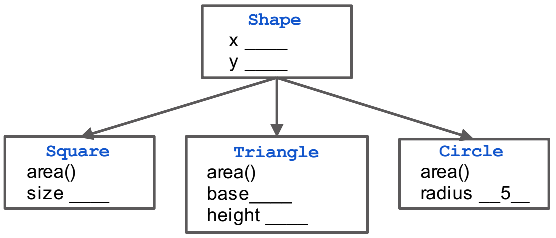
Recitation 4

Abstract classes, Interfaces

A Little More Geometry!



Demo 1: Complete this function

```
/** Return the sum of the areas of
  * the shapes in s */
static double sumAreas(Shape[] s) { }
```

1. Operator `instanceof` and casting are required
2. Adding new `Shape` subclasses breaks `sumAreas`

A Partial Solution:

Add method area to class Shape:

```
public double area() {
      return 0;
}

public double area() {
      throw new RuntimeException("area not
overridden");
}
```

Problems not solved

1. What is a Shape that isn't a Circle, Square, Triangle, etc? What is *only* a shape, nothing more specific?
   a. `Shape s= new Shape(...);` Should be disallowed

2. What if a subclass doesn't override area()?
   a. Can't force the subclass to override it!
   b. Incorrect value returned or exception thrown.

Solution: Abstract classes

Abstract class
Means that it can't be instantiated.
`new Shape()` illegal

```
public abstract class Shape {

    public double area() {
    return 0;
  }
}
```

Solution: Abstract methods

```
public abstract class Shape {

  public abstract double area();

}
```

Abstract method
Subclass must override.

- Can also have implemented methods
- Place abstract method only in abstract class.
- Semicolon instead of body.

Demo 2: A better solution

We modify class Shape to be abstract and make `area()` an abstract method.

- Abstract class prevents instantiation of class Shape
- Abstract method forces all subclasses to override `area()`

Abstract Classes, Abstract Methods

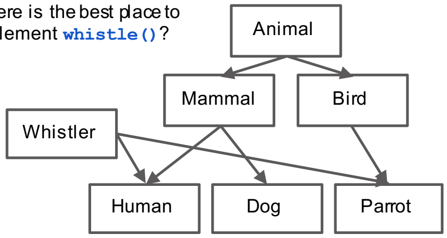
1. **Cannot instantiate an object of an abstract class.**
   (Cannot use new-expression)

2. **A subclass must override abstract methods.**

Interfaces

Problem

Where is the best place to implement **`whistle()`**?

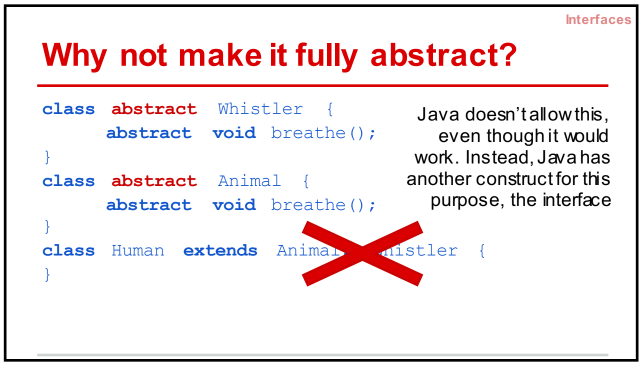


No multiple inheritance in Java!

```
class Whistler {
     void breathe() { … }
}
class Animal {
     void breathe() { … }
}
class Human extends Animal, Whistler {
}
```

`new Human().breathe();`

Which breathe() should java run in class Human?

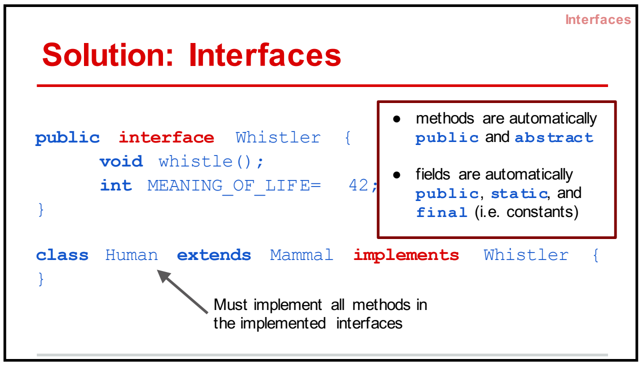


Interfaces

Why not make it fully abstract?

```
class abstract Whistler {
      abstract void breathe();
}
class abstract Animal {
      abstract void breathe();
}
class Human extends Animal, Whistler {
}
```

Java doesn't allow this, even though it would work. Instead, Java has another construct for this purpose, the interface



Interfaces

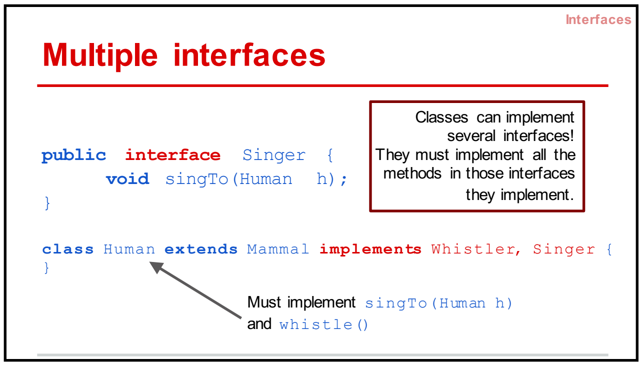
Solution: Interfaces

```
public interface Whistler {
      void whistle();
      int MEANING_OF_LIFE= 42;
}

class Human extends Mammal implements Whistler {
}
```

- methods are automatically `public` and `abstract`
- fields are automatically `public`, `static`, and `final` (i.e. constants)

Must implement all methods in the implemented interfaces



Interfaces

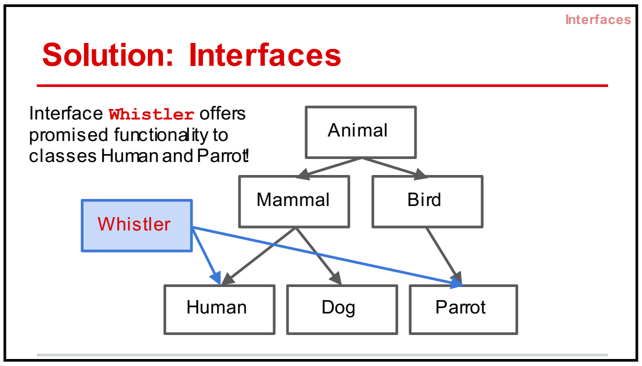
Multiple interfaces

```
public interface Singer {
      void singTo(Human h);
}

class Human extends Mammal implements Whistler, Singer {
}
```

Classes can implement several interfaces! They must implement all the methods in those interfaces they implement.

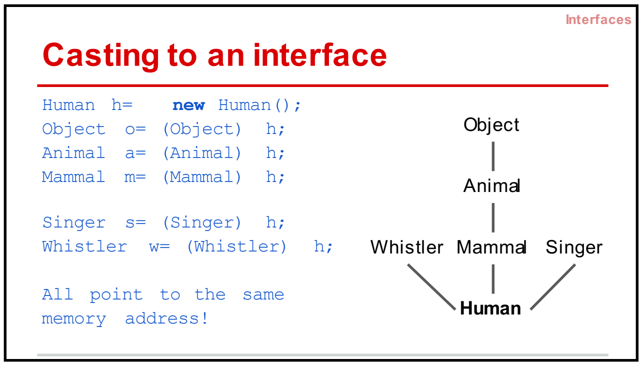
Must implement `singTo(Human h)` and `whistle()`



Interfaces

Solution: Interfaces

Interface **Whistler** offers promised functionality to classes Human and Parrot!



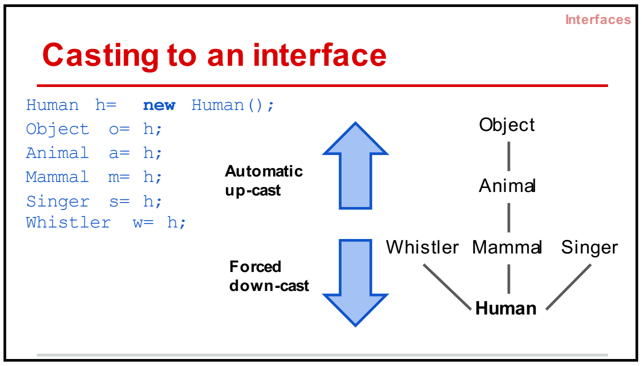
Interfaces

Casting to an interface

```
Human h= new Human();
Object o= (Object) h;
Animal a= (Animal) h;
Mammal m= (Mammal) h;

Singer s= (Singer) h;
Whistler w= (Whistler) h;

All point to the same
memory address!
```



Interfaces

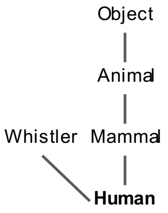
Casting to an interface

```
Human h= new Human();
Object o= h;
Animal a= h;
Mammal m= h;
Singer s= h;
Whistler w= h;
```

Interfaces

Casting up to an interface automatically

```
class Human … implements Whistler {
   void listenTo(Whistler w) {...}
}
Human h = new Human(...);
Human h1= new Human(...);
h.listenTo(h1);
```



Arg h1 of the call has type Human. Its value is being stored in w, which is of type Whistler. Java does an upward cast automatically. It costs no time; it is just a matter of perception.

Demo 3: Implement `Comparable<T>`

Implement interface Comparable in class Shape:

```
public interface Comparable<T> {
  /** = a negative integer if this object < c,
      = 0 if this object = c,
      = a positive integer if this object > c.
      Throw a ClassCastException if c can’t
           be cast to the class of this object.
   */
  int compareTo(T c);
}
```

Shape implements `Comparable<T>`

```
public class Shape implements Comparable<Shape> {
    ...
    /** … */
    public int compareTo(Shape s) {
       double diff= area() - s.area();
       return (diff == 0 ? 0 : (diff < 0 ? -1 : +1));
    }
}
```

Beauty of interfaces

`Arrays.sort` sorts an array of *any* class C, as long as C implements interface `Comparable<T>` without needing to know any implementation details of the class.

Classes that implement Comparable:

```
Boolean    Byte        Double      Integer
String     BigDecimal  BigInteger  Calendar
Time       Timestamp   and 100 others
```

String sorting

`Arrays.sort(Object[] b)` sorts an array of *any* class C, as long as C implements interface `Comparable<T>`.

`String` implements `Comparable`, so you can write

```
   String[] strings= ...;
   ...
   Arrays.sort(strings);
```

During the sorting, when comparing elements, a String’s compareTo function is used

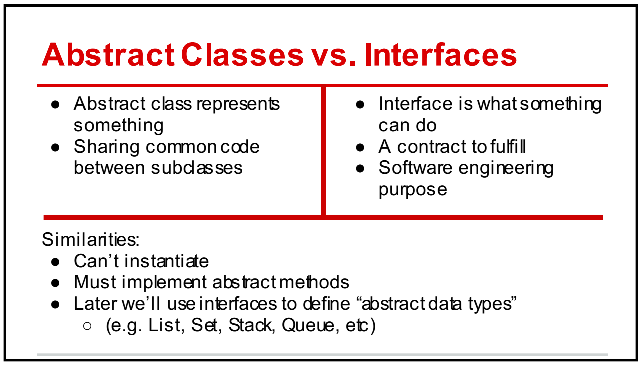
And Shape sorting, too!

`Arrays.sort(Object[] b)` sorts an array of *any* class C, as long as C implements interface `Comparable<T>`.

`Shape` implements `Comparable`, so you can write

```
   Shape[] shapes= ...;  ...
   Arrays.sort(shapes);
```

During the sorting, when comparing elements, a Shape’s compareTo function is used



Abstract Classes vs. Interfaces

- Abstract class represents something
- Sharing common code between subclasses

- Interface is what something can do
- A contract to fulfill
- Software engineering purpose

Similarities:

- Can't instantiate
- Must implement abstract methods
- Later we'll use interfaces to define "abstract data types"
    - (e.g. List, Set, Stack, Queue, etc)