Interfaces

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Relatedness of types

- Consider the task of writing classes to represent 2D shapes such as `Circle`, `Rectangle`, and `Triangle`.
- There are certain attributes or operations that are common to all shapes:
  perimeter, area
- By being a Shape, you promise that you can compute those attributes, but each shape computes them differently.

Interface as a contract

- Analogous to the idea of roles or certifications in real life:
  - "I'm certified as a CPA accountant. The certification assures you that I know how to do taxes, perform audits."

  Compare to:
  - "I'm certified as a Shape. That means you can be sure that I know how to compute my area and perimeter."

The area and perimiter of shapes

- Rectangle (as defined by width w and height h):
  area $= w\,h$
  perimeter $= 2w + 2h$

- Circle (as defined by radius r):
  area $= \pi r^2$
  perimeter $= 2\pi r$

- Triangle (as defined by side lengths a, b, and c)
  area $= \sqrt{s(s-a)(s-b)(s-c)}$
  where $s = \frac{1}{2}(a+b+c)$
  perimeter $= a + b + c$

Interfaces

- **interface**: A list of methods that a class promises to implement.
  - Inheritance gives you an is-a relationship and code-sharing.
    - An Executive object can be treated as a StaffMember, and Executive inherits StaffMember's code.
  - Interfaces give you an is-a relationship without code sharing.
    - Only method **stubs** in the interface
    - Object **can-act-as** any interface it **implements**
    - A Rectangle object can be treated as a Shape as long as it implements the interface.

Interfaces with abstract classes

```
public abstract class Shape {
      public abstract double area();
      public abstract double perimeter();
  }
```

Java Interfaces

- An interface for shapes:

```
public interface Shape {
    public double area();
    public double perimeter();
}
```

  - This interface describes the features common to all shapes. (Every shape has an area and perimeter.)

- Interface declaration syntax:

```
public interface <name> {
    public <type> <name>(<type> <name>, ..., <type> <name>);
    public <type> <name>(<type> <name>, ..., <type> <name>);
    ...
    public <type> <name>(<type> <name>, ..., <type> <name>);
}
```

- All methods are public!

Implementing an interface

```
public class Circle implements Shape {
    private double radius;

    // Constructs a new circle with the given radius.
    public Circle(double radius) {
        this.radius = radius;
    }

    // Returns the area of the circle.
    public double area() {
        return Math.PI * radius * radius;
    }

    // Returns the perimeter of the circle.
    public double perimeter() {
        return 2.0 * Math.PI * radius;
    }
}
```

Implementing an interface

- A class can declare that it *implements* an interface.
  - This means the class contains an implementation for each of the abstract methods in that interface. (Otherwise, the class will fail to compile.)

- Syntax for implementing an interface

```
public class <name> implements
<interface name> {
    . . .
}
```

Requirements

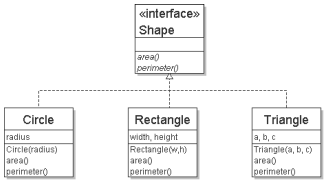
- If we write a class that claims to be a `Shape` but doesn't implement the `area` and `perimeter` methods, it will not compile.
  - Example:

```
public class Banana implements Shape {
    //without implementing area or perimiter
}
```

  - The compiler error message:

```
Banana.java:1: Banana is not abstract and does
not override abstract method area() in Shape
public class Banana implements Shape {
            ^
```

Diagramming an interface



- We draw arrows upward from the classes to the interface(s) they implement.
  - There is a supertype-subtype relationship here; e.g., all Circles are Shapes, but not all Shapes are Circles.

Rectangle

```
public class Rectangle implements Shape {
    private double width;
    private double height;

    // Constructs a new rectangle with the given
  dimensions.
    public Rectangle(double width, double height) {
        this.width = width;
        this.height = height;
    }

    // Returns the area of this rectangle.
    public double area() {
        return width * height;
    }

    // Returns the perimeter of this rectangle.
    public double perimeter() {
        return 2.0 * (width + height);
    }
}
```

Triangle

```
public class Triangle implements Shape {
    private double a;
    private double b;
    private double c;

    // Constructs a new Triangle given side lengths.
    public Triangle(double a, double b, double c) {
        this.a = a;
        this.b = b;
        this.c = c;
    }
    // Returns a triangle's area using Heron's formula.
    public double area() {
        double s = (a + b + c) / 2.0;
        return Math.sqrt(s * (s - a)*(s - b)*(s - c));
    }
    // Returns the perimeter of the triangle.
    public double perimeter() {
        return a + b + c;
    }
}
```

Interfaces and polymorphism

- The is-a relationship provided by the interface means that the client can take advantage of polymorphism.
- Example: Interface is a type!

```
public static void printInfo(Shape s) {
    System.out.println("The shape: " + s);
    System.out.println("area : " + s.area());
    System.out.println("perim: " + s.perimeter());
    System.out.println();
}
```

- Any object that implements the interface may be passed as the parameter to the above method.

```
Circle circ = new Circle(12.0);
Triangle tri = new Triangle(5, 12, 13);
printInfo(circ);
printInfo(tri);
```

Interfaces and polymorphism

- We can create an array of an interface type, and store any object implementing that interface as an element.

```
Circle circ = new Circle(12.0);
Rectangle rect = new Rectangle(4, 7);
Triangle tri = new Triangle(5, 12, 13);
Shape[] shapes = {circ, tri, rect};
for (int i = 0; i < shapes.length; i++) {
    printInfo(shapes[i]);
}
```

  - Each element of the array executes the appropriate behavior for its object when it is passed to the `printInfo` method, or when `area` or `perimeter` is called on it.

Comments about Interfaces

- The term interface also refers to the set of public methods through which we can interact with objects of a class.
- Methods of an interface are abstract.
- Think of an interface as an abstract base class with all abstract methods
- Interfaces are used to define a contract for how you interact with an object, independent of the underlying implementation.
- Separate behavior (interface) from the implementation

When to use interfaces or abstract classes

- An abstract class: mix of abstract and non-abstract methods, so some default implementations.
- An abstract class can also have static methods, private and protected methods, etc.

Interfaces and inheritance

- Interfaces allow us to get around the Java limitation of no multiple inheritance – a class can implement several interfaces

```
class ImplementsSeveral implements
   Interface1, Interface2 {
   // implementation
}
```

- Inheritance can be applied to interfaces – an interface can be derived from another interface

Commonly used Java interfaces

- The Java class library contains classes and interfaces
- `Comparable` – allows us to order the elements of an arbitrary class
- `Serializable` (in `java.io`) – for classes whose objects are able to be saved to files.
- `List, Set, Map, Iterator` (in `java.util`) – describe data structures for storing collections of objects

Comparable

```
public interface Comparable<E> {
    public int compareTo(E other);
}
```

- A class can implement the `Comparable` interface to define a natural ordering for its objects.
- A call of `a.compareTo(b)` should return:

a value <	0	if `a` comes "before" `b` in the ordering,
a value >	0	if `a` comes "after" `b` in the ordering,
or	0	if `a` and `b` are considered "equal" in the ordering.

`compareTo` tricks

- delegation trick - If your object's fields are comparable (such as strings), you can use their `compareTo`:

```
// sort by employee name
public int compareTo(StaffMember other) {
    return name.compareTo(other.getName());
}
```

`Comparable` and sorting

- The `Arrays` class in `java.util` has a static method `sort` that sorts the elements of an array

```
StaffMember [] staff = new StaffMember[3];
staff[0] = new Executive(…);
staff[1] = new Employee(…)
staff[2] = new Hourly(…);
staff[3] = new Volunteer(…);
Arrays.sort(staff);
```

Note that you will need to provide an implementation of compareTo

- Show StaffMember example

Another example

```
public class Contact implements Comparable<Contact>{
    private String firstName, lastName, phone;
    public boolean equals (Object other) {
       if (!(other instanceof Contact)) return false;
       return (lastName.equals(((Contact)other).getLastName()) &&
               firstName.equals(((Contact)other).getFirstName()));
    }
    //  Uses both last and first names to determine ordering.
    public int compareTo (Contact other) {
       String otherFirst = other.getFirstName();
       String otherLast = other.getLastName();
       if (lastName.equals(otherLast))
            return firstName.compareTo(otherFirst);
       else
            return lastName.compareTo(otherLast);
    }
}
```

Note the difference in the parameters of compareTo() and equals()
In version 1.4 of Java compareTo() needed parameter of type Object

```
import java.util.*;
public class PhoneList {
   public static void main (String[] args) {
      Contact[] friends = new Contact[6];

      friends[0] = new Contact ("John", "Smith", "610-555-7384");
      friends[1] = new Contact ("Sarah", "Barnes", "215-555-3827");
      friends[2] = new Contact ("Mark", "Riley", "733-555-2969");
      friends[3] = new Contact ("Laura", "Getz", "663-555-3984");
      friends[4] = new Contact ("Larry", "Smith", "464-555-3489");
      friends[5] = new Contact ("Frank", "Phelps", "322-555-2284");

      Arrays.sort(friends);
      for (int i=0; i<friends.length; i++)
         System.out.println (friends[i]);
   }
}
```

ArrayList

- The ArrayList declaration:
  `public class ArrayList<E> extends AbstractList<E> implements List<E>, RandomAccess, Cloneable, Serializable`
- The `List` interface includes:

Method	
`E get(int index)`	Returns the element at the specified position
`int indexOf(Object o)`	Returns the index of the first occurrence of the specified element
`E remove(int index)`	Removes the element at the specified position
`E set(int index, E element)`	Replaces the element at the specified position

Lists and collections

- The declaration of the List interface:
  `public interface List<E> extends Collection<E>`
- Has methods that any collection of elements should have: `add, clear(), contains, isEmpty(), remove, size()`

Interface for a sorted list

- Let's design the interface for a list of items that is supposed to be maintained in sorted order.