Basics of programming 3

Logging

Log4J

Logging motivation

- Logging
  - Runtime activity
    - Observing application operation
  - Persistent
    - Available even after application stops
      - c.f. runtime debugging
  - Helps debugging
    - During errors causes might be found
    - The only help in many cases
      - Multithreaded debugging is hard

Manual logging

- System.out.println()
  - Simple
  - Regular and logging messages mixed
    - No filtering
  - Immovable solution
    - Switching on-off?
    - Hard to change output channel
      - Embedded systems don’t have a console

System logging

- Solution: logging support
  - Log messages sent to the logging system
    - Built in support for printout
  - Requirements
    - Easy reconfiguration
      - Filtering
      - Modifiable output format
        - console, file, OS, DB
    - Efficiency
      - Logging takes as much as 4% of time on average
      - No overhead when switched off

Logging framework

- Apache Log4J
  - Born in 1999, current version is 2.0
    - 1.x and 2.x has usage differences
    - basic architecture and concepts are same
  - Java class library, open source
    - single .jar file must be added to classpath
- java.util.logging
  - Since 2002 in JDK 1.4
  - Very similar to log4j
    - fewer built in functionality

Log4J Logger

- The application uses a Logger object for logging

```
import org.apache.logging.log4j.*;

class MyClass {
	private static final Logger logger =
		LogManager.getLogger("MyLogger");

	public void foo() {
		logger.info("Log this");
	}
}
```

Logger methods

- Methods for sending log messages
  - void trace(Object message [,Throwable t])
  - void debug(Object message [,Throwable t])
  - void info(Object message [,Throwable t])
  - void warning(Object message [,Throwable t])
  - void fatal(Object message [,Throwable t])
    - For each logging level
    - Message is usually String, but can be any object
    - Even exceptions can be logged with an optional parameter

Logger methods

- Methods to set and read logging level
  - void setLevel(Level level)
  - boolean isTraceEnabled() / isInfoEnabled(), etc.
- Static methods for accessing Logger objects
  - static Logger getRootLogger()
    - root instance (loggers form a hierarchy)
  - static Logger getLogger(String name)
    - instance with the given name

LogManager methods

- Static methods for accessing Logger objects
  - static Logger getRootLogger()
    - root instance (loggers form a hierarchy)
  - static Logger getLogger(String name)
  - static Logger getLogger(Class clazz)
  - static Logger getLogger(Object o)
    - instance with the given name, class, object

Logger hierarchy

- Logger objects organized into a hierarchy
  - Based on their names, automatically
  - Hierarchy levels are separated by dots (“.”)
    - Similar to package names and members
    - E.g. *hu.bme* logger is parent of *hu.bme.iit*
    - Top of hierarchy is a noname root
  - Log messages reach parent loggers as well
    - This can be explicitly overridden
      - void setAdditivity(boolean flag)

Logging levels

- Best practice
  - Logger name = full name of class
- Each logger instance has a logging level
  - Messages below this level are discarded
    - Parents get discarded messages as well
  - If no level is set, inherits from parent

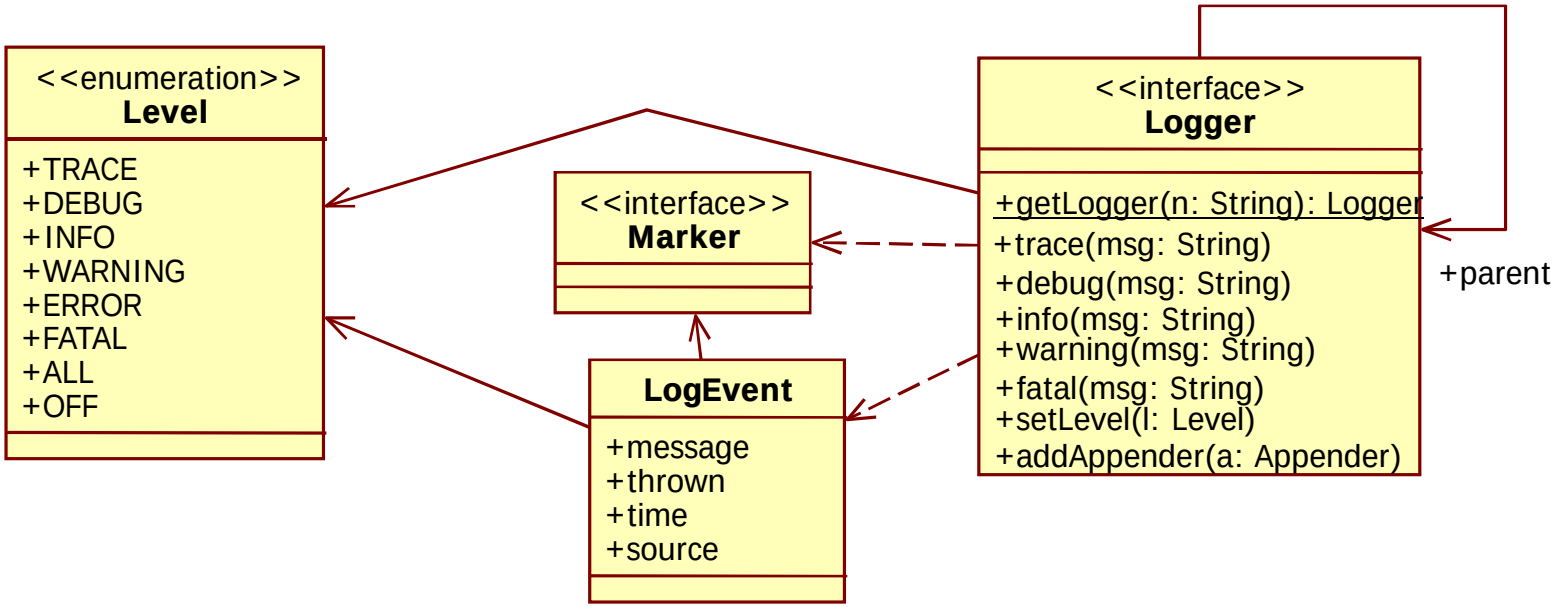
Logging levels 2

- org.apache.log4j.Level (decreasing order):
  - FATAL: The application can not continue
  - ERROR: Error, an operation failed
  - WARN: Warnings
  - INFO: Messages during normal operations
  - DEBUG: Log messages for debugging
  - TRACE: Low level, relating to method calls
- Each log message carries its level

Logging levels 3

- Special values
  - Level.ALL: All messages
  - Level.OFF: No messages
- Only used for logger configuration

Log4J class hierarchy



Appender

- Prints out the log messages
  - Each logger object can have any number of appenders
    - void addAppender(Appender appender)
  - Enables multiple target for log messages
    - In addition to parents' appenders
- Good range of Appenders available

Appender classes

- ConsoleAppender
  - Logging for standard output or std error
    - setTarget(String)
- FileAppender
  - Logging into a file
    - setFile(String), setAppend(boolean)
  - RollingFileAppender
    - If size limit is reached, new file is opened
  - DailyRolledFileAppender
    - After a predefined time new file is opened

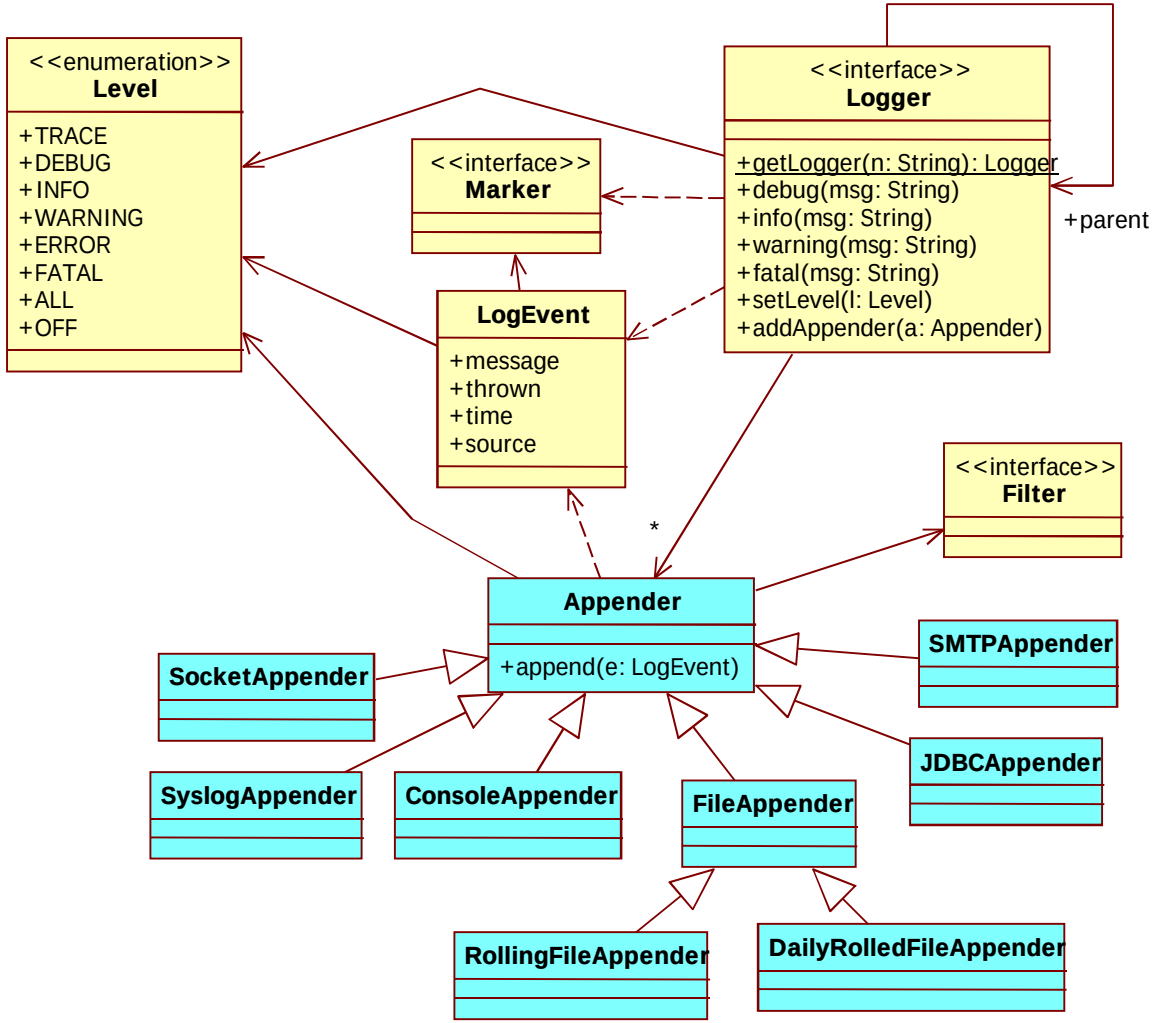
Appender classes 2

- SocketAppender
  - Sending log messages over the network
- SMTPAppender
  - Last N log messages are sent in an email
- JDBCAppender
  - Log messages stored into a DB
- SyslogAppender, NTEventAppender
  - OS specific logging is used

Appender usage

- Appenders have a wide range of configurability
  - getter-setter function provided
- Accept LogEvents
  - accept(LogEvent e): abstract method
- Can have Filters
  - Filters filter events, etc.
  - decision: accept, deny, neutral

Log4J class hierarchy



LoggingEvent

- LoggingEvent object
  - Created when a logger method is called
    - Holds the *message*
    - The level of the message
    - Place and time of calling the logger method
    - Name of logger, etc.
  - From this object readable output is generated
    - Done by *Layout* objects

Layout

- Each *Appender* has a *Layout* object
  - void setLayout(Layout layout)
- Simplest *Layout* classes
  - SimpleLayout
    - Prints the level and text of the message
  - HTMLLayout
    - Creates an HTML table from the messages
  - XMLLayout
    - Creates an XML document from the messages

```
DEBUG - Message 1
```

PatternLayout

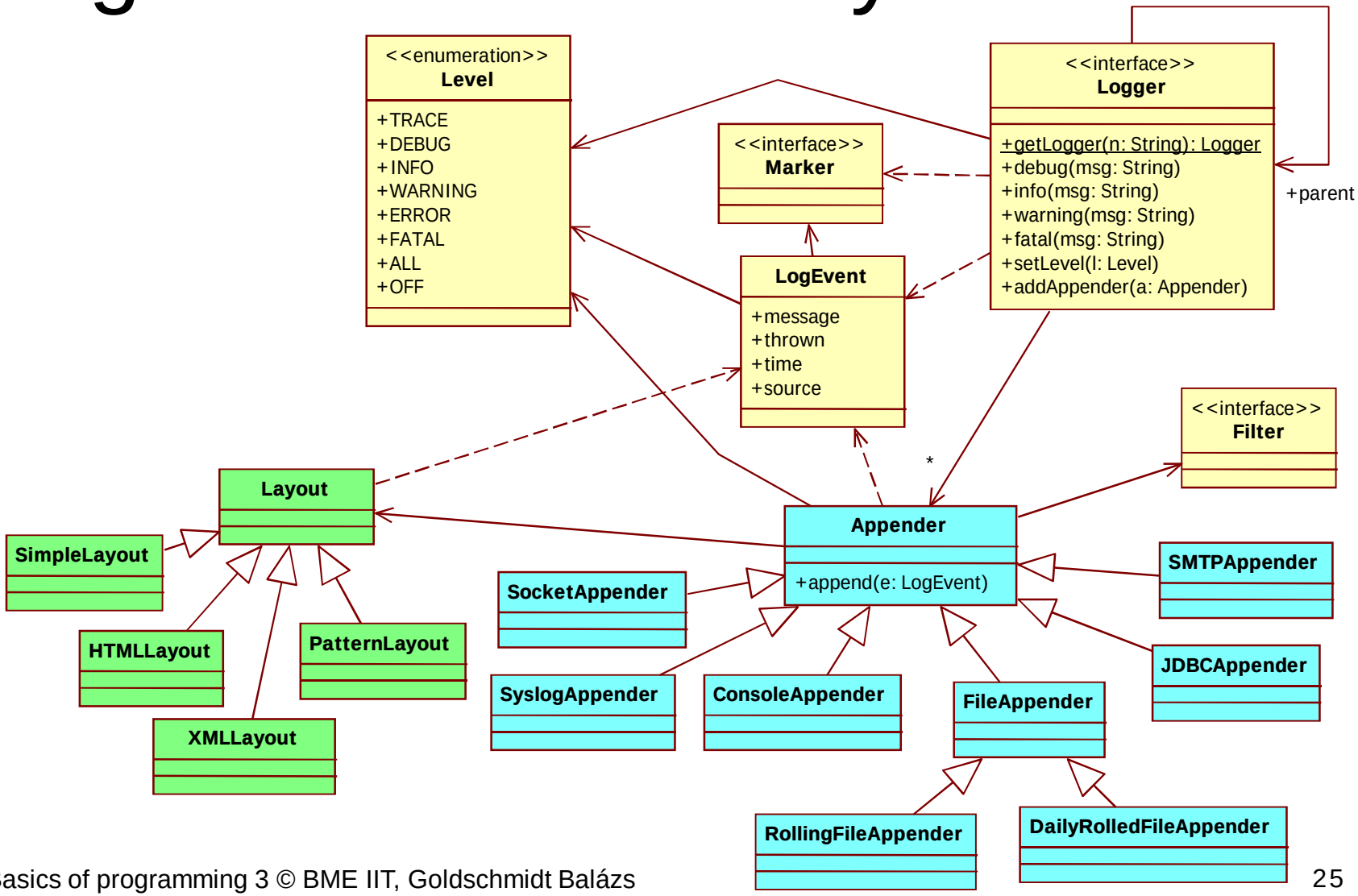
- One of the most commonly used Layout class
- Format is set by a format string
  - via *ctr* or *setConversionPattern(String pattern)*
  - example format string:
    - **"%-5p [%t]: %m%n"**

```
DEBUG [main]: Message 1
WARN  [main]: Message 2
```

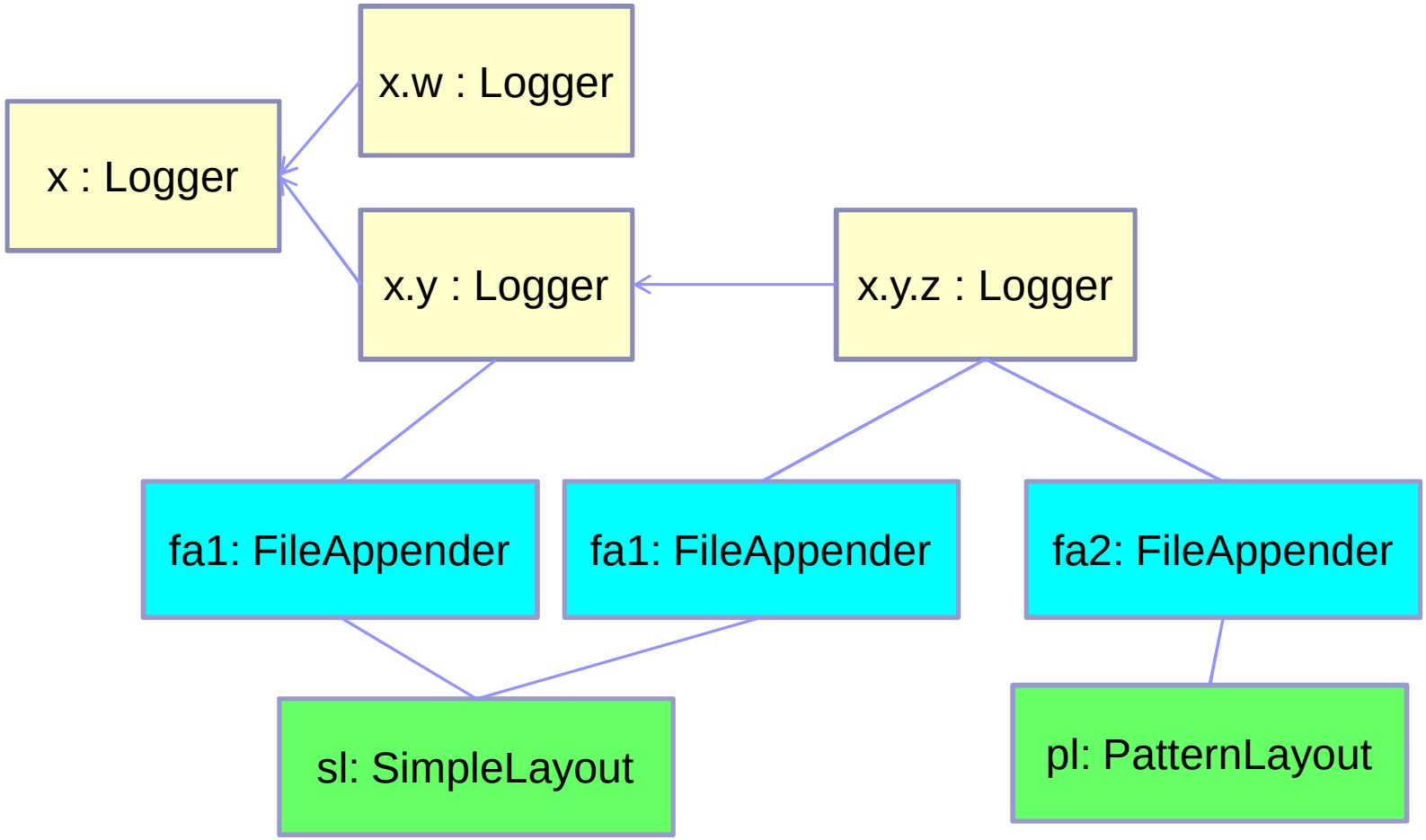
PatternLayout format

- Format string
  - Any character sequence is allowed
    - Printed without modification
  - Percent sign ("%") for placeholders (c.f. *printf*)
    - %c: name of logger
    - %C: name of caller class
    - %d{yyyy-MM-dd HH:mm:ss}: timestamp
    - %m: message text
    - %p: level
    - %n: newline
    - etc.

Log4J class hierarchy



Log4J example architecture



Configuring Log4J

- Appenders have to be assigned to loggers
  - From within our application *(forbidden since 2.0)*
    - e.g. at the beginning of the main() method
    - this configuration can not be modified later

```
Logger.getRootLogger().addAppender(
  new ConsoleAppender(
    new PatternLayout("%p - %m")
  ));
Logger.getRootLogger().setLevel(Level.DEBUG);
```

Configuring Log4J /2

- Using a configuration file
  - Two formats: property file, XML file (v1.x)
  - Additonal format: JSON (v2.x)
  - No need for recompilation
  - Programmatic setting for v1.0:

```
public static void main(String[] args) {
  // either
  PropertyConfigurator.configure("log4j.properties");
  // or
  DOMConfigurator.configure("log4j.xml");
}
```

Configuring Log4J /3

- Configuration files are automatically found
  - At application startup searching in CLASSPATH
    - *log4j.xml, log4j.properties*
    - *log4j2.xml, log4j2.properties, log4j2.json*
  - They are usually put among *.class* files
    - bin directory
    - root of jar file

Configuring Log4J /4

- Log4J can be configured via system properties
  - log4j.debug: debug on/off
    - mostly for configuration errors
  - log4j.configuration: name of default config file
    - Absolute URL for exact specification
    - Relative URL for search in CLASSPATH

```
java –Dlog4j.configuration=log.conf myapp.Application
```

Log4J properties file

- Stores key=value pairs
  - different in 1.x and 2.x
  - Keys form a hierarchy
    - Mapping Logger hierarchy
    - JavaBean attributes of the classes
  - Classic solution, widespread
    - Might be confusing because of the flat structure

```
log4j.rootLogger=DEBUG, R
log4j.appender.R=org.apache.log4j.ConsoleAppender
log4j.appender.R.layout=org.apache.log4j.SimpleLayout
log4j.appender.R.threshold=INFO
```

Log4J properties in XML

- XML file (1.x differs from 2.x)
  - Sui generis hierarchical, easier to read (?)
  - Newer approach
    - Newer config options only in XML

```
<log4j:configuration xmlns:log4j="…">
  <appender name="R" class="org.apache.log4j.ConsoleAppender">
    <param name="threshold" value="info" />
    <layout class="org.apache.log4j.SimpleLayout" />
  </appender>
  <root>
    <priority value ="debug" />
    <appender-ref ref="R" />
  </root>
</log4j:configuration>
```

Log4J properties in XML (v2)

```
<?xml version="1.0" encoding="UTF-8"?>
<Configuration package="logging" status="WARN">
  <Appenders>
    <Console name=“Screen" target="SYSTEM_OUT">
        <PatternLayout pattern="%msg%n"/>
    </Console>
    <File name=“LogFile" fileName="log4j.txt">
        <PatternLayout pattern="File: %d{HH:mm:ss} [%t] %-5level
                                %logger{36} - %msg%n"/>
    </File>
  </Appenders>
  <Loggers>
    <Logger name="logging.Main" level="trace">
        <AppenderRef ref=“Screen"/>
        <AppenderRef ref=“LogFile"/>
    </Logger>
    <Root level="trace">
        <AppenderRef ref=“Screen"/>
    </Root>
  </Loggers>
</Configuration>
```

Log4J properties in JSON

- JSON file (2.x only)
  - Sui generis hierarchical, easier to read (?)
  - Even newer approach
    - Direct mapping between XML and JSON

```
{"configuration":
  { "package":"logging", "status":"warn",
    "appenders": { "appender": [
       { "type":"Console", "name":“Screen", "target":"SYSTEM_OUT",
         "PatternLayout": { "pattern":"%msg%n" }},
       ...
    ] },
    "loggers": { "logger": [
       { "name":"logging.Main", "level":"trace",
           "AppenderRef": { "ref":“Screen" }],
       "root": { "level":"trace", "AppenderRef": { "ref":“Screen" }}
}}}
```

Proprerty vs XML – an example

```
log4j.debug=true

log4j.rootLogger=INFO, logfile



log4j.logger.hu.bme=DEBUG, console



...
```

```
<log4j:configuration xmlns:log4j=
  "http://jakarta.apache.org/log4j/"
  debug="true">

  <root>
    <priority value="info" />
    <appender-ref ref="logfile" />
  </root>

  <logger name="hu.bme">
    <level value="debug" />
    <appender-ref ref="console" />
  </logger>

  ...
```

Proprerty vs XML – an example

```
log4j.appender.console= \
  org.apache.log4j.ConsoleAppender
log4j.appender.console.target= \
  System.out
log4j.appender.console.layout= \
  org.apache.log4j.SimpleLayout

log4j.appender.logfile= \
  org.apache.log4j.FileAppender
log4j.appender.logfile.fileName= \
  app.log
log4j.appender.logfile.layout= \
  org.apache.log4j.PatternLayout
log4j.appender.logfile.layout. \
  ConversionPattern=%d %c - %m%n
```

```
  <appender name="console" class=
 "org.apache.log4j.ConsoleAppender">
    <param name="target"
           value="System.out" />
    <layout class=
 "org.apache.log4j.SimpleLayout" />
  </appender>
 <appender name="logfile" class=
 "org.apache.log4j.FileAppender">
   <param name="fileName"
    value="app.log" />
    <layout class=
 "org.apache.log4j.PatternLayout">
      <param name=
         "ConversionPattern"
         value="%d %c - %m%n"/>
    </layout>
  </appender>
</log4j:configuration>
```

java.util.logging

java.util.logging

- Similar architecture to Log4J
  - *Logger*
    - used to log messages for a specific component.
    - methods with level names (`logger.info("message")`)
    - hierarchical namespace
  - *LogRecord*:
    - passes logging requests between the logging framework and individual log handlers.
    - level, source name, message, millis, sequenceNumber, etc.

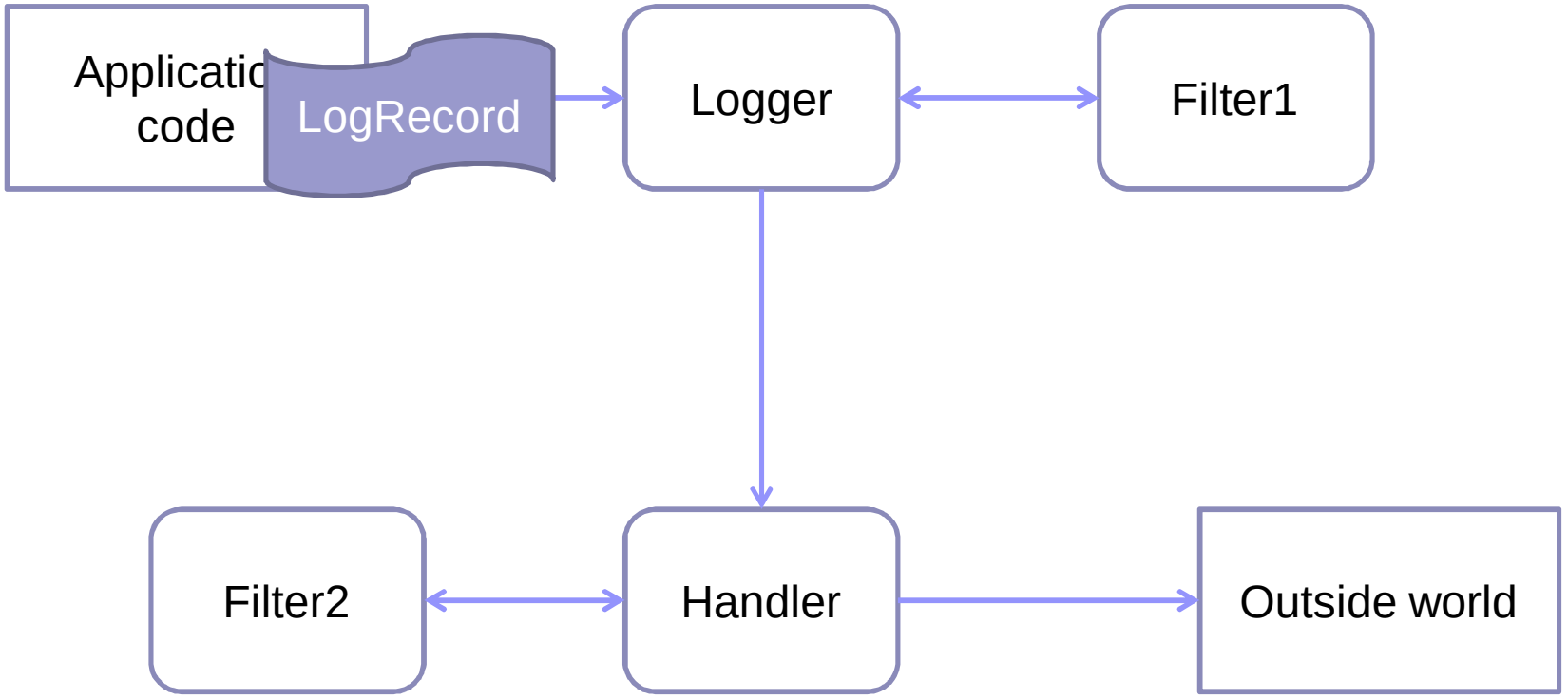
java.util.logging

- *Level*
  - a set of standard logging levels
  - `OFF`, `SEVERE`, `WARNING`, `INFO`, `CONFIG`, `FINE`, `FINER`, `FINEST`, `ALL`
- *Handler (like Appender in log4j)*:
  - Exports *LogRecord* objects to a variety of destinations
  - e.g. `ConsoleHandler`, `FileHandler`, `SocketHandler`, `StreamHandler`
- *Formatter (like Layout in log4j)*
  - supports formatting *LogRecord* objects
  - e.g. `SimpleFormatter`, `XMLFormatter`

java.util.logging

- *Filter (interface)*
  - fine-grained control over what gets logged
  - `boolean isLoggable(LogRecord record)`
- *LogManager*
  - keeps track of global logging information
  - logging control properties read from the configuration file

Logging in action



Example use (def. config.)

```
public class Nose {
    // Obtain a suitable logger.
    private static Logger logger =
        Logger.getLogger("com.wombat.nose");
    public static void main(String argv[]) {
        // Log a FINE tracing message
        logger.fine("doing stuff");
        try {
            Wombat.sneeze();
        } catch (Exception ex) {
            // Log the exception
            logger.log(Level.WARNING, "trouble sneezing", ex);
        }
        logger.fine("done");
    }
}
```

Example use (inline config)

```
public class Nose {
    // Obtain a suitable logger.
    private static Logger logger =
        Logger.getLogger("com.wombat.nose");
    private static FileHandler fh =
        new FileHandler("mylog.txt");
    public static void main(String argv[]) {
        // Send logger output to our FileHandler.
        logger.addHandler(fh);
        // Request that every detail gets logged.
        logger.setLevel(Level.ALL);

        //...
```