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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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
  - Always return a fresh new object, never reuse one
  - Can't return a subtype of the class they belong to

- Solution: Creational patterns!
  - Sharing
    - Singleton
    - Interning
    - Flyweight
  - Factories
    - Factory method
    - Factory object
  - 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

- Variety of possible implementations
  - Eager instantiation: creates the instance when the class is loaded to guarantee availability
  - 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;
    }
}

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

- HTTPRequest class handles authentication
- Don't want to have to redo authentication for each request
- Would you prefer eager or lazy instantiation here? Why?

Creational Patterns: Singleton

```java
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;
    }
}
```

Creational Patterns: Singleton

- Comparator compares objects
- Only needs to be created once
- Doesn't hold state that is important during runtime
- Would you prefer eager or lazy instantiation here? Why?

Creational Patterns: Singleton

```java
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: 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?

Creational Patterns: Interning

```java
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 + ")";
    }
}
```

Creational Patterns: Interning

```java
public class Point {
    public static Map<String, Point> instances =
        new HashMap<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
    public 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.   •

Creational Patterns: Factories

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


City seattle = new City();
seattle.getSterotypicalPerson();
// 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
  - Factory object
    - Abstract superclass defines what can be customized
    - Concrete subclass does the customization, returns appropriate subclass

Creational Patterns: Factory Method

```
public class City {
        public Stereotype getStereotypicalPerson() {…}
}
public class Seattle extends City {
        @Override
        public Stereotype getStereotypicalPerson() {
                return new SeattleStereotype();
        }
}
City seattle = new Seattle();
seattle.getSterotypicalPerson();
```

Creational Patterns: Factory Object

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

Creational Patterns: Factory Object

```java
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");
    }
}
```

```java
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

Creational Patterns: Factory Object

```java
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();
    }
}
```

From: http://en.wikipedia.org/wiki/Abstract_factory_pattern

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

Creational Patterns: Builder

```java
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;
}
```

Creational Patterns: Builder

```java
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

Creational Patterns: Test Your Knowledge

- Pretend that we're making a SportsGame class that will be used to represent a sporting event

- Each SportsGame instance will keep track of the athletes on each team

- We want to be able to talk about specific sports, like basketball and football

- Football games will only have football players, basketball games will only have basketball players, etc…

Creational Patterns: Test Your Knowledge

```java
public class SportsGame {

    private ArrayList<Athlete> team1, team2;

    public SportsMatch() {
        team1 = new ArrayList<Athlete>();
        team2 = new ArrayList<Athlete>();
        team1.add(makeAthlete());
        team2.add(makeAthlete());
    }
    protected Athlete makeAthlete() {
        return new Athlete();
    }
}
```

What if I want to make a BasketballGame?

Creational Patterns: Test Your Knowledge

```java
public class BasketballGame {

    private ArrayList<BasketballPlayer> team1, team2;

    public SportsMatch() {
        team1 = new ArrayList<BasketballPlayer>();
        team2 = new ArrayList<BasketballPlayer>();
        team1.add(makeBasketballPlayer());
        team2.add(makeBasketballPlayer());
    }
    protected BasketballPlayer makeBasketballPlayer() {
        return new BasketballPlayer();
    }
}
```

Creational Patterns: Test Your Knowledge

```java
public class SportsGame {

        private ArrayList<Athlete> team1, team2;

        public SportsMatch() {
                team1 = new ArrayList<Athlete>();
                team2 = new ArrayList<Athlete>();
                team1.add(makeAthlete());
                team2.add(makeAthlete());
        }
        protected makeAthlete() {
                return new Athlete();
        }
}

public class BasketballGame extends SportsGame {
        @Override
        protected Athlete makeAthlete() {
                return new BasketballPlayer();
        }
}
```

template method => Factory Method

BasketballGame extends SportsGame

BasketballPlayer is a subclass of Athlete

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

Pattern	Functionality	Interface	Purpose
Adapter	same	different	modify the interface
Decorator	different	same	extend behavior
Proxy	same	same	restrict access

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
  - Communication: manage network details when using a remote object
  - Security: permit access only if proper credentials
  - Creation: object might not yet exist because creation is expensive