



Principles of Computer Science I

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CSC 120 – Fall 2006
Lecture Unit 9 - Designing Classes



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Lecture Outline

- Choosing and designing classes
 - UML
- Understanding side effects
- Pre- and postconditions
- Static methods and fields
- Scope rules
- Organizing classes using packages

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Choosing Classes

- Class represents a single concept/abstraction from the problem domain
 - Name for the class should be a *noun*
- Concepts from mathematics
 - Point
 - Rectangle
 - Eclipse
- Abstractions of real-life entities
 - BankAccount
 - CashRegister


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Choosing Classes (cont.)

- *Actor* classes (names end in *-er*, *-or*)
 - Objects of these classes do some sort of work for you
 - Scanner
 - Random (better name: RandomNumberGenerator)
- *Utility* classes
 - No objects; just contain collection of static methods and constants
 - Math
- *Program starters*
 - Contain only a *main* method
- Actions are not classes: e.g. ComputePaycheck

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Cohesion

- Criteria for analyzing quality of a public interface: *cohesion* and *coupling*
- A class should represent a single concept
 - Cohesive: all its features relate to the concept that the class represents
- Non-cohesive example (split into two classes):


```
public class CashRegister {
    public void enterPayment(int dollars, int quarters, int dimes,
                           int nickels, int pennies)
    . . .
    public static final double NICKEL_VALUE = 0.05;
    public static final double DIME_VALUE = 0.1;
    public static final double QUARTER_VALUE = 0.25;
    . . .
}
```

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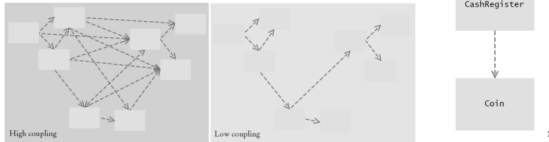
Coupling

- A class *depends* on another if it uses objects of that class
 - CashRegister depends on Coin (not vice versa)
- *Coupling*: the amount of dependence classes have on each other
 - Many classes of a program depend on each other: high coupling
 - Few dependencies between classes: low coupling
- Which is better, high or low?
 - Hint: think about effect of interface changes

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UML Diagrams

- 'Unified Modeling Language'
 - Notation for object-oriented analysis and design
- Class diagrams denote dependencies by dashed line with arrow pointing to class that is depended on



Consistency

- Another useful criterion for good design
- Follow consistent scheme for class/method names and parameters
- Java standard library contains many inconsistencies
 - `JOptionPane.showInputDialog(prompt)`
 - `JOptionPane.showMessageDialog(null, message)`

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Accessor/Mutator Methods

- *Accessor*: does not change the state of the implicit parameter

```
double balance = account.getBalance();
```
- *Mutator*: modifies the object on which it is invoked

```
account.deposit(1000);
```

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Immutable Classes

- Contains only accessor methods, no mutator methods
- Example: `String`

```
String name = "John Q. Public";
String uppercased = name.toUpperCase();
// name is not changed
```
- Advantage of immutable classes
 - Safe to give out copies of references to objects – object cannot be modified unexpectedly

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Side Effects

- *Side effect*: any externally observable modification of data
 - Mutator method modifies implicit parameter object
 - Another kind of side effect:

```
public void transfer(double amount, BankAccount other) {
    balance = balance - amount;
    other.balance = other.balance + amount;
    // Modifies explicit parameter
}
```

 - Updating explicit parameter can be surprising – best to avoid
 - Another kind of side effect: output

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Output Side Effects

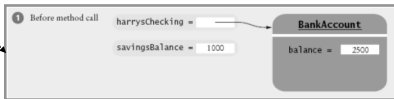
- ```
public void printBalance() { // Not recommended
 System.out.println("The balance is now $" + balance);
}
```
- Problems:
    - Message in English
    - Depends on `System.out`
  - Best to decouple input/output from actual work of classes
  - In general, try to minimize side effects beyond modification of implicit parameter

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## Common Error: Trying to Modify Primitive Type Parameter

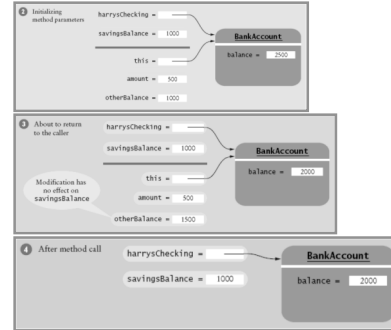
- Scenario (doesn't work):
 

```
double savingsBalance = 1000;
harrysChecking.transfer(500, savingsBalance);
System.out.println(savingsBalance);
...
void transfer(double amount, double otherBalance) {
 balance = balance - amount;
 otherBalance = otherBalance + amount;
}
```



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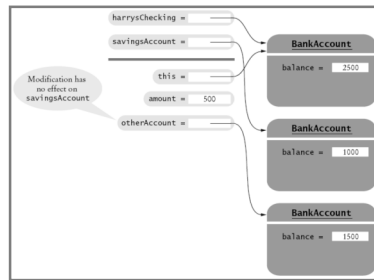
## Modifying Primitive Type Parameter has no Effect on Caller



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## Call-by-Value Example

harrysChecking.transfer(500, savingsAccount);



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## Call-by-Value / Call-by-Reference

- Call by value:** Method parameters are copied into the parameter variables when a method starts
- Call by reference:** Methods can modify parameters
- Java has call by value for both primitive types and object references
  - A method can change state of object reference parameters, but cannot replace an object reference with another

```
public class BankAccount {
 ...
 public void transfer(double amount, BankAccount otherAccount) {
 balance = balance - amount;
 double newBalance = otherAccount.balance + amount;
 otherAccount = new BankAccount(newBalance); // Won't work
 }
}
```

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## Preconditions

- Precondition:** Requirement that the caller of a method must meet
  - If precondition is violated, method is not responsible for computing correct result
- Good idea to document preconditions so that callers don't pass bad parameters
- Typical uses of preconditions
  - To restrict/constrain parameters of a method
  - To require that method is only called when object is in an appropriate state

```
/**
 * Deposits money into this account.
 * @param amount the amount of money to deposit
 * (Precondition: amount >= 0)
 */
public void deposit(double amount) { . . . }
```

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## Checking Preconditions

- Method may skip check of the precondition (puts full trust/responsibility on caller)
  - Efficient, but dangerous if there is a violation
- May throw an exception (Ch. 15)
  - Inefficient - has to check every time
- May use an assertion check
  - Causes error if the assertion fails
- After testing, can disable all assertion checks to allow program to run at full speed

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## Assertions

- Syntax: `assert condition;`
- Logical condition in a program that you believe should be true

```
public void deposit(double amount) {
 assert amount >= 0;
 balance = balance + amount;
}
```

- By default, assertion checking is disabled when running Java programs
- To enable assertion checking:
  - `java -enableassertions MyProgramName`
  - Can use `-ea` as shortcut instead of `-enableassertions`

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## Bad Way to Handle Violations

```
public void deposit(double amount) {
 if (amount < 0) return;
 balance = balance + amount;
}
```

- Doesn't abort the program if precondition is violated
- But hard to debug if something is going wrong – nothing to tell you cause of the problem

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## Postconditions

- Condition that is true after a method is completed
  - If method is called according to its preconditions, then is must ensure that its postconditions hold
- Two kinds of postconditions
  - Return value is computed correctly
  - Object is in a certain state after method call is completed

```
/**
 * Deposits money into this account.
 * (Postcondition: getBalance() >= 0)
 * @param amount the amount of money to deposit
 * (Precondition: amount >= 0)
 */
```

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## Pre- and Postconditions

- Don't document trivial postconditions that repeat the @return clause

```
/**
 * ...
 * @return the account balance
 * (Postcondition: the return value equals the account balance
 * ...
 */
```
- State conditions in terms of public interface, not private fields

```
amount <= getBalance()
// not account <= balance
```
- Pre- and postconditions spell out a contract between pieces of code

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## Class Invariants

- Statement about an object that is true after every constructor and is preserved by every mutator (provide preconditions are met)

```
/**
 * A bank account has a balance that can be
 * changed by deposits and withdrawals
 * (Invariant: getBalance() >= 0)
 */
public class BankAccount { ... }
```

- Once you formulate a class invariant, check that the methods preserve it

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## Static Methods

- In Java, every method must be defined within a class
  - Most methods operate on a particular instance of an object of that class (the 'implicit parameter')
  - Some methods are not invoked (called) on an object
- Example: `Math.sqrt( x )`
- Why?
  - Method does some computation that only needs numbers – numbers aren't objects, so can't call methods on them: `x.sqrt()` is not legal in Java ( `x` is a double )

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## Static Methods (cont.)

```
public class Financial {
 /** Computes a percentage of an amount.
 * @param p the percentage to apply
 * @param a the amount to which the percentage is applied
 * @return p percent of a
 */
 public static double percentOf(double p, double a) {
 return (p / 100) * a;
 }
 // More financial methods can be added here . . .
}
```

- To call a static method, use class name, not an object  
`double tax = Financial.percentOf( taxRate, total );`
- main method is static because there are no objects when program first starts

- Note: origin of term 'static' is historical; better name would be *class methods*

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## Static Fields

- A *static field* belongs to the class, not to any single object of the class
  - Also called a 'class field'
  - Static field is shared by all instances of the same class

```
public class BankAccount {
 . . .
 private double balance;
 private int accountNumber;
 private static int lastAssignedNumber = 1000;
}
```

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## Initializing Static Fields

- Three ways
  - Do nothing – will be initialized to default values (0 for numbers, false for boolean, null for objects)
  - Use an explicit initializer  
`private static int lastAssignedNumber = 1000;`
  - Use a static initialization block
    - Less common - Advanced topic 9.3

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## Static Field Access

- Static fields should always be private
- Exception: Static constants, may be public to allow other classes to access them

```
public class BankAccount {
 . . .
 public static final double OVERDRAFT_FEE = 5.0;
}
```

- Minimize the use of static fields (except static final fields - constants)

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## Scope of Variables

- The *scope* of a variable: region of a program in which the variable can be accessed
- Local variable scope extends from point of declaration to end of enclosing block
- Scope of a local variable cannot contain definition of another variable with the same name
- Can have local variables with identical names if scopes do not overlap
  - Example: same variable name can be used in different methods - refers to different variables

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## Scope of Class Members

- Members: fields and methods collectively
- Private members have *class scope*: can be accessed anywhere within the class
- Public members accessible by any code
  - From outside the class, must use *qualified name*
    - `Math.sqrt` or `other.balance`
  - Within the class, do not need to qualify field and method names
    - Refer automatically to `this` – the implicit parameter

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## Overlapping Scope

```
public class Coin {
 ...
 public Coin(double value, String name) {
 this.value = value;
 this.name = name;
 }
 public double getExchangeValue(double exchRate) {
 double value; // local variable
 ...
 return value;
 }
 ...
 private String name;
 private double value;
}
```

- Local variables *shadow* fields (instance variables) with the same name
- Shadowed fields can still be accessed by qualifying them explicitly with the `this` reference

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## Organizing Classes

- Large Java programs consist of many classes (10+, 100+, ...)
- Problem: having all those files just in one directory
- Package**: set of related Java classes
  - Structuring mechanism to organize files/classes
- All classes in a given package have line at the top of the file:
 

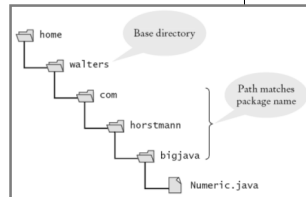
```
package packageName;
```

  - Package names consist of one or more identifiers separated by periods
    - `com.horstmann.bigjava`

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## Package Structure

- Java *package* and *class* names correspond to *directory* (folder) and *file* names



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## Some Standard Library Packages

| Package       | Purpose                                   | Sample Class |
|---------------|-------------------------------------------|--------------|
| java.lang     | Language Support                          | Math         |
| java.util     | Utilities                                 | Random       |
| java.io       | Input and Output                          | PrintScreen  |
| java.awt      | Abstract Windowing Toolkit                | Color        |
| java.applet   | Applets                                   | Applet       |
| java.net      | Networking                                | Socket       |
| java.sql      | Database Access                           | ResultSet    |
| java.swing    | Swing user interface                      | JButton      |
| org.omg.CORBA | Common Object Request Broker Architecture | IntHolder    |

## Importing Packages

- Can always use classes without 'importing' their package – just use fully qualified name

```
java.util.Scanner in = new java.util.Scanner(System.in);
```

- But, gets tedious using qualified names
- Importing the package allows you to just use the class name

```
import java.util.Scanner;
...
Scanner in = new Scanner(System.in);
```

- Shortcut to import all classes in a package:
 

```
import java.util.*;
```
- Don't need to import `java.lang` or other classes in the same package

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