Chapter 10 Thinking in Objects

Motivations

You see the advantages of object-oriented programming from the preceding two chapters. This chapter will demonstrate how to solve problems using the object-oriented paradigm. Before studying these examples, we first introduce several language features for supporting these examples.

Objectives

- To create immutable objects from immutable classes to protect the contents of objects (§10.2).
- To determine the scope of variables in the context of a class (§10.3).
- To use the keyword **this** to refer to the calling object itself (§10.4).
- To apply class abstraction to develop software (§10.5).
- To explore the differences between the procedural paradigm and object-oriented paradigm (§10.6).
- To develop classes for modeling composition relationships (§10.7).
- To design programs using the object-oriented paradigm (§§10.8–10.10).
- To design classes that follow the class-design guidelines (§10.11).
- To create objects for primitive values using the wrapper classes (**Byte**, **Short**, **Integer**, **Long**, **Float**, **Double**, **Character**, and **Boolean**) (§10.12).
- To simplify programming using automatic conversion between primitive types and wrapper class types (§10.13).
- To use the **BigInteger** and **BigDecimal** classes for computing very large numbers with arbitrary precisions (§10.14).

Immutable Objects and Classes

If the contents of an object cannot be changed once the object is created, the object is called an *immutable object* and its class is called an *immutable class*. If you delete the set method in the Circle class in the preceding example, the class would be immutable because radius is private and cannot be changed without a set method.

A class with all private data fields and without mutators is not necessarily immutable. For example, the following class Student has all private data fields and no mutators, but it is mutable.

Example

```
public class Student {
  private int id;
  private BirthDate birthDate;

  public Student(int ssn,
      int year, int month, int day) {
    id = ssn;
    birthDate = new BirthDate(year, month, day);
  }

  public int getId() {
    return id;
  }

  public BirthDate getBirthDate() {
    return birthDate;
  }
}
```

```
public class BirthDate {
  private int year;
  private int month;
  private int day;

  public BirthDate(int newYear,
      int newMonth, int newDay) {
    year = newYear;
    month = newMonth;
    day = newDay;
  }

  public void setYear(int newYear) {
    year = newYear;
  }
}
```

```
public class Test {
  public static void main(String[] args) {
    Student student = new Student(111223333, 1970, 5, 3);
    BirthDate date = student.getBirthDate();
    date.setYear(2010); // Now the student birth year is changed!
  }
}
```

What Class is Immutable?

For a class to be immutable, it must mark all data fields private and provide no mutator methods and no accessor methods that would return a reference to a mutable data field object.

Scope of Variables

- The scope of instance and static variables is the entire class. They can be declared anywhere inside a class.
- The scope of a local variable starts from its declaration and continues to the end of the block that contains the variable. A local variable must be initialized explicitly before it can be used.

The this Keyword

- The this keyword is the name of a reference that refers to an object itself. One common use of the this keyword is reference a class's *hidden data fields*.
- Another common use of the this keyword to enable a constructor to invoke another constructor of the same class.

Reference the Hidden Data Fields

```
public class F {
  private int i = 5;
  private static double k = 0;

  void setI(int i) {
    this.i = i;
  }

  static void setK(double k) {
    F.k = k;
  }
}
```

```
Suppose that f1 and f2 are two objects of F.
F f1 = new F(); F f2 = new F();

Invoking f1.setI(10) is to execute
   this.i = 10, where this refers f1

Invoking f2.setI(45) is to execute
   this.i = 45, where this refers f2
```

Calling Overloaded Constructor

```
public class Circle {
  private double radius;

  public Circle(double radius) {
    this.radius = radius;
  }

  public Circle() {
    this(1.0);
  }

  public double getArea() {
    return this.radius * this.radius * Math.PI;
  }
}
```

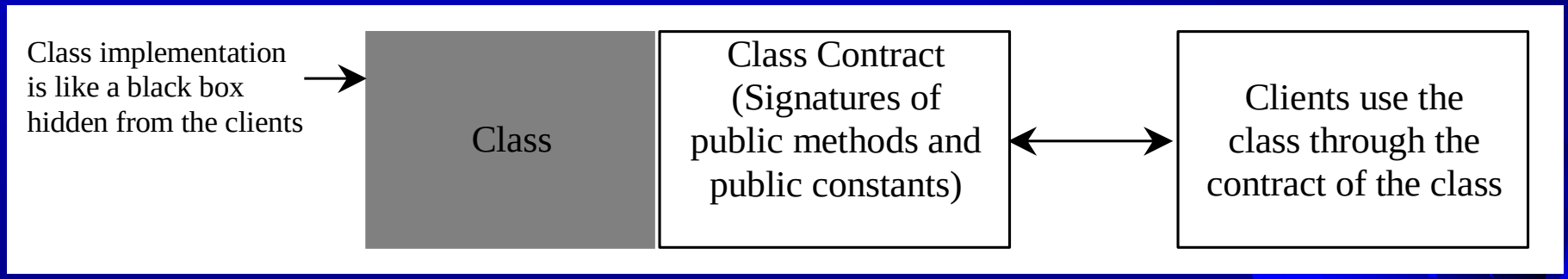
this must be explicitly used to reference the data field radius of the object being constructed

this is used to invoke another constructor

Every instance variable belongs to an instance represented by this, which is normally omitted

Class Abstraction and Encapsulation

Class abstraction means to separate class implementation from the use of the class. The creator of the class provides a description of the class and let the user know how the class can be used. The user of the class does not need to know how the class is implemented. The detail of implementation is encapsulated and hidden from the user.



Designing the Loan Class

Loan	
-annualInterestRate: double	The annual interest rate of the loan (default: 2.5).
-numberOfYears: int	The number of years for the loan (default: 1)
-loanAmount: double	The loan amount (default: 1000).
-loanDate: Date	The date this loan was created.
+Loan()	Constructs a default Loan object.
+Loan(annualInterestRate: double, numberOfYears: int, loanAmount: double)	Constructs a loan with specified interest rate, years, and loan amount.
+getAnnualInterestRate(): double	Returns the annual interest rate of this loan.
+getNumberOfYears(): int	Returns the number of the years of this loan.
+getLoanAmount(): double	Returns the amount of this loan.
+getLoanDate(): Date	Returns the date of the creation of this loan.
+setAnnualInterestRate(annualInterestRate: double): void	Sets a new annual interest rate to this loan.
+setNumberOfYears(numberOfYears: int): void	Sets a new number of years to this loan.
+setLoanAmount(loanAmount: double): void	Sets a new amount to this loan.
+getMonthlyPayment(): double	Returns the monthly payment of this loan.
+getTotalPayment(): double	Returns the total payment of this loan.

Loan

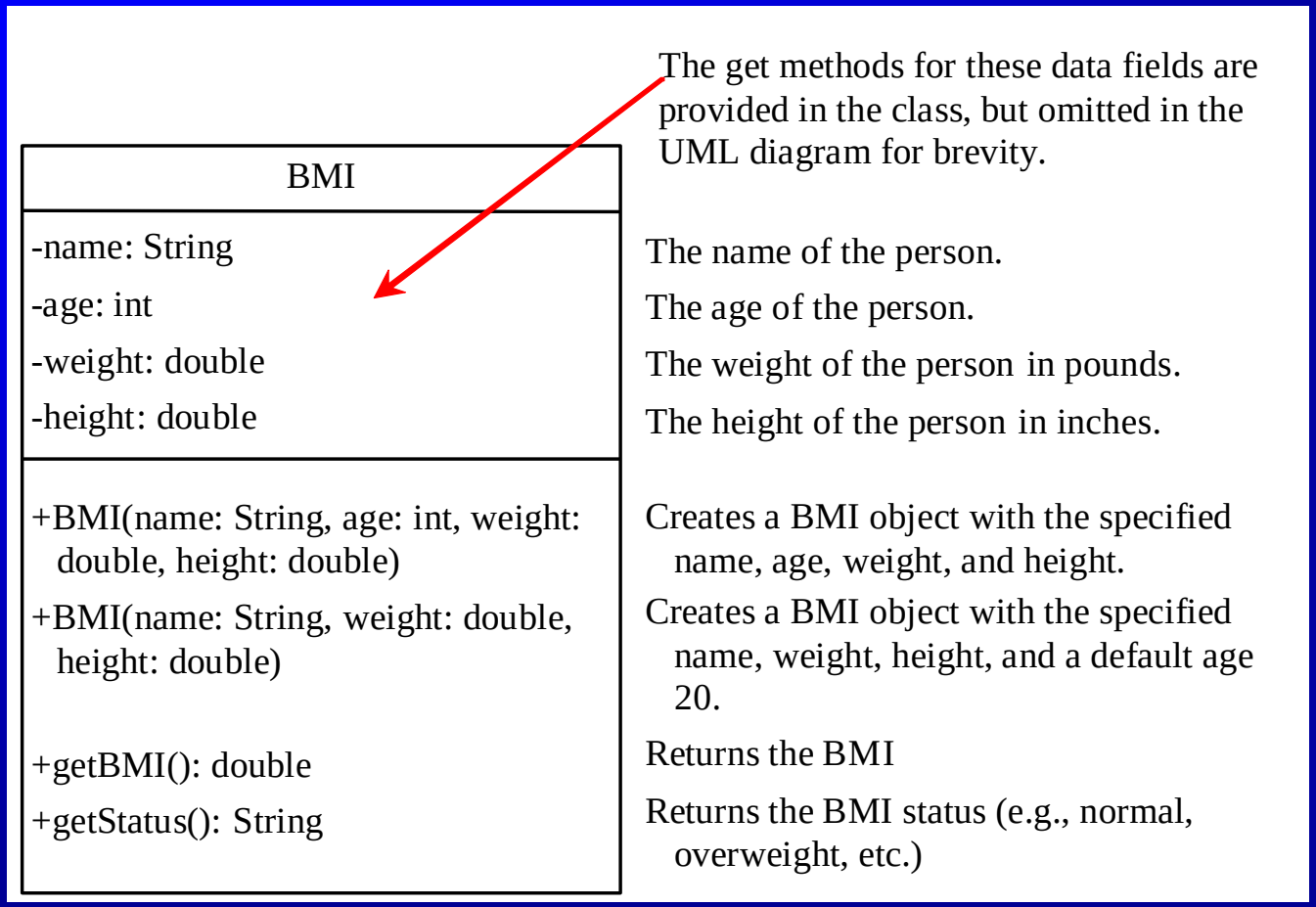
TestLoanClass

Run

Object-Oriented Thinking

Chapters 1-7 introduced fundamental programming techniques for problem solving using loops, methods, and arrays. The studies of these techniques lay a solid foundation for object-oriented programming. Classes provide more flexibility and modularity for building reusable software. This section improves the solution for a problem introduced in Chapter 3 using the object-oriented approach. From the improvements, you will gain the insight on the differences between the procedural programming and object-oriented programming and see the benefits of developing reusable code using objects and classes.

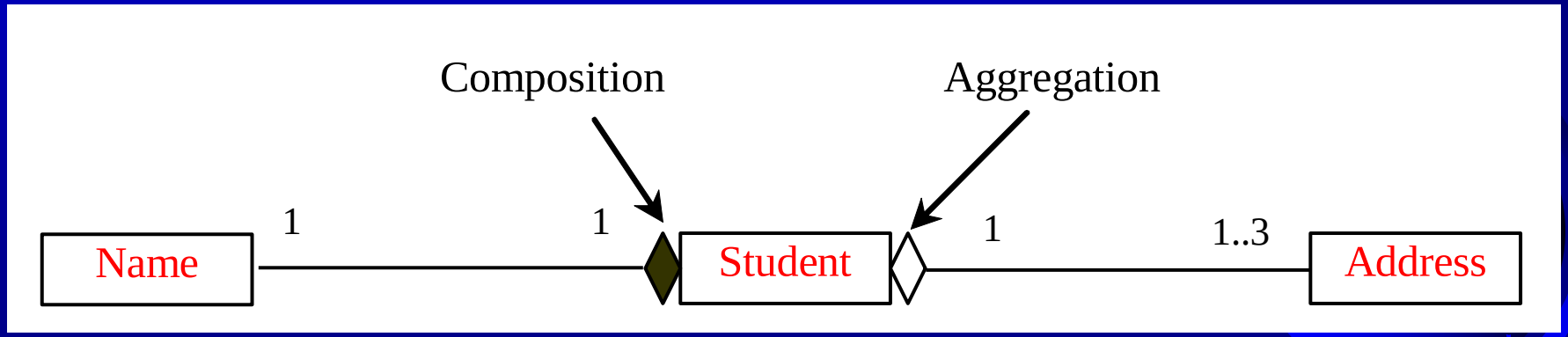
The BMI Class



BMI | UseBMIClass | Run

Object Composition

Composition is actually a special case of the aggregation relationship. Aggregation models *has-a* relationships and represents an ownership relationship between two objects. The owner object is called an *aggregating object* and its class an *aggregating class*. The subject object is called an *aggregated object* and its class an *aggregated class*.



Class Representation

An aggregation relationship is usually represented as a data field in the aggregating class. For example, the relationship in Figure 10.6 can be represented as follows:

```
public class Name {
  ...
}
```

Aggregated class

```
public class Student {
  private Name name;
  private Address address;

  ...
}
```

Aggregating class

```
public class Address {
  ...
}
```

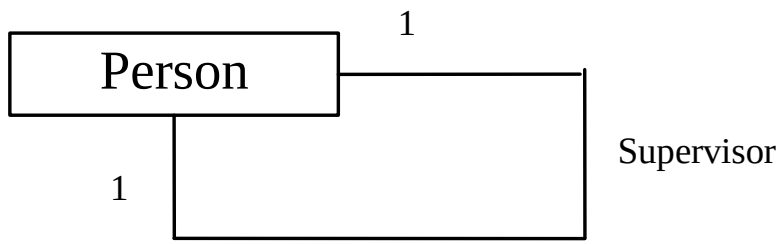
Aggregated class

Aggregation or Composition

Since aggregation and composition relationships are represented using classes in similar ways, many texts don't differentiate them and call both compositions.

Aggregation Between Same Class

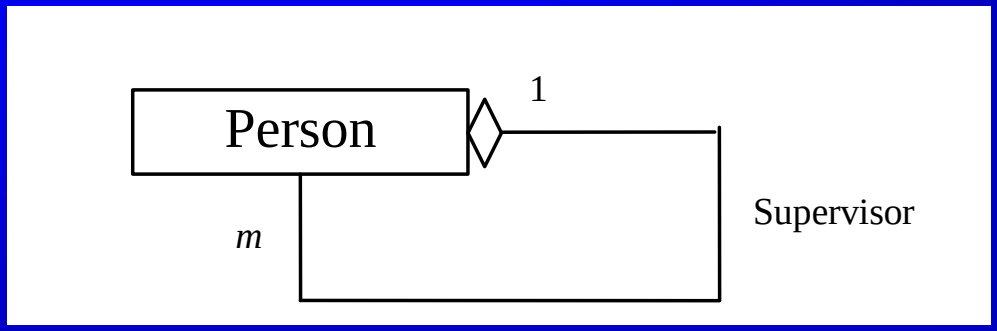
Aggregation may exist between objects of the same class. For example, a person may have a supervisor.




```
public class Person {
  // The type for the data is the class itself
  private Person supervisor;
  ...
}
```

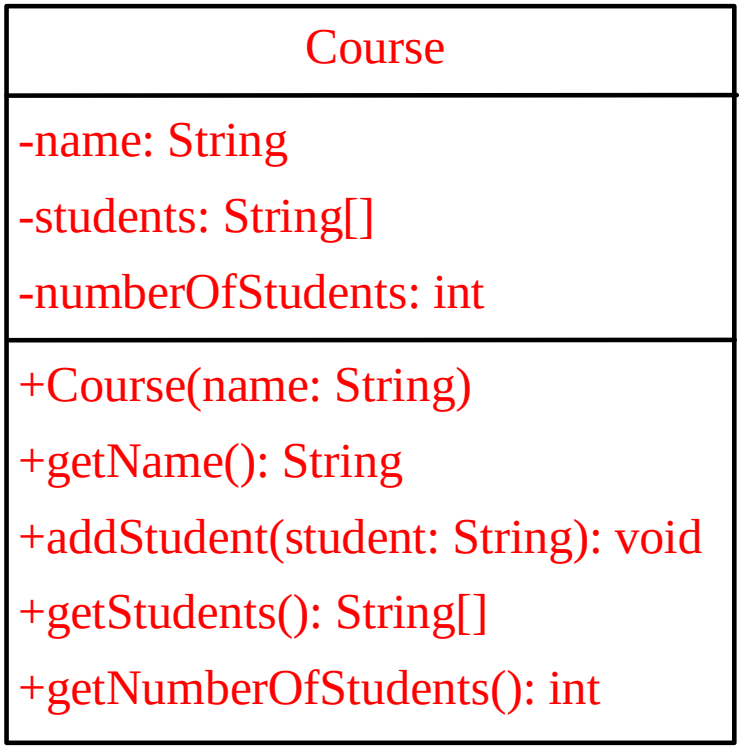
Aggregation Between Same Class

What happens if a person has several supervisors?




```
public class Person {
  ...
  private Person[] supervisors;
}
```

Example: The Course Class



The name of the course.

The students who take the course.

The number of students (default: 0).

Creates a Course with the specified name.

Returns the course name.

Adds a new student to the course list.

Returns the students for the course.

Returns the number of students for the course.

Course | TestCource | Run

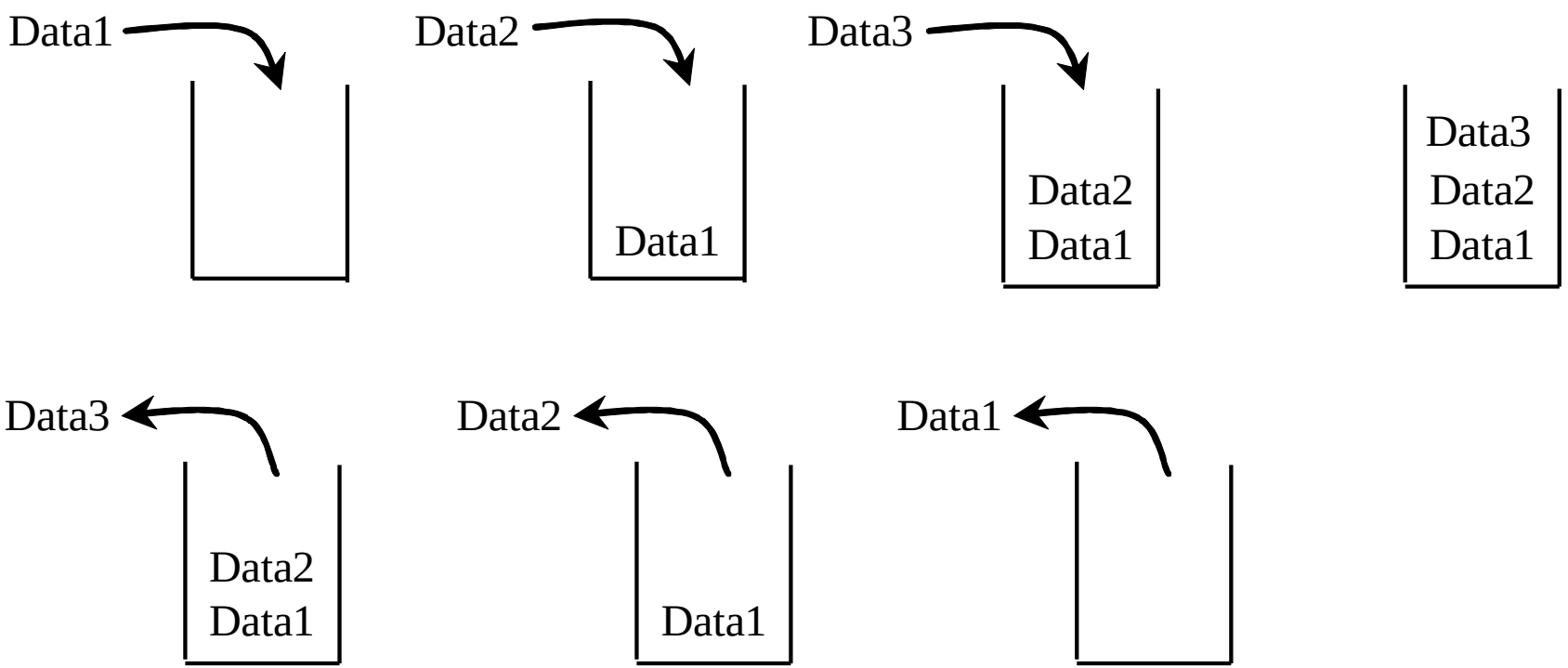
Example: The `StackOfIntegers` Class

StackOfIntegers	
-elements: int[]	An array to store integers in the stack.
-size: int	The number of integers in the stack.
+StackOfIntegers()	Constructs an empty stack with a default capacity of 16.
+StackOfIntegers(capacity: int)	Constructs an empty stack with a specified capacity.
+empty(): boolean	Returns true if the stack is empty.
+peek(): int	Returns the integer at the top of the stack without removing it from the stack.
+push(value: int): int	Stores an integer into the top of the stack.
+pop(): int	Removes the integer at the top of the stack and returns it.
+getSize(): int	Returns the number of elements in the stack.

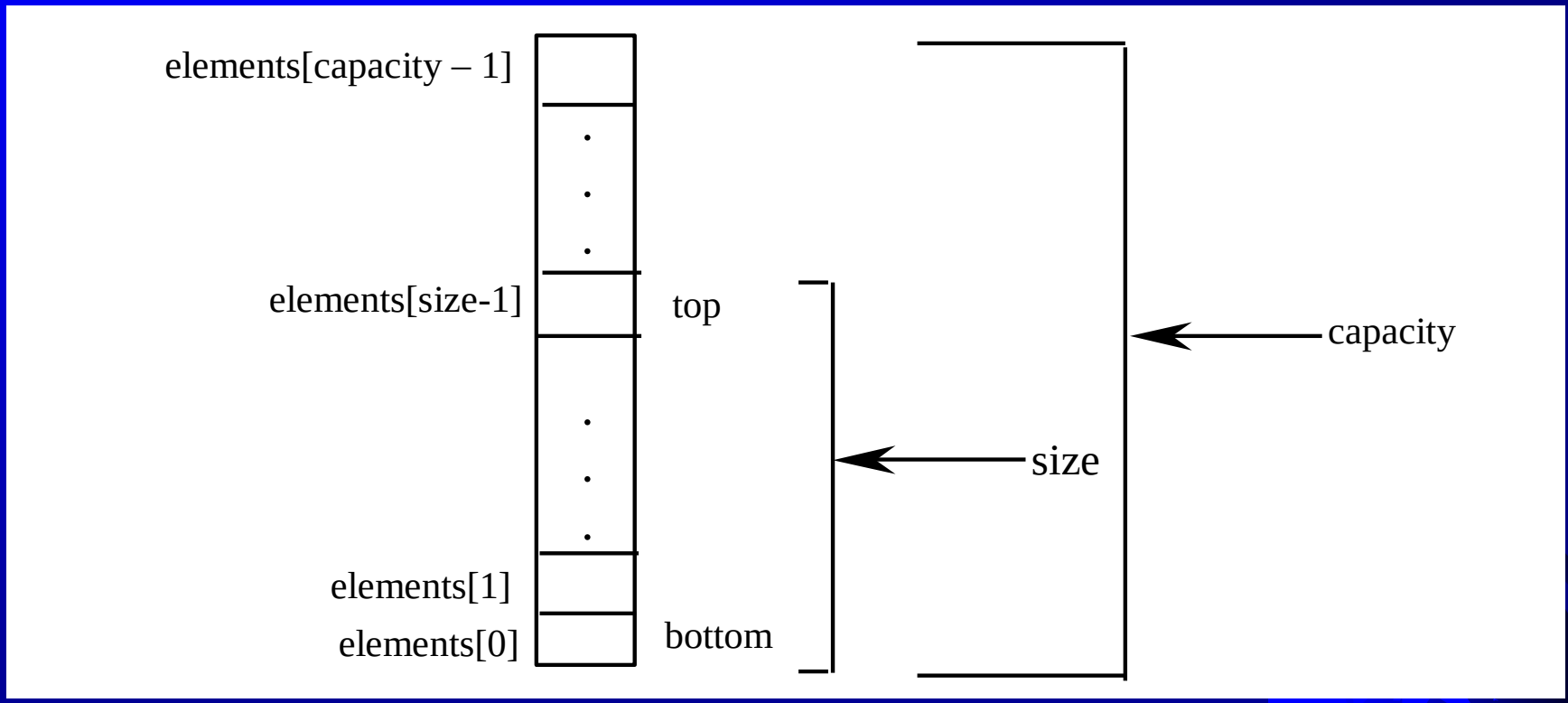
TestStackOfIntegers

Run

Designing the StackOfIntegers Class



Implementing `StackOfIntegers` Class



StackOfIntegers

Designing the GuessDate Class

GuessDate	
-dates: int[][][]	The static array to hold dates.
+getValue(setNo: int, row: int, column: int): int	Returns a date at the specified row and column in a given set.

GuessDate UseGuessDateClass Run

Designing a Class

- (Coherence) A class should describe a single entity, and all the class operations should logically fit together to support a coherent purpose. You can use a class for students, for example, but you should not combine students and staff in the same class, because students and staff have different entities.

Designing a Class, cont.

- (Separating responsibilities) A single entity with too many responsibilities can be broken into several classes to separate responsibilities. The classes String, StringBuilder, and StringBuffer all deal with strings, for example, but have different responsibilities. The String class deals with immutable strings, the StringBuilder class is for creating mutable strings, and the StringBuffer class is similar to StringBuilder except that StringBuffer contains synchronized methods for updating strings.

Designing a Class, cont.

- Classes are designed for reuse. Users can incorporate classes in many different combinations, orders, and environments. Therefore, you should design a class that imposes no restrictions on what or when the user can do with it, design the properties to ensure that the user can set properties in any order, with any combination of values, and design methods to function independently of their order of occurrence.

Designing a Class, cont.

- Provide a public no-arg constructor and override the equals method and the toString method defined in the Object class whenever possible.

Designing a Class, cont.

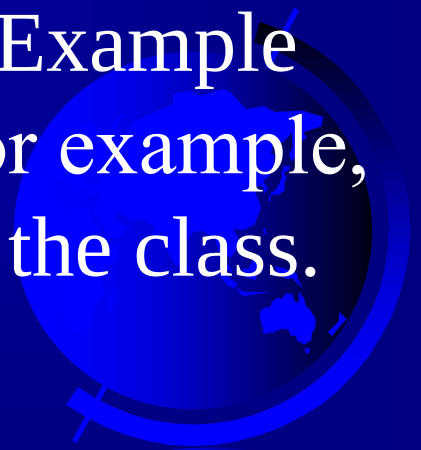
- Follow standard Java programming style and naming conventions. Choose informative names for classes, data fields, and methods. Always place the data declaration before the constructor, and place constructors before methods. Always provide a constructor and initialize variables to avoid programming errors.

Using Visibility Modifiers

- Each class can present two contracts – one for the users of the class and one for the extenders of the class. Make the fields private and accessor methods public if they are intended for the users of the class. Make the fields or method protected if they are intended for extenders of the class. The contract for the extenders encompasses the contract for the users. The extended class may increase the visibility of an instance method from protected to public, or change its implementation, but you should never change the implementation in a way that violates that contract.

Using Visibility Modifiers, cont.

- A class should use the private modifier to hide its data from direct access by clients. You can use get methods and set methods to provide users with access to the private data, but only to private data you want the user to see or to modify. A class should also hide methods not intended for client use. The gcd method in the Rational class in Example 11.2, "The Rational Class," is private, for example, because it is only for internal use within the class.



Using the static Modifier

- A property that is shared by all the instances of the class should be declared as a static property.

Wrapper Classes

- Boolean
- Character
- Short
- Byte
- Integer
- Long
- Float
- Double

NOTE: (1) The wrapper classes do not have no-arg constructors. (2) The instances of all wrapper classes are immutable, i.e., their internal values cannot be changed once the objects are created.

The toString, equals, and hashCode Methods

Each wrapper class overrides the toString, equals, and hashCode methods defined in the Object class. Since all the numeric wrapper classes and the Character class implement the Comparable interface, the compareTo method is implemented in these classes.

The Integer and Double Classes

java.lang.Integer
-value: int +MAX_VALUE: int +MIN_VALUE: int
+Integer(value: int) +Integer(s: String) +byteValue(): byte +shortValue(): short +intValue(): int +longVlaue(): long +floatValue(): float +doubleValue():double +compareTo(o: Integer): int +toString(): String +valueOf(s: String): Integer +valueOf(s: String, radix: int): Integer +parseInt(s: String): int +parseInt(s: String, radix: int): int

java.lang.Double
-value: double +MAX_VALUE: double +MIN_VALUE: double
+Double(value: double) +Double(s: String) +byteValue(): byte +shortValue(): short +intValue(): int +longVlaue(): long +floatValue(): float +doubleValue():double +compareTo(o: Double): int +toString(): String +valueOf(s: String): Double +valueOf(s: String, radix: int): Double +parseDouble(s: String): double +parseDouble(s: String, radix: int): double

The `Integer` Class and the `Double` Class

- Constructors
- Class Constants `MAX_VALUE`, `MIN_VALUE`
- Conversion Methods

Numeric Wrapper Class Constructors

You can construct a wrapper object either from a primitive data type value or from a string representing the numeric value. The constructors for Integer and Double are:

public Integer(int value)

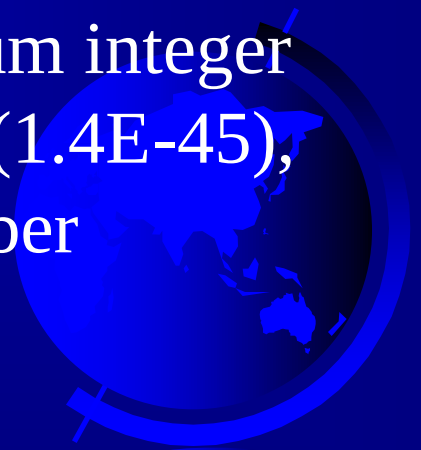
public Integer(String s)

public Double(double value)

public Double(String s)

Numeric Wrapper Class Constants

Each numerical wrapper class has the constants MAX_VALUE and MIN_VALUE. MAX_VALUE represents the maximum value of the corresponding primitive data type. For Byte, Short, Integer, and Long, MIN_VALUE represents the minimum byte, short, int, and long values. For Float and Double, MIN_VALUE represents the minimum *positive* float and double values. The following statements display the maximum integer (2,147,483,647), the minimum positive float (1.4E-45), and the maximum double floating-point number (1.79769313486231570e+308d).



Conversion Methods

Each numeric wrapper class implements the abstract methods doubleValue, floatValue, intValue, longValue, and shortValue, which are defined in the Number class. These methods "convert" objects into primitive type values.

The Static valueOf Methods

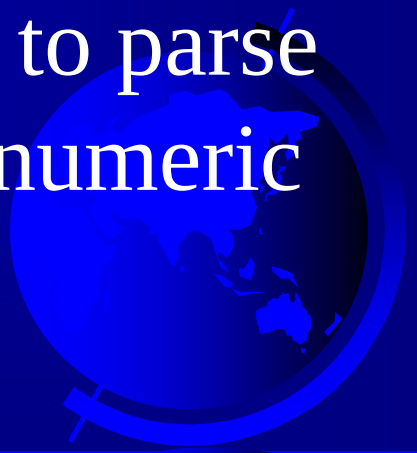
The numeric wrapper classes have a useful class method, valueOf(String s). This method creates a new object initialized to the value represented by the specified string. For example:

```
Double doubleObject = Double.valueOf("12.4");

Integer integerObject = Integer.valueOf("12");
```

The Methods for Parsing Strings into Numbers

You have used the parseInt method in the Integer class to parse a numeric string into an int value and the parseDouble method in the Double class to parse a numeric string into a double value. Each numeric wrapper class has two overloaded parsing methods to parse a numeric string into an appropriate numeric value.



Automatic Conversion Between Primitive Types and Wrapper Class Types

JDK 1.5 allows primitive type and wrapper classes to be converted automatically. For example, the following statement in (a) can be simplified as in (b):

```
Integer[] intArray = {new Integer(2),
  new Integer(4), new Integer(3)};
```

(a)

Equivalent

```
Integer[] intArray = {2, 4, 3};
```

New JDK 1.5 boxing

(b)

```
Integer[] intArray = {1, 2, 3};
System.out.println(intArray[0] + intArray[1] + intArray[2]);
```

Unboxing

BigInteger and BigDecimal

If you need to compute with very large integers or high precision floating-point values, you can use the BigInteger and BigDecimal classes in the java.math package. Both are *immutable*. Both extend the Number class and implement the Comparable interface.

BigInteger and BigDecimal

```
BigInteger a = new BigInteger("92233720368547758O7");
BigInteger b = new BigInteger("2");
BigInteger c = a.multiply(b); // 92233720368547758O7 * 2
System.out.println(c);
```

LargeFactorial Run

```
BigDecimal a = new BigDecimal(1.0);
BigDecimal b = new BigDecimal(3);
BigDecimal c = a.divide(b, 20, BigDecimal.ROUND_UP);
System.out.println(c);
```