# Toolbox for Selenium Tests in Java: WebDriverManager and Selenium-Jupiter

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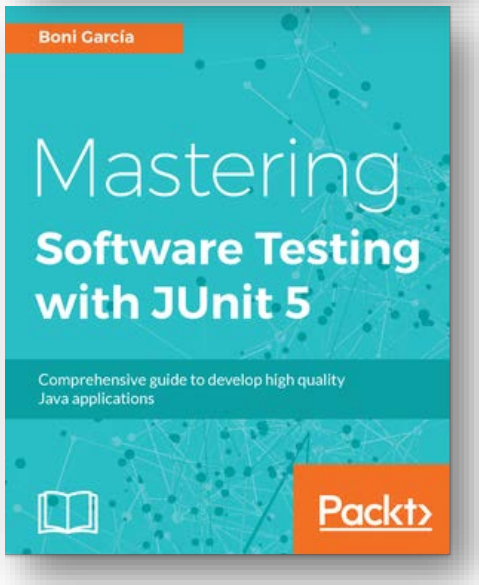
# Boni García

- PhD in Information and Communications Technology from Technical University of Madrid (UPM) in Spain. Dissertation focused on software testing with Selenium
- Assistant Professor at King Juan Carlos University (URJC) in Spain
- Open source software enthusiast. Creator and maintainer of a number of projects: WebDriverManager, Selenium-Jupiter, DualSub
- Author of more than 30 research papers in different journals, magazines, international conferences, and the book Mastering Software Testing with JUnit 5



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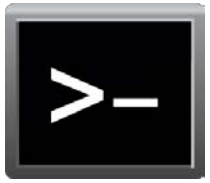
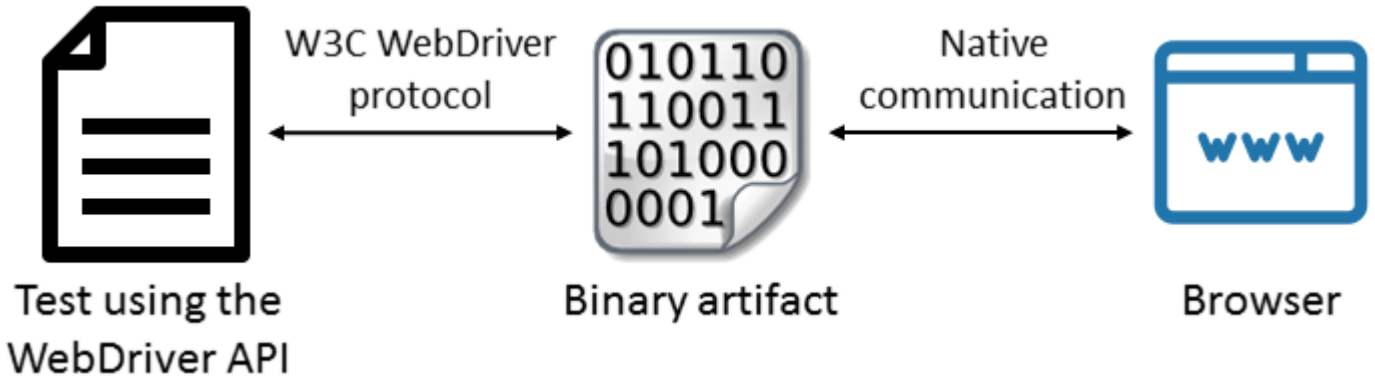
Toolbox for Selenium in Java (but not only Java)

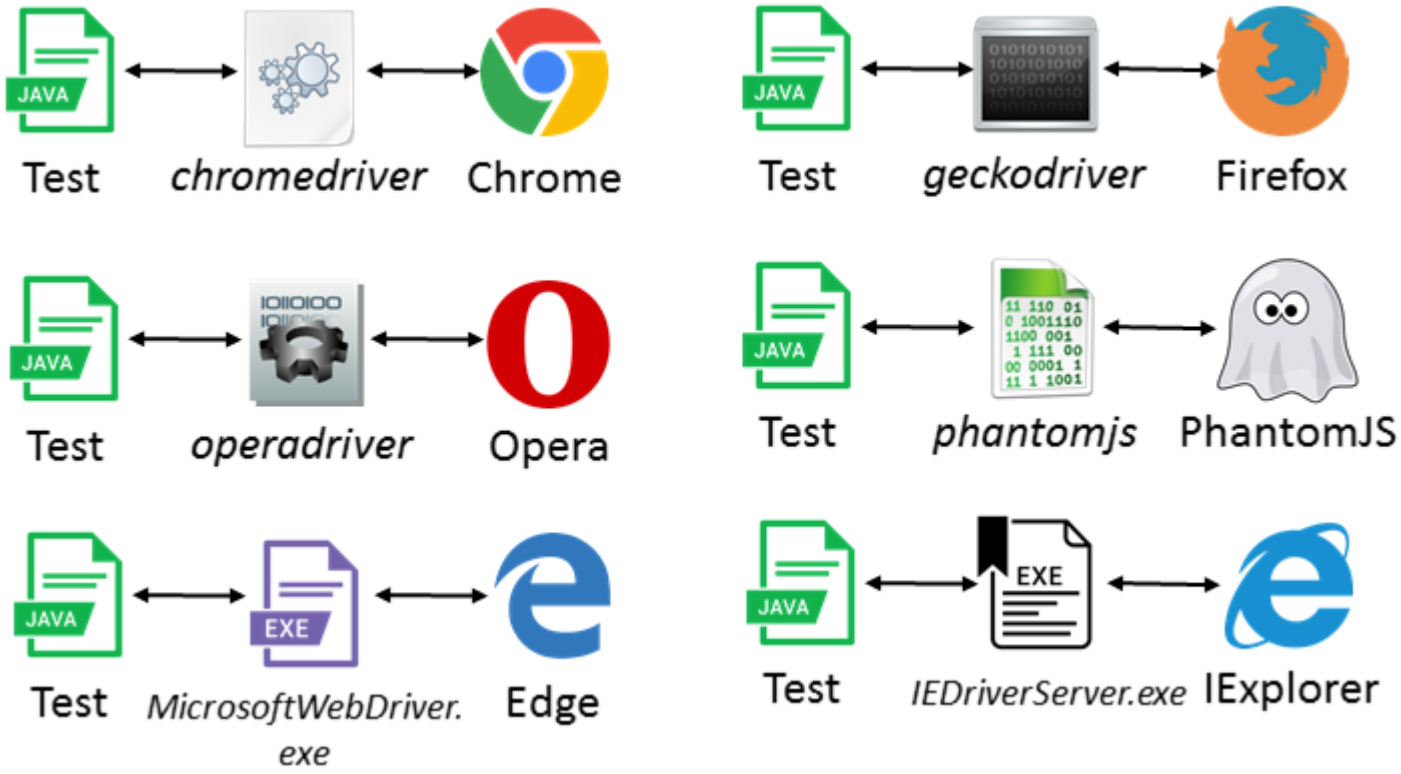




# WebDriverManager - Motivation

- **Selenium WebDriver** allows to control different types of browsers (such as Chrome, Firefox, Opera, Edge, and so on) programmatically using different programming languages (Java, JavaScript, Python, C#, …)
- Browser is driven using native mechanism, so we need a binary file (*driver*) in between the test using the WebDriver API and the actual browser




# WebDriverManager - Motivation




```
System.setProperty("webdriver.chrome.driver", "/path/to/chromedriver");
System.setProperty("webdriver.opera.driver", "/path/to/operadriver");
System.setProperty("webdriver.ie.driver", "C:/path/to/IEDriverServer.exe");
System.setProperty("webdriver.edge.driver", "C:/path/to/MicrosoftWebDriver.exe");
System.setProperty("phantomjs.binary.path", "/path/to/phantomjs");
System.setProperty("webdriver.gecko.driver", "/path/to/geckodriver");
```

Java

Se

# WebDriverManager - Motivation

- Driver management is painful:
  - Driver (chromedriver, geckodriver, etc.) must be downloaded manually for the proper platform running the test (i.e. Windows, Linux, Mac)
  - Proper driver version must match the browser version
  - Browser are constantly updated (and drivers too)
  - Tests are not portable (different operative systems, path to driver)

# WebDriverManager - Motivation

# WebDriverManager - Objective



- **WebDriverManager** is a Java library that allows to **automate** the management of the binary drivers (chromedriver, geckodriver, etc.) required by Selenium WebDriver

```
dependencies {
    testCompile("io.github.bonigarcia:webdrivermanager:3.4.0")
}
```

```
<dependency>
    <groupId>io.github.bonigarcia</groupId>
    <artifactId>webdrivermanager</artifactId>
    <version>3.4.0</version>
    <scope>test</scope>
</dependency>
```

Maven™

```
WebDriverManager.chromedriver().setup();
WebDriverManager.firefoxdriver().setup();
WebDriverManager.operadriver().setup();
WebDriverManager.edgedriver().setup();
WebDriverManager.iedriver().setup();
WebDriverManager.phantomjs().setup();
```


https://github.com/bonigarcia/webdrivermanager

# WebDriverManager - Objective

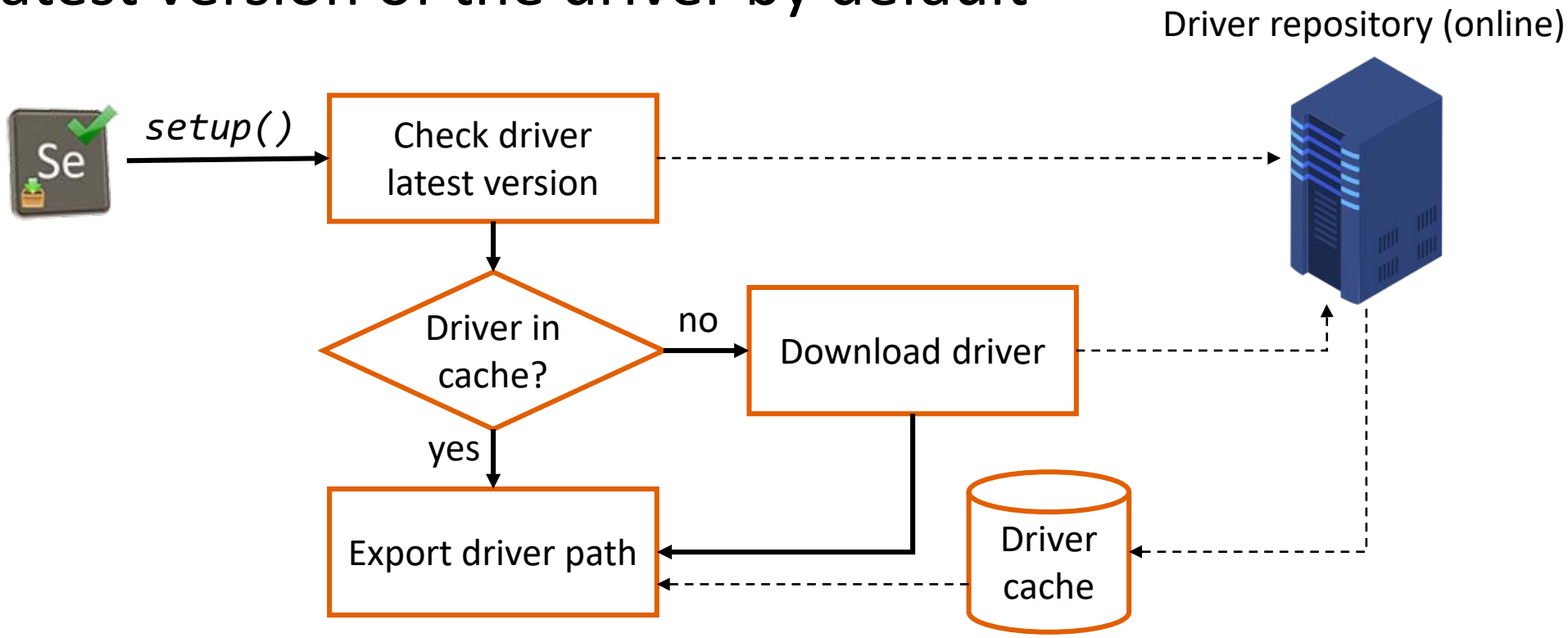
```java
public class ChromeTest {

    private WebDriver driver;

    @BeforeClass
    public static void setupClass() {
        WebDriverManager.chromedriver().setup();
    }

    @Before
    public void setupTest() {
        driver = new ChromeDriver();
    }

    @After
    public void teardown() {
        if (driver != null) {
            driver.quit();
        }
    }

    @Test
    public void test() {
        // Your test code here
    }

}
```

```java
public class ChromeTest {

    private WebDriver driver;

    @BeforeClass
    public static void setupClass() {
        WebDriverManager.firefoxdriver().setup();
    }

    @Before
    public void setupTest() {
        driver = new FirefoxDriver();
    }

    @After
    public void teardown() {
        if (driver != null) {
            driver.quit();
        }
    }

    @Test
    public void test() {
        // Your test code here
    }

}
```

JUnit

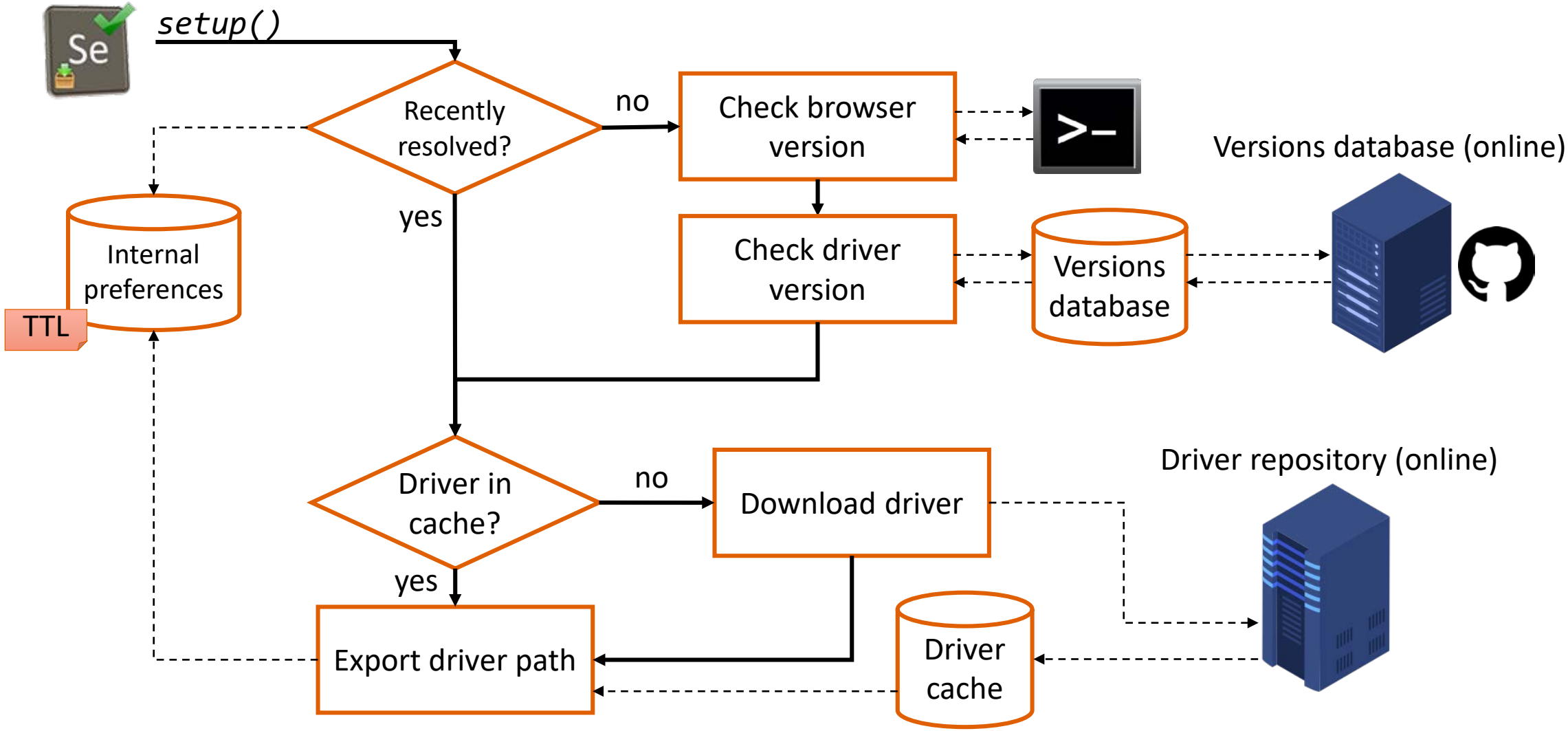
# WebDriverManager - Design

- WebDriverManager was first released on 21st March 2015
- In its earlier versions, WebDriverManager downloaded the latest version of the driver by default



# WebDriverManager - Design

- Currently, WebDriverManager resolution algorithm is much richer



# WebDriverManager - API

- WebDriverManager exposes a fluent API. For instance:

```
WebDriverManager.chromedriver().setup();
```

Default usage for managing chromedriver

```
WebDriverManager.chromedriver().version("2.46").setup();
```

Force a given version (2.46) for chromedriver

```
WebDriverManager.firefoxdriver().arch32().setup();
```

Force 32-bit architecture for geckodriver

```
WebDriverManager.operadriver().forceDownload().setup();
```

Force the download of operadriver

```
WebDriverManager.phantomjs().avoidPreferences().setup();
```

Avoid the use of preferences for PhantomJS driver

```
WebDriverManager.edgedriver().proxy("server:port").setup();
```

Set proxy setup when managing Edge driver

# WebDriverManager - API

- More examples of the WebDriverManager API:

| Method | Description |
|---|---|
| `version(String)` | Set a concrete version for the driver to be downloaded |
| `targetPath(String)` | Change cache path (by default `~/.m2/repository/webdriver`) |
| `architecture(Architecture)` | Force a given architecture: 32-bits or 64-bits |
| `operatingSystem(OperatingSystem)` | Force a given OS: `WIN`, `LINUX`, `MAC` |
| `proxy(String)` | Use a HTTP proxy for the Internet connection |
| `avoidPreferences()` | Avoid the use of Java preferences |
| `driverRepositoryUrl(URL)` | Set a custom repository URL |
| `timeout(int)` | Change connection timeout |
| `browserPath()` | Set path for a given browser |
| `ttl()` | Change time-to-live (by default 3600 seconds) |
| `forceDownload()` | Force to download driver even if it exists in cache |

https://github.com/bonigarcia/webdrivermanager

# WebDriverManager - Configuration

- WebDriverManager is highly configurable with:
  1. Environment variables. For example

```
export WDM_TARGETPATH=~/.selenium
```

```
export WDM_CHROMEDRIVERVERSION=2.46
```

  2. Java properties. For example:

```
mvn test -Dwdm.targetPath=~/.selenium
```

```
gradle test -Dwdm.chromeDriverVersion=2.46
```

  3. Configuration manager in Java. For example:

```
WebDriverManager.chromedriver().version("2.46").setup();
```

```
WebDriverManager.globalConfig().setTargetPath("~/.selenium");
```

# WebDriverManager - Beyond Java

- WebDriverManager can be also used:

1. As CLI (command line interface) tool:

```
> java -jar webdrivermanager-3.4.0-fat.jar chrome
[INFO] Using WebDriverManager to resolve chrome
[INFO] Reading https://chromedriver.storage.googleapis.com/ to seek chromedriver
[INFO] Latest version of chromedriver is 2.37
[INFO] Downloading https://chromedriver.storage.googleapis.com/2.37/chromedriver_win32.zip
to folder D:\projects\webdrivermanager
[INFO] Resulting binary D:\projects\webdrivermanager\target\chromedriver.exe
```

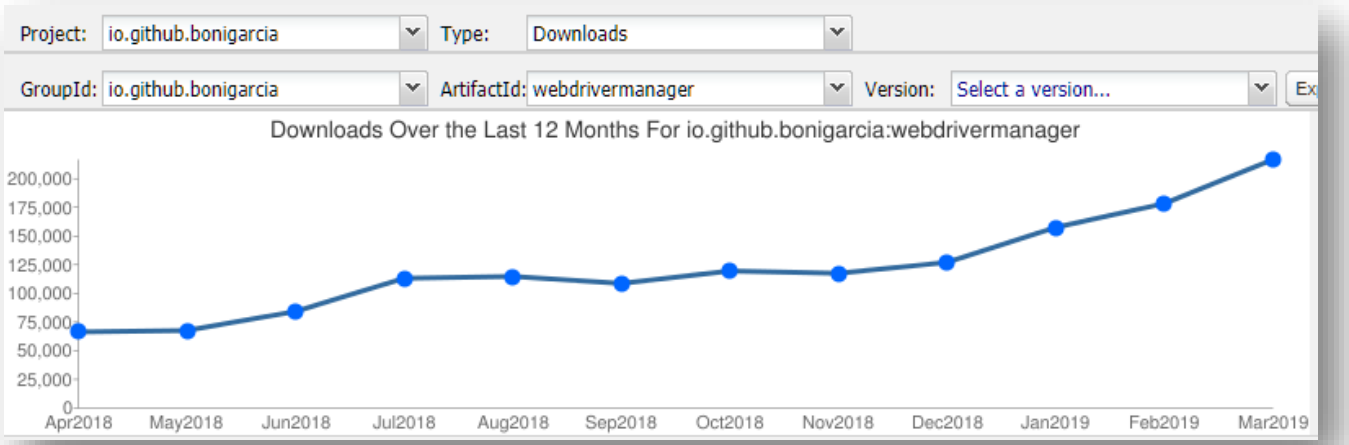
2. As server (using a REST-like API):

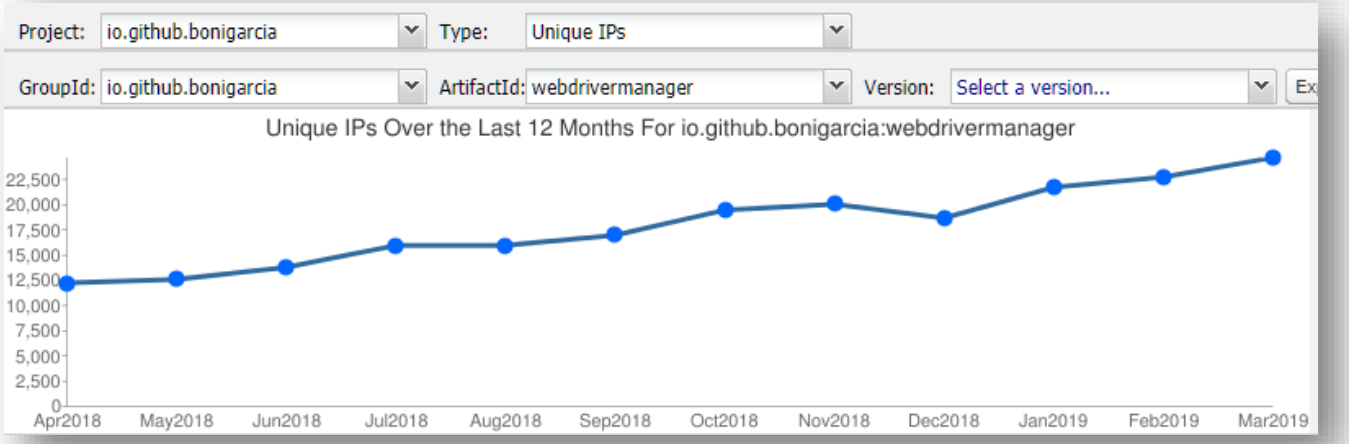
```
> java -jar webdrivermanager-3.4.0-fat.jar server
[INFO] WebDriverManager server listening on port 4041
```

Examples of requests to WebDriverManager Server:
http://localhost:4041/firefoxdriver
http://localhost:4041/chromedriver?chromeDriverVersion=2.40

# WebDriverManager - Conclusions

- WebDriverManager is a helper library for automating the management of Selenium drivers (chromedriver, etc.)



# WebDriverManager - Conclusions

- WebDriverManager is used in different projects in the Selenium ecosystem. For instance:
  - io.appium » java-client: https://github.com/appium/java-client
  - com.codeborne » selenide: https://github.com/selenide/selenide
- WebDriverManager concept has been ported to other languages:
  - webdriver-manager (Node.js): https://github.com/angular/webdriver-manager
  - webdriver_manager (Python): https://github.com/jeffnyman/webdriver_manager
  - WebDriverManager.Net (.Net): https://github.com/rosolko/WebDriverManager.Net
  - Webdrivers Gem (Ruby): https://github.com/titusfortner/webdrivers
- WebDriverManager is in constant evolution. Its roadmap includes:
  - Support Edge based on Chromium
  - Using aspects (cross-cutting concerns) to resolve drivers automatically when instantiating WebDriver objects

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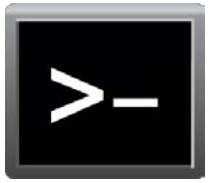
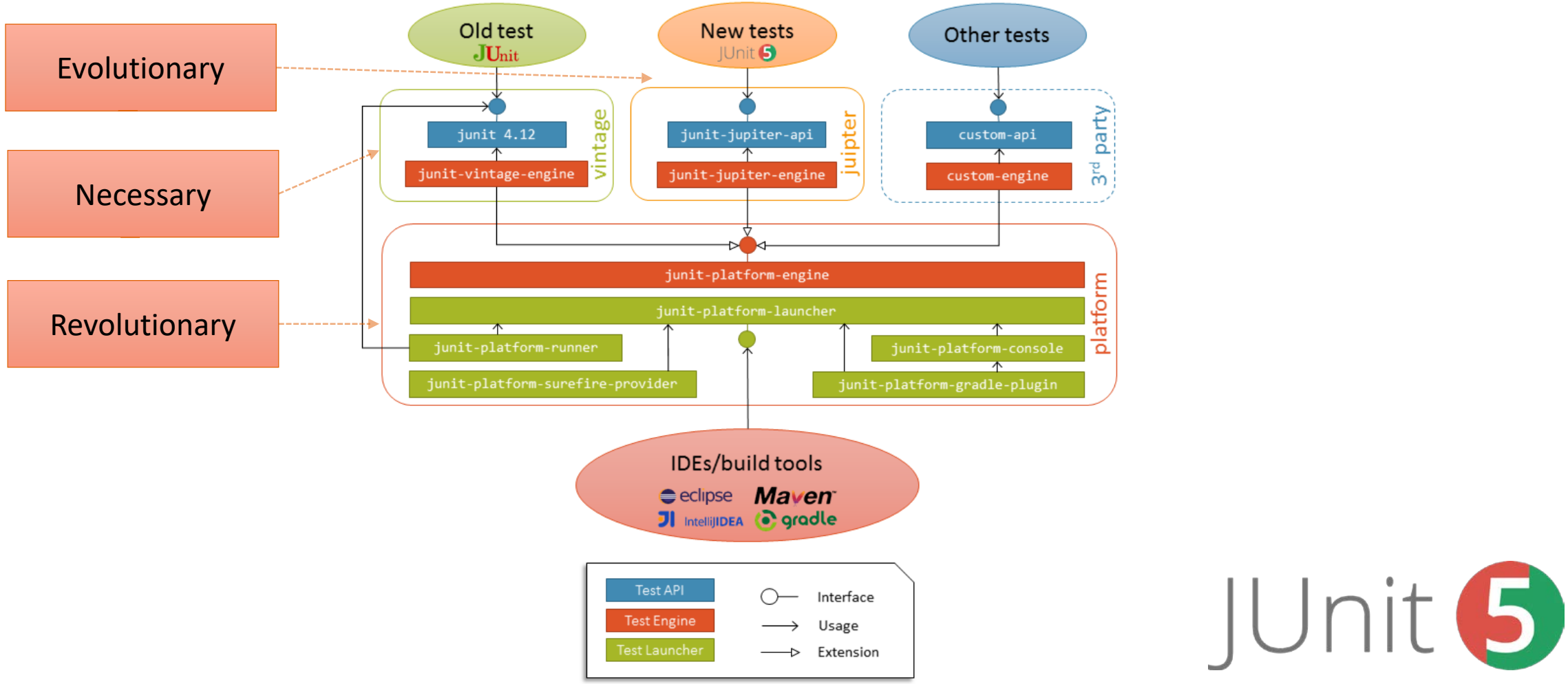
Selenium-Jupiter 

Toolbox for Selenium in Java (but not only Java)


# Selenium-Jupiter - Motivation

- **JUnit 5** (stable) was first released on September 2017



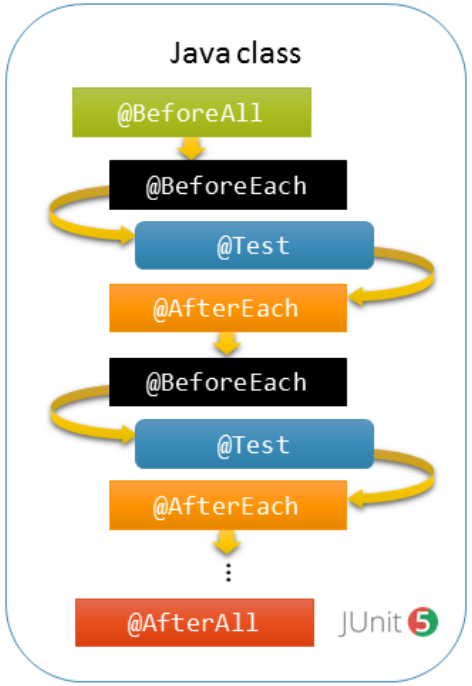

JUnit 5

# Selenium-Jupiter - Motivation

- **JUnit 5** provides a brand-new programming an extension model called **Jupiter**
- Basic test are similar than in JUnit 4 and provide a wide range of new features, such as:
  - Enhanced parameterized tests
  - Parallel execution
  - Test ordering
  - Kotlin support
  - …

https://junit.org/junit5/docs/current/user-guide/

```java
import org.junit.jupiter.api.AfterAll;
import org.junit.jupiter.api.AfterEach;
import org.junit.jupiter.api.BeforeAll;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;

class BasicJUnit5Test {

    @BeforeAll
    static void setupAll() {
        // setup all tests
    }

    @BeforeEach
    void setup() {
        // setup each test
    }

    @Test
    void test() {
        // exercise and verify SUT
    }

    @AfterEach
    void teardown() {
        // teardown each test
    }

    @AfterAll
    static void teardownAll() {
        // teardown all tests
    }
}
```

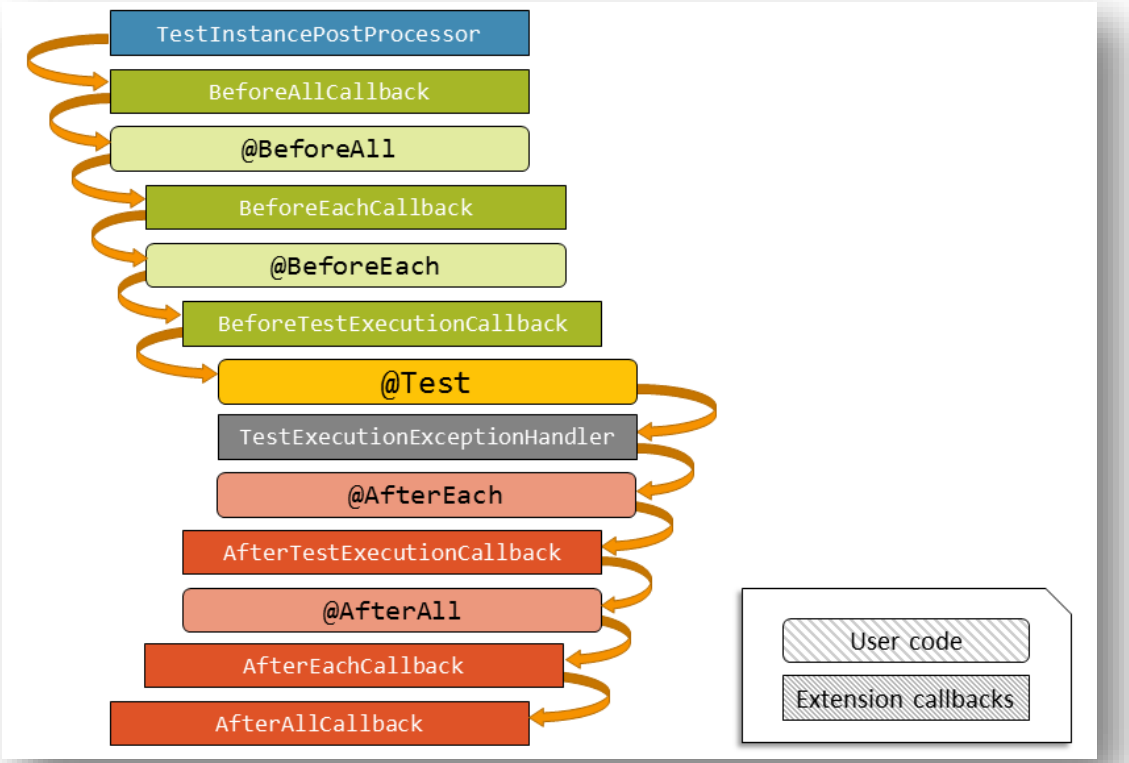


# Selenium-Jupiter - Motivation

- The **extension model** of JUnit 5 allows to add custom features to the programming model through extension points:

1. Custom logic in the test lifecycle
2. Dependency injection in test methods and constructors
3. Test templates
4. Test conditional execution

Very convenient for Selenium!

# Selenium-Jupiter - Objective



- **Selenium-Jupiter** is a JUnit 5 extension aimed to ease the use of **Selenium** from Java tests
- Thanks to the Jupiter extension model, the required boilerplate to use Selenium from JUnit 5 is minimum
- Moreover, it allows to use browser and Android devices in **Docker** containers in a effortless manner

```xml
<dependency>
    <groupId>io.github.bonigarcia</groupId>
    <artifactId>selenium-jupiter</artifactId>
    <version>3.2.0</version>
    <scope>test</scope>
</dependency>
```

Maven

```
dependencies {
    testCompile("io.github.bonigarcia:selenium-jupiter:3.2.0")
}
```


https://github.com/bonigarcia/selenium-jupiter

# Selenium-Jupiter - Local browsers

- Selenium-Jupiter uses the **dependency injection** mechanism to instantiate/release WebDriver objects before/after tests

```
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.openqa.selenium.chrome.ChromeDriver;
import org.openqa.selenium.firefox.FirefoxDriver;
import io.github.bonigarcia.SeleniumExtension;

@ExtendWith(SeleniumExtension.class)
public class ChromeAndFirefoxJupiterTest {

    @Test
    public void testWithOneChrome(ChromeDriver chromeDriver) {
        // Use Chrome in this test
    }

    @Test
    public void testWithFirefox(FirefoxDriver firefoxDriver) {
        // Use Firefox in this test
    }

    @Test
    public void testWithChromeAndFirefox(ChromeDriver chromeDriver,
            FirefoxDriver firefoxDriver) {
        // Use Chrome and Firefox in this test
    }

}
```

We simply need to specify the type of browser to be used, as test or constructor parameters:

- `ChromeDriver`
- `FirefoxDriver`
- `OperaDriver`
- `SafariDriver`
- `EdgeDriver`
- `InternetExplorerDriver`
- `HtmlUnitDriver`
- `PhantomJSDriver`
- `AppiumDriver`

Internally, Selenium-Jupiter uses **WebDriverManager** to resolve properly the required binary drivers to control local browsers

# Selenium-Jupiter - Remote browsers

- Selenium-Jupiter provides the annotation `@DriverUrl` to locate the **Selenium or Appium server** and `@DriverCapabilities` to specify the desired capabilities

```
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.openqa.selenium.Capabilities;
import org.openqa.selenium.remote.RemoteWebDriver;
import io.github.bonigarcia.DriverCapabilities;
import io.github.bonigarcia.DriverUrl;
import io.github.bonigarcia.SeleniumExtension;

@ExtendWith(SeleniumExtension.class)
public class SauceLabsJupiterTest {

    @DriverUrl
    String url = "https://ondemand.eu-central-1.saucelabs.com/wd/hub";

    @DriverCapabilities
    DesiredCapabilities capabilities = new DesiredCapabilities();
    {
        capabilities.setCapability("username", "<my-saucelabs-user>");
        capabilities.setCapability("accessKey", "<my-saucelabs-key>");
        capabilities.setCapability("browserName", "Chrome");
        capabilities.setCapability("platform", "Windows 10");
        capabilities.setCapability("version", "59.0");
        capabilities.setCapability("name", "selenium-jupiter-and-saucelabs");
    }

    @Test
    void testWithSaucelabs(RemoteWebDriver driver) {
        // test
    }

}
```

SAUCELABS

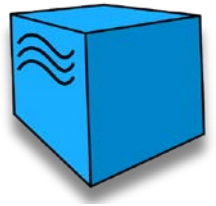
# Selenium-Jupiter - Remote browsers

- Selenium-Jupiter provides the annotation `@DriverUrl` to locate the **Selenium or Appium server** and `@DriverCapabilities` to specify the desired capabilities

```java
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.openqa.selenium.remote.DesiredCapabilities;

import io.appium.java_client.AppiumDriver;
import io.github.bonigarcia.seljup.DriverCapabilities;
import io.github.bonigarcia.seljup.DriverUrl;
import io.github.bonigarcia.seljup.SeleniumExtension;

@ExtendWith(SeleniumExtension.class)
public class AppiumWithGlobalOptionsChromeJupiterTest {

    @DriverUrl
    String url = "http://localhost:4723/wd/hub";

    @DriverCapabilities
    DesiredCapabilities capabilities = new DesiredCapabilities();
    {
        capabilities.setCapability("browserName", "chrome");
        capabilities.setCapability("deviceName", "Samsung Galaxy S6");
    }

    @Test
    void testWithAndroid(AppiumDriver<WebElement> driver) {
        // test
    }

}
```

# Selenium-Jupiter - *Dockerized* browsers


- Selenium-Jupiter provides seamless integration with **Docker**
- The annotation `@DockerBrowser` is used to declare a *dockerized* browsers. The supported browser are
  - Chrome, Firefox, and Opera:
    - Docker images for stable versions are maintained by **Aerokube**
    - Beta and unstable (Chrome and Firefox) are maintained by **ElasTest**
  - Edge and Internet Explorer:
    - Due to license, these Docker images are not hosted in Docker Hub
    - It can be built following a tutorial provided by **Aerokube**
  - Android devices:
    - Docker images for Android devices are maintained in the **docker-android** project (by Budi Utomo)




# Selenium-Jupiter - *Dockerized* browsers

- Browser in Docker containers example:

```
import static io.github.bonigarcia.BrowserType.CHROME;
import static io.github.bonigarcia.BrowserType.FIREFOX;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.openqa.selenium.remote.RemoteWebDriver;

import io.github.bonigarcia.DockerBrowser;
import io.github.bonigarcia.SeleniumExtension;

@ExtendWith(SeleniumExtension.class)
public class DockerChromeJupiterTest {

    @Test
    public void testChrome(@DockerBrowser(type = CHROME) RemoteWebDriver driver) {
        // test
    }

    @Test
    public void testChromeWithVersion(@DockerBrowser(type = FIREFOX, version = "66.0")
            RemoteWebDriver driver) {
       // test
    }

}
```

Supported browser types are: *CHROME*, *FIREFOX*, *OPERA*, y *EDGE* , *IEXPLORER* and *ANDROID*

If version is not specified, the latest stable will be used. For that, Selenium-Jupiter internally connects to **Docker Hub** to find out the latest version (***ever green Docker browser***)

The parameter *version* admits the following special values: *latest*, *latest-**, *beta*, y *unstable*

# Selenium-Jupiter - *Dockerized* browsers

- Browsers in Docker containers can be used to create **performance** tests:

```
import static io.github.bonigarcia.BrowserType.CHROME;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.openqa.selenium.remote.RemoteWebDriver;

import java.util.List;

import io.github.bonigarcia.DockerBrowser;
import io.github.bonigarcia.SeleniumExtension;

@ExtendWith(SeleniumExtension.class)
public class DockerChromeJupiterTest {

    static final int NUM_BROWSERS = 10;

    @Test
    public void testPerformance(
            @DockerBrowser(type = CHROME, size = NUM_BROWSERS) List<RemoteWebDriver> driverList) {
        // test
    }

}
```

In this test, we will have 10 Chrome browsers ready to be used by the test logic

# Selenium-Jupiter - *Dockerized* browsers

- Android in Docker container example:

```
import static io.github.bonigarcia.BrowserType.ANDROID;

import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.openqa.selenium.remote.RemoteWebDriver;

import io.github.bonigarcia.DockerBrowser;
import io.github.bonigarcia.SeleniumExtension;

@ExtendWith(SeleniumExtension.class)
public class DockerAndroidCustomJupiterTest {

    @Test
    public void testAndroid(@DockerBrowser(type = ANDROID, version = "8.1",
            deviceName = "Nexus S") RemoteWebDriver driver) {
        // test
    }

}
```

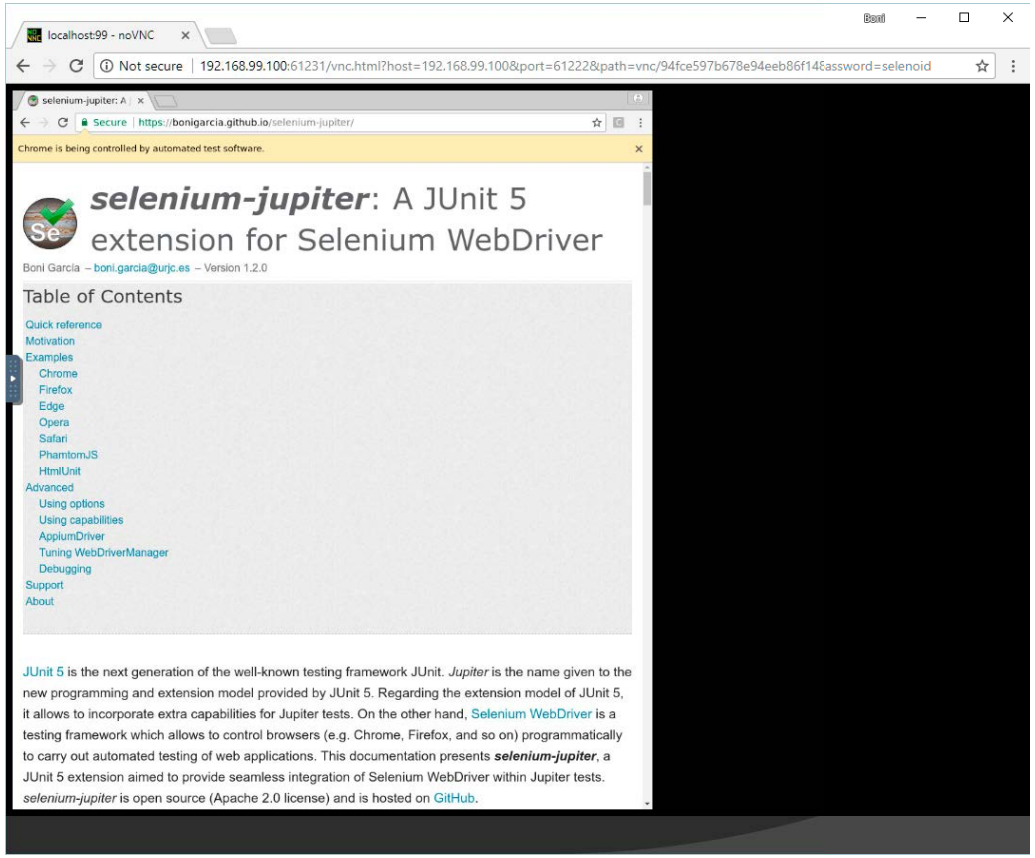
When using Android in Docker containers, the type of device can be specified

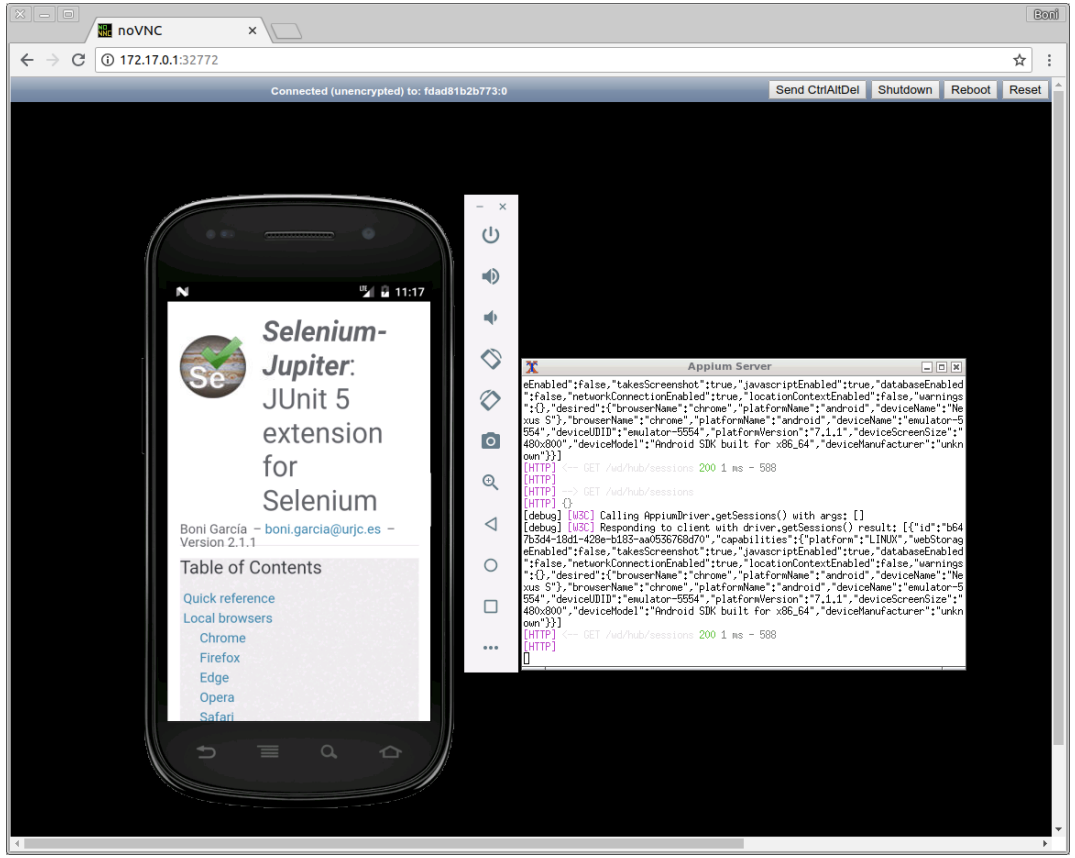
| Android version | API level | Browser name |
|---|---|---|
| 5.0.1 | 21 | browser |
| 5.1.1 | 22 | browser |
| 6.0 | 23 | chrome |
| 7.0 | 24 | chrome |
| 7.1.1 | 25 | chrome |
| 8.0 | 26 | chrome |
| 8.1 | 27 | chrome |
| 9.0 | 28 | chrome |

| Type | Device name |
|---|---|
| Phone | Samsung Galaxy S6 |
| Phone | Nexus 4 |
| Phone | Nexus 5 |
| Phone | Nexus One |
| Phone | Nexus S |
| Tablet | Nexus 7 |

# Selenium-Jupiter - *Dockerized* browsers

- When using Docker containers, it is possible to interact with the remote session using **VNC** (and also recording these sessions)

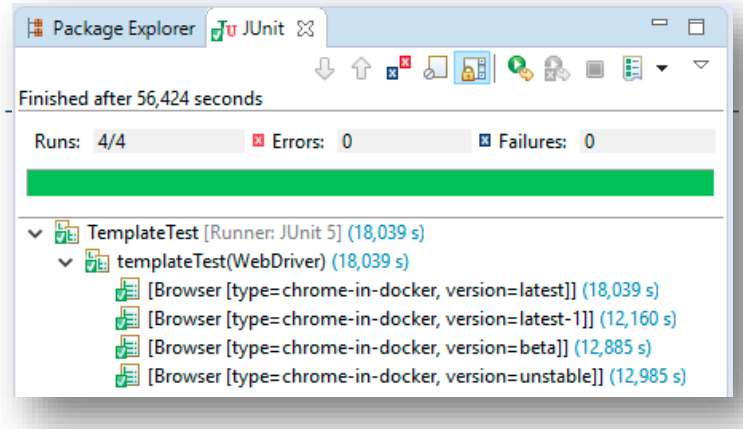


# Selenium-Jupiter - Test templates

- Selenium-Jupiter use the JUnit 5's support for test templates
- A template defines the number and types of browser used by a test:
  1. By means of a JSON file:

```java
import org.junit.jupiter.api.TestTemplate;
import org.junit.jupiter.api.extension.ExtendWith;
import org.openqa.selenium.WebDriver;

import io.github.bonigarcia.SeleniumExtension;

@ExtendWith(SeleniumExtension.class)
public class TemplateTest {

    @TestTemplate
    void templateTest(WebDriver driver) {
       // test
    }

}
```

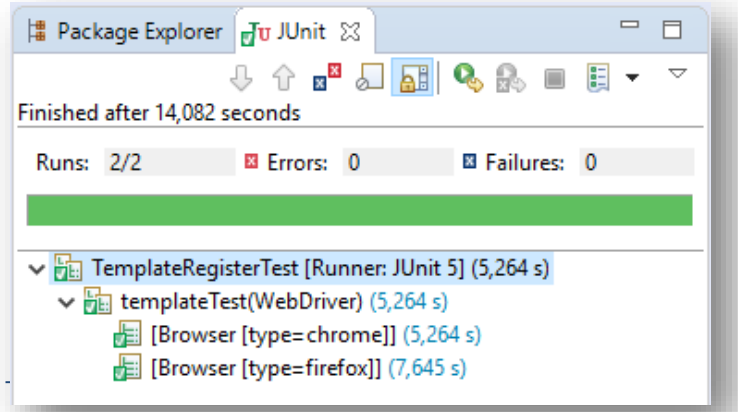



```json
{
   "browsers": [
      [
         {
            "type": "chrome-in-docker",
            "version": "latest"
         }
      ],
      [
         {
            "type": "chrome-in-docker",
            "version": "latest-1"
         }
      ],
      [
         {
            "type": "chrome-in-docker",
            "version": "beta"
         }
      ],
      [
         {
            "type": "chrome-in-docker",
            "version": "unstable"
         }
      ]
   ]
}
```

# Selenium-Jupiter - Test templates

- Selenium-Jupiter use the JUnit 5's support for test templates
- A template defines the number and types of browser used by a test:
  2. Programmatically:

```
import org.junit.jupiter.api.BeforeAll;
import org.junit.jupiter.api.TestTemplate;
import org.junit.jupiter.api.extension.RegisterExtension;
import org.openqa.selenium.WebDriver;
import io.github.bonigarcia.BrowserBuilder;
import io.github.bonigarcia.BrowsersTemplate.Browser;
import io.github.bonigarcia.SeleniumExtension;

public class TemplateRegisterTest {

    @RegisterExtension
    static SeleniumExtension seleniumExtension = new SeleniumExtension();

    @BeforeAll
    static void setup() {
        Browser chrome = BrowserBuilder.chrome().build();
        Browser firefox = BrowserBuilder.firefox().build();
        seleniumExtension.addBrowsers(chrome, firefox);
    }

    @TestTemplate
    void templateTest(WebDriver driver) {
        // ...
    }

}
```



# Selenium-Jupiter - Configuration

- Selenium-Jupiter is also highly configurable with:
  1. Environment variables. For example

```
export SEL_JUP_VNC=true
```

```
export SEL_JUP_RECORDING=true
```

  2. Java properties. For example:

```
mvn test -Dsel.jup.vnc=true
```

```
gradle test -Dsel.jup.vnc=true
```

  3. Configuration manager in Java. For example:

```
@RegisterExtension
static SeleniumExtension seleniumExtension = new SeleniumExtension();

@BeforeAll
static void setup() {
    seleniumExtension.getConfig().setVnc(true);
    seleniumExtension.getConfig().setRecording(true);
}
```

# Selenium-Jupiter - Beyond Java

- Selenium-Jupiter can be also used:

1. As CLI (command line interface) tool:

```
> java -jar selenium-jupiter-3.2.0-fat.jar chrome
[INFO] Using SeleniumJupiter to execute chrome (latest) in Docker
[INFO] Using CHROME version 73.0 (latest)
[INFO] Starting Docker container aerokube/selenoid:1.8.4
[DEBUG] Creating WebDriver for CHROME at http://172.17.0.1:32784/wd/hub
Jan 07, 2019 6:55:17 PM org.openqa.selenium.remote.ProtocolHandshake createSession
INFO: Detected dialect: OSS
[INFO] Starting Docker container psharkey/novnc:3.3-t6
[INFO] Session id 8edd28c130bb2bc62f8e4467c20f4dc0
[INFO] VNC URL (copy and paste in a browser navigation bar to interact with remote session)
[INFO]
http://172.17.0.1:32785/vnc.html?host=172.17.0.1&port=32784&path=vnc/8edd28c130bb2bc62f8e44
67c20f4dc0&resize=scale&autoconnect=true&password=selenoid
[INFO] Press ENTER to exit

[INFO] Stopping Docker container aerokube/selenoid:1.8.4
[INFO] Stopping Docker container psharkey/novnc:3.3-t6
```

Selenium-Jupiter allows to control Docker browsers through VNC

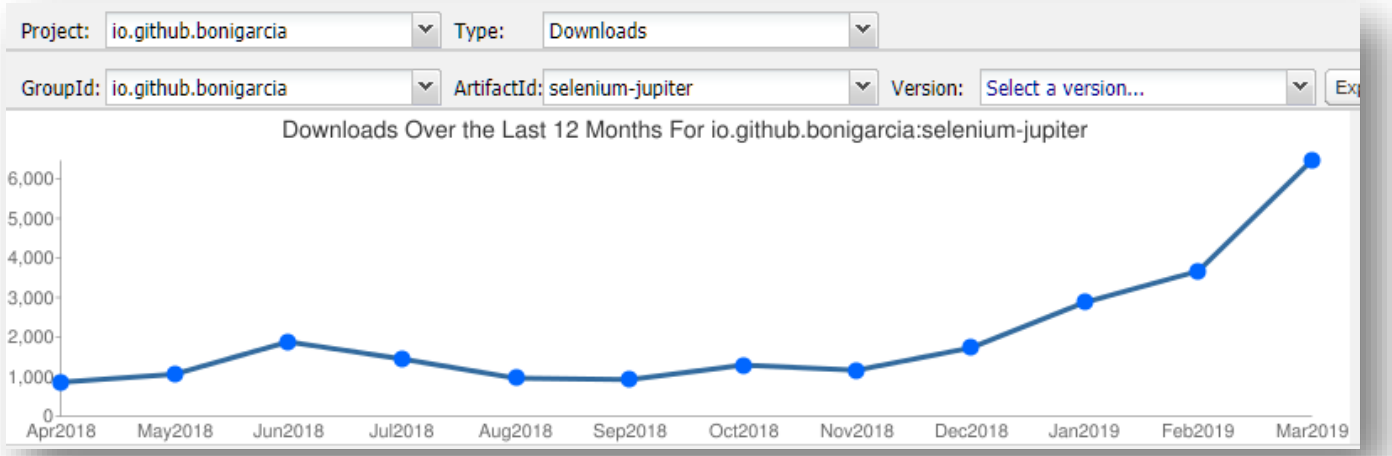
2. As server (using a REST-like API):

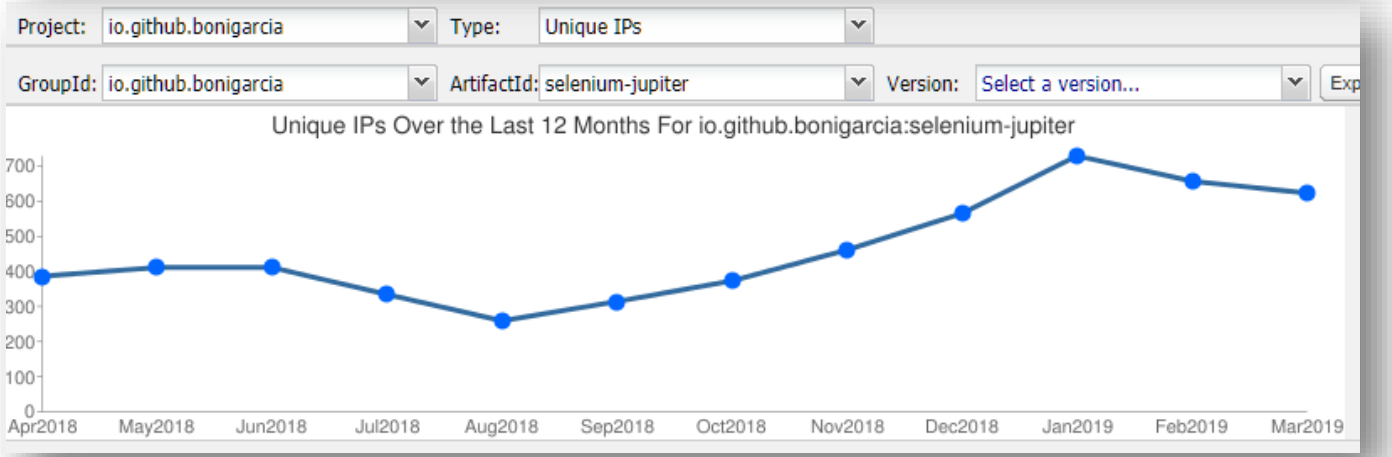
```
java -jar webdrivermanager-3.2.0-fat.jar server
[INFO] Selenium-Jupiter server listening on http://localhost:4042/wd/hub
```

Selenium-Jupiter becomes a **Selenium Server**

# Selenium-Jupiter - Conclusions

- Selenium-Jupiter is a JUnit 5 extension for Selenium (WebDriver, Grid) and Appium



# Selenium-Jupiter - Conclusions

- Selenium-Jupiter has much more features such as:
  - Using WebDriver `@Options` in tests (e.g. `ChromeOptions`, `FirefoxOptions`, etc.)
  - Screenshots at the end of test (as PNG image or Base64)
  - Integration with Jenkins (publishing test results in the Jenkins GUI)
  - Integration with Genymotion (cloud provider for Android devices)
  - Generic driver (configurable type of browser)
  - Single session (reuse browser in different tests)

https://bonigarcia.github.io/selenium-jupiter/

- Selenium-Jupiter is evolving in the near future. Its roadmap includes:
  - Improve test template support (e.g. specifying options within the template)
  - Improve scalability for performance tests (candidate technology: **Kubernetes**)

# Toolbox for Selenium Tests in Java: WebDriverManager and Selenium-Jupiter

Thank you very much!
Q&A

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