CMSC 132: OBJECT-ORIENTED PROGRAMMING II

Design Patterns I

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Design Patterns

- Descriptions of reusable solutions to common software design problems (e.g, Iterator pattern)
- Captures the experience of experts
- Goals
  - Solve common programming challenges
  - Improve reliability of solution
  - Aid rapid software development
  - Useful for real-world applications
- Design patterns are like recipes – generic solutions to expected situations
- Design patterns are language independent
- Recognizing when and where to use design patterns requires familiarity & experience
- Design pattern libraries serve as a glossary of idioms for understanding common, but complex solutions
- Design patterns are used throughout the Java Class Libraries

Documentation Format

1. Motivation or context for pattern
2. Prerequisites for using a pattern
3. Description of program structure
4. List of participants (classes & objects)
5. Collaborations (interactions) between participants
6. Consequences of using pattern (good & bad)
7. Implementation techniques & issues
8. Example codes
9. Known uses
10. Related patterns

Types of Design Patterns

- Creational
  - Deal with the best way to create objects
- Structural
  - Ways to bring together groups of objects
- Behavioral
  - Ways for objects to communicate & interact

Creational Patterns

1. Abstract Factory- Creates an instance of several families of classes
2. Builder - Separates object construction from its representation
3. Factory Method - Creates an instance of several derived classes
4. Prototype - A fully initialized instance to be copied or cloned
5. Singleton - A class of which only a single instance can exist

Structural Patterns

6. Adapter - Match interfaces of different classes
7. Bridge - Separates an object's interface from its implementation
8. Composite - A tree structure of simple and composite objects
9. Decorator - Add responsibilities to objects dynamically
10. Façade - Single class that represents an entire subsystem
11. Flyweight - Fine-grained instance used for efficient sharing
12. Proxy - Object representing another object

Behavioral Patterns

13. Chain of Responsibility - A way of passing a request between a chain of objects
14. Command - Encapsulate a command request as an object
15. Interpreter - A way to include language elements in a program
16. Iterator - Sequentially access the elements of a collection
17. Mediator - Defines simplified communication between classes
18. Memento - Capture and restore an object's internal state

Behavioral Patterns (cont.)

19. Observer - A way of notifying change to a number of classes
20. State - Alter an object's behavior when its state changes
21. Strategy - Encapsulates an algorithm inside a class
22. Template Method - Defer the exact steps of an algorithm to a subclass
23. Visitor - Defines a new operation to a class without changing class

Iterator Pattern

- **Definition**
  - Move through collection of objects without knowing its internal representation
- **Where to use & benefits**
  - Use a standard interface to represent data objects
  - Uses standard iterator built in each standard collection, like List, Sort, or Map
  - Need to distinguish variations in the traversal of an aggregate
- **Example**
  - Iterator for collection
  - Original
    - Examine elements of collection directly
  - Using pattern
    - Collection provides Iterator class for examining elements in collection

Iterator Example

```
public interface Iterator<V> {
    bool hasNext();
    V next();
    void remove();
}

Iterator<V> it = myCollection.iterator();

while ( it.hasNext() ) {
    V x = it.next();   // finds all objects
    …                  //   in collection
}
```

Singleton Pattern

- **Definition**
  - One instance of a class or value accessible globally
- **Where to use & benefits**
  - Ensure unique instance by defining class final
  - Access to the instance only via methods provided
- **Example**

```
public class Employee {
    public static final int ID = 1234;              // ID is a singleton
}

public final class MySingleton {

    // declare the unique instance of the class
    private static MySingleton uniq = new MySingleton();

    // private constructor only accessed from this class
    private MySingleton() { … }

    // return reference to unique instance of class
    public static MySingleton getInstance() {
        return uniq;
    }
}
```

Adapter Pattern

- **Definition**
  - Convert existing interfaces to new interface
- **Where to use & benefits**
  - Help match an interface
  - Make unrelated classes work together
  - Increase transparency of classes
- **Example**
  - Adapter from integer Set to integer Priority Queue
  - Original
    - Integer set does not support Priority Queue
  - Using pattern
    - Adapter provides interface for using Set as Priority Queue
    - Add needed functionality in Adapter methods

Adapter Example

```
public interface PriorityQueue {        // Priority Queue
      void add(Object o);
      int size( );
      Object removeSmallest( );
}

public class PriorityQueueAdapter implements PriorityQueue {
      Set s;

      PriorityQueueAdapter(Set s)       { this.s = s; }

      public void add(Object o)         { s.add(o); }

      int size( )                       { return s.size(); }

      public Integer removeSmallest( ) {
         Integer smallest = Integer.MAX_VALUE;
         for (Integer i : s) {
              if (i.compareTo(smallest) < 0)
                  smallest = i;
          }
          s.remove(smallest);
          return smallest;
      }
}
```

Factory Pattern

- **Definition**
  - Provides an abstraction for deciding which class should be instantiated based on parameters given
- **Where to use & benefits**
  - A class cannot anticipate which subclasses must be created
  - Separate a family of objects using shared interface
  - Hide concrete classes from the client
- **Example**
  - Car Factory produces different Car objects
  - Original
    - Different classes implement Car interface
    - Directly instantiate car objects
    - Need to modify client to change cars
  - Using pattern
    - Use car factory class to produce car objects
    - Can change cars by changing car factory

Factory Example

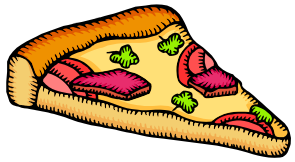
```
class Ferrari implements Car;      // fast car
class Bentley implements Car;      // antique car
class Explorer implements Car;     // family SUV
Car fast = new Ferrari();          // returns fast car
```

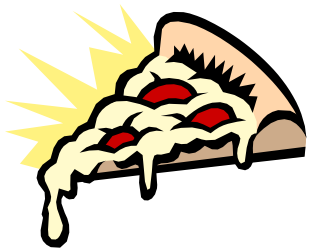
```
public class carFactory {
   public static Car create(String type) {
     if (type.equals("fast"))          return new Ferrari();
     if (type.equals(“antique"))       return new Bentley();
     else if (type.equals(“family”) return new Explorer();
}   }

Car fast = carFactory.create("fast"); // returns fast car
```

Decorator Pattern

- **Definition**
  - Attach additional responsibilities or functions to an object dynamically or statically
- **Where to use & benefits**
  - Provide flexible alternative to subclassing
  - Add new function to an object without affecting other objects
  - Make responsibilities easily added and removed dynamically & transparently to the object
- **Example**
  - Pizza Decorator adds toppings to Pizza
  - Original
    - Pizza subclasses
    - Combinatorial explosion in # of subclasses
  - Using pattern
    - Pizza decorator classes add toppings to Pizza objects dynamically
    - Can create different combinations of toppings without modifying Pizza class
    - **Example:** PizzaDecoratorCode





Decorator Pattern

- Examples from Java I/O
  - Interface
    - InputStream
  - Concrete subclasses
    - FileInputStream, ByteArrayInputStream
  - Decorators
    - BufferedInputStream, DataInputStream
  - Code
    - InputStream s = new DataInputStream(new BufferedInputStream (new FileInputStream()));

Marker Interface Pattern

- **Definition**
  - Label semantic attributes of a class
- **Where to use & benefits**
  - Need to indicate attribute(s) of a class
  - Allows identification of attributes of objects without assuming they are instances of any particular class
- **Example**
  - Classes with desirable property GoodProperty
  - *Original*
    - Store flag for GoodProperty in each class
  - *Using pattern*
    - Label class using GoodProperty interface
- **Examples from Java**
  - Cloneable
  - Serializable

Marker Interface Example

```
public interface SafePet { }        // no methods

class Dog implements SafePet { … }
class Piranha { … }

Dog dog  = new Dog();
Piranha piranha  = new Piranha();

if (dog instanceof SafePet) …              // True
if (piranha instanceof SafePet) …          // False
```