CSE 143 Java

Inheritance

Reading: Ch. 9, 14

Composition: "has a"

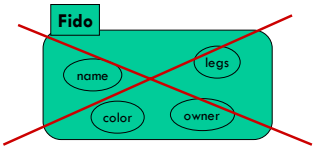
- Classes and objects can be related in several ways
- One way: *composition*, *aggregation*, or *reference*
- Dog has-a owner, dog has legs, dog has collar, etc.
- In java: one object refers to another object
  - via an instance variable

```
public class Dog {
    private String name;   /        // this dog's name
    private int  age;                //this dog's age
    private Person owner;            // this dog's owner
    private Dog mother,  father;     // this dog's parents
    private Color coatColor;         //etc, etc.
}
```

- One can think of the dog as "composed" of various objects: "composition"

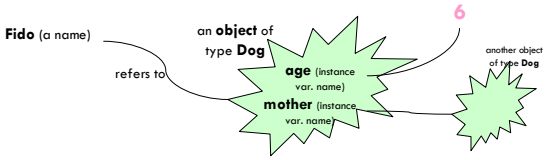
Picturing the Relationships

- Dog Fido; //might be 6 years old, brown, owned by Marge, etc.
- Dog Apollo; //might be 2 years old, missing a leg, etc.
- In Java, it is a mistake to think of the parts of an object as being "inside" the whole.



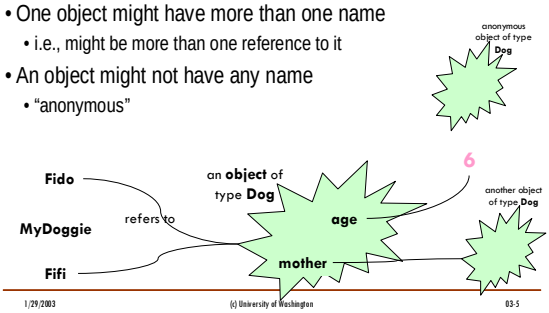
Drawing Names and Objects

- Names and objects
  - Very different things!
- In general, names are applied to objects
  - Objects can *refer* to other objects using instance variable names



Drawing Names and Objects

- A name might not refer to any object
- One object might have more than one name
  - i.e., might be more than one reference to it
- An object might not have any name
  - "anonymous"



Specialization – "is a"

- Specialization relations can form *classification hierarchies*
  - cats and dogs are special kinds of mammals;
    mammals and birds are special kinds of animals;
    animals and plants are special kinds of living things
  - lines and triangles are special kinds of polygons;
    rectangles, ovals, and polygons are special kinds of shapes
- Keep in mind: Specialization is not the same as composition
  - A cat "is-an" animal vs. a cat "has-a" tail

"is-a" in Programming

- Classes &/or interfaces can be related via *specialization*
  - one class/interface is *a special kind of* another class/interface
  - Rectangle class is a kind of Shape
- So far, we have seen one Java technique to capture this idea: interfaces
- Java interfaces are one special case of a more general design approach: Inheritance

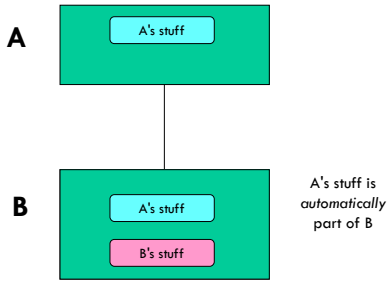
Inheritance

- Java provides direct support for "is-a" relations
  - likewise C++, C#, and other object-oriented languages
- Class ***inheritance***
  - one class can **inherit from** another class,
    meaning that it's is a special kind of the other
- Terminology
  - Original class is called the **base class** or **superclass**
  - Specializing class is called the **derived class** or **subclass**

Inheritance: The Main Programming Facts

- Subclass **inherits** all instance variables and methods of the inherited class
  - All instance variables and methods of the superclass are *automatically* part of the subclass
  - Constructors are a special case (later)
- Subclass can **add** additional methods and instance variables
- Subclass can provide **different versions** of inherited methods

B extends A



Interfaces vs. Class Inheritance

- An interface is a simple form of inheritance
- If B **implements** interface A, then B inherits the stuff in A (which is nothing but the method signatures of B)
- If B **extends** class A, then B inherits the stuff in A (which can include method code and instance variables)
- To distinguish the two, people sometimes say "interface inheritance" vs. "class inheritance".
- What if you heard the phrase "code inheritance"?

Example: Representing Animals

- Generic Animal

```
public class Animal {
   private int numLegs;

   /** Return the number of legs */
   public int getNumLegs( ) {
      return this.numLegs;
   }

   /** Return the noise this animal makes */
   public String noise( ) {
      return "?";
   }
}
```

Specific Animals

• Cats

```
public class Cat extends Animal {
  // inherit numLegs and getNumLegs()

  // additional inst. vars and methods
  ....

  /** Return the noise a cat makes */
  public String noise( ) {
    return "meow";
  }
}
```

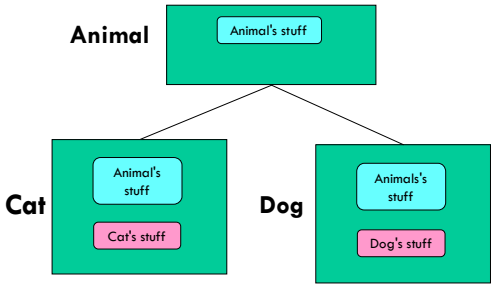
• Dogs

```
public class Dog extends Animal {
  // inherit numLegs and getNumLegs()

  // additional inst. vars and methods
  ....

  /** Return the noise a dog makes */
  public String noise( ) {
    return "WOOF!!";
  }
}
```

Cat extends Animal / Dog extends Animal



More Java

If class D extends B /inherits from B...

- Class D ***inherits*** all methods and fields from class B
- But... "all" is too strong
  - constructors are *not* inherited
  - same is true of static methods and static fields
    - although these static members are still available in the subclass
- Class D may contain additional (new) methods and fields
  - But has no way to delete any

Never to be Forgotten

If class D extends/inherits from B...

Every object of type D is also an object of type B

- a D can do anything that a B can do (because of inheritance)
- a D can be used in any context where a B is appropriate

Method Overriding

- If class D extends B, class D may provide an *alternative*, *replacement* implementation of any method it would otherwise inherit from B
- The definition in D is said to ***override*** the definition in B

- An overriding method cannot change the number of arguments or their types, or the type of the result [why?]
  - can only provide a different body
- Can you override an instance variable?
  - Not exactly... ask me in person if you're really curious

Polymorphism

- *Polymorphic*: "having many forms"
- A variable that can refer to objects of different types is said to be *polymorphic*
- Methods with polymorphic arguments are also said to be polymorphic

```
public void speak(Animal a) {
    System.out.println(a.noise( ));
}
```

- Polymorphic methods can be *reused* for many types

Static and Dynamic Types

- With polymorphism, we can distinguish between
  - Static type: the declared type of the variable (fixed during execution)
  - Dynamic type: the run-time class of the object the variable currently refers to (can change as program executes)

```
public String noise() {  // this has static type Animal
    ...
}

Cat foofoo = new Cat( );
foofoo.noise (foofoo);  //inside noise(), this has dynamic type Cat

Dog fido = new Dog( );
foofoo.noise (fido);  // inside noise(), this has dynamic type Dog
```


Dynamic Dispatch

- "Dispatch" refers to the act of actually placing a method in execution at run-time
- When types are static, the compiler knows exactly what method must execute.
- When types are dynamic... the compiler knows the *name* of the method – but there could be ambiguity about which version of the method will actually be needed at run-time.
  - In this case, the decision is deferred until run-time, and we refer to it as dynamic dispatch

Method Lookup: How Dynamic Dispatch Works

- When a message is sent to an object, the right method to invoke is the one in the *most specific class* that the object is an instance of
  - Makes sure that method overriding always has an effect
- Method lookup (a.k.a. **dynamic dispatch**) algorithm:
  - Start with the *run-time class* of the receiver object (not the static type!)
  - Search that class for a matching method
  - If one is found, invoke it
  - Otherwise, go to the superclass, and continue searching
- Example:

```
Animal a = new Cat( );
System.out.println(a.noise( ));
a = new Dog( );
System.out.println(a.getNumLegs( ));
```


Summary

- Object-oriented programming is hugely important
  - Lots of new concepts and terms
  - Lots of new programming and modeling power
  - Used more and more widely
- Ideas (so far!)
  - Composition ("has a") vs. specialization ("is a")
  - Inheritance
  - Method overriding
  - Polymorphism, static vs. dynamic types
  - Method lookup, dynamic dispatch