Note about the Reflection API
Overview

- reflection, introspection
- allows for
  - obtaining information about classes, fields, methods
  - creating objects
  - calling methods
  - ...
- the package `java.lang.reflect`
- the class `java.lang.Class<T>`
java.lang.Class

- an instance of the class **Class** represents a class (interface, enum,...) in a running program
- primitive types also represented as instances of **Class**
- no constructor
- instances created automatically during loading the class code to JVM
  - classes are loaded to JVM when firstly used
java.lang.Class

- obtaining an instance of Class
  - `getClass()`
    - the method of the Object class
    - returns the class of the object on which was called
  - the class literal
    - `JmenoTridy.class`
    - the class for the given type
  - `Class.forName(String className)`
    - static method
    - returns the class of the given name
- for primitive types
  - the static attribute TYPE on the wrapper classes
    - `Integer.TYPE`
  - the literal `class`
    - `int.class`
class are loaded to JVM by a `classloader`
- `java.lang.ClassLoader`
- the standard classloader looks up classes in `CLASSPATH`
- own classloaders can be created
- `Class.forName(String className, boolean initialize, ClassLoader cl)`
  - loads the class by the given classloader and returns an instance of the `Class`
- `getClassLoader()`
  - the method of `Class`
  - the classloader, which loaded the class
java.lang.Class: methods

- String getName()
  - returns the name of the class
  - for primitive types returns their names
  - for array returns a string beginning with the chars ']' (number of ']' corresponds to dimension) and then an identification of the element type

```java
String.class.getName() // returns "java.lang.String"
byte.class.getName()    // returns "byte"
(new Object[3]).getClass().getName() // returns "[Ljava.lang.Object;"
(new int[3][4][5][6][7][8][9]).getClass().getName() // returns "[[[[[[[I"
```
java.lang.Class: methods

- public URL getResource(String name)
- public InputStream getResourceAsStream(String name)
  - reads a resource
    - image, ..... anything
  - data loaded by a classloader => loading by the same rules as loading classes
  - a name of the resource ~ a hierarchical name as of classes
    - dots replaced by `'/'

java.lang.Class: methods

• is... methods
  - boolean isEnum()
  - boolean isInterface()
  - ...

• get... methods
  - Field[] getFields()
  - Method[] getMethods()
  - Constructor[] getConstructors()
  - ...

• ...

Usage of Reflection API

- information about code
- dynamic loading
- plugins
- proxy classes
- …

- more details in summer semester
jar
Overview

- creating archives composed of .class files
- JAR ~ Java Archive
- file
  - extension .jar
  - format – ZIP
  - file META-INF/MANIFEST.MF
    - description of the content
- usage – distribution of software
  - CLASSPATH can contain .jar files
  - .jar files can be directly executed
- can contain also other files than .class files
  - images
  - audio
  - anything else
Usage

- creating an archive
  
  \texttt{jar cf file.jar *.class}
  
  - creates the file.jar with all .class files
  - adds the MANIFEST.MF file to it

  \texttt{jar cmf manifest file.jar *.class}
  
  - creates the file.jar with the given MANIFEST file

  \texttt{jar cf0 soubor.jar *.class}
  
  - no compression

  - see documentation for other parameters

- API for working with jar files
  
  - java.util.jar, java.util.zip
MANIFEST.MF file

- list of tuples
  - name : value
  - inspired by the standard RFC822
- tuples can be grouped
  - groups separated by an empty line
  - main group (the first one)
  - groups for individual entries in the archive
- length of lines – max 65535
- end of lines
  - CR LF, LF, CR
MANIFEST.MF files

• main group
  - Manifest-Version
  - Created-By
  - Signature-Version
  - Class-Path
  - Main-Class
    • applications can be launched
      java -jar archive.jar

• other section
  - the first tuple
    Name: path_to_the_entry_in_the_archive
Jar and Ant

- the task **jar**
  - parameters
    - destfile, basedir, includes, excludes, manifest
  - inner elements
    - manifest
  - example

```xml
<jar destfile="${dist}/lib/app.jar"
    basedir="${build}/classes"
    excludes="**/Test.class"
/>

<jar destfile="test.jar" basedir=".">
    <include name="build"/>
    <manifest>
        <attribute name="Built-By" value="${user.name}"/>
        <section name="common/class1.class">
            <attribute name="Sealed" value="false"/>
        </section>
    </manifest>
</jar>
```
java.util.jar

- similar to java.util.zip

- `JarInputStream`, `JarOutputStream`
  - children of `ZipInputStream` and `ZipOutputStream`
  - `JarInputStream` has the `getManifest()` method

- `JarEntry`
  - child of `ZipEntry`
  - obtaining attributes

- `Manifest`
  - the `MANIFEST.MF` file
Modules

• a module
  - explicitly defines what is provided but also what is *required*

• why?
  - the *classpath* concept is “fragile”
  - no encapsulation
Modular apps – motivation

• why
  – applications get more complex
  – assembled from pieces
  – developed by distributed teams
  – complex dependencies
  – good architecture
    • know your dependencies
    • manage your dependencies
Module declaration

- module-info.java
  ```java
  module com.foo.bar {
      requires com.foo.baz;
      exports com.foo.bar.alpha;
      exports com.foo.bar.beta;
  }
  ```

- modular artifact
  - modular JAR – JAR with module-info.class
  - a new format JMOD
    - a ZIP with classes, native code, configuration,...
Modules and JDK

- JDK std library modularized too
  - java.base – always „required“

```java
module java.base {
  exports java.io;
  exports java.lang;
  exports java.lang.annotation;
  exports java.lang.invoke;
  exports java.lang.module;
  exports java.lang.ref;
  exports java.lang.reflect;
  exports java.math;
  exports java.net;
  ...
```
Module readability & module path

- When one module depends directly upon another

  Module *reads* another module (or, equivalently, second module is *readable* by first)

- **Module path** – equivalent to classpath
  - but for modules
    - -p, --module-path
module com.foo.app {
    requires com.foo.bar;
    requires java.sql;
}

Module graph

com.foo.app

com.foo.bar

java.xml

com.foo.baz

java.base

java.logging

java.sql
Compatibility with “old” Java

- Classpath still supported
  - in fact – modules are “optional”

- Unnamed module
  - artefacts outside any module
    - “old” code
  - reads every other module
  - exports all of its packages to every other module
 Modules

• more details in summer semester
Unit testing
Introduction

- unit testing
  - testing “small” units of functionality
  - a unit – independent on other ones
    - tests are separated
    - creating helper objects for tests
      - context
  - typically in OO languages
    - unit ~ method
  - ideally – unit tests for all units in a program
    - typically in OO languages
      - for all public methods
Test-driven development

- tests first

JUnit

- support for unit testing in Java
- http://www.junit.org/
- usage based on annotations
  - older versions based on inheritance and naming conventions
- slightly different usage in different versions
  - 5, 4, 3
Usage

- test methods marked by the @Test annotation
- JUnit is run on a set of classes
  - searches in them all @Test methods
  - executes them

- other annotations
  - @BeforeEach (@Before)
    • a method run before each test
    • intended for “environment” preparation
  - @AfterEach (@After)
    • a method run after each test
    • intended for “cleaning”
  - @BeforeAll (@BeforeClass)
    • a method run before all tests in the given class
  - @AfterAll (@AfterClass)
    • a method run after all tests in the given class
public class SimpleTest {

    private Collection collection;

    @BeforeAll
    public static void oneTimeSetUp() {
        // one-time initialization code
    }

    @AfterAll
    public static void oneTimeTearDown() {
        // one-time cleanup code
    }

    @BeforeEach
    public void setUp() {
        collection = new ArrayList();
    }

    @AfterEach
    public void tearDown() {
        collection.clear();
    }

    @Test
    public void testEmptyCollection() {
        assertTrue(collection.isEmpty());
    }

    @Test
    public void testOneItemCollection() {
        collection.add("itemA");
        assertEquals(1, collection.size());
    }
}
Assert

- `assertTrue`
- `assertFalse`
- `assertEquals`
- `assert...`
  - static methods of `org.junit.jupiter.api.Assertions` (org.junit.Assert)
  - testing conditions in tests
  - test fails if `assert...` fails
    - `assert...()` throws AssertionError

- in general
  - test is successful if the method terminates regularly
  - test fails if the method throws an exception
Testing exceptions

• how to test “correctly” thrown exceptions?

```java
assertThrows(IndexOutOfBoundsException.class, () -> {
    new ArrayList<Object>().get(0);
});
```

• in older versions

```java
@Test(expected= IndexOutOfBoundsException.class) public void empty() {
    new ArrayList<Object>().get(0);
}
```
Running tests

- from code
  ```java
  org.junit.runner.JUnitCore.runClasses(TestClass1.class, ...);
  ```
- from command line
  ```
  java -jar junit.jar --select-class TestClass1
  ```
- from Ant
  - the task junit
    ```xml
    <junit printsummary="yes" fork="yes" haltonfailure="yes">
    <formatter type="plain"/>
    <test name="my.test.TestCase"/>
    </junit>
    ```
- from Maven
  - mvn test
- from IDE
TestNG

- [http://testng.org/](http://testng.org/)
- inspired by JUnit
- slightly different set of features
  - originally
  - now, more-or-less the same
- basic usage is the same
Java

Reactive programming
Reactive programming (RP)

- data streams and propagating of changes in a program
  - data changes are automatically propagated

- publisher-subscriber
  - architectural pattern
  - one of particular models for RP
  - publisher publishes data
  - subscriber asynchronously data consumes
  - there can be processor between P and S transforming data

- why RP
  - simpler code, more efficient, …
  - “an extension” of the stream API
Publisher-Subscriber in Java

- Flow API (Reactive streams)
- java.util.concurrent.Flow
  - since Java 9

- "a combination of iterator and observer patterns"
Flow API

@FunctionalInterface
public static interface Flow.Publisher<T> {
    public void subscribe(Flow.Subscriber<? super T> subscriber);
}

public static interface Flow.Subscriber<T> {
    public void onSubscribe(Flow.Subscription subscription);
    public void onNext(T item);
    public void onError(Throwable throwable);
    public void onComplete();
}

public static interface Flow.Subscription {
    public void request(long n);
    public void cancel();
}

public static interface Flow.Processor<T,R> extends
        Flow.Subscriber<T>, Flow.Publisher<R> {
}
Flow API

- SubmissionPublisher
  - implements the Publisher interface
  - asynchronously publishes given data
  - the constructor without parameters
    - uses ForkJoinPool.commonPool()
  - other constructors – an argument for an executor
  - methods
    - subscribe(Flow.Subscriber<? super T> subscriber)
    - submit(T item)
    - ...
Observer pattern

• an object (observer) „observes“ another object (observable) – if the other object changes, it notifies all its observers

  − java.util.Observer
  − java.util.Observable
    • warning – Deprecated since Java 9 (replaced by Flow)

  Observable
  + addObserver()
  + notifyObservers()

  Observer
  + update()

• usage
  − UI
    • Observable – UI components
    • Observer – reactions to UI events
More about threads
ThreadLocal

• own copy for each thread
• typically used as static fields

• methods

T get()
protected T initialValue()
void remove()
void set(T value)
static <S> ThreadLocal<S> withInitial(Supplier<?
extends S> supplier)
Java

What next...
What next

• NPRG021 Advanced programming for Java platform
  – summer 2/2
  – synopsis
    • GUI (Swing, JavaFX)
    • Modules, Reflection API, Classloaders, Security
    • Generics, annotations
    • RMI
    • JavaBeans
    • Java Enterprise Edition: EJB, Servlets, Java Server Pages, Spring,…
    • Java Micro Edition: Java for mobile and embedded systems, CLDC, MIDP, MEEP
    • RTSJ, Java APIs for XML, JDBC, JMX,…
    • Kotlin and other “Java” languages
    • Android
  – partially mandatory for NPRG059 Advanced Programming Praxis
    • a mandatory course for several Master study branches