

# Pure Java Main Application

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# Chapter 1. Introduction

This material provides an introduction to building a bare bones Java application using a single, simple Java class, packaging that in a Java ARchive (JAR), and executing it two ways:

- as a class in the classpath
- as the Main-Class of a JAR

## 1.1. Goals

The student will learn:

- foundational build concepts for simple, pure-Java solution

## 1.2. Objectives

At the conclusion of this lecture and related exercises, the student will be able to:

1. create source code for an executable Java class
2. add that Java class to a Maven module
3. build the module using a Maven pom.xml
4. execute the application using a classpath
5. configure the application as an executable JAR
6. execute an application packaged as an executable JAR

# Chapter 2. Simple Java Class with a Main

Our simple Java application starts with a public class with a static main() method that optionally accepts command-line arguments from the caller

```
package info.ejava.examples.app.build.javamain;

import java.util.List;

public class SimpleMainApp { ①
    public static void main(String...args) { ② ③
        System.out.println("Hello " + List.of(args));
    }
}
```

- ① public class
- ② implements a static main() method
- ③ optionally accepts arguments

# Chapter 3. Project Source Tree

This class is placed within a module source tree in the `src/main/java` directory below a set of additional directories (`info/ejava/examples/app/build/javamain`) that match the Java package name of the class (`info.ejava.examples.app.build.javamain`)

```
|-- pom.xml ①
|-- src
|   |-- main ②
|   |   |-- java
|   |   |   |-- info
|   |   |   |   |-- ejava
|   |   |   |   |   |-- examples
|   |   |   |   |   |   |-- app
|   |   |   |   |   |   |   |-- build
|   |   |   |   |   |   |   |   |-- javamain
|   |   |   |   |   |   |   |   |-- SimpleMainApp.java
|   |   |-- resources ③
|   |-- test ④
|       |-- java
|       |-- resources
```

- ① `pom.xml` will define our project artifact and how to build it
- ② `src/main` will contain the pre-built, source form of our artifacts that will be part of our primary JAR output for the module
- ③ `src/main/resources` is commonly used for property files or other resource files read in during the program execution
- ④ `src/test` is will contain the pre-built, source form of our test artifacts. These will not be part of the primary JAR output for the module

# Chapter 4. Building the Java Archive (JAR) with Maven

In setting up the build within Maven, I am going to limit the focus to just compiling our simple Java class and packaging that into a standard Java JAR.

## 4.1. Add Core pom.xml Document

Add the core document with required GAV information (`groupId`, `artifactId`, `version`) to the `pom.xml` file at the root of the module tree. Packaging is also required but will have a default of `jar` if not supplied.

```
<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>info.ejava.examples.app</groupId> ①
  <artifactId>java-app-example</artifactId> ②
  <version>6.1.0-SNAPSHOT</version> ③
  <packaging>jar</packaging> ④
</project>
```

① `groupId`

② `artifactId`

③ `version`

④ `packaging`



Module directory should be the same name/spelling as `artifactId` to align with default directory naming patterns used by plugins.



Packaging specification is optional in this case. The default packaging is `jar`

## 4.2. Add Optional Elements to pom.xml

- `name`

```
<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>info.ejava.examples.app</groupId>
<artifactId>java-app-example</artifactId>
<version>6.1.0-SNAPSHOT</version>
<packaging>jar</packaging>

<name>App::Build::Java Main Example</name> ①
</project>
```

① `name` appears in Maven build output but not required

## 4.3. Define Plugin Versions

Define plugin versions so the module can be deterministically built in multiple environments

- Each version of Maven has a set of default plugins and plugin versions
- Each plugin version may or may not have a set of defaults (e.g., not Java 17) that are compatible with our module

```
<properties>
  <java.target.version>17</java.target.version>
  <maven-compiler-plugin.version>3.13.0</maven-compiler-plugin.version>
  <maven-jar-plugin.version>3.4.2</maven-jar-plugin.version>
</properties>

<pluginManagement>
  <plugins>
    <plugin>
      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-compiler-plugin</artifactId>
      <version>${maven-compiler-plugin.version}</version>
      <configuration>
        <release>${java.target.version}</release>
      </configuration>
    </plugin>
  </plugins>
</pluginManagement>
```

The `jar` packaging will automatically activate the `maven-compiler-plugin` and `maven-jar-plugin`. Our definition above identifies the version of the plugin to be used (if used) and any desired configuration of the plugin(s).

## 4.4. pluginManagement vs. plugins

- Use `pluginManagement` to define a plugin if it activated in the module build
  - useful to promote consistency in multi-module builds
  - commonly seen in parent modules

- Use `plugins` to declare that a plugin be active in the module build
  - ideally only used by child modules
  - our child module indirectly activated several plugins by using the `jar` packaging type



# Chapter 5. Build the Module

Maven modules are commonly built with the following commands/ [phases](#)

- **clean** removes previously built artifacts
- **package** creates primary artifact(s) (e.g., JAR)
  - processes main and test resources
  - compiles main and test classes
  - runs unit tests
  - builds the archive

```
[INFO] Scanning for projects...
[INFO]
[INFO] -----< info.ejava.examples.app:java-app-example >-----
[INFO] Building App::Build::Java App Example 6.1.0-SNAPSHOT
[INFO]   from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- maven-clean-plugin:3.4.0:clean (default-clean) @ java-app-example ---
[INFO] Deleting ../java-app-example/target
[INFO]
[INFO] --- maven-resources-plugin:3.3.1:resources (default-resources) @ java-app-example ---
[INFO] Copying 0 resource from src/main/resources to target/classes
[INFO]
[INFO] --- maven-compiler-plugin:3.13.0:compile (default-compile) @ java-app-example ---
[INFO] Recompiling the module because of changed source code.
[INFO] Compiling 1 source file with javac [debug parameters release 17] to target/classes
[INFO]
[INFO] --- maven-resources-plugin:3.3.1:testResources (default-testResources) @ java-app-example ---
[INFO] Copying 0 resource from src/test/resources to target/test-classes
[INFO]
[INFO] --- maven-compiler-plugin:3.13.0:testCompile (default-testCompile) @ java-app-example ---
[INFO] Recompiling the module because of changed dependency.
[INFO]
[INFO] --- maven-surefire-plugin:3.3.1:test (default-test) @ java-app-example ---
[INFO]
[INFO] --- maven-jar-plugin:3.4.2:jar (default-jar) @ java-app-example ---
[INFO] Building jar: ../java-app-example/target/java-app-example-6.1.0-SNAPSHOT.jar
[INFO]
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
```

[INFO] Total time: 1.783 s

# Chapter 6. Project Build Tree

The produced build tree from `mvn clean package` contains the following key artifacts (and more)

```
|-- pom.xml
|-- src
`-- target
    |-- classes ①
    |   |-- info
    |   |   |-- ejava
    |   |   |   |-- examples
    |   |   |   |   |-- app
    |   |   |   |   |   |-- build
    |   |   |   |   |   |   |-- javamain
    |   |   |   |   |   |   |   |-- SimpleMainApp.class
    |   |   |   |   |   |   |   ...
    |   |   |   |   |   |   |   |-- java-app-example-6.1.0-SNAPSHOT.jar ②
    |   |   |   |   |   |   |   ...
    |   |   |   |   |   |   |   `-- test-classes ③
```

- ① `target/classes` for built artifacts from `src/main`
- ② primary artifact(s) (e.g., Java Archive (JAR))
- ③ `target/test-classes` for built artifacts from `src/test`

# Chapter 7. Resulting Java Archive (JAR)

Maven adds a few extra files to the META-INF directory that we can ignore. The key files we want to focus on are:

- `SimpleMainApp.class` is the compiled version of our application
- `[META-INF/MANIFEST.MF]`(<https://docs.oracle.com/javase/tutorial/deployment/jar/manifestindex.html>) contains properties relevant to the archive

```
$ jar tf target/java-app-example-*-SNAPSHOT.jar | egrep -v "/" | sort
META-INF/MANIFEST.MF
META-INF/maven/info.ejava.examples.app/java-app-example/pom.properties
META-INF/maven/info.ejava.examples.app/java-app-example/pom.xml
info/ejava/examples/app/build/javamain/SimpleMainApp.class
```



- `jar tf` lists the contents of the JAR
- `egrep` is being used to exclude non-files (i.e., directories) that end with "/"
- `sort` performs an ordering of the output
- `|` pipe character sends the stdout of previous command to the stdin of the next command

# Chapter 8. Execute the Application

The application is executed by

- invoking the `java` command
- adding the JAR file (and any other dependencies) to the classpath
- specifying the fully qualified class name of the class that contains our `main()` method

*Example with no arguments*

```
$ java -cp target/java-app-example-*-SNAPSHOT.jar  
info.ejava.examples.app.build.javamain.SimpleMainApp
```

```
Output:  
Hello []
```

*Example with arguments*

```
$ java -cp target/java-app-example-*-SNAPSHOT.jar  
info.ejava.examples.app.build.javamain.SimpleMainApp arg1 arg2 "arg3 and 4"
```

```
Output:  
Hello [arg1, arg2, arg3 and 4]
```

- example passed three (3) arguments separated by spaces
  - third argument (`arg3` and `arg4`) used quotes around the entire string to escape spaces and have them included in the single parameter

# Chapter 9. Configure Application as an Executable JAR

To execute a specific Java class within a classpath is conceptually simple. However, there is a lot more to know than we need to when there may be only a single entry point. In the following sections we will assign a default Main-Class by using the [MANIFEST.MF properties](#)

## 9.1. Add Main-Class property to MANIFEST.MF

```
$ unzip -qc target/java-app-example-*-SNAPSHOT.jar META-INF/MANIFEST.MF
```

```
Manifest-Version: 1.0
Created-By: Maven JAR Plugin 3.4.2
Build-Jdk-Spec: 17
Main-Class: info.ejava.examples.app.build.javamain.SimpleMainApp
```

## 9.2. Automate Additions to MANIFEST.MF using Maven

One way to surgically add that property is thru the [maven-jar-plugin](#)

```
<plugin>
  <groupId>org.apache.maven.plugins</groupId>
  <artifactId>maven-jar-plugin</artifactId>
  <version>${maven-jar-plugin.version}</version>
  <configuration>
    <archive>
      <manifest>
        <mainClass>
info.ejava.examples.app.build.javamain.SimpleMainApp</mainClass>
        </manifest>
      </archive>
    </configuration>
  </plugin>
```



This is a very specific plugin configuration that would only apply to a specific child module. Therefore, we would place this in a `plugins` declaration versus a `pluginsManagement` definition.

# Chapter 10. Execute the JAR versus just adding to classpath

The executable JAR is executed by

- invoking the `java` command
- adding the `-jar` option
- adding the JAR file (and any other dependencies) to the classpath

*Example with no arguments*

```
$ java -jar target/java-app-example-*-SNAPSHOT.jar
```

Output:  
Hello []

*Example with arguments*

```
$ java -jar target/java-app-example-*-SNAPSHOT.jar one two "three and four"
```

Output:  
Hello [one, two, three and four]

- example passed three (3) arguments separated by spaces
  - third argument (`three and four`) used quotes around the entire string to escape spaces and have them included in the single parameter

# Chapter 11. Configure pom.xml to Test

At this point we are ready to create an automated execution of our JAR as a part of the build. We have to do that after the `packaging` phase and will leverage the `integration-test` Maven phase

```
<build>
  ...
  <plugin>
    <groupId>org.apache.maven.plugins</groupId>
    <artifactId>maven-antrun-plugin</artifactId> ①
    <executions>
      <execution>
        <id>execute-jar</id>
        <phase>integration-test</phase> ④
        <goals>
          <goal>run</goal>
        </goals>
        <configuration>
          <tasks>
            <java fork="true" classname=
"info.ejava.examples.app.build.javamain.SimpleMainApp"> ②
              <classpath>
                <pathelement path=
"${project.build.directory}/${project.build.finalName}.jar"/>
              </classpath>
              <arg value="Ant-supplied java -cp"/>
              <arg value="Command Line"/>
              <arg value="args"/>
            </java>

            <java fork="true"
              jar=
"${project.build.directory}/${project.build.finalName}.jar"> ③
              <arg value="Ant-supplied java -jar"/>
              <arg value="Command Line"/>
              <arg value="args"/>
            </java>
          </tasks>
        </configuration>
      </execution>
    </executions>
  </plugin>
</plugins>
</build>
```

- ① Using the `maven-ant-run` plugin to execute Ant task
- ② Using the `java` Ant task to execute shell `java -cp` command line
- ③ Using the `java` Ant task to execute shell `java -jar` command line



#### ④ Running the plugin during the `integration-phase`

- Order
  1. `package`
  2. `pre-integration`
  3. `integration-test`
  4. `post-integration`
  5. `verify`

## 11.1. Execute JAR as part of the build

```
$ mvn clean verify
[INFO] Scanning for projects...
[INFO]
[INFO] -----< info.ejava.examples.app:java-app-example >-----
...
[INFO] --- maven-jar-plugin:3.2.2:jar (default-jar) @ java-app-example -①
[INFO] Building jar: ../java-app-example/target/java-app-example-6.1.0-SNAPSHOT.jar
[INFO]
...
[INFO] --- maven-antrun-plugin:3.1.0:run (execute-jar) @ java-app-example ---
[INFO] Executing tasks ②
[INFO]     [java] Hello [Ant-supplied java -cp, Command Line, args]
[INFO]     [java] Hello [Ant-supplied java -jar, Command Line, args]
[INFO] Executed tasks
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----

[INFO] --- maven-jar-plugin:3.4.2:jar (default-jar) @ java-app-example -①
[INFO] Building jar: ../java-app-example/target/java-app-example-6.1.0-SNAPSHOT.jar
[INFO]
...
[INFO] --- maven-antrun-plugin:3.1.0:run (execute-jar) @ java-app-example ---
[INFO] Executing tasks ②
[INFO]     [java] Hello [Ant-supplied java -cp, Command Line, args]
[INFO]     [java] Hello [Ant-supplied java -jar, Command Line, args]
[INFO] Executed tasks
[INFO] -----
[INFO] BUILD SUCCESS
```

① Our plugin is executing

② Our application was executed and the results displayed

# Chapter 12. Summary

1. The JVM will execute the static `main()` method of the class specified in the java command
2. The class must be in the JVM classpath
3. Maven can be used to build a JAR with classes
4. A JAR can be the subject of a java execution
5. The Java `META-INF/MANIFEST.MF Main-Class` property within the target JAR can express the class with the `main()` method to execute
6. The maven-jar-plugin can be used to add properties to the `META-INF/MANIFEST.MF` file
7. A Maven build can be configured to execute a JAR