CSc 133 Lecture Notes

6 - Interfaces

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Overview

- **Class Interfaces, UML Interface Notation, The Java *Interface* Construct**
- **Predefined Interfaces**
- **Interface Hierarchies**
- **Interface Subtypes**
- **Interfaces and Polymorphism**
- **Abstract Classes vs. Interfaces**
- **Multiple Inheritance via Interfaces**

Interface (Java) - Definition

An interface in the Java programming language is an abstract type that is used to specify a behavior that classes must implement. They are similar to protocols.

Interfaces are declared using the interface keyword, and may only contain method signature and constant declarations (variable declarations that are declared to be both static and final).

Source: https://en.wikipedia.org/wiki/Interface_(Java)

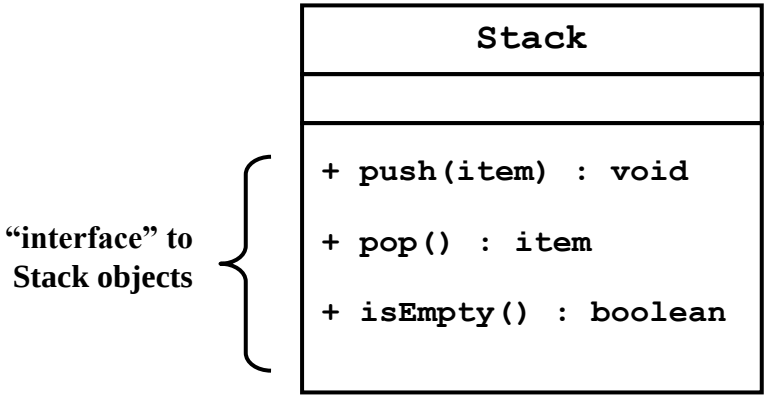
It is basically a **contract** or a promise the class has to make.

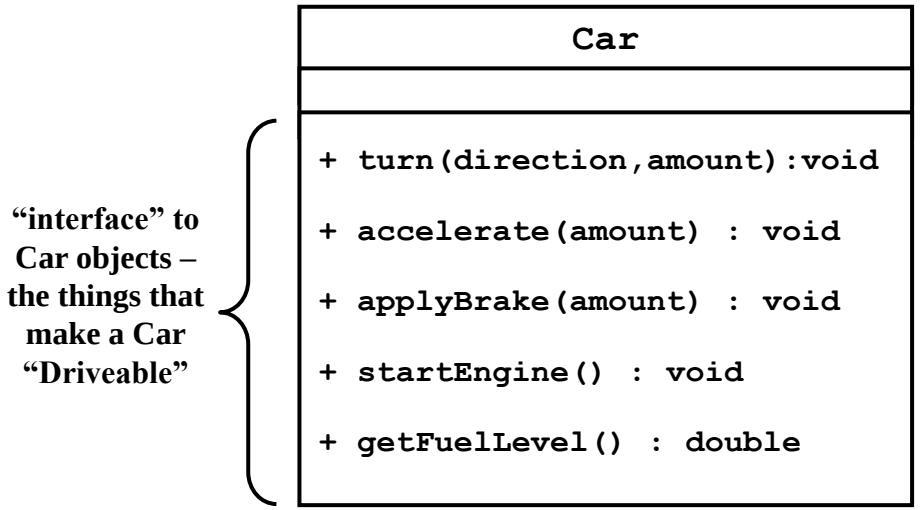
All methods of an Interface do not contain implementation (method bodies) as of all versions below Java 8.

CLASS INTERFACES

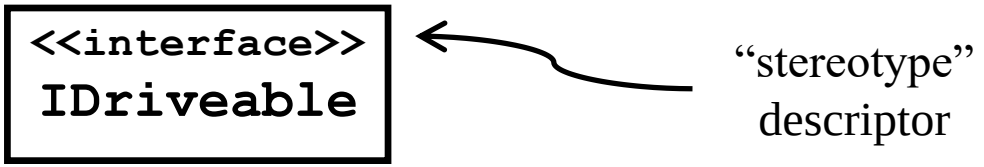
Every class definition creates an “interface”

- The exposed (non-private) parts of an object





UML Interface Notation



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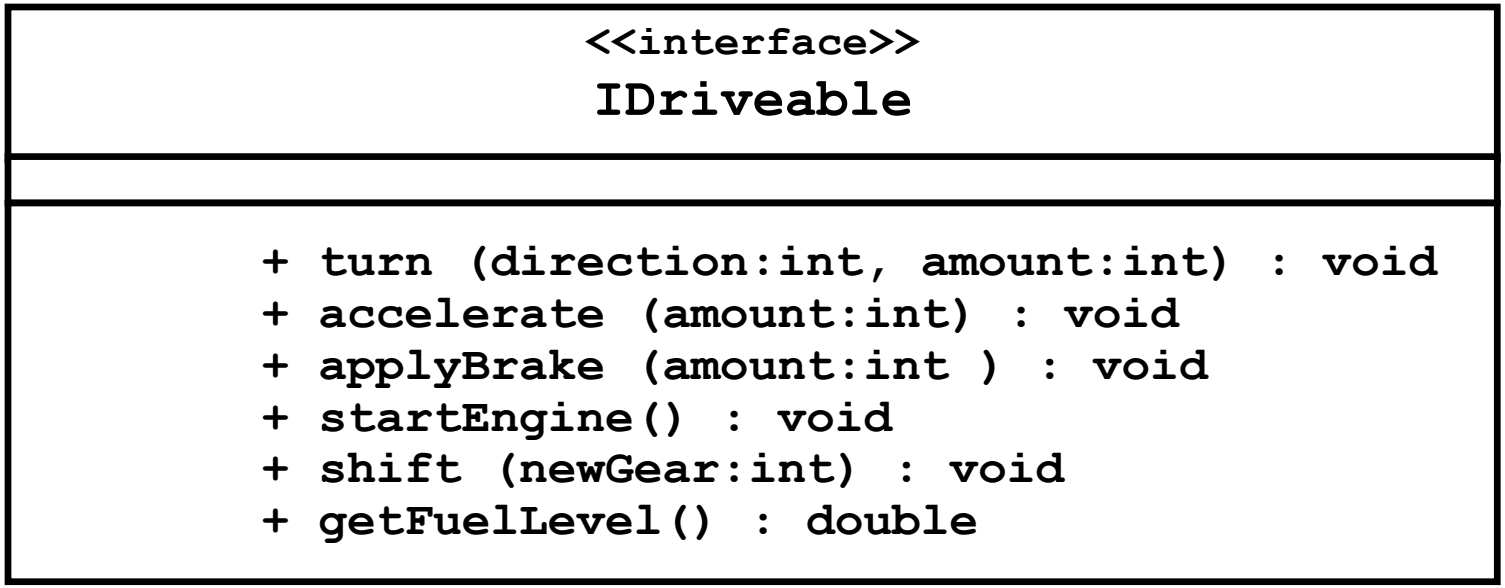
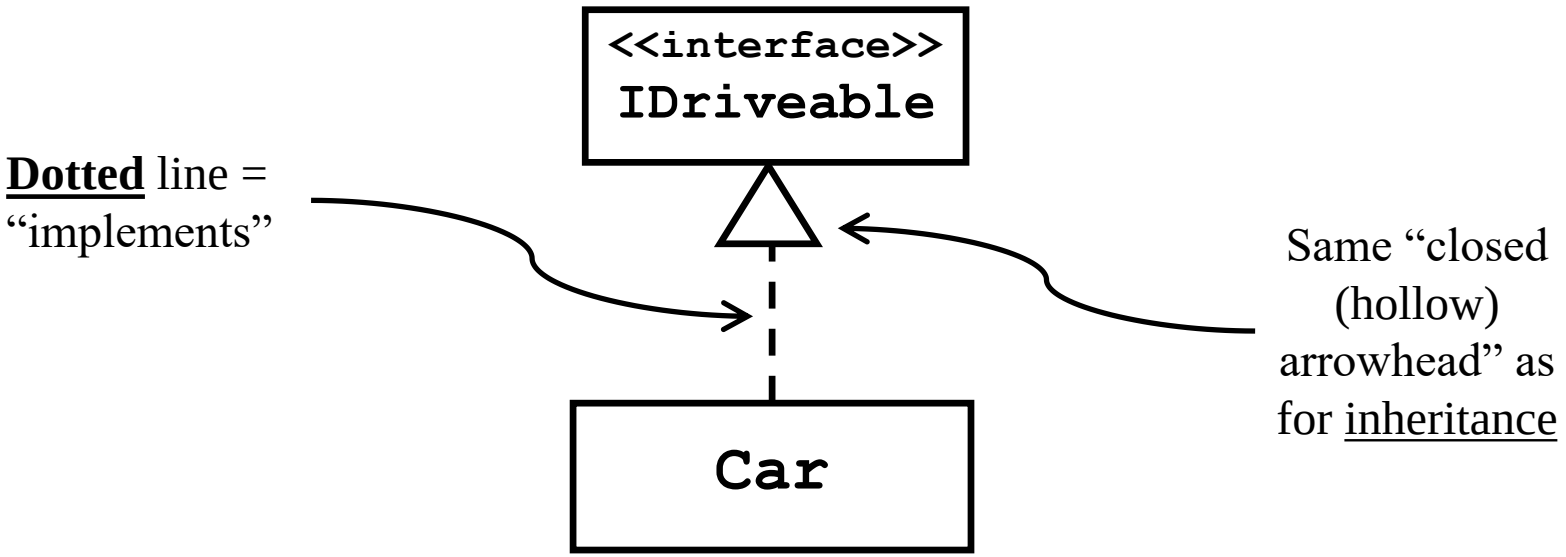


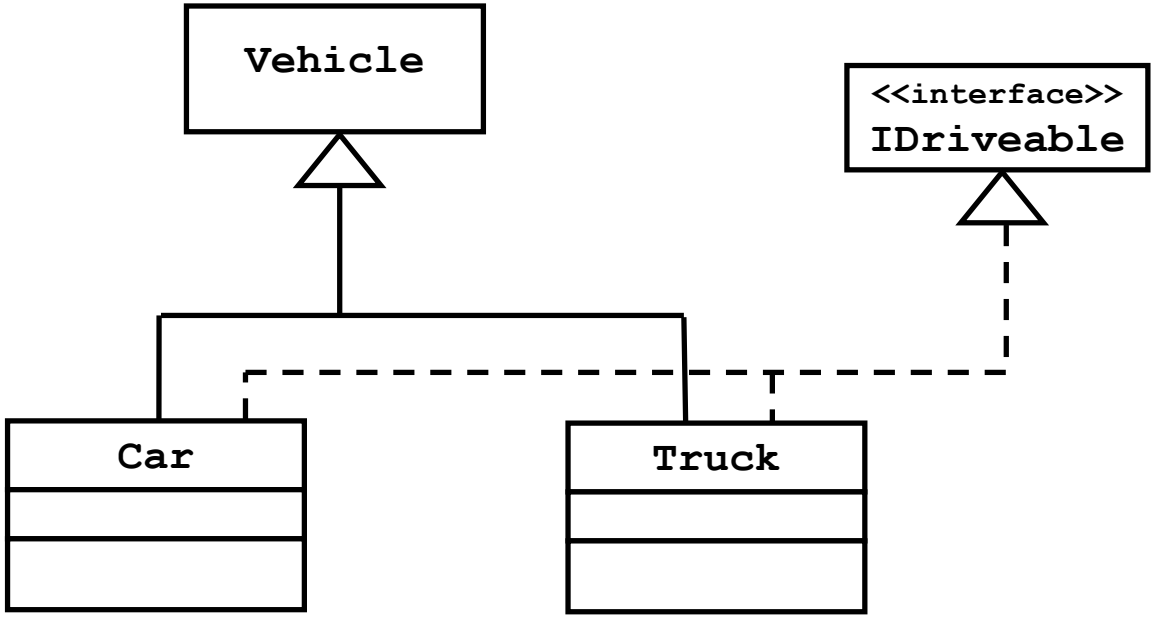
UML Interface Notation (cont.)

- **Class `Car` implements interface `"IDriveable"`:**



UML Interface Notation (cont.)

- Car and Truck both derive from "`Vehicle`"
- Car and Truck both implement "`IDriveable`"



Java *Interface* construct

Characteristics of a class "interface" :

- Defines a set of methods with specific signatures
  - All methods are **public**
- Usually does *not* specify any *implementation* *(generally have abstract methods)*
  - *Java 8 introduced "default" and "static" interface methods that have body*
- Can have fields
  - All fields are **public** AND **static** AND **final**

(default visibility for interface fields and methods is public instead of package-private)

Java *Interface* construct (cont.)

Java allows specification of an "interface" independently from any particular class:

```
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

Classes can agree to "implement" an interface:

```
public class Car extends Vehicle implements IDriveable {
    public void turn (int direction, int amount) {...}
    public void accelerate (int amount) {...}
    public void applyBrake (int amount) {...}
    public void startEngine() {...}
    public void shift (int newGear) {...}
    public double getFuelLevel ( ) {...}
    /*... other Car methods (if any) here ... */
}
```

- "**`implements`**" in a concrete class == "provides bodies for all abstract methods"
- *Compiler checks!*

Using Java Interfaces (cont.)

Multiple classes may provide the same *interface* but with different *implementations*

- **Example: Truck also implements "`IDriveable`" – but in a different way:**

```
public class Truck extends Vehicle implements IDriveable {

    public void turn (int direction, int amount) {...}
    public void accelerate (int amount) {...}

    public void applyBrake (int amount)
      { different code here to apply Truck brakes... }
    public void startEngine()
      { truck engine startup code... }
    public void shift (int newGear)
      { truck shifting code... }
    public double getFuelLevel ( )
      { code to check multiple fuel tanks... }

    /*... other Truck methods here ... */
}
```

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
}
```

"Interfaces" In C++

- **"Abstract" Methods:**

```
virtual void turn (int direction, int amount) = 0 ;
```

- **"Abstract" Classes :**

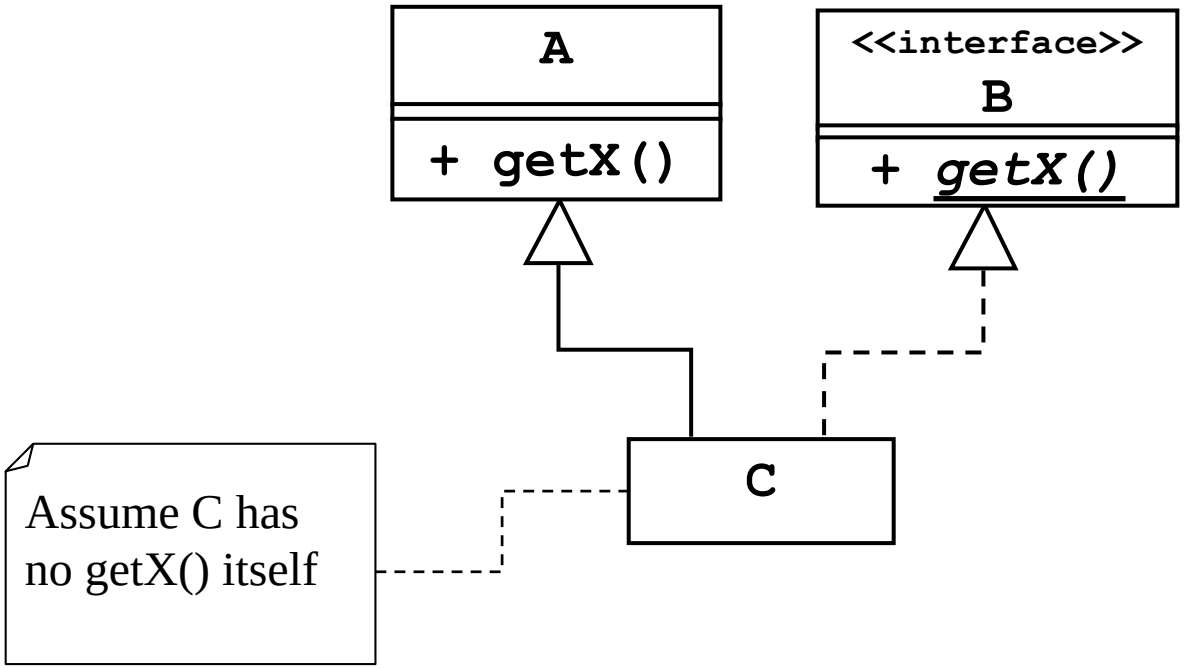
```
class IDriveable {
  public:
        virtual void turn (int direction, int amount) = 0 ;
        virtual void accelerate (int amount) = 0 ;
        ...
};
```

- **"Abstract" Classes as Interfaces :**

```
class Vehicle { ... };
class Car : public IDriveable, Vehicle
{ ... };
```

Quiz:

Which **`getX()`** is called in objects of type C?



Predefined Interfaces in CN1

- **Many CN1 Classes implement built-in interfaces**
- **User Classes can also implement them**

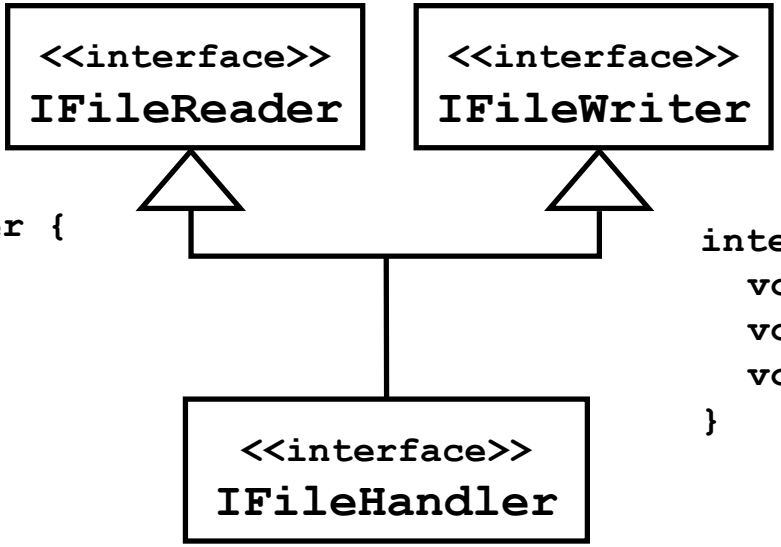
Examples:

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

```
interface Comparable {
  int compareTo (Object otherObj);
}
```

Interface Hierarchies

Interfaces can *extend* other interfaces




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

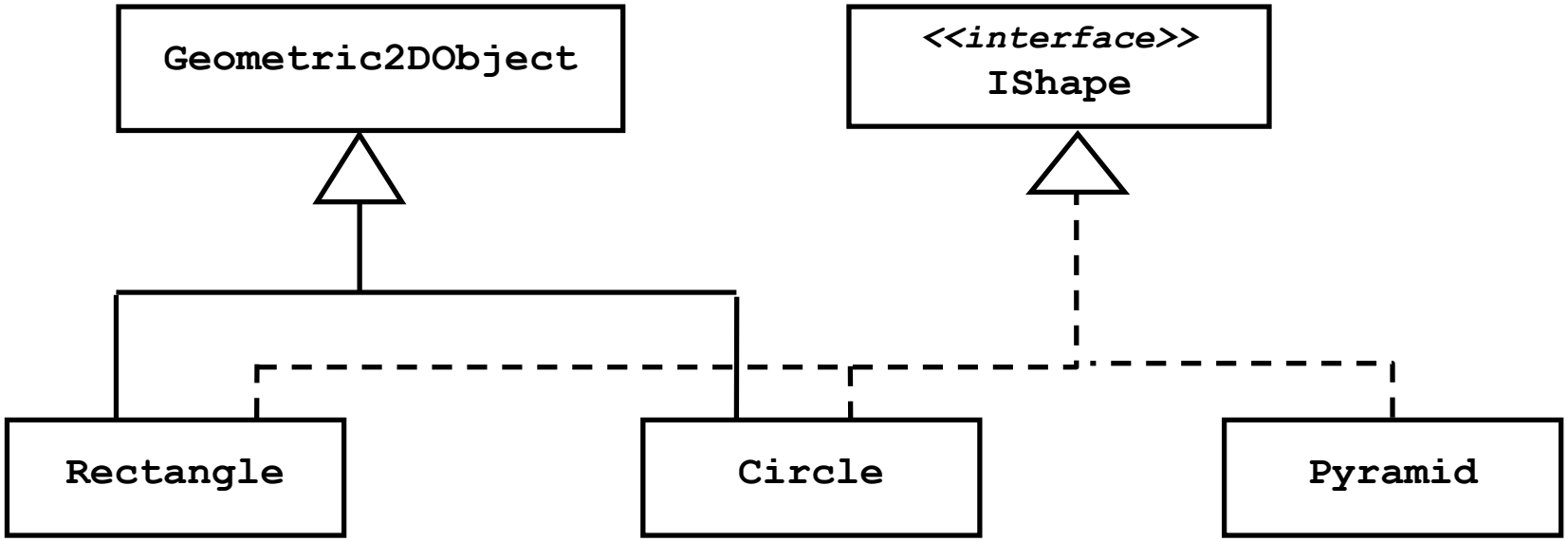
```
interface IFileWriter {
  void writeByte (byte b);
  void writeInt (int theInt);
  void writeString (String s);
}
```

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

Interface Subtypes

If a Class implements an Interface, it is considered a "subtype" of the "interface type":

- **A Circle "IS-A" Geometric2DObject**
- **A Circle "IS-A" IShape**



Interface Subtypes (cont.)

- **Objects can be upcast to *interface types:***

```
Circle myCircle = new Circle();
IShape myShape = (IShape) myCircle ;
```

- **Interfaces, like superclasses, provide objects with:**

  "apparent type" vs. *"actual type"*

- ***Variable of interface type, like superclass type, can hold many different types of objects!***

Interfaces and Polymorphism

- *Apparent* type = What does it look like at a particular place in program (changes).

Determines: What methods may be invoked

- *Actual* type = What was it created from (never changes)

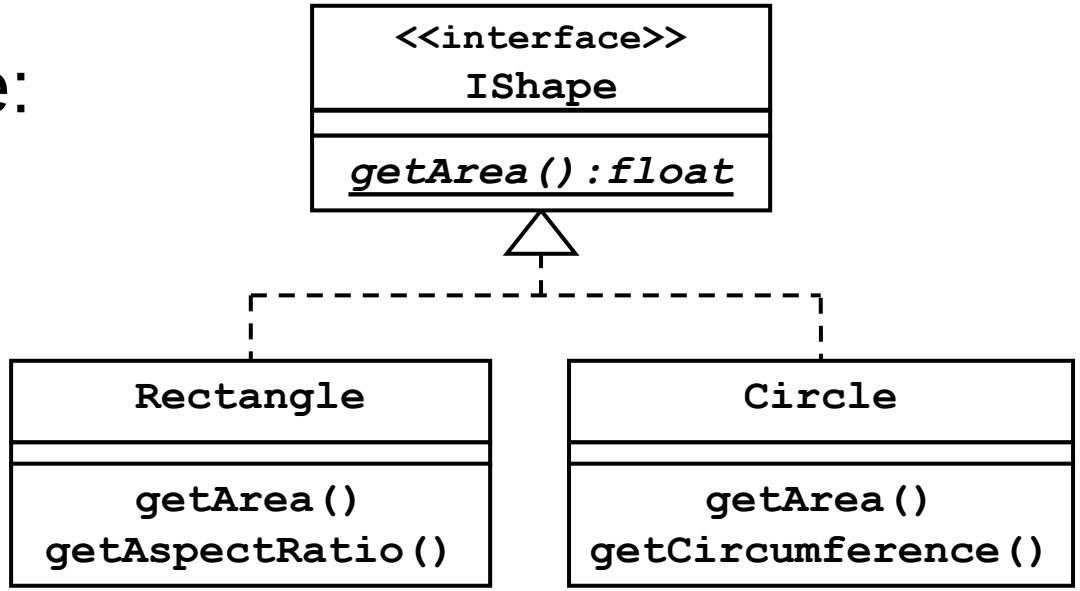
Determines: Which implementation to call when the method is invoked

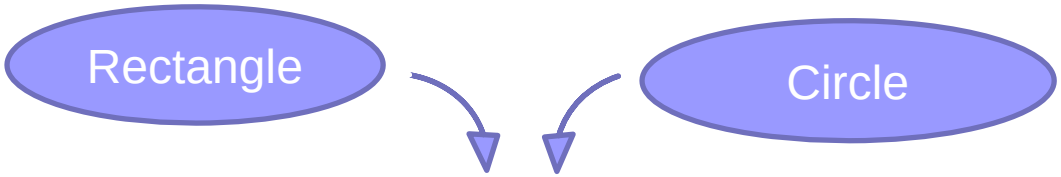
```
IShape [ ] myThings = new IShape [10] ;
myThings[0] = new Rectangle();
myThings[1] = new Circle();
//...code here to add more rectangles, circles, or other "shapes"

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:

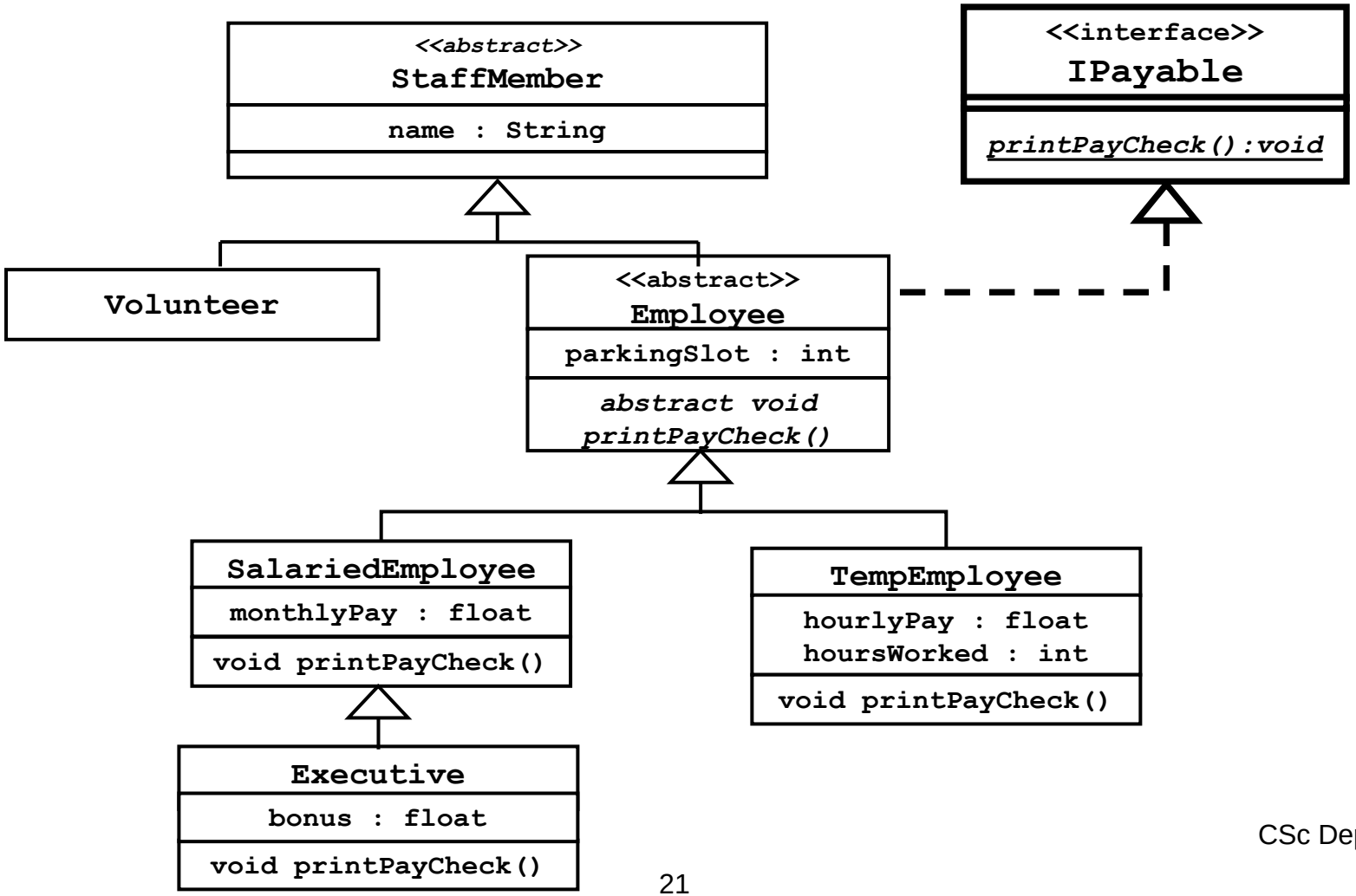





```
void process (IShape s) {
   ...
   s.getArea();              //legal; all IShapes have getArea()
   ...
   s.getAspectRatio();       //illegal,  even if 's' is a Rectangle
                             //  (generates a compiler error)
}
```

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() ;
}
```

Abstract Classes vs. Interfaces

```
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

Abstract Classes vs. Interfaces (cont.)

- We can easily add a Bird and "make it talk":

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

- Making a CuckooClock "talk" is a problem:

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

We can't pass a CuckooClock to Interrogator – it's not an animal.

And it is illegal (in Java) to also extend animal (can only "extend" once!)

Abstract Classes vs. Interfaces (cont.)

The interface of an abstract class can be separated:

```
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 (cont.)

Use of interfaces can *increase Polymorphism:*

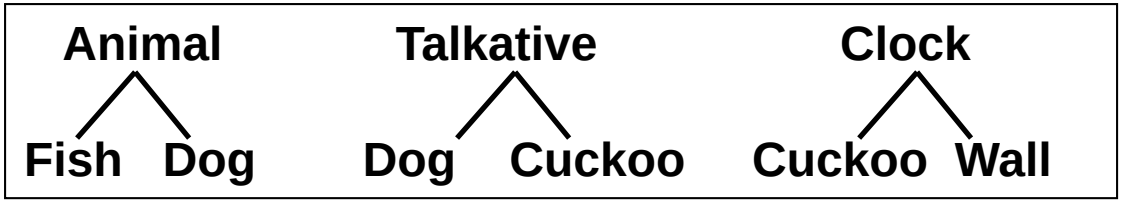
```
class CuckooClock extends Clock implements ITalkative {
  void talk() {
    System.out.println("Cuckoo! Cuckoo!");
  }
}


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

Now we can pass a CuckooClock to an Interrogator!

Abstract Classes vs. Interfaces (cont.)

Interfaces allow for *multiple hierarchies*:




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

abstract class Animal {
  abstract void move();
}

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!"); }
}
```

Abstract Class vs. Interface: Which?

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)

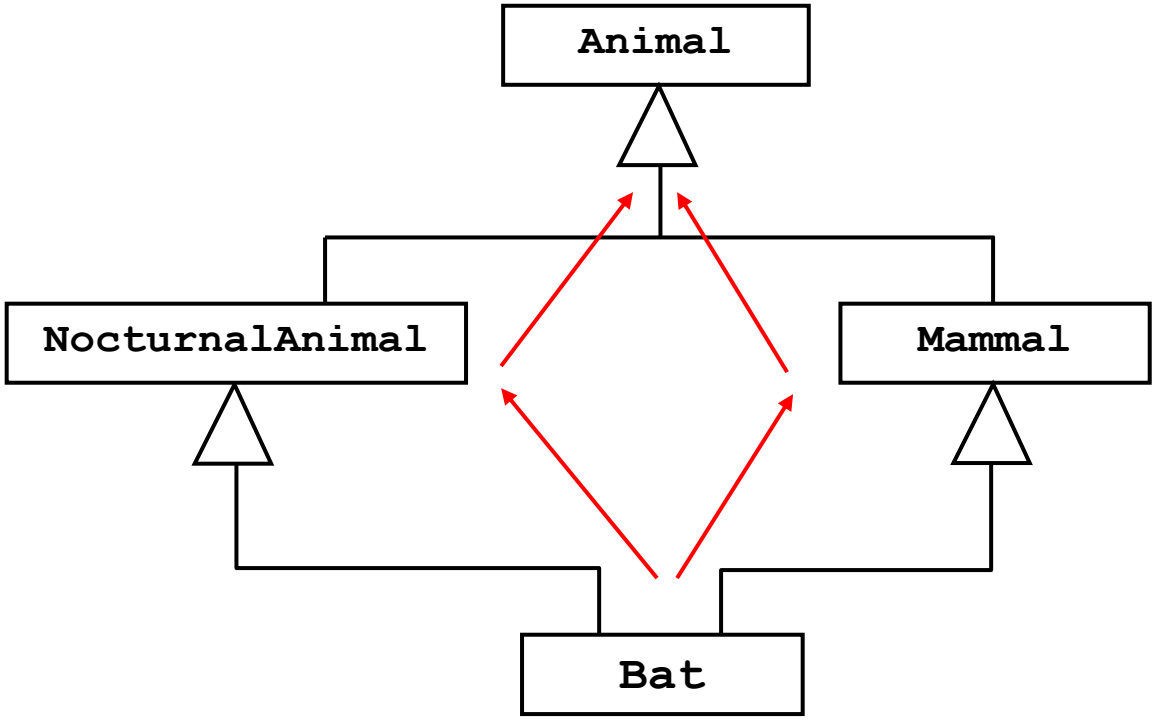
Abstract Class vs. Interface: Which?

Interfaces are a good choice when:

- The relationship between the methods and the implementing class is not extremely strong
  - Example: many classes implement “Comparable” or “Cloneable”; these concepts are not tied to a specific class
- Before Java 8:
  - An API is likely to be stable (again: adding interface methods *breaks implementing classes)*
- Something like Multiple Inheritance is desired

(see next slides…)

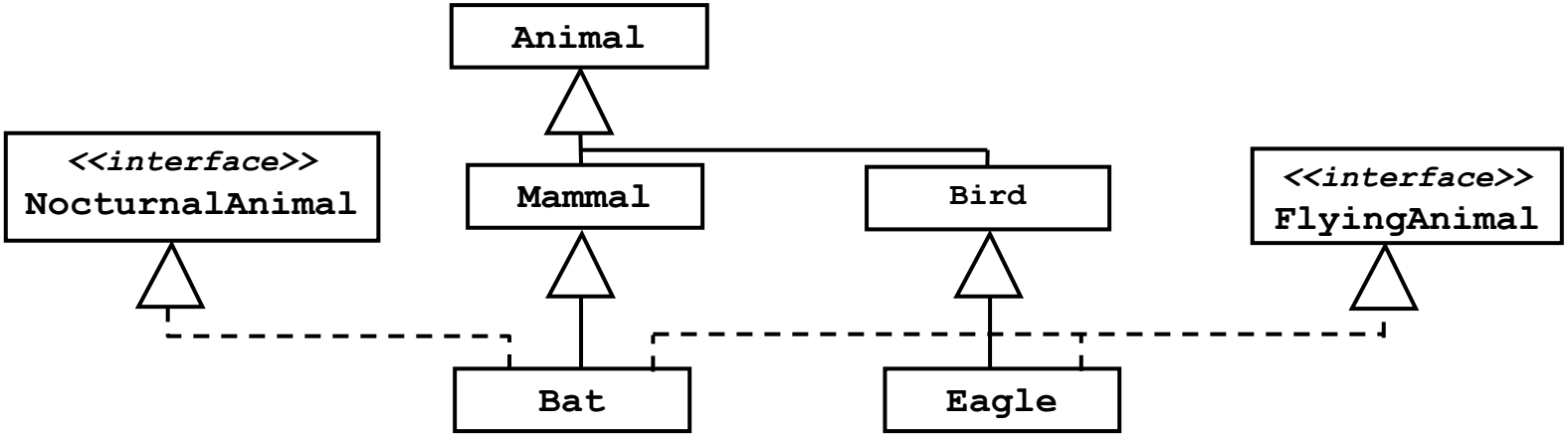
Multiple Inheritance Revisited



A possible alternative Animal Hierarchy

Multiple Inheritance via *Interfaces*

Can say this exactly in Java:




```
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  {...}
```

Does Java support multiple inheritance?

- Of interfaces – Yes
- Of implementations – No (before Java 8)