CMSC 132: Object-Oriented Programming II

Effective Java II

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Effective Java

Collection of tips for programming in Java

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Quick look at 3 topics (out of 57)

1. Duplicate Object Creation
2. Defensive Copying
3. Immutable Classes

Slides borrowed from Bloch & adapted
1) Avoid Duplicate Object Creation

- Reuse existing object instead

- Simplest example

  ```java
  String s = new String("DON’T DO THIS!");
  String s = "Do this instead";
  ```

- Since Strings constants are reused

- In loops, savings can be substantial
public class Person {
    private final Date birthDate;

    public Person(Date birthDate) {
        this.birthDate = birthDate;
    }

    // UNNECESSARY OBJECT CREATION
    public boolean bornBefore2000() {
        Calendar gmtCal = Calendar.getInstance(TimeZone.getTimeZone("GMT"));
        gmtCal.set(2000, Calendar.JANUARY, 1, 0, 0, 0);
        Date MILLENIUM = gmtCal.getTime();
        return birthDate.before(MILLENIUM);
    }
}
Object Duplication Example (cont.)

```java
class Person {
    ...
    // STATIC INITIALIZATION CREATES OBJECT ONCE
    private static final Date MILLENIUM;
    static {
        Calendar gmtCal = Calendar.getInstance(TimeZone.getTimeZone("GMT"));
        gmtCal.set(2000, Calendar.JANUARY, 1, 0, 0, 0);
        Date MILLENIUM = gmtCal.getTime();
    }
    public boolean bornBefore2000() {
        return birthDate.before(MILLENIUM);
    }
}
```
Object Duplication Summary

- Don’t create unnecessary duplicate objects
  - Reuse improves clarity and performance

- But don't be afraid to create objects
  - Object creation is cheap on modern JVMs
  - Can enhance simplicity, power, robustness
2) Defensive Copying

- Java programming language is safe
  - Immune to buffer overruns, wild pointers, etc…
  - Unlike C, C++

- Makes it possible to write robust classes
  - Correctness doesn’t depend on other modules
  - Even in safe language, requires effort
Defensive Programming

- Assume clients will try to destroy invariants
  - May actually be true
  - More likely – honest mistakes

- Ensure class invariants survive any inputs
This Class is Not Robust!

// GOAL – PERSON’S BIRTHDAY IS INVARIANT

public class Person {
    // PROTECTS birthDate FROM MODIFICATION?
    private final Date birthDate;
    public Person(Date birthDate) {
        this.birthDate = birthDate;
    }
    // RETURNS birthDate
    public Date bday() { return birthDate; }
}
The Problem – Date is Mutable

Constructors can allow invariant to be modified

// ATTACK INTERNALS OF PERSON
Date today = new Date();
Person p = new Person(today);
today.setYear(78);    // MODIFIES P’S BIRTHDAY!
The Solution – Defensive Copying

public class Person {
  private final Date birthDate;

  // REPAIRED CONSTRUCTOR
  // DEFENSIVELY COPIES PARAMETERS
  public Person(Date birthDate) {
    this.birthDate = new Date(birthDate.getTime());
  }

  // RETURNS birthDate
  public Date bday() { return birthDate; }
}
An Important Detail

- First copy parameters, then check copy validity
- Eliminate window of vulnerability...
- ...between parameter check and copy
- Thwarts multithreaded attack

```java
public Person(Date birthDate) {
  // VULNERABLE, DON’T CHECK birthDate HERE
  this.birthDate =
      new Date(birthDate.getTime());
  // CHECK this.birthDate HERE INSTEAD
}
```
Another Important Detail

- Use constructor, not clone, to make copies
  - Necessary because Date class is nonfinal
- Attacker could implement malicious subclass
  - Records reference to each instance in list
  - Provides attacker with access to instance list
- ...and pass subclass to Person() constructor
Malicious subclass example

```java
public class MaliciousDate extends Date {
    public long getTime() {
        sendToAttacker(this);
        return super.getTime();
    }

    public int compareTo(Object o) {
        sendToAttacker(o);
        return super.compareTo(o);
    }
}
```

MaliciousDate myBad = new MaliciousDate();
Person p = new Person( mybad );
More Defensive Copying

- Constructors are only half the battle
- Accessors can allow invariant to be modified

```java
// ACCESSOR ATTACK ON INTERNALS OF PERSON
Date today = new Date();
Person p = new Person(today);
Date bday = p.bday();
bday.setYear(78); // MODIFIES P’S BIRTHDAY!
```
More Defensive Copying

Solution – defensive copying in accessors

```java
// REPAIRED ACCESSOR DEFENSIVELY COPY FIELDS
public class Person {
   // RETURNS CLONE (COPY) OF birthDate
   public Date bday() {
      return (Date) birthDate.clone();
   }
}

Now Person class is robust!
```
Defensive Copying Summary

- Don’t incorporate mutable parameters into object – make defensive copies
  - Constructors
  - Static factories
  - Pseudo-constructors
  - Mutators
- Return defensive copies of mutable fields
  - Accessors
- Real lesson – use immutable components
  - Eliminates the need for defensive copying
3) Immutable Classes

- Class whose instances cannot be modified
- Examples
  - String
  - Integer
  - BigInteger
- How, why, and when to use them
How to Write an Immutable Class

- Don’t provide any mutators
- Ensure that no methods may be overridden
- Make all fields final
- Make all fields private
- Ensure exclusive access to any mutable components
public final class Fval {
   private final float f;
   public Fval(float f) {
      this.f = f;
   }
   // ACCESSORS WITHOUT CORRESPONDING MUTATORS
   public float value() { return f; }

   // ALL OPERATIONS RETURN NEW Fval
   public Fval add(Fval x) {
      return new Fval(f + x.f);
   }
   // SUBTRACT, MULTIPLY, ETC. SIMILAR TO ADD
public boolean equals(Object o) {
    if (o == this) return true;
    if (!(o instanceof Fval))
        return false;
    Fval c = (Fval) o;
    return (Float.floatToIntBits(f) ==
            Float.floatToIntBits(c.f));
}
Distinguishing Characteristic

- Return new instance instead of modifying
- Functional programming
- May seem unnatural at first
- Many advantages
Advantage 1 – Simplicity

- Instances have exactly one state
- Easy to design, implement
- Constructors establish invariants
- Invariants can never be corrupted
- Requires no effort on the part of clients
Advantage 2 – Inherently Thread-Safe

- No need for synchronization
  - Internal or external
  - Since no writes to shared data
- Can’t be corrupted by concurrent access
- By far the easiest approach to thread safety
Advantage 3 – Can Be Shared Freely

// EXPORTED CONSTANTS
public static final Fval ZERO = new Fval(0);
public static final Fval ONE  = new Fval(1);

// STATIC FACTORY CAN CACHE COMMON VALUES
public static Fval valueOf(float f) { ... }

// PRIVATE CONSTRUCTOR MAKES FACTORY MANDATORY
private Fval (float f) {
    this.f = f;
}
Advantage 4 – No Copies

- No need for defensive copies
- No need for any copies at all!
- No need for clone or copy constructor
- Not well understood in the early days

```java
public String(String s);  // Should not exist
```
Advantage 5 – Composability

- Excellent building blocks
- Easier to maintain invariants
  - If component objects won't change
- Special cases
  - Map keys
  - Set elements
The Major Disadvantage

- Separate instance for each distinct value
- Creating these instances can be costly
  
  ```java
  BigInteger moby = ...;  // A million bits
  moby = moby.flipBit(0); // Ouch!
  ```
  
- Problem magnified for multistep operations
  - Provide common multistep operations as primitives
  - Alternatively provide mutable companion class
When To Make Classes Immutable

- Always, unless there's a good reason not to
- Always make small “value classes” immutable
  - Color
  - PhoneNumber
  - Price
- Date and Point (both mutable) were mistakes!
- Experts often use long instead of Date
When To Make Classes Mutable

- Class represents entity whose state changes
  - Real world
    - BankAccount, TrafficLight
  - Abstract
    - Iterator, Matcher, Collection
  - Process classes
    - Thread, Timer

- If class must be mutable, minimize mutability
  - Constructors should fully initialize instance
  - Avoid reinitialize methods
More Effective Java Summary

- Reuse objects where appropriate
  - Improves clarity and performance
- Make defensive copies where required
  - Provides robustness
- Write immutable classes
  - Simple, thread-safe, sharable and reusable