Technological foundations of software development

Automate build production

ICM – Computer Science Major – Course unit on Technological foundations of computer science
M1 Cyber Physical and Social Systems – Course unit on CPS2 engineering and development, Part 2: Technological foundations of software development
Maxime Lefrançois https://maxime-lefrancois.info
online: https://ci.mines-stetienne.fr/cps2/course/tfsd/

Objectives of the session

This session aims to familiarize you with the methods and tools for automating code production: compilation, testing, packaging, deployment, etc. In particular, we will see:

- make
- Apache Maven

Technological foundations of software development

Automate build production

Part 1: « Automate »: What? Why? How?

https://www.commitstrip.com/en/2015/06/22/can-we-automate-everything/?

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this session
Build Production

Technological foundations of software development

Automate build production

Part 1: « Automate »: What? Why? How?

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« Automate »: What ?

- Check the licenses of the files, check that the remote repository has no new commit, ...
- Potentially generate source code
- Download or update dependencies
- Manage additional resources
- Compile sources, optimize code
- Run unit tests
- Generate documentation
- Package executable code
- Deploy in a test environment and execute integration tests
- Verify the integrity of the archive, check the quality of the code, ...
- Deploy in a production environment, publish the code version
- Create and push a git tag
- ...

https://en.wikipedia.org/wiki/Build_automation

« Automate »: Why ?

- Accelerate software production
- Improve software quality
- Avoid redundant tasks
- Limit bad software versions
- History: traceability, non-repudiation

- Save time and money

- As a **building block** for continuous integration and deployment

https://en.wikipedia.org/wiki/Build_automation

« Automate »: How ?

- Build automation utilities
  - examples: make, rake, msbuild, ant, maven, gradle, webpack, ...
  - automate simple and repeatable tasks
  - order tasks to achieve goals
  - execute only the necessary tasks

  - Two paradigms:
    - task-oriented: breaks down goals into tasks
    - product-oriented: breaks down into sub-products to be generated

https://en.wikipedia.org/wiki/Build_automation

« Automate »: How ?

- **Build automation servers**
  - run build automation utilities

  - Three paradigms:
    - **On-demand automation:** the user requests the execution of the production
    - **Scheduled automation:** execution is scheduled (e.g. nightly build)
    - **Triggered automation:** execution is triggered by an event (e.g., commit on master)

https://en.wikipedia.org/wiki/Build_automation

Technological foundations of software development

Automate build production

Part 2: Build automation utilities

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Technological foundations of software development

Automate build production

Part 2: Build automation utilities

Part 2.1: *Make-like*

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Make-like build automation utilities

- macros, declarative programming
- first implementation by Stuart Feldman (Bell Labs, released in 1976)
- many variants of the tool
  - make, GNU gmake, Microsoft nmake (in Visual Studio), google Kati (for Android OS) …
- still widely used today

https://en.wikipedia.org/wiki/Make_(software)
https://makefiletutorial.com/#makefile-cookbook

file `makefile` (or `Makefile`, or `GNUmakefile`, …)

```
srcfiles := $(shell echo src/{00..99}.txt)
destfiles := $(patsubst src/%.txt,dest/%.txt,$(srcfiles))

tutorial:
    @echo "10 questions about Isaac's Makefile in the MCQ"

src/%.txt:
    @[ -d src ] || mkdir src
    echo $* > $@

dest/%.txt: src/%.txt
    @[ -d dest ] || mkdir dest
    cp $< $@

destination: $(destfiles)


.PHONY: tutorial destination
```

Macros: reusable pieces of text or values that can be substituted throughout the build

Declarative programming rules

```
target [target ...]: [component ...]
[Tab ↹] [command 1]
…
[Tab ↹] [command n]
```

"tutorial" and "destination" aren't actual filename, soe we define them as .PHONY

```
$ make              # calls rule “tutorial”
$ make dest/00.txt # calls third rule, which needs second.
$ make destination # updates all targets
```

call with target file names

https://en.wikipedia.org/wiki/Make_(software)
https://makefiletutorial.com/#makefile-cookbook

To read for MCQ test

- “Isaac’s Makefile” https://gist.github.com/isaacs/62a2d1825d04437c6f08

Technological foundations of software development

Automate build production

Part 1: Build automation utilities

Part 2.2: for Java

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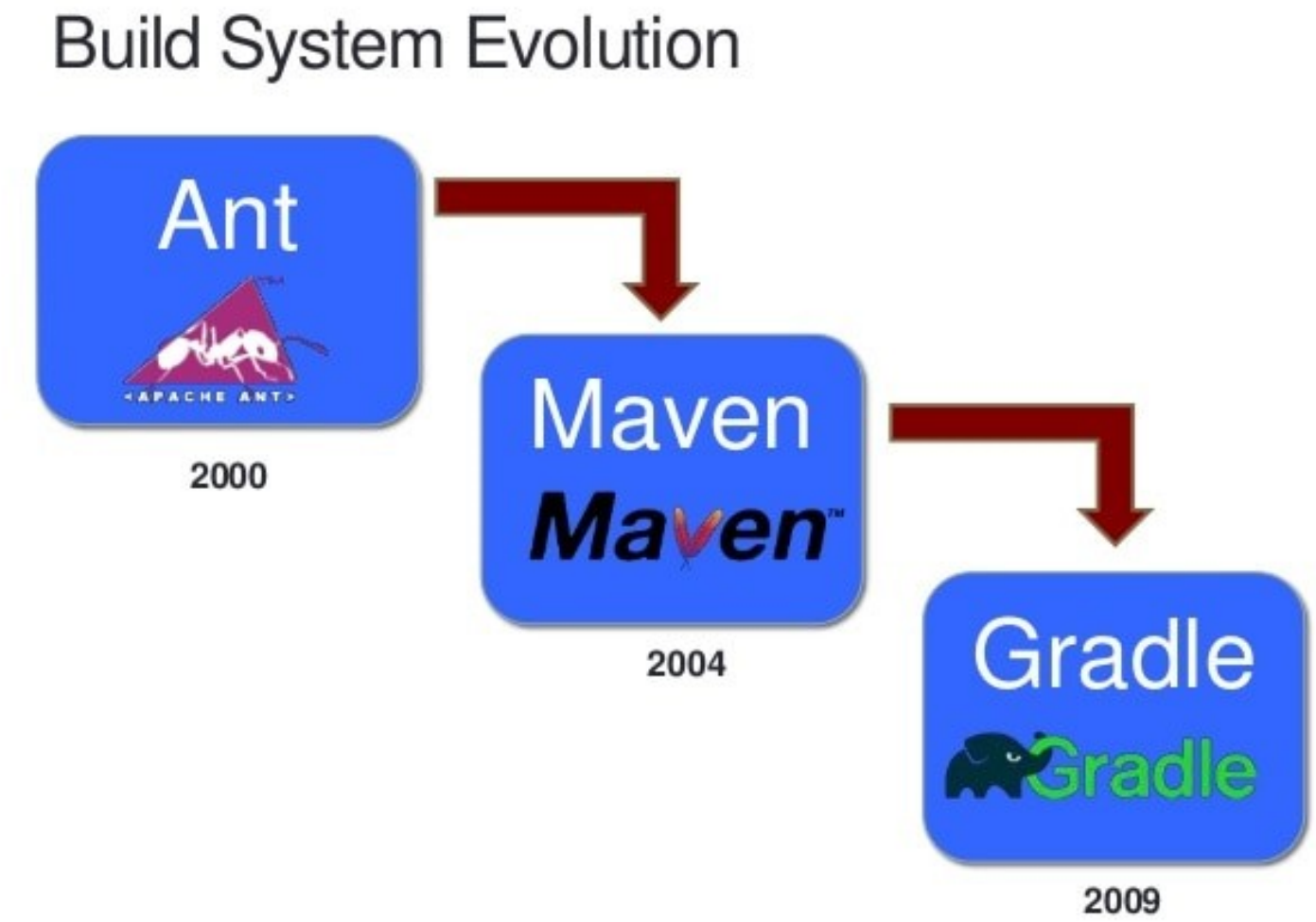
For Java


Build System Evolution
Ant
APACHE ANT
2000
Maven
Maven
2004
Gradle
Gradle
2009

For Java

Apache Ant ("Another Neat Tool")
Apache Software Foundation, v1 2000 ;
written in **Java**
XML project files, complex, verbose

https://en.wikipedia.org/wiki/Apache_Ant

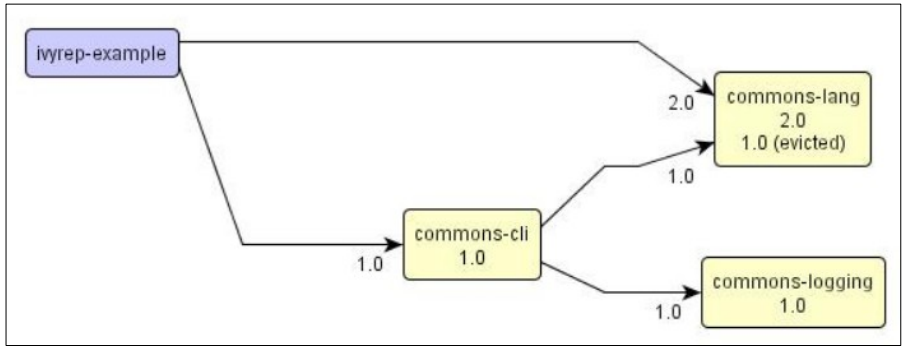
```
<project name="HelloWorldBuildTest" basedir="." default="main">
  <property name="src.dir"     value="src"/>
  <property name="build.dir"   value="build"/>
  <property name="classes.dir" value="${build.dir}/classes"/>
  <property name="jar.dir"     value="${build.dir}/jar"/>
  <property name="lib.dir"     value="lib"/>
  <property name="main-class"  value="packagename.HelloWorld"/>

  <path id="classpath">
    <fileset dir="${lib.dir}" includes="**/*.jar"/>
  </path>
  <target name="clean">
    <delete dir="${build.dir}"/>
  </target>
  <target name="compile">
    <mkdir dir="${classes.dir}"/>
    <javac srcdir="${src.dir}" destdir="${classes.dir}" classpathref="classpath"/>
  </target>
  <target name="jar" depends="compile">
    <mkdir dir="${jar.dir}"/>
    <jar destfile="${jar.dir}/${ant.project.name}.jar" basedir="${classes.dir}">
      <manifest>
        <attribute name="Main-Class" value="${main-class}"/>
      </manifest>
    </jar>
  </target>
  <target name="run" depends="jar">
```

http://blog.travelmarx.com/2011/10/java-apache-ant-and-hello-world.html

+ Apache Ivy
Transitive dependency manager
example:

```
<dependency org="com.google.code.gson" name="gson" rev="2.8.8"/>
```

http://ant.apache.org/ivy/



http://www.jaya.free.fr/ivy/doc/print.html

For Java

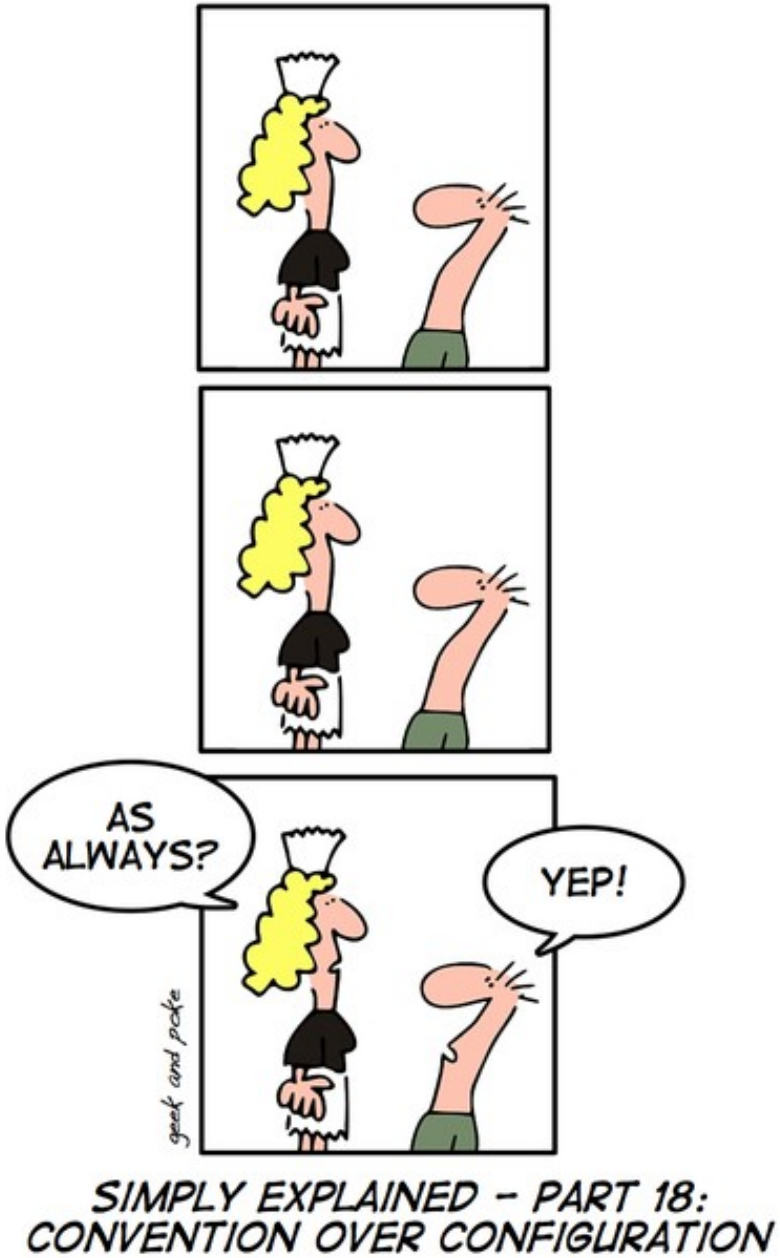
Apache Maven

Apache Software Foundation, v1 2004; v2 2005; v3 2013

written in **Java**

Convention over configuration

- objective: limit the number of decisions a developer has to make.



https://en.wikipedia.org/wiki/Apache_Maven

https://devopedia.org/convention-over-configuration

For Java

Apache Maven

Apache Software Foundation, v1 2004; v2 2005; v3 2013

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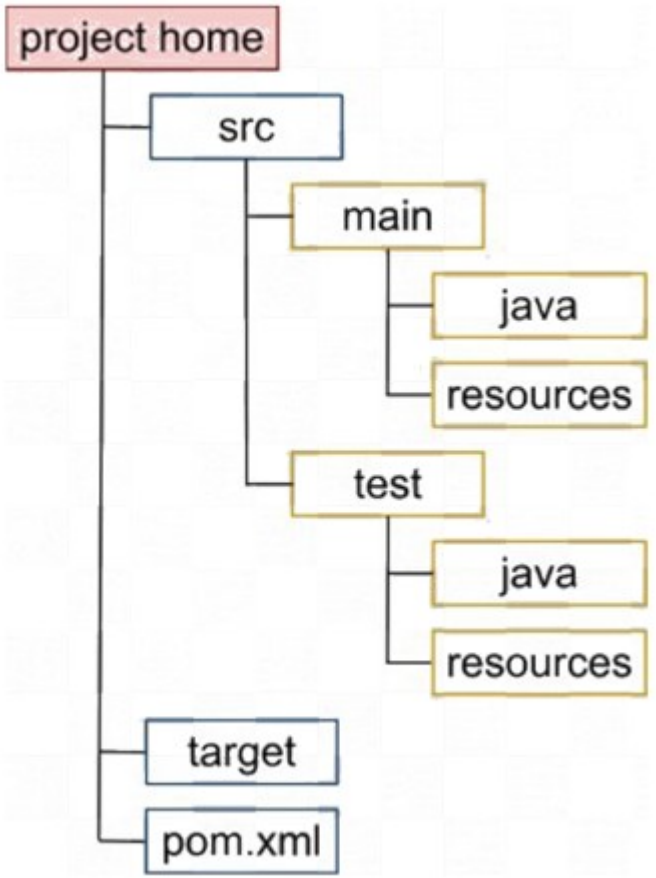
Convention over configuration

- Conventions for the project structure



https://en.wikipedia.org/wiki/Apache_Maven

For Java

Apache Maven

Apache Software Foundation, v1 2004; v2 2005; v3 2013

written in **Java**

Convention over configuration

- Conventions for the project structure
- A project is described by an XML file: le **POM** (**P**roject **O**bject **M**odel)

```xml
<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 https://maven.apache.org/xsd/maven-4.0.0.xsd">
  <modelVersion>4.0.0</modelVersion>

  <!-- The Basics -->
  <groupId>...</groupId>
  <artifactId>...</artifactId>
  <version>...</version>
  <packaging>...</packaging>
  <dependencies>...</dependencies>
  <parent>...</parent>
  <dependencyManagement>...</dependencyManagement>
  <modules>...</modules>
  <properties>...</properties>

  <!-- Build Settings -->
  <build>...</build>
  <reporting>...</reporting>

  <!-- More Project Information -->
  <name>...</name>
  <description>...</description>
  <url>...</url>
  <inceptionYear>...</inceptionYear>
  <licenses>...</licenses>
  <organization>...</organization>
  <developers>...</developers>
  <contributors>...</contributors>

  <!-- Environment Settings -->
  <issueManagement>...</issueManagement>
  <ciManagement>...</ciManagement>
  <mailingLists>...</mailingLists>
  <scm>...</scm>
  <prerequisites>...</prerequisites>
  <repositories>...</repositories>
  <pluginRepositories>...</pluginRepositories>
  <distributionManagement>...</distributionManagement>
  <profiles>...</profiles>
</project>
```

https://maven.apache.org/guides/introduction/introduction-to-the-pom.html

https://en.wikipedia.org/wiki/Apache_Maven

For Java

Apache Maven

Apache Software Foundation, v1 2004; v2 2005; v3 2013

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2.    xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 https://maven.apache.org/xsd/maven-4.0.0.xsd">
3.    <modelVersion>4.0.0</modelVersion>
4.
5.    <!-- The Basics -->
6.    <groupId>...</groupId>
7.    <artifactId>...</artifactId>
8.    <version>...</version>
9.    <packaging>...</packaging>
10.   <dependencies>...</dependencies>
11.   <parent>...</parent>
12.   <dependencyManagement>...</dependency...ment>
13.   <modules>...</modules>
14.   <properties>...</properties>
15.
16.   <!-- Build Settings -->
17.   <build>...</build>
18.   <reporting>...</reporting>
19.
20.   <!-- More Project Information -->
21.   <name>...</name>
22.   <description>...</description>
23.   <url>...</url>
24.   <inceptionYear>...</inceptionYear>
25.   <licenses>...</licenses>
26.   <organization>...</organization>
27.   <developers>...</developers>
28.   <contributors>...</contributors>
29.
30.   <!-- Environment Settings -->
31.   <issueManagement>...</issueManagement>
32.   <ciManagement>...</ciManagement>
33.   <mailingLists>...</mailingLists>
34.   <scm>...</scm>
35.   <prerequisites>...</prerequisites>
36.   <repositories>...</repositories>
37.   <pluginRepositories>...</pluginRepositories>
38.   <distributionManagement>...</distributionManagement>
39.   <profiles>...</profiles>
40. </project>
```

G-A-V

jar (default), war, pom, ...

dependencies

inheritance and multi-modules

configuration ${prop}

plugins used during the build

plugins for reporting

metadata about the projet

config. environnement

https://maven.apache.org/guides/introduction/introduction-to-the-pom.html

https://en.wikipedia.org/wiki/Apache_Maven

For Java

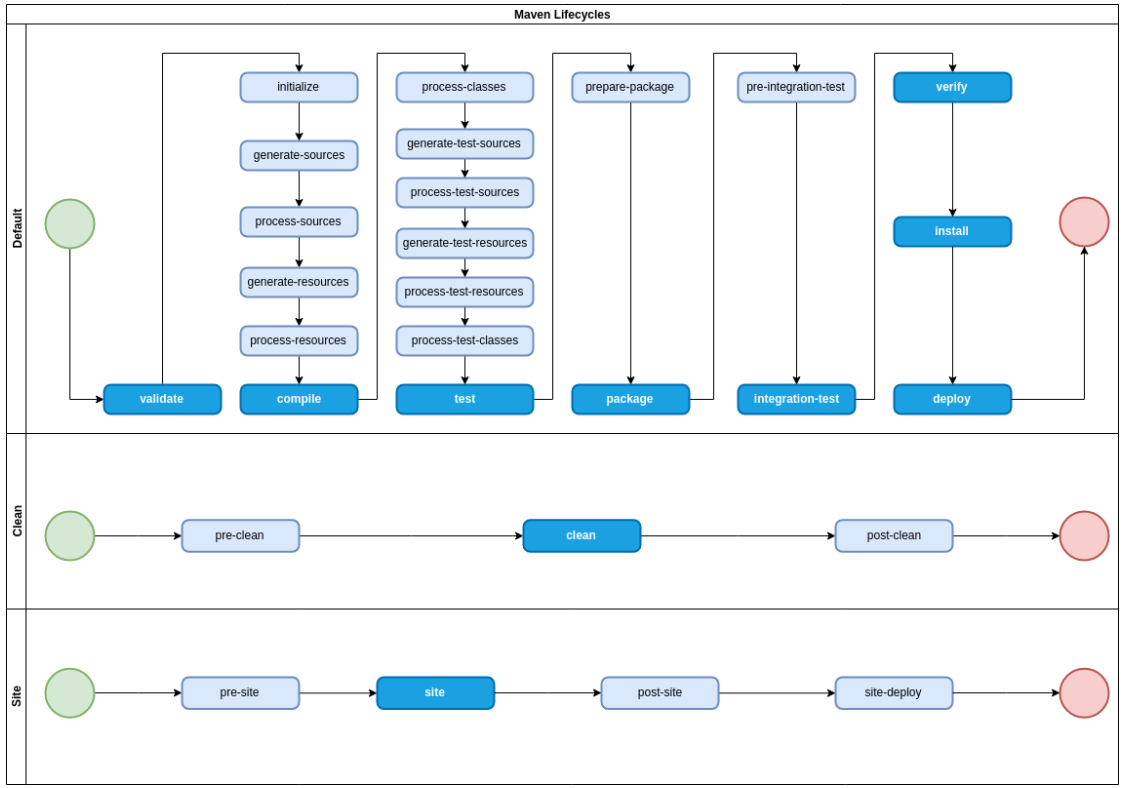
Apache Maven

Apache Software Foundation, v1 2004; v2 2005; v3 2013

written in **Java**

Convention over configuration

- Conventions for the project structure
- A project is described by an XML file: le **POM** (**P**roject **O**bject **M**odel)
- Standardized life cycle (phases)



https://medium.com/@yetanothersoftwareengineer/maven-lifecycle-phases-plugins-and-goals-25d8e33fa22

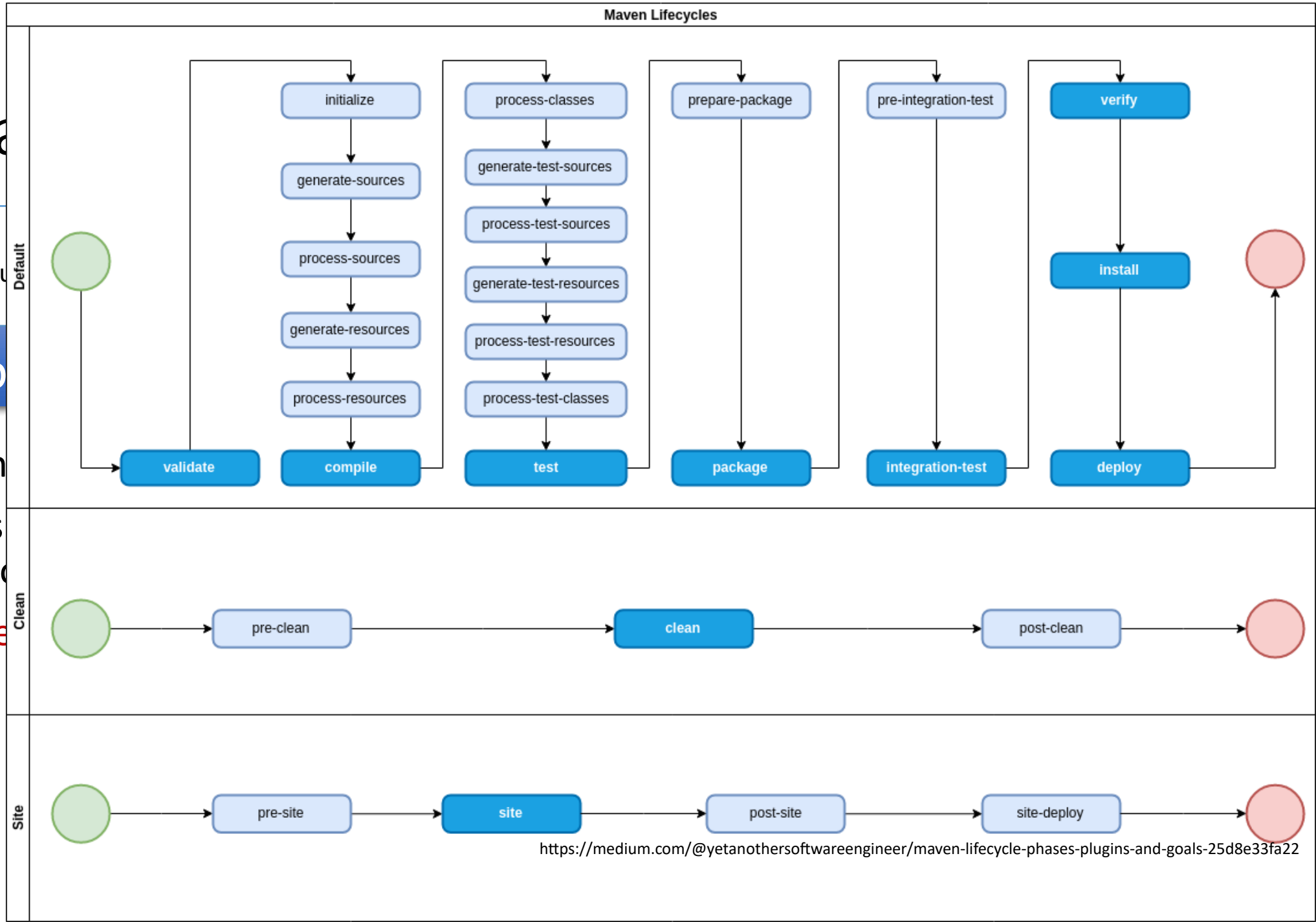
https://en.wikipedia.org/wiki/Apache_Maven

For Java

Apache Maven
Apache Software Fou
written in **Java**

Conventio

- Convention
- A project is
  le **POM** (Pr
- Standardize



https://medium.com/@yetanothersoftwareengineer/maven-lifecycle-phases-plugins-and-goals-25d8e33fa22

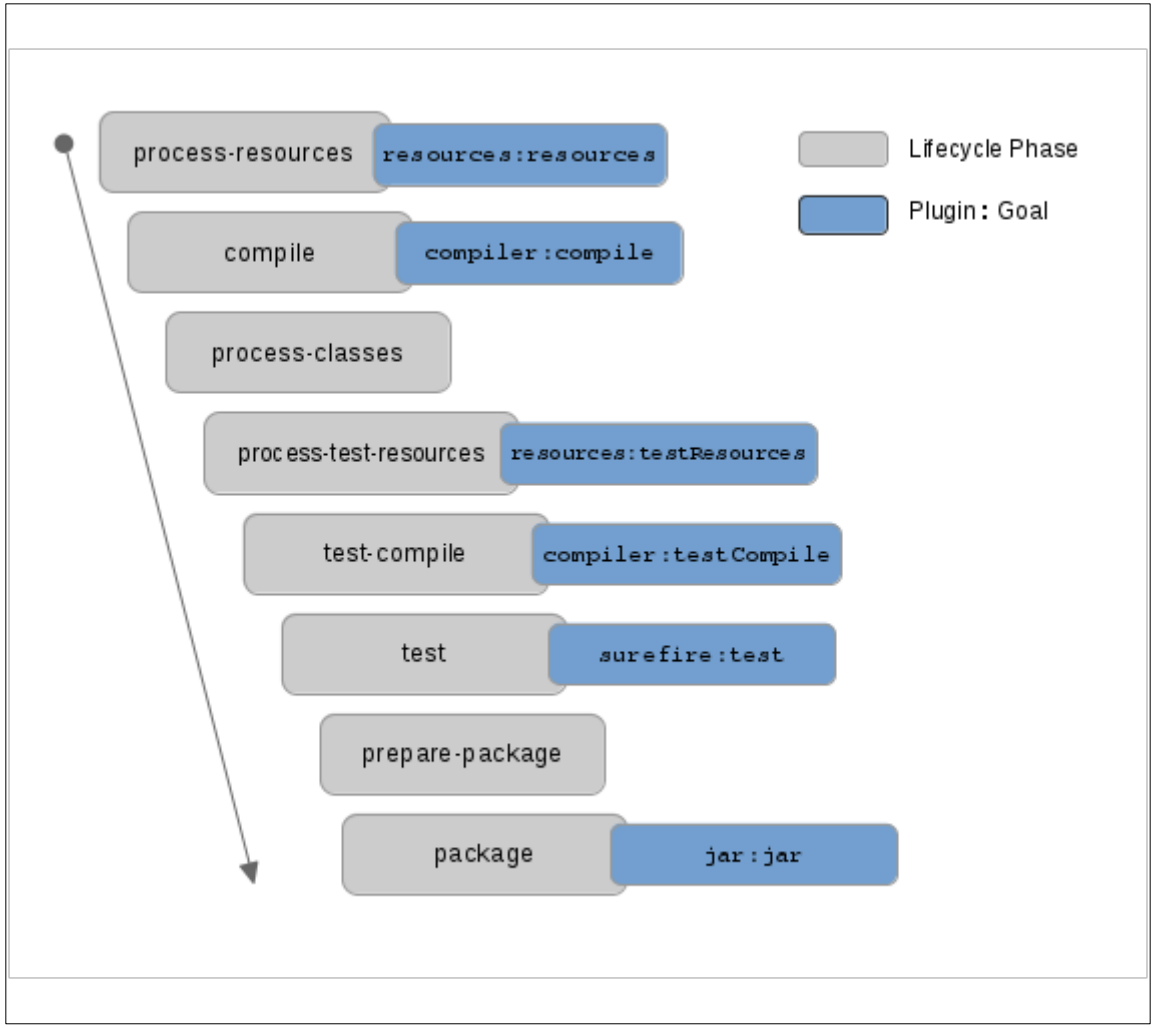
https://en.wikipedia.org/wiki/Apache_Maven

For Java

Apache Maven
Apache Software Foundation, v1 2004; v2 2005; v3 2013
written in **Java**

Convention over configuration

- Conventions for the project structure
- A project is described by an XML file: le **POM** (**P**roject **O**bject **M**odel)
- Standardized life cycle (phases)
- Convention for **plugin goals** executed at each phase of the lifecycle



Example for `<packaging>jar</packaging>`

https://en.wikipedia.org/wiki/Apache_Maven

https://webdevdesigner.com/q/maven-lifecycle-vs-phase-vs-plugin-vs-goal-closed-34346/

For Java

Apache Maven
Apache Software Foundation, v1 2004; v2 2005; v3 2013
written in **Java**

Dependency management

- Use G-A-V coordinates
- concepts:
  - **repositories:** where dependencies are downloaded to
  - **scope:** context of use of the dependency
  - **transitivity:** dependencies of dependencies
  - **inheritance:** inheritance of dependencies from parent project

```
1.  <project xmlns="http://maven.apache.org/POM/
2.    xsi:schemaLocation="http://maven.apache.or
3.    ...
4.    <dependencies>
5.      <dependency>
6.        <groupId>junit</groupId>
7.        <artifactId>junit</artifactId>
8.        <version>4.12</version>
9.        <type>jar</type>
10.       <scope>test</scope>
11.       <optional>true</optional>
12.     </dependency>
13.     ...
14.   </dependencies>
15.   ...
16. </project>
```

https://maven.apache.org/pom.html#dependencies

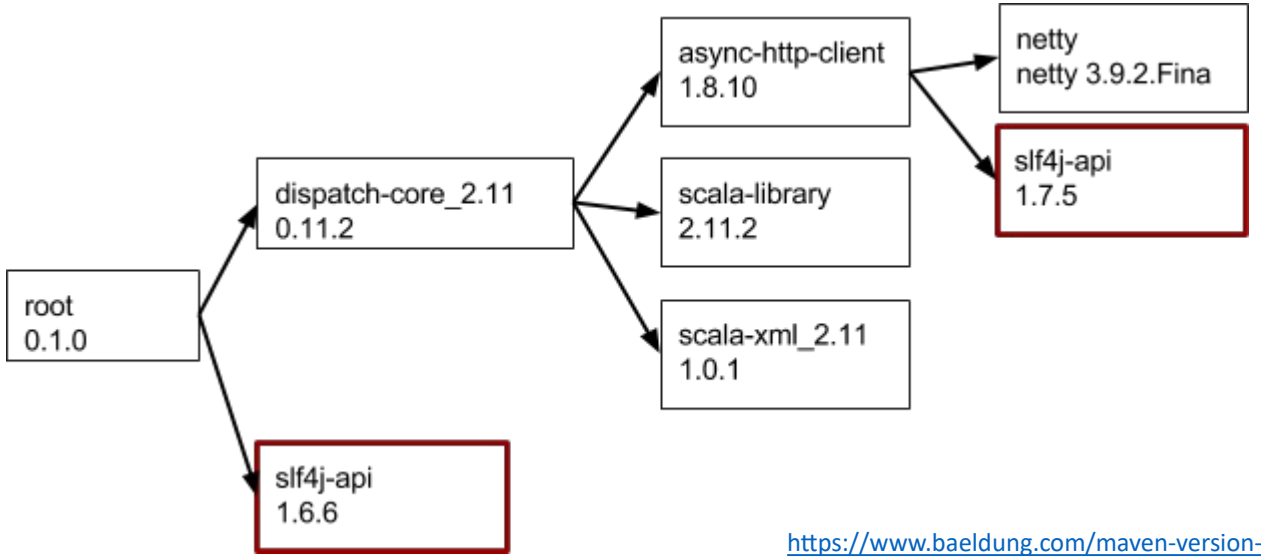
https://en.wikipedia.org/wiki/Apache_Maven

For Java

Apache Maven
Apache Software Foundation, v1 2004; v2 2005; v3 2013
written in **Java**

Dependency management

- Use G-A-V coordinates
- ⚠ dependence on multiple versions of the same artifact?



https://en.wikipedia.org/wiki/Apache_Maven

https://www.baeldung.com/maven-version-collision

For Java

Apache Maven
Apache Software Foundation, v1 2004; v2 2005; v3 2013
written in **Java**

Dependency management

- Use G-A-V coordinates
- ⚠ dependence on multiple versions of the same artifact?

➢ **Flexibility in version numbers :**

- [1.0,) : version 1.0 or greater
- (,1.0] : version lower or equal to 1.0
- [1.0,1.2] : between versions 1.0 and 1.2, inclusive
- (,1.2),(1.2,) : all versions except 1.2
- [1.0,2.0) : version greater or equal to 1.0 and lower than 2.0

➢Other solutions: https://www.baeldung.com/maven-version-collision

https://en.wikipedia.org/wiki/Apache_Maven

For Java

Apache Maven

Apache Software Foundation, v1 2004; v2 2005; v3 2013
written in **Java**

Everything is plugin

- A plugin is a jar that contains a class annotated `@Mojo`
- **`<G>:<A>:<V>:<goal>`**
  - example: `org.apache.maven.plugins:maven-compiler-plugin:3.8.1:compile`
- Convention for plugin goals executed at each phase of the lifecycle
- Configuration of other plugins, ...
  - Many plugins already published by Maven https://maven.apache.org/plugins/
  - Example: https://maven.apache.org/plugins/maven-deploy-plugin/examples/deploy-ftp.html
  - Convention for the phases to which a goal is attached

https://en.wikipedia.org/wiki/Apache_Maven

For Java

Apache Maven

Apache Software Foundation, v1 2004; v2 2005; v3 2013
written in **Java**

- **Execution** of a life cycle goal
  - Executes all goals associated with all phases ≤ `package`

```
$ mvn package
```

- **Execution** of a specific goal of a specific plugin
  - Executes goal `effective-pom` from plugin `help`

```
$ mvn help:effective-pom
$ mvn org.apache.maven.plugins:maven-help-plugin:3.2.0:effective-pom
```

- Passing parameters (same as in POM `<parameters>…</parameters>`)
  - Executes goal `describe` from plugin `help`

```
$ mvn help:describe -Dplugin=help –Dminimal
```

https://en.wikipedia.org/wiki/Apache_Maven

For Java

Apache Maven

Apache Software Foundation, v1 2004; v2 2005; v3 2013
written in **Java**

- pointers:
  - @fr http://www.jmdoudoux.fr/java/dej/indexavecframes.htm
    chapter 93. Maven (except: 93.2, 93.3.6, 93.3.7, 93.3.9
  - https://maven.apache.org/guides/getting-started/maven-in-five-minutes.html
  - https://maven.apache.org/guides/getting-started/index.html

https://en.wikipedia.org/wiki/Apache_Maven

For Java

Apache Gradle
Open Source, 2007
written in Java, Groovy, Kotlin

Convention over configuration

- Domain specific language (DSL) rather than XML
  - DSL based on Groovy, or on Kotlin
  - More expressive, concise, flexible, than Ant and Maven
- Acyclic oriented graph of tasks
  - execution of tasks in parallel or in sequence
  - dependencies between tasks
  - incremental production

https://en.wikipedia.org/wiki/Apache_Maven

pom.xml

```xml
<?xml version="1.0" encoding="UTF-8"?>
<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/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>

    <groupId>fr.mines_stetienne.ci.i2si</groupId>
    <artifactId>calculator</artifactId>
    <version>0.8.32</version>

    <name>Calculator</name>
    <description>The example Calculator maven project</description>
    <inceptionYear>2019</inceptionYear>

    <properties>
        <maven.compiler.source>1.8</maven.compiler.source>
        <maven.compiler.target>1.8</maven.compiler.target>
    </properties>

    <organization>
        <name>École des Mines de Saint-Étienne</name>
        <url>http://www.mines-stetienne.fr/</url>
    </organization>

    <licenses>
        <license>
            <name>The Apache Software License, Version 2.0</name>
            <url>http://www.apache.org/licenses/LICENSE-2.0.txt</url>
        </license>
    </licenses>

    <dependencies>
    <dependency>
        <groupId>org.slf4j</groupId>
        <artifactId>slf4j-log4j12</artifactId>
        <version>1.7.25</version>
    </dependency>
        <dependency>
            <groupId>commons-cli</groupId>
            <artifactId>commons-cli</artifactId>
            <version>1.4</version>
        </dependency>
        <dependency>
            <groupId>junit</groupId>
            <artifactId>junit</artifactId>
            <version>4.12</version>
            <scope>test</scope>
        </dependency>
    </dependencies>

</project>
```

build.gradle

```
apply plugin: 'java'
apply plugin: 'maven'

group = 'fr.mines_stetienne.ci.i2si'
version = '0.8.32'

description = """Calculator"""

sourceCompatibility = 1.5
targetCompatibility = 1.5

repositories {

     maven { url "https://repo.maven.apache.org/maven2" }
}
dependencies {
    compile group: 'org.slf4j', name: 'slf4j-log4j12', version:'1.7.25'
    compile group: 'commons-cli', name: 'commons-cli', version:'1.4'
    testCompile group: 'junit', name: 'junit', version:'4.12'
}
```

settings.gradle

```
rootProject.name = 'calculator'
```

For Java

Apache Gradle
Open Source, 2007
written in Java, Groovy, Kotlin

- Viewed in details in the course “Web Programming”
- pointers:
  - https://docs.gradle.org/current/userguide/what_is_gradle.html
  - https://spring.io/guides/gs/gradle/
  - https://dev-mind.fr/training/gradle/gradle_en.html

https://en.wikipedia.org/wiki/Apache_Maven

Technological foundations of software development

Automate build production

Part 1: Build automation utilities

Part 2.3: For node.js / front-end dev

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For node.js / front-end dev

Dependency Managers

https://www.npmjs.com/

- main central repository for js
- package.json - example: https://github.com/angular/angular-cli/blob/master/package.json

https://yarnpkg.com/

- npm + caching (limits downloads) + parallelization

https://www.developerdrive.com/best-build-tools-frontend-development/

For node.js / front-end dev

Tasks automation

grunt https://gruntjs.com/

- task automation: minification, linting, testing, ...

gulp https://gulpjs.com/

- grunt + faster (ram vs i/o) + big ecosystem (plugins)

https://www.developerdrive.com/best-build-tools-frontend-development/

For node.js / front-end dev

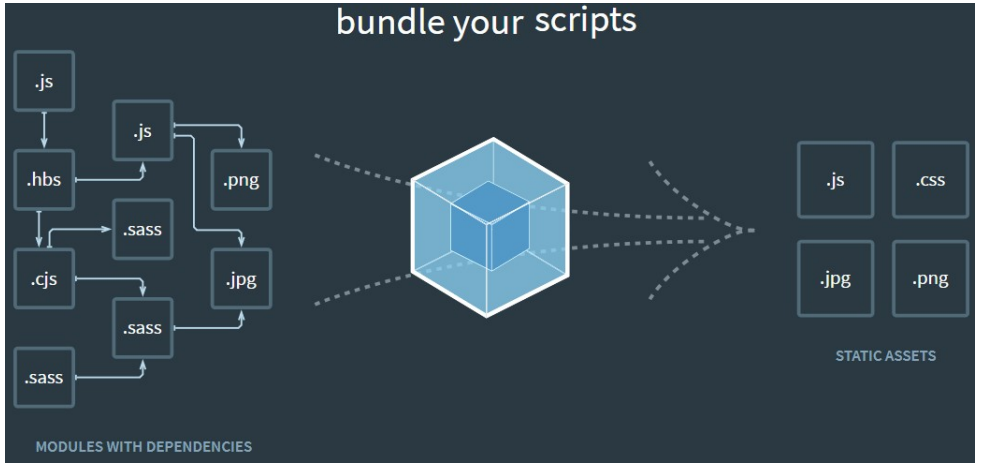
bundling of code and dependencies so that the client downloads only one js file and one css file

browserify http://browserify.org/

- package the code and the dependencies (*require()* fonction of Node.js)
- only one js

webpack https://webpack.js.org/

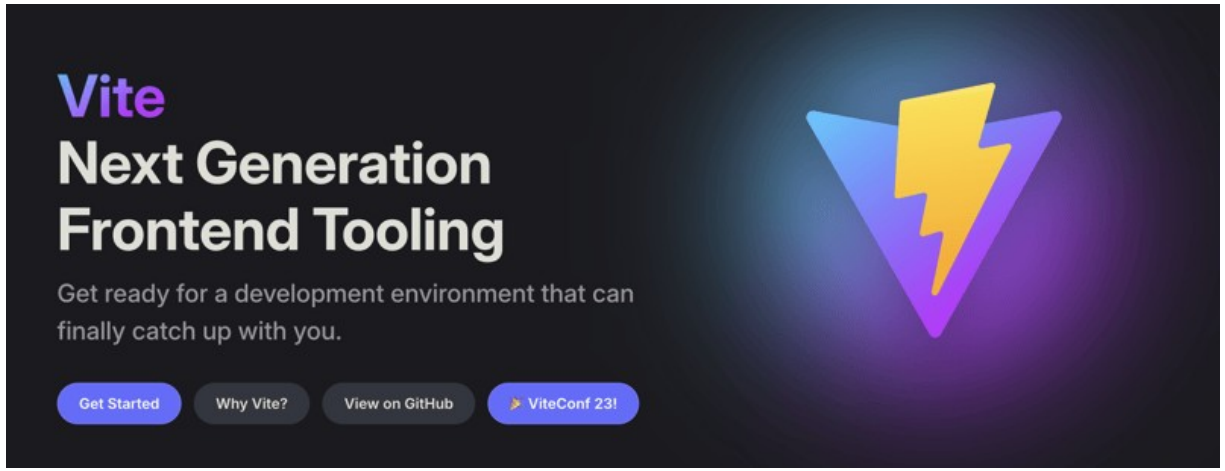
- The solution to recommend *today*



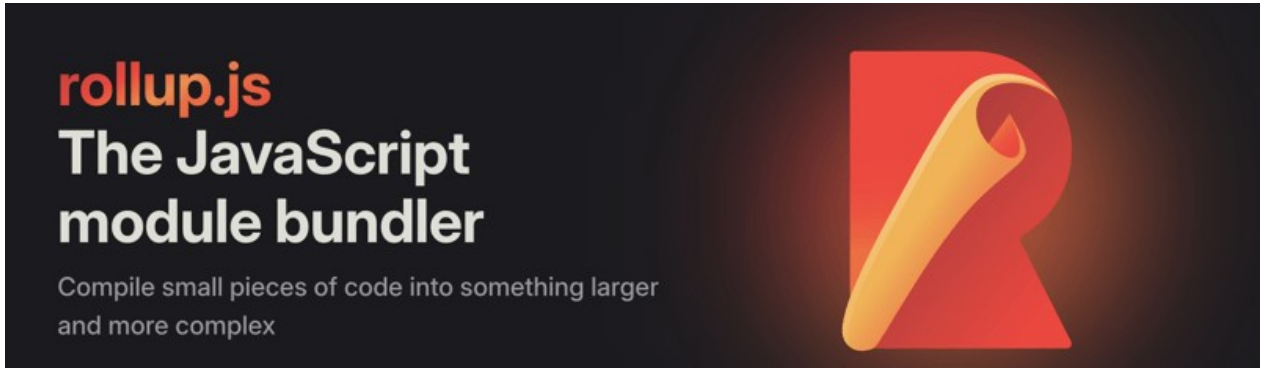
https://www.developerdrive.com/best-build-tools-frontend-development/

webpack was recommended in 2022.
In 2024 there are these alternatives:

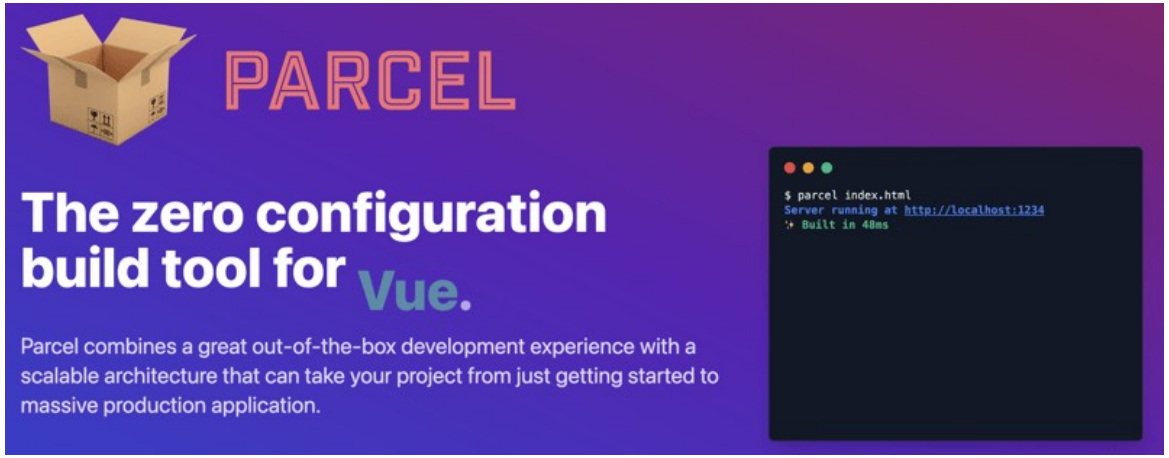
For node.js / front-end dev



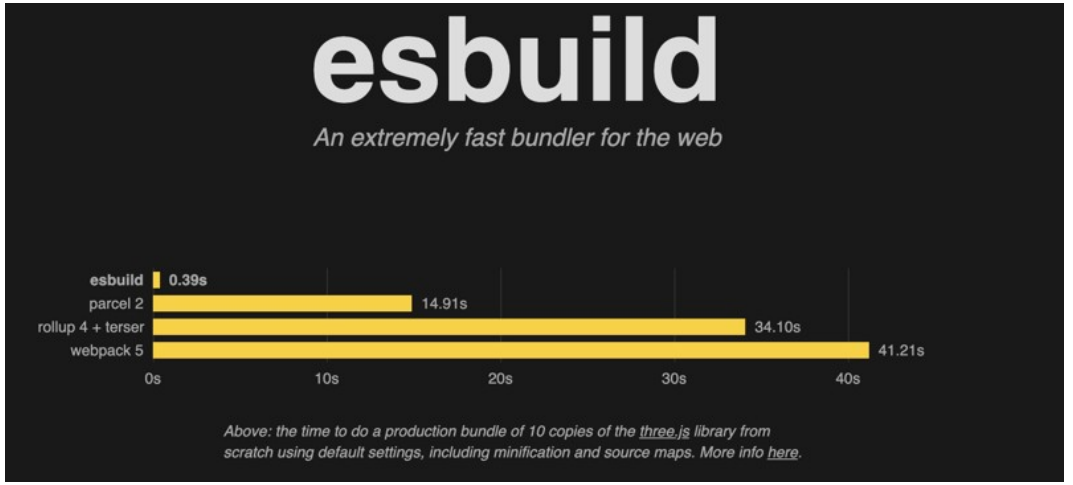
https://vitejs.dev/



https://rollupjs.org/



https://parceljs.org/



https://esbuild.github.io/

https://dev.to/strapi/top-5-alternatives-to-webpack-1dll

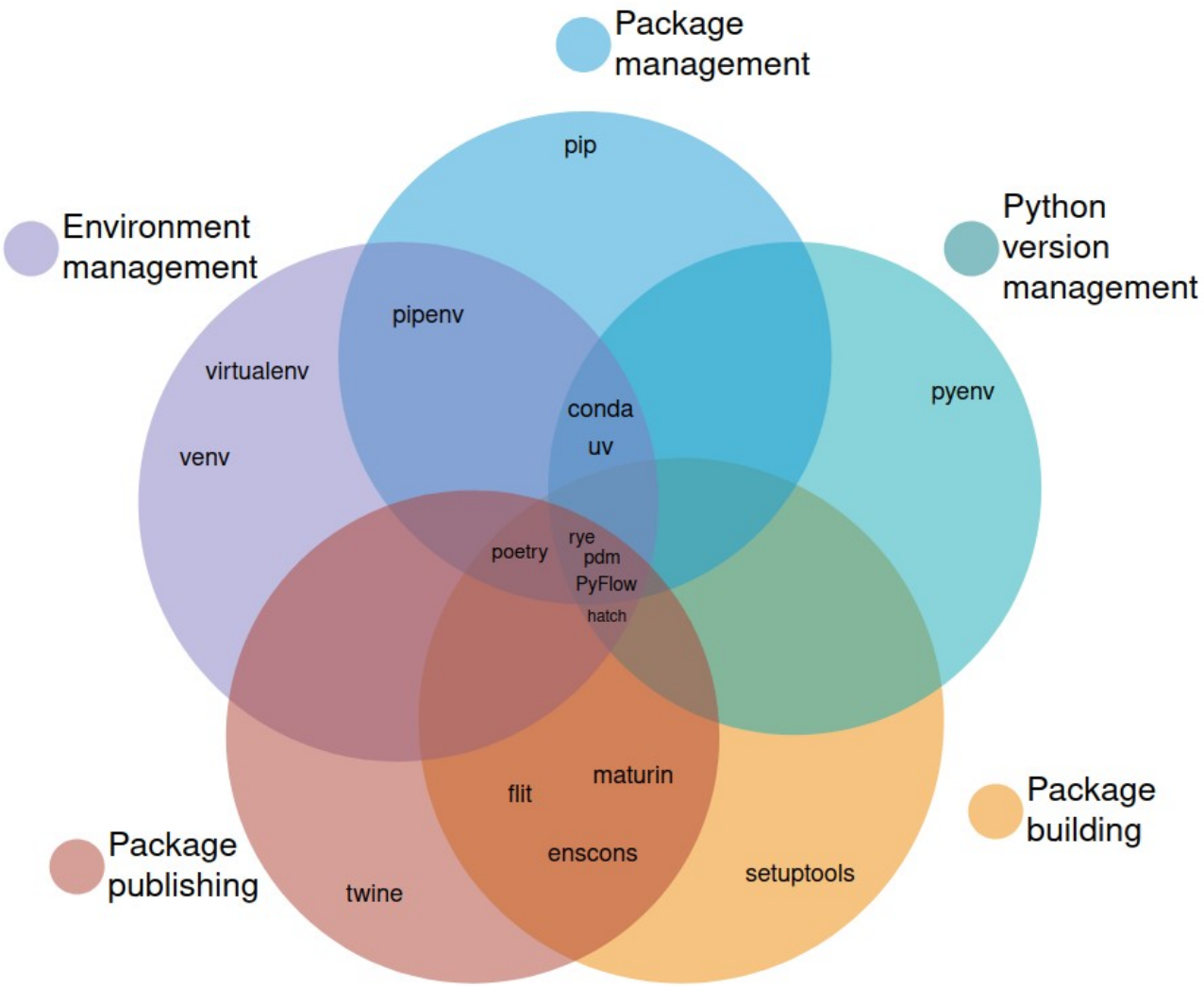
Technological foundations of software development

Automate build production

Part 1: Build automation utilities

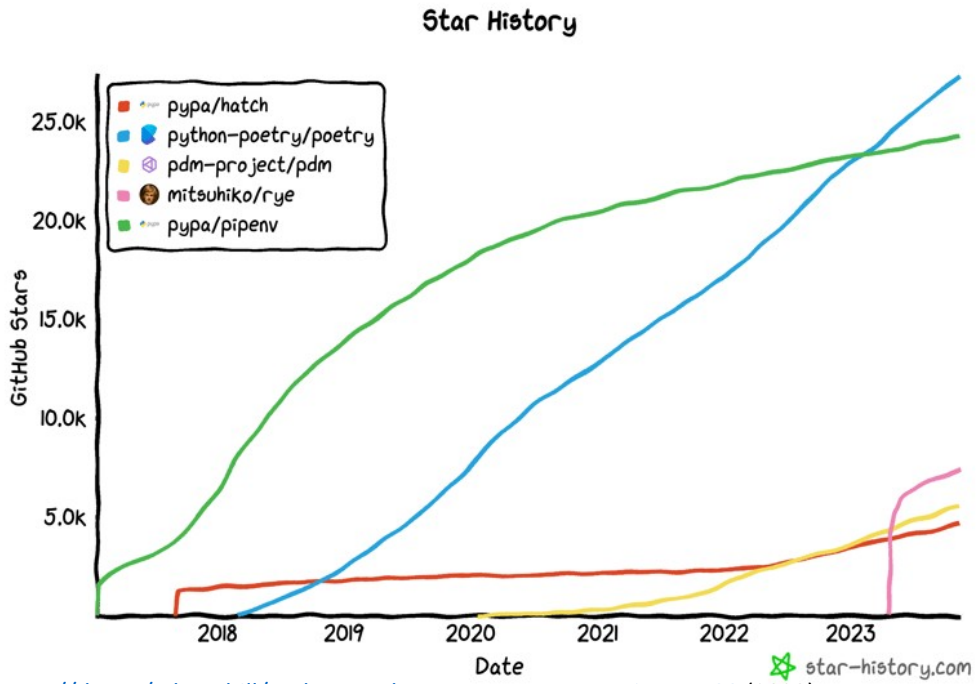
Part 2.4: For python

ICM – Computer Science Major – Course unit on Technological foundations of computer science
M1 Cyber Physical and Social Systems – Course unit on CPS2 engineering and development, Part 2: Technological foundations of software development
Maxime Lefrançois https://maxime-lefrancois.info
online: https://ci.mines-stetienne.fr/cps2/course/tfsd/



https://alpopkes.com/posts/python/packaging_tools/

	Flit	Poetry	PDM	Hatch	Rye	uv
Does the tool manage dependencies?	✗	✓	✓	✗	✓	✓
Does it resolve/lock dependencies?	✗	✓	✓	✗	✓	✓
Is there a clean build/publish flow?	✓	✓	✓	✓	✓	✗
Does it allow to use plugins?	✗	✓	✓	✓	✗	✗
Does it support PEP 660 (editable installs)?	✓	✓	✓	✓	✓	✓
Does it support PEP 621 (project metadata)?	✓	✗	✓	✓	✓	✓



https://dev.to/adamghill/python-package-manager-comparison-1g98 (2023)

Example: Poetry

Poetry

dependency management, linting, autoformatting, testing, and publishing in python

https://python-poetry.org/

MIT License - Open source: https://github.com/python-poetry/poetry

- Managing different environments
- Installing python packages
- Environment reproducibility
- Packaging and publishing python packages

```
$ poetry init / poetry install
$ poetry add "package==version"
$ poetry update
$ poetry run
$ poetry shell - exit
```

See https://medium.com/edge-analytics/python-best-practices-2934de825fd2

Example: Hatch

Hatch

dependency management, linting, autoformatting, testing, and publishing in python

https://hatch.pypa.io/latest/

MIT License - Open source: https://github.com/pypa/hatch

- Standardized build system with reproducible builds by default
- Robust environment management with support for custom scripts and UV
- Configurable Python distribution management
- Test execution with known best practices
- Static analysis with sane defaults
- Built-in Python script runner
- Easy publishing to PyPI or other indices
- Version management
- Best practice project generation
- Responsive CLI, ~2-3x faster than equivalent tools

To read for MCQ test

- To read (necessary for questions in the MCQ)
  - The pyproject.toml guide https://alpopkes.com/posts/python/packaging_tools/
  - “An unbiased evaluation of environment management and packaging tools” https://alpopkes.com/posts/python/packaging_tools/

Technological foundations of software development

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online: https://ci.mines-stetienne.fr/cps2/course/tfsd/

… Your turn

Complete the TODO section:

https://ci.mines-stetienne.fr/cps2/course/tfsd/course-4.html#_todos