

Lesson 1

Object-Oriented Programming and Class Hierarchies

WHOLENESS OF THE LESSON

- Object oriented languages allow you to build and exploit hierarchies of classes in order to write code that may be more easily reused in new applications.
Pure knowledge has infinite organizing power, and administers the whole universe with minimum effort.

Chapter Objectives

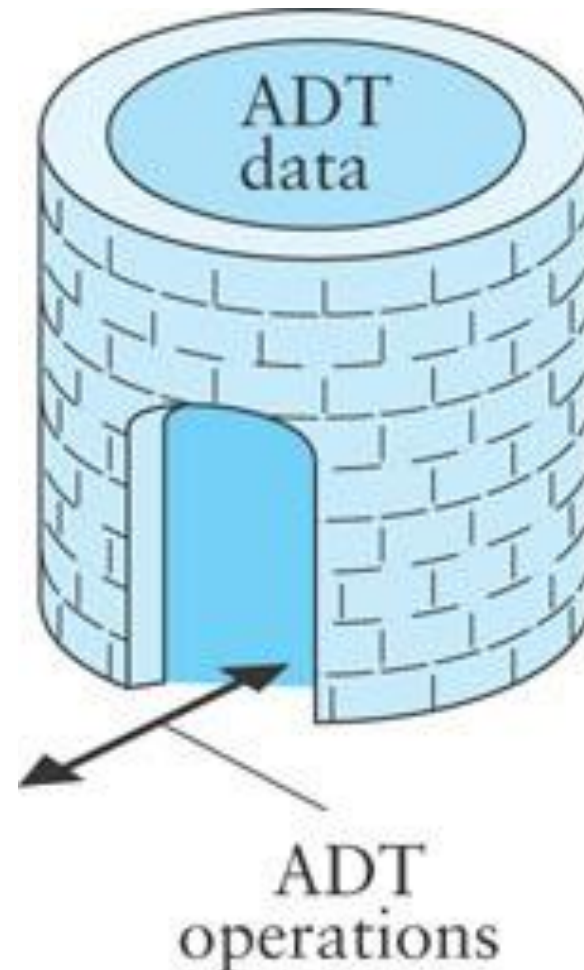
- ❑ Abstract Data Type
- ❑ Interfaces
- ❑ Inheritance and code reuse
- ❑ How Java determines which method to execute when there are multiple methods
- ❑ Abstract classes
- ❑ Abstract data types and interfaces
- ❑ Object class and overriding Object class methods
- ❑ Exception hierarchy
- ❑ Checked and unchecked exceptions
- ❑ Packages and visibility
- ❑ Case study : Class hierarchy for shapes

ADTs, Interfaces, and the Java API

Section 1.1

ADTs(Abstract Data Type)

- ❑ An encapsulation of data and methods
- ❑ Allows for reusable code
- ❑ The user need not know about the implementation of the ADT
- ❑ A user interacts with the ADT using only public methods



ADTs (cont.)

- ADTs facilitate storage, organization, and processing of information
- Such ADTs often are called *data structures*
(Array, List, Map, Queue, Set, Stack, Table, Tree, and Vector)
- A *data structure* is an arrangement of data in a computer's memory.
- Data structures include arrays, linked lists, stacks, binary trees, and hash tables, among others.
(we'll talk more about data structures in tomorrow's lecture).
- The correct choice of data structure allows major improvements in program efficiency.
- The Java Collections Framework provides implementations of common data structures (Lesson 02)

Interfaces

- An interface specifies or describes an ADT to the applications programmer:
 - ▣ the methods and the actions that they must perform
 - ▣ what arguments, if any, must be passed to each method
 - ▣ what result the method will return
- The interface can be viewed as a *contract* which guarantees how the ADT will function

Interfaces (cont.)

- A class that *implements the interface* provides code for the ADT
- As long as the implementation satisfies the ADT contract, the programmer may implement it as he or she chooses
- In addition to implementing all data fields and methods in the interface, the programmer may add:
 - ▣ data fields not in the implementation
 - ▣ methods not in the implementation
 - ▣ constructors (an interface cannot contain constructors because it cannot be instantiated)

Example: ATM Interface

- An Automated Teller Machine (ATM) enables a user to perform certain banking operations from a remote location. It must provide operations to:
 - ▣ verify a user's Personal Identification Number (PIN)
 - ▣ allow the user to choose a particular account
 - ▣ withdraw a specified amount of money
 - ▣ display the result of an operation
 - ▣ display an account balance
- A class that implements an ATM must provide a method for each operation

Example: ATM Interface (cont.)

Interface

- An automated teller machine (ATM) enables a user to perform certain banking operations from a remote location. It must support the following operations:
 - ▣ verify a user's Personal Identification Number (PIN)
 - ▣ allow the user to choose a particular account
 - ▣ withdraw a specified amount of money
 - ▣ display the result of an operation
 - ▣ display an account balance

Code

```
/** The interface for an ATM. */
public interface ATM {

    boolean verifyPIN(String pin);

    String selectAccount();

    boolean withdraw(double amount);

    double showBalance();

    boolean deposit(double amount);

}
```

Interfaces (cont.)

- The interface definition shows only headings for its methods
- Because only headings are shown, they are considered *abstract methods*
- Each abstract method must be defined in a class that implements the interface

Interface Definition

FORM:

```
public interface interfaceName {  
    abstract method headings  
    constant declarations  
}
```

EXAMPLE:

```
public interface Payable {  
    public abstract double  
    calcSalary();  
    public abstract boolean salaried();  
    public static final  
        double DEDUCTIONS = 25.5;  
}
```

- Constants are defined in the interface
- DEDUCTIONS are accessible in classes that implement the interface

- The keywords `public` and `abstract` are implicit in each *abstract method* definition
- And keywords `public` `static` `final` are implicit in each *constant* declaration
- As such, they may be omitted

Interface Definition (cont.)

FORM:

```
public interface interfaceName {  
    abstract method headings  
    constant declarations  
}
```

EXAMPLE:

```
public interface Payable {  
    double calcSalary();  
    boolean salaried();  
    double DEDUCTIONS = 25.5;  
}
```

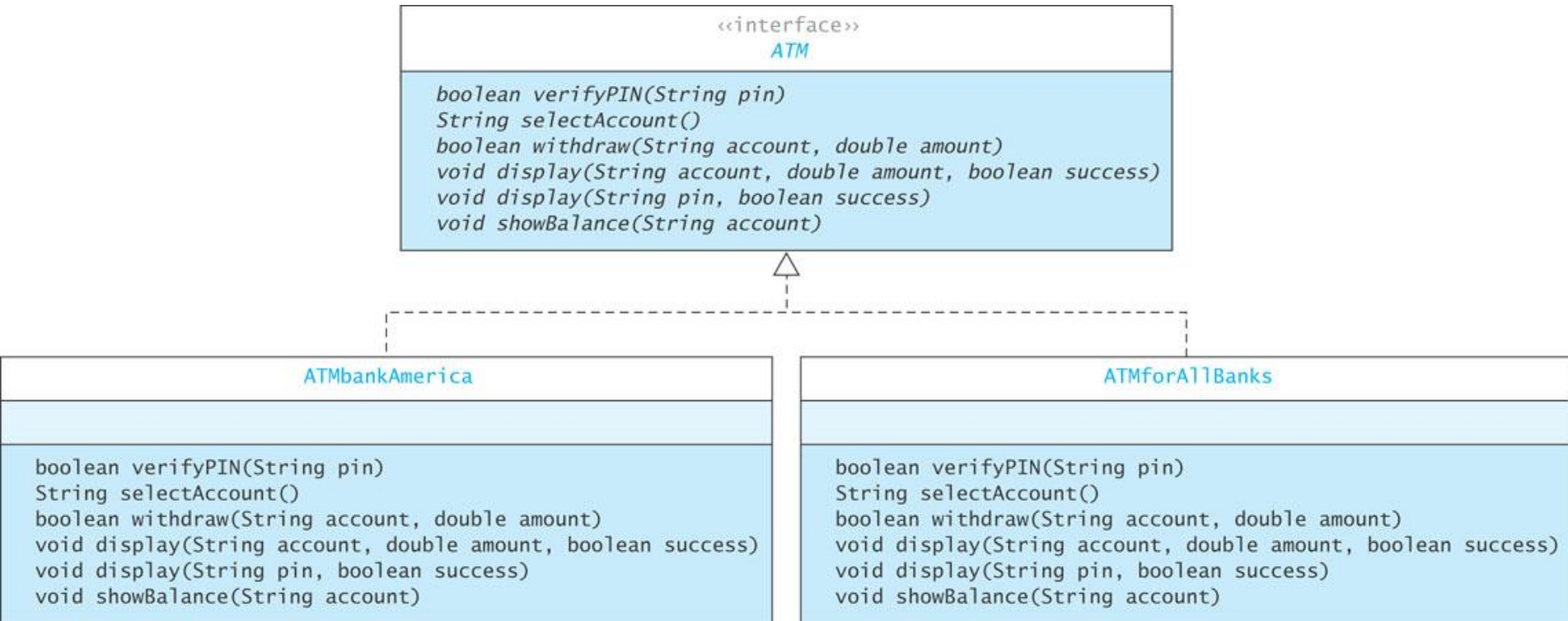
The `implements` Clause

- For a class to implement an interface, it must end with the `implements` clause

```
public class ATMbankAmerica implements ATM  
public class ATMforAllBanks implements ATM
```

- A class may implement more than one interface—their names are separated by commas

UML Diagram of Interface & Implementers



The implements Clause: Pitfalls

- ❑ The Java compiler verifies that a class defines all the abstract methods in its interface(s)
- ❑ A syntax error will occur if a method is not defined or is not defined correctly:

`Class ATMforAllBanks should be declared abstract; it does not define method verifyPIN(String) in interface ATM`

- ❑ If a class contains an undefined abstract method, the compiler will require that the class to be declared an abstract class

The implements Clause: Pitfalls (cont.)

- ❑ You cannot instantiate an interface:

```
ATM anATM = new ATM();    // invalid statement
```

- ❑ Doing so will cause a syntax error:

```
interface ATM is abstract; cannot be instantiated
```

Declaring a Variable of an Interface Type

- While you cannot instantiate an interface, you can declare a variable that has an interface type

```
/* expected type */
```

```
ATMbankAmerica ATM0 = new ATMBankAmerica();
```

```
/* interface type */
```

```
ATM ATM1 = new ATMBankAmerica();
```

```
ATM ATM2 = new ATMforAllBanks();
```

- The reason for wanting to do this will become clear when we discuss *polymorphism*

Main Point 1

- Java Interface can be used to specify an abstract data type and Java class can be used to implement an ADT. *Science of Consciousness: The concept of an interface is analogous to the creation itself – the creation may be viewed as an “interface” to the undifferentiated field of pure consciousness; each object and avenue of activity in the creation serves as a reminder and embodiment of the ultimate reality.*



Introduction to Object-Oriented Programming

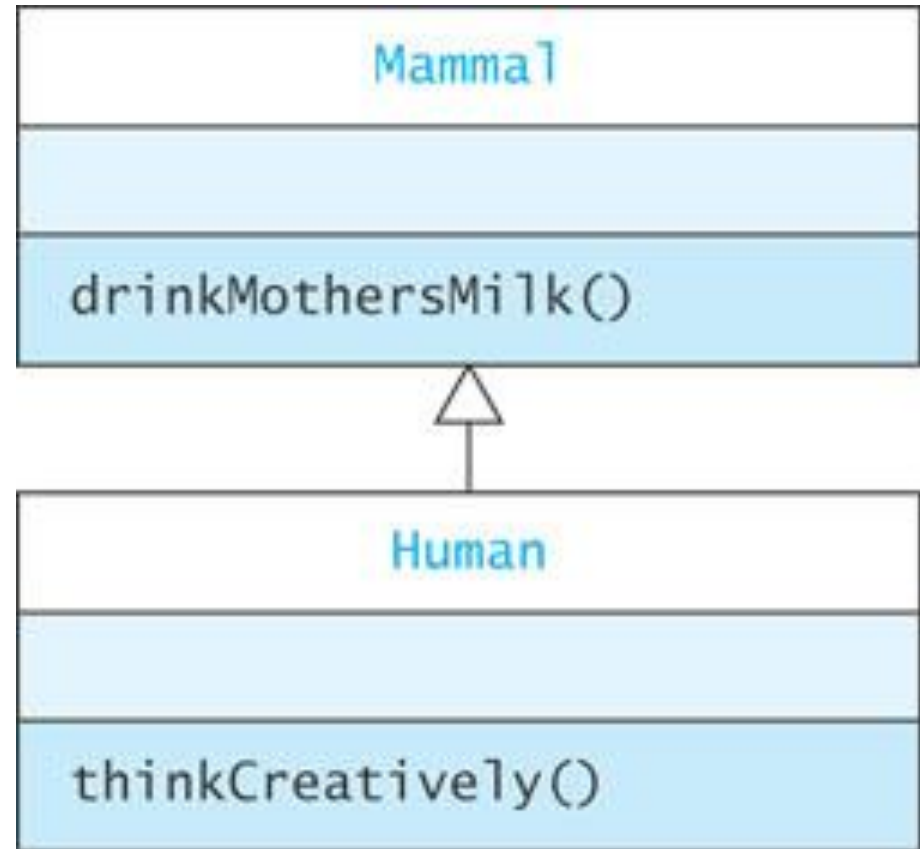
Section 1.2

Object-Oriented Programming

- Object-oriented programming (OOP) is popular because:
 - ▣ it enables *reuse* of previous code saved as *classes*
 - ▣ which saves times because previously written code has been tested and debugged already
- If a new class is similar to an existing class, the existing class can be extended
- This extension of an existing class is called *inheritance*

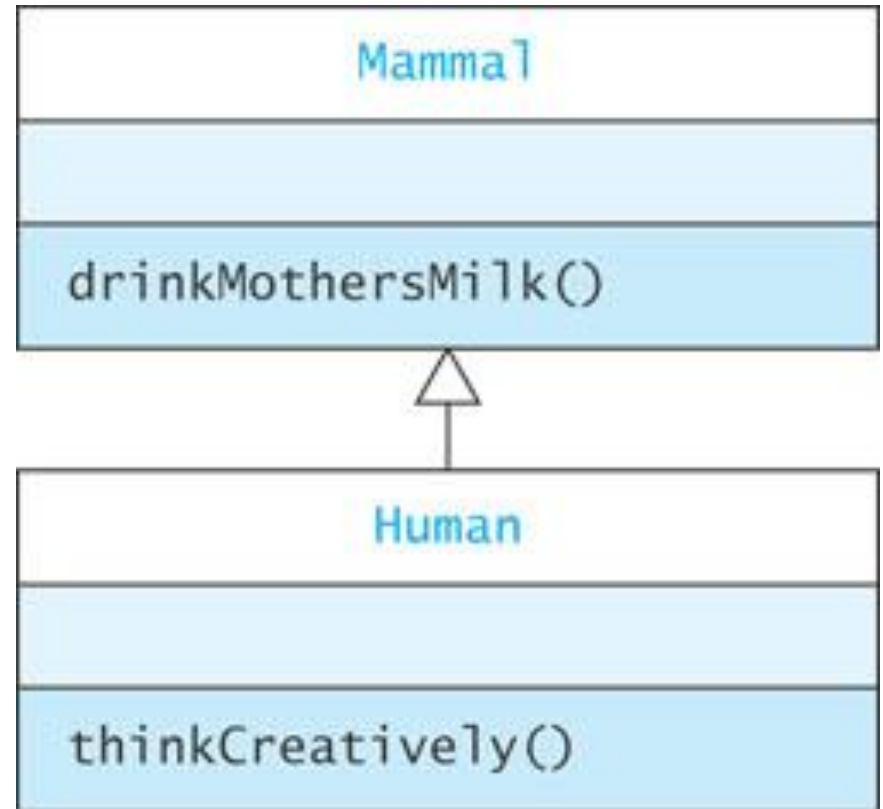
Inheritance

- A Human *is a* Mammal
- Human has all the data fields and methods defined by Mammal
- Mammal is the *superclass* of Human
- Human is a *subclass* of Mammal
- Human may define other variables and methods that are not contained in Mammal



Inheritance (cont.)

- ❑ Mammal has only method `drinkMothersMilk()`
- ❑ Human has method `drinkMothersMilk()` and `thinkCreatively()`
- ❑ Objects lower in the hierarchy are generally more powerful than their superclasses because of additional attributes



A Superclass and Subclass Example (cont.)

- Computer
- A computer has
 - ▣ manufacturer
 - ▣ processor
 - ▣ RAM
 - ▣ disk

Computer
<pre>String manufacturer String processor int ramSize int diskSize double processorSpeed</pre>



A Superclass and Subclass Example (cont.)

Computer

```
String manufacturer  
String processor  
int ramSize  
int diskSize  
double processorSpeed
```

```
int getRamSize()  
int getDiskSize()  
double getProcessorSpeed()  
Double computePower()  
String toString()
```



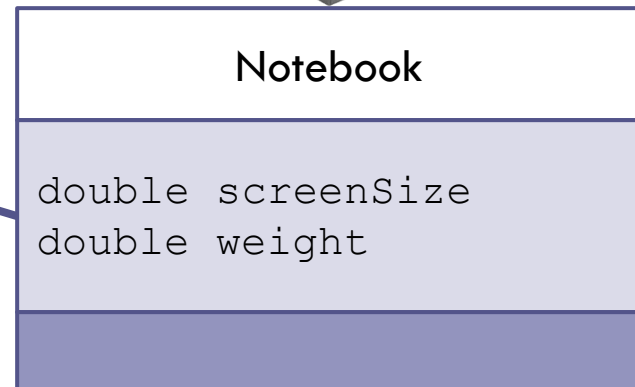
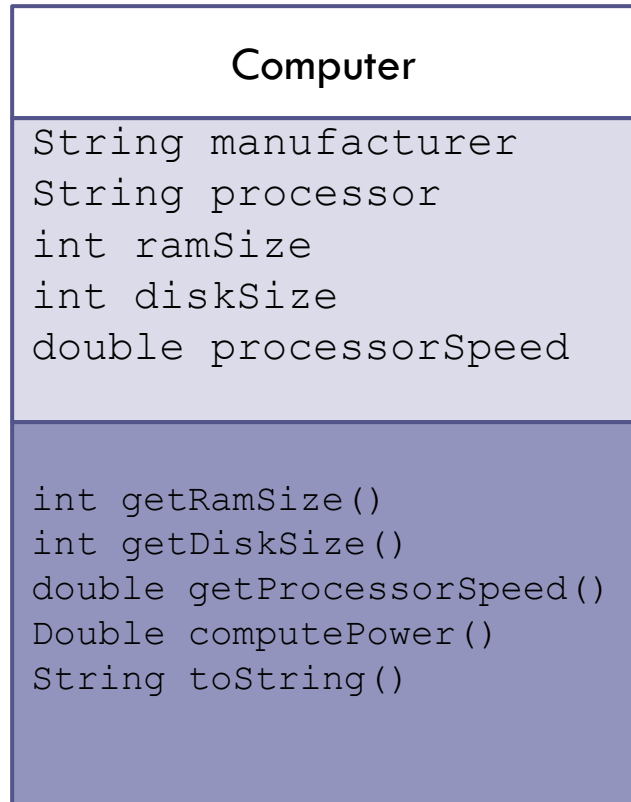
A Superclass and Subclass Example

(cont.)

- Notebook
- A Notebook has all the properties of Computer,
 - ▣ manufacturer
 - ▣ processor
 - ▣ RAM
 - ▣ Disk
- plus,
 - ▣ screen size
 - ▣ weight



A Superclass and Subclass Example (cont.)



A Superclass and Subclass Example

(cont.)

- The constructor of a subclass begins by initializing the data fields inherited from the superclass(es)

```
super(man, proc, ram, disk, procSpeed);
```

which invokes the superclass constructor with the signature

```
Computer(String man, String processor, double ram,  
          int disk, double procSpeed)
```

[Open → W1|1 / Computer.java](#)

A Superclass and Subclass Example (cont.)

```
/** Class that represents a computers */
public class Computer {
    // Data fields
    private String manufacturer;
    private String processor;
    private double ramSize;
    private int diskSize;
    private double processorSpeed;

    // Methods
    /** Initializes a Computer object with all properties specified.
     * @param man The computer manufacturer
     * @param processor The processor type
     * @param ram The RAM size
     * @param disk The disk size
     * @param procSpeed The processor speed
     */
    public Computer(String man, String processor, double ram, int disk,
                    double procSpeed) {
        manufactuer = man;
        this.processor = processor;
        ramSize = ram;
        diskSize = disk;
        processorSpeed = procSpeed;
    }
}
```

Use of this

If you wrote this line as

```
processor = processor;
```

you would simply copy the variable processor to itself. To access the field, you need to prefix this:

```
this.processor = processor;
```

A Superclass and Subclass Example (cont.)

```
// methods
/** Initializes a Notebook object with all properties specified.
    @param man The computer manufacturer
    @param processor The processor type
    @param ram The RAM size
    @param disk The disk size
    @param procSpeed The processor speed
    @param screen The screen size
    @param wei The weight
 */
public Notebook(String man, String processor, double ram, int disk,
                double procSpeed, double screen, double wei) {
    super(man, proc, ram, disk, procSpeed);
    screenSize = screen;
    weight = wei;
}
```

super ()
super (argumentList)

The `super ()` call in a class constructor invokes the superclass's constructor that has the corresponding *argumentList*.

The `super ()` call must be the first statement in a constructor.

The No-Parameter Constructor

- If the execution of any constructor in a subclass does not invoke a superclass constructor—an explicit call to *super()*—Java automatically invokes the no-parameter constructor for the superclass
- If no constructors are defined for a class, the no-parameter constructor for that class is provided by default
- However, if any constructors are defined, you must explicitly define a no-parameter constructor

Method Overriding, Method Overloading, and Polymorphism

Section 1.3

Method Overriding

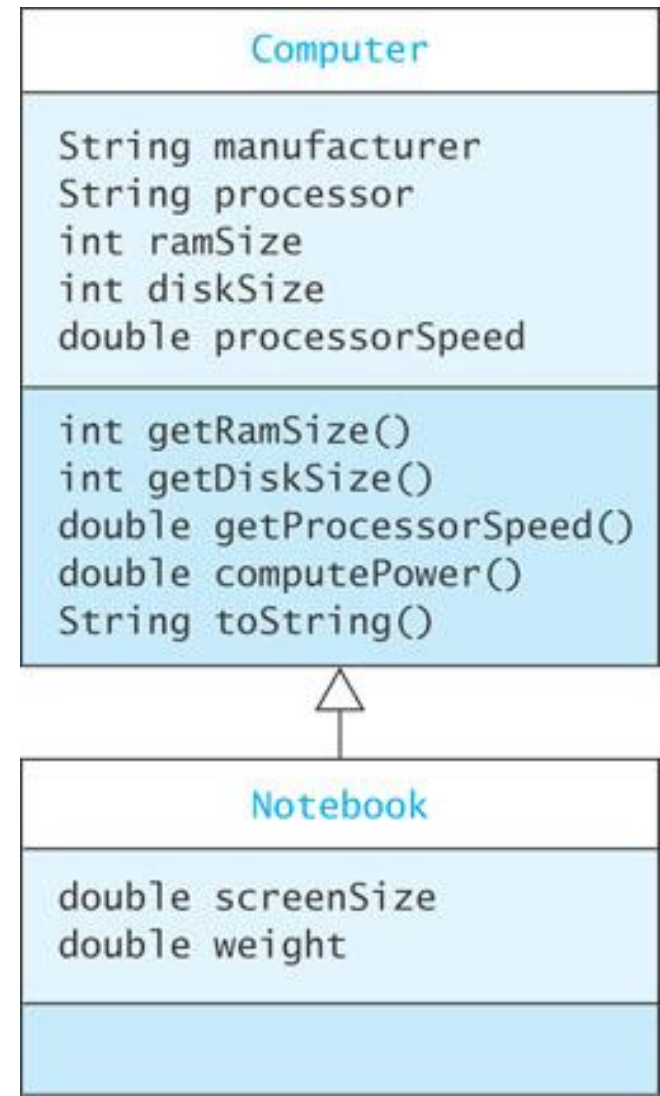
- Continuing the previous example, if we declare and then run:

```
Computer myComputer = new
    Computer("Acme", "Intel", 2, 160,
        2.4);

Notebook yourComputer = new
    Notebook("DellGate", "AMD", 4, 240,
        1.8, 15.0, 7.5);

System.out.println("My computer is:\n"
    + myComputer.toString());

System.out.println("Your computer
    is:\n" + yourComputer.toString());
```



Method Overriding (cont.)

- the output would be:

My Computer is:

Manufacturer: Acme

CPU: Intel

RAM: 2.0 gigabytes

Disk: 160 gigabytes

Speed: 2.4 gigahertz

Your Computer is:

Manufacturer: DellGate

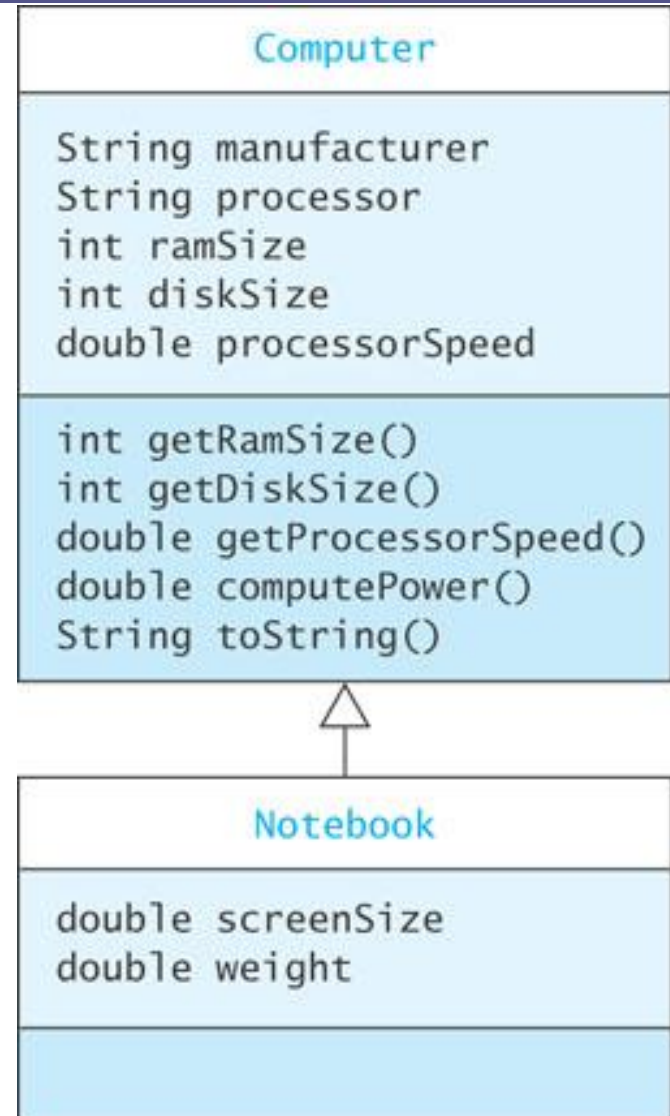
CPU: AMD

RAM: 4.0 gigabytes

Disk: 240 gigabytes

Speed: 1.8 gigahertz

- The screensize and weight variables are not printed because Notebook has not defined a toString() method



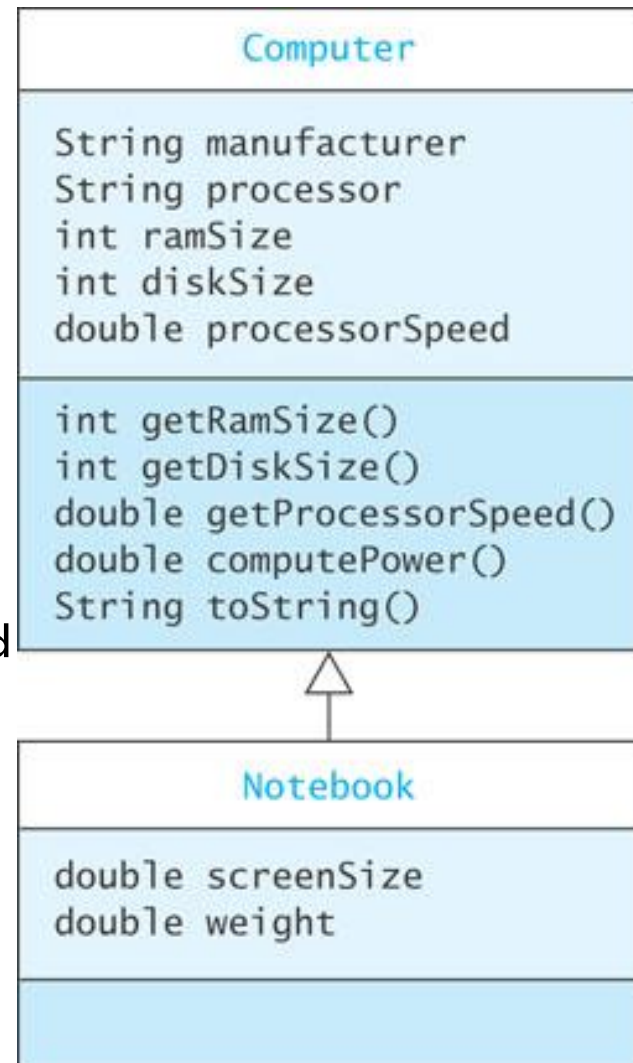
Method Overriding (cont.)

- To define a `toString()` for

Notebook:

```
public String toString() {  
    String = result = super.toString() +  
        "\nScreen size: " +  
        screenSize + " inches" +  
        "\nWeight: " + weight +  
        " pounds";  
    return result;  
}
```

- Now Notebook's `toString()` method will **override** Computer's inherited `toString()` method and will be called for all Notebook objects



Method Overriding (cont.)

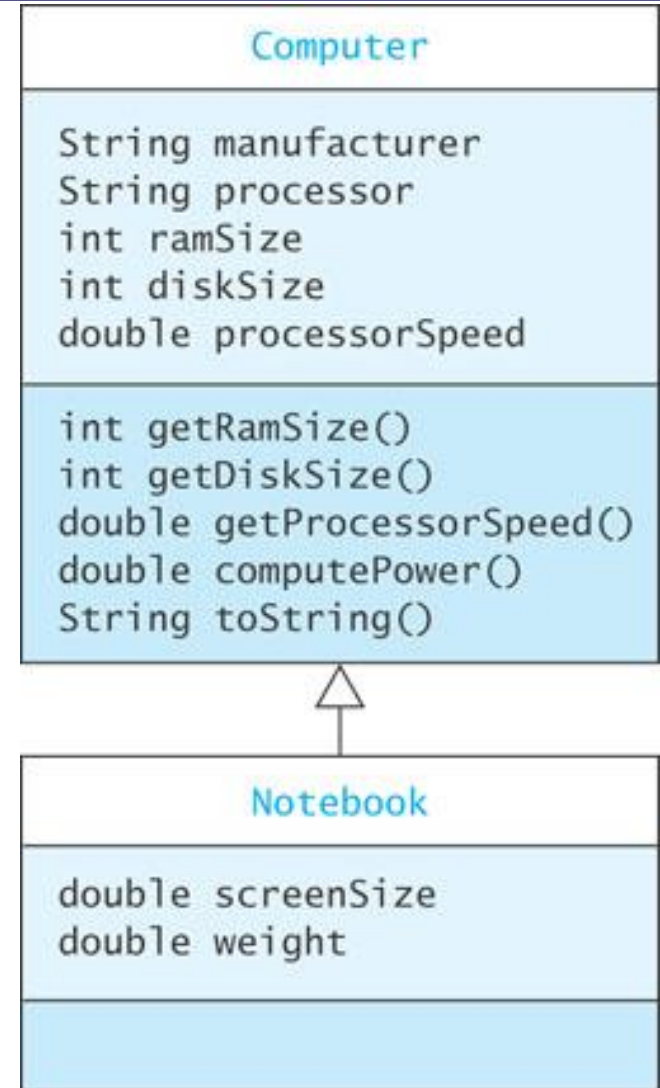
- To define a `toString()` for Notebook:

```
public String toString() {  
    String result = super.toString() +  
        "\nScreen size: " +  
        screenSize + " inches" +  
        "\nWeight: " + weight +  
        " pounds";  
    return result;  
}
```

- Now Notebook's `toString()` method will **override** its Computer's `toString()` and will be called for all Notebook objects.

`super.methodName()`

Using the prefix **super** in a call to a method *methodName* calls the method with that name in the superclass of the current class



Method Overloading (cont.)

- Methods in the class hierarchy which have the same name, return type, and parameters *override* corresponding inherited methods
- Methods with the same name but different parameters are *overloaded*

Method Overloading (cont.)

- Take, for example, our Notebook constructor:

```
public Notebook(String man, String processor, double ram, int disk,  
                double procSpeed, double screen, double wei) {  
    . . .  
}
```

- If we want to have a default manufacturer for a Notebook, we can create a constructor with six parameters instead of seven

This call invokes the seven-parameter constructor passing on the six parameters in this constructor, plus the default manufacturer constant `DEFAULT_NB_MAN`

```
public Notebook(String processor, double ram, int disk,  
                double procSpeed, double screen, double wei) {  
    this(DEFAULT_NB_MAN, double ram, int disk, double procSpeed,  
          double screen, double wei);  
}
```

Method Overloading: Pitfall

- ❑ When *overriding* a method, the method must have the same name and the same number and types of parameters in the same order
- ❑ If not, the method will *overload*
- ❑ This error is common; the annotation `@Override` preceding an overridden method will signal the compiler to issue an error if it does not find a corresponding method to override

```
@Override  
public String toString() {  
    . . .  
}
```

- ❑ It is good programming practice to use the `@Override` annotation in your code

Polymorphism

- ❑ Polymorphism means *having many forms*
- ❑ Polymorphism is a central feature of OOP
- ❑ It enables the JVM to determine at run time which of the classes in a hierarchy is referenced by a superclass variable or parameter

Polymorphism (cont.)

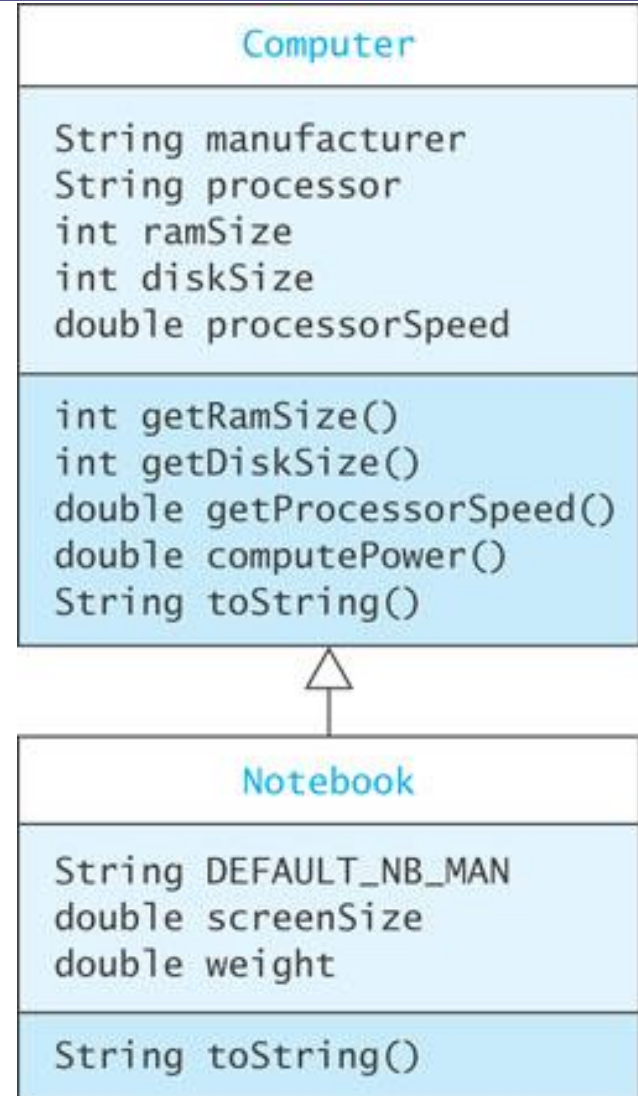
- For example, if you write a program to reference computers, you may want a variable to reference a `Computer` **or** a `Notebook`
- If you declare the reference variable as `Computer theComputer;` it can reference either a `Computer` **or** a `Notebook`—because a `Notebook` *is-a* `Computer`

Polymorphism (cont.)

- Suppose the following statements are executed:

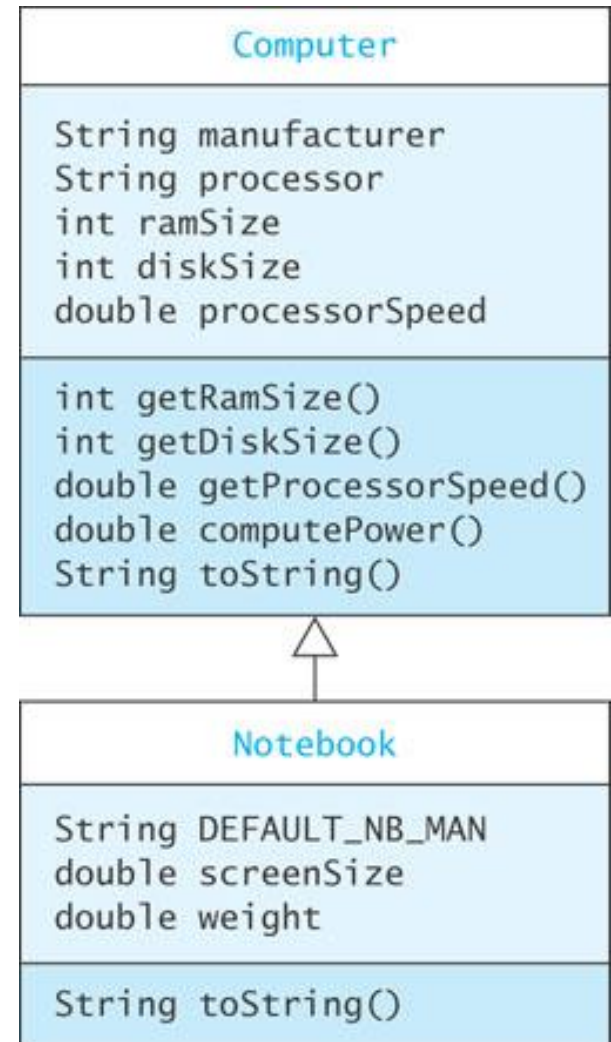
```
Computer theComputer = new  
    Notebook("Bravo", "Intel", 4, 240, 2/4,  
        15.07.5);  
  
System.out.println(theComputer.toString());
```

- The variable `theComputer` is of type `Computer`,
- Which `toString()` method will be called, `Computer`'s or `Notebook`'s?



Polymorphism (cont.)

- ❑ The JVM correctly identifies the **type of** theComputer as Notebook and calls the toString() method associated with Notebook
- ❑ This is an example of *polymorphism*
- ❑ The type cannot be determined at *compile time*, but it can be determined at *run time*
- ❑ Refer Notebook2.java



Methods with Class Parameters

- ❑ Polymorphism simplifies programming when writing methods with class parameters
- ❑ If we want to compare the power of two computers (either `Computers` or `Notebooks`) we do not need to overload methods with parameters for two `Computers`, or two `Notebooks`, or a `Computer` and a `Notebook`
- ❑ We simply write one method with two parameters of type `Computer` and allow the JVM, using polymorphism, to call the correct method

Methods with Class Parameters (cont.)

```
/** Compares power of this computer and its argument computer  
@param aComputer The computer being compared to this computer  
@return -1 if this computer has less power,  
0 if the same, and  
+1 if this computer has more power.  
  
*/  
public int comparePower(Computer aComputer) {  
    if (this.computePower() < aComputer.computePower())  
        return -1;  
    else if (this.computePower() == aComputer.computePower())  
        return 0;  
    else return 1;  
}
```

Main Point 2

- One class (the *subclass*) inherits from another class (the *superclass*) if all protected and public data and methods in the superclass are automatically accessible to the subclass, even though the subclass may have additional methods and data not found in the superclass. Java supports this notion of inheritance. In Java syntax, a class is declared to be a subclass of another by using the *extends* keyword. *Science of Consciousness: Individual intelligence "inherits from" cosmic intelligence, though each "implementation" is unique.*

Abstract Classes

Section 1.4

Abstract Classes

- An abstract class is denoted by using the word `abstract` in its heading:

visibility abstract class className

- An abstract class differs from an actual class (sometimes called a concrete class) in two respects:
 - An abstract class cannot be instantiated
 - An abstract class may declare abstract methods
- Just as in an interface, an abstract method is declared through a method heading:

visibility abstract resultType methodName (parameterList);

- An actual class that is a subclass of an abstract class must provide an implementation for each abstract method

Abstract Classes (cont.)

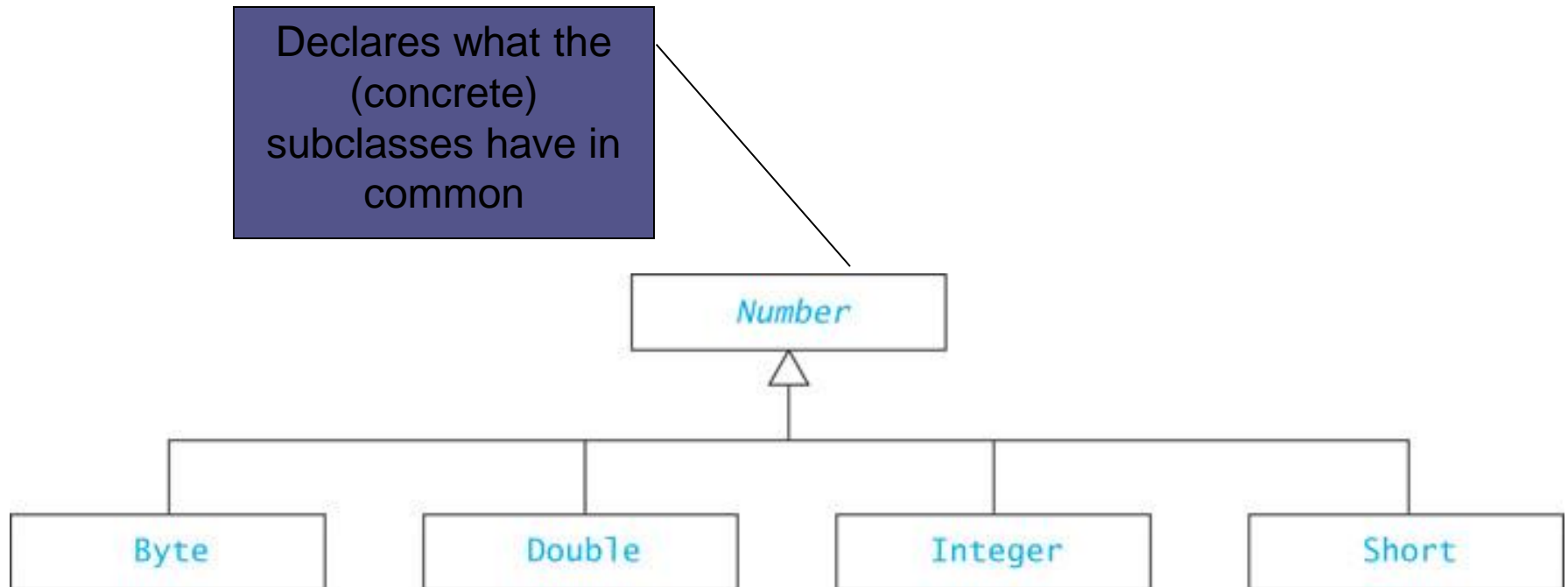
- Use an abstract class in a class hierarchy when you need a base class for two or more subclasses that share some attributes
- You can declare some or all of the attributes and define some or all of the methods that are common to these subclasses
- You can also require that the actual subclasses implement certain methods by declaring these methods abstract

Example of an Abstract Class

```
public abstract class Food {
    public final String name;
    private double calories;
    // Actual methods
    public double getCalories () {
        return calories;
    }
    protected Food (String name, double calories) {
        this.name      = name;
        this.calories = calories;
    }
    // Abstract methods
    public abstract double percentProtein();
    public abstract double percentFat();
    public abstract double percentCarbs();
}
```

Java Wrapper Classes

- A *wrapper class* is used to store a primitive-type value in an object type



Interfaces, Abstract Classes, and Concrete Classes

- A Java *interface* can declare methods, but cannot implement them
- Methods of an interface are called abstract methods.
- An *abstract class* can have:
 - abstract methods (no body)
 - concrete methods (with a body)
 - data fields
- Unlike a concrete class, an *abstract class*
 - cannot be instantiated
 - can declare abstract methods which *must* be implemented in all *concrete* subclasses

Abstract Classes and Interfaces

- Abstract classes and interfaces cannot be instantiated
- An abstract class *can* have constructors!
 - *Purpose*: initialize data fields when a subclass object is created
 - The subclass uses **super (...)** to call the constructor
- An abstract class may *implement* an interface, but need not define all methods of the interface
 - Implementation is left to subclasses

Inheriting from Interfaces vs Classes

- A class can *extend* 0 or 1 superclass
- An interface cannot extend a class
- A class or interface can *implement* 0 or more interfaces

Summary of Features of Actual Classes, Abstract Classes, and Interfaces

Property	Actual Class	Abstract Class	Interface
Instances (objects) of this can be created.	Yes	No	No
This can define instance variables and methods.	Yes	Yes	No
This can define constants.	Yes	Yes	Yes
The number of these a class can extend.	0 or 1	0 or 1	0
The number of these a class can implement.	0	0	Any number
This can extend another class.	Yes	Yes	No
This can declare abstract methods.	No	Yes	Yes
Variables of this type can be declared.	Yes	Yes	Yes

Main Point 3

- Abstract classes and Interfaces are both strongly related to the concept of Inheritance. The interface is the most abstract entity and by programming to interfaces, we generate more flexible code.

Science of Consciousness: Greater abstraction holds the possibility of greater potential; this principle is especially evident in the case of the unified field.

Class Object and Casting

Section 1.5

Class Object

- Object is the root of the class hierarchy
- Every *class* has Object as a superclass
- All classes inherit the methods of Object but may override them

Method	Behavior
boolean equals(Object obj)	Compares this object to its argument.
int hashCode()	Returns an integer hash code value for this object.
String toString()	Returns a string that textually represents the object.
Class<?> getClass()	Returns a unique object that identifies the class of this object.

Class **Class**

- Every class has a `Class` object that is created automatically when the class is loaded into an application
- Each `Class` object is unique for the class
- Method `getClass()` is a member of `Object` that returns a reference to this unique object
- In the previous example, if `this.getClass() == obj.getClass()` is true, then we know that `obj` and `this` are both of class `Employee`

Main Point 4

- All classes in Java belong to the inheritance hierarchy headed by the Object class. **Science of Consciousness:** *Likewise, all individual consciousness inherits from the single unified field.*

Packages and Visibility

Section 1.6

Packages

- A Java *package* is a group of *cooperating classes*
- The Java API is organized as packages
- Indicate the package of a class at the top of the file:
`package classPackage;`
- Classes in the *same package* should be in the *same directory* (folder)
- The folder must have the same name as the package
- Classes in the *same folder* must be
in the *same package*

Packages and Visibility

- ❑ Classes *not* part of a package can only access `public` members of classes in the package
 - ❑ If a class is not part of the package, it must access the public classes by their complete name, which would be `packageName.className`
 - ❑ For example,
- `x = Java.awt.Color.GREEN;`
- ❑ If the package is imported, the `packageName` prefix is not required.

```
import java.awt.Color;  
...  
x = Color.GREEN;
```

The Default Package

- ❑ Files which do not specify a package are part of the default package
- ❑ If you do not declare packages, all of your classes belong to the default package
- ❑ The default package is intended for use during the early stages of implementation or for small prototypes
- ❑ When you develop an application, declare its classes to be in the same package

Visibility

- You know about three visibility layers, `public`, `protected`, `private`
- A fourth layer, *package visibility*, lies between `private` and `protected`
- Classes, data fields, and methods with package visibility are accessible to all other methods of the same package, but are not accessible to methods outside the package
- Classes, data fields, and methods that are declared `protected` are visible within subclasses that are declared *outside* the package (in addition to being visible to all members *inside* the package)
- There is no keyword to indicate package visibility
- Package visibility is the default in a package if `public`, `protected`, `private` are not used

Visibility Supports Encapsulation

- Visibility rules enforce encapsulation in Java
- `private`: for members that should be invisible even in subclasses
- `package`: shields classes and members from classes outside the package
- `protected`: provides visibility to extenders of classes in the package
- `public`: provides visibility to all

Visibility Supports Encapsulation

(cont.)

Visibility	Applied to Classes	Applied to Class Members
private	Applicable to inner classes. Accessible only to members of the class in which it is declared.	Visible only within this class.
Default or package	Visible to classes in this package.	Visible to classes in this package.
protected	Applicable to inner classes. Visible to classes in this package and to classes outside the package that extend the class in which it is declared.	Visible to classes in this package and to classes outside the package that extend this class.
public	Visible to all classes.	Visible to all classes. The class defining the member must also be public.

Visibility Supports Encapsulation

(cont.)

- ❑ Encapsulation insulates against change
- ❑ Greater visibility means less encapsulation
- ❑ So... use the most restrictive visibility possible to get the job done!

package p1;

```
public class C1 {  
    public int x;  
    protected int y;  
    int z;  
    private int u;  
  
    protected void m() {  
    }  
}
```

```
public class C2 {  
    C1 o = new C1();  
    can access o.x;  
    can access o.y;  
    can access o.z;  
    cannot access o.u;  
  
    can invoke o.m();  
}
```



package p2;

```
public class C3  
    extends C1 {  
    can access x;  
    can access y;  
    can access z;  
    cannot access u;  
  
    can invoke m();  
}
```

```
public class C4  
    extends C1 {  
    can access x;  
    can access y;  
    cannot access z;  
    cannot access u;  
  
    can invoke m();  
}
```

```
public class C5 {  
    C1 o = new C1();  
    can access o.x;  
    cannot access o.y;  
    cannot access o.z;  
    cannot access o.u;  
  
    cannot invoke o.m();  
}
```

Visibility modifiers are used to control how data and methods are accessed.

A Java Inheritance Example—The Exception Class Hierarchy

Section 1.7

Errors and exceptions

- ❑ 1. Compile-time errors
- ❑ 2. Run-time errors
- ❑ 3. Logic errors

Compile-time & Logic Errors

□ **Compile-time errors**

- These errors are errors which prevents the code from compiling because of error in the syntax such as missing a semicolon at the end of a statement or due to missing braces, class not found, etc. These errors will be detected by java compiler and displays the error onto the screen while compiling.

□ **Logic errors**

- These errors are due to the mistakes made by the programmer. It will not be detected by a compiler nor by the JVM. Errors may be due to wrong idea or concept used by a programmer while coding.

Run-time Errors

□ Run-time errors

- These errors are errors which occur when the program is running. Run time errors are not detected by the java compiler. It is the JVM which detects it while the program is running.

□ Examples of run-time errors include

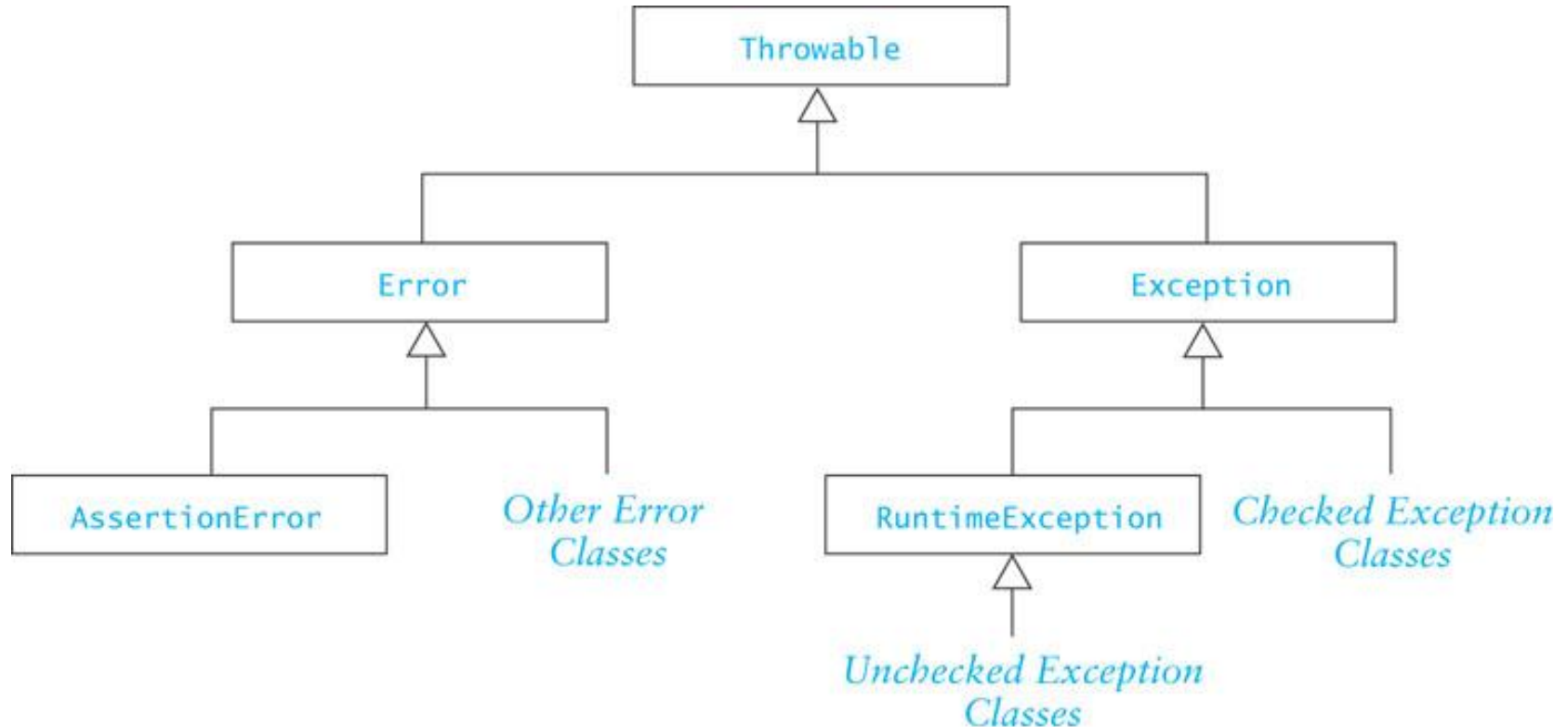
- division by zero
- array index out of bounds
- number format error
- null pointer exception

Exceptions

Class	Cause/Consequence
ArithmeticException	An attempt to perform an integer division by zero.
ArrayIndexOutOfBoundsException	An attempt to access an array element using an index (subscript) less than zero or greater than or equal to the array's length.
NumberFormatException	An attempt to convert a string that is not numeric to a number.
NullPointerException	An attempt to use a <code>null</code> reference value to access an object.
NoSuchElementException	An attempt to get a next element after all elements were accessed.
InputMismatchException	The token returned by a <code>Scanner</code> <code>next...</code> method does not match the pattern for the expected data type.

Class Throwable

- Throwable is the superclass of all exceptions
- All exception classes inherit its methods



Class Throwable (cont.)

- Throwable has several useful methods that are available to all of its subclasses

Method	Behavior
String getMessage()	Returns the detail message.
void printStackTrace()	Prints the stack trace to System.err.
String toString()	Returns the name of the exception followed by the detail message.

Checked and Unchecked Exceptions

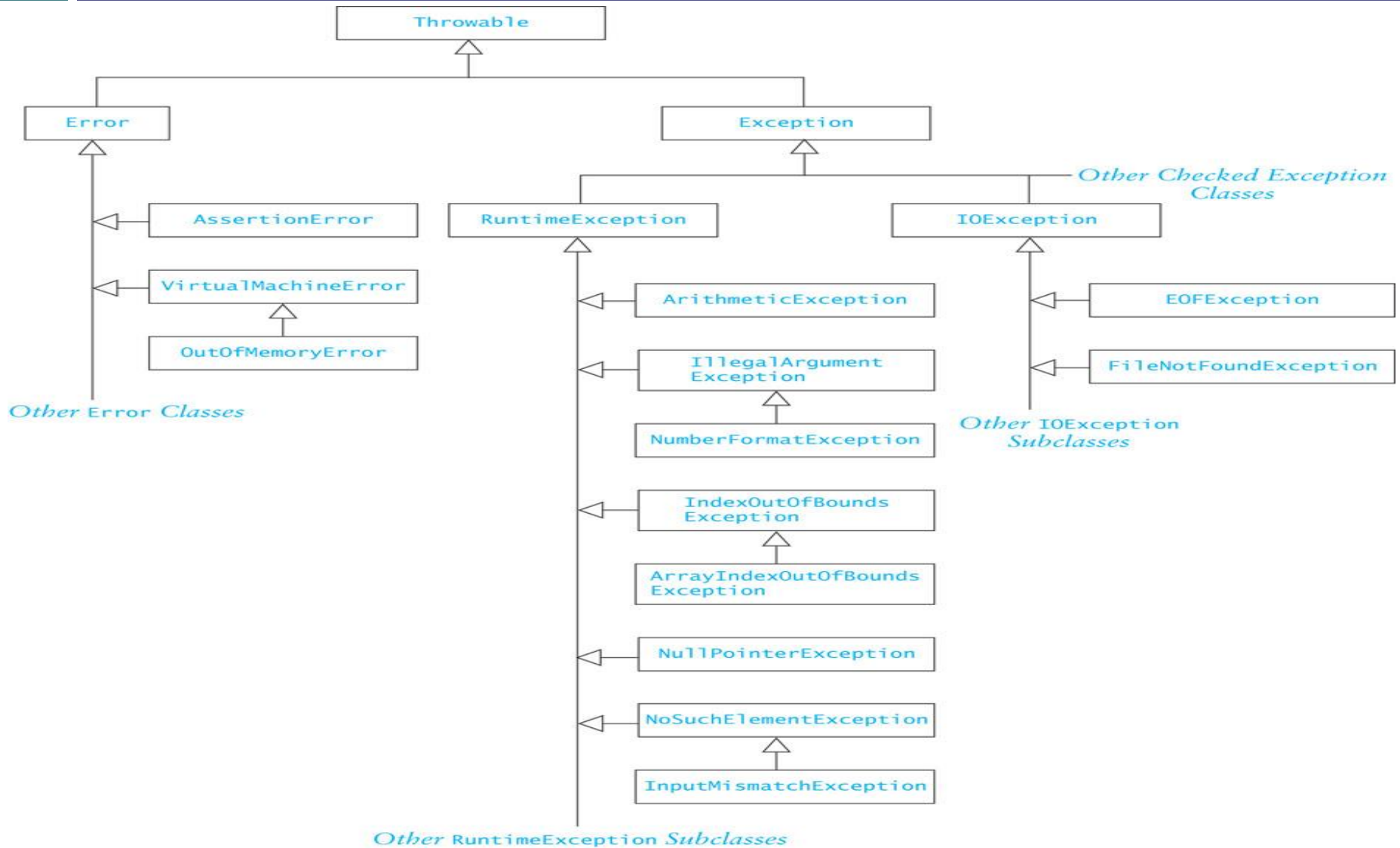
- *Checked* exceptions
 - ▣ normally not due to programmer error
 - ▣ generally beyond the control of the programmer
 - ▣ all input/output errors are checked exceptions
 - ▣ **Examples:** `IOException`, `FileNotFoundException`
- *Unchecked* exceptions result from
 - ▣ programmer error (try to prevent them with defensive programming).
 - ▣ a serious external condition that is unrecoverable
 - ▣ **Examples:** `NullPointerException`,
`ArrayIndexOutOfBoundsException`

Checked and Unchecked Exceptions (cont.)

- The class `Error` and its subclasses represent errors due to serious external conditions; they are unchecked
 - ▣ Example: `OutOfMemoryError`
 - ▣ You cannot foresee or guard against them
 - ▣ While you can attempt to handle them, it is generally not a good idea as you will probably be unsuccessful

- The class `Exception` and its subclasses can be handled by a program
 - ▣ `RuntimeException` and its subclasses are unchecked
 - ▣ *All others must be either:*
 - explicitly *caught* or
 - explicitly *mentioned as thrown* by the method

Checked and Unchecked Exceptions (cont.)



Some Common Unchecked Exceptions

- ❑ `ArithmeticException`: **division by zero, etc.**
- ❑ `ArrayIndexOutOfBoundsException`
- ❑ `NumberFormatException`: **converting a “bad” string to a number**
- ❑ `NullPointerException`
- ❑ `NoSuchElementException`: **no more tokens available**

Main Point 5

- Java's exception-handling model supports best practices in handling exceptions that arise during program execution. **Science of Consciousness:**
Establishing awareness in the home of all the laws of nature results in a life spontaneously lived in accord with natural law.

A Shape Class Hierarchy

1.8

Case Study: Processing Geometric Figures

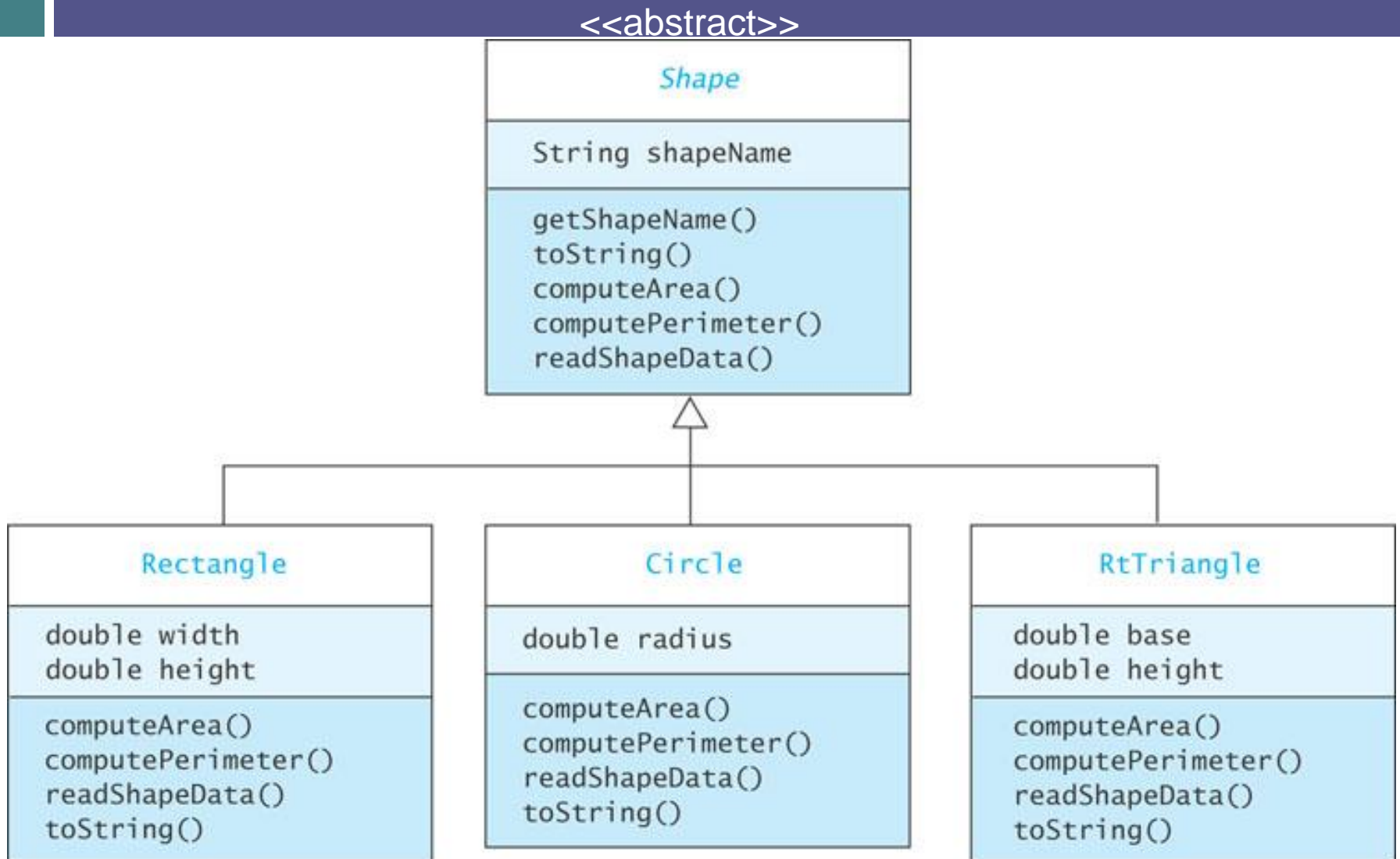
Problem

We want to process some standard geometric shapes. Each figure object will be one of three standard shapes (rectangle, circle, right triangle). We want to do standard computations, such as finding the area and perimeter, for any of these shapes.

Analysis

For each geometric shape, we need a class that represents the shape and knows how to perform the standard computations on it. These classes will be `Rectangle`, `Circle`, and `RtTriangle`. To ensure that these shape classes all define the required computational methods (finding area and perimeter), we will make them abstract methods in the base class (`Shape`) for the shape hierarchy. If a shape class does not have the required methods, we will get a syntax error when we attempt to compile it.

Shape Class Hierarchy



Class Rectangle

Data Field	Attribute
double width	Width of a rectangle
double height	Height of a rectangle
Method	Behavior
double computeArea()	Computes the rectangle area ($\text{width} \times \text{height}$)
double computePerimeter()	Computes the rectangle perimeter ($2 \times \text{width} + 2 \times \text{height}$)
void readShapeData()	Reads the width and height
String toString()	Returns a string representing the state