Maven Basics

"Code with Passion"

Topics

- What is Maven?
- Maven installation
- Creating “helloworld” Maven project
- POM
- Archetype
- Plugins and goals
- Lifecycles and phases
- Repositories
- Dependency management
- Maven Web Project structure
- Maven vs. Ant

Topics covered in “Maven Advanced”

- Multi-module project
- Grouping Dependencies
- POM inheritance
- Profiles
- Dependency management
- Site generation

What is Maven?

What is Maven?

- Software project management tool
  - ”building software” is its primary function but it can do a lot more
- Project Object Model (POM) based - *pom.xml*
  - *pom.xml* maintains project's build, reporting and documentation
  - POM can be inherited between parent and child project
- Based on “Convention over configuration” principle
  - Minimum configuration is needed
- You specify “what needs to be done”
  - Not “how it needs to be done” (as in the case of Ant)
- Plug-in architecture
  - Vibrant Maven Eco-system

Maven's Objectives

- Making the build process easy
  - Why do we have to waste so much time maintaining the build?
- Providing a uniform build system
  - Why each developer has to maintain their own build environment?
- Providing quality project information
  - Why do we have to do extra work to get project info?
- Providing guidelines for best practices development
  - How can we capture best practices in project management/build process?
- Allowing transparent migration to new features
  - How can tool vendors to do their innovation without affecting my build?

Providing Quality Project Information

- Maven provides plenty of useful project information that is in part taken from your POM and in part generated from your project's sources
  - Change log document created directly from source control
  - Cross referenced sources
  - Mailing lists
  - Dependency list
  - Unit test reports including coverage
  - Many more (through plug-in's)

Maven Features (1)

- Simple project setup that follows best practices - get a new project or module started in seconds
- Consistent usage across all projects means no ramp up time for new developers coming onto a project
- Superior dependency management including automatic updating, transitive dependencies
  - Maven ”Dependency Management” scheme allows Maven community defines a set of dependency list that are proven to work together
  - Example: Whenever Spring comes out new version, it also publishes all the dependencies that are proven to work together with the new Spring version
- Able to easily work with multiple projects at the same time

Maven Features (2)

- A large and growing repository of libraries and metadata to use out of the box, and arrangements in place with the largest Open Source projects for real-time availability of their latest releases
- Extensible, with the ability to easily write plugins in Java or scripting languages
- Instant access to new features with little or no extra configuration
- Maven wrapper – “mvnw”
  - Assures a correct Maven version is used per project

Maven Installation

Installation is simple

- Download it and unzip it
  - http://maven.apache.org/download.html
- Make sure JAVA_HOME environment variable is set to JDK directory
- Add it to the PATH environment variable
  - Linux

```
export MAVEN_HOME=/home/sang/apache-maven-3.0.1
export PATH=$PATH:$MAVEN_HOME/bin
```

  - Windows

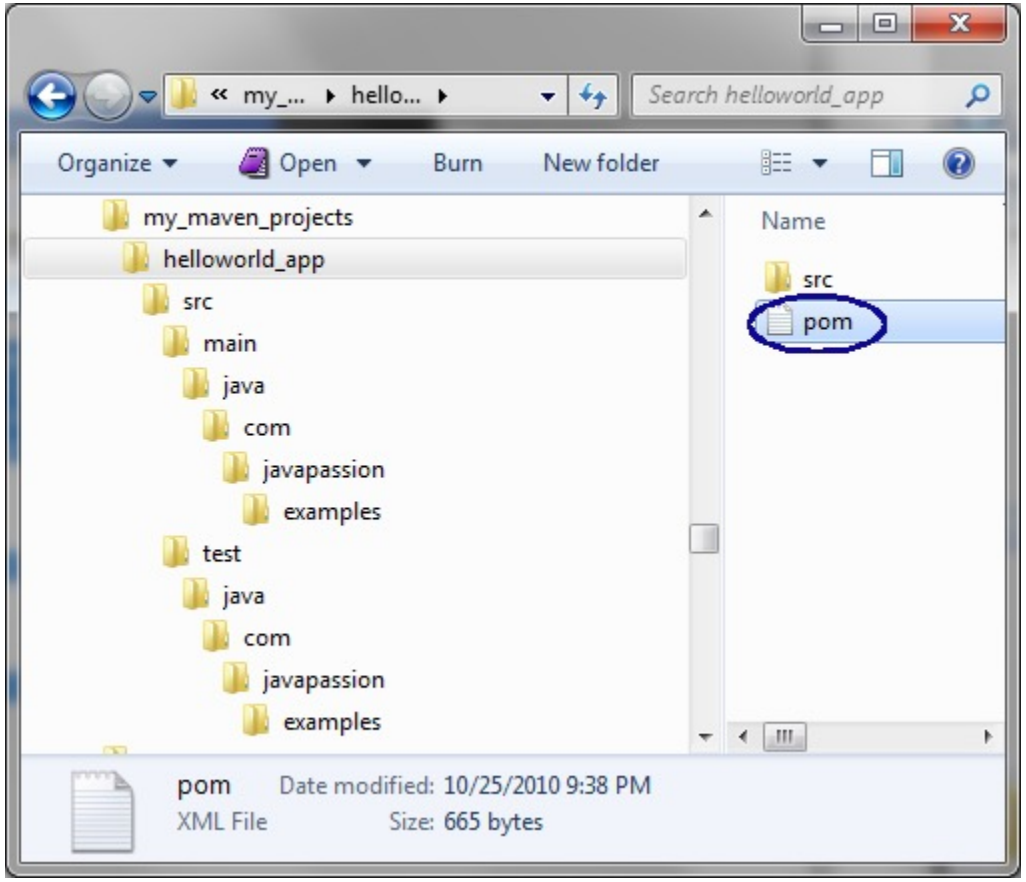
```
set M2_HOME=:\Program Files\apache-maven-3.0.1
set PATH=%PATH%;%M2_HOME%\bin
```

Creating “Helloworld” Maven Project

Steps to create a simple project

- *mvn archetype:generate*
  - Asking Maven to generate a Maven project
- You will be prompted to provide the following info.
  - Archetype (project type)
  - Group Id
  - Artifact Id
  - Version
  - Package
- End result
  - Project directory structure (for a chosen archetype)
  - *pom.xml*

Maven Created pom.xml



Maven Created Directory Structure (for maven-archetype-quickstart)

- <name of the project>
  - src/
    - main/java/
      - com/mycompany/examples
    - test/java/
      - com/mycompany/examples

Lab:

Exercise 1: Create a simple Maven Project at the command line

Step 1-3

5072_tools_maven.zip

pom.xml
(POM file)

What is POM file?

- Contains project information such as
  - What type of project?
  - What is the project's name?
  - What is the project's identity (coordinates)?
  - What are the build customizations?
  - What are the dependencies?
  - What plug-ins are used?
  - …

POM file (Simplest version)

```
<project xmlns="http://maven.apache.org/POM/4.0.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://maven.apache.org/POM/4.0.0
http://maven.apache.org/maven-v4_0_0.xsd">
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.mycompany.examples</groupId>
  <artifactId>helloworld_app</artifactId>
  <packaging>jar</packaging>
  <version>1.0-SNAPSHOT</version>
  <name>helloworld_app</name>
  <url>http://maven.apache.org</url>
  <dependencies>
    <dependency>
      <groupId>junit</groupId>
      <artifactId>junit</artifactId>
      <version>3.8.1</version>
      <scope>test</scope>
    </dependency>
  </dependencies>
</project>
```

Project Identity (Artifact Identity)

- Everything (your projects, plug-in's, dependencies) in Maven world is a project and every project has a unique identity
- Project identity is specified by project “coordinates”
  - Consider it as an address for a specific point in “space”
  - Uniquely identifies a project in repositories
- Dependencies and parent references are described with their own project coordinates
- Created with the combination of the following

```
<groupId>com.javapassion.examples</groupId>
<artifactId>helloworld_app</artifactId>
<version>1.0-SNAPSHOT</version>
```

Project Identity (Project Coordinates)

- groupId
  - Typically represents an organization
  - Convention is using reverse domain name
  - Example: com.mycompany.examples
- artifactId
  - A unique identifier under groupId
- version
  - A specific version of a project under artifactId

Archetype

What is Archetype?

- “Archetype” is “an original model or type after which other similar things can be patterned or prototyped”
  - Can be thought of a project template
- Captures the best practices
  - Directory structure, dependencies, plugin's needed
- There are many archetypes already provided by Maven community
  - Simple Java SE app
  - Spring app
  - Hibernate app
  - JSF app
  - Kafka app
  - Many more

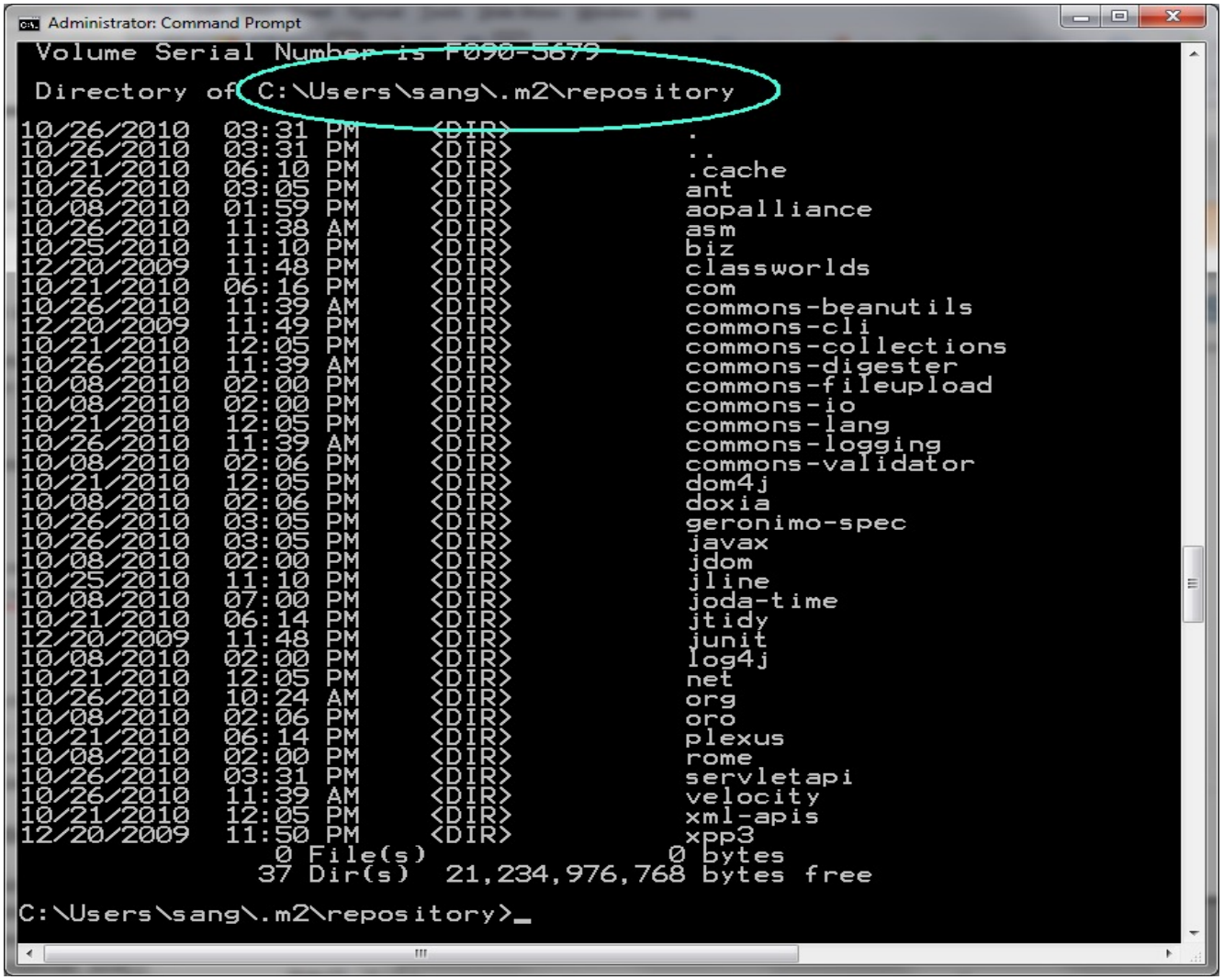
User-specific configuration & Local repository

User specific configuration and Local Repository

- <Home_directory>/.m2/settings.xml
  - Contains user specific configuration for authentication, repositories, proxy server and port, and other information to customize the behavior of Maven

- <Home_directory>/.m2/repository
  - Local Maven repository
  - Stores locally generated artifacts (jar files, war files, etc.)
  - Stores copies of dependencies and plug-in's downloaded from remote repositories

<Home_directory>/.m2/repository



Maven Lifecycle & Phases

Build Lifecycle Basics

- Maven is based around the central concept of a build lifecycle
  - What this means is that the process for building and distributing a particular artifact (project) is clearly defined
  - For the person building a project, this means that it is only necessary to learn a small set of commands to build any Maven project, and the POM will ensure they get the results they desired

- There are three built-in build lifecycles:
  - *default* - handles your project build/test/deployment
  - *clean* – handles project cleaning
  - *site* - handles the creation of your project's site documentation

Phases of Build Lifecycle

- Each of these build lifecycles is defined by a different list of build phases, wherein a build phase represents a stage in the lifecycle.

“Default” Lifecycle's Build Phases

- *validate* - validate the project is correct and all necessary information is available
- *compile* - compile the source code of the project
- *test* - test the compiled source code using a suitable unit testing framework. These tests should not require the code be packaged or deployed
- *package* - take the compiled code and package it in its distributable format, such as a JAR or a WAR file
- *integration-test* - process and deploy the package, if necessary, into an environment where integration tests can be run
- *verify* - run any checks to verify the package is valid and meets quality criteria
- *install* - install the package into the local repository, for use as a dependency in other projects locally
- *deploy* - done in an integration or release environment, copies the final package to the remote repository for sharing with other developers and projects.

Build Lifecycle Basics

- These build phases are executed sequentially to complete the lifecycle
- *mvn compile (or mvnw compile)*
  - All the phases up to compile phase will be executed in sequence
- *mvn test (or mvwn test)*
  - All the phases up to test phase will be executed in sequence
- *mvn install (or mvnw install)*
  - All the phases up to *install* phase will be executed in sequence
- *mvn integration-test (or mvnw integtration-test)*
  - All the phases up to *integration-test* phase (validate, compile, package, etc.) will be executed in sequence

“Clean” Lifecycle's Phases

- *pre-clean* - executes processes needed prior to the actual project cleaning
- *clean* - remove all files generated by the previous build
- *post-clean* - executes processes needed to finalize the project cleaning

Phases and Goals

- Plugin goals can be attached to a lifecycle phase
- As Maven moves through the phases in a lifecycle, it will execute the goals attached to each particular phase
  - Each phase may have zero or more goals (of various plugins) bound to it

Lab:

Exercise 1: Create a simple Maven Project at the comman dline

Step 4-6

5072_tools_maven.zip

Maven Repositories

What is a Repository?

- Maintains plugins and artifacts
  - The plugins and artifacts are retrieved from the remote repository "as needed" basis
- Default remote repositories maintain public plugins and artifacts
  - https://mvnrepository.com/
  - Called "Maven Central"
- Custom repositories can be set up to maintain non-public plugins and artifacts
  - The default remote repositories can be replaced or augmented with references to custom repositories

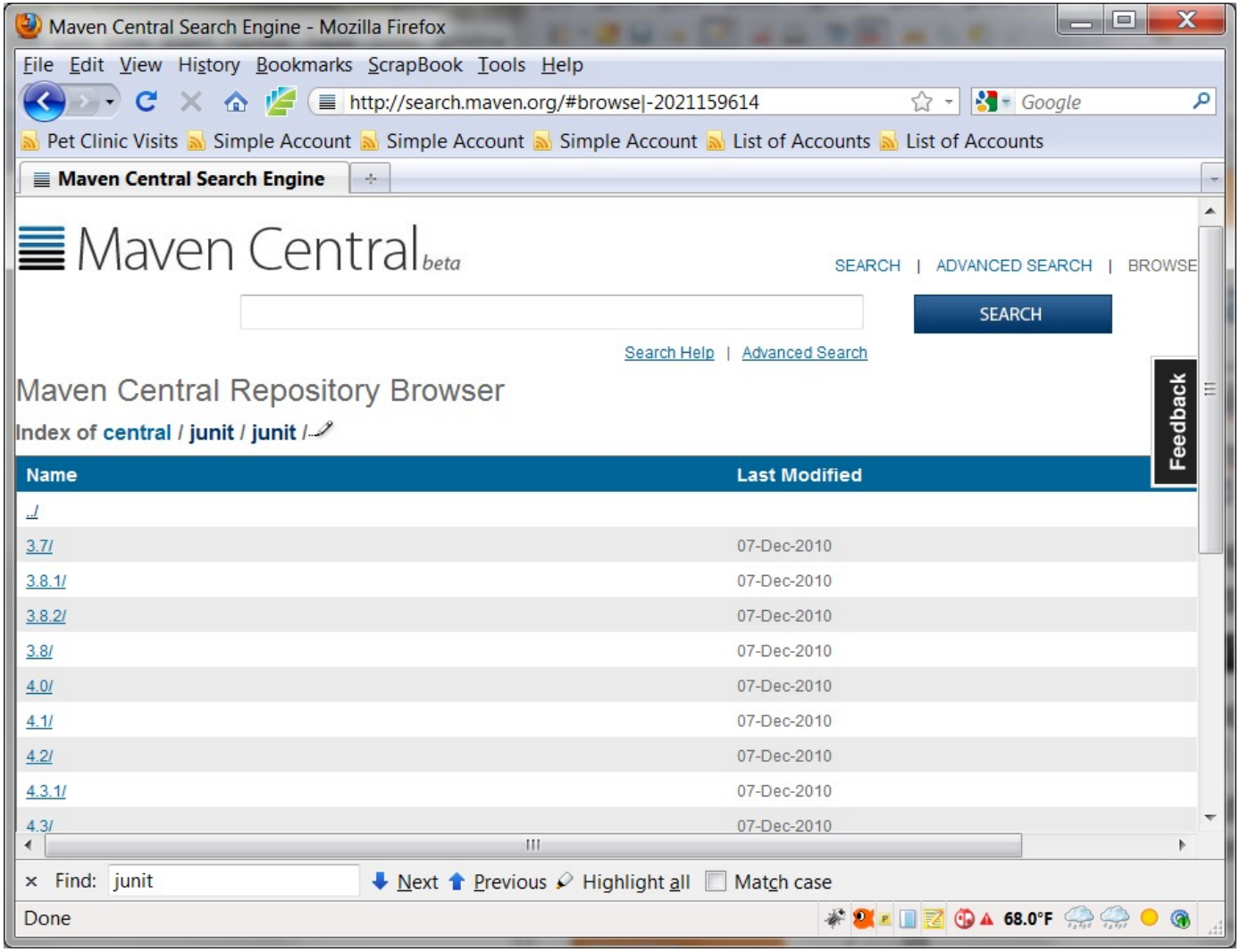
Repository Structure

- Each artifact is maintained in a directory structure that matches a project coordinates
  - /<groupId>/<artifactId>/<version>/<artifactId>-<version>.<packaging>

- Example #1
  - “org.apache.commons:commons-email:1.1” (artifact)
  - “/org/apache/commons/commons-emai/1.1/commons-email-1.1.jar” (directory path)
- Example #2
  - junit:junit:3.8.1 is available as /junit/junit/3.8.1/junit-3.8.1.jar

- Maven can easily locate the artifact in a repository (local and remote) based on artifact coordinates

Maven Central



Lab:

Maven Central Demo
http://search.maven.org/#browse|47

Plugins and Goals

Plugin Architecture

- Maven is based on Plugin architecture
  - All Maven tasks are performed through plugins
- Maven core is basically a shell
  - It parses a POM file and figures out which plugins are needed and then download them
- Plugins are downloaded, like dependencies are downloaded, from remote repositories as needed basis and updated periodically
  - A plugin is a Maven project and has its own identity (coordinates)
  - A downloaded plugin is then maintained in the local repository

What is Maven Plugin?

- A Maven plugin is a collection of one or more goals
  - <Home-Directory>/.m2/repository/org/apache/maven/plugin

- Examples of “ready-to-use” plugins
  - Archetype plugin - contains goals for creating Maven projects
  - Jar plugin - contains goals for creating JAR files
  - Compiler plugin - contains goals for compiling source code and unit tests
  - Hibernate3 plugin - contains goals for integration with the Hibernate library

Custom Plugin

- You can create a custom plugin
- A custom plugin can be written in many languages
  - Java, Groovy, Ant, Ruby, etc

Benefits of Plugin Architecture

- Common plugin used by everyone to every project
  - Everyone understands what the plugin does - no need to relearn
- Plugin can evolve/improve without breaking other parts of the build
- Change/improvement in a plugin (by community) benefit everyone

What is Maven Goal?

- Goal is a unit of task
  - Same as “target” in Ant

- Example goals
  - “generate” goal of the “archetype” plugin
  - “compile” goal of the “compiler” plugin
  - “test” goal of the “surefire” plugin

Plugins Can be Configured

- Plugins can be configured via configuration properties
- Example - Use JDK 1.6 for Compiler plugin

```
<build>
  <plugins>
    <plugin>
      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-compiler-plugin</artifactId>
      <version>2.3.2</version>
      <configuration>
         <source>1.6</source>
         <target>1.6</target>
      </configuration>
    </plugin>
  </plugins>
</build>
```

Example: Make Executable Jar Plug-in

```
<build>
  <plugins>
    <plugin>

      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-jar-plugin</artifactId>
      <configuration>
          <archive>
             <manifest>
                <addClasspath>true</addClasspath>
                <mainClass>com.mycompany.examples.App</mainClass>
             </manifest>
          </archive>
      </configuration>

    </plugin>
  </plugins>
</build>
```

Lab:

Exercise 2: Use a “Make Executable Jar” Plugin

5072_tools_maven.zip

Dependency Management

How Dependency is Specified

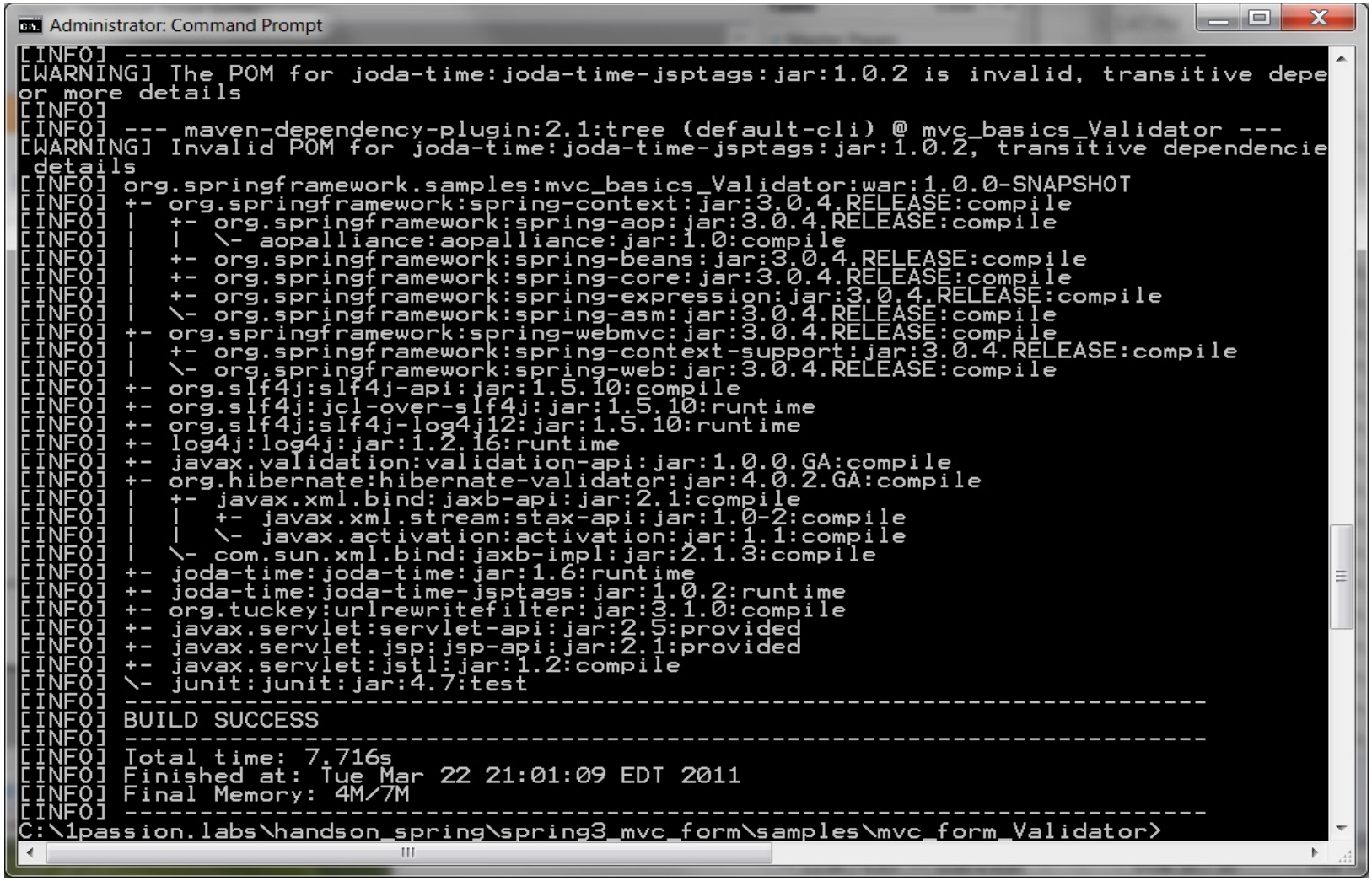
- Each dependency is specified using the coordinates

```
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
    instance"
  xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-v4_0_0.xsd">
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.javapassion.examples</groupId>
  <artifactId>helloworld_app</artifactId>
  <packaging>jar</packaging>
  <version>1.0-SNAPSHOT</version>
  <name>helloworld_app</name>
  <url>http://maven.apache.org</url>
  <dependencies>
    <dependency>
      <groupId>junit</groupId>
      <artifactId>junit</artifactId>
      <version>3.8.1</version>
      <scope>test</scope>
    </dependency>
  </dependencies>
</project>
```

Transitive Dependencies

- Usage scenario
  - Your project depends on a library A
  - Library A depends on 5 other libraries - B,C,D,E,F
- Your project need to specify dependency only on A
  - Maven will handle the fact that A depends on B,C,D,E,F
- Maven also handles the conflict between dependencies
- You can see the dependency tree through Maven command
  - *mvn dependency:tree*

mvn dependency:tree



Dependency Scope

- Each dependency is specified with a scope

```
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
    instance"
  xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-v4_0_0.xsd">
  <modelVersion>4.0.0</modelVersion>
  <groupId>com.javapassion.examples</groupId>
  <artifactId>helloworld_app</artifactId>
  <packaging>jar</packaging>
  <version>1.0-SNAPSHOT</version>
  <name>helloworld_app</name>
  <url>http://maven.apache.org</url>
  <dependencies>
    <dependency>
      <groupId>junit</groupId>
      <artifactId>junit</artifactId>
      <version>3.8.1</version>
      <scope>test</scope>
    </dependency>
  </dependencies>
</project>
```

Dependency Scope Example

- When a dependency has a scope of “test”, it will not be available to the “compile” goal of the Compiler plugin
- It will be added to the classpath for only the “*compiler:testCompile*” and “*surefire:test*” goals

Dependency Scope (1)

- compile
  - Default scope, used if none is specified.
- provided
  - Much like compile, but indicates you expect the JDK or a container to provide the dependency at runtime.
  - For example, when building a web application, you would set the dependency on the Servlet API and related Java EE APIs to scope *provided* because the web container provides those classes.
  - This scope is only available on the compilation and test classpath, and is not transitive.
- runtime
  - The dependency is not required for compilation, but is for execution. It is in the runtime and test classpaths, but not the compile classpath.

Dependency Scopes (2)

- test
  - Dependency is not required for normal use of the application, and is only available for the test compilation and execution phases.
- system
  - Similar to *provided* except that you have to provide the JAR which contains it explicitly. The artifact is always available and is not looked up in a repository.
- import (only available in Maven 2.0.9 or later)
  - Only used on a dependency of type pom in the <dependencyManagement> section

Packaging of Dependencies

- When you create a JAR for a project
  - Dependencies are not bundled with the generated artifact - they are used only for compilation
- When you create a WAR/EAR file
  - You can configure POM so that dependencies are bundled with the generated artifact
  - You can also configure to exclude certain dependencies using “provided” scope - a dependency is needed for compilation but should be not be bundled

Lab:

Exercise 3: Add Log4J Dependency
5072_tools_maven.zip

Maven Support in IDE's

Maven Support

- Each IDE uses its own proprietary project metadata
  - Results in IDE lock-in
- Maven standardized project metadata
  - Developer can use whatever IDE of his/her choice on any Maven projects
- All major IDE's (Eclipse, Intellij IDEA, etc) support Maven
  - Create a Maven project, Import a Maven project
  - Extras: form-based POM editor
- Tight integration with other IDE build tools
  - Version management
  - Task management

Lab:

Exercise 5: Import a Maven Project into Eclipse
5072_tools_maven.zip

Maven Web Project Structure

Maven Web Project Structure

- /src/main/java - source files for the dynamic content of the application
- /src/test/java - source files for unit tests
- /src/main/webapp - files for creating a valid web application, e.g. “web.xml“, view pages, etc
- /target - compiled and packaged deliverable
- pom.xml

Lab:

Exercise 7: Create a simple Maven Web Project using Eclipse 5072_tools_maven.zip

Comparison to Ant

Example: Ant

```
<project name="my-project" default="dist" basedir=".">
    <description>
        simple example build file
    </description>
  <!-- set global properties for this build -->
  <property name="src" location="src/main/java"/>
  <property name="build" location="target/classes"/>
  <property name="dist"  location="target"/>

  <target name="init">
    <!-- Create the time stamp -->
    <tstamp/>
    <!-- Create the build directory structure used by compile -->
    <mkdir dir="${build}"/>
  </target>

  <target name="compile" depends="init"
        description="compile the source " >
    <!-- Compile the java code from ${src} into ${build} -->
    <javac srcdir="${src}" destdir="${build}"/>
  </target>

  <target name="dist" depends="compile"
        description="generate the distribution" >
    <!-- Create the distribution directory -->
    <mkdir dir="${dist}/lib"/>

    <!-- Put everything in ${build} into the MyProject-${DSTAMP}.jar file -->
    <jar jarfile="${dist}/lib/MyProject-${DSTAMP}.jar" basedir="${build}"/>
  </target>

  <target name="clean"
        description="clean up" >
    <!-- Delete the ${build} and ${dist} directory trees -->
    <delete dir="${build}"/>
    <delete dir="${dist}"/>
  </target>
</project>
```

Ant vs. Maven

- Ant
  - It doesn't have formal conventions like a common project directory structure or default behavior. You have to tell Ant exactly where to find the source and where to put the output.
  - It is procedural. You have to tell Ant exactly what to do and when to do it. You have to tell it to compile, then copy, then compress.
  - It doesn't have a lifecycle. You have to define tasks and task dependencies.

Example: Maven

```
<project>
  <modelVersion>4.0.0</modelVersion>
  <groupId>org.sonatype.mavenbook</groupId>
  <artifactId>my-project</artifactId>
  <version>1.0</version>
</project>
```

Ant vs. Maven

- Maven
  - It has conventions. It knows where your source code is because you followed the convention. Maven's Compiler plugin puts the bytecode in target/classes, and it produces a JAR file in target.
  - It is declarative. All you had to do is to create a pom.xml file and put your source in the default directory. Maven takes care of the rest.
  - It has a lifecycle which gets invoked when you executes mvn install. This command told Maven to execute a series of sequential lifecycle phases until it reaches the install lifecycle phase. As a side-effect of this journey through the lifecycle, Maven executes a number of default plugin goals which did things like compile and create a JAR.

Code with Passion!