CS203 Programming with Data Structures
Object-Oriented Programming Concepts

Chengyu Sun
California State University, Los Angeles

Overview

- Encapsulation
- Inheritance
- Polymorphism
- Abstract classes
- Interfaces

Access Modifiers

- `public` – can be accessed from anywhere
- `private` – can be accessed only within the class
- `protected` – can be accessed within the class, in subclasses, or within the same package
- No modifier – can be accessed within the same package

Access Control Example

```
public class Foo {

   public int a;
   private int b;
   protected int c;

   public Foo()
   {
      a = 1;
      b = 2;
      c = 3;
   }


}
```

```
public class Bar {

   public Bar () {}

   public void print( Foo f )
   {
      System.out.println(f.a); // ??
      System.out.println(f.b); // ??
      System.out.println(f.c); // ??
   }

   public static void main( String args[] )
   {
      (new Bar()).print( new Foo() );
   }
}
```

Encapsulation

- Separate implementation details from interface
  - Control access to internal data
  - Change class implementation without breaking code that uses the class

Access to Private Fields

- *Getter* and *Setter* methods
  - Point
    - getX(), getY()
    - setX(), setY()
- What not just make x, y public??

Inheritance

- Code re-use
- *Subclass* inherits members of a *superclass*
  - Class variables
  - Methods
  - *Except constructors*
- Inherits != Can Access
  - `public` and `protected`
  - Subclass may have more members than the superclass

Keyword `super`

- A reference to the superclass
- A reference to a constructor of the superclass

Keyword `final`

- A final class cannot be inherited
  - public `final` class Classname {…}
- A final variable cannot changes its value
  - Similar to *constants* in other languages
  - Convenience
  - Readability
  - `final double PI = 3.1415926;`

Overriding

- A subclass method has the same *signature* as a method of the superclass
- Method *signature*
  - Access modifier
  - Return Type
  - Name
  - List of parameters

Overriding Examples

- public String toString()
  - All Java classes implicitly inherits from the `Object` class
  - toString() is one of the methods defined in the `Object` class

Polymorphism

- An object of a subclass can be used as an object of the superclass
- The reverse is not true. Why??

Polymorphism Example

```
public class A {

   public A() {}

   public void afunc()
   {
      System.out.println( "afunc" );
   }
}

public class B extends A {

   public B() {}

   public void bfunc()
   {
      System.out.println( "bfunc" );
   }
}
```

```
A a1 = new A();
B b1 = new B();

A a2 = new B();  // ??
B b2 = new A();  // ??

a2.afunc(); // ??

a2.bfunc(); // ??
```

Polymorphism Example

```
public class A {

   public A() {}

   public void afunc()
   {
      System.out.println( "afunc" );
   }
}

public class B extends A {

   public B() {}

   public void bfunc()
   {
      System.out.println( "bfunc" );
   }
}
```

```
A a1 = new A();
B b1 = new B();

A a2 = new B();  // OK
B b2 = new A();  // Error!

a2.afunc(); // OK

a2.bfunc(); // Error!

((B) a2).bfunc(); // OK

((B) a1).bfunc(); // Error!
```

Dynamic Dispatching

- When multiple implementations of the same method exist due to overriding, which method to invoke is determined by the actual class of the object
- *Dynamic* means the decision is make at runtime (as oppose to compile time)

Dynamic Dispatching Example

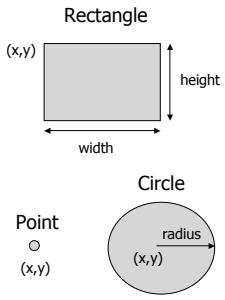
```
public class A {

   public A() {}

   public void afunc()
   {
      System.out.println( "afunc" );
   }
}
```

```
A a = new A();
B b = new B();

A a2 = new B();

a.afunc(); // ??
b.afunc(); // ??
a2.afunc(); // ??
```

```
public class B extends A {

   public B() {}

   public void afunc()
   {
      System.out.println( "b's afunc" );
   }

   public void bfunc()
   {
      System.out.println( "bfunc" );
   }
}
```

Shapes

- Attributes
  - Location
  - Length, width, Radius
- Operations
  - Move
  - Draw



Shape Class

```
public class Shape {

      protected int x, y; // initial location

   public Shape( int x, int y )
   {
      this.x = x;
      this.y = y;
   }

   public void move( int newX, int newY )
   {
      x = newX;
      y = newY;
   }

   public void draw() { ??? }
}
```

Abstract Shape Class

- An abstract class
  - Some operations are known and some are not
  - Unknown operations can be declared as abstract methods
  - Cannot be instantiated

```
public abstract class Shape {

        int x, y; // location

    public Shape( int x, int y )
    {
        this.x = x;
        this.y = y;
    }

    void move( int newX, int newY )
    {
        x = newX;
        y = newY;
    }

    public abstract void draw();
}
```

Subclasses of Shape

- Point, Rectangle, and Circle
- A concrete class
  - A subclass of an abstract superclass
  - Must implement (override) the abstract methods
  - Can be instantiated

Sort Integers

```
public void sort( int a[] )
{
    int left = 0;
    while( left < a.length-1 )
    {
        int index = left;
        for( int i=left ; i < a.length ; ++i )
            if( a[i] < a[index] ) index = i;

        // swap a[index] and a[left]
        int tmp = a[index];
        a[index] = a[left];
        a[left] = tmp;

        ++left;
    }
}
```

Sort Objects

- Any objects that has a lessThan() method

```
public abstract class Comparable {

    public Comparable() {}

    // return true if this object is less than o
    public abstract boolean lessThan( ?? o );
}
```

A More General Sort

```
public void sort( Comparable a[] )
{
    int left = 0;
    while( left < a.length-1 )
    {
        int index = left;
        for( int i=left ; i < a.length ; ++i )
            if( a[i].lessThan(a[index]) ) index = i;

        // swap a[index] and a[left]
        int tmp = a[index];
        a[index] = a[left];
        a[left] = tmp;

        ++left;
    }
}
```

The Need for Multiple Inheritance

- What if we want to sort an array of `Point`?
  - Inherit both Shape *and* Comparable?

The Problem of Multiple Inheritance

```
public class A {
... ...
    public int x;

  public void foobar()
  {
     ...
  }

}
```

```
public class B {
... ...
    public int x;

  public void foobar()
  {
     ...
  }

}
```

```
public class C extends A, B
{
   ... ...
}
```

- Which x or `foobar()` does C inherit?

Interface

- Java's answer to multiple inheritance
- A interface only contains
  - Method declarations
    - No method implementations
    - All methods are implicitly `public` and `abstract`
  - Constants
    - All constants are implicitly `public`, `static`, and `final`

Interface Examples

```
public interface ActionListener
{
    public void actionPerformed(ActionEvent ae);
}

public interface AdjustmentListener
{
    public void adjustmentValueChanged(AdjustmentEvent e);
}

public interface MouseListener
{
    public void mousePressed();
    public void mouseClicked();
    public void mouseReleased();
    public void mouseEntered();
    public void mouseExited();
}
```

`Comparable` Interface

```
public interface Comparable {

    boolean lessThan( Object c );

}
```

Interface Usage

```
public class Point extends Shape implements Comparable {

    public Point( int x, int y ) { super(x,y); }

    public void draw() { ... }

    public boolean lessThan( Object o )
    {
        Point p = (Point) o; // cast to a Point for comparable
        ??
    }

} // end of class Point
```

Abstract Class vs. Interface

- Abstract class
  - An incomplete class
  - Class variables
  - Constructors
  - Methods and abstract methods
  - `extends`
  - Single inheritance
  - Cannot be instantiated
- Interface
  - Not a class at all
  - Only constants
  - No constructors
  - Only abstract methods (method declarations)
  - `implements`
  - Multiple implementation
  - Cannot be instantiated