

CMSC 132: Object-Oriented Programming II

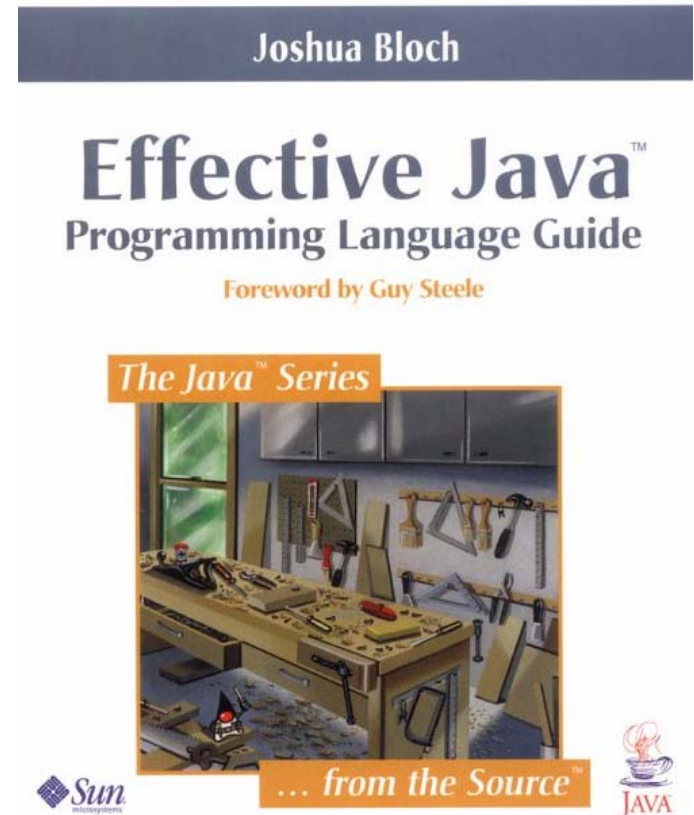


Effective Java II

Department of Computer Science
University of Maryland, College Park

Effective Java

- **Collection of tips for programming in Java**
 - **By Joshua Bloch (Sun)**
- **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

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

- Since Strings constants are reused

- In loops, savings can be substantial

Object Duplication Example

```
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.)

```
public 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() { // FASTER!  
        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**

```
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**

Another Important Detail (cont.)

■ Malicious subclass example

```
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

```
// 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

```
// 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**

Immutable Fval Class Example

```
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
```

Immutable Float Example (cont.)

```
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
 - `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

```
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
 - Examples
 - 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**