CSE201: Monsoon 2020, CSE Section
Advanced Programming

Lecture 05: Interfaces and Polymorphism
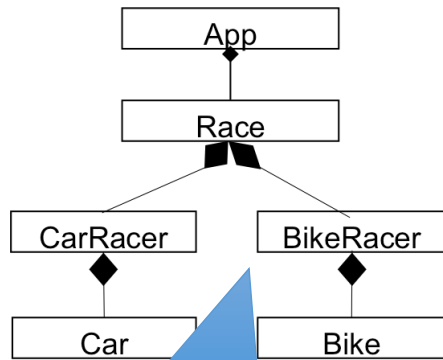
Vivek Kumar

Computer Science and Engineering

IIIT Delhi

vivekk@iiitd.ac.in

Last Lecture

App
Race
CarRacer   BikeRacer
Car   Bike

Do we need two different Racer classes??

- Imagine this program:
  - Sophia and Dan are racing from their home to city center
    - whoever gets there first, wins!
    - catch: they don't get to choose their method of transportation
- Design a program that
  - assigns mode of transportation to each racer
  - starts the race
- For now, assume transportation options are `Car` and `Bike`

I am skipping this slide as you already have the recording of previous lecture

How about one Racer class with different methods?

```
public class Racer {

    public Racer() {
        //constructor
    }
    public void useCar(Car myCar){//code elided}
    public void useBike(Bike myBike){//code elided}
    public void useHoverboard(Hoverboard myHb){//code elided}
    public void useHorse(Horse myHorse){//code elided}
    public void useScooter(Scooter myScooter){//code elided}
    public void useMotorcycle(Motorcycle myMc) {//code elided}
    public void usePogoStick(PogoStick myPogo){//code elided}
    // And more...
}
```
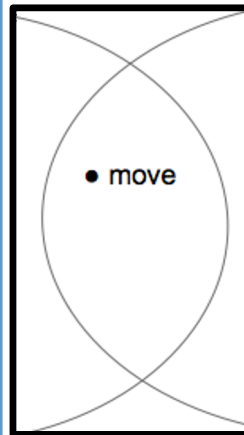
Interfaces in Java

- Group similar capabilities/function of different classes together

- Interfaces can only declare methods - not define them

- Interfaces are contracts that classes agree to

- If classes choose to implement given interface, it must define all methods declared in interface
  - if classes don't implement one of interface's methods, the compiler raises error

Any similarities?

• move

Declaring an Interface

```
public interface Transporter {

    public void move();

}
```

@Override is an annotation – a signal to the compiler (and to anyone reading your code)

Implementing an Interface

```
public class Car implements Transporter {
    public Car() {
        //code elided
    }
    public void drive(){
        //code elided
    }
@Override
public void move(){
    this.drive();
    this.brake();
    this.drive();
}
//more methods elided
}
```

This Lecture

- Interfaces and Polymorphism

Back to the Race

● Let's make transportation classes use an interface

```java
public class Car implements Transporter{

    public Car() {
        //code elided
    }
    public void drive(){
        //code elided
    }
    @Override
    public void move() {
        this.drive();
    }
    //more methods elided
}
```
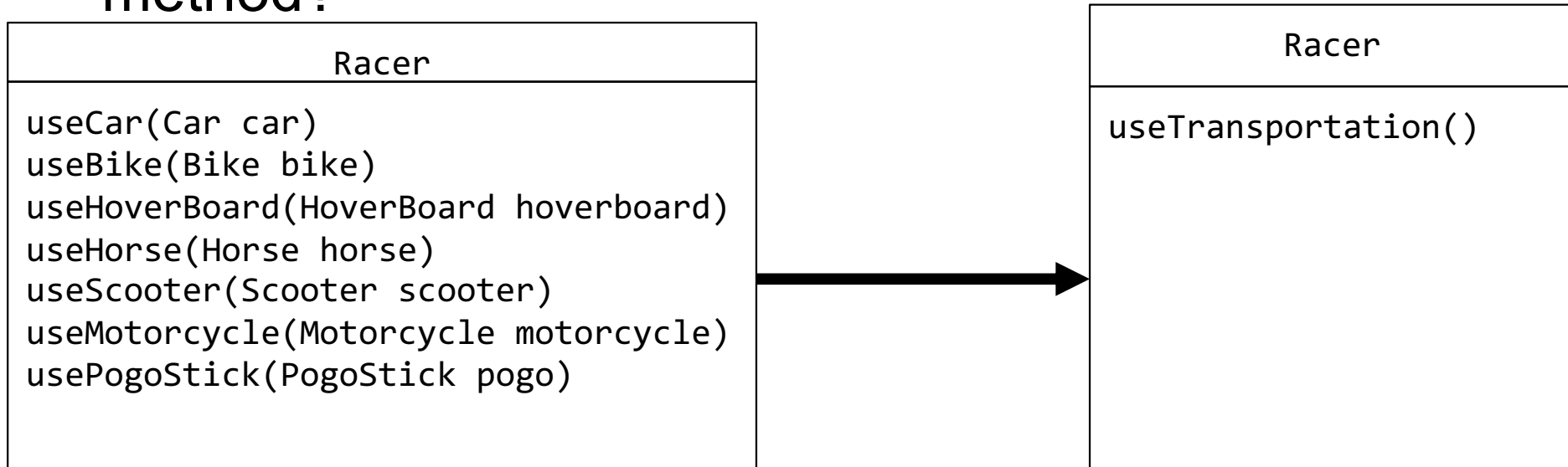
```java
public class Bike implements Transporter{

    public Bike() {
        //code elided
    }
    public void pedal(){
        //code elided
    }
    @Override
    public void move() {
        this.pedal();
    }

    //more methods elided
}
```

Leveraging Interfaces

- Given that there's guarantee anything that implements Transporter knows how to move, how can it be leveraged to create single useTransportation() method?

Racer
useCar(Car car) useBike(Bike bike) useHoverBoard(HoverBoard hoverboard) useHorse(Horse horse) useScooter(Scooter scooter) useMotorcycle(Motorcycle motorcycle) usePogoStick(PogoStick pogo)

Racer
useTransportation()

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Introducing Polymorphism

- Poly = many, morph = forms

- A way of coding generically
  - way of referencing many related objects as one generic type
    - cars and bikes can both `move()` → refer to them as `Transporter` objects
    - phones and camera can both `getCharged()` → refer to them as `Chargeable` objects, i.e., objects that implement `Chargeable` interface
    - cars and mobile phones can both `playRadio()` → refer to them as `RadioPlayer` objects

- How do we write one generic `useTransportation()` method?

What would this look like in code?

```
public class Racer {

    //previous code elided
    public void useTransportation(Transporter transportation) {
        transportation.move();
    }

}
```

This is polymorphism!
transportation object passed in could be instance of Car, Bike, etc., i.e., any class that implements the interface

Let's break this down.

```
public class Racer {

    //previous code elided
    public void useTransportation(Transporter transportation) {
        transportation.move();
    }

}
```

1. Actual vs. Declared Type
2. Method resolution

Actual vs. Declared Type (1/2)

- Consider following piece of code:

```
Transporter dansCar = new Car();
```

- ...is that legal?
  - doesn't Java do strict type checking? (type on LHS = type on RHS)
  - how can instances of `Car` get stored in `Transporter` variable?

Actual vs. Declared Type (2/2)

- Can treat Car/Bike object as Transporter objects
- Car is the actual type
  - Java will look in this class for the definition of the method
- Transporter is declared type
  - Java will limit caller so it can only call methods on instances that are declared as Transporter objects
- If Car defines playRadio() method. Is transportation.playRadio() correct?

```
Transporter transportation = new Car();
transportation.playRadio();
```

Nope. The playRadio() method is not declared in Transporter interface, therefore Java does not recognize it as viable method call

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Determining the Declared Type

- What methods do Car and Bike have in common?
  - `move()`

- How do we know that?
  - they implement `Transporter`
    - guarantees that they have `move()` method

- Think of `Transporter` like the "lowest common denominator"
  - it's what all transportation classes will have in common

```
  Bike implements Transporter
void move();
void dropKickstand();//etc.
```

```
  Car implements Transporter
void move();
void playRadio();//etc.
```

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Is this legal?

`Transporter sophiasBike = new Bike();` ✓

`Transporter sophiasCar = new Car();` ✓

`Transporter sophiasRadio = new Radio();` ✗

Radio wouldn't implement Transporter. Since Radio cannot "act as" a Transporter, you cannot treat it as Transporter.

Motivations for Polymorphism

- Many different kinds of transportation but only care about their shared capability

  o   i.e. how they move

- Polymorphism let programmers sacrifice specificity for generality

  o   treat any number of classes as their lowest common denominator

  o   limited to methods declared in that denominator

    ▪   can only use methods declared in `Transporter`

- For this program, that sacrifice is ok!

  o   `Racer` doesn't care if instance of `Car` can `playRadio()` or if instance of `Bike` can `dropKickstand()`

  o   only method `Racer` wants to call is `move()`

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Polymorphism in Parameters

● What are implications of this method declaration?

```
public void useTransportation(Transporter transportation) {
    //code elided
}
```

● useTransportation will accept any object that implements Transporter

● useTransportation can only call methods declared in Transporter

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Is this legal?

```
Transporter sophiasBike = new Bike();
_sophia.useTransportation(sophiasBike);
```
✔

```
Car sophiasCar = new Car();
_sophia.useTransportation(sophiasCar);
```
✔

```
Radio sophiasRadio = new Radio();
_sophia.useTransportation(sophiasRadio);
```
✖

Even though sophiasCar is declared as a Car, the compiler can still verify that it implements Transporter.

A Radio wouldn't implement Transporter. Therefore, useTransportation() cannot treat it like a Transporter object.

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Why move()? (1/2)

- Why call move()?

- What move() method gets executed?

```
public class Racer {

    //previous code elided
    public void useTransportation(Transporter transportation) {
        transportation.move();
    }

}
```

Why move()? (2/2)

- Only have access to `Transporter` object
  - cannot call `transportation.drive()` or `transportation.pedal()`
    - that's okay, because all that's needed is `move()`
  - limited to the methods declared in `Transporter`

Method Resolution: Which `move()` is executed?

- Consider this line of code in Race class:

  ```
  _sophia.useTransportation(new Bike());
  ```

- Remember what useTransportation method looked like

  ```
  public void useTransportation(Transporter transportation) {
      transportation.move();
  }
  ```

What is "actual type" of transportation in this method invocation?

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Method Resolution (1/4)

```java
public class Race {

    private Racer_sophia;
    //previous code elided

    public void startRace() {
        _sophia.useTransportation(new Bike());
    }
}
```

```java
public class Racer {
    //previous code elided

    public void useTransportation(Transporter
    transportation) {
        transportation.move();
    }

}
```

- Bike is actual type
    - Racer was handed instance of Bike
        - new Bike() is argument
- Transporter is declared type
    - Racer treats Bike object as Transporter object
- So... what happens in transportation.move()?
    - What move() method gets used?

Method Resolution (2/4)

```java
public class Race {
    //previous code elided
    public void startRace() {
        _sophia.useTransportation(new Bike());
    }
}
```

```java
public class Racer {
    //previous code elided
    public void useTransportation(Transporter
    transportation) {
        transportation.move();
    }
}
```

```java
public class Bike implements Transporter {
    //previous code elided
    public void move() {
        this.pedal();
    }
}
```

- _Sophia is a Racer
- Bike's move() method gets used
- Why?
  - Bike is actual type
    - Java will execute methods defined in Bike class
  - Transporter is declared type
    - Java limits methods that can be called to those declared in Transporter interface

Method Resolution (3/4)

● What if _sophia received instance of Car?

    ○ What move() method would get called then?

        ■ Car's!

```
public class Race {

    //previous code elided

    public void startRace() {
        _sophia.useTransportation(new Car());
    }
}
```

Method Resolution (4/4)

- This method resolution is example of <mark>dynamic binding</mark>, which is when actual method implementation used is not determined until runtime

  o contrast with static binding, in which method gets resolved at compile time

- `move()` method is bound dynamically – Java does not know which `move()` method to use until program runs

  o same "`transport.move()`" line of code could be executed indefinite number of times with different method resolution each time

Clicker Question

## Given the following class:

```
public class Laptop implements Typeable, Clickable {
    public void type() {
        // code elided
    }
    public void click() {
        //code elided
    }
}
```

Given that typeable has declared the type method and clickable has declared the click method, which of the following calls is/are valid?

A.
```
Typeable macBook= new Typeable();
macBook.type();
```

C.
```
Typable macBook= new Laptop();
macBook.click();
```

B.
```
Clickable macBook = new Clickable();
macBook.type();
```

D.
```
Clickable macBook = new Laptop();
macBook.click();
```

Why does that work? (1/2)

- Declared type and actual type work together
  - declared type keeps things generic
    - can reference a lot of objects using one generic type
  - actual type ensures specificity
    - when defining implementing class, the methods can get implemented in any way

This is my `Transporter` object!

Declared

Car
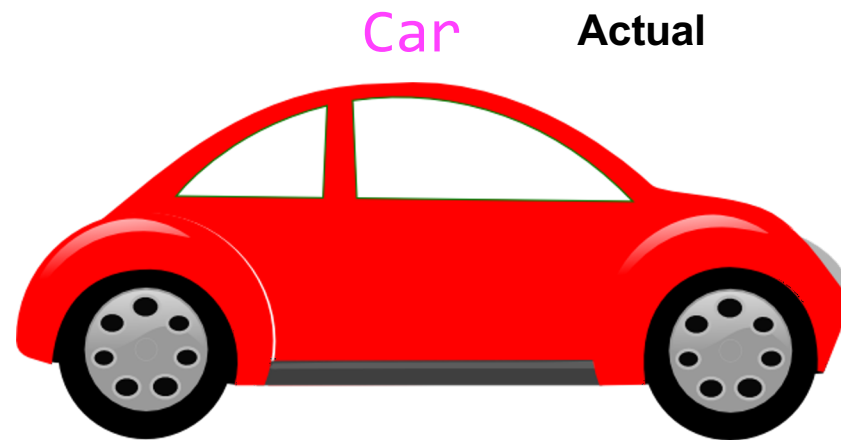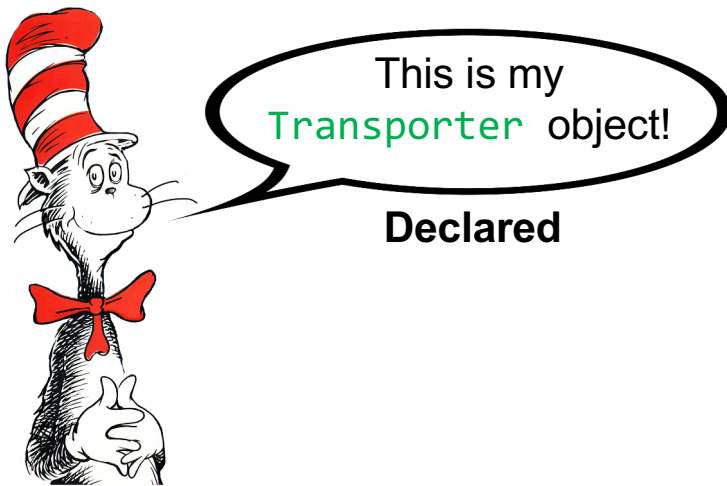
Actual

Why does that work? (2/2)

- Declared type and actual type work together
  - declared type keeps things generic
    - can reference a lot of objects using one generic type
  - actual type ensures specificity
    - when defining implementing class, the methods can get implemented in any way

Bike **Actual**

This is my
Transporter object!
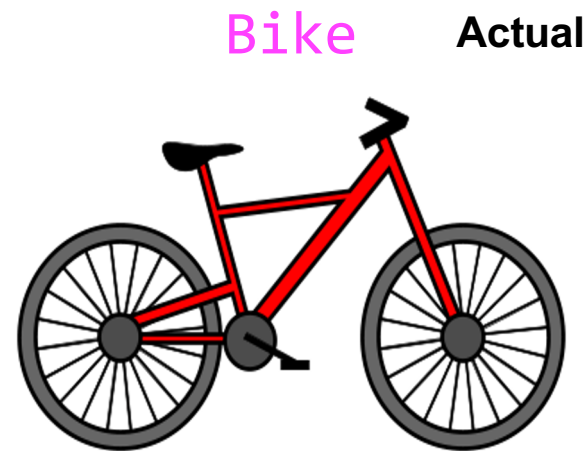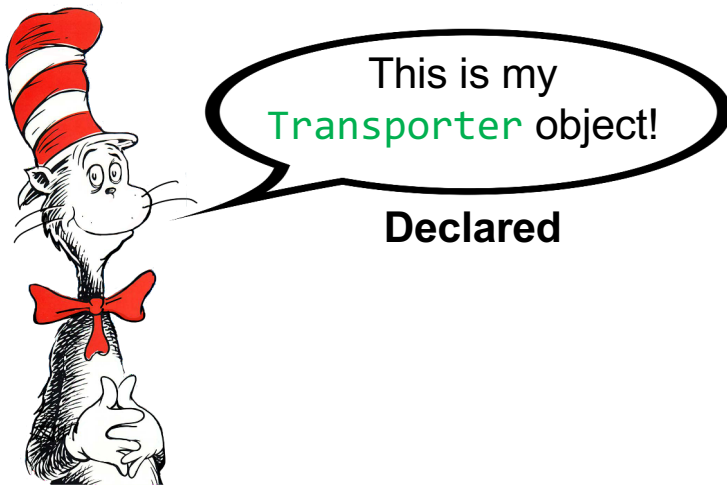
Declared

When to use polymorphism?

- Using only functionality declared in interface or specialized functionality from implementing class?
  - o if only using functionality from the interface → polymorphism!
  - o if need specialized methods from implementing class, don't use polymorphism

Why use interfaces?

- Contractual enforcement
  - will guarantee that class has certain capabilities
    - `Car` implements `Transporter`, therefore it must know how to `move()`

- Polymorphism
  - Can have implementation-agnostic classes and methods
    - know that these capability exists, don't care how they're implemented
    - allows for more generic programming
      - `useTransportation` can take in any `Transporter` object
      - can easily extend this program to use any form of transportation, with minimal changes to existing code
    - an extremely powerful tool for extensible programming

Why is this important?

- With 2 modes of transportation!

- Old Design:
  - need more classes → more specialized methods (`useRollerblades()`, `useBike()`, etc)

- New Design:
  - as long as the new classes implement `Transporter`, `Racer` doesn't care what transportation it has been given
  - don't need to change `Racer`!
    - less work for you!
    - just add more transportation classes that implement `Transporter`

The Program

```java
public class App {
    public App() {
        Race r = new Race();
        r.startRace();
    }
}
```

```java
public class Race {
    private Racer _dan, _sophia;

    public Race(){
        _dan = new Racer();
        _sophia = new Racer();
    }
    public void startRace() {
        _dan.useTransportation(new Car());
        _sophia.useTransportation(new Bike());
    }
}
```

```java
public interface Transporter {
    public void move();
}
```

```java
public class Racer {
    public Racer() {}

    public void useTransportation(Transporter transport){
        transport.move();
    }
}
```

```java
public class Car implements Transporter {
    public Car() {}
    public void drive() {
        //code elided
    }
    public void move() {
        this.drive();
    }
}
```

```java
public class Bike implements Transporter {
    public Bike() {}
    public void pedal() {
        //code elided
    }
    public void move() {
        this.pedal();
    }
}
```

In Summary

- Interfaces are contracts
  - force classes to define certain methods

- Polymorphism allows for extremely generic code
  - treats multiple classes as their "generic type" while still allowing specific method implementations to be executed

- Polymorphism + Interfaces
  - generic coding

- Why is it helpful?
  - want you to be the laziest (but cleanest) programmer you can be

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Next Lecture

- Inheritance and polymorphism

- Assignment-1 to be announced today evening
    - All assignments (including this) are individual implementations (no group assignments)
    - We are very strict about plagiarism. IIITD plagiarism policy will be strictly followed
    - Deadline Sunday midnight
    - Make sure to upload your solution before the deadline. We will not evaluate any late submissions (zero marks for late submission)