Structural Programming and Data Structures

Winter 2000

CMPUT 102: Inheritance

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Course Content

• Introduction	• Vectors
• Objects	• Testing/Debugging
• Methods	• Arrays
• Tracing Programs	• Searching
• Object State	• Files I/O
• Sharing resources	• Sorting
• Selection	• **Inheritance**
• Repetition	• Recursion

Objectives of Lecture 24

Inheritance

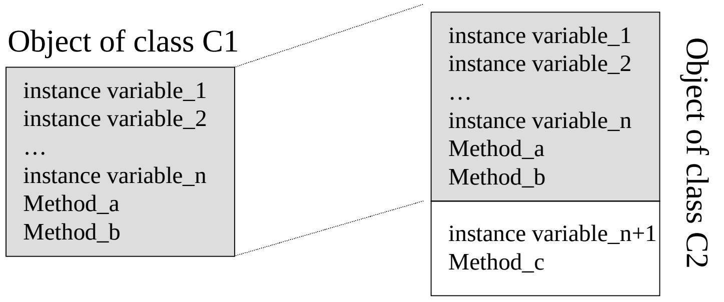
- Introduce the notion of inheritance in object-oriented programming;
- Understand the concepts of superclass (base class) and subclass (derived class);
- Learn how to take advantage of similarities between objects from different classes to derive one class from another and inherit instance variables and methods.

Outline of Lecture 24

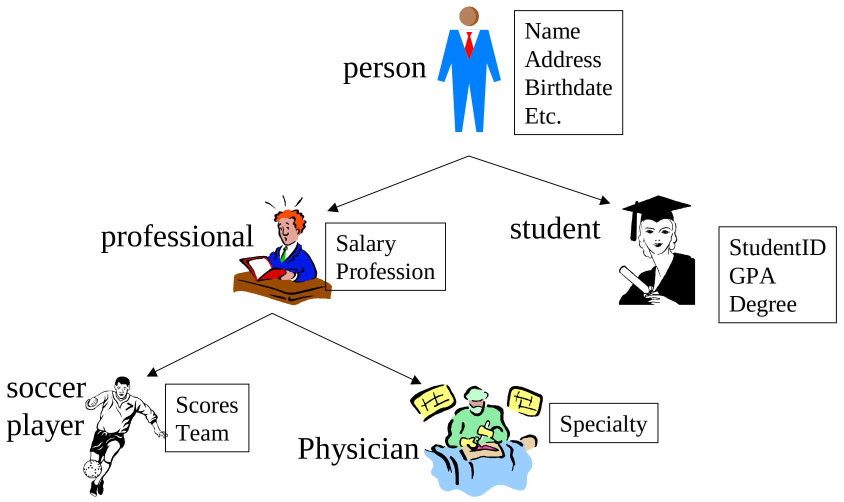
- Subclasses and Superclasses
- Type inheritance
- Method inheritance
- Representation inheritance
- Constructor inheritance

The Idea Behind Inheritance

- Extending the capabilities (i.e. behaviour and state) of a class C1 in order to generate a new class C2 with the same capabilities as C1 in addition to new capabilities.



Inheritance Hierarchy

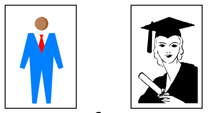


Inheritance in the Real World

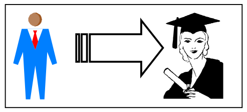
- How is a student like a person?
- Well, every student is a person!
- Students have all of the “properties” of persons, plus some others.
- For example, every person has a name and an age and so does every student.
- However, not every person is a student.
- Every student has a student id and a grade point average, that other persons don't have.

Two Different Approaches

- In Java, we model a person by a Person class.
- In Java, we model a student by a Student class.
- Introduce two independent classes, one for Student and one for Person
  - we lost relationships between the two
  - a Student class has to redefine all the properties of a Person class

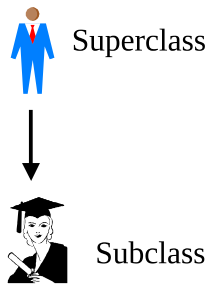


- Define a Student class as a specialization of a Person class
  - characterize special relationships
  - software reusability



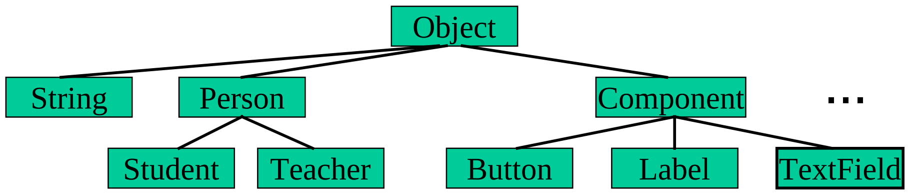
Subclasses and Superclasses

- Since a student is like a person with extra properties, we say the class Student is a **subclass** of the class Person (or **derived class**).
- We also say that Person is a **superclass** of Student (or **base class**).



The Java Inheritance Tree

- In general, Person can have other subclasses as well, say Teacher.
- We put all the classes in an **inheritance tree** with class Object as the root.
- We draw the tree with the root at the top.



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Type Inheritance

- We say that a subclass **inherits** all of the messages from its superclass.
- Any message that can be sent to an instance of a class can also be sent to an instance of its subclasses.
- However, you can add additional instance messages and static messages to a subclass.

Type Inheritance (con't)

- If you declare the type of a variable to be some class, it can then be bound to an instance of that class or any subclass.
- If the type of a message parameter or the return type of a message is a class, you can use any subclass as well.
- The property of being able to use an instance of a subclass, wherever you can use an instance of a class is called **substitutability**.

Type Inheritance Example

- Assume that we are defining a class called Store.
- Assume that we have already defined a class called Person, with a message called name() and two subclasses: Student and Teacher.
- Assume that we have defined a message in this "Store" class called register that takes a Person as a parameter:

```
public void register(Person aPerson) {
// Register the given Person as a customer.
```

Type Inheritance Example (con't)

- Here is a method that creates a Person, Student or Teacher customer, depending on a char parameter.

```
public Person createCustomer(char aChar, String aString){
   Person customer;

   if (aChar == 'T')          customer = new Teacher(nameString);
   else if (aChar == 'S')     customer = new Student(nameString);
   else                       customer = new Person(nameString);

   System.out.println("Welcome " + customer.name());
   this.register(customer);
   return customer;
}
```

Instance Variable and Static Variable (Representation) Inheritance

- In Java, a subclass also inherits all of the instance variables and all of the static variables of its superclass.
- However, if a variable is private, it cannot be accessed directly in the subclass code.
- If a variable is declared as **protected** it can be accessed directly in the subclass code.
- A subclass can also add state by defining additional instance and static variables.

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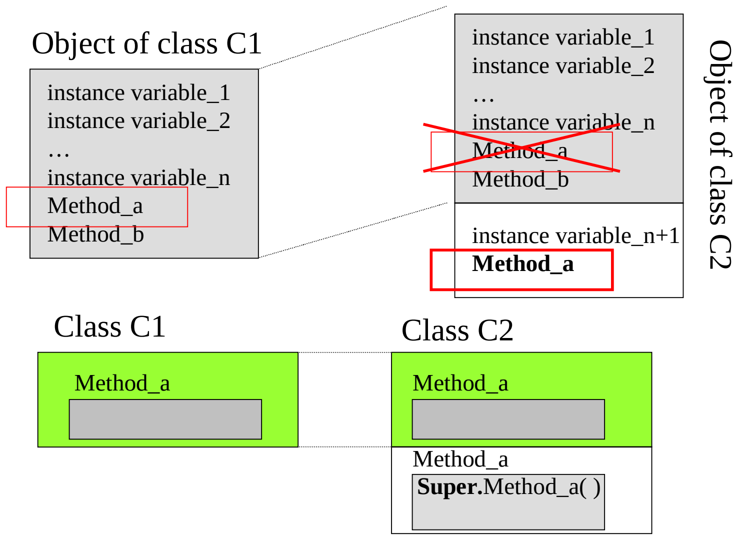
Method (Implementation) Inheritance

- In Java, a subclass also inherits the methods of its superclass, so they do not have to be re-implemented.
- However, you can also **override** any method if you want.
- In addition, you can add some code to an inherited method, using the **super** object reference.

Method Override



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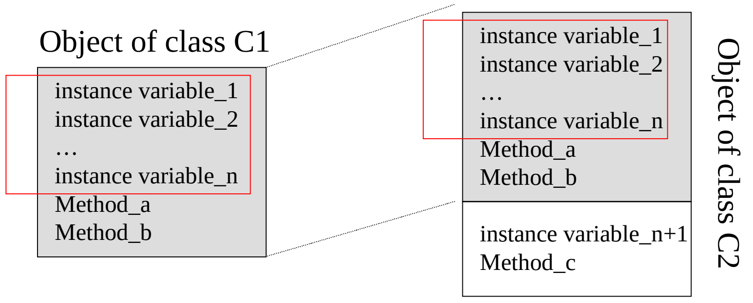
Representation (or Data) Inheritance



Representation/Implementation Inheritance - Example

```
public class Person {
// Each instance represents a Person.
. . .
// Public methods
    public void output() {
    // Output a representation of myself
            System.out.print("name: " + this.name + " age: ");
            System.out.print(this.age());
    }
. . .
// Instance Variables
    protected    String    name;
    private      Date      birthdate;
. . .
```

name is protected: it is accessed only by class Person and its subclasses.

Representation /Implementation Inheritance - Example (con't)

```
public class Student extends Person {
// Each instance represents a Student.
// Public methods
    public void output() {
    // Output a representation of myself
            super.output();
            System.out.print(" id: ");
            System.out.print(this.id);
    }
  ...
// Instance Variables
// cannot access birthdate, but can access name because it is protected
private int   id;
...
```

Calls the output() method of the superclass Person.

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Constructor Chaining

- Constructors are not inherited like other methods. We say constructors are chained.
- If you want to call another constructor in the same subclass, you just use “**this()**” with the appropriate arguments.
- If you want to call another constructor in the superclass, you just use “**super()**” with the appropriate arguments.

Constructor Chaining (con’t)

- However, each constructor must “ultimately” call one of the constructors in its superclass.
- This can be done in one of three ways:
  - An explicit call to super() with arguments.
  - A call to another constructor in the subclass using this() with arguments.
  - If neither of these appear as the first statement of the subclass constructor, the compiler inserts an implicit call to the zero argument super constructor super(). However, the a constructor with no arguments should exist in the superclass.

Constructors - Example

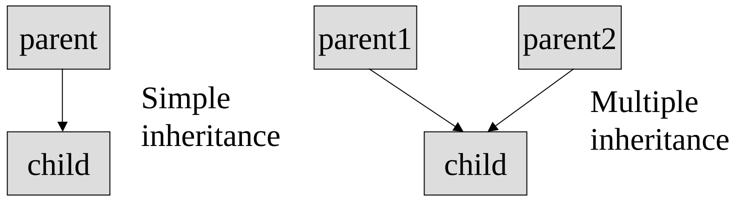
```
public class Person {
// Each instance represents a Person.
// Constructors
   public Person() {
   // Set the name “unknown” and birtdate: today
         this.name = “unknown”;
         this.birthdate = new Date();
   }

   public Person(String nameString) {
   // Set the given name and birthdate: today
         this(); // do the 0 argument constructor first
         this.name = nameString;
   }
```

Constructors - Example (con’t)

```
public class Student extends Person {
// Each instance represents a Student.
   public Student() {
   // Set the name: “unknown”, birtdate: today, id: 0
         this.id = 0; // implicit call to super(); first
   }
   public Student(String nameString) {
   // Set the given name, birthdate: today, id: 0
         super(nameString); // explicit call
         this.id = 0;
   }
   public Student(String nameString, int anInt) {
   // Set the given name and id, birthdate: today
         this(nameString); // or super(nameString)
         this.id = anInt;
   }
```

Multiple Inheritance

- Multiple inheritance is the inheritance of properties from more than just one base class.
- Java does not allow multiple inheritance.
- Other Object-Oriented languages such as C^{++} allow multiple inheritance;


parent
child
Simple inheritance
parent1
parent2
child
Multiple inheritance