JAVA

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

```
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`

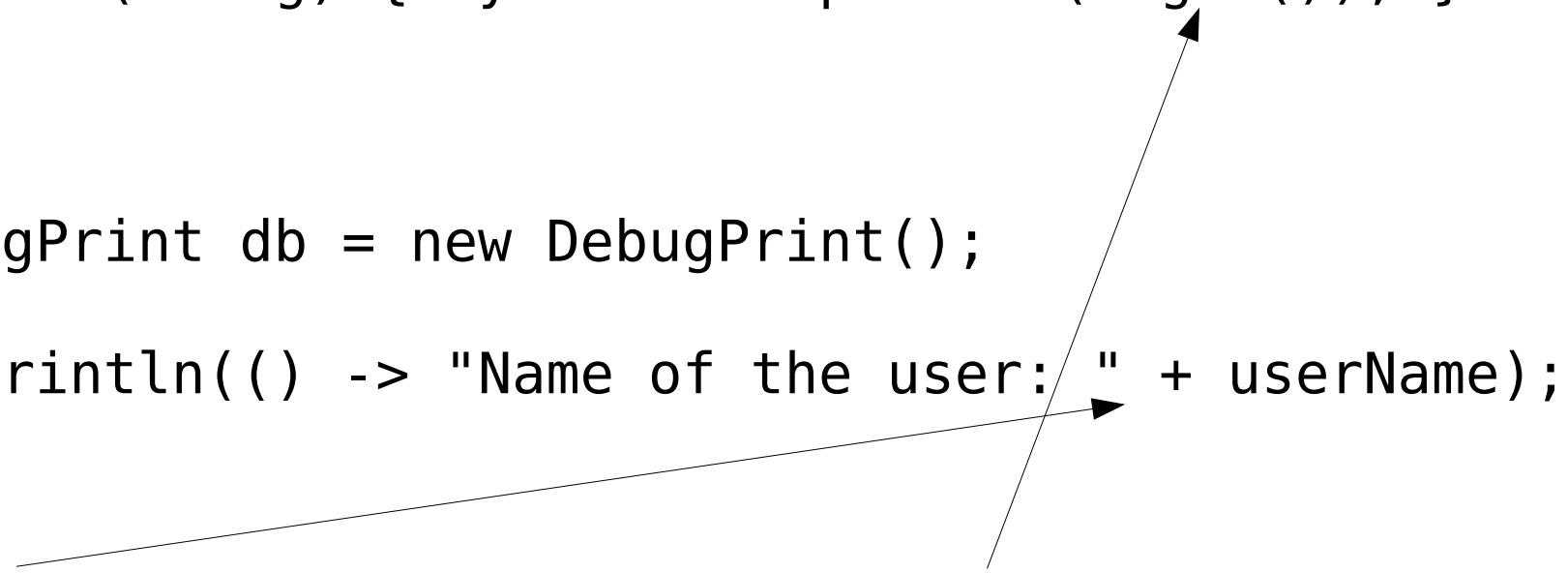
  BUT it is created always

  - `new StringBuffer().append(...`

Lazy functions

- better

```
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()); }
  }
}
...
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

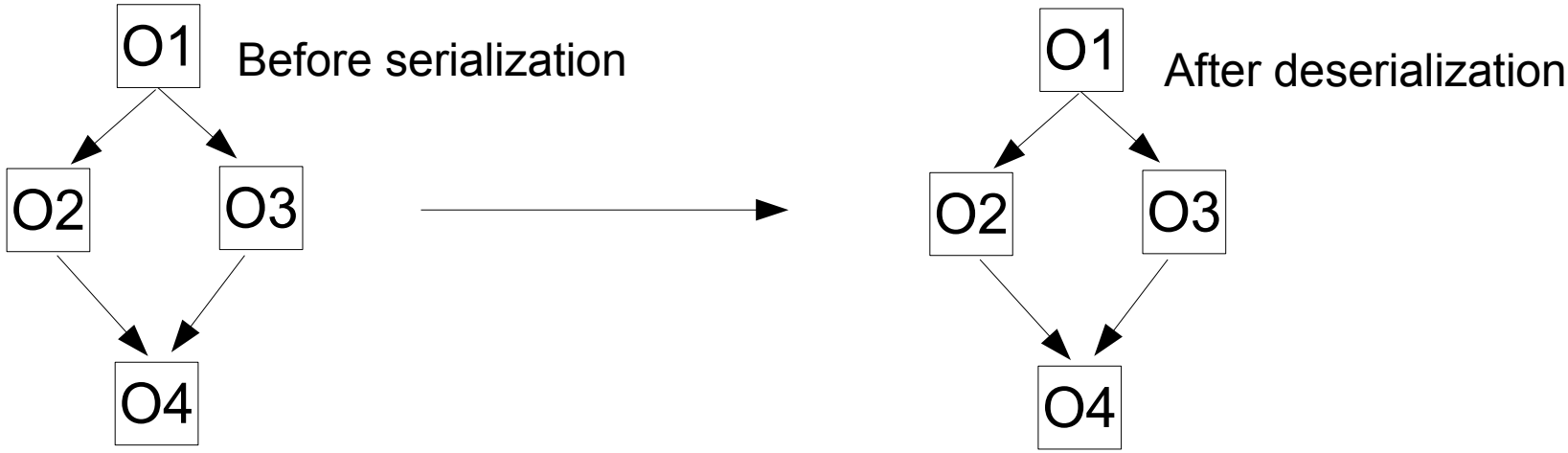
- `java.io.Serializable`
  - empty interface
  - serializable objects must implement it
- `ObjectOutputStream`
  - extends `OutputStream`
  - implements `DataOutput` and `ObjectOutput`
  - the method `void writeObject(Object o)`
- `ObjectInputStream`
  - extends `InputStream`
  - implements `DataInput`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

Example

```
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.



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

```
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

```
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

```
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 "/"

Example

```
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

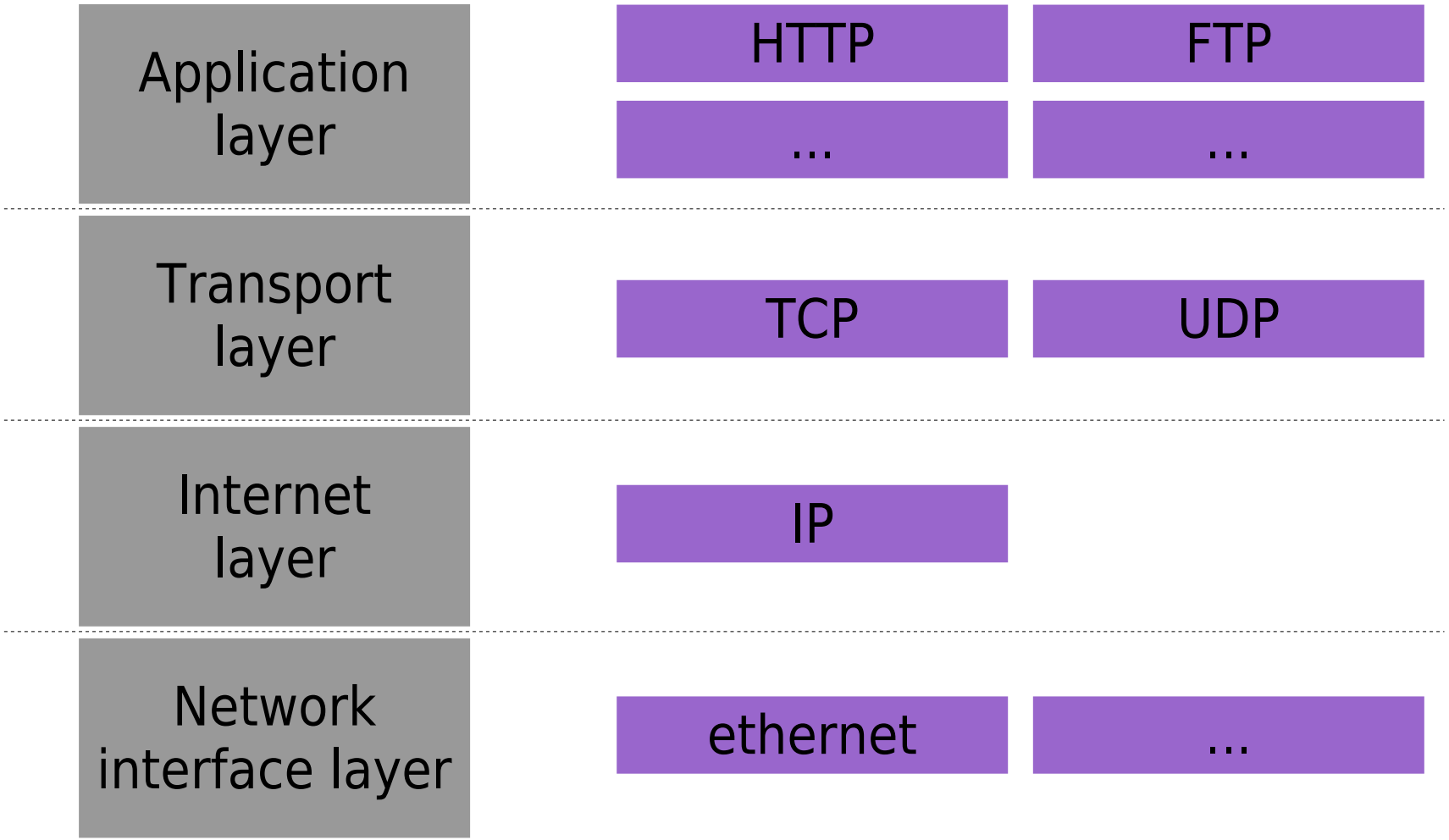
- all methods are thread safe
- can be safely used from multiple JVMs at the same time

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
...

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(), ...

java.net

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

```
public class InetName {
  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());
  }
}
```

java.net

Sockets

Overview

- socket = endpoint of a connection
- TCP
  - reliable communication
- connections in both directions
  - both IntputStream 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

```
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

```
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 connections
- 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()
    - sets/returns a buffer for the datagram
  - int getLength()
  - void setLength(int a)
    - length of data in the datagram