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**

```java
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
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

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

```java
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
```