# Reusing Classes

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# Reusing Classes

- Overview
  - Composition
  - Inheritance
  - Polymorphism
  - Method overloading vs. overriding
  - Visibility of variables and methods
  - Specification of a contract
    - Abstract classes, interfaces

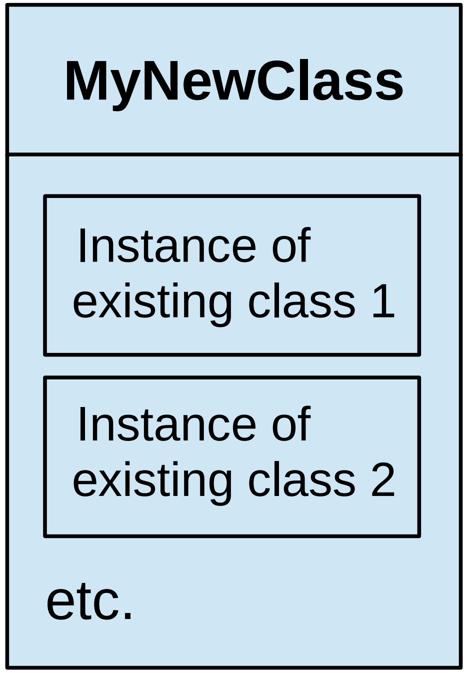
# Reusing Classes

- Software development
  - One of the holy grails of OOP: reusing classes
  - When you need a class, you can
    - Get the perfect one off the shelf » one extreme
      - e.g., library,  GUI builder environment
    - Write it completely from scratch » other extreme
    - Reuse an existing class with **composition**
    - Reuse an existing class or class framework with **inheritance**
  - A good class design is important

# Reusing Classes

- Composition
  - Simplest way to reuse existing code
  - Instances of existing classes inside a new class
    - Flexibility: can change objects at runtime
    - A “has-a” relationship between classes

```
class MyNewClass {
    Foo x = new Foo();
    Bar x = new Bar();
    Baz x = new Baz();
    ...
}
```



MyNewClass

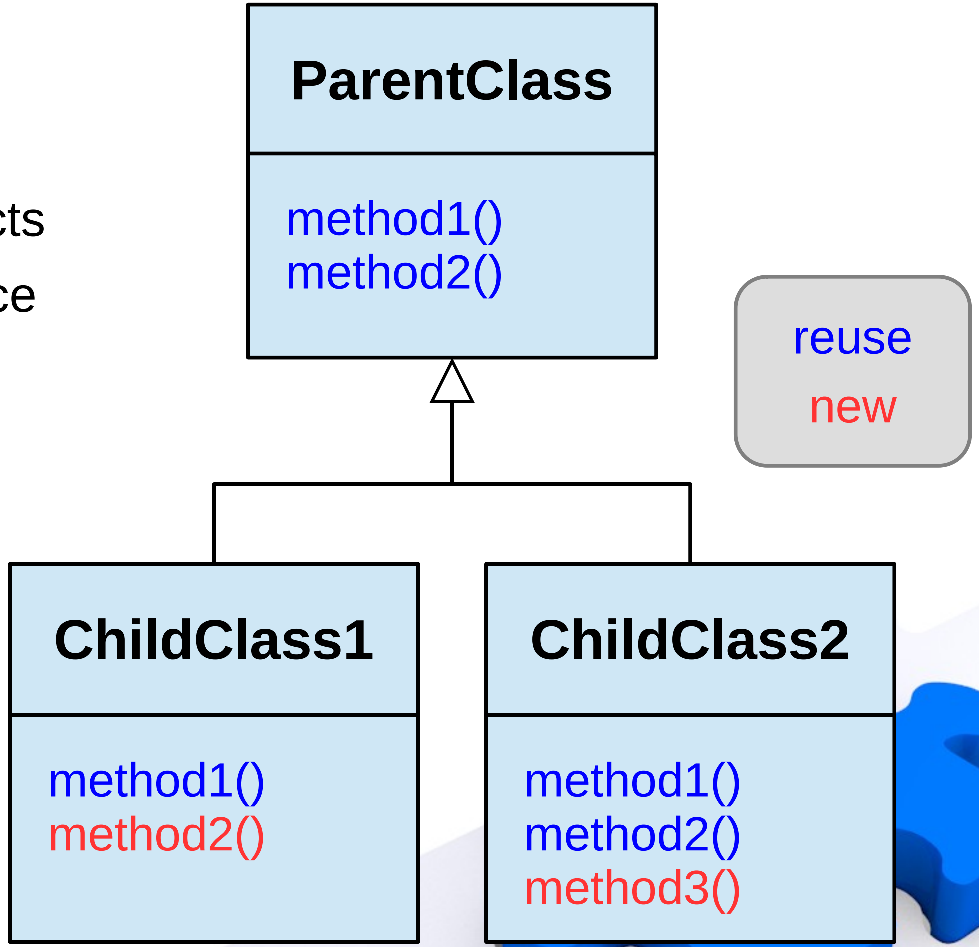
Instance of existing class 1

Instance of existing class 2

etc.

# Reusing Classes

- Inheritance
  - Pure inheritance
    - Interface duplication for interchangeable objects
    - Redefinition of methods with the same interface
    - An “is-a” relationship between classes
  - Extension inheritance
    - Inheritance to extend the interface
    - Additional variables and methods
    - An “is-like-a” relationship between classes
  - Single inheritance (e.g., Java)
    vs. Multiple inheritance (e.g., C++)



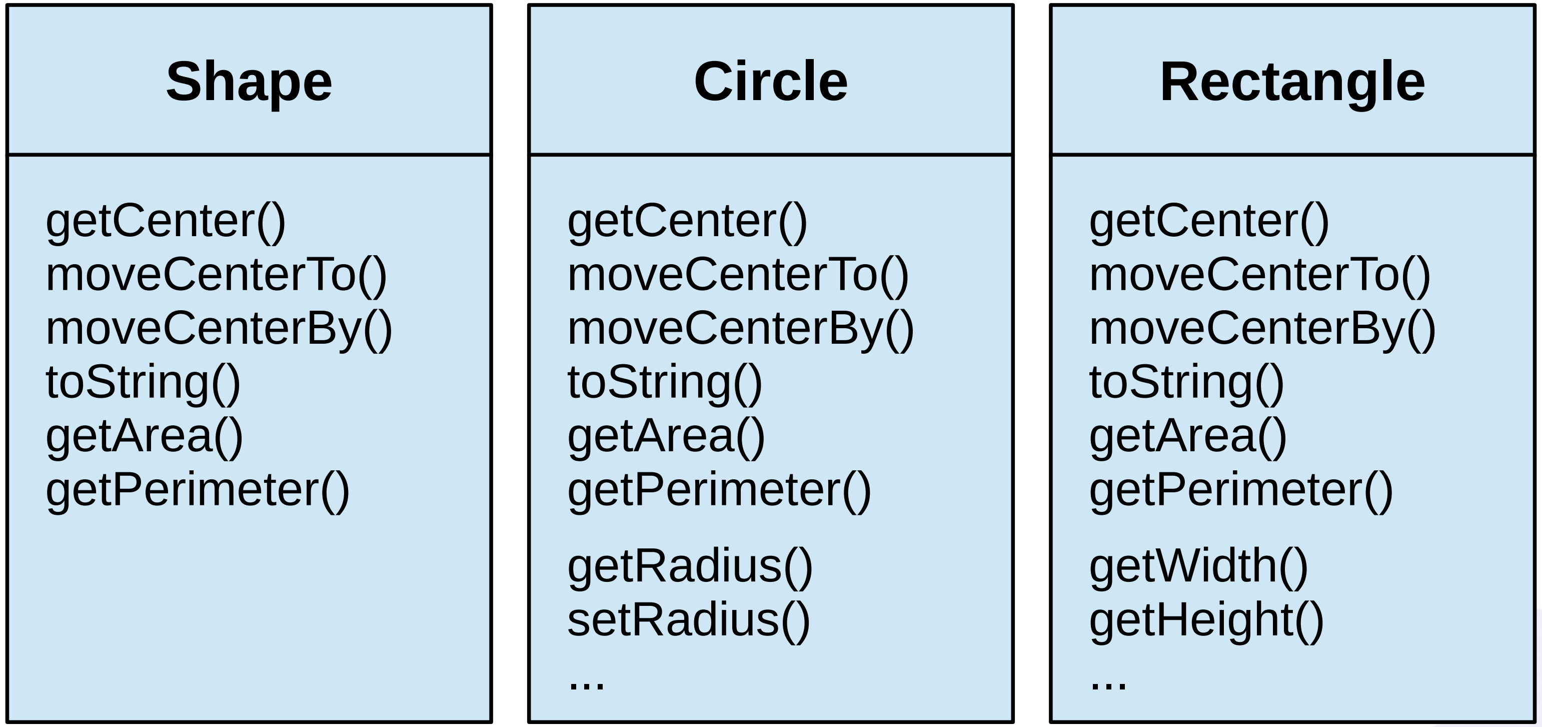
# Reusing Classes

- Inheritance
  - Terminology
    - Parent, superclass, base class, ...
    - Child, subclass, derived class, ...
  - Class **Object** is the root of the class hierarchy
    - Every class has Object as a superclass
  - A class can have at most one parent but of course more ancestors
  - Creating a subclass by the **extends** keyword

```
class <class name> extends <class name>
```

# Reusing Classes

- Inheritance
  - Example: the classes Shape, Circle, Rectangle



**Shape**

getCenter()
moveCenterTo()
moveCenterBy()
toString()
getArea()
getPerimeter()

**Circle**

getCenter()
moveCenterTo()
moveCenterBy()
toString()
getArea()
getPerimeter()

getRadius()
setRadius()
...

**Rectangle**

getCenter()
moveCenterTo()
moveCenterBy()
toString()
getArea()
getPerimeter()

getWidth()
getHeight()
...

a Circle is a Shape

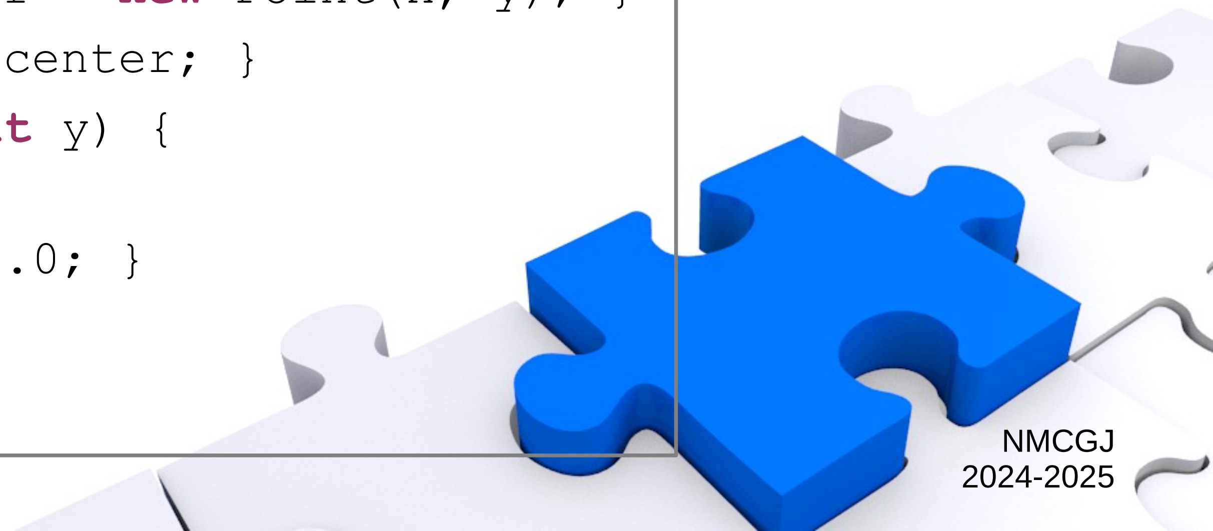
a Rectangle is a Shape

# Reusing Classes

- Inheritance
  - Example: the classes Shape, Circle, Rectangle

```
public class Shape {
   protected Point center;

   public Shape() { center = new Point(); }
   public Shape(int x, int y) { center = new Point(x, y); }
   public Point getCenter() { return center; }
   public void moveCenterTo(int x, int y) {
      center.setLocation(x, y); }
   public double getArea() { return 0.0; }
   ...
}
```



# Reusing Classes

- Inheritance
  - Example: the classes Shape, Circle, Rectangle

```
public class Point {
    protected int coordX, coordY;

    public Point() { setLocation(0, 0); }
    public Point(int x, int y) { setLocation(x, y); }
    public void setLocation(int x, int y) {
        coordX = x; coordY = y; }
    public int getX() { return coordX; }
    public int getY() { return coordY; }
    ...
}
```

# Reusing Classes

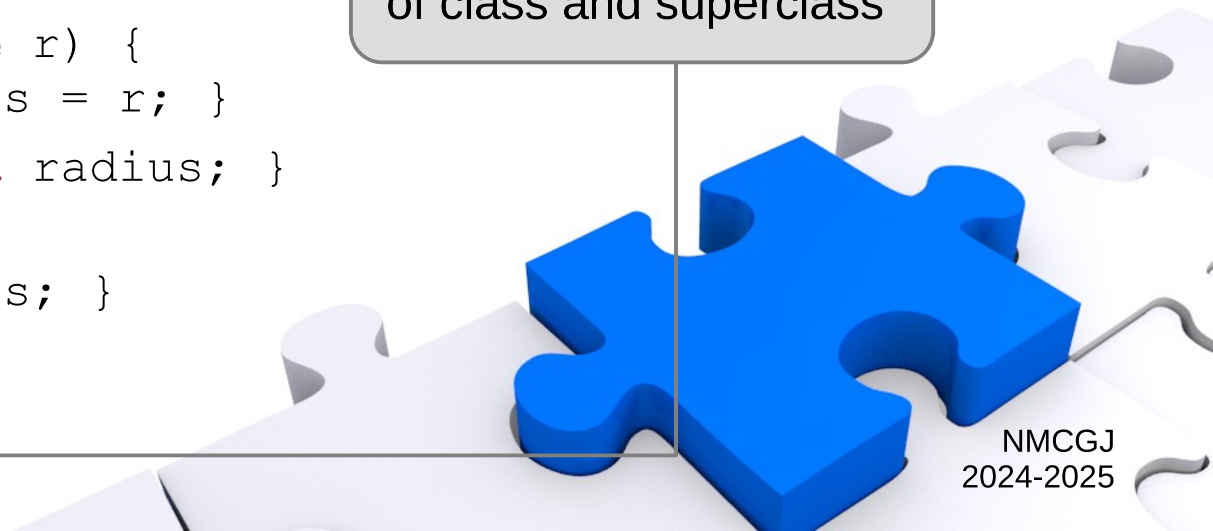
- Inheritance
  - Example: the classes Shape, Circle, Rectangle

```
public class Circle extends Shape {
   protected double radius;

   public Circle() {
      center = new Point(); radius = 1.0; }
   public Circle(int x, int y, double r) {
      center = new Point(x, y); radius = r; }
   public double getRadius() { return radius; }
   public double getArea() {
      return Math.PI * radius * radius; }
   ...
}
```

inherits from Shape the methods getCenter, moveCenterTo, ... but NOT the constructors

initialize class variables of class and superclass



# Reusing Classes

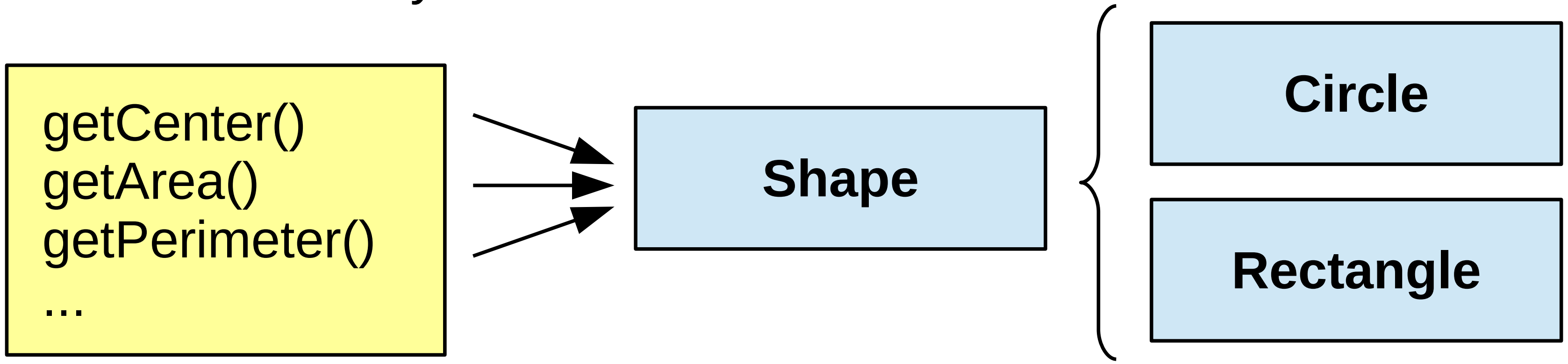
- Polymorphism
  - Upcasting
    - A variable of class X can refer to objects of class X or any of its subclasses

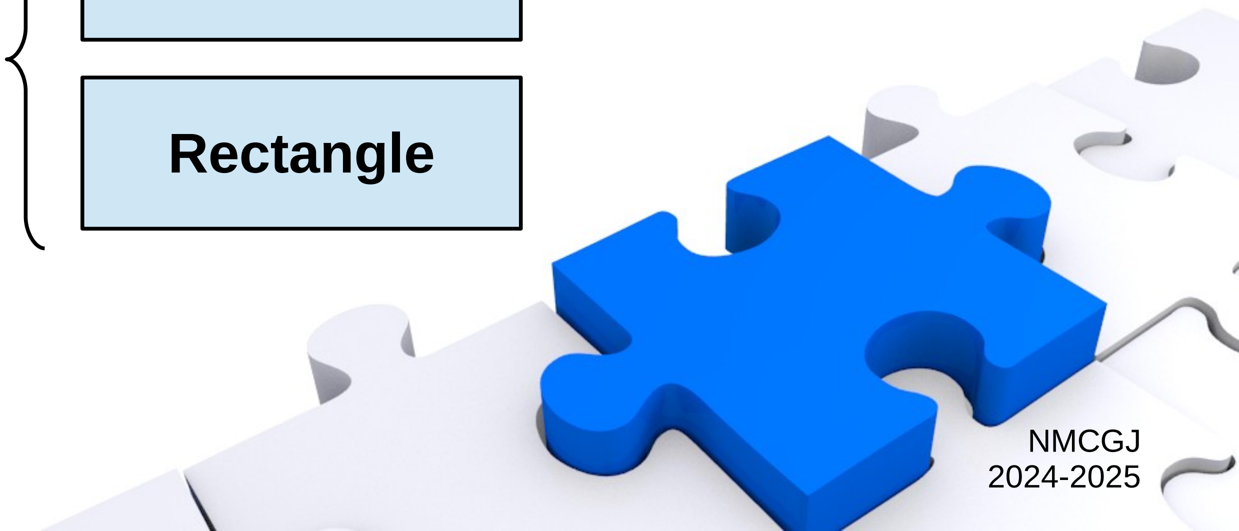
```
Shape shape;
shape = new Shape();
shape = new Circle(1, 0, 2.5);
```

  - Separation of interface from implementation
    - Substitutability
    - Extensibility

# Reusing Classes

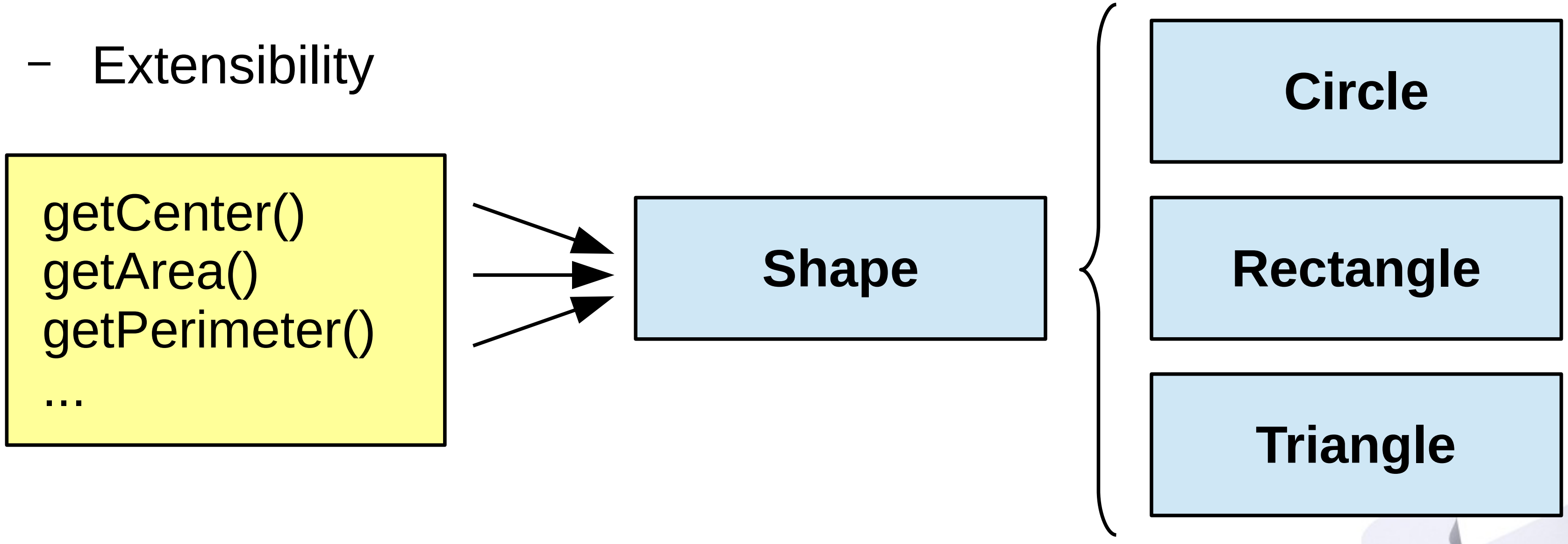
- Polymorphism
  - Upcasting
    - A variable of class X can refer to objects of class X or any of its subclasses
  - Substitutability





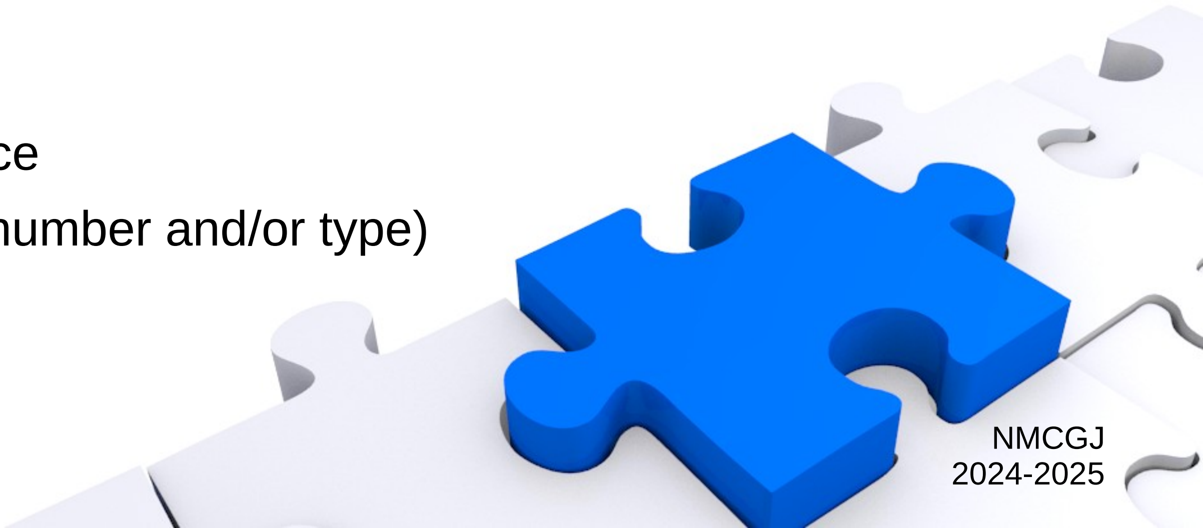
# Reusing Classes

- Polymorphism
  - Upcasting
    - A variable of class X can refer to objects of class X or any of its subclasses
  - Extensibility



# Reusing Classes

- Method overriding versus overloading
  - Method binding = connecting a method call to a method body
  - Method overriding
    - Redefinition of a (parent) method with exactly the same interface
    - Same name, same number of parameters, same type of parameters
    - Dynamic binding (at run-time)
  - Method overloading
    - Redefinition of a method with a similar interface
    - Same name, but different set of parameters (number and/or type)
    - Static binding (at compile time)



# Reusing Classes

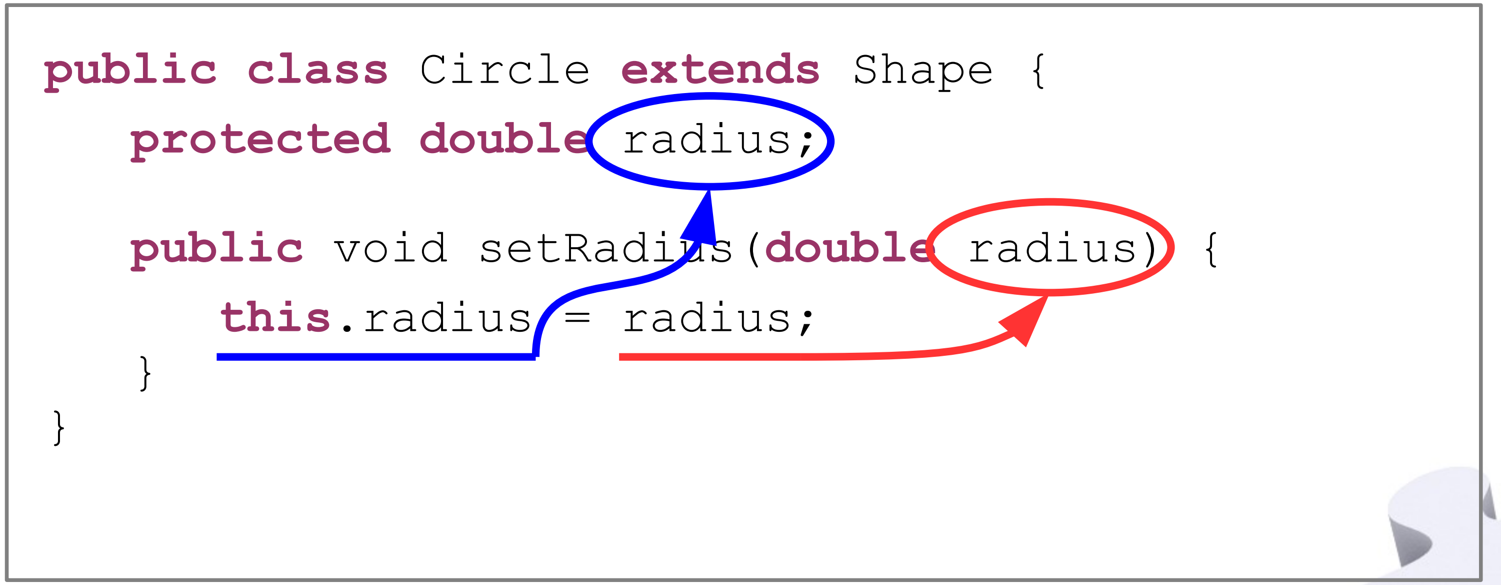
- Visibility of variables and methods
  - Recall: **public** – **private** – **protected**
    - Public: visible to the world (everybody outside and inside the class)
    - Private: visible only to the class
    - Protected: visible to the package and all subclasses
    - Default (friendly), no keyword: visible to the package
  - Use **public** or **protected** to be accessible to subclasses
  - Good access strategy
    - Limit direct access to variables
    - Control access via Getters/Setters (methods)

# Reusing Classes

- Visibility of variables and methods
  - Name conflicts of variables inside methods
    - Priority: local variables > parameters > class variables > parent class variables
  - Name conflicts of methods
    - Priority: methods > parent methods
  - Name conflicts can be avoided by a self-referencing pointer
    - The **this** keyword
    - The **super** keyword

# Reusing Classes

- Visibility of variables and methods
  - The **this** keyword is a reference to the current object
    - Referring to class variables
    - Referring to methods inside class (no extra functionality)



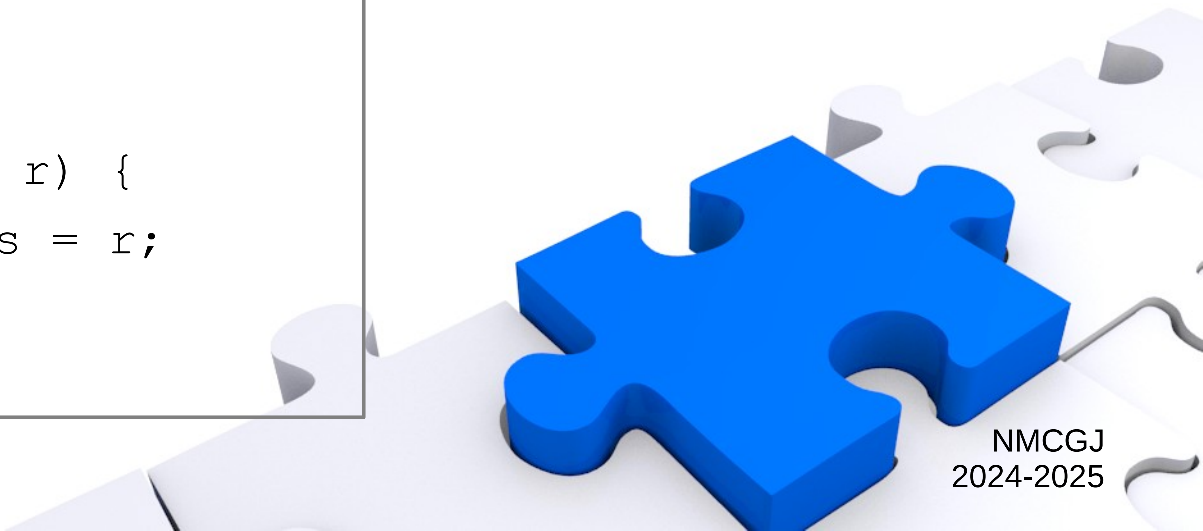
```
public class Circle extends Shape {
    protected double radius;

    public void setRadius(double radius) {
        this.radius = radius;
    }
}
```

# Reusing Classes

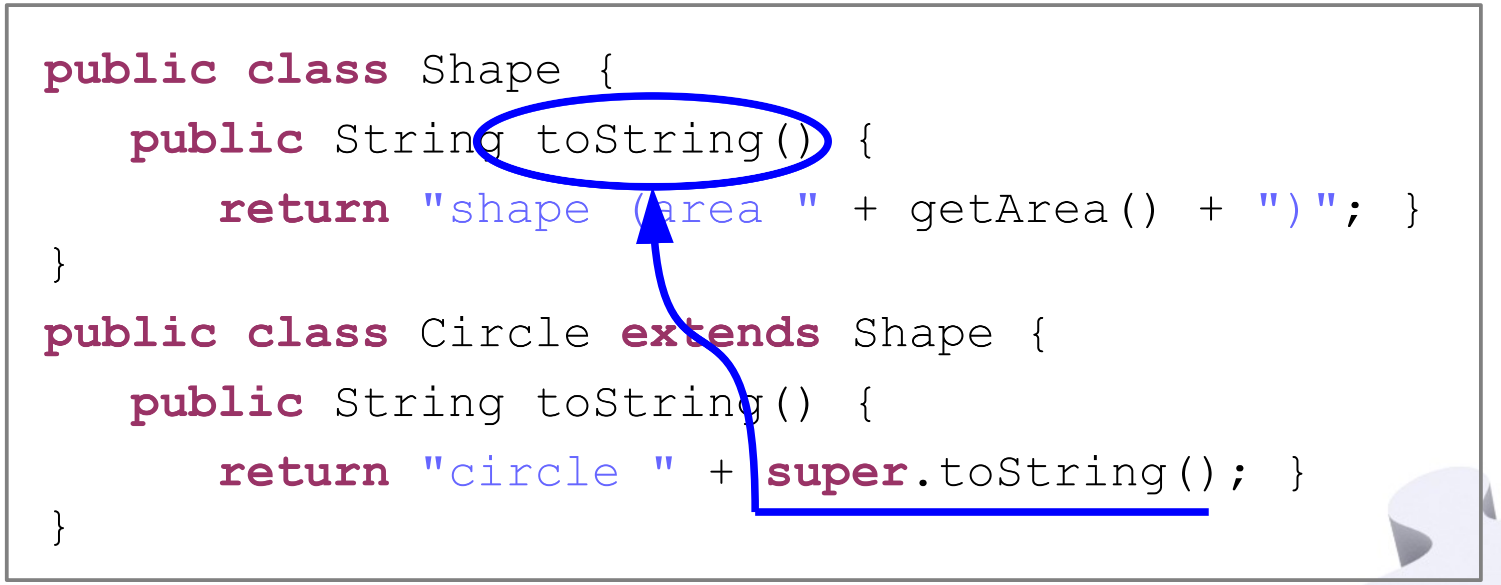
- Visibility of variables and methods
  - Constructor delegation using the **this** keyword
    - This guarantees consistent initialization
    - It has to be the first statement in the constructor

```
public class Circle extends Shape {
   public Circle() {
      this(0, 0, 1.0);
   }
   public Circle(int x, int y, double r) {
      center = new Point(x, y); radius = r;
   }
}
```



# Reusing Classes

- Visibility of variables and methods
  - The **super** keyword is a reference to the current parent object
    - Referring to parent class variables
    - Referring to parent methods

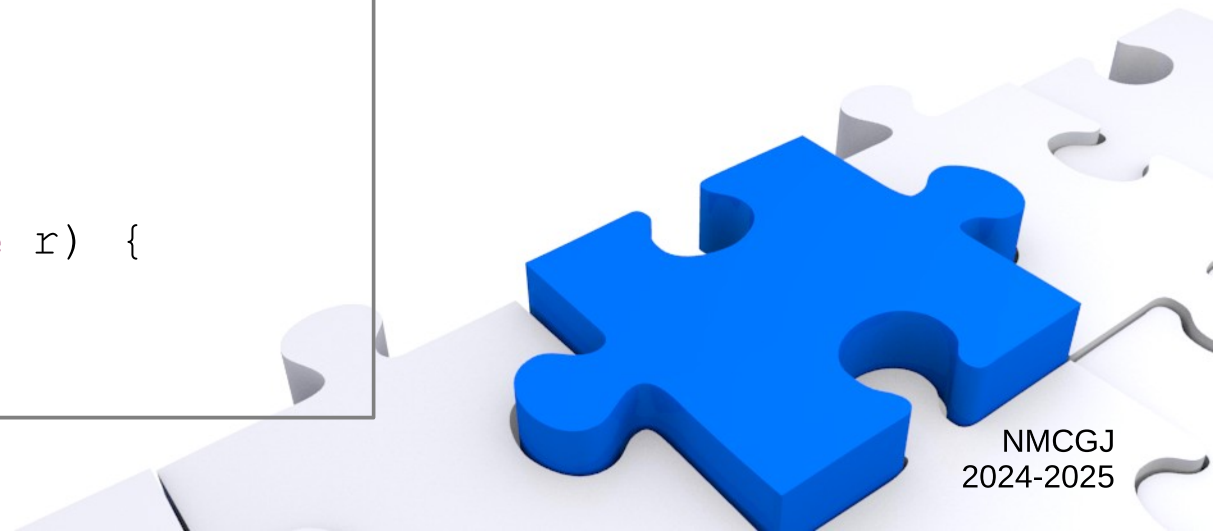


```
public class Shape {
   public String toString() {
      return "shape (area " + getArea() + ")"; }
}
public class Circle extends Shape {
   public String toString() {
      return "circle " + super.toString(); }
}
```

# Reusing Classes

- Visibility of variables and methods
  - Constructor delegation using the **super** keyword
    - Constructors are not inherited; implicit default call super() if available
    - It has to be the first statement in the constructor

```
public class Shape {
   public Shape(int x, int y) {
      center = new Point(x, y); }
}
public class Circle extends Shape {
   public Circle(int x, int y, double r) {
      super(x, y); radius = r; }
}
```



# Reusing Classes

- Specification of a contract
  - Separation of interface from implementation
  - Abstract classes using the **abstract** keyword
    - an “is-a” or “is-like-a” relationship
    - One or more methods in the class have no implementation
  - Pure interfaces using the **interface** keyword
    - a “can-do” relationship
    - No method has an implementation
  - A class can implement
    - One abstract class via the **extends** keyword
    - Multiple interfaces via the **implements** keyword

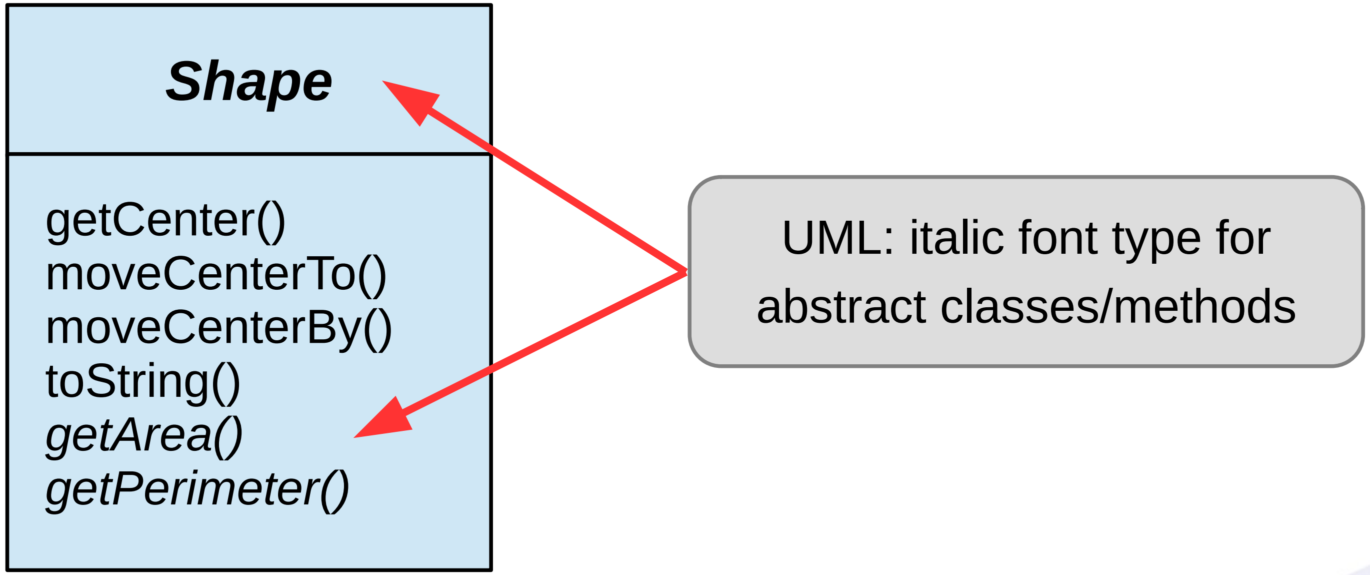
# Reusing Classes

- Specification of a contract
  - Abstract classes
    - Postponing implementation till where it makes sense
    - Creating objects can only through (not abstract) subclasses

```
public abstract class Shape {
   ...
   public abstract double getArea();
}
public class Circle extends Shape {
   ...
   public double getArea() {
      return Math.PI * radius * radius; }
}
```

# Reusing Classes

- Specification of a contract
  - Abstract classes
    - Postponing implementation till where it makes sense
    - Creating objects can only through (not abstract) subclasses



***Shape***

getCenter()
moveCenterTo()
moveCenterBy()
toString()
*getArea()*
*getPerimeter()*

UML: italic font type for abstract classes/methods

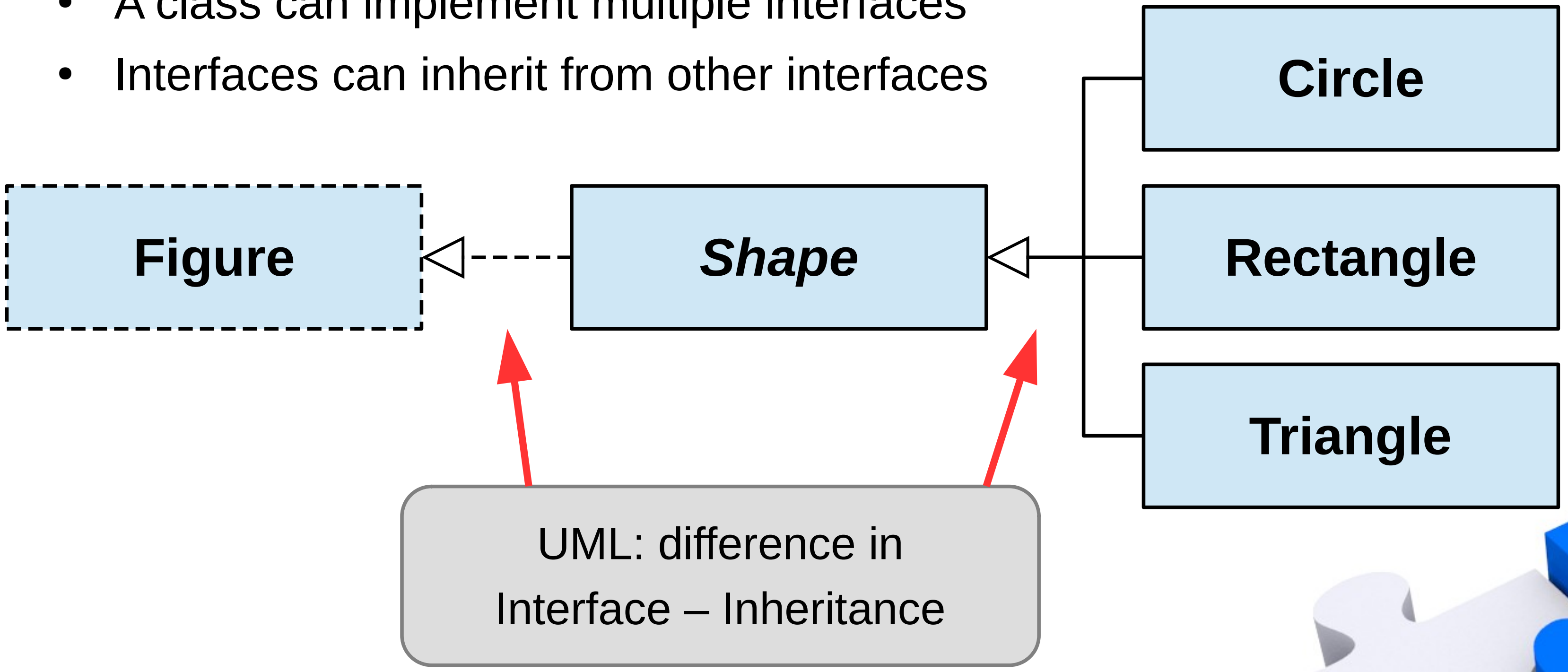
# Reusing Classes

- Specification of a contract
  - Pure interfaces
    - A class can implement multiple interfaces
    - Interfaces can inherit from other interfaces

```
public interface Figure {
   public void moveCenterTo(int x, int y);
}
public class Shape implements Figure {
   ...
   public void moveCenterTo(int x, int y) {
      center.setLocation(x, y); }
}
```

# Reusing Classes

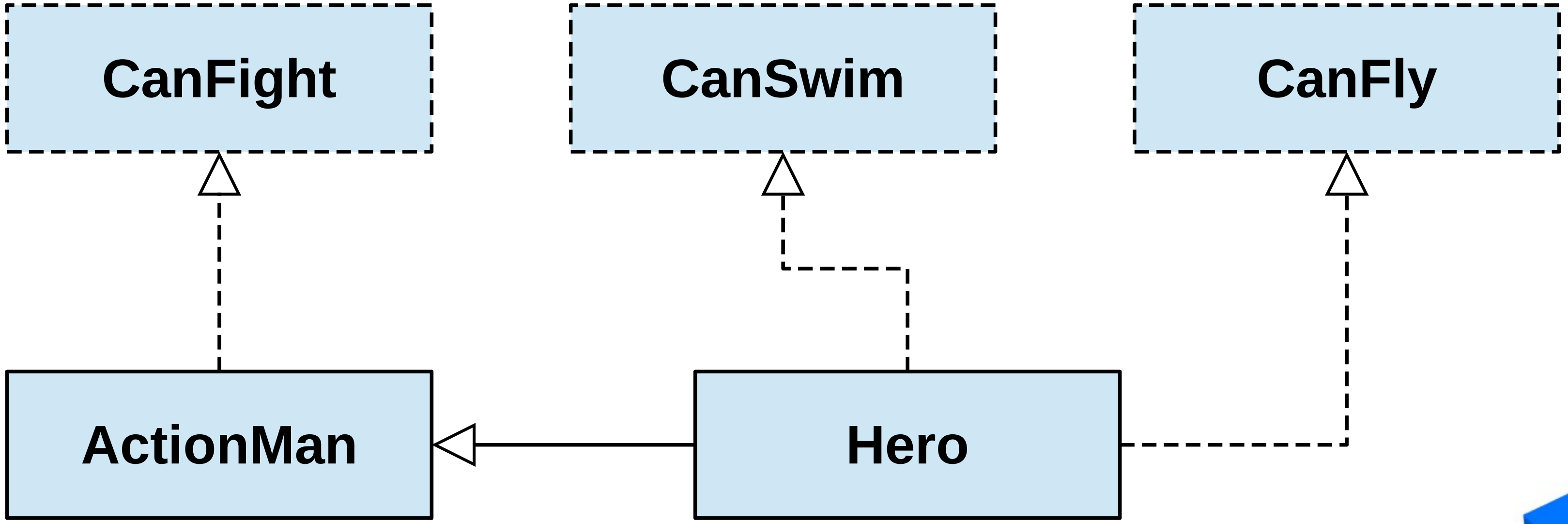
- Specification of a contract
  - Pure interfaces
    - A class can implement multiple interfaces
    - Interfaces can inherit from other interfaces



UML: difference in Interface – Inheritance

# Reusing Classes

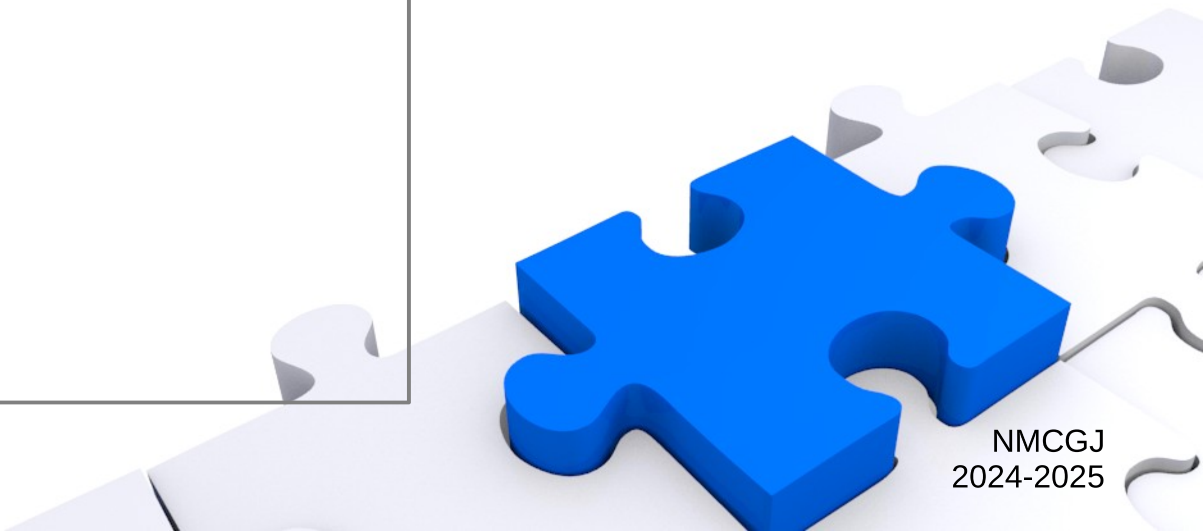
- Specification of a contract
  - Example: Adventure



# Reusing Classes

- Specification of a contract
  - Example: Adventure

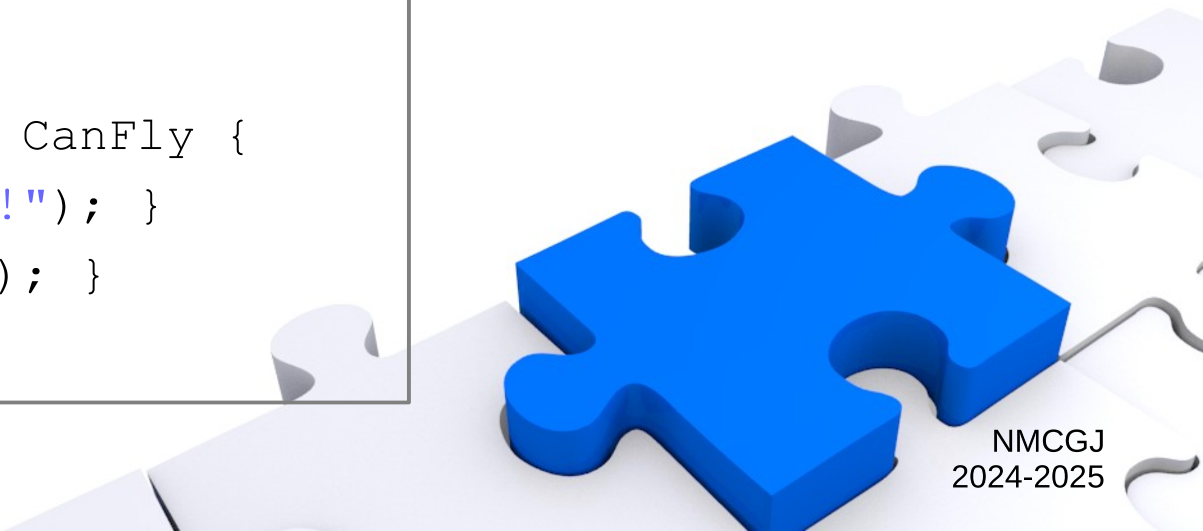
```
public interface CanFight {
   public void fight();
}
public interface CanSwim {
   public void swim();
}
public interface CanFly {
   public void fly();
}
```



# Reusing Classes

- Specification of a contract
  - Example: Adventure

```
public class ActionMan implements CanFight {
   public void fight() { perform("Fight!"); }
   protected void perform(String action) {
      System.out.println(action); }
}
public class Hero extends ActionMan
                  implements CanSwim, CanFly {
   public void swim() { perform("Swim!"); }
   public void fly() { perform("Fly!"); }
}
```



# Reusing Classes

- Specification of a contract
  - Example: Adventure

```
public class Adventure {
   public static void t(CanFight x) { x.fight(); }
   public static void u(CanSwim x) { x.swim(); }
   public static void v(CanFly x) { x.fly(); }
   public static void main(String[] args) {
      Hero h = new Hero();
      t(h); // Treat it as a CanFight
      u(h); // Treat it as a CanSwim
      v(h); // Treat it as a CanFly
}}
```

# Reusing Classes

- Specification of a contract
  - Pure interfaces
    - Class variables are automatically **static** and **final**
    - An interface is convenient to create groups of constants (like **enum**)

```
public interface Months {
   int JANUARY = 1, FEBRUARY = 2, MARCH = 3,
       APRIL = 4, MAY = 5, JUNE = 6, JULY = 7,
       AUGUST = 8, SEPTEMBER = 9, OCTOBER = 10,
       NOVEMBER = 11, DECEMBER = 12;
}
```

# Reusing Classes

- Example: interfaces
  - Look at the file InterFaceEx.java
  - Make a class diagram of all the involved classes/interfaces
  - Predict the output of the main method