CSE201: Monsoon 2022
Advanced Programming

Lecture 07: Abstract Class and Immutable Class

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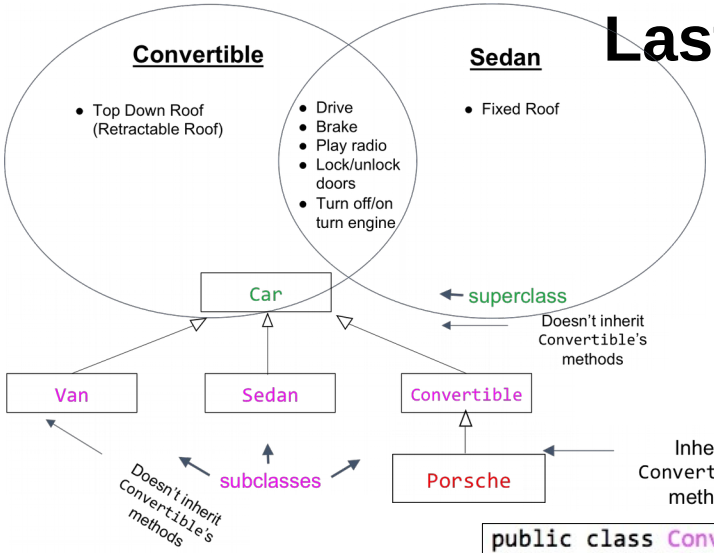
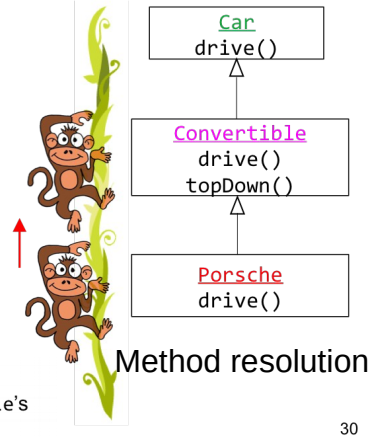
Last Lecture: Inheritance & Polymorphism





Method resolution

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```
public class Car {

    private Engine _engine;
    //other variables elided

    public Car() {
        _engine = new Engine();
    }
    public void drive() {
        this.goFortyMPH();
    }
    public void goFortyMPH() {
        //code elided
    }
    protected void cleanEngine()
{ ... }
}
```

```
public class Convertible extends Car {

    public Convertible(){

    }

    public void putTopDown(){
        //code elided
    }
}
```

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```
public class Convertible extends Car {
    //constructor elided
    public void cleanCar() {
        _engine.steamClean();
    }
}
```

```
public class Sedan extends Car {

    public Sedan () {
        //code elided
    }

    @Override
    public void drive(){
        this.turnOnEngine();
        super.drive(); // super == parent
                       class
        this.addPinToMap();
        super.drive();
        super.drive();
        this.addPinToMap();
    }
}
```

```
public class Racer {

    //previous code elided

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

}
```

- Adding new methods
- Accessing superclass fields/methods
- Overriding superclass methods
- Polymorphism
- Method resolution

This Lecture

- Inheritance and Polymorphism (continued from last lecture)
- Abstract class and abstract methods
- Immutable classes

Slide acknowledgements: CS15, Brown University

Indirectly Accessing `private` Instance Variables in Superclass by defining Accessors and Mutators

```
public class Car  {

    private Radio _myRadio;

    public Car() {
        _myRadio = new Radio();
    }

    protected Radio getRadio(){
        return _myRadio;
    }
    protected void setRadio(Radio
radio){
        _myRadio = radio;
    }

}
```

- Remember from earlier that private variables are not directly inherited by subclasses
- If `Car` does want its subclasses to be able to access and change the value of `_myRadio`, it can define protected accessor and mutator methods
  - Will non-subclasses be able to access `getRadio()` and `setRadio()` ?
- Very carefully consider these design decisions in your own programs – which properties will need to be accessible to other classes?

Calling Accessors/Mutators From Subclass

- `Convertible` can get a reference to `_radio` by calling `this.getRadio()`
  - Subclasses automatically inherit these public accessor and mutator methods
- Note that using “double dot” we’ve chained two methods together
  - First, `getRadio` is called, and returns the radio
  - Next, `setFavorite` is called on that radio

```
public class Convertible extends Car {
   public Convertible() {
   }

   public void setRadioPresets(){
      this.getRadio().setFavorite(1,
95.5);
      this.getRadio().setFavorite(2,
92.3);
   }
}
```

Let’s step through some code

- Somewhere in our code, a `Convertible` is instantiated

```
//somewhere in the program
Convertible convertible = new
Convertible();
convertible.setRadioPresets();
```

- The next line of code calls `setRadioPresets()`
- Let’s step into `setRadioPresets()`

Let’s step through some code

- When someone calls `setRadioPresets()`; first line is `this.getRadio()`
- `getRadio()` returns `_myRadio`
- What is the value of `_myRadio` at this point in the code?
  - Has it been initialized?
  - Nope, assuming that the structure of class Car is exactly as shown on right side (i.e. without any constructor), we’ll run into a `NullPointerException` here :(

```
public class Convertible extends Car {
   public Convertible() { //code elided
   }

   public void setRadioPresets() {
      this.getRadio().setFavorite(1, 95.5);
      this.getRadio().setFavorite(2, 92.3);
   }
}
```

```
public class Car {

   private Radio _myRadio;

   public Radio getRadio() {
      return _myRadio;
   }
}
```

Making Sure Superclass's Instance Variables are Initialized

- `Convertible` may declare its own instance variables, which it initializes in its constructor
- `Car`'s instance variables are initialized in the `Car` constructor
- When we instantiate `Convertible`, how can we make sure `Car`'s instance variables are initialized too?
  - Case-1: Car has a default constructor that instantiate all its fields
  - Case-2: Car has a parameterized constructor for initializing all its fields

super(): Invoking Superclass's Default Constructor (Case 1)

- Let's assume that Car's instance variables (like _radio) are initialized in Car's default constructor
- Whenever we instantiate Convertible, default constructor of Car is called automatically
- To **explicitly** invoke Car's default constructor, we can call super() inside the constructor of Convertible
  - **Can only make this call once**, and it must be the very first line in the subclass's constructor

```
public class Convertible extends Car {

   private ConvertibleTop _top;

   public Convertible() {
      super();
      _top = new ConvertibleTop();
      this.setRadioPresets();
   }

   public void setRadioPresets(){
      this.getRadio().setFavorite(1,
95.5);
      this.getRadio().setFavorite(2,
92.3);
   }
}
```

super(): Invoking Superclass's Parameterized Constructor (Case 2)

```
public class Car {

    private Racer _driver;
    public Car(Racer driver) {
        _driver = driver;
    }
    ......
}
```

```
public class Convertible extends
Car {

    private ConvertibleTop _top;

    public Convertible(Racer
driver) {
        super(driver);
        _top = new
ConvertibleTop();
    }

    ......
```

- What if the superclass's constructor takes in a parameter?
  - We've modified `Car`'s constructor to take in a `Racer` as a parameter
  - How do we invoke this constructor correctly from the subclass?
- In this case, need the `Convertible`'s constructor to also take in a `Racer`
- The `Racer` is then passed as an argument to `super()` – now `Racer`'s constructor will initialize `_driver` to the instance of `Racer` that was passed to the `Convertible`

What if we don't call `super()`?

- What if we forget to call `super()`?
- If you don't explicitly call `super()` first thing in your constructor, Java automatically calls it for you, passing in no arguments
- But if superclass's constructor requires a parameter, you'll get an error!
- In this case, we get a **compiler error** saying that there is no constructor "`public Car()`", since it was declared with a parameter

```
public class Convertible extends Car {

    private ConvertibleTop _top;

    public Convertible(Racer driver) {
        //oops forgot to call super()
        _top = new ConvertibleTop();
    }

    ......
}
```

How to Load Passengers?

- What if we wanted to seat all of the passengers in the car?
- Sedan, Convertible, and Van all have different numbers of seats
  - They will all have different implementations of the same method

Solution-1: Using Constructor Parameters

```
public class Convertible extends Car {
     private Passenger _p1;
     public Convertible(Racer driver, Passenger
p1) {
          super(driver);
    _p1 = p1;
     }
     //code with passengers elided
}
```

```
public class Sedan extends Car {
     private Passenger _p1, _p2, _p3, _p4;
     public Sedan(Racer driver, Passenger p1,
Passenger p2, Passenger p3, Passenger p4) {
          super(driver);
    _p1 = p1;
    _p2 = p2;
    _p3 = p4;
     }
    //code with passengers elided
}
```

- Notice how we only need to pass `driver` to `super()`
- We can add additional parameters in the constructor that only the subclasses will use
- Note that super() has to be the first statement inside the constructor.

Any drawbacks in Previous Approach?

- How about creating an interface Passengers with a method loadPassenger?
  - Which class should implement that?
    - Superclass (Car) or Subclasses (Convertible, Sedan, and Van) ?
  - Issues
    - Creating an extra interface (possibly a new file)
    - Each subclass should have the declaration in the following form:
      - public class Sedan extends Car implements Passengers { …. }

`abstract` Methods and Classes

- We declare a method `abstract` in a superclass when the subclasses can't really re-use any implementation the superclass might provide
- In this case, we know that all `Car`s should `loadPassengers`, but each subclass will `loadPassengers` very differently
- `abstract` method is declared in superclass, but not defined – up to subclasses farther down hierarchy to provide their own implementations

Solution-2: `Using abstract` Methods and Classes

- Here, we've modified `Car` to make it an `abstract` class: a class with preferably an `abstract` method
  - You can avoid abstract method and just mark class as abstract if you don't wish to allow object creation of this class
- We declare both `Car` and its `loadPassengers` method `abstract`: if one of a class's methods is `abstract`, the class itself must also be declared `abstract`
- An `abstract` method is only declared by the superclass, not implemented – use semicolon after declaration instead of curly braces

```
public abstract class Car {

    private Racer _driver;

    public Car(Racer driver) {
        _driver = driver;
    }

    public abstract void
loadPassengers();

}
```

Solution-2: `Using abstract` Methods and Classes

```
public class Convertible extends Car{
    @Override
    public void loadPassengers(){
       Passenger p1 = new Passenger();
       p1.sit();
    }
}
```

```
public class Sedan extends Car{
   @Override
   public void loadPassengers(){
       Passenger p1 = new Passenger();
       p1.sit();
       ......
       Passenger p3 = new Passenger();
       p3.sit();
   }
}
```

```
public class Van extends Car{
    @Override
    public void loadPassengers(){
       Passenger p1 = new Passenger();
       p1.sit();
       .....
       .....
       Passenger p6 = new Passenger();
       p6.sit();
    }
}
```

- All concrete subclasses of `Car` override by providing a concrete implementation for `Car`'s abstract `loadPassengers()` method
- As usual, method signature must match the one that `Car` declared

`abstract` Methods and Classes

- `abstract` classes cannot be instantiated!
  - This makes sense – shouldn't be able to just instantiate a generic `Car`, since it has no code to `loadPassengers()`
  - Instead, provide implementation of `loadPassengers()` in concrete subclass, and instantiate subclass
- Subclass at any level in inheritance hierarchy can make `abstract` method concrete by providing implementation
- Even though an `abstract` class can't be instantiated, its constructor must still be invoked via `super()` by a subclass
  - because only the superclass knows about (and therefore only it can initialize) its own instance variables

So.. What's the difference?

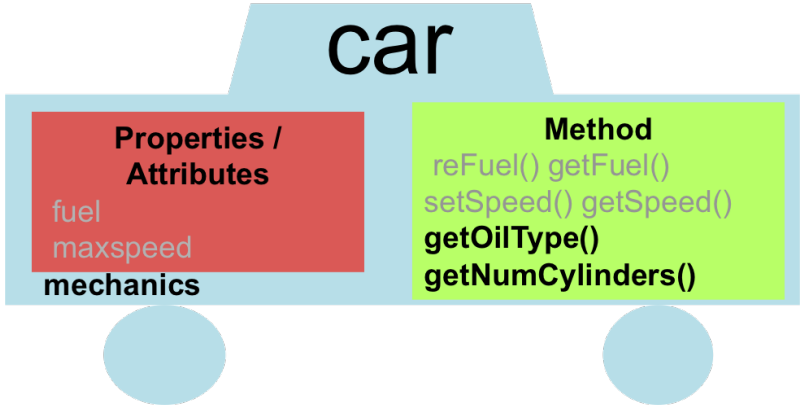
- You might be wondering: what's the difference between `abstract` classes and interfaces?
- `abstract` Classes:
  - Can define instance variables
  - Can define a mix of concrete and `abstract` methods
  - You can only inherit from one class
- Interfaces:
  - Cannot define any instance variables/concrete methods
  - You can implement multiple interfaces

Note: Java, like most programming languages, is evolving. In Java 8, interfaces and `abstract` classes are even closer in that you can have concrete methods in interfaces. We will not make use of this in CSE201.

What if the Cars are Getting Modified?

No modifications should ever be allowed !!

Immutable Classes (1/5)



1. Don't provide any methods that modify the object's state.
2. Make all fields `private`. (ensure encapsulation)
3. Make all fields `final`.

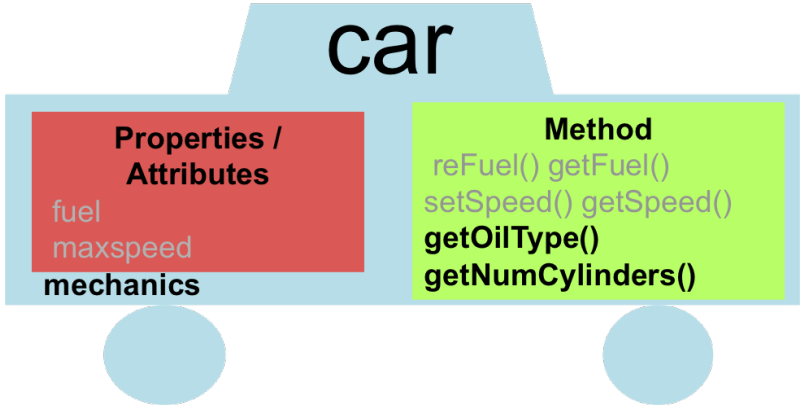
```
public class Mechanics {
    private final String oilType;
    private final int numCylinders;

    public Mechanics(String oil, int cylinders)
    public String getOilType();
    public int getNumCylinders();
}
```

Question

- Immutable classes have their fields marked as *final*. Then, why can’t we make those fields as *public* and let clients access them without any getter methods ?

Immutable Classes (2/5)

1. Don't provide any methods that modify the object's state.
2. Make all fields `private`. (ensure encapsulation)
3. Make all fields `final`.

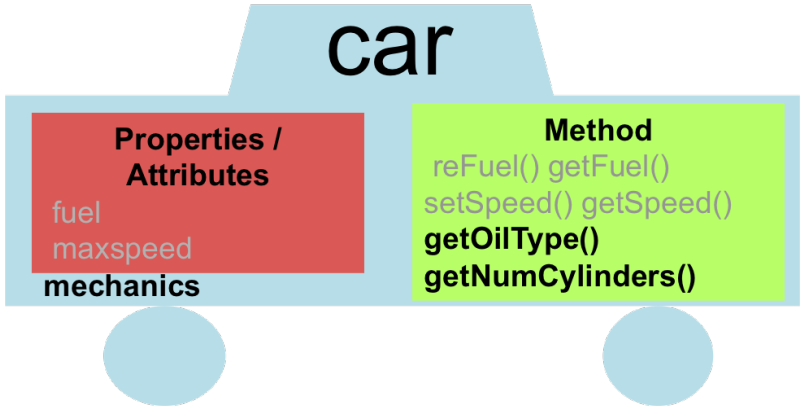



```
public class Mechanics {
   public final Tire tire;
   .......

}

// The user can easily do this:
mechanics.tire.setSize(20);
```

```
public class Tire {
    private int size;
    public int getSize();
    public void setSize(int);
}
```

Immutable Classes (3/5)

1. Don't provide any methods that modify the object's state.
2. Make all fields `private`. (ensure encapsulation)
3. Make all fields `final`.

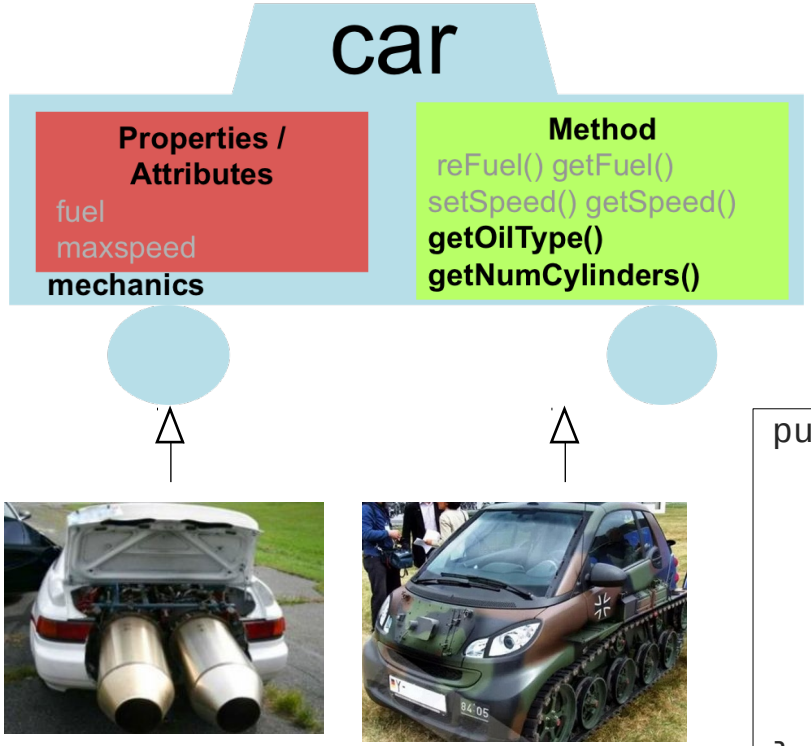


- Setting a reference variable final means that it can never be reassigned to refer to a different object.
  - You can't set that reference to refer to another object later (=).
  - It does not mean that the object's state can never change!

```
public class Mechanics {
   private final Tire tire;
   .......
   public Tire getTire(){return tire;}
}

// The user can easily do this:
mechanics.getTire().setSize(20);
```

```
public class Tire {
    private int size;
    public int getSize();
    public void setSize(int);
}
```

Immutable Classes (4/5)

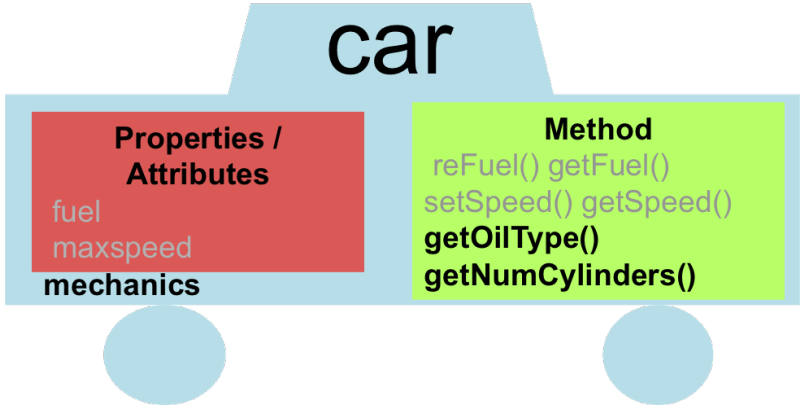



```
public class Mechanics {
    private final String oilType;
    private final int numCylinders;

    public Mechanics(String oil, int cylinders)
    public String getOilType();
    public int getNumCylinders();
}
```

```
public class ModifiedMechanics extends Mechanics {

  ......
  @Override
  public String getOilType(){
      return “Rocket Fuel”;
  }
  @Override
  public int getNumCylinders(){return 18;}//Bugatti
}
```

How to fix these?

Immutable Classes (5/5)




```
public final class Mechanics {
    private final String oilType;
    private final int numCylinders;

    public Mechanics(String oil, int cylinders)
    public String getOilType();
    public int getNumCylinders();
}
```

Mechanics cannot be extended as it is declared as final

```
public class ModifiedMechanics extends Mechanics {

  ......
  @Override
  public String getOilType(){
      return “Rocket Fuel”;
  }
  @Override
  public int getNumCylinders(){return 18;}//Bugatti
}
```

Summary: Making a Class Immutable

1. Don't provide any methods that modify the object's state.
2. Make all fields `private`. (ensure encapsulation)
3. Make all fields `final`.
4. Ensure exclusive access to any mutable object fields.
   - Don't let a client get a reference to a field that is a mutable object (don't allow any mutable representation exposure.)
5. Ensure that the class cannot be *extended*.

Next Lecture (Tomorrow)

- Class Object