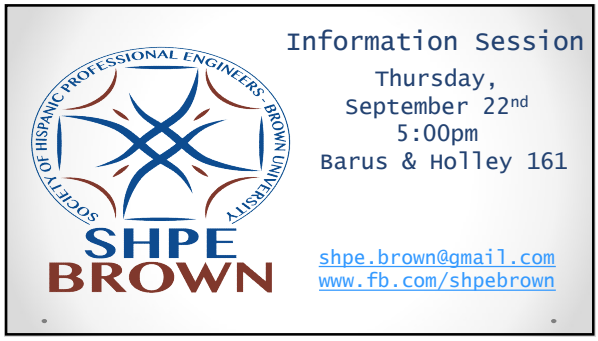

Information Session

Thursday,
September 22nd
5:00pm
Barus & Holley 161

shpe.brown@gmail.com
www.fb.com/shpebrown

Google

CS15 & beyond

Google

Gregory Chatzinoff '15

Software Engineer, Chrome iOS

About Me

At Brown:

- CS A.B.
- Research Assistant in Andy's group
- HTA'd/TA'd CS15 (played Joffrey in Game of Thrones skit)
- Involved with student government

Since graduation:

- Software Engineer on Chrome iOS team in Mountain View, CA
  - UI improvements, stability/memory management experiments, back end work, data analysis, etc.

CS15 is a transformative course

Life of a Software Engineer in Industry

- Large codebase with many contributors
  - Code lasts a long time
- Design Docs
- Code Reviews

Google

gchatz@google.com

Google

Wendy Ginsberg ’15

Associate Product Manager, Chrome Web Platform

Who am I?

Studied Computer Science (Class of ‘15)

- Started late, from Engineering
- Bachelor of Arts
- Took classes in 13 depts
- Musical Forum & Brown Debating Union

Worked as a TA

- **CS15: 2013, 2014**
- CS8, CS1951A, HIST97

Google

CS15

kicked my butt & changed my life

Google

“What if I don’t (think I) want to be a Software Engineer…?”

Google

I’m not a Software Engineer!

Associate Product Manager at Google

- PM on the **Polymer** team. OOP on Web!
- Create vision, manage development, oversee product launch, repeat.
- “Captain of the [Pirate] Ship”

Internships

- Web/Mobile Developer at DreamIt Ventures
- Software Engineer at Redfin

Google

Google

Wendy Ginsberg
Associate Product Manager, APM
wmginsberg@google.com
(include “CS15” in subject)

Google

Wendy Ginsberg
Associate Product Manager, APM
wmginsberg@google.com
(include “CS15” in subject)

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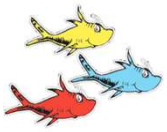
Interfaces and Polymorphism



Recall: Declaring vs. Defining Methods

- What’s the difference between declaring and defining a method?
  - method declaration is the scope (`public`), return type (`void`), name and parameters (`makeSounds()`)
  - method definition is the body of the method – the actual implementation (the code that actually makes the sounds)

```
public class Dog {
    //constructor elided

    public void makeSounds() {
        this.bark();
        this.whine();
        this.bark();
    }
    public void bark() {
        //code elided
    }
    public void whine() {
        //code elided
    }
}
```

15/80

Review of Association

```
public class School{
  private Teacher _teacher;
  public School() {
  _teacher = new Teacher(this);
  this.assignTeacher();
  }
  public void assignTeacher() {
     //code elided
  }
}
```

```
public class Teacher{
  private School _school;

  public Teacher(School school) {
  _school = school;
  }
   //other code elided
}
```

- Does `School` contain `Teacher`?
  - Yes! `School` instantiated `Teacher`, therefore `School` contains `Teacher`- `Teacher` is a component of School
- Can `School` send messages to `Teacher`?
- Does `Teacher` contain `School`?
  - No! `Teacher` knows about `School` that created it, but does not contain it

Using What You Know

- Imagine this program:
  - Sophia and Dan are racing from their dorms to CIT
    - 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`

17/80

Goal 1: Assign transportation to each racer

- Need transportation classes (something to give to racers)
- Let's use `Car` and `Bike` classes
- Both classes will need to describe how the transportation moves
  - `Car` needs `drive` method
  - `Bike` needs `pedal` method

Coding the project

- Let's build transportation classes

```
public class Car {

    public Car() {//constructor
        //code elided
    }
    public void drive(){
        //code elided
    }
    //more methods elided
}
```

```
public class Bike {

    public Bike() {//constructor
        //code elided
    }
    public void pedal(){
        //code elided
    }
    //more methods elided
}
```


Goal 1: Assign transportation to each racer

- Need racer classes that will use their type of transportation
  - `CarRacer`
  - `BikeRacer`
- What methods will we need? What capabilities should each `-Racer` class have?
- `CarRacer` needs to know when to use the car
  - write `useCar()` method
- `BikeRacer` needs to know when to use the bike
  - write `useBike()` method

Coding the project (cont.)

- Let's build the racer classes

```
public class CarRacer {
    private Car _car;

    public CarRacer() {
        _car = new Car();
    }

    public void useCar(){
        _car.drive();
    }
    //more methods elided
}
```

```
public class BikeRacer {
    private Bike _bike;

    public BikeRacer() {
        _bike = new Bike();
    }

    public void useBike(){
        _bike.pedal();
    }
    //more methods elided
}
```


Goal 2: Tell the racers to start the race

- `Race` class contains `Racers`
  - App contains `Race`
- `Race` class will have `startRace()` method
  - `startRace()` tells each racer to use their transportation
- `startRace()` gets called in App

```
startRace:
    Tell _dan to useCar
    Tell _sophia to useBike
```


Coding the project (cont.)

- Let's build the `Race` class

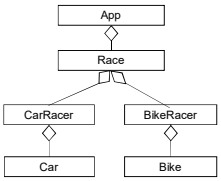
```
public class Race {
    private CarRacer _dan;
    private BikeRacer _sophia;

    public Race() {
        _dan = new CarRacer();
        _sophia = new BikeRacer();
    }

    public void startRace() {
        _dan.useCar();
        _sophia.useBike();
    }
}
```

Coding the project (cont.)

```
public class App {

    public App() {
        Race cs15Race = new Race();
        cs15Race.startRace();
    }

    public static void main (String[] args) {
        new App();
    }
}
```

- Now build the App class
- Now the race to the CIT!

What does our design look like?



How would this program run?

- An instance of `App` gets initialized
- `App`'s constructor initializes an instance of `Race`
- `Race`'s constructor initializes `_dan` (`CarRacer`) and `_sophia` (`BikeRacer`)
  - `CarRacer`'s constructor initializes a `_car` (Car)
  - `BikeRacer`'s constructor initializes a `_bike`
- App calls `race.startRace()`
- `race` calls `_dan.useCar()` and `_sophia.useBike()`
- `_dan` calls `_car.drive()`
- `_sophia` calls `_bike.pedal()`

Can we do better?

Things to think about

- Do we need two different `Racer` classes?
  - Want multiple instances of `Racers` that use different modes of transportation
  - But how?

Solution 1: Create one `Racer` class with methods!

- Create one `Racer` class
  - define different methods for each type of transportation
- `_dan` is instance of `Racer` and elsewhere we have:

```
Car dansCar = new Car();
_dan.useCar(dansCar);
```

  - `Car`'s `drive()` method will be invoked
- But any given instance of `Racer` will need a new method to accommodate every kind of transportation!

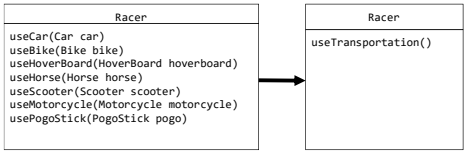
```
public class Racer {
    public Racer(){
        //constructor
    }

    public void useCar(Car myCar){
        myCar.drive();
    }

    public void useBike(Bike myBike){
        myBike.pedal();
    }
}
```


Solution 1 Drawbacks

- Now imagine all the CS15 TAs join the race and there are 10 different modes of transportation
- Writing these similar `useX()` methods are a lot of work for you, the developer, and inefficient coding style

```
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…
}
```

Is there another solution?



- Can we go from left to right?

Interfaces and Polymorphism

- In order to simplify code, need to learn
  - Interfaces
  - Polymorphism

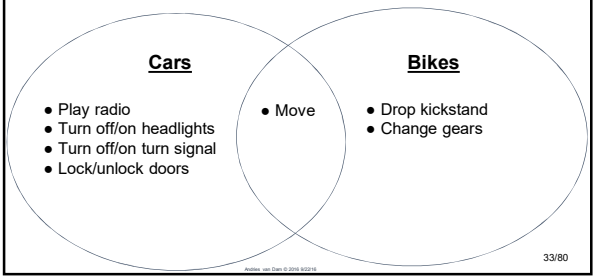
```
public class Car implements Transporter {

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

```
public class Racer {

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

}
```

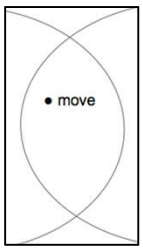

Interfaces: Spot the Similarities

- What do cars and bikes have in common?
- What do cars and bikes not have in common?

Cars vs. Bikes



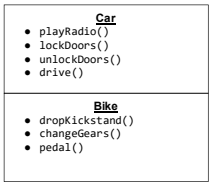
Digging deeper into the similarities



- How similar are they when they move?
  - do they move in same way?
- Not very similar
  - cars drive
  - bikes pedal
- Both can move, but in different ways

Can we model this in code?

- Many real-world objects have several broad similarities
  - cars and bikes can move
  - cars and laptops can play radio
  - phones and Teslas can be charged
- Take `Car` and `Bike` class
  - how can their similar functionalities get enumerated in one place?
  - how can their broad relationship get portrayed through code?



Introducing Interfaces

- Interfaces group similar capabilities/function of different classes together
- Model "acts-as" relationship
- `Car`s and `Bike`s could implement a `Transporter` interface
  - they can transport people from one place to another
  - "act as" transporters
    - objects that can move
    - have shared functionality, such as moving, braking, turning etc.
  - for this lecture, interfaces are green and classes that implement them pink

Introducing Interfaces

- 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
    - later we'll discuss strong motivations for this contract enforcement
- Interfaces don't define their methods - implementing classes do
  - Interfaces only care about the fact that the methods get defined - not how – *implementation-agnostic*
- Models similarities while ensuring consistency
  - What does this mean?

Let's break that down

1) Models Similarities

2) Ensures Consistency

Models Similarities While **Ensuring Consistency**

- How does this help our program?
- We know `Car`s and `Bike`s both need to move
  - i.e., should all have some `move()` method
  - let compiler know that too!
- Let's make the `Transporter` interface!
  - what methods should the `Transporter` interface declare?
    - `move()`
    - only using a `move()` for simplicity, but `brake()`, etc. would also be useful
  - compiler doesn't care how method is defined, just that it's been defined
  - general tip: methods that interface declares should model functionality all implementing classes share

Interface Example (1/4)

What does this look like?

```
public interface Transporter {

    public void move();

}
```

- That's it!
- Interfaces, just like classes, have their own `.java` file. This file would be `Transporter.java`

Interface Example (2/4)

What does this look like?

```
public interface Transporter {

    public void move();

}
```

- Declare it as interface rather than class

Interface Example (3/4)

What does this look like?

```
public interface Transporter {

    public void move();

}
```

- Declare methods - the contract
- In this case, only one method required: `move()`
- All classes that sign contract (implement this interface) must define actual implementation of any declared methods

Interface Example (4/4)

What does this look like?

```
public interface Transporter {

    public void move();

}
```

- Interfaces can only declare methods - not define them
- Notice: method declaration end with semicolons, not curly braces!

Clicker Questions

Which line of this program is incorrect?

```
A. public interface Colorable {
       public Color getColor() {
           B. return Color.WHITE;
       }
   }
```

```
C. public class Rectangle implements Colorable {
       //constructor elided
       D. @Override
       public Color getColor() {
           E. return Color.PURPLE;
       }
   }
```


Implementing an Interface (1/6)

Let's modify `Car`

```
public class Car implements Transporter {

    public Car() {
        // constructor
    }

    public void drive() {
        // code for driving the car
    }

}
```

- Let's modify `Car` to implement `Transporter`
  - declare that `Car` "acts-as" `Transporter`
- Add `implements Transporter` to class declaration
- Promises compiler that `Car` will define all methods in `Transporter` interface
  - i.e., `move()`
- Will this code compile?

Implementing an Interface (2/6)

```
public class Car implements Transporter {

    public Car() {
        // constructor
    }

    public void drive() {
        // code for driving the car
    }

}
```

"Error: `Car` does not override `method move() in Transporter`" *

- Will this code compile?
  - nope :(
- Never implemented `move()` and `drive()` - doesn't suffice. Compiler will complain accordingly

*Note: the full error message is "`Car is not abstract and does not override abstract method move() in Transporter`." We'll get more into the meaning of abstract in a later lecture.

Implementing an Interface (3/6)

```
public class Car implements Transporter {

    public Car() {
        // constructor
    }

    public void drive() {
        //code for driving car
    }

    @Override
    public void move() {
        this.drive();
    }

}
```

- Next: honor contract by defining a `move()` method
- Method ***signature*** (name and number/type of arguments) must match how its declared in interface

Implementing an Interface (4/6)

What does `@Override` mean?

```
public class Car implements Transporter {

    public Car() {
        // constructor
    }

    public void drive() {
        //code for driving car
    }

    @Override
    public void move() {
        this.drive();
    }

}
```

- Include `@Override` right above the method signature
- `@Override` is an annotation – a signal to the compiler (and to anyone reading your code)
  - allows compiler to enforce that interface actually has method declared
  - more explanation of `@Override` in next lecture
- Annotations, like comments, have no effect on how code behaves at runtime

Implementing an Interface (5/6)

```
public class Car implements Transporter {

    //previous code elided

    public void drive() {
        //code for driving car
    }

    @Override
    public void move() {
        this.drive();
        this.brake();
        this.drive();
    }
    public void brake() { //code elided}
}
```

- Defining interface method is like defining any other method
- Definition can be as complex or as simple as it needs to be
- Ex.: Let's modify `Car`'s move method to include braking
- What will instance of `Car` do if `move()` gets called on it?

Implementing an Interface (6/6)

- As with signing multiple contracts, classes can implement multiple interfaces
  - "I signed my rent agreement, so I'm a renter, but I also signed my employment contract, so I'm an employee. I'm the same person."
  - what if I wanted `Car` to change color as well?
  - create a `Colorable` interface
  - add that interface to `Car`'s class declaration
- Implementing class must define every single method in each of its every interfaces

```
public interface Colorable {

    public void setColor(Color c);
    public Color getColor();

}

public class Car implements Transporter, Colorable{

    public Car(){ //body elided }
    public void drive(){ //body elided }
    public void move(){ //body elided }
    public void setColor(Color c){ //body elided }
    public Color getColor(){ //body elided  }
}
```


Modeling Similarities While Ensuring Consistency

- Interfaces are formal contracts and ensure consistency
  - compiler will check to ensure all methods declared in interface are defined
- Can trust that any object from class that implements `Transporter` can `move()`
- Will know how 2 classes are related if both implement `Transporter`

Clicker Question

Given the following interface:

```
public interface Clickable {
    public void click();
}
```

Which of the following would work as an implementation of the Clickable interface? (don't worry about what changeXPosition does)

A.
```
@Override
public void click() {
    this.changeXPosition(100.0);
}
```

B.
```
@Override
public void click(double xPosition) {
    this.changeXPosition(xPosition);
}
```

C.
```
@Override
public void clickIt() {
    this.changeXPosition(100.0);
}
```

D.
```
@Override
public double click() {
    return this.changeXPosition(100.0);
}
```


Back to the CIT Race

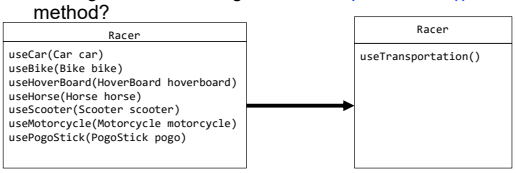
- Let's make transportation classes use an interface

```
public class Car implements Transporter{

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

```
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?



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 Teslas can both `getCharged()` → refer to them as `Chargeable` objects, i.e., objects that implement `Chargeable` interface
    - cars and boomboxes 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

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.
```


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
  - i.e. how they move
- Polymorphism let programmers sacrifice specificity for generality
  - treat any number of classes as their lowest common denominator
  - limited to methods declared in that denominator
    - can only use methods declared in `Transporter`
- For this program, that sacrifice is ok!
  - `Racer` doesn't care if instance of `Car` can `playRadio()` or if instance of `Bike` can `dropKickstand()`
  - only method `Racer` wants to call is `move()`

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`

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.

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?

Method Resolution (1/4)

```
public class Race {

    private Racer _sophia;
    //previous code elided

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

```
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)

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

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

```
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 dynamic binding, which is when actual method implementation used is not determined until runtime
  - 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
  - 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 valid?

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

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

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

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

72 / 80

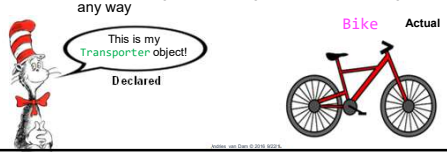
Why does that work? (1/2)

- 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

73/80

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, methods can get implemented in any way



74/80

When to use polymorphism?

- Using only functionality declared in interface or specialized functionality from implementing class?
  - if only using functionality from the interface → polymorphism!
  - if need specialized methods from implementing class, don't use polymorphism
- If defining `goOnScenicDrive()`…
  - Want to put `topDown()` on `Convertible`, but not every `Car` can put top down
    - Don't use polymorphism, every `Car` can't `goOnScenicDrive()` i.e., can't code generically

75/80

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

76/80

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`

77/80

The Program

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

```
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());
    }
}
```

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

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

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

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

```
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

Announcements

- HW2 and LiteBrite are released today
- HW2 is due on Sunday (9/25) 2PM
  - Remember: homeworks only have **one** handin time
- LiteBrite early handin is **Tuesday 09/27**, on-time handin is **Thursday 9/29**, late handin is **Saturday 10/1**
  - LiteBrite help slides will be released on Friday
- Review sessions are held every Thursday from 7:30-9pm and Sunday from 12:00-1:30pm in MacMillan 115
- **START EARLY, START TODAY, START YESTERDAY!!!!!**
- ***PLEASE FILL OUT THE INITIAL SURVEY***