CS 635 Advanced Object-Oriented Design & Programming
Spring Semester, 2014
Doc 17 Factory Method, Abstract Factory, Prototype
April 17, 2014

Factory Method

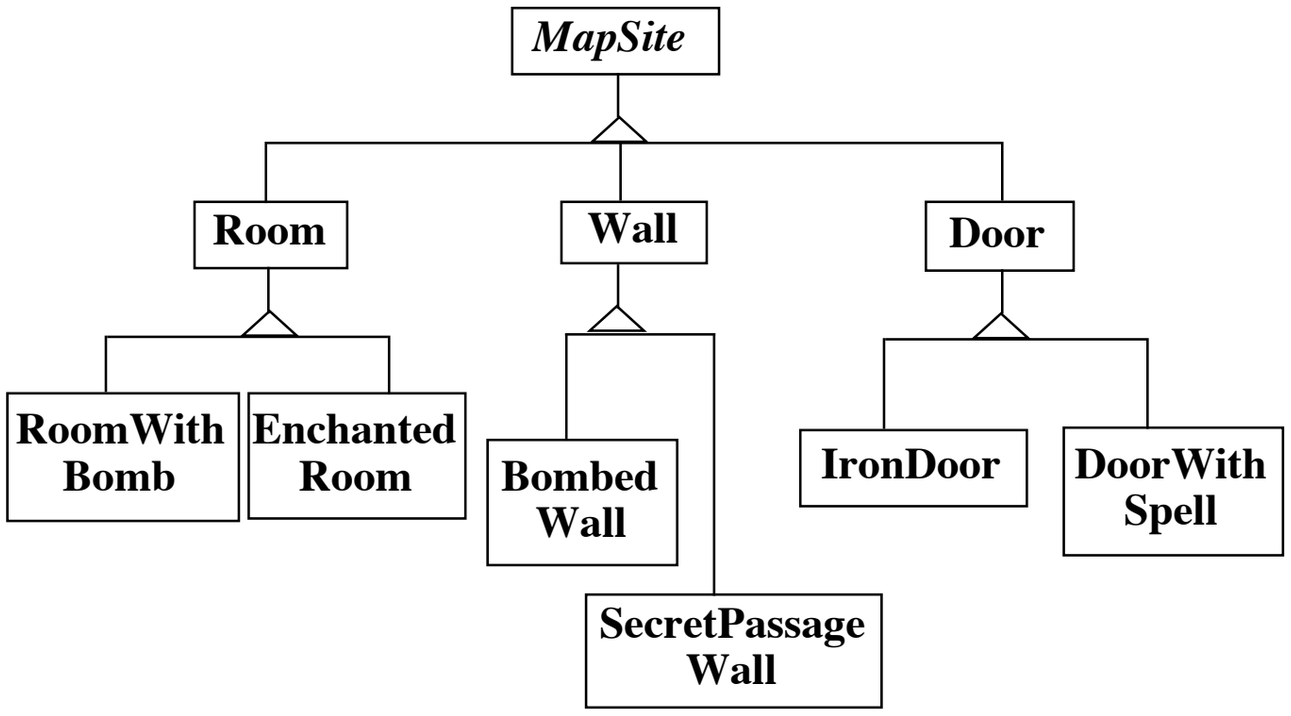
Factory Method

A template method for creating objects

```
public class Example {
      protected Bar bar() { return new Bar(); }

       public void foo() {
            blah
            Bar soap = bar();
            blah;
      }
```

Maze Game Example



Maze Game Example

```
class MazeGame{
    public Maze makeMaze() { return new Maze(); }
    public Room makeRoom(int n ) { return new Room( n ); }
    public Wall makeWall() { return new Wall(); }
    public Door makeDoor() { return new Door(); }

    public Maze CreateMaze(){
        Maze aMaze = makeMaze();
        Room r1 = makeRoom( 1 );
        Room r2 = makeRoom( 2 );
        Door theDoor = makeDoor( r1, r2);

        aMaze.addRoom( r1 );
        aMaze.addRoom( r2 );
        etc

        return aMaze;
        }
}
```

```
class BombedMazeGame extends MazeGame {

    public Room makeRoom(int n )  {
        return new RoomWithABomb( n );
    }

    public Wall makeWall() {
        return new BombedWall();
    }
}
```

Don't repeat your self

```
public class LinkedList extends Collection {
    public OrderedLinkedList() {
        this(defaultOrder());
    }

    public LinkedList(Order listOrder ) {
        this(listOrder, new OrderedCollection());
    }

    public LinkedList(Collection items) {
        this(defaultOrder(), items);
    }

    protected Order defaultOrder() {
        return new RandomOrder();
    }
```

Implementation Variation

```
class Hershey {

    public Candy makeChocolateStuff( CandyType id ) {
        if ( id == MarsBars ) return new MarsBars();
        if ( id == M&Ms ) return new M&Ms();
        if ( id == SpecialRich ) return new SpecialRich();

        return new PureChocolate();
    }

    class GenericBrand extends Hershey {
        public Candy makeChocolateStuff( CandyType id ) {
            if ( id == M&Ms ) return new Flupps();
            if ( id == Milk ) return new MilkChocolate();
            return super.makeChocolateStuff(id);
        }
    }
```

Using C++ Templates

```
template <class ChocolateType>
class Hershey
        {
        public:
                virtual Candy* makeChocolateStuff( );
        }

template <class ChocolateType>
Candy*
Hershey<ChocolateType>::makeChocolateStuff( )
        {
        return new ChocolateType;
        }

Hershey<SpecialRich> theBest;
```

Smalltalk Variant

Return the class, caller creates an object

```
chocolateStuff
        ^SpecialRich
```

```
some code
candy := (self chocolateStuff) new
mode code
```

Use Factory Method When

A class can't anticipate the class of objects it must create

A class wants its subclasses to specify the objects it creates

You want to localize the knowledge of which help classes is used in a class

But when is this?

CS 580 Example - Testing a Server

```
public class SDWitterServer {
	public void run(int port) throws IOException {
		ServerSocket input = new ServerSocket( port );

		while (true) {
			Socket client = input.accept();
			processRequest(
				client.getInputStream(),
				client.getOutputStream());
			client.close();
		}
	}

	void processRequest(InputStream in,OutputStream out) {
		do a bunch of stuff
	}

	etc.
```


This code requires us to send/receive data over the network, which at times is not convenient in unit tests.

Using Factory Method

```
public class SDWitterServer {
        public void run(int port) throws IOException {
                ServerSocket input = this.serverSocket( port );

                while (true) {
                        Socket client = input.accept();
                        processRequest(
                                client.getInputStream(),
                                client.getOutputStream());
                        client.close();
                }
        }

        ServerSocket serverSocket( int port) {
                return new ServerSocket(port);
        }

        etc.
```

TestServer

```
public class TestServer extends SDWitterServer {
	MockServerSocket testSocket;

	ServerSocket serverSocket( int port) {
		return testSocket;
	}
}
```

Other than using a different type of socket it performs the operations as the parent class

```
public class Tests extends Testcase {
	public void testLogin() {
		TestServer server = new TestServer();
		server.testSocket = new MockServerSocket("client command to login");
		server.run();
		assertTrue(server.testSocket.serverResponse() = "the correct response here");
	}
}
```


The situation is more complex than shown here. I simplified it to avoid details that might confuse people.

MockServerSocket

Returns a fake (Mock) client connection

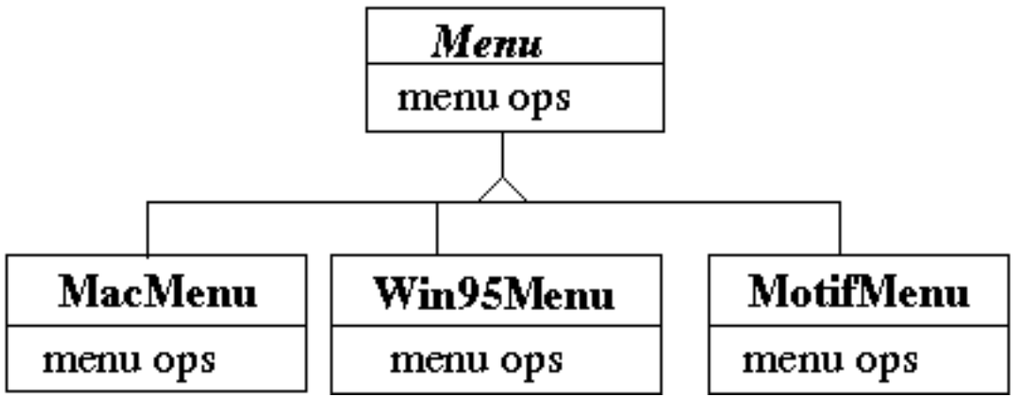
Fakes client connection

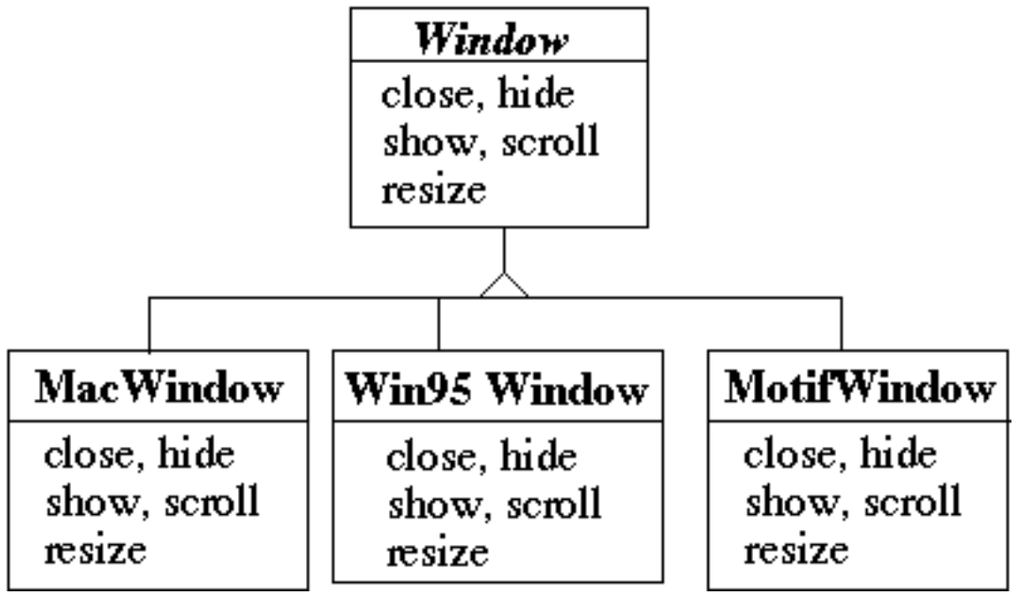
- Does not use network
- Contains fixed requests
- Records server responses

Abstract Factory

Abstract Factory

Write a cross platform window toolkit





Bad Code Dependencies

```
public void installDisneyMenu()
        {
        Menu disney = new MacMenu();
        disney.addItem( "Disney World" );
        disney.addItem( "Donald Duck" );
        disney.addItem( "Mickey Mouse" );
        disney.addGrayBar( );
        disney.addItem( "Minnie Mouse" );
        disney.addItem( "Pluto" );
        etc.
        }
```

Use Abstract Factory

```
abstract class WidgetFactory {
        public Window createWindow();
        public Menu createMenu();
        public Button createButton();
        }
```

```
class MacWidgetFactory extends WidgetFactory {
        public Window createWindow()
                { code to create a mac window }

        public Menu createMenu()
                { code to create a mac Menu }

        public Button createButton()
                { code to create a mac button }
}
```

```
class Win95WidgetFactory extends WidgetFactory {
        public Window createWindow()
                { code to create a Win95 window }

        public Menu createMenu()
                { code to create a Win95 Menu }

        public Button createButton()
                { code to create a Win95 button }
}
```

Use one Factory per Application

```
public void installDisneyMenu(WidgetFactory myFactory)
      {
      Menu disney = myFactory.createMenu();
      disney.addItem( "Disney World" );
      disney.addItem( "Donald Duck" );
      disney.addItem( "Mickey Mouse" );
      disney.addGrayBar( );
      disney.addItem( "Minnie Mouse" );
      disney.addItem( "Pluto" );
      etc.
      }
```

Abstract Factory

Encapsulate a group of individual factories that have a common theme

Separates the details of implementation of a set of objects
from its general usage

How Do Abstract Factories create Things?

Use Subclass Factory Method

```
abstract class WidgetFactory
        {
        public Window createWindow();
        public Menu createMenu();
        public Button createButton();
        }

class MacWidgetFactory extends WidgetFactory
        {
        public Window createWindow()
                { return new MacWidow() }

        public Menu createMenu()
                { return new MacMenu() }

        public Button createButton()
                { return new MacButton()  }
        }
```

Use Widget Factory Method

```
abstract class WidgetFactory {
        private Window windowFactory;
        private Menu menuFactory;
        private Button buttonFactory;

        public Window createWindow()
                { return windowFactory.createWindow() }

        public Menu createMenu();
                { return menuFactory.createMenu() }

        public Button createButton()
                { return buttonFactory.createMenu() }
}
```

```
class MacWidgetFactory extends WidgetFactory {
        public MacWidgetFactory() {
                windowFactory = new MacWindow();
                menuFactory = new MacMenu();
                buttonFactory = new MacButton();
        }
}
```

```
class MacWindow extends Window {
        public Window createWindow() { blah }
        etc.
```

Why Widget Factory Method?

```
abstract class WidgetFactory {
        private Window windowFactory;
        private Menu menuFactory;
        private Button buttonFactory;

        public Window createWindow()
                { return windowFactory.createWindow() }

        public Window createWindow( Rectangle size)
                { return windowFactory.createWindow( size ) }

        public Window createWindow( Rectangle size, String title)
                { return windowFactory.createWindow( size, title) }

        public Window createFancyWindow()
                { return windowFactory.createFancyWindow() }

        public Window createPlainWindow()
                { return windowFactory.createPlainWindow() }
```

Multiple ways to create Widget

Use Prototype

```
class WidgetFactory{
        private Window windowPrototype;
        private Menu menuPrototype;
        private Button buttonPrototype;

        public WidgetFactory( Window windowPrototype,
                                        Menu menuPrototype,
                                        Button buttonPrototype)
                {
                this.windowPrototype = windowPrototype;
                this.menuPrototype = menuPrototype;
                this.buttonPrototype = buttonPrototype;
                }

        public Window createWindow()
                { return windowPrototype.createWindow() }

        public Window createWindow( Rectangle size)
                { return windowPrototype.createWindow( size ) }

        public Window                ()
                { return menuPrototype.createMenu() }
        etc.
```

How to prevent Cheating?

```
public void installDisneyMenu(WidgetFactory myFactory)
    {
    // We ship next week, I can't get the stupid generic Menu
    // to do the fancy Mac menu stuff
    // Windows version won't ship for 6 months
    // Will fix this later

    MacMenu disney = (MacMenu) myFactory.createMenu();
    disney.addItem( "Disney World" );
    disney.addItem( "Donald Duck" );
    disney.addItem( "Mickey Mouse" );
    disney.addMacGrayBar( );
    disney.addItem( "Minnie Mouse" );
    disney.addItem( "Pluto" );
    etc.
    }
```

Prototype

Prototype

Specify the kinds of objects to create using a prototypical instance, and create new objects by copying this prototype

Applicability

Use the Prototype pattern when

A system should be independent of how its products are created, composed, and represented; and

When the classes to instantiate are specified at run-time; or

To avoid building a class hierarchy of factories that parallels the class hierarchy of products; or

When instances of a class can have one of only a few different combinations of state.

Insurance Example

Insurance agents start with a standard policy and customize it

Two basic strategies:

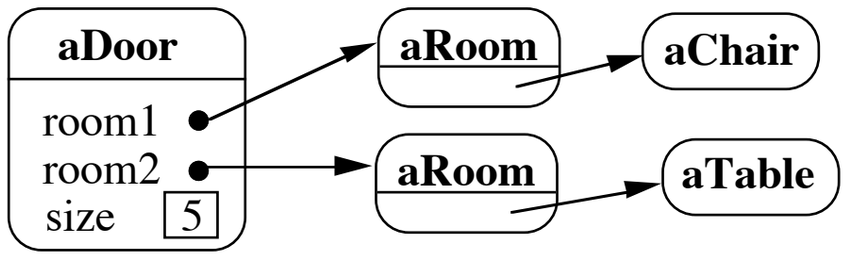
Copy the original and edit the copy

Store only the differences between original and the customize version in a decorator

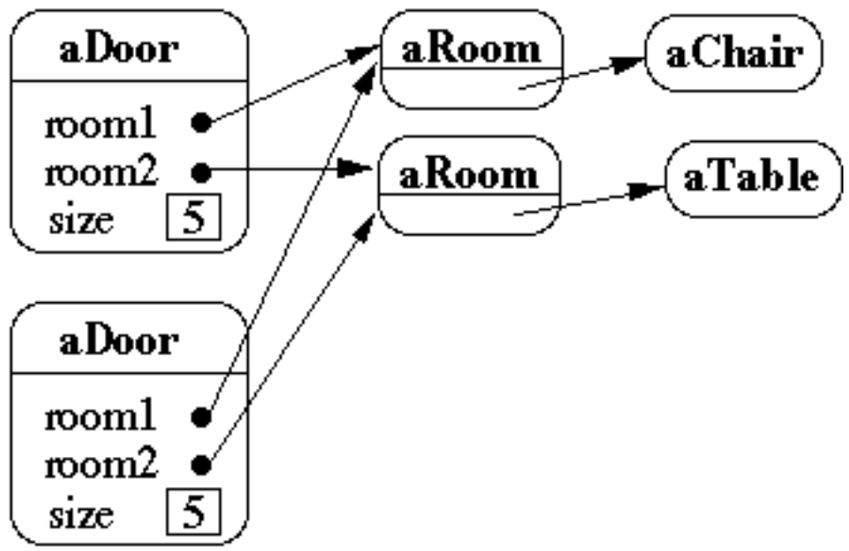
Copying Issues

Shallow Copy Verse Deep Copy

Original Objects

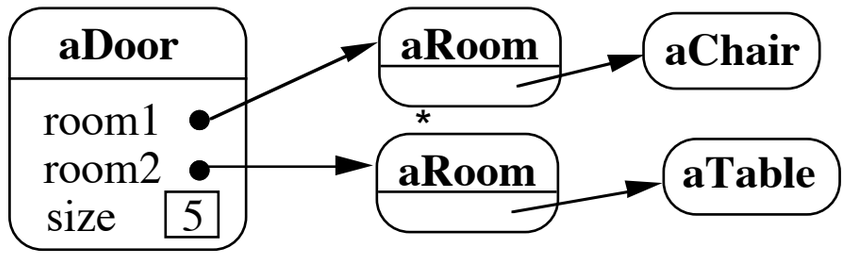


Shallow Copy

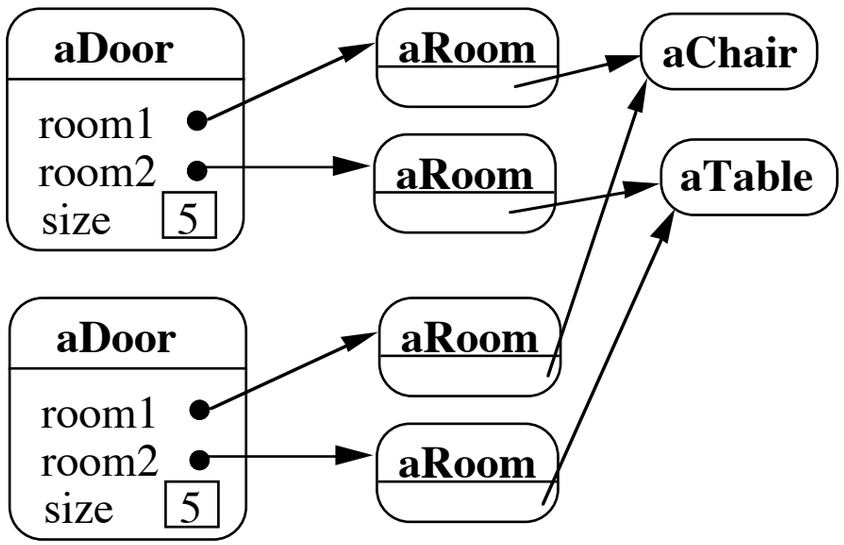


Shallow Copy Verse Deep Copy

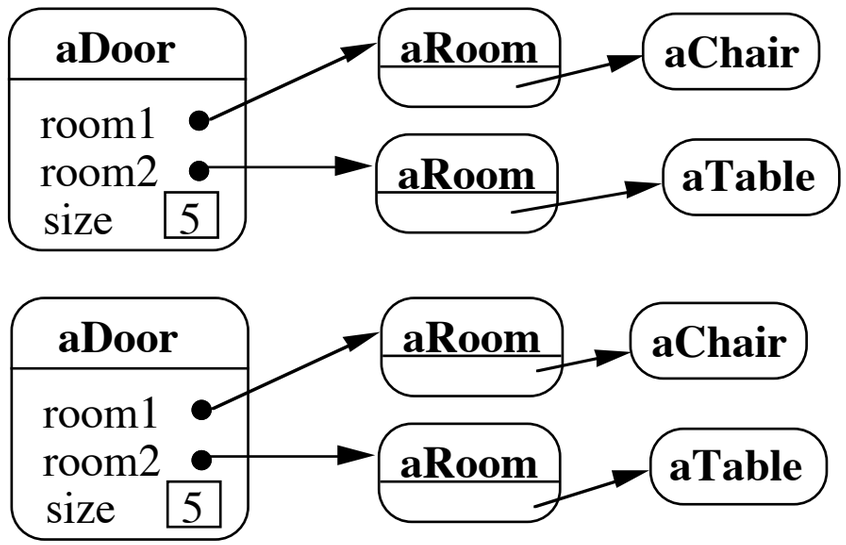
Original Objects



Deep Copy



Deeper Copy



Cloning Issues - C++ Copy Constructors

```
class Door {
        public:
                Door();
                Door( const Door&);
                virtual Door* clone() const;

                virtual void Initialize( Room*, Room* );
                // stuff not shown
        private:
                Room* room1;
                Room* room2;
        }

Door::Door ( const Door& other ) //Copy constructor {
        room1 = other.room1;
        room2 = other.room2;
        }

Door* Door::clone()  const {
        return new Door( *this );
        }
```

Cloning Issues - Java Clone

Shallow Copy

```
class Door implements Cloneable {
        private Room room1;
        private Room room2;

        public Object clone() throws  CloneNotSupportedException {
                return super.clone();
        }
}
```

Deep Copy

```
public class Door implements Cloneable {
        private Room room1;
        private Room room2;

        public Object clone() throws CloneNotSupportedException {
                Door thisCloned =(Door) super.clone();
                thisCloned.room1 = (Room)room1.clone();
                thisCloned.room2 = (Room)room2.clone();
                return thisCloned;
        }
}
```

Prototype-based Languages

No classes

Behaviour reuse (inheritance)

Cloning existing objects which serve as prototypes

Some Prototype-based languages

- Self
- JavaScript
- Squeak (eToys)
- Perl with Class::Prototyped module