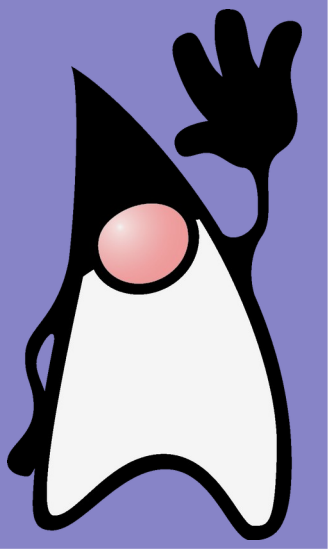
Java

Strings



String

- instances of `java.lang.String`
- compiler works with them *almost* like with primitive types
  - String literals = instances of the String class

- **immutable!!!**
  - modifications via clases `StringBuffer, StringBuilder`
- operator +
  - String concatenation
  - if there is at least a single String in a + expression -> all is converted to Strings and concatenated
    - method `toString()`
      - defined in the class Object
      - commonly overridden
  - creates a new String

will be later

operators priority still holds

Strings

- What is printed out?

```
System.out.println("hello " + 1 + 2)
```

- And now?

```
System.out.println(1 + 2 + " hello")
```

java.lang.String

- constructors

```
String();
String(char[] value);
String(byte[] bytes);
String(byte[] bytes, String charsetName);
String(String value);
String(StringBuffer value);
String(StringBuilder value);
...
```

java.lang.String

- methods
  - `int length();`
  - `char charAt(int index);`
    - `IndexOutOfBoundException`
  - `boolean equals(Object o);`
    - compares Strings
    - == compares references

```
String a = new String("hello");
String b = new String("hello");
System.out.println(a==b);  // false
System.out.println(a.equals(b)); //true
```

String interning

- What is printed out?

```
String a = "hello";
String b = "hello";
System.out.println(a==b);
```

true

- virtual machine stores only one copy of each String literal
  - called *string interning*
  - stored in the string pool (special region of the memory)

- manual interning

```
String a = new String("hello");
String b = "hello";
System.out.println(a==b);  // false
a = a.intern();
System.out.println(a==b);  // true
```

java.lang.String

- methods
  - `int compareTo(String s);`
    - lexicographical comparison
  - `int compareToIgnoreCase(String s);`
  - `int indexOf(char c);`
  - `int indexOf(String s);`
    - return -1, if there is no such char or substring
  - `String substring(int beginIndex);`
  - `String substring(int beginIndex, int endIndex);`
  - `String replaceFirst(String regexp, String repl);`
  - `String replaceAll(String regexp, String repl);`
  - `String join(CharSequence delimiter, CharSequence... elements);`
  - `...`

Strings

- methods can be called on String constants also

```
String s;
...
if ("ahoj".equals(s)) {
   ...
```

java.util.StringJoiner

- constructors
  - `StringJoiner(CharSequence delimiter)`
  - `StringJoiner(CharSequence delimiter, CharSequence prefix, CharSequence suffix)`

- usage

```
StringJoiner sj = new StringJoiner(":", "[", "]");
sj.add("George").add("Sally").add("Fred");
String desiredString = sj.toString();  // [George:Sally:Fred]
```

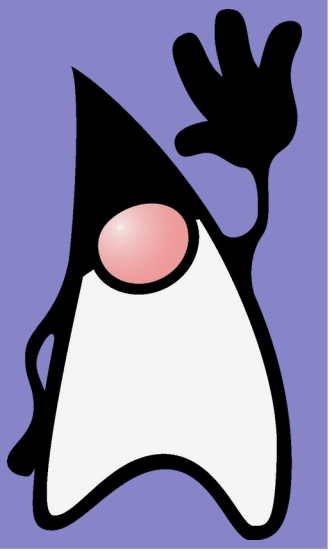
Internal representation of String

- till Java 8
  - char[]

- since Java 9
  - so-called *Compact Strings*
  - char[] or byte[]
    - automatically chosen based on the String content

Java

Wrapper types

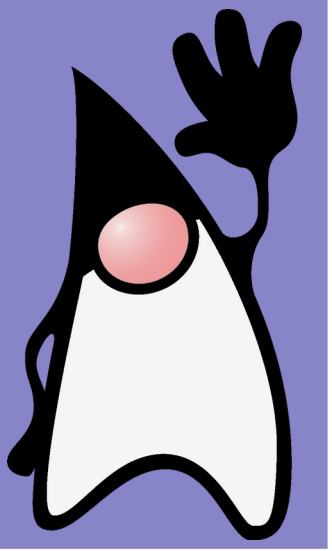


Wrappers

- immutable
- Integer
  - constructors – deprecated since Java 9
    - ~~`Integer(int value)`~~
    - ~~`Integer(String s)`~~
  - methods
    - `int intValue()`
    - `static Integer valueOf(int I)`
      - can cache values
    - `static int parseInt(String s)`
    - `...`
- other wrapper types similarly

Java

More about methods



Local variables

- definition anywhere in body
- visible in a block
  - see the first lecture
- no initialization
- can be defined as **`final`**
  - constants
  - no other modifier can be used
- *effectively final*
  - defined without **`final`** but the value is never changed after it is initialized
  - since Java 8

Type inference for loc. vars

- since Java 10
- only for local variables

```
var s = "hello";
var list = new ArrayList<String>();
```

- var – reserved type name
  - it is not a keyword

- requires initialization
- not always applicable
  - cannot be used with
    - null
    - array initialization
    - lambdas
    - ...

Method overloading

- several methods with the same name but different parameters
  - different number and/or type

```
public void draw(String s) {
    ...
}
public void draw(int i) {
    ...
}
public void draw(int i, double f) {
    ...
}
```

- cannot overload just by a different return type

Recursive calls

- recursion – a method calls itself

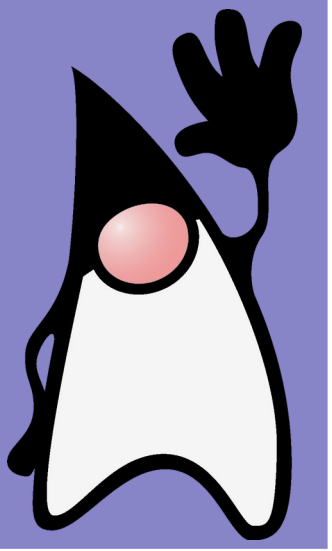
```
public static long factorial(int n) {
    if (n == 1) return 1;
    return n * factorial(n-1);
}
```

- be aware about termination

- non terminated -> stack overrun
  - a size of the stack can be set

Java

Exceptions



Exceptions

- errors reporting and handling
  - an exception represents an error state of a program
- exception = an instance of `java.lang.Throwable`
- two subclasses – `java.lang.Error` and `java.lang.Exception`
  - specific exceptions – children of the above two classes
- `java.lang.Error`
  - "unrecoverable" errors
  - should not be caught
  - e.g. `OutOfMemoryError`
- `java.lang.Exception`
  - recoverable errors
  - should (has to) be caught
  - e.g. `java.io.IOException`

Exception handling

- statement `try/catch/finally`

```
try {
   ... // a block of code where an exception
         // can happen and we want to handle it
} catch (Exception1 e) {
   // handling of exceptions with the
    // Exception1 type and its subtypes
} catch (Exception2 e) {
   // handling of exceptions with the
    // Exception2 type and its subtypes
} finally {
   // executes always
}
```

Exception handling

- if the exception is not caught in a block where it occurs, it propagates to the upper block
- if the exception is not caught in a method, it propagates to the calling method
- it the exception reaches `main()` and it not caught, it terminates the virtual machine
  - information about the exception is printed

try/catch/finally

- catch or finally can be omitted
  - but both cannot be omitted

Extended try (since Java 7)

- interface **`AutoClosable`** and extended **`try`**
  - example:

```
class Foo implements AutoClosable {
   ...
   public void close() {  …  }
}

try ( Foo f1 = new Foo(); Foo f2 = new Foo() ) {
    ...
} catch (...) {
    ...
} finaly {
    ...
}
```

  - at the end of **`try`** (normally or by an exception), **`close()`** is always called on all the objects in the **`try`** declaration
    - called in the reverse order than declared

Extended try

- both catch and finally can be omitted together

```
try (Resource r = new Resource()) {
    ...
}
```

- since Java 9, (effectively) final variables can be used in extended try

```
final Resource resource1 = new Resource("res1");
Resource resource2 = new Resource("res2");

try (resource1;  resource2) {
    ...
}
```

„multi“ catch (since Java 7)

```
class Exception1 extends Exception {}
class Exception2 extends Exception {}

try {
  boolean test = true;
  if (test) {
    throw new Exception1();
  } else {
    throw new Exception2();
  }
} catch (Exception1 | Exception2 e) {
  ...
}
```

Exception declaration

- a method that can throw an exception must either
  - catch the exception, or
  - declare the exception via `throws`

```
public void openFile() throws IOException {
   ...
}
```

- it is not necessary to declare following exceptions
  - children of `java.lang.Error`
  - children of `java.lang.RuntimeException`
    - it extends `java.lang.Exception`
    - ex. `NullPointerException`, `ArrayIndexOutOfBoundException`

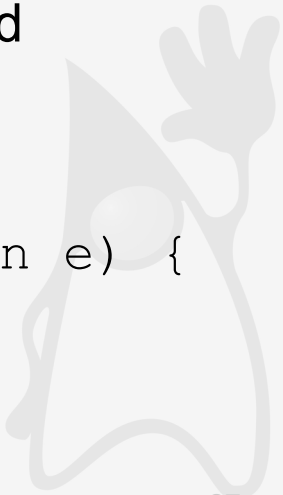
Throwing exceptions

- statement `throw`
  - throws (generates) an exception
  - "argument" – a reference to `Throwable`

```
throw new MyException();
```

- existing exceptions can be thrown but, commonly, own ones are used
- exceptions can be “re-thrown”

```
try {
   ...
} catch (Exception e) {
   ...
   throw e;
}
```



Re-throwing

```
class Exception1 extends Exception {}
class Exception2 extends Exception {}

public static void main(String[] args) throws Exception1, Exception2 {
  try {
    boolean test = true;
    if (test) {
      throw new Exception1();
    } else {
      throw new Exception2();
    }
  } catch (Exception e) {
    throw e;
  }
}
```

Exceptions “remember” their types (since Java 7)

java.lang.Throwable

- has the field (private) typed String
  - contains a detailed description of the exception
  - method `String getMessage()`
- constructors
  - `Throwable()`
  - `Throwable(String mesg)`
  - `Throwable(String mesg, Throwable cause)`
  - `Throwable(Throwable cause)`
- methods
  - `void printStackTrace()`

Own exceptions

```
public class MyException extends Exception {
  public MyException() {
    super();
  }
  public MyException(String s) {
    super(s);
  }
  public MyException(String s, Throwable t) {
    super(s, t);
  }
  public MyException(Throwable t) {
    super(t);
  }
}
```

Chains of exceptions

```
...
try {
   ...
   ...
} catch (Exception1 e) {
   ...
   throw new Exception2(e);
}
...
```

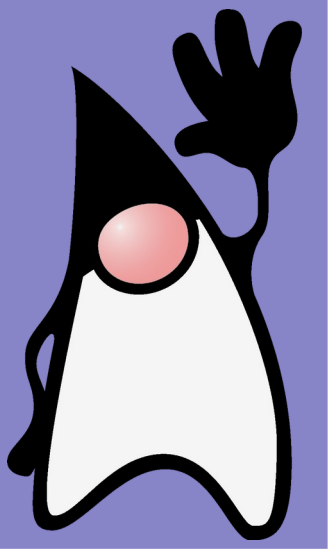
- throwing an exception as a reaction to another exception
  - it is common
    - reacting to a “system” exception by an “own” one

Suppressing exception

- in several cases an exception can suppress another one
  - it is not chaining of exceptions!
  - typically it can happen
    - if an exception occurs in the **`finally`** block
    - in the extended **`try`** block (Java 7)
- **`Throwable[] getSuppressed()`**
  - method in **`Throwable`**
  - returns an array of suppressed exceptions

Java

Inner classes



Inner classes

- defined in the body of another class

```
public class MyClass {
  class InnerClass {
    int i = 0;
    public int value() { return i; }
  }
  public void add() {
    InnerClass a = new InnerClass();
  }
}
```

Inner classes

- the inner class can return a reference to the outer class

```
public class MyClass {
  class InnerClass {
    int i = 0;
    public int value() { return i; }
  }
  public InnerClass add() {
    return new InnerClass();
  }
  public static void main(String[] args){
    MyClass p = new MyClass();
    MyClass.InnerClass a = p.add();
  }
}
```

Hiding inner class

- inner class can be `private` or `protected`
- access to it via an interface

```
public interface MyIface {
  int value();
}
public class MyClass {
  private class InnerClass implements MyIface {
    private i = 0;
    public int value() {return i;}
  }
  public MyIface add() {return new InnerClass();}
}
...
public static void main(String[] args) {
  MyClass p = new MyClass();
  MyIface a = p.add();
  // error - MyClass.InnerClass a = p.add();
}
```

Inner classes in methods

- an inner class can be defined in method or just a block of code
- visible just in the method (block)

```
public class MyClass {
  public MyIface add() {
    class InnerClass implements MyIface {
      private i = 0;
      public int value() {return i;}
    }
    return new InnerClass();
  }
  public static void main(String[] args) {
    MyClass p = new MyClass();
    MyIface a = p.add();
    // error - MyClass.InnerClass a = p.add();
  }
}
```

Anonymous inner classes

```
public class MyClass {
  public MyIface add() {
    return new MyIface() {
      private i = 0;
      public int value() {return i;}
    };
  }

  public static void main(String[] args) {
    MyClass p = new MyClass();
    MyIface a = p.add();
  }
}
```

Anonymous inner classes

```
public class Wrap {
  private int v;
  public Wrap(int value) { v = value; }
  public int value() { return v; }
}
public class MyClass {
  public Wrap wrap(int v) {
    return new Wrap(v) {
      public int value() {
        return super.value() * 10;
      }
    };
  }
  public static void main(String[] args) {
    MyClass p = new MyClass();
    Wrap a = p.wrap(5);
  }
}
```

Anon. inner classes: initialization

- elements outside an anon. in. class necessary in the anon. in. class must be **`final`** or "effectively" final

```
public class MyClass {
  public MyIface add(final int val) {
    return new MyIface() {
      private int i = val;
      public int value() {return i;}
    };
  }
```

Anon. inner classes: initialization

- anon. inner classes cannot have a constructor
  - because they are anonymous
- object initializer

```
public class MyClass {
  public MyIface add(final int val) {
    return new MyIface() {
      private int i;
      {
        if (val < 0)
          i = 0;
        else
          i = val;
       }
      public int value() {return i;}
    };
  }
```

Relation of inner and outer class

- the instance of an inner class can access **all** elements of the instance of the outer class

```
interface Iterator {
  boolean hasNext();
  Object next();
}
public class Array {
  private Object[] o;
  private int next = 0;
  public Array(int size) {
    o = new Object [size];
  }

  public void add(Object x) {
    if (next < o.length) {
      o[next] = x;
      next++;
    }
  }
  private class AIterator
  implements Iterator {
    int i = 0;
    public boolean hasNext() {
      return i < o.length;
    }

    public Object next() {
      if (i < o.length)
        return o[i++];
      else
        throw new NoNextElement();
    }
  }

  public Iterator getIterator() {
    return new AIterator();
  }
}
```

Relation of inner and outer class

- a reference to the instance of the outer class
  - `OuterClassName.this`
  - previous example – classes `Array` and `AIterator`
    - the reference to the instance of `Array` from `Array.AIterator` – `Array.this`

Relation of inner and outer class

- creation of the instance of an inner class outside of its outer class

```
public class MyClass {
  class InnerClass {
  }
  public static void main(String[] args) {
    MyClass p = new MyClass();
    MyClass.InnerClass i = p.new InnerClass();
  }
}
```

- an instance of an inner class cannot be created without an instance of its outer class
  - instances of an inner class always have a (hidden) reference to an instance of its outer class

Inner classes in inner classes

- from an inner class, an outer class on any level of nesting can be accessed

```
class A {
  private void f() {}
  class B {
    private void g() {}
    class C {
      void h() {
        g();
        f();
} } } }
```

```
public class X {
  public static void
  main(String[] args) {
    A a = new A();
    A.B b = a.new B();
    A.B.C c = b.new C();
    c.h();
  }
}
```

Inheriting from inner classes

- a reference to an instance of the outer class has to be **explicitly** passed

```
class WithInner {
  class Inner {}
}
class InheritInner extends WithInner.Inner {
  InheritInner(WithInner wi) {
    wi.super();
  }
  // InheritInner() {} // compile-time error

  public static void main(String[] argv) {
    WithInner wi = new WithInner();
    InheritInner ii = new InheritInner(wi);
  }
}
```

Nested classes

- defined with the keyword `static`
- do not have a reference to an instance of its outer class
- can have static elements
  - inner classes cannot have static elements
- do not need an instance of the outer class
  - they do not have the reference to it
- in fact, they are regular classes just placed in the namespace of the outer class

```
public class MyClass {
  public static class NestedClass {
  }

  public static void main(String[] args) {
    MyClass.NestedClass nc = new MyClass.NestedClass();
  }
}
```

Nested classes

- can be defined in an interface
  - inner classes cannot be

```
interface MyInterface {
  static class Nested {
    int a, b;
    public Nested() {}
    void m();
  }
}
```

Inner classes and .class files

- inner (or nested) class – own .class file
- `OuterName$InnerName.class`
  - `MyClass$InnerClass.class`
- anonymous inner classes
  - `OuterName$SequentialNumber.class`
  - `MyClass$1.class`
- a nested class can have the `main` method
  - launching: `java OuterName$NestedName`

Reasons for using inner classes

- hiding an implementation
- access to all elements of the outer class
- “callbacks”
- ...