Java Tutorial: Working with Objects and Classes

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Overview

Part 1

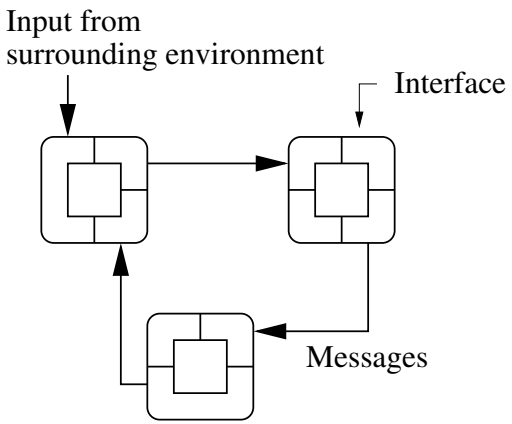
Working with Objects

Working with Objects and Classes

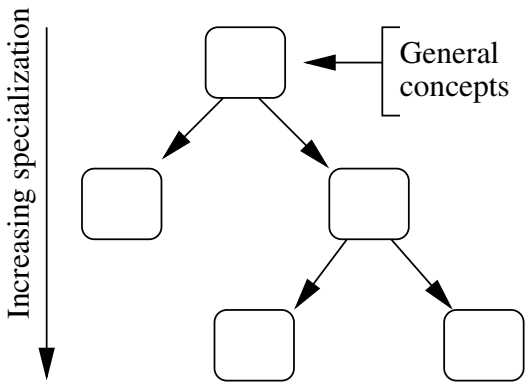
Motivating Ideas

- Simplify the way we view the real world,
- Provide mechanisms for assembly of complex systems.
- Provide mechanisms for handling systems that are subject to change.

Organizational and Efficiency Mechanisms



Network of Communicating Objects



Problem Domain Concepts organized
into a Class Hierarchy.

Object-based Software

Basic Assumptions

- Everything is an object.
- New kinds of objects can be created by making a package containing other existing objects.
- Objects have relationships for other types of objects.
- Objects have type.
- Object communicate via message passing – all objects of the same type can receive and send the same kinds of messages.
- Objects can have executable behavior.
- Objects can be design to respond to occurrences and events.
- Systems will be created through a composition (assembly) of objects.

Working with Objects and Classes

Working with Objects and Classes:

- Collections of objects share similar traits (e.g., data, structure, behavior).
- Collections of objects will form relationships with other collections of objects.

Definition of a Class

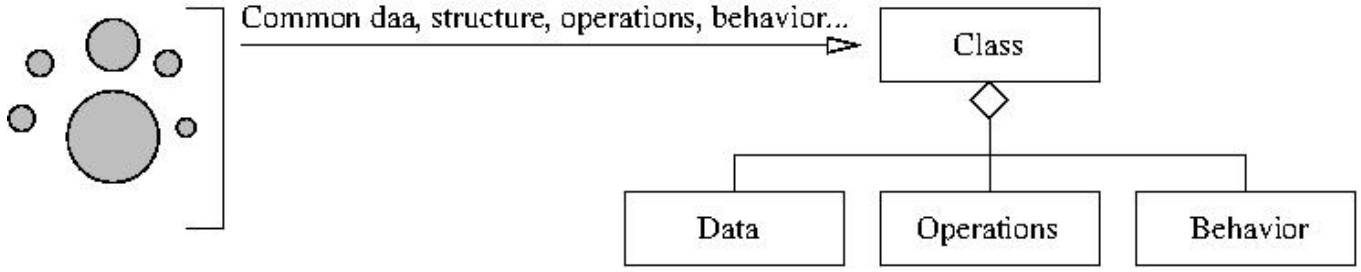
A class is a specification (or blueprint) of an object's structure and behavior.

Definition of an Object

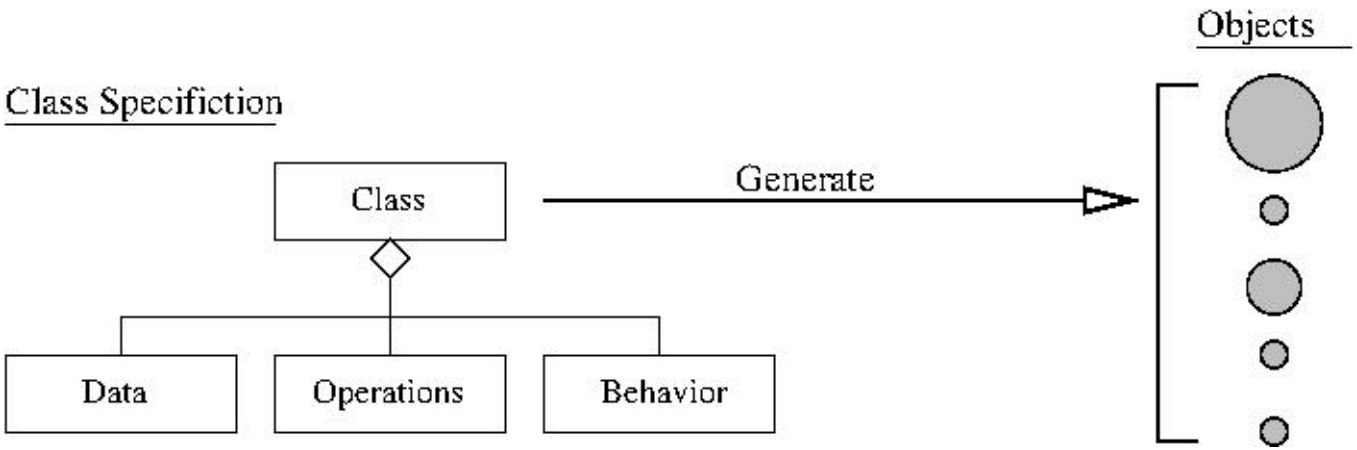
An object is an instance of a class.

Working with Objects and Classes

From Collections of Objects to Classes:



Generation of Objects from Class Specifications:



Working with Objects and Classes

Key Design Tasks

- Identify objects and their attributes and functions,
- Establish relationships among the objects,
- Establish the interfaces for each object,
- Implement and test the individual objects,
- Assemble and test the system.

Implicit Assumptions $\rightarrow$ Connection to Data Mining

- Manual synthesis of the object model is realistic for systems that have a modest number of elements and relationships.
- As the dimensionality of the problem increases some form of automation will be needed to discover elements and relationships.

Example 1. Working with Points

A Very Simple Class in Java

```
1       public class Point {
2          int x, y;
3
4          public Point ( int x, int y ) {
5             this.x = x; this.y = y;
6          }
7       }
```

Creating an Object

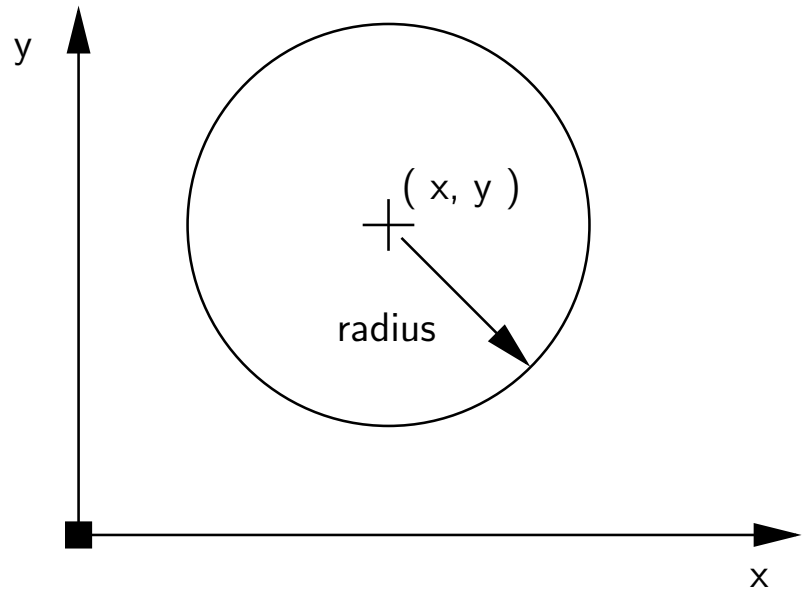
```
8       Point  first = new Point ( 1, 2 );
9       Point second = new Point ( 2, 5 );
```

Accessing and Printing the attributes on an Object

```
10      System.out.printf(" first point (x,y) = (%2d, %2d)\n",  first.x,  first.y );
11      System.out.printf("second point (x,y) = (%2d, %2d)\n", second.x, second.y );
```

Example 2. Working with Circles

A circle can be described by the `(x,y)` position of its center and by its `radius`.



There are numerous things we can do with circles:

- Compute their circumference, perimeter or area,
- Check if a point is inside a circle.

Example 2. Working with Circles

```
1   /*
2    *  ====================================================================
3    *  Circle(): Basic implementation of a circle program.
4    *
5    *  Written by: Mark Austin                                  February, 2019
6    *  ====================================================================
7    */
8
9   import java.lang.Math.*;
10
11  public class Circle {
12      public double dX, dY, dRadius;
13
14      // Constructor
15
16      public Circle () {}
17
18      public Circle( double dX, double dY, double dRadius ) {
19          this.dX = dX;
20          this.dY = dY;
21          this.dRadius = dRadius;
22      }
23
24      // Compute the circle area ....
25
26      public double Area() {
27         return Math.PI*dRadius*dRadius;
28      }
```

Example 2. Working with Circles

```
29
30        // Copy circle parameters to a string format ...
31
32        public String toString() {
33           return "(x,y) = (" + dX + "," + dY + "): Radius = " + dRadius;
34        }
35
36        // ------------------------------------------------------
37        // Exercise methods in class Circle ...
38        // ------------------------------------------------------
39
40        public static void main( String [] args ) {
41
42           System.out.println("Exercise methods in class Circle");
43           System.out.println("================================");
44
45           Circle cA = new Circle();
46           cA.dX = 1.0; cA.dY = 2.0; cA.dRadius = 3.0;
47
48           Circle cB = new Circle( 1.0, 2.0, 2.0 );
49
50           System.out.printf("Circle cA : %s\n", cA.toString() );
51           System.out.printf("Circle cA : Area = %5.2f\n", cA.Area() );
52           System.out.printf("Circle cB : %s\n", cB );
53           System.out.printf("Circle cB : Area = %5.2f\n", cB.Area() );
54        }
55     }
```

Example 2. Working with Circles

Script of Program Input and Output

```
Exercise methods in class Circle
================================
Circle cA : (x,y) = (1.0,2.0): Radius = 3.0
Circle cA : Area = 28.27
Circle cB : (x,y) = (1.0,2.0): Radius = 2.0
Circle cB : Area = 12.57
```

Points to note:

- Objects are created with constructor methods. The line:

  ```
  public Circle () {}
  ```

  is the default constructor. It creates circle objects with all of the circle attribute values initialized to zero.

Example 2. Working with Circles

More points to note:

- The next three statements use the dot notation (.) to manually initialize the (x,y) coordinates of the circle center and its radius.
- A second constructor method:

```
public Circle( double dX, double dY, double dRadius ) {
}
```

  creates a circle object and initializes the circle attribute values in one line.
- Statements of the form `this.dX = dX` take the value of dX passed to the contructor method and assign it to the attribute dX associated with this object.

Accessing Object Data and Object Methods

Now that we have created an object, we can use its data fields. The dot operator (.) is used to access the different public variables of an object.

Example 1

```
Circle cA = new Circle();
cA.dX = 1.0;
cA.dY = 2.0;
cA.dRadius = 3.0;
```

To access the methods of an object, we use the same syntax as accessing the data of the object, i.e., the dot operator (.).

Accessing Object Methods

Example 2

```
Circle cA  = new Circle();
cA.dRadius = 2.5;
double dArea = cA.getArea();
```

Notice that we did not write `dArea = getArea( cA );`

Example 3

Let a, b, c, and d be complex numbers. To compute a*b + c*d we write

```
a = new Complex(1,1); .. etc ..

Complex sum = a.Mult(b).Add( c.Mult(d) );
```

Encapsulation and Data Hiding

Encapsulation and Data Hiding

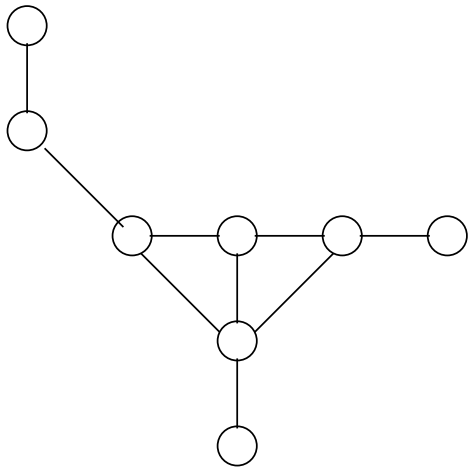
Definition of Aggregation

- Aggregation is the grouping of components into a package.
- Aggregation does not imply that the components are hidden or inaccessible. It merely implies that the components are part of a whole.

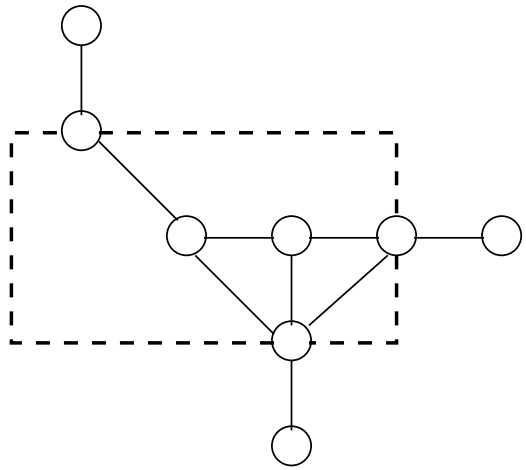
Definition of Encapsulation

- Encapsulation is a much stronger form of organization.
- Encapsulation forces users of a system to deal with it as an abstraction (e.g., a black box) with well-defined interfaces that define what the entity is, what it does, and how it should be used.
- The only way to access an object's state is to send it a message that causes one of the object's internal methods to execute.

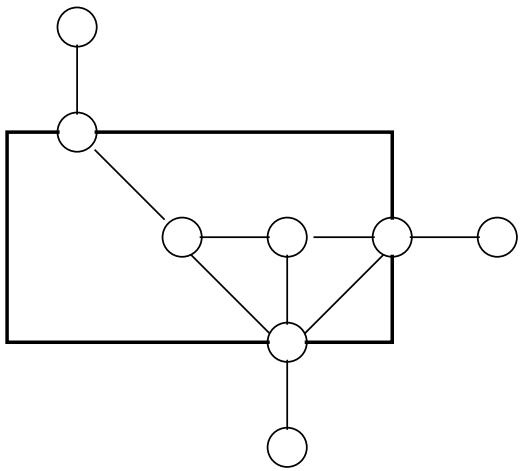
Encapsulation and Data Hiding



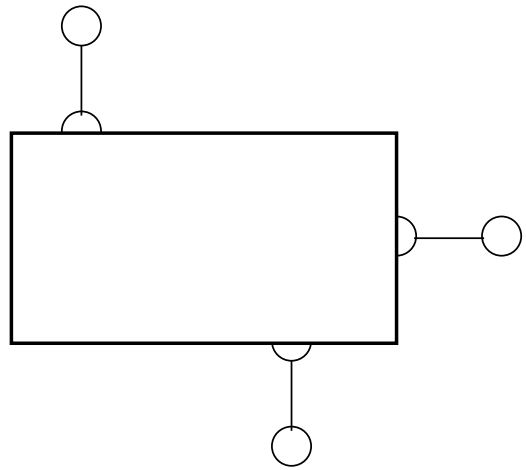
Unstructured Components



Aggregation



Designer's view of Aggregation



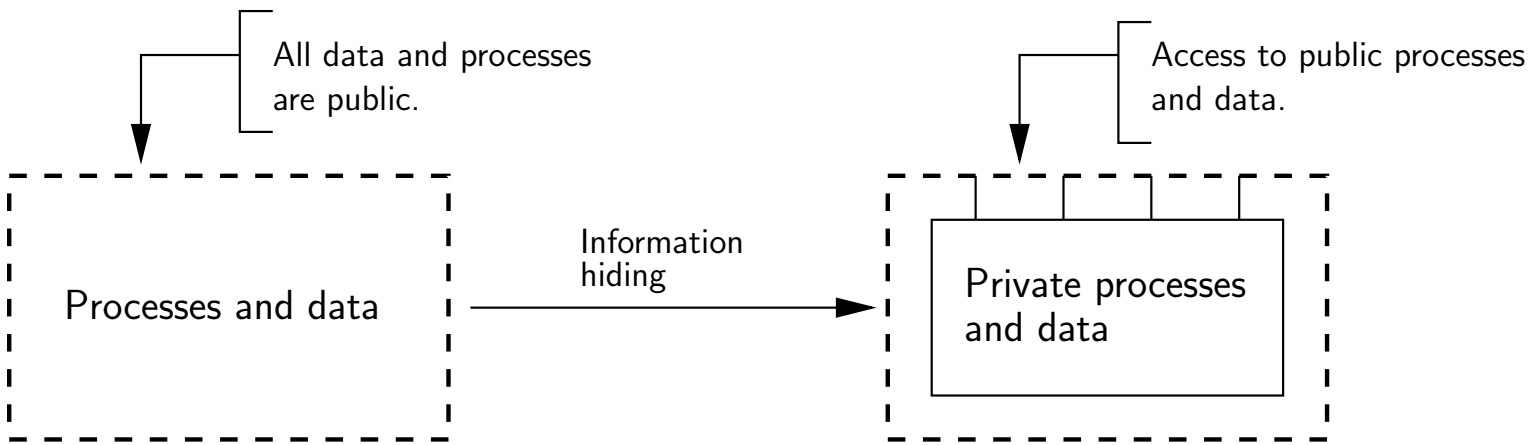
Encapsulation – User's view of Abstraction

Encapsulation and Data Hiding

Principle of Information Hiding

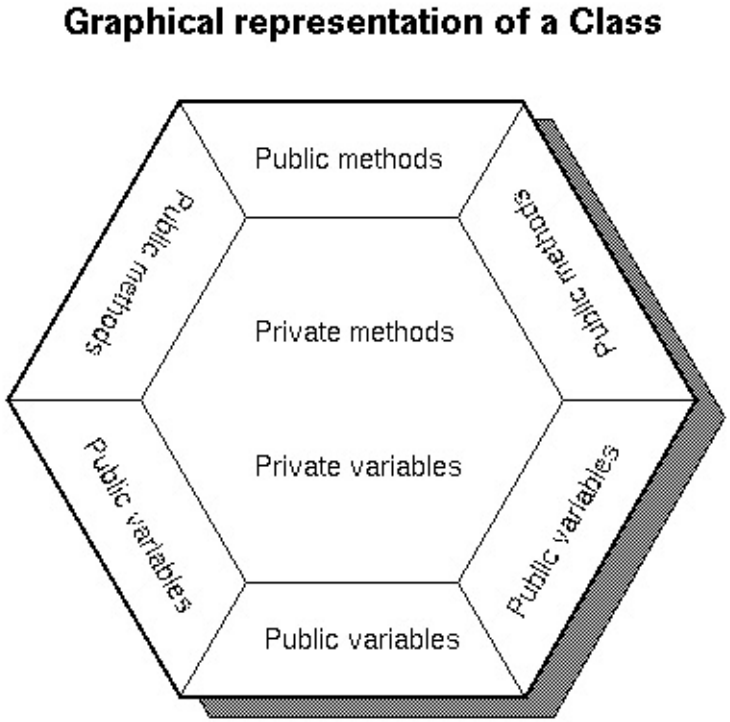
The principle of information hiding states that information which is likely to change (e.g., over the lifetime of a software/systems package) should be hidden inside a module.

Application. Process for Implementation of Information Hiding.



Encapsulation and Data Hiding

Graphical Representation of a Class



The object wrapping protects the object code from unintended access by other code.

Encapsulation and Data Hiding

In object-oriented terminology, and particularly in Java,

- The wrapper object is usually called a class, the functions inside the class are called private methods,
- The data inside the class are private variables.
- Public methods are the interface functions for the outside world to access your private methods.

Implementation. The keyword private in:

```
public class Point {
   private int x, y;
   .... .....
}
```

restricts to scope of x and y to lie inside the boundary of Point objects.

Encapsulation and Data Hiding

Access to a point's coordinates is controlled through the public methods:

```
public int  getX() {
   return x;
}
public void setX(int x) {
   this.x = x;
}
```

Example 2. Revised Circle Program

Revised circle program where data and circle properties can only be accessed through an interface.

```
1   /*
2    *  ================================================================
3    *  Circle(): Implementation of the Circle class where data and circle
4    *            properties can only be accessed through an interface.
5    *
6    *  Written by: Mark Austin                                 February, 2019
7    *  ================================================================
8    */
9
10  import java.lang.Math.*;
11
12  public class Circle {
13      protected double dX, dY, dRadius;
14
15      // Constructor
16
17      public Circle () {}
18
19      public Circle( double dX, double dY, double dRadius ) {
20          this.dX = dX;
21          this.dY = dY;
22          this.dRadius = dRadius;
23      }
24
25      // Compute the circle area ....
```

Example 2. Revised Circle Program

```
26
27        private double Area() {
28           return Math.PI*dRadius*dRadius;
29        }
30
31        // Create public interface for variables and area computation....
32
33        public void setX (double dX) {
34            this.dX = dX;
35        }
36
37        public double getX () {
38            return dX;
39        }
40
41        ... details for setY() and getY() removed ...
42
43        public void setRadius (double dRadius ) {
44            this.dRadius = dRadius;
45        }
46
47        public double getRadius () {
48            return dRadius;
49        }
50
51        public double getArea() {
52            return Area();
53        }
54
55        // Copy circle parameters to a string format ...
```

Example 2. Revised Circle Program

```
56
57        public String toString() {
58           return "(x,y) = (" + dX + "," + dY + "): Radius = " + dRadius;
59        }
60
61        // ------------------------------------------------------
62        // Exercise methods in class Circle ...
63        // ------------------------------------------------------
64
65        public static void main( String [] args ) {
66
67           System.out.println("Exercise methods in class Circle");
68           System.out.println("================================");
69
70           Circle cA = new Circle();
71           cA.setX(1.0);
72           cA.setY(2.0);
73           cA.setRadius(3.0);
74
75           Circle cB = new Circle( 1.0, 2.0, 2.0 );
76
77           System.out.printf("Circle cA : %s\n", cA.toString() );
78           System.out.printf("Circle cA : Area = %5.2f\n", cA.getArea() );
79
80           System.out.printf("Circle cB : %s\n", cB );
81           System.out.printf("Circle cB : Area = %5.2f\n", cB.getArea() );
82        }
83     }
```

Example 2. Revised Circle Program

Points to note:

- Use of the keyword protected in:

  ```
  protected double dX, dY, dRadius;
  ```

  restricts access of `dX`, `dY` and `dRadius` to methods within Circle and any subclass of Circle.
- The methods `getX()` and `setX()`, etc, create a public interface for Circle.
- By convention, the toString() method creates and returns a string description of the objects contents. And it can be called in two ways as demonstrated at the bottom of main(). The fragment of code cA.toString() will return a string which will be matched against the %s format specification. However, cB also calls toString() and is shorthand for cB.toString().

Relationships Among Classes

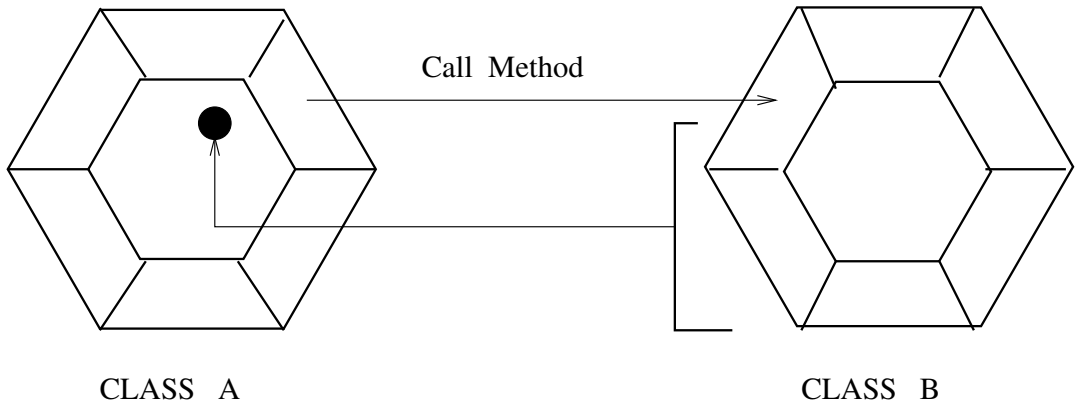
Relationships Among Classes

Motivation

- Classes and objects by themselves are not enough to describe the structure of a system.
- We also need to express relationships among classes.
- Object-oriented software packages are assembled from collections of classes and class-hierarchies that are related in three fundamental ways.

Relationships Among Classes

1. **Use:** Class A uses Class B (method call).



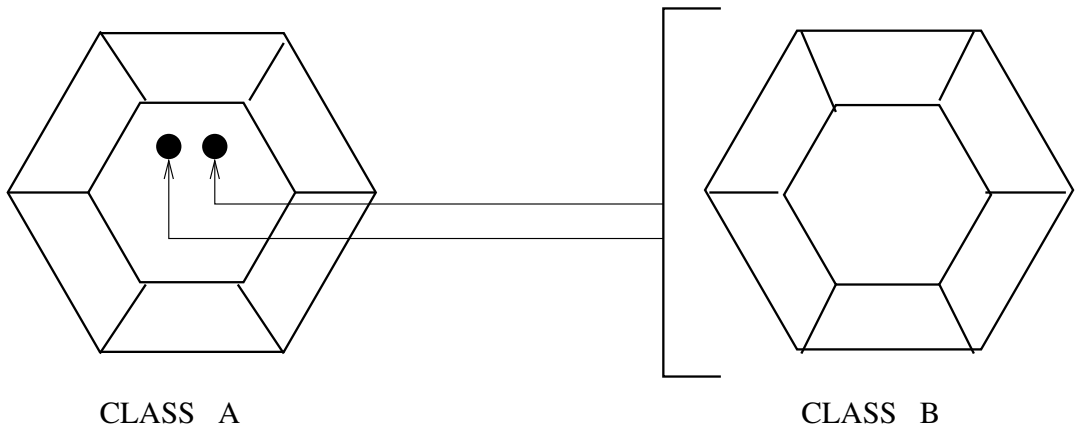
Class `A` uses Class `B` if a method in `A` calls a method in an object of type B.

Example

```
double dAngle = Math.sin ( Math.PI / 3.0 );
```

Relationships Among Classes

2. Containment (Has a): Class A contains a reference to Class B.



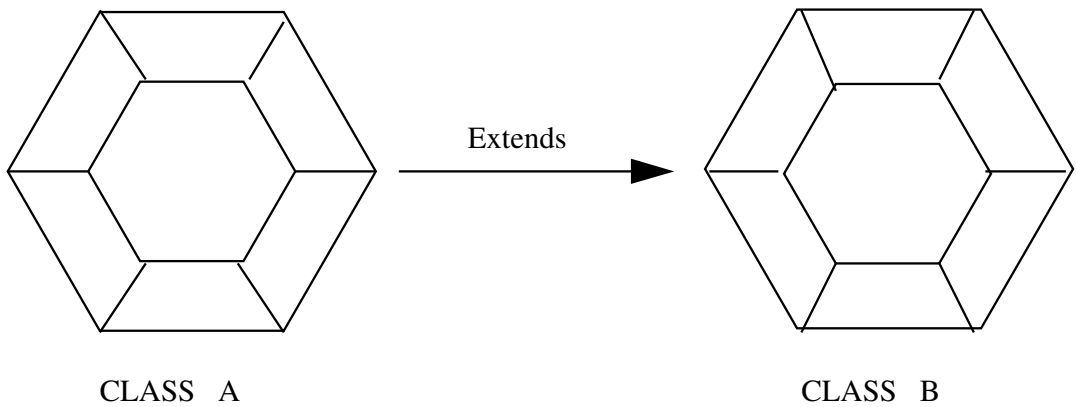
Clearly, containment is a special case of use (i.e., see Item 1.).

Example

```
public class LineSegment {
   private Point start, end;
   .......
}
```

Relationships Among Classes

3. Inheritance (Is a): In everyday life, we think of inheritance as something that is received from a predecessor or past generation. Here, Class B inherits the data and methods (extends) from Class A.



Examples of Java Code

```
public class ColoredCircle extends Circle { .... }
public class GraphicalView extends JFrame { .... }
```