Recap

- We addressed the following items in the last week
- Notion of *design patterns*
  - **Composite**: compose objects in hierarchies
- UML Notation
  - Class Diagrams: Static relationship between classes

Notes

- I have posted a set of Lecture Notes to the moodle.
  - Fairly complete outline of the course
  - Will update as needed
- Repository with Design Patterns code examples[1]
- Office hours: Weds Morning until 10:30 and Tues 16-17

[1] `https://github.com/marks1024/java-projects`

Objectives

- Briefly Discuss the ACM Code of Ethics
- Continue talking about design patterns
  - Observer
  - Strategy
  - Singleton
  - Decorator

Code of Ethics in Software Engineering

- A joint task force of the ACM and IEEE created a guide to ethics consisting of 8 principles
- Think of the code as a *tool* rather than a *proscription*

ACM/IEEE Code of Ethics (Paraphrased)[2]

- PUBLIC act in the public interest
- CLIENT AND EMPLOYER act in the best interests of the client
- PRODUCT maintain high quality standards in software products
- JUDGEMENT integrity in professional judgments
- MANAGEMENT ethical approach to management of software projects
- PROFESSION maintain reputation of the profession
- COLLEAGUES treat your peers and colleagues with respect
- SELF continual learning over the lifetime in the profession

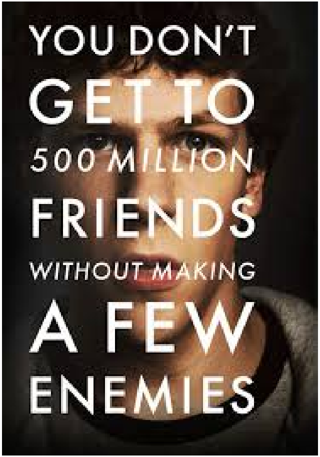
[2] Don Gotterbarn, Keith Miller, and Simon Rogerson. "Software engineering code of ethics". In: *Communications of the ACM* 40.11 (1997), pp. 110–118.

IT in Popular Culture[3]

- The media is an important perspective on software and tech.
- Some milestones of Programmers/Devs in Media
  - *True Names* (1981)
  - *Wargames* (1983)
  - *Jurassic Park* (1993)
  - *The Matrix* (1999)
  - *The Social Network* (2010)

[3] pictured: Dennis Nedry in *Jurasic Park* (1993)

Sidebar: The Social Network



- Quintessential image of the programmer in our time?

Current Issues in Software

- Privacy and Free Speech on social media
- 2016 US Elections
  - Secure systems (Clinton/DNC email hacking)
  - Influence of questionable news sources
- General Data Protection Regulation (GDPR)
  - *right to be forgotten*
  - *right to explanation*
- Recent headline: "HUD complaint accuses Facebook ads of violating Fair Housing Act"[4]

[4] https://techcrunch.com/2018/08/19/hud-complaint-accuses-facebook-ads-of-violating-fair-housing-act/

Design Patterns

- Patterns catalog a large amount of accumulated knowledge about designing systems
- *Discovered* rather than *invented*
- Clever uses of language features to make behaviors reconfigurable at *runtime*

Design Pattern[5]

Descriptions of communicating objects and classes that are customized to solve a general design problem in a particular context.

[5] Erich Gamma. *Design patterns: elements of reusable object-oriented software*. Pearson Education India, 1995.

The Observer Pattern

- Way to implement a publisher/subscriber relationship between objects
- Classes Involved:
  - Observable, Publisher, Subject
  - Observer, Subscriber, Listener
- Picture mechanism in two ways: Listeners *listen* for changes in Subject **or** Subject *notifies* Listeners of changes

Observer[6]

"Define a one-to-many dependency between objects so that when an object changes state, all its dependents are notified and updated automatically."

[6] Erich Gamma. *Design patterns: elements of reusable object-oriented software*. Pearson Education India, 1995.

Example

- For our example we will think of the subject as a sensor and the listeners some objects that need to be updated when the sensor detects an event
- Sensor will have the responsibility of updating its listeners of changes
- Requirements:
  - Interface for all listeners
  - Interface for the Subject
  - Subject needs to keep track of its listeners
- Gives enough information to sketch out a basic class diagram

Ordered Interactions

- UML *Sequence Diagrams* allow us to model the interaction between objects ordered in time
- Elements of Sequence Diagrams
    - Time runs down the page
    - Each object represented by a vertical line
    - *Actor* represented by a stick figure
    - Interactions between objects are represented by horizontal arrows
- In sequence diagrams only the order of interactions is shown

Simulating Events in a Separate Thread

- Create a new thread to create events randomly
- Implement the Runnable interface

```
@Override
public void run() {

int n = 20;

   try {
      while(!ended) {
         // System.out.format("Loop Number %d \n", n);
         n = n-1;
         if (n < 1) {
            ended=true;
         }

      Thread.sleep(1000);

      if (Math.random() > 0.6) {
         System.out.println("SensorEnv: Event! :)");
         sens.eventHappened();
      } else {
         System.out.println("SensorEnv: No Event! :(");
      }

      } // while
   } catch (InterruptedException e) {
      e.printStackTrace();
   }
}
```

Main Client

- The `main` method in our application creates the subject and listener objects
- A new thread is launched for the environment

```
public class SensorClient {

   public static void main(String[] args) {

      SensorSubject sens = new SensorSubject();
      SensorListener o1 = new SensorListener("Listener 1",sens);
      SensorListener o2 = new SensorListener("Listener 2",sens);

      Thread t = new Thread(new SensorEnv(sens));
      t.start();
   }
}
```

Sensed and Listens interfaces

- Interfaces are defined for both the publishers and subscribers
- Sensor needs to be able to register listeners and notify them
- The Listeners have one method for being updated

```
public interface Sensed {
   public void addListener(Listens o);
   public void removeListener(Listens o);
   public void notifyListeners();
}

public interface Listens {
   public void update();
}
```

Java Collections

```
private Set<Listens> sensorListeners;
// ...
this.sensorListeners = new HashSet<Listens>();
```

- Java Collections contain a number of *interfaces* for data structures: `List`,`Map`,`Queue`,`Set`
- Uniqueness matters for `Set`
- With `new` need one of the implementations such as `HashSet` or `ArrayList`

Exercise with Observer

- A number of classes have been given for demonstrating the observer pattern
- Remaining classes that are needed are the concrete implementations of the concrete `SensorSubject` and `SensorListener`

```
SensorEnv: No Event! :(
SensorEnv: No Event! :(
SensorEnv: Event! :)
SensorSubject: 1 Events Have Happened!
SensorListener: Update detected by Listener 2!
SensorListener: Update detected by Listener 1!
SensorEnv: No Event! :(
SensorEnv: No Event! :(
SensorEnv: No Event! :(
SensorEnv: No Event! :(
SensorEnv: Event! :)
SensorSubject: 2 Events Have Happened!
SensorListener: Update detected by Listener 2!
SensorListener: Update detected by Listener 1!
SensorEnv: No Event! :(
SensorEnv: No Event! :(
SensorEnv: No Event! :(
```

Coupling and Cohesion[7]

General Design Principle

Aim for *low coupling* and *high cohesion*

- The Observer pattern demonstrates the power of loosely coupled designs
- Coupling refers to how much one object has to know about another object to interact
- The subject cares that listeners implement the `Listens` interface
- Cohesion refers to how much a class does a single thing

[7] Eric Freeman et al. *Head first design patterns*. O'Reilly Media, Inc., 2004.

Strategy Pattern Example

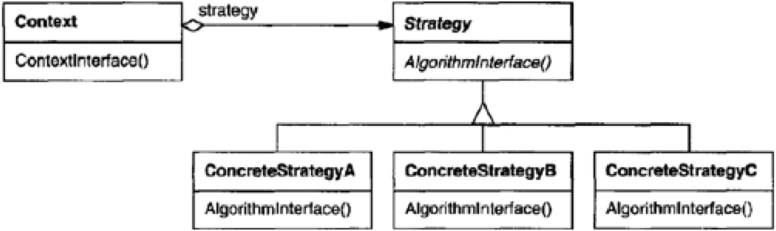
- *Strategy* is about being able to reconfigure algorithms at runtime
- Use encapsulation and delegation to make algorithms interchangeable
    - Different algorithms for objects of different classes
- In GoF, Strategy is motivated by an example of putting line breaks in text.

```
public class MyText {
    private String buff;

    public MyText(String buff) {
        this.buff = buff;
    }

    public String makeLineBreaks() {
        return // Implement linebreaking here
    }
}
```

Problems with a Simple Solution

- Linebreaking functionality baked into the `MyText` class
- Difficult/Awkward to change the linebreaking algorithm
  - Need to make changes to our main class
  - Switching between behaviors will require some fields and conditional/case statements
- Instead, abstract the algorithm into a separate interface

Strategy Design Pattern [8]



- An example of "favor composition over inheritance"
  - Get new linebreak behaviors by putting objects together, not subclassing
- Addresses the possibility of any future changes to the algorithm that may be needed

[8] Class diagram from Gamma, *Design patterns: elements of reusable object-oriented software*, op. cit.

Linebreaks with Strategy (1)

- The code below shows how the `MyText` class might look if we used strategy to vary the line-breaking behavior

```
public class MyText {
    private String buff;
    private BreakBehavior b;

    public MyText(String buff, BreakBehavior b) {
        this.buff = buff;
        this.b = b;
    }

    public String makeLineBreaks() {
        return b.linebreak(buff);
    }

    public void setB(BreakBehavior b) {
        this.b = b;
    }
}
```

Linebreaks with Strategy (2)

- To encapsulate a particular algorithm, write a class that implements the behavior interface

```
import org.apache.commons.text.WordUtils;

public class SimpleBreakBehavior implements BreakBehavior {
    @Override
    public String linebreak(String s) {
        return WordUtils.wrap(s, 10);
    }

}
```

Linebreaks with Strategy (3)

- We can write as many implementations of the algorithm as we need
- Easily change them at runtime using the setter method in the `MyText` class

```
public class NoBreakBehavior implements BreakBehavior {

    @Override
    public String linebreak(String s) {
        return s;
    }

}
```

Linebreaks with Strategy (4)

- The listing below shows how we might actually use the MyText class and change the runtime behavior

```
public class StrategyPatternExample {
    public static void main(String[] args) {
        MyText t = new MyText("This is a sentence.",
                               new SimpleBreakBehavior());

        System.out.println("---\nWith simple line breaks \n");
        System.out.println(t.makeLineBreaks());

        t.setB(new NoBreakBehavior());

        System.out.println("---\nWith no line breaks \n");
        System.out.println(t.makeLineBreaks());
    }
}
```

The Singleton Pattern

- The singleton pattern is used when we want to have a unique instance of a class and provide a global point of access to it.
- The pattern itself only consists of a single class
- Classic implementation of the singleton uses a private constructor and a static variable

Singleton

"Ensure a class has only one instance, and provide a global point of access to it." *GoF*

Restricting Object Creation

```
public class Singleton {
    //

    private Singleton() {}

    //
}
```

- The classic singleton implementation uses a `private` constructor
- What are the implications of this?

Providing access to the singleton instance

```
public class Singleton {

   private Singleton() {}

   public static Singleton getInstance() {}
}
```

- What should be the contents of the `getInstance()` method?

The getInstance() method

```
public class Singleton {

   private Singleton() {}

   public static Singleton getInstance() {
      return new Singleton();
      }
}
```

- What *type* of static variable do we need, and how can we ensure that only one object can be created.

The Complete Singleton Implementation

```
public class Singleton {
   private static Singleton uniqueInstance;

   private Singleton() {}

   public static Singleton getInstance() {
      if (uniqueInstance == null) {
         uniqueInstance = new Singleton();
         }

      return uniqueInstance;
      }
}
```

- Here we have all of the basic elements of the singleton pattern

Issues with Singleton

- Uses
  - Can be useful if we need some kind of global state in an application
  - Factory patterns often employ a singleton
- Issues
  - Usefulness or appropriateness of singletons are debated
  - Sometimes called an *antipattern*
  - Issue with multi-threading

Dealing with multi-threading

```
public static synchronized Singleton getInstance() {
   if (uniqueInstance == null) {
      uniqueInstance = new Singleton();
      }

   return uniqueInstance;
   }
```

- One option to deal with multi-threading problems is to declare the `getInstance()` method `synchronized`
- The synchronized keyword basically ensures that method calls are atomic

The Decorator Pattern

- Way to attach behavior or responsibilities to an object at runtime
- Classes Involved:
  - Component Interface
  - Base Classes
  - Decorator Classes

Decorator

"Attach additional responsibilities to an object dynamically. Decorators provide a flexible alternative to subclassing for extending functionality." *GoF*

UI Widgets or Views

- Implement classes for a simple windowed user interface beginning with a box that displays text, a `TextView`
- Variant of the text box should allow for scroll bars
- We might to also want other features such as fancy borders or a menu
- This is the problem of a *class explosion*
- Inheritance is not the best solution because it requires all possibilities to be known at the time of design

Example: Streams and File Readers

```
BufferedReader br = new BufferedReader(new FileReader("./text3.txt"));
```

- Typical syntax for reading a file in Java
- New functionality is obtained by passing the `FileReader` in the constructor of the `BufferedReader`
- A plain `FileReader` has been decorated with a `BufferedReader`

java.io Classes

- Many classes in the Java io library follow a similar pattern
- This code shows the example for an `InputStream`

```
InputStream is =
new LCInputStream(
  new BufferedInputStream(
    new FileInputStream("./text3.txt")));

    BufferedReader bufr =
    new BufferedReader(
      new InputStreamReader(is));
      StringBuilder sb = new StringBuilder();
      String line = new String();
      while((line = bufr.readLine()) != null) {
        sb.append(line);
      }
      bufr.close();
      is.close();

      dString = sb.toString();
```

Examining BufferedInputStream

```
public class BufferedInputStream extends FilterInputStream
```

- Wrap the `InputStream` in another object that introduces some additional functionality (in this case some simple text processing)
- Examine the `BufferedInputStream` code to see what our own class needs to do

```
InputStream is =
    new LCInputStream(
        new BufferedInputStream(
            new FileInputStream("./text3.txt")));
```

Decorator Example

- Write a simple example of the decorator for printing formatted text to the console
- Notice usage of the Java *reflection*

```
public static void main(String[] args) {
  TextComponent tx = new TextBase("The Text!");
  System.out.println(tx.getClass().toString());
  System.out.println(tx.produceText());

  tx = new CapitalDecorator(tx);
  System.out.println(tx.getClass().toString());
  System.out.println(tx.produceText());

  tx = new BorderDecorator(tx);
  System.out.println(tx.getClass().toString());
  System.out.println(tx.produceText());

  tx = new DashBorderDecorator(tx);
  System.out.println(tx.getClass().toString());
  System.out.println(tx.produceText());

}
```

Decorator Example From Scratch (cont.)

- Output from the application is shown below
- As we decorator with more objects the object assumes more responsibilities

```
class com.example.textdecorator.TextBase
The Text!
class com.example.textdecorator.CapitalDecorator
THE TEXT!
class com.example.textdecorator.BorderDecorator
*** THE TEXT! ***
class com.example.textdecorator.DashBorderDecorator
--- *** THE TEXT! *** ---
```

The Base Class

- Output from the application is shown below
- As we decorator with more objects the object assumes more responsibilities

```
public class TextBase extends TextComponent {

  private String s;

  public TextBase(String s) {
    this.s = s;
  }

  @Override
  public String produceText() {
    return s;
  }
}
```

The Decorator Interface

- The Decorator interface contains a component field called `next` to which it delegates the functionality of `produceText()`

```
public abstract class TextDecorator extends TextComponent {
  protected TextComponent next;

  public TextDecorator(TextComponent t) {
    this.next = t;
  }

  public String produceText() {
    return this.next.produceText();
  }
}
```

A Concrete Decorator Implementation

- We can introduce new behaviors in our decorator implementations

```
public class DashBorderDecorator extends TextDecorator {

  public DashBorderDecorator(TextComponent t) {
    super(t);
  }

  @Override
  public String produceText() {
      return "--- " + super.produceText() + " ---";
  }
}
```

Open-Closed Principle and Delegation

General Design Principle

Classes should be open for extension but closed for modification

- Want to extend functionality without having to modify source code
- When using a deep inheritance tree the design can become rigid or there may be too much implementation code in the base classes
- Delegation:
  - The Decorator delegates part of its responsibilities to the object that it wraps