CENG 1004
Introduction to Object Oriented Programming

Spring 2018

WEEK 9

New Requirement

- Assume your drawing application also allows user to put text on the drawing area and Drawing class has a new method that draws Shapes and Texts by calling the their draw methods

```
public class Text {

    private String text;

    public Text(String text){
        this.text = text;
    }

    public void draw(){
        //to be imlemented
    }
}
```

New Requirement

- Similarly each Shape class also has draw method

```
public class Circle {
    ...
    public void draw(){
        //to be imlemented
    }
}
public class Rectangle {
    ...
    public void draw(){
        //to be imlemented
    }
}
```

New Requirement

- And we will have a draw metod in Drawing class that can draw all the shapes and texts it contains

```
public class DrawingV4{
    ArrayList<Shape> shapes = new ArrayList<Shape>();
    ArrayList<Text> texts = new ArrayList<Text>();
    ...
    public void draw(){
        //call draw methods of all the shapes and texts
    }
}
```

draw method in Drawing

- And we will have a draw metod in Drawing class that can draw all the shapes and texts it contains

```
public class DrawingV4{
    ...
    public void draw(){
        for (Shape shape : shapes){
            //call draw methods of each shape
        }

        for (Text text : texts){
            text.draw();
        }
    }
}
```

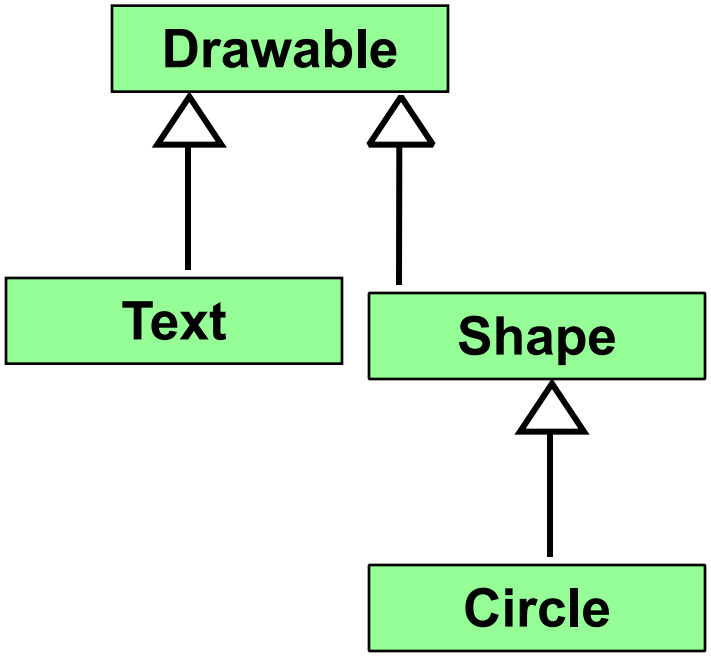
DrawingV4

- We have two lists and in the class to hold drawable objects
  - We have to declare new List for each drawable type
- We have two for loops in the draw method
  - We have to add new loop to draw new drawable types

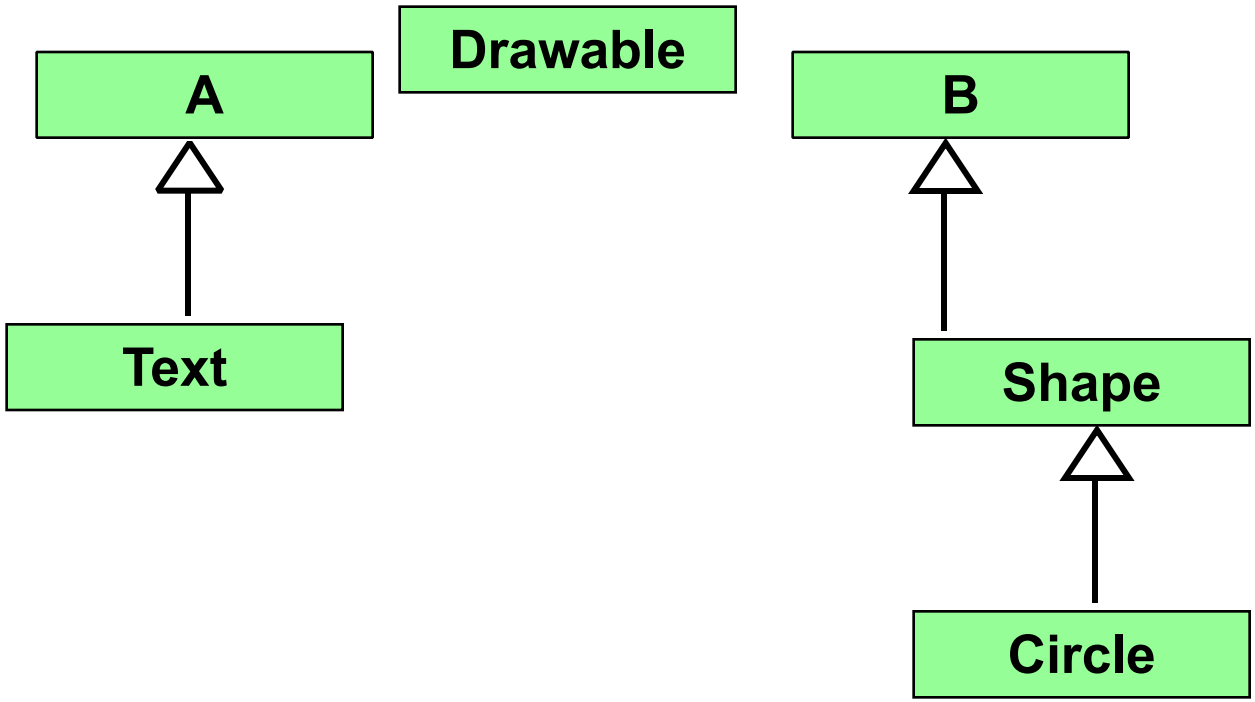
Drawing (Version 5)

```
public class DrawingV5{
    ArrayList<Drawable> drawables= new ArrayList<Drawable>();
        ...
    public void draw(){
        for (Drawable drawable: drawables){
            drawable.draw();
        }
    }
}
```

We can again use inheritance



Assume Text and Shape have already superclasses



- Multiple Inheritance is not allowed in Java

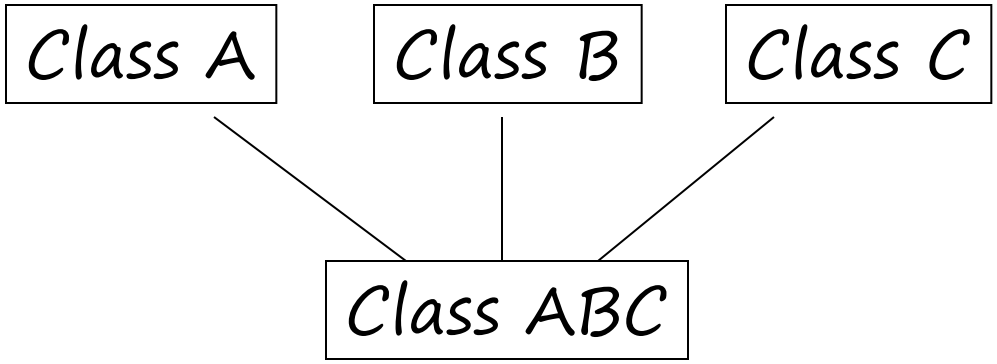
Interface

- An interface specifies a group of behaviors and gives them a name.
- Classes can choose to implement interfaces which require them to implement all of the methods in the interface.
- An interface is a named collection of method definitions and constants ONLY.
- A class that implements the interface agrees to implement all the methods defined in the interface, thereby agreeing to certain behaviors.

Interface and Abstract Classes

- An interface cannot implement any methods, whereas an abstract class can.
- A class can implement many interfaces but can have only one superclass.
- An interface is not part of the class hierarchy. Unrelated classes can implement the same interface.

Multiple Inheritance



Class ABC inherits all variables and methods from Class A, Class B, and Class C.

Java does NOT support multiple inheritances.

However, you can use interface to implement the functionality of multiple inheritance.

Interface Body

- The interface body contains method declarations for **ALL** the methods included in the interface.
- A method declaration within an interface is followed by a semicolon (;) because an interface does not provide implementations for the methods declared within it.
- All methods declared in an interface are implicitly public and abstract.

Drawable Interface

```
public interface Drawable {

    public void draw();

}
```

Drawable Text

```
public class Text  implements Drawable{

    private String text;

    public Text(String text){
        this.text = text;
    }

    public void draw(){
        //to be imlemented
    }
}
```

Drawable Shape

```
public abstract class Shape implements Drawable{

    public abstract double area();

    public abstract double perimeter();

}
```

Generics

Generics

- Some bugs are easier to detect than others. Compile-time bugs, for example, can be detected early on

- Generics add stability to your code by making more of your bugs detectable at compile time.

Why Use Generics

- Generics enable types (classes and interfaces) to be parameters when defining classes, interfaces and methods.
  - Stronger type checks at compile time.
  - Elimination of casts.
  - Enabling programmers to implement generic algorithms.

Generics Example

- The following code snippet without generics requires casting:

```
List list = new ArrayList();
list.add("hello");
String s = (String) list.get(0);
```

- When re-written to use generics, the code does not require casting:

```
List<String> list = new ArrayList<String>();
list.add("hello");
String s = list.get(0);   // no cast
```

Generic Types

- A generic type is a generic class or interface that is parameterized over types.

- The following Box class will be modified to demonstrate the concept.

```
public class Box {
    private Object object;

    public void set(Object object){
              this.object = object;
    }
    public Object get() {
              return object;
    }
}
```

A Generic Version of the Box Class

```
public class Box<T> {
    // T stands for "Type"
    private T t;

    public void set(T t) {
        this.t = t;
    }
    public T get() {
        return t;
    }
}
```

Generic Class Definition

- A generic class is defined with the following format:

```
class name<T1, T2, ..., Tn>{
   ...
 }
```

- This same technique can be applied to create generic interfaces

Type Parameter Naming Conventions

- By convention, type parameter names are single, uppercase letters.
- The most commonly used type parameter names are:

  E - Element (used extensively by the Java Collections Framework)

  K - Key

  N - Number

  T - Type

  V - Value

  S,U,V etc. - 2nd, 3rd, 4th types

Invoking and Instantiating a Generic Type

- To reference the generic Box class from within your code, you must perform a generic type invocation, which replaces **T** with some concrete value, such as **Integer**:

```
Box<Integer> integerBox;
```

- Similar to an ordinary method invocation, but instead of passing an argument to a method, you are passing a type argument — Integer in this case — to the Box class itself.

Invoking and Instantiating a Generic Type

- Like any other variable declaration, this code does not actually create a new Box object.
- It simply declares that integerBox will hold a reference to a "Box of Integer", which is how Box<Integer> is read.
- To instantiate this class, use the new keyword, as usual, but place <Integer> between the class name and the parenthesis:

```
Box<Integer> integerBox = new Box<Integer>();
```

The Diamond

- You can replace the type arguments required to invoke the constructor of a generic class with an empty set of type arguments (<>) as long as the compiler can determine, or infer, the type arguments from the context.

```
Box<Integer> integerBox = new Box<>();
```

- This pair of angle brackets, <>, is informally called the diamond.

Multiple Type Parameters

- As mentioned previously, a generic class can have multiple type parameters.

```
public interface Pair<K, V> {
    public K getKey();
    public V getValue();
}
```

Multiple Type Parameters

```
public class PairImpl<K, V> implements Pair<K, V> {

    private K key;
    private V value;

    public PairImpl(K key, V value) {
      this.key = key;
      this.value = value;
    }

    public K getKey()   { return key; }
    public V getValue() { return value; }
}
```

Multiple Type Parameters

- The following statements create two instantiations of the PairImpl class:

```
Pair<String, Integer> p1 = new PairImpl<String, Integer>("Even", 8);

Pair<String, String>  p2 = new PairImpl<String, String>("hello",
   "world");
```

Multiple Type Parameters

- You can also substitute a type parameter (i.e., K or V) with a parameterized type (i.e., List<String>).

```
Pair<String, Box<Integer>> p = new PairImpl<>("primes", new
   Box<Integer>(...));
```

Raw Types

- A raw type is the name of a generic class or interface without any type arguments.

- If the actual type argument is omitted, you create a raw type of Box<T>:

```
Box rawBox = new Box();
```

Raw Types

- When using raw types, you essentially get pre-generics behavior — a Box gives you Objects.
- For backward compatibility, assigning a parameterized type to its raw type is allowed.
- You should avoid using raw types.

Generic Methods

- Generic methods are methods that introduce their own type parameters. This is similar to declaring a generic type, but the type parameter's scope is limited to the method where it is declared.

```
public class Util {
    public static <K, V> boolean compare(Pair<K, V> p1,
       Pair<K, V> p2) {
        return p1.getKey().equals(p2.getKey()) &&
               p1.getValue().equals(p2.getValue());
    }
}
```

Generic Methods

- The complete syntax for invoking this method would be:

```
Pair<Integer, String> p1 = new Pair<>(1, "apple");
Pair<Integer, String> p2 = new Pair<>(2, "pear");
boolean same = Util.<Integer, String>compare(p1, p2);
```

- The type has been explicitly provided, as shown in bold. Generally, this can be left out and the compiler will infer the type that is needed:

```
boolean same = Util.compare(p1, p2);
```

- This feature, known as type inference, allows you to invoke a generic method as an ordinary method, without specifying a type between angle brackets.

Bounded Type Parameters

- There may be times when you want to restrict the types that can be used as type arguments in a parameterized type

- For example, a method that operates on numbers might only want to accept instances of Number or its subclasses.

Bounded Type Parameters

- To declare a bounded type parameter, list the type parameter's name, followed by the extends keyword, followed by its upper bound, which in this example is Number.

```
public <U extends Number> void inspect(U u){

  System.out.println("U: " + u.getClass().getName());

}
```

Generic Methods and Bounded Type Parameters

```
public static <T> int countGreaterThan(T[] anArray, T
   elem) {
     int count = 0;
     for (T e : anArray)
         if (e > elem)  // compiler error
             ++count;
     return count;
}
```

- Does not compile because the greater than operator (>) applies only to primitive types such as short, int, double, long, float, byte, and char.

- You cannot use the > operator to compare objects. To fix the problem, use a type parameter bounded by the Comparable<T> interface:

```
public interface Comparable<T> {
     public int compareTo(T o);
}
```

Generic Methods and Bounded Type Parameters

The resulting code will be:

```
public static <T extends Comparable<T>> int
   countGreaterThan(T[] anArray, T elem) {

    int count = 0;

    for (T e : anArray)
        if (e.compareTo(elem) > 0)
            ++count;

    return count;
}
```

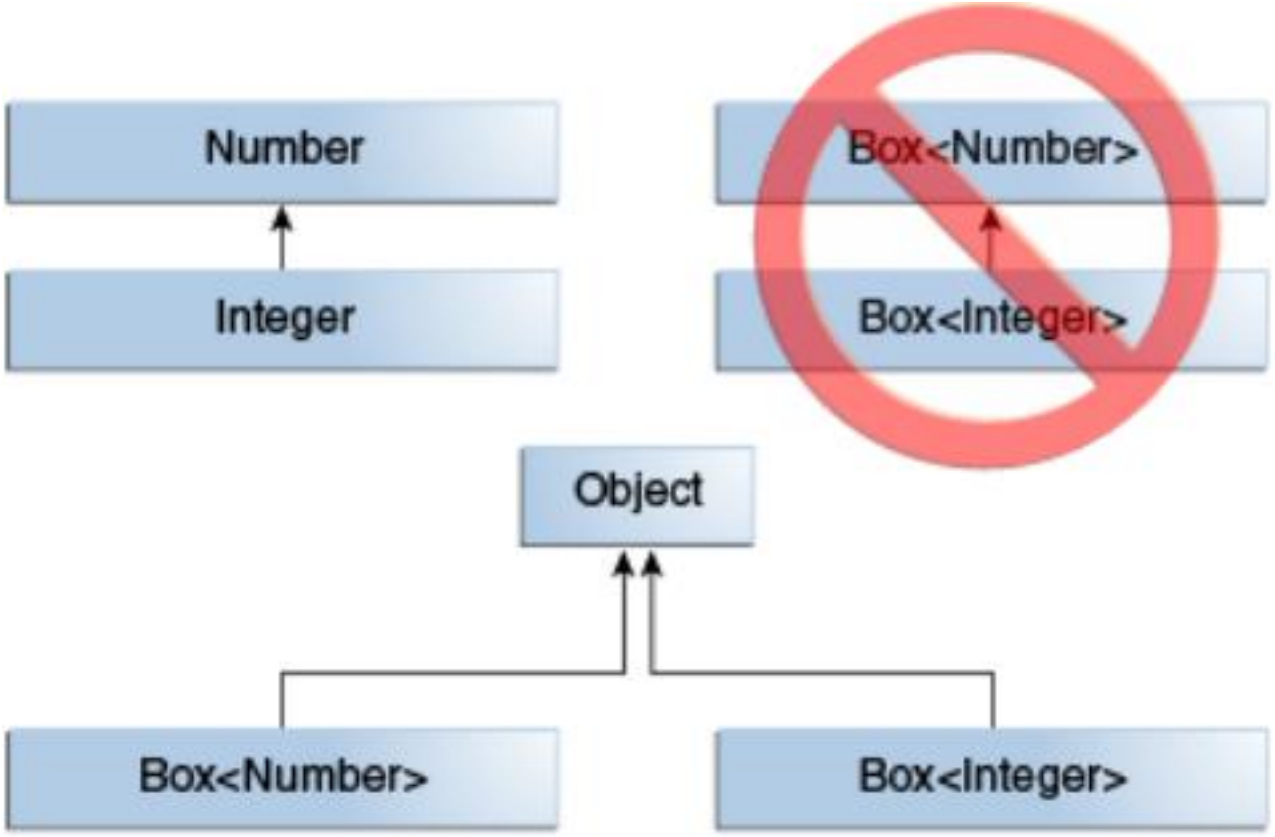
Multiple Bounds

- A type parameter can have multiple bounds:

```
Class A { /* ... */ }
interface B { /* ... */ }
interface C { /* ... */ }

class D <T extends A & B & C> { /* ... */ }
```

Generics, Inheritance, and Subtypes



Generics, Inheritance, and Subtypes

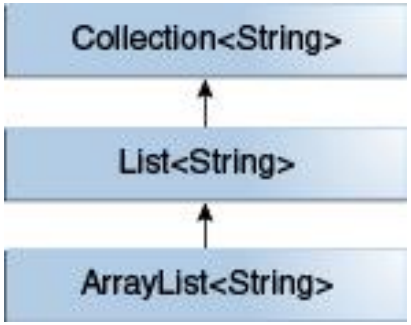
- Now consider the following method:

```
public void boxTest(Box<Number> n) { /* ... */ }
```

- Are you allowed to pass in `Box<Integer>` or `Box<Double>`, as you might expect?

- The answer is "no", because `Box<Integer>` and `Box<Double>` are not subtypes of `Box<Number>`.

Generic Classes and Subtyping



- `ArrayList<E>` implements `List<E>`, and `List<E>` extends `Collection<E>`.
- So `ArrayList<String>` is a subtype of `List<String>`, which is a subtype of `Collection<String>`.
- So long as you do not vary the type argument, the subtyping relationship is preserved between the types.

Generic Classes and Subtyping

Is the following possible?

```
List<String> listStrings = new ArrayList<String>();
List<Object> listObjects = listStrings;
```

Well, we know that the following is of course fine:

```
String str = "hello";
Object obj = str;
```

Answer is: NO (compilation error)

This comes to avoid the following:

```
listObjects.add(7);
String str = listStrings.get(0); // wd've been run-time error
```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Wildcards

Suppose we want to implement the following function:

```
void printCollection(Collection col) {
        for(Object obj : col) {
                System.out.println(obj);
        }
}
```

But we want to do it in a "generic" way, so we write:

```
void printCollection(Collection<Object> col) {
        for(Object obj : col) {
                System.out.println(obj);
        }
}
```

Can get ONLY collection of Objects

(go one slide back for explanation)

Cannot support Collection<String> Collection<Float> etc.

What's wrong with the 2nd implementation?

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Wildcards

The proper way is:

```
void printCollection(Collection<? extends Object> col) {
        for(Object obj : col) {
                System.out.println(obj);
        }
}
```

Which is the same, for this case, as:

```
void printCollection(Collection<?> col) {
        for(Object obj : col) {
                System.out.println(obj);
        }
}
```

Now we support all type of Collections!

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Wildcards

One more wildcard example:

```
public interface Map<K,V> {
        …
        void putAll(Map<? extends K, ? extends V> map)
        …
}
```

And another one:

```
public interface Collection<E> {
        …
        void addAll(Collection<? extends E> coll)
        …
}
```


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References

- http://math.hws.edu/javanotes/
- https://docs.oracle.com/javase/tutorial/java/generics/
- http://www2.mta.ac.il/~amirk/java/presentations/03-Collections.ppt
- http://www.uwosh.edu/faculty_staff/huen/262/f09/slides/20_ch22_Collections.ppt
- https://examples.javacodegeeks.com/core-java/util/comparator/java-comparator-example/