45426: Teste e Qualidade de Software

Integration testing (and Spring Boot)

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Learning objetives

Relate the test of API with the right level of testing in the “pyramid of tests”

Justify the need for “slicing” test scopes.

Discuss diferente strategies to test layered applicationsin Spring Boot.

Read SpringBoot tests with mocking of dependencies.

Popular testing tools for the Java developer

Basics (unit)

JUnit, TestNG

Spock

Hamcrest, AssertJ, Truth

Multi-layer apps/backend

Arquillian

SpringBoot testing

Mocking objects behavior

Mockito

EasyMock

Web/functional testing

Selenium IDE

API Testing

REST-Assured

Story-driven (BDD)

Cucumber

See also: https://dzone.com/articles/10-essential-testing-tools-for-java-developers

Hamcrest

“Matchers” that can be combined to create flexible expressions of intent (in unit testing)

Matchers as used for “asserts” but **also to define expectations** in mocks.

guide/reference

```
assertThat(5, Matchers.equalTo(5));

assertThat(5, Matchers.greaterThanOrEqualTo(5));

assertThat(str1, equalToIgnoringWhiteSpace(str2));

// collections
assertThat(emptyList, empty());

String[] hamcrestMatchers = { "collections", "beans",
"text", "number" };
assertThat("text", isOneOf(hamcrestMatchers));

// object level inspection
assertThat(person, hasProperty("address", equalTo("New
York")));
assertThat(person1, samePropertyValuesAs(person2));
```

AssertJ (similar to Google Truth)

Integrated in Spring Boot

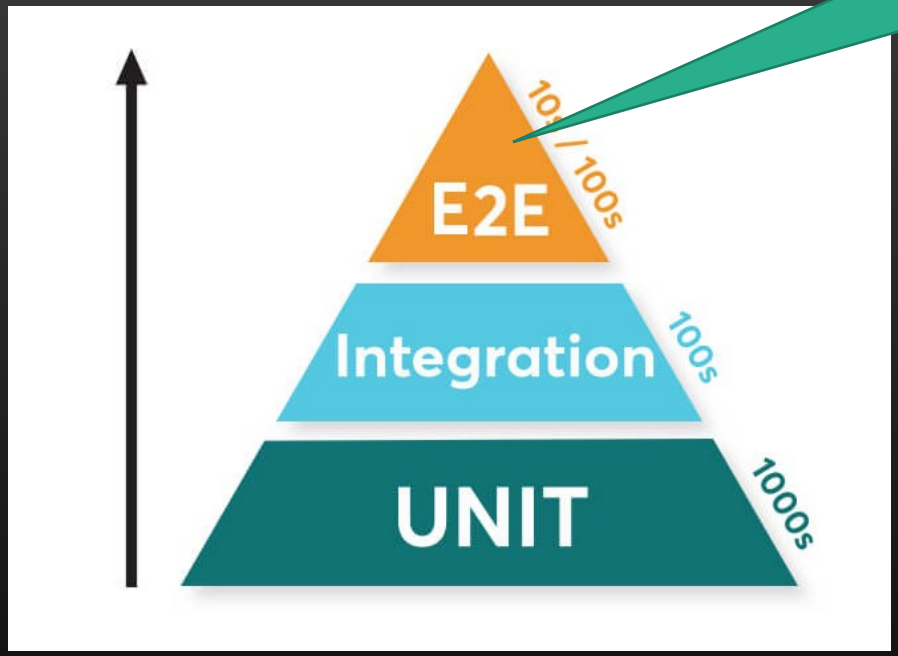
Fluent assertions, with method chaining syntax:

```
// basic assertions
assertThat(frodo.getName()).isEqualTo("Frodo");
assertThat(frodo).isNotEqualTo(sauron);

// chaining string specific assertions
assertThat(frodo.getName()).startsWith("Fro")
                           .endsWith("do")
                           .isEqualToIgnoringCase("frodo");

// collection specific assertions (there are plenty more)
// in the examples below fellowshipOfTheRing is a List<TolkienCharacter>
assertThat(fellowshipOfTheRing).hasSize(9)
                               .contains(frodo, sam)
                               .doesNotContain(sauron);

// as() is used to describe the test and will be shown before the error message
assertThat(frodo.getAge()).as("check %s's age", frodo.getName()).isEqualTo(33);
```

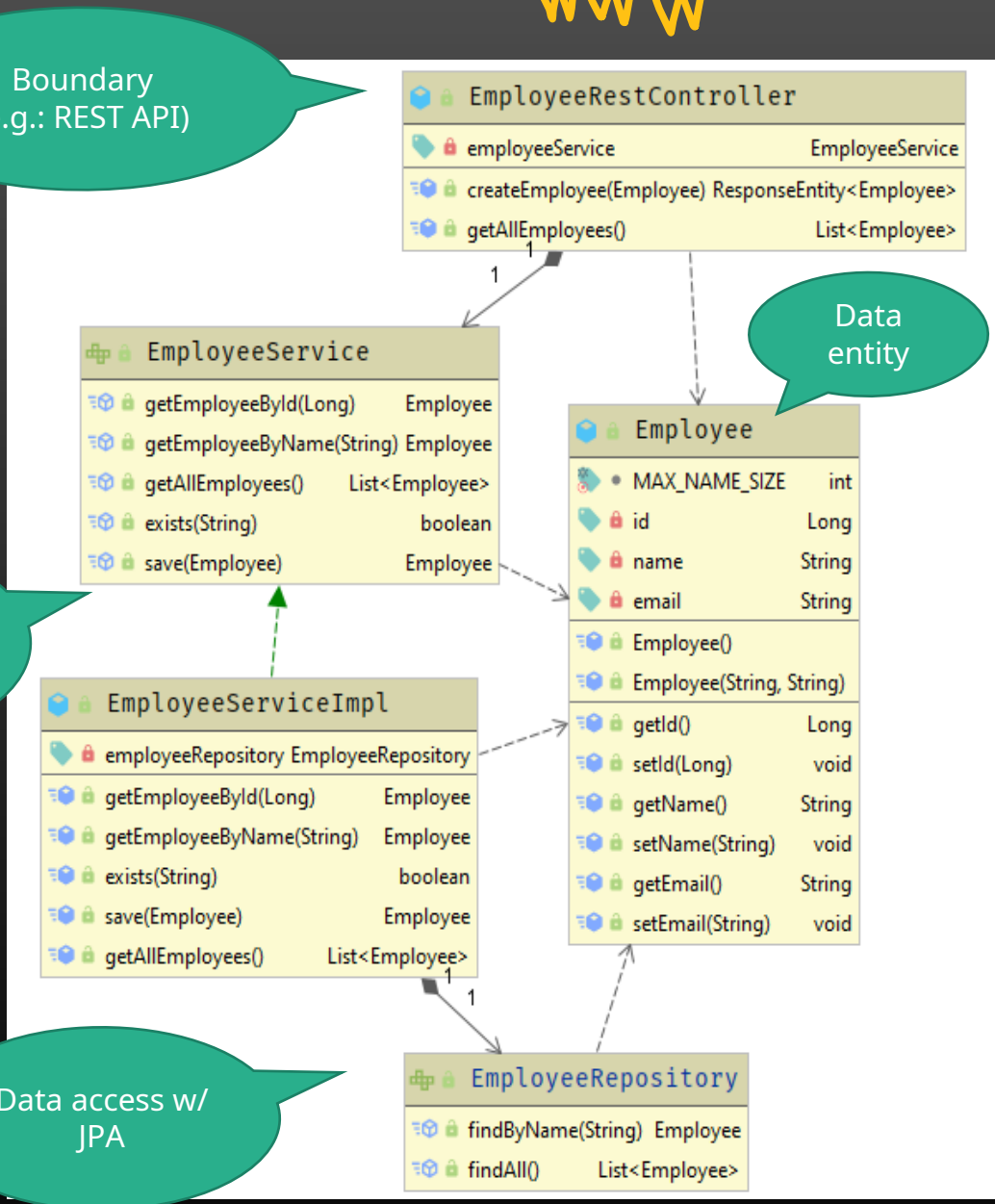

See also: https://www.baeldung.com/introduction-to-assertj

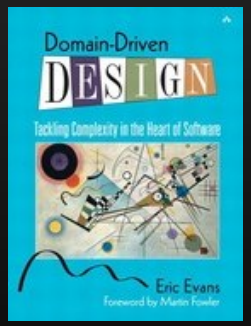
Recall UAT scope

What can we conclude about the root case of an error, when an acceptance test fails?



SB typical layers





https://learning.oreilly.com/library/view/domain-driven-design-tackling/0321125215/

BD

```java
@RestController
@RequestMapping("/api")
public class EmployeeRestController {

    @Autowired
    private EmployeeService employeeService;

    @PostMapping("/employees" )
    public ResponseEntity<Employee> createEmployee(@RequestBody Employee employee) {
        HttpStatus status = HttpStatus.CREATED;
        Employee saved = employeeService.save(employee);
        return new ResponseEntity<>(saved, status);
    }
```

Boundary

```java
@Service
public class EmployeeServiceImpl implements EmployeeService {

    @Autowired
    private EmployeeRepository employeeRepository;
```

Domain logic

```java
@Repository
public interface EmployeeRepository
        extends JpaRepository<Employee, Long> {

    public Employee findByName(String name);

    public List<Employee> findAll();

}
```

Data access

Spring Boot components

Components registration

In each layer, we have various components.

Simply put, to detect them automatically, Spring uses classpath scanning annotations.

Then, it registers each component in the ApplicationContext.

A few of these annotations:

@Component: generic stereotype for any Spring-managed component

@Service: "components" meant to be used at the service layer

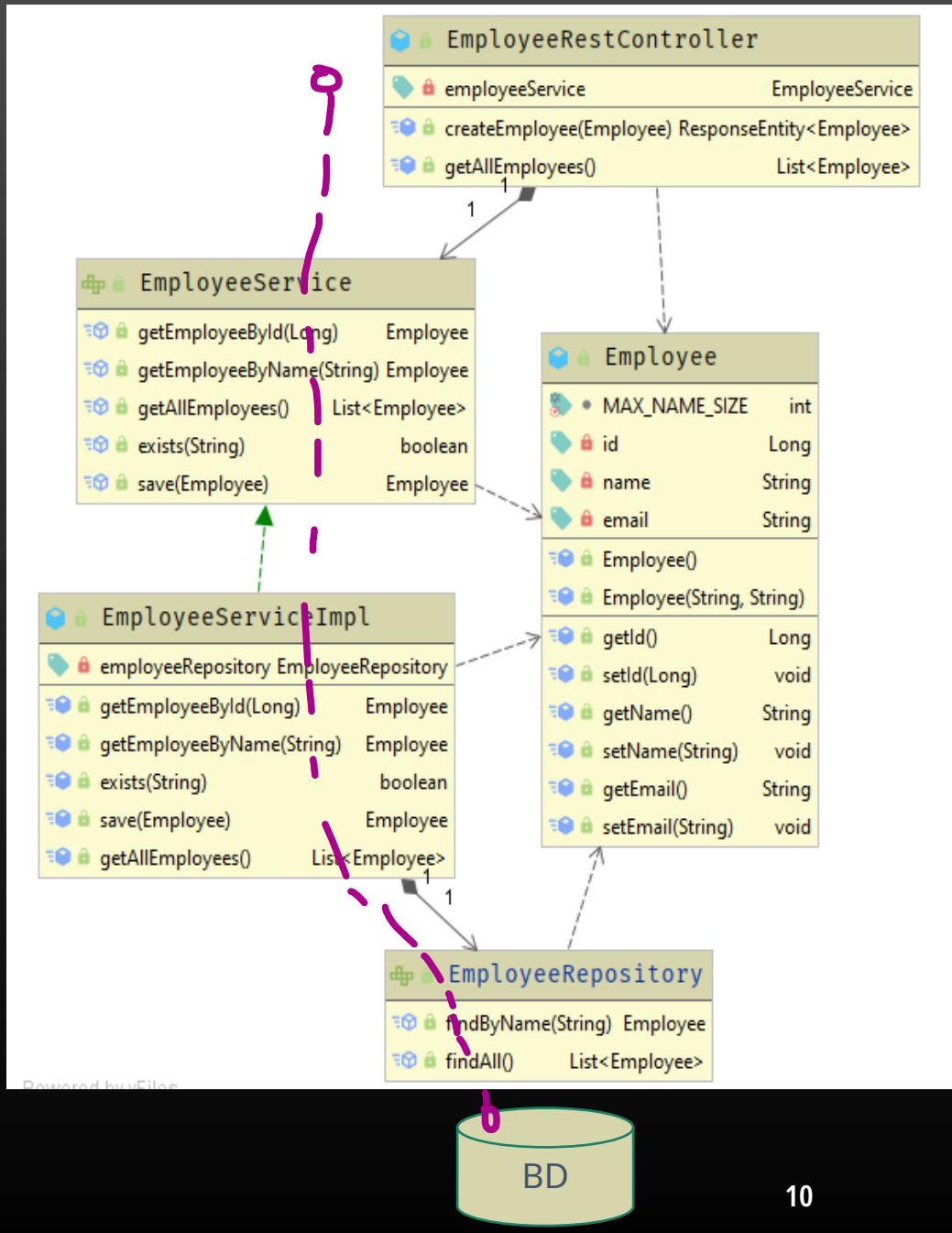
@Repository: classes at the persistence layer, which will act as a database repository

@Service and *@Repository* are special cases of *@Component*.

Test scope

Scenario:

- call the REST-endpoint and verify behavior
- full-scope integration test



Spring Boot testing

A helper framework used to simplify the creation of Spring Framework apps

Provides:

- Curated dependencies
- “Starter” configurations (data, web, testing,...)
- “Opinionated” auto-configuration of many components
- Sensible defaults

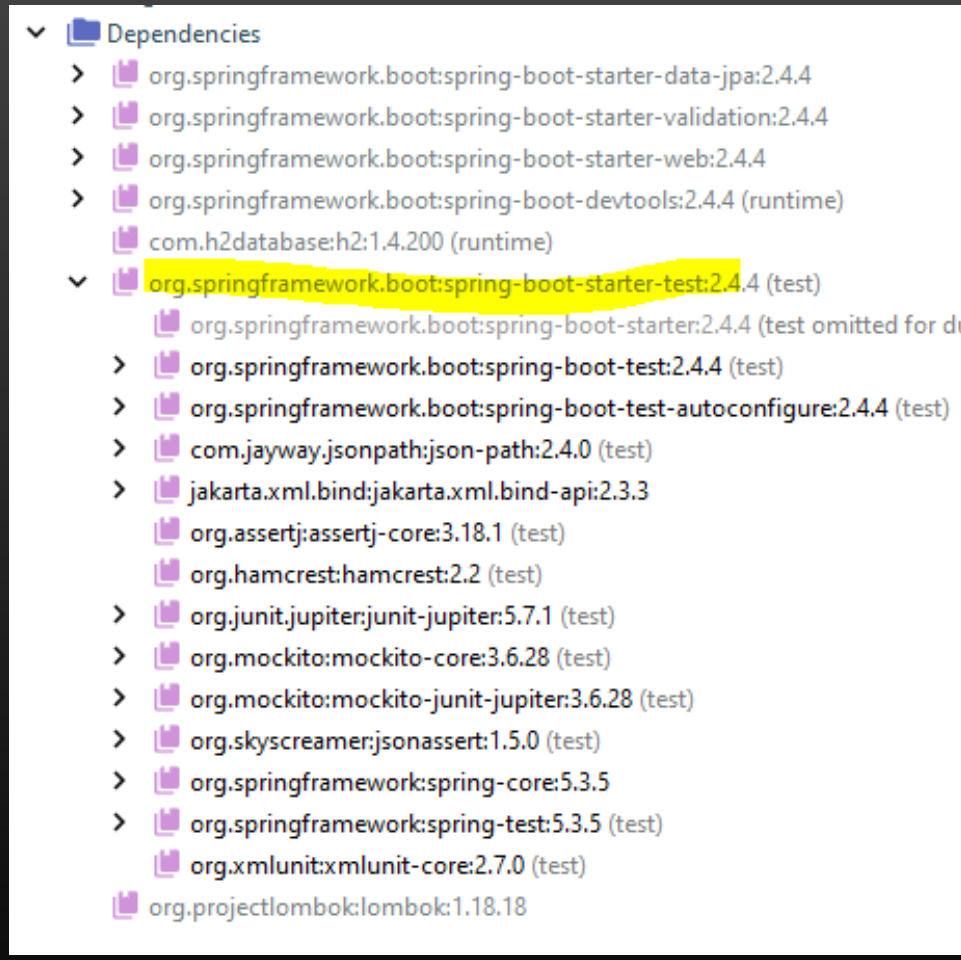
Extending SB philosophy to testing

Test features enabled with

- **spring-boot-starter-test**

Starter provides:

- Helpful testing dependencies
- Testing auto-config



Testing the REST controller (full stack, web server started)

```java
@SpringBootTest(webEnvironment = WebEnvironment.RANDOM_PORT)
@AutoConfigureTestDatabase     //prepare automatic in-memory db for tests
public class EmployeeRestControllerTemplateIT {

    // prepare an special HTTP client for tests
    @Autowired
    private TestRestTemplate restTemplate;

    @Autowired
    private EmployeeRepository repository;

    @AfterEach
    public void resetDb() { repository.deleteAll(); }

    @Test
    public void whenValidInput_thenCreateEmployee() {
        Employee bob = new Employee( name: "bob",  email: "bob@deti.com");
        ResponseEntity<Employee> entity = restTemplate.postForEntity( url: "/api/employees", bob, Employee.class

        // was the POST able to save one new entity?
        List<Employee> found = repository.findAll();
        assertThat(found).extracting(Employee::getName).containsOnly("bob");
    }

    @Test
    public void givenEmployees_whenGetEmployees_thenStatus200()  {
        insertTestEmployeeToRepo( name: "bob",  email: "bob@deti.com");
        insertTestEmployeeToRepo( name: "alex",  email: "alex@deti.com");

        ResponseEntity<List<Employee>> response =
                restTemplate.exchange( url: "/api/employees", HttpMethod.GET,  requestEntity: null, new ParameterizedT
        // did the GET retrieved exactly two instances?
        assertThat(response.getStatusCode()).isEqualTo(HttpStatus.OK);
        assertThat(response.getBody()).extracting(Employee::getName).containsExactly("bob",  "alex");
```

```java
@SpringBootTest(webEnvironment = WebEnvironment.RANDOM_PORT)
@AutoConfigureTestDatabase     //prepare automatic in-memory db for tests
public class EEmployeeRestControllerTemplateIT {

    // prepare an special HTTP client for tests
    @Autowired
    private TestRestTemplate restTemplate;

    @Autowired
    private EmployeeRepository repository;

    @AfterEach
    public void resetDb() { repository.deleteAll(); }

    @Test
    public void whenValidInput_thenCreateEmployee() {
        Employee bob = new Employee( name: "bob",  email: "bob@deti.com");
        ResponseEntity<Employee> entity = restTemplate.postForEntity( url: "/api/employees",

        // was the POST able to save one new entity?
        List<Employee> found = repository.findAll();
        assertThat(found).extracting(Employee

    }
```

Interact w/ controller using a REST client

Optionally use a mocked servlet environment

```java
@SpringBootTest(webEnvironment = WebEnvironment.MOCK )
@AutoConfigureMockMvc
@AutoConfigureTestDatabase
public class DEmployeeRestControllerIT {

    @Autowired
    private MockMvc mvc;

    @Autowired
    private EmployeeRepository repository;

    @AfterEach
    public void resetDb() { repository.deleteAll(); }

    @Test
    public void whenValidInput_thenCreateEmployee() throws IOException, Exception {
        Employee bob = new Employee( name: "bob",  email: "bob@deti.com");
        mvc.perform(post( urlTemplate: "/api/employees")
                .contentType(MediaType.APPLICATION_JSON)
                .content(JsonUtil.toJson(bob)));

        List<Employee> found = repository.findAll();
        assertThat(found).extracting(Employee::getName).containsOnly("bob");
```

Interact w/ controller using the MockMvc interface

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. (Most of the stack is used; your code will be called in the same way; removes the cost of starting the server.)

@SpringBootTest

@SpringBootTest annotation

Enable FULL context, using all available auto configurations

Heavy!

better to limit Application Context to a set of spring components that participate in test scenario, by listing them (with annotations)

Slicing the test context

Only load slices of functionality when testing spring boot

@xxxxxTest at class level, e.g.: @DataJpaTest, @DataMongoTest, @JsonTest, @WebMvcTest,...

Mind JUnit version

@RunWith(SpringRunner.class) required for JU4

SpringRunner is an alias for the SpringJUnit4ClassRunner.

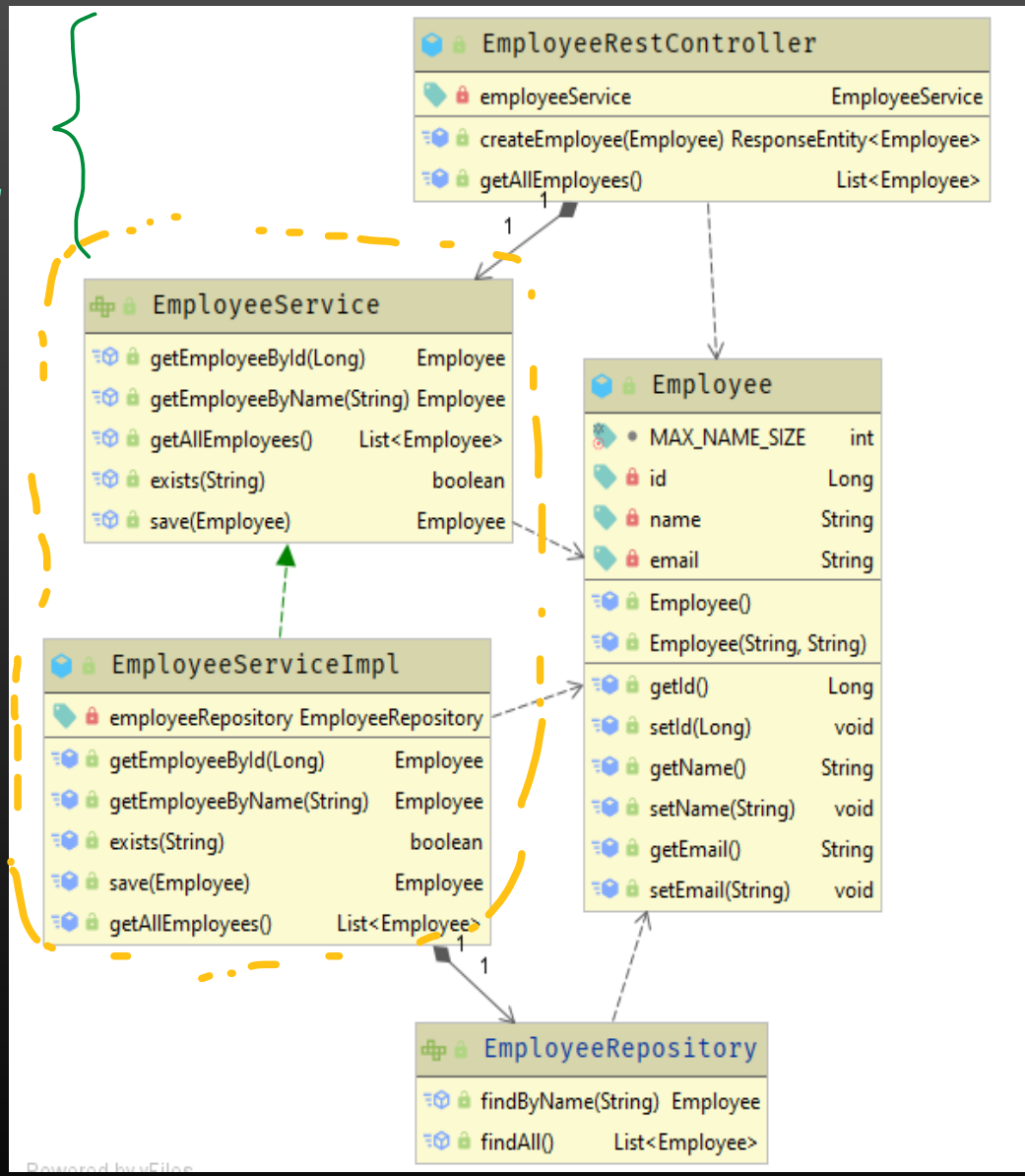
Test scope: controller

Scenario:

- Test the boundary (Controller)
- Focus on REST contract: path expressions, parameters, JSON,...

Strategy:

- Enable web MVC
- Mock Service behavior



MockMvc

```java
@WebMvcTest(EmployeeRestController.class)
public class EmployeeController_WithMockServiceIT {

    @Autowired
    private MockMvc mvcForTests;

    @MockBean
    private EmployeeService service;

    @Test
    public void whenPostEmployee_thenCreateEmployee( ) throws Exception {
        Employee alex = new Employee( name: "alex",  email: "alex@deti.com");

        given(service.save(Mockito.any())).willReturn(alex);
        // when( service.save(Mockito.any()) ).thenReturn( alex);

        mvcForTests.perform(post( urlTemplate: "/api/employees")
                .contentType(MediaType.APPLICATION_JSON)
                .content(JsonUtil.toJson(alex)))
                .andExpect(status().isCreated())
                .andExpect(jsonPath( expression: "$.name", is( value: "alex")));
        verify(service, times( wantedNumberOfInvocations: 1)).save(Mockito.any());
    }

    @Test
    public void givenEmployees_whenGetEmployees_thenReturnJsonArray() throws Exception {
        Employee alex = new Employee( name: "alex",  email: "alex@deti.com");
        Employee john = new Employee( name: "john",  email: "john@deti.com");
        Employee bob = new Employee( name: "bob",  email: "bob@deti.com");
        List<Employee> allEmployees = Arrays.asList(alex, john, bob);

        given(service.getAllEmployees()).willReturn(allEmployees);

        mvcForTests.perform(get( urlTemplate: "/api/employees").contentType(MediaType.APPLICATION_JSON))
                .andExpect(status().isOk())
                .andExpect(jsonPath( expression: "$", hasSize(3)))
                .andExpect(jsonPath( expression: "$[0].name", is(alex.getName())))
                .andExpect(jsonPath( expression: "$[1].name", is(john.getName())))
                .andExpect(jsonPath( expression: "$[2].name", is(bob.getName())));

        verify(service, VerificationModeFactory.times( wantedNumberOfInvocations: 1)).getAllEmployees();
    }
```

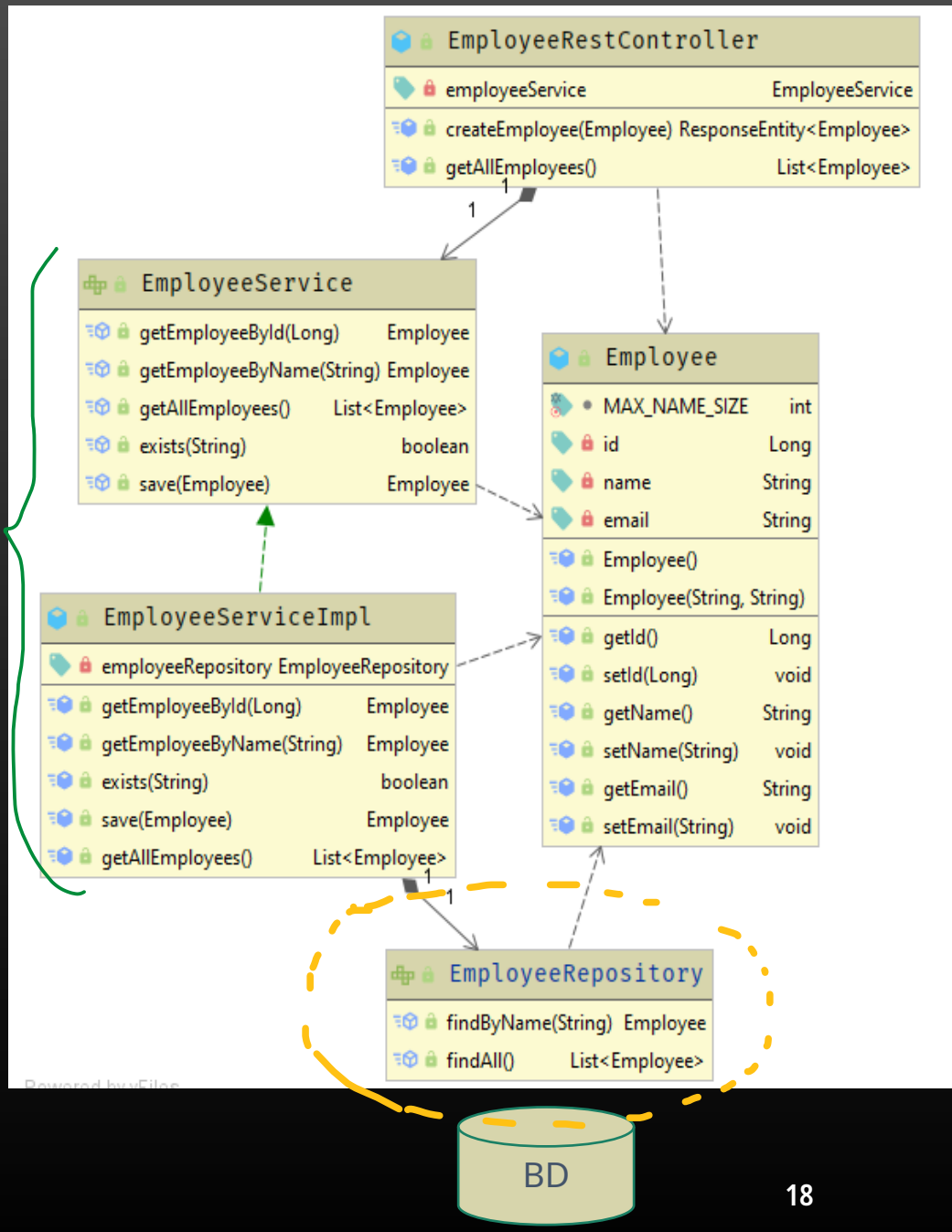
Test scope: service /domain logic

Scenario:

- Test the Service
- Focus on bizz logic and “high level” data use

Strategy:

- Make the test a standard JUnit test
- Mock dependencies on the data source provider (Repository)



Mock repository access

```java
@ExtendWith(MockitoExtension.class)
public class EmployeeService_UnitTest {

    // lenient is required because we load some expectations in the setup
    // that are not used in all the tests. As an alternative, the expectations
    // could move into each test method and be trimmed
    @Mock( lenient = true)
    private EmployeeRepository employeeRepository;

    @InjectMocks
    private EmployeeServiceImpl employeeService;

    // useful instances
    private Employee john, bob, alex;

    @BeforeEach
    public void setUp() {
        john = new Employee( name: "john",  email: "john@deti.com"); john.setId(111L);
        bob = new Employee( name: "bob",  email: "bob@deti.com");
        alex = new Employee( name: "alex",  email: "alex@deti.com");

        List<Employee> allEmployees = Arrays.asList(john, bob, alex);

        Mockito.when(employeeRepository.findByName(john.getName())).thenReturn(john);
        Mockito.when(employeeRepository.findByName(alex.getName())).thenReturn(alex);
        Mockito.when(employeeRepository.findByName("wrong_name")).thenReturn(null);
        Mockito.when(employeeRepository.findById(john.getId())).thenReturn(Optional.of(john));
        Mockito.when(employeeRepository.findAll()).thenReturn(allEmployees);
        Mockito.when(employeeRepository.findById(-99L)).thenReturn(Optional.empty());
    }

    @Test
    public void whenValidName_thenEmployeeShouldBeFound() {
        Employee found = employeeService.getEmployeeByName( alex.getName() );

        assertThat(found.getName()).isEqualTo( alex.getName() );
        verify(employeeRepository,times( wantedNumberOfInvocations: 1)).findByName( alex.getName() );
    }

    @Test
    public void whenInValidName_thenEmployeeShouldNotBeFound() {
        Employee fromDb = employeeService.getEmployeeByName("wrong_name");
```

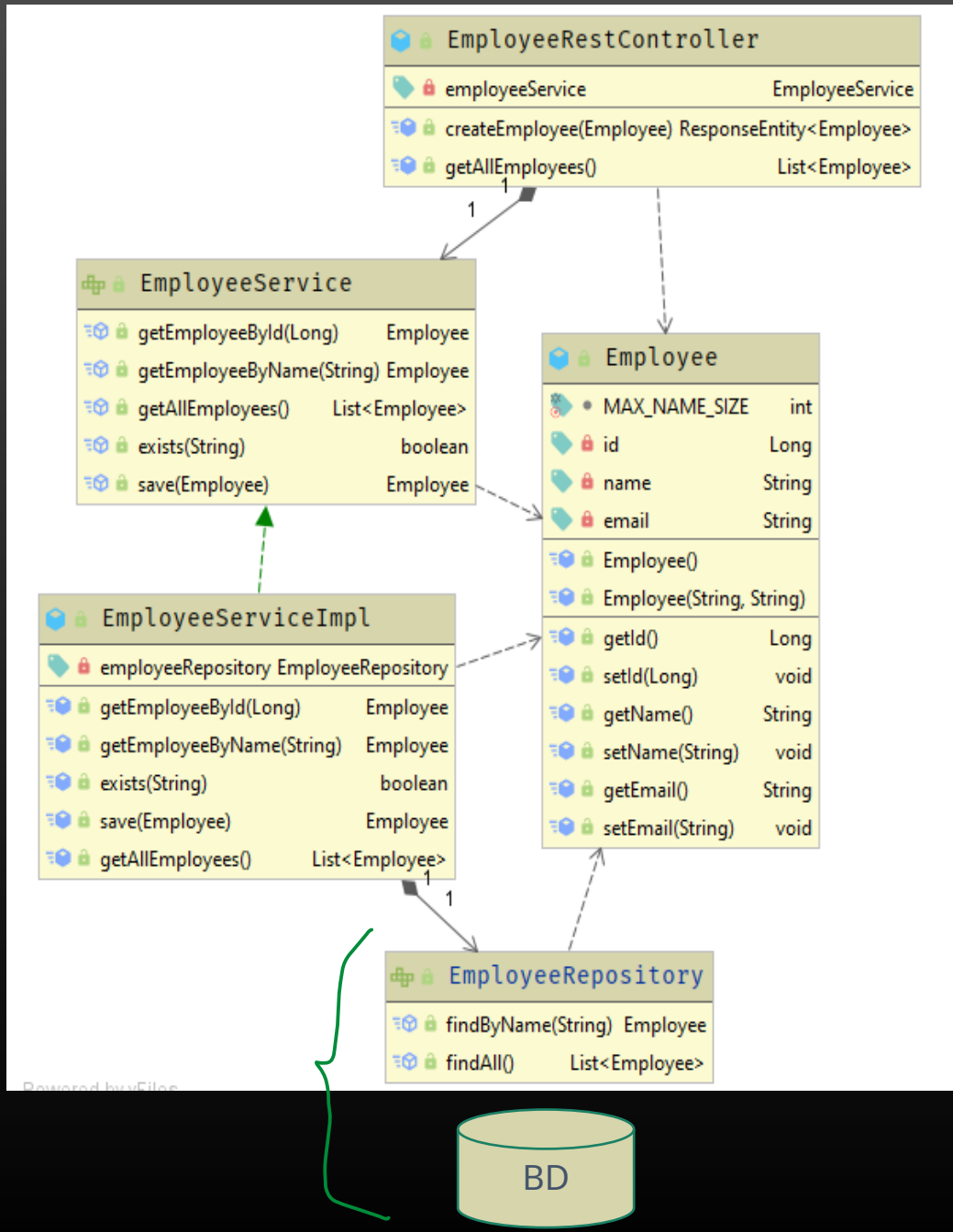
Test scope: JPA

Scenario:

- Test the data access interface
- Focus on complex queries

Strategy:

- Load only JPA-related instrumentation
- Use TestEntityManager



Focus on JPA data access methods

```java
@DataJpaTest
class EmployeeRepositoryTest {

    @Autowired
    private TestEntityManager entityManager;

    @Autowired
    private EmployeeRepository employeeRepository;

    @Test
    public void whenFindAlexByName_thenReturnAlexEmployee() {
        Employee alex = new Employee( name: "alex",  email: "alex@deti.com");
        entityManager.persistAndFlush(alex); //ensure data is persisted at thi

        Employee found = employeeRepository.findByName(alex.getName());
        assertThat( found ).isEqualTo(alex);
    }

    @Test
    public void whenInvalidEmployeeName_thenReturnNull() {
        Employee fromDb = employeeRepository.findByName("Does Not Exist");
        assertThat(fromDb).isNull();
    }

    @Test
    public void whenFindEmployedByExistingId_thenReturnEmployee() {
        Employee emp = new Employee( name: "test",  email: "test@deti.com");
        entityManager.persistAndFlush(emp);

        Employee fromDb = employeeRepository.findById(emp.getId()).orElse( other
        assertThat(fromDb).isNotNull();
        assertThat(fromDb.getEmail()).isEqualTo( emp.getEmail());
    }
```

References

Spring.io docs

Testing the web layer

Eugen Paraschiv's tutorials

Testing in Spring Boot