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

```java
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

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

```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
```