Interfaces

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 perimeter of shapes

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

- Circle (as defined by radius *r*):
  area = πr^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 encodes an is-a relationship and provides code-sharing.
    - An Executive object can be treated as a StaffMember, and Executive inherits StaffMember's code.
  - An interface specifies what an object is capable of; no code sharing.
    - Only method **stubs** in the interface
    - Object **can-act-as** any interface it **implements**
    - A Rectangle does what you expect from a Shape as long as it implements the interface.

Java Interfaces

- An interface for shapes:

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

  - This interface describes the functionality common to all shapes. (Every shape knows how to compute its 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 needs to contain an implementation for each of the methods in that interface.
    (Otherwise, the class will fail to compile.)
- Syntax for implementing an interface

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

Requirements

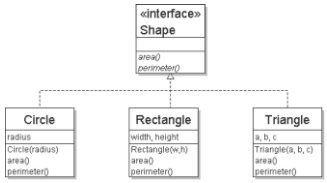
- If we write a class that claims act like a `Shape` but doesn't implement the `area` and `perimeter` methods, it will not compile.
  - Example:

```
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 from the classes to the interface(s) they implement.
- Like inheritance, an interface represents an is-a relationship (a Circle is a Shape).

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

- Polymorphism is possible with interfaces.
- Example:

```
public static void printInfo(Shape s) { Interface is a type!
    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 methods abstract
- 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

Commonly used Java interfaces

- The Java class library contains several interfaces:
  - `Comparable` – allows us to order the elements of an arbitrary class
  - `Serializable` (in `java.io`) – for saving objects to a file.
  - `List, Set, Map, Iterator` (in `java.util`) – describe data structures for storing collections of objects

The Java Comparable interface

- A class can implement the `Comparable` interface to define an ordering for its objects.

```
public interface Comparable<E> {
    public int compareTo(E other);
}
public class Employee implements
Comparable<Employee> { … }
```

- 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.

`Comparable` and sorting

- If you implement Comparable, you can sort arbitrary objects using the method `Arrays.sort`

```
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

compareTo tricks

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

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