Introduction to OOP

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Agenda

- History
  - Key OOP Concepts
  - Object, Class
  - Instantiation, Constructors
  - Encapsulation
  - Inheritance and Subclasses
  - Abstraction
  - Reuse
  - Polymorphism, Dynamic Binding
- Object-Oriented Design and Modeling

Agenda

There are different approaches to writing computer programs.

Procedural programming

Object oriented programming

They all involve decomposing your programs into parts.

"And so, from Europe, we get things such … object-oriented analysis and design (a clever way of breaking up software programming instructions and data into small, reusable objects, based on certain abstraction principles and design hierarchies.)"

-Michael A. Cusumano, The Business Of Software

OOP …since 1962

Simula 1 (1962 - 1965) and Simula 67 (1967) Norwegian Computing Center, Oslo, Norway by Ole-Johan Dahl and Kristen Nygaard.

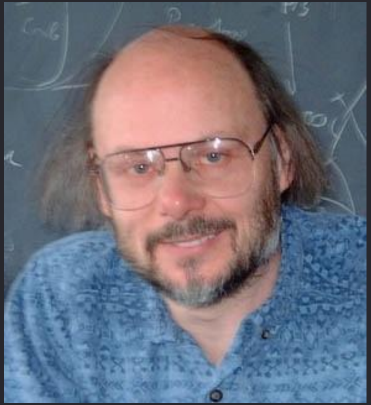
Dahl and Nygaard at the time of Simula's development

Turing Award Winners - 2001

OOP …sincs 1962

Smalltalk (1970s), Alan Kay's group at Xerox PARC

C++ (early 1980s), Bjarne Stroustrup, Bell Labs



OOP Languages

Modula – 3, Oberon, Eiffel, Java, C#, Python

- many languages have some Object Oriented version or capability

One of the dominant styles for implementing complex programs with large numbers of interacting components

- … but not the only programming paradigm and there are variations on object oriented programming

Definition –OOP, Class

Object-oriented programming is a method of programming based on a hierarchy of classes, and well-defined and cooperating objects
A class is a structure that defines the data and the methods to work on that data. When you write programs in the Java language, all program data is wrapped in a class, whether it is a class you write or a class you use from the Java platform API libraries

Definition –Class, Object

Class: a collection of data (fields/ variables) and methods that operate on that data

- define the contents/capabilities of the instances (objects) of the class
- a class can be viewed as a factory for objects
- a class defines a recipe for its objects

Examples of a class (Java)

```
class Customer {
    // Fields
    private String name;     //Can get but not change
    private double salary;  // Cannot get or set
    // Constructor
    Customer(String n, double s) {
        name = n; order = s;
    }
    // Methods
    void pay () {
        System.out.println("Pay to the order of " +
                                   name + " $" + order);
    }
    public String getName() { return name; } // getter
}
```

Definition –Class, Objsct

Object creation: memory is allocated for the object’s fields as defined in the class

Initialization is specified through a constructor

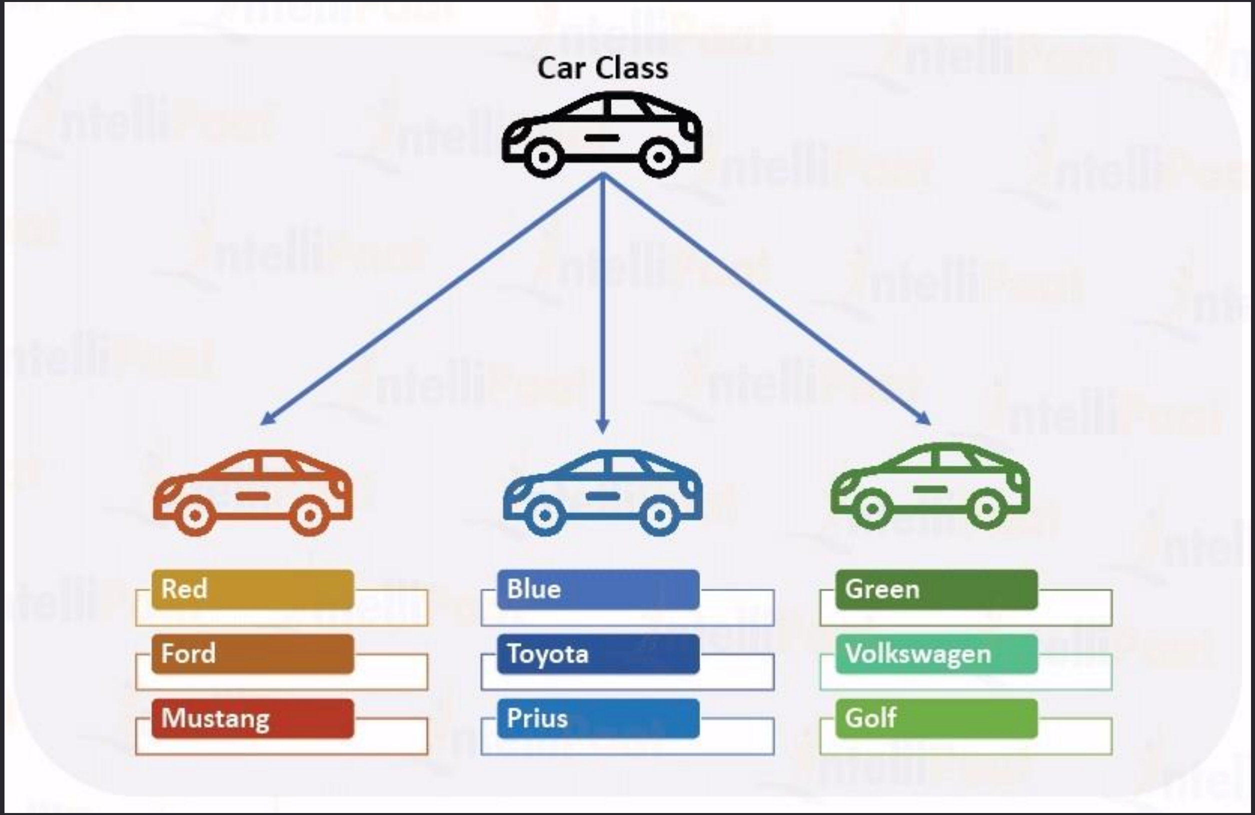
A special method invoked when objects are created

Different objects have the same attributes but the values of those attributes can vary

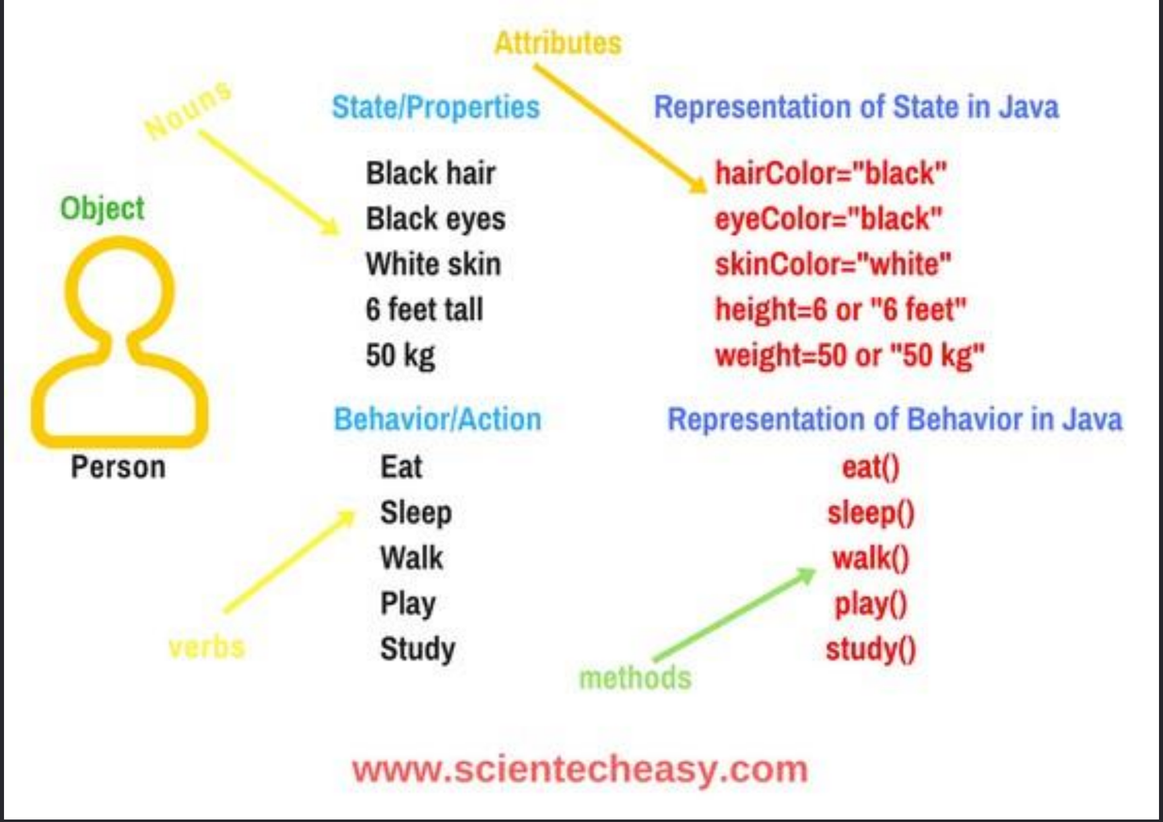
Reminder: The class definition specifies the attributes and methods for *all objects*

The current value of an object’s attribute’s determines it’s state.

Concept: Classes describe objects



Concept: Classes describe objects



State/Properties

Black hair
Black eyes
White skin
6 feet tall
50 kg

Representation of State in Java

hairColor="black"
eyeColor="black"
skinColor="white"
height=6 or "6 feet"
weight=50 or "50 kg"

Behavior/Action

Eat
Sleep
Walk
Play
Study

Representation of Behavior in Java

eat()
sleep()
walk()
play()
study()

www.scientecheasy.com

Notation: How to dsclars and crsats objscts

```
Employee secretary;   // declares secretary
secretary = new Employee (); // allocates space
Employee secretary = new Employee(); // does both
```

But the secretary is still "blank" (null)

```
secretary.name = "Adele";   // dot notation
secretary.birthday ();   // sends a message
```

Notation: How to references a field or method

Inside a class, no dots are necessary

```
    class Person { ... age = age + 1; ...}
```

Outside a class, you need to say which object you are talking to

```
    if (john.age < 75) john.birthday ();
```

If you don't have an object, you cannot use its fields or methods!

Inheritance

Inheritance:

programming language feature that allows for the implicit definition of variables/methods for a class through an existing class

An object *also* inherits:

the fields described in the class's superclasses

the methods described in the class's superclasses

A class is *not* a complete description of its objects!

Concept: Classes form a hierarchy

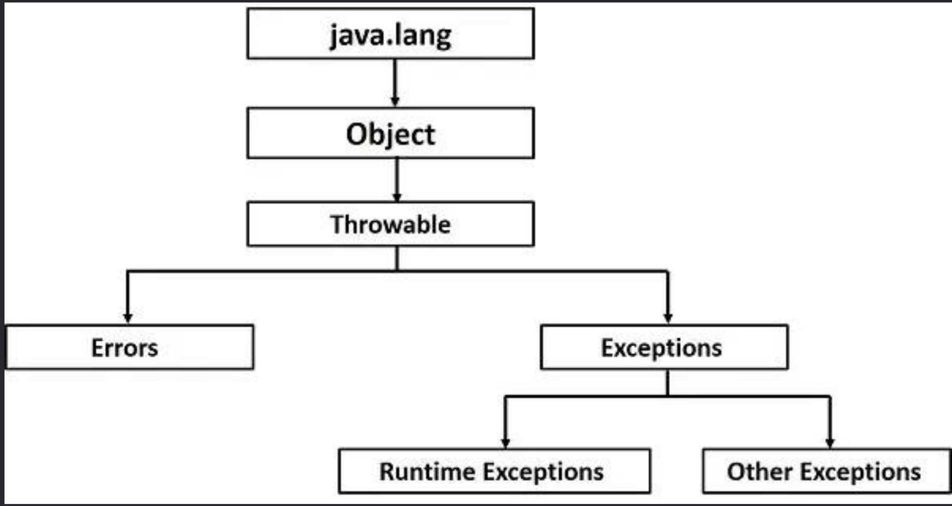
Classes are arranged in a treelike structure called a hierarchy

The class at the root is named Object

Every class, except Object, has a superclass

When you define a class, you specify its superclass

- If you don't specify a superclass, Object is assumed



Concspt: Classss form a hierarchy

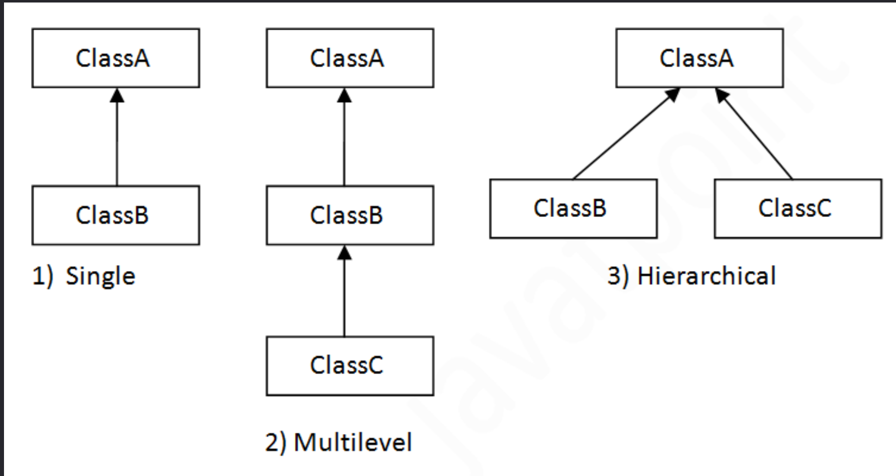
Subclass relationship

B is a subclass of A

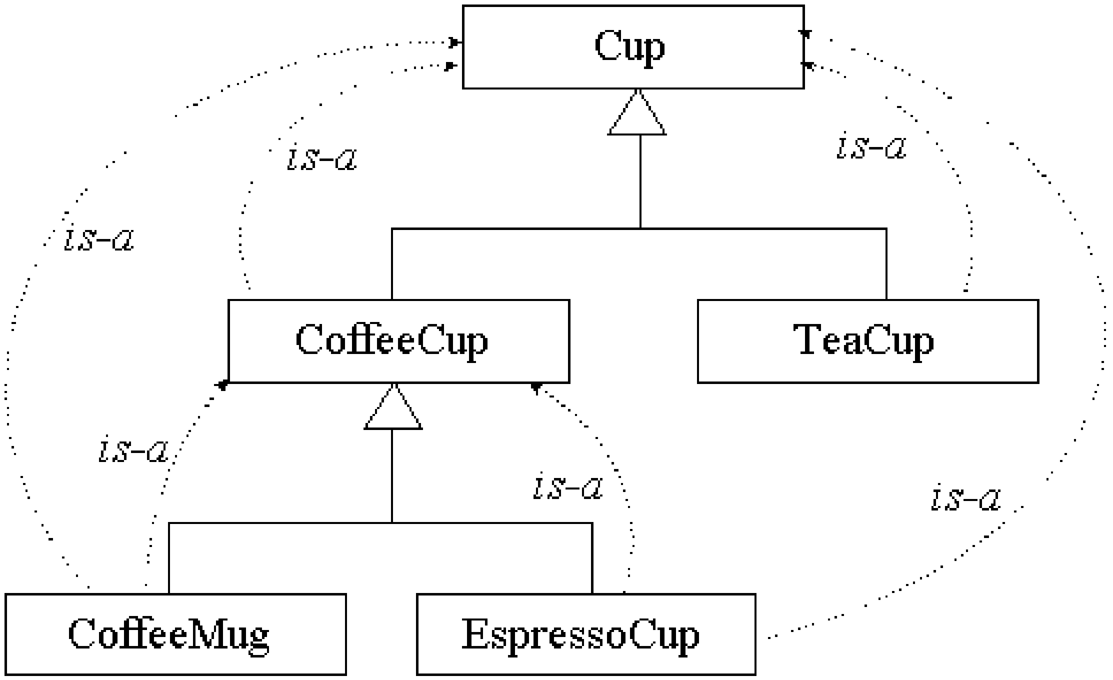
B inherits all definitions (variables/methods) in A

A class may have several ancestors, up to Object

Every class may have one or more subclasses



Exampls of (part of) a hierarchy



Example of inheritance

```
class Person {
   String name;
   int age;
   void birthday () {
      age = age + 1;
   }
}
```

```
class Employee
         extends Person {
   double salary;
   void pay () { ...}
}
```

Every Employee has name and age fields and birthday method *as well as* a salary field and a pay method.

Example: Assignment of subclasses

```
class Dog { … }
class Poodle extends Dog { … }
Dog myDog;
Dog rover = new Dog ();
Poodle yourPoodle;
Poodle fifi = new Poodle ();

myDog = rover;                      // ok
yourPoodle = fifi;                 // ok
myDog = fifi;                      //ok
yourPoodle = rover;                 // illegal
yourPoodle = (Poodle) rover;        //runtime check
```

Encapsulation

- Also know as separation of concerns and information hiding
- When creating new data types (classes) the details of the actual data and the way operations work is hidden from the other programmers who will use those new data types
  - So they don't have to worry about them
  - So they can be changed without any ill effects (loose coupling)
- Encapsulation makes it easier to be able to use something
  - microwave, radio, ipod, the Java String class

Encapsulation (A capsule)

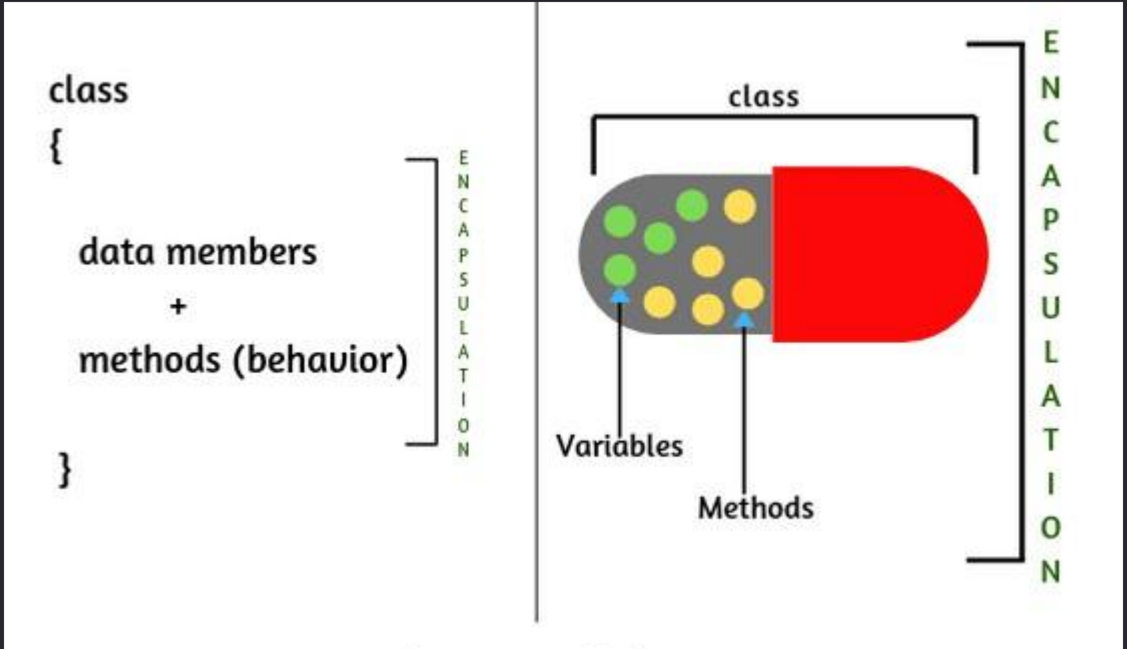


Fig: Encapsulation

Kinds of accsss in Java

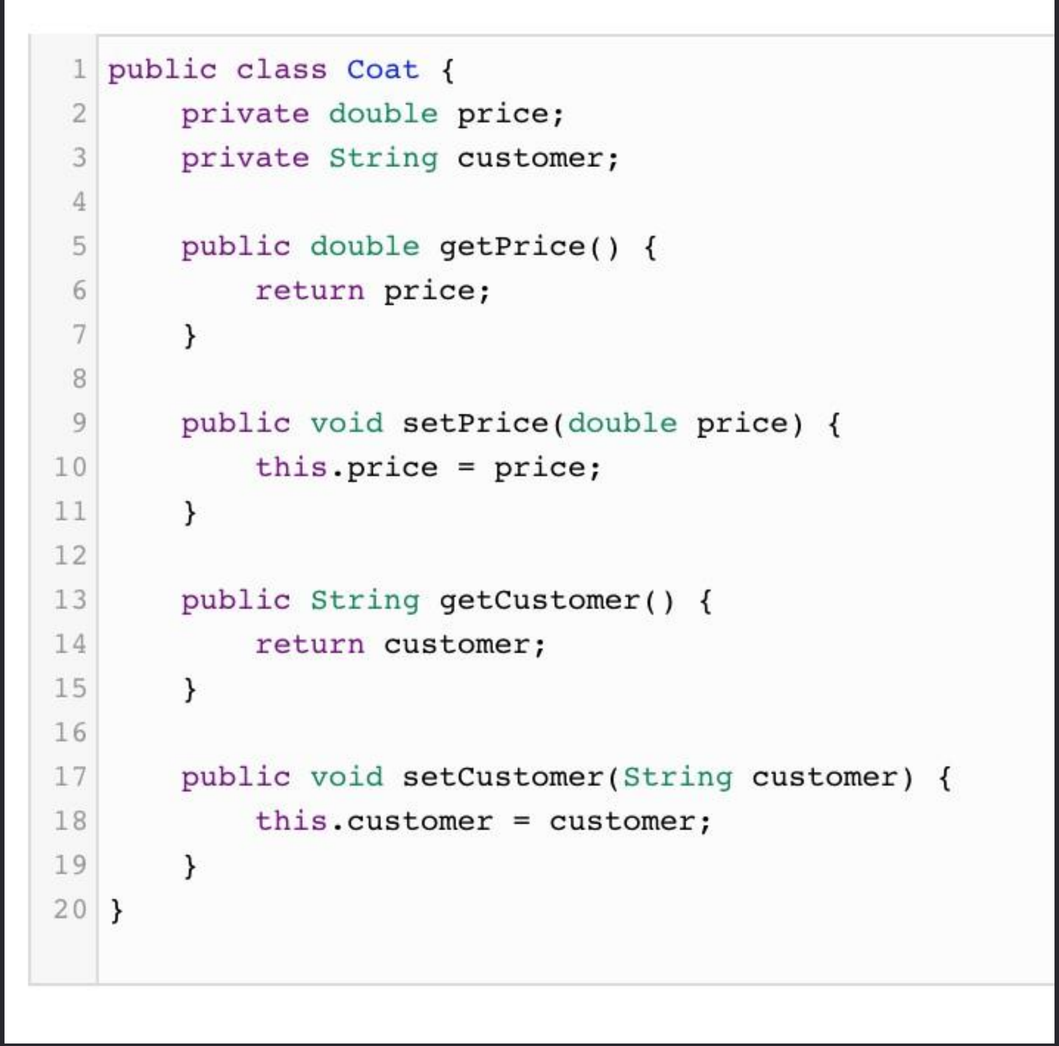
Java provides four levels of access:

- public: available everywhere
- protected: available within the package (in the same subdirectory) and to all subclasses
- [default]: available within the package
- private: only available within the class itself

The default is called package visibility

In small programs this isn't important...right?

Encapsulation



```java
public class Coat {
    private double price;
    private String customer;

    public double getPrice() {
        return price;
    }

    public void setPrice(double price) {
        this.price = price;
    }

    public String getCustomer() {
        return customer;
    }

    public void setCustomer(String customer) {
        this.customer = customer;
    }
}
```

Abstraction

OOP is about ***abstraction***

Abstraction is a method of hiding the implementation detail and only show the functionalities

Encapsulation and Inheritance are examples of abstraction

Polymorphism

Polymorphism means many (poly) shapes (morph)

In Java, polymorphism refers to the fact that you can have multiple methods with the same name in the same class

There are two kinds of polymorphism:

- Overloading
  - Two or more methods with different signatures
- Overriding
  - Replacing an inherited method with another having the same signature

Polymorphism

two methods have to differ in their *names* or in the *number* or *types* of their parameters

- foo(int i) and foo(int i, int j) are different
- foo(int i) and foo(int k) are the same
- foo(int i, double d) and foo(double d, int i) are different

Overloading

```
class Test {
    public static void main(String args[]) {
        myPrint(5);
        myPrint(5.0);
    }

    static void myPrint(int i) {
        System.out.println("int i = " + i);
    }

    static void myPrint(double d) { // same name, different parameters
        System.out.println("double d = " + d);
    }
}
```

```
int i = 5
double d = 5.0
```

Overriding

```
class Animal {
    public static void main(String args[]) {
        Animal animal = new Animal();
        Dog dog = new Dog();
        animal.print();
        dog.print();
    }
    void print() {
        System.out.println("Superclass  Animal");
    }
}
public class Dog extends Animal {
    void print() {
        System.out.println("Subclass  Dog");
    }
}
```

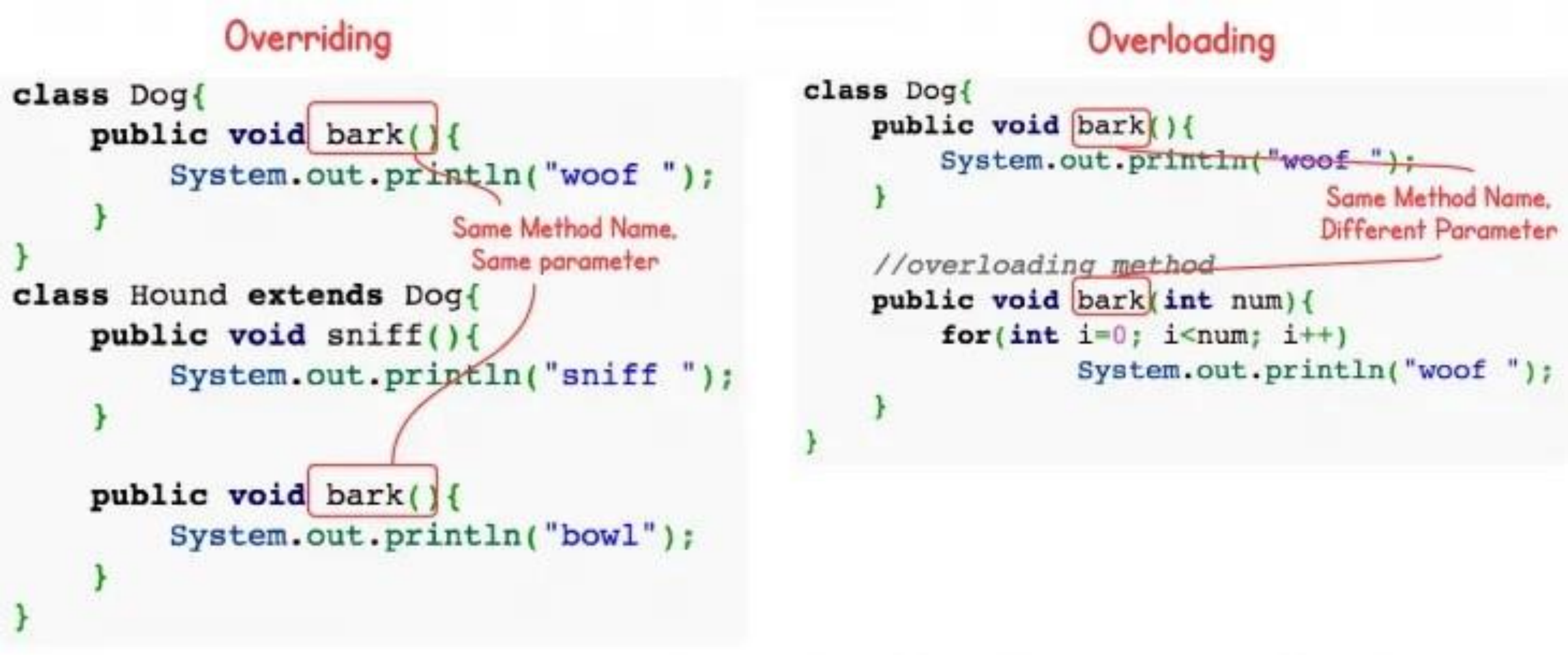
```
Superclass Animal
Subclass Dog
```

This is called overriding a method

Method print in Dog overrides method print in Animal

A subclass variable can *shadow* a superclass variable, but a subclass method can *override* a superclass method

Another examples



Overriding

```java
class Dog{
    public void bark(){
        System.out.println("woof ");
    }
}
class Hound extends Dog{
    public void sniff(){
        System.out.println("sniff ");
    }

    public void bark(){
        System.out.println("bowl");
    }
}
```

Same Method Name,
Same parameter

Overloading

```java
class Dog{
    public void bark(){
        System.out.println("woof ");
    }

    //overloading method
    public void bark(int num){
        for(int i=0; i<num; i++)
            System.out.println("woof ");
    }
}
```

Same Method Name,
Different Parameter

When to do?

- You should *overload* a method when you want to do essentially the same thing, but with different parameters
- You should *override* an inherited method if you want to do something slightly different than in the superclass
  - It's almost always a good idea to override public void toString() -- it's handy for debugging, and for many other reasons
  - To test your own objects for equality, override public void equals(Object o)
  - There are special methods (in java.util.Arrays) that you can use for testing array equality

Reuse

Inheritance encourages software reuse

Existing code need not be rewritten

Successful reuse occurs only through careful planning and design

- when defining classes, anticipate future modifications and extensions

Building Complex Systems

From Software Engineering:
complex systems are difficult to manage

Proper use of OOP aids in managing this complexity

The analysis and design of OO systems require corresponding modeling techniques

Object-Oriented Modeling

UML: Unified Modeling Language
- OO Modeling Standard
- Booch, Jacobson, Rumbaugh

What is depicted?
- Class details and static relationships
- System functionality
- Object interaction
- State transition within an object

Some UML Modeling Techniques

Class Diagrams

Use Cases/Use Case Diagrams

Interaction Diagrams

State Diagrams

Object-Oriented Design Models

- Static Model
    - Class Diagrams
- Dynamic Model
    - Use Cases, Interaction Diagrams, State Diagrams, others