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Constructors

# Inheritance and Polymorphism

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# Topics

Java Inheritance
Class hierarchy - An example

## Visibility

I can see what you can't
Constructors and inheritance



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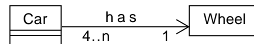
# Known

- Between objects, relationships exist

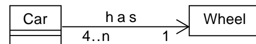
# Known

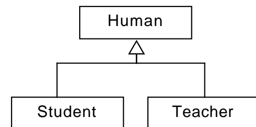
- Between objects, relationships exist
- An association represents a **Has-a**-relationship
  - A human being has two legs
  - A chair has 4 chair legs
  - A car has 4 wheels



# Known

- Between objects, relationships exist
- An association represents a **Has-a**-relationship
  - A human being has two legs
  - A chair has 4 chair legs
  - A car has 4 wheels
- Also, a **Is-a**-relationship exists
  - Apples and pears are fruit species
  - Students and lecturers are humans
  - The type defines characteristics for its elements
    - Every human being has an eye color
    - Every human being has a hair color
    - Every human being has a size
  - Java represents this relationship by inheritance
  - *Parents* give their *Childs* characteristics



# Java Inheritance

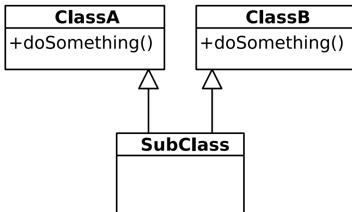
- Java defines classes in hierarchical relationships
- Therefore, classes have a **Is-a**-relationship with their parent class
- The keyword `extends` shows that a class is derived from another class
- Therefore, a class becomes a sub class
- The parent class is the super class
- The sub class inherits all **visible** characteristics of the super class

# The implicit base class `Object`

- Classes without the `extends`-keyword automatically inherit from `Object`
- Object is an implicit super class
- Every class inherits either directly or indirectly from `java.lang.Object`
- All visible attributes and methods, like `toString()`, are inherited

# No Multiple inheritance in Java

- Java only allows single inheritance
- Behind the `extends`-keyword, only *one* super class is allowed
- languages like C++, Python, and Perl allow Multiple Inheritance. Why does java not?




- `new SubClass().doSomething();` **Do what???**

# Example *Person*

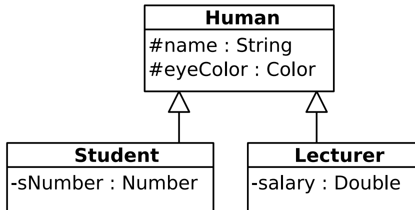



Figure: A class hierarchy for our school

- Students and Lecturers are Humans
- with ao a name and an eye color
- `TeamLeader` could have been a sub class of Lecturer

# Example *Human*

```java
package nl.fontys.pro2.week1;

import java.awt.Color;

public class Human {
    String name;
    Color eyeColor;
}
```

```java
package nl.fontys.pro2.week1;

public class Student extends Human {
    Number number;
}
```

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# Example *Human*

```
public static void main(String[] args) {
    Student theStud = new Student();
    theStud.name = "Richard Stallman";
}
```

- Class Student can use the inherited attributes `name` and `eyeColor`
- Changes in a super class are automatically represented in sub classes
- Therefore, a sub class has a very strong coupling to its super class
- Super classes *don't know* their sub classes


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# peekabo:I can see what you can't

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# Visibility

- Sub classes inherit all **visible** characteristics from their super class
- `public`: visible for all classes
- package-private: visible for all classes in the same package
- `private`: only visible within class (including contained inner class)
- In addition: `protected`:
  - protected attributes and methods are inherited by all sub classes
  - are visible for all classes in the same package
- In the visibility sense: `public` > `protected` > *package-private* > `private`
- `Protected` -protection is weaker than package-private!

# Visibility table

Table: Normalized visibility table.

| Modifier | Class | Package | Subclass | World |
|---|---|---|---|---|
| public | y | y | y | y |
| protected | y | y | y | - |
| (default) | y | y | - | - |
| private | y | - | - | - |

# Usage of constructors with inheritance

- When a an object is created the following happens: The JVM allocates memory for the object, then the constructors are called in order of hierarchy, top to bottom.
- In contrast to methods, constructors are not inherited
- Sub classes need a constructor to enable objects to be created
- Within the constructor, Java automatically invokes the super class default-constructor
- When no constructor has explicitly been defined, the implicit default constructor is used

# A super constructor

- `super()` invokes the super constructor explicitly
- The default constructor is always invoked implicitly
- `super` can invoke parameterized constructors
- Mandatory, if super class does not have default constructor

```
public class Student extends Human {
    public Student(Number number){ ... }
}
```

```
public class StudAssistant extends Student {
    public StudAssistant(Number sNumber){
        super(sNumber);
    }
}
```

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# Summary constructors and methods

- Constructors
  - can't be `abstract`, `final`, `native`, `static` or `synchronized`
  - don't have a return value, even not void
  - are not inherited
  - Can have any of visibility attributes
  - `this(...)` refers to another constructor in the same class
  - `super(...)` invokes a constructor of super class
- Methods
  - can be public, protected, package-private, private, abstract, final, native, static or synchronized
  - can have return values, or void
  - Visible methods are inherited
  - Inherited visibility cannot be changed
  - `this` is a reference to the current instance of the class
  - With `super`, overridden methods of the superclass can be invoked

# Polymorphism, abstract classes and interfaces Part II

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# Static and dynamic types

- Seemingly trivial relationships
  - A Student is a Human
  - A Lecturer is a Human
  - A Human is an Object
  - A Student is a Student
- In Java:

```
Human   studentIsHuman   = new Student();
Human   lecturerIsHuman  = new Lecturer();
Object  humanIsObject    = new Human();
Student studentIsStudent = new Student();
```

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# Static and Dynamic types

- The declared type is the so-called **static type**
- The initialised type is the **dynamic type**
- The declared type or L-Value is configured with their static type. An object knows its dynamic type.
- Variables are treated as being of a static type

```
Human studHum = new Student();
System.out.println(studHum.getName());
// The following will not work:
System.out.println(studHum.getSNumber());
```



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# Static and dynamic types

- Variables can not simply be initialised with *lesser*[1] types.
- In case of the correct dynamic type, a typecast helps
- `instanceof` verifies dynamic types

```
Human stud = new Student();
// next line will not work:
Student stud2 = stud;
// This one will:
Student stud3 = (Student) stud;
// Because stud has the dynamic type  Student
if(stud instanceof Student){
    // instanceof tests the dynamic Typ
}
```

[1] less specific

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# Override a method

- Methods of Super classes are overwritten when
  - The name **and**
  - the list of parameters (number of params and their type, not their name)
  - **and** return type
  - **exactly** match that of the super classes method
- The annotation `@Override` lets the compiler also check whether a method is actually and correctly overwritten
- The method of the superclass is then ruled out, right?
- Example: override the `toString()` method of `Object`

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# Override a method

- makes calling overridden methods possible
- You can only reach one level higher with super: Chaining of `super` keywording at a deeper inheritance hierarchy is not possible
- `Super` methods are not accessible from the outside. A call to a `super....` method can only be made on `this`, inside the defining class, not any other object.

```
public class Student extends Human {
...
    @Override
    public void setName(String name) {
        if(isNiceName(name)){
            super.setName(name);
        }
    }
}
```

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# prohibit method override

- The keyword `final` prohibits overriding.
  - In classes, thereby prohibiting extension
    - example `final class Integer`
  - for methods, thereby prohibiting that they can be overridden
    - example: `public final wait()`[2]
- Quiz: could you come up with a use for a `protected final` method?

[2] Defined in this way in `java.lang.Object`

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# Topics


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- Static and Dynamic Types
- Overridding Methods

## Puk
- Polymorphism

## Abstract classes and methods
- Interfaces

## Java8 interfaces: default and static

## multiple inheritance of implementation
- Example: Parents
- Example: Child interfaces

# Polymorphism

Polymorphism is the ability to provide a single interface to entities of different types

- Visible methods of super classes also exist in sub classes
- Super classes can predefine implementations, which can be overwritten, if required
- We can however be sure the methods exist



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# Polymorphism - Example

```
public class Human extends Object {
...
  @Override
  public String toString(){
    return "[Human:...";
  }
}
```

```
public class Student extends Human {
...
  @Override
  public String toString(){
    return "[Student:...";
  }
}
```



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# Polymorphism - Example

```java
Student student = new Student();
System.out.println(student);

Human human = new Student();
System.out.println(human);

Object object = new Student();
System.out.println(object);
```

What will the output look like?


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# Polymorphism - Example

- During runtime, the method `toString()` from `Student` will always be used
- In contrast to the compiler, the runtime environment knows the dynamic type
- This is called **dynamic binding**, because the actual type of an object is only determined at runtime
- The method that is the deepest one in the class hierarchy is chosen



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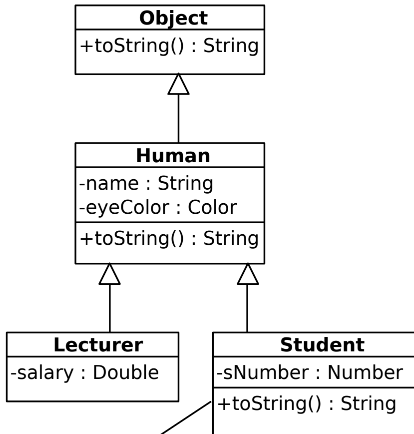
# Polymorphism - Example

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# Exceptions on polymorphism

- Not all methods are dynamically bound
  - Only **overridden** methods participate
  - Methods which can't be overridden will bound statically
  - `private`, `static` and `final` methods fall in this category.

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# Abstract classes

## Definition

Two of the three mandatory components[a] of a method declaration comprise the method signature—the method's name and the parameter types.

[a] A throws clause is possible, but optional

- Abstract classes can't be instantiated[3]
- An abstract class can be used as a static (or declaration) type.
- Useful, for example for classes which are only used as super class, to provide signatures for sub classes
- The keyword `abstract` identifies abstract classes
- Abstract classes are the opposite of concrete classes
- Abstract-ness is only about method declarations. Fields cannot be defined abstract.
- A signature can only occur once in a class defintion, including its inheritance hierarchy. Rationale: In Java all methods can be called ignoring (and thereby NOT declaring) the result.

[3] Not even when none of the methods is abstract

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# Abstract classes

- Abstract classes are often used in inheritance
- They behave like concrete classes
- A subclass can extend an abstract class and can be abstract itself again

```
public abstract class Human{
...
}
```

```
Human stud1 = new Student();
Human[] humans = new Human[] {new Student(), new Lecturer() };
```

Where could abstract classes be used for as well?



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# Abstract methods

- Methods in abstract classes *could* also be abstract
- They only define a method signature for the sub class
- *Concrete* sub classess have to implement these

```
public abstract class Human extends Object { ①
    ...
    protected abstract void dress();
}
```

① the inheritance from Object is implicit and should normally not be included.

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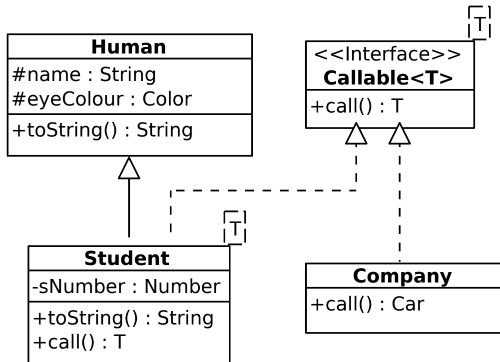
# Interfaces

- It's difficult to give classes multiple types by using inheritance
- Inheritance is always done in order, Human inherits from Object, Students inherits from Human, etc.
- Sometimes, classes need to have types from different hierarchies



# Interfaces

- Instead of `class`, `interface` is used
- Methods in interfaces don't have a body
- All methods are automatically `abstract` and `public`
- Constructors are useless and therefore not allowed
- Instance variables are not allowed either, `static`-variables however are allowed (automatically `final`)

```
public interface Callable<T> {

    T call();

}
```

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# Interfaces

```
public class Student extends Human
                 implements Callable{
    //...
    public void call() {...}
}
```

```
public class Student extends Human
    implements Callable, Annoyable{
    //...

    public void call() {...}

    public StressLevel annoy(double degree) {...}
}
```



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# Interfaces

```
public class Student extends Human
                 implements Callable{
    //...
    public void call() {...}
}
```

```
public class Student extends Human
    implements Callable, Annoyable{
    //...

    public void call() {...}

    public StressLevel annoy(double degree) {...}
}
```




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# Interfaces

- Classes can implement multiple interfaces
- Interfaces can extend zero, one or **multiple** other interfaces
- They allow objects to act in different roles
- A powerful object can be reduced to a single method
- Usage analogous to usage of abstract classes

```
Callable callable = new Student();
Human human = (Student) callable;
```

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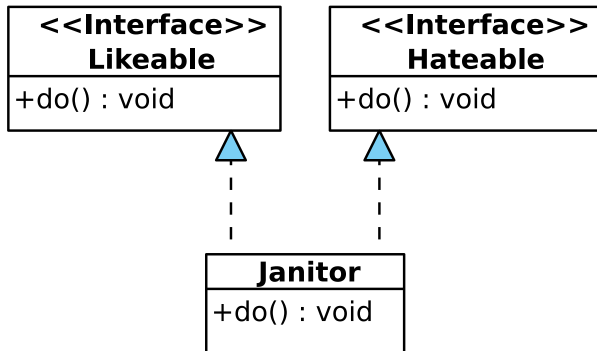
# Interfaces




What will happen now?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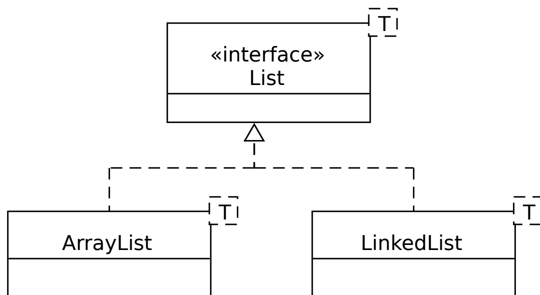
# Interfaces as specification

- Separation of functionality and implementation
- Clients communicate implementation-independent
- Alternative implementations can be used





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# Interfaces vs. Abstract classes

```java
public interface Callable<T> {

    T call();

}
```

```java
public abstract class Callable<T> {

    abstract T call();

}
```

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# Java8 interfaces: default and static methods

To be able to extend of the framework without breaking existing interfaces and implementing classes, Java 8 introduces a few new concepts.

- `static` methods (implementations) in `interface`s.
- `default` method (implementations!) in `interface`s.

- It allows the extension of interfaces without breaking existing implementing classes.
- The static methods are typically helpers for the default methods.
- It also implies multiple inheritance for said default methods.
- If a conflict is possible, the implementation programmer must help the compiler by specifying which default variant method is to be taken.
- The first use case of this extension is the stream framework, introduced in Java 8, in combination with $\lambda$ expression.

# Multiple inheritance example, parents

```
interface AnInterface {

    default String getName() {
        return "An";
    }
}

interface BnInterface {

    default String getName() {
        return "Bn";
    }
}
```

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# Multiple inheritance example, child

```
interface CnInterface extends AnInterface,
                              BnInterface {

    // resolve which super to use.
    // also works in implementing classes
    @Override
    default String getName() {
        return AnInterface.super.getName();
    }

}
```

**Note** that a class implementing (either[4]) one of the inherited interfaces-methods with the same signature must also specify which variant to select, using the same construction as above.

See **DEMO**

[4] Because signatur duplication is not allowed, exactly one must be choosen.



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# Not all understood? For next time read:

- Java Tutorial on Polymorphims
- Java 8 tutorial on default methods `http://docs.oracle.com/javase/tutorial/java/IandI/defaultmethods.html`

## Questions?

Questions or remarks?



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