Design Patterns in C++

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Hands-on environment:

Visual Studio 2013 / 2010 express edition / Code::Blocks Latest 16.x ver NoSetup

I hear and I forget; I see and I remember; I do and I understand.

a Chinese proverb

Where ever possible we will understand the concepts and do hands on exercise

Introduction... name, total experience, experience in c++ & what are you working on, your expectation etc...

about me...

Bachelor in Computer Engineering, Bombay University, 1991

1991 - 1995

C/C++ - system level development;
Wrote debugger on x86 embedded platform
Worked at system level startup company
Further studies while at work:
CDAC – PGDST (1994-95)

1995 - 1999

Worked at Networking startup companies at Silicon Valley, CA - Development role (C/C++ /Java)

1999 - 2007

Intel San Jose:
Wrote Microcode dataplane libraries for IXP Network Processors; Developed UT infrastructure
Intel India:
Engineering Manager, PMP – Network domain;
Researcher – Storage Virtualization Domain
Intel Multicore University Program

2007 - date

Freelance Corporate Trainer:
Topics taken: Multicore, Unit Testing, C Prog & Optimization, Advanced C++, Design Patterns, Secure Coding, SDLC, SAS...
Consultant , Entrepreneur
Social Cause – Founded Science Society of India - Running science fairs, Hackathons

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Ground Rules – Let us agree

- Want to get your commitment on few ground rules... on controlling distractions
- Cell phones in silent mode.
- Email set to “out of office.. attending training”
- You do not need to answer a call – take it as a missed call and follow up during breaks
- Let us not take breaks at free-will
- (it is contagious if one person takes a bio break others tend to follow...)
- We will follow break timings: ~10.45 to 11.00 am and 3.30 to 3.45 pm
- Lunch: 12.45 to 1.45pm
- Let us check our emails & any other general internet access during the breaks...
- If you want any breaks in between tell me - and we will take a break.
- We may stop the session ~4.45 pm
- Any other expectation you have from my side??

Design Pattern

- What is it?

Design Pattern

- What is it?
  - Making use of a solution from the past experience and applying it immediately without rediscovering
  - *How many times have we said...i have solved this problem earlier…*
  - Inherently we are grounds-up people...
  - *“A design pattern names, abstracts, and identifies the key aspects of a common design structure that make it useful for creating a reusable object-oriented design”*

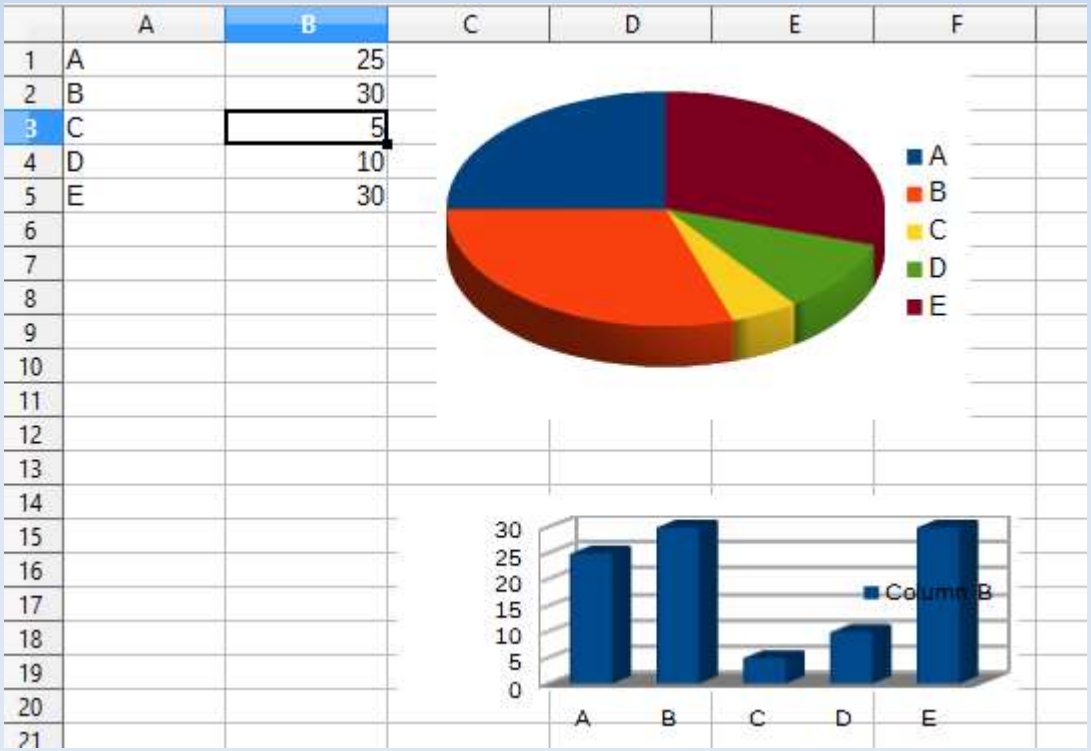
MVC

- Model / View / Controller
  - Model is the application / business logic
  - View is the presentation layer
  - Controller is the way UI reacts to input
  - Provides a framework of separation of functionality - instead of all together

MVC

- We could think as subscribe/notify protocol
- All the views register with model
- When model changes its value – it notifies all its subscribers
- Model notifies data change, view communicates to get the data

MVC demo



There are others patterns as well..

Design Patterns Classification

- Creational
  - Deals with how objects are created
- Structural
  - Deals with composition of class/object
- Behavioural
  - Object interaction and responsibility division

Design Patterns Classification

- Creational
  - Deals with how objects are created
  - e.g. Factory Method (class)
  - Singleton (object)
- Structural
  - Deals with composition of class/object
  - e.g. Adapter (class)
  - Facade (object)
- Behavioural
  - Object interaction and responsibility division
  - Template method (class)
  - Observer (object)

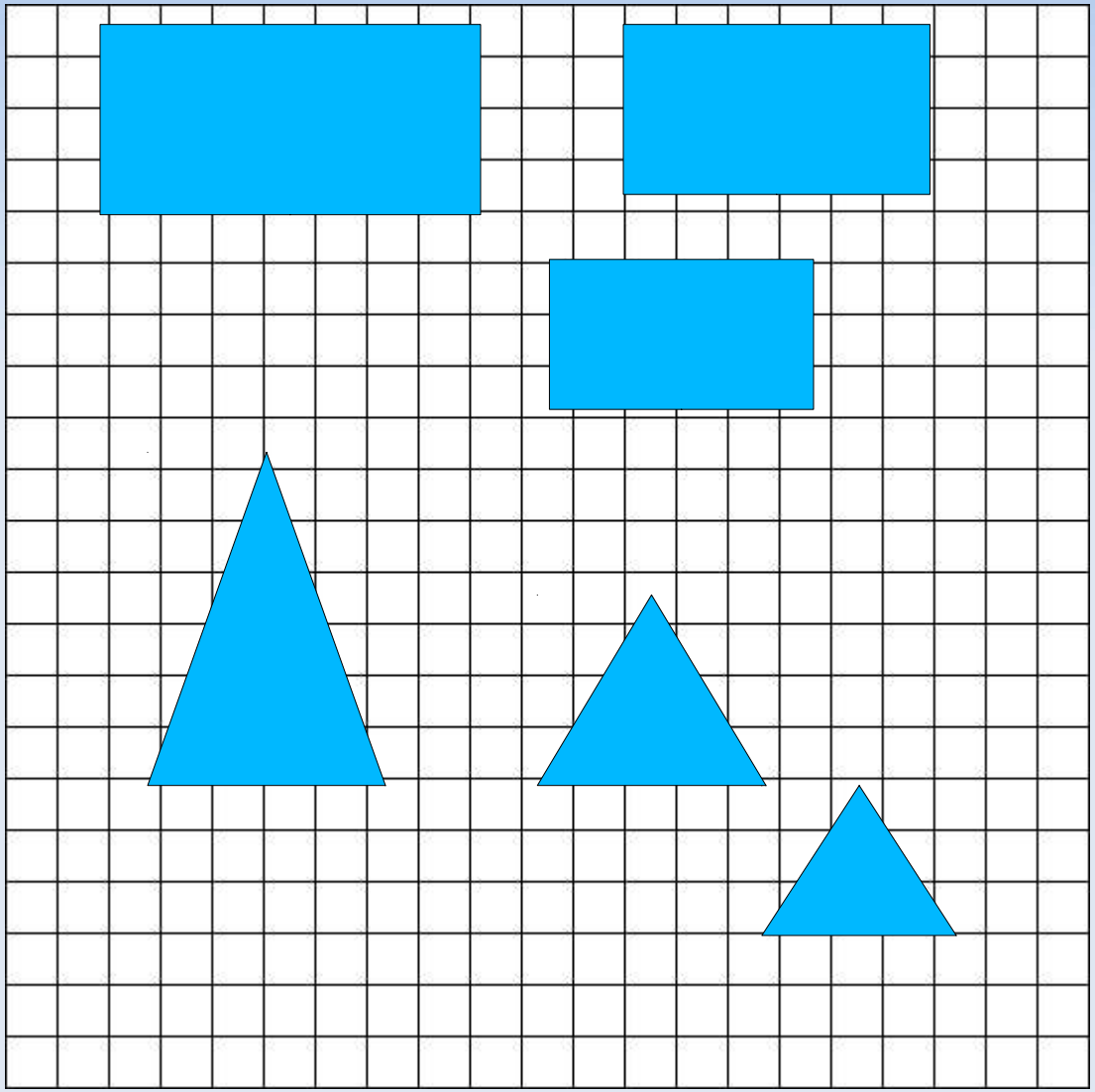
Class patterns deal with classes and derived classes, determined at compile time

Object patterns are more dynamic – deal with run-time creation of object

Both use inheritance

Most patterns are object scope

Design classes for this scenario



- This grid contains many Rectangles & Triangles
- Rectangle is a Polygon
- Triangle is a Polygon

Object Oriented Concepts

- Patterns make use of various OOP concepts
- Composition, Aggregation
- Inheritance, Encapsulation,
- Polymorphism

Object Oriented Concepts

- Let us identify the objects in this room?

Object Oriented Concepts

- Let us identify the objects in this room?
  - The table, the chair, the projector, the door, window, white-board, the computer, lights, attendees
  - Each has a specific functionality or single responsibility
  - And has a clearly defined independent interface(s) on how to use them

Object Composition

- Each object may be composed of other elements or “has” elements
- A mobile phone **has** a [key-pad], touch screen, speaker, mic, charging interface [USB interface], ...

Object Composition

- Each object may be composed of other elements or “has” elements
- A mobile phone **has** a [key-pad], touch screen, speaker, mic, charging interface [USB interface], ...
- A car **has** a steering wheel, engine, dashboard, wheels, radiator, …
- A chair **has** ?

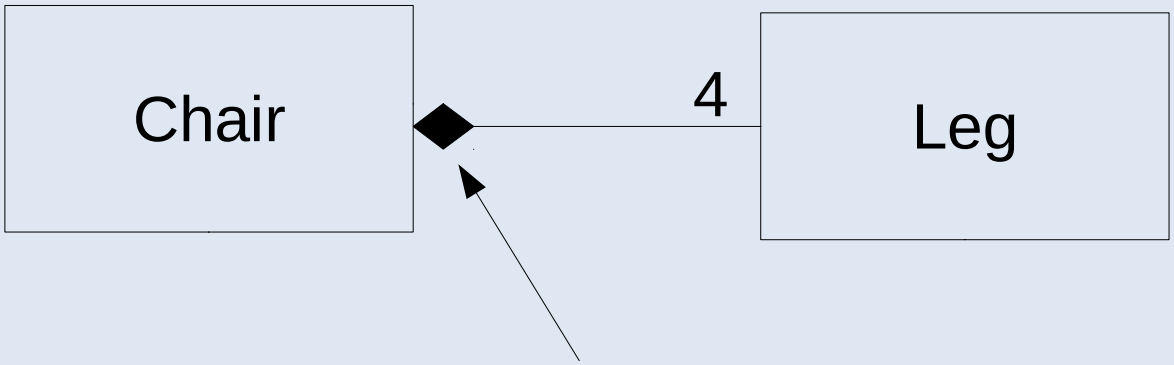
Object Composition

- Each object may be composed of other elements or “has” elements
- A mobile phone **has** a [key-pad], touch screen, speaker, mic, charging interface [USB interface], ...
- A car **has** a steering wheel, engine, dashboard, wheels, radiator, …
- A chair **has** legs, seat, arm-rest, back-rest

If we remove one leg from the chair – does it continue to be a chair?

Object Composition

- Removing one element from the object would make the object incomplete. e.g
  - Removing the leg from the chair may render it useless (it no longer continues to be a chair)
  - Any other examples?



Ownership –
Company -->Employee Id
Bank ->Bank Account No...

Aggregation

- Specifying the containment relationships
- This room **consists of** attendees/participants
- Usage wise we may say
  - This room **has** many chairs & tables
  - This room **has** one projector
- But
  - The above is different from saying
  - A car **has** a steering wheel, engine, dashboard, wheels, radiator, …
- How?

Aggregation

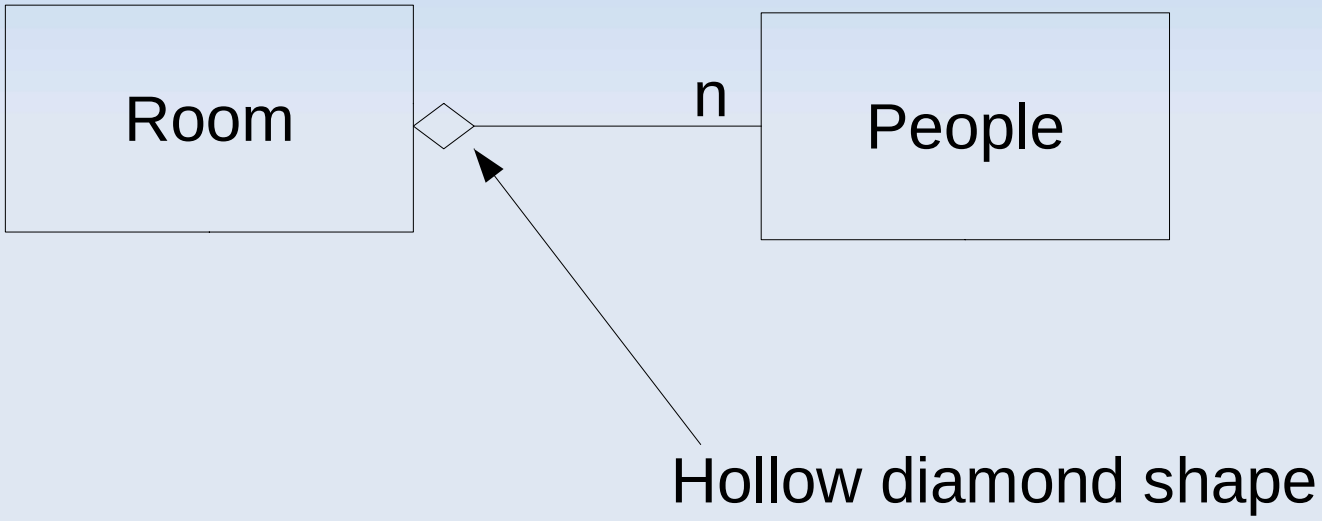
- Remove chairs from the room – still the room exists. Just that chairs might have been shifted to another room.
  - The above is a aggregate “containment” relationship
- Removing steering wheel from the car – makes the car incomplete.
  - The above is a composition relationship

Aggregation

- Say you had a mobile phone object (an instance)
  - While destroying a mobile phone object – one is likely to destroy its sub object such as [keypad], lcd etc because they are within a single composition
- Basket containing mobile phones – if the basket is being destroyed the cell phones can still exist and may be moved to another basket
  - Basket consists of mobile phones
- Similarly people in a room

Aggregation

- Room has many people



Composition & Aggregation

- Is it clear?

Association

- One can also think of association concept
  - e.g.
  - a teacher teaches students
  - an employee uses swipe badge
- It tells about two different entity having independent ownership but the associate together for some purpose
- We can think of this as a mapper for a task
- *From an implementation perspective - we should use aggregation concept and achieve the same*

Inheritance

- Now, let us see Inheritance

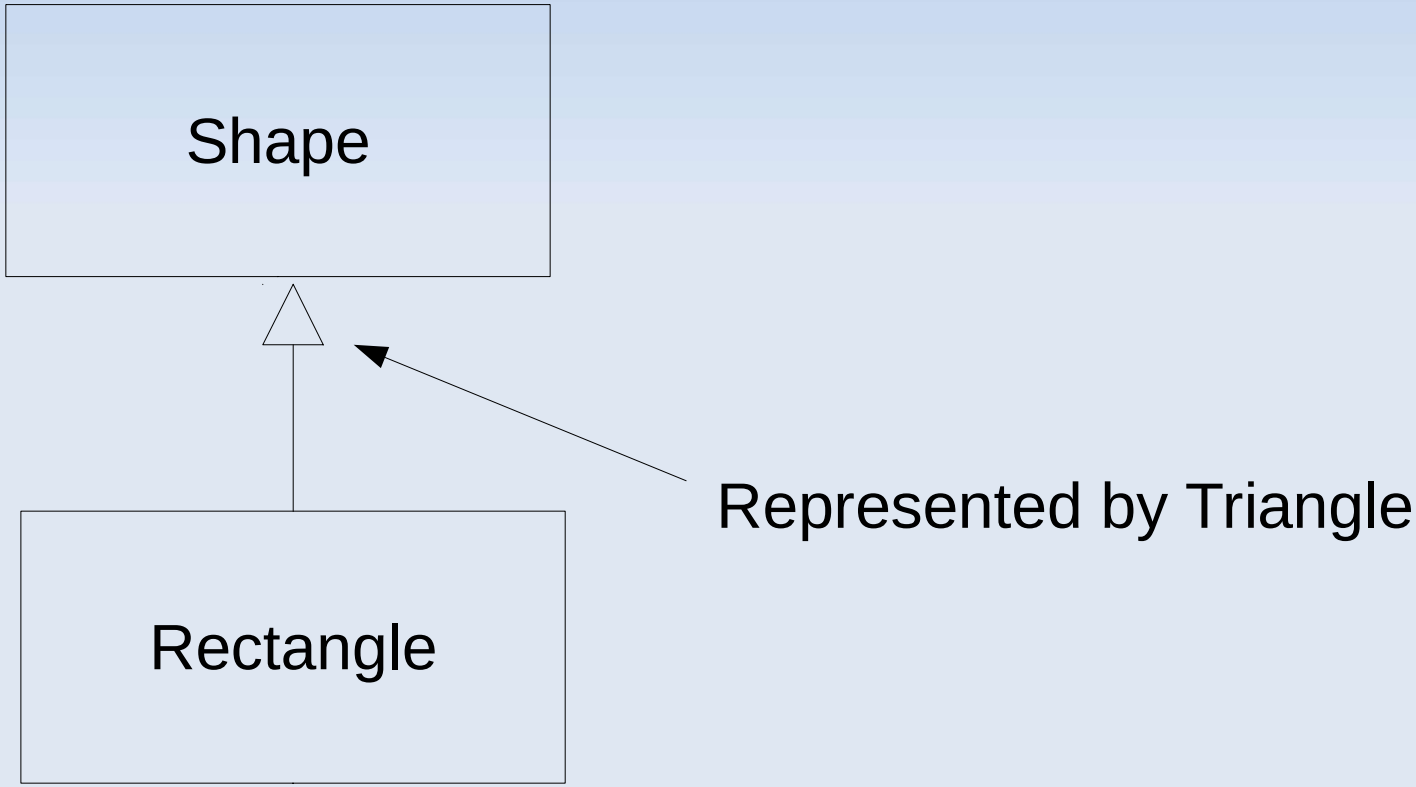
Inheritance

- This **is a** roll-able chair
  - This has all the properties of a chair with the addition that it is roll-able
  - We can also say – this has inherited all the properties of a chair with the addition of it rolling capability
  - Rollable-chair **is-a** chair
- This is a LED TV
  - This has inherited all the properties of TV
  - With the addition that it is based on LED technology
  - LED_TV **is-a** TV
- This **is a** USB Hard Disk
  - Has inherited all the properties of Hard Disk
  - It still maintains the original properties of a hard disk with additional capability that it is USB based
  - USB-HD **is-a** Hard Disk
  - *It has not changed its property or morphed to become a gaming console*

What about an org structure?

Inheritance

- Rectangle is-a Shape



Encapsulation

- Hiding the internal complexity of the object
- For e.g. a driver does not need to know how the internal combustion engine works
  - You use the car by knowing the interface given - accelerator, break, clutch, start ignition
  - Whether the car is a petrol car or electric car or runs on CNG – the interface remains the same
- Generic interface but error-prone e.g. same diesel and petrol nozzle size
- Similarly objects you create must have interface that does not expose the internal workings (which may change)
- Users of your objects continue to call the interface exposed by you while you change/optimize the underlying implementation. e.g. audio player

Polymorphism

- Is an ability to create an object that has more than one form
- For e.g. if there is an object type Bird. Parrot and Crow are inherited from Bird
  - Parrot is a Bird; Crow is a Bird
  - At **run-time** if the Bird object is pointing to Parrot then calling a method fly() - will make the Parrot fly;
  - It is also called as late-binding

Design Exercise

- Do an OO software design for a two-player Chess game
- The application need not have to be played against computer

Player-2

Player-1

Write C++ classes

Chess game- what do you see?

- What do you see

Player-2

Player-1

Chess game- what do you see?

Player-2

Player-1

- What do you see
- 1 ChessBoard
- 32 ChessPieces
  - 16 White colour - attribute
    - 8 Pawns, 1K, 1Q, 2B, 2Kn, 2R
  - 16 Black colour - attribute
    - 8 Pawns, 1K, 1Q, 2B, 2Kn, 2R
- 2 Players
  - Player 1, Player 2
- What are the controls – who decides how the logic will play

Chess game- what do you see?

Player-2

Player-1

- What do you see
- 1 ChessBoard
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  - 16 White colour - attribute
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- 2 Players
  - Player 1, Player 2
- What are the controls – who decides how the logic will play
- Game Controller

For each of the above,
What are the possible operations?

Chess game - operations

Player-2

Player-1

what are the possible views?

- What do you see & what are the operations possible
- 1 ChessBoard
  - **Stores chesspieces, one can query pieces at location**
- 32 ChessPieces
  - **Checks the move, move itself**
  - 16 White colour - attribute
    - 8 Pawns, 1K, 1Q, 2B, 2Kn, 2R
  - 16 Black colour - attribute
    - 8 Pawns, 1K, 1Q, 2B, 2Kn, 2R
- 2 Players
  - **Makes the move, interacts with user, takes turn**
  - Player 1, Player 2
- What are the controls – who decides how the logic will play
- Game Controller
  - **Start Game**
  - **Control the game flow**
  - **Stop Game**
  - **Declare results**

Chess game

- Think about relationships (consists of)
  - Chessgame consists of players, board & chess pieces. They follow chess rules to play
    - *Consists* will generally go as?
      - a data member
    - class Chessgame

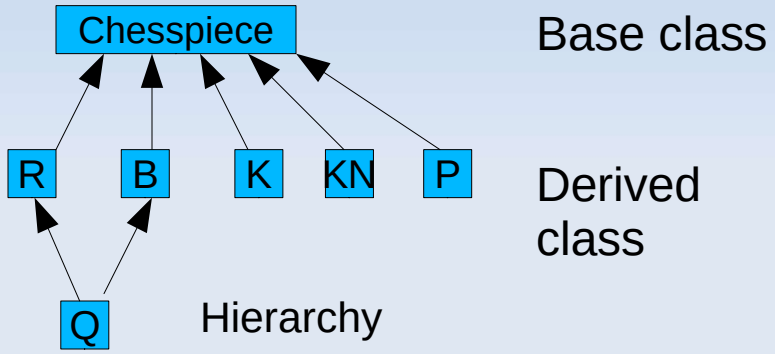
```
{
    ChessBoard cb;
    Player p1, p2;
    Chesspieces cp[32];
    ChessControl cc;
}
```

Use any drawing notation to capture this, with any constraint

Numbers generally will go as instances 32 chesspieces, 2 players etc.

Chess game

- Think about hierarchy (is-a)
  - Pawn *is a* Chesspiece
  - Knight *is a* Chesspiece
  - King *is a* Chesspiece
  - Rook *is a* Chesspiece
  - Bishop *is a* Chesspiece
  - Queen *is a* Chesspiece
    - It has all the characteristics of Rook & Bishop



- Operations on each classes – go as member function; associated storage will go as data member

Chessgame class

```
class Chessgame
{
protected:
      ChessBoard *cb;
      Chesspiece *cp[32];
      Player *p1;
      Player *p2;
      ChessControl *cc;
public:
      Chessgame(ChessBoard *p_cb,
        Chesspiece *p_cp[],
        Player *p_p1;
        Player *p_p2;
        ChessControl *p_cc)
      {
            cb = p_cb;
            cp = p_cp;
            p1 = p_p1;
            p2 = p_p2;
            cc = p_cc;
      }
...
};
```

Use pointers or references

When creating objects – one can think about using factory design pattern

Exercise summary

- Object Model
  - Composition (ChessGame)
  - Inheritance (is a – Rook is-a chesspiece)
  - Encapsulation (hide implementation - clean interfaces; chessboard->getpiece(x,y); chesspiece->move())
  - Polymorphism (chesspieceView->draw())
- C++ implementation allows you to create such models

Object

- Object is an instance of class
  - Object supports interface defined by the class
- Is there a difference between object's type and it class?
  - Yes
  - Objects of different classes may have same type
  - e.g.
  - Shape& s1 = Rectangle();
  - Shape& s2 = Square();

Class inheritance & Interface inheritance

- Class inheritance involves representation and code sharing, you implement the additional functionality (or only the changes to the parent)
- In our chess example – For Queen we inherited from Rook & Knight
- Interface inheritance describes when an object can be used in place of another
  - If we have an abstract class message-interface and messageQ inherits from message-interface class
  - Later if we want to use Pipe, we just have to create a sub-class from message-interface
  - It would just need to be substituted with Pipe

Interface inheritance & Class inheritance

```
class mesg_if
{
public:
  virtual void init() = 0;
  virtual void recv() = 0;
  virtual void send() = 0;

};

class msgq : public mesg_if
{
public:
  void init()
  {
    // implement msgq-init
  }

  void recv()
  {
    // implement msgq - recv
  }

  void send()
  {
    // implement msgq - send
  }
};
```

```
class animal
{
};

class horse : public animal
{
public:
  virtual void mf1();
  virtual void mf2();
};

class flying_horse : public horse
{
public:
  void mf2(); // override
};
```

Class Inheritance:
Here we share/reuse the base implementation

Interface Inheritance:
Here we substitute with another implementation

Design patterns depend on this concept

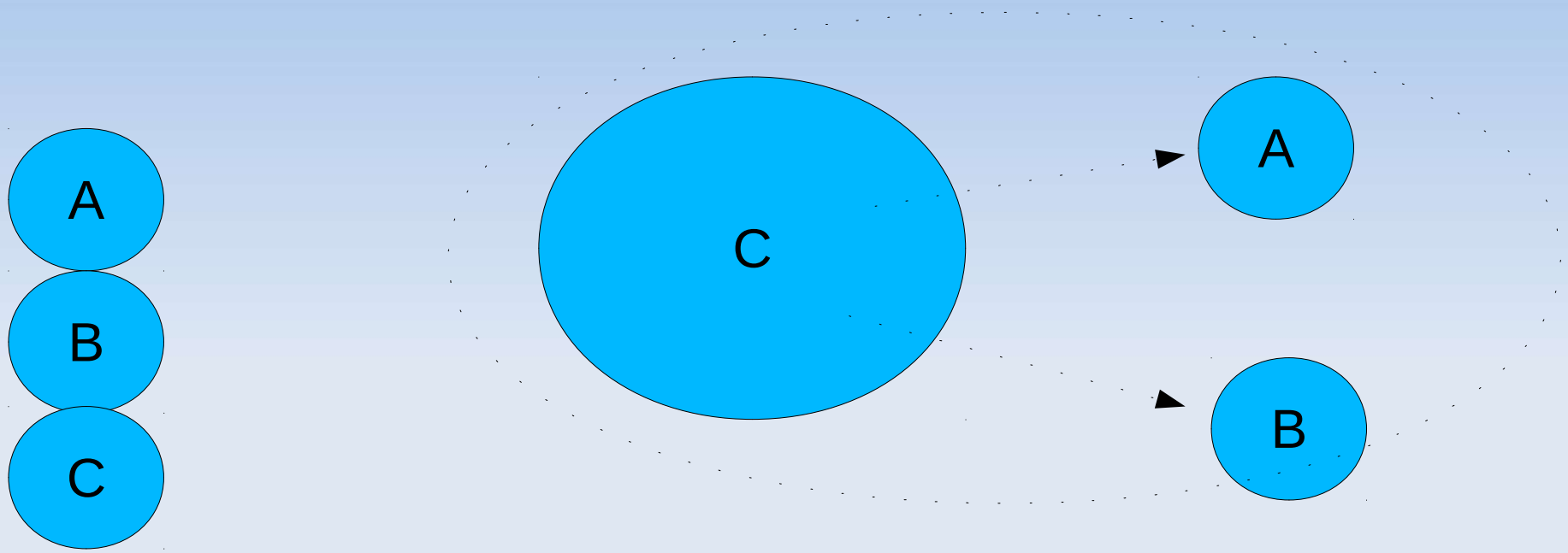
Benefits of interface inheritance

- *Benefits to manipulating objects solely in terms of the interface defined by abstract classes:*
  - *Clients remain unaware of the specific types of objects they use, as long as the objects adhere to the interface that clients expect.*
  - *Clients remain unaware of the classes that implement these objects. Clients only know about the abstract class(es) defining the interface.*

Program to an interface, not an implementation.
Make code dependent on abstractions rather than concrete!
It also improves testability

When we need to create concrete things – use creational design patterns

Inheritance vs Composition

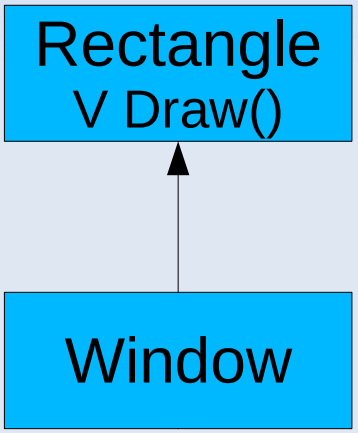


Given a choice,
use object composition instead of class inheritance

Delegation

- Inheritance vs Composition

A (Inheritance)



B (Composition)

```
Window
Draw()
{
  pRectangle->Draw();
}
```

Delegation

- Inheritance vs Composition

A (Inheritance)

```
class Rectangle
{
      virtual void Draw();
      ...
};
class Window : public Rectangle
{
};
```

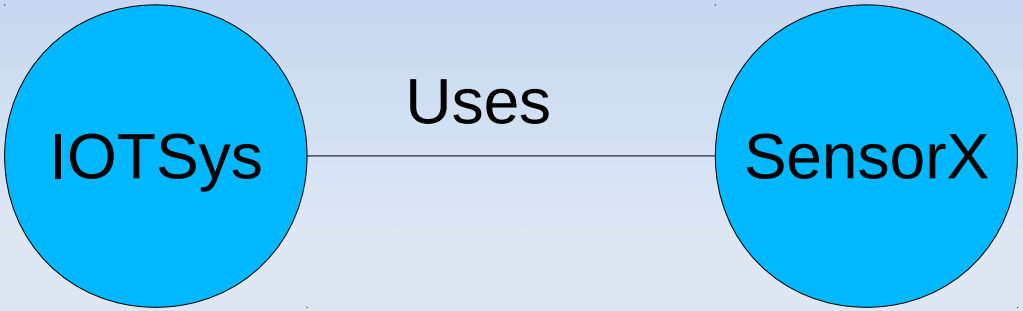
B (Composition)

```
class Window
{
      Rectangle *pRectangle;
      void setRect(Rectangle *pRect)
      {
            pRectangle = pRect;
      }
      void Draw()
      {
            pRectangle->Draw();
      }
};
```

Later, if we need a window with rounded rectangle
Which method will accommodate the change easily - A or B?

Exercise: IOT system uses SensorX

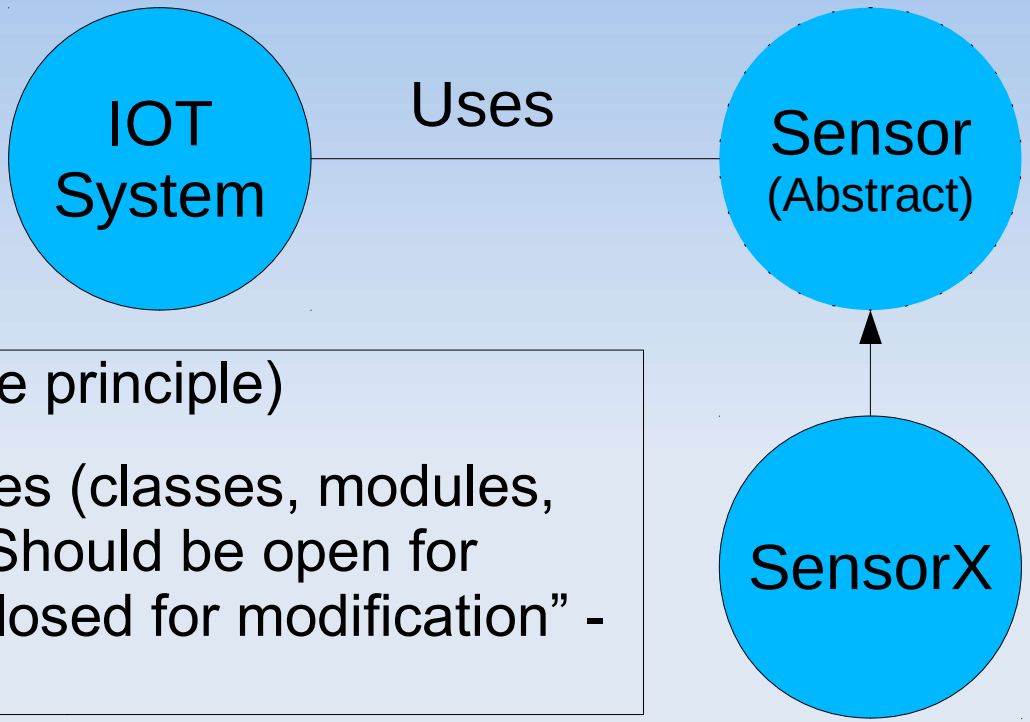
- IOT system class uses SensorX class to display value
- SensorX does open, getval, close – design this




```
class SensorX
{
public:
 void open() { // code specific to  SensorX }
 void getval() { // code specific to SensorX }
 void close(){ // code specific to SensorX }
};
class IOTSys
{
protected:
 SensorX sx;
public:
 void display() { sx.open(); cout << sx.getval(); sx.close() }
...
}
```

This is very rigid design (not good!)

Client uses SensorX



- OCP (open/close principle)

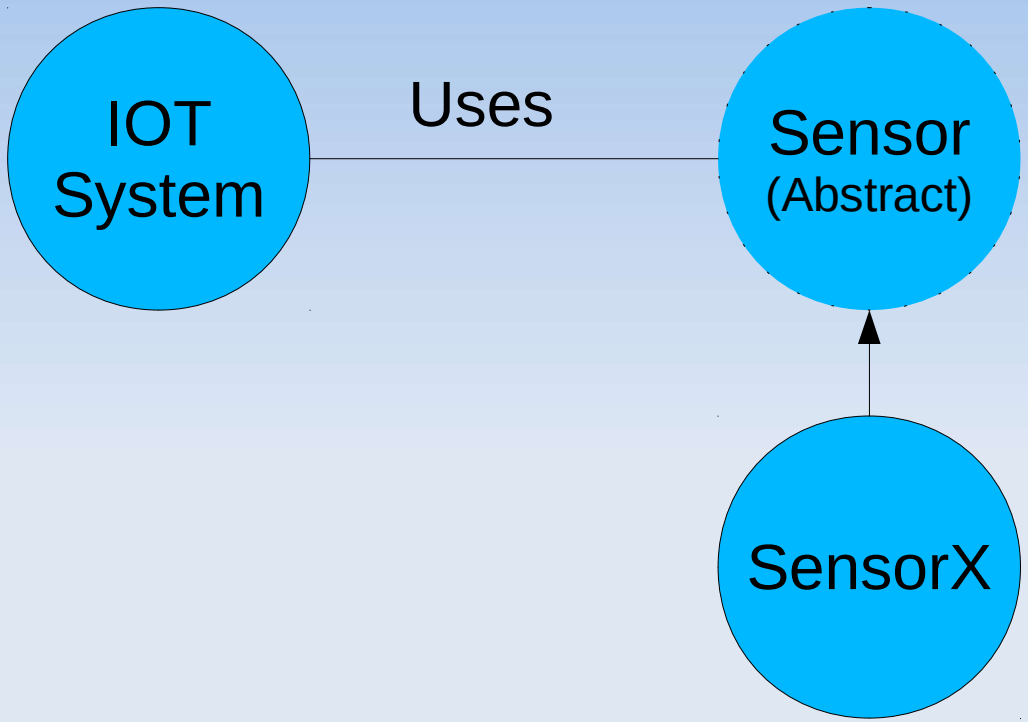
  “Software entities (classes, modules, functions, etc.) Should be open for extension, but closed for modification” - B. Meyer

- IOT System uses Sensor (Containment relationship)

Otherwise it is stuck with a specific SensorX behaviour;
Any new sensor SensorY comes, we will have to change the client;

Should not have If (x) then use sensorx else use sensory – sensorz comes we will have to modify the code for supporting zsensor feature

IOT System uses SensorX




```
class Sensor
{
public:
 virtual void open()=0;
 virtual void getval()=0;
 virtual void close()=0;
};
```

```
class SensorX : public Sensor
{
public:
 // code specific to SensorX }
 virtual void open () { // code }
 virtual void getval() { // code }
 virtual void close(){ // code }
};
```

```
class IOTSys
{
 Server *m_pSensor;
public:
 IOTSys(Sensor *pSensor)
 {
  m_pSensor = pSensor;
 }
  void display() { pSensor->open();pSensor->getval(); pSensor->close();}
};
```

What's a bad design?

- We never intend to design anything bad
- We understand what is a bad design

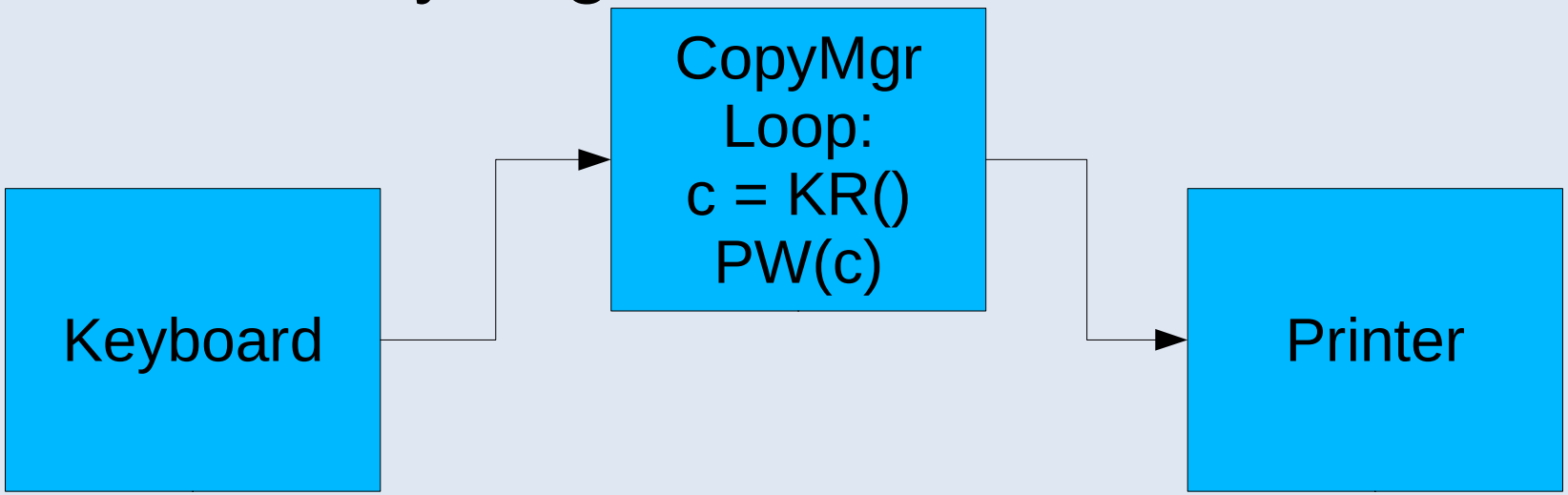
  a) One that is hard to change (Rigidity)

  b) When change was done then unexpected parts of system started breaking (Fragility)

  c) Hard to reuse in other application it is tightly entangled (Immobility)

Dependency Inversion

- E.g. If we have want to develop an application that reads from keyboard, copies in to memory and writes to printer
- How would you go about?



Exercise: Write classes for this.

Dependency Inversion

```
class Keyboard
{
 int opendev();
 unsigned char read();
 int closedev();
}

class Printer
{
 int opendev();
 int write(unsigned char);
 int closedev();
}
```

```
class CopyMgr
{
public:
 docopy()
 {
  Keyboard kb;
  Printer p;

  kb.opendev();
  p.opendev();
  bool end_flag = false;
  char ch;
  while (1)
  {
   ch = kb.read()
   if (ch == EOF)
     break;
   p.write(ch);
  }

  kb.closedev();
  p.closedev();
 }
};
```

Which class represents the core-logic?

CopyMgr

If we want to change it to read from disk – which component will have to be re-written?

CopyMgr

Is it a good design or bad design?

Bad design - does not allow reuse of the core component CopyMgr

Dependency Inversion

- Here high level component CopyMgr is dependent on low level component that it controls such as Keyboard & Printer
- If we make the higher level component independent of the low level component that it controls, then we can reuse it
- In general, dependency should be towards abstraction & not concrete classes
- Let us try to redesign it.

Dependency Inversion

```
class ReaderDevice
{
 int opendev()=0;
 unsigned char read()=0;
 int closedev()=0;
};

class Keyboard : public ReaderDevice
{
 int opendev();
 unsigned char read();
 int closedev();
};

class WriterDevice
{
 int opendev()=0;
 unsigned char write()=0;
 int closedev()=0;
};
class Printer : public WriterDevice
{
 int opendev();
 int write(unsigned char);
 int closedev();
};
```

```
class CopyMgr
{
public:
void docopy(ReaderDevice& rd, WriterDevice& wd)
{

 rd.opendev();
 wd.opendev();
 char ch;
 while (1)
 {
  ch = rd.read()
  if (ch == EOF)
   break;
  wd.write(ch);
 }
 rd.closedev();
 wd.closedev();
 }
};
```

-CopyMgr contains abstract reader and writer class
-CopyMgr depends on the abstractions - it does not depend on Keyboard or Printer
-Keyboard and Printer depends on abstract reader and writer class
-Dependencies “inverted”

Dependency Inversion Principle

1) High level modules should not depend upon low level modules. Both should depend upon abstractions.

2) Abstractions should not depend upon details. Details Should depend upon abstractions.

- The term “inverted” - traditional design thinking vouches for High Level Modules depend on low level module

The Liskov Substitution Principle (LSP, lsp) is a concept in Object Oriented Programming that states: Functions that use pointers or references to base classes must be able to use objects of derived classes without knowing it.

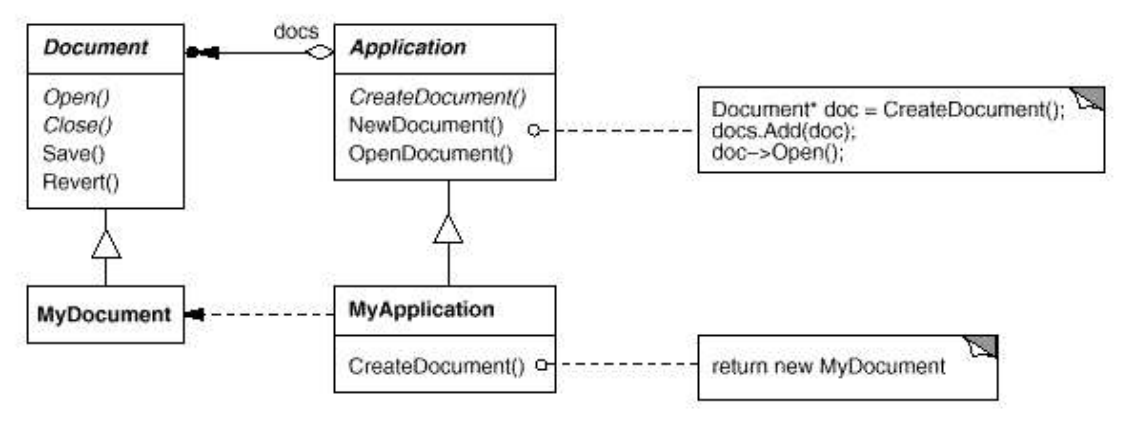
Cause for re-design

- To maximize reuse, the design should accept changes to existing requirements
- Causes for redesign
  - Creating object by directly specifying the class
    - Create it indirectly (Factory pattern)
  - Dependent on specific operation
    - Avoid hard-coding of requests (Chain of Responsibility pattern)
  - H/w, S/w dependence
    - Try making it independent of specific H/w or S/w
  - Dependence on object representation
    - Client that know how object is represented & use that fact. Client code will change when the object representation changes. Hide it. (Iterator pattern)
  - Tight Coupling
    - Tightly coupled classes makes is harder to re-use in isolation

Factory Method Design Pattern

- Problem
  - Consider a case of multiple document interface
  - When you do file→new, multiple types of documents can be created
  - If the framework has the “knowledge” of all the documents and application – it would not scale well
  - Extending it to support other document types will require modification to framework
  - Factory Method lets a class defer instantiation to subclasses
- Intent
  - Define an interface for creating an object, but let subclasses decide which class to instantiate. Factory Method lets a class defer instantiation to subclasses

Factory Method Design Pattern



•Application subclasses redefine an abstract CreateDocument operation on Application to return the appropriate Document subclass.

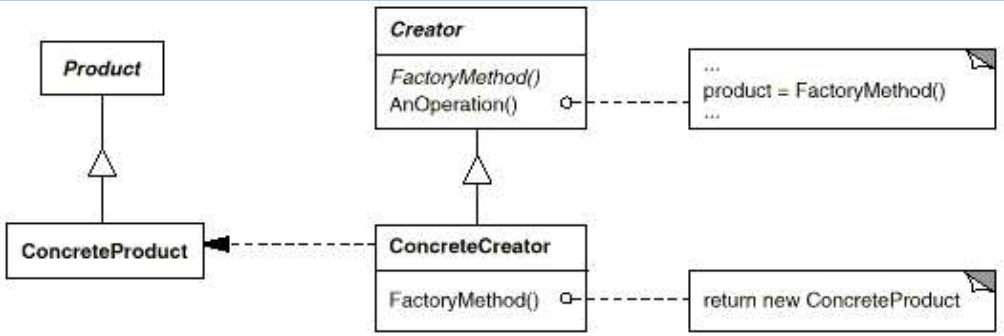
•Once an Application subclass is instantiated, it can then instantiate application-specific Documents without knowing their class.

•The **CreateDocument** is a factory method because it's responsible for "manufacturing" an object.

Factory Method Design Pattern

- Used 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

Hands-on



Let us do FactoryMethod exercise for the above design
Implement

1. an abstract Product class – method *GetName()=0*
2. two concrete class ProductA, ProductB
3. a class called Creator containing abstract method *Product * Create(int id)=0*
4. a class concrete subclass from Creator call it CreateSimple – implements Create and returns ProductA * or ProductB * based on id parameter
5. Let main() ask the user, a choice, ProductA or ProductB, based on selection create ProductA or ProductB using the CreatSimple class

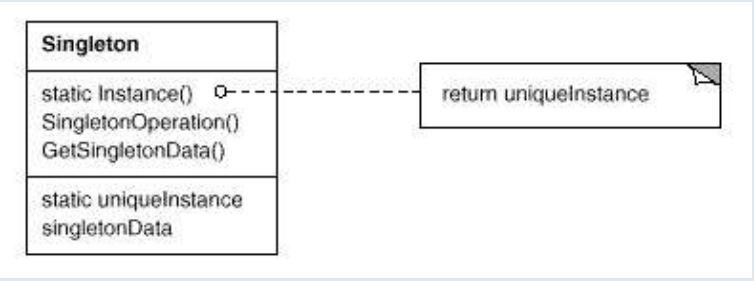
Singleton

- Problem:
  - There are many cases when only one instance is desired across the system. E.g one print spooler instance, one service configurator, one serial port handler
  - One can use global variables, but how do you ensure that there are no two global variable of the same type
- Intent:
  - Ensure a class only has one instance, and provide a global point of access to it

    Singleton enforces only one instance of the class

Singleton

- Used When
  - there must be exactly one instance of a class, and it must be accessible to clients from a well-known access point.



- Defines an Instance method that lets clients access its unique Instance

- Also may be responsible for creating its own unique instance

Singleton- Benefits

- Controlled access to sole instance
  - Can have strict control over how and when clients access it
- Reduced name space
  - Avoids polluting the global name space
- Flexible & more control
  - static member functions in C++ can never be virtual, so subclasses can't override them polymorphically

Singleton-hands-on

```
class Singleton
{
public:
	static Singleton* Instance();
	// constructor is protected,
// ensures only one instance cannot be
created outside the hierarchy methods
protected:
	Singleton() {}
private:
	static Singleton* _instance;

};

Singleton* Singleton::_instance = NULL;

Singleton* Singleton::Instance()
{
	// lazy initialization, only with
Instance() is requested it initializes
_instance
	if (_instance == NULL)
	{
		_instance = new
Singleton();
	}
	return _instance;
}
```

```
int main(int argc, char* argv[])
{
	Singleton* pSingleton =  Singleton::Instance();
	Singleton* pSingleton2 = Singleton::Instance();

	return 0;
}
```

Singleton – Hands-on

- Write a logger class using Singleton pattern
- Instance() method should return the existing instance of logger class
- Log (message) should log the message to a log file
- Open() - Should open the logger file
- Close() - Should close the logger file

Using singleton in logger context is useful – since we do not have to be worried about what is the current logger context and how to change it. Since there is only one instance

Singleton-Logger

```
#include <iostream>
#include <fstream>

class Logger
{
public:
        static Logger* Instance();
        static void open();
        static void log(const char *mes-
sage, int log_level);
        static void close();

        // constructor is protected, en-
sures only one instance will be created
protected:
        Logger() {}

        static int log_level;
        static bool inited;

        static const char * const LogFile-
Name;
        static ofstream ofs;

private:
        static Logger* _instance;
};
```

```
Logger* Logger::_instance = NULL;
const char* const Logger::LogFileName = "msg.log";
bool Logger::inited = false;
ofstream Logger::ofs;

Logger* Logger::Instance()
{
        // lazy initialization, only with Instance() is
requested it initializes _instance
        if (_instance == NULL)
        {
                _instance = new Logger();
        }
        return _instance;
}

void Logger::open()
{
        if (!inited)
        {
                ofs.open(LogFileName);
                if (!ofs.good())
                {
                        throw runtime_error("Unable to
initialize");
                }
                inited = true;
        }
}
```

Singleton- Logger

```
void Logger::log(const char *msg, int level)
{
        if (!inited) {
                open();
        }
        ofs << level << ":: " << msg<< endl;
}

void Logger::close()
{
        if (inited) {
                ofs.close();
                inited = false;
        }

}
```

```
int main(int argc, char* argv[])
{
        Logger* pLogger= Logger::Instance();
        pLogger->log("hello1", 1);
        pLogger->log("hello2", 1);
        pLogger->log("hello3", 1);
        pLogger->close();

        return 0;
}
```

Is this code multithreaded safe?
No. Thread-safety needs to be implemented for multi-threading use

Singleton- Logger

- If we change the existing logger class could be to move the open and close member functions to constructor and destructor respectively
  - By this change we would not be able to call close() to close the filestream; which we could have done prior to system shutdown
  - Note that we are creating an instance using new operator, so during system shutdown – the delete of _instance will not be called automatically
  - We would have to create a static cleanup class instance inside the Instance method & the destructor of the cleanup class will delete the instance pointer

Singleton - ServiceLocator

```
using namespace std;
#include <map>
class ComponentServiceMap
{
protected:
	static ComponentServiceMap CSMapInstance;
	std::map<string, void *> mComponentBroker;
private:
	ComponentServiceMap() { cout << "in constructor " << endl; }

	virtual ~ComponentServiceMap() { cout << "destructor" << endl; };
public:
	bool RegisterServiceForName(string service_name, void *service_ptr)
	{
		auto res = mComponentBroker.insert(make_pair(service_name, service_ptr));
		return res.second;
	}
	void *LookupServiceByName(string service_name)
	{
		auto it = mComponentBroker.find(service_name);
		if (it == mComponentBroker.end())
		{
			string message = service_name + ": Not Found";
			throw out_of_range(message);
		}
		return it->second;
	}
```

Singleton - ServiceLocator

```
        void DeleteService(string service_name)
        {
                mComponentBroker.erase(service_name);
        }
        static ComponentServiceMap& GetInstance() { return CSMapInstance; }
};
```

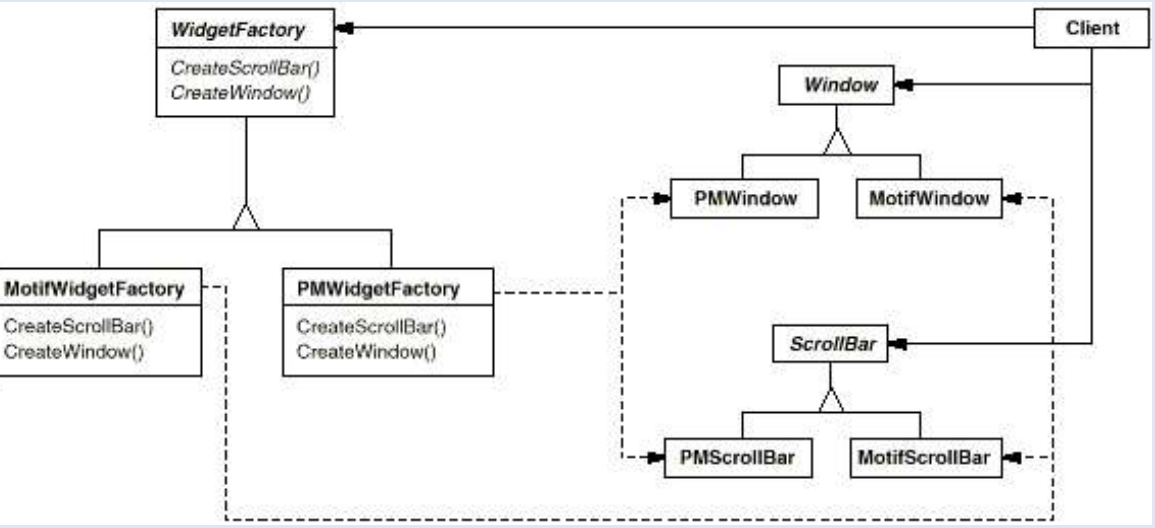
```
ComponentServiceMap ComponentServiceMap::CSMapInstance;

int main(int argc, char* argv[])
{
char *svc_ptr1 = "Time Service"; // this must point to Time Service
char *svc_ptr2 = "Web Service"; // this must point to Web Service
string service_name1 = "time";
string service_name2 = "web";

ComponentServiceMap::GetInstance().RegisterServiceForName(service_name1, svc_ptr1);
ComponentServiceMap::GetInstance().RegisterServiceForName(service_name2, svc_ptr2);

char *sptr1 = static_cast<char *> (ComponentServiceMap::GetInstance().LookupServiceByName("time"));
cout << "Looking up time service:" << sptr1 << endl;

char *sptr2 = static_cast<char *> (ComponentServiceMap::GetInstance().LookupServiceByName("web"));
cout << "Looking up web service:" << sptr2 << endl;
}
```

Abstract Factory

- Problem
  - Consider a case where you have to implement GUI. And there are different presentation manager libraries available. The gui widgets such as buttons, scroll bars may have a slightly different appearance in these sets.
  - By design, we need to have a way such that these can be changed as and when needed
  - If we code towards one widget manager then it may be hard to change the look & feel later.
  - Abstract Factory design helps here...

Abstract Factory

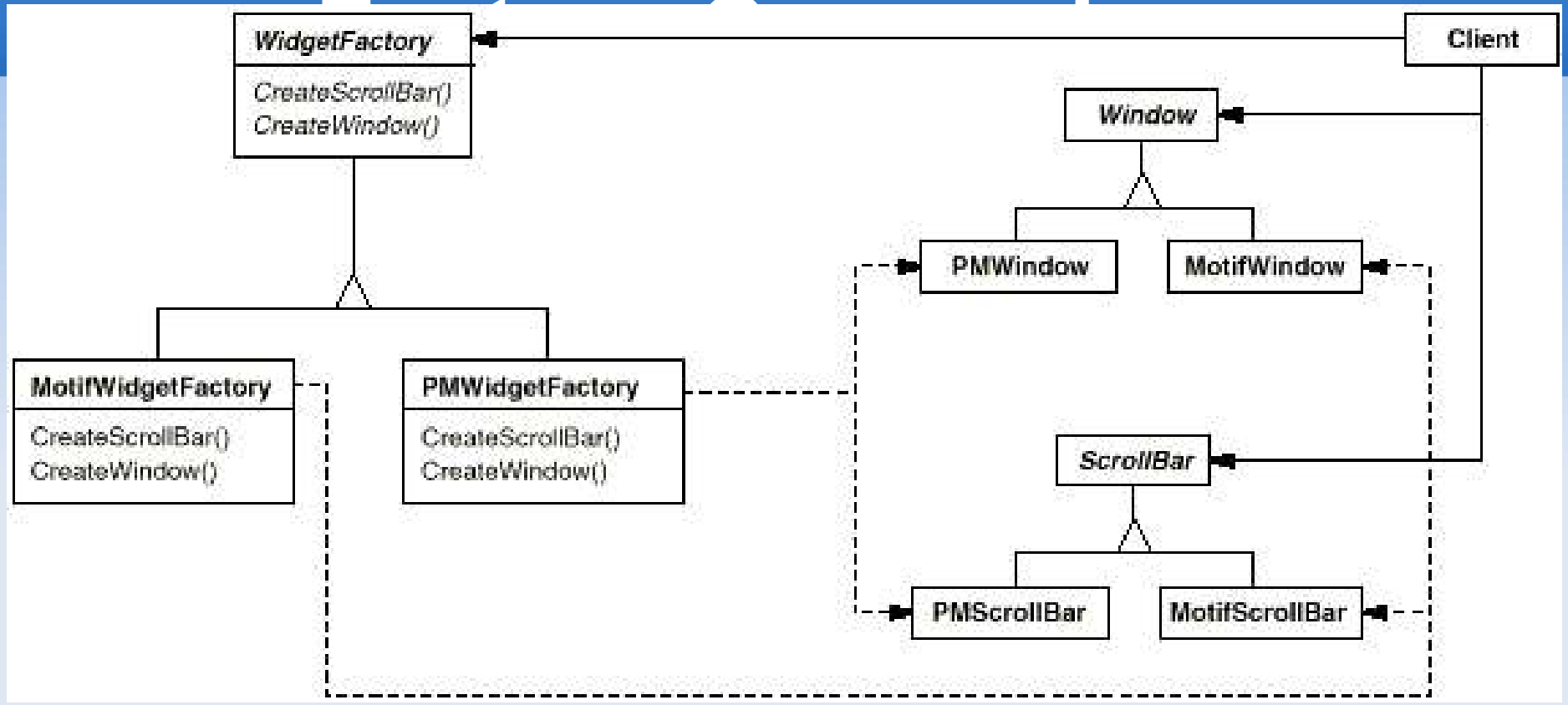
- Intent
  - Provide an interface for creating families of related or dependent objects without specifying their concrete classes

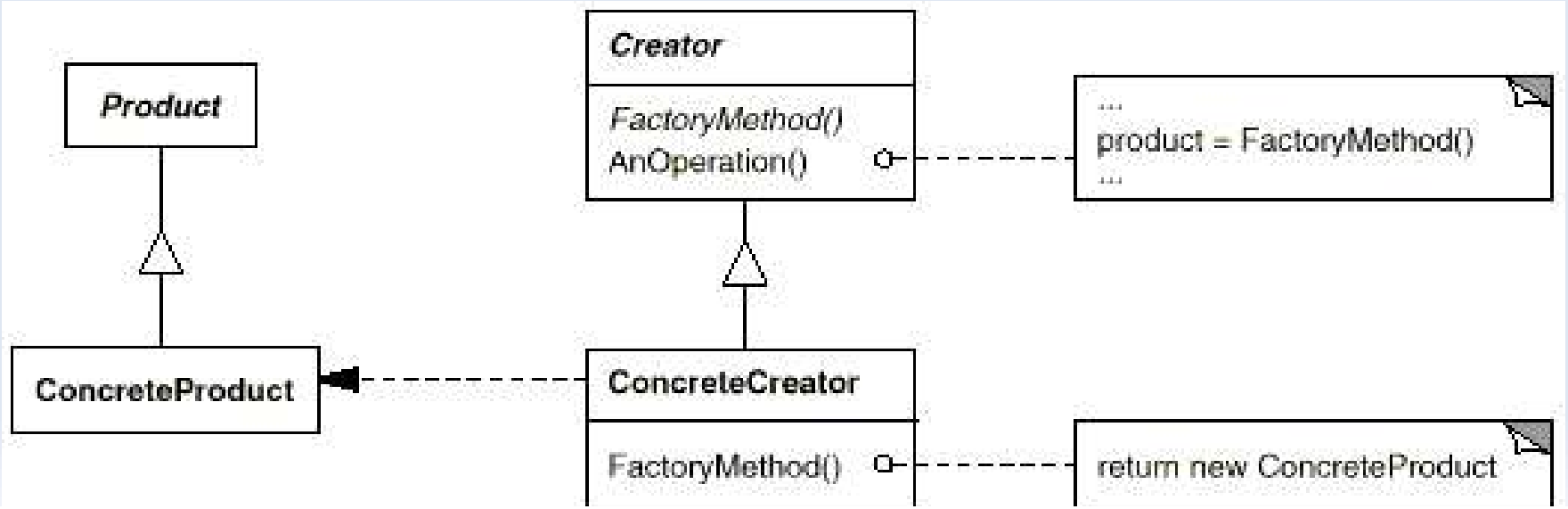


1. Define an abstract WidgetFactory class – it will have interface to create basic widgets
2. For each Widget there is also an abstract class
The concrete widget class will create the appropriate look and feel widget
3. Client will use Widget Factory's interface to get the appropriate concrete widget pointers
4. Client is not aware of exact concrete class it is using – thereby making it independent of the type of family widgets

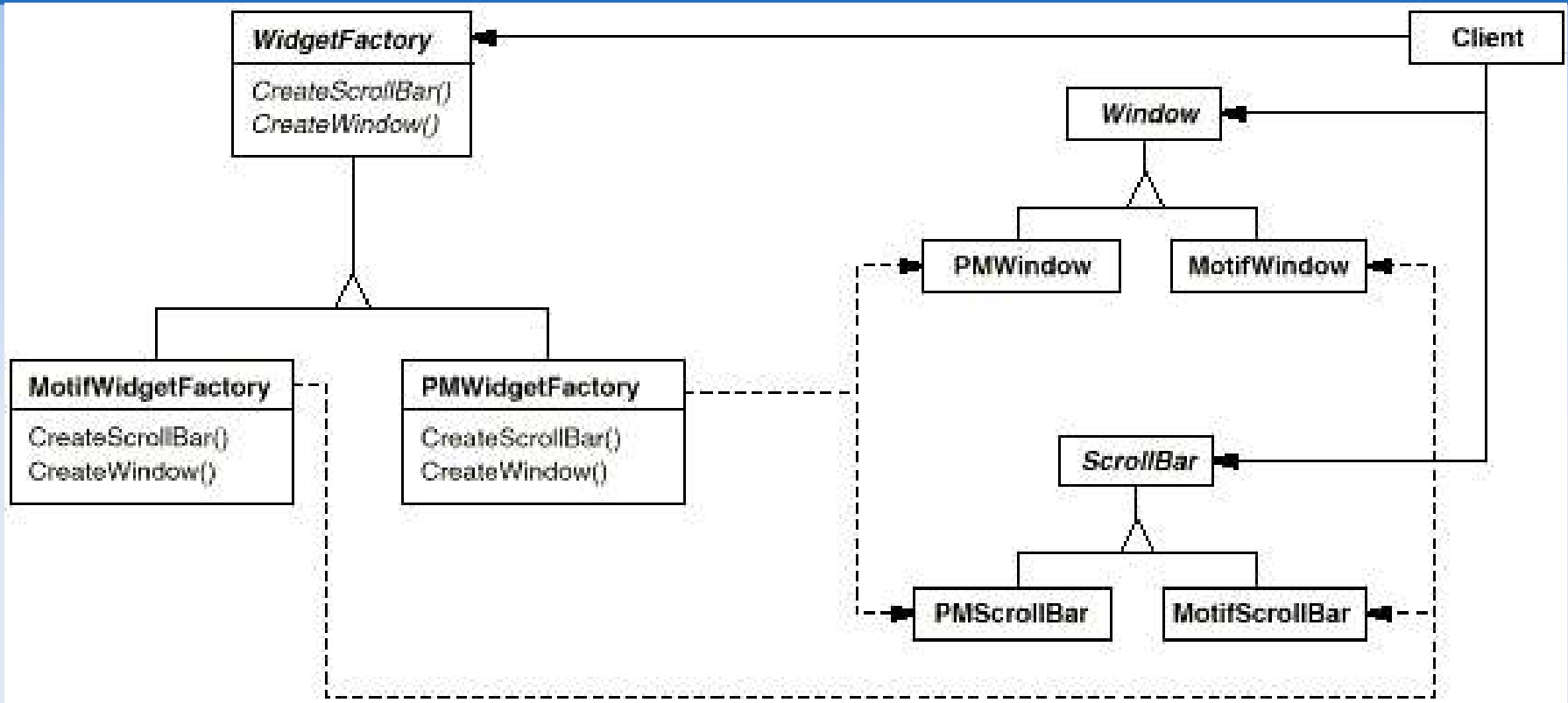
The concrete factory can be singleton

Factory Method & Abstract





Exercise



- Write AbsractFactory class for the above – you can use concrete AwidgetFactory, BWidgetFactory; AWindow, BWindow, AScrollBar, BScrollBar
- The client class will have CreateWindow, CreateScrollBar methods with a simple provision to use either AwidgetFactory or BWidgetFactory

Abstract Factory

```
class Window
{
public:
        virtual const char *getName() = 0;
};

class ScrollBar
{
public:
        virtual const char *getName() = 0;

};
class AWindow : public Window
{
public:
        virtual const char *getName()
        {
                return "AWindow";
        }
};
class BWindow : public Window
{
public:
        virtual const char *getName()
        {
                return "BWindow";
        }
};
```

```
class AScrollBar : public ScrollBar
{
public:
        virtual const char *getName()
        {
                return "AScrollBar";
        }
};
class BScrollBar : public ScrollBar
{
public:
        virtual const char *getName()
        {
                return "BScrollBar";
        }
};
class WidgetFactory
{
public:
        virtual Window *CreateWindow() = 0;
        virtual ScrollBar *CreateScrollBar() = 0;
};
```

Abstract Factory

```
class AWidgetFactory : public WidgetFactory
{
public:
        virtual Window *CreateWindow()
        {
                return new AWindow();
        }
        virtual ScrollBar *CreateScrollBar()
        {
                return new AScrollBar();
        }
};
class BWidgetFactory : public WidgetFactory
{
public:
        virtual Window *CreateWindow()
        {
                return new BWindow();
        }
        virtual ScrollBar *CreateScrollBar()
        {
                return new BScrollBar();
        }
};
```

```
class Client
{
protected:
        WidgetFactory *pwFamily;

public:
        Client(WidgetFactory *_pwFamily)
        {
                pwFamily = _pwFamily;
        }

        Window *CreateWindow()
        {
                return pwFamily->CreateWindow();
        }

        ScrollBar *CreateScrollBar()
        {
                return pwFamily->CreateScrollBar();
        }
};
```

Abstract Factory

```
int main(int argc, char* argv[])
{
        AWidgetFactory awf;
        Client *pClient = new Client(&awf);
        ScrollBar *pScrollBar = pClient->CreateScrollBar();
        Window *pWindow = pClient->CreateWindow();
        std::cout << pScrollBar->getName() << endl;
        std::cout << pWindow->getName() << endl;

        return 0;
}
```