The 5 Stages of Debugging
At some point in each of our lives, we must face errors in our code. Debugging is a natural healing process to help us through these times. It is important to recognize these common stages and realize that debugging will eventually come to an end.

**Denial**
This stage is often characterized by such phrases as "What? That's impossible," or "I know this is right." A strong sign of denial is recompiling without changing any code, "just in case."

**Bargaining/Self-Blame**
Several programming errors are uncovered and the programmer feels stupid and guilty for having made them. Bargaining is common: "If I fix this, will you please compile?" Also, "I only have 14 errors to go!"

**Anger**
Cryptic error messages send the programmer into a rage. This stage is accompanied by an hours-long and profanity-filled diatribe about the limitations of the language directed at whomever will listen.

**Depression**
Following the outburst, the programmer becomes aware that hours have gone by unproductively and there is still no solution in sight. The programmer becomes listless. Posture often deteriorates.

**Acceptance**
The programmer finally accepts the situation, declares the bug a "feature", and goes to play some Quake.
Section 9: Design Patterns

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with material from David Mailhot, Hal Perkins, Mike Ernst
Agenda

• What are design patterns?
• Creational patterns
• Structural patterns
What Is A Design Pattern

- A standard solution to a common programming problem
- A technique for making code more flexible
- Shorthand for describing program design and how program components are connected
Creational Patterns

• Problem: Constructors in Java are not flexible
  o Always return a fresh new object, never reuse one
  o Can’t return a subtype of the class they belong to

• Solution: Creational patterns!
  o Sharing
    • Singleton
    • Interning
    • Flyweight
  o Factories
    • Factory method
    • Factory object
  o Builder
Creational Patterns: Sharing

- The old way: Java constructors always return a new object
- **Singleton**: only one object exists at runtime
  - Factory method returns the same object every time
- **Interning**: only one object with a particular (abstract) value exists at runtime
  - Factory method returns an existing object, not a new one
- **Flyweight**: separate intrinsic and extrinsic state, represents them separately, and interns the intrinsic state
  - Implicit representation uses no space
  - Not as common/important
Creational Patterns: Singleton

• For a class where only one object of that class can ever exist

• Two possible implementations
  o Eager instantiation: creates the instance when the class is loaded to guarantee availability
  o Lazy instantiation: only creates the instance once it’s needed to avoid unnecessary creation
Creational Patterns:
Singleton

Eager instantiation

```java
public class Bank {
    private static Bank INSTANCE = new Bank();

    // private constructor
    private Bank() { … }

    // factory method
    public static Bank getInstance() {
        return INSTANCE;
    }
}
```

```java
Bank b = new Bank();
Bank b = Bank.getInstance();
```
Creational Patterns: Singleton

- Lazy instantiation

```java
public class Bank {
    private static Bank INSTANCE;

    // private constructor
    private Bank() { … }

    // factory method
    public static Bank getInstance() {
        if (INSTANCE == null) {
            INSTANCE = new Bank();
        }
        return INSTANCE;
    }
}

Bank b = new Bank();
Bank b = Bank.getInstance();
```
Creational Patterns: Singleton

• Would you prefer eager or lazy instantiation for an HttpServletRequest class?
  o handles authentication
  o definitely needed for any HTTP transaction

• Would you prefer eager or lazy instantiation for a Comparator class?
  o compares objects
  o may or may not be used at runtime
public class HttpRequest {
    private static class HttpRequestHolder {
        public static final HttpRequest INSTANCE = new HttpRequest();
    }

    /* Singleton – Don’t instantiate */
    private HttpRequest() { … }

    public static HttpRequest getInstance() {
        return HttpRequestHolder.INSTANCE;
    }
}
public class LengthComparator implements Comparator<String> {
    private int compare(String s1, String s2) {
        return s1.length() - s2.length();
    }

    /* Singleton – Don’t instantiate */
    private LengthComparator() { ... }
    private static LengthComparator comp = null;

    public static LengthComparator getInstance() {
        if (comp == null) {
            comp = new LengthComparator();
        }
        return comp;
    }
}

Creational Patterns: Singleton
Creational Patterns: Interning

• Similar to Singleton, except instead of just having one object per class, there’s one object per **abstract value** of the class
• Saves memory by compacting multiple copies
• Requires the class being interned to be immutable. Why?
public class Point {
    private int x, y;

    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }

    public int getX() { return x; }
    public int getY() { return y; }

    @Override
    public String toString() {
        return "(" + x + "," + y + ")";
    }
}
public class Point {
    private static Map<String, Point> instances =
        new WeakHashMap<String, Point>();

    public static Point getInstance(int x, int y) {
        String key = x + "," + y;
        if (!instances.containsKey(key))
            instances.put(key, new Point(x, y));
        return instances.get(key);
    }

    private final int x, y; // immutable
    private Point(int x, int y) {
    }
}

If our point was represented with r and theta, we’d need to constrain them for use in the key. Otherwise, we’d have “5, pi” and “5, 3pi” as different entries in our map even though they are the same abstract value.
public class City {
    public Stereotype getStereotypicalPerson() {
    }
}

City seattle = new City();
seattle.getStereotypicalPerson();
// we want a SeattleStereotype
Creational Patterns: Factories

- Factories solve the problem that Java constructors cannot return a subtype of the class they belong to.

- Two options:
  - Factory method
    - Helper method creates and returns objects
    - Method defines the interface for creating an object, but defers instantiation to subclasses
  - Factory object
    - Abstract superclass defines what can be customized
    - Concrete subclass does the customization, returns appropriate subclass
    - Object provides the interface for creating families of related/dependent objects without specifying their concrete classes
Creational Patterns: Factory Method

```java
public class City {
    public Stereotype getStereotypicalPerson() {…}
}

public class Seattle extends City {
    @Override
    public Stereotype getStereotypicalPerson() {
        return new SeattleStereotype();
    }
}

City seattle = new Seattle();
seattle.getStereotypicalPerson();
```
interface StereotypeFactory {
    Stereotype getStereotype();
}
class SeattleStereotypeFactory implements StereotypeFactory {
    public Stereotype getStereotype() {
        return new SeattleStereotype();
    }
}

class City {
    public City(StereotypeFactory f) {...}
    public Stereotype getStereotypicalPerson() {
        f.getStereotype();
    }
}

City seattle = new City(new SeattleStereotypeFactory());
seattle.getStereotypicalPerson();
interface Button {
    void paint();
}

class WinButton implements Button {
    public void paint() {
        System.out.println("I'm a WinButton");
    }
}

class OSXButton implements Button {
    public void paint() {
        System.out.println("I'm an OSXButton");
    }
}

interface GUIFactory {
    Button createButton();
}

class WinFactory implements GUIFactory {
    public Button createButton() {
        return new WinButton();
    }
}

class OSXFactory implements GUIFactory {
    public Button createButton() {
        return new OSXButton();
    }
}

From: http://en.wikipedia.org/wiki/Abstract_factory_pattern
public class Application {
    public static void main(String[] args) {
        GUIFactory factory = createOSSpecificFactory();
        Button button = factory.createButton();
        button.paint();
    }

    public static GUIFactory createOSSpecificFactory() {
        int sys = readFromConfigFile("OS_TYPE");
        if (sys == 0) return new WinFactory();
        else return new OSXFactory();
    }
}
Creational Patterns: Builder

• The class has an inner class `Builder` and is created using the `Builder` instead of the constructor.
• The `Builder` takes optional parameters via setter methods (e.g., `setX()`, `setY()`, etc.).
• When the client is done supplying parameters, she calls `build()` on the `Builder`, finalizing the builder and returning an instance of the object desired.
public class NutritionFacts {
    // required
    private final int servingSize, servings;
    // optional
    private final int calories, fat, sodium;

    public NutritionFacts(int servingSize, int servings) {
        this(servingSize, servings, 0);
    }

    public NutritionFacts(int servingSize, int servings, int calories) {
        this(servingSize, servings, calories, 0);
    }

    public NutritionFacts(int servingSize, int servings, int calories, int fat) {
        this(servingSize, servings, calories, fat, 0);
    }

    public NutritionFacts(int servingSize, int servings, int calories, int fat, int sodium) {
        this.servingSize  = servingSize;
        this.servings     = servings;
        this.calories     = calories;
        this.fat          = fat;
        this.sodium       = sodium;
    }
}
public class NutritionFacts {
    private final int servingSize, servings, calories, fat, sodium;

    public static class Builder {
        // required
        private final int servingSize, servings;
        // optional, initialized to default values
        private final int calories = 0;
        private final int fat = 0;
        private final int sodium = 0;

        public Builder(int servingSize, int servings) {
            this.servingSize = servingSize;
            this.servings = servings;
        }

        public Builder calories(int val) { calories = val; return this; }
        public Builder fat(int val) { fat = val; return this; }
        public Builder sodium(int val) { sodium = val; return this; }
        public NutritionFacts build() { return new NutritionFacts(this); }
    }

    public NutritionFacts(Builder builder) {
        this.servingSize = builder.servingSize;
        this.servings = builder.servings;
        this.calories = builder.calories;
        this.fat = builder.fat;
        this.sodium = builder.sodium;
    }
}
Creational Patterns: Builder

- Useful when you have many constructor parameters
  - It is hard to remember which order they should all go in
- Easily allows for optional parameters
  - If you have $n$ optional parameters, you need $2^n$ constructors, but only one builder
Structural Patterns

- Problem: Sometimes difficult to realize relationships between entities
  - Important for code readability
- Solution: Structural patterns!
  - We’re just going to talk about wrappers, which translate between incompatible interfaces

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Functionality</th>
<th>Interface</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapter</td>
<td>same</td>
<td>different</td>
<td>modify the interface</td>
</tr>
<tr>
<td>Decorator</td>
<td>different</td>
<td>same</td>
<td>extend behavior</td>
</tr>
<tr>
<td>Proxy</td>
<td>same</td>
<td>same</td>
<td>restrict access</td>
</tr>
</tbody>
</table>
Structural Patterns: Adapter

- Changes an interface without changing functionality
  - Rename a method
  - Convert units

- Examples:
  - Angles passed in using radians vs. degrees
  - Bytes vs. strings
  - Hex vs. decimal numbers
Structural Patterns: Decorator

- Adds functionality without changing the interface
  - Add caching
- Adds to existing methods to do something additional while still preserving the previous spec
  - Add logging
- Decorators can remove functionality without changing the interface
  - UnmodifiableList with add() and put()
Structural Patterns: Proxy

• Wraps the class while maintaining the same interface and functionality
• Integer vs. int, Boolean vs. boolean
• Controls access to other objects
  o Communication: manage network details when using a remote object
  o Security: permit access only if proper credentials
  o Creation: object might not yet exist because creation is expensive