Computer Science 210: Data Structures

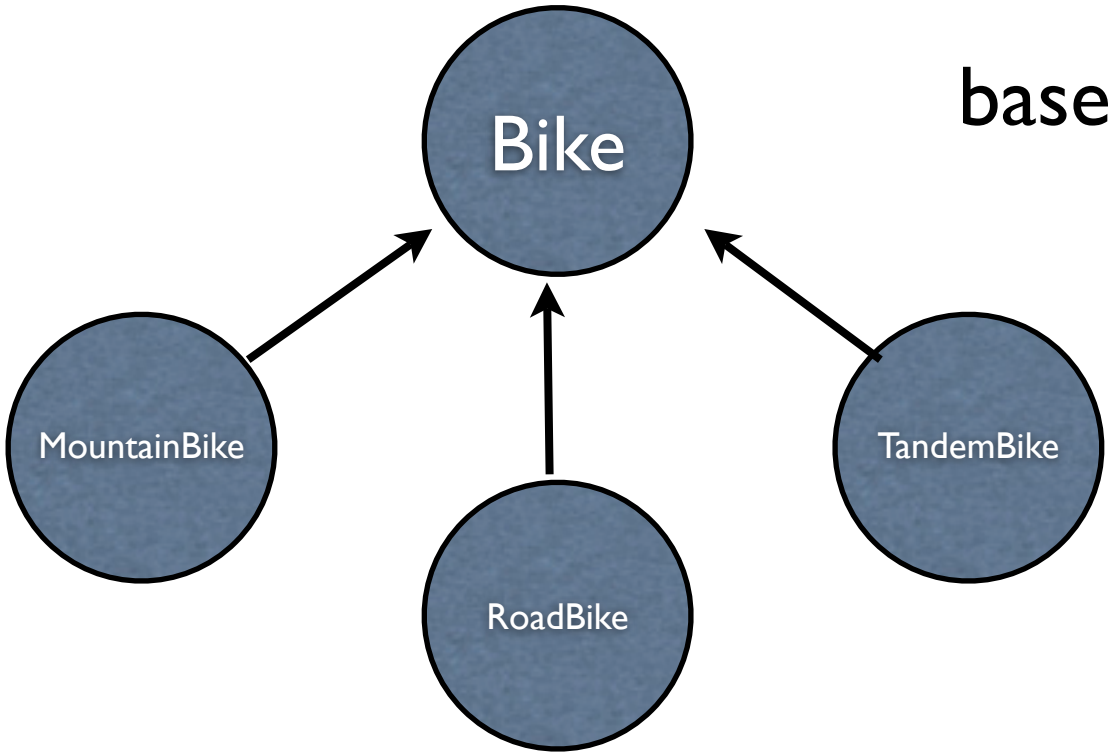
Object Oriented (OO) concepts

Summary

- OO concepts
  - inheritance
  - polymorphism
  - this
  - exceptions
  - interfaces

Inheritance

- Inheritance is the capability of a class to use the properties and methods of another class while adding its own functionality.
- It's a mechanism for sharing/reusing code
  - captures similarities between classes



base-class/super-class

sub-classes

- A sub-class inherits all public and protected members of its parent

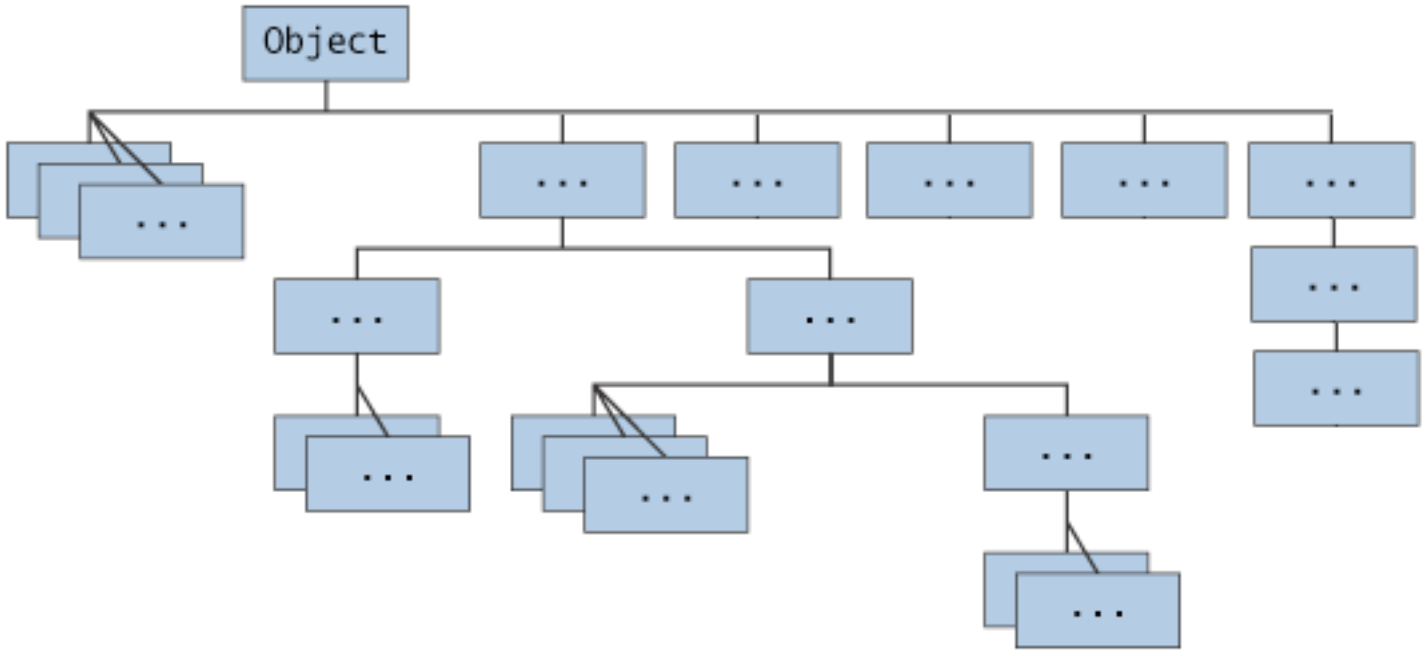
Example

```
public class Bicycle {

    public int gear;
    public int speed;

    public Bicycle(int startSpeed, int startGear) {..}
    public void setGear(int newValue) {..}
    public void applyBrake(int decrement) {..}
    public void speedUp(int increment) {..}
}
```

```
public class MountainBike extends Bicycle {

    // the MountainBike subclass adds one field
    public int seatHeight;

    // the MountainBike subclass has one constructor
    public MountainBike(int startHeight, int startSpeed, int startGear) {
        super(startSpeed, startGear);
        seatHeight = startHeight;
    }

    // the MountainBike subclass adds one method
    public void setHeight(int newValue) {...}


}
```

Inheritance in Java

- ***Object*** is the highest superclass (ie. ***root*** class) of Java
  - all other classes are subclasses (children or descendants) of Object
- Object class defined defined in the `java.lang` package; includes methods such as:
  - `hashCode()`
  - `toString()`
  - `getClass()`
- when your class does not extend any specific class, it extends Object by default



All Classes in the Java Platform are Descendants of Object

Inheritance

- Using inheritance
  - When you want to create a new class and there is already a class that includes some of the code that you want, you can derive your new class from the existing class.
  - In doing this, you can reuse the fields and methods of the existing class without having to write (and debug!) them yourself.

- Terminology
  - A class that is derived from another class is called a *subclass* (also a *derived class*, *extended class*, or *child class*).
  - The class from which the subclass is derived is called a *superclass* (also a *base class* or a *parent class*).
  - Excepting `Object`, which has no superclass, every class has one and only one direct superclass (single inheritance). In the absence of any other explicit superclass, every class is implicitly a subclass of `Object`.
  - Classes can be derived from classes that are derived from classes that are derived from classes, and so on, and ultimately derived from the topmost class, `Object`. Such a class is said to be *descended* from all the classes in the inheritance chain stretching back to `Object`.

What You Can Do in a Subclass

- The inherited fields and method can be used directly
- You can declare new fields in the subclass that are not in the superclass
- You can declare new methods in the subclass that are not in the superclass
- You can override a method
  - write a new method in the subclass that has the same signature as the one in the superclass
  - you can invoke superclass method using keyword super
- You can write a subclass constructor
  - invokes the constructor of the superclass by using super

Calling super in a constructor

```
public MountainBike(int startHeight, int startSpeed, int startGear) {

   //call superclass constructor to create a Bike
   super(startCadence, startSpeed, startGear);

    seatHeight = startHeight;
 }
```

Calling super in an overridden method

```
public class Superclass {

    public void printMethod() {
        System.out.println("Printed in Superclass.");
    }
}
public class Subclass extends Superclass {

    public void printMethod() { //overrides printMethod in Superclass
        super.printMethod();
        System.out.println("Printed in Subclass");
    }

    public static void main(String[] args) {
        Subclass s = new Subclass();
        s.printMethod();
    }
}
```

this

- within a method this refers to the current object
- Used when a field is shadowed by a method or constructor parameter.

```
public class Point {
    public int x = 0;
    public int y = 0;

    //constructor
    public Point(int a, int b) {
        x = a;
        y = b;
    }
}
```

- but it could have been written like this:

```
public class Point {
    public int x = 0;
    public int y = 0;

    //constructor
    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }
}
```

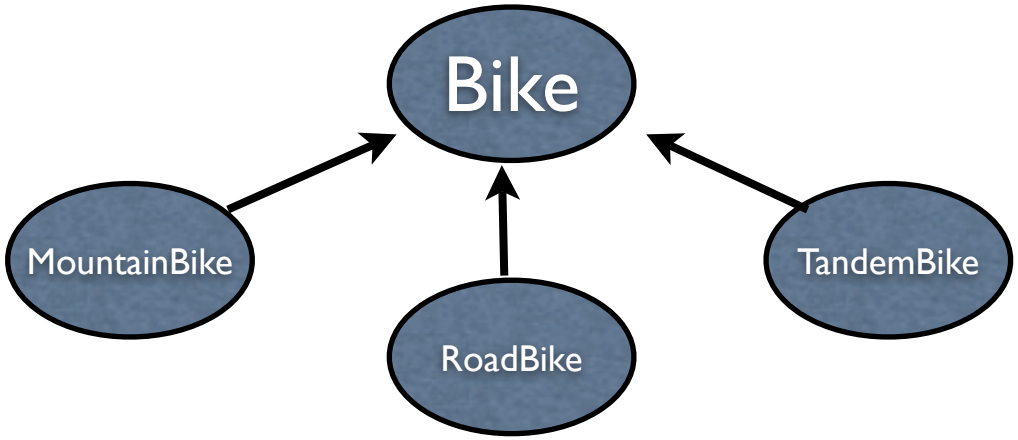
this

- Using this with a Constructor
  - From within a constructor, you can use `this` keyword to call another constructor in the same class (doing so is called an *explicit constructor invocation)*

```
public class Rectangle {
    private int x, y;
    private int width, height;

    public Rectangle() {
        this(0, 0, 0, 0);
    }
    public Rectangle(int width, int height) {
        this(0, 0, width, height);
    }
    public Rectangle(int x, int y, int width, int height) {
        this.x = x;
        this.y = y;
        this.width = width;
        this.height = height;
    }
    ...
}
```

Casting objects

- a MountainBike is a Bike
- a MountainBike is also an Object
- a Bike is not (necessarily) a MountainBike



- In Java: A variable of type T can be of type {T or any subclass of T}
- Example

```
Object bike;
//bike is allowed to be any subclass of Object
bike  = new MountainBike();
```

- this is called casting: changing the type of an object

- We'll use this by defining data structures that work generically with Objects; when we instantiate the data structure, we can fill in any type of objects.

- Implicit casting in an inheritance hierarchy: a subclass can be used in place of a superclass

Casting examples

```
Bike b;
MountainBike mb;
mb = new MountainBike(..);

//implicit casting of a MountainBike to a Bike
b = mb;
```

```
class Person {
    //any person has a bike
    Bike b;
    void Person(Bike b) {
        this.b = b;
}
```

a person that owns a bike

```
...
MountainBike mb = new MountainBike();
Person p = new Person(mb);
```

a mountainbike is a bike

Interfaces

- An interface is a collection of method signatures (with no bodies)
- similar to a class

```
public interface OperateCar {

   // method signatures
   int turn(Direction direction, double radius,);
   int changeLanes(Direction direction, double startSpeed, double endSpeed);
   int signalTurn(Direction direction, boolean signalOn);
           ......
}
```

- When a class implements an interface it must implement all methods in that interface

```
public class OperateBMW760i implements OperateCar {

   int signalTurn(Direction direction, boolean signalOn) {
      //code to turn BMW's LEFT turn indicator lights on
      //code to turn BMW's LEFT turn indicator lights off
      //code to turn BMW's RIGHT turn indicator lights on
      //code to turn BMW's RIGHT turn indicator lights off
   }

   // other members, as needed


}
```

Interfaces

- Interfaces are used to describe the functionality of a software in an abstract way (since methods have no bodies)
- Advantage:
  - the implementation can change while interface remains the same
  - multiple implementations
- E.g., a digital image processing library writes its classes to implement an interface, and publishes its interface (API-application programming interface)
  - the implementation of the methods is usually not disclosed
  - moreover, it can change
  - a graphics package may decide to use this library
    - only needs to know the API
- Interfaces in Java
  - a class can inherit from a SINGLE class
  - a class can implement many interfaces

Object-Oriented Design

- In an object-oriented language you model/design the world using classes.

- To create the world you instantiate classes thus creating objects. Objects respond to events and this determines how your world behaves.
  - Each class models one part of the world.
  - Usually in a project there is one class that creates the world---it creates the objects and starts the initial events (e.g. timer events); after that the world evolves.

- You model and create your project's world. Your design **goals** are:
  - Robustness
    - your world is capable of handling unexpected inputs without crashing
    - your world recovers gracefully from errors
  - Adaptability
    - your world can be changed/adapted to new requirements
  - Reusability
    - your world is general/simple enough so that it can be re-used

- Code sharing is good.
  - avoids re-inventing the wheel
  - reliable (code is debugged many times)

Design Principles

To achieve the design goals, you follow a couple of **principles**:

- Abstraction
  - distill a complicated system down to its most fundamental parts and describe it simply

- Encapsulation
  - different components should NOT reveal internal details of their implementation
    - e.g. data of an object is private (not public)
  - one should be able to use a class by reading its interface
    - interface of a class: the set of methods it supports
    - e.g. read Java online docs and use the class; no need to know implementation

- Modularity
  - divide the code into separate functional units