Testing Spring web applications

What you'll learn

- Define tests using Spring Boot
- Run the test and push the test report to Xray
- Validate in Jira that the test results are available

Overview

Spring Framework is a well-known Java framework to build Java-based applications, supporting IoC (Inversion of Control) principle.

Sprint Boot provides an opinionated extension on top of Spring that aims to minimize configuration burden and ease the implementation of applications.

With Spring it's possible to create web applications, REST services, and more.

Prerequisites

For this example we will use the built-in testing facilities provided by Spring to test the application developed in Spring Boot

We will need:

- Java and Maven installed in your machine
- xray-junit-extension maven plugin, to take advantage of some annotations that allow us to embed additional information on the generated JUnit XML report (optional)
  - create a file to enable the generation of an enhanced JUnit XML report that Xray can take advantage of
    - **test/resources/META-INF/services/org.junit.platform.launcher.TestExecutionListener**

```
app.getxray.xray.junit.customjunitxml.EnhancedLegacyXmlReportGeneratingListener
```

  - configure the new reporter to generate the report in specific file (e.g., reports/TEST-junit-jupiter.xml)
    - **test/resources/xray-junit-extensions.properties**

```
report_directory=reports
```

To start using Spring Boot please follow the Quick Start Guide documentation; you can also use Spring initializr to make a working skeleton of a project using Spring and its dependencies.

Usually, Spring applications have these layers:

1. web/presentation layer
   a. controllers, exception handlers, filters, ...
2. service layer
   a. services with business logic
3. persistence/data layer
   a. JPA Repository, Entity
   b. database

The target SUT is a web application implemented using Spring Boot, having a REST API to manage users and some controllers that return text acting like typical servlets.

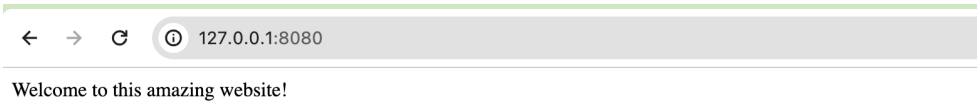
Our Spring application provides:

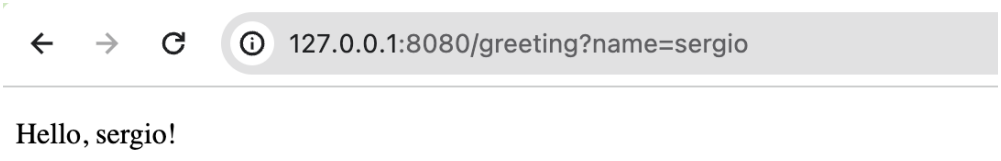
- 3 controllers:
  - IndexController: that is used to return the text "Welcome to this amazing website!" whenever accessing the root page /
  - GreetingController: that is used to return a greeting message (e.g., "Hello, xxx!") based on an HTML template
  - UserRestController: that provides a REST API to manage users using several endpoints under the */users* base URL
- 1 service:
  - UserService/UserServiceImpl: to perform business logic on users; in this case just as a small layer on top of the repository (UserRepository)

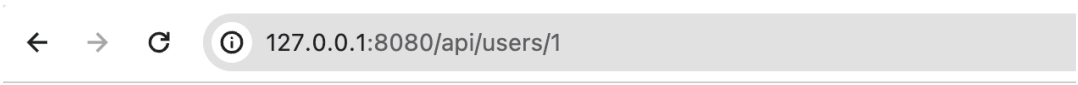
- 1 entity and 1 associated repository:
    - User: a persistable entity
    - UserRepository: a JPA repository of User objects

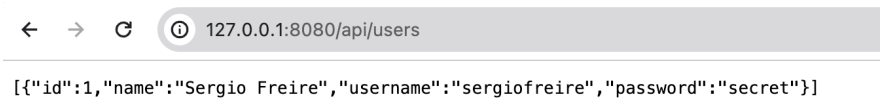
We can run our Spring application from the command line.

```
mvn spring-boot:run
```









We'll implement JUnit 5 tests for all these layers:

- web:
  - we'll test the IndexController and GreetingController controllers
  - we'll test the REST API provided by the UserRestController controller
- service:
  - we will unit test the UserServiceImpl, avoiding usage of database, to test the logic of the service; we'll use Mockito to mock responses of the UserRepository
- data:
  - we'll test the UserRepository in isolation, without loading the web environment
  - an in-memory database (H2) will be used

Spring Boot supports test slicing; the idea is to provide slices of the whole *ApplicationContext* by loading fewer components, thus providing efficiency. We'll see more about @DataJpaTest and @WebMvcTest ahead.

To test at the data layer, we can use @DataJpaTest as a test slice to test our UserRepository repository and the User entity.

- By default, tests annotated with @DataJpaTest are transactional and roll back at the end of each test. They also use an embedded in-memory database (H2).
- Can make use of @TestEntityManage: a test-friendly EntityManager that provides additional methods useful for testing

To test at the service layer, we won't need to boot the application; we can perform unit tests and mock dependency on the data layer.

To test at web layer we can follow different approaches by annotating the related test classes:

- `@SpringBootTest`
  - loads the full application; more resource intensive
  - web server port is injected using @LocalServerPort; a friendly REST client can be used by an injected TestRestTemplate
  - can use a specific database for testing purposes using @AutoConfigureTestDatabase and @TestPropertySource
- `@SpringBootTest`(webEnvironment = WebEnvironment.MOCK, classes = ...) + @AutoConfigureMockMvc
  - loads the full application except the web server itself
    - *Another useful approach is to not start the server at all but to test only the layer below that, where Spring handles the incoming HTTP request and hands it off to your controller. That way, almost all of the full stack is used, and your code will be called in exactly the same way as if it were processing a real HTTP request but without the cost of starting the server*
  - access to MVC framework is made using an injected reference to MockMvc using @Autowired
- `@WebMvcTest(xxx.class)`
  - loads a test slice focused just on the web layer, providing a simplified web environment
  - access to MVC framework is made using an injected reference to MockMvc using @Autowired
  - usually `@WebMvcTest` is used in combination with `@MockBean` or `@Import` to create any collaborators required by your `@Controller` beans.

Let's see some examples, precisely focused more on the web layer.

The following code snippet shows usage of @WebMvcTest to test a slice containing just the web layer. In this case we're testing the output of the root page.

Even though we don't have to use them, we'll also take advantage of 2 annotations provided by the xray-junit-extensions maven plugin to showcase additional features:

- **@XrayTest**: to map the Junit test to an existing Test issue that already exists in Jira
- **@Requirement**: to link the test to an existing requirement/story in Jira

IndexControllerMockedIT.java

```
package com.idera.xray.tutorials.springboot;

import static org.hamcrest.Matchers.equalTo;
import static org.springframework.test.web.servlet.result.MockMvcResultMatchers.content;
import static org.springframework.test.web.servlet.result.MockMvcResultMatchers.status;
import org.junit.jupiter.api.Test;
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.boot.test.autoconfigure.web.servlet.WebMvcTest;
import org.springframework.http.MediaType;
import org.springframework.test.web.servlet.MockMvc;
import org.springframework.test.web.servlet.request.MockMvcRequestBuilders;
import com.idera.xray.tutorials.springboot.boundary.IndexController;

// @SpringBootTest
// @AutoConfigureMockMvc; it is implied whenever @WebMvcTest is used

// @WebMvcTest annotation is used to test only the web layer of the application
// It disables full auto-configuration and instead apply only configuration relevant to MVC tests
@WebMvcTest(IndexController.class)
public class IndexControllerMockedIT {

        @Autowired
        private MockMvc mvc;

        @Test
        @XrayTest(key = "XT-676")
        @Requirement("XT-675")
    public void getWelcomeMessage() throws Exception {
                mvc.perform(MockMvcRequestBuilders.get("/").accept(MediaType.TEXT_PLAIN))
                                .andExpect(status().isOk())
                                .andExpect(content().string(equalTo("Welcome to this amazing website!")));
        }
}
```

The following code snippet loads the whole application using @SpringBootTest to test the REST API endpoints used to manage users.

UserRestControllerIT.java

```
package com.idera.xray.tutorials.springboot;

import org.json.JSONException;
import org.json.JSONObject;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.boot.test.autoconfigure.jdbc.AutoConfigureTestDatabase;
import org.springframework.boot.test.context.SpringBootTest;
import org.springframework.boot.test.context.SpringBootTest.WebEnvironment;
import org.springframework.boot.test.web.client.TestRestTemplate;
import org.springframework.core.ParameterizedTypeReference;
import org.springframework.http.HttpMethod;
import org.springframework.http.HttpStatus;
import org.springframework.http.ResponseEntity;
import org.springframework.web.util.UriComponentsBuilder;
import org.springframework.boot.test.web.server.LocalServerPort;
import com.idera.xray.tutorials.springboot.data.User;
import com.idera.xray.tutorials.springboot.data.UserRepository;
import app.getxray.xray.junit.customjunitxml.annotations.XrayTest;
import java.util.List;
import static org.assertj.core.api.Assertions.assertThat;

/* @SpringBootTest loads the full application, including the web server
 * @AutoConfigureTestDatabase is used to configure a test database instead of the application-defined database
*/
@SpringBootTest(webEnvironment = WebEnvironment.RANDOM_PORT)
@AutoConfigureTestDatabase
class UserRestControllerIT {

    @LocalServerPort
    int randomServerPort;

    @Autowired
    private TestRestTemplate restTemplate;

    @Autowired
    private UserRepository repository;

    User user1;

    @BeforeEach
    public void resetDb() {
        repository.deleteAll();
        user1 = repository.save(new User("Sergio Freire", "sergiofreire", "dummypassword"));
    }

    @Test
     void createUserWithSuccess() {
        User john = new User("John Doe", "johndoe", "dummypassword");
        ResponseEntity<User> entity = restTemplate.postForEntity("/api/users", john, User.class);

        List<User> foundUsers = repository.findAll();
        assertThat(foundUsers).extracting(User::getUsername).contains("johndoe");
    }

    @Test
     void dontCreateUserForInvalidData() {
        User john = new User("John Doe", "", "dummypassword");
        ResponseEntity<User> response = restTemplate.postForEntity("/api/users", john, User.class);

        // ideally, the server shouldnt return 500, but 400 (bad request)
        assertThat(response.getStatusCode()).isEqualTo(HttpStatus.INTERNAL_SERVER_ERROR);

        List<User> found = repository.findAll();
```

```
        assertThat(found).hasSize(1);
        assertThat(found).extracting(User::getName).doesNotContain("John Doe");
    }

    @Test
    void getUserWithSuccess() {
        String endpoint = UriComponentsBuilder.newInstance()
                .scheme("http")
                .host("127.0.0.1")
                .port(randomServerPort)
                .pathSegment("api", "users", user1.getId().toString() )
                .build()
                .toUriString();

        ResponseEntity<User> response = restTemplate.exchange(endpoint, HttpMethod.GET, null, new
ParameterizedTypeReference<User>() {
        });
        User user = response.getBody();

        assertThat(response.getStatusCode()).isEqualTo(HttpStatus.OK);
        assertThat(user1.equals(user)).isTrue();
    }

    @Test
    void getUserUnsuccess() throws JSONException {
        /*
        String endpoint = UriComponentsBuilder.newInstance()
                .scheme("http")
                .host("127.0.0.1")
                .port(randomServerPort)
                .pathSegment("api", "users", "-1" )
                .build()
                .toUriString();

        */

        ResponseEntity<JSONObject> response = restTemplate.exchange("/api/user/-1", HttpMethod.GET, null, new
ParameterizedTypeReference<JSONObject>() {
        });

        assertThat(response.getStatusCode()).isEqualTo(HttpStatus.NOT_FOUND);
    }


    @Test
     void listAllUsersWithSuccess()  {
        createTempUser("Amanda James", "amanda", "dummypassword");
        createTempUser("Robert Junior", "robert", "dummypassword");

        ResponseEntity<List<User>> response = restTemplate
                .exchange("/api/users", HttpMethod.GET, null, new ParameterizedTypeReference<List<User>>() {
                });

        assertThat(response.getStatusCode()).isEqualTo(HttpStatus.OK);
        assertThat(response.getBody()).extracting(User::getName).containsExactly("Sergio Freire", "Amanda
James", "Robert Junior");
    }

    @Test
    void deleteUserWithSuccess() {
        ResponseEntity<User> response = restTemplate.exchange("/api/users/" + user1.getId(), HttpMethod.DELETE,
null, User.class);
        assertThat(response.getStatusCode()).isEqualTo(HttpStatus.OK);
        assertThat(response.getBody().getName()).isEqualTo("Sergio Freire");

        List<User> found = repository.findAll();
        assertThat(found).isEmpty();
    }

    @Test
    void deleteUserUnsuccess() {
```

```
        ResponseEntity<User> response = restTemplate.exchange("/api/users/" + (user1.getId()+2), HttpMethod.
DELETE, null, User.class);
        assertThat(response.getStatusCode()).isEqualTo(HttpStatus.NOT_FOUND);

        List<User> found = repository.findAll();
        assertThat(found).hasSize(1);
    }

    private void createTempUser(String name, String username, String password) {
        User user = new User(name, username, password);
        repository.saveAndFlush(user);
    }

}
```

In our case, we have tests that will be picked by *surefire* plugin and other ones that will be picked by *failsafe* plugin.

Once the code is implemented it can be executed with the following command:

```
mvn test failsafe:integration-test
```

The results are immediately available in the terminal.

Ultimately this will lead to multiple JUnit XML reports (in `target/surefire-reports/` and `target/failsafe-reports/`, respectively).

If we use the xray-junit-extensions maven plugin, it will generate 1 JUnit XML report (i.e., in `reports/TEST-junit-jupiter.xml`) with all results of the last task executed (i.e., the integration tests ran by failsafe on the previous *mvn* command).

In this example, all tests have succeeded, as seen in the previous terminal screenshot. It generates the following JUnit XML report.

JUnit XML Report

```
<?xml version="1.0" encoding="UTF-8"?>
<testsuite name="JUnit Jupiter" tests="11" skipped="0" failures="0" errors="0" time="6"
    hostname="Sergios-MBP.lan" timestamp="2024-02-20T18:15:39">
    <properties>
        <property name="CONSOLE_LOG_CHARSET" value="UTF-8" />
        <property name="FILE_LOG_CHARSET" value="UTF-8" />
        <property name="user.country" value="PT" />
        <property name="user.timezone" value="Europe/Lisbon" />
    </properties>
```

```
    <testcase name="getPersonalizedGreeting"
        classname="com.idera.xray.tutorials.springboot.GreetingControllerMockedIT" time="0"
        started-at="2024-02-20T18:15:37.51681" finished-at="2024-02-20T18:15:37.814122">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.GreetingControllerMockedIT]/
[method:getPersonalizedGreeting()]
display-name: getPersonalizedGreeting()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <testcase name="dontCreateUserForInvalidData"
        classname="com.idera.xray.tutorials.springboot.UserRestControllerIT" time="0"
        started-at="2024-02-20T18:15:38.375802" finished-at="2024-02-20T18:15:38.766131">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.UserRestControllerIT]/[method:
dontCreateUserForInvalidData()]
display-name: dontCreateUserForInvalidData()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <testcase name="getUserUnsuccess"
        classname="com.idera.xray.tutorials.springboot.UserRestControllerIT" time="0"
        started-at="2024-02-20T18:15:38.845142" finished-at="2024-02-20T18:15:38.868507">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.UserRestControllerIT]/[method:
getUserUnsuccess()]
display-name: getUserUnsuccess()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <testcase name="deleteUserWithSuccess"
        classname="com.idera.xray.tutorials.springboot.UserRestControllerIT" time="0"
        started-at="2024-02-20T18:15:38.804222" finished-at="2024-02-20T18:15:38.824641">
        <system-out><![CDATA[
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deleteUserWithSuccess()]
display-name: deleteUserWithSuccess()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <testcase name="createUserWithSuccess"
        classname="com.idera.xray.tutorials.springboot.UserRestControllerIT" time="0"
        started-at="2024-02-20T18:15:38.825412" finished-at="2024-02-20T18:15:38.844362">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.UserRestControllerIT]/[method:
createUserWithSuccess()]
display-name: createUserWithSuccess()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <testcase name="getDefaultGreeting"
        classname="com.idera.xray.tutorials.springboot.GreetingControllerMockedIT" time="0"
        started-at="2024-02-20T18:15:37.814867" finished-at="2024-02-20T18:15:37.818444">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.GreetingControllerMockedIT]/
[method:getDefaultGreeting()]
display-name: getDefaultGreeting()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
```

```
    </testcase>
    <testcase name="getWelcomeMessage"
        classname="com.idera.xray.tutorials.springboot.IndexControllerMockedIT" time="0"
        started-at="2024-02-20T18:15:39.091011" finished-at="2024-02-20T18:15:39.097803">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.IndexControllerMockedIT]/[method:
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display-name: getWelcomeMessage()
]]></system-out>
        <properties>
            <property name="requirements" value="XT-675" />
            <property name="test_key" value="XT-676" />
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <testcase name="getUserWithSuccess"
        classname="com.idera.xray.tutorials.springboot.UserRestControllerIT" time="0"
        started-at="2024-02-20T18:15:38.767197" finished-at="2024-02-20T18:15:38.803133">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.UserRestControllerIT]/[method:
getUserWithSuccess()]
display-name: getUserWithSuccess()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <testcase name="listAllUsersWithSuccess"
        classname="com.idera.xray.tutorials.springboot.UserRestControllerIT" time="0"
        started-at="2024-02-20T18:15:38.888027" finished-at="2024-02-20T18:15:38.909762">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.UserRestControllerIT]/[method:
listAllUsersWithSuccess()]
display-name: listAllUsersWithSuccess()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <testcase name="getWelcomeMessage"
        classname="com.idera.xray.tutorials.springboot.IndexControllerIT" time="0"
        started-at="2024-02-20T18:15:36.488501" finished-at="2024-02-20T18:15:37.25418">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.IndexControllerIT]/[method:
getWelcomeMessage()]
display-name: getWelcomeMessage()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <testcase name="deleteUserUnsuccess"
        classname="com.idera.xray.tutorials.springboot.UserRestControllerIT" time="0"
        started-at="2024-02-20T18:15:38.869301" finished-at="2024-02-20T18:15:38.887141">
        <system-out><![CDATA[
unique-id: [engine:junit-jupiter]/[class:com.idera.xray.tutorials.springboot.UserRestControllerIT]/[method:
deleteUserUnsuccess()]
display-name: deleteUserUnsuccess()
]]></system-out>
        <properties>
            <property name="_dummy_" value="" />
        </properties>
    </testcase>
    <system-out><![CDATA[
unique-id: [engine:junit-jupiter]
display-name: JUnit Jupiter
]]></system-out>
</testsuite>
```

Integrating with Xray

Once we produced JUnit reports with the test results, it is a matter of importing those results into your Jira instance. This can be done by simply submitting automation results to Xray through the REST API, by using one of the available CI/CD plugins (e.g. for Jenkins), or using the Jira interface.

API

API

Once you have the report file available you can upload it to Xray through a request to the REST API endpoint for JUnit, and for that the first step is to follow the instructions in v1 or v2 (depending on your usage) to obtain the token we will be using in the subsequent requests.

Authentication

The request made will look like:

```
curl -H "Content-Type: application/json" -X POST --data '{ "client_id": "CLIENTID","client_secret":
"CLIENTSECRET" }'  https://xray.cloud.getxray.app/api/v2/authenticate
```

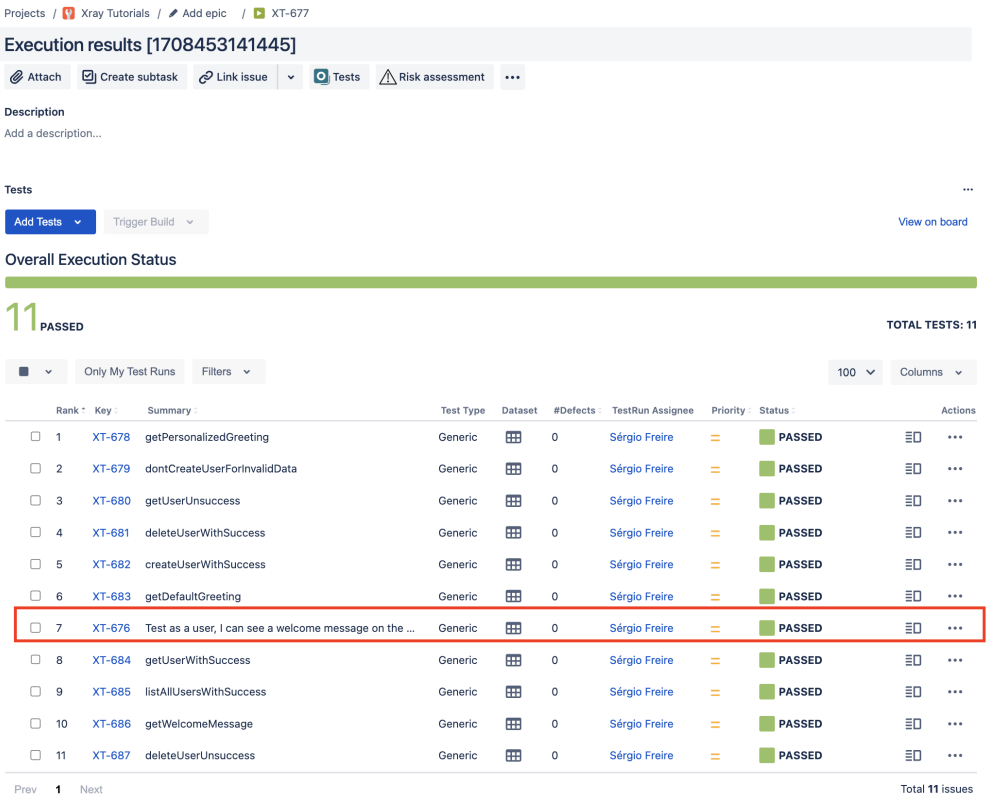
The response of this request will return the token to be used in the subsequent requests for authentication purposes.

JUnit XML results

Once you have the token we will use it in the API request with the definition of some common fields on the Test Execution, such as the target project, project version, etc.

```
curl -H "Content-Type: text/xml" -X POST -H "Authorization: Bearer $token"  --data @"reports/TEST-junit-jupiter.
xml" https://xray.cloud.getxray.app/api/v2/import/execution/junit?projectKey=XT&testPlanKey=XT-674
```

With this command we are creating a new Test Execution in the referred Test Plan with a generic summary and tests with a summary based on the test name. One of the tests was not auto-provisioned as it already existed beforehand and was referred in the the test code using the @XrayTest annotation.

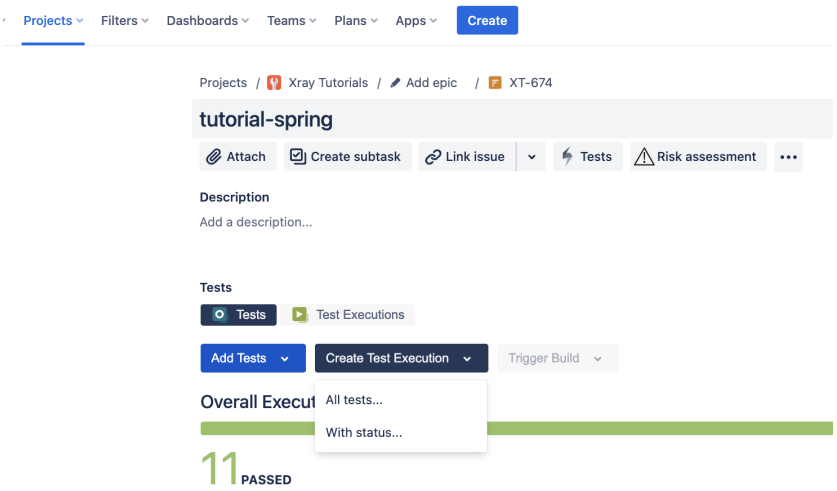


Jira UI

Jira UI

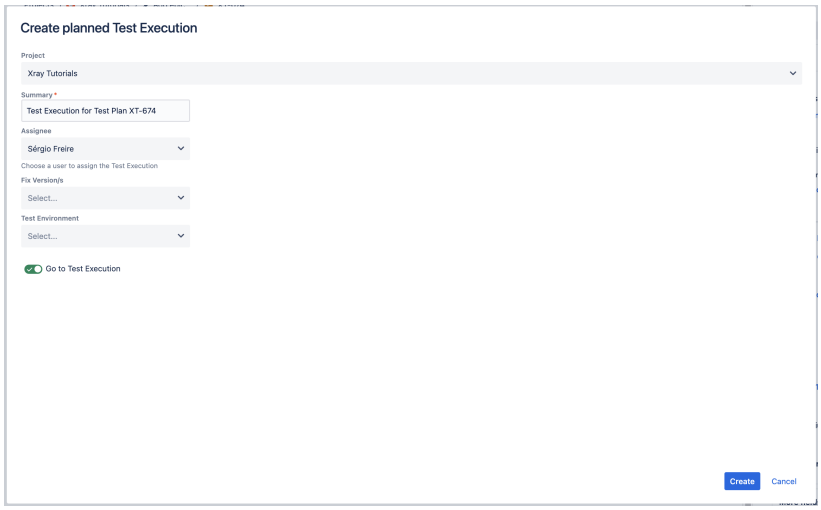
1

Create a Test Execution linked to the Test Plan that you have.



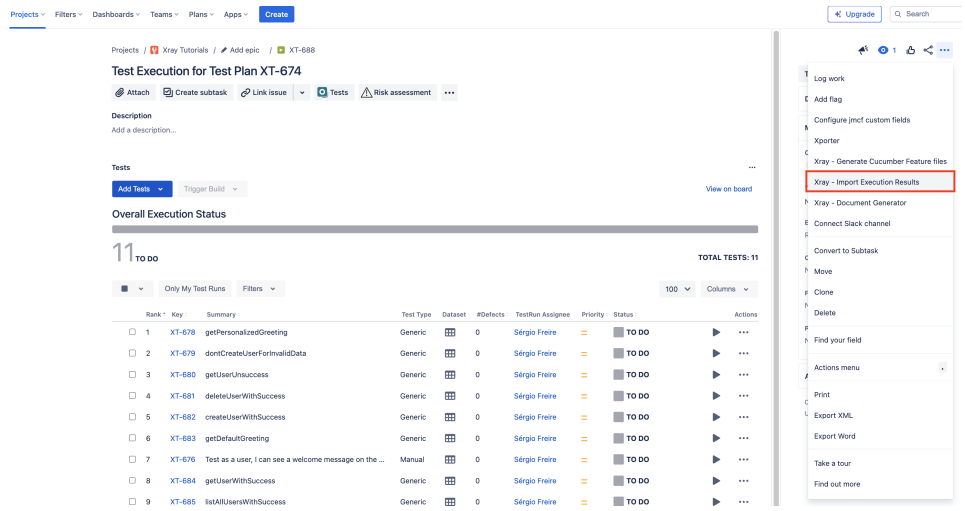
2

Fill in the necessary fields and press "*Create*".



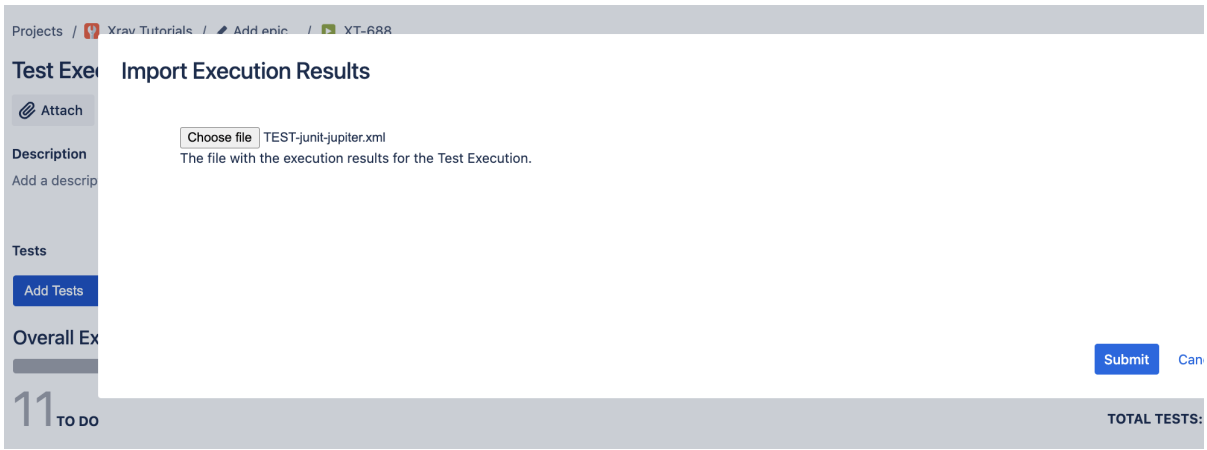
3

Open the Test Execution and import the JUnit report



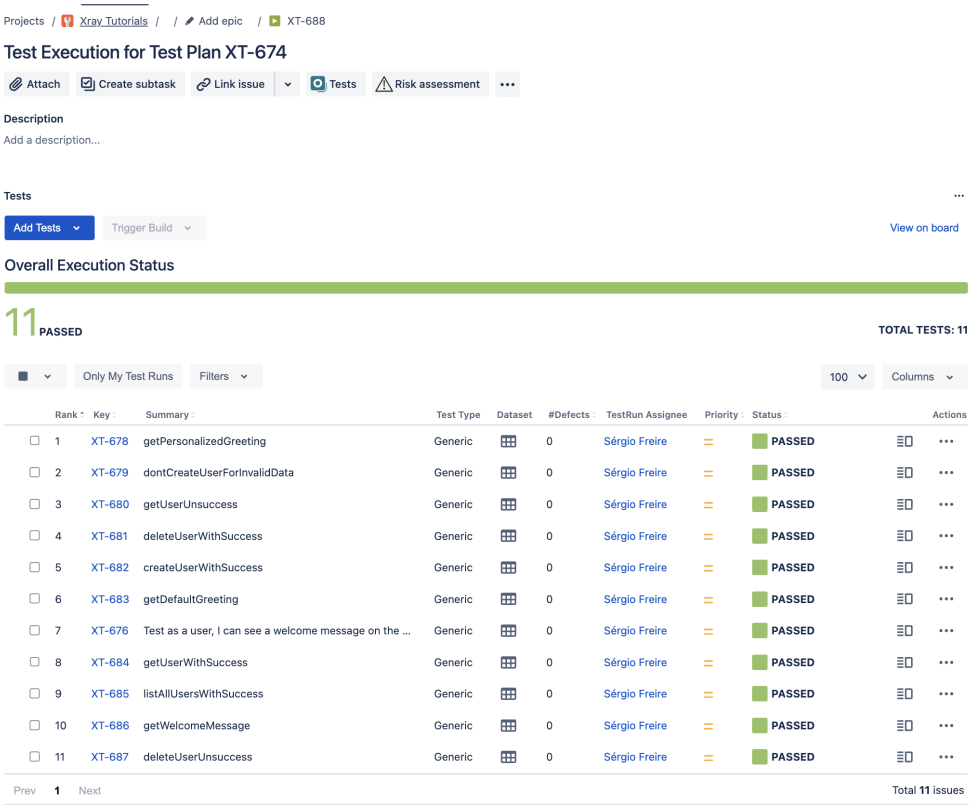
4

Choose the results file and press *"Submit"*

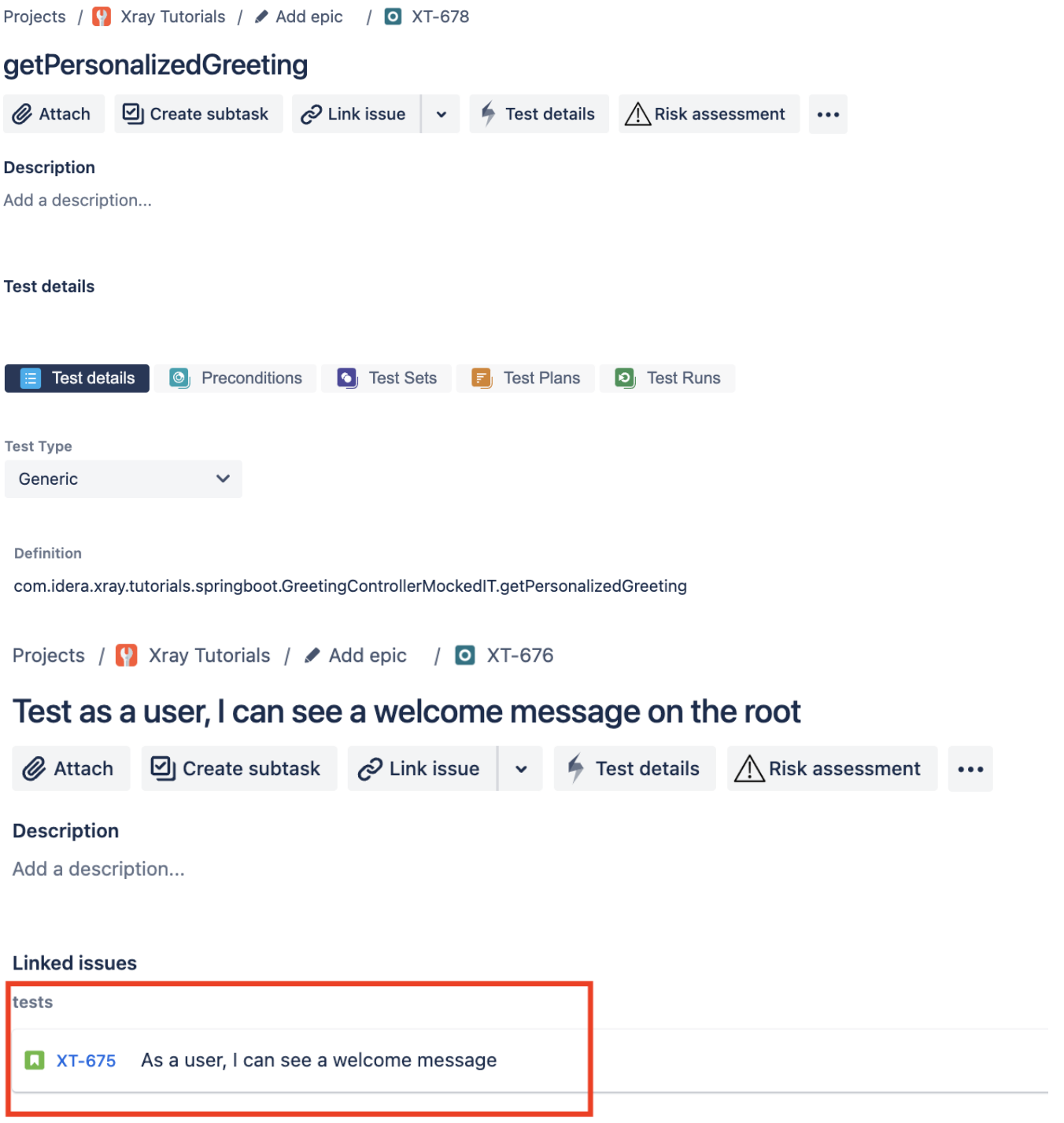


5

The Test Execution is now updated with the test results imported.



Tests implemented using JUnit will have a corresponding Test entity in Xray. Once results are uploaded, Test issues corresponding to the tests are auto-provisioned (e.g., XT-678), unless they already exist; in our case, we have explicitly mentioned an existing Test issue (XT-676) from one of the tests.

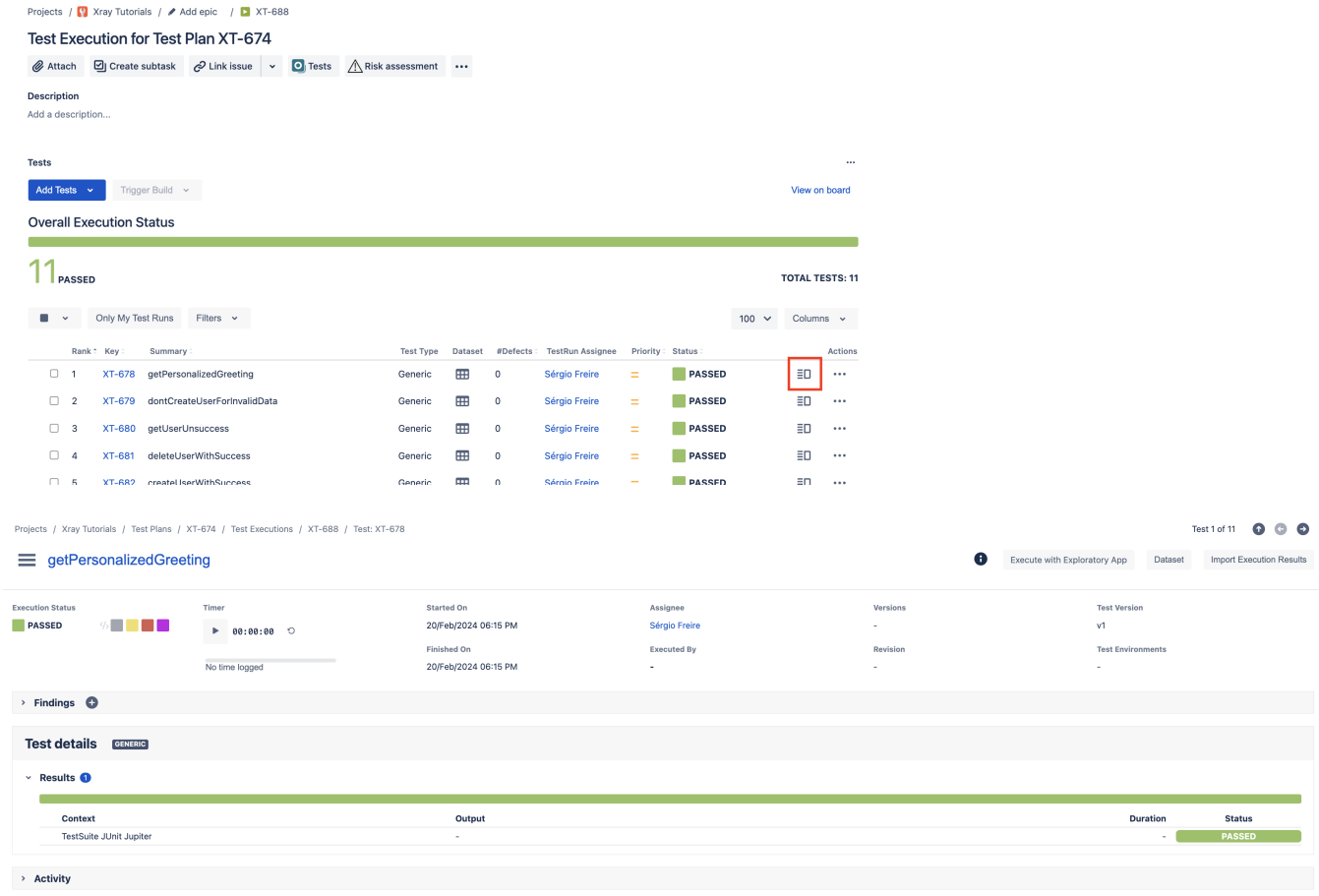


As we have annotated one of the tests with @Requirement (provided by the xray-junit-extensions project), the linkage/coverage of the user story (XT-675) is made whenever importing the results.

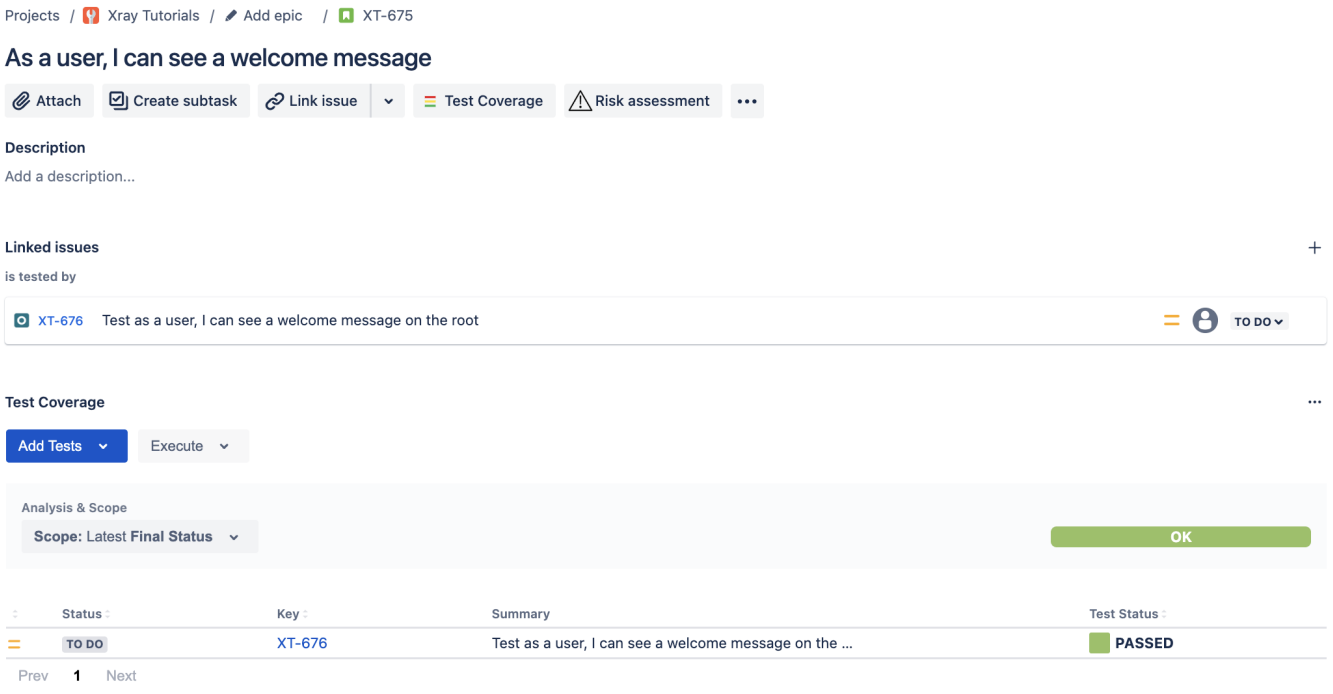
Xray uses a concatenation of the suite name and the test name as the unique identifier for the test.

In Xray, results are stored in a Test Execution, usually a new one. The Test Execution contains a Test Run per each test that was executed.

Detailed results, including logs and exceptions reported during execution of the test, can be seen on the execution screen details of each Test Run, accessible through the *execution details* as we can see here:



As we linked one of the Tests to an existing Story (using the @Requirement annotatiob provided by the xray-junit-extensions project), on the Story issue screen we can track coverage having in mind the result of that test. We could link other Tests on the code or later on in Xray, by adding them using the "Add Tests" option.



Tips

- after results are imported, in Jira Tests can be linked to existing requirements/user stories, so you can track the impact on their coverage; in this tutorial we've shown also how to link the test to a story right from the code.
- results from multiple builds can be linked to an existing Test Plan, to facilitate the analysis of test result trends across builds.
- results can be associated with a Test Environment, in case you want to analyze coverage and test results by that environment later on. A Test Environment can be a testing stage (e.g. dev, staging, preprod, prod) or a identifier of the device/application used to interact with the system (e.g. browser, mobile OS).

References

- Spring project
- Spring Framework
- Sprint Boot
- Spring guides
- Spring Testing
- article on Testing the web layer
- xray-junit-extensions