Maven 2 – The powerful buildsystem

a presentation for EL4J developers

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ELCA We make it work.

Agenda

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- Concepts 40’
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Introduction

- Maven intro
  - Maven is a software project management and description tool. Based on the concept of a project object model (POM), Maven can manage a project's build, reporting and documentation from a central project description.
  - Vision: The POM contains *all metadata* about a project: source code and documentation repositories, involved persons, release descriptions, all dependencies, reports we are interested in, how to build, deploy and test applications, what the project website contains, …
  - In the context of this presentation, when we talk of *Maven* we mean *Maven 2*.
- License
  - The Apache Software License, Version 2.0
- Homepage
  - http://maven.apache.org
- Our recommended Version
  - 2.1-SNAPSHOT
    ➔ We use a self-built version with the bug fix for:
    http://sourceforge.net/project/showfiles.php?group_id=147215
  - CAVEAT: when upgrading do a `rm -r M2_REPO/org/apache/maven`

Maven 2 – The powerful build system

1. Installation
2. Concepts
3. Where to find …
4. Daily usage
5. Advanced usage

Installation

Prerequisites

- JDK 5 or higher
  - JDK installed and JAVA_HOME set, javac available
- Cygwin
  - http://www.cygwin.com/

Installation steps

- Follow the steps of the `README.txt` in the convenienceZip from

http://sourceforge.net/project/showfiles.php?group_id=147215

Use the newest convenience.zip if possible!

- Verify that maven and Java is correctly installed by launching `./checkInstallation.sh` in cygwin

Demo?

Optional steps

- Install subversion
  - Download and install the Subversion tool, as described under http://intranet/Business_Process/Utilities/Subversion/Subversion.php EL4J
- Checkout the sources of EL4J
  - Choose a location where to checkout the new EL4J (internal and external stuff) configured for Maven 2 (i.e. **`D:/Projects/EL4J`**) and create this directory path. We name this path **`EL4J_ROOT`**.
  - Open a command line in **`EL4J_ROOT`** and execute

```
svn checkout https://svn.sourceforge.net/
    svnroot/el4j/trunk/el4j external
```


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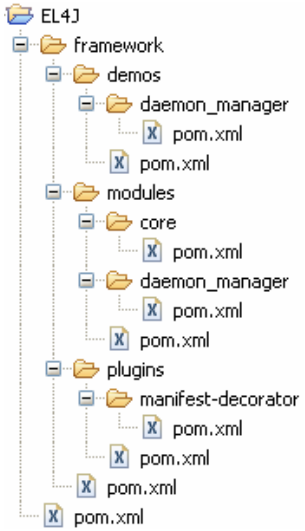
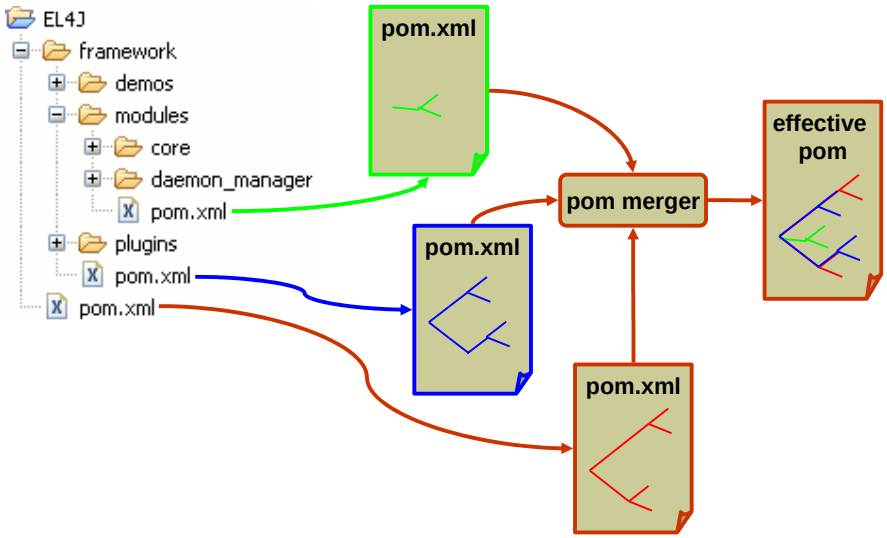
Concepts - Inheritance



- Every “pom.xml” file contains Maven configuration. (In Maven 1 this file had the name “project.xml”.)
- Here, the project “EL4J” contains the “root pom” (meaning that it has no parent pom). It has one sub-module, the “framework”.
- The “framework” itself is also a project, depends on “EL4J” and has the three modules “plugins”, “modules” and “demos”. And so on …

Concepts – Merging of pom files (is implicit)



Concepts – Properties

A *property* is an important concept in Maven. A property is a name-value pair (e.g. el4j-home = c:/Projects/EL4J/checkout)

Properties can be set in various ways (lowest to highest precedence)

- File `~/.m2/settings.xml` (you can also set a specific file on mvn cmd line (with –s))
- In the `properties` section of **`pom.xml`** files (can be inherited from parent)
- In profiles (in the global settings or in **`pom.xml`** files)
- On the command line with the prefix –D (e.g. `-Dname=value`). These properties will actually be standard Java System Properties. When looking up a maven property, java system properties are always checked first.

How to access properties

- In the normal strings of the pom.xml files you can always refer to a property via ${*name*} where *name* is the name of the property
- When certain files are copied, a *filter* applies, i.e. occurences of properties in the form ${*name*} are replaced

Concepts – Properties

How to see all active properties defined?

- Please refer to the **`help:effective-settings`** goal (see later)

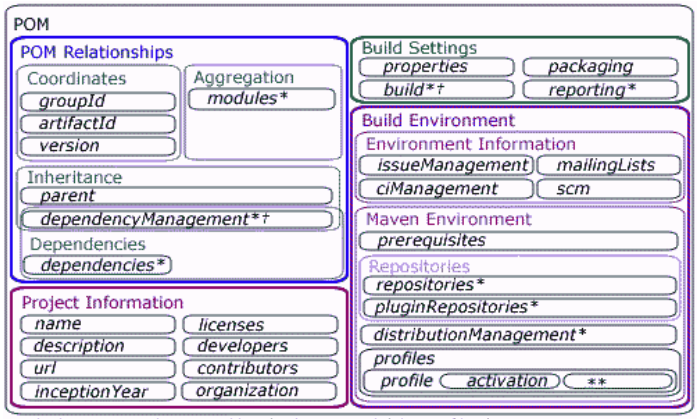
What files are filtered when copying (in EL4J)

- All files under `src/main/env` and `src/test/env`
- Please refer also to the env module (it defines support for different environments)
  - http://el4j.sourceforge.net/plugins/maven-env-support-plugin/index.html

Concepts – Maven model (POM)

POM structure overview (details in next slides)

- The "pom.xml" file is a **schema validated** xml file.



* Element may be overridden (at least mostly) by *profile* element settings
** Profile elements are the *-suffixed elements
† Contains elements for meant for inheritance

Concepts – Maven model (POM)

```
<?xml version="1.0" ... ?>
<project xmlns="http://ma..."
  xmlns:xsi="http://www.w3..."
  xsi:schemaLocation="...xsd">

  <modelVersion/>
  <parent>
    <groupId/>
    <artifactId/>
    <version/>
    <relativePath/>
  </parent>

  ...

</project>
```

- **modelVersion**
  Currently for Maven 2 it must be set to "4.0.0". "3.0.0" is for Maven 1.1.
- **parent**
  Optionally points to the parent pom (the parent pom must be of type pom).
  - **relativePath**
    Is the location where the parent can be found (no must). Default: "../pom.xml"
  - groupId, artifactId, version
    ➔ see next slide…

  CAVEAT: there is not automatic inheritance of the ../pom.xml . You need to explicitly configure the dependency.

Content in gray is considered less important

Concepts – Maven model

```
<project>

  ...

  <groupId/>
  <artifactId/>
  <version/>
  <packaging/>

  ...

</project>
```

- **groupId**
  Identifier such as "ch.elca.el4j.modules"
- **artifactId**
  Identifier such as "module-core"
- **version**
  Version identifier such as "1.2-SNAPSHOT" or "1.1.3"
- **packaging**
  The type of the current artifact (pom):
  - **jar**
    Is the default. Means that this artifact contains java source files to compile.
  - **pom**
    For artifacts just used as descriptor. Normal for projects that are not "leafs" of the artifact hierarchy.
  - Further types:
    war, ear, maven-plugin

Concepts – Maven model

```
<project>

  ...

  <build>
    <sourceDirectory/>
    <scriptSourceDirectory/>
    <testSourceDirectory/>
    <outputDirectory/>
    <testOutputDirectory/>

    ...

  </build>

  ...

</project>
```

- **Build (optional)**
  Contains the info how to build the current artifact.
  - **sourceDirectory**
    Contains java source files.
    Default: "src/main/java"
  - **scriptSourceDirectory**
    Contains script files.
    Default: "src/main/scripts"
  - **testSourceDirectory**
    Like "sourceDirectory" but for test sources. Default: "src/test/java"
  - **outputDirectory**
    Where to compile java sources and copy scripts and other resources.
    Default: "target/classes"
  - **testOutputDirectory**
    Like "outputDirectory" but for the test part. Default: "target/test-classes"

Concepts – Maven model

```
<project>

  ...
  <build>
    ...

    <defaultGoal/>
    <resources/>
    <testResources/>
    <directory/>
    <finalName/>

    ...
  </build>
  ...
</project>
```

- **build**
  - **defaultGoal**
    Is the goal to execute if no goal is defined on the command line. Goals will be explained later. There's no global default.
  - **resources**
    Points to the resource directories. Content will be copied to the "outputDirectory".
    By default: "src/main/resources"
  - **testResources**
    Points to test resource directories. Their content will be copied to the "testOutputDirectory".
    By default: "src/test/resources"
  - **directory**
    Top-level directory where to put built parts.
    Default: "target"
  - **finalName**
    The name to use for built objects like jar, war and ear. Default: ${artifactId}-${version}

Concepts – Maven model

```
<project>

  ...
  <build>
    ...

    <filters/>
    <plugins/>
    <pluginManagement>
      <plugins/>
    </pluginManagement>
  </build>
  ...
</project>
```

- **build**
  - **filters**
    Points to property files used for filtering. Filtering was explained in the properties section.
  - **plugins**
    Are the plugins to be used in this artifact. These plugins join the Maven lifecycle. Typically plugins will not be configured here but only within the pluginManagement/plugins section.
  - **pluginManagement**
    - **plugins**
      Same as the plugins before but these plugins do not join the Maven lifecycle. Typically plugins are preconfigured here.

Concepts – Maven model

```
<project>

  ...

  <profiles/>
  <modules/>
  <repositories/>
  <pluginRepositories/>

  ...

</project>
```

- **profiles**
  Contains *profiles* that can be dynamically activated by setting a property, via a jdk version, an os type or the presence of a file. A profile contains normal pom.xml content, it can *override* parent pom.xml content.
- **modules** (only for pom artifacts)
  Are the child artifacts of the current artifact. (Only those will be built!)
- **repositories**
  Are the locations from where artifacts can be downloaded. These repositories are used for artifacts that are not maven plugins.
- **pluginRepositories**
  Same as "repositories" but only used to download maven plugin artifacts.

Concepts – Maven model

```
<project>

  ...

  <dependencies/>
  <dependencyManagement/>
    <dependencies/>
  <reporting/>
  <properties/>

</project>
```

- **dependencies**
  Are the artifacts the current artifact depends on. Such an artifact has a scope i.e. `test` so it is only in classpath for testing (i.e. JUnit). The default scope is `compile`, meaning that the artifact is always in the classpath.
- **dependencyManagement**
  - **dependencies**
    Same as previous but the current artifact does not have a dependency to them. It is used to preconfigure dependencies, used in child artifacts. Analogue to "plugins" and "pluginManagement".
- **reporting**
  Are special Maven plugins used for site generation. They join the Maven lifecycle like plugins referenced in previously shown "plugins" element.
- **properties**
  Are name-value-pairs that can be used to simplify configuration.

Concepts – Maven lifecycles

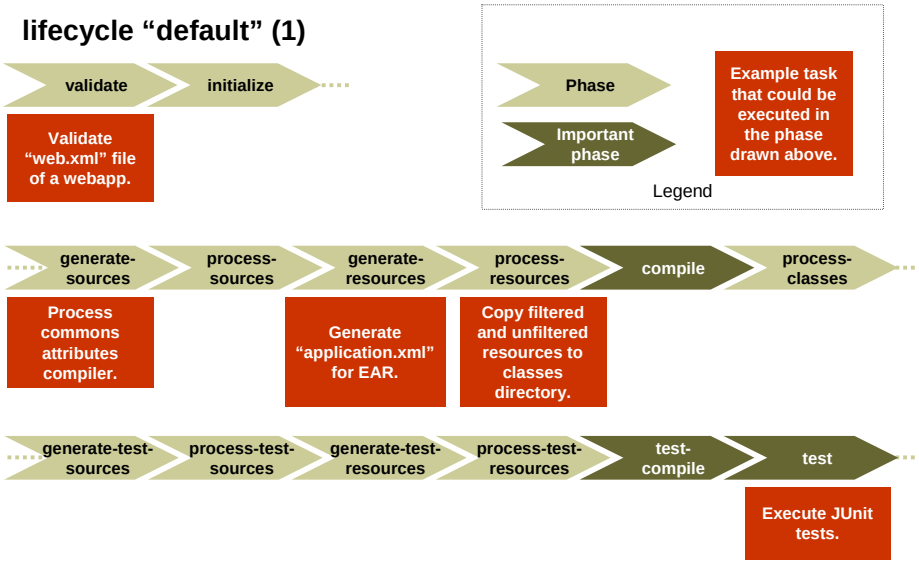
A *lifecycle* is a combination of one or more *phases*

Maven knows by default the following three *lifecycles:*

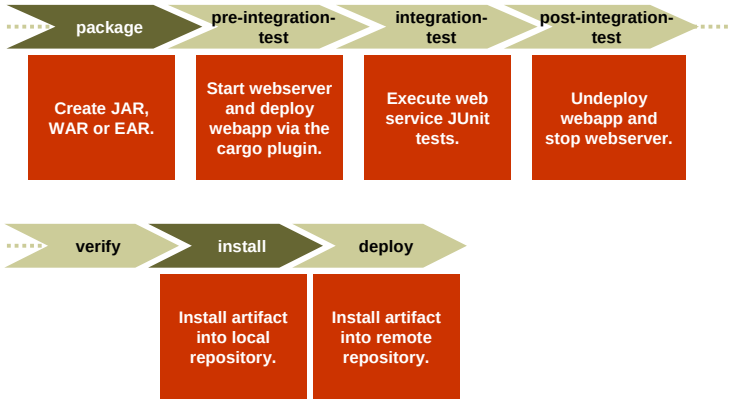
- **default**
  Is used for most activities on artifacts like performing a build.
- **clean**
  Is used to delete generated parts.
- **site**
  Is used to generate a website for the current artifact.

A *lifecycle* has one or more *phases*, and *goals* can be *attached* to a phase. When phases of the lifecycles above are started, some predefined plugin-goals are automatically executed.
More about this on the next slides…

lifecycle “default” (1)

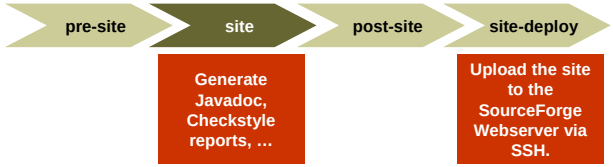


lifecycle “default” (2)



lifecycle “clean”

lifecycle “site”



Using mvn on the command line

How to launch maven on the command line:

`mvn <artifactId:goal>` : execute the goal `goal` of the artifcact id `artifactId`

```
mvn <groupId:artifactId:version:goal>
```

`mvn <phase>` : execute up to phase `<phase>`

You can combine multiple goals or phases on the command line such as `mvn clean install db:start`

Concepts – Maven plugins (selection)

	Short plugin list	
	Plugin	**Description**
*	antrun	Run a set of ant tasks from a phase of the build.
*	assembly	Build an assembly (distribution) of sources and binaries.
*	checkstyle	Generate a checkstyle report.
	clean	Clean up after the build.
	compiler	Compiles Java sources.
	deploy	Deploy the built artifact to the remote repository.
	ear	Generate an EAR from the current project.
	eclipse	Generate an Eclipse project file for the current project.
	ejb	Build an EJB (and optional client) from the current project.
	help	Get information about the working environment for the project.
	install	Install the built artifact into the local repository.
	jar	Build a JAR from the current project.
	javadoc	Generate Javadoc for the project.
	jxr	Generate a source cross reference (analog to javadoc).
	resources	Copy the resources to the output directory for including in the JAR.
	site	Generate a site for the current project.
	source	Build a JAR of sources for use in IDEs and distribution to the repository.
	surefire	Run the Junit tests in an isolated classloader.
	war	Build a WAR from the current project.

Parent inheritance vs. artifact dependencies

Two ways to "reuse" configuration:

Parent inheritance

- Most of the pom.xml files are "merged"
- Use this for:
  - plugin definitions
  - build process definitions
- **Don't use this for dependencies** (you get typically **"too much"** when you use this for dependencies, only "single inheritance" is possible)

Dependencies to other artifacts (jars, other maven projects)

- Normal **transitive** dependencies (A -> B, B -> C => A -> C)
- Dependencies can have a scope (test, runtime, compile, provided) to be activated only in certain cases.
- Use this for:
  - When you require other maven artifacts (jar/ ear/ war files).
    - Either: external libraries or other modules (both are treated the same!)

=>Artifact dependency provides a *subset* of the parent inheritance.

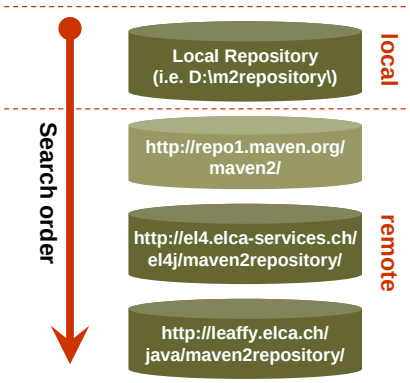
Concepts – Artifact lookup in *repositories*

If an artifact has a dependency to another artifact or a plugin, Maven will go through the given repositories until it finds the requested artifact.

As shown in the Maven model we can have separate repositories for plugins and their dependencies and separate repositories for all other dependencies.

In EL4J we use the "ibiblio" repository only as "pluginRepository" to prevent having unexpected dependencies.

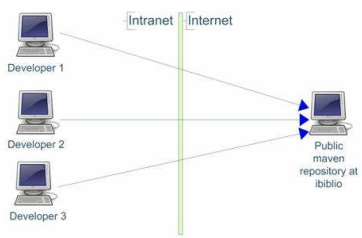
Hierachy of Maven2 repositories:



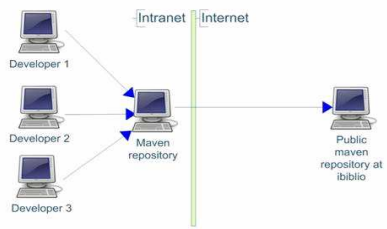
Concepts - Proximity

Proximity is a proxy for maven repositories:
http://blogs.sonatype.com/jvanzyl/2007

Direct connection :



Indirect connection (**with Proximity**):



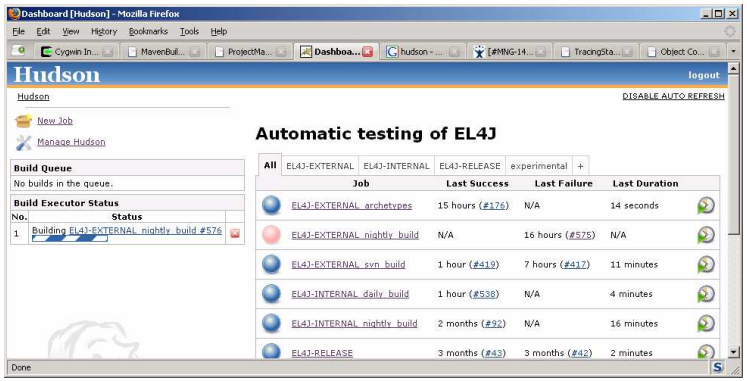
Concepts - Continuous integration with Hudson

Hudson can rebuild your project automatically:

- Periodically (e.g. every night, every 2 hours)
- Whenever there is a change in SVN

Hudson for EL4J:

- http://wiki.elca.ch/twiki/el4j/bin/view/EL4J/AutomaticBuildInfrastructure



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Resources

- Documentation
  - Maven **CheatSheet** (our recommended default reference) http://wiki.elca.ch/twiki/el4j/bin/view/EL4J/MavenCheatSheet
  - FAQ with many ideas how to fix maven issues: http://wiki.elca.ch/twiki/el4j/bin/view/EL4J/FrequentlyAskedQuestions
  - Book: Better Builds with Maven – The How-To guide for Maven 2 (PDF
    - http://www.mergere.com/m2book_download.jsp
  - Getting started guide of maven
    - http://maven.apache.org/guides/getting-started/index.html
  - EL4J wiki: http://wiki.elca.ch/twiki/el4j/bin/view/EL4J/MavenBuildSystem
  - Available plugins from Apache and Codehaus
    - http://maven.apache.org/plugins/index.html
    - http://mojo.codehaus.org/
- Help
  - Subscribe to the very active Maven user mailing list (users@maven.apache.org).
  - Use Google to find help in Maven user mailing list http://www.google.ch/search?q=site:http://mail-archives.apache.org/mod_mbox/maven-users+MY SEARCH QUERY
    - To only get messages from 2006 just modify the URL a bit http://www.google.ch/search?q=site:http://mail-archives.apache.org/mod_mbox/maven-users/2006+MY SEARCH QUERY

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Maven 2 – The powerful build system

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Daily usage

- `cd EL4J_ROOT/external`
- `mvn -N install`
  - Take a look at your local repository.
- `mvn -N`
- `mvn install -Dmaven.test.skip=true`
- `cd framework/modules/core`
- `mvn clean`
  - Inspect content of current directory.
- `mvn compile`
  - Inspect directory target.
- `mvn test`
- `mvn surefire:test`
  - What is the difference between "`mvn surefire:test`" and "`mvn test`"?

Avoids recursion

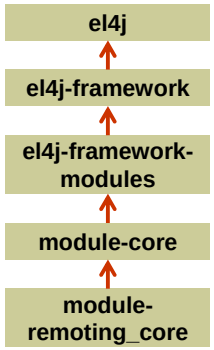
No phase or goal: default goal

Skip tests

Daily usage

- Remove directory `el4j-framework-modules` from local repository (`M2_REPO/ch/elca/el4j/modules`).
- `mvn clean`
- `mvn compile`
  - What happens? Why?
- `cd ../remoting_core`
- `mvn clean`
- `mvn compile`
  - What happens? Why?
- `cd ..`
- `mvn -N install`
- `cd core`
- `mvn install -Dmaven.test.skip=true`
- `cd ../remoting_core`
- `mvn install -Dmaven.test.skip=true`
- `cd ../core`
- `mvn site`

project dependency of this example:



Daily usage (– answers to questions)

Certain goals of the compile phase require another project to exist. The phase `clean` does not require a project, but the phase `compile` needs other projects (it needs the compiled code in order to run).

Maven does only build other projects in certain cases! The previous slide illustrates the 2 different cases:

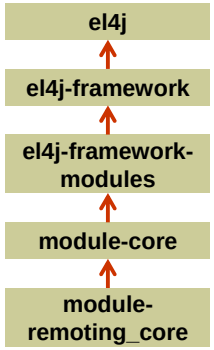
- In the first case it works, because mvn directly looks in the direct directory or pom hierachy (but not in transitive dependencies!)
  This is different from the EL4Ant behavior!
- In the second case it does not work, because the dependency is not in the direct hierarchy (=subdirectory) of the artifact.

Remark: we would actually prefer the earlier EL4Ant behavior and will look into how to achive it. For now we keep the maven convention as it directly follows from some core maven hypothesis.

Daily usage - Eclipse

- Start Eclipse with workspace **`EL4J_ROOT/external/framework/workspace`**
- Import your preferences (e.g. `preferences-external.epf`).
- Close Eclipse.

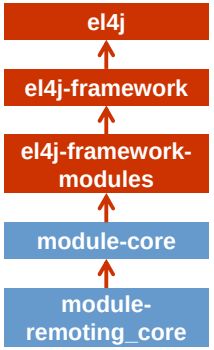
- **`mvn -N eclipse:add-maven-repo -Declipse.workspace= "EL4J_ROOT/external/framework/workspace"`**
  - By this command the classpath variable **`M2_REPO`** has been added to the given workspace (you can also set the eclipse build variable M2_REPO manually).
- Start Eclipse again with the same workspace.



Daily usage - Eclipse

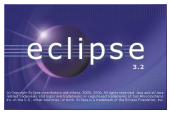
- **`mvn eclipse:clean eclipse:eclipse`**
  - Creates the Eclipse project newly for **`module-remoting_core`**
  - Import this project in opened workspace. Does the project compile in Eclipse?
- **`cd ..`**
- **`mvn eclipse:clean eclipse:eclipse`**
  - Go into Eclipse and refresh project **`module-remoting_core`**
  - Does the project still compile in Eclipse?
  - Import project **`module-core`** in Eclipse and refresh both projects.

Take care: if you create eclipse files (.project and .classpath) for a set of projects together, it establishes direct (=eclipse-level dependencies), if you create them individually it establishes links to the local mvn repository.
The `<reactorProjectGroupIdPrefixes>` parameter fixes this.



Daily usage

- Eclipse issues
  - Eclipse is just a helper for Maven, it is not a replacement!
    - Examples: Filtering of environment files, …
  - Executed tests in Eclipse can have different results than executed tests with Maven. The relevant results (for us) are the ones from Maven. There can be various causes for this behaviour:
    - Eclipse projects don't separate the compile and test scopes but Maven does. This can be dangerous i.e. if dir test resources contains Spring bean xml files in directory "mandatory"!
    - Maven always has dependent artifacts as jar files in its classpath. In Eclipse, depending on the execution level/directory of the "mvn eclipse:eclipse" command, some dependencies are in classpath as jar and some directly as directory with its classes. The test classes itself are always via directory in classpath.
    - Eclipse has its own compiler. There are some cases (specially Java 5 syntax) tests work if classes compiled with Eclipse compiler and don't work if classes are compiled with Sun's compiler. The (for us) relevant compiler is the one from Sun.



Daily usage – Problem solving

- A list of potential maven issues with their solution can also be found under:
  - http://wiki.elca.ch/twiki/el4j/bin/view/EL4J/FrequentlyAskedQuestions
- **`mvn –N help:effective-pom`**
  - Prints the effective pom on console. You can define the parameter *output* to get the effective pom in a file. Example:
    `mvn –N help:effective-pom –Doutput=effective-pom.xml`
- **`mvn –N help:effective-settings`**
  - Prints the effective settings on the console. You can define the parameter *output* to get the effective settings in a file. Example:
    `mvn –N help:effective-settings –Doutput=effective-settings.xml`

➔ The settings file in the directory `~/.m2/` does override settings configured in directory `M2_HOME/conf/`

Daily usage – Missing third party artifacts

Sometimes you create an artifact and this artifact must have a dependency to a third party jar such as “spring-2.0.jar”. With the repository helper from EL4J you have the possibility to easily install this new artifact in your local repository and directly in a remote repository. The jar file must have the following name:

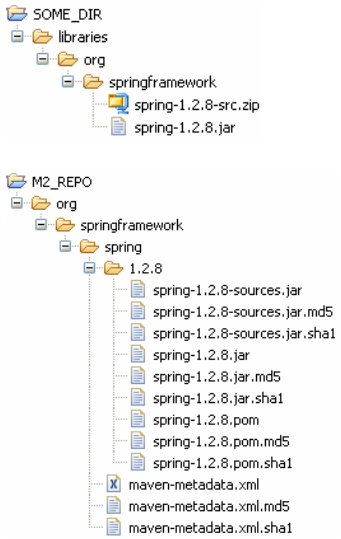
name-version.jar

If you have a zip that contains the java source as well, this zip must have the following name:

name-version-src.zip

The *name* will be the artifactId. The groupId of the artifact will be determined by taking the delta between your given library system path (`libraryDirectory`) and the path of where these files are located. Slashes or backslashes in this delta are replaced by dots. No leading/trailing dots are permitted. The next slide shows an example of this.

Daily usage – Missing third party artifacts



In the example on the left the following task has been executed in SOME_DIR.

```
mvn repohelper:install-libraries
  -DlibraryDirectory=libraries
```

The artifact org.springframework:spring:1.2.8 is now installed in the local repository and ready for local use.

To deploy libraries to a remote server just use the goal **`deploy-libraries`** instead of **`install-libraries`** and with additional parameter **`repositoryId`**. If the repository with this id is not defined in your **`pom.xml`** (see element **`distributionManagement`**) you must in additionally add the parameter **`repositoryUrl`** or **`repositoryDirectory`** that points to the remote repository. BTW, the username and password can be saved in the **`settings.xml`** file.

In **`EL4J_ROOT/external/helpers/upload`** there are two helper artifacts to install/deploy libraries in the external and internal repository. Example: Just put your libraries in **`EL4J_ROOT/external/helpers/upload/external/libraries`** and execute the specific goal without any parameters in **`EL4J_ROOT/external/helpers/upload/external`**.

Database plugin usage

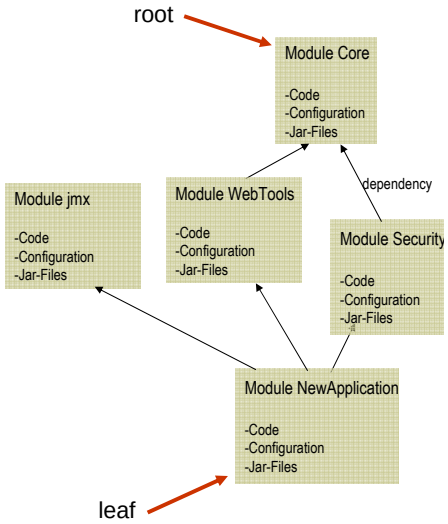
Launch and re-init db (of current project), block until Ctrl-C:

```
cd newApplication
mvn db:prepare db:block
```

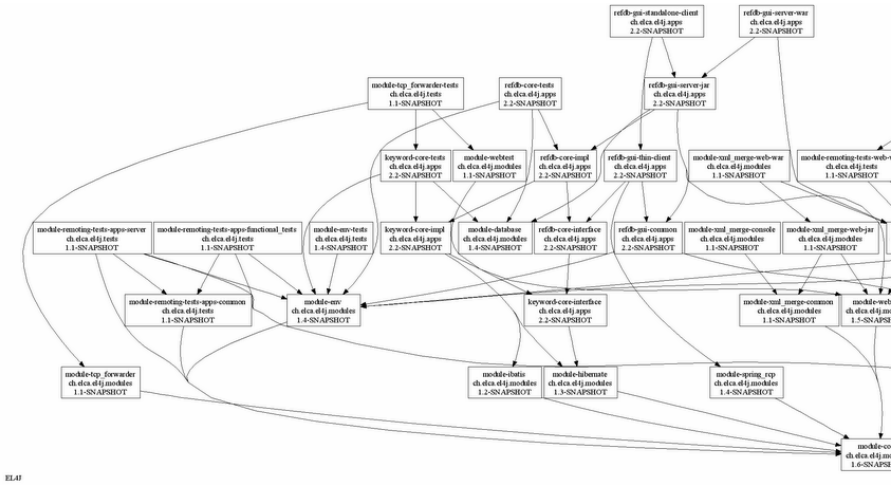
Same without db launch

```
mvn db:silentDrop db:create
```

Applies all SQL scripts of your project and all projects it depends on.
Scripts are applied in “right” order (root→leaf for creation, leaf-> root for destruction)



Maven Dependency Graph plugin



Maven Dependency Graph plugin

- Display Overview over a project's dependencies
- Two goals are available:
  - Depgraph
    - Displays a singe project's dependencies
  - Fullgraph
    - Displays the whole dependency structure for all maven projects in this and all subfolders
- Uses Graphviz to draw the graph
- Various configuration properties
  - Filter the artifacts' name, group and version using regular expressions
  - Create DOT file for further processing with other tools
- Example

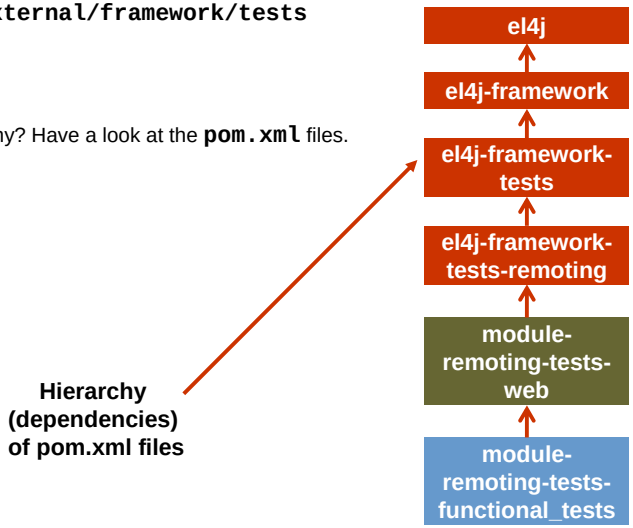
```
mvn depgraph:fullgraph -Ddepgraph.groupFilter="ch.elca"
```


Maven 2 – The powerful build system

1. Installation
2. Concepts
3. Where to find …
4. Daily usage
5. Advanced usage

Advanced usage

- `cd EL4J_ROOT/external/framework/tests`
- `mvn –N`
- `cd remoting`
- `mvn install`
  - What happens? Why? Have a look at the **`pom.xml`** files.



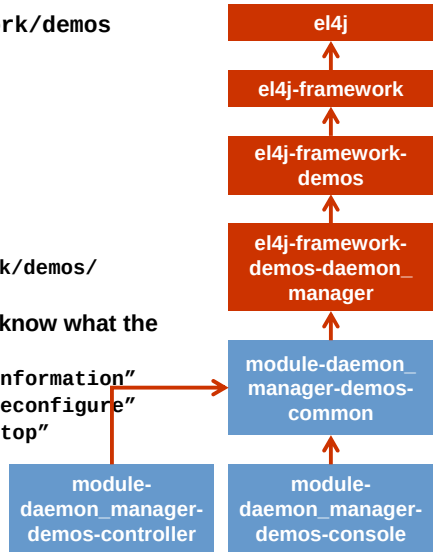
Advanced usage (answers to questions)

It executes the functional tests:

- Create jars, wars, start tomcat, deploy the war, execute functional tests, undeploy war, stop tomcat
- In case tomcat does not yet exist, it is automatically downloaded (by default in the external-tools directory)

Advanced usage

- `cd EL4J_ROOT/external/framework/demos`
- `mvn –N`
- `cd daemon_manager`
- `mvn install`
- `cd controller`
- `mvn exec:java`
  - Which class will be executed?
- Open another command line
  - `cd EL4J_ROOT/external/framework/demos/daemon_manager/console`
  - Take a look in the pom.xml file to know what the following commands will execute.
    - `mvn exec:java –Dexec.args="information"`
    - `mvn exec:java –Dexec.args="reconfigure"`
    - `mvn exec:java –Dexec.args="stop"`



Advanced usage (solution)

It executes the daemon manager (= the controller) on the console. You can then access the controller from remote (via the console (see the 3 actions from the previous slide))

Problem solving

- `mvn –N help:describe -DgroupId=... –DartifactId=... -Dfull=true`
  - Describs all goals of the given plugin (groupId & artifactId). Example:
    `mvn –N help:describe -DgroupId=ch.elca.el4j.plugins –DartifactId=maven-env-support-plugin -Dfull=true`
- `mvn –N help:describe -DgroupId=... –DartifactId=... –Dmojo=... -Dfull=true`
  - Describes the given goal (aka mojo) of the given plugin. Example:
    `mvn –N help:describe -DgroupId=ch.elca.el4j.plugins –DartifactId=maven-env-support-plugin -Dmojo=resources -Dfull=true`
  - Instead off **`groupId`** & **`artifactId`** you can use parameter plugin with format **`groupId:artifactId`** and you can even use the plugin prefix. Examples:

```
mvn –N help:describe –Dplugin=repohelper
    -Dmojo=deploy-libraries -Dfull=true
mvn –N help:describe –Dplugin=jar
    -Dmojo=sign -Dfull=true
```

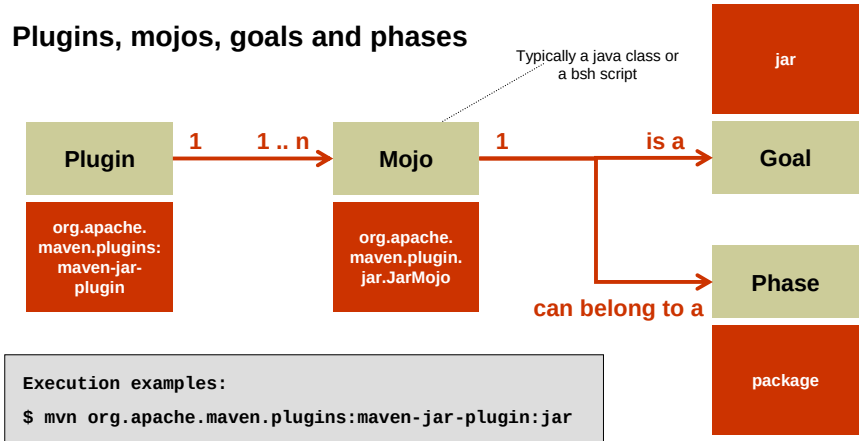

Classloading and multiple JVMs

Maven uses internally the library classworlds (an improvement to the normal classloader hierachy) to organize the classpaths.

Sometimes mvn and applications launched with mvn run in 2 different JVM.

Maven plugins

Plugins, mojos, goals and phases




```
Execution examples:
$ mvn org.apache.maven.plugins:maven-jar-plugin:jar
$ mvn jar:jar
$ mvn package
➔ Attention: All goals of mojos bound to
phase <= "package" will be executed!
```


Plug-in development

- A plugin artifact is like a jar artifact (= a project that generates a jar-file).
- The packaging of its pom must be set to **`maven-plugin`**.
- Mojos can be annotated with Commons Attributes, so no plug-in descriptor must be written.
- A class needs to implement the interface **`org.apache.maven.plugin.Mojo`** to be a mojo.
- Plugins of EL4J are in the directory **`EL4J_ROOT/external/maven/plugins`**
  - **`maven-checkclipse-helper-plugin`**
  - **`maven-env-support-plugin`**
  - **`maven-manifest-decorator-plugin`**
  - **`maven-repohelper-plugin`**
  - **`maven-database-plugin`**
  - **`maven-depgraph-plugin`**
  - **`maven-jaxws-plugin`**
  - **`maven-version-plugin`**
- Remark: writing a plugin is quite easy!

Thank you for your attention

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Where to find …

- Plugins
  - Use Google to find out available plugin versions
    http://www.google.ch/search?q=site:ibiblio.org/maven2+MY SEARCH QUERY
- Issue Management
  - Maven Components
    - http://jira.codehaus.org/browse/MNG
  - Other Maven Technologies and Maven Plugins
    - http://jira.codehaus.org/secure/BrowseProjects.jspa
      ➔ Go to categories "Maven Technologies" and "Maven 2 plugins"

Where to find what is inside Maven 2

- Maven Wagon
  - http://maven.apache.org/wagon/
  - Maven Wagon is a transport abstraction that is used in Maven's artifact and repository handling code.
  - Used to down- and upload artifacts.
  - Protocols file, http, https, ftp, sftp, svn and scp are available.

- Plexus Container
  - http://plexus.codehaus.org/
  - Plexus is similar to other *inversion-of-control* (IoC) or *dependency injection* frameworks such as the Spring Framework (http://www.springframework.org).
  - Used for configuration.