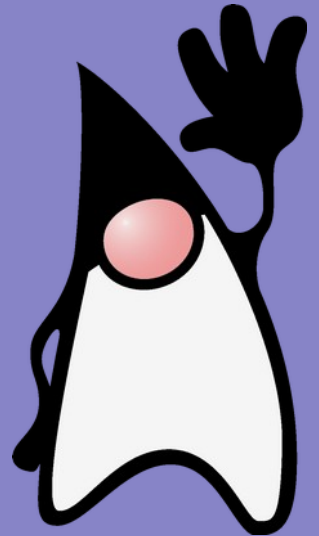


# Java

## Classes



# Class definition

---

- complete definition

```
[public] [abstract] [final] [sealed] [non-sealed]  
                                class Name  
  
    [extends Parent]  
    [implements ListOfInterfaces]  
    [permits ListOfNames] {  
        ... // class body  
    }
```

- **public** – public class
- **abstract** – no instance can be created
- **final** – class cannot be extended
- **sealed** – allowed children after **permits**
  - since Java 17



# Constructor

---

- constructor
  - object initialization
- declaration
  - the same name as the class
  - no return type
  - modifier – only visibility
  - several constructors
    - with different arguments
    - selected by arguments of **new**

```
class MyClass {  
    int value;  
    public MyClass() { value = 10; }  
    public MyClass(int v) { value = v; }  
}
```



# Object removal

---

- garbage collector
- ~~• `finalize()` method~~
  - ~~– present in every class~~
  - ~~– called before object's removal~~
  - ~~– **it is not a destructor like in other languages**~~
  - ~~– not known when it is called~~
  - ~~– calling is not guaranteed~~
    - ~~▪ object need not be removed by garbage collecting~~
      - ~~– e.g. at the end of the program~~
  - ~~– calls of `finalize()` are not chained~~

**`finalize()` deprecated since Java 9**

# Initialization of fields

---

- in constructor  
or
- direct

```
class MyClass {  
    int a = 5;  
    float b = 1.2;  
    MyClass2 c = new MyClass2();  
    int d = fn();  
    int e = g(f);    // error!  
    int f = 4;  
    ...  
}
```



# Initialization: `static`

---

- just once
- before first access or before first instance of a class is created
- direct

```
static int a = 1;
```

- static initializer

```
class MyClass {  
    static int a;  
    static {  
        a = 10;  
    }  
    ...  
}
```

- it is possible to have multiple **static** blocks in a single class
  - they execute in the given order



# Initialization: "non-static"

---

- similar to `static` initializer
- necessary for initialization of *anonymous inner classes*

```
class MyClass {  
    int a;  
    int b;  
    {  
        a = 5;  
        b = 10;  
    }  
    ...  
}
```



# Classes: inheritance

---

- parent specification – **extends** *ParentName*
- single inheritance
  - single parent only
- class `java.lang.Object`
  - each class inherits from this class
    - directly or indirectly
  - the only class without parent
- multiple inheritance only via **Interfaces**





# Polymorphism

---

- polymorphism ~ inheritance
- cast
  - automated – child to parent

```
class A { /*...*/ }  
class B extends A { /*...*/ }
```

```
A a = new B();  
Object o = a;
```

```
B b = (B) o;
```



# Polymorphism – constructor

---

- constructor of the parent
  - `super()`
- other constructor of the same object
  - `this()`
- calling other constructors
  - only as the first statement and just once
- parent's constructor is called always
  - even if not explicitly called
  - exception – `this()`
- class without constructor declared
  - has default constructor
    - calls `super()` only



# java.lang.Object

---

```
Object clone()  
boolean equals(Object obj)  
void finalize()  
Class<?> getClass()  
int hashCode()  
void notify()  
void notifyAll()  
String toString()  
void wait()  
void wait(long timeout)  
void wait(long timeout, int nanos)
```



# Classes: visibility of members

---

- must be specified for each member
- fields and methods
  - **public**
    - from everywhere (if the class is also visible)
  - **protected**
    - from the same package and children
  - **private**
    - just from the same class
  - without a visibility modifier
    - from the same package
- holds within a single module



# Classes: other modifiers

---

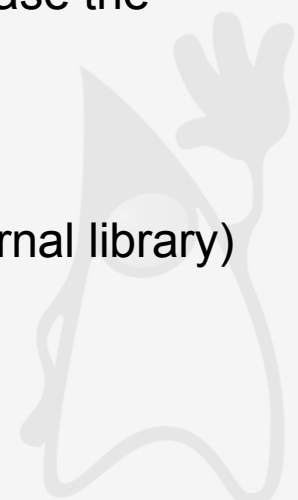
- **final**
  - field
    - constant
    - must have initializer
    - after initialization cannot be changed
  - method
    - cannot be overridden in children
- **transient**
  - field
  - does not belong to a persistent state of the object
- **volatile**
  - field
  - non-synchronized access of multiple threads
  - no optimization can be performed



# Classes: modifiers of methods

---

- **abstract**
  - no method body
  - the class must be also **abstract**
    - no instance can be created
  - method body – semicolon
- **synchronized**
  - calling thread must obtain a lock on the called object (or the class in the case the method is **static**)
- **native**
  - native method
  - implementation directly in native code for a particular platform (as an external library)
  - method body – semicolon
- **static**
  - see the previous lecture



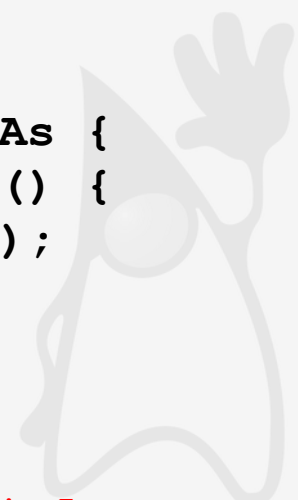
# Classes: method modifiers

---

- no modifier `virtual`
- all methods are virtual
  - static methods ***are not*** virtual

```
public class A {  
    public void foo() {  
        System.out.print("A");  
    }  
}  
  
public class B extends A {  
    public void foo() {  
        System.out.print("B");  
    }  
}  
....  
A a = new B();  
a.foo(); // prints out B
```

```
public class As {  
    public static void foo() {  
        System.out.print("A");  
    }  
}  
  
public class Bs extends As {  
    public static void foo() {  
        System.out.print("B");  
    }  
}  
....  
A a = new B();  
a.foo(); // prints out A
```



# Static methods

---

- static methods are called on a class
  - do not belong to any object

```
class As {  
    public static void foo() { ..... }  
}
```

```
As.foo();
```

- they can be “called” on an object (a class instance); but in reality only a type of the reference is taken
  - value of the object is ignored
  - type (and thus a method to be called) is determined at compile time
    - see the previous slide





# this

---

- reference to the object of the executed method
- can be used in methods and initializers only

```
public class MyClass {  
    private int a;  
    public MyClass(int a) {  
        this.a = a;  
    }  
}
```



# super

---

- access to members of the direct parent
- in the case S is direct parent of C  
`((S) this).name ~ super.name`
- `super.super` **cannot be used**

```
class T1 { int x = 1; }
class T2 extends T1 { int x = 2; }
class T3 extends T2 {
    int x = 3;
    void test() {
        System.out.println(x);           // 3
        System.out.println(super.x);     // 2
        System.out.println(((T2) this).x); // 2
        System.out.println(((T1) this).x); // 1
    }
}
```



# super

---

- `super` can be used with methods too
- WARNING – casting `this` does not work
  - a code can be compiled but the same method will be called recursively

```
class TX1 {  
    public void foo() { /*...*/ }  
}  
class TX2 extends TX1 {  
    public void foo() { /*...*/ }  
}  
public class TX3 extends TX2 {  
    public void foo() {  
        ((TX1) this).foo();  
        System.out.println("TX3.foo()");  
    }  
}
```



# Sealed classes

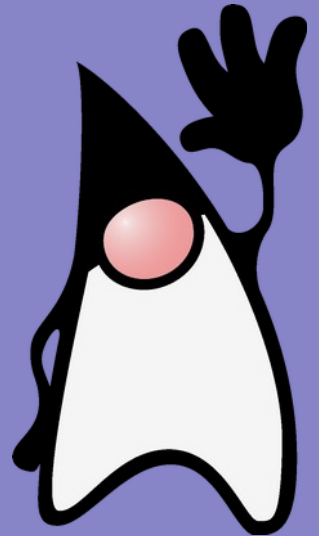
---

- since Java 17
- allowed child classes explicitly listed
  - after **permits**
  - children have to be available at compile-time
- children have to be **sealed**, **non-sealed** or **final**



# Java

## Interfaces



# Interface

---

- only interface
- since Java 8, there can be an implementation
  - default methods
- can contain
  - method declarations
  - fields
  - inner interfaces

```
public interface Iterator {  
    boolean hasNext();  
    Object next();  
    void remove();  
}
```



# Interface: fields

---

- implicitly they are `public, static and final`
- must be initialized
- `super` and `this` cannot be used in initialization

```
public interface Iface {  
    int a = 5;  
    String s = "hello";  
}
```



# Interface: methods

---

- without implementation
  - implicitly **abstract** and **public**
  - cannot be
    - **synchronized**
    - **native**
    - **final**
- **default** methods
  - since Java 8
  - contains implementation
  - intended for extending interfaces
- **static** methods
  - since Java 8
  - the same as the static methods in classes
- **private** methods
  - since Java 9
  - can be used only from **default** and **static** methods





# Interface: inheritance

---

- multiple inheritance

```
interface Iface1 { ... }
```

```
interface Iface2 { ... }
```

```
interface Iface3 extends Iface1, Iface2 { ... }
```



# Classes and interfaces

---

- classes implement interfaces

```
public interface Colorable {  
    void setColor(int c);  
    int getColor();  
}  
public class Point { int x,y; }  
public class ColoredPoint extends Point implements Colorable {  
    int color;  
    public void setColor(int c) {  
        color = c; }  
    public int getColor() { return color;}  
}
```

```
Colorable c = new ColoredPoint();
```



# Classes and interfaces

---

- a class must implement all methods of its interfaces except the default methods
  - not true for abstract classes
- a single method in a class can implement several interfaces

```
interface A { void log(String msg); }  
interface B { void log(String msg); }
```

```
public class C implements A, B {  
    public void log(String msg) {  
        System.out.println(msg);  
    }  
}
```



# Interfaces and default methods

---

- the implementation in a class has always precedence over the implementation in interfaces
- if implementing two interfaces with the same **default** method, then the method has to be implemented in the class
  - otherwise the class cannot be compiled

```
interface If1 {  
    default void foo() {...}  
}
```

```
interface If2 {  
    default void foo() {...}  
}
```

```
class Mixed implements  
    If1, If2 {  
}
```

cannot be compiled

# Interfaces and default methods

---

- it is forbidden to define a default method for a public method from `java.lang.Object`

```
interface Iface {  
    public default boolean equals(Object obj) {  
        return false;  
    }  
}
```

- the implementation in a class has always precedence over the implementation in interfaces
  - even an inherited one

# Interfaces and default methods

---

```
interface If1 {  
    default void foo() {  
        System.out.println("interface");  
    }  
}
```

```
class A {  
    public void foo() {  
        System.out.println("class");  
    }  
}
```

```
class B extends A implements If1 {  
    public static void main(String[] args) {  
        B b = new B();  
        b.foo();    // -> "class"  
    }  
}
```

# Sealed interfaces

---

- a list of classes that can implement the interface and a list of interfaces that can extend the interface

```
sealed interface Expr
    permits ConstantExpr, PlusExpr, TimesExpr, NegExpr {
    public int eval();
}
```

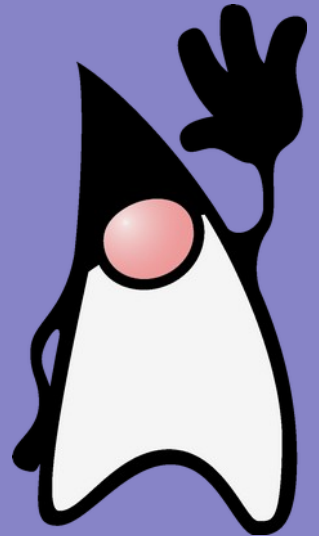
```
final class ConstantExpr implements Expr {
    /*....*/
}
```

```
final class PlusExpr implements Expr {
    /*....*/
}
```



# Java

## Arrays





# Array definition

---

- array ~ object
- variable ~ reference

```
int[]      a;      // array
short[][]  b;      // 2-dimensional array
Object[]   c,      // array
           d;      // array
long       e,      // non-array
           f[];    // array
```



# Array initialization

---

- "static"

```
int[] a = { 1, 2, 3, 4, 5 };  
char[] c = { 'h', 'e', 'l', 'l', 'o' };  
String[] s = { "hello", "bye" };  
  
int[][] d = { { 1, 2 }, { 3, 4 } };
```



# Array initialization

---

- dynamic

```
int[] array = new int [10];  
float[][] matrix = new float[3][3];
```

- just several dimensions can be specified

- but first ones
- empty brackets for the rest

```
float[][] matrix = new float[3][];  
for (int i=0;i<3;i++)  
    matrix[i] = new float [3];
```

```
// wrong  
int[][][][] a = new int[3][][3][];
```



# Array initialization

---

- "non-rectangular" array

```
int a[][] = { {1, 2}, {1, 2, 3}, {1, 2, 3, 4, 5} };
```

```
int b[][] = new int [3][];  
for (int i=0; i<3; i++)  
    b[i] = new int [i+1];
```



# Array initialization

---

- no constructor is called
- elements in the created array (using `new`) – default values
  - references – null
  - int – 0
  - ...
- expressions in array creation (**`new`**) – fully evaluated from left

```
int i = 4;  
int ia[][] = new int[i][i=3];  
// array 4x3
```



# Access to array

---

- `array[index]`
- **indexes** – always `0..length-1`
- **bounds always checked**
  - cannot be switched off
  - exception thrown for out of bounds access  
`ArrayIndexOutOfBoundsException`
- **array length** – field **length**

```
int[] a = { 1, 2, 3 };  
for (int i=0; i < a.length; i++) {  
    ....  
}
```



# Array ~ object

---

- `int[] intArray = new int [100];`
- `String[] strArray = new String [100];`
- array is object

```
Object o1 = strArray;    // OK  
Object o2 = intArray;    // OK
```

- but

```
Object[] oa1 = strArray; // OK  
Object[] oa2 = intArray; // error
```



# Array ~ object

---

```
Object[] oa = new Object [2];  
oa[0] = new String("hello");  
oa[1] = new String("world");
```

```
String[] sa1 = oa;
```

Error – cannot be compiled

```
String[] sa2 = (String[]) oa;
```

Error too  
can be compiled but run-time error





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