ECE450 – Software Engineering II

Today: **Design Patterns III**

Detour: The "simplest" creational pattern: *Singleton*

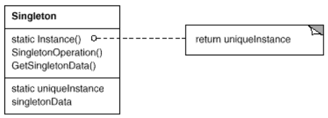
- *Ensure a class only has one instance, and provide a global point of access to it*
- In my experience, if there is one pattern people know of, it's Singleton.
  - Catchy name
  - Simple concept
- Again, in my experience, if there is one pattern people *get wrong*, it's Singleton.
  - Used as a simple substitute for global variables
  - ...while thinking that there is nothing wrong with that: "They're not global variables –they're a Singleton!"
- And even when people get the *concept* right, they frequently get the *implementation* wrong.
  - Threatened by parallel programs
  - Subclassing vs. protecting the one and only instance

When is it OK to use Singletons?

- Sometimes we need only one instance of an object
  - One file system
  - One print spooler
- If you think you need only one instance of the object, answer these questions:
  - Can you assign ownership of the single instance reasonably?
  - Is lazy initialization desirable?
  - Is global access not provided otherwise?
- If all criteria are satisfied, you might need a Singleton after all.
  - Threatened by parallel programs
  - Subclassing vs. protecting the one and only instance

Singleton's structure

- Singleton
  - Defines a class-scoped instance() operation that lets clients access its unique instance
  - May be responsible for creating its own unique instance



Sample code (not the real deal)

```
public class SingletonObject {

   private SingletonObject() {
        // Just making the constructor private...
   }

   public static SingletonObject getSingletonObject() {
        if (ref == null)
                 // The object has not been created yet
                 ref = new SingletonObject();
        return ref;
   }

   private static SingletonObject ref;
}
```


But there's a threading problem…

```
public class SingletonObject {

   private SingletonObject() {
        // No code, just making the constructor private...
   }

   public static synchronized SingletonObject getSingletonObject() {
        if (ref == null)
                 // The object has not been created yet
                 ref = new SingletonObject();
        return ref;
   }

   private static SingletonObject ref;
}
```


Attack of the clones

```
public class Clone {

   public static void main(String args[]) throws Exception {
     // Get a singleton
     SingletonObject obj = SingletonObject.getSingletonObject();

     // Oh crap...
     SingletonObject clone = (SingletonObject) obj.clone();
   }
}
```

- Note: Only really a problem if your Singleton class is extending another class that supports cloning
  - …since clone() is a protected method

Sample code (the real deal)

```
public class SingletonObject {

   private SingletonObject() {
        // Just making the constructor private...
   }

   public static synchronized SingletonObject getSingletonObject() {
        if (ref == null)
                 // The object has not been created yet
                 ref = new SingletonObject();
        return ref;
   }

   public Object clone() throws CloneNotSupportedException {
        // You shall not pass!
        throw CloneNotSupportedException;
   }

   private static SingletonObject ref;
}
```

Consequences

- Controlled access to sole instance
  - Because Singleton encapsulates the sole instance, it has strict control
- Reduced name space
  - One access method only
- Variable number of instances
  - You could change your mind to have *n* (e.g. 5) instances

Implementation

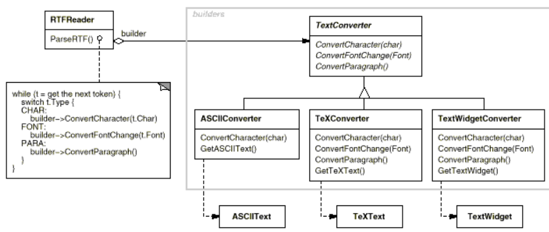
- Implementation is very language-dependent
  - ...and Singletons are more necessary in some language than others
- Not an excuse for using global variables!
  - "The Singleton design pattern is one of the most inappropriately used patterns. Singletons are intended to be used when a class must have exactly one instance, no more, no less ... [Designers] frequently use Singletons in a misguided attempt to replace global variables ... A Singleton is, for intents and purposes, a global variable. The Singleton does not do away with the global; it merely renames it." –Jim Hyslop

Back to that pretty maze of ours...

- We've explored several ways to construct the elements of the maze
  - Factory methods
  - Abstract factories
  - Prototypes
- We'll see one more and, with that, finish our tour through creational patterns...

Introducing the *Builder*

- *Separate the construction of a complex object from its representation so that the same construction process can create different representations*
  - E.g. read in Rich Text Format, converting to many different formats on load.

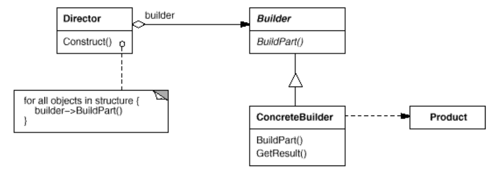


Applicability

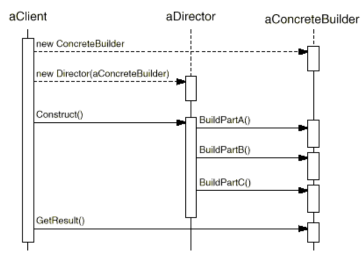
- Use when:
  - The algorithm for creating a complex object should be independent of the parts that make up the object and how they are assembled
  - The construction process must allow different representations for the object that is constructed

Structure

- Builder
  - Specifies an abstract interface for creating parts of a Product object
- Concrete Builder
  - Constructs and assembles parts of the product by implementing the Builder interface
  - Defines and keeps track of the representation it creates
  - Provides an interface for retrieving the product
- Director
  - Constructs an object using the Builder interface
- Product
  - Represents the complex object under construction
  - Includes classes that define the constituent parts, including interfaces for assembling the parts into the final result



Collaborations



- The Client creates the Director object and configures it with the Builder object
- Director notifies the Builder whenever a part of the product should be built
- Builder handles requests from the director and adds parts to the product
- The client retrieves the product from the Builder

Sample code

```
public abstract class MazeBuilder {
    public void buildRoom(int r){}
    public void buildDoor(int r1, int direction, int r2){}
    public Maze getMaze(){return null;}
}


public class MazeGame {
    …
    public Maze createMaze(MazeBuilder b) {
        b.buildRoom(1);
        b.buildRoom(2);
        b.buildDoor(1, Direction.North, 2);
        return b.getMaze();
    }
    …
}
```

Sample code

```
public class StandardMazeBuilder extends MazeBuilder
{
    private Maze currentMaze;

    public Maze getMaze() {
        if( currentMaze==null )
           currentMaze = new Maze();
        return currentMaze;
    }

    public void buildRoom(int r) {
        if( getMaze().getRoom(r) == null ) {
            Room room = new Room(r);
            getMaze().addRoom(room);
            for(int d = Direction.First; d <= Direction.Last; d++)
                room.setSide(d, new Wall());
         }
    }
    …
}
```


Sample code

```
public class StandardMazeBuilder extends MazeBuilder
{
    …
    public void buildDoor(int r1, int d, int r2) {
        Room room1 = getMaze().getRoom(r1);
        Room room2 = getMaze().getRoom(r2);
        if( room1 == null ) {
            buildRoom(r1);
            room1 = getMaze().getRoom(r1);
        }
        if( room2 == null ) {
            buildRoom(r2);
            room2 = getMaze().getRoom(r2);
        }
        Door door = new Door(room1, room2);
        room1.setSide(d, door);
        room2.setSide(Direction.opposite(d), door);
    }
    …
}
```


Sample code

```
public class CountingMazeBuilder extends MazeBuilder
{
    private int rooms = 0;
    private int doors = 0;

    public void buildDoor(int r1, int direction, int r2) {
        doors++;
    }

    public void buildRoom(int r) {
        rooms++;
    }

    public int getDoors() { return doors; }
    public int getRooms() { return rooms; }

}
```


Sample code

```
public class MazeGame
{
    public static void main(String args[]) {
        MazeGame mg = new MazeGame();
        Maze m = mg.createMaze(new StandardMazeBuilder());
        System.out.println(m);

        CountingMazeBuilder cmb = new CountingMazeBuilder();
        mg.createMaze(cmb);
        System.out.println("rooms = "+cmb.getRooms());
        System.out.println("doors = "+cmb.getDoors());
    }

    …
}
```

Sample code
(Abstract factory reminder)

```
public Maze createMaze(MazeFactory f) {
        Room r1 = f.makeRoom(1);
        Room r2 = f.makeRoom(2);
        Door d  = f.makeDoor(r1,r2);

        r1.setSide(Direction.North, f.makeWall());
        r1.setSide(Direction.East, d);
        r1.setSide(Direction.West, f.makeWall());
        r1.setSide(Direction.South, f.makeWall());

        r2.setSide(Direction.North, f.makeWall());
        r2.setSide(Direction.East, f.makeWall());
        r2.setSide(Direction.West, d);
        r2.setSide(Direction.South, f.makeWall());

        Maze m  = f.makeMaze();
        m.addRoom(r1);
        m.addRoom(r2);
        return m;
    }
```


Sample code
(Builder comparison)

```
public Maze createMaze(MazeBuilder b) {
        b.buildDoor(1, Direction.North, 2);
        // A bit extreme, but you get the point...

        return b.getMaze();
    }
```


Consequences

- Lets you vary a product's internal representation
  - And hides details on how the product is assembled
- Isolates code for construction and representation
  - Clients don't need to know anything about the classes that define the product's internal structure; such classes don't appear in Builder's interface
- Gives you finer control over the production process
  - Constructs the product step by step under the director's control, instead of in one shot

Implementation

- Assembly and construction interface
  - Builders construct their products in step-by-step fashion.
  - Builder class interface must be general enough to allow the construction of products for all kinds of concrete builders
- Why no abstract class for products?
  - In the common case, the products produced by the concrete builders differ so greatly in their representation that there is little to gain from giving different products a common parent class

Creational patterns recap

- If createMaze() calls virtuals to construct components
  - Factory method
- If createMaze() is passed a parameter object to create rooms, walls, and all other elements of the same family
  - Abstract factory
- If createMaze() is passed a parameter object to create and connect mazes step by step
  - Builder
- If createMaze() is parameterized with various prototypical rooms, doors, walls, …, which it copies and then adds to the maze
  - Prototype
- If we need to ensure that there is only one maze per game, or one factory that produces its elements
  - Singleton