

CS102

Introduction to data structures, algorithms, and object-oriented programming

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Inheritance & Class Hierarchies

The central new idea in object-oriented programming -- the idea that really distinguishes it from traditional programming -- is to allow classes to express the similarities among objects that share **some**, but not all, of their structure and behavior.

has-a Relationship

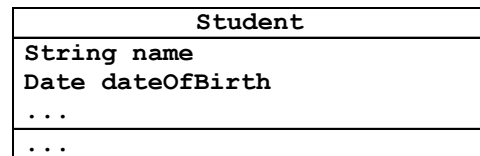
```
class Student
```

```
{  
  private String name;  
  private Date dateOfBirth;  
  ...  
}
```

- a **Student** *has-a* **String** for its name
- a **Student** *has-a* **Date** for its dateOfBirth

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In UML Terms



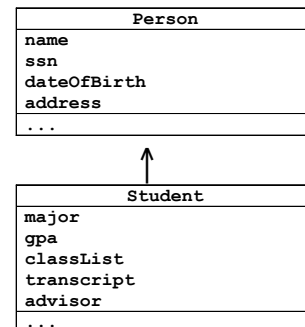
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Terminology for Inheritance

The term inheritance refers to the fact that one class can inherit part or all of its structure and behavior from another class. A subclass is created by using the extends keyword in the subclass signature.

- parent class ← child class
- superclass ← subclass
- base class ← derived class

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Syntax to Set Up Inheritance

- class **Student** **extends** **Person**

Makes an object of **Student** class to also be an object of **Person** class.

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is-a Relationship

- a **Student** is-a **Person**
- Every **Student** object is also a **Person** object.
- Class **Student** inherits non-private data & methods from Class **Person**.

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Inheritance Promotes Software Reuse

- Start with a class to which you want to add fields/methods.
- Extend that class and add additional capabilities to the subclasses.
- Classes that are specified as **final** cannot be extended.

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Programmer Decisions

- What methods and variables of the parent class can the child class see?
- What if the child wants to add a method or variable *with the same name* as a method or variable of the parent? Method overloading

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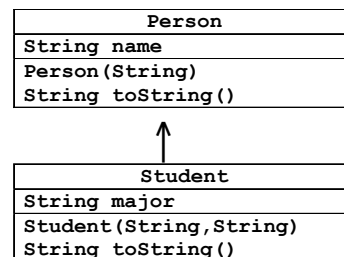
Why Not Modify Existing Code...

...instead of subclassing?

- Source code may not be available to us and the implementation may be difficult to understand.
- Our changes could break the existing code.

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Smaller Example of subclassing



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Simple Person class

```
class Person
{
    protected String name;
    public Person ( String name )
    { this.name = name; }
    public String toString() { return name; }
}
```

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```
public class Student extends Person {
    private String major; // added field in subclass
    public Student ( String name, String major )
    { super(name); // call to Person constructor
      this.major = major;
    }
    public String toString()
    {
        return this.name + " (" + this.major + ")";
    }
}
```

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- Use the parent's constructor to initialize parent variables (in a subclass, this will be a call to `super()` with zero or more parameters).
- Inside a subclass constructor, a call to the superclass constructor must be the first line. If not, there will be an error.

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Another Person class

```
class Person
{
    // name is non-accessible, even from subclasses
    private String name;
    public String toString()
    {
        return name;
    }
}
```

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```
class Student extends Person
{
    private String major;
    public String toString()
    {
        return super.toString() + " (" + major + ")";
    }
}
```

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Object — The Top of All Hierarchies

Every class is a subclass of the Object class (i.e., extends the Object class).
Inherited methods include:

- `public String toString()`
- `public boolean equals(Object)`

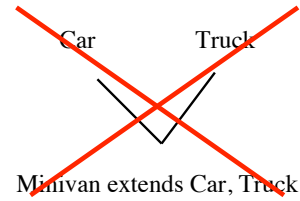
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Overriding vs Overloading

- Don't confuse overriding with overloading.
- Can anyone tell me the difference?

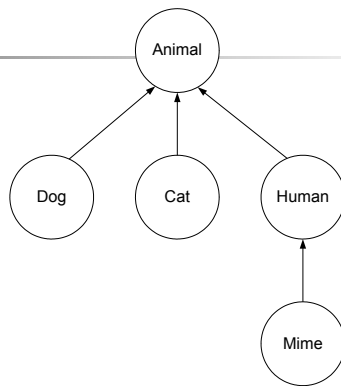
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Single vs Multiple Inheritance



- Java allows only single inheritance, i.e., a subclass can extend only one superclass.

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```
class Animal
class Dog extends Animal
class Cat extends Animal
class Human extends Animal
class Mime extends Human
```

- *Each has*
public void speak()

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public void speak() in each class contains the single print statement:

- *Animal:*
System.out.println(" generic animal noise ");
- *Dog:*
System.out.println("woof");
- *Cat:*
System.out.println("meow");
- *Human:*
System.out.println("hello");
- *Mime:*
System.out.println();

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```
Animal [] animals = new Animal[MAX];
animals[0] = new Dog();
animals[1] = new Cat();
animals[2] = new Human();
animals[3] = new Dog();
animals[4] = new Mime();
animals[5] = new Cat();
animals[6] = new Animal();

for ( int i = 0 ; i < MAX ; i++ )
{
    animals[i].speak();
}
```

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Motivation for Abstract Classes

- We shouldn't instantiate `Animal` —
The class is too generic!
- Let's make `Animal` an *abstract class*.

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```
abstract class Animal
{
//-----
    abstract public void speak();
//-----
}
```

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```
Animal [] animals = new Animal[MAX];
animals[0] = new Dog();
animals[1] = new Cat();
animals[2] = new Human();
animals[3] = new Dog();
animals[4] = new Mime();
animals[5] = new Cat();
animals[6] = new Cat();
```

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Interfaces

- Java only allows *single* inheritance, so a subclass can only have one superclass, including abstract classes.
- Interfaces can be used to achieve most of the effects of multiple inheritance. A class that implements an interface is a subtype of the interface.

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Interfaces

Interfaces are like abstract classes, but they can contain no method bodies, only method *stubs*.

Classes that *implement* an interface are required to provide full method bodies for each method stub in the interface.

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Interfaces

Interfaces can be a data type for a declared variable, but the instantiated type must be a subtype of the interface.

Classes can implement any number of interfaces and they must have method bodies for all method stubs in the interface.

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Interfaces

Because of the inheritance model Java provides, an object can have multiple data types.

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Structural recursion in Java

Recall the definition of a list in Scheme:

- A list of integers (IList) is either:
- empty, or it is a
- constructed list, formed by using (cons element LON), where LON is an IList.

We can make a similar structure in Java using an Interface:

```
public interface IList {  
    // stub for method to return length of this IList  
    public int length();  
    // stub for method to sum all integers in this IList  
    public int sum();  
}
```

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Structural recursion in Java

A subtype of interface IList to represent a constructed list:

```
public class ConsList implements IList {  
    int first;  
    IList rest;  
    // fully implemented method returns length of this IList  
    public int length() {  
        return 1 + this.rest.length();  
    }  
    // fully implemented method returns sum of numbers in this IList  
    public int sum() {  
        return this.first + this.rest.sum();  
    }  
}
```

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Structural recursion in Java

A subtype of interface IList to represent an empty list:

```
public class MTList implements IList {  
    // implementation of length method for empty list  
    public int length() {  
        return 0;  
    }  
    // implementation of sum method for empty list  
    public int sum() {  
        return 0;  
    }  
}
```

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