest "single dispatch" - the operation that is executed depends on: the name of the request, and the type of the receiver. In "double dispatch", the operation executed depends on: the name of the request, and the type of TWO receivers (the type of the Visitor and the type of the element it visits).

The implementation proceeds as follows. Create a Visitor class hierarchy that defines a pure virtual visit() method in the abstract base class for each concrete derived class in the aggregate node hierarchy. Each visit() method accepts a single argument - a pointer or reference to an original Element derived class.

Each operation to be supported is modeled with a concrete derived class of the Visitor hierarchy. The visit() methods declared in the Visitor base class are now defined in each derived subclass by allocating the "type query and cast" code in the original implementation to the appropriate overloaded visit() method.

Add a single pure virtual accept() method to the base class of the Element hierarchy. accept() is defined to receive a single argument - a pointer or reference to the abstract base class of the Visitor hierarchy.

Each concrete derived class of the Element hierarchy implements the accept() method by simply calling the visit() method on the concrete derived instance of the Visitor hierarchy that it was passed, passing its "this" pointer as the sole argument.

Everything for "elements" and "visitors" is now set-up. When the client needs an operation to be performed, he creates an instance of the Visitor object, calls the accept() method on each Element object, and passes the Visitor object.

The accept() method causes flow of control to find the correct Element subclass. Then when the visit() method is invoked, flow of control is vectored to the correct Visitor subclass. accept() dispatch plus visit() dispatch equals double dispatch.

<u>Code listing 14 (visitor.cpp)</u>

```
#include <iostream>
using namespace std;
#define interface struct

interface Shape
{
  public:
    virtual void accept(class Visitor*) = 0;
};

class Circle: public Shape
{
  public:
    void accept(Visitor*);
    void getRadius()
    {
      cout << "Circle::getRadius\n";
```

```
    }
};

class Square: public Shape
{
  public:
    void accept(Visitor*);
    void getLength()
    {
      cout << "Square::getLength\n";
    }
};

class Rectangle: public Shape
{
  public:
    void accept(Visitor* v);
    void calculateArea()
    {
      cout << "Rectangle::calculateArea\n";
    }
};

interface Visitor
{
  public:
    virtual void visit(Circle*) = 0;
    virtual void visit(Square*) = 0;
    virtual void visit(Rectangle*) = 0;
};

class CountVisitor: public Visitor
{
  public:
    CountVisitor()
    {
      m_CircleCount = m_SquareCount = m_RectangleCount = 0;
    }
    void visit(Circle*)
    {
      m_CircleCount++;
    }
    void visit(Square*)
    {
      m_SquareCount++;
    }
    void visit(Rectangle*)
    {
      m_RectangleCount++;
    }
    void report_num()
    {
      cout << "Circles " << m_CircleCount
        << ", Squares "  << m_SquareCount
        << ", Rectangles " << m_RectangleCount << endl;
    }
  private:
```

```
    int m_CircleCount, m_SquareCount, m_RectangleCount;
};

class CallVisitor: public Visitor
{
  public:
    void visit(Circle *cobj)
    {
      cobj->getRadius();
    }
    void visit(Square *sobj)
    {
      sobj->getLength();
    }
    void visit(Rectangle *robj)
    {
      robj->calculateArea();
    }
};

void Circle::accept(Visitor *v)
{
  v->visit(this);
}

void Square::accept(Visitor *v)
{
  v->visit(this);
}

void Rectangle::accept(Visitor *v)
{
  v->visit(this);
}

int main()
{
  Shape *set[] =
  {
    new Circle, new Square, new Rectangle, new Circle, new Circle,
      new Rectangle, NULL
  };

  CountVisitor countOperation;
  CallVisitor callOperation;
  for (int i = 0; set[i]; i++)
  {
    set[i]->accept(&countOperation);
    set[i]->accept(&callOperation);
  }
  countOperation.report_num();
}
```

Behavioral patterns: Strategy

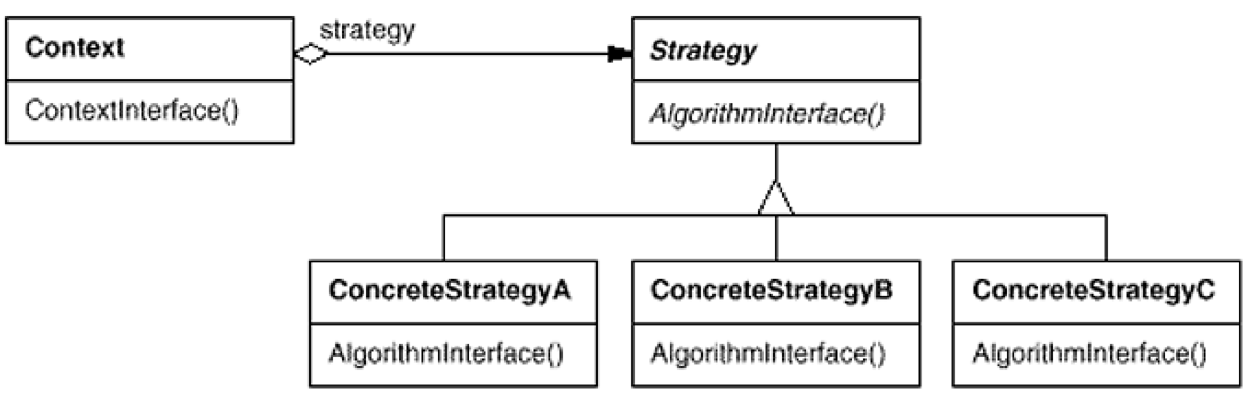
In Strategy pattern, a class behavior or its algorithm can be changed at run time. Define a family of algorithms, encapsulate each one, and make them interchangeable. Strategy lets the algorithm vary independently from clients that use it.

You have more ways for doing an operation; with strategy you can choice the algorithm at run-time and you can modify a single Strategy without a lot of side-effects at compile-time.

Use the Strategy pattern when

- many related classes differ only in their behavior. Strategies provide a way to configure a class with one of many behaviors.
- you need different variants of an algorithm. For example, you might define algorithms reflecting different space/time trade-offs. Strategies can be used when these variants are implemented as a class hierarchy of algorithms.
- an algorithm uses data that clients shouldn't know about. Use the Strategy pattern to avoid exposing complex, algorithm-specific data structures.
- a class defines many behaviors, and these appear as multiple conditional statements in its operations. Instead of many conditionals, move related conditional branches into their own Strategy class.

Structure



Participants

Strategy (Strategy)
declares an interface common to all supported algorithms. Context uses this interface to call the algorithm defined by a ConcreteStrategy.

ConcreteStrategy (OperationAdd, OperationSubtract, OperationMultiply)
implements the algorithm using the Strategy interface.

Context (Context)
is configured with a ConcreteStrategy object.
maintains a reference to a Strategy object.
may define an interface that lets Strategy access its data.

In Strategy pattern, we create objects which represent various strategies and a context object whose behavior varies as per its strategy object. The strategy object changes the executing algorithm of the context object.

Code listing 15 (strategy.cpp)

```
#include <iostream>
#include <string.h>
using namespace std;

#define interface struct

interface Strategy {
  virtual int doOperation(int num1, int num2) = 0;
};

class OperationAdd : public Strategy {
  public:
    int doOperation(int num1, int num2) {
      return num1 + num2;
    }
};

class OperationSubtract : public Strategy {
  public:
    int doOperation(int num1, int num2) {
      return num1 - num2;
    }
};

class OperationMultiply : public Strategy {
  public:
    int doOperation(int num1, int num2) {
      return num1 * num2;
    }
};

class Context {
  Strategy *strategy;

  public:
    Context(Strategy *strategy){
      this->strategy = strategy;
    }

    int executeStrategy(int num1, int num2){
      return strategy->doOperation(num1, num2);
    }
};

void main() {
  Context *context = new Context(new OperationAdd());
  cout << context->executeStrategy(10, 5) << endl;

  context = new Context(new OperationSubtract());
  cout << context->executeStrategy(10, 5) << endl;
```

```
  context = new Context(new OperationMultiply());
  cout << context->executeStrategy(10, 5) << endl;
}
```

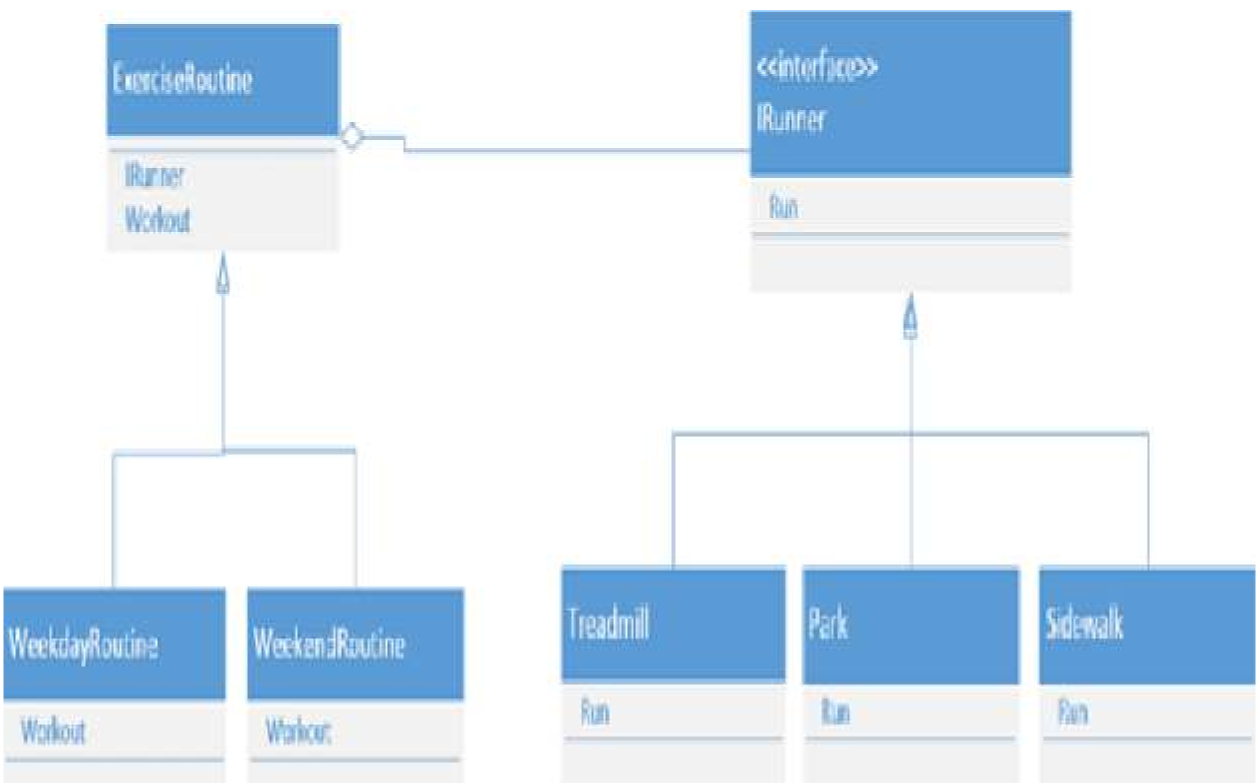
Difference between Bridge and Strategy

The simple answer is "They are similar but different". The implementations are similar but the intentions are different. To give an analogy, a city bus and school bus are both similar vehicles, but they are used for different purposes. One is used to transport people between various parts of the city as a commuter service. The other is used for transporting kids to schools.

Strategy pattern is used when you wish to plug algorithm or strategy at run time. As category of pattern also implies that it deals with behavior of the objects.

On the other hand bridge is structural pattern and deals with structural hierarchy of the objects. It decouples the abstraction from implementation by introducing a refined abstraction between them. Refined abstraction can be confused with the run time strategy plugged (in Strategy pattern). Bridge pattern deals with the structural aspects by providing a mechanism to avoid creating number of classes.

Bridge scenario:
As part of my exercise routine, I want to have a weekday exercise routine and a weekend routine. The routine involves running either on a treadmill, park or sidewalk.

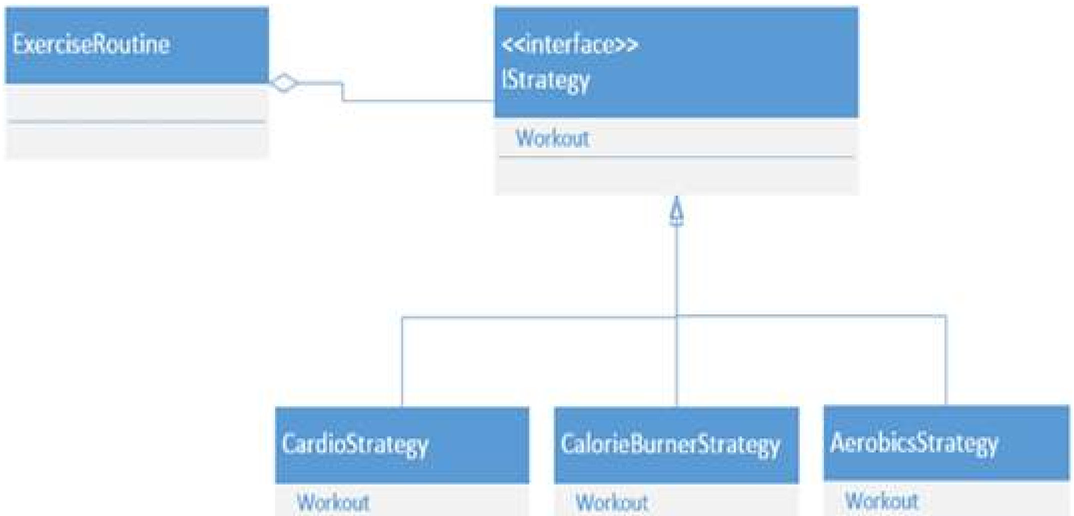


The client sets the Runner type and invokes the workout as below

```
ExerciseRoutine *obj = new WeekdayRoutine();
obj->setRunner(new Treadmill());
obj->workout();
obj->setRunner(new Park());
```

```
obj->workout();
```

Strategy Scenario:
As part of my daily exercise routine, I want to choose an appropriate workout strategy for the day before starting my workout.



An exercise routine consists of a specific workout. Before the workout begins, a workout strategy is chosen by the client. The following code snippet explains the behavior.

```
ExerciseRoutine *context = new ExerciseRoutine(new CardioStrategy());
context->executeStrategy();
```

The algorithm for the specific type of workout is encapsulated from the client who interacts only with the interface of the strategy.

Code listing 16 (bridge2.cpp)

```
#include <iostream>
#include <string.h>
using namespace std;

#define interface struct

interface IRunner {
  virtual void Run() = 0;
};

class Treadmill : public IRunner
{
  public:
    void Run() {
      cout << "Running on Treadmill " << endl;
    }
};

class Park : public IRunner
{
  public:
    void Run() {
```

```
      cout << "Running in Park " << endl;
    }
};

class ExerciseRoutine
{
  protected:
    IRunner *runner;
  public:
    void setRunner(IRunner *runner)
    {
      this->runner = runner;
    }
    virtual void workout() = 0;
};

class WeekdayRoutine : public ExerciseRoutine
{
  public:
    void workout()
    {
      cout << "Weekday ";
      runner->Run();
    }
};

class WeekendRoutine : public ExerciseRoutine
{
  public:
    void workout()
    {
      cout << "Weekend ";
      runner->Run();
    }
};

void main() {
  ExerciseRoutine *obj = new WeekdayRoutine();
  obj->setRunner(new Treadmill());
  obj->workout();
  obj->setRunner(new Park());
  obj->workout();

  obj = new WeekendRoutine();
  obj->setRunner(new Treadmill());
  obj->workout();
  obj->setRunner(new Park());
  obj->workout();
}
```

<u>Code listing 17 (strategy2.cpp)</u>

```
#include <iostream>
#include <string.h>
using namespace std;

#define interface struct
```

```
interface IStrategy {
  virtual void Workout() = 0;
};

class CardioStrategy : public IStrategy
{
  public:
    void Workout() {
      cout << "Cardio workout " << endl;
    }
};

class AerobicsStrategy : public IStrategy
{
  public:
    void Workout() {
      cout << "Aerobics workout " << endl;
    }
};

class ExerciseRoutine {
  IStrategy *strategy;

  public:
    ExerciseRoutine(IStrategy *strategy){
      this->strategy = strategy;
    }

    void executeStrategy(){
      return strategy->Workout();
    }
};

void main() {
  ExerciseRoutine *context =
      new ExerciseRoutine(new CardioStrategy());
  context->executeStrategy();

  context = new ExerciseRoutine(new AerobicsStrategy());
  context->executeStrategy();
}
```