Programming in Java
Part III – Inheritance

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Agenda

Inheritance

Access control

Polymorphism

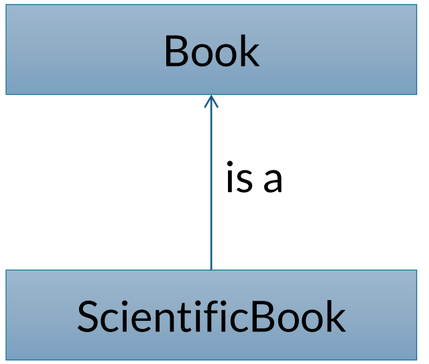
Interfaces

Inheritance

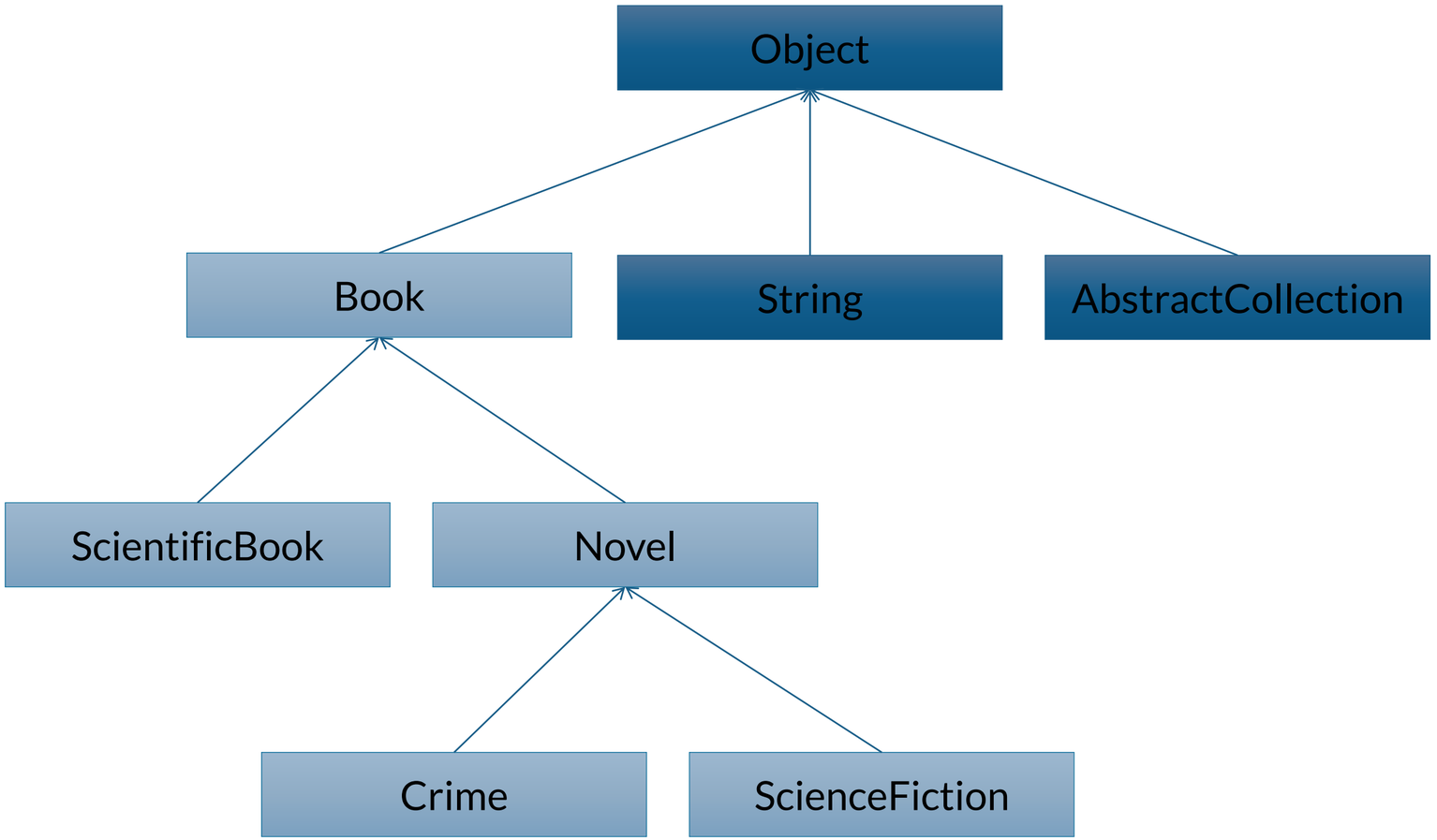
Inheritance allows to define new classes by reusing other classes, specifying just the differences.

It is possible to define a new class (subclass) by specifying that the class must be like other class (superclass)

```
public class ScientificBook extends Book {
  String area;
  boolean proceeding = false;
}
```

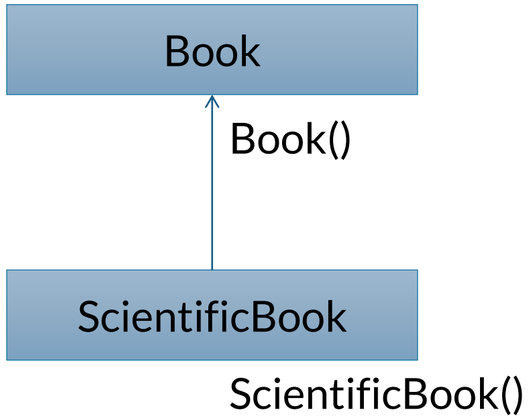


Inheritance



Constructors definition

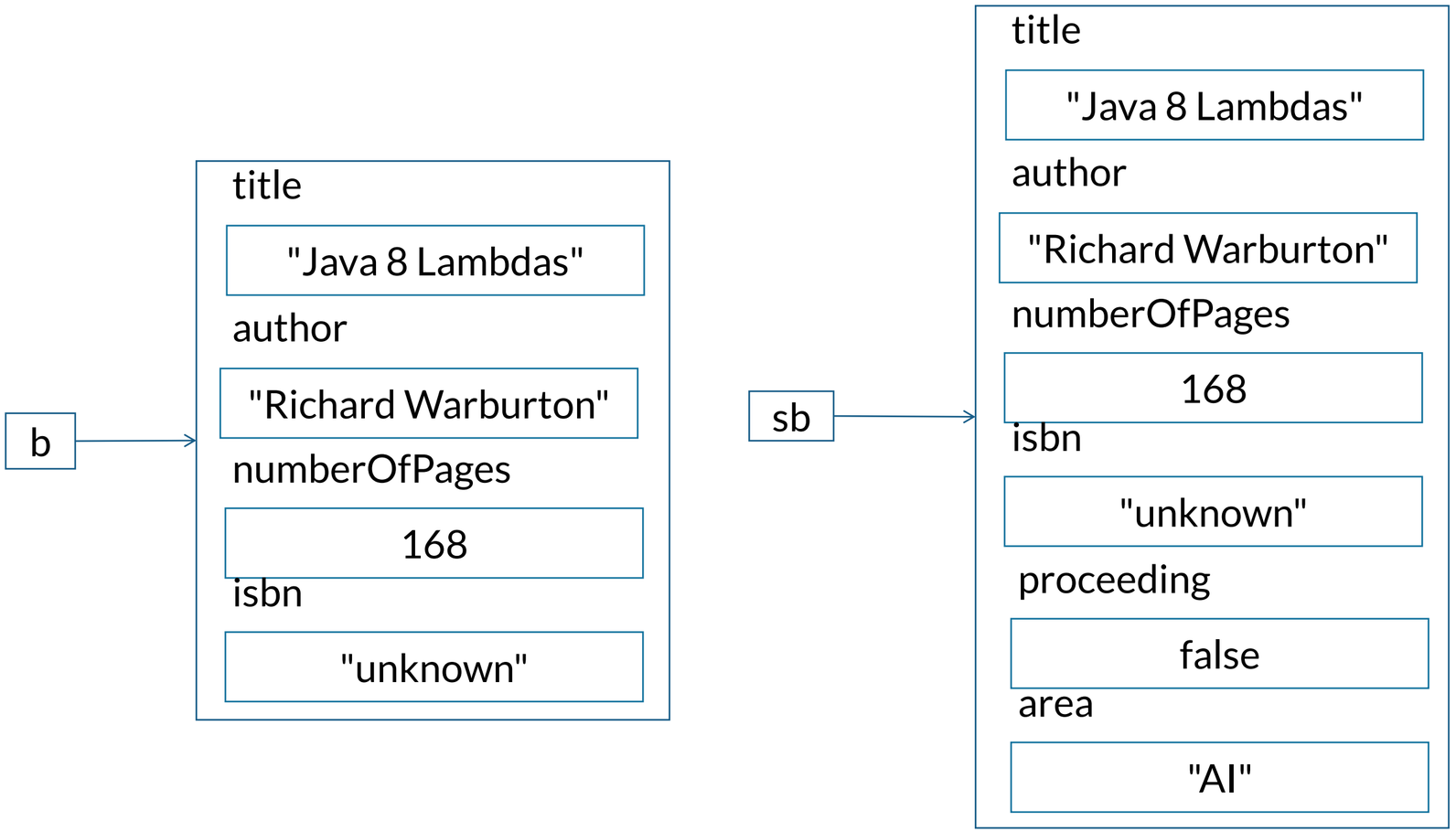
```
public class ScientificBook extends Book {
 String area;
 boolean proceeding = false;

 ScientificBook(String tit, String aut, int num, String isbn, String a) {
  super(tit,aut,num,isbn);
  area = a;
 }
}
```



If the superclass defines a constructor, the subclass has to define it and call the higher one by using super

```
ScientificBook sb;
sb = new ScientificBook("Neural Networks","Simon Haykin",696,"0-02-352761-7","AI");
```

Constructors definition



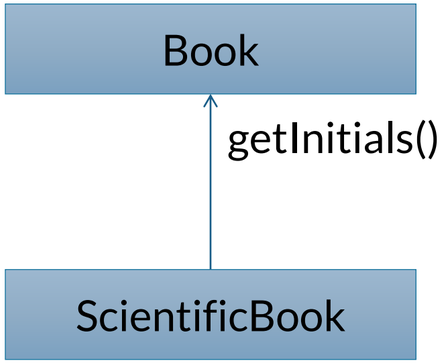

```
ScientificBook sb;
sb = new ScientificBook(" Java 8 Lambdas "," Richard Warburton ",168,  "978-1-449-37077-0","AI");
Book b = new Book("Java 8 Lambdas","Richard Warburton",168);
```

Inheritance with methods

- ✓ New methods can be defined in the subclass to specify the behavior of the objects of this class
- ✓ When a message is sent to an object, the method is searched for in the class of the receptor object.
- ✓ If it is not found then it is searched for higher up in the hierarchy.

Inherited methods

Inherited method can be used directly on the instances of the subclass



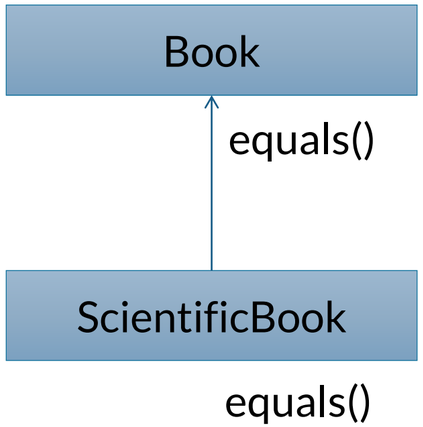

```
ScientificBook sb;
sb = new ScientificBook("Neural Networks","Simon Haykin", 696,  "0-02-352761-7","AI");
System.out.println(sb.getInitials());
```

S.H.

Overridden methods

```
public class ScientificBook extends Book {
 String area;
 boolean proceeding = false;

 ScientificBook(String tit, String aut,
     int num, String isbn, String a) {
  super(tit,aut,num,isbn);
  area = a;
 }

 @override
 public boolean equals(ScientificBook b){
   return super.equals(b) && area.equals(b.area) &&
                proceeding == b.proceeding;
 }
}
```

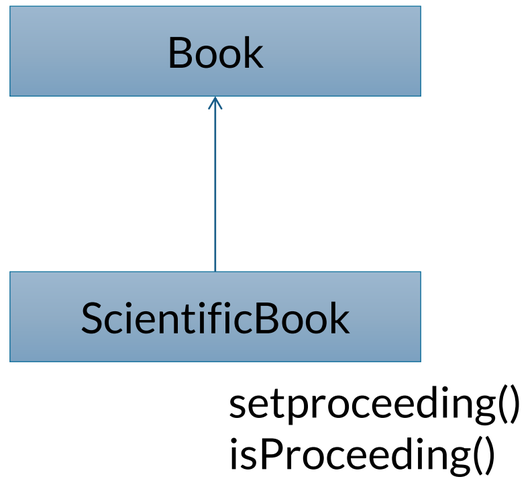
Methods in the subclass can override the methods in the superclass



New methods definition

```
public class ScientificBook extends Book {
  …

 boolean proceeding = false;

  …

public void setProceeding() {
   proceeding = true;
 }

public boolean isProceeding() {
   return proceeding;
 }
}
```

New methods can also be defined



Methods: an example

```
public class TestScientificBooks {
 public static void main(String[] args) {
  ScientificBook sb1,sb2;

  sb1 = new ScientificBook("Neural Networks","Simon Haykin", 696,"0-02-352761-7", "AI");
  sb2 = new ScientificBook("Neural Networks","Simon Haykin", 696,"0-02-352761-7",  "AI");
  sb2.setProceeding();
  ScientificBook.setLocation("Kampar");

  System.out.println(sb1.getInitials());
  System.out.println(sb1.equals(sb2));
  System.out.println(sb1.getLocation());
 }
}
```

```
$ java TestScientificBooks
S.H.
false
ScientificBooks are located in Kampar
```

InstanceOf and getClass()

```
Book b1 = new Book("Java 8 Lambdas","Richard Warburton",168);
System.out.println(b1.getClass().getName());
```

```
Book
```

getClass() returns the runtime class of an object

instanceof is an operator that determines if an object is an instance of a specified class

```
Book b1 = new Book("Java 8 Lambdas","Richard Warburton",168);
System.out.println(b1 instanceof Book);
```

```
true
```

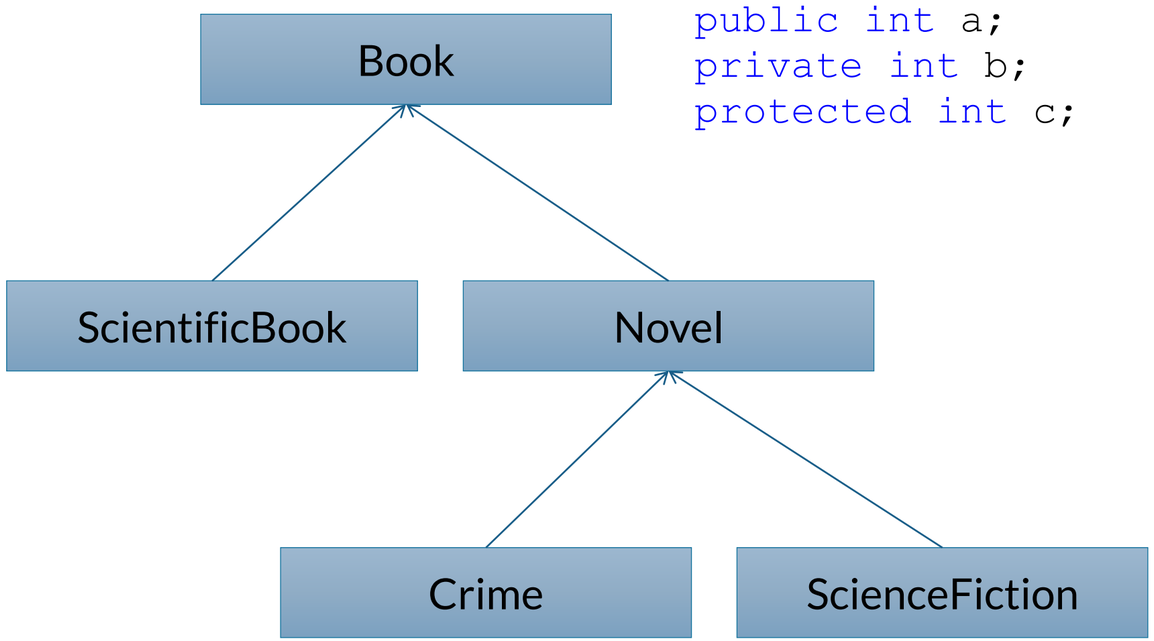
InstanceOf and getClass(): an example

```
public class TestClass {
 public static void main(String[] args) {
  Book b1 = new Book("Java 8 Lambdas","Richard Warburton",168);
  ScientificBook sb1 = new ScientificBook("Neural Networks", "Simon Haykin",696,"0-02-352761-7",
                "Artificial Intelligence");

  System.out.println(b1.getClass().getName());
  System.out.println(sb1.getClass().getName());
  System.out.println(b1 instanceof Book);
  System.out.println(sb1 instanceof Book);
  System.out.println(b1 instanceof ScientificBook);
  System.out.println(sb1 instanceof ScientificBook);
 }
}
```

```
$ java TestClass
Book
ScientificBook
true true false true
```

Access control

It is possible to control the access to methods and variables from other classes with the modifiers: public, private, protected




```
public int a;
private int b;
protected int c;
```

Access control

Currently, it is possible to set the proceeding condition of a scientific book in two ways

```
sb1.setProceeding();
```

However, direct access to a data member should not be allowed in order to guarantee encapsulation!

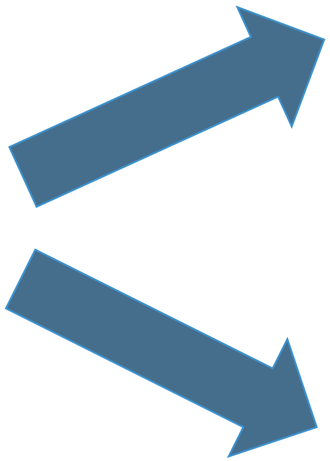
```
sb1.proceeding = true;
```

```
public class ScientificBook extends Book {
  private boolean proceeding = false;
 …
}
```

```
sb1.setProceeding();      // fine
sb1.proceeding = true;    // wrong
```

Final and abstract

The modifiers final and abstract can be applied to both classes and methods:



A final class does not allow sub-classing

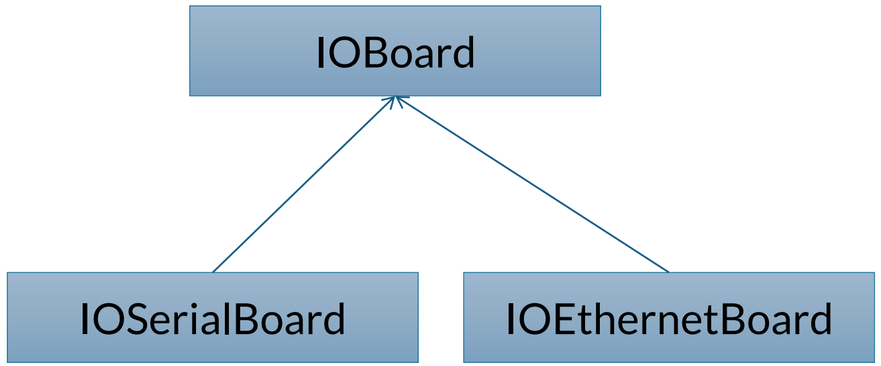
A final method cannot be redefined in a subclass

An abstract class cannot be instantiated

An abstract method has no body, and must be redefined in a subclass

Final and abstract: an example

the class IOBoard and its subclasses used to represent hardware input/output boards



IOBoard is a container for the common behavior of the other boards

Final and abstract: an example

```
public abstract class IOBoard {
  private String name;
  private int numErrors = 0;

  IOBoard(String s) {
    System.out.println("IOBoard constructor");
    name = s;
  }
  final public void anotherError() {
    numErrors++;
  }
  final public int getNumErrors() {
    return numErrors;
  }
  abstract public void initialize();
  abstract public void read();
  abstract public void write();
  abstract public void close();
}
```

The method anotherError() is final, cannot be redefined in subclasses

The other methods are abstract, subclasses must implement them

Final and abstract: an example

```
public class IOSerialBoard extends IOBoard {
 private int port;

 IOSerialBoard(String s,int p) {
  super(s); port = p;
  System.out.println("IOSerialBoard constructor");
 }
 public void initialize() {
  System.out.println("initialize method in IOSerialBoard");
 }
 public void read() {
  System.out.println("read method in IOSerialBoard");
 }
 public void write() {
  System.out.println("write method in IOSerialBoard");
 }
 public void close() {
  System.out.println("close method in IOSerialBoard");
 }
}
```

Final and abstract: an example

```
public class IOEthernetBoard extends IOBoard {
 private long networkAddress;

 IOEthernetBoard(String s,long netAdd) {
  super(s); networkAddress = netAdd;
  System.out.println("IOEthernetBoard constructor");
 }
 public void initialize() {
  System.out.println("initialize method in IOEthernetBoard");
 }
 public void read() {
  System.out.println("read method in IOEthernetBoard");
 }
 public void write() {
  System.out.println("write method in IOEthernetBoard");
 }
 public void close() {
  System.out.println("close method in IOEthernetBoard");
 }
}
```

Final and abstract: an example

```
public class TestBoards1 {
  public static void main(String[] args) {
    IOSerialBoard serial = new IOSerialBoard("my first port", 0x2f8);
    serial.initialize();
    serial.read();
    serial.close();
  }
}
```

```
$ java TestBoards1
IOBoard constructor
IOSerialBoard constructor
initialize method in IOSerialBoard
read method in IOSerialBoard
close method in IOSerialBoard
```

Polymorphism

- ✓ It is one of the most important concepts in Object Oriented Programming

- ✓ A solution is polymorphic if the same interface can be used to control a number of different implementations.

- ✓ Example: the power-on interface to request the same operation on a number of very different devices

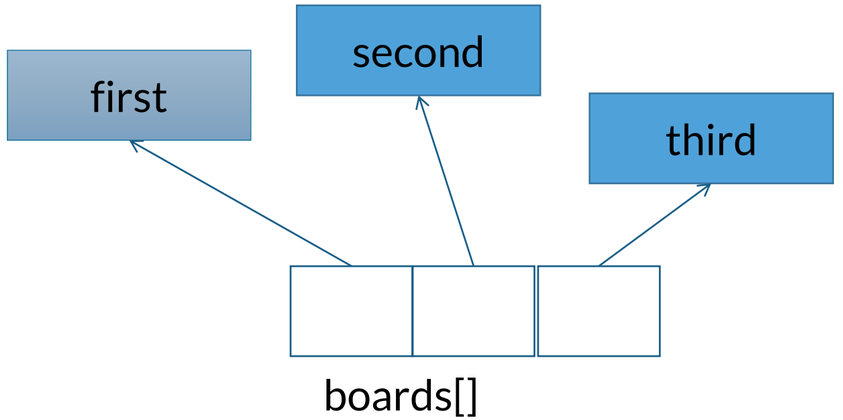
Polymorphism

An array of boards can be defined with IOBoard

Operations are executed based on its corresponding implementation

```
IOBoard[] board = new IOBoard[3];

board[0] = new IOSerialBoard("my first port",0x2f8);
board[1] = new IOEthernetBoard("my second port",0x3ef8dda8);
board[2] = new IOEthernetBoard("my third port",0x3ef8dda9);
```

```
for(int i = 0;i < 3;i++)
    board[i].initialize();

for(int i = 0;i < 3;i++)
    board[i].read();

for(int i = 0;i < 3;i++)
    board[i].close();
```



Interfaces

An interface describes what classes should do, without specifying how they should do it.

An interface looks like a class definition where

all fields are static and final

there can be abstract methods (public)

there can be static methods (public)

there can be default methods (public)

Interfaces

```
interface IOBoardInterface {
  void initialize();
  void read();
  void write();
  void close();
}
```

```
interface NiceBehavior {
  String getName();
  String getGreeting();
  void sayGoodBye();
  default void sayHello() {
    System.out.println("Hello"); // if not implemented
  }
  static void sayBye() {
    System.out.println("Bye"); // if not implemented
  }
}
```

Interfaces

```
public class IOSerialBoard2 implements IOBoardInterface, Nice Behavior {
  private int port;

  public void initialize() { … }
  public void read() { … }
  public void write() { … }
  public void close() { … }

  public String getName() { … }
  public String getGreeting() { ... }
  public void sayGoodBye() { … }

}
```

Note a class can implement more than one interface (not to be confused with multiple inheritance, in fact, there is no inheritance in this example)

Interfaces

It is possible to declare variables of type interface

```
public class TestInterface {
    public static void main(String[] args) {

        IoSerialBoard2 test = new IoSerialBoard2();
        NiceBehavior nb = test;
        nb.sayHello();
        nb.sayGoodBye();
    }
}
```

Is new NiceBehavior() valid?

Is nb.open() valid?

Please note that an interface can extend another interface

Thank you!

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