CSC 133
Object-Oriented Computer Graphics Programming

OOP Concepts III – Abstraction

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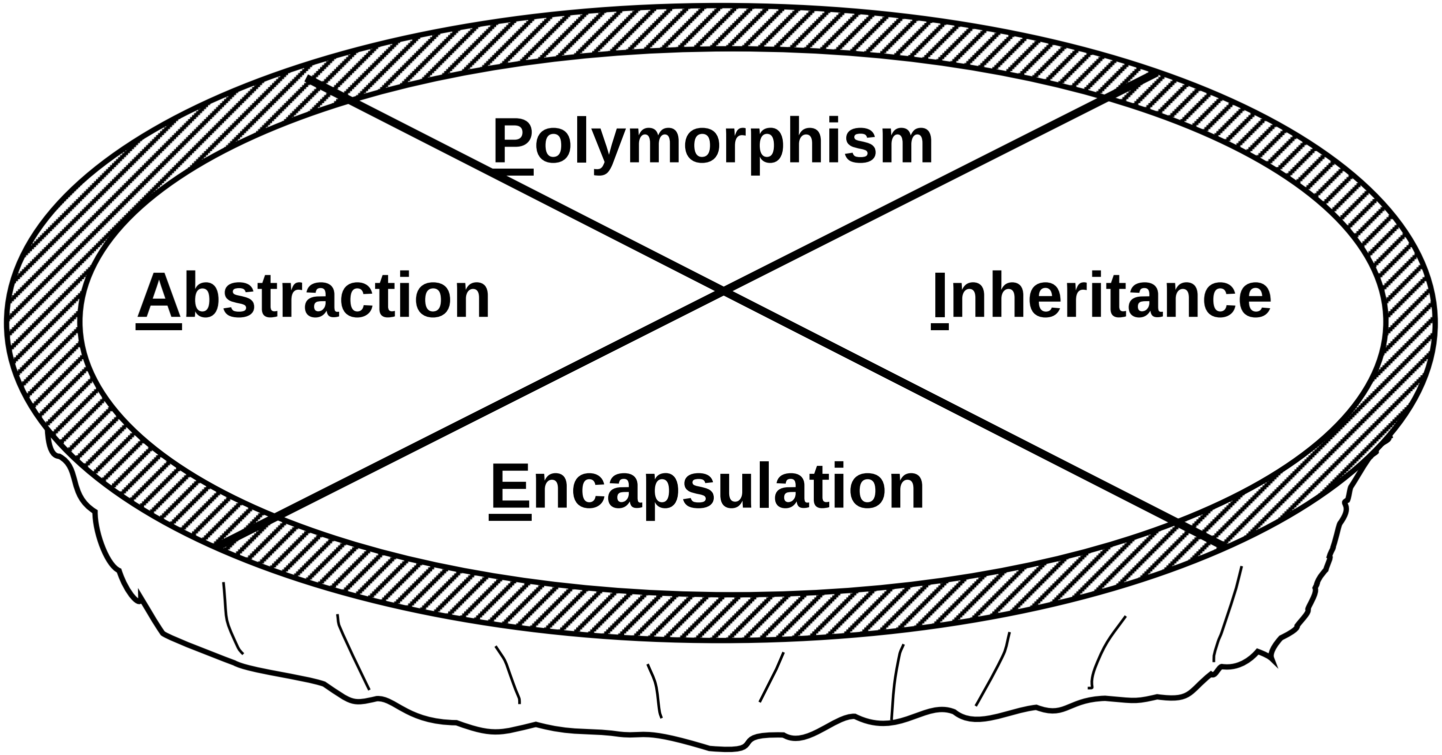
SACRAMENTO STATE

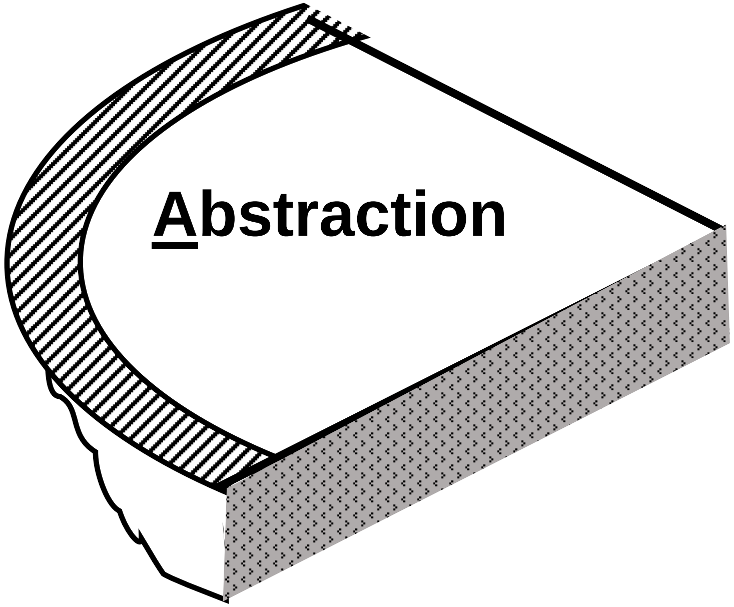
“A Pie”

Four distinct OOP Concepts (or Pillars)



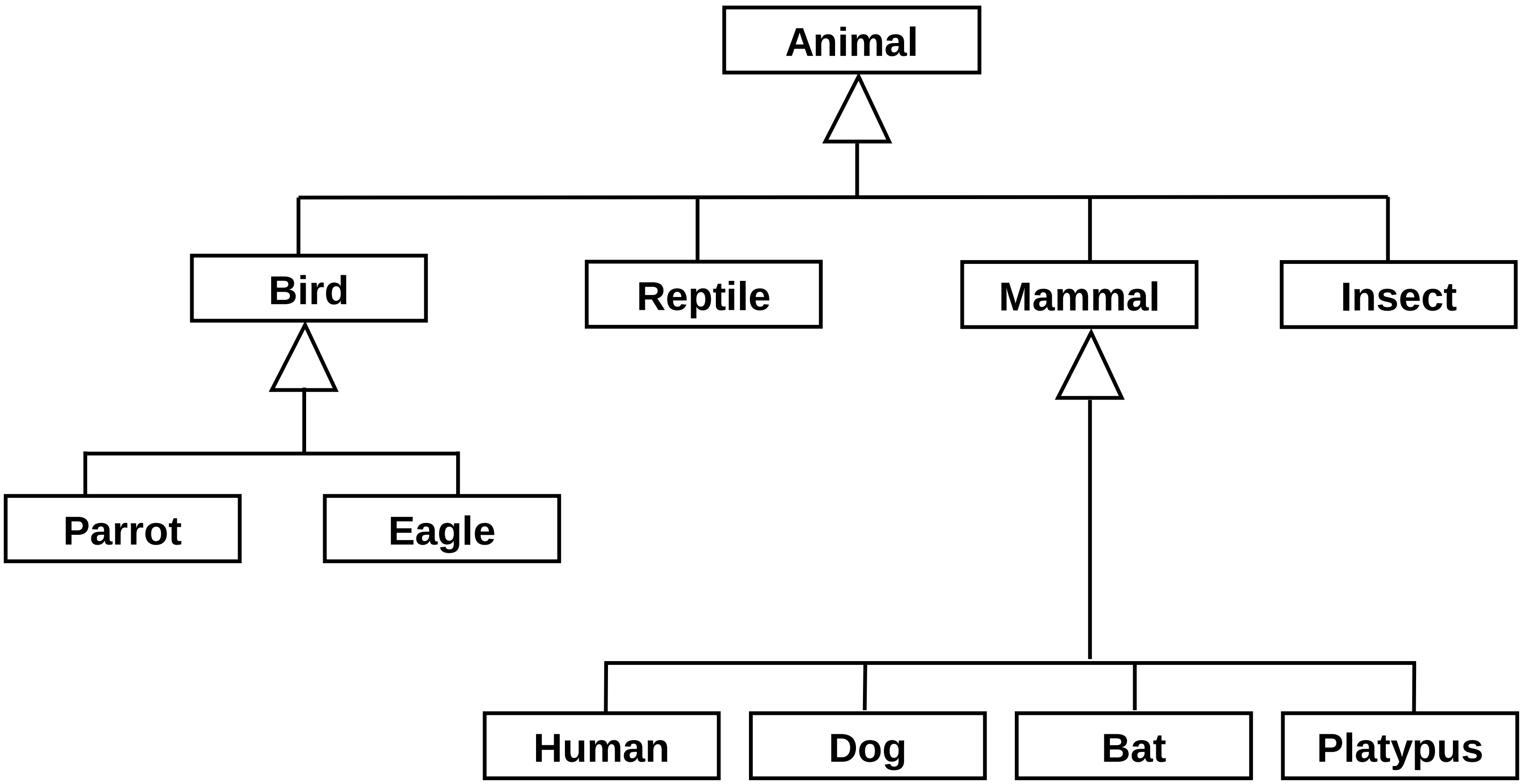
Last Lecture

We ate two more parts



Abstraction

Inheritance hierarchy



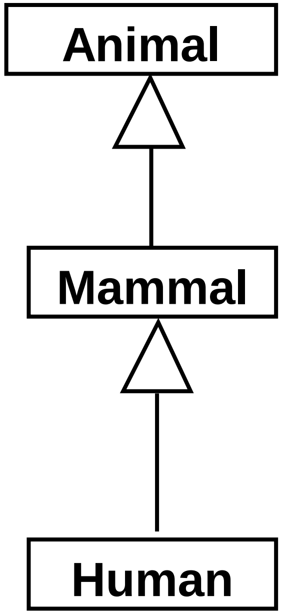
Behaviour?

We know

- human can move
- Mammal can move
- Animal can move

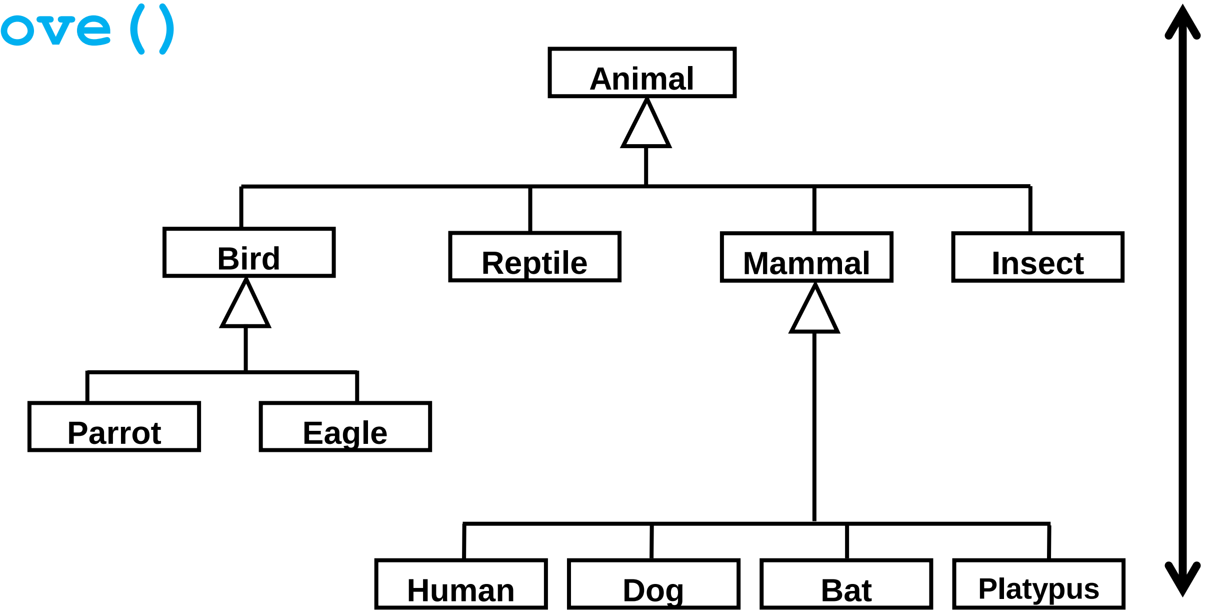
But how?

- Human can move their arm, leg, or head
- Mammal?
- Animal?



Class Level

- Some classes will never logically be instantiated
  - `Animal`, `Mammal`, …
- Some methods cannot be "specified" completely at a given class level
  - `move()`



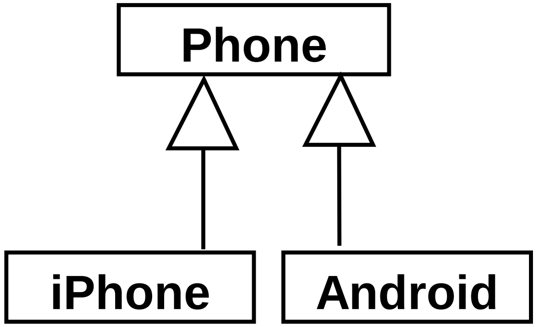
General, abstract

Specific, detail

Cannot Define It

Know it can do, but cannot define how

- When parent class is a general concept



But we need it for polymorphism

```
For all phone
      phone.installOS();
```

Solution?

Empty method

```
    public void installOS() { }
```

Works, but unclear and unsafe

- Other people think you forget to implement it
- We may forget to override it but no compile error
- Want a reminder

Abstract Class and Method

- Use the keyword `abstract`
- Both classes and methods can be declared abstract in Java:

```
public abstract class Animal {
    public abstract void move ();
}
```

- End by semi-colon instead of function body {…}
  - Do not need to implement it

Abstract vs Concrete

Abstract

- With keyword
- No function body
- End with ;

```
public abstract void move();
```

Concrete

- Non-abstract
- With function body
- End with }

```
public void move(){
        x += 1;
        y += 1;
}
```

Inheritance for Specification

The third usage of inheritance:

- Parents declared the behaviours without implementation
- Child now implement it.

Inherit from Abstract

Abstract classes cannot be instantiated

```
Animal a = new Animal(); ✗
```

But can be inherited

```
public mammal extends Animal {
      public void move () {...}
}
```

Then override the abstract method.

Abstract vs Modifier

- `static`
- `final`
- `private`
  - cannot be declared abstract
  - No way to override or change them
  - No way to provide a “specification”

- `public`
- `Protected`
  - can be declared abstract.

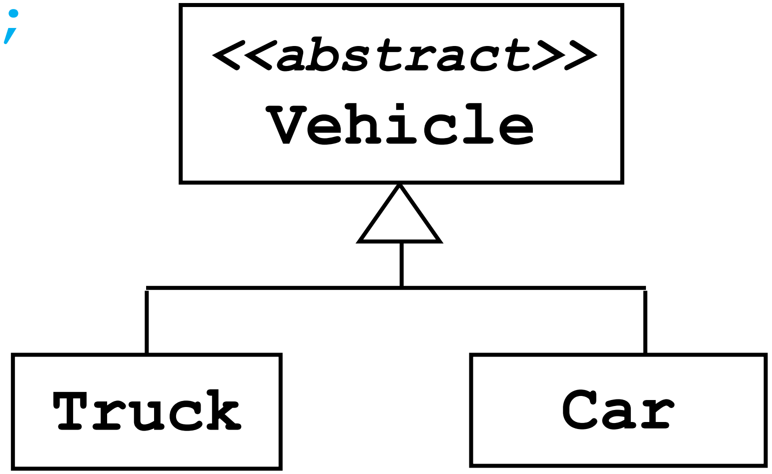
Requirements

- If a class contains an abstract method
  - This class is an abstract class
  - This class must have keyword `abstract`
- Abstract classes can contain concrete methods
- If a child does not implement every abstract methods from parent
  - The child must have keyword `abstract` too

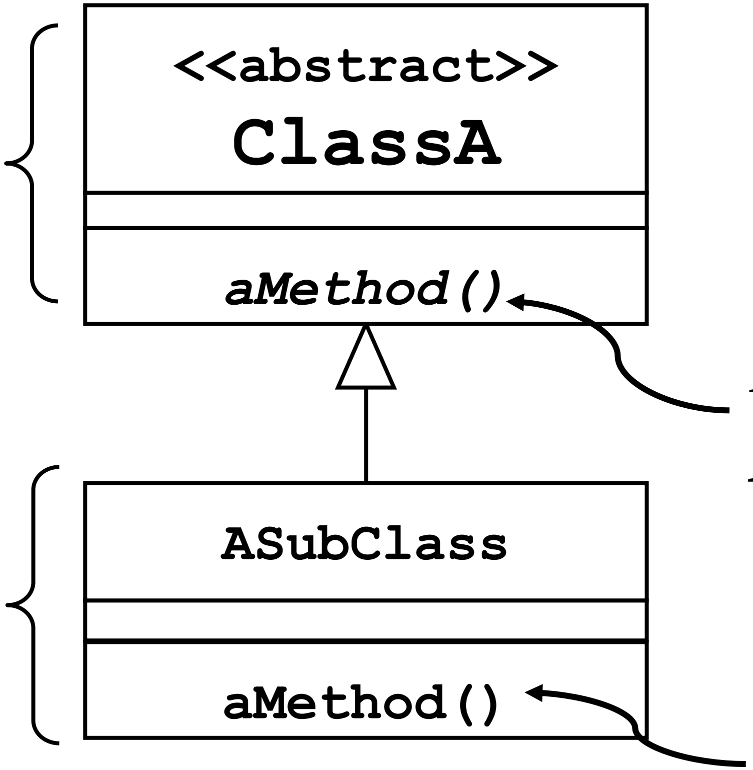
Abstract Class Reference

Reference to abstract type

```
Vehicle v ;
Truck t = new Truck();
Car c = new Car();
...
v = t ;
...
v = c ;
```



UML for Abstraction



<<abstract>>

ClassA

aMethod()

ASubClass

aMethod()

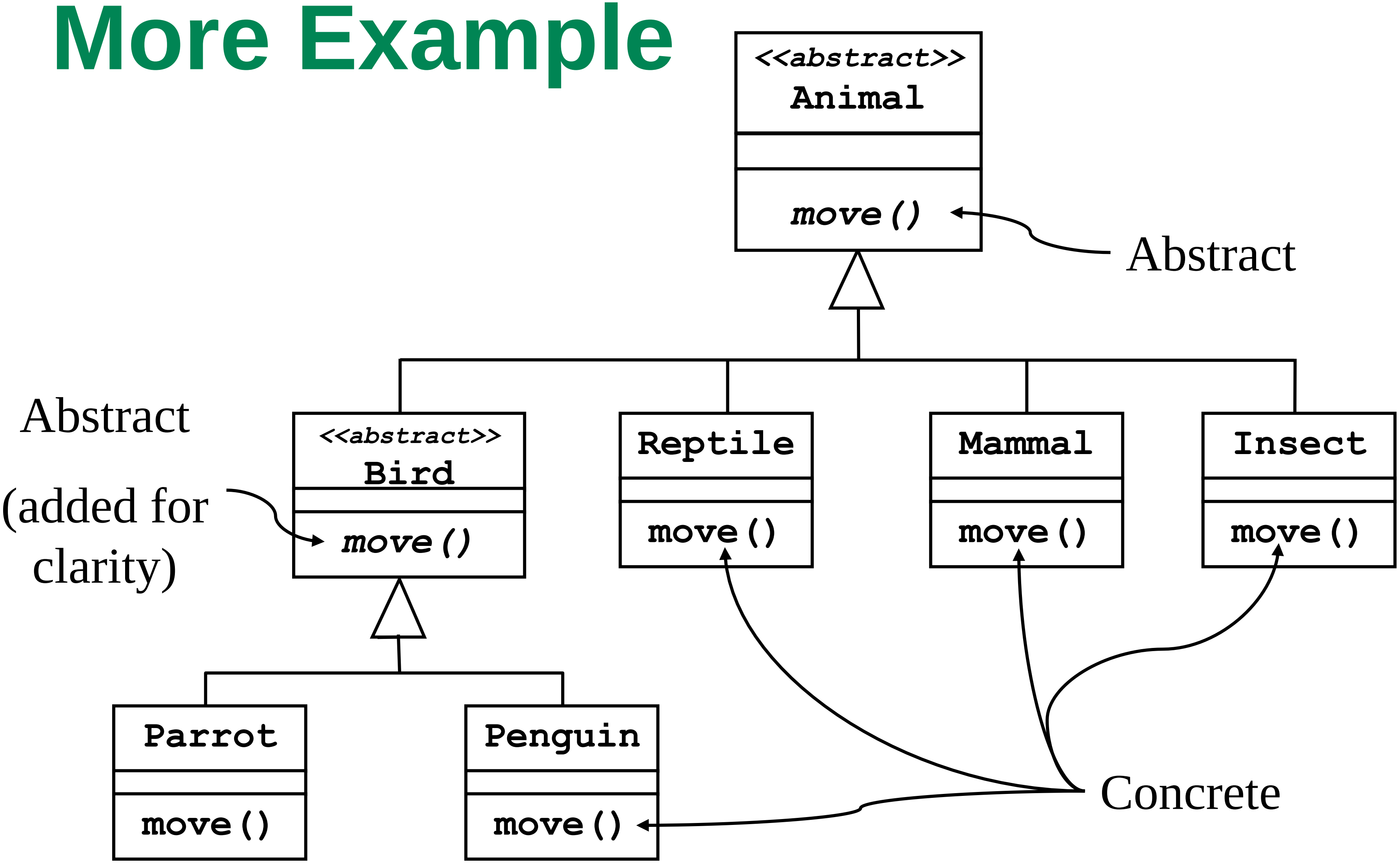
Abstract class

Concrete class

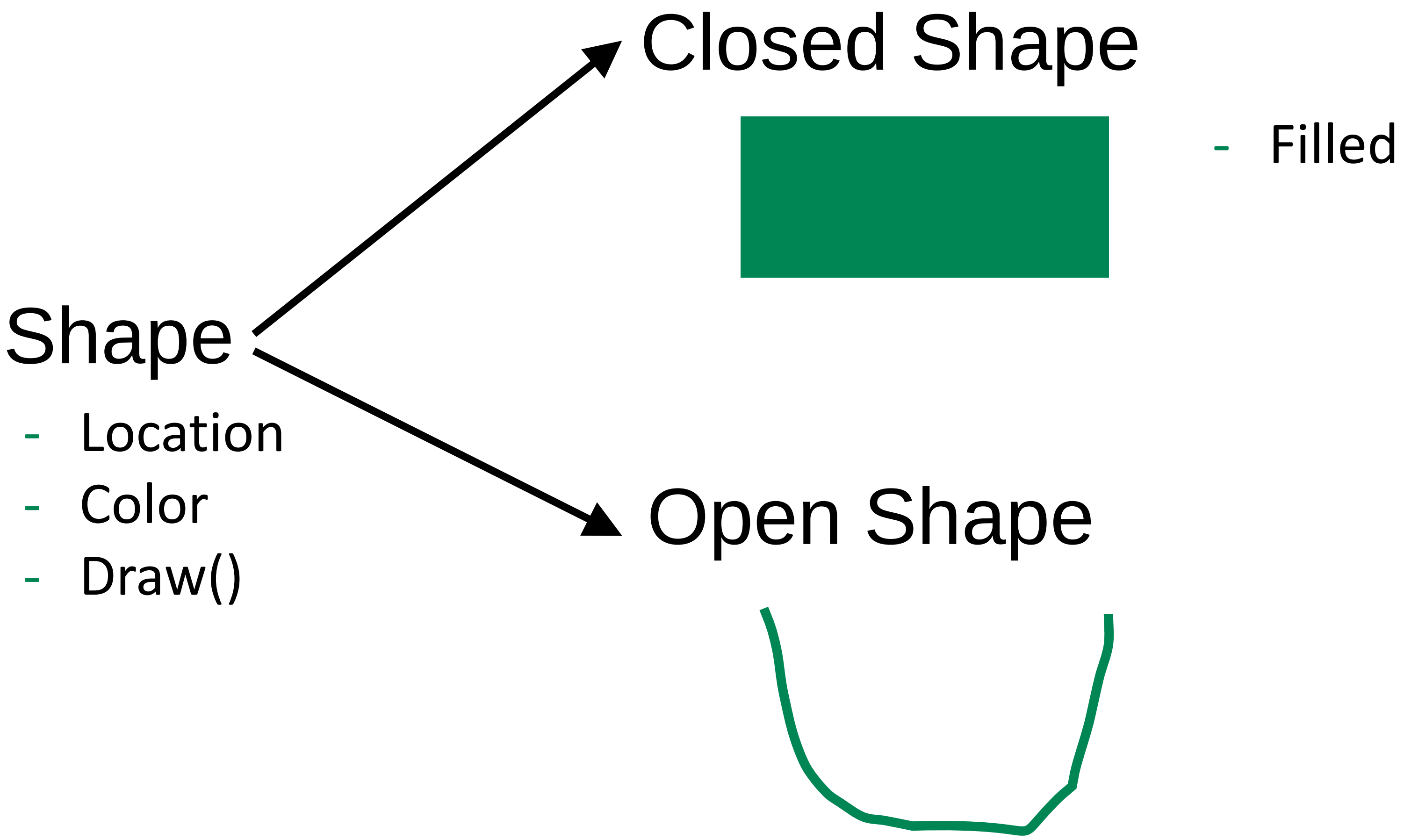
Abstract method: ***Italics***

Implementation

More Example



Example: Shapes



Shape

- Location
- Color
- Draw()

Closed Shape

- Filled

Open Shape

Example: Shape class

```
public abstract class Shape {
  private int color;
  private Point location;
  public Shape()   {
    color = ColorUtil.rgb(0,0,0);
    location = new Point (0,0);
  }
  public Point getLocation() { return location;  }
  public int getColor() { return color; }
  public void setLocation (Point newLoc) {
    location = newLoc;
  }
  public void setColor (int newColor) {
    color = newColor;
  }
  public abstract void draw(Graphics g);
}
```

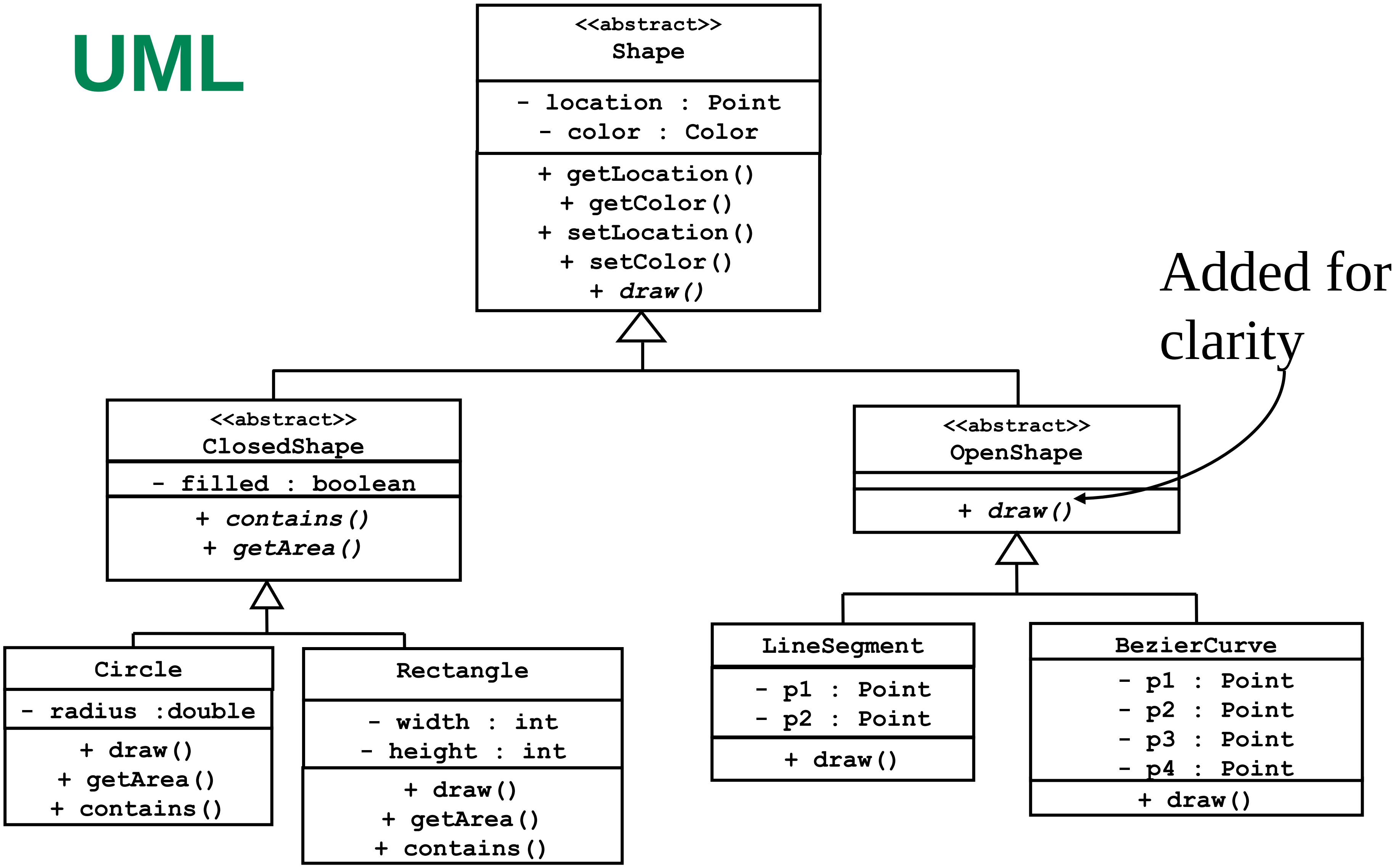
Example: ClosedShape

```
public abstract class ClosedShape extends Shape {
 private boolean filled;   // attribute common
 public ClosedShape() {
  filled = false;
 }
 public ClosedShape(boolean filled) {
  this.filled = filled;
 }
 public boolean isFilled() { return filled;}
 public void setIsFilled(boolean filled) {
  this.filled = filled;
 }
 public abstract boolean contains(Point p);
 public abstract double getArea();
}
```

Example: Rectangle

```
public class Rectangle extends ClosedShape {
  private int width;
  private int height;
  public Rectangle() {
    super(true);
    width = 2;
    height = 1;
  }
  public boolean contains(Point p) { ... }
  public double getArea() {
    return (double) (width * height) ;
  }
  public void draw (Graphics g) {
    if (isFilled()) {
      //  code here to draw a filled (solid) rectangle
    } else {
      //  code here to draw a lined rectangle
    }
  }
}
```

UML



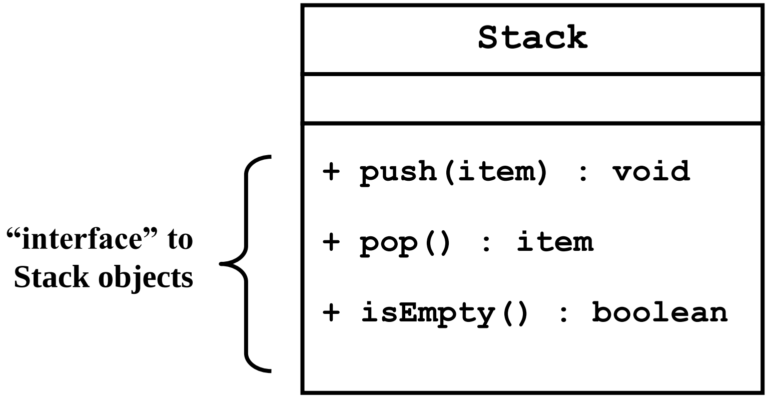
<<abstract>>
Shape
- location : Point
- color : Color
+ getLocation()
+ getColor()
+ setLocation()
+ setColor()
+ *draw()*
<<abstract>>
ClosedShape
- filled : boolean
+ *contains()*
+ *getArea()*
<<abstract>>
OpenShape
+ *draw()*
Added for clarity
Circle
- radius :double
+ draw()
+ getArea()
+ contains()
Rectangle
- width : int
- height : int
+ draw()
+ getArea()
+ contains()
LineSegment
- p1 : Point
- p2 : Point
+ draw()
BezierCurve
- p1 : Point
- p2 : Point
- p3 : Point
- p4 : Point
+ draw()

Interface

Class Interface

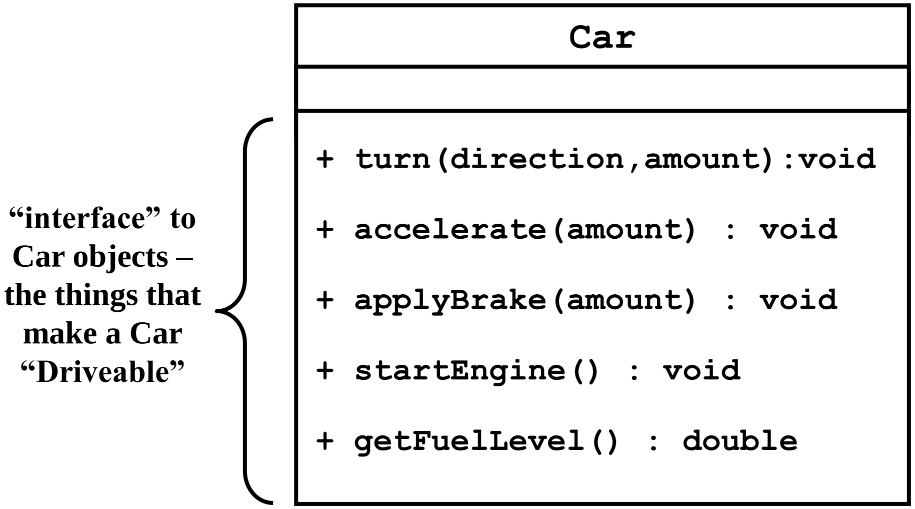
A special class that define behaviors

- Without any implementation
- Defines a set of methods with specific signatures



“interface” to Stack objects

```
Stack

+ push(item) : void
+ pop() : item
+ isEmpty() : boolean
```



“interface” to Car objects – the things that make a Car “Driveable”

```
Car

+ turn(direction,amount):void
+ accelerate(amount) : void
+ applyBrake(amount) : void
+ startEngine() : void
+ getFuelLevel() : double
```

Java Interface Characteristic

- All methods must be public
  - Default visibility
- Usually, no method implementation
  - After Java 8, default or class methods can have body in interface
- All fields must be public and static and final
  - Public constant variables
  - Default

Java Interface Construct

Keyword `interface`

```
public interface IDriveable {
  void turn (int direction, int amount);
  void accelerate (int amount);
  void applyBrake (int amount);
  void startEngine ( );
  void shift (int newGear);
  double getFuelLevel ( );
}
```

Using Java Interfaces

Use keyword `implement`:

```
public class Car implements IDriveable {
    public void accelerate (int amount){...}
    public void applyBrake (int amount){...}
    ...
}
```

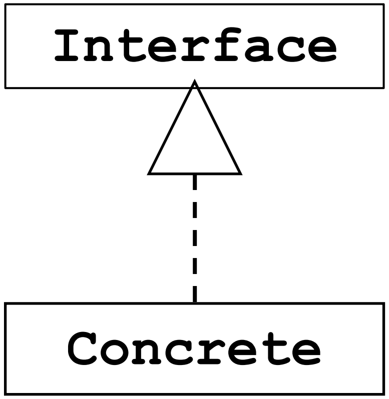
We must provide bodies for all methods

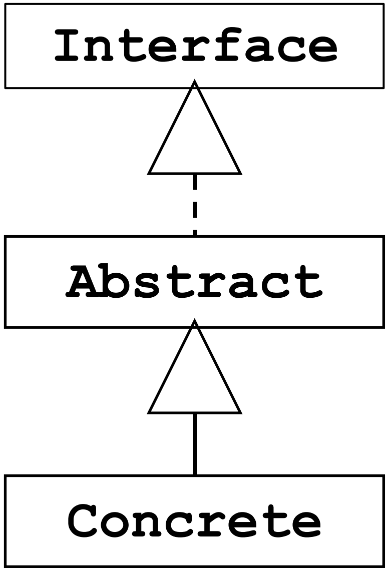
- Compiler checks!

Provide Bodies

You can provide all function bodies in the child class of the interface.

- Or set the child as an abstract class





Interface Relationship

“is”

- No “a” as it usually follow an adjective.

Inheritance: is-a

- Car is a vehicle

Interface: is

- Car is driveable

Different implementation

Different class can have different implementation for the same interface

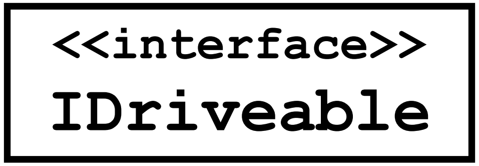
- Brake for `car` and `truck`

```
interface IDrivable{
   public void brake();
}
```

```
class car implements IDrivable{
   public void brake(){
      //short time...
   }
}
```

```
class truck implements IDrivable{
   public void brake(){
      //longer time...
   }
}
```

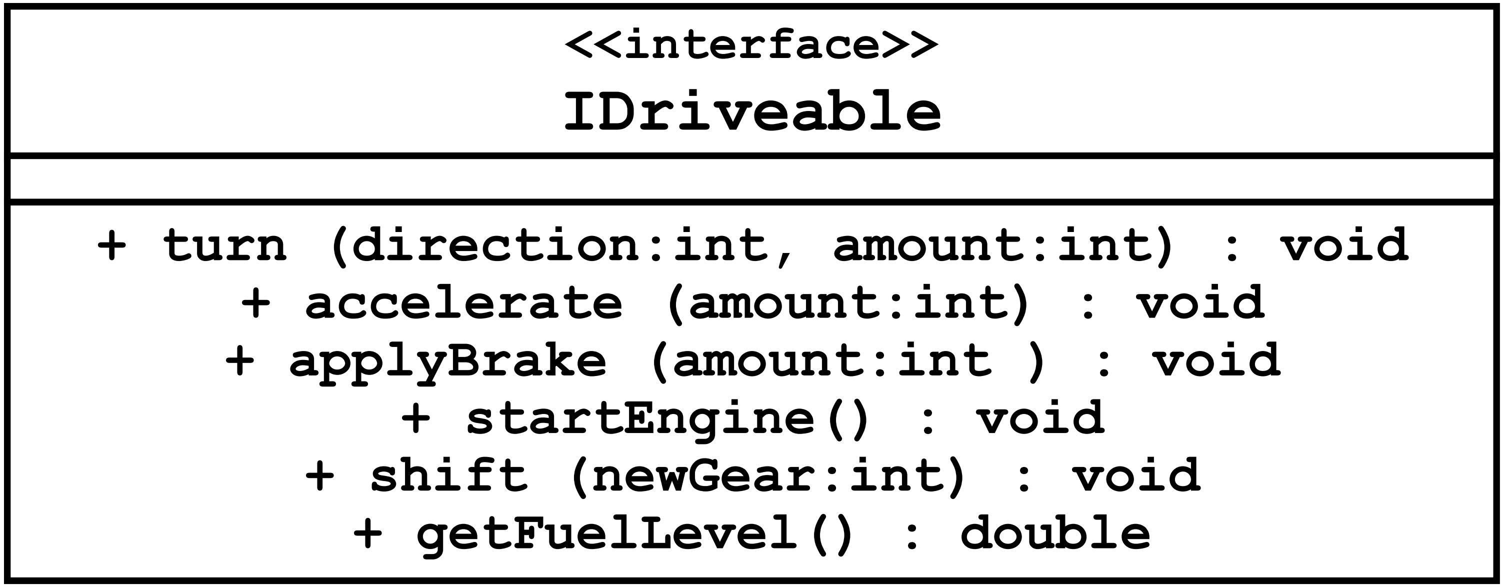
UML Interface Notation



<<interface>>

IDriveable

or



<<interface>>

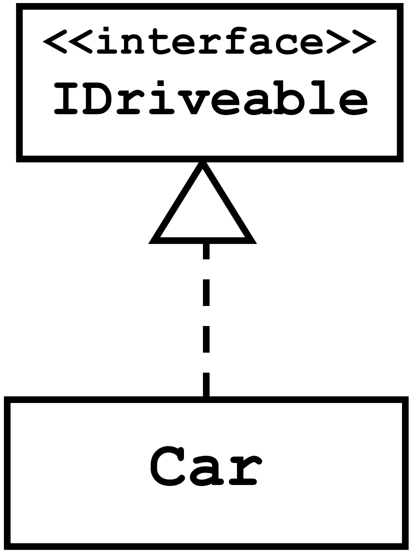
IDriveable

+ turn (direction:int, amount:int) : void
+ accelerate (amount:int) : void
+ applyBrake (amount:int) : void
+ startEngine() : void
+ shift (newGear:int) : void
+ getFuelLevel() : double

UML Interface Relationship

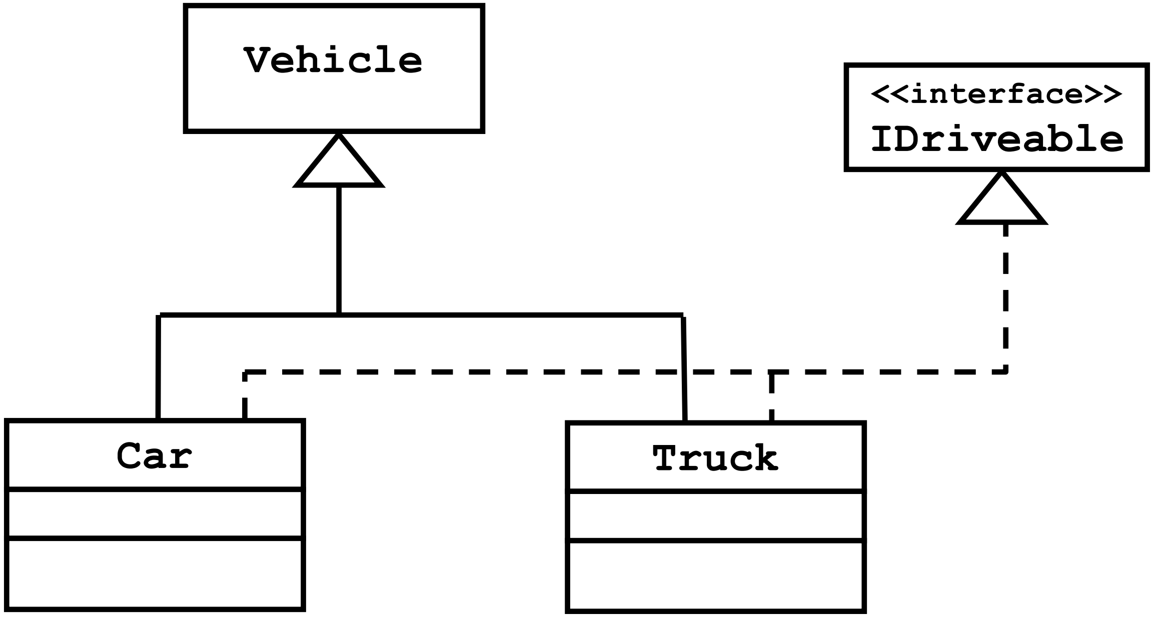
Class `Car` implements interface `Idriveable`

- Dotted arrow
- Same arrowhead as for inheritance



Multiple Relationship

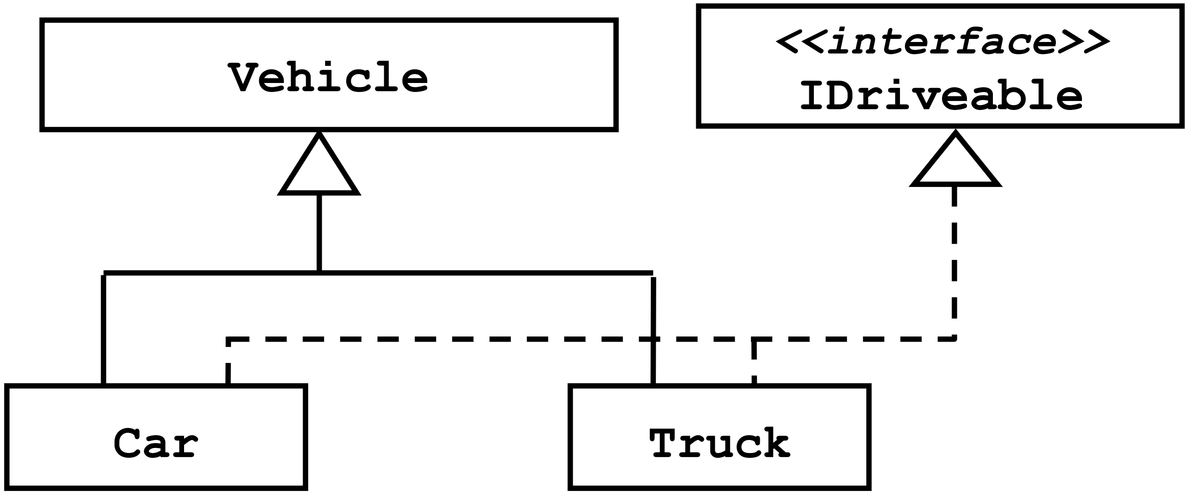
- Car and Truck can both
  - Derive from Vehicle
  - Implement IDriveable



Interface Subtypes

If a class implements an interface

- considered a “subtype” of the “interface type”:
- `Car` and `truck` subtype of IDriveable



Interface Inheritance

- Subclasses inherit interface implementations

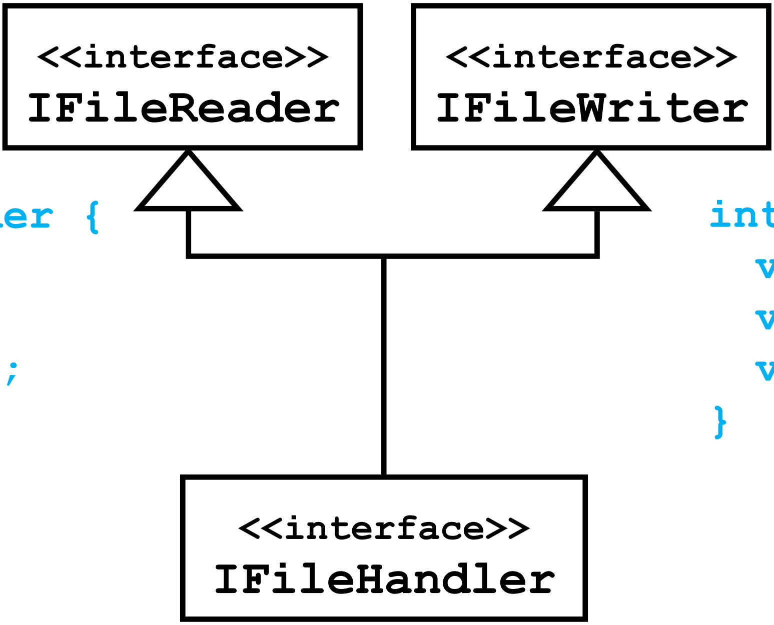
```
public interface IDriveable {
  void turn (int dir, int amt);
  void accelerate (int amt);
  void applyBrake (int amt);
  void startEngine ( );
  void shift (int newGear);
  double getFuelLevel ( );
}
```

```
public class Vehicle implements IDriveable {
  public void turn(int dir, int amt){...}
  public void accelerate (int amt) {...}
  public void applyBrake (int amt) {...}
  public void startEngine( ) {...}
  public void shift (int newGear) {...}
  public double getFuelLevel ( ) {...}
}
```

```
public class Car extends Vehicle {
  public void applyBrake (int amt) {...}
  public void startEngine ( ) {...}
  public void shift (int newGear) {...}
  public double getFuelLevel( ) {...}
  // Car doesn't need to specify "turn()" or "accelerate()"
  // because they are inherited from Vehicle
}
```

Interface Hierarchies

Interfaces can extend other interfaces



```
interface IFileReader {
  byte readByte();
  int readInt();
  String readLine();
}
```

```
interface IFileWriter {
  void writeByte ();
  void writeInt ();
  void writeString ();
}
```

```
interface IFileHandler extends IFileReader, IFileWriter {
  void open ();
  void close ( );
}
```

Problem

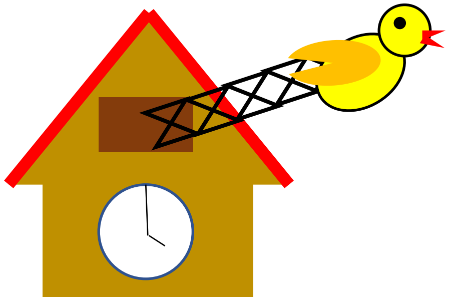
```
abstract class Animal {
  abstract void talk();
}

class Dog extends Animal {
  void talk() {
    System.out.println(“Woof!”);
  }
}

class Cat extends Animal {
  void talk() {
    System.out.println(“Meow!”);
  }
}
```

```
class Example {
  ...
  Animal animal = new Dog();
  Interrogator.makeItTalk(animal);
  animal = new Cat();
  Interrogator.makeItTalk(animal);
  ...
}
```

```
class Interrogator {
 static void
    makeItTalk(Animal subject) {
      subject.talk();
    }
}
```

Example after Bill Venners, www.javaworld.com

Reuse same function



- Bird is an animal it can talk:

```
class Bird extends Animal {
  void talk() {
    System.out.println("Tweet! Tweet!");
  }
}
```

- CuckooClock is a clock, it can talk too

```
class CuckooClock extends Clock {
  void talk() {
    System.out.println("Cuckoo! Cuckoo!");
  }
}
```

- Cannot pass a CuckooClock to Interrogator – it's not an animal.

```
makeItTalk(Animal subject) { ... }
```

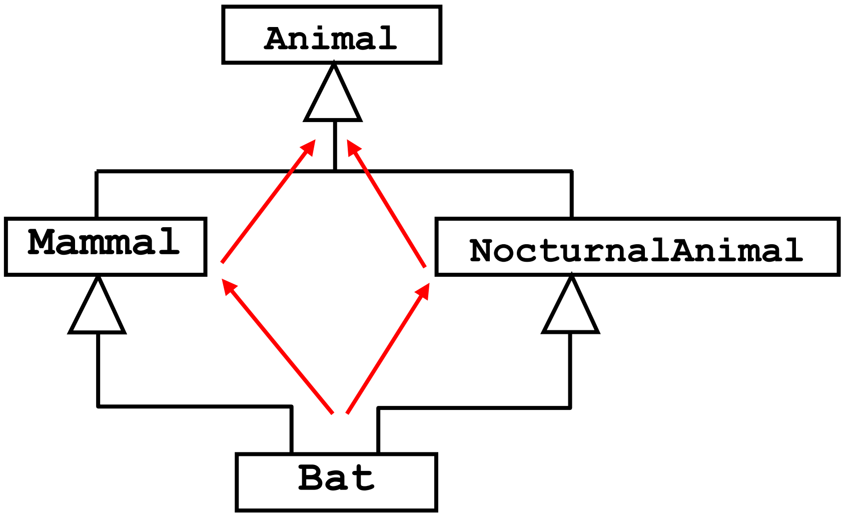
Multiple Inheritance?

Can we extend multiple class?

```
class CuckooClock extends Clock, Animal
```

Java did not support

And CuckooClock is not an animal!



A possible alternative Animal Hierarchy

Solution

Separate the interface and the abstract class

```
interface ITalkative {
 void talk();
}

abstract class Animal implements ITalkative {
 abstract void talk();
}

class Dog extends Animal {
 void talk() { System.out.println("Woof!"); }
}

class Cat extends Animal {
 void talk() { System.out.println("Meow!");
 }
}
```

Abstract Classes vs. Interfaces

Use of interfaces can *increase Polymorphism:*

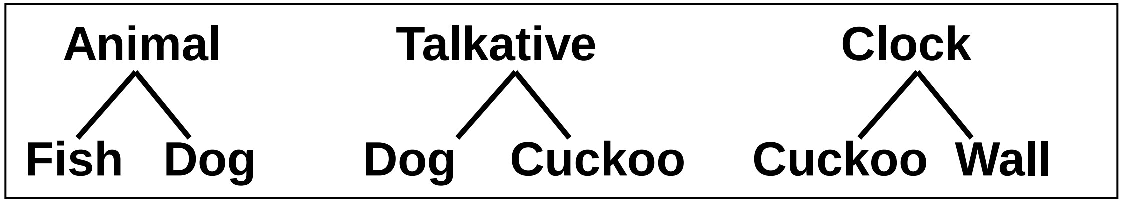
```
class CuckooClock extends Clock implements ITalkative {
  void talk() {
    System.out.println(“Cuckoo! Cuckoo!”);
  }
}
```

```
class Interrogator {
 static void makeItTalk(ITalkative subject) {
     subject.talk();
    }
}
```

Now we can pass a CuckooClock to an Interrogator!

Interfaces for multiple hierarchies

```
interface ITalkative {
  void talk();
}

abstract class Animal {
  abstract void move();
}
```



Animal
Fish Dog

Talkative
Dog Cuckoo

Clock
Cuckoo Wall

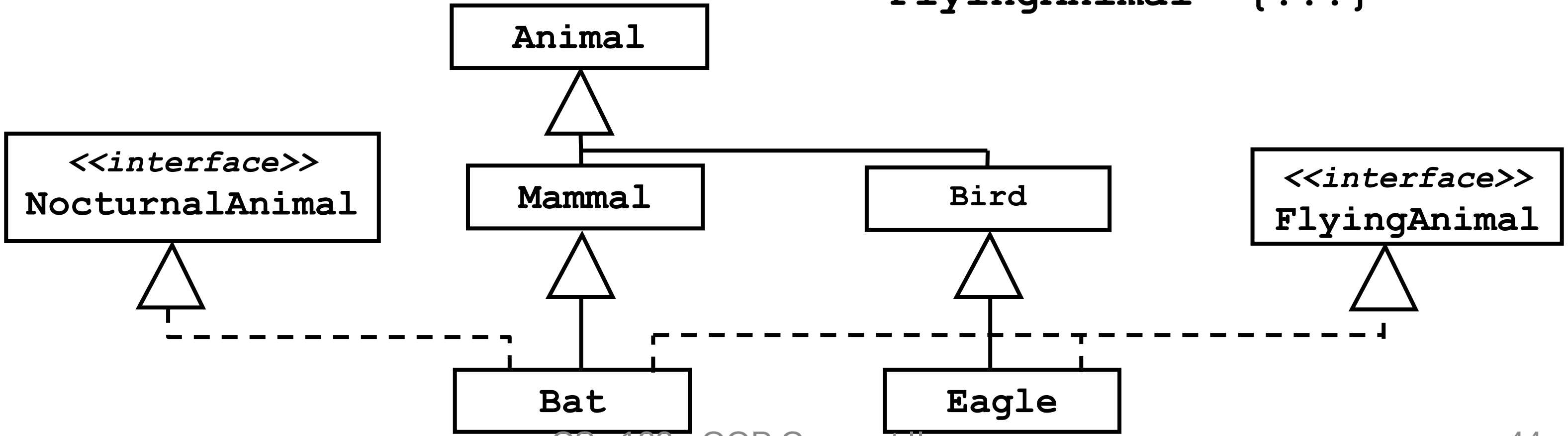
```
class Fish extends Animal { // not talkative!
  void move() { //code here for swimming }
}

class Dog extends Animal implements ITalkative {
  void talk() { System.out.println(“Woof!”); }
  void move() { //code here for walking/running }
}

class CuckooClock extends Clock implements ITalkative {
  void talk() { System.out.println(“Cuckoo!”); }
}
```

Multiple Inheritance via Interfaces

```
  public class Animal {...}
  public class Mammal extends Animal {...}
  public interface NocturnalAnimal {...}
  public class Bat extends Mammal implements NocturnalAnimal
{...}
```

and more:

```
  public interface FlyingAnimal {...}
  public class Bat extends Mammal implements NocturnalAnimal,
                                   FlyingAnimal  {...}
```



Abstract Class?

Abstract classes are a good choice when:

- There is a clear inheritance hierarchy to be defined (e.g. “kinds of animals”)
- We need non-public, non-static, or non-final fields OR private or protected methods
- Before Java 8:
  - There are at least *some* concrete methods shared between subclasses
  - We need to add new methods in the future (adding concrete methods to an abstract class does NOT break its subclasses)

Or Interface?

Interfaces are a good choice when:

- A class is an imagine concepts
  - Example: many classes implement “Comparable” or “Cloneable”; these concepts are not tied to a specific class
- Something like Multiple Inheritance is desired

Reference Type

1. Apparent type

- What does it look like at a particular place in program (changes).
- Reference type
- Determines what methods can be called

2. Actual type

- What was it created from (never changes)
- Determines which implementation to call

1

```
StaffMember [ ] staffList = new StaffMember[6];
staffList[0] = new SalariedEmployee (“Sam”);
```

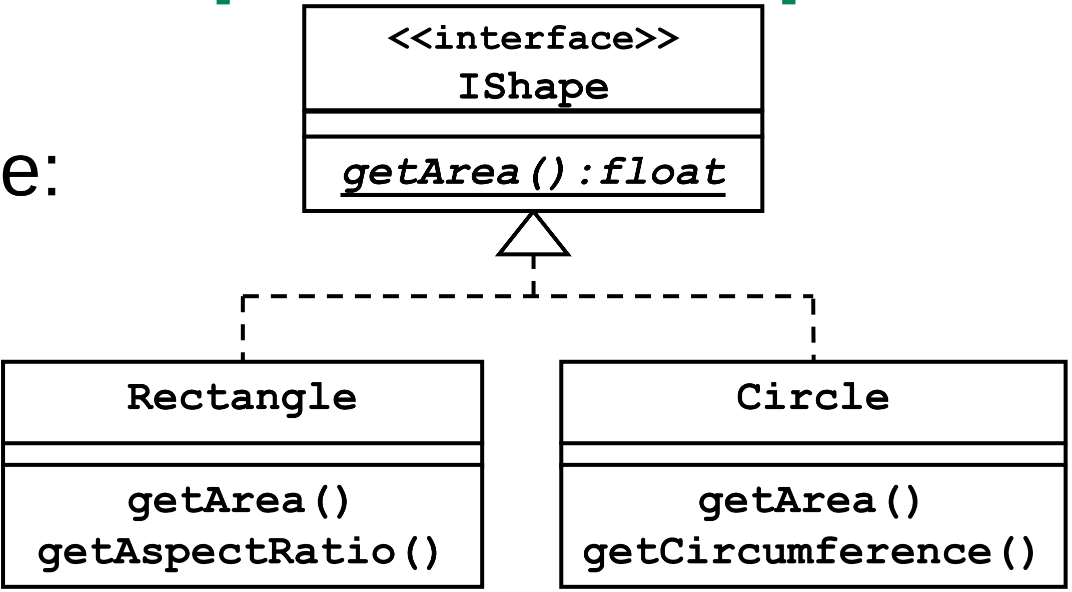
2

Interfaces and Polymorphism

```
IShape [ ] myThings = new IShape [10] ;
myThings[0] = new Rectangle();
myThings[1] = new Circle();
//...code here to add more rectangles, circles, or other
  “shapes”

for (int i=0; i<myThings.length; i++) {
  IShape nextThing = myThings[i];
  process ( nextThing );
}
...
void process (IShape aShape) {
  // code here to process a IShape object, making calls to
  IShape methods.
  // Note this code only knows the apparent type, and only
  IShape methods
  // are visible - but any methods invoked are those of the
  actual type.
}
```

Interface Polymorphism Example

- Suppose we have:



<<interface>>
IShape

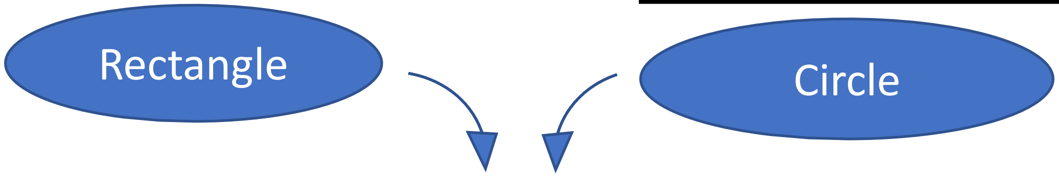
getArea():float

Rectangle

getArea()
getAspectRatio()

Circle

getArea()
getCircumference()



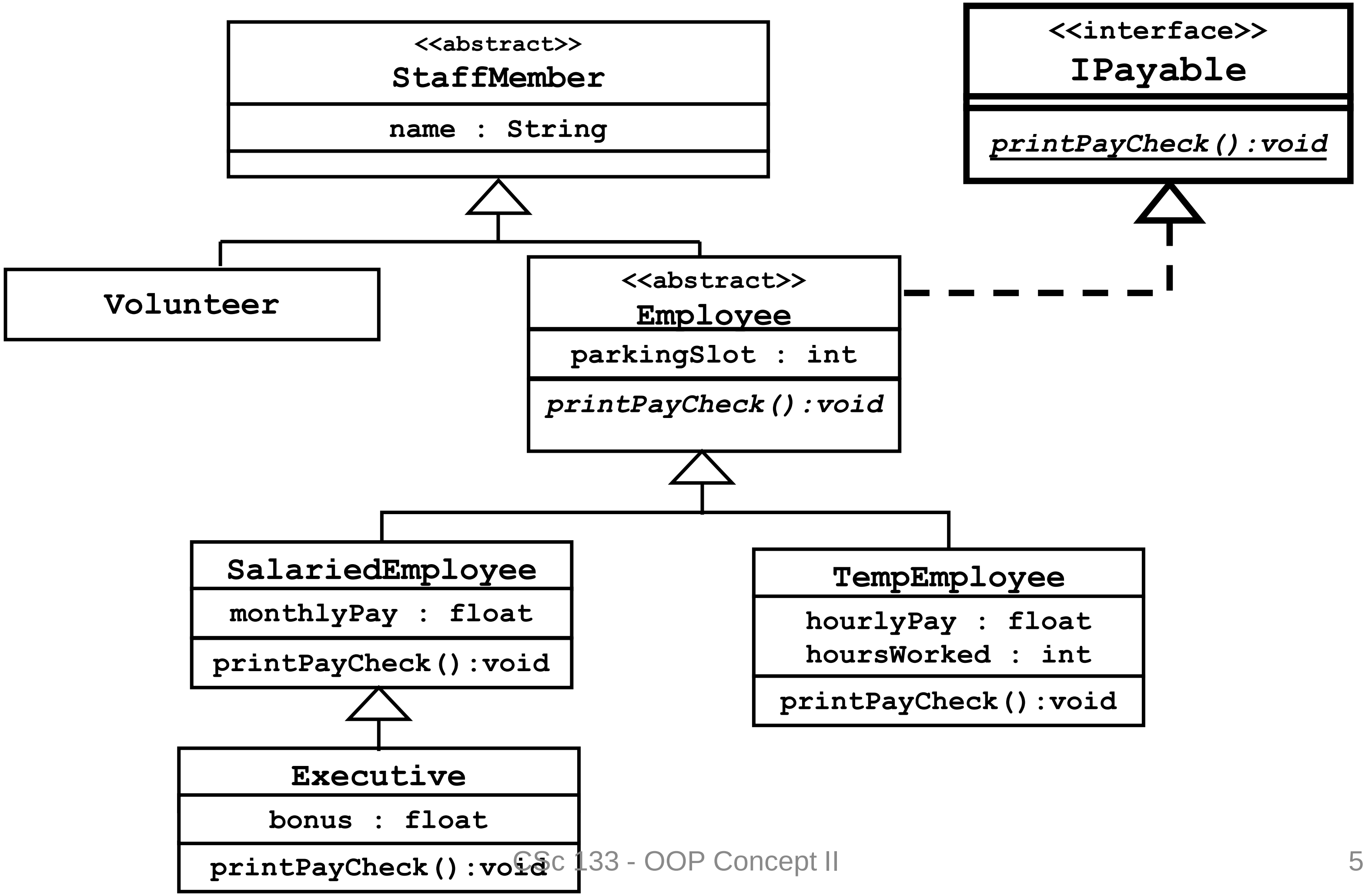
Rectangle

Circle

```
void process (IShape s) {
   ...
   s.getArea();          //legal; all IShapes have getArea()
   ...
   s.getAspectRatio(); //illegal,  even if 's' is a Rectangle
                       //  (generates a compiler error)
}
```

Polymorphic Safety Revisited

- StaffMember hierarchy using Interfaces:



Interface Polymorphic Safety

```
public class StaffMember {
   ...
}

public interface IPayable {
   public void printPayCheck() ;
}

//Every kind of "Employee" IS-A "payable" (must provide printPayCheck())
public abstract class Employee extends StaffMember implements IPayable
{
   ...
   abstract public void printPayCheck() ;
}
```

```
//client using interface polymorphism to safely print paychecks:
for (int i=0; i<staffList.length; i++) {
   if (staffList[i] instanceof IPayable)
      ((IPayable)staffList[i]).printPayCheck() ;
}
```

CN1 Predefined Interfaces

- CN1 provide built-in interfaces class
  - You can also implement them

Examples:

```
interface Shape {
  boolean contains(int x, int y);
  Rectangle getBounds();
  Shape intersection(Rectangle rect);
  //other methods...
}
interface Comparable {
  int compareTo (Object otherObj);
}
```

Any Questions?