Interfaces

EECS2011 X:
Fundamentals of Data Structures
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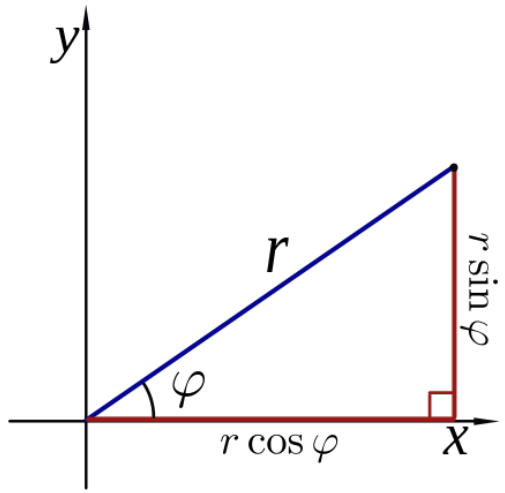
Learning Outcomes

This module is designed to help you learn about:

- What an ***interface*** is
- Reinforce: ***Polymorphism*** and ***dynamic binding***

Interface (1.1)

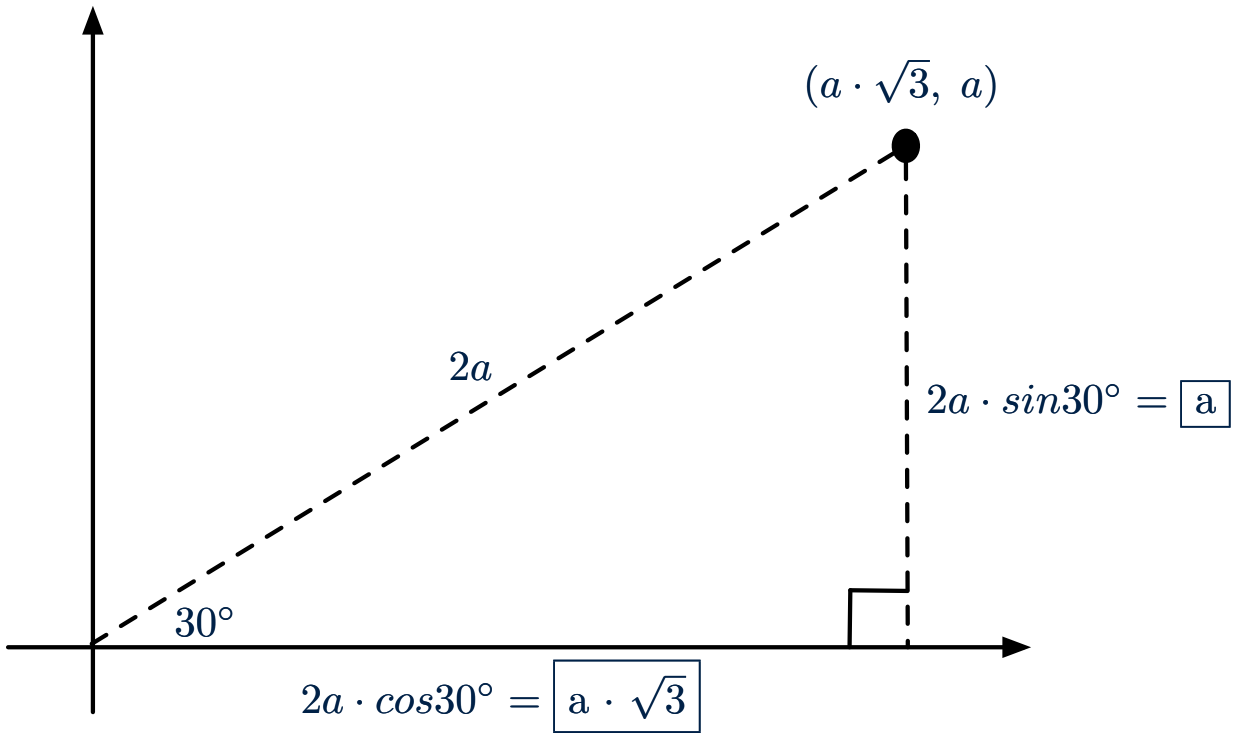
- We may implement `Point` using two representation systems:



  - The *Cartesian system* stores the *absolute* positions of `x` and `y`.
  - The *Polar system* stores the *relative* position: the angle (in radian) `phi` and distance `r` from the origin (0.0).
- As far as users of a `Point` object `p` is concerned, being able to call `p.getX()` and `p.getY()` is what matters.
- How `p.getX()` and `p.getY()` are internally computed, depending on the *dynamic type* of `p`, do not matter to users.

Interface (1.2)

Recall: $sin30° = \frac{1}{2}$ and $cos30° = \frac{1}{2} \cdot \sqrt{3}$



We consider the same point represented differently as:

- $r = 2a$, $\psi = 30°$ [polar system]
- $x = 2a \cdot cos30° = a \cdot \sqrt{3}$, $y = 2a \cdot sin30° = a$ [cartesian system]

Interface (2)

```
public interface Point {
   public double getX();
   public double getY();
}
```

- An interface `Point` defines how users may access a point: either get its *x* coordinate or its *y* coordinate.
- Methods `getX` and `getY` similar to `getArea` in `Polygon`, have no implementations, but *headers* only.
- ∴ `Point` cannot be used as a *dynamic type*
- Writing `new Point(...)` is forbidden!

Interface (3)

```
public class CartesianPoint implements Point {
  private double x;
  private double y;
  public CartesianPoint(double x, double y) {
    this.x = x;
    this.y = y;
  }
  public double getX() { return x; }
  public double getY() { return y; }
}
```

- `CartesianPoint` is a possible implementation of `Point`.
- Attributes `x` and `y` declared according to the *Cartesian system*
- All method from the interface `Point` are implemented in the sub-class `CartesianPoint`.
- ∴ `CartesianPoint` can be used as a *dynamic type*
- `Point p = new CartesianPoint(3, 4)` allowed!

Interface (4)

```
public class PolarPoint implements Point {
  private double phi;
  private double r;
  public PolarPoint(double r, double phi) {
    this.r = r;
    this.phi = phi;
  }
  public double getX() { return Math.cos(phi) * r; }
  public double getY() { return Math.sin(phi) * r; }
}
```

- `PolarPoint` is a possible implementation of `Point`.
- Attributes `phi` and `r` declared according to the *Polar system*
- All method from the interface `Point` are implemented in the sub-class `PolarPoint`.
- ∴ `PolarPoint` can be used as a *dynamic type*
- `Point p = new PolarPoint(3, π/6)` allowed! [360° = 2π]

Interface (5)

```
1  public class PointTester {
2    public static void main(String[] args) {
3      double A = 5;
4      double X = A * Math.sqrt(3);
5      double Y = A;
6      Point p;
7      p = new CartisianPoint(X, Y); /* polymorphism */
8      print("(" + p.getX() + ", " + p.getY() + ")"); /* dyn. bin. */
9      p = new PolarPoint(2 * A, Math.toRadians(30)); /* polymorphism */
10     print("(" + p.getX() + ", " + p.getY() + ")"); /* dyn. bin. */
11   }
12 }
```

- **Lines 7 and 9** illustrate *polymorphism*, how?
- **Lines 8 and 10** illustrate *dynamic binding*, how?

Interface (6)

- An *interface*:
  - Has **all** its methods with no implementation bodies.
  - Leaves complete freedom to its ***implementors***.
- Recommended to use an *interface* as the ***static type*** of:
  - A *variable*
    e.g., `Point p`
  - A *method parameter*
    e.g., `void moveUp(Point p)`
  - A *method return value*
    e.g., `Point getPoint(double v1, double v2, boolean isCartesian)`
- It is forbidden to use an *interface* as a ***dynamic type***
  e.g., `Point p = new Point(...)` is not allowed!
- Instead, create objects whose ***dynamic types*** are descendant classes of the *interface* ⇒ Exploit *dynamic binding*!

Abstract Classes vs. Interfaces: When to Use Which?

- Use *interfaces* when:
  - There is a *common set of functionalities* that can be implemented via *a variety of strategies*.
    e.g., Interface `Point` declares headers of `getX()` and `getY()`.
  - Each descendant class represents a different implementation strategy for the same set of functionalities.
  - `CartesianPoint` and `PolarPoinnt` represent different strategies for supporting `getX()` and `getY()`.
- Use *abstract classes* when:
  - *Some (not all) implementations can be shared* by descendants, and *some (not all) implementations cannot be shared*.
    e.g., Abstract class `Polygon`:
    - Defines implementation of `getPerimeter`, to be shared by `Rectangle` and `Triangle`.
    - Declares header of `getArea`, to be implemented by `Rectangle` and `Triangle`.

Beyond this lecture. . .

Study the `ExampleInterfaces` source code:

- Draw the ***inheritance hierarchy*** based on the class declarations
- Use the ***debugger*** to step into the various method calls (e.g., `getArea()` of Polygon, `getX()` of Point) to see which version of the method gets executed (i.e., ***dynamic binding***).

Index (1)