CS 635 Advanced Object-Oriented Design & Programming
Spring Semester, 2001
Doc 9 Factory Method & Prototype
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References

Design Patterns: Elements of Reusable Object-Oriented Software, Gamma, Helm, Johnson, Vlissides, Addison-Wesley, 1995, pp. 107-126

The Design Patterns Smalltalk Companion, Alpert, Brown, Woolf, 1998, pp. 63-89

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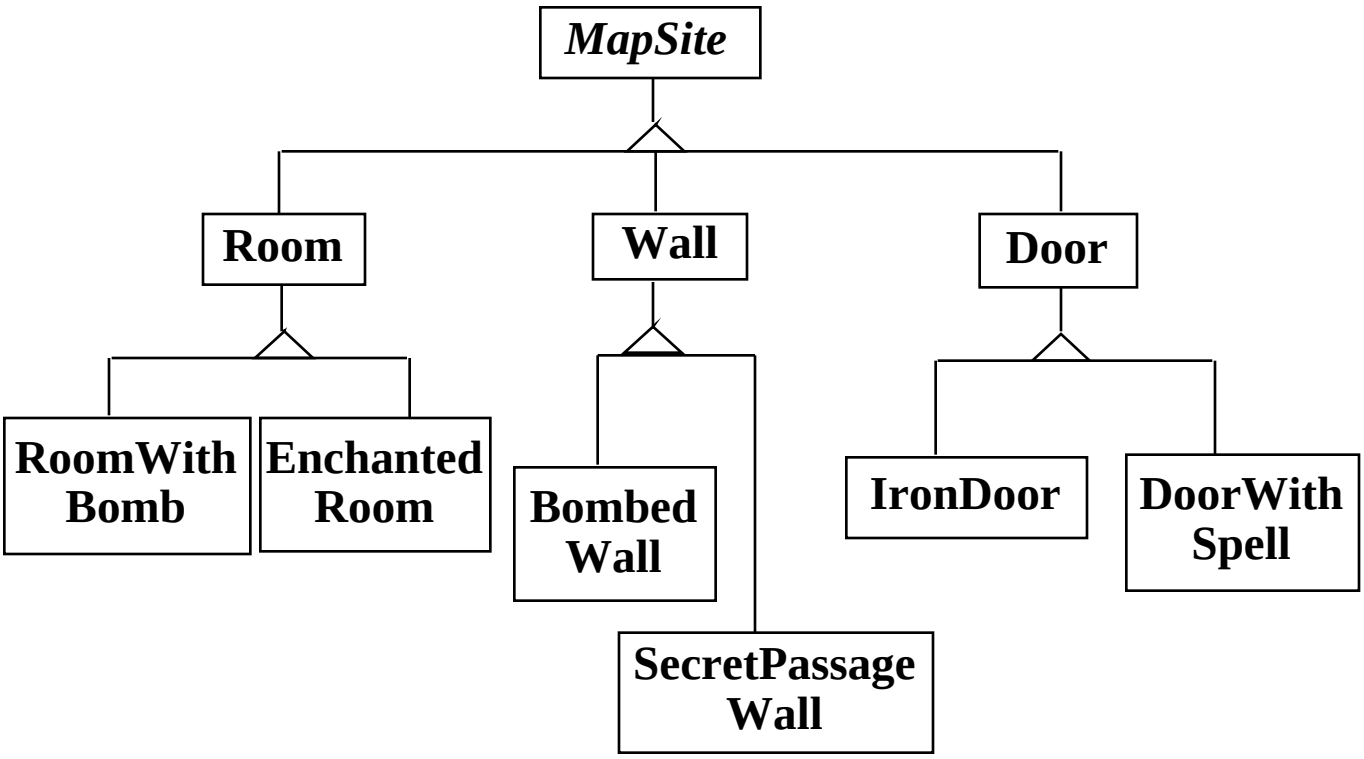
Factory Method

A template method for creating objects

Example - Maze Game

Classes for Mazes



Now a maze game has to make a maze

Maze Class Version 1

```
class MazeGame
  {

  public Maze createMaze()
    {
    Maze aMaze = new Maze();

    Room r1 = new Room( 1 );
    Room r2 = new Room( 2 );
    Door theDoor = new Door( r1, r2);

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

    etc.

    return aMaze;
    }
  }
```

How do we make other Mazes?

Subclass MazeGame, override createMaze

```
class BombedMazeGame extends MazeGame
  {

  public Maze createMaze()
    {
    Maze aMaze = new Maze();

    Room r1 = new RoomWithABomb( 1 );
    Room r2 = new RoomWithABomb( 2 );
    Door theDoor = new Door( r1, r2);

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

    etc.
```

Note the amount of cut and paste!

How do we make other Mazes?

Use Factory Method

```
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;
    }
  }
```

Now subclass MazeGame override make methods

CreateMaze method stays the same

```
class BombedMazeGame extends MazeGame
  {

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

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

Applicability

Use 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

Consequences

- Eliminates need to hard code specific classes in code
- Requires subclassing to vary types used
- Provides hooks for subclasses
- Connects Parallel class hierarchies

Implementation
Two Major Varieties

- Top level Factory method is in an abstract class

```
abstract class MazeGame
   {
   public Maze makeMaze();
   public Room makeRoom(int n );
   public Wall makeWall();
   public Door makeDoor();
   etc.
   }

class MazeGame
   {
   public:
      virtual Maze* makeMaze() = 0;
      virtual Room* makeRoom(int n ) = 0;
      virtual Wall* makeWall() = 0;
      virtual Door* makeDoor() = 0;
```

- Top level Factory method is in a concrete class

See examples on previous slides

Implementation - Continued
Parameterized Factory Methods

Let the factory method return multiple products

```
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();
      }
   }
```

C++ Templates to Avoid Subclassing

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

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

Hershey<SpecialRich> theBest;
```

Java forName and Factory methods

With Java's reflection you can use a Class or a String to specify which type of object to create

Using a string replaces compile checks with runtime errors

```
class Hershey
   {
   private String chocolateType;

   public Hershey( String chocolate )
      {
      chocolateType = chocolate;
      }

   public Candy makeChocolateStuff( )
      {
      Class candyClass =  Class.forName( chocolateType );
      return (Candy) candyClass.newInstance();
      }
```

```
Hershey theBest = new Heshsey( "SpecialRich" );
```

Clients Can Use Factory Methods

```
class CandyStore
   {
   Hershey supplier;
   public restock()
      {
      blah

      if ( chocolateStock.amount() < 10 )
         {
         chocolateStock.add(
            supplier.makeChocolateStuff() );
         }

   blah
```

Prototype
Intent

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.

  It may be easier to have the proper number of prototypes and clone them rather than instantiating the class manually each time

Implementation/Sample Code

Simple Example

```
class Prototype
   {
   public Prototype clone()
      {
      code to make a copy of current Prototype object
      return clone;
      }

      // add what ever else you want the class to do
   }

class Protoplasm extends  Prototype
   {
   public Prototype clone()
      {
      code to make a copy of current Protoplasm object
      return clone;
      }

   // add more other stuff
   }

ClientCodeMethod( Prototype example )
   {
   Prototype myCopy = example.clone();

   // do some work using myCopy
   }
```

Cloning Issues
How to in 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 );
   }
```

How to in Java - Object clone()

protected Object clone() throws CloneNotSupportedException

A bitwise clone of the current object is created

Returns:
A clone of this Object.

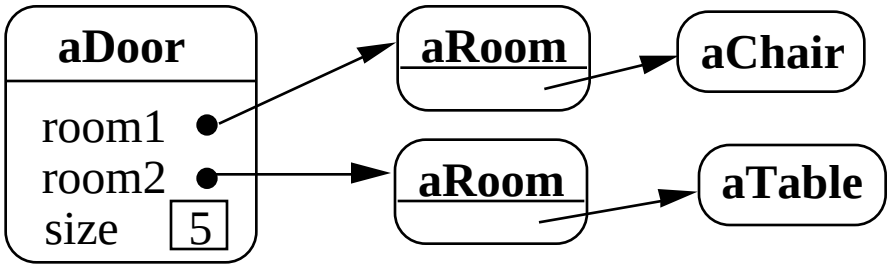
Throws: OutOfMemoryError
If there is not enough memory.

Throws: CloneNotSupportedException
Object explicitly does not want to be cloned, or it does not support the Cloneable interface.

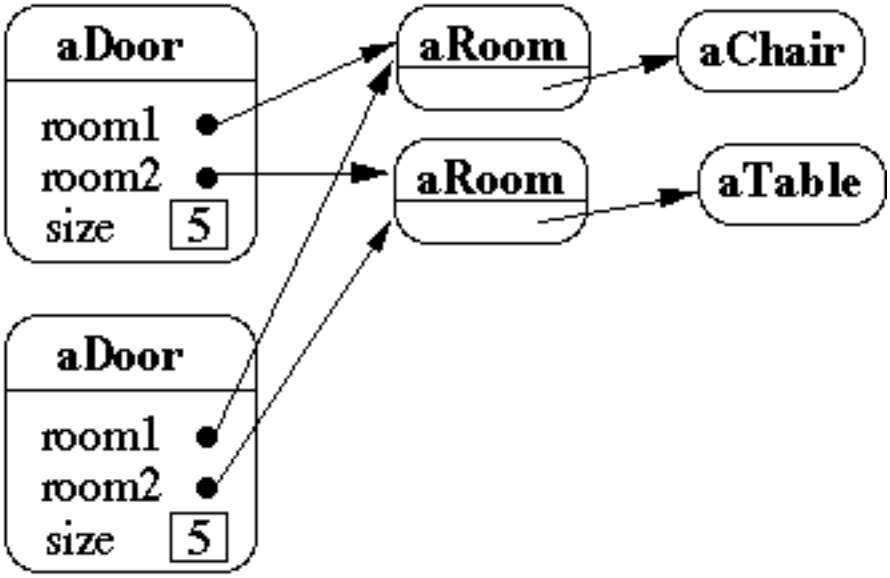
```
class Door implements Cloneable
  {
  public void Initialize( Room a, Room b)
    { room1 = a; room2 = b; }

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

Shallow Copy Verse Deep Copy

Original Objects

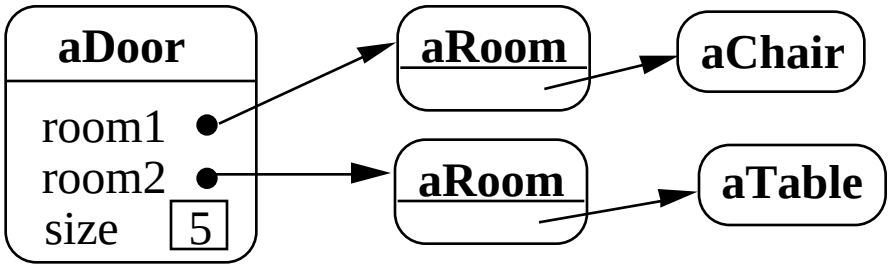


Shallow Copy

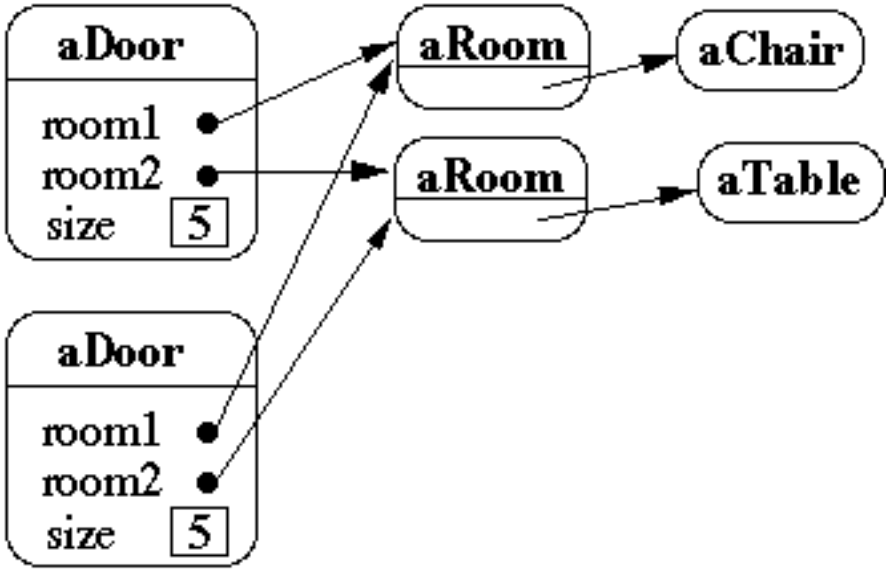


Shallow Copy Verse Deep Copy

Original Objects



Deep Copy



Template or Boilerplate Objects

May wish to specify how an object differs from a standard configuration

Example: Insurance policy

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

Consequences

- Adding and removing products at run-time
- Specifying new objects by varying values
- Specifying new objects by varying structure
- Reducing subclassing (from factory method)
- Configuring an application with classes dynamically

Implementation Issues

- Using a prototype manager
- Implementing the Clone operation
- Initializing clones