CSCI 5308

ADVANCED TOPICS IN SOFTWARE DEVELOPMENT

ASSIGNMENT - 1

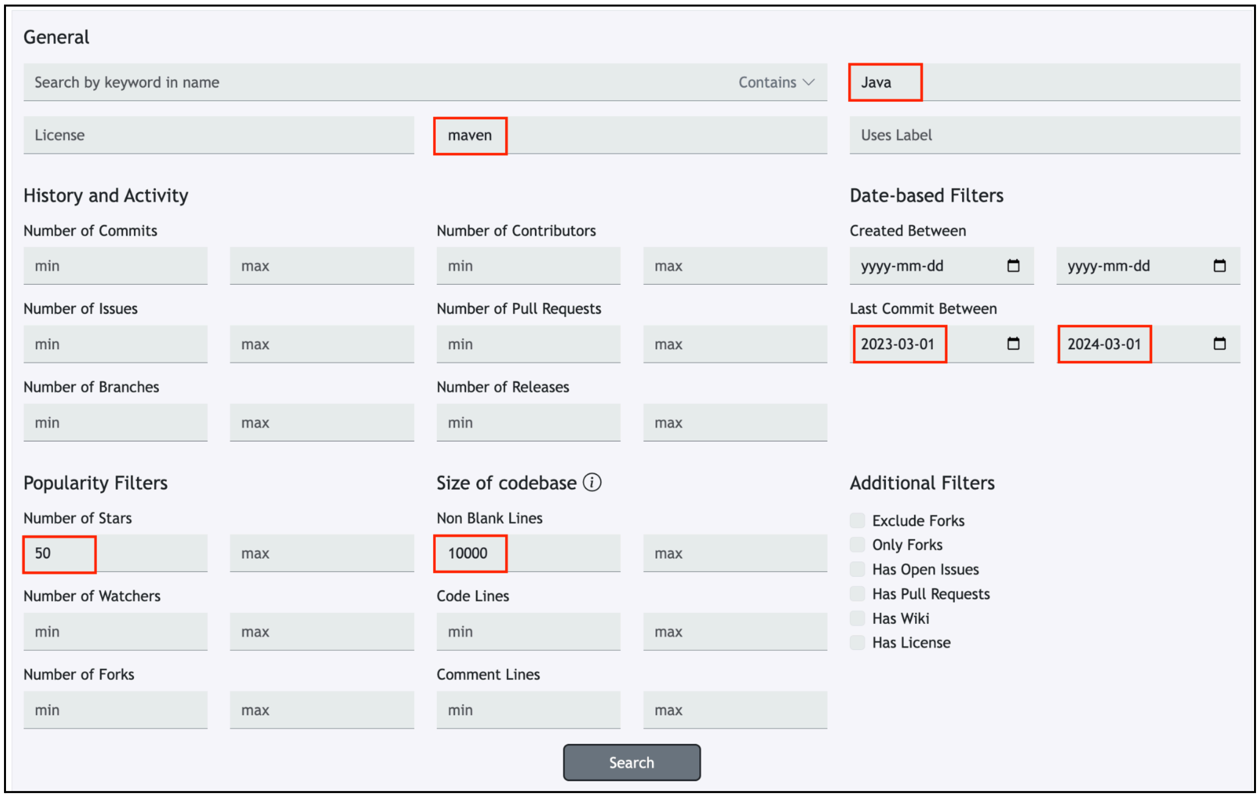
Banner ID: B00958098
Original Creator’s Github Repository: https://github.com/slabiak/AppointmentScheduler
Forked Github Repository:
https://github.com/kapoor98ak/AppointmentScheduler/tree/working-develop

Table of Contents

Task-1

For this task, we had to choose a Java-based open-source repository that satisfies some conditions. I utilized SEART's [1] github repository search tool to find a repository that would satisfy the following requirements.

The SEART (SoftwarE Analytics Research Team) group is part of the Software Institute at the Università della Svizzera italiana, located in Lugano, Switzerland. They perform research in the area of software engineering, with focus on software analytics, recommender systems for software developers, and empirical software engineering.



General

Search by keyword in name | Contains | Java

License | maven | Uses Label

History and Activity

Number of Commits	min	max
Number of Issues	min	max
Number of Branches	min	max
Number of Contributors	min	max
Number of Pull Requests	min	max
Number of Releases	min	max

Date-based Filters

Created Between	yyyy-mm-dd	yyyy-mm-dd
Last Commit Between	2023-03-01	2024-03-01

Popularity Filters

Number of Stars	50	max
Number of Watchers	min	max
Number of Forks	min	max

Size of codebase

Non Blank Lines	10000	max
Code Lines	min	max
Comment Lines	min	max

Additional Filters

- Exclude Forks
- Only Forks
- Has Open Issues
- Has Pull Requests
- Has Wiki
- Has License

Fig 1: SEART's Search Entries to fulfill all the required criteria

Requirements:

✅ It must be a maven or gradle-based project
- The project is a Maven based project (see in Fig 2.)

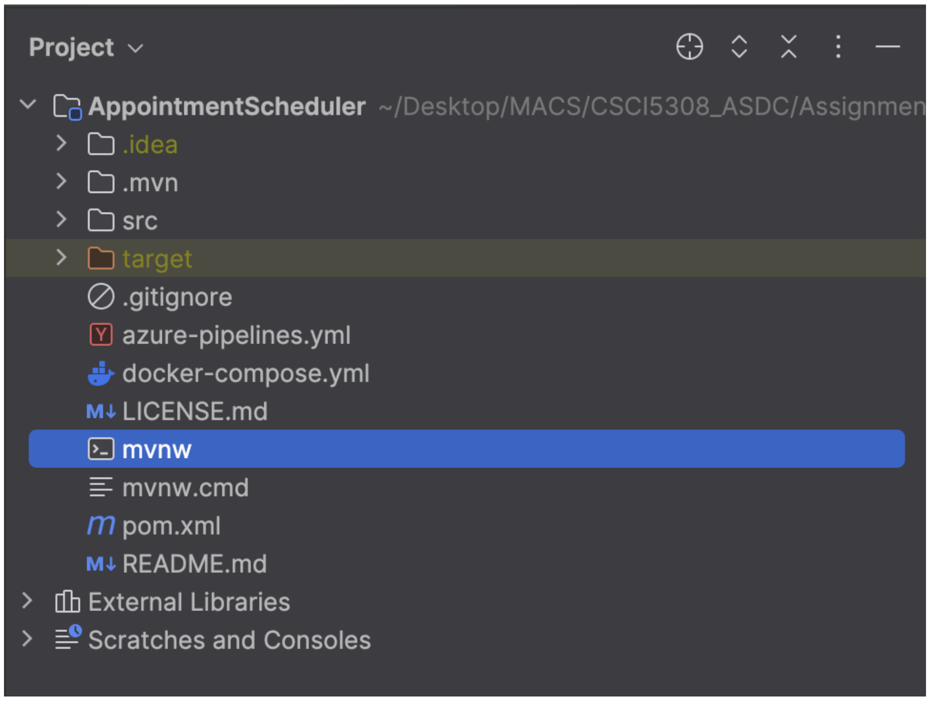
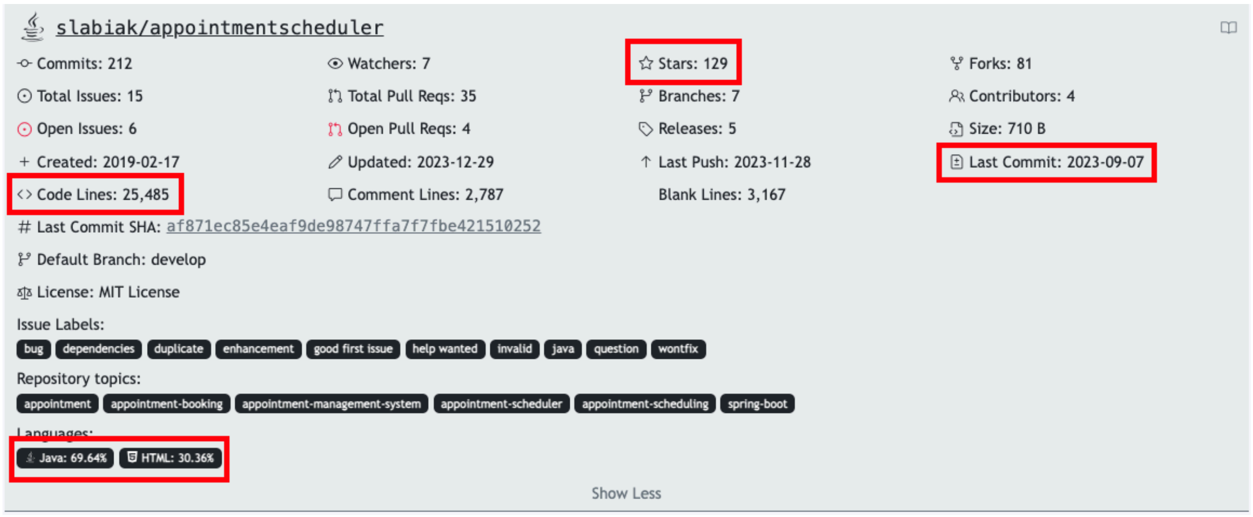

```
Project
AppointmentScheduler ~/Desktop/MACS/CSCI5308_ASDC/Assignmen
  .idea
  .mvn
  src
  target
  .gitignore
  azure-pipelines.yml
  docker-compose.yml
  LICENSE.md
  mvnw
  mvnw.cmd
  pom.xml
  README.md
External Libraries
Scratches and Consoles
```

Fig 2: AppointentScheduler is a Maven based project.

✅ It must have at least 10,000 lines of code
- ○ The project has 22,000+ code lines (see in Fig 3.)

✅ It must have at least 50 stars
- ○ The project has 129 stars (see in Fig 3.)


slabiak/appointmentscheduler

Commits: 212	Watchers: 7	Stars: 129	Forks: 81
Total Issues: 15	Total Pull Reqs: 35	Branches: 7	Contributors: 4
Open Issues: 6	Open Pull Reqs: 4	Releases: 5	Size: 710 B
Created: 2019-02-17	Updated: 2023-12-29	Last Push: 2023-11-28	Last Commit: 2023-09-07
Code Lines: 25,485	Comment Lines: 2,787	Blank Lines: 3,167	

Last Commit SHA: af871ec85e4eaf9de98747ffa7f7fbe421510252

Default Branch: develop

License: MIT License

Issue Labels:
bug dependencies duplicate enhancement good first issue help wanted invalid java question wontfix

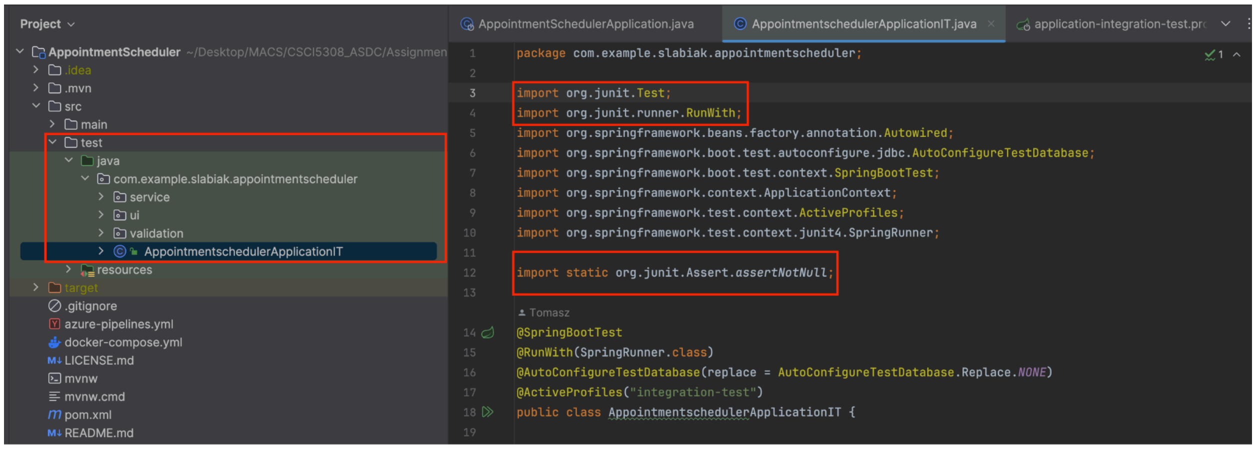
Repository topics:
appointment appointment-booking appointment-management-system appointment-scheduler appointment-scheduling spring-boot

Languages:
Java: 69.64% HTML: 30.36%

Show Less

Fig 3: Image showing repository metadata

✅ It must have tests written using the JUnit framework


Project
AppointmentSchedulerApplication.java
AppointmentschedulerApplicationIT.java
application-integration-test.pr

```
AppointmentScheduler ~/Desktop/MACS/CSCI5308_ASDC/Assignmen
  .idea
  .mvn
  src
    main
    test
      java
        com.example.slabiak.appointmentscheduler
          service
          ui
          validation
          AppointmentschedulerApplicationIT
      resources
  target
  .gitignore
  azure-pipelines.yml
  docker-compose.yml
  LICENSE.md
  mvnw
  mvnw.cmd
  pom.xml
  README.md
```

```java
package com.example.slabiak.appointmentscheduler;

import org.junit.Test;
import org.junit.runner.RunWith;
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.context.ApplicationContext;
import org.springframework.test.context.ActiveProfiles;
import org.springframework.test.context.junit4.SpringRunner;

import static org.junit.Assert.assertNotNull;

Tomasz
@SpringBootTest
@RunWith(SpringRunner.class)
@AutoConfigureTestDatabase(replace = AutoConfigureTestDatabase.Replace.NONE)
@ActiveProfiles("integration-test")
public class AppointmentschedulerApplicationIT {

```

Fig 4: Image showing tests written in JUnit

✅ It must not be a tutorial or example repository
- The Appointment scheduler project is neither an example website or a tutorial.
- **Appointment scheduler:** This is a Spring Boot Web Application to manage and schedule appointments between providers and customers. It has many features such as automatic invoicing, email notifications, appointments cancelation, providers individual working plans with brakes etc.[2]

✅ It must be active (at least one commit in the past one year).
- The project's last commit was in September' 2023 (see in Fig 3.)

Task-2

For this task, we have to provide quantitative measures of test implementation. We can use the total number of automated tests and code coverage (branch) as the quantitative measures.

I referred to this [3] article for developing my understanding on code coverage and I will be citing lines from the same in this task.

Code Coverage

Code coverage describes the percentage of code covered by **automated tests**; it checks which parts of code run during the test suite and which don't.

Just writing Unit Tests is an insufficient metric to count towards the reliability of the program, we need to quantify the usability of the test suite by checking what is the "reach" of our test suite. In other words, *how much of our code base is being reached by our unit tests [3].*

Ways to measure code coverage

1. Statement Coverage

   Statement coverage can be calculated by Number of executed statements / Total number of statements * 100.

   That way of measuring code coverage is able to:
   - verify the do's and don'ts of the written code
   - find dead code and unused statements
   - test different flow paths and checks which ones are not covered

   Statement coverage is typically discussed in the **context of an entire test suite** rather than individual test cases.

2. Branch Coverage

   Branch coverage tells us how many of each decision in a decision-making tree is executed at least once.
   By branches we mean: **conditional statements, loops, switch statements**.

   Branch coverage can be calculated by Number of executed branches / Total number of branches * 100

That way of measuring code coverage is able to:

- verify if the execution of the test suite reaches all branches
- detects possible abnormal behavior of each branch
- can test areas of the source code that other approaches may discount

3. Function Coverage

Function coverage tells us if each function of a program is being called at least once.
It is also critical to test functions with a set of input parameters so that the test suites will check if functions behave properly in different scenarios.

Function coverage can be calculated by Number of executed functions / Total number of functions * 100

Function coverage is the broadest metric compared to the rest. High percentage of code coverage doesn't always mean that code is ideal and faultless.

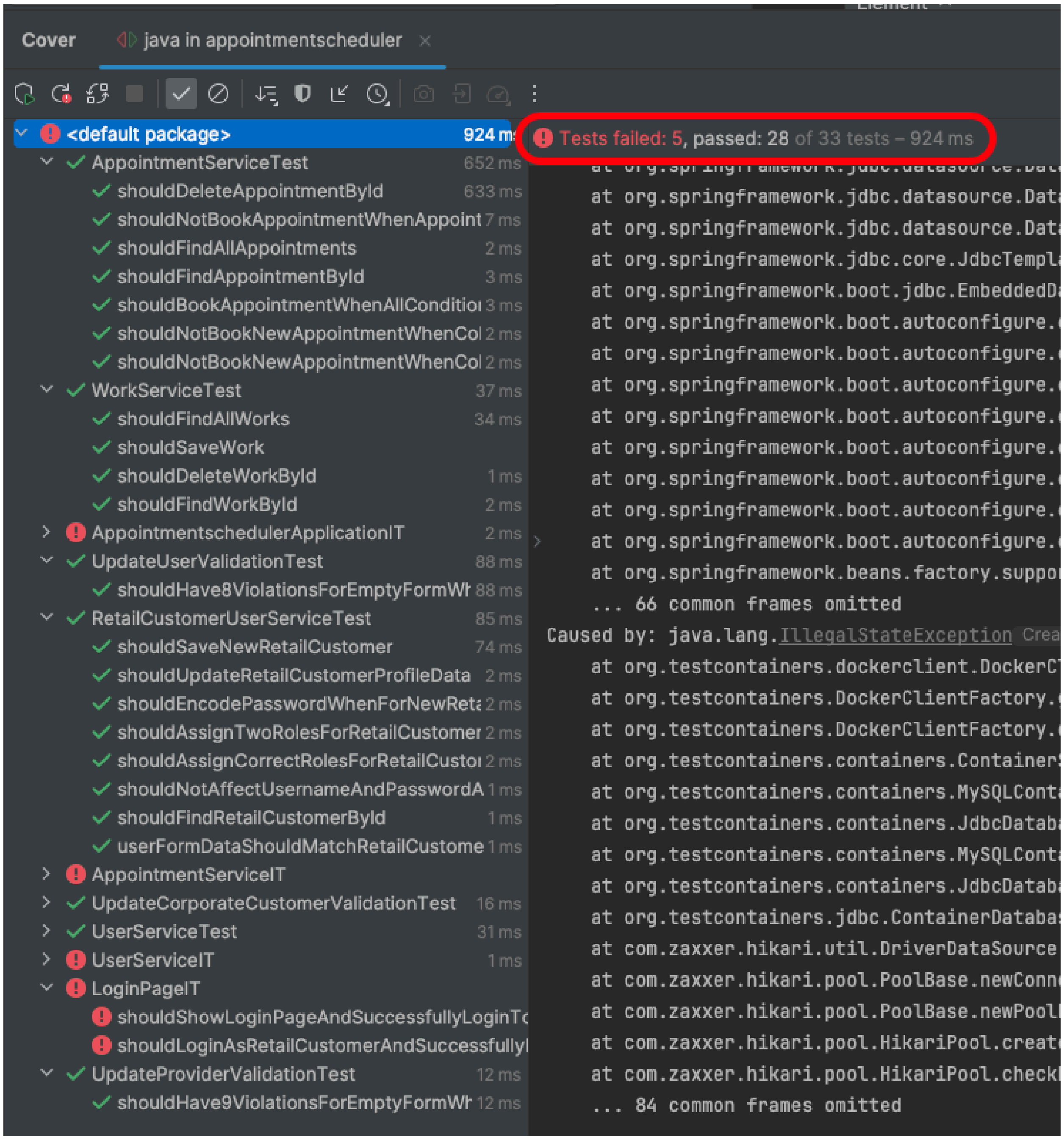
Code Coverage in Appointment Scheduler

Appointment Scheduler's root directory has a test folder.
In there, there are 3 sub-directories.

1. **Service**
- Here the test classes mainly focus on services for users, work, and appointments.
2. **UI**
- Here there are tests for the HTML UI.
3. **Validations**
- Here are the update validations where we check the user information update flow.

Automated Tests

- Initially, 28 automated tests out of 33 automated tests passed and 5 of them failed.
- The test cases which were passed and failed are shown in Fig 5.



Cover   java in appointmentscheduler ×

```
<default package>                                  924 ms
  AppointmentServiceTest                           652 ms
    shouldDeleteAppointmentById                    633 ms
    shouldNotBookAppointmentWhenAppoint              7 ms
    shouldFindAllAppointments                        2 ms
    shouldFindAppointmentById                        3 ms
    shouldBookAppointmentWhenAllConditio             3 ms
    shouldNotBookNewAppointmentWhenCo                2 ms
    shouldNotBookNewAppointmentWhenCo                2 ms
  WorkServiceTest                                   37 ms
    shouldFindAllWorks                              34 ms
    shouldSaveWork
    shouldDeleteWorkById                             1 ms
    shouldFindWorkById                               2 ms
  AppointmentschedulerApplicationIT                  2 ms
  UpdateUserValidationTest                          88 ms
    shouldHave8ViolationsForEmptyFormWh             88 ms
  RetailCustomerUserServiceTest                     85 ms
    shouldSaveNewRetailCustomer                     74 ms
    shouldUpdateRetailCustomerProfileData            2 ms
    shouldEncodePasswordWhenForNewRet                2 ms
    shouldAssignTwoRolesForRetailCustomer            2 ms
    shouldAssignCorrectRolesForRetailCusto           2 ms
    shouldNotAffectUsernameAndPasswordA              1 ms
    shouldFindRetailCustomerById                     1 ms
    userFormDataShouldMatchRetailCustome             1 ms
  AppointmentServiceIT
  UpdateCorporateCustomerValidationTest             16 ms
  UserServiceTest                                   31 ms
  UserServiceIT                                      1 ms
  LoginPageIT
    shouldShowLoginPageAndSuccessfullyLoginTo
    shouldLoginAsRetailCustomerAndSuccessfully
  UpdateProviderValidationTest                      12 ms
    shouldHave9ViolationsForEmptyFormWh             12 ms
```

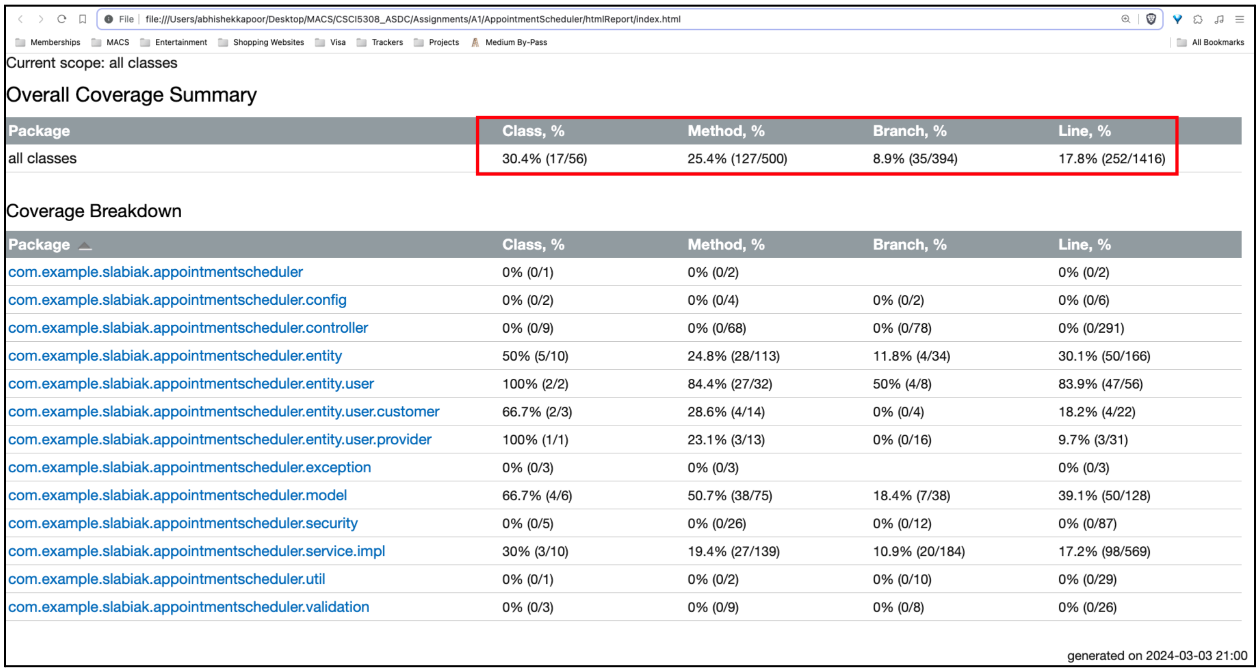
```
Tests failed: 5, passed: 28 of 33 tests – 924 ms
    at org.springframework.jdbc.datasource.Data
    at org.springframework.jdbc.datasource.Data
    at org.springframework.jdbc.datasource.Data
    at org.springframework.jdbc.core.JdbcTempla
    at org.springframework.boot.jdbc.EmbeddedDa
    at org.springframework.boot.autoconfigure.
    at org.springframework.boot.autoconfigure.
    at org.springframework.boot.autoconfigure.
    at org.springframework.boot.autoconfigure.
    at org.springframework.boot.autoconfigure.
    at org.springframework.boot.autoconfigure.
    at org.springframework.boot.autoconfigure.
    at org.springframework.boot.autoconfigure.
    at org.springframework.beans.factory.suppo
    ... 66 common frames omitted
Caused by: java.lang.IllegalStateException Crea
    at org.testcontainers.dockerclient.DockerC
    at org.testcontainers.DockerClientFactory.
    at org.testcontainers.DockerClientFactory.
    at org.testcontainers.containers.Container
    at org.testcontainers.containers.MySQLConta
    at org.testcontainers.containers.JdbcDataba
    at org.testcontainers.containers.MySQLConta
    at org.testcontainers.containers.JdbcDataba
    at org.testcontainers.jdbc.ContainerDataba
    at com.zaxxer.hikari.util.DriverDataSource
    at com.zaxxer.hikari.pool.PoolBase.newConn
    at com.zaxxer.hikari.pool.PoolBase.newPool
    at com.zaxxer.hikari.pool.HikariPool.creat
    at com.zaxxer.hikari.pool.HikariPool.check
    ... 84 common frames omitted
```

Fig 5: Image showing 28 out of 33 Automated tests passing

Code Coverage

- For generating the report for the Test Coverage metrics, I used both IntelliJ Coverage plugin[4] and Jacoco dependency[5].
- In Fig 6, we can see the initial test metrics for the Appointment Scheduler.
  We have
    - Only 8.9% Branch Coverage
    - Only 17.8% Line Coverage
    - and only 25% Function or Method Coverage

- Per the reports, the test cases cover
    - 17 classes out of 56 classes.
    - 127 methods out of 500 methods.
    - 252 lines of code out of 1416 lines of code. The
- Per the Fig 6, the Branch coverage can be see as 8%. This report is generated using the IntelliJ's coverage plugin report.


File | file:///Users/abhishekkapoor/Desktop/MACS/CSCI5308_ASDC/Assignments/A1/AppointmentScheduler/htmlReport/index.html
Memberships
MACS
Entertainment
Shopping Websites
Visa
Trackers
Projects
Medium By-Pass
All Bookmarks

Current scope: all classes

Overall Coverage Summary

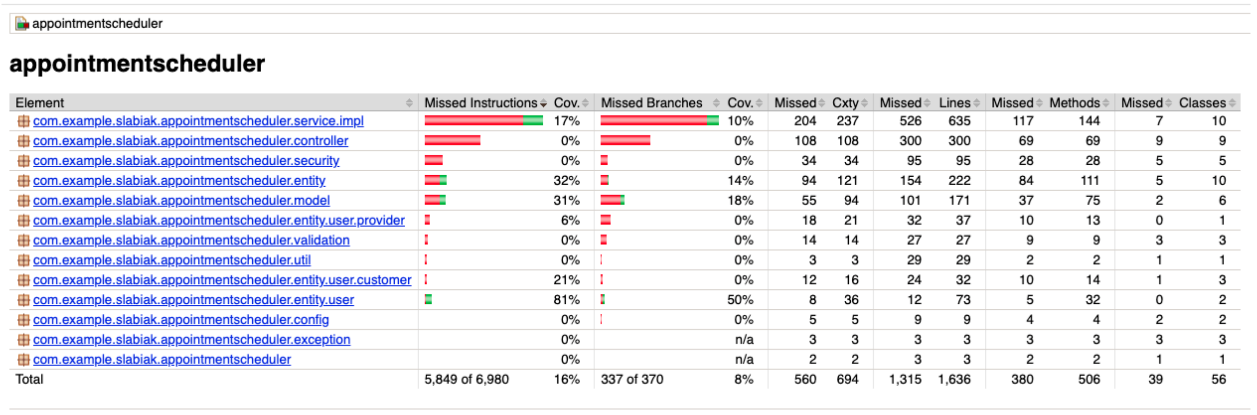
Package	Class, %	Method, %	Branch, %	Line, %
all classes	30.4% (17/56)	25.4% (127/500)	8.9% (35/394)	17.8% (252/1416)

Coverage Breakdown

Package	Class, %	Method, %	Branch, %	Line, %
com.example.slabiak.appointmentscheduler	0% (0/1)	0% (0/2)		0% (0/2)
com.example.slabiak.appointmentscheduler.config	0% (0/2)	0% (0/4)	0% (0/2)	0% (0/6)
com.example.slabiak.appointmentscheduler.controller	0% (0/9)	0% (0/68)	0% (0/78)	0% (0/291)
com.example.slabiak.appointmentscheduler.entity	50% (5/10)	24.8% (28/113)	11.8% (4/34)	30.1% (50/166)
com.example.slabiak.appointmentscheduler.entity.user	100% (2/2)	84.4% (27/32)	50% (4/8)	83.9% (47/56)
com.example.slabiak.appointmentscheduler.entity.user.customer	66.7% (2/3)	28.6% (4/14)	0% (0/4)	18.2% (4/22)
com.example.slabiak.appointmentscheduler.entity.user.provider	100% (1/1)	23.1% (3/13)	0% (0/16)	9.7% (3/31)
com.example.slabiak.appointmentscheduler.exception	0% (0/3)	0% (0/3)		0% (0/3)
com.example.slabiak.appointmentscheduler.model	66.7% (4/6)	50.7% (38/75)	18.4% (7/38)	39.1% (50/128)
com.example.slabiak.appointmentscheduler.security	0% (0/5)	0% (0/26)	0% (0/12)	0% (0/87)
com.example.slabiak.appointmentscheduler.service.impl	30% (3/10)	19.4% (27/139)	10.9% (20/184)	17.2% (98/569)
com.example.slabiak.appointmentscheduler.util	0% (0/1)	0% (0/2)	0% (0/10)	0% (0/29)
com.example.slabiak.appointmentscheduler.validation	0% (0/3)	0% (0/9)	0% (0/8)	0% (0/26)

generated on 2024-03-03 21:00

Fig 6: Image showing Automated test metrics for Appointment Scheduler



appointmentscheduler

appointmentscheduler

Element	Missed Instructions	Cov.	Missed Branches	Cov.	Missed	Cxty	Missed	Lines	Missed	Methods	Missed	Classes
com.example.slabiak.appointmentscheduler.service.impl		17%		10%	204	237	526	635	117	144	7	10
com.example.slabiak.appointmentscheduler.controller		0%		0%	108	108	300	300	69	69	9	9
com.example.slabiak.appointmentscheduler.security		0%		0%	34	34	95	95	28	28	5	5
com.example.slabiak.appointmentscheduler.entity		32%		14%	94	121	154	222	84	111	5	10
com.example.slabiak.appointmentscheduler.model		31%		18%	55	94	101	171	37	75	2	6
com.example.slabiak.appointmentscheduler.entity.user.provider		6%		0%	18	21	32	37	10	13	0	1
com.example.slabiak.appointmentscheduler.validation		0%		0%	14	14	27	27	9	9	3	3
com.example.slabiak.appointmentscheduler.util		0%		0%	3	3	29	29	2	2	1	1
com.example.slabiak.appointmentscheduler.entity.user.customer		21%		0%	12	16	24	32	10	14	1	3
com.example.slabiak.appointmentscheduler.entity.user		81%		50%	8	36	12	73	5	32	0	2
com.example.slabiak.appointmentscheduler.config		0%		0%	5	5	9	9	4	4	2	2
com.example.slabiak.appointmentscheduler.exception		0%		n/a	3	3	3	3	3	3	3	3
com.example.slabiak.appointmentscheduler		0%		n/a	2	2	3	3	2	2	1	1
Total	5,849 of 6,980	16%	337 of 370	8%	560	694	1,315	1,636	380	506	39	56

Fig 7: Image showing Jacoco Test Metrics Report for the Project

Task-3

For this task, we have to critique the test implementation in the project and provide at least three strong and weak aspects to support our arguments of the test implementation.

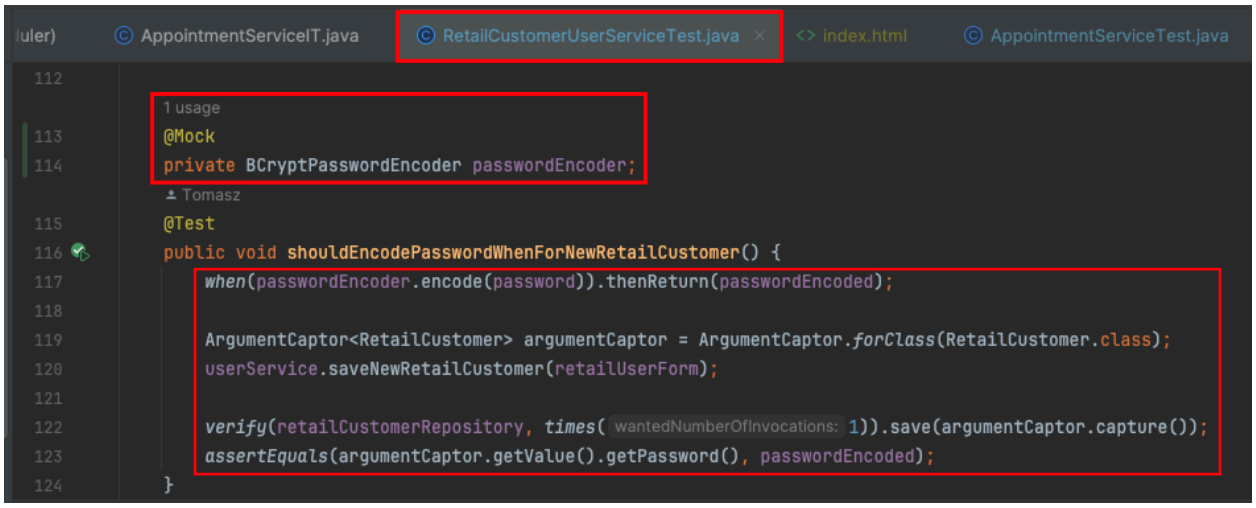
Strong Aspects

With my limited knowledge of the Test Smells and the JUnit Test Best Practices, I could only find one String Aspect for the Test Implementation in the project.

Usage of Mocking

1. **Mocking**
- Mocking is when we create objects that act like their real counterparts.
- They are used to isolate the code being tested and we can control the testing environment.
- The goal of mocking is to mimic the behavior of dependencies without actually invoking them as it makes our test cases as independent as they can be and also, for speed.
- Appointment Scheduler uses Mockito dependency to create and manage mock objects.
- It should also be noted that an over-reliance on mocking can lead to tests that don't accurately reflect the real-world behavior of the system. It's crucial to have a balance between isolating code for testing purposes and ensuring that the tests remain representative of actual system behavior.

2. **Mocking used in the Project**
- The project has multiple instances where mocking is aptly used like shown in the Fig 8.
- There, we can see that the code uses @Mocks to create mock classes for BCryptPasswordEncoder and defines what should happen when the instance if called.



luler)
AppointmentServiceIT.java
RetailCustomerUserServiceTest.java
index.html
AppointmentServiceTest.java
1 usage
Tomasz

```
@Mock
private BCryptPasswordEncoder passwordEncoder;

@Test
public void shouldEncodePasswordWhenForNewRetailCustomer() {
    when(passwordEncoder.encode(password)).thenReturn(passwordEncoded);

    ArgumentCaptor<RetailCustomer> argumentCaptor = ArgumentCaptor.forClass(RetailCustomer.class);
    userService.saveNewRetailCustomer(retailUserForm);

    verify(retailCustomerRepository, times( wantedNumberOfInvocations: 1)).save(argumentCaptor.capture());
    assertEquals(argumentCaptor.getValue().getPassword(), passwordEncoded);
}
```

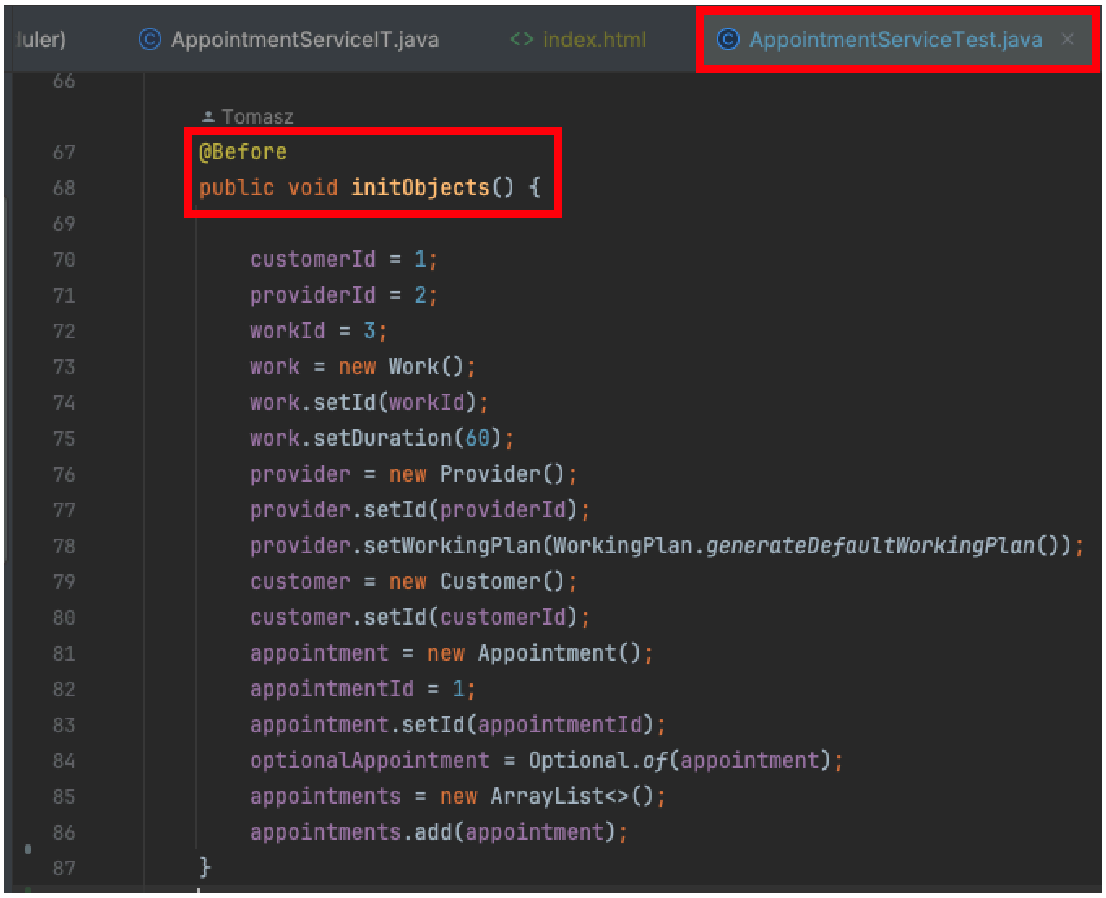
Fig 8: Image showing the use of @Mock and when(...).thenReturn(...) methods

Usage of @Before scripts

1. **@Before notation in JUnit**

- The @Before annotation is used when different test cases share the same logic[6].
- The method with the @Before annotation always runs before the execution of each test case.
- This annotation is commonly used to develop necessary preconditions for each @Test method.
- Some examples of common expensive operations are the creation of a database connection or the startup of a server[7].

2. **Before Scripts in the project**


luler)   AppointmentServiceIT.java   index.html   AppointmentServiceTest.java

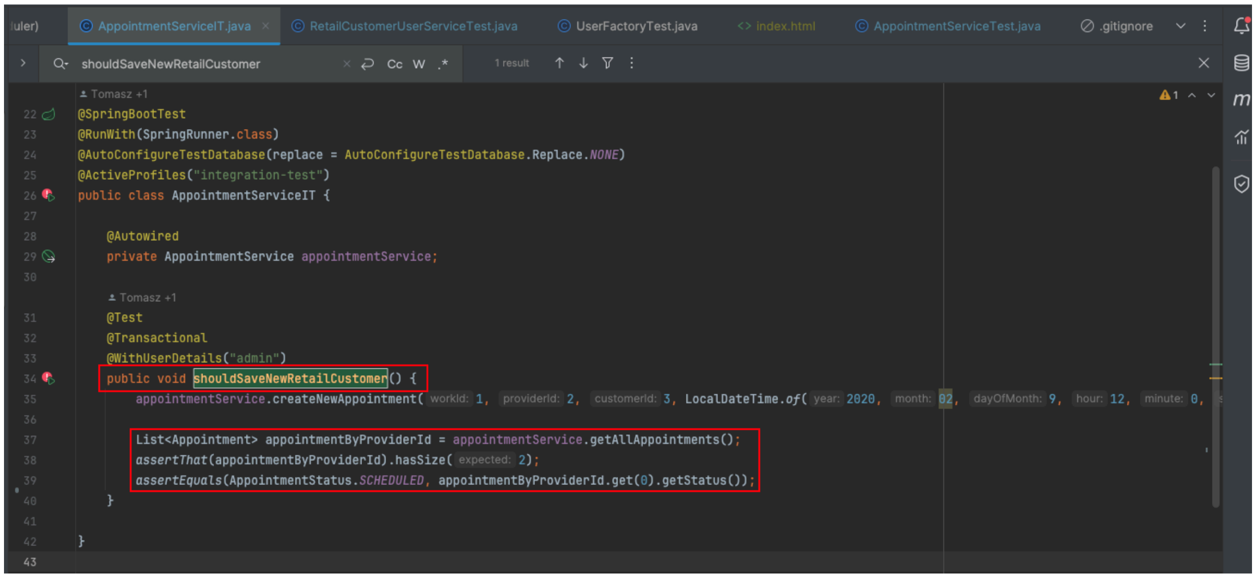
```
Tomasz
@Before
public void initObjects() {

    customerId = 1;
    providerId = 2;
    workId = 3;
    work = new Work();
    work.setId(workId);
    work.setDuration(60);
    provider = new Provider();
    provider.setId(providerId);
    provider.setWorkingPlan(WorkingPlan.generateDefaultWorkingPlan());
    customer = new Customer();
    customer.setId(customerId);
    appointment = new Appointment();
    appointmentId = 1;
    appointment.setId(appointmentId);
    optionalAppointment = Optional.of(appointment);
    appointments = new ArrayList<>();
    appointments.add(appointment);
}
```

Fig 9: Image showing the use of @Before script

Weak Aspects

Ambiguous Test Naming

- For enhanced code comprehension, we should ensure that the names of test methods correctly convey the functionality they are verifying.
- This helps easier understanding for other developers regarding the purpose of each test.
- In the project, we can see that there is a test with a misleading name.
- In Fig 10, we can he test method named "shouldSaveNewRetailCustomer" is not the best choice because it suggests that the test is about saving a retail customer, while it's testing the creation of a new appointment



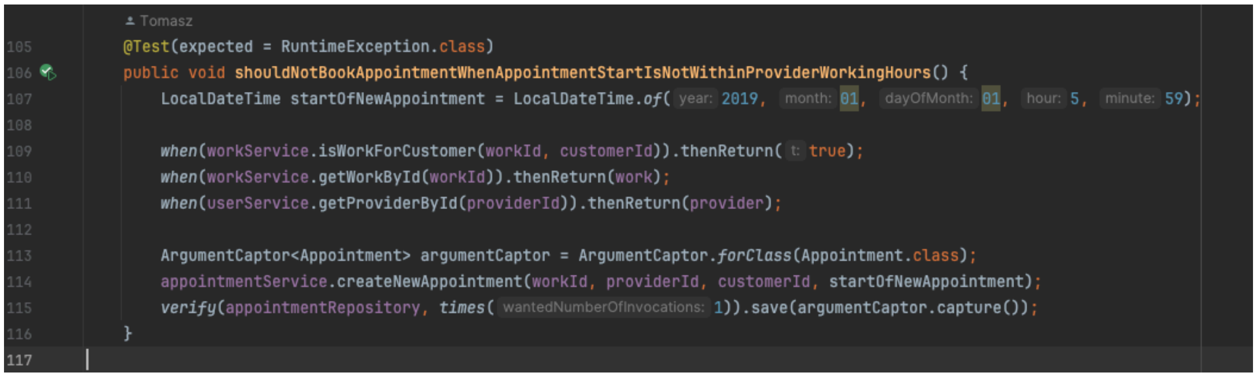
uler)
AppointmentServiceIT.java
RetailCustomerUserServiceTest.java
UserFactoryTest.java
index.html
AppointmentServiceTest.java
.gitignore
shouldSaveNewRetailCustomer
Cc W .*
1 result

```
Tomasz +1
@SpringBootTest
@RunWith(SpringRunner.class)
@AutoConfigureTestDatabase(replace = AutoConfigureTestDatabase.Replace.NONE)
@ActiveProfiles("integration-test")
public class AppointmentServiceIT {

    @Autowired
    private AppointmentService appointmentService;

    Tomasz +1
    @Test
    @Transactional
    @WithUserDetails("admin")
    public void shouldSaveNewRetailCustomer() {
        appointmentService.createNewAppointment( workId: 1,  providerId: 2,  customerId: 3, LocalDateTime.of( year: 2020,  month: 02,  dayOfMonth: 9,  hour: 12,  minute: 0,

        List<Appointment> appointmentByProviderId = appointmentService.getAllAppointments();
        assertThat(appointmentByProviderId).hasSize( expected: 2);
        assertEquals(AppointmentStatus.SCHEDULED, appointmentByProviderId.get(0).getStatus());
    }

}
```

Fig 10: Image showing the min-naming of the shouldSaveNewRetailCustomer() test

Magic Numbers and Exception testing

- Currently, the Test cases majorly use magic numbers as test data, which can hinder understanding for others about the reasoning behind using them (See Fig 11).
- To improve, we can replace the magic numbers with constant data for improved clarity.
- The test folder's unit tests often ignore the scenarios leading to cases where Exceptions can be raised.
- We can add unit tests by considering scenarios where the program may result in runtime exceptions.

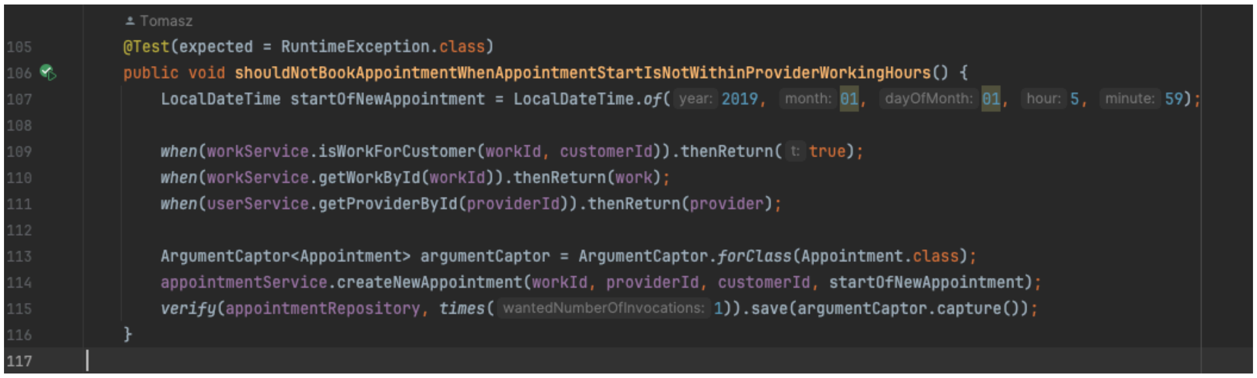


```java
≗ Tomasz
@Test(expected = RuntimeException.class)
public void shouldNotBookAppointmentWhenAppointmentStartIsNotWithinProviderWorkingHours() {
    LocalDateTime startOfNewAppointment = LocalDateTime.of( year: 2019, month: 01, dayOfMonth: 01, hour: 5, minute: 59);

    when(workService.isWorkForCustomer(workId, customerId)).thenReturn( t: true);
    when(workService.getWorkById(workId)).thenReturn(work);
    when(userService.getProviderById(providerId)).thenReturn(provider);

    ArgumentCaptor<Appointment> argumentCaptor = ArgumentCaptor.forClass(Appointment.class);
    appointmentService.createNewAppointment(workId, providerId, customerId, startOfNewAppointment);
    verify(appointmentRepository, times( wantedNumberOfInvocations: 1)).save(argumentCaptor.capture());
}
```

Fig 11: Image showing use of the Magic-number in the shouldNotBookAppointmentWhenAppointmentStartIsNotWithinProviderWorkingHours() test

Documentation and Comments

- Currently, the test methods currently lack comments and proper documentation outlining the actual job of the test and verification it performs.
- Including proper comments describing the expected behavior of the test can significantly improve the understandability of the tests for other developers.
- It is a best practice to follow to consistently include comments and documentation within the test case code.
- By using JavaDocs, we can get a structured approach for thorough commenting and style of the test code.
- As seen in Fig 12, the test's objective is currently ambiguous, and the absence of a comment contributes to the lack of clarity. With a descriptive comment, the true purpose of the test would become comprehensible.



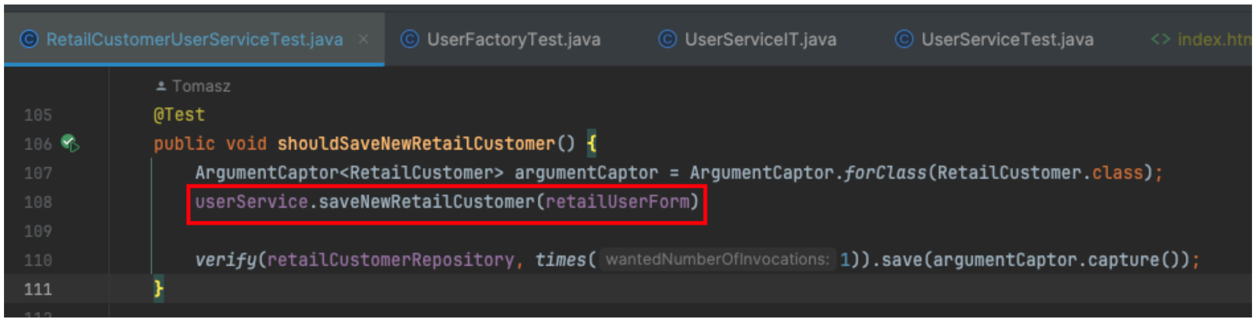
```java
≗ Tomasz
@Test(expected = RuntimeException.class)
public void shouldNotBookAppointmentWhenAppointmentStartIsNotWithinProviderWorkingHours() {
    LocalDateTime startOfNewAppointment = LocalDateTime.of( year: 2019, month: 01, dayOfMonth: 01, hour: 5, minute: 59);

    when(workService.isWorkForCustomer(workId, customerId)).thenReturn( t: true);
    when(workService.getWorkById(workId)).thenReturn(work);
    when(userService.getProviderById(providerId)).thenReturn(provider);

    ArgumentCaptor<Appointment> argumentCaptor = ArgumentCaptor.forClass(Appointment.class);
    appointmentService.createNewAppointment(workId, providerId, customerId, startOfNewAppointment);
    verify(appointmentRepository, times( wantedNumberOfInvocations: 1)).save(argumentCaptor.capture());
}
```

Fig 12: Lack of proper commenting makes it difficult to understand the test's intent

Live Database Connections

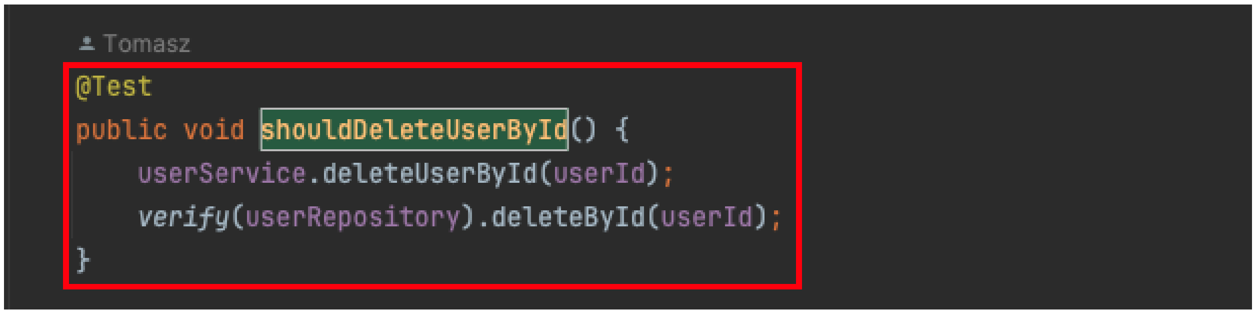
- In the repository test cases, we can notice that it's a standard practice to establish direct connections with databases for various operations.
- When conducting unit tests with JUnit, it is advisable to test one method in isolation at a time. It helps in avoiding dependencies on other classes or databases.

- When a method interfaces with external components such as databases, it can introduce delay and add complexity to the testing process.
- To streamline testing, we generate stubs, fakes, or mock objects for these external dependencies, ensuring the effectiveness of the tests independently of other code.
- In Fig 13 and Fig 14, we can clearly see that the test cases actually try to interact with the database object that go against the best practices.



```
RetailCustomerUserServiceTest.java ×   UserFactoryTest.java   UserServiceIT.java   UserServiceTest.java   <> index.htm

    Tomasz
    @Test
    public void shouldSaveNewRetailCustomer() {
        ArgumentCaptor<RetailCustomer> argumentCaptor = ArgumentCaptor.forClass(RetailCustomer.class);
        userService.saveNewRetailCustomer(retailUserForm)

        verify(retailCustomerRepository, times( wantedNumberOfInvocations: 1)).save(argumentCaptor.capture());
    }
```

Fig 13: Image showing the mis-naming of the shouldSaveNewRetailCustomer() test

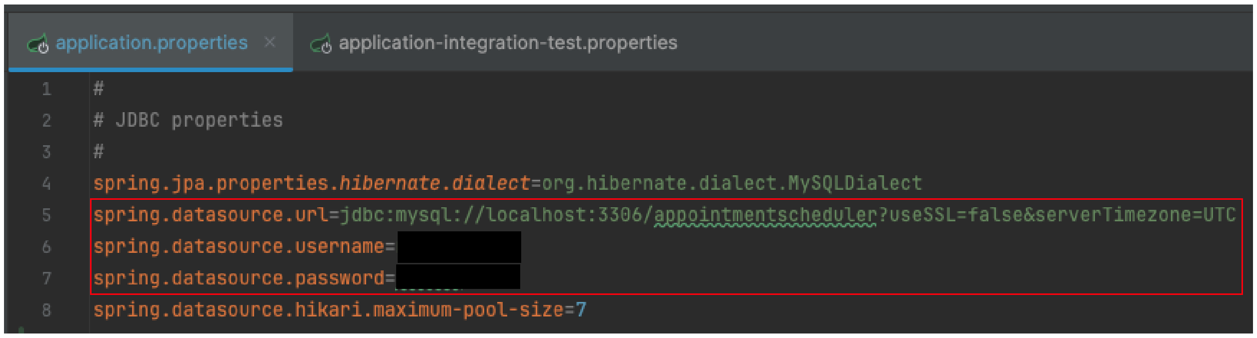


```
Tomasz
@Test
public void shouldDeleteUserById() {
    userService.deleteUserById(userId);
    verify(userRepository).deleteById(userId);
}
```

Fig 14: Image showing the min-naming of the shouldSaveNewRetailCustomer() test

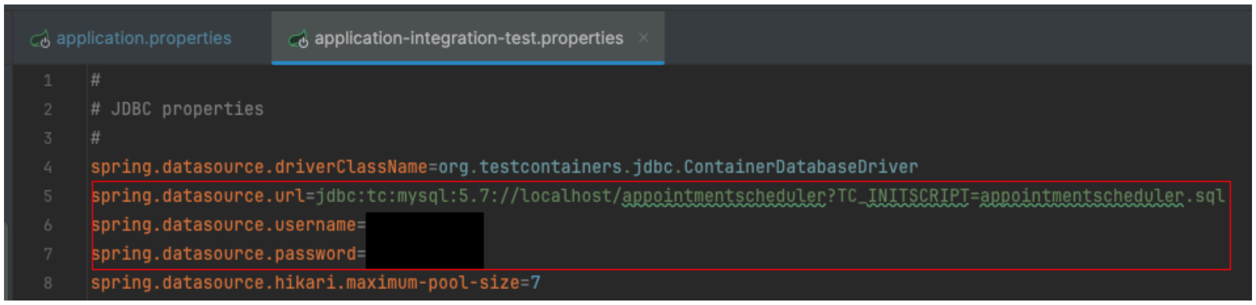
Production Database Connection made in Test Environment

- In the property files for the main src application and the test folder, the property file mentions the database connection string as a different parameter (See Fig 15 for reference)



```
application.properties ×   application-integration-test.properties

#
# JDBC properties
#
spring.jpa.properties.hibernate.dialect=org.hibernate.dialect.MySQLDialect
spring.datasource.url=jdbc:mysql://localhost:3306/appointmentscheduler?useSSL=false&serverTimezone=UTC
spring.datasource.username=[redacted]
spring.datasource.password=[redacted]
spring.datasource.hikari.maximum-pool-size=7
```

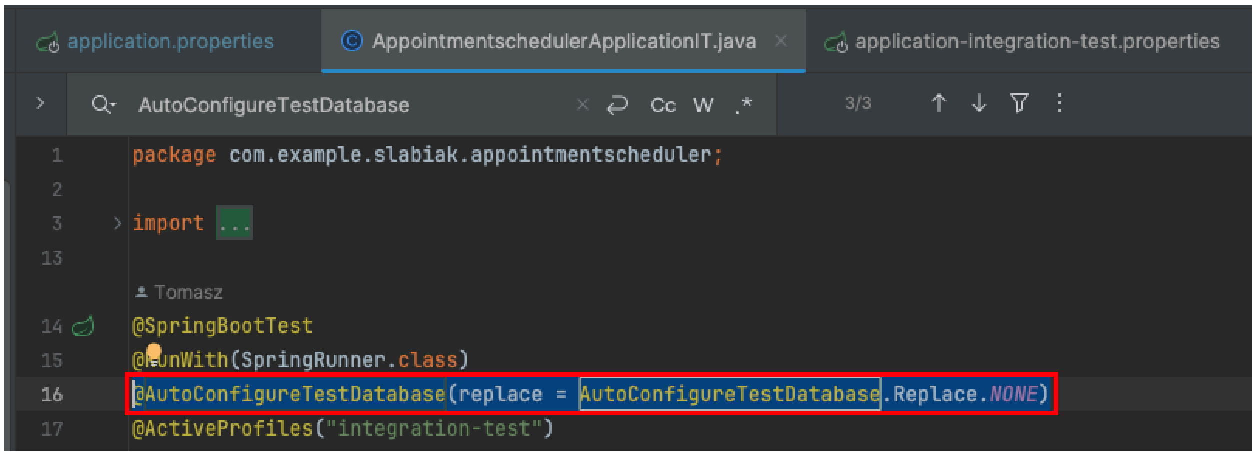
Fig 15: Application property file - Main Application



```
#
# JDBC properties
#
spring.datasource.driverClassName=org.testcontainers.jdbc.ContainerDatabaseDriver
spring.datasource.url=jdbc:tc:mysql:5.7://localhost/appointmentscheduler?TC_INITSCRIPT=appointmentscheduler.sql
spring.datasource.username=[redacted]
spring.datasource.password=
spring.datasource.hikari.maximum-pool-size=7
```

Fig 16: Application property file - Test sub-directory

- We can notice that this configuration will be making the changes directly in the production database because of the code shown in the Fig 17


application.properties
AppointmentschedulerApplicationIT.java
application-integration-test.properties
AutoConfigureTestDatabase
Cc
W
.*
3/3
Tomasz

```
package com.example.slabiak.appointmentscheduler;

import ...

@SpringBootTest
@RunWith(SpringRunner.class)
@AutoConfigureTestDatabase(replace = AutoConfigureTestDatabase.Replace.NONE)
@ActiveProfiles("integration-test")
```

Fig 17: Main Test file - Test subdirectory reusing the same database connection

- The test will be using the same database configuration as the main application and it will be affecting the production Data.
- To correct this, we might need a separate testing schema to avoid interfering with the production.

Task-4

For this part, we have to Implement at least **three** new tests for the repository. It could be for new source code elements (new class or method) or for existing code. The newly added tests must not fail due to compilation issues; however, it is fine if they identify a new bug in the project.

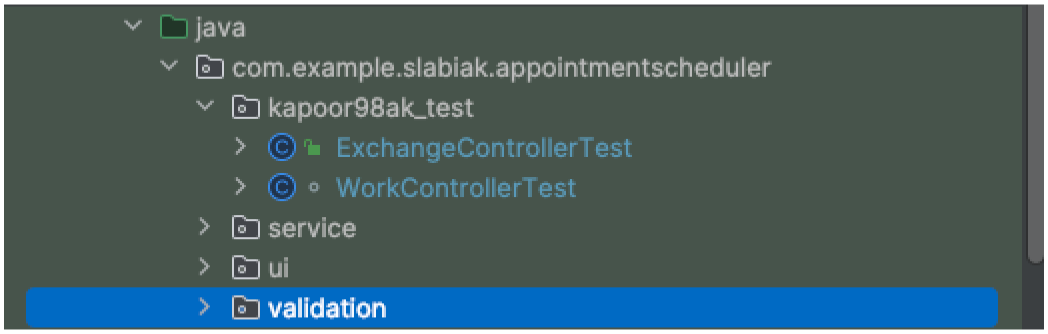
The newly added tests must improve the code coverage and not be trivial (for example, creating a new test from an existing test by changing the passed parameters; or, creating a test case for getter/setter method).

I tested the following two controller classes, as the repository did not include test cases for them:

- WorkController
- ExchangeController

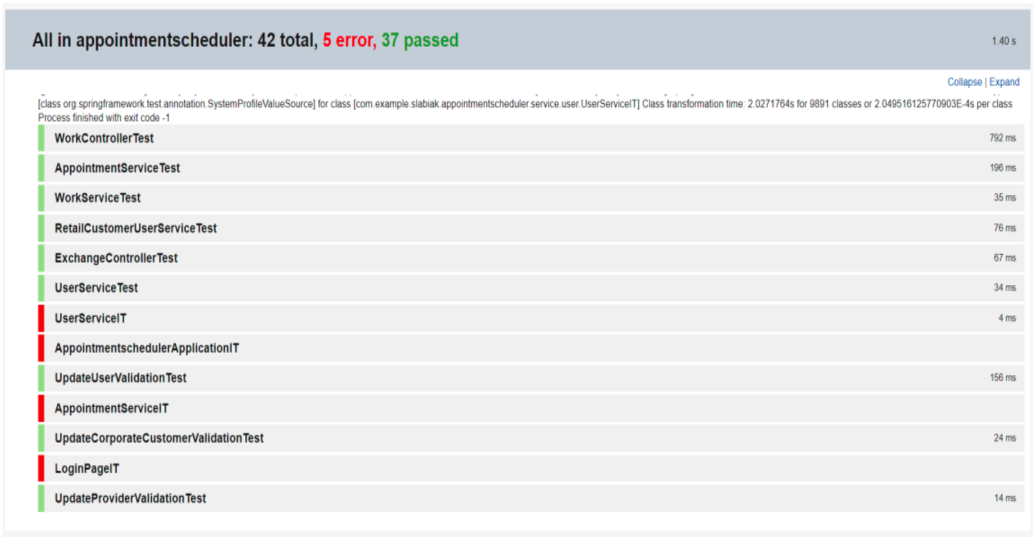
The test cases are pushed to the repository.

Test cases are listed in Fig 18.



```
java
  com.example.slabiak.appointmentscheduler
    kapoor98ak_test
      ExchangeControllerTest
      WorkControllerTest
    service
    ui
    validation
```

Fig 18: Created Test Cases for the Appointment Builder



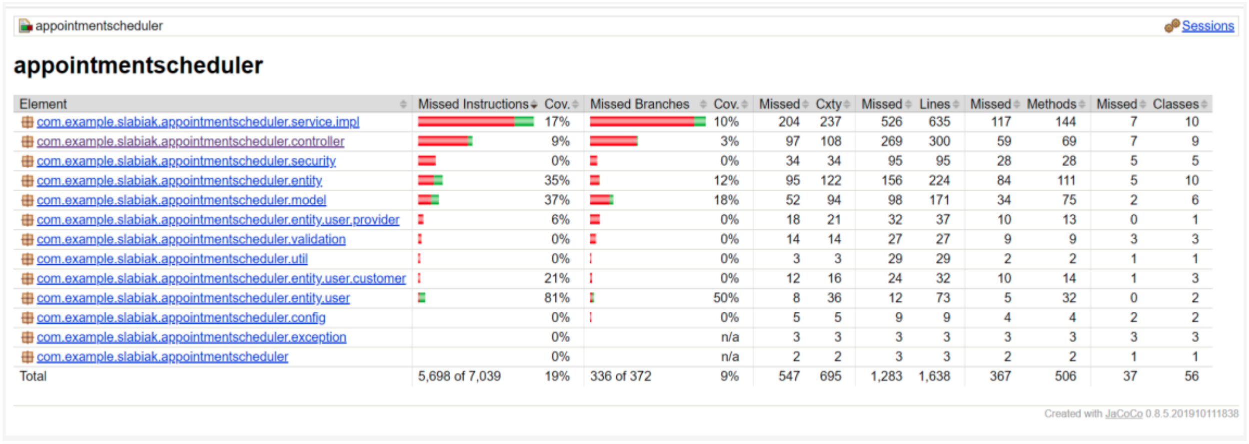
All in appointmentscheduler: 42 total, 5 error, 37 passed 1.40 s

Collapse | Expand

```
[class org.springframework.test.annotation.SystemProfileValueSource] for class [com.example.slabiak.appointmentscheduler.service.user.UserServiceIT] Class transformation time: 2.0271764s for 9891 classes or 2.049516125770903E-4s per class
Process finished with exit code -1
```

WorkControllerTest	792 ms
AppointmentServiceTest	196 ms
WorkServiceTest	35 ms
RetailCustomerUserServiceTest	76 ms
ExchangeControllerTest	67 ms
UserServiceTest	34 ms
UserServiceIT	4 ms
AppointmentschedulerApplicationIT	
UpdateUserValidationTest	156 ms
AppointmentServiceIT	
UpdateCorporateCustomerValidationTest	24 ms
LoginPageIT	
UpdateProviderValidationTest	14 ms

Fig 20: New result of Automated Tests



appointmentscheduler Sessions

appointmentscheduler

Element	Missed Instructions	Cov.	Missed Branches	Cov.	Missed	Cxty	Missed	Lines	Missed	Methods	Missed	Classes
com.example.slabiak.appointmentscheduler.service.impl		17%		10%	204	237	526	635	117	144	7	10
com.example.slabiak.appointmentscheduler.controller		9%		3%	97	108	269	300	59	69	7	9
com.example.slabiak.appointmentscheduler.security		0%		0%	34	34	95	95	28	28	5	5
com.example.slabiak.appointmentscheduler.entity		35%		12%	95	122	156	224	84	111	5	10
com.example.slabiak.appointmentscheduler.model		37%		18%	52	94	98	171	34	75	2	6
com.example.slabiak.appointmentscheduler.entity.user.provider		6%		0%	18	21	32	37	10	13	0	1
com.example.slabiak.appointmentscheduler.validation		0%		0%	14	14	27	27	9	9	3	3
com.example.slabiak.appointmentscheduler.util		0%		0%	3	3	29	29	2	2	1	1
com.example.slabiak.appointmentscheduler.entity.user.customer		21%		0%	12	16	24	32	10	14	1	3
com.example.slabiak.appointmentscheduler.entity.user		81%		50%	8	36	12	73	5	32	0	2
com.example.slabiak.appointmentscheduler.config		0%		0%	5	5	9	9	4	4	2	2
com.example.slabiak.appointmentscheduler.exception		0%		n/a	3	3	3	3	3	3	3	3
com.example.slabiak.appointmentscheduler		0%		n/a	2	2	3	3	2	2	1	1
Total	5,698 of 7,039	19%	336 of 372	9%	547	695	1,283	1,638	367	506	37	56

Created with JaCoCo 0.8.5.201910111838

Fig 21: New result of Code Coverage

References

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[2] Appointment scheduler. [Online]. Available: https://github.com/slabiak/AppointmentScheduler/.

[3] Baeldung. "Code Coverage." Baeldung, January 1, 2024. [Online]. Available: https://www.baeldung.com/cs/code-coverage.

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[6] Educative. “What is the @Before annotation in JUnit testing?”. [Online]. Available: https://www.educative.io/answers/what-is-the-before-annotation-in-junit-testing

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