

6a

Object-Oriented Programming: Inheritance



OBJECTIVES

In this lecture you will learn:

- How inheritance promotes software reusability.
- The notions of super classes and subclasses.
- To use keyword `extends` to create a class that inherits attributes and behaviors from another class.
- To use access modifier `protected` to give subclass methods access to superclass members.
- To access super class members with `super`.
- How constructors are used in inheritance hierarchies.
- The methods of class `Object`, the direct or indirect superclass of all classes in Java.



- 6a.1 Introduction**
- 6a.2 Superclasses and Subclasses**
- 6a.3 protected Members**
- 6a.4 Relationship between Superclasses and Subclasses**
 - 6a.4.1 Creating and Using a CommissionEmployee Class**
 - 6a.4.2 Creating a BasePlusCommissionEmployee Class without Using Inheritance**
 - 6a.4.3 Creating a CommissionEmployee–BasePlusCommissionEmployee Inheritance Hierarchy**
 - 6a.4.4 CommissionEmployee–BasePlusCommissionEmployee Inheritance Hierarchy Using protected Instance Variables**
 - 6a.4.5 CommissionEmployee–BasePlusCommissionEmployee Inheritance Hierarchy Using private Instance Variables**

Outline

- 6a.5 Constructors in Subclasses**
- 6a.6 Software Engineering with Inheritance**
- 6a.7 Object Class**
- 6a.8 Inheritance in JavaFX**
- 6a.9 GUI and Graphics Case Study: Displaying Text and Images Using Labels and Text**



6a.1 Introduction

- **Inheritance**

- **Software reusability**
- **Create new class from existing class**
 - **Absorb existing class's data and behaviors**
 - **Enhance with new capabilities**
- **Subclass extends superclass**
 - **Subclass**
 - **More specialized group of objects**
 - **Behaviors inherited from superclass**
 - **Can customize**
 - **Additional behaviors**



6a.1 Introduction (Cont.)

- **Class hierarchy**
 - **Direct superclass**
 - **Inherited explicitly (one level up hierarchy)**
 - **Indirect superclass**
 - **Inherited two or more levels up hierarchy**
 - **Single inheritance**
 - **Inherits from one superclass**
 - **Multiple inheritance**
 - **Inherits from multiple superclasses**
 - **Java does not support multiple inheritance**



6a.2 Superclasses and subclasses

- **Superclasses and subclasses**
 - Object of one class “is an” object of another class
 - **Example: Rectangle is quadrilateral.**
 - Class **Rectangle** inherits from class **Quadrilateral**
 - **Quadrilateral**: superclass
 - **Rectangle**: subclass
 - Superclass typically represents larger set of objects than subclasses
 - **Example:**
 - superclass: **Vehicle**
 - Cars, trucks, boats, bicycles, ...
 - subclass: **Car**
 - Smaller, more-specific subset of vehicles



Superclass	Subclasses
Student	GraduateStudent, UndergraduateStudent
Shape	Circle, Triangle, Rectangle
Loan	CarLoan, HomeImprovementLoan, MortgageLoan
Employee	Faculty, Staff
BankAccount	CheckingAccount, SavingsAccount

Fig. 6a.1 | Inheritance examples.

6a.2 Superclasses and subclasses (Cont.)

- **Inheritance hierarchy**

- **Inheritance relationships: tree-like hierarchy structure**
- **Each class becomes**
 - **superclass**
 - **Supply members to other classes**

OR

- **subclass**
 - **Inherit members from other classes**

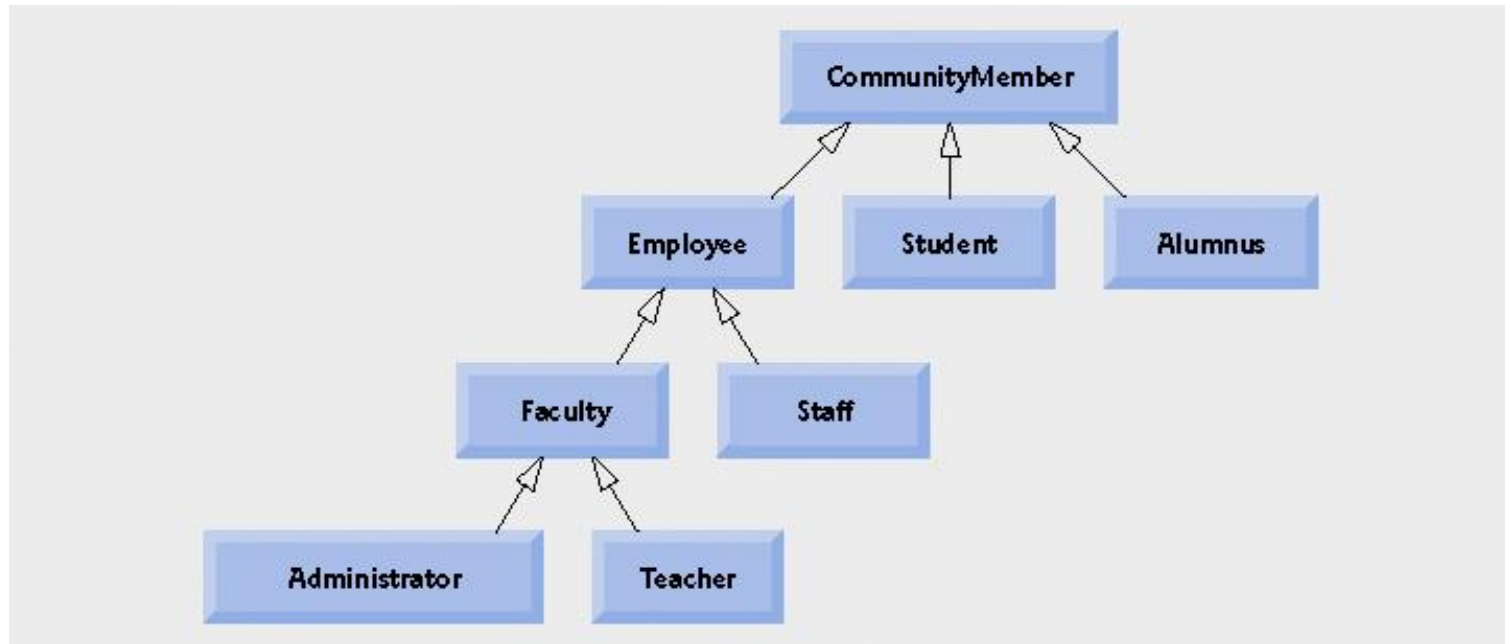


Fig. 6a.2 | Inheritance hierarchy for university CommunityMembers

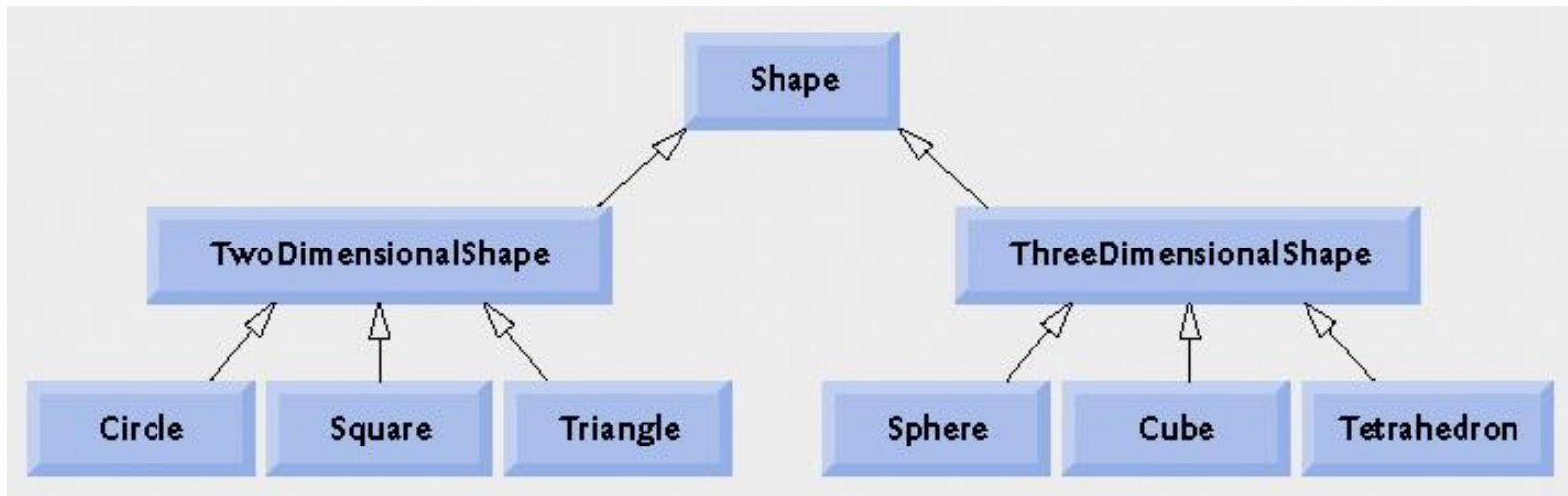


Fig. 6a.3 | Inheritance hierarchy for Shapes.

6a.3 protected Members

- **protected access**

- Intermediate level of protection between **public** and **private**
- **protected members accessible by**
 - **superclass members**
 - **subclass members**
 - **Class members in the same package**
- **Subclass access to superclass member**
 - **Keyword `super` and a dot (`.`)**



Software Engineering Observation 6a.1

Methods of a subclass cannot directly access private members of their superclass. A subclass can change the state of private superclass instance variables only through non-private methods provided in the superclass and inherited by the subclass.

Software Engineering Observation 6a.2

Declaring private instance variables helps programmers test, debug and correctly modify systems. If a subclass could access its superclass's private instance variables, classes that inherit from that subclass could access the instance variables as well. This would propagate access to what should be private instance variables, and the benefits of information hiding would be lost.

6a.4 Relationship between Superclasses and Subclasses

- **Superclass and subclass relationship**

- **Example:**

CommissionEmployee/BasePlusCommissionEmployee inheritance hierarchy

- **CommissionEmployee**

- **First name, last name, SSN, commission rate, gross sale amount**

- **BasePlusCommissionEmployee**

- **First name, last name, SSN, commission rate, gross sale amount**
 - **Base salary**

6a.4.1 Creating and Using a CommissionEmployee Class

- **Class CommissionEmployee**
 - **Extends class Object**
 - **Keyword extends**
 - **Every class in Java extends an existing class**
 - **Except Object**
 - **Every class inherits Object's methods**
 - **New class implicitly extends Object**
 - **If it does not extend another class**



Software Engineering Observation 6a.3

The Java compiler sets the superclass of a class to Object when the class declaration does not explicitly extend a superclass.

Outline

```

1 // Fig. 9.4: CommissionEmployee.java
2 // CommissionEmployee class represents a commission empl
3
4 public class CommissionEmployee extends Object
5 {
6     private String firstName;
7     private String lastName;
8     private String socialSecurityNumber;
9     private double grossSales; // gross weekly sales
10    private double commissionRate; // commission percent
11
12    // five-argument constructor
13    public CommissionEmployee( String first, String last, String ssn,
14        double sales, double rate )
15    {
16        // implicit call to Object constructor occurs here
17        firstName = first;
18        lastName = last;
19        socialSecurityNumber = ssn;
20        setGrossSales( sales ); // validate and store gross sales
21        setCommissionRate( rate ); // validate and store commission rate
22    } // end five-argument CommissionEmployee constructor
23
24    // set first name
25    public void setFirstName( String first )
26    {
27        firstName = first;
28    } // end method setFirstName
29

```

Declare private
instance variables

Class CommissionEmployee
extends class Object

Implicit call to
Object constructor

Initialize instance variables

Invoke methods `setGrossSales` and
`setCommissionRate` to validate data

CommissionEmployee
.java

(1 of 4)

Line 4

Lines 6-10

Line 16

Lines 20-21



Outline

CommissionEmployee
.java

(2 of 4)

```
30 // return first name
31 public String getFirstName()
32 {
33     return firstName;
34 } // end method getFirstName
35
36 // set last name
37 public void setLastName( String last )
38 {
39     lastName = last;
40 } // end method setLastName
41
42 // return last name
43 public String getLastName()
44 {
45     return lastName;
46 } // end method getLastName
47
48 // set social security number
49 public void setSocialSecurityNumber( String ssn )
50 {
51     socialSecurityNumber = ssn; // should validate
52 } // end method setSocialSecurityNumber
53
54 // return social security number
55 public String getSocialSecurityNumber()
56 {
57     return socialSecurityNumber;
58 } // end method getSocialSecurityNumber
59
```



Outline

CommissionEmployee
.java

(3 of 4)

Lines 85-88

```
60 // set gross sales amount
61 public void setGrossSales( double sales )
62 {
63     grossSales = ( sales < 0.0 ) ? 0.0 : sales;
64 } // end method setGrossSales
65
66 // return gross sales amount
67 public double getGrossSales()
68 {
69     return grossSales;
70 } // end method getGrossSales
71
72 // set commission rate
73 public void setCommissionRate( double rate )
74 {
75     commissionRate = ( rate > 0.0 && rate < 1.0 ) ? rate : 0.0;
76 } // end method setCommissionRate
77
78 // return commission rate
79 public double getCommissionRate()
80 {
81     return commissionRate;
82 } // end method getCommissionRate
83
84 // calculate earnings
85 public double earnings()
86 {
87     return commissionRate * grossSales;
88 } // end method earnings
89
```

Calculate earnings



Outline

```
90 // return String representation of CommissionEmployee object
91 public String toString()
92 {
93     return String.format( "%s: %s %s\n%s: %s\n%s: %s\n",
94         "commission employee", firstName, lastName,
95         "social security number", socialSecurityNumber,
96         "gross sales", grossSales,
97         "commission rate", commissionRate );
98 } // end method toString
99 } // end class CommissionEmployee
```

Override method toString
of class Object

CommissionEmployee
.java

(4 of 4)

Lines 91-98



Common Programming Error 6a.1

It is a syntax error to override a method with a more restricted access modifier—a `public` method of the superclass cannot become a `protected` or `private` method in the subclass; a `protected` method of the superclass cannot become a `private` method in the subclass. Doing so would break the “is-a” relationship in which it is required that all subclass objects be able to respond to method calls that are made to `public` methods declared in the superclass.(cont...)

Common Programming Error 6a.1

If a `public` method could be overridden as a `protected` or `private` method, the subclass objects would not be able to respond to the same method calls as superclass objects. Once a method is declared `public` in a superclass, the method remains `public` for all that class's direct and indirect subclasses.

Outline

CommissionEmployee
Test.java

(1 of 2)

Lines 9-10

Lines 15-25

26-27

```

1 // Fig. 9.5: CommissionEmployeeTest.java
2 // Testing class CommissionEmployee.
3
4 public class CommissionEmployeeTest
5 {
6     public static void main( String args[] )
7     {
8         // instantiate CommissionEmployee object
9         CommissionEmployee employee = new CommissionEmployee(
10             "Sue", "Jones", "222-22-2222", 10000, .06 );
11
12         // get commission employee data
13         System.out.println(
14             "Employee information obtained by get methods: \n" );
15         System.out.printf( "%s %s\n", "Employee's first name is",
16             employee.getFirstName() );
17         System.out.printf( "%s %s\n", "Employee's last name is",
18             employee.getLastName() );
19         System.out.printf( "%s %s\n", "Social security number is",
20             employee.getSocialSecurityNumber() );
21         System.out.printf( "%s %.2f\n", "Gross sales is",
22             employee.getGrossSales() );
23         System.out.printf( "%s %.2f\n", "Commission rate is",
24             employee.getCommissionRate() );
25
26         employee.setGrossSales( 500 ); // set gross sales
27         employee.setCommissionRate( .1 ); // set commission rate
28

```

Instantiate CommissionEmployee object

Use CommissionEmployee's *get* methods
to retrieve the object's instance variable values

Use CommissionEmployee's *set* methods
to change the object's instance variable values



Outline

```
29      System.out.printf( "\n%s:\n\n%s\n",  
30          "Updated employee information obtained by toString", employee );  
31  } // end main  
32 } // end class CommissionEmployeeTest
```

Implicitly call object's
toString method

onEmployee

Test.java

(2 of 2)

Line 30

Program output

Employee information obtained by get methods:

First name is Sue
Last name is Jones
Social security number is 222-22-2222
Gross sales is 10000.00
Commission rate is 0.06

Updated employee information obtained by toString:

commission employee: Sue Jones
social security number: 222-22-2222
gross sales: 500.00
commission rate: 0.10



6a.4.2 Creating a BasePlusCommissionEmployee Class without Using Inheritance

- **Class BasePlusCommissionEmployee**
 - Implicitly extends **Object**
 - Much of the code is similar to **CommissionEmployee**
 - **private** instance variables
 - **public** methods
 - **constructor**
 - **Additions**
 - **private** instance variable **baseSalary**
 - **Methods** **setBaseSalary** and **getBaseSalary**

Outline

BasePlusCommission
Employee.java

```
1 // Fig. 9.6: BasePlusCommissionEmployee.java
2 // BasePlusCommissionEmployee class represents an employee that receives
3 // a base salary in addition to commission.
4
5 public class BasePlusCommissionEmployee
6 {
7     private String firstName;
8     private String lastName;
9     private String socialSecurityNumber;
10    private double grossSales; // gross weekly sales
11    private double commissionRate; // commission percentage
12    private double baseSalary; // base salary per week
13
14    // six-argument constructor
15    public BasePlusCommissionEmployee( String first, String last,
16        String ssn, double sales, double rate, double salary )
17    {
18        // implicit call to Object constructor occurs here
19        firstName = first;
20        lastName = last;
21        socialSecurityNumber = ssn;
22        setGrossSales( sales ); // validate and store
23        setCommissionRate( rate ); // validate and store commission rate
24        setBaseSalary( salary ); // validate and store base salary
25    } // end six-argument BasePlusCommissionEmployee constructor
26
```

Add instance variable baseSalary

Line 12

Line 24

Use method setBaseSalary
to validate data



Outline

BasePlusCommission
Employee.java

(2 of 4)

```
27 // set first name
28 public void setFirstName( String first )
29 {
30     firstName = first;
31 } // end method setFirstName
32
33 // return first name
34 public String getFirstName()
35 {
36     return firstName;
37 } // end method getFirstName
38
39 // set last name
40 public void setLastName( String last )
41 {
42     lastName = last;
43 } // end method setLastName
44
45 // return last name
46 public String getLastName()
47 {
48     return lastName;
49 } // end method getLastName
50
51 // set social security number
52 public void setSocialSecurityNumber( String ssn )
53 {
54     socialSecurityNumber = ssn; // should validate
55 } // end method setSocialSecurityNumber
56
```



Outline

BasePlusCommission Employee.java

(3 of 4)

```
57 // return social security number
58 public String getSocialSecurityNumber()
59 {
60     return socialSecurityNumber;
61 } // end method getSocialSecurityNumber
62
63 // set gross sales amount
64 public void setGrossSales( double sales )
65 {
66     grossSales = ( sales < 0.0 ) ? 0.0 : sales;
67 } // end method setGrossSales
68
69 // return gross sales amount
70 public double getGrossSales()
71 {
72     return grossSales;
73 } // end method getGrossSales
74
75 // set commission rate
76 public void setCommissionRate( double rate )
77 {
78     commissionRate = ( rate > 0.0 && rate < 1.0 ) ? rate : 0.0;
79 } // end method setCommissionRate
80
81 // return commission rate
82 public double getCommissionRate()
83 {
84     return commissionRate;
85 } // end method getCommissionRate
86
```



Outline

BasePlusCommissionEmployee.java

(4 of 4)

Lines 88-91

Lines 94-97

Line 102

Lines 108-113

```

87 // set base salary
88 public void setBaseSalary( double salary )
89 {
90     baseSalary = ( salary < 0.0 ) ? 0.0 : salary;
91 } // end method setBaseSalary
92
93 // return base salary
94 public double getBaseSalary()
95 {
96     return baseSalary;
97 } // end method getBaseSalary
98
99 // calculate ea
100 public double
101 {
102     return baseSalary + ( commissionRate * grossSales );
103 } // end method earnings
104
105 // return String representation of BasePlusCommissionEmployee
106 public String toString()
107 {
108     return String.format(
109         "%s: %s %s\n%s: %s\n%s: %.2f\n%s: %.2f\n%s: %.2f",
110         "base-salaried commission employee", firstName, lastName,
111         "social security number", socialSecurityNumber,
112         "gross sales", grossSales, "commission rate",
113         "base salary", baseSalary );
114 } // end method toString
115 } // end class BasePlusCommissionEmployee
  
```

Method setBaseSalary validates data and sets instance variable baseSalary

Method getBaseSalary returns the value of instance variable baseSalary

Update method earnings to calculate the earnings of a base-salaried commission employee

Update method toString to display base salary



Outline

```
1 // Fig. 9.7: BasePlusCommissionEmployeeTest.java
2 // Testing class BasePlusCommissionEmployee.
```

```
3
4 public class BasePlusCommissionEmployeeTest
5 {
```

```
6     public static void main( String args[] )
```

```
7     {
8         // instantiate BasePlusCommissionEmployee object
9         BasePlusCommissionEmployee employee =
10             new BasePlusCommissionEmployee(
11                 "Bob", "Lewis", "333-33-3333", 5000, .04, 300 );
12
13         // get base-salaried commission employee data
14         System.out.println(
15             "Employee information obtained by get methods: \n" );
16         System.out.printf( "%s %s\n",
17             employee.getFirstName() );
18         System.out.printf( "%s %s\n",
19             employee.getLastName() );
20         System.out.printf( "%s %s\n", "Social security number is",
21             employee.getSocialSecurityNumber() );
22         System.out.printf( "%s %.2f\n", "Gross sales is",
23             employee.getGrossSales() );
24         System.out.printf( "%s %.2f\n", "Commission rate is",
25             employee.getCommissionRate() );
26         System.out.printf( "%s %.2f\n", "Base salary is",
27             employee.getBaseSalary() );
28     }
```

Instantiate BasePlusCommissionEmployee object
BasePlusCommissionEmployeeTest.java

(1 of 2)

Line 9-11

Lines 16-27

Use BasePlusCommissionEmployee's *get* methods
to retrieve the object's instance variable values



Outline

Use BasePlusCommissionEmployee's
setBaseSalary methods to set base salary

BasePlusCommission
EmployeeTest.java

Explicitly call object's toString
method

(2 of 2)

Line 29

Line 33

Program output

```

29     employee.setBaseSalary( 1000 ); // set base salary
30
31     system.out.printf( "\n%s:\n\n%s\n",
32         "Updated employee information obtained by toString:",
33         employee.toString() );
34 } // end main
35 } // end class BasePlusCommissionEmployee

```

Employee information obtained by get methods:

```

First name is Bob
Last name is Lewis
Social security number is 333-33-3333
Gross sales is 5000.00
Commission rate is 0.04
Base salary is 300.00

```

Updated employee information obtained by toString:

```

base-salaried commission employee: Bob Lewis
social security number: 333-33-3333
gross sales: 5000.00
commission rate: 0.04
base salary: 1000.00

```



Software Engineering Observation 6a.4

Copying and pasting code from one class to another can spread errors across multiple source code files. To avoid duplicating code (and possibly errors), use inheritance, rather than the “copy-and-paste” approach, in situations where you want one class to “absorb” the instance variables and methods of another class.

Software Engineering Observation 6a.5

With inheritance, the common instance variables and methods of all the classes in the hierarchy are declared in a superclass. When changes are required for these common features, software developers need only to make the changes in the superclass—subclasses then inherit the changes. Without inheritance, changes would need to be made to all the source code files that contain a copy of the code in question.

6a.4.3 Creating a CommissionEmployee–BasePlusCommissionEmployee Inheritance Hierarchy

- **Class BasePlusCommissionEmployee2**
 - Extends class **CommissionEmployee**
 - Is a **CommissionEmployee**
 - Has instance variable **baseSalary**
 - Inherits **public** and **protected** members
 - Constructor not inherited

Outline

```

1 // Fig. 9.8: BasePlusCommissionEmployee2.java
2 // BasePlusCommissionEmployee2 inherits from class CommissionEmployee.
3
4 public class BasePlusCommissionEmployee2 extends CommissionEmployee
5 {
6     private double baseSalary; // base salary per week
7
8     // six-argument constructor
9     public BasePlusCommissionEmployee2( String first, String last,
10         String ssn, double sales, double rate, double salary )
11     {
12         // explicit call to superclass CommissionEmployee constructor
13         super( first, last, ssn, sales, rate );
14
15         setBaseSalary( salary ); // validate and store base salary
16     } // end six-argument BasePlusCommissionEmployee2 constructor
17
18     // set base salary
19     public void setBaseSalary( double salary )
20     {
21         baseSalary = ( salary < 0.0 ) ? 0.0 : salary;
22     } // end method setBaseSalary
23

```

BasePlusCommissionEmployee2.java

Class BasePlusCommissionEmployee2 is a subclass of CommissionEmployee

Line 4

Line 13

Invoke the superclass constructor using the superclass constructor call syntax



Outline

BasePlusCommission

```

24 // return base salary
25 public double getBaseSalary()
26 {
27     return baseSalary;
28 } // end method getBaseSalary

```

```

29
30 // calculate earnings
31 public double earnings()
32 {

```

Compiler generates errors because superclass's instance variable **commissionRate** and **grossSales** are private

```

33     // not allowed: commissionRate and grossSales private in superclass
34     return baseSalary + ( commissionRate * grossSales );
35 } // end method earnings

```

(2 of 3)

Line 34

```

36
37 // return String representation
38 public String toString()
39 {

```

Compiler generates errors because superclass's instance variable **firstName**, **lastName**, **socialSecurityNumber**, **grossSales** and **commissionRate** are private

```

40     // not allowed: attempts to access private variables
41     return String.format(
42         "%s: %s %s\n%s: %s\n%s: %.2f\n%s: %.2f\n%s: %.2f",
43         "base-salaried commission employee", firstName, lastName,
44         "social security number", socialSecurityNumber,
45         "gross sales", grossSales, "commission rate", commissionRate,
46         "base salary", baseSalary );
47 } // end method toString
48 } // end class BasePlusCommissionEmployee2

```

Lines 41-46



Outline

BasePlusCommissionEmployee2.java

(3 of 3)

Compiler generated errors

```
BasePlusCommissionEmployee2.java:34: commissionRate has private access in
CommissionEmployee
    return baseSalary + ( commissionRate * grossSales );
                           ^
BasePlusCommissionEmployee2.java:34: grossSales has private access in
CommissionEmployee
    return baseSalary + ( commissionRate * grossSales );
                                   ^
BasePlusCommissionEmployee2.java:43: firstName has private access in
CommissionEmployee
    "base-salaried commission employee", firstName, lastName,
                                         ^
BasePlusCommissionEmployee2.java:43: lastName has private access in
CommissionEmployee
    "base-salaried commission employee", firstName, lastName,
                                                    ^
BasePlusCommissionEmployee2.java:44: socialSecurityNumber has private access in
CommissionEmployee
    "social security number", socialSecurityNumber,
                               ^
BasePlusCommissionEmployee2.java:45: grossSales has private access in
CommissionEmployee
    "gross sales", grossSales, "commission rate", commissionRate,
                   ^
BasePlusCommissionEmployee2.java:45: commissionRate has private access in
CommissionEmployee
    "gross sales", grossSales, "commission rate", commissionRate,
                                                    ^
```

7 errors



Common Programming Error 6a.2

A compilation error occurs if a subclass constructor calls one of its superclass constructors with arguments that do not match exactly the number and types of parameters specified in one of the superclass constructor declarations.

6a.4.4 CommissionEmployee-BasePlusCommissionEmployee Inheritance Hierarchy Using protected Instance Variables

- Use **protected** instance variables
 - Enable class **BasePlusCommissionEmployee** to directly access superclass instance variables
 - Superclass's **protected** members are inherited by all subclasses of that superclass

Outline

Commission

Employee2.java

(1 of 4)

Line 6-10

```
1 // Fig. 9.9: CommissionEmployee2.java
2 // CommissionEmployee2 class represents a commission employee.
3
4 public class CommissionEmployee2
5 {
6     protected String firstName;
7     protected String lastName;
8     protected String socialSecurityNumber;
9     protected double grossSales; // gross weekly sales
10    protected double commissionRate; // commission percentage
11
12    // five-argument constructor
13    public CommissionEmployee2( String first, String last, String ssn,
14        double sales, double rate )
15    {
16        // implicit call to Object constructor occurs here
17        firstName = first;
18        lastName = last;
19        socialSecurityNumber = ssn;
20        setGrossSales( sales ); // validate and store gross sales
21        setCommissionRate( rate ); // validate and store commission rate
22    } // end five-argument CommissionEmployee2 constructor
23
24    // set first name
25    public void setFirstName( String first )
26    {
27        firstName = first;
28    } // end method setFirstName
29
```

Declare protected
instance variables



Outline

Commission

Employee2.java

(2 of 4)

```
30 // return first name
31 public String getFirstName()
32 {
33     return firstName;
34 } // end method getFirstName
35
36 // set last name
37 public void setLastName( String last )
38 {
39     lastName = last;
40 } // end method setLastName
41
42 // return last name
43 public String getLastName()
44 {
45     return lastName;
46 } // end method getLastName
47
48 // set social security number
49 public void setSocialSecurityNumber( String ssn )
50 {
51     socialSecurityNumber = ssn; // should validate
52 } // end method setSocialSecurityNumber
53
54 // return social security number
55 public String getSocialSecurityNumber()
56 {
57     return socialSecurityNumber;
58 } // end method getSocialSecurityNumber
59
```



Outline

Commission

Employee2.java

(3 of 4)

```
60 // set gross sales amount
61 public void setGrossSales( double sales )
62 {
63     grossSales = ( sales < 0.0 ) ? 0.0 : sales;
64 } // end method setGrossSales
65
66 // return gross sales amount
67 public double getGrossSales()
68 {
69     return grossSales;
70 } // end method getGrossSales
71
72 // set commission rate
73 public void setCommissionRate( double rate )
74 {
75     commissionRate = ( rate > 0.0 && rate < 1.0 ) ? rate : 0.0;
76 } // end method setCommissionRate
77
78 // return commission rate
79 public double getCommissionRate()
80 {
81     return commissionRate;
82 } // end method getCommissionRate
83
84 // calculate earnings
85 public double earnings()
86 {
87     return commissionRate * grossSales;
88 } // end method earnings
89
```



```
90 // return String representation of CommissionEmployee2 object
91 public String toString()
92 {
93     return String.format( "%s: %s %s\n%s: %s\n%s: %.2f\n%s: %.2f",
94         "commission employee", firstName, lastName,
95         "social security number", socialSecurityNumber,
96         "gross sales", grossSales,
97         "commission rate", commissionRate );
98 } // end method toString
99 } // end class CommissionEmployee2
```

Outline

Commission

Employee2.java

(4 of 4)



Outline

BasePlusCommission
Employee3.java

```

1 // Fig. 9.10: BasePlusCommissionEmployee3.java
2 // BasePlusCommissionEmployee3 inherits from CommissionEmployee2 and has
3 // access to CommissionEmployee2's protected members.
4
5 public class BasePlusCommissionEmployee3 extends CommissionEmployee2
6 {
7     private double baseSalary; // base salary per week
8
9     // six-argument constructor
10    public BasePlusCommissionEmployee3( String first, String last,
11        String ssn, double sales, double rate, double salary )
12    {
13        super( first, last, ssn, sales, rate );
14        setBaseSalary( salary ); // validate and store base salary
15    } // end six-argument BasePlusCommissionEmployee3 constructor
16
17    // set base salary
18    public void setBaseSalary( double salary )
19    {
20        baseSalary = ( salary < 0.0 ) ? 0.0 : salary;
21    } // end method setBaseSalary
22
23    // return base salary
24    public double getBaseSalary()
25    {
26        return baseSalary;
27    } // end method getBaseSalary
28

```

Must call superclass's
constructor

of 2)

Line 13



Outline

BasePlusCommission
Employee3.java

Directly access
superclass's protected
instance variables

Line 32

Lines 38-43

```
29 // calculate earnings
30 public double earnings()
31 {
32     return baseSalary + ( commissionRate * grossSales );
33 } // end method earnings
34
35 // return String representation of BasePlusCommissionEmployee3
36 public String toString()
37 {
38     return String.format(
39         "%s: %s %s\n%s: %s\n%s: %.2f\n%s: %.2f\n%s: %.2f",
40         "base-salaried commission employee", firstName, lastName,
41         "social security number", socialSecurityNumber,
42         "gross sales", grossSales, "commission rate", commissionRate,
43         "base salary", baseSalary );
44 } // end method toString
45 } // end class BasePlusCommissionEmployee3
```



Outline

BasePlusCommission
EmployeeTest3.java

(1 of 2)

```
1 // Fig. 9.11: BasePlusCommissionEmployeeTest3.java
2 // Testing class BasePlusCommissionEmployee3.
3
4 public class BasePlusCommissionEmployeeTest3
5 {
6     public static void main( String args[] )
7     {
8         // instantiate BasePlusCommissionEmployee3 object
9         BasePlusCommissionEmployee3 employee =
10             new BasePlusCommissionEmployee3(
11                 "Bob", "Lewis", "333-33-3333", 5000, .04, 300 );
12
13         // get base-salaried commission employee data
14         System.out.println(
15             "Employee information obtained by get methods: \n" );
16         System.out.printf( "%s %s\n", "First name is",
17             employee.getFirstName() );
18         System.out.printf( "%s %s\n", "Last name is",
19             employee.getLastName() );
20         System.out.printf( "%s %s\n", "Social security number is",
21             employee.getSocialSecurityNumber() );
22         System.out.printf( "%s %.2f\n", "Gross sales is",
23             employee.getGrossSales() );
24         System.out.printf( "%s %.2f\n", "Commission rate is",
25             employee.getCommissionRate() );
26         System.out.printf( "%s %.2f\n", "Base salary is",
27             employee.getBaseSalary() );
28
```



Outline

BasePlusCommission
EmployeeTest3.java

(2 of 2)

Program output

```
29     employee.setBaseSalary( 1000 ); // set base salary
30
31     system.out.printf( "\n%s:\n\n%s\n",
32         "Updated employee information obtained by toString",
33         employee.toString() );
34 } // end main
35 } // end class BasePlusCommissionEmployeeTest3
```

Employee information obtained by get methods:

First name is Bob
Last name is Lewis
Social security number is 333-33-3333
Gross sales is 5000.00
Commission rate is 0.04
Base salary is 300.00

Updated employee information obtained by toString:

base-salaried commission employee: Bob Lewis
social security number: 333-33-3333
gross sales: 5000.00
commission rate: 0.04
base salary: 1000.00



6a.4.4 CommissionEmployee-BasePlusCommissionEmployee Inheritance Hierarchy Using protected Instance Variables (Cont.)

- **Using protected instance variables**
 - **Advantages**
 - subclasses can modify values directly
 - Slight increase in performance
 - Avoid set/get method call overhead
 - **Disadvantages**
 - No validity checking
 - subclass can assign illegal value
 - Implementation dependent
 - subclass methods more likely dependent on superclass implementation
 - superclass implementation changes may result in subclass modifications
 - Fragile (brittle) software

Software Engineering Observation 6a.6

Use the protected access modifier when a superclass should provide a method only to its subclasses and other classes in the same package, but not to other clients.

Software Engineering Observation 6a.7

Declaring superclass instance variables `private` (as opposed to `protected`) enables the superclass implementation of these instance variables to change without affecting subclass implementations.

Error-Prevention Tip 6a.1

When possible, do not include protected instance variables in a superclass. Instead, include non-private methods that access private instance variables. This will ensure that objects of the class maintain consistent states.

6a.4.5 CommissionEmployee-BasePlusCommissionEmployee Inheritance Hierarchy

Using private Instance Variables

- **Reexamine hierarchy**
 - Use the best software engineering practice
 - Declare instance variables as **private**
 - Provide public *get* and *set* methods
 - Use *get* method to obtain values of instance variables

Outline

Commission

Employee3.java

(1 of 4)

Lines 6-10

```
1 // Fig. 9.12: CommissionEmployee3.java
2 // CommissionEmployee3 class represents a commission employee.
3
4 public class CommissionEmployee3
5 {
6     private String firstName;
7     private String lastName;
8     private String socialSecurityNumber;
9     private double grossSales; // gross weekly sales
10    private double commissionRate; // commission percentage
11
12    // five-argument constructor
13    public CommissionEmployee3( String first, String last, String ssn,
14        double sales, double rate )
15    {
16        // implicit call to Object constructor occurs here
17        firstName = first;
18        lastName = last;
19        socialSecurityNumber = ssn;
20        setGrossSales( sales ); // validate and store gross sales
21        setCommissionRate( rate ); // validate and store commission rate
22    } // end five-argument CommissionEmployee3 constructor
23
24    // set first name
25    public void setFirstName( String first )
26    {
27        firstName = first;
28    } // end method setFirstName
29
```

Declare private
instance variables



Outline

Commission

Employee3.java

(2 of 4)

```
30 // return first name
31 public String getFirstName()
32 {
33     return firstName;
34 } // end method getFirstName
35
36 // set last name
37 public void setLastName( String last )
38 {
39     lastName = last;
40 } // end method setLastName
41
42 // return last name
43 public String getLastName()
44 {
45     return lastName;
46 } // end method getLastName
47
48 // set social security number
49 public void setSocialSecurityNumber( String ssn )
50 {
51     socialSecurityNumber = ssn; // should validate
52 } // end method setSocialSecurityNumber
53
54 // return social security number
55 public String getSocialSecurityNumber()
56 {
57     return socialSecurityNumber;
58 } // end method getSocialSecurityNumber
59
```



Outline

Commission

Employee3.java

(3 of 4)

```
60 // set gross sales amount
61 public void setGrossSales( double sales )
62 {
63     grossSales = ( sales < 0.0 ) ? 0.0 : sales;
64 } // end method setGrossSales
65
66 // return gross sales amount
67 public double getGrossSales()
68 {
69     return grossSales;
70 } // end method getGrossSales
71
72 // set commission rate
73 public void setCommissionRate( double rate )
74 {
75     commissionRate = ( rate > 0.0 && rate < 1.0 ) ? rate : 0.0;
76 } // end method setCommissionRate
77
78 // return commission rate
79 public double getCommissionRate()
80 {
81     return commissionRate;
82 } // end method getCommissionRate
83
```



Outline

```
84 // calculate earnings
85 public double earnings()
86 {
87     return getCommissionRate() * getGrossSales();
88 } // end method earnings
89
90 // return String representation of CommissionEmployee
91 public String toString()
92 {
93     return String.format( "%s: %s %s\n%s: %s\n%s: %.2f\n%s: %.2f",
94         "commission employee", getFirstName(), getLastName(),
95         "social security number", getSocialSecurityNumber(),
96         "gross sales", getGrossSales(),
97         "commission rate", getCommissionRate() );
98 } // end method toString
99 } // end class CommissionEmployee3
```

Use *get* methods to obtain the values of instance variables

CommissionEmployee

Employee3.java

(4 of 4)

Line 87

Lines 94-97



Outline

BasePlusCommission
Employee4.java

```
1 // Fig. 9.13: BasePlusCommissionEmployee4.java
2 // BasePlusCommissionEmployee4 class inherits from CommissionEmployee3 and
3 // accesses CommissionEmployee3's private data via CommissionEmployee3's
4 // public methods.
5
6 public class BasePlusCommissionEmployee4 extends CommissionEmployee3
7 {
8     private double baseSalary; // base salary per week
9
10    // six-argument constructor
11    public BasePlusCommissionEmployee4( String first, String last,
12        String ssn, double sales, double rate, double salary )
13    {
14        super( first, last, ssn, sales, rate );
15        setBaseSalary( salary ); // validate and store base salary
16    } // end six-argument BasePlusCommissionEmployee4 constructor
17
18    // set base salary
19    public void setBaseSalary( double salary )
20    {
21        baseSalary = ( salary < 0.0 ) ? 0.0 : salary;
22    } // end method setBaseSalary
23
```

Inherits from
CommissionEmployee3



Outline

```

24 // return base salary
25 public double getBaseSalary()
26 {
27     return baseSalary;
28 } // end method getBaseSalary
29
30 // calculate earnings
31 public double earnings()
32 {
33     return getBaseSalary() + super.earnings();
34 } // end method earnings
35
36 // return String representation of BasePlusCommissionEmployee
37 public String toString()
38 {
39     return String.format( "%s %s\n%s: %.2f", "base-salaried",
40                          super.toString(), "base salary", getBaseSalary() );
41 } // end method toString
42 } // end class BasePlusCommissionEmployee4

```

Invoke an overridden superclass method from a subclass

(2 of 2)

Use *get* methods to obtain the values of instance variables

Lines 40

Invoke an overridden superclass method from a subclass



Common Programming Error 6a.3

When a superclass method is overridden in a subclass, the subclass version often calls the superclass version to do a portion of the work. Failure to prefix the superclass method name with the keyword `super` and a dot (.) separator when referencing the superclass's method causes the subclass method to call itself, creating an error called infinite recursion. Recursion, used correctly, is a powerful capability discussed in Chapter 15, Recursion.

Outline

1 // Fig. 9.14: BasePlusCommissionEmployeeTest4.java

2 // Testing class BasePlusCommissionEmployee4.

3

4 public class BasePlusCommissionEmployeeTest4

5 {

6 public static void main(String args[])

7 {

8 // instantiate BasePlusCommissionEmployee4 object

9 BasePlusCommissionEmployee4 employee =

10 new BasePlusCommissionEmployee4(

11 "Bob", "Lewis", "333-33-3333", 5000, .04, 300);

12

13 // get base-salaried commission employee data

14 System.out.println(

15 "Employee information obtained by get methods: \n");

16 System.out.printf("%s %s\n", "First name is",

17 employee.getFirstName());

18 System.out.printf("%s %s\n", "Last name is",

19 employee.getLastName());

20 System.out.printf("%s %s\n", "Social security number is",

21 employee.getSocialSecurityNumber());

22 System.out.printf("%s %.2f\n", "Gross sales is",

23 employee.getGrossSales());

24 System.out.printf("%s %.2f\n", "Commission rate is",

25 employee.getCommissionRate());

26 System.out.printf("%s %.2f\n", "Base salary

27 employee.getBaseSalary());

28

Create
BasePlusCommissionEmployee4
object.

Lines 9-11

Lines 16-25

Use inherited *get* methods to
access inherited **private**
instance variables

Use BasePlusCommissionEmployee4 *get*
method to access **private** instance variable.



Outline

Use `BasePlusCommissionEmployee4` *set* method to modify private instance variable `baseSalary`.

```

29  employee.setBaseSalary( 1000 ); // set base salary
30
31  system.out.printf( "\n%s:\n\n%s\n",
32      "Updated employee information obtained by toString()",
33      employee.toString() );
34  } // end main
35 } // end class BasePlusCommissionEmployeeTest4

```

EmployeeTest4.java

(2 of 2)

Employee information obtained by get methods:

```

First name is Bob
Last name is Lewis
Social security number is 333-33-3333
Gross sales is 5000.00
Commission rate is 0.04
Base salary is 300.00

```

Updated employee information obtained by toString:

```

base-salaried commission employee: Bob Lewis
social security number: 333-33-3333
gross sales: 5000.00
commission rate: 0.04
base salary: 1000.00

```



6a.5 Constructors in Subclasses

- **Instantiating subclass object**
 - **Chain of constructor calls**
 - **subclass constructor invokes superclass constructor**
 - **Implicitly or explicitly**
 - **Base of inheritance hierarchy**
 - **Last constructor called in chain is `Object`'s constructor**
 - **Original subclass constructor's body finishes executing last**
 - **Example: `CommissionEmployee3`–
`BasePlusCommissionEmployee4` hierarchy**
 - **`CommissionEmployee3` constructor called second last (last is `Object` constructor)**
 - **`CommissionEmployee3` constructor's body finishes execution second (first is `Object` constructor's body)**

Software Engineering Observation 6a.8

When a program creates a subclass object, the subclass constructor immediately calls the superclass constructor (explicitly, via `super`, or implicitly). The superclass constructor's body executes to initialize the superclass's instance variables that are part of the subclass object, then the subclass constructor's body executes to initialize the subclass-only instance variables.(cont...)

Software Engineering Observation 6a.8

Java ensures that even if a constructor does not assign a value to an instance variable, the variable is still initialized to its default value (e.g., 0 for primitive numeric types, false for booleans, null for references).

Outline

CommissionEmployee 4.java

(1 of 4)

Lines 23-24

```
1 // Fig. 9.15: CommissionEmployee4.java
2 // CommissionEmployee4 class represents a commission employee.
3
4 public class CommissionEmployee4
5 {
6     private String firstName;
7     private String lastName;
8     private String socialSecurityNumber;
9     private double grossSales; // gross weekly sales
10    private double commissionRate; // commission percentage
11
12    // five-argument constructor
13    public CommissionEmployee4( String first, String last, String ssn,
14        double sales, double rate )
15    {
16        // implicit call to Object constructor occurs here
17        firstName = first;
18        lastName = last;
19        socialSecurityNumber = ssn;
20        setGrossSales( sales ); // validate and
21        setCommissionRate( rate ); // validate
22
23        System.out.printf(
24            "\nCommissionEmployee4 constructor:\n%s\n", this );
25    } // end five-argument CommissionEmployee4 constructor
26
```

Constructor outputs message to demonstrate method call order.



Outline

CommissionEmployee 4.java

(2 of 4)

```
27 // set first name
28 public void setFirstName( String first )
29 {
30     firstName = first;
31 } // end method setFirstName
32
33 // return first name
34 public String getFirstName()
35 {
36     return firstName;
37 } // end method getFirstName
38
39 // set last name
40 public void setLastName( String last )
41 {
42     lastName = last;
43 } // end method setLastName
44
45 // return last name
46 public String getLastName()
47 {
48     return lastName;
49 } // end method getLastName
50
51 // set social security number
52 public void setSocialSecurityNumber( String ssn )
53 {
54     socialSecurityNumber = ssn; // should validate
55 } // end method setSocialSecurityNumber
56
```



Outline

CommissionEmployee 4.java

(3 of 4)

```
57 // return social security number
58 public String getSocialSecurityNumber()
59 {
60     return socialSecurityNumber;
61 } // end method getSocialSecurityNumber
62
63 // set gross sales amount
64 public void setGrossSales( double sales )
65 {
66     grossSales = ( sales < 0.0 ) ? 0.0 : sales;
67 } // end method setGrossSales
68
69 // return gross sales amount
70 public double getGrossSales()
71 {
72     return grossSales;
73 } // end method getGrossSales
74
75 // set commission rate
76 public void setCommissionRate( double rate )
77 {
78     commissionRate = ( rate > 0.0 && rate < 1.0 ) ? rate : 0.0;
79 } // end method setCommissionRate
80
```



Outline

CommissionEmployee 4.java

(4 of 4)

```
81 // return commission rate
82 public double getCommissionRate()
83 {
84     return commissionRate;
85 } // end method getCommissionRate
86
87 // calculate earnings
88 public double earnings()
89 {
90     return getCommissionRate() * getGrossSales();
91 } // end method earnings
92
93 // return String representation of CommissionEmployee4 object
94 public String toString()
95 {
96     return String.format( "%s: %s %s\n%s: %s\n%s: %.2f\n%s: %.2f",
97         "commission employee", getFirstName(), getLastName(),
98         "social security number", getSocialSecurityNumber(),
99         "gross sales", getGrossSales(),
100        "commission rate", getCommissionRate() );
101 } // end method toString
102 } // end class CommissionEmployee4
```



Outline

BasePlusCommissionEmployee5.java

(1 of 2)

Lines 15-16

```

1 // Fig. 9.16: BasePlusCommissionEmployee5.java
2 // BasePlusCommissionEmployee5 class declaration.
3
4 public class BasePlusCommissionEmployee5 extends CommissionEmployee4
5 {
6     private double baseSalary; // base salary per week
7
8     // six-argument constructor
9     public BasePlusCommissionEmployee5( String first, String last,
10         String ssn, double sales, double rate, double salary )
11     {
12         super( first, last, ssn, sales, rate )
13         setBaseSalary( salary ); // validate a
14
15         system.out.printf(
16             "\nBasePlusCommissionEmployee5 constructor:\n%s\n", this );
17     } // end six-argument BasePlusCommissionEmployee5 constructor
18
19     // set base salary
20     public void setBaseSalary( double salary )
21     {
22         baseSalary = ( salary < 0.0 ) ? 0.0 : salary;
23     } // end method setBaseSalary
24

```

Constructor outputs message to demonstrate method call order.



Outline

BasePlusCommission
Employee5.java

(2 of 2)

```
25 // return base salary
26 public double getBaseSalary()
27 {
28     return baseSalary;
29 } // end method getBaseSalary
30
31 // calculate earnings
32 public double earnings()
33 {
34     return getBaseSalary() + super.earnings();
35 } // end method earnings
36
37 // return String representation of BasePlusCommissionEmployee5
38 public String toString()
39 {
40     return String.format( "%s %s\n%s: %.2f", "base-salaried",
41                             super.toString(), "base salary", getBaseSalary() );
42 } // end method toString
43 } // end class BasePlusCommissionEmployee5
```



Outline

```

1 // Fig. 9.17: ConstructorTest.java
2 // Display order in which superclass and subclass constructors are called.
3
4 public class ConstructorTest
5 {
6     public static void main( String args[] )
7     {
8         CommissionEmployee4 employee1 = new CommissionEmployee4(
9             "Bob", "Lewis", "333-33-3333", 5000, .04 );
10
11         System.out.println();
12         BasePlusCommissionEmployee5 employee2 =
13             new BasePlusCommissionEmployee5(
14                 "Lisa", "Jones", "555-55-5555", 2000, .06, 800 );
15
16         System.out.println();
17         BasePlusCommissionEmployee5 employee3 =
18             new BasePlusCommissionEmployee5(
19                 "Mark", "Sands", "888-88-8888", 8000, .15, 2000 );
20     } // end main
21 } // end class ConstructorTest

```

Instantiate
CommissionEmployee4 object

ConstructorTest

.java

(1 of 2)

Instantiate two
BasePlusCommissionEmployee5
objects to demonstrate order of subclass
and superclass constructor method calls.



Outline

ConstructorTest

.java

(2 of 2)

Subclass

BasePlusCommissionEmployee5

constructor body executes after superclass
CommissionEmployee4's constructor
finishes execution.

CommissionEmployee4 constructor:
commission employee: Bob Lewis
social security number: 333-33-3333
gross sales: 5000.00
commission rate: 0.04

CommissionEmployee4 constructor:
base-salaried commission employee: Lisa Jones
social security number: 555-55-5555
gross sales: 2000.00
commission rate: 0.06
base salary: 0.00

BasePlusCommissionEmployee5 constructor:
base-salaried commission employee: Lisa Jones
social security number: 555-55-5555
gross sales: 2000.00
commission rate: 0.06
base salary: 800.00

CommissionEmployee4 constructor:
base-salaried commission employee: Mark Sands
social security number: 888-88-8888
gross sales: 8000.00
commission rate: 0.15
base salary: 0.00

BasePlusCommissionEmployee5 constructor:
base-salaried commission employee: Mark Sands
social security number: 888-88-8888
gross sales: 8000.00
commission rate: 0.15
base salary: 2000.00



Правила за писане на конструктори на класове в йерархия на наследственост

1. Пишем **базовия клас** на йерархията от наследственост по правилата за моделиране на клас, дадени в **лекция 11.1** в следната последователност
 - A. *private* клас данни
 - B. SET и GET методи за всички клас данни
 - C. Конструктор за общо ползване (извиква set методите за данните)
 - D. Конструктор по подразбиране (извиква конструктора за общо ползване)
 - E. Конструктор за копиране (извиква конструктора за общо ползване)
 - F. **Всички останали клас методи**
 - G. *String toString()* метод

Правила за писане базов клас-деклариране на данните

```
// Fig. 6a.15a: CommissionEmployee4.java
// CommissionEmployee4 class represents a commission employee.

public class CommissionEmployee4
{
    private String firstName;
    private String lastName;
    private String socialSecurityNumber;
    private double grossSales; // gross weekly sales
    private double commissionRate; // commission percentage
```

Правила за писане базов клас-SET и GET методи

```
// set first name
public void setFirstName( String first )
{
    firstName = first;
} // end method setFirstName

// return first name
public String getFirstName()
{
    return firstName;
} // end method getFirstName

// set last name
public void setLastName( String last )
{
    lastName = last;
} // end method setLastName

// return last name
public String getLastName()
{
    return lastName;
} // end method getLastName
```



Правила за писане базов клас-SET и GET методи ...

```
// set social security number
public void setSocialSecurityNumber( String ssn )
{
    socialSecurityNumber = ssn; // should validate
} // end method setSocialSecurityNumber

// return social security number
public String getSocialSecurityNumber()
{
    return socialSecurityNumber;
} // end method getSocialSecurityNumber

// set gross sales amount
public void setGrossSales( double sales )
{
    grossSales = ( sales < 0.0 ) ? 0.0 : sales;
} // end method setGrossSales

// return gross sales amount
public double getGrossSales()
{
    return grossSales;
} // end method getGrossSales
```

Правила за писане базов клас-SET и GET методи ...

```
// set commission rate
public void setCommissionRate( double rate )
{
    commissionRate = ( rate > 0.0 && rate < 1.0 ) ? rate : 0.0;
} // end method setCommissionRate

// return commission rate
public double getCommissionRate()
{
    return commissionRate;
} // end method getCommissionRate
```

Правила за писане базов клас-конструктор за общо ползване

```

private String firstName;
private String lastName;
private String socialSecurityNumber;
private double grossSales;           // gross weekly sales
private double commissionRate;       // commission percentage
// five-argument constructor
public CommissionEmployee4( String first, String last, String ssn,
                           double sales, double rate )
{
    // implicit call to Object constructor occurs here
    firstName = first;
    lastName = last;
    socialSecurityNumber = ssn;
    setGrossSales( sales ); // validate and store gross sales
    setCommissionRate( rate ); // validate and store commission rate

    System.out.printf(
        "\nCommissionEmployee4 constructor:\n%s\n", this );
} // end five-argument CommissionEmployee4 constructor

```



Правила за писане базов клас-конструктори по подразбиране и за копиране

```
// default constructor
public CommissionEmployee4( )
{
    this("", "", "", 0.0, 0.0);
} // end five-argument CommissionEmployee4 constructor

// copy constructor
public CommissionEmployee4(CommissionEmployee4 c )
{
    this(c.firstName, c.lastName, c.socialSecurityNumber,
        c.grossSales, c.commissionRate);
} // end five-argument CommissionEmployee4 constructor
```


Правила за писане базов клас- други методи на класа и *toString()* метода

```
// calculate earnings
public double earnings()
{
    return getCommissionRate() * getGrossSales();
} // end method earnings

// return String representation of CommissionEmployee4 object
public String toString()
{
    return String.format( "%s: %s %s\n%s: %s\n%s: %.2f\n%s: %.2f",
        "commission employee", getFirstName(), getLastName(),
        "social security number", getSocialSecurityNumber(),
        "gross sales", getGrossSales(),
        "commission rate", getCommissionRate() );
} // end method toString
```

Правила за писане на конструктори на класове в йерархия на наследственост

2. Пишем всеки от производните класове на йерархията от наследственост по следните правила в следната последователност
 - A. Декларира всички **private** клас данни, които са различни от онаследените
 - B. SET и GET методи за всички клас данни, които са различни от онаследените
 - C. Конструктор за общо ползване
 - a. Извиква конструкторът за общо ползване на директния базов клас и инициализира ВСИЧКИ онаследени данни
 - b. извиква set методите за данните, които са различни от онаследените
 - D. Конструктор по подразбиране (извиква **конструктора за общо ползване на текущия клас**, задава **стойности по подразбиране за всички** данни – онаследени и тези, дефинирани в текущия клас)
 - E. Конструктор за копиране (извиква **конструктора за общо ползване на текущия клас** , използва **GET методи за онаследени клас данни**)
 - F. **Всички останали клас методи**
 - G. *String toString()* метод

Правила за писане произведен клас- - деклариране на новите данни

```
// Fig. 6a.16a.: BasePlusCommissionEmployee5.java  
// Modified BasePlusCommissionEmployee5 class declaration.
```

```
public class BasePlusCommissionEmployee5 extends CommissionEmployee4  
{  
    // Тук не се декларира отново данните, които са онаследени!  
    private double baseSalary; // base salary per week
```

Правила за писане произволен клас

SET и GET методи само за новите данни

```
// set base salary
```

```
public void setBaseSalary( double salary )  
{  
    baseSalary = ( salary < 0.0 ) ? 0.0 : salary;  
} // end method setBaseSalary
```

```
// return base salary
```

```
public double getBaseSalary()  
{  
    return baseSalary;  
} // end method getBaseSalary
```

Правила за писане произволен клас

Конструктор за общо ползване

```
// six-argument constructor- инициализира ВСИЧКИ данни

public BasePlusCommissionEmployee5( String first, String last,
    String ssn, double sales, double rate, double salary )
{
    super( first, last, ssn, sales, rate ); // инициализира онаследените
    // следва инициализация на всички данни, които не са онаследени
    setBaseSalary( salary ); // validate and store base salary

    System.out.printf(
        "\nBasePlusCommissionEmployee5 constructor:\n%s\n", this );
} // end six-argument BasePlusCommissionEmployee5 constructor
```

Правила за писане произведен клас

Конструктори по подразбиране и за копиране

```
// default constructor
public BasePlusCommissionEmployee5( )
{
    this("", "", "", 0.0, 0.0, 0.0);
} // end six-argument BasePlusCommissionEmployee5 constructor

// default constructor
public BasePlusCommissionEmployee5( BasePlusCommissionEmployee5 b)
{
    this( b.getFirstName(), b.getLastName(),
          b.getSocialSecurityNumber(),
          b.getGrossSales(), b.getCommissionRate(), b.baseSalary);
} // end six-argument BasePlusCommissionEmployee5 constructor
```

Правила за писане произведен клас

други методи на класа и *toString()* метода

```
// calculate earnings
public double earnings()
{
    return getBaseSalary() + super.earnings();
} // end method earnings

// return String representation of BasePlusCommissionEmployee5
public String toString()
{
    return String.format( "%s %s\n%s: %.2f", "base-salaried",
        super.toString(), "base salary", getBaseSalary() );
} // end method toString
```

6a.6 Software Engineering with Inheritance

- **Customizing existing software**
 - **Inherit from existing classes**
 - **Include additional members**
 - **Redefine superclass members**
 - **No direct access to superclass's source code**
 - **Link to object code**
 - **Independent software vendors (ISVs)**
 - **Develop proprietary code for sale/license**
 - **Available in object-code format**
 - **Users derive new classes**
 - **Without accessing ISV proprietary source code**

Software Engineering Observation 6a.9

Despite the fact that inheriting from a class does not require access to the class's source code, developers often insist on seeing the source code to understand how the class is implemented. Developers in industry want to ensure that they are extending a solid class—for example, a class that performs well and is implemented securely.

Software Engineering Observation

6a.10

At the design stage in an object-oriented system, the designer often finds that certain classes are closely related. The designer should “factor out” common instance variables and methods and place them in a superclass. Then the designer should use inheritance to develop subclasses, specializing them with capabilities beyond those inherited from the superclass.

Software Engineering Observation

6a.11

Declaring a subclass does not affect its superclass's source code. Inheritance preserves the integrity of the superclass.

Software Engineering Observation

6a.12

Just as designers of non-object-oriented systems should avoid method proliferation, designers of object-oriented systems should avoid class proliferation. Such proliferation creates management problems and can hinder software reusability, because in a huge class library it becomes difficult for a client to locate the most appropriate classes. The alternative is to create fewer classes that provide more substantial functionality, but such classes might prove cumbersome.

Performance Tip 6a.1

If subclasses are larger than they need to be (i.e., contain too much functionality), memory and processing resources might be wasted. Extend the superclass that contains the functionality that is closest to what is needed.

6a.7 Object Class

- **Class Object methods**
 - clone
 - equals
 - finalize
 - getClass
 - hashCode
 - notify, notifyAll, wait
 - toString

Method	Description
<code>clone</code>	<p>This protected method, which takes no arguments and returns an Object reference, makes a copy of the object on which it is called. When cloning is required for objects of a class, the class should override method <code>clone</code> as a <code>public</code> method and should implement interface <code>Cloneable</code> (package <code>java.lang</code>). The default implementation of this method performs a so-called shallow copy—instance variable values in one object are copied into another object of the same type. For reference types, only the references are copied. A typical overridden <code>clone</code> method's implementation would perform a deep copy that creates a new object for each reference type instance variable. There are many subtleties to overriding method <code>clone</code>. You can learn more about cloning in the following article:</p> <p>java.sun.com/developer/JDCTechTips/2001/tt0306.html</p>

Fig. 6a.18 | Object methods that are inherited directly or indirectly by all classes.
(Part 1 of 4)

Method	Description
Equals	<p>This method compares two objects for equality and returns true if they are equal and false otherwise. The method takes any Object as an argument. When objects of a particular class must be compared for equality, the class should override method equals to compare the contents of the two objects. The method's implementation should meet the following requirements:</p> <ul style="list-style-type: none"> • It should return false if the argument is null. • It should return true if an object is compared to itself, as in <code>object1.equals(object1)</code>. • It should return true only if both <code>object1.equals(object2)</code> and <code>object2.equals(object1)</code> would return true. • For three objects, if <code>object1.equals(object2)</code> returns true and <code>object2.equals(object3)</code> returns true, then <code>object1.equals(object3)</code> should also return true. • If equals is called multiple times with the two objects and the objects do not change, the method should consistently return true if the objects are equal and false otherwise. <p>A class that overrides equals should also override hashCode to ensure that equal objects have identical hashcodes. The default equals implementation uses operator == to determine whether two references <i>refer to the same object</i> in memory. Section 29.3.3 demonstrates class String's equals method and differentiates between comparing String objects with == and with equals.</p>

**Fig. 6a.18 | Object methods that are inherited directly or indirectly by all classes.
(Part 2 of 4)**

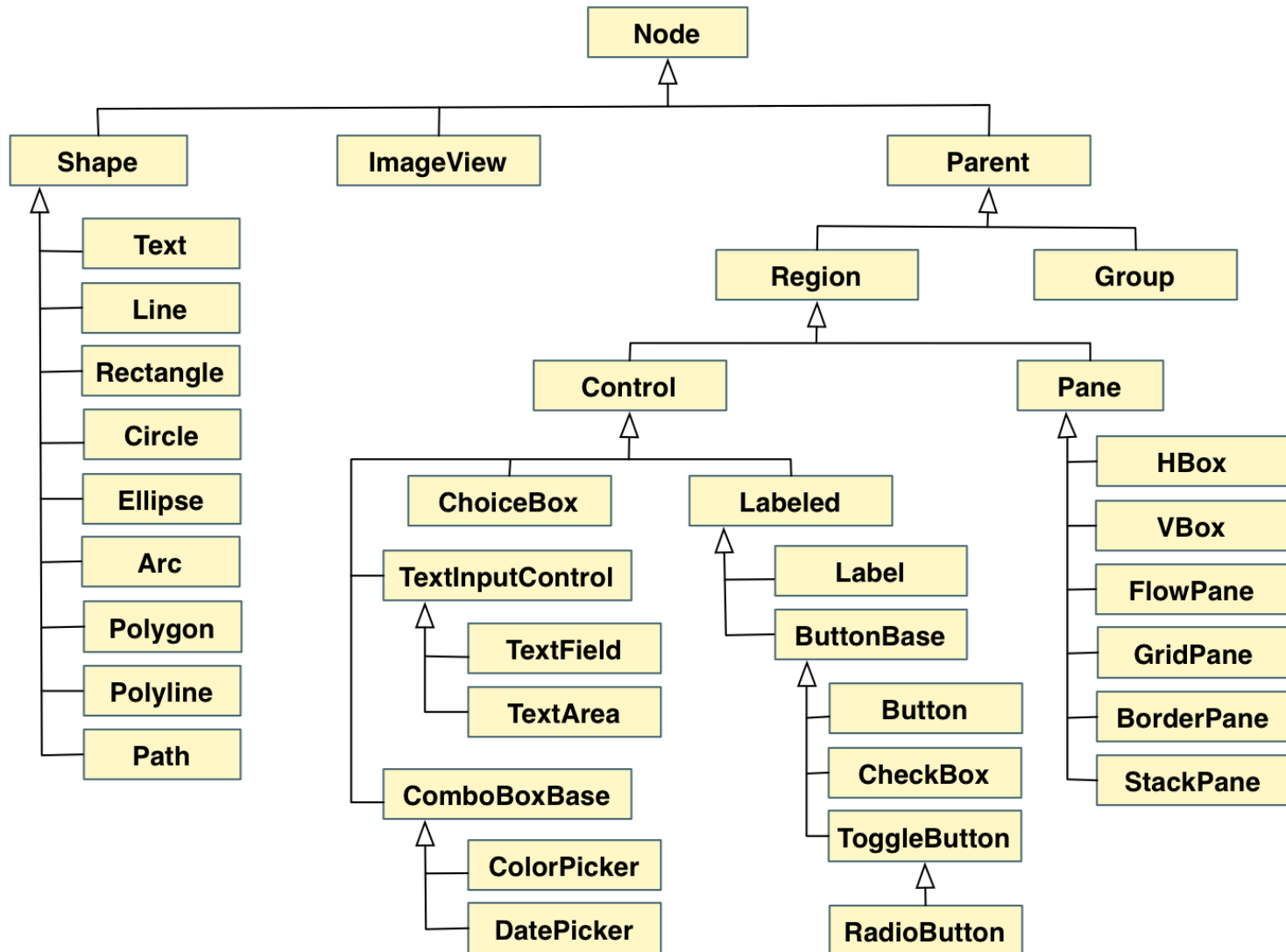
Method	Description
<code>finalize</code>	This protected method (introduced in Section 8.10 and Section 8.11) is called by the garbage collector to perform termination housekeeping on an object just before the garbage collector reclaims the object's memory. It is not guaranteed that the garbage collector will reclaim an object, so it cannot be guaranteed that the object's <code>finalize</code> method will execute. The method must specify an empty parameter list and must return <code>void</code> . The default implementation of this method serves as a placeholder that does nothing.
<code>getClass</code>	Every object in Java knows its own type at execution time. Method <code>getClass</code> (used in Section 10.5 and Section 21.3) returns an object of class <code>Class</code> (package <code>java.lang</code>) that contains information about the object's type, such as its class name (returned by <code>Class</code> method <code>getName</code>). You can learn more about class <code>Class</code> in the online API documentation at java.sun.com/j2se/5.0/docs/api/java/lang/Class.html .

Fig. 6a.18 | Object methods that are inherited directly or indirectly by all classes.
(Part 3 of 4)

Method	Description
hashCode	A hashtable is a data structure (discussed in Section 19.10) that relates one object, called the key, to another object, called the value. When initially inserting a value into a hashtable, the key's hashCode method is called. The hashcode value returned is used by the hashtable to determine the location at which to insert the corresponding value. The key's hashcode is also used by the hashtable to locate the key's corresponding value.
notify, notifyAll, wait	Methods notify , notifyAll and the three overloaded versions of wait are related to multithreading, which is discussed in Chapter 23. In J2SE 5.0, the multithreading model has changed substantially, but these features continue to be supported.
toString	This method (introduced in Section 9.4.1) returns a String representation of an object. The default implementation of this method returns the package name and class name of the object's class followed by a hexadecimal representation of the value returned by the object's hashCode method.

Fig. 6a.18 | Object methods that are inherited directly or indirectly by all classes.
(Part 4 of 4)

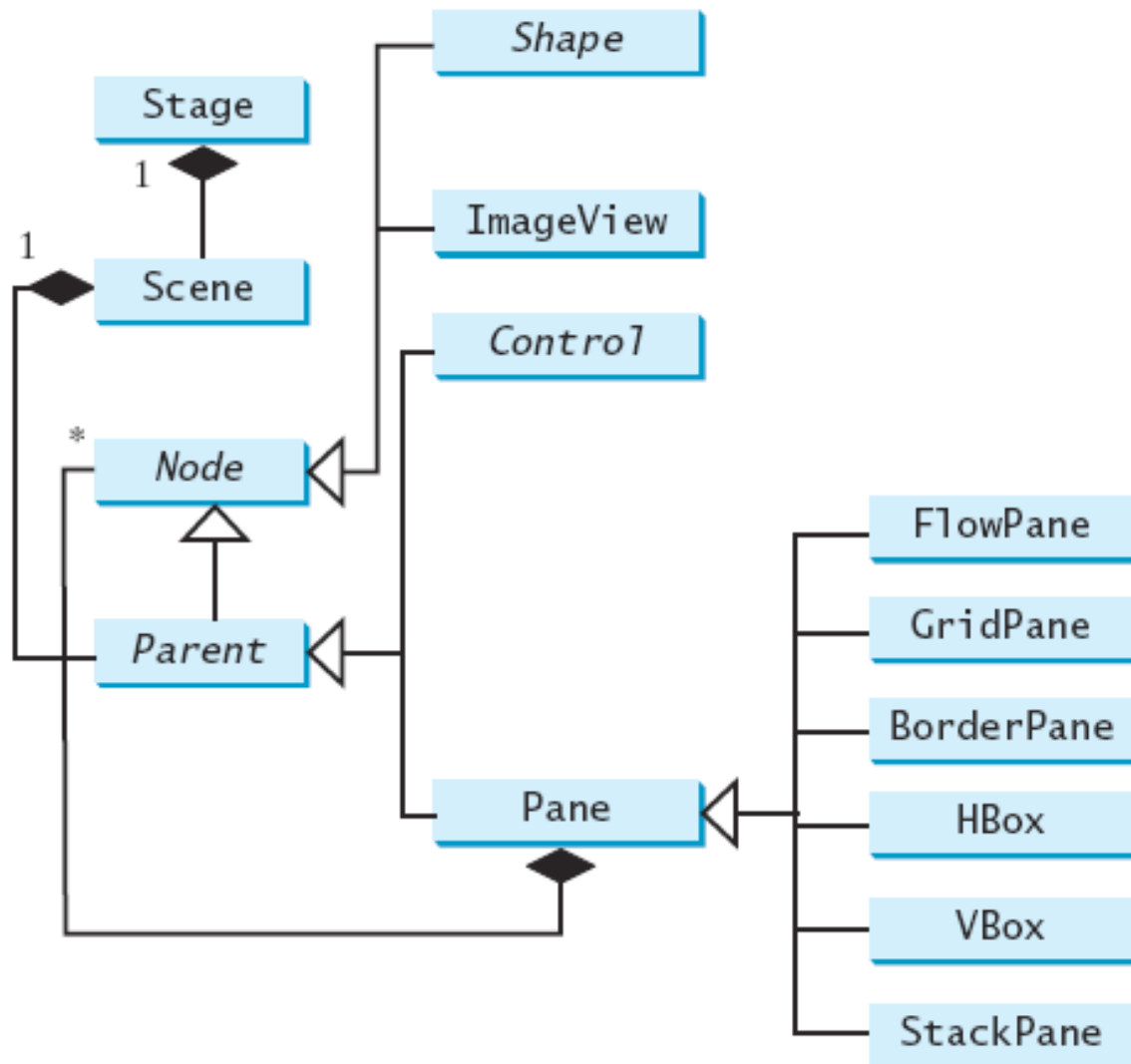
6a.8 Inheritance in JavaFX



6a.8 Inheritance in JavaFX

- All shape classes are derived from **Shape**, which manages stroke and fill
- **Nodes derived from Parent can hold other nodes**
 - So shapes cannot hold other nodes
- Any **Region can be styled** with CSS
- All **layout panes** are derived from **Pane**
- **Control**s have various intermediate classes to organize common characteristics

6a.8 Inheritance in JavaFX



6a.8 Inheritance in JavaFX

- Note the difference between the scene graph (containment) and the inheritance hierarchy
- Only a **Parent** can serve as the **root node** of a scene
- So a **Pane** can be the **root node** of a scene, and could contain a **Circle** and a **Button**
- A **ChoiceBox** could be the **root** node of a scene, but a **Rectangle** could not

6a.9 GUI and Graphics Case Study: Displaying Text and Images Using Labels

- **Labels in JavaFX**

- **Display information and instructions. If you want to show the purpose of an input control by placing one or more words next to it, and/or you want to allow direct keyboard navigation to an input control, you use a `Label`.**
- **`Label` displays a text element**
 - **Display a line or wrap multiple lines of text**
 - **Display an image**
 - **Display both text and image**
 - **Rotate and translate a `Label`**

6a.8 GUI and Graphics Case Study: Displaying Text and Images Using Labels

• **Text** in JavaFX

- Display pieces of text . If you want to display text content not associated with input, you use **Text**. A **Text** is a geometric shape (like a **Rectangle** or a **Circle**), while **Label** is a UI control (like a **Button** or a **TextField**).

Use **Text** to apply effects, animation, and transformations to text nodes in the same way as to any other nodes. Because the **Node** class inherits from the **Shape** class, you can set a stroke or apply a fill setting to text nodes in the same way as to any shape


```

1import javafx.application.Application;
2import javafx.geometry.Insets;
3import javafx.geometry.Pos;
4import javafx.scene.Scene;
5import javafx.scene.control.Label;
6import javafx.scene.image.Image;
7import javafx.scene.image.ImageView;
8import javafx.scene.layout.HBox;
9import javafx.scene.paint.Color;
10import javafx.scene.text.Font;
11import javafx.stage.Stage;
12
13public class JavaFXLabelDemo extends Application {
14
15    @Override
16    public void start(Stage primaryStage){
17
18        HBox root = new HBox();
19        root.setSpacing(14);
20        root.setPadding(new Insets(14, 14, 14, 14));
21        root.setStyle("-fx-background-color: white");
22        root.setAlignment(Pos.CENTER);
23        // An empty label
24        // Label label1 = new Label();
25        //A label with the text element and graphical icon
26        Image image = new Image(getClass().getResourceAsStream("Capture.JPG"));

```

Create a JavaFX Application

Setup layout properties for the HBOX

Load the Image from the image file located in current package of the source code

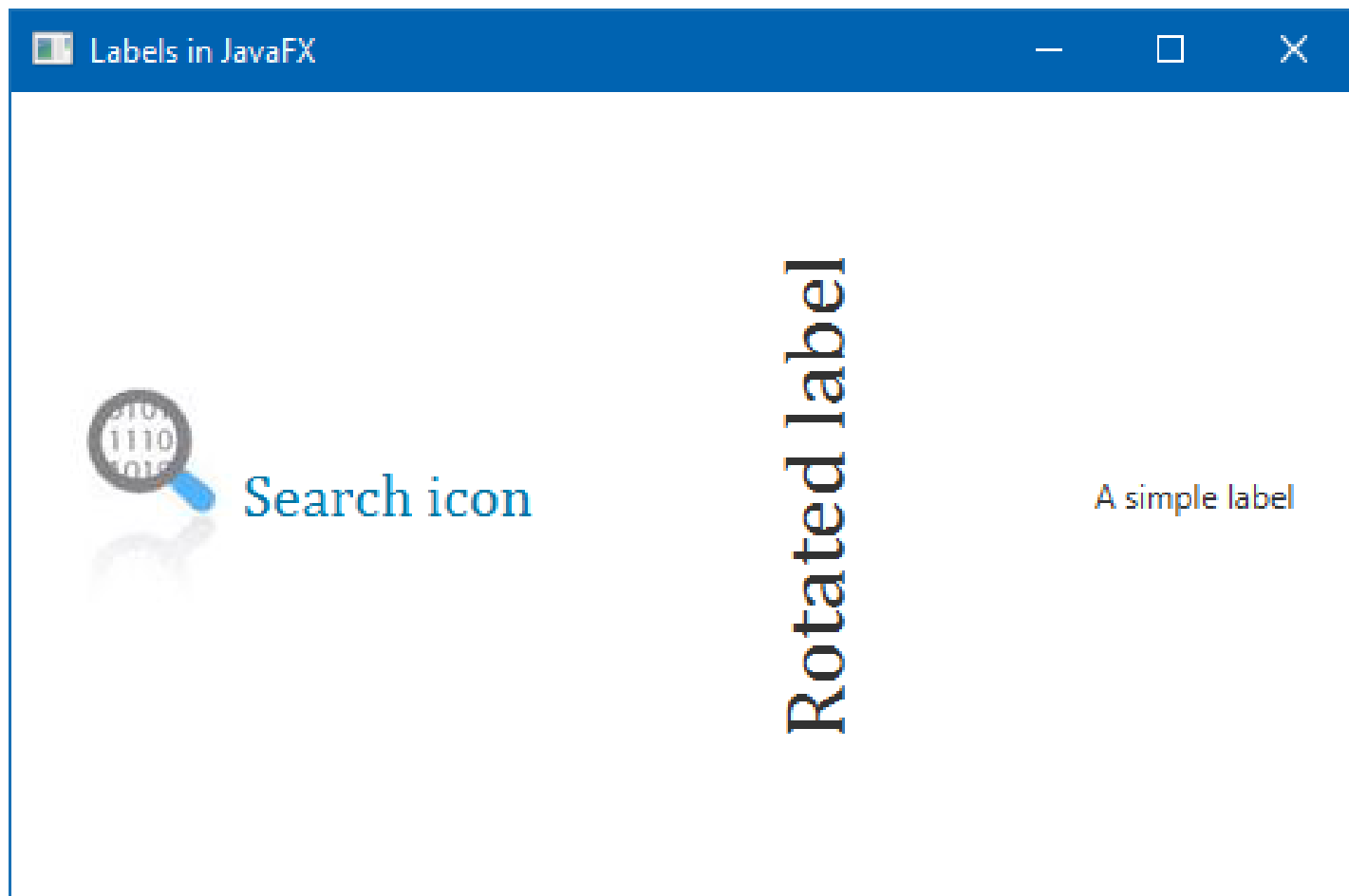
JavaFXLabelDemo.java



```
27 Label label1 = new Label("Search icon", new ImageView(image));
28 label1.setFont(new Font("Cambria", 22));
29 label1.setTextFill(Color.web("#0076a3"));
30 //A label with the text element and given font
31 Label label2 = new Label("Rotated label");
32 label2.setFont(new Font("Cambria", 32));
33 label2.setRotate(270);
34 // A label with the text element
35 Label label3 = new Label("A simple label");
36 label3.prefWidth(20);
37
38 root.getChildren().addAll(label1, label2, label3);
39 Scene scene = new Scene(root, 500, 300);
40
41 primaryStage.setTitle("Labels in JavaFX");
42 primaryStage.setScene(scene);
43 primaryStage.show();
44 }
45
46 public static void main(String[] args) {
47     launch(args);
48 }
49 }
```

Attach the labels to the Hbox





Label properties

```

1 import javafx.application.Application;
2 import static javafx.application.Application.launch;
3 import javafx.geometry.Insets;
4 import javafx.geometry.Pos;
5 import javafx.scene.Scene;
6 import javafx.scene.layout.AnchorPane;
7 import javafx.scene.layout.VBox;
8 import javafx.scene.paint.Color;
9 import javafx.scene.text.Font;
10 import javafx.scene.text.FontWeight;
11 import javafx.scene.text.Text;
12 import javafx.stage.Stage;
13
14 public class JavaFXTextlDemo extends Application {
15
16     @Override
17     public void start(Stage primaryStage) {
18         AnchorPane root = new AnchorPane();
19         VBox vb = new VBox();
20         vb.setSpacing(14);
21         vb.setPadding(new Insets(14, 14, 14, 14));
22         vb.setStyle("-fx-background-color: white");
23         vb.setAlignment(Pos.TOP_LEFT);
24         //Define text at a given location with coordinates x=10, y=200
25         Text text1 = new Text(10, 200, "This text sample starts at [10,200]");
26         root.getChildren().addAll(vb, text1);

```

Create a JavaFX Application

Setup layout properties for the
VBox

Display the Text at [10, 200]

JavaFXTextDemo.java

```

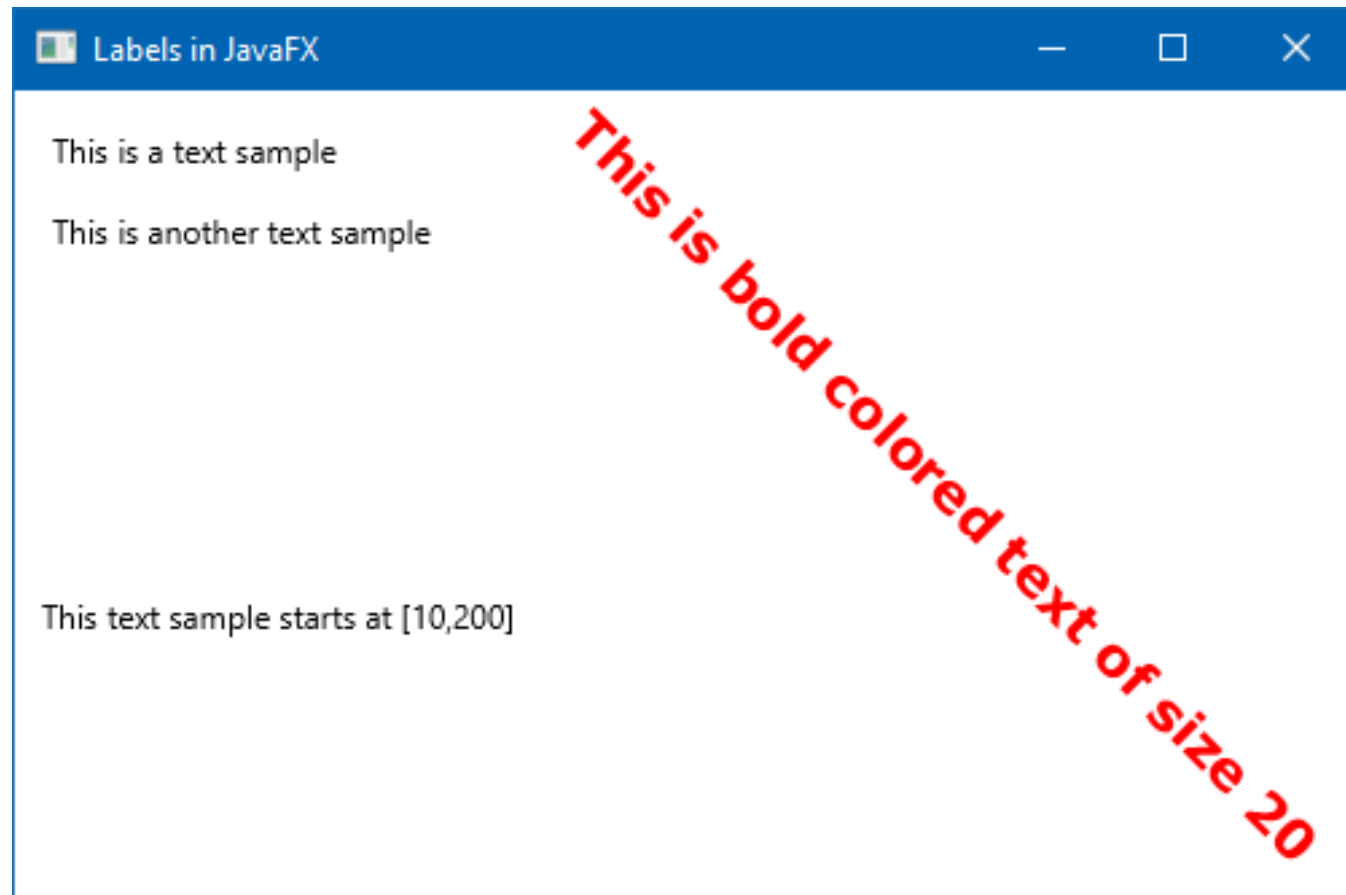
27 // An empty Text
28 Text text2 = new Text();
29 //Assign a string to Text
30 text2.setText("This is a text sample");
31 // Assign the string in the text constructor
32 Text text3 = new Text("This is another text sample");
33 // Assign the font and transformation properties for Text
34 Text text4 = new Text("This is bold colored text of size 20");
35 //text4.setFont(Font.font("Verdana", FontPosture.ITALIC ,20));
36 text4.setFill(Color.RED);
37 text4.setFont(Font.font("Verdana", FontWeight.BOLD, 20));
38 text4.setRotate(45);
39 text4.setTranslateY(60);
40 text4.setTranslateX(140);
41
42 vb.getChildren().addAll(text2, text3, text4);
43 Scene scene = new Scene(root, 500, 300);
44
45 primaryStage.setTitle("Labels in JavaFX");
46 primaryStage.setScene(scene);
47 primaryStage.show();
48 }
49
50 public static void main(String[] args) {
51     launch(args);
52 }
53 }

```

Set font and transformation properties for a Text

Attach the Texts to the VBox





Text properties

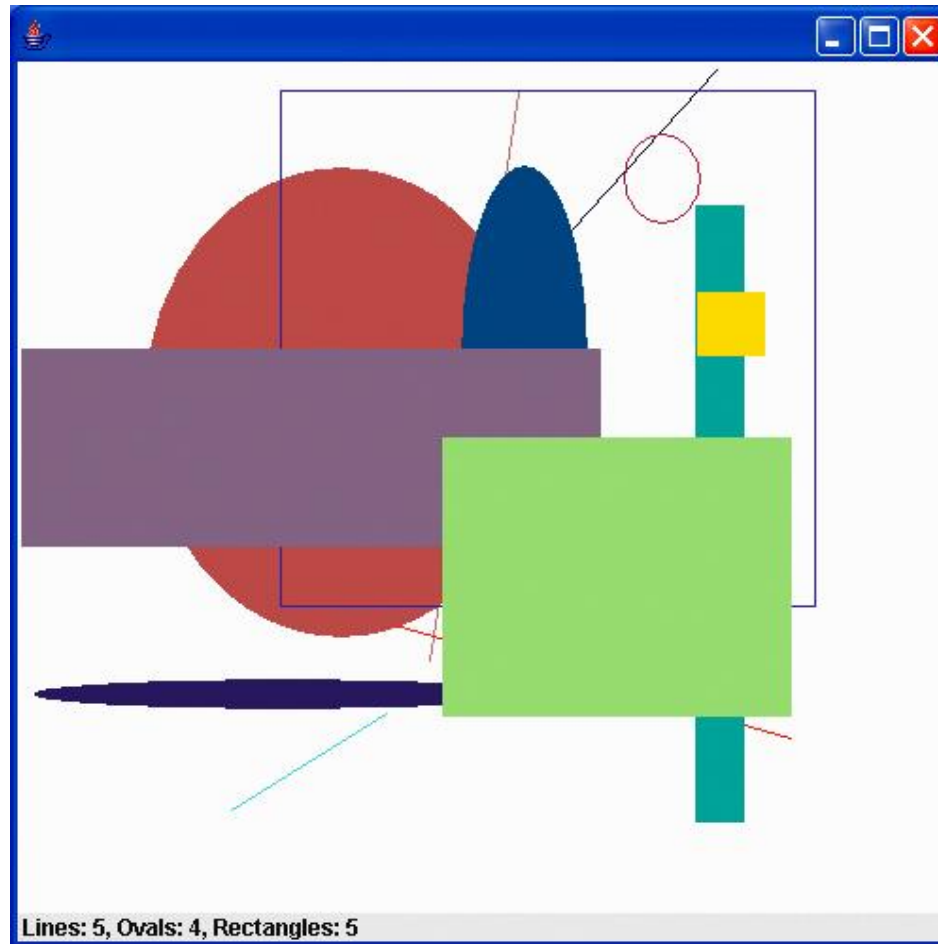


Fig. 6a.20 | Label displaying shape statistics.