

Topic 7

Interfaces and Abstract Classes

“I prefer Agassiz in the abstract, rather than in the concrete.”



Interfaces

Multiple Inheritance

- ▶ There are classes where the “is-a” test is true for more than one other class
 - a graduate teaching assistant is a graduate student
 - a graduate teaching assistant is a faculty member
- ▶ Java requires all classes to inherit from exactly one other class
 - does not allow multiple inheritance
 - some object oriented languages do

Problems with Multiple Inheritance

- ▶ Suppose multiple inheritance was allowed

```
public class GradTA extends Faculty, GradStudent
```
- ▶ Suppose Faculty overrides toString and that GradStudent overrides toString as well

```
GradTA tal = new GradTA();
System.out.println( tal.toString() );
```
- ▶ What is the problem
- ▶ Certainly possible to overcome the problem
 - provide access to both (scope resolution in C++)
 - require GradTA to pick a version of toString or override it itself (Eiffel)

Interfaces – Not quite Multiple Inheritance

- ▶ Java does not allow multiple inheritance
 - syntax headaches not worth the benefits
- ▶ Java has a mechanism to allow specification of a data type with NO implementation
 - *interfaces*
- ▶ Pure Design
 - allow a form of multiple inheritance without the possibility of conflicting implementations

A List Interface

- ▶ What if we wanted to specify the operations for a List, but no implementation?
- ▶ Allow for multiple, different implementations.
- ▶ Provides a way of creating *abstractions*.
 - a central idea of computer science and programming.
 - specify "what" without specifying "how"
 - "Abstraction is a mechanism and practice to reduce and factor out details so that one can focus on a few concepts at a time. "

Interface Syntax

```
public interface List{
    public void add(Object val);
    public int size();
    public Object get(int location);
    public void insert(int location,
        Object val);
    public void addAll(List other);
    public Object remove(int location);
}
```

Interfaces

- ▶ All methods in interfaces are public and abstract
 - can leave off those modifiers in method headers
- ▶ No constructors
- ▶ No instance variables
- ▶ can have class constants

```
public static final int DEFAULT_SIDES = 6
```

Implementing Interfaces

- ▶ A class inherits (extends) exactly one other class, but ...
- ▶ A class can *implement* as many interfaces as it likes

```
public class ArrayList implements List
```

- ▶ A class that implements an interface must provide implementations of all method declared in the interface or the class must be **abstract**
- ▶ interfaces can extend other interfaces

Why interfaces?

- ▶ Interfaces allow the creation of *abstract data types*
 - "A set of data values and associated operations that are precisely specified independent of any particular implementation."
 - multiple implementations allowed
- ▶ Interfaces allow a class to be specified without worrying about the implementation
 - do design first
 - What will this data type do?
 - Don't worry about implementation until design is done.
 - separation of concerns
- ▶ allow a form of multiple inheritance

The Comparable Interface

- ▶ The Java Standard Library contains a number of interfaces
 - names are italicized in the class listing
- ▶ One of the most important interfaces is the Comparable interface



Comparable Interface version 1.4

```
package java.lang

public interface Comparable
{
    public int compareTo( Object other );
}
```

- ▶ compareTo should return an int <0 if the calling object is less than the parameter, 0 if they are equal, and an int >0 if the calling object is greater than the parameter

Implementing Comparable

- ▶ Any class that has a *natural ordering* of its objects (that is objects of that type can be sorted based on some internal attribute) should implement the Comparable interface
- ▶ Back to the `ClosedShape` example
- ▶ Suppose we want to be able to sort `ClosedShapes` and it is to be based on area

Example `compareTo`

- ▶ Suppose we have a class to model playing cards
 - Ace of Spades, King of Hearts, Two of Clubs
- ▶ each card has a suit and a value, represented by ints
- ▶ this version of `compareTo` will compare values first and then break ties with suits



`compareTo` in a Card class

```
public class Card implements Comparable
{
    public int compareTo(Object otherObject)
    {
        Card other = (Card)otherObject;
        int result = this.myRank - other.myRank;
        if(result == 0)
            result = this.mySuit - other.mySuit;
        return result
    }
    // other methods not shown
}
```

Assume ints for ranks (2, 3, 4, 5, 6,...) and suits (0 is clubs, 1 is diamonds, 2 is hearts, 3 is spades).

Interfaces and Polymorphism

- ▶ Interfaces may be used as the data type for object variables
- ▶ Can't simply create objects of that type
- ▶ Can refer to any objects that implement the interface or descendants
- ▶ Assume `Card` implements `Comparable`
`Card c = new Card();`
`Comparable comp1 = new Card();`
`Comparable comp2 = c;`

Polymorphism Again! What can this Sort?

```
public static void SelSort(Comparable[] list)
{
    Comparable temp;
    int smallest;
    for(int i = 0; i < list.length - 1; i++)
    {
        small = i;
        for(int j = i + 1; j < list.length; j++)
        {
            if( list[j].compareTo(list[small]) < 0)
                small = j;
        } // end of j loop
        temp = list[i];
        list[i] = list[small];
        list[small] = temp;
    } // end of i loop
}
```

Abstract Classes

Part Class, part Interface

Back to the ClosedShape Example

- ▶ One behavior we might want in ClosedShapes is a way to get the area
- ▶ problem: How do I get the area of something that is “just a ClosedShape”?

The ClosedShape class

```
public class ClosedShape
{
    private double myX;
    private double myY;

    public double getArea()
    {
        //Hmmm???!
    }

    //

}
// Other methods not shown
```

Doesn't seem like we have enough information to get the area if all we know is it is a ClosedShape.

Options

1. Just leave it for the sub classes.
 - ▶ Have each sub class define `getArea()` if they want to.
2. Define `getArea()` in `ClosedShape` and simply return 0.
 - ▶ Sub classes can override the method with more meaningful behavior.



Leave it to the Sub - Classes

```
// no getArea() in ClosedShape

public void printAreas(ClosedShape[] shapes)
{
    for( ClosedShape s : shapes )
    {
        System.out.println( s.getArea() );
    }
}

ClosedShape[] shapes = new ClosedShape[2];
shapes[0] = new Rectangle(1, 2, 3, 4);
shapes[1] = new Circle(1, 2, 3);
printAreas( shapes );
```

Will the above code compile?

How does the compiler determine if a method call is allowed?

Fix by Casting

```
// no getArea() in ClosedShape

public void printAreas(ClosedShape[] shapes)
{
    for( ClosedShape s : shapes )
    {
        if( s instanceof Rectangle )
            System.out.println( ((Rectangle)s).getArea() );
        else if( s instanceof Circle )
            System.out.println( ((Circle)s).getArea() );
    }
}

ClosedShape[] shapes = new ClosedShape[2];
shapes[0] = new Rectangle(1, 2, 3, 4);
shapes[1] = new Circle(1, 2, 3);
printAreas( shapes );
```

What happens as we add more sub classes of `ClosedShape`?

What happens if one of the objects is just a `ClosedShape`?

Fix with Dummy Method

```
// getArea() in ClosedShape returns 0

public void printAreas(ClosedShape[] shapes)
{
    for( ClosedShape s : shapes )
    {
        System.out.println( s.getArea() );
    }
}

ClosedShape[] shapes = new ClosedShape[2];
shapes[0] = new Rectangle(1, 2, 3, 4);
shapes[1] = new Circle(1, 2, 3);
printAreas( shapes );
```

What happens if sub classes don't override `getArea()`?

Does that make sense?

A Better Fix

- ▶ We know we want to be able to find the area of objects that are instances of `ClosedShape`
- ▶ The problem is we don't know how to do that if all we know is it a `ClosedShape`
- ▶ Make `getArea` an abstract method
- ▶ Java keyword

Making `getArea` Abstract

```
public class ClosedShape
{   private double myX;
    private double myY;

    public abstract double getArea();
    // I know I want it.
    // Just don't know how, yet...

}
// Other methods not shown
```

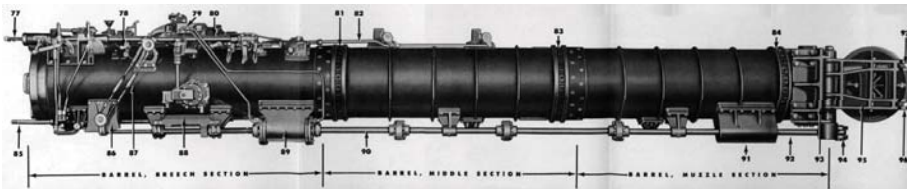
Methods that are declared abstract have no body or an undefined behavior.

All methods in an interface are abstract.

Problems with Abstract Methods

Given `getArea()` is now an abstract method what is wrong with the following code?

```
ClosedShape s = new ClosedShape();
System.out.println( s.getArea() );
```



Undefined Behavior = Bad

- ▶ Not good to have undefined behaviors
- ▶ If a class has 1 or more abstract methods, the class must also be declared abstract.
 - version of `ClosedShape` shown would cause a compile error
- ▶ Even if a class has zero abstract methods a programmer can still choose to make it abstract
 - if it models some abstract thing
 - is there anything that is just a “Mammal”?

Abstract Classes

```
public abstract class ClosedShape
{
    private double myX;
    private double myY;

    public abstract double getArea();
    // I know I want it.
    // Just don't know how, yet...
}
// Other methods not shown
```

if a class is abstract the compiler will not allow constructors of that class to be called

```
ClosedShape s = new ClosedShape(1, 2);
//syntax error
```

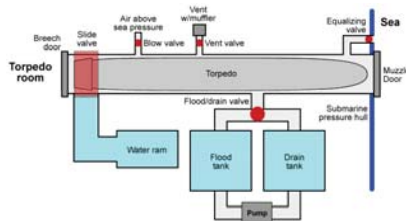
Abstract Classes

- ▶ In other words you can't create instances of objects where the lowest or most specific class type is an abstract class
- ▶ Prevents having an object with an undefined behavior
- ▶ Why would you still want to have constructors in an abstract class?
- ▶ Object variables of classes that are abstract types may still be declared

```
ClosedShape s; //okay
```

Sub Classes of Abstract Classes

- ▶ Classes that extend an abstract class must provided a working version of any abstract methods from the parent class
 - or they must be declared to be abstract as well
 - could still decide to keep a class abstract regardless of status of abstract methods



Implementing getArea()

```
public class Rectangle extends ClosedShape
{
    private double myWidth;
    private double myHeight;

    public double getArea()
    {
        return myWidth * myHeight;
    }

    // other methods not shown
}

public class Square extends Rectangle
{
    public Square()
    {
    }

    public Square(double side)
    {
        super(side, side);
    }

    public Square(double x, double y, double side)
    {
        super(side, side, x, y);
    }
}
```


A Circle Class

```
public class Circle extends ClosedShape
{   double dMyRadius;

    public Circle()
    {   super(0,0); }

    public Circle(double radius)
    {   super(0,0);
        dMyRadius = radius;
    }

    public Circle(double x, double y, double radius)
    {   super(x,y);
        dMyRadius = radius;
    }

    public double getArea()
    {   return Math.PI * dMyRadius * dMyRadius; }

    public String toString()
    {   return super.toString() + " radius: " + dMyRadius; }
}
```

Polymorphism in Action

```
public class UsesShapes
{   public static void go()
    {   ClosedShape[] sList = new ClosedShape[10];
        double a, b, c, d;
        int x;
        for(int i = 0; i < 10; i++)
        {   a = Math.random() * 100;
            b = Math.random() * 100;
            c = Math.random() * 100;
            d = Math.random() * 100;
            x = (int)(Math.random() * 3 );
            if( x == 0 )
                sList[i] = new Rectangle(a,b,c,d);
            else if(x == 1)
                sList[i] = new Square(a, c, d);
            else
                sList[i] = new Circle(a, c, d);
        }
        double total = 0.0;
        for(int i = 0; i < 10; i++)
        {   total += sList[i].getArea();
            System.out.println( sList[i] );
        }
    }
}
```

The Kicker

- ▶ We want to expand our pallet of shapes
- ▶ Triangle could also be a sub class of ClosedShape.
 - it would *inherit* from ClosedShape

```
public double getArea()
{   return 0.5 * dMyWidth * dMyHeight;}
```

- ▶ What changes do we have to make to the code on the previous slide for totaling area so it will now handle Triangles as well?
- ▶ Inheritance is can be described as new code using old code.
- ▶ Polymorphism can be described as old code using new code.

Comparable in ClosedShape

```
public abstract class ClosedShape implements Comparable
{   private double myX;
    private double myY;

    public abstract double getArea();

    public int compareTo(Object other)
    {   int result;
        ClosedShape otherShape = (ClosedShape)other;
        double diff = getArea() - otherShape.getArea();
        if( diff == 0 )
            result = 0;
        else if( diff < 0 )
            result = -1;
        else
            result = 1;
        return result
    }
}
```

About ClosedShapes compareTo

- ▶ don't have to return -1, 1.
 - Any int less than 0 or int greater than 0 based on 2 objects
- ▶ the `compareTo` method makes use of the `getArea()` method which is abstract in `ClosedShape`
 - how is that possible?