Additional notes about functional programming

(continuation from the previous lecture)
Functional programming

- a function in FP ~ “a mathematical function”
  - takes arguments
  - returns a result(s)
  - **no side-effects!!!**
    - **WARNING:** I/O operations are also side-effects
      - no exception thrown
        - can be considered as side-effects too
      - lazy if possible

- data (lists) are non-modifiable
  - functions return new ones
Lazy functions

- example
  ```java
  class DebugPrint {
    private boolean debug;
    public void setDebug(boolean d) { debug = d; }
    public void println(String s) {
      if (debug) { System.out.println(s); }
    }
  }
  
  DebugPrint db = new DebugPrint();
  ...
  db.println("Name of the user: " + userName);
  ```

- the string is necessary only if debug == true
  - BUT it is created always
    - new StringBuffer().append(...
Lazy functions

- better

```java
class DebugPrint {
    private boolean debug;
    public void setDebug(boolean d) { debug = d; }
    public void println(Supplier<String> c) {
        if (debug) { System.out.println(c.get()); }
    }
}
```

```java
DebugPrint db = new DebugPrint();
... db.println(() -> "Name of the user: " + userName);
```

- the string is created only if it is really necessary
Not throwing exceptions

- a special value returned in case of error
- null is not ideal
  - calls cannot be chained

- Optional<T>
  - class
  - a container for value that can be null
  - methods
    - boolean isPresent()
    - T get()
    - void ifPresent(Consumer<? super T> consumer)
    - ...
  - new instances
    - static <T> Optional<T> empty()
    - static <T> Optional<T> of(T value)
    - static <T> Optional<T> ofNullable(T value)
Serialization
Overview

- "saving" complete objects
  - objects “survive” through programs' executions
- persistence
  - lightweight persistence
  - explicit saving and loading
- serialized objects can be transferred via network
- saving a state of objects
  - attributes
- code of the class of the object must be available

- possibly dangerous
  - might be removed/replaced in future
Usage

- **java.io.Serializable**
  - empty interface
  - serializable objects must implement it
- **ObjectOutputStream**
  - extends OutputStream
  - implements DataOutput and ObjectOutput
  - the method `void writeObject(Object o)`
- **ObjectInputStream**
  - extends InputStream
  - implements DataInput and ObjectInput
  - the method `Object readObject()`
Example

```java
public class Data implements Serializable {
    private int d;
    public Data(int d) {this.d = d;}
    public String toString() {
        return super.toString() + ", d=", d;
    }
}
...
Data data = new Data(1);
...
ObjectOutputStream out = new ObjectOutputStream(
        new FileOutputStream("file.dat"));
out.writeObject(data);
...
ObjectInputStream in = new ObjectInputStream(
        new FileInputStream("file.dat"));
data = (Data) in.readObject();
```
Serialization

- all attributes (even private ones) are serialized/deserialized
  - the attribute modifier `transient`
    - the attribute will not be saved/read
- both primitive and also references are saved
  - recursively are saved all objects from the attributes
  - during deserialization objects are created “in the same shape”
  - př.

![Diagram](attachment://diagram.png)
Own serialization

- interface Externalizable
  - extends Serializable
  - two methods
    - void readExternal(ObjectInput in)
    - void writeExternal(ObjectOutput out)
- objects implement Externalizable instead of Serializable
- the rest is the same (almost)
- the transient modifier has no meaning
  - saving/reading through the methods writeExternal and readExternal
- writeExternal and readExternal are called automatically
Example

```java
public class Data2 implements Externalizable {
    public Data2() { System.out.println("Data2"); }
    public void writeExternal(ObjectOutput out)
        throws IOException {
        System.out.println("Data2.writeExternal");
    }
    public void readExternal(ObjectInput in)
        throws IOException, ClassNotFoundException {
        System.out.println("Data2.readExternal");
    }
}

Data2 d = new Data2();
ObjectOutputStream o = ....
o.writeObject(d);
...
ObjectInputStream i = ....
d = (Data2) o.readObject();
```
Wrong example

```java
public class Data3 implements Externalizable {
    Data3() { System.out.println("Data3"); }
    public void writeExternal(ObjectOutput out)
        throws IOException {
        System.out.println("Data3.writeExternal");
    }
    public void readExternal(ObjectInput in)
        throws IOException, ClassNotFoundException {
        System.out.println("Data3.readExternal");
    }
}
...
Data3 d = new Data3();
ObjectOutputStream o = ....
o.writeObject(d);
...
ObjectInputStream i = ....
d = (Data3) o.readObject();  // an exception occurs!!
```
Loading objects

• implicit serialization (implementing Serializable)
  - during loading no constructor is called
  - objects are created directly
• own serialization (implementing Externalizable)
  - first, a constructor is called
    • the default constructor without parameters
    • must be available
  - then, the `readExternal()` is called on the object
Another approach

• implement the interface Serializable
• and add 2 „magic“ methods
  – private void writeObject(ObjectOutputStream stream) throws IOException;
  – private void readObject(ObjectInputStream stream) throws IOException, ClassNotFoundException

• both methods must have exactly the given signature
  – must be private
• in readObject() and writeObject(), default loading/saving can be called by the methods
defaultReadObject() and defaultWriteObject()
Example

```java
public class Test implements Serializable {
    private String a;
    private transient String b;
    public Test(String aa, String bb) {
        a = "Not Transient: " + aa;
        b = "Transient: " + bb;
    }
    private void writeObject(ObjectOutputStream stream)
    throws IOException {
        stream.defaultWriteObject();
        stream.writeObject(b);
    }
    private void readObject(ObjectInputStream stream)
    throws IOException, ClassNotFoundException {
        stream.defaultReadObject();
        b = (String)stream.readObject();
    }
}
```
Other „magic“ methods

• private void readObjectNoData() throws ObjectStreamException
  – called during loading an object if some of its classes (the class or superclasses) are not stored in a stream
  – usage – when class hierarchy is changed between storing/loading
    • ex: saving an object of the class Monkey, which extends Animal and loading the object of the class Monkey, which extends Mammal and it extends Animal (the method is used on the class Mammal)
Other „magic“ methods

• *anything* `Object readResolve() throws ObjectStreamException`
  – if the method exists, deserialization of an object of the class returns the result of this method

• *anything* `Object writeReplace() throws ObjectStreamException`
  – if exists, its result is serialized
serialVersionUID

- anything static final long serialVersionUID = value
  - if during deserialization the saved value is different from the value in the class, the InvalidClassException is thrown
  - not necessary to use
    - created automatically during serialization
  - but its explicit declaration is strongly recommended
Serialization and std library

- many classes in the std. library implement Serializable
- warning – serialization may not work between different Java version
  - typically a warning in the documentation

Warning: Serialized objects of this class will not be compatible with future Swing releases. The current serialization support is appropriate for short term storage or RMI between applications ...
Preferences
Overview

• the package java.util.prefs
• since Java 1.4
• for storing/loading a configuration of programs
• automatically stored/loaded
  – exact place depends on OS
  – separately per user
• only primitive types and strings (max. 8 KB long)
• tuples
  – key – value
  – does not implement the interface Map
• hierarchical structure (tree)
  – usually just a single node
Usage

- static methods of the class Preferences
- `Preferences userNodeForPackage(Class c)`
  - returns a node of preferences associated with the package of the given class
- `Preferences systemNodeForPackage(Class c)`
  - as the previous method
  - a node common for all users
- ex:
  - `p = Preferences.userNodeForPackage(Foo.class)`
- name of the node ~ full name of the package
  - dots are replaced by slashes "/"
public class Prefs {
    public static void main(String[] args) {
        Preferences prefs = Preferences.
            .userNodeForPackage(Prefs.class);
        prefs.put("url", "http://somewhere/");
        prefs.putInt("port", 1234);
        prefs.putBoolean("connected", true);
        int port = prefs.getInt("port", 1234);

        String[] keys = prefs.keys();
        for (int i; i<keys.length; i++) {
            System.out.println(keys[i] + ": "+
                                 prefs.get(keys[i], null));
        }
    }
}
Methods

- **String get(String key, String def)**
  - returns a value of the key
  - the implicit value must be set
- **int getInt(String key, int def)**
  - as get
  - defined for all the primitive types
- **void put(String key, String val)**
  - assignes a value to the key
  - defined also for all the primitive types
- **String[] keys()**
  - return all keys
- **void flush()**
  - writes the changes
Methods

- **void clear()**
  - clears all the preferences in the node
- **String name()**
  - a name of the node
- **String absolutePath()**
  - an absolute name of the node

- all methods are thread safe
- can be safely used from multiple JVMs at the same time
Communication over network
Overview

- the `java.net` package
- since Java 1.0
- easy communication over network
- almost as using files
  - streams over network
- protocols TCP and UDP
  - Internet
TCP/IP model

Application layer
- HTTP
- FTP
- ...

Transport layer
- TCP
- UDP

Internet layer
- IP

Network interface layer
- ethernet
- ...

Layer Stack: Application, Transport, Internet, Network Interface

Protocols: HTTP, FTP, TCP, UDP, IP, etc.
URI and URL
java.net.URI

- representation of URI
  - unique resource identifier (RFC 2396)
- structure URI
  - [scheme:]scheme-specific-part[#fragment]
- absolute URI – has a schema
  - relative URI – has not a schema
- "opaque" URI – the specific part does not start with the slash
  - ex: mailto:java-net@java.sun.com
  - news:comp.lang.java
- hierarchical URI – either an absolute URI starting with the slash or relative URI
  - př: http://java.sun.com/j2se/1.3/
    ..../demo/jfc/SwingSet2/src/SwingSet2.java
java.net.URI

• hierarchical URI – structure
  – [scheme:][//authority][path][?query][#fragment]
  – authority
    • [user-info@]host[:port]
• all parts of URI are Strings, except the port, which is int
• normalization of URI
  – removing and replacing "." and ".."
java.net.URI: methods

- String getScheme()
- String getSchemeSpecificPart()
- String getPath()
- String getHost()

- boolean isAbsolute()
- boolean isOpaque()
- void normalize()

URL toURL()
- creates URL from URI
- an exception thrown if cannot be created
**java.net.URL**

- URL is a special case of URI
- unique resource locator
- specifying resources in the web
  - http://www.mff.cuni.cz/
- similar methods like URI
  - get...
- `InputStream openStream()`
  - opens a stream for reading a file specified by the URL
- `URLConnection openConnection()`
  - creates a connection to the URL object
URLConnection

- representation of a connection between the application and URL
- usage
  1. obtaining a connection (openConnection())
  2. setting parameters
     - e.g. setUseCaches()
  3. creating the connection (connect())
     - the remote object is available then
  4. obtaining content and information
     - content – getContent() 
     - headers – getHeaderField()
     - streams – getInputStream(), getOutputStream()
     - other – getContentType(), getDate(), ...
Identification (DNS)
InetAddress

- represents an IP address
- obtaining an address
  - static methods of InetAddress
  - InetAddress getByName(String host)
    - IP address of the given name of a node
    - returns localhost for null
  - InetAddress getByAddress(byte[] addr)
    - IP address for the given address
    - length of the addr array – 4 for IPv4, 16 for IPv6
  - InetAddress getLocalHost()
    - address of localhost (127.0.0.1)
Example

```java
public class InetAddress {
    public static void main(String[] args) throws Exception {
        InetAddress a = InetAddress.getByName(args[0]);
        System.out.println(a);
    }
}

public class Localhost {
    public static void main(String[] args) throws Exception {
        System.out.println(InetAddress.getByName(null));
        System.out.println(InetAddress.getLocalHost());
    }
}
```
Sockets
Overview

- socket = endpoint of a connection
- TCP
  - reliable communication
- connections in both directions
  - both InputStream and OutputStream can be obtained
- the ServerSocket class
  - creates a "listening" socket
  - the accept() method
    - waits for an incoming connection
    - returns a socket for communication
- the Socket class
  - a socket for communication
Example: simple server

```java
try (ServerSocket s = new ServerSocket(6666)) {
    System.out.println("Server ready");
    try (Socket socket = s.accept()) {
        InputStream in = socket.getInputStream();
        OutputStream out = socket.getOutputStream();
        while (true) {
            ... 
            in.read();
            ...
            out.write(...);
            ...
        }
    }
}
```
Example: simple client

```java
InetAddress addr = InetAddress.getByName(null);
Socket socket = new Socket(addr, 6666);
try (InputStream in = socket.getInputStream();
     OutputStream out = socket.getOutputStream()) {
    while (...) {
        ...
        out.write(...);
        ...
        in.read();
        ...
    }
}
```
Serving incoming requests

- the previous example – simple server
  - serves only one connection
- serving multiple connections
  - a new thread for each incoming connection

or

- channels and the Selector class
  - serving multiple requests in a single thread
  - the selector holds a set of sockets
    - the select() method waits until at least one socket is ready to be used
  - similar to the select() function in UNIX systems
Multithread server

class ServeConnection extends Thread {
    private Socket socket; private InputStream in;
    private OutputStream out;
    public ServeConnection(Socket s) throws IOException {
        socket = s; in = ...; out = ...; start();
    }
    public void run() {
        while (true) {
            in.read();
            out.write(...);
        }
    }
}

public class Server {
    public static void main(String[] args) throws IOException {
        ServerSocket s = new ServerSocket(6666);
        while (true) {
            Socket socket = s.accept();
            new ServeConnection(socket);
        }
    }
}
java.net

UDP
Overview

- unreliable communication
- the DatagramSocket class
  - for both server and client
  - sending/receiving datagrams
  - void send(DatagramPacket d)
  - void receive(DatagramPacket d)
- the DatagramPacket class
  - a datagram
  - void setData(byte[] buf)
  - byte[] getData()
  - int getLength()
  - void setLength(int a)
    - length of data in the datagram