



Spring Boot Spring Testing RESTful API





Somkiat Puisungnoen

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Intro

Software Craftsmanship

Software Practitioner at สยามชานาญกิจ พ.ศ. 2556

Agile Practitioner and Technical at SPRINT3r

Somkiat Puisungnoen 15 mins · Bangkok · ...

Java and Bigdata



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**[https://github.com/up1/
course-springboot-2024](https://github.com/up1/course-springboot-2024)**



Spring Boot



Agenda

REST (REpresentational State Transfer)

Introduction to Spring Boot

Goals of Spring Boot

Better project structure of Spring Boot

Develop RESTful APIs

Error handling

Layer in Spring Boot project

Working with Spring Data (JPA and JDBC)



Agenda

Manage transaction

Secure service with Spring Security

Observable service

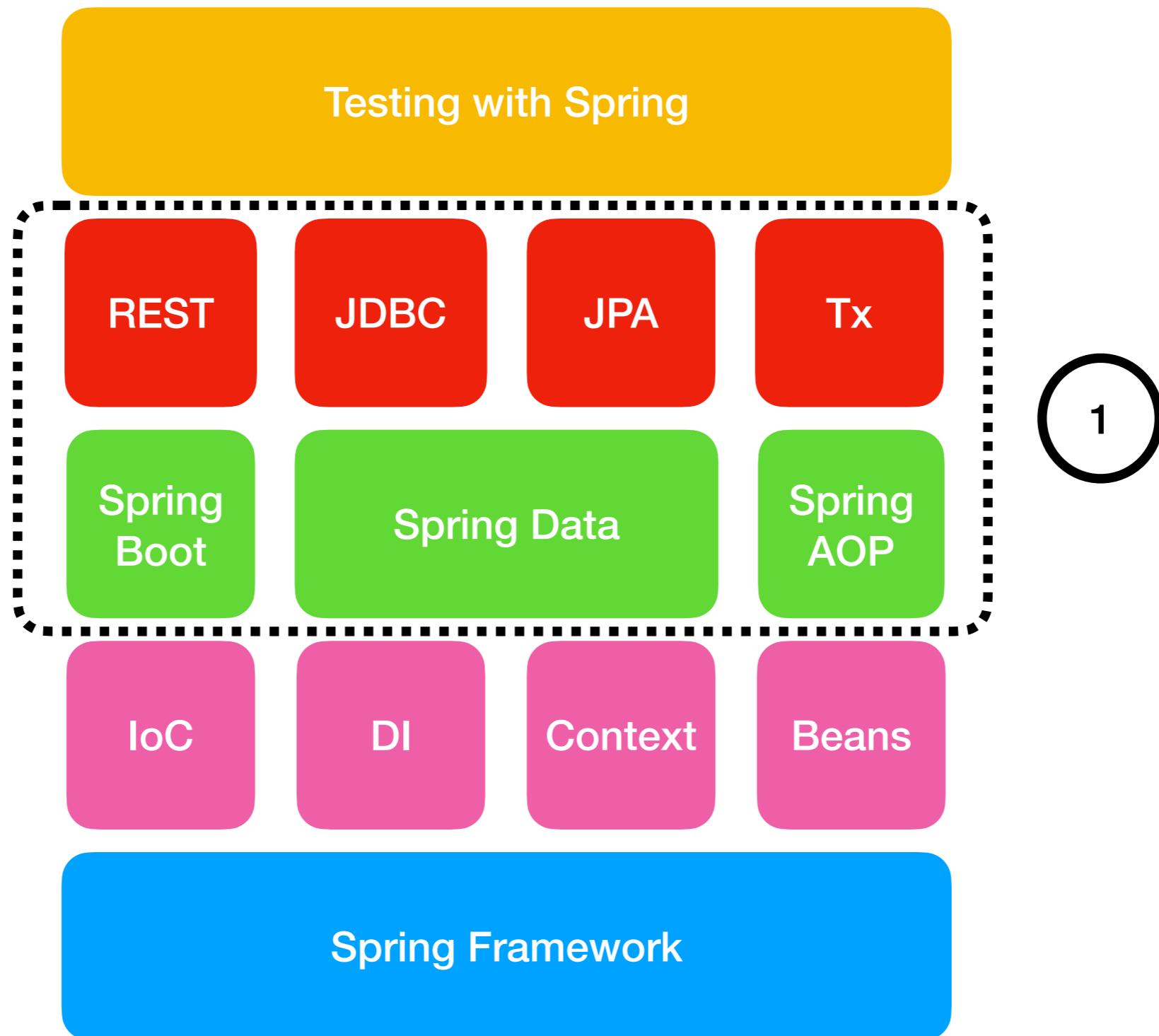
Application metrics

Distributed tracing

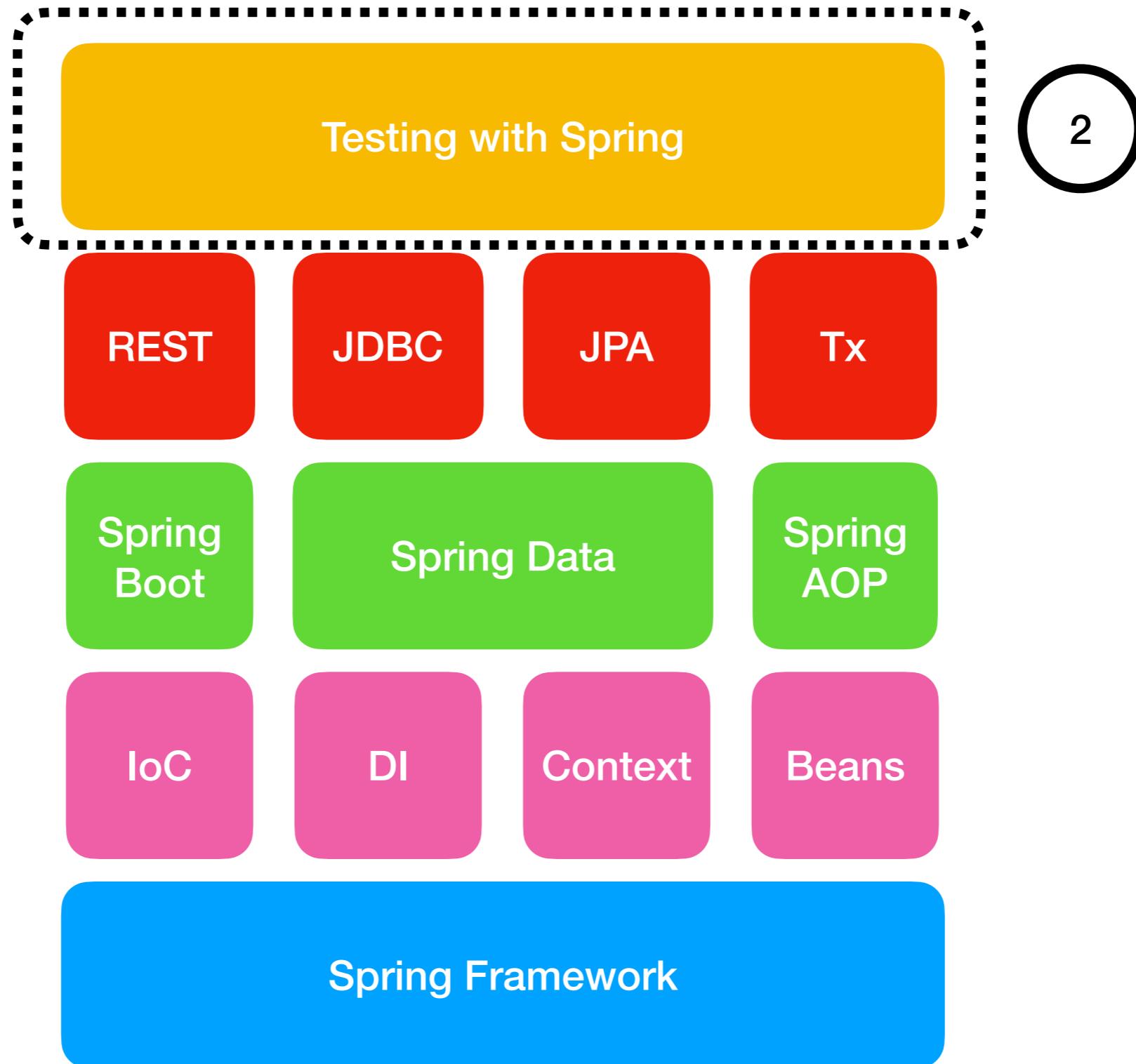
Centralized logging



Workshop



Workshop



My Rule

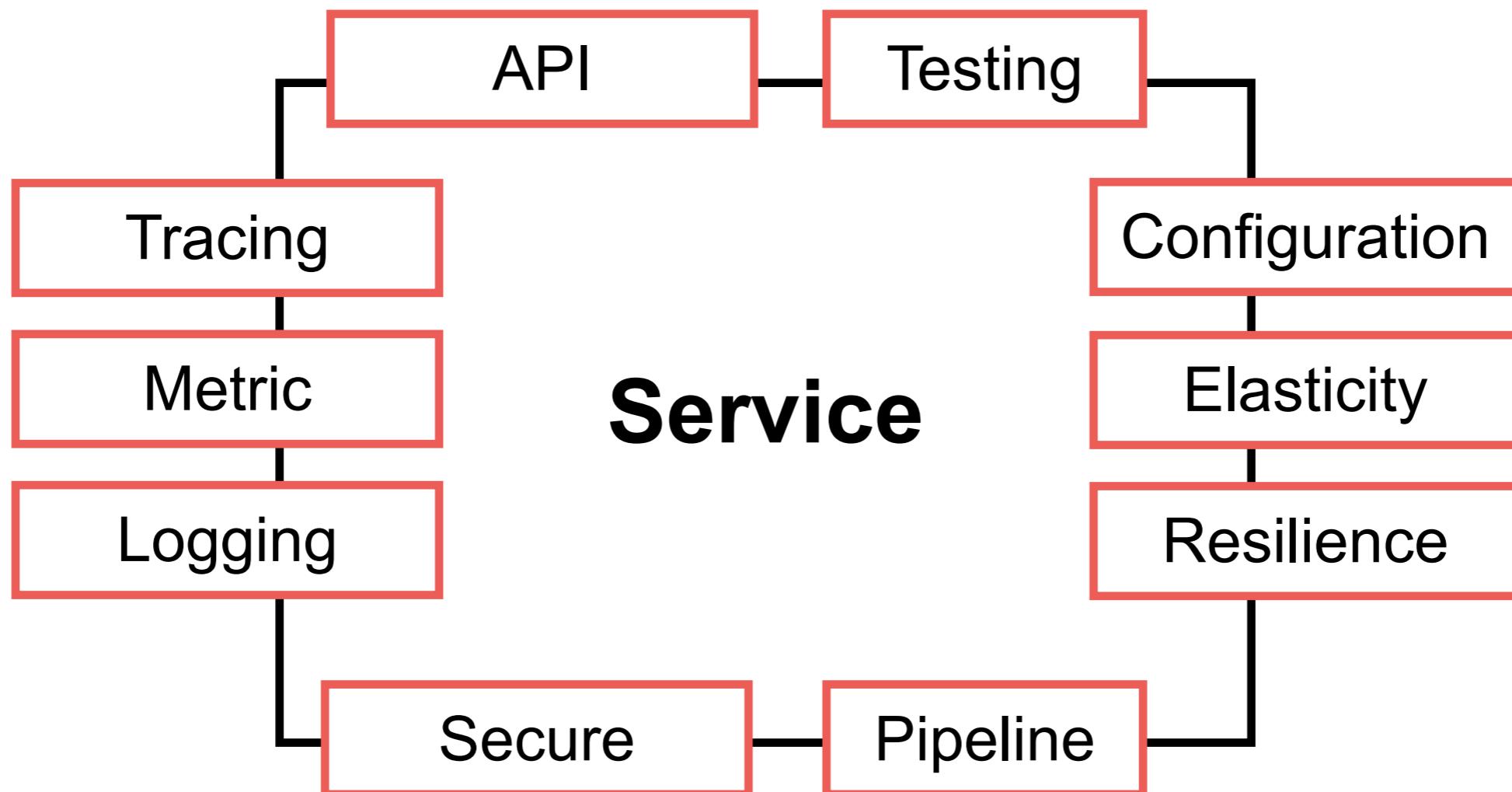
Always write tests



Let's start



Properties of Service



APIs

Application Programming Interface

REST API

gRPC

Messaging



Develop REST API



<https://spring.io/projects/spring-boot>



Spring Framework



Spring Boot



Create Spring Boot project

The screenshot shows the Spring Initializr web interface for creating a new Spring Boot project. The configuration is as follows:

- Project:** Maven (selected)
- Language:** Java (selected)
- Spring Boot:** 3.3.2 (selected)
- Project Metadata:**
 - Group: com.example
 - Artifact: demo
 - Name: demo
 - Description: Demo project for Spring Boot
 - Package name: com.example.demo
 - Packaging: Jar (selected)
 - Java: 21 (selected)
- Dependencies:**
 - Spring Web** (selected): Build web, including RESTful, applications using Spring MVC. Uses Apache Tomcat as the default embedded container.
 - Spring Data JPA**: Persist data in SQL stores with Java Persistence API using Spring Data and Hibernate.
 - H2 Database**: Provides a fast in-memory database that supports JDBC API and R2DBC access, with a small (2mb) footprint. Supports embedded and server modes as well as a browser based console application.

<https://start.spring.io/>



REST

REpresentation **S**tate **T**ransfer

The style of **software architecture** behind
RESTful services

Defined in 2000 by Roy Fielding

https://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm



Goals

Scalability
Generality of interfaces
Independent deployment of components



REST properties

Performance

Scalability

Simplicity

Modification

Visibility

Portability

Reliability



REST constraints

Client-server

Stateless

Cacheable

Layer system

Uniform
interface

Code on
demand

eg. JavaScript



RESTful service

Implementation from REST



REST Request Messages

RESTful request is typically in form of
Uniform Resource Identifiers (URI)



REST Request Messages

RESTful request is typically in form of
Uniform Resource Identifiers (URI)

Structure of URI depend on specific service



REST Request Messages

RESTful request is typically in form of
Uniform Resource Identifiers (URI)

Structure of URI depend on specific service

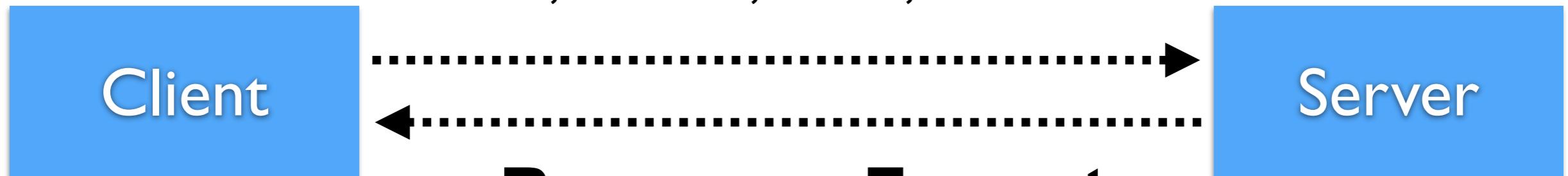
Request can include parameter and data in
body of request as XML, JSON etc.



REST Request & Response

Request Method

GET, POST, PUT, DELETE



Response Format

XML or JSON



Status Code

Code	Description
1xx	Information
2xx	Successful
3xx	Redirection
4xx	Client error
5xx	Server error

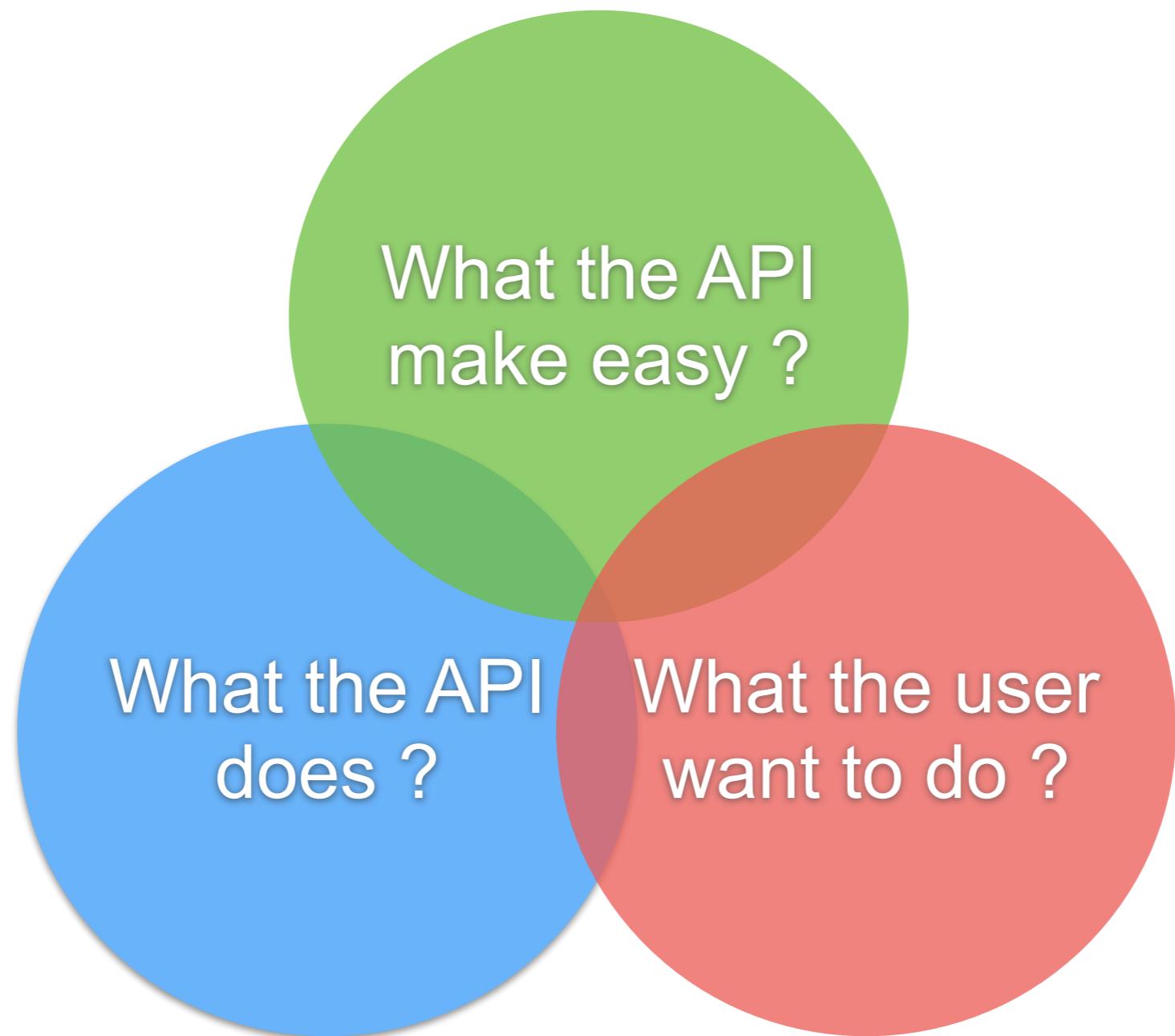
<https://developer.mozilla.org/en-US/docs/Web/HTTP/Status>



Response format ?



Good APIs ?



Principles of API Design



Principles of API Design

Consistency

Statelessness

Resource-oriented design

Use standard
HTTP methods

Versioning

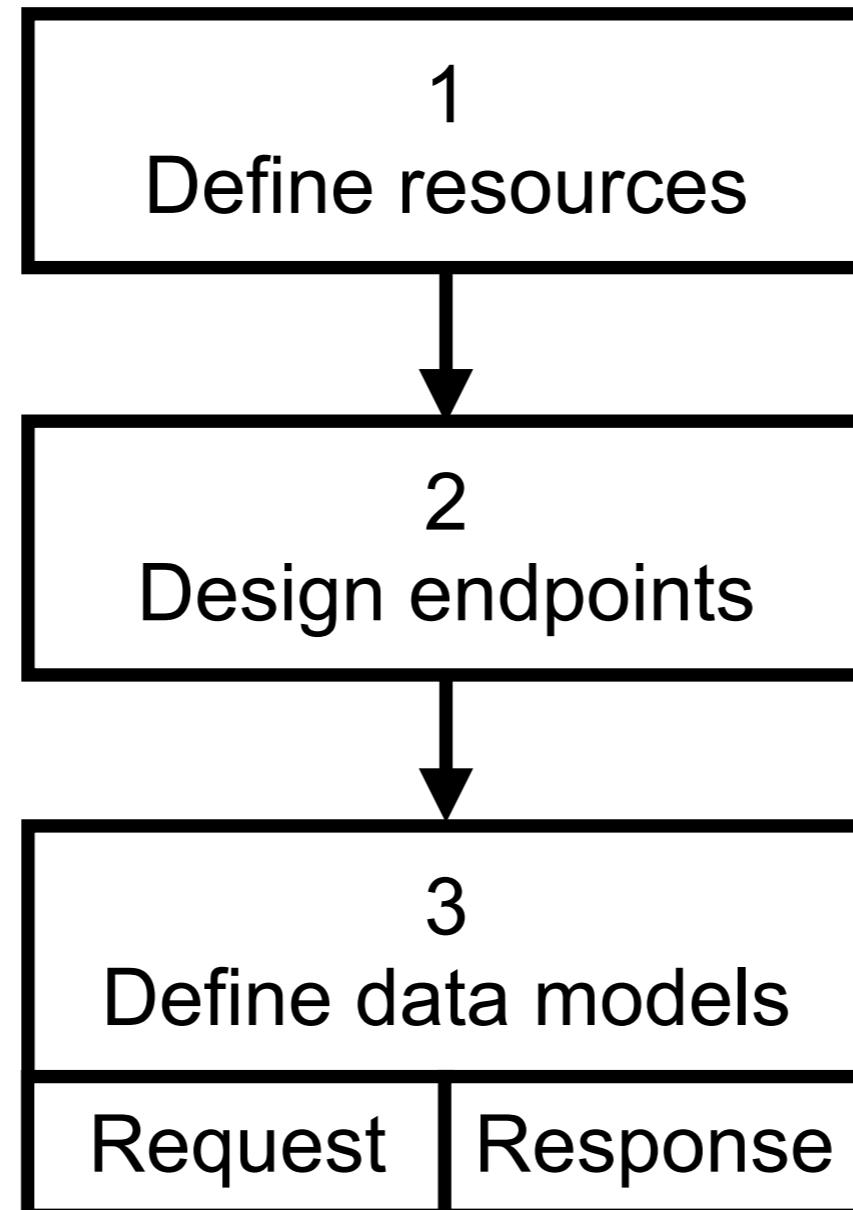


HTTP Methods meaning

Method	Meaning
GET	Read data
POST	Create/Insert new data
PUT/PATCH	Update data or insert if a new id
DELETE	Delete data



Steps to Design APIs



More !!

Authentication
Authorization

Pagination and
filtering

Rate Limiting

Pagination and
filtering

Error handling

Documentation

Testing

Monitoring and
Observability



Implementation

Coding

Testing



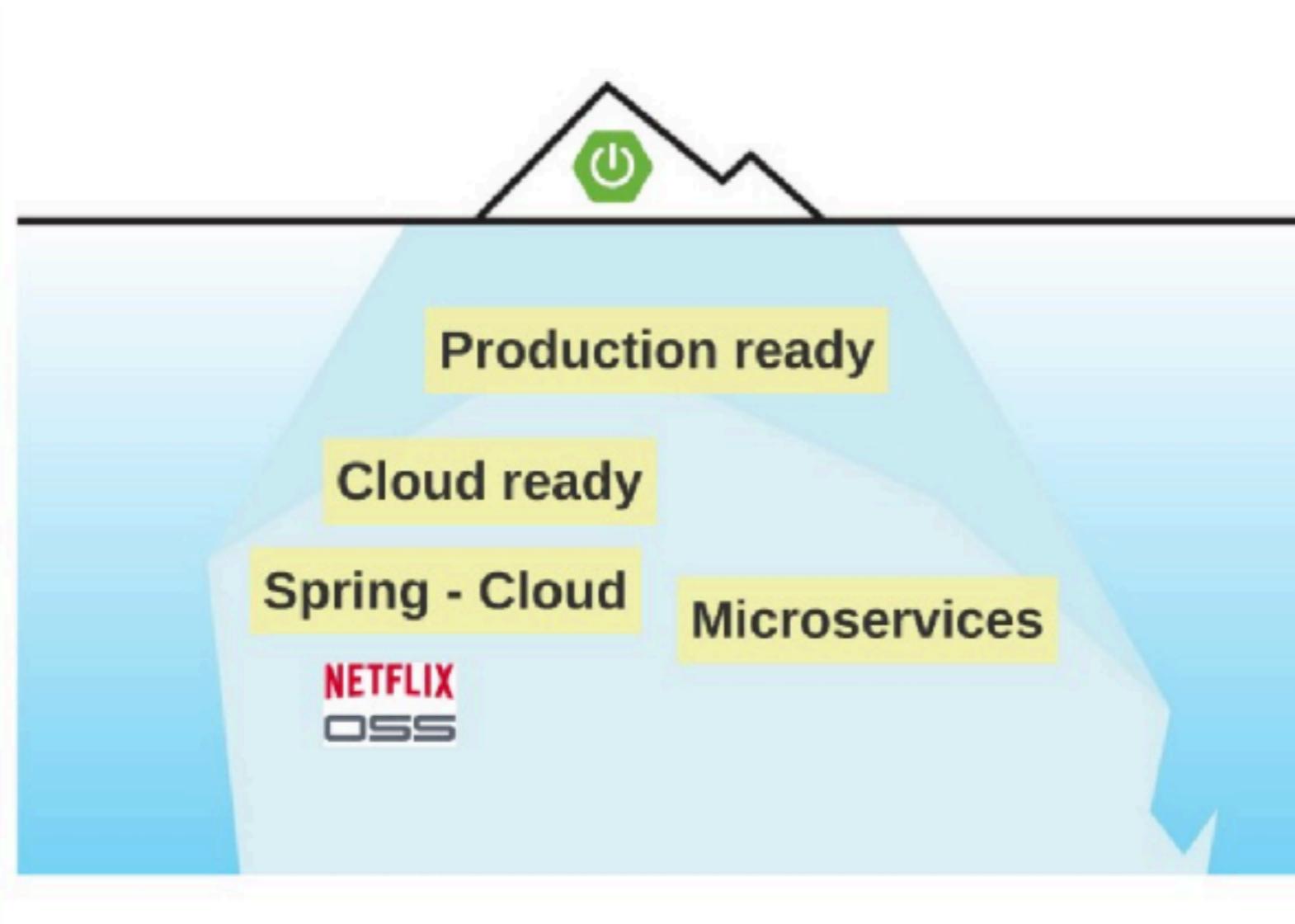
Spring Boot

3.3.2 (current)



Why Spring Boot ?

Application skeleton generator
Reduce effort to add new technologies



What ?

Embedded application server

Integration with tools/technologies (starter)

Production tools (monitoring, health check)

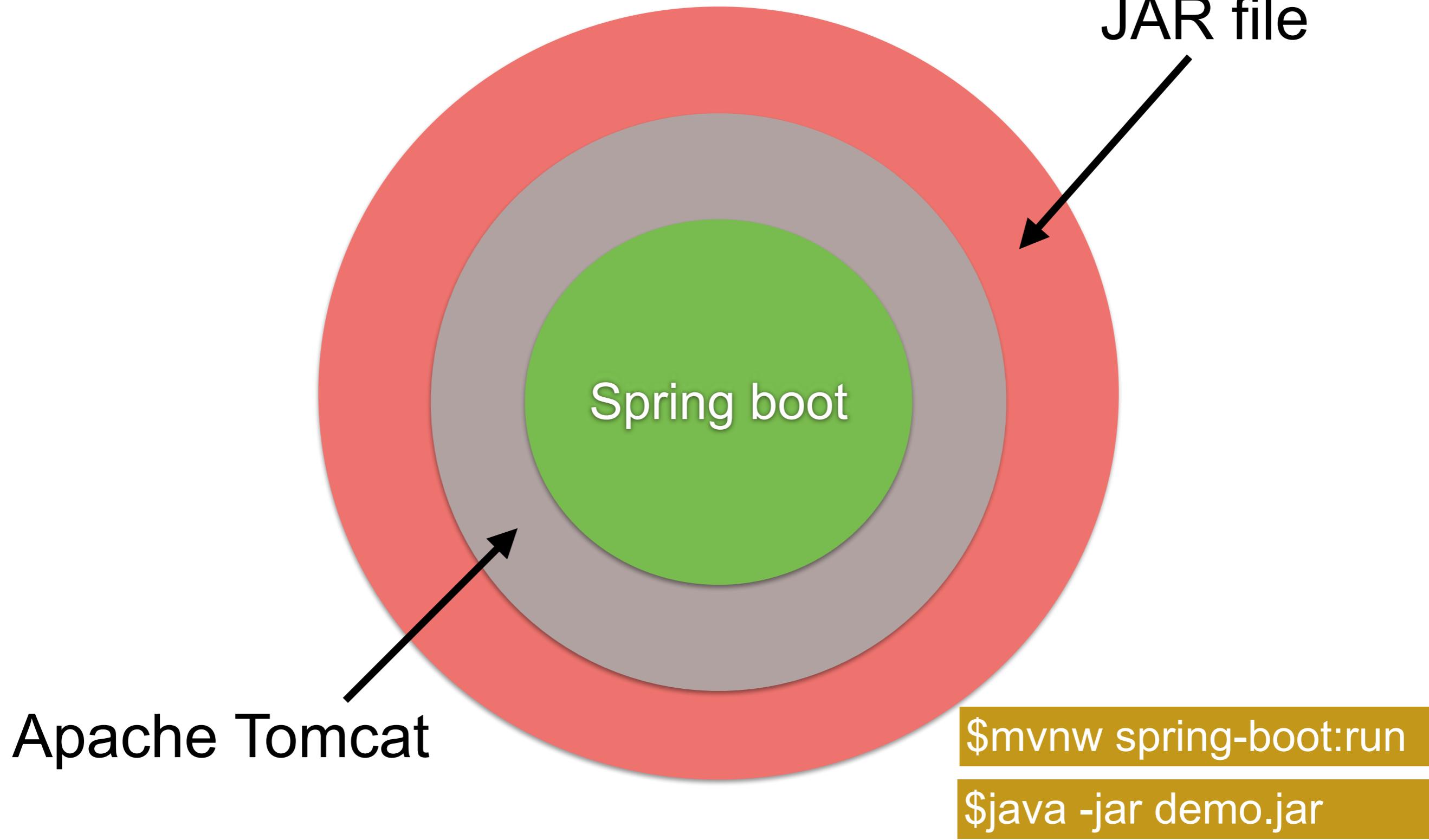
Configuration management

Dev tools

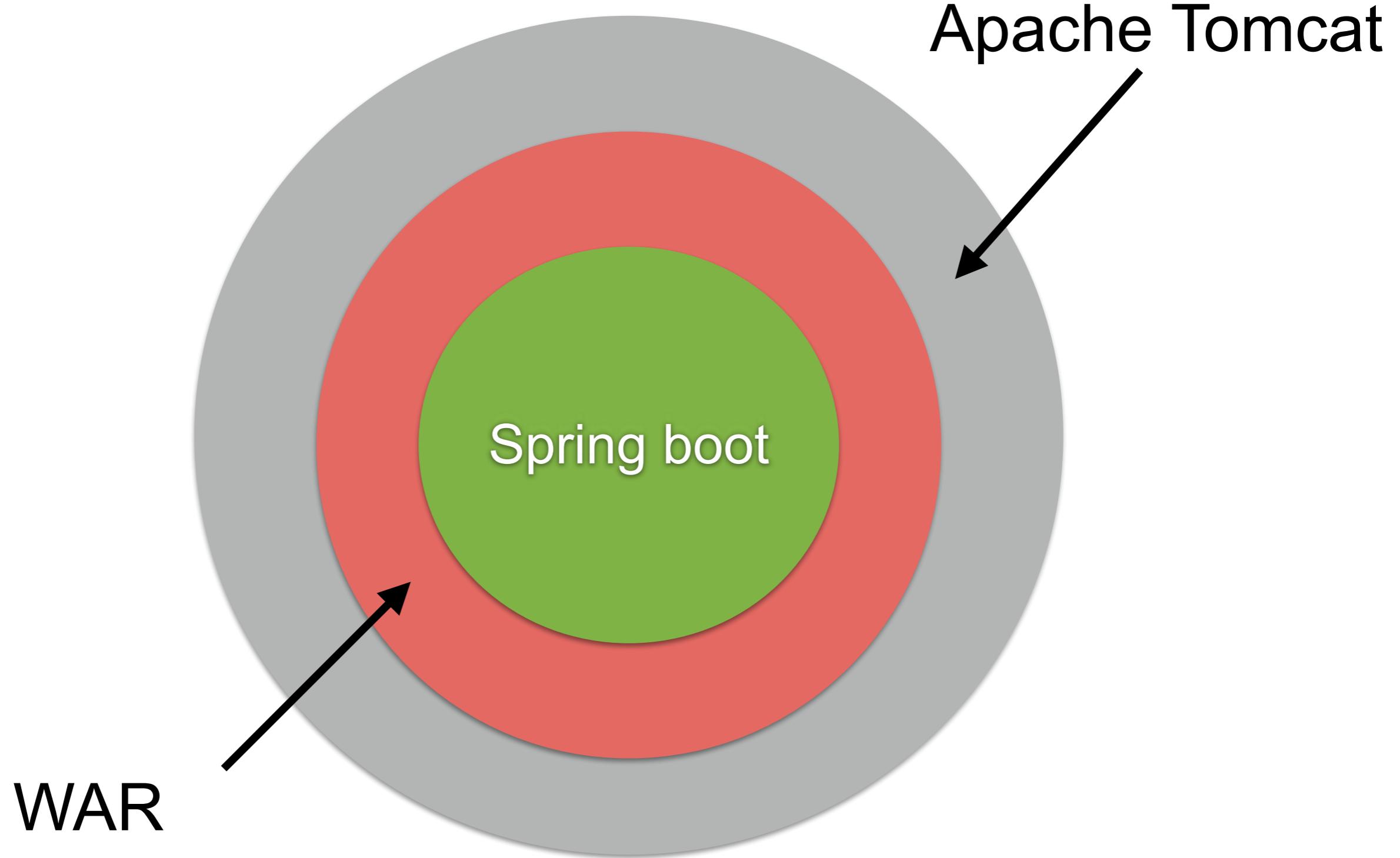
No source code generation, no XML



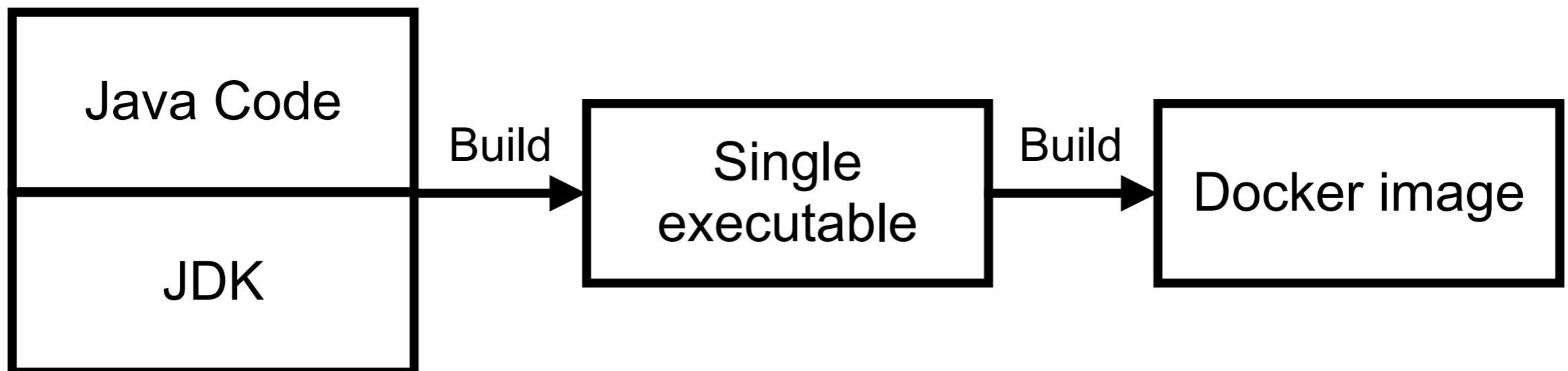
How ?



Traditional Deployment



GraalVM Native Support



<https://www.graalvm.org/>



Add to Spring Boot project



The screenshot shows the Spring Initializr web interface. On the left, there are sections for 'Project' (Gradle - Groovy selected), 'Language' (Java selected), and 'Spring Boot' (3.1.4 selected). On the right, a red dashed box highlights the 'Dependencies' section, which includes 'GraalVM Native Support' (selected) under 'DEVELOPER TOOLS'. Below it, a note says 'Support for compiling Spring applications to native executables using the GraalVM native-image compiler.' At the bottom of the dependencies section is a button labeled 'ADD DEPENDENCIES... M + B'.

Project
 Gradle - Groovy Gradle - Kotlin
 Maven

Language
 Java Kotlin Groovy

Spring Boot
 3.2.0 (SNAPSHOT) 3.2.0 (M3) 3.1.5 (SNAPSHOT) 3.1.4
 3.0.12 (SNAPSHOT) 3.0.11 2.7.17 (SNAPSHOT) 2.7.18

Project Metadata

Group: com.example

Artifact: demo

Name: demo

Description: Demo project for Spring Boot

Package name: com.example.demo

Packaging: Jar War

Java: 21 17 11 8

Dependencies

GraalVM Native Support DEVELOPER TOOLS

Support for compiling Spring applications to native executables using the GraalVM native-image compiler.

ADD DEPENDENCIES... M + B

1. GraalVM support

<https://docs.spring.io/spring-boot/docs/current/reference/html/native-image.html>



Building RESTful API with Spring Boot



Create new project



Project
 Gradle - Groovy Gradle - Kotlin
 Maven

Language
 Java Kotlin Groovy

Spring Boot
 3.2.0 (SNAPSHOT) 3.2.0 (M2) 3.1.4 (SNAPSHOT) 3.1.3
 3.0.11 (SNAPSHOT) 3.0.10 2.7.16 (SNAPSHOT) 2.7.15

Project Metadata
Group: com.example
Artifact: demo
Name: demo
Description: Demo project for Spring Boot
Package name: com.example.demo
Packaging: Jar War
Java: 20 17 11 8

Dependencies

[ADD DEPENDENCIES...](#) 36 + 3

Spring Web WEB

Build web, including RESTful applications using Spring MVC. Uses Apache Tomcat as the default embedded container.

H2 Database SQL

Provides a fast in-memory database that supports JDBC API and H2DBC access, with a small (2mb) footprint. Supports embedded and server modes as well as a browser based console application.

Spring Data JPA SQL

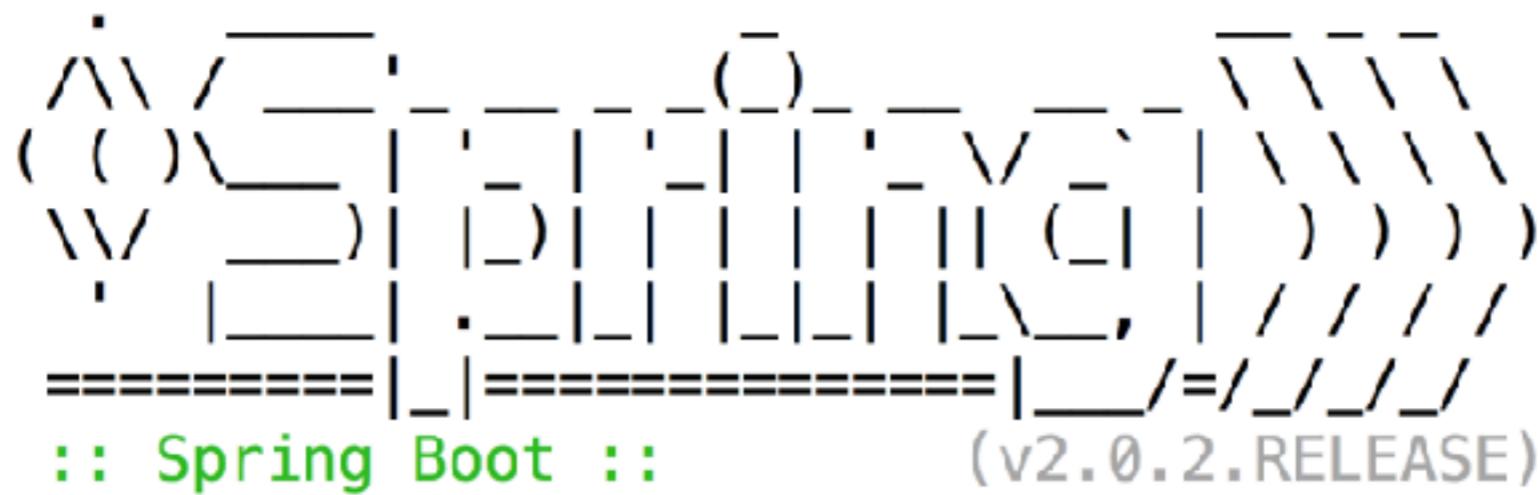
Persist data in SQL stores with Java Persistence API using Spring Data and Hibernate.

1. Spring Web
2. Spring Data JPA
3. H2 Database



Run project (Dev mode)

```
./mvnw spring-boot:run
```



```
2018-06-07 13:03:30.412  INFO 12828 --- [  
  oApplication           : Starting DemoApplication on  
D 12828 (started by somkiat in /Users/somkiat/Down  
2018-06-07 13:03:30.418  INFO 12828 --- [  
  oApplication           : No active profile set, fall
```



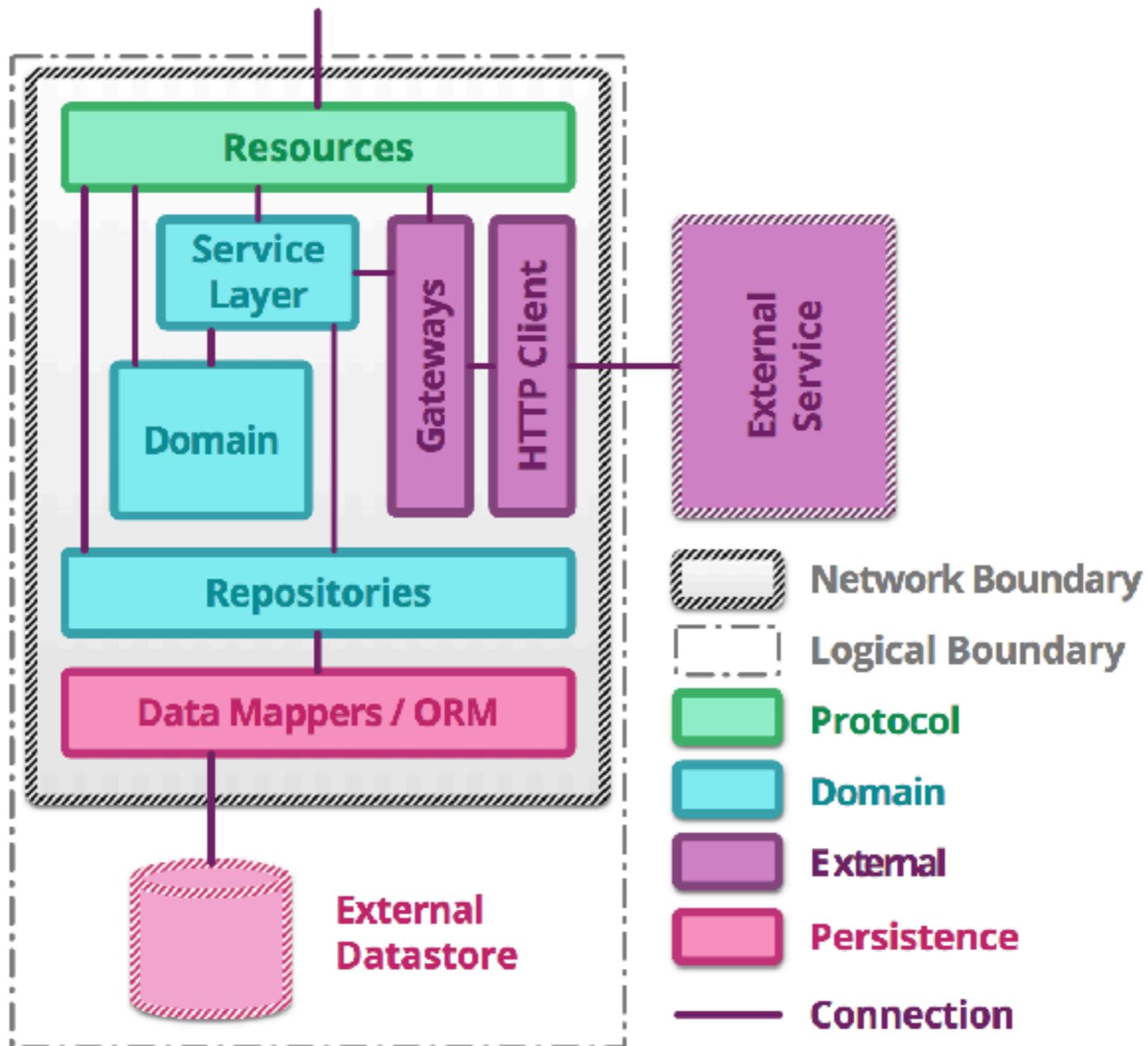
Run project (production mode)

```
./mvnw package  
$java -jar target/<file name>.jar
```

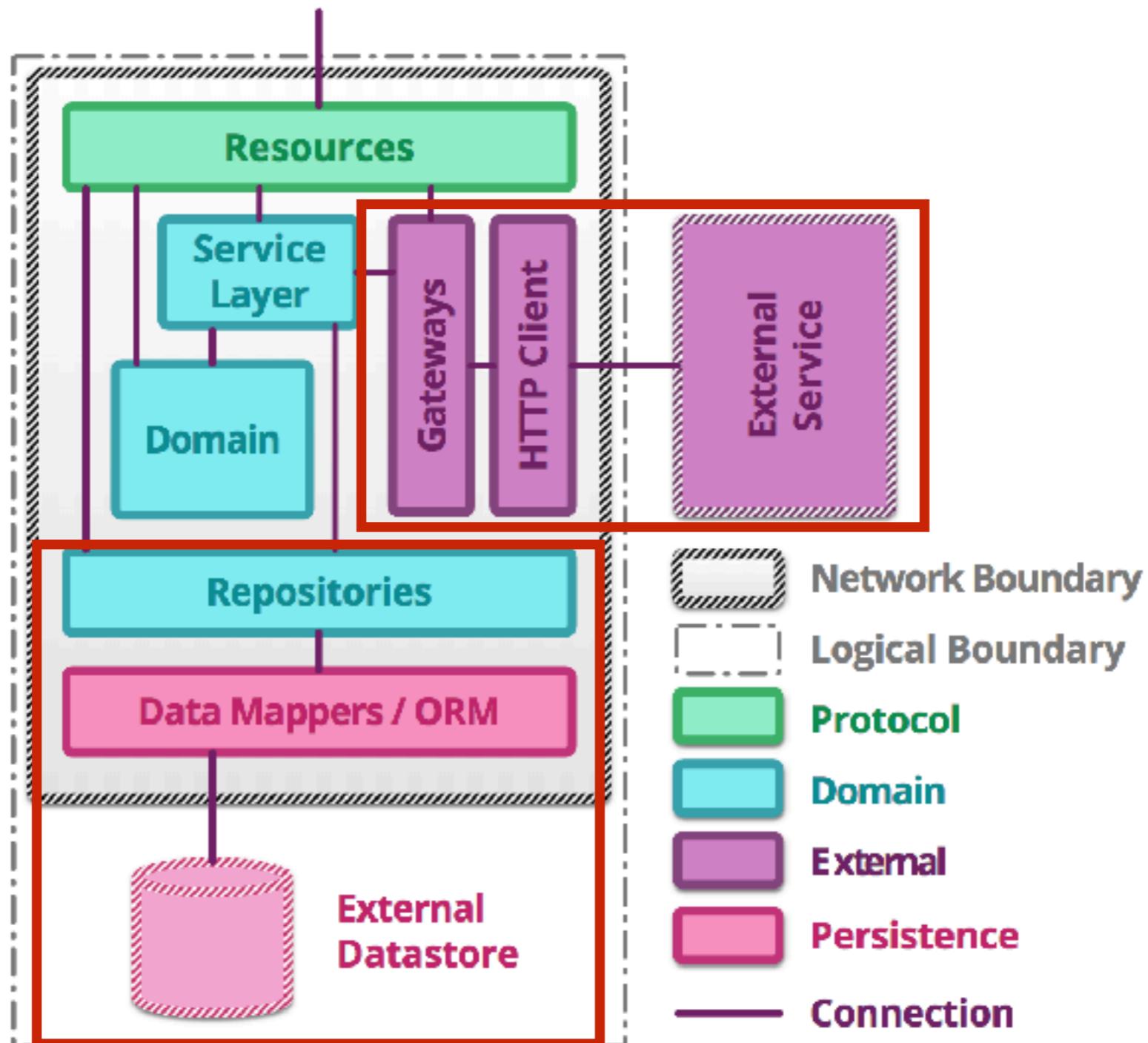
```
2018-06-07 13:03:30.412  INFO 12828 --- [  
oApplication           : Starting DemoApplication on  
D 12828 (started by somkiat in /Users/somkiat/Down  
2018-06-07 13:03:30.418  INFO 12828 --- [  
oApplication           : No active profile set, fall
```



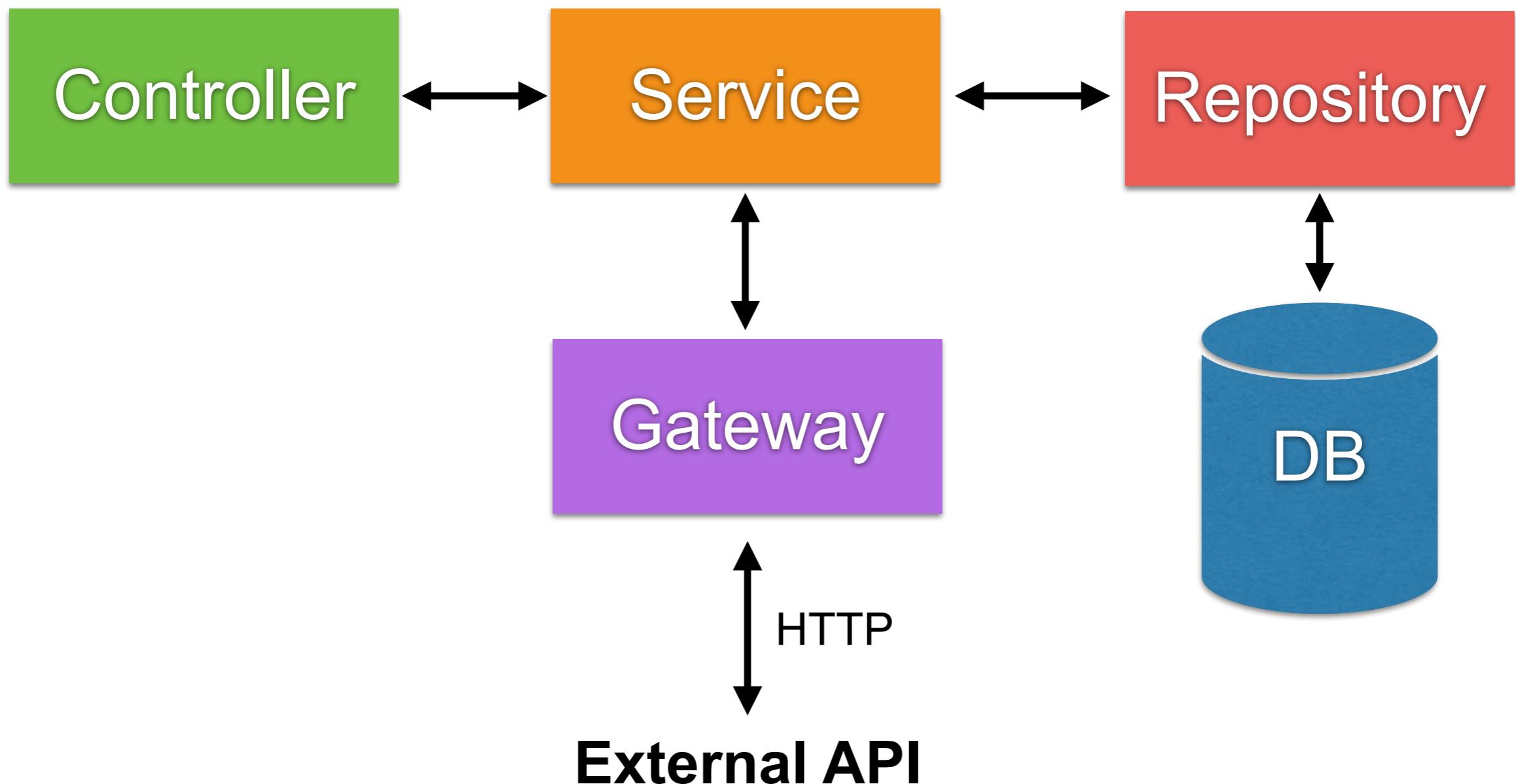
Project Structure



Service Structure



Structure of Spring Boot project



Controller

Request and Response
Validation input

Delegate to others classes such as service and repository



Service

Control the flow of main business logic
Manage database transaction
Don't reuse service



Repository

Manage data in data store such as RDBMS and
NoSQL



Gateway

Call external service via network such as
WebServices and RESTful APIs



Spring Boot Structure (1)

Separate by function/domain/feature

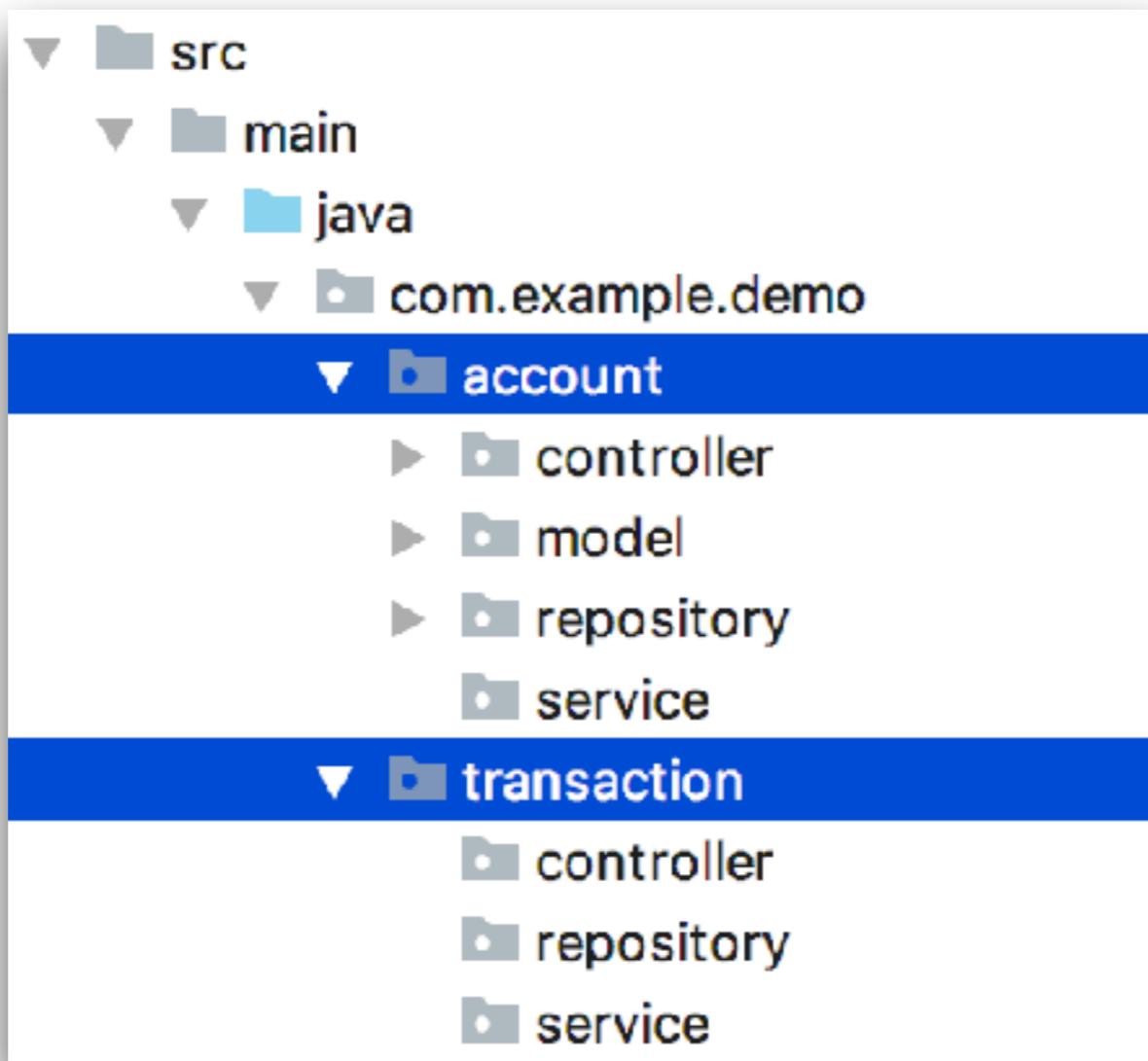
- feature1**
 - controller
 - service
 - repository
- feature2**
 - controller
 - service
 - repository

<https://docs.spring.io/spring-boot/reference/using/structuring-your-code.html>



Spring Boot Structure (2)

Separate by function/domain/feature



Configurations

A twelve-factor app should externalize all such configurations that vary between deployments

File application.properties

```
spring.datasource.url=jdbc:mysql://${MYSQL_HOST}:${MYSQL_PORT}/movies  
spring.datasource.username=${MYSQL_USER}  
spring.datasource.password=${MYSQL_PASSWORD}
```

Usage

```
set MYSQL_HOST=localhost  
set MYSQL_PORT=3306  
set MYSQL_USER=movies  
set MYSQL_PASSWORD=password
```

<https://docs.spring.io/spring-boot/reference/features/external-config.html>



Convert from properties to YAML

Yaml to properties / Properties to Yaml converter

[**<< to yaml**](#) [**to properties >>**](#)

Yaml

```
spring:  
  h2:  
    console:  
      enabled: 'true'  
  profiles: test  
  kafka:  
    streams:  
      bootstrap-servers: localhost:9092,  
      192.168.0.1:9092
```

Properties

```
spring.profiles=test  
spring.h2.console.enabled=true  
spring.kafka.streams.bootstrap-  
servers=localhost:9092, 192.168.0.1:9092
```

[**convert >>**](#)

[**<< convert**](#)

[**<< convert**](#) [**convert >>**](#)

YAML

<https://mageddo.com/tools/yaml-converter>



Convert in IntelliJ IDEA

The screenshot shows the IntelliJ IDEA plugin marketplace interface. A red dashed box highlights the search results for 'convert YAML'. The results list includes:

- Convert YAML and Properties File** by chencn, 111.9K downloads, 3.49 rating, Install button.
- Properties to YAML Converter** by Jakub Kubrynski, 103.4K downloads, 3.50 rating, Install button.
- convert yaml to properties** by zhang min, 11.3K downloads, 1.90 rating, Install button.
- JSON-YAML-XML Converter** by Syncro Soft, 2.6K downloads, 3.57 rating, Paid status, Install button.
- Format-converter** by Dmitrii_Priporov, 596 downloads, 4.47 rating, Install button.

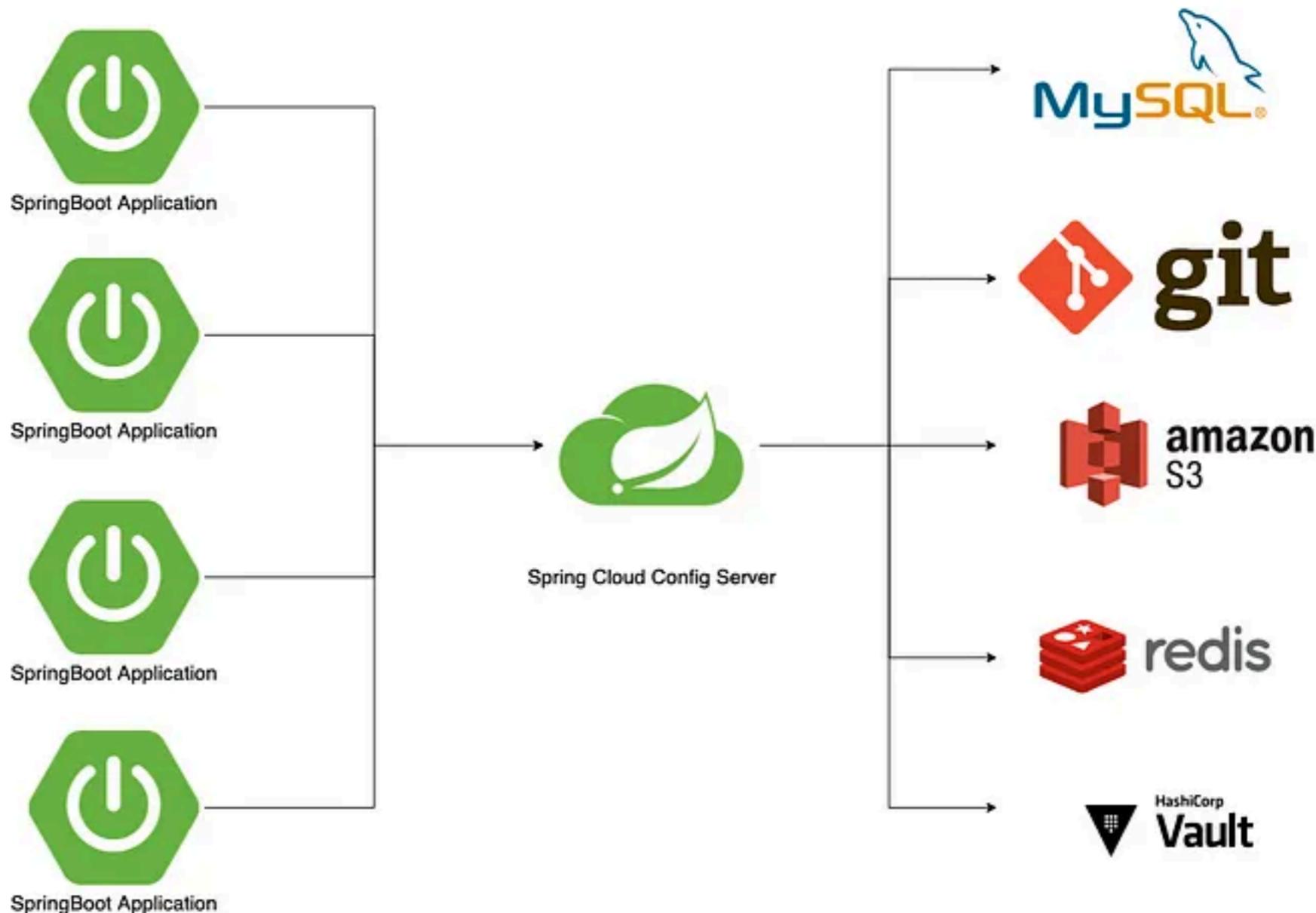
A second red dashed box highlights the details page for the 'Convert YAML and Properties File' plugin. The page includes:

- Code Tools** section.
- Convert YAML and Properties File** title.
- chencn** link to plugin homepage.
- Install** button and version **1.0.5**.
- Reviews** and **Additional Info** sections.
- Overview** and **What's New** tabs.
- A screenshot of the plugin's interface showing file conversion.

<https://plugins.jetbrains.com/plugin/13804-convert-yaml-and-properties-file>



Centralized Configuration



<https://spring.io/projects/spring-cloud-config>



Design RESTful APIs



Users

Method	Path	Description
GET	/users	Get all users
GET	/users/{id}	Get user by id
POST	/users	Create new user
PUT	/users/{id}	Update user
DELETE	/users/{id}	Delete user by id

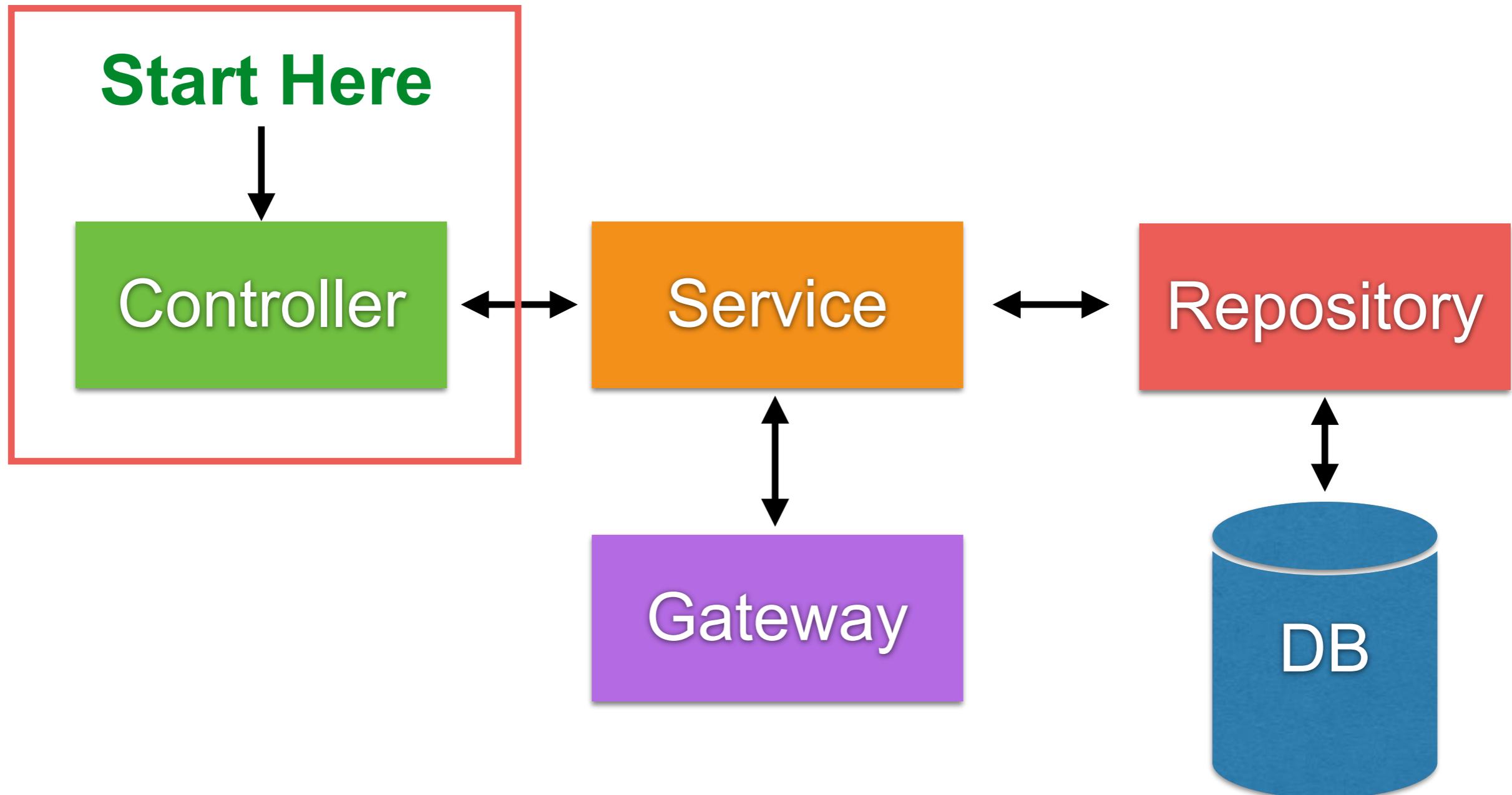


HTTP status codes

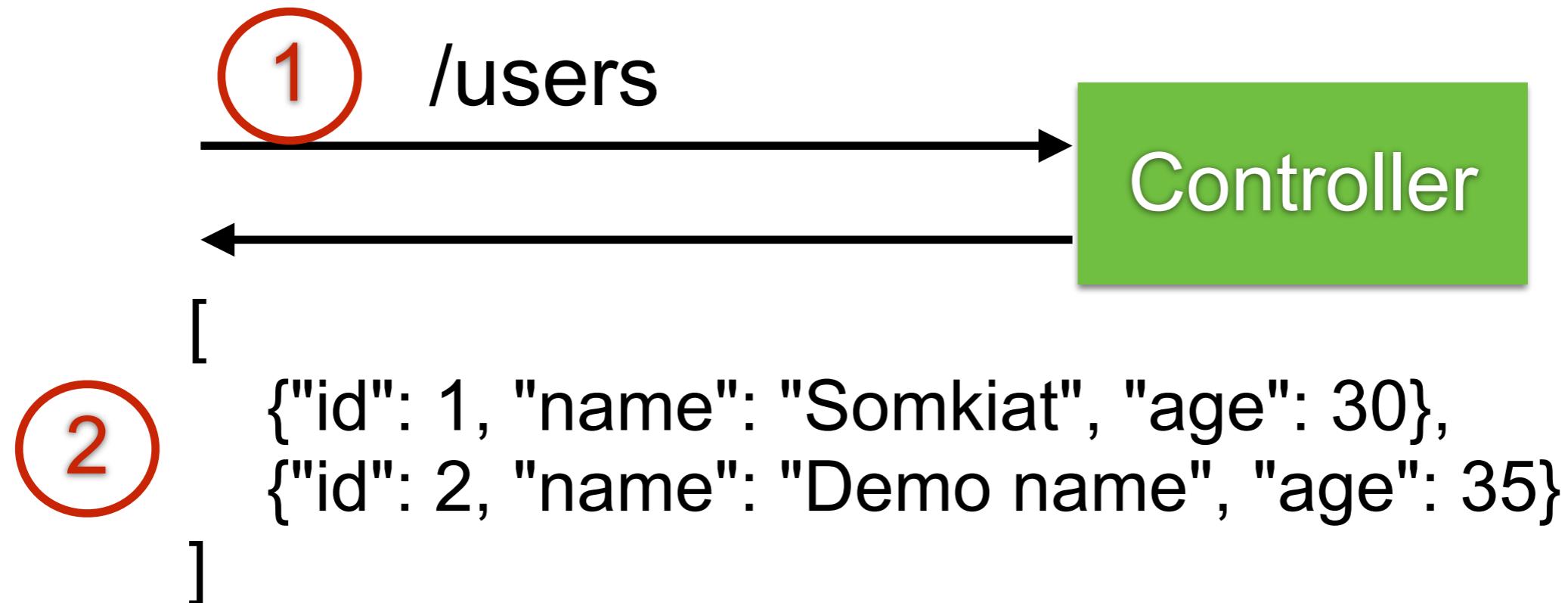
Code	Description	Example
1xx	Informational responses	100 = Continue 101 Switching protocols
2xx	Success	200 = OK 201 = Created
3xx	Redirection	300 = Multiple choices 301 = Moved permanently
4xx	Client errors	400 = Bad request 403 = Forbidden 404 = Not found
5xx	Server errors	500 = Internal server error 502 = Bad gateway 503 = Service unavailable



Basic structure of Spring Boot



Get all users



1. Create REST Controller

UserController.java

```
@RestController
public class UserController {

    @GetMapping("/users")
    public List<UserResponse> getAllUsers() {
        List<UserResponse> userResponseList = new ArrayList<>();
        userResponseList.add(new UserResponse(1, "demo 1", 30));
        userResponseList.add(new UserResponse(2, "demo 2", 35));
        return userResponseList;
    }
}
```



2. Create model class

UserResponse.java

```
public class UserResponse {  
    private int id;  
    private String name;  
    private int age;  
  
    public UserResponse() {}  
  
    public UserResponse(int id, String name, int age) {  
        this.id = id;  
        this.name = name;  
        this.age = age;  
    }  
}
```



3. Compile and Packaging

\$mvnw clean package



4. Run

```
$java -jar target/hello.jar
```



5. Open in browser

<http://localhost:8080/users>

```
[  
  {  
    "id": 1,  
    "name": "demo 1",  
    "age": 30  
  },  
  {  
    "id": 2,  
    "name": "demo 2",  
    "age": 35  
  }]  
]
```



Create more APIs

Get user by id

Create a new user

Update user by id

Delete user by id



Get user by id

GET /users/{id}

```
@GetMapping("/users/{id}")
public UserResponse getUserById(
    @PathVariable int id) {

    UserResponse userResponse = new UserResponse(id, "Demo", 40);
    return userResponse;
}
```



Create UserResponse

POJO
Setter/Getter

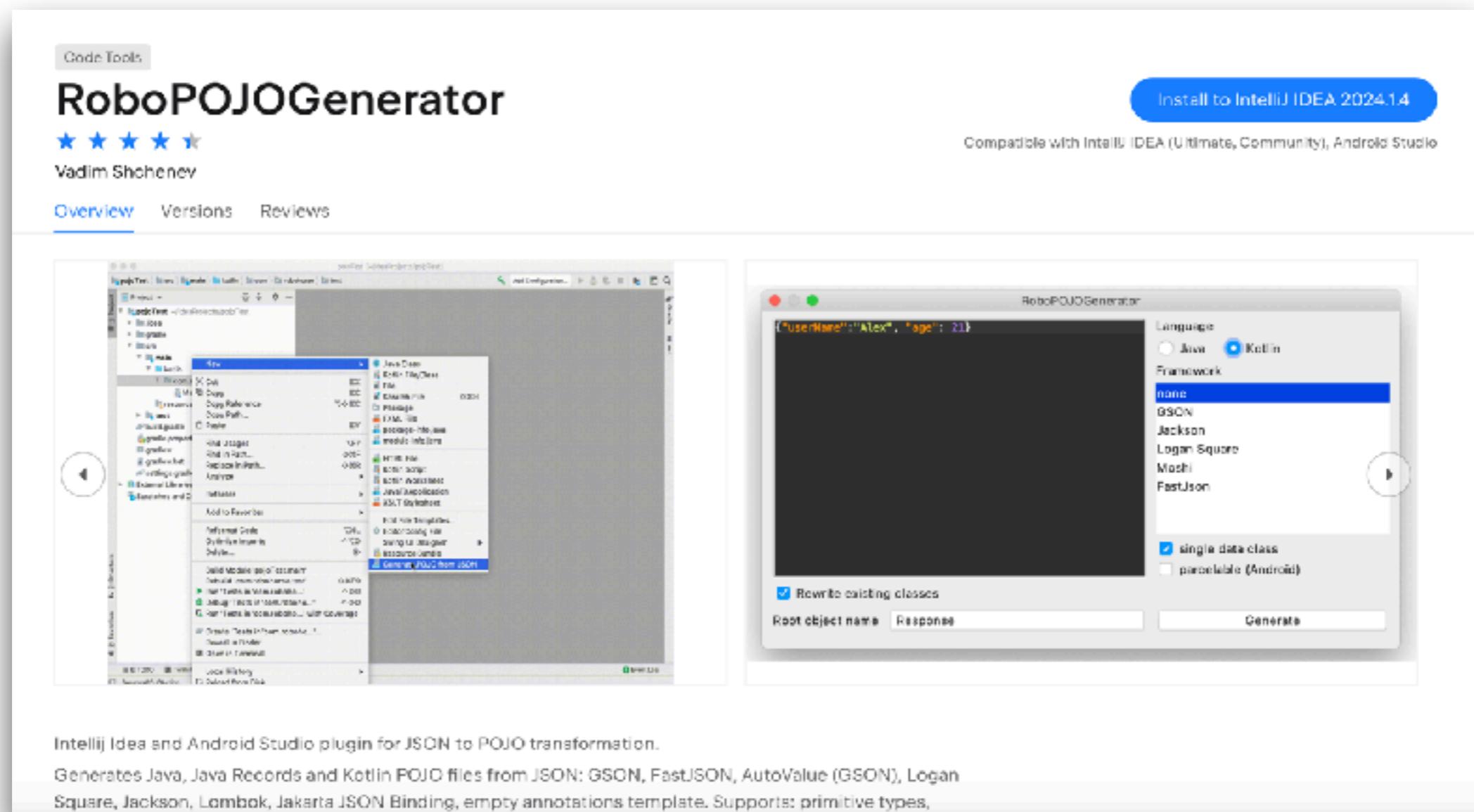
Lombok

Record
Java 14+



Convert JSON to POJO

IntelliJ IDEA



<https://plugins.jetbrains.com/plugin/8634-robopojogenerator>



Convert JSON to POJO

VS Code

The screenshot shows the Visual Studio Marketplace page for the "quicktype" extension. The extension is titled "Paste JSON as Code" and is developed by "quicktype". It has 2,314,268 installs and a rating of 4.6 stars from 46 reviews. It is described as free. The description below the title states: "Copy JSON, paste as Go, TypeScript, C#, C++ and more." There are two buttons at the bottom: a green "Install" button and a "Trouble Installing?" link. Below the main section, there are tabs for "Overview" (which is selected), "Version History", "Q & A", and "Rating & Review". A large text block at the bottom lists supported languages and frameworks: "Supports C (cJSON), C#, C++, Crystal, Dart, Elm, Flow, Go, Haskell, JSON Schema, Java, JavaScript, JavaScript PropTypes, Kotlin, Objective-C, PHP, Pike, Python, Ruby, Rust, Scala3, Smithy, Swift, TypeScript, TypeScript Effect Schema and TypeScript Zod".

<https://marketplace.visualstudio.com/items?itemName=quicktype.quicktype>



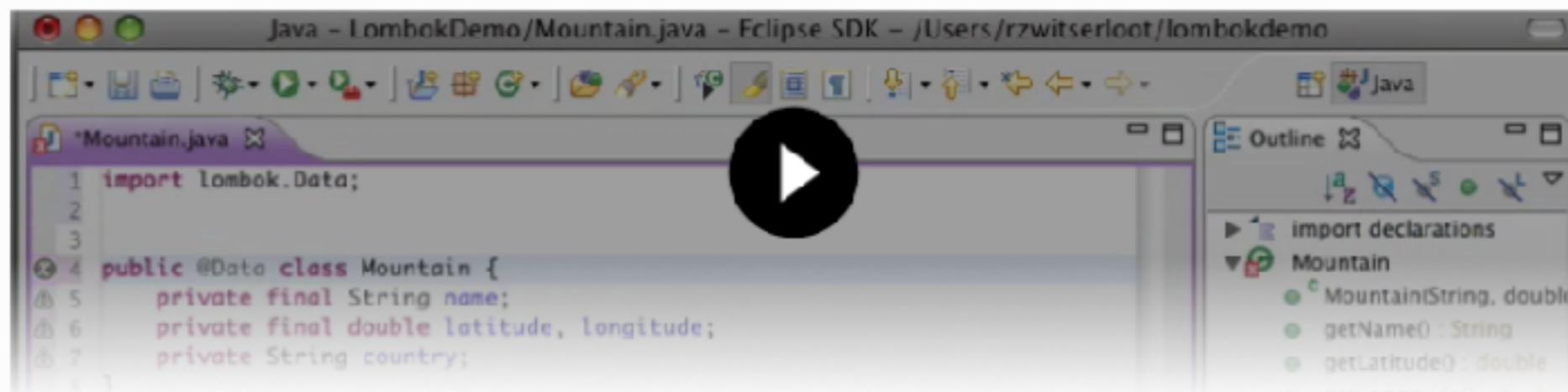
Lombok



Using Lombok

Project Lombok

Project Lombok is a Java library that automatically plugs into your editor and build tools, spicing up your Java. Never write another getter or equals method again, with one annotation your class has a fully featured builder, Automate your logging variables, and much more.



Project Lombok is **powered by:**

<https://projectlombok.org/>



IntelliJ IDEA plug-in

The screenshot shows the IntelliJ IDEA plugin marketplace interface. A red dashed box highlights the search results for 'lombok'. The first result, 'Lombok' by JetBrains s.r.o., is selected and has a checkmark next to its name. To the right, the plugin's details page is displayed, featuring the title 'Lombok' and a link to the 'Plugin homepage'. Below the title are buttons for 'Disable' and '232.9921.47'. A navigation bar at the bottom of the details page includes 'Overview' (which is underlined), 'What's New', 'Reviews', and 'Additional Info'. The 'Overview' section contains the heading 'IntelliJ Lombok plugin' and a description: 'A plugin that adds first-class support for Project Lombok Features'. A bulleted list of features follows: '@Getter and @Setter', '@FieldNameConstants', '@ToString', '@EqualsAndHashCode', '@AllArgsConstructor, @RequiredArgsConstructor and @NoArgsConstructor'.

Plugins Marketplace Installed 1 ⚙️ ← →

Search Results (36) Sort By: Relevance

Q: lombok

Lombok ✓
↓ 14.6M ⭐ 4.04 232.9921.47 JetBrains s.r.o.

Lombok Builder Helper ✓
↓ 197.4K 1.5.0 dorukguner

KFANG AGENT Kfang Agent Lombok Install
↓ 80.6K 彭清龙

RoboPOJOGenerator Update ✓
↓ 342.2K ⭐ 4.66 2.3.3 → 2.4.1 Vadim Shchenev

Lombok HermitCrab Install
↓ 451 1747533293

GsonFormatPlus Install
↓ 401.5K ⭐ 4.17 sun-men

Tools Integration

Lombok
JetBrains s.r.o. [Plugin homepage](#)

Disable | 232.9921.47

Overview What's New Reviews Additional Info

IntelliJ Lombok plugin

A plugin that adds first-class support for Project Lombok Features

- [@Getter and @Setter](#)
- [@FieldNameConstants](#)
- [@ToString](#)
- [@EqualsAndHashCode](#)
- [@AllArgsConstructor, @RequiredArgsConstructor and @NoArgsConstructor](#)

<https://plugins.jetbrains.com/plugin/6317-lombok>



Use Lombok

```
@Data  
@Builder  
@NoArgsConstructor  
@AllArgsConstructor  
public class UserRequest {  
    private String email;  
    private String password;  
}
```



Create more controller ..



Create a new user

POST /users

```
@PostMapping("/users")
public UserResponse createNewUser(
    @RequestBody UserRequest newUser) {
    UserResponse newUserResponse = new UserResponse(
        1,
        newUser.getName(),
        newUser.getAge());
    return newUserResponse;
}
```



Update user by id

PUT /users/{id}

```
@PutMapping("/users/{id}")
public UserResponse updateUser(@RequestBody UserRequest newUser,
                               @PathVariable int id) {
    // TODO
    // 1. find by id
    // 2. found => update user
    // 3. not found => ?? (create ? or throw error)
    UserResponse updatedUserResponse = new UserResponse(
        id,
        newUser.getName(),
        newUser.getAge());
    return updatedUserResponse;
}
```



Delete user by id

DELETE /users/{id}

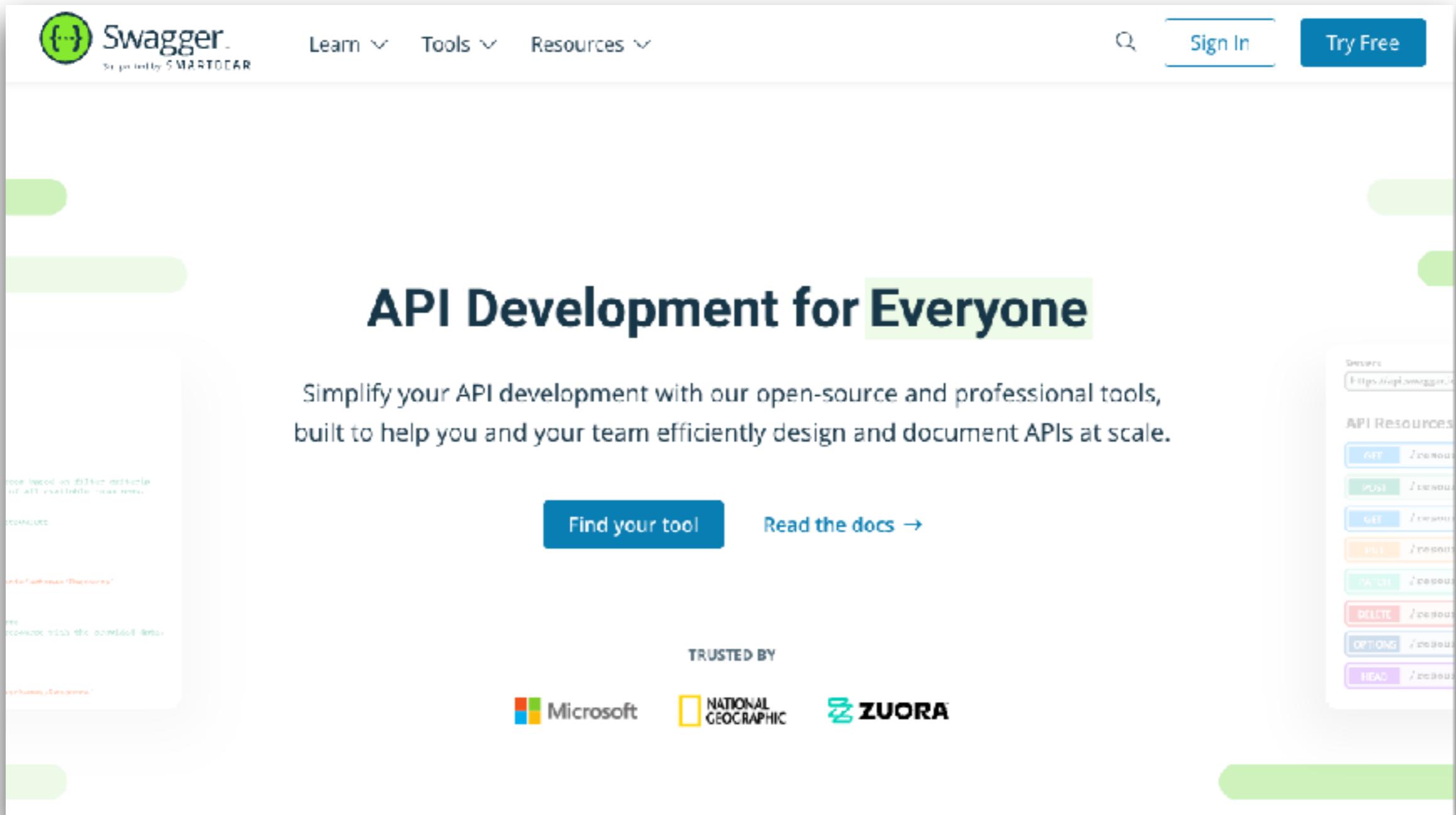
```
@DeleteMapping("/users/{id}")
public void deleteUser(@PathVariable int id) {
    // TODO
}
```



API Documentation



Swagger/ Open API



The screenshot shows the official Swagger website. At the top, there's a navigation bar with links for "Learn", "Tools", and "Resources". On the right side of the header are a search bar, a "Sign In" button, and a prominent "Try Free" button. Below the header, a large green banner features the text "API Development for Everyone". Underneath the banner, a sub-headline reads: "Simplify your API development with our open-source and professional tools, built to help you and your team efficiently design and document APIs at scale." To the left of the main content area, there's a sidebar with various links and sections. On the right, there's a sidebar titled "API Resources" listing various HTTP methods: GET, POST, PUT, PATCH, DELETE, OPTIONS, and HEAD, each associated with a small icon and a link. The main content area also contains buttons for "Find your tool" and "Read the docs →". Logos for Microsoft, National Geographic, and Zuora are displayed under the "TRUSTED BY" heading.

<https://swagger.io/>



Example

The screenshot shows the Swagger Petstore API documentation. At the top, it displays the URL <https://petstore.swagger.io/v2/swagger.json>. The main title is "Swagger Petstore" with version 1.0.7 and OAS 2.0. Below the title, there's a note about the sample server and links to "Terms of service", "Contact the developer", and "Apache 2.0". A "Find out more about Swagger" link is also present. On the left, there's a dropdown for "Schemes" set to "HTTPS" and an "Authorize" button with a lock icon. The main content area is titled "pet" and lists various API endpoints:

- POST /pet/{petId}/uploadImage** uploads an image
- POST /pet** Add a new pet to the store
- PUT /pet** Update an existing pet
- GET /pet/findByStatus** Finds Pets by status
- GET /pet/findByTags** Finds Pets by tags
- GET /pet/{petId}** Find pet by ID
- POST /pet/{petId}** Updates a pet in the store with form data.
- DELETE /pet/{petId}** Deletes a pet



Swagger + Spring Boot 3

Spring Doc



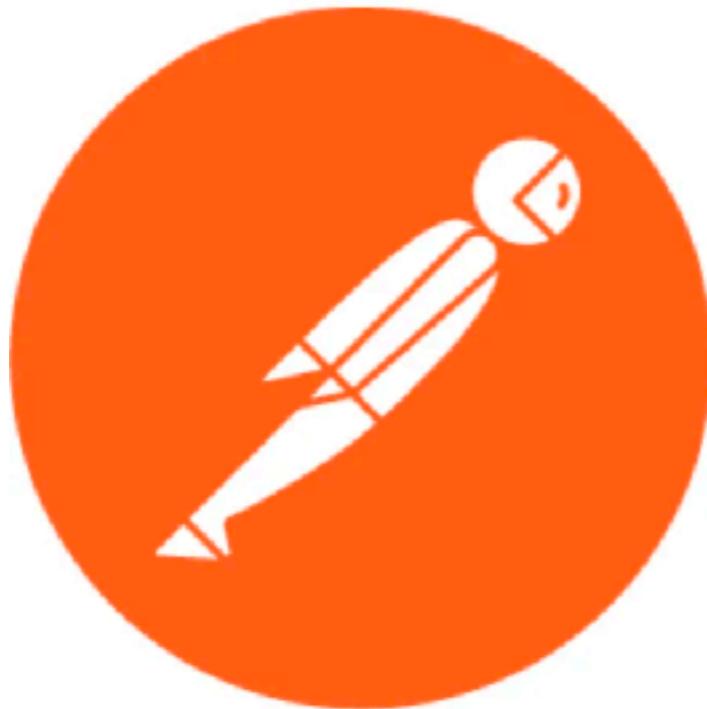
<https://springdoc.org/>



How to test UserController ?



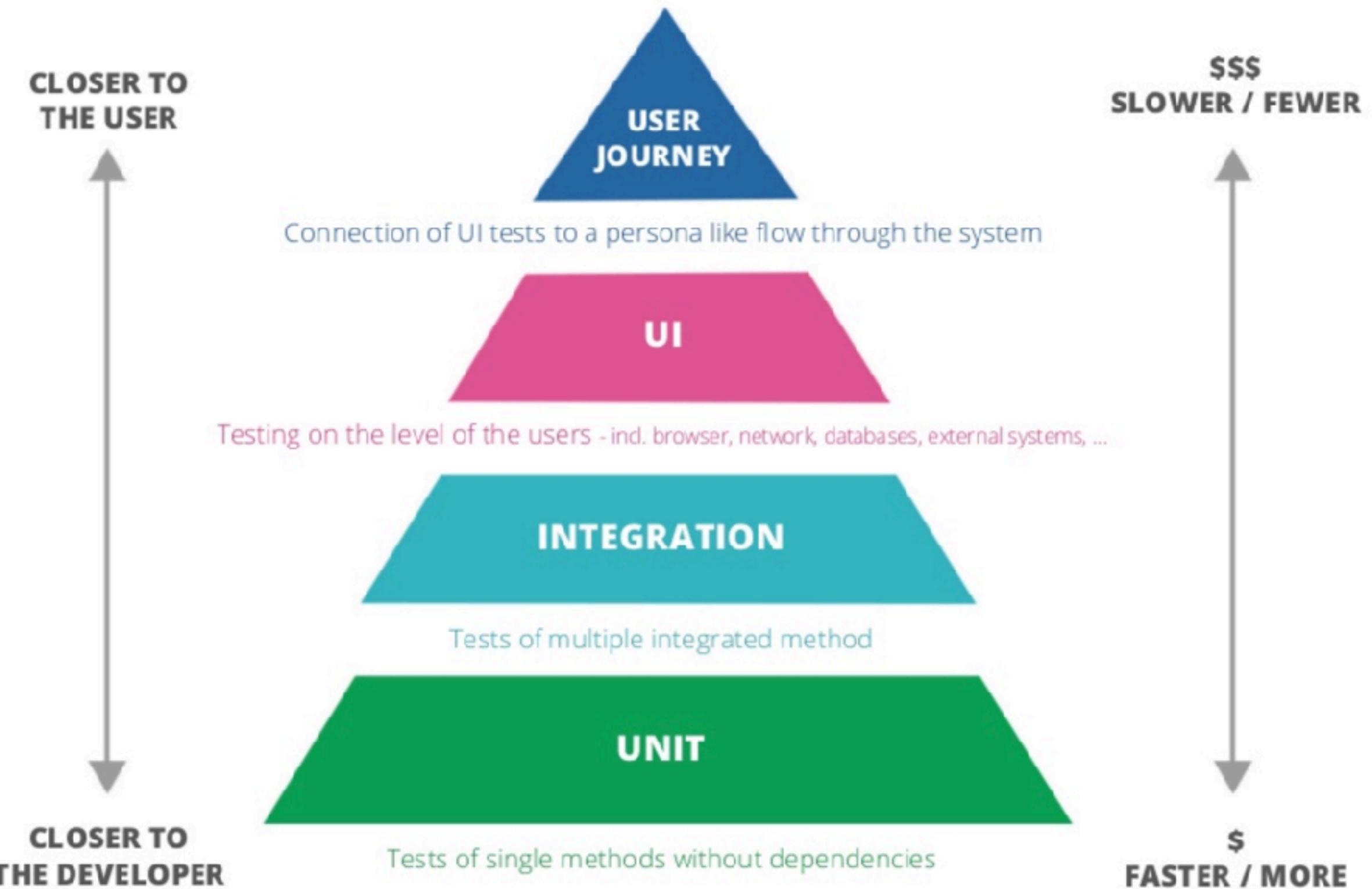
Postman



POSTMAN

<https://www.postman.com/downloads/>





Controller testing

How to testing with Spring Boot ?

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-test</artifactId>
    <scope>test</scope>
</dependency>
```

<https://docs.spring.io/spring-boot/docs/current/reference/html/features.html#features.testing>



Spring Boot Testing

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-test</artifactId>
    <scope>test</scope>
</dependency>
```



<https://docs.spring.io/spring-boot/docs/current/reference/html/features.html#features.testing>



Testing in Spring Boot

@SpringBootTest
@WebMVCTest
@JsonTest
@DataJpaTest
@RestClientTest



Testing in Spring Boot

@SpringBootTest

@WebMVC Test

@JsonTest

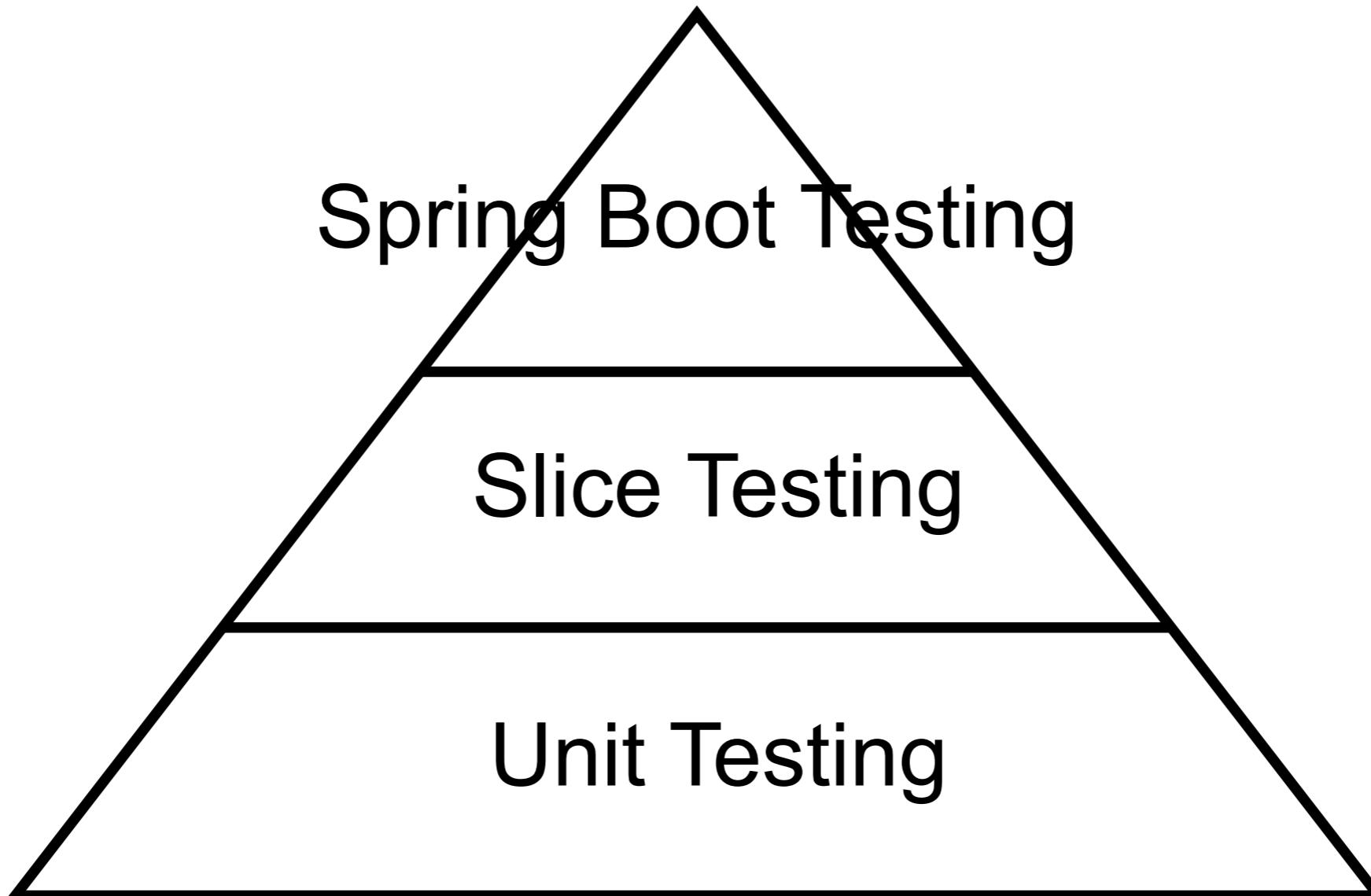
@DataJpaTest

@RestClientTest

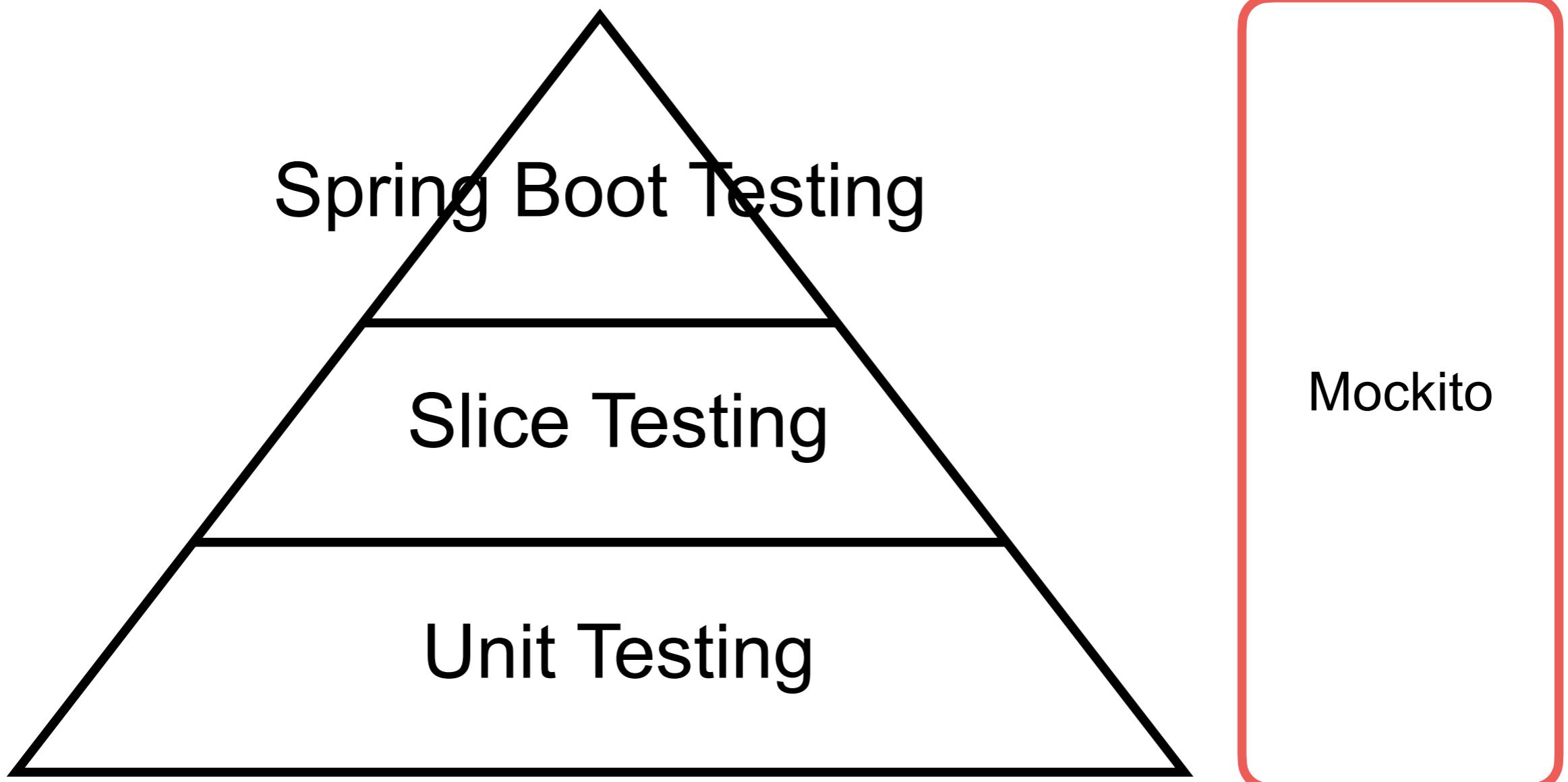
Slice testing



Testing in Spring Boot



Testing in Spring Boot



Controller testing

1. Spring Boot Testing
2. Slice Testing with MockMvc
3. Unit Testing



1. SpringBootTest

Application context

Controller Advice

Controllers

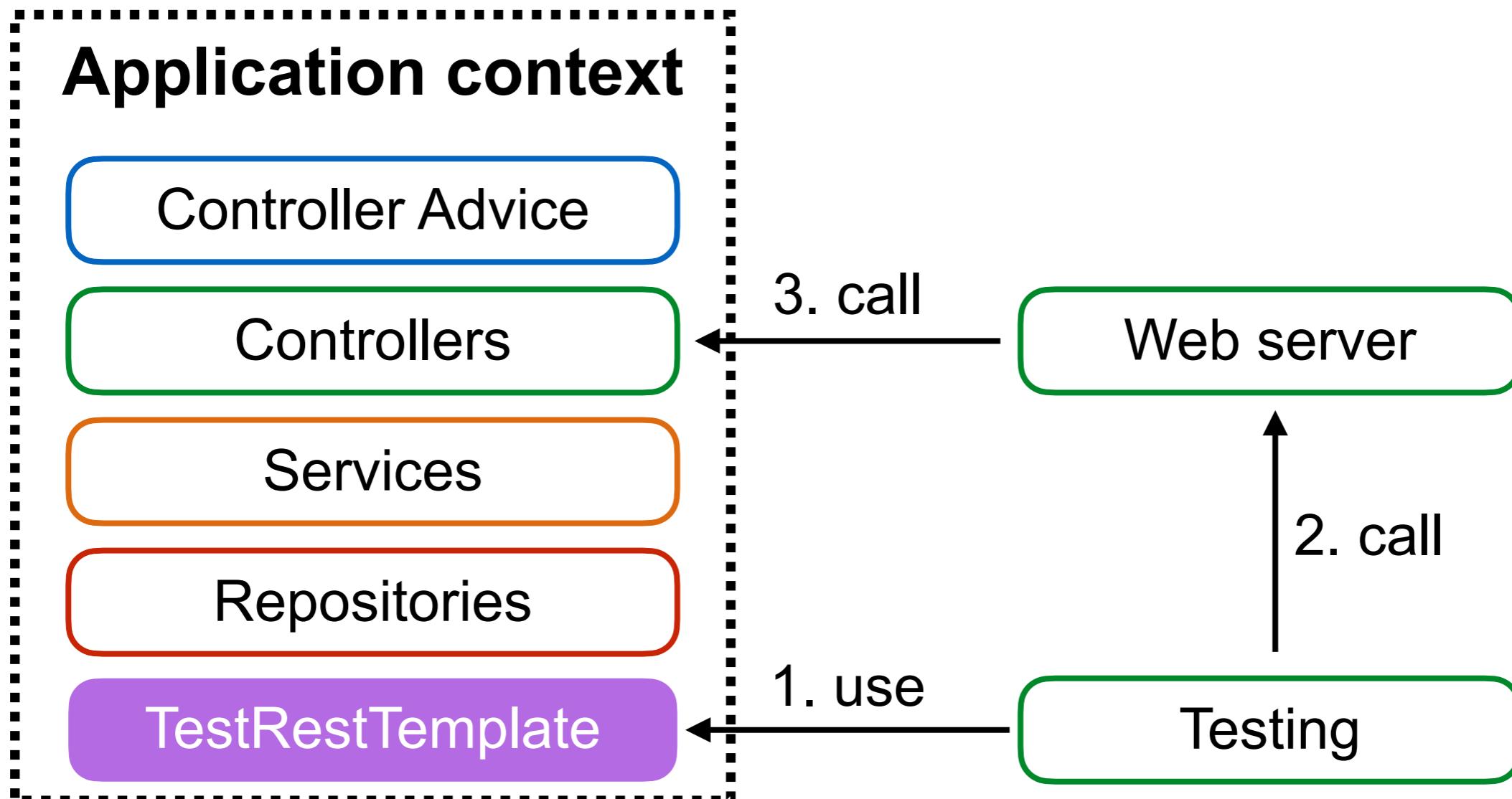
Services

Repositories

<https://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#features.testing>



1. SpringBootTest



SpringBootTest #1

```
@RunWith(SpringRunner.class)
@SpringBootTest(webEnvironment
        = SpringBootTest.WebEnvironment.RANDOM_PORT)
public class HelloControllerTest {

    @Autowired
    private TestRestTemplate testRestTemplate;

    @Test
    public void sayHi() {
        // Action :: Call controller
        Hello actualResult
            = testRestTemplate.getForObject("/hello/somkiat",
                                            Hello.class);

        // Assertion :: Check result with expected result
        assertEquals("Hello, somkiat", actualResult.getMessage());
    }
}
```



SpringBootTest #2

```
@RunWith(SpringRunner.class)
@SpringBootTest(webEnvironment
        = SpringBootTest.WebEnvironment.RANDOM_PORT)
public class HelloControllerTest {

    @Autowired
    private TestRestTemplate testRestTemplate;

    @Test
    public void sayHi() {
        // Action :: Call controller
        Hello actualResult
            = testRestTemplate.getForObject("/hello/somkiat",
                Hello.class);

        // Assertion :: Check result with expected result
        assertEquals("Hello, somkiat", actualResult.getMessage());
    }
}
```



SpringBootTest #3

```
@RunWith(SpringRunner.class)
@SpringBootTest(webEnvironment
        = SpringBootTest.WebEnvironment.RANDOM_PORT)
public class HelloControllerTest {

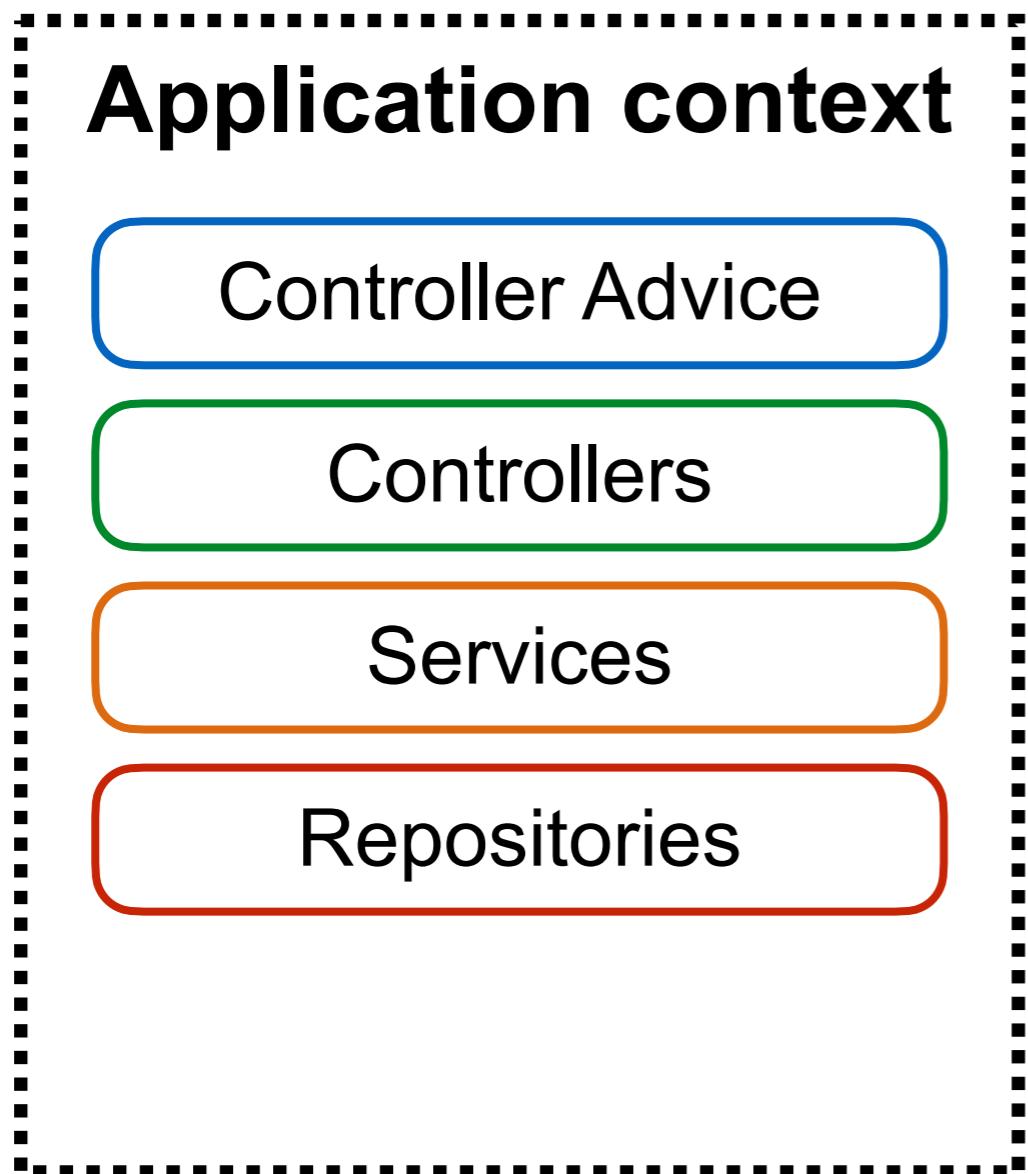
    @Autowired
    private TestRestTemplate testRestTemplate;

    @Test
    public void sayHi() {
        // Action :: Call controller
        Hello actualResult
                = testRestTemplate.getForObject("/hello/somkiat",
                                                Hello.class);

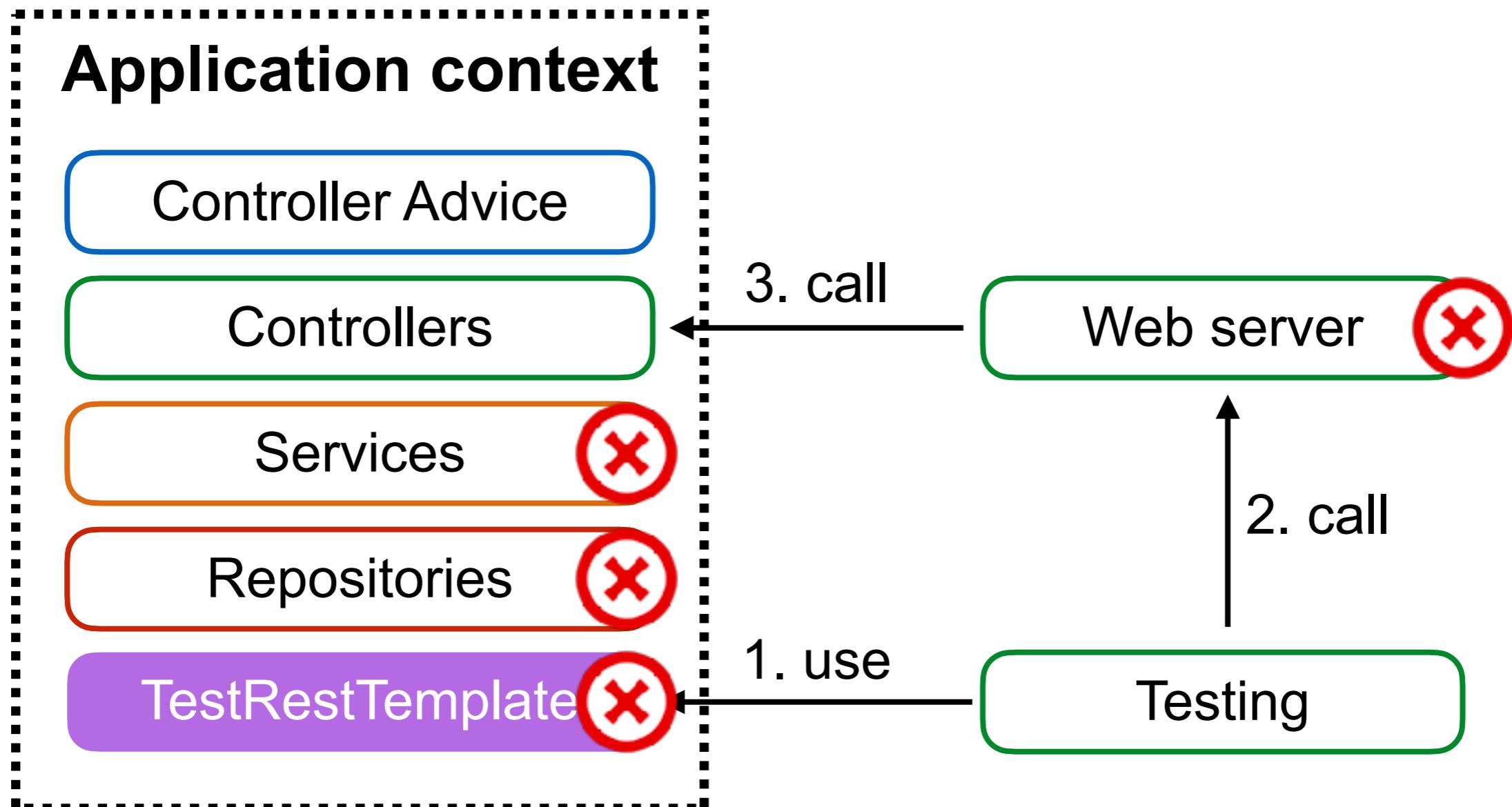
        // Assertion :: Check result with expected result
        assertEquals("Hello, somkiat", actualResult.getMessage());
    }
}
```



2. Slice Testing with MockMVC



2. Slice Testing with MockMVC



MockMvcTest #1

```
@RunWith(SpringRunner.class)
@WebMvcTest(NumberController.class)
public class NumberControllerMockMvcTest {

    @MockBean
    private MyRandom stubRandom;

    @Autowired
    private MockMvc mvc;

    @Test
    public void success() throws Exception {
        NumberControllerResponse expected
            = new NumberControllerResponse("5555");

        // Stub
        given(stubRandom.nextInt(10)).willReturn(5555);
    }
}
```



MockMvcTest #2

```
@RunWith(SpringRunner.class)
@WebMvcTest(NumberController.class)
public class NumberControllerMockMvcTest {

    @MockBean
    private MyRandom stubRandom;

    @Autowired
    private MockMvc mvc;

    @Test
    public void success() throws Exception {
        NumberControllerResponse expected
            = new NumberControllerResponse("5555");

        // Stub
        given(stubRandom.nextInt(10)).willReturn(5555);

        // ...
    }
}
```



MockMvcTest #3

Use ObjectMapper to convert JSON to object

```
// Call API HTTP response code = 200
String response =
    this.mvc.perform(get("/number"))
    .andExpect(status().isOk())
    .andReturn()
    .getResponse().getContentAsString();

// Convert JSON message to Object
ObjectMapper mapper = new ObjectMapper();
NumberControllerResponse actual =
    mapper.readValue(response,
        NumberControllerResponse.class);
```



3. Unit testing with Controller



Unit test

Use Test Double

In java, use Mockito library



<http://site.mockito.org/>



Unit testing with Mockito #1

```
@ExtendWith(MockitoExtension.class)
public class NumberControllerUnitTest {

    @Mock
    private MyRandom stubRandom;

    @Test
    public void success() throws Exception {
        NumberControllerResponse expected
            = new NumberControllerResponse("5555");

        // Stub
        given(stubRandom.nextInt(10)).willReturn(5555);
    }
}
```



Unit testing with Mockito #2

```
@ExtendWith(MockitoExtension.class)
public class NumberControllerUnitTest {

    @Mock
    private MyRandom stubRandom;

    @Test
    public void success() throws Exception {
        NumberControllerResponse expected
            = new NumberControllerResponse("5555");

        // Stub
        given(stubRandom.nextInt(10)).willReturn(5555);
    }
}
```



Unit testing with Mockito #3

```
@Test
public void success() throws Exception {
    NumberControllerResponse expected
        = new NumberControllerResponse("5555");

    // Stub
    given(stubRandom.nextInt(10)).willReturn(5555);

    // Call
    NumberController controller = new NumberController(stubRandom);
    NumberControllerResponse actual = controller.randomNumber();

    // Assert
    assertEquals("5555", actual.getValue());
    assertEquals(expected, actual);
}
```



Error handling



Working with Error Responses

ErrorResponse

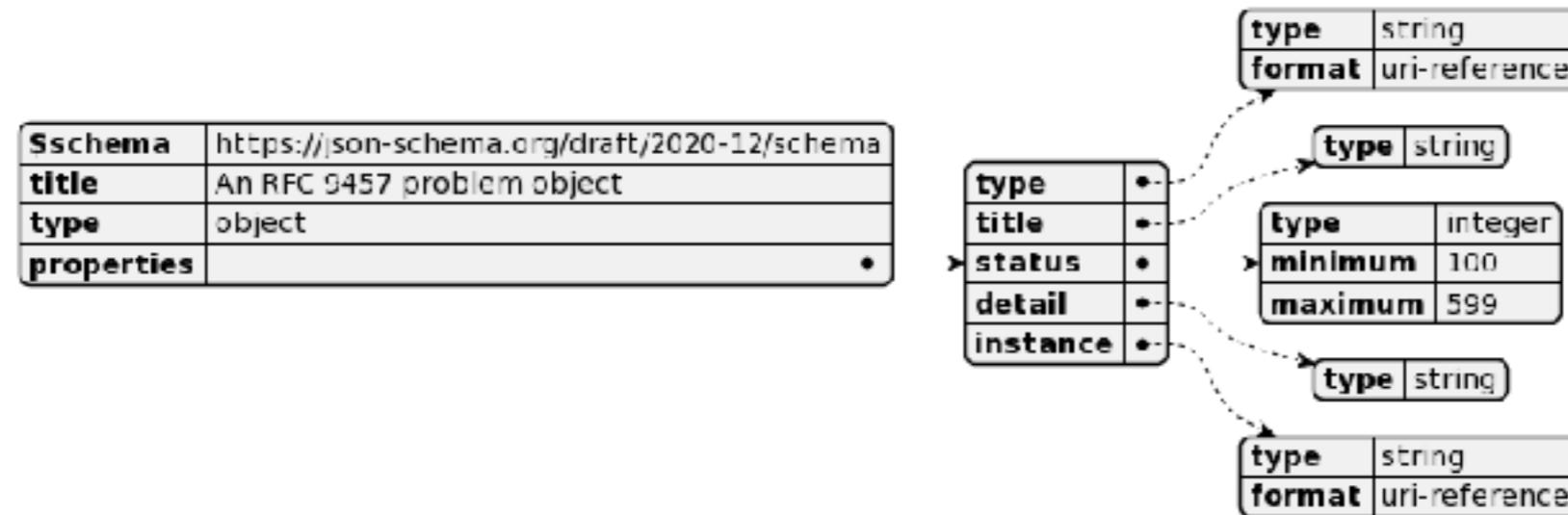
ProblemDetail

Customization

<https://docs.spring.io/spring-framework/reference/web/webmvc/mvc-ann-rest-exceptions.html>



ProblemDetail



```
{  
  "type": "https://problems-registry.smartbear.com/missing-body-property",  
  "status": 400,  
  "title": "Missing body property",  
  "detail": "The request is missing an expected body property.",  
  "code": "400-09",  
  "instance": "/logs/registrations/d24b2953-ce05-488e-bf31-67de50d3d085",  
  "errors": [  
    {  
      "detail": "The body property {name} is required",  
      "pointer": "/name"  
    }  
  ]  
}
```

<https://docs.spring.io/spring-framework/docs/current/javadoc-api/org/springframework/http/ProblemDetail.html>



Spring Framework

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ProblemDetail

Enable ProblemDetail for error by default

application.properties

```
spring.mvc.problemdetails.enabled=true
```



Example in ControllerAdvice

```
@RestControllerAdvice
class HelloControllerAdvice {

    @ExceptionHandler(InvalidInputException.class)
    public ProblemDetail handleInvalidInputException(
        InvalidInputException e, WebRequest request) {

        ProblemDetail problemDetail
            = ProblemDetail
                .forStatusAndDetail(HttpStatus.BAD_REQUEST, e.getMessage());
        problemDetail.setInstance(URI.create("demo-instance"));
        problemDetail.setTitle("demo");

        return problemDetail;
    }
}
```



Error handling

```
@Service
public class UserService {

    private AccountRepository accountRepository;

    @Autowired
    public UserService(AccountRepository accountRepository) {
        this.accountRepository = accountRepository;
    }

    public Account getAccount(int id) {
        Optional<Account> account = accountRepository.findById(id);
        if(account.isPresent()) {
            return account.get();
        }
        throw new MyAccountNotFoundException(
            String.format("Account id=[%d] not found", id));
    }
}
```



MyAccountNotFoundException

```
public class MyAccountNotFoundException  
    extends RuntimeException {
```

```
    public MyAccountNotFoundException(String message) {  
        super(message);  
    }
```

```
}
```



Response Status

404 = Not Found

Status	Description
400	Request body doesn't meet API spec
401	Authentication/Authorization fail
403	User can't perform the operation
404	Resource does not exist
405	Unsupported operation
500	Error on server



Handling error in Spring Boot

```
@RestControllerAdvice  
public class AccountControllerHandler {  
  
    @ExceptionHandler(MyAccountNotFoundException.class)  
    public ResponseEntity<ExceptionResponse> accountNotFound(  
        MyAccountNotFoundException exception) {  
  
        ExceptionResponse response =  
            new ExceptionResponse(exception.getMessage(),  
                "More detail");  
  
        return new ResponseEntity<ExceptionResponse>(response,  
            HttpStatus.NOT_FOUND);  
    }  
}
```

1



Handling error in Spring Boot

```
@RestControllerAdvice  
public class AccountControllerHandler {  
  
    @ExceptionHandler(MyAccountNotFoundException.class)  
    public ResponseEntity<ExceptionResponse> accountNotFound(  
        MyAccountNotFoundException exception) {  
  
        ExceptionResponse response =  
            new ExceptionResponse(exception.getMessage(),  
                "More detail");  
  
        return new ResponseEntity<ExceptionResponse>(response,  
            HttpStatus.NOT_FOUND);  
    }  
}
```

2



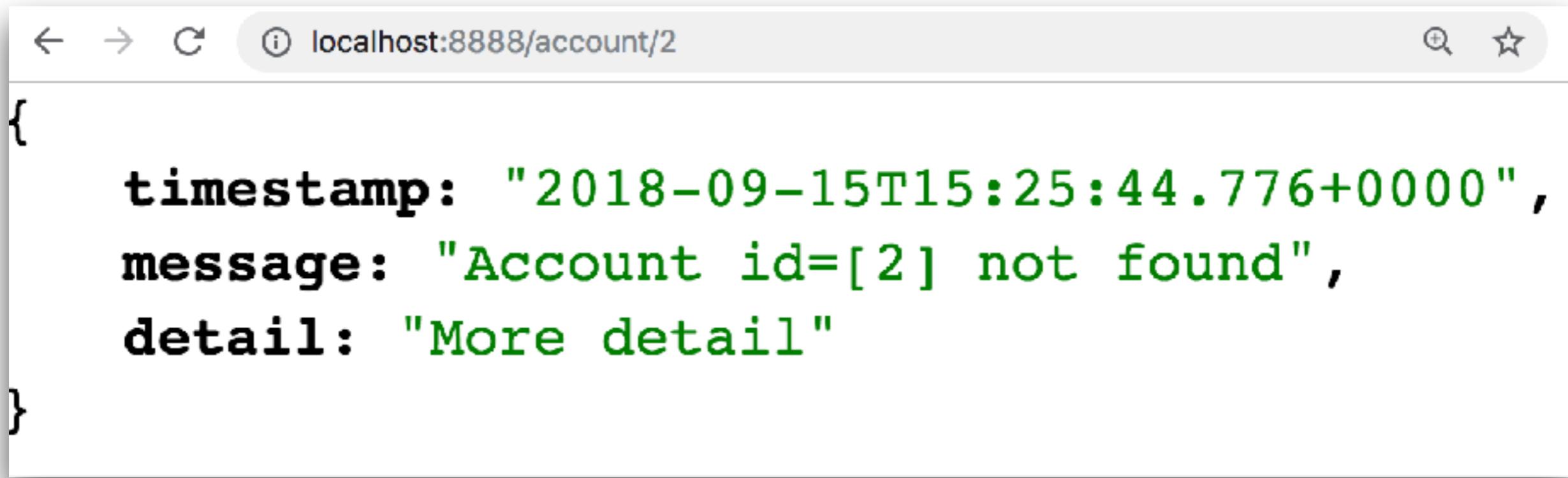
ExceptionResponse

Response format of error

```
public class ExceptionResponse{  
  
    private Date timestamp = new Date();  
    private String message;  
    private String detail;  
  
    public ExceptionResponse(String message, String detail) {  
        this.message = message;  
        this.detail = detail;  
    }  
}
```



Result of API



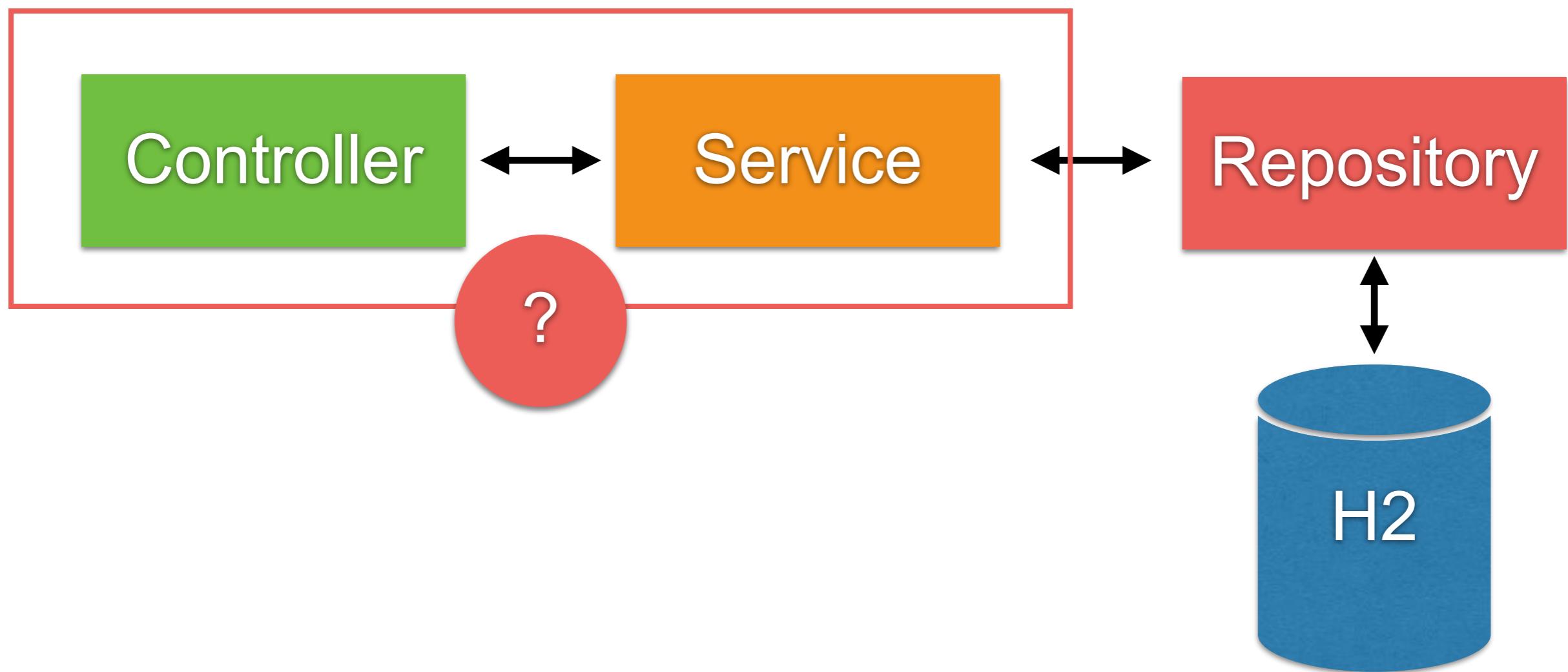
```
← → C ⓘ localhost:8888/account/2 🔍 ⭐  
{  
  timestamp: "2018-09-15T15:25:44.776+0000",  
  message: "Account id=[ 2 ] not found",  
  detail: "More detail"  
}
```



How to test ?



How to test with Error/Exception ?



Testing with WebMvcTest and MockMvc

Try to check data in response

```
@Test  
public void getByIdWithNotFoundAccount() throws Exception {  
    // Stub  
    given(userService.getAccount(2))  
        .willThrow(new MyAccountNotFoundException("Not found"));  
  
    mockMvc.perform(  
        get("/account/2")  
            .accept(MediaType.APPLICATION_JSON))  
        .andExpect(status().isNotFound())  
        .andExpect(content().contentType(MediaType.APPLICATION_JSON_UTF8))  
        .andExpect(jsonPath("$.message", is("Not found")));  
}
```

1



Testing with WebMvcTest and MockMvc

Try to check data in response

```
@Test  
public void getByIdWithNotFoundAccount() throws Exception {  
    // Stub  
    given(userService.getAccount(2))  
        .willThrow(new MyAccountNotFoundException("Not found"));  
  
    mockMvc.perform(  
        get("/account/2")  
            .accept(MediaType.APPLICATION_JSON))  
        .andExpect(status().isNotFound())  
        .andExpect(content().contentType(MediaType.APPLICATION_JSON_UTF8))  
        .andExpect(jsonPath("$.message", is("Not found")));  
}
```

2



Testing with Service

Try to check exception

```
@ExtendWith(MockitoExtension.class)
public class UserServiceTest {

    @Mock
    private UserRepository userRepository;

    @Test
    public void user_not_found_with_exception() {
        given(userRepository.findById(1))
            .willReturn(Optional.empty());
        UserService userService = new UserService();
        userService.setRepository(userRepository);

        Assertions.assertThrows(RuntimeException.class, () -> {
            userService.getData(1);
        });
    }
}
```



Compile with testing

\$mvnw clean test

```
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 2, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO]
```



Code coverage



"Code coverage can show the high risk areas in a program, but never the risk-free."

Paul Reilly, 2018, Kotlin TDD with Code Coverage



Code coverage

A tool to measure how much of your code is covered by tests that break down into classes, methods and lines.



Code coverage

But 100% of code coverage **does not mean** that your code is 100% correct



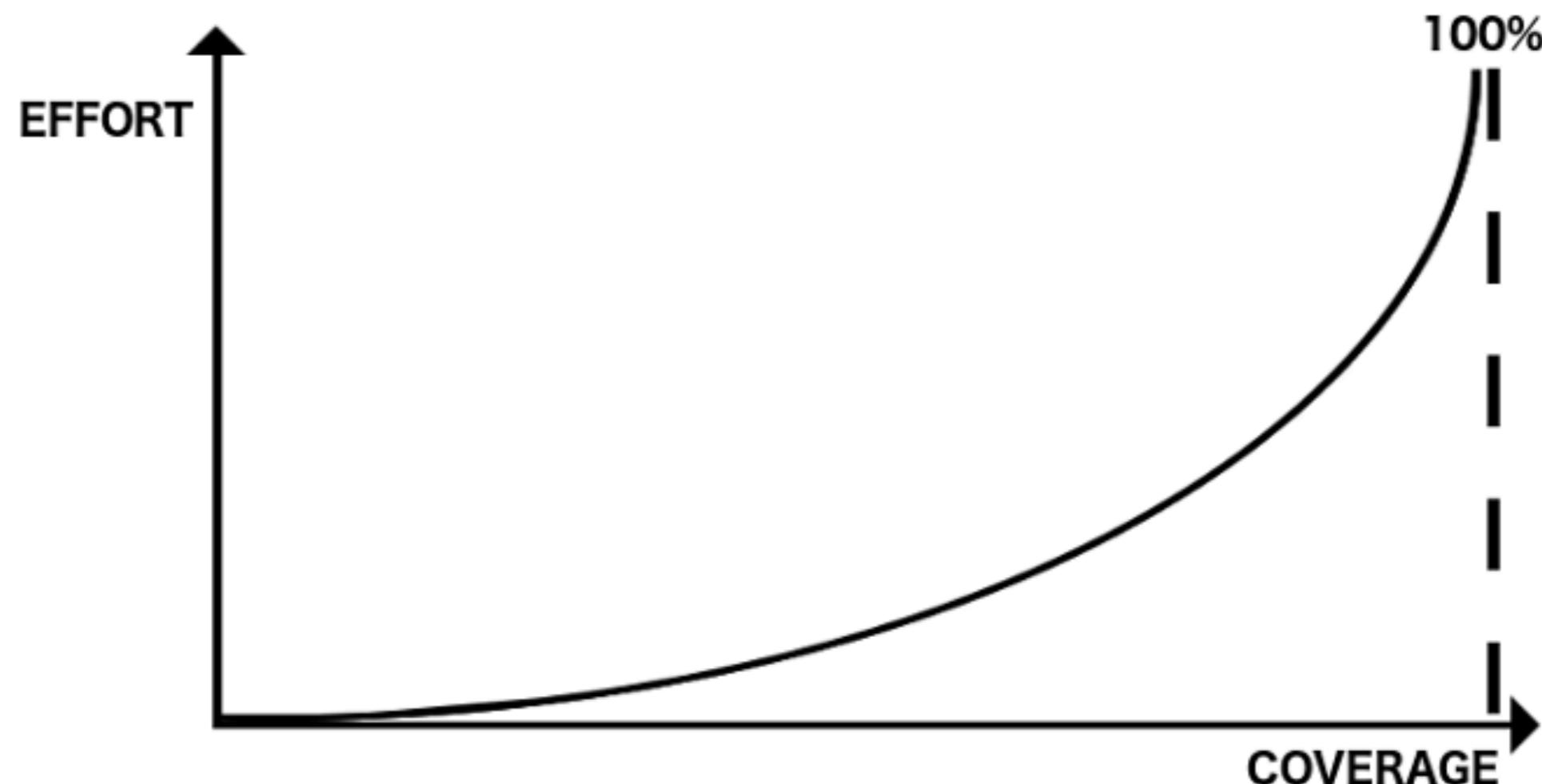
Code coverage

Powerful tool to improve the quality of your code

Code coverage != quality of tests



Code coverage 100% ?



% of Code/Test coverage



Code coverage with Java

Cobertura
Jacoco

<http://bit.ly/2DIlsDeX>



Run test again

\$mvnw clean package

Cobertura Report generation was successful.

Cobertura 2.1.1 - GNU GPL License (NO WARRANTY) - See COPYRIGHT file

Cobertura: Loaded information on 3 classes.

time: 125ms

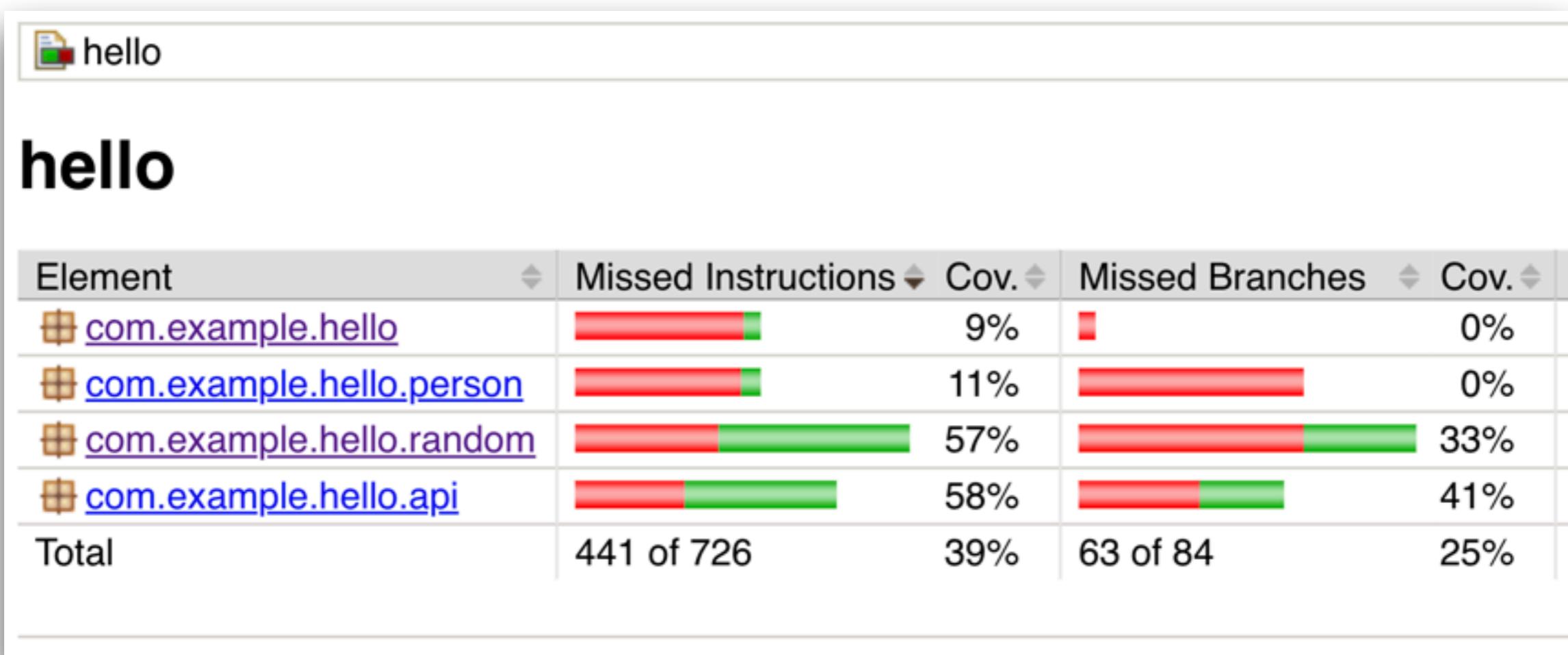
Cobertura Report generation was successful.

BUILD SUCCESS



Coverage report

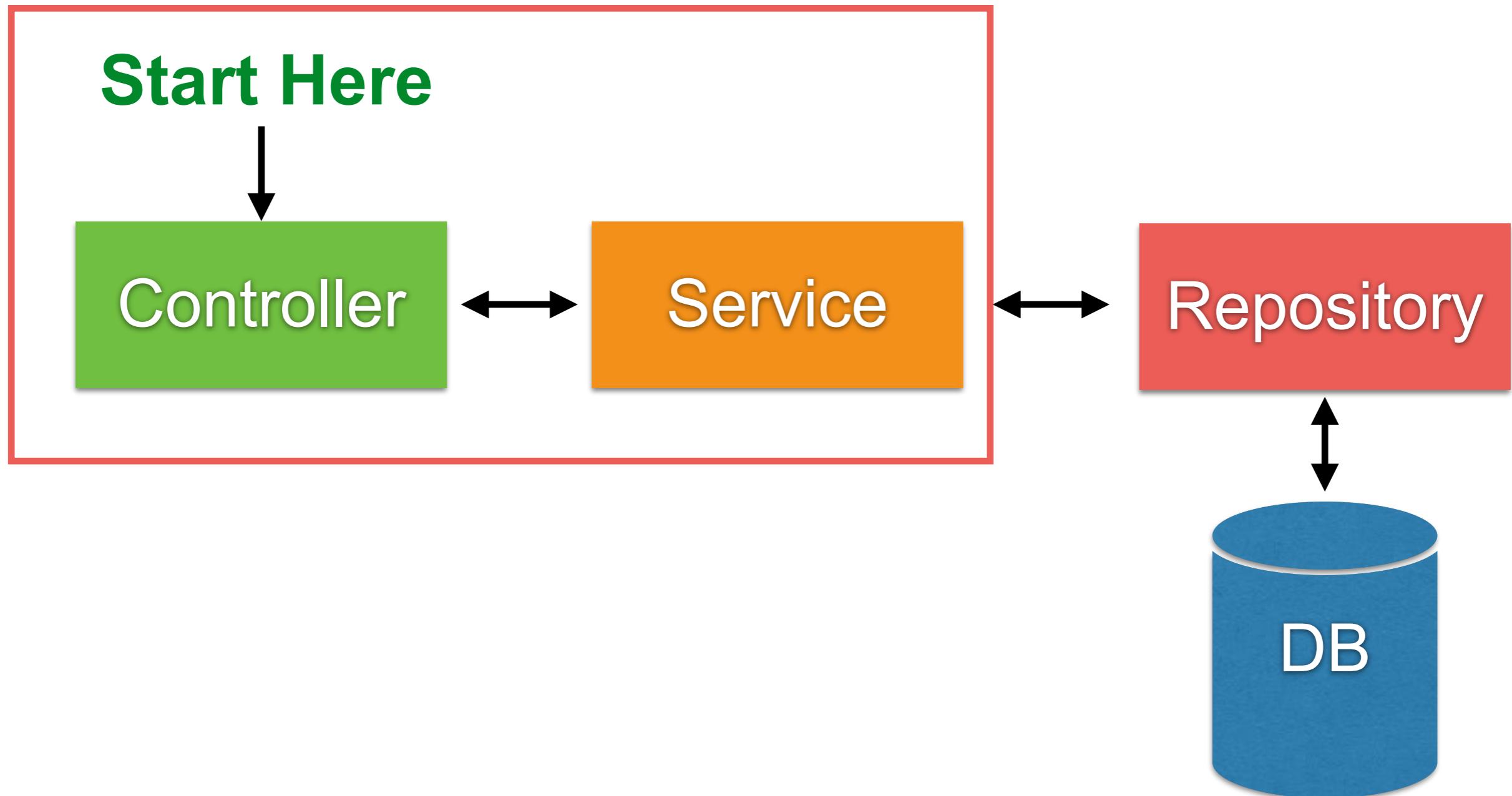
open target/site/jacoco/index.html



Move business logic to service

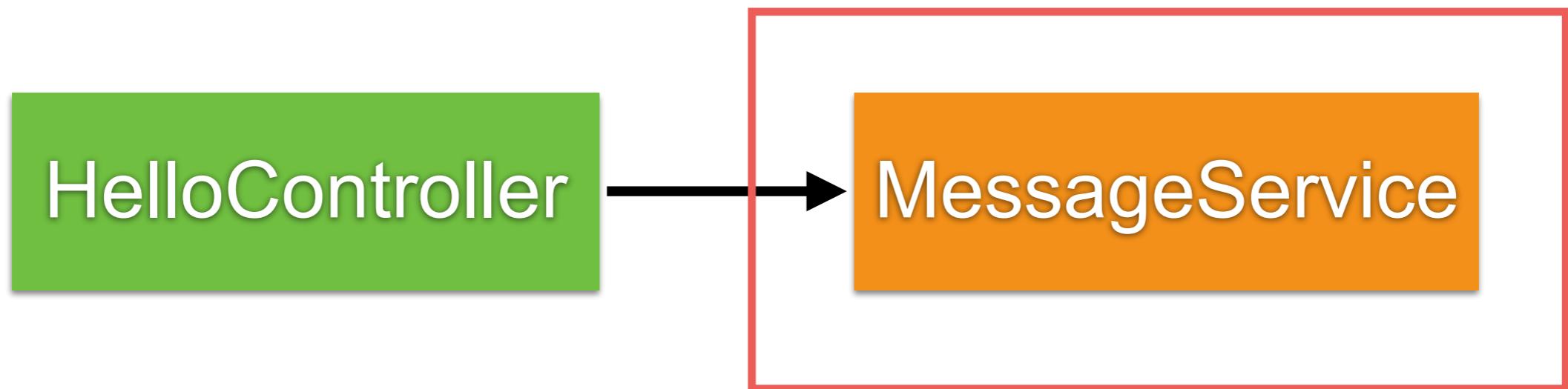


Working with service



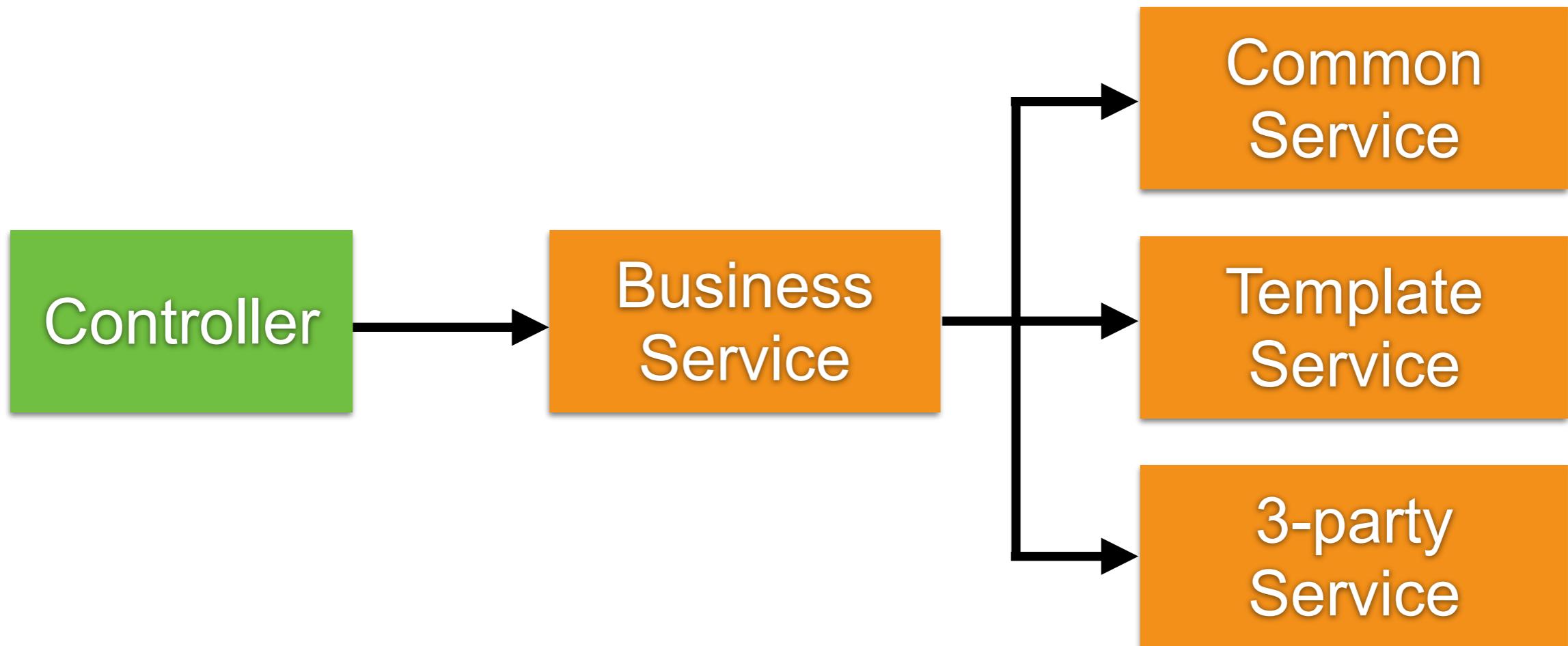
Move business logic to service

Service class or interface ?

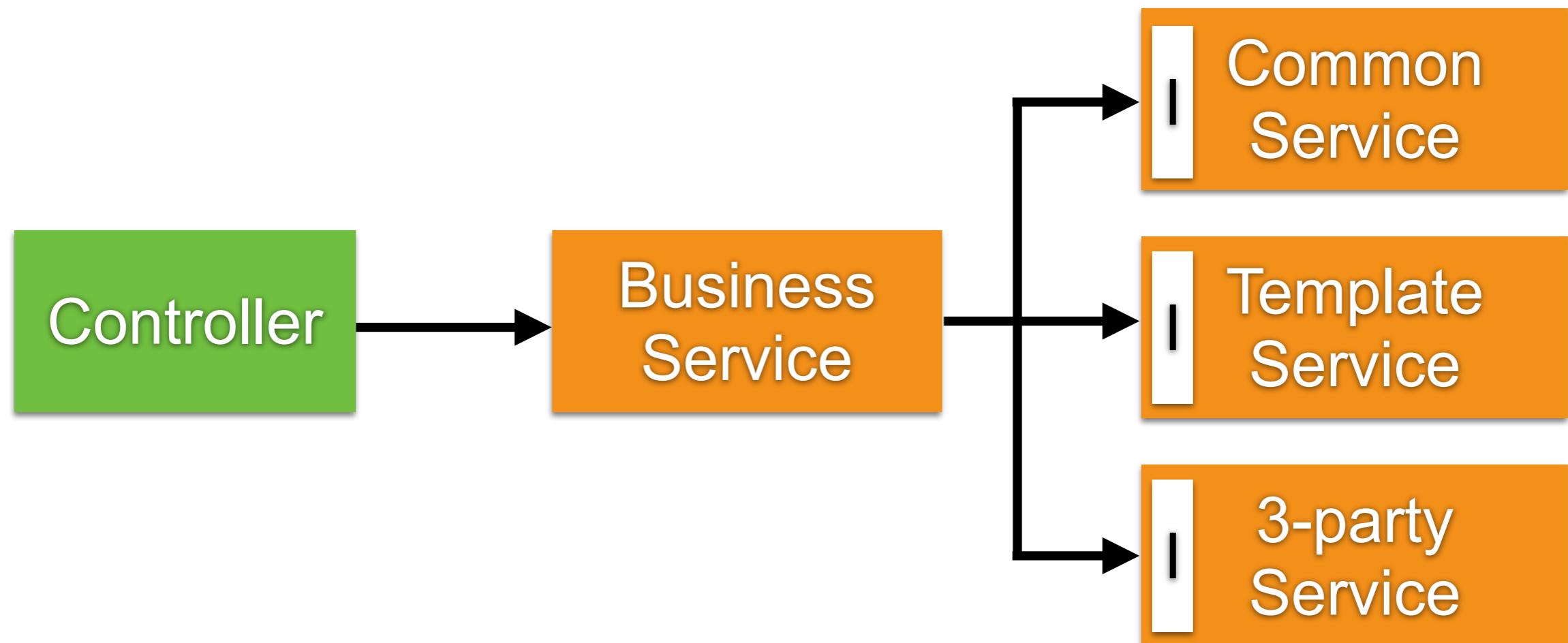


Types of service

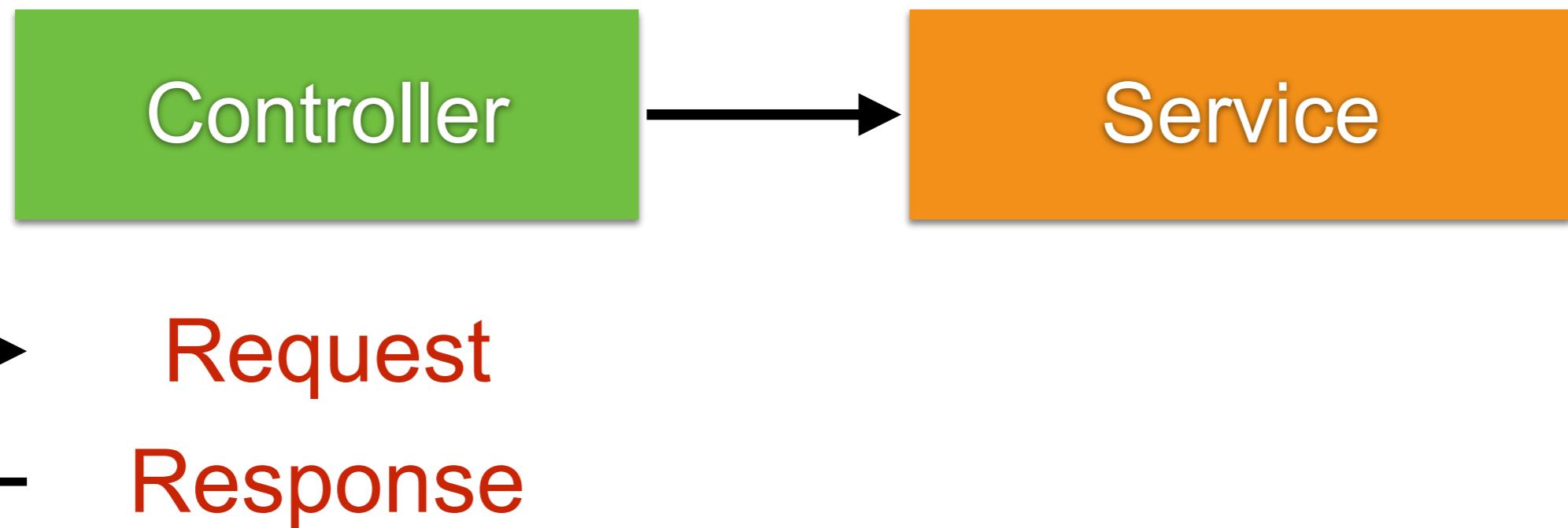
Business services (not reuse)
Common/Template/3-party services



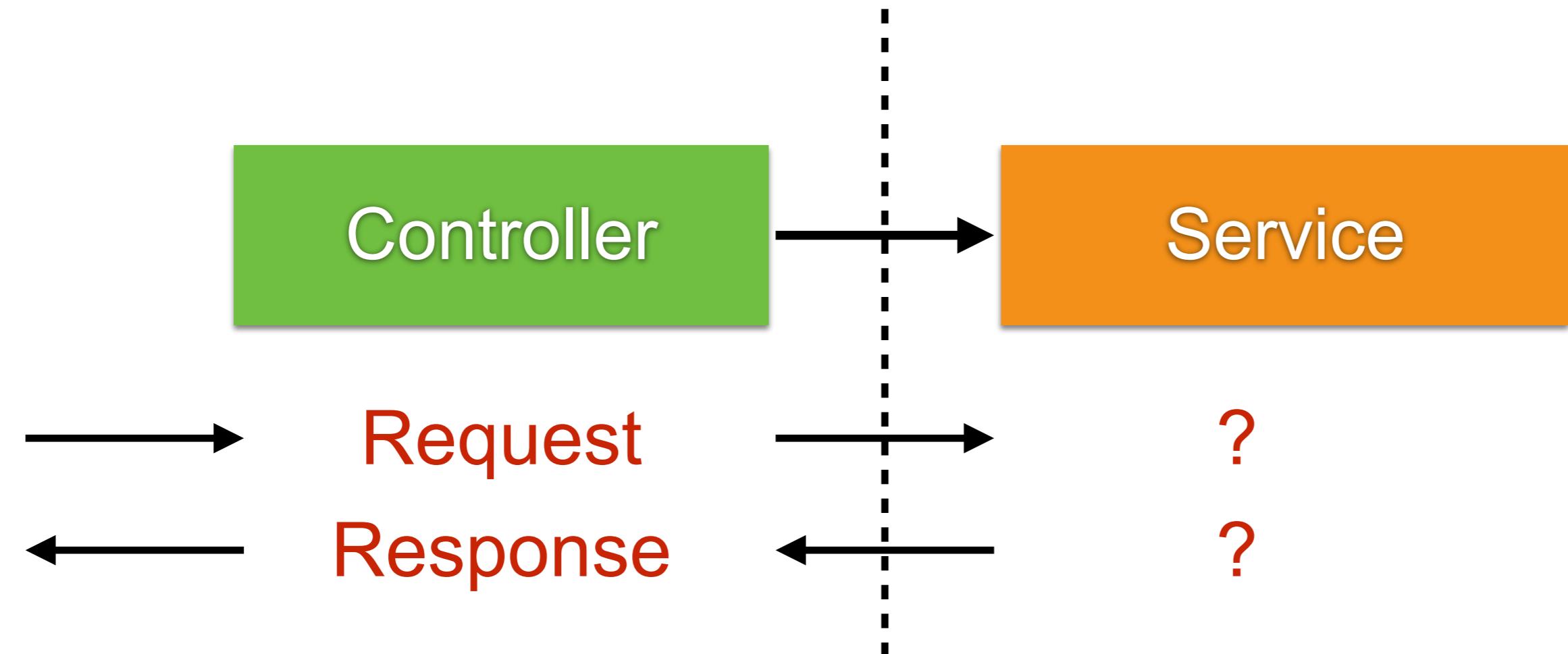
Interface for common service



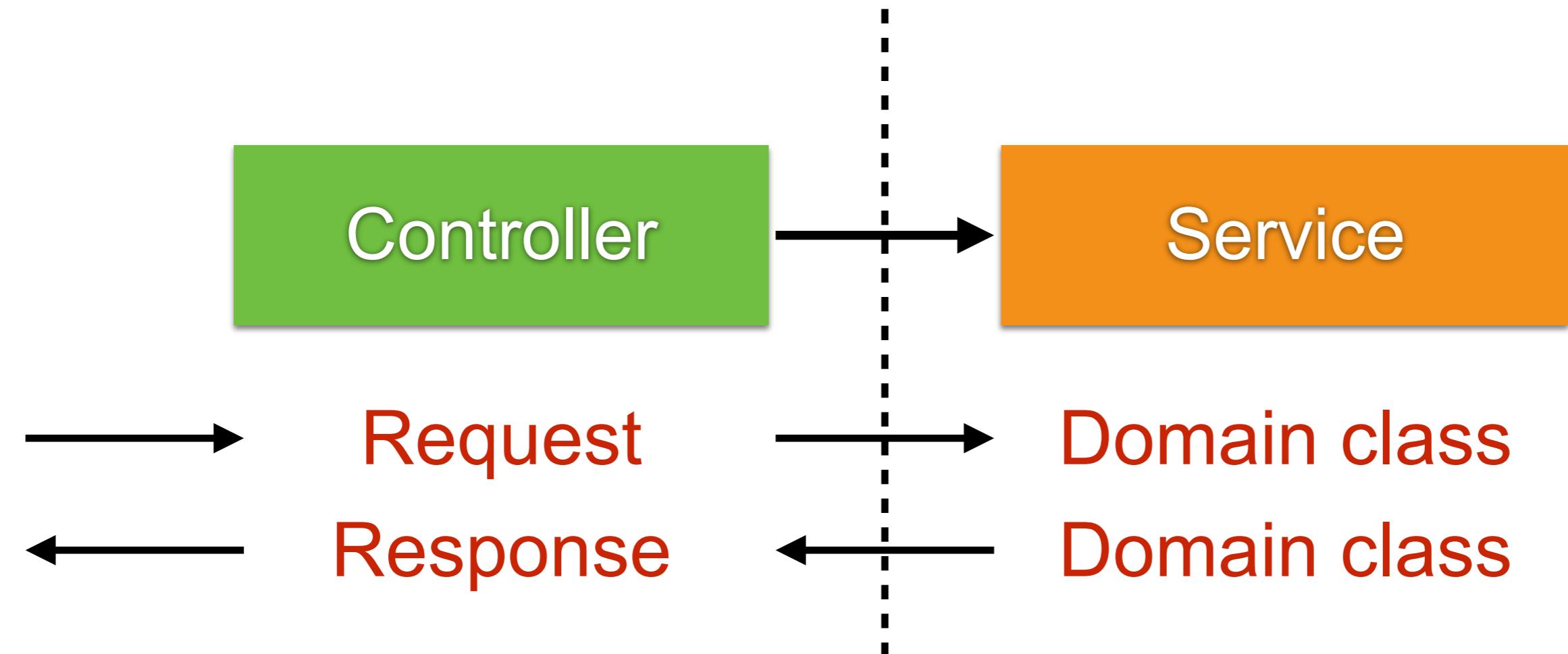
Data Model for service ?



Data Model ?

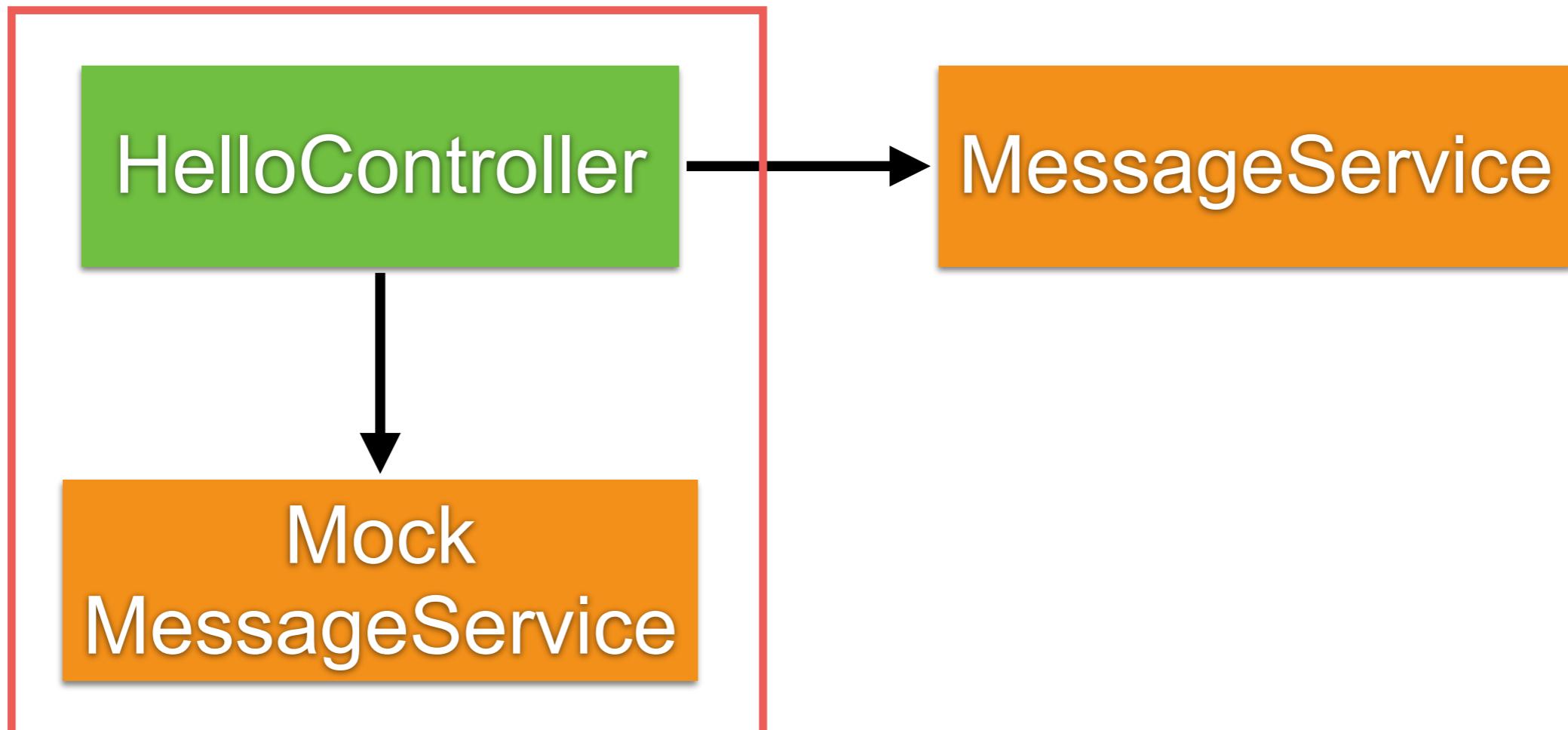


Data Model ?



Testing controller with service

Try to mocking service with Mockito



Run all tests !!

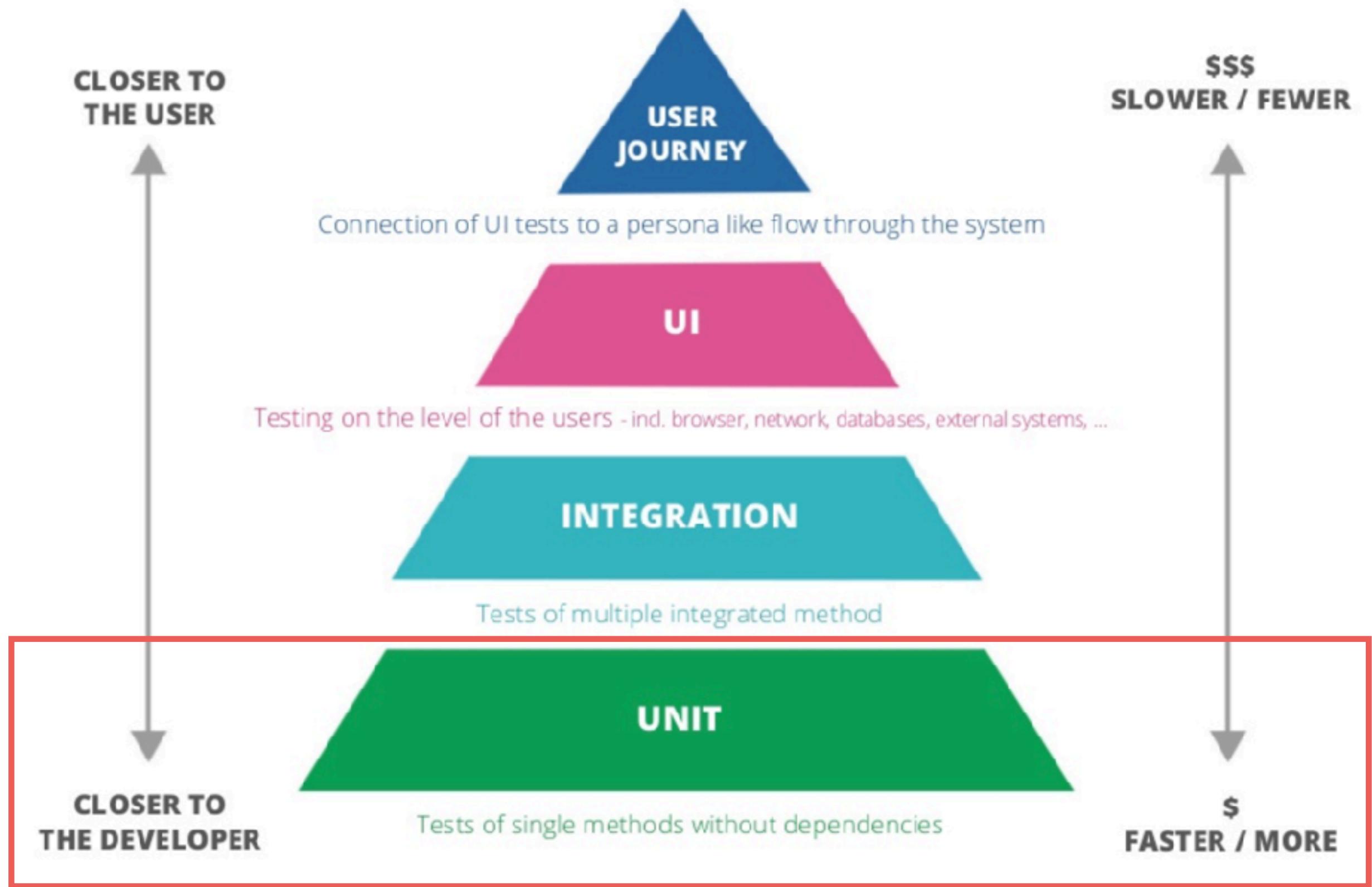
\$mvnw clean test

```
[INFO]
[INFO] Results:
[INFO]
[WARNING] Tests run: 10, Failures: 0, Errors: 0,
[INFO]
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 18.299 s
[INFO] Finished at: 2018-08-20T23:36:31+07:00
[INFO] -----
```

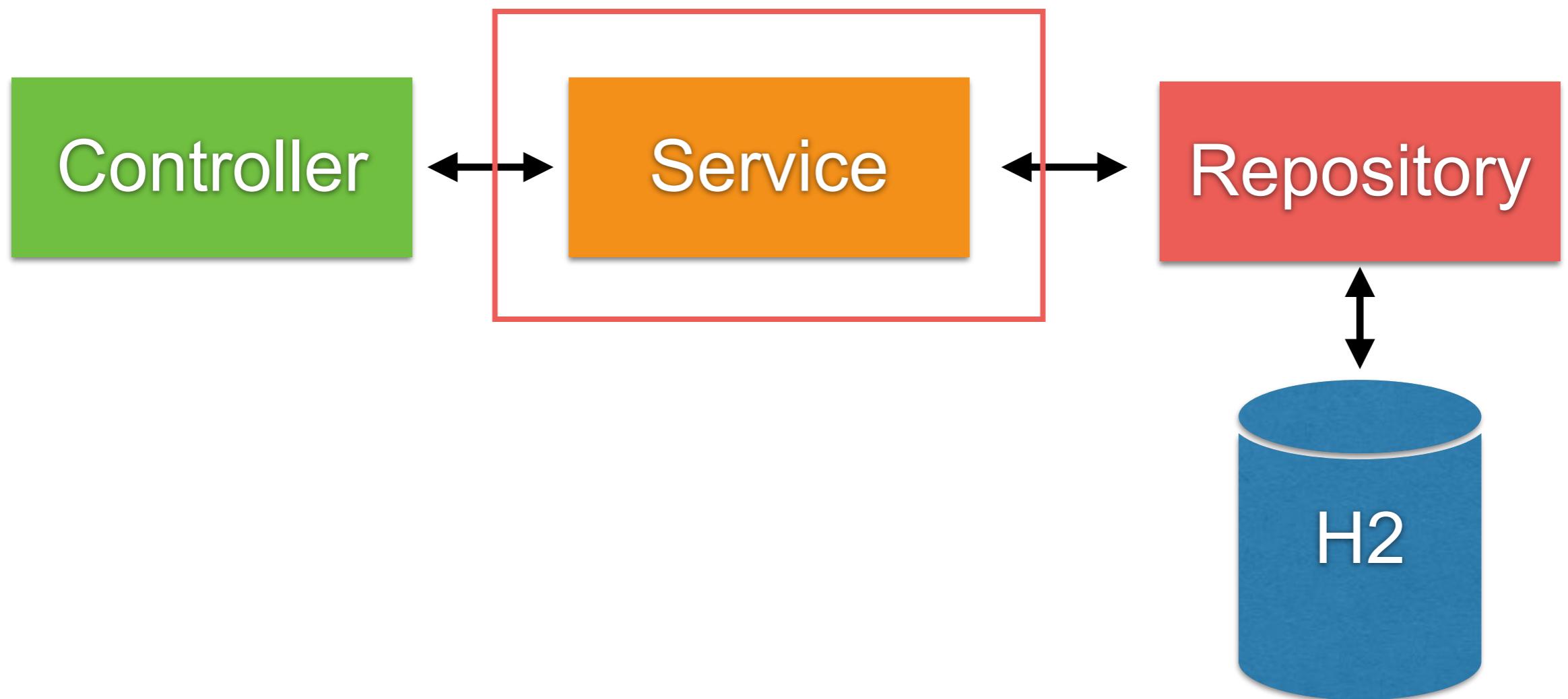


How to improve the speed of testing ?





Service Testing ?



Service Testing

```
@ExtendWith(MockitoExtension.class)
public class UserServiceTest {

    @Mock
    private AccountRepository accountRepository;

    @Test
    public void getAccount() {
        // Stub
        Account account = new Account();
        account.setUserName("user");
        account.setPassword("pass");
        account.setSalary(1000);
        given(accountRepository.findById(1))
            .willReturn(Optional.of(account));

        UserService userService = new UserService(accountRepository);
        Account actualAccount = userService.getAccount(1);
        assertNotNull(actualAccount);
    }
}
```

1



Service Testing

```
@ExtendWith(MockitoExtension.class)
```

```
public class UserServiceTest {
```

```
    @Mock
```

```
    private AccountRepository accountRepository;
```

```
    @Test
```

```
    public void getAccount() {
```

```
        // Stub
```

```
        Account account = new Account();
```

```
        account.setUserName("user");
```

```
        account.setPassword("pass");
```

```
        account.setSalary(1000);
```

```
        given(accountRepository.findById(1))
```

```
            .willReturn(Optional.of(account));
```



2

```
        UserService userService = new UserService(accountRepository);
```

```
        Account actualAccount = userService.getAccount(1);
```

```
        assertNotNull(actualAccount);
```

```
}
```

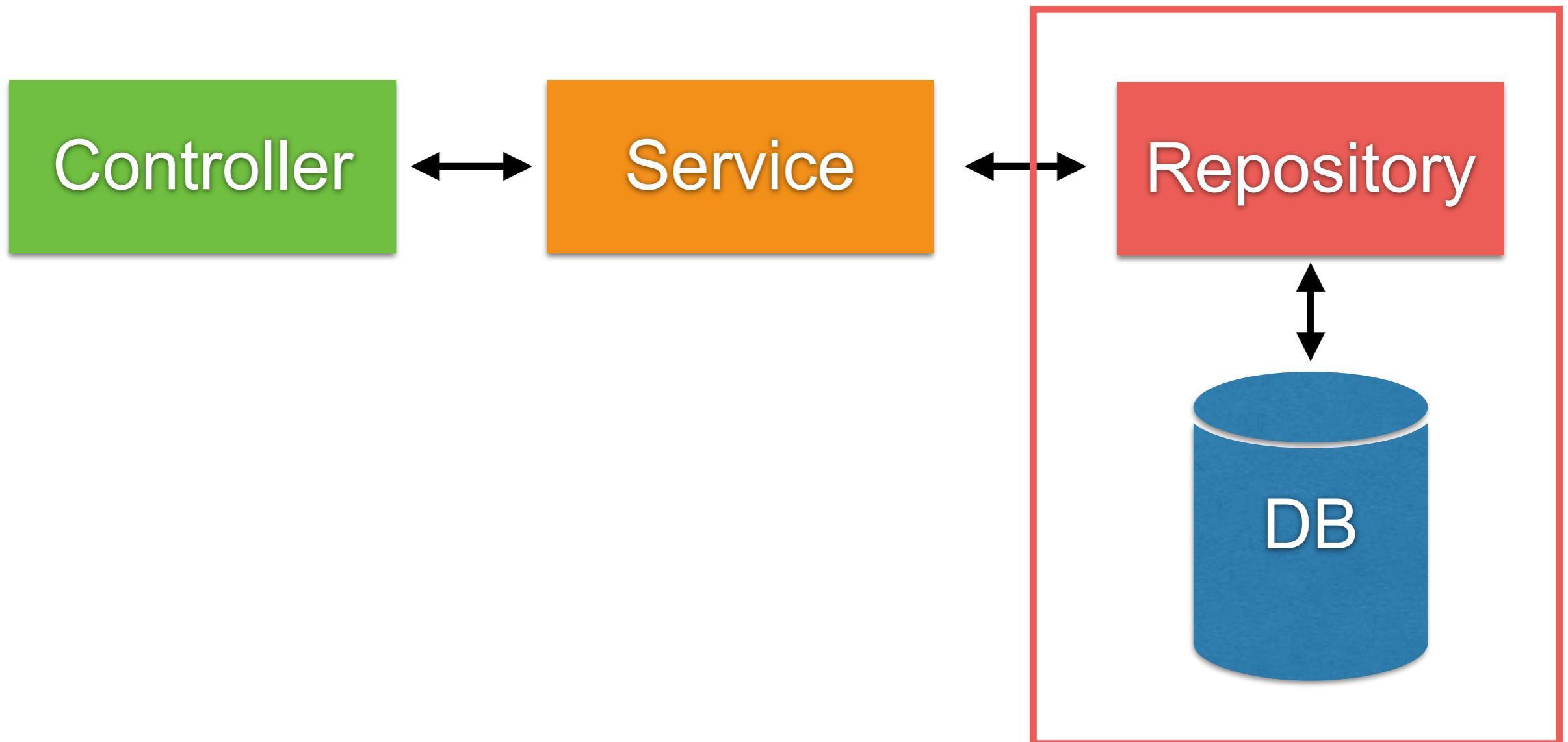
```
}
```



Working with Repository



Working with repository



Basic of JDBC

```
// 1. Load jdbc driver
Class.forName("postgresql");

// 2. Create connection
Connection connection = DriverManager.getConnection("", "", "");

// 3. Prepared Statement
String sql = "SELECT * FROM TABLE WHERE name=?";
PreparedStatement pStmt = connection.prepareStatement(sql);

// 4. Query
ResultSet resultSet = pStmt.executeQuery();
while(resultSet.next()) {

}

// 5. Release resource
if(resultSet != null) {
    resultSet.close();
    resultSet = null;
}
```



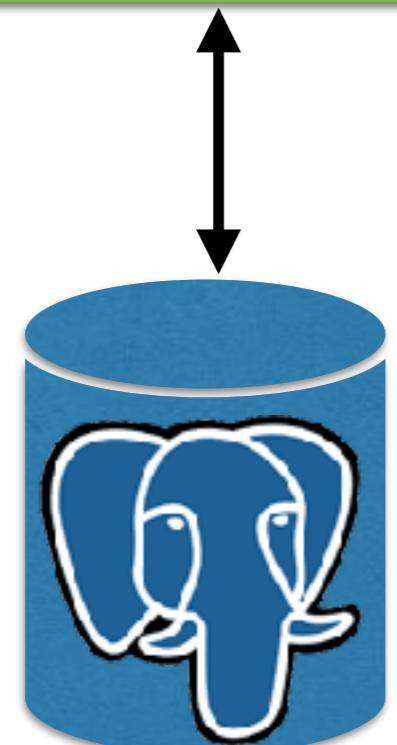
Framework !!

```
// 1. Load jdbc driver  
Class.forName("postgresql");  
Manage by Framework  
// 2. Create connection  
Connection connection = DriverManager.getConnection("", "", "");  
  
// 3. Prepared Statement  
String sql = "SELECT * FROM TABLE WHERE name=?";  
PreparedStatement pStmt = connection.prepareStatement(sql);  
  
// 4. Query  
ResultSet resultSet = pStmt.executeQuery();  
while(resultSet.next()) {  
  
}  
  
// 5. Release resource  
if(resultSet != null) {  
    resultSet.close();  
    resultSet = null;  
}
```

Manage by Framework

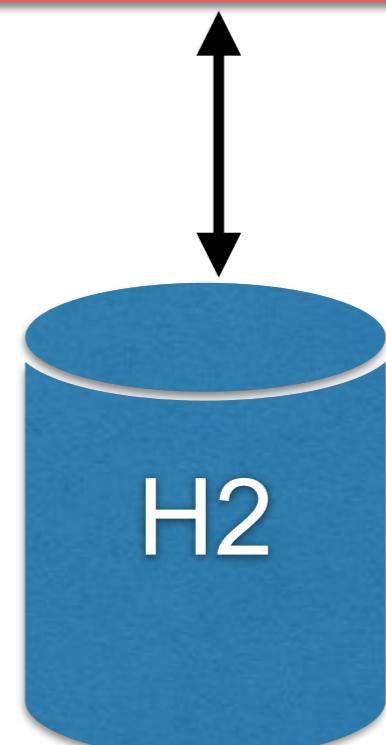
Working with Database ?

Production



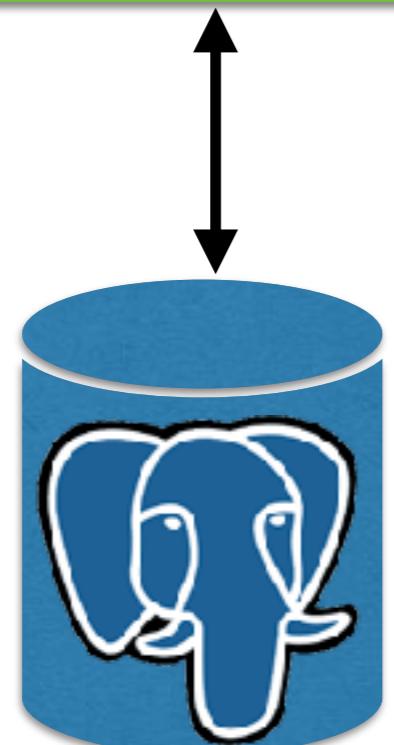
PostgreSQL

Testing



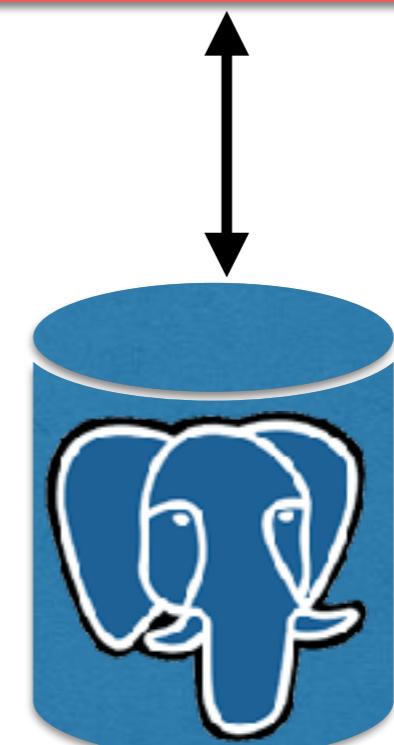
Working with Database ?

Production



PostgreSQL

Testing

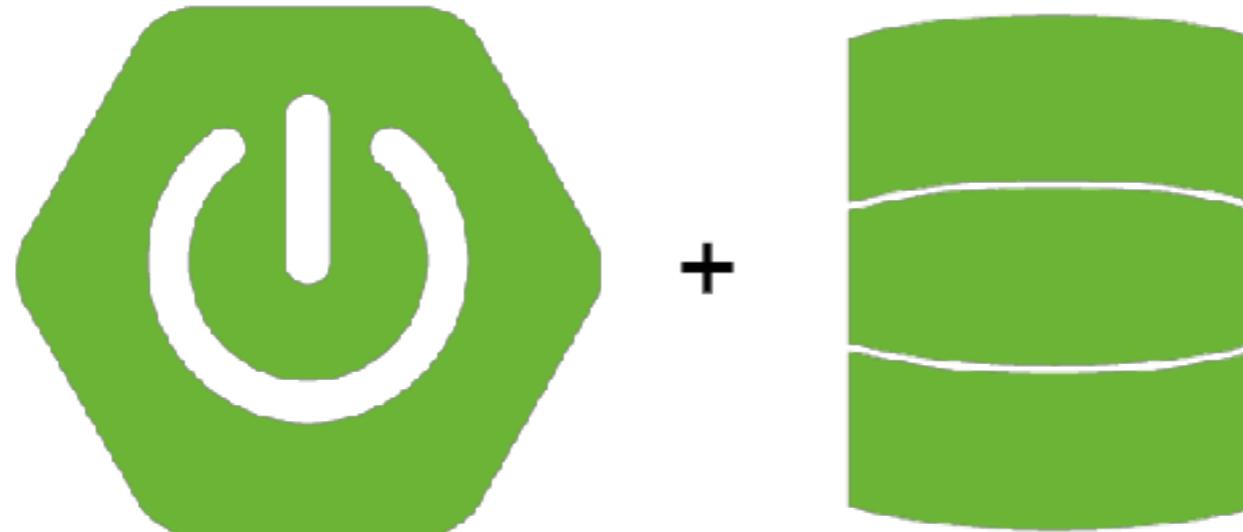


PostgreSQL



Working with repository

We're using Spring Data



<https://spring.io/projects/spring-data>



Spring Data

JDBC

JPA

MongoDB

Redis

more ...

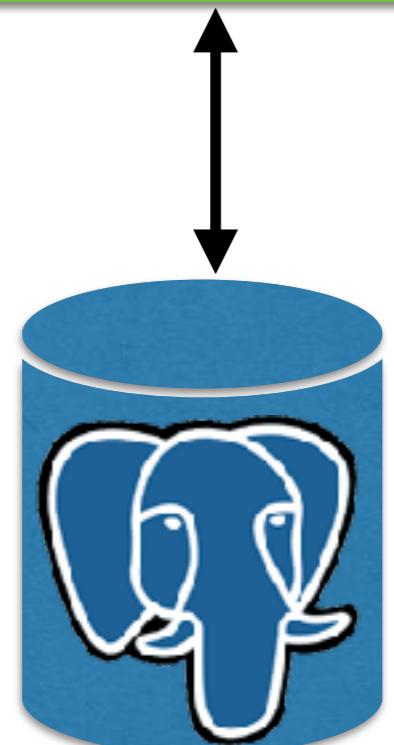


Working with Spring Data JPA



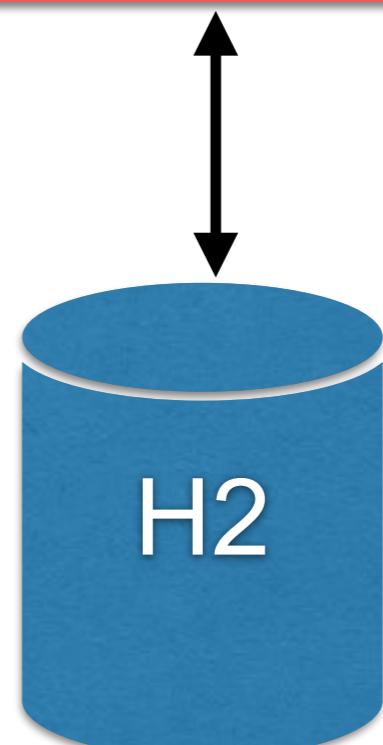
Working with Database

Production



PostgreSQ_L

Testing



Modify pom.xml

Add library of Spring Data JPA, PostgreSQL, H2

Dependencies

ADD DEPENDENCIES... ⌂ + B

PostgreSQL Driver SQL

A JDBC and R2DBC driver that allows Java programs to connect to a PostgreSQL database using standard, database independent Java code.

H2 Database SQL

Provides a fast in-memory database that supports JDBC API and R2DBC access, with a small (2mb) footprint. Supports embedded and server modes as well as a browser based console application.

Spring Data JPA SQL

Persist data in SQL stores with Java Persistence API using Spring Data and Hibernate.

<https://start.spring.io/>



Modify pom.xml

H2 for testing

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-data-jpa</artifactId>
</dependency>
```

```
<dependency>
    <groupId>com.h2database</groupId>
    <artifactId>h2</artifactId>
    <scope>test</scope>
</dependency>
```

```
<dependency>
    <groupId>org.postgresql</groupId>
    <artifactId>postgresql</artifactId>
    <scope>runtime</scope>
</dependency>
```



Modify pom.xml

PostgreSQL for production

```
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter-data-jpa</artifactId>
</dependency>

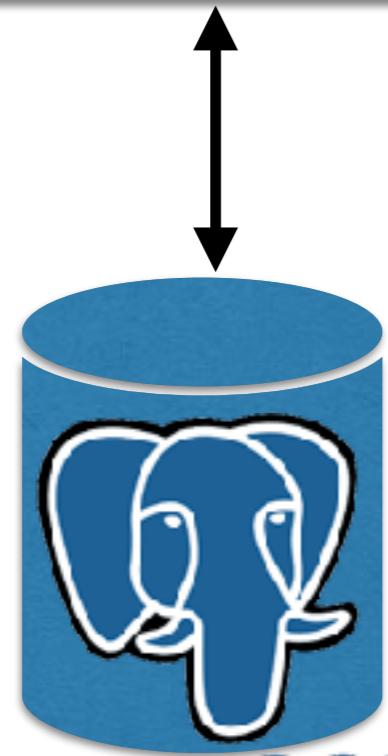
<dependency>
    <groupId>com.h2database</groupId>
    <artifactId>h2</artifactId>
    <scope>test</scope>
</dependency>

<dependency>
    <groupId>org.postgresql</groupId>
    <artifactId>postgresql</artifactId>
    <scope>runtime</scope>
</dependency>
```



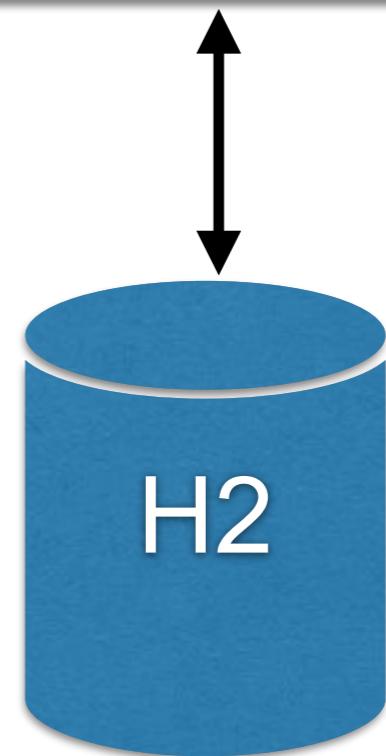
Start in testing scope

Production

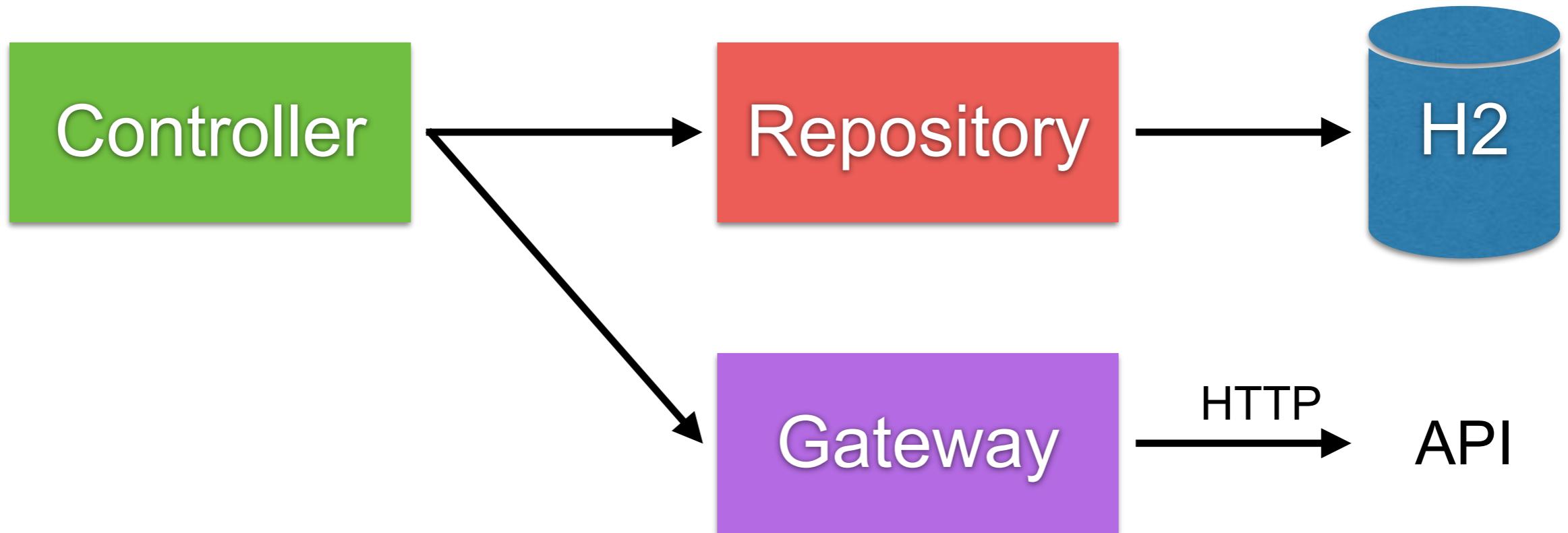


Postgre**SQ**L

Testing

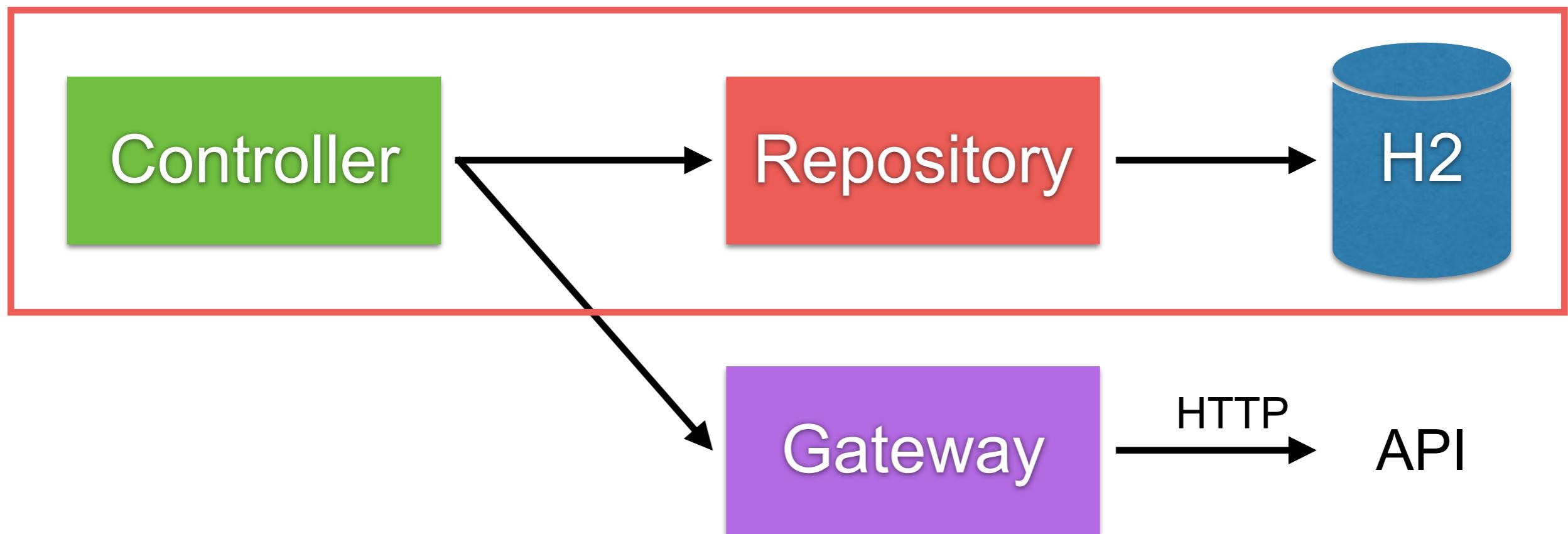


Use cases



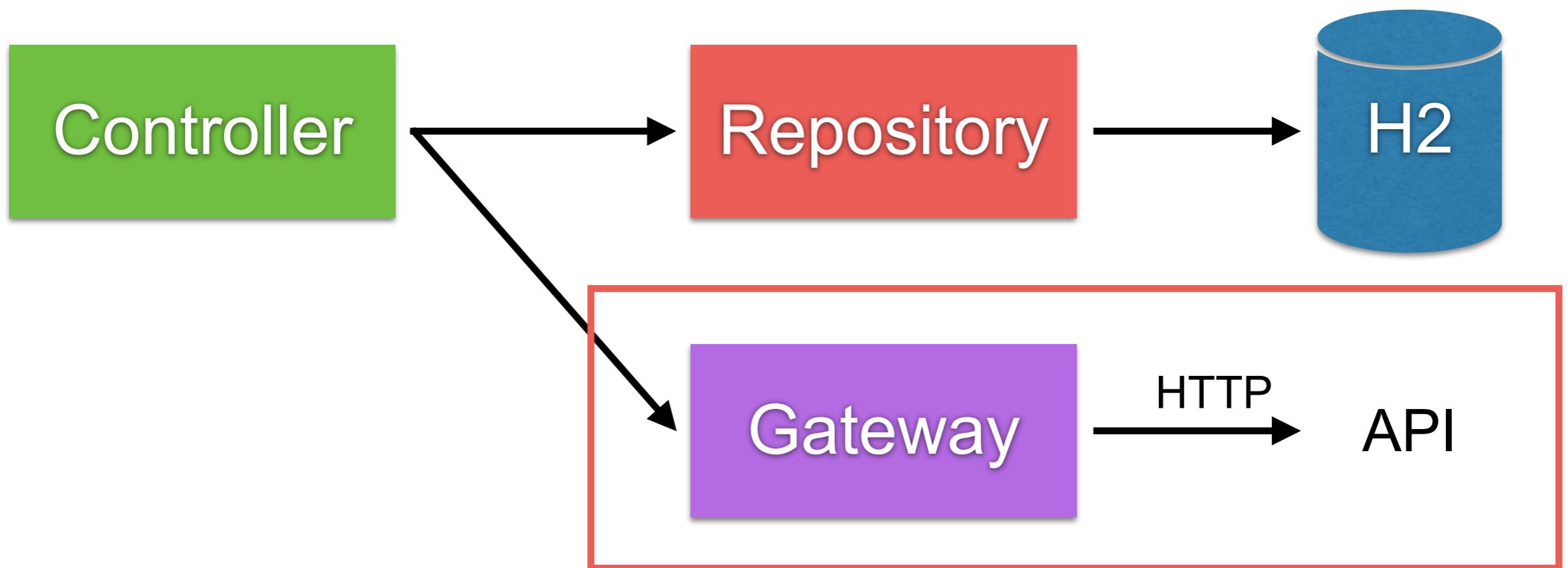
Use case 1

Working with repository



Use case 2

Working with API



Use case 1

Working with Database



Use case 1

Working with repository

3. HelloController



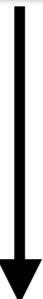
2. PersonRepository



Controller

Repository

H2



4. PersonResponse

1. Person



1. Create Entity class

In package person

```
@Entity  
public class Person {  
  
    @Id  
    @GeneratedValue(strategy = GenerationType.AUTO)  
    private long id;  
    private String firstName;  
    private String lastName;  
  
    public Person() {  
    }  
}
```



2. Create repository with JPA

PersonRepository.java

```
import java.util.Optional;  
  
import org.springframework.data.repository.CrudRepository;  
  
public interface PersonRepository  
    extends CrudRepository<Person, Long> {  
  
    Optional<Person> findByLastName(String lastName);  
  
}
```



2. Create repository with JPA

PersonRepository.java

```
import java.util.Optional;  
  
import org.springframework.data.repository.CrudRepository;  
  
public interface PersonRepository  
    extends CrudRepository<Person, Long> {  
  
    Optional<Person> findByLastName(String lastName);  
}
```

*SELECT * FROM Person WHERE LastName=?*

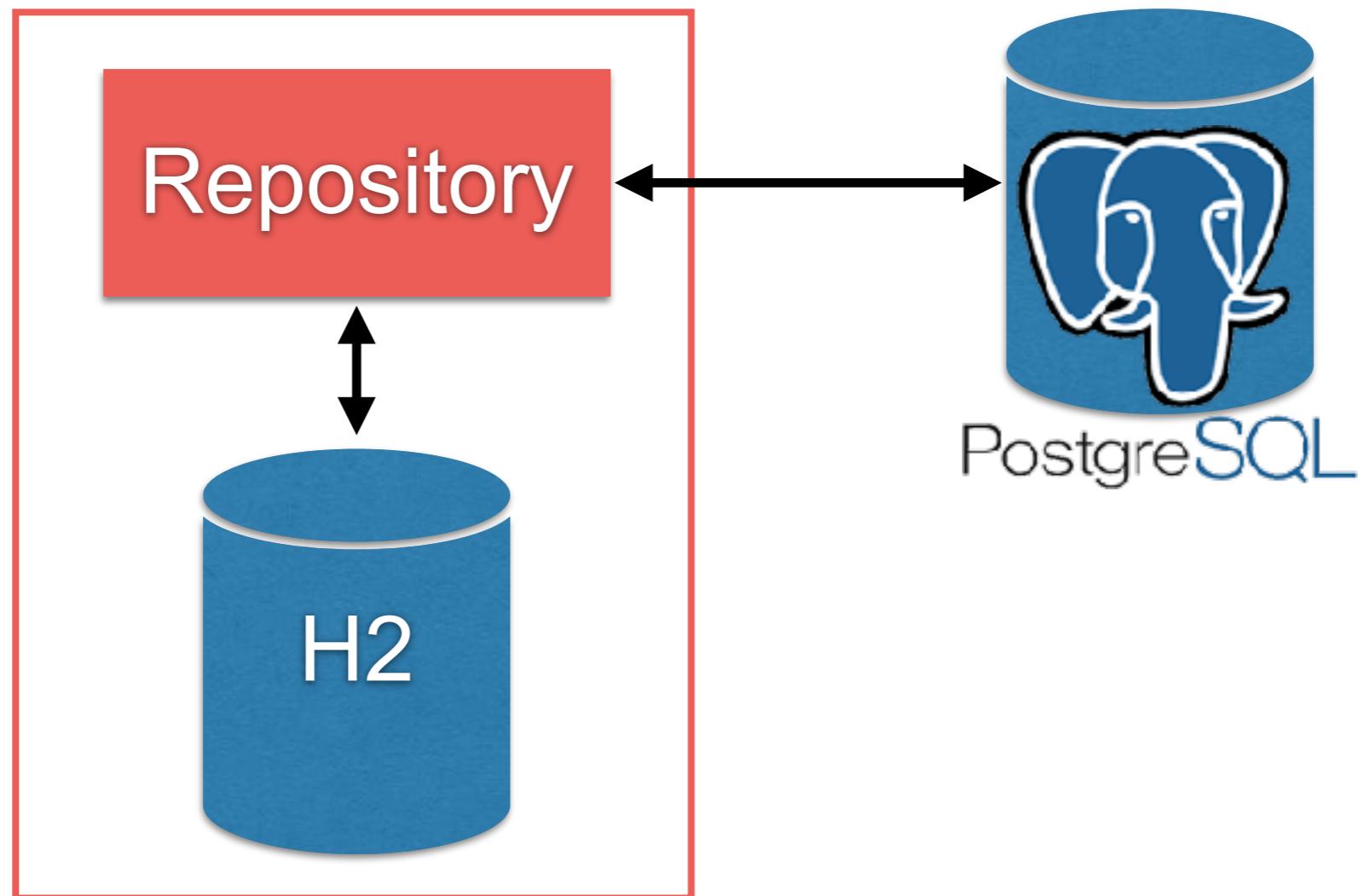


How to testing repository ?



Repository Testing

Using `@DataJpaTest` (slice testing)



Working with In-memory database



Repository Testing #1

Setup test with @DataJpaTest

```
@RunWith(SpringRunner.class)
@DataJpaTest
public class PersonRepositoryTest {

    @Autowired
    private PersonRepository repository;

    @After
    public void tearDown() throws Exception {
        repository.deleteAll();
    }

}
```



Repository Testing #2

Auto wired repository for testing

```
@RunWith(SpringRunner.class)
@DataJpaTest
public class PersonRepositoryTest {

    @Autowired
    private PersonRepository repository;

    @After
    public void tearDown() throws Exception {
        repository.deleteAll();
    }

}
```



Repository Testing #3

Clear data in table after executed each test case

```
@RunWith(SpringRunner.class)
@DataJpaTest
public class PersonRepositoryTest {

    @Autowired
    private PersonRepository repository;

    @After
    public void tearDown() throws Exception {
        repository.deleteAll();
    }

}
```



Repository Testing #3

Write your first test case

```
@Test  
public void should_save_fetch_a_person() {  
  
    Person somkiat = new Person("Somkiat", "Pui");  
    repository.save(somkiat);  
  
    Optional<Person> maybeSomkiat  
        = repository.findByLastName("Pui");  
  
    assertEquals(maybeSomkiat, Optional.of(somkiat));  
}
```



Run test

\$mvnw clean test

Hibernate: drop table person if exists

Hibernate: drop sequence if exists hibernate_sequence

Hibernate: create sequence hibernate_sequence start with 1 increment by 1

Hibernate: create table person (id varchar(255) not null, first_name varchar(255), last_name varchar(255), primary key (id))

Insert data

Hibernate: call next value for hibernate_sequence

Hibernate: insert into person (first_name, last_name, id) values (?, ?, ?)

Hibernate: select person0_.id as id1_0_, person0_.first_name as first_na2_0_, person0_.last_name as last_nam3_0_ from person person0_ where person0_.last_name=?

Hibernate: select person0_.id as id1_0_, person0_.first_name as first_na2_0_, person0_.last_name as last_nam3_0_ from person person0_

2

Query data

Hibernate: drop table person if exists

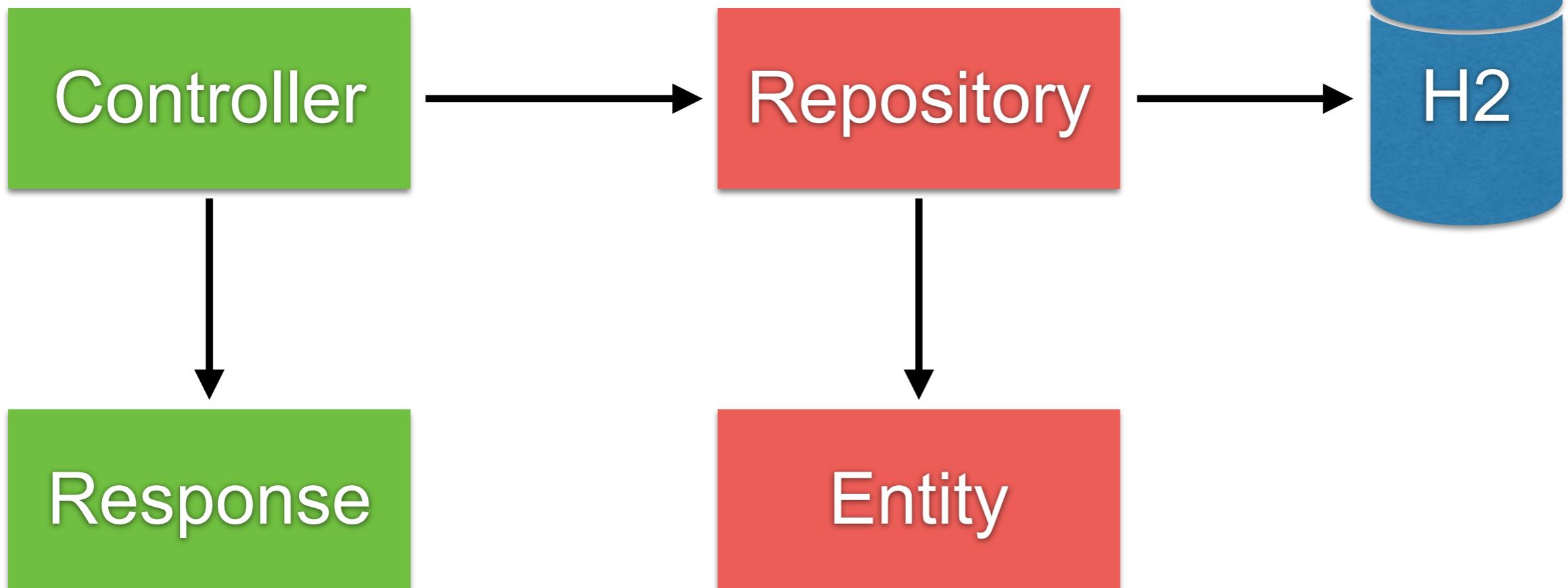
Hibernate: drop sequence if exists hibernate_sequence



Use case 1

Integrate repository with controller

3. HelloController 2. PersonRepository



1. Person

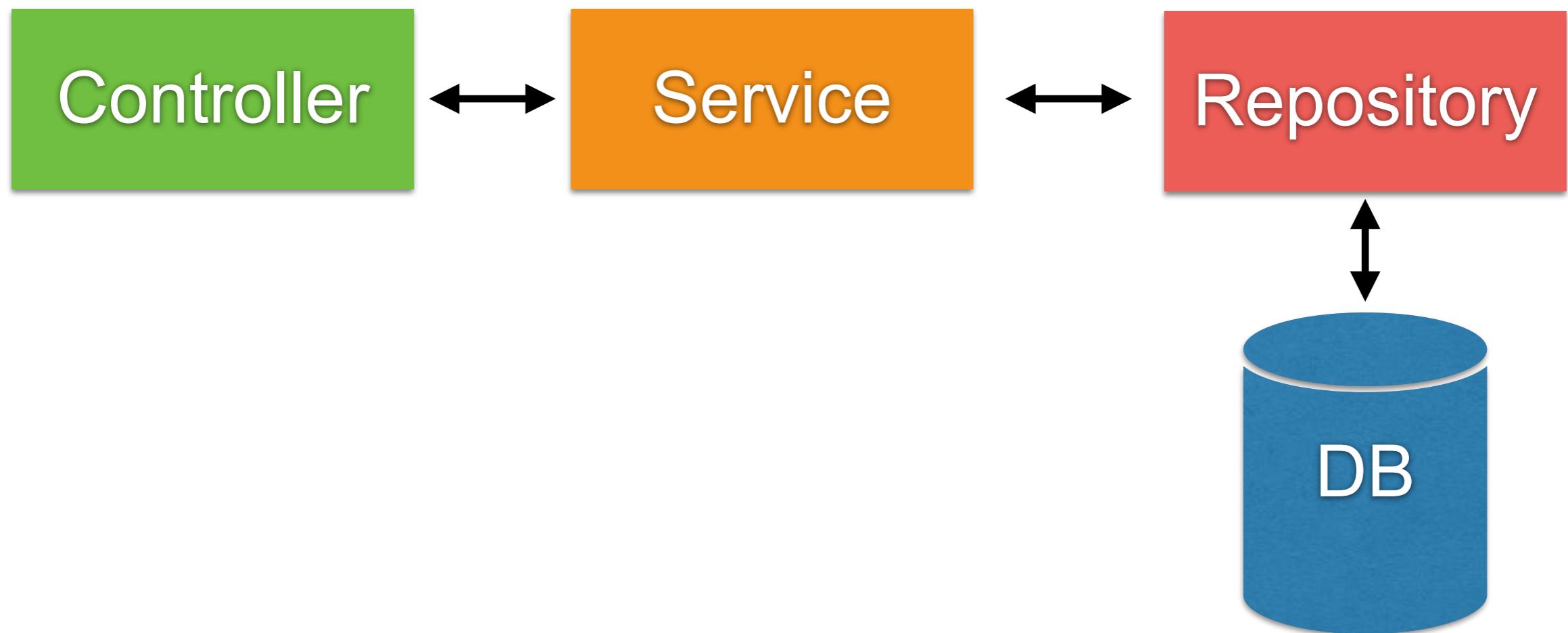
4. PersonResponse



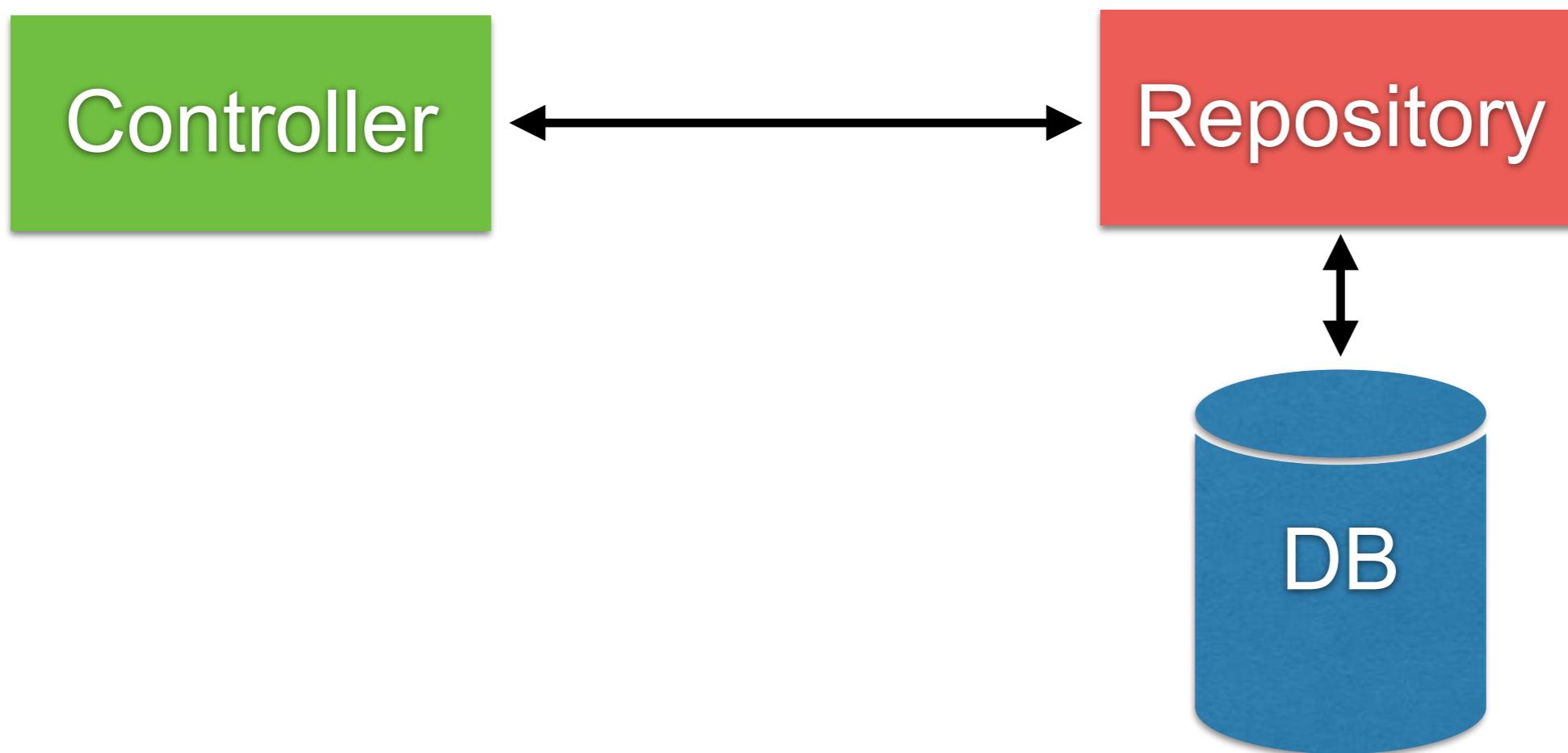
Integrate repository with service/controller



Service use repository ?



Controller use repository ?



Controller call repository

Create HelloController.java

```
@RestController
public class HelloController {

    private final PersonRepository personRepository;

    @Autowired
    public HelloController(final PersonRepository personRepository) {
        this.personRepository = personRepository;
    }
}
```



Controller call repository

Create HelloController.java

```
@GetMapping("/hello/{lastName}")
public HelloResponse hello(@PathVariable final String lastName) {

    Optional<Person> foundPerson
        = personRepository.findByLastName(lastName);

    return foundPerson
        .map(person ->
            new HelloResponse(person.getFirstName(),
                person.getLastName()))
        .orElseThrow(() -> new RuntimeException());
}
```



Run spring boot

\$mvnw spring-boot:run



Fix !!!

Modify src/main/resources/application.properties

server.port=8088

spring.datasource.url=jdbc:postgresql://127.0.0.1:15432/postgres

spring.datasource.username=testuser

spring.datasource.password=password

spring.datasource.platform=POSTGRESQL

spring.jpa.show-sql=true

spring.jpa.hibernate.ddl-auto=create-drop

spring.jpa.database-platform=org.hibernate.dialect.PostgreSQLDialect

Start database server !!



Fix !!!

Modify pom.xml

Delete or comment postgresql dependency

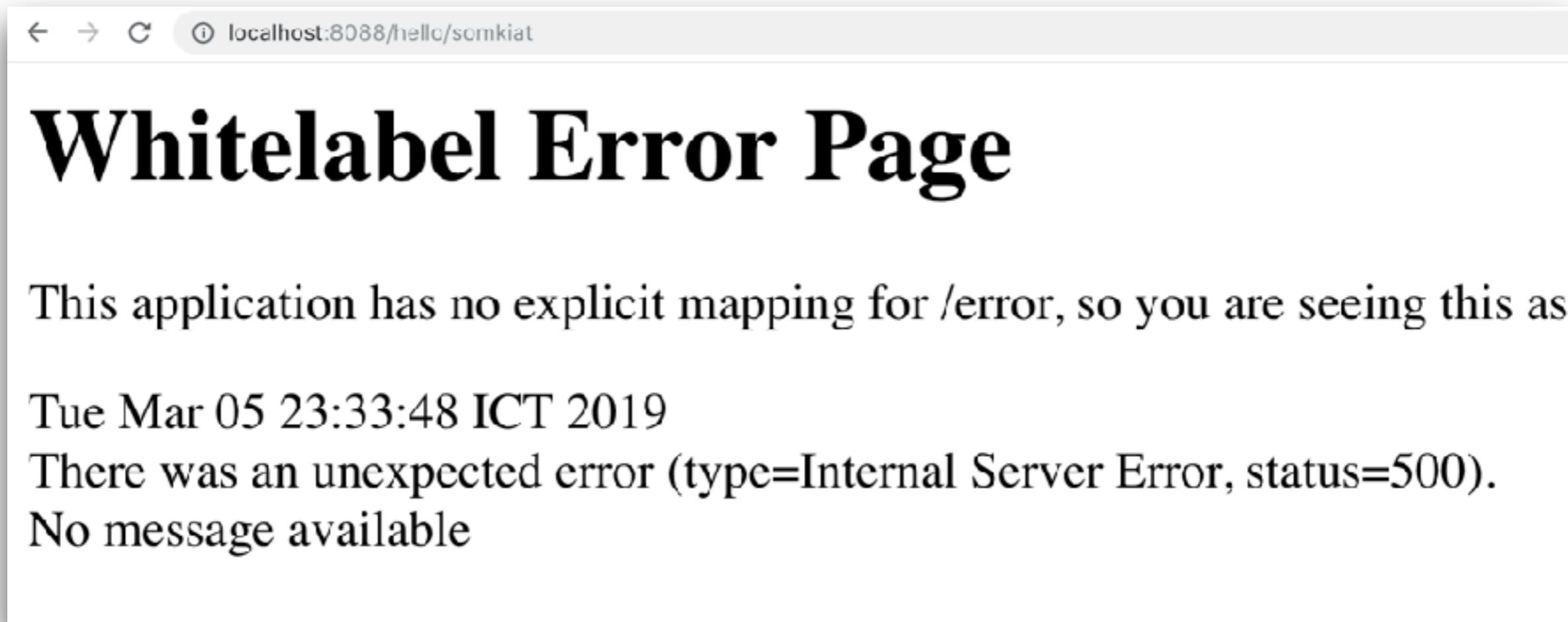
```
<dependency>
    <groupId>com.h2database</groupId>
    <artifactId>h2</artifactId>
    <scope>runtime</scope>
</dependency>

<!-- <dependency>
    <groupId>org.postgresql</groupId>
    <artifactId>postgresql</artifactId>
    <scope>runtime</scope>
</dependency> -->
```



Run spring boot

\$mvnw spring-boot:run



Initial data in database



Initial database #1

Using @Bean and CommandLineRunner

```
@Bean
public CommandLineRunner initData(MessageRepository repository) {
    return new CommandLineRunner() {

        @Override
        public void run(String... args) throws Exception {
            repository.save(new Message("somkiat1"));
            repository.save(new Message("somkiat2"));
        }
    };
}
```



Initial database #2

Using @PostConstruct

```
@PostConstruct  
public void initData() {  
    Account account1 = new Account();  
    account1.setAccountId("01");  
    accountRepository.save(account1);  
    Account account2 = new Account();  
    account2.setAccountId("02");  
    accountRepository.save(account2);  
}
```



Initial database #3

Schema (resources/schema.sql)

Data (resources/data.sql)

Schema.sql

```
CREATE TABLE account(
    id BIGINT AUTO_INCREMENT PRIMARY KEY,
    account_Id VARCHAR(16) NOT NULL UNIQUE,
    mobile_No VARCHAR(10),
    name VARCHAR(50),
    account_Type CHAR(2)
);
```

Data.sql

```
INSERT INTO account (account_Id) VALUES ('01');
INSERT INTO account (account_Id) VALUES ('02');
```



Initial database 2

Disable auto generate DDL from JPA in file application.yml

```
spring:  
  jpa:  
    show-sql: true  
    hibernate:  
      ddl-auto: none
```



Initial database 2

Problem with naming strategy !!

```
spring:  
  jpa:  
    show-sql: true  
    hibernate:  
      ddl-auto: none  
      naming:  
        physical-strategy:  
          org.springframework.boot.orm.jpa.hibernate.SpringPhysicalNamingStrategy  
        implicit-strategy:  
          org.springframework.boot.orm.jpa.hibernate.SpringImplicitNamingStrategy
```

<https://github.com/spring-projects/spring-boot/tree/master/spring-boot-project/spring-boot/src/main/java/org/springframework/boot/orm/jpa/hibernate>



Run and see from logging

Execute file schema.sql and data.sql

```
.datasource.init.ScriptUtils      : Executing SQL script from URL [file:/Users/somki...  
.datasource.init.ScriptUtils      : Executed SQL script from URL [file:/Users/somki...  
.datasource.init.ScriptUtils      : Executing SQL script from URL [file:/Users/somki...  
.datasource.init.ScriptUtils      : Executed SQL script from URL [file:/Users/somki...
```



Run spring boot

\$mvnw spring-boot:run



Write controller testing ?

\$mvnw clean test



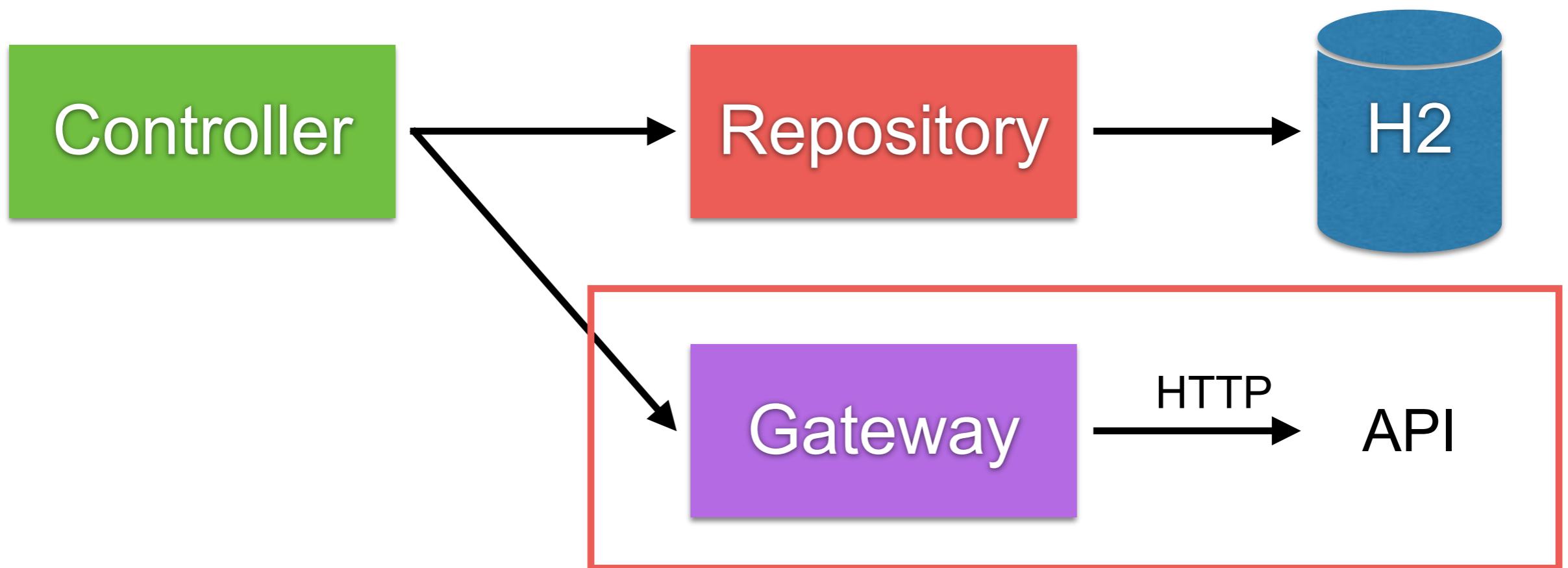
Use case 2

Working with API



Use case 2

Working with API



JSON Place Holder

<https://jsonplaceholder.cypress.io/posts/1>

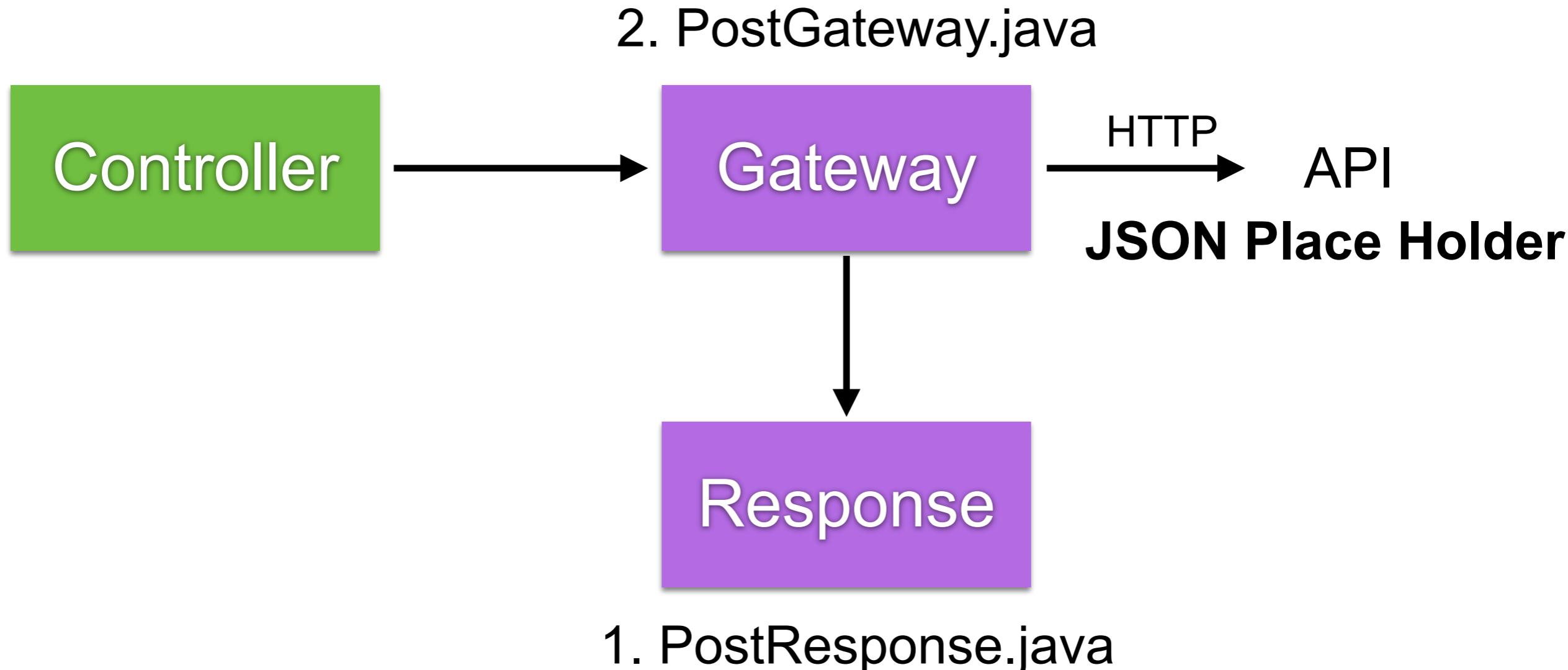
The screenshot shows a web-based API testing interface for JSONPlaceholder. At the top, the title "JSONPlaceholder" is displayed in large, bold letters. Below it, a subtitle reads "Fake Online REST API for Testing and Prototyping" and "Powered by [JSON Server + LowDB](#)". A code snippet in a light gray box illustrates a JavaScript fetch call:

```
fetch('https://jsonplaceholder.cypress.io/todos/1')
  .then(response => response.json())
  .then(json => console.log(json))
```

At the bottom of the interface is a blue "Try it" button.



Working with API



Library to call external APIs

Rest Template

OpenFeign

HTTP Interface

Spring framework 6



1. Create Response class

In package post

```
public class PostResponse {  
    private int id;  
    private int userId;  
    private String title;  
    private String body;
```



2. Create PostGateway class #1

In package post

```
@Component
public class PostGateway {

    private final RestTemplate restTemplate;
    private final String postApiUrl;

    @Autowired
    public PostGateway(final RestTemplate restTemplate,
                       @Value("${post.api.url}") final String postApiUrl) {
        this.restTemplate = restTemplate;
        this.postApiUrl = postApiUrl;
    }
}
```



2. Create PostGateway class #1

In package post

```
@Component
public class PostGateway {

    private final RestTemplate restTemplate;
    private final String postApiUrl;

    @Autowired
    public PostGateway(final RestTemplate restTemplate,
        @Value("${post.api.url}") final String postApiUrl) {
        this.restTemplate = restTemplate;
        this.postApiUrl = postApiUrl;
    }
}
```

Configuration ?



Configuration

Configuration in file application.properties

```
post.api.url=https://jsonplaceholder.cypress.io
```



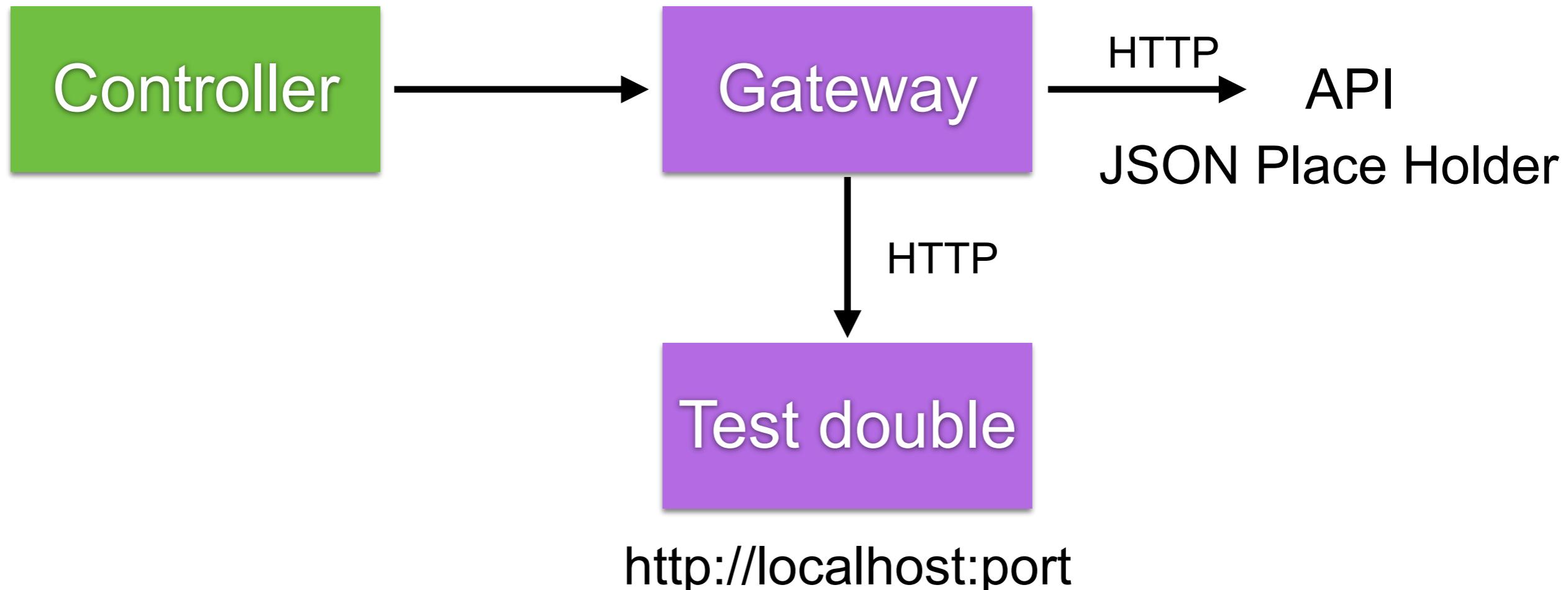
2. Create PostGateway class #2

Get data from API

```
public Optional<PostResponse> getPostById(int id) {  
    String url = String.format("%s/posts/%d", postApiUrl, id);  
  
    try {  
        return Optional.ofNullable(  
            restTemplate.getForObject(url, PostResponse.class));  
    } catch (RestClientException e) {  
        return Optional.empty();  
    }  
}
```



Testing with API



Testing with API

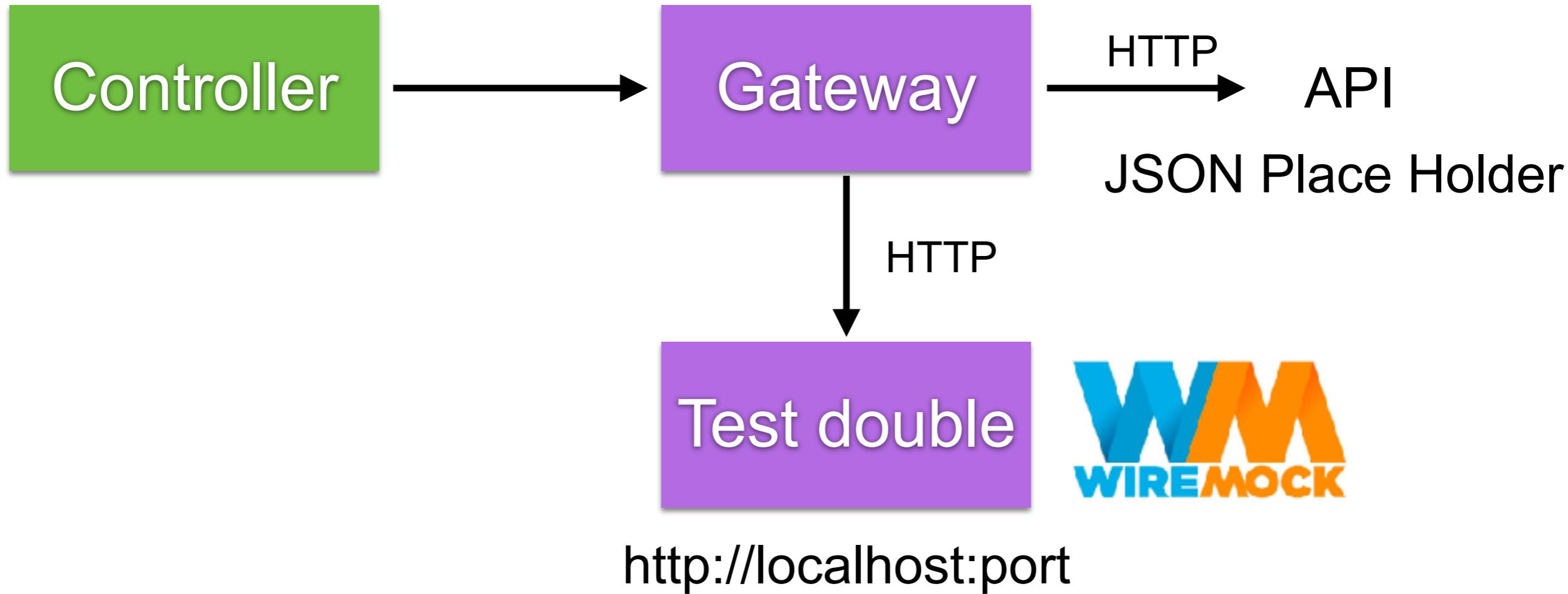
Unit testing with Mockito

Component testing with WireMock

Consumer testing with Pact



Component testing with WireMock



/src/test/resources/application.properties

post.api.url=http://localhost:9999



Component testing #1

Working with WireMock

```
@RunWith(SpringRunner.class)
@SpringBootTest(webEnvironment = WebEnvironment.RANDOM_PORT)
@AutoConfigureWireMock(port = 9999)
public class PostGatewayComponentTest {

    @Autowired
    private PostGateway postGateway;
```

“Default port = 9999”



Component testing #2

Success case

```
@Test  
public void getPostById() throws IOException {  
    stubFor(get(urlPathEqualTo("/posts/1"))  
        .willReturn(aResponse()  
            .withBody(read("classpath:postApiResponse.json"))  
            .withHeader(CONTENT_TYPE, MediaType.APPLICATION_JSON_VALUE)  
            .withStatus(200));  
  
    Optional<PostResponse> postResponse = postGateway.getPostById(1);  
    assertEquals(11, postResponse.get().getId());  
    assertEquals(11, postResponse.get().getUserId());  
    assertEquals("Test Title", postResponse.get().getTitle());  
    assertEquals("Test Body", postResponse.get().getBody());  
}
```

Stub response



Component testing #3

Read data from resources folder

```
public static String read(String filePath) throws IOException {  
    File file = ResourceUtils.getFile(filePath);  
    return new String(Files.readAllBytes(file.toPath()));  
}
```



Component testing #4

File postApiResponse.json

```
{  
  "userId": 11,  
  "id": 11,  
  "title": "Test Title",  
  "body": "Test Body"  
}
```



Write controller testing ?

\$mvnw clean test



Separate tests with jUnit



<https://semaphoreci.com/community/tutorials/how-to-split-junit-tests-in-a-continuous-integration-environment>



Separate test with jUnit



Working with jUnit 4 Category

Create interface in each category

```
package com.lotto.lotto.category;  
  
public interface UnitTest {  
}
```

```
package com.lotto.lotto.category;  
  
public interface SlicingTest {  
}
```

```
package com.lotto.lotto.category;  
  
public interface IntegrationTest {  
}
```



Add category in each test class

```
@RunWith(SpringRunner.class)
@SpringBootTest(webEnvironment = WebEnvironment.RANDOM_PORT)
@Category(IntegrationTest.class)
public class AccountControllerTest {

    @Autowired
    private TestRestTemplate testRestTemplate;

    @MockBean
    private UserService userService;
```



Run test by category

```
$mvnw clean test  
-Dgroups="com.lotto.lotto.category.UnitTest"
```



jUnit 5 Tagging and Filtering

```
import org.junit.jupiter.api.Tag;
import org.junit.jupiter.api.Test;

@Tag("fast")
@Tag("model")
class TaggingDemo {

    @Test
    @Tag("taxes")
    void testingTaxCalculation() {
    }

}
```

<https://junit.org/junit5/docs/current/user-guide/#writing-tests-tagging-and-filtering>



Run test by tag

```
$mvnw clean test  
-Dgroups="fast, model"
```



Aspect-Oriented Programming

AOP



Aspects ?

Reusable blocks of code that are injected into application at runtime

Powerful tools for adding behavior

Solve cross-cutting concerns in one place



Common Applications of Aspects

Logging
Transaction management
Caching
Security



Why use Aspects ?

Reduce code duplication

DRY (Don't Repeat Yourself)

Maintain application logic



Parts of Spring Aspect

Join Point
Pointcut
Advice
Aspect



Working with transaction

<https://github.com/up1/course-springboot-2022/wiki/Transaction-Management>



Important Quality Service



Important Quality Service

Security
Observability
Configurability



Secure Service

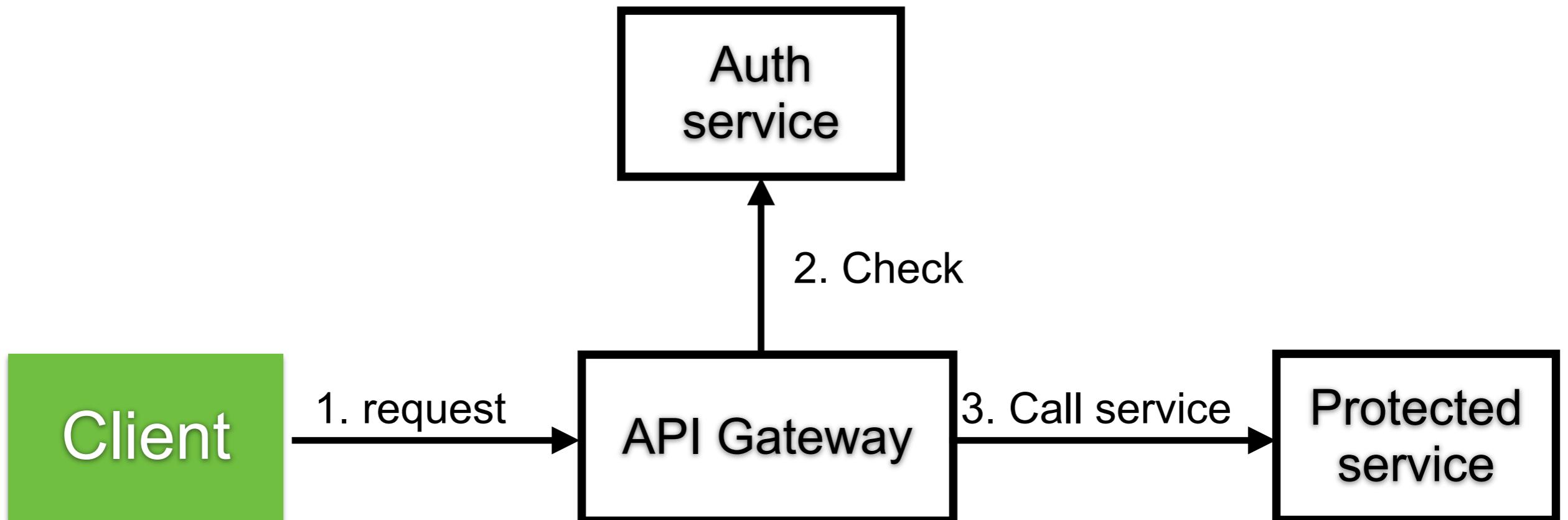


Secure Service

API Gateway
Within service



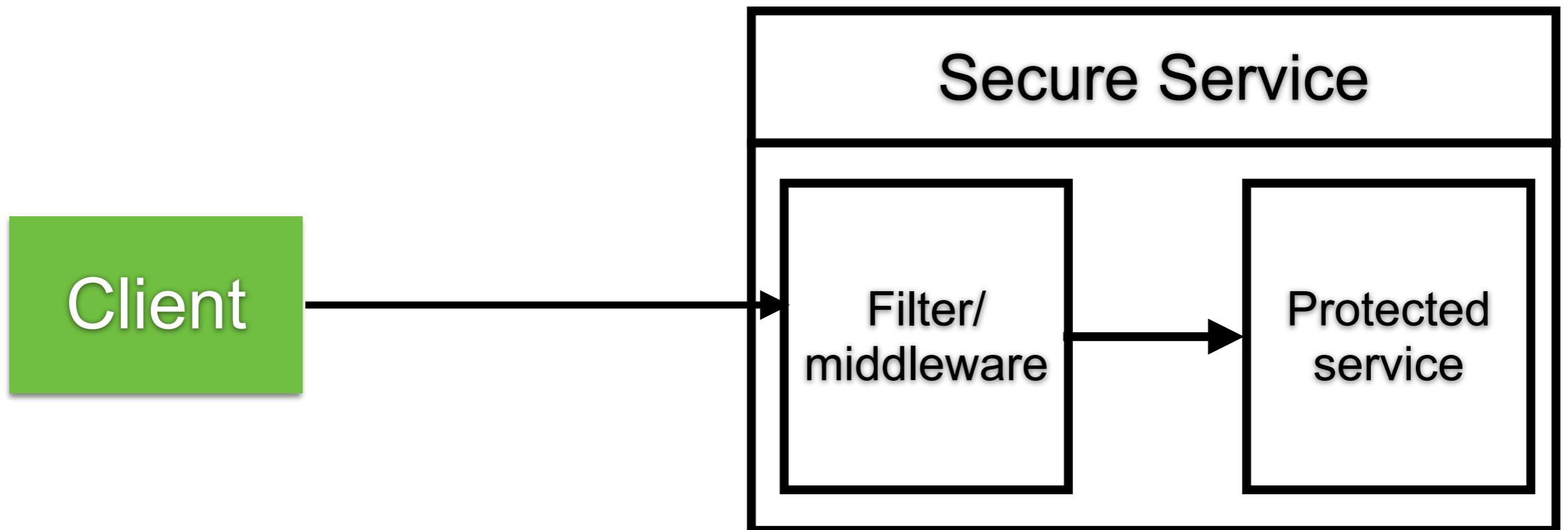
API Gateway



Kong



Within service



<https://github.com/up1/demo-spring-security>



Secure Service with Spring

Working with Spring Security
Support authentication and authorization

Spring Boot 3

Spring Security 6

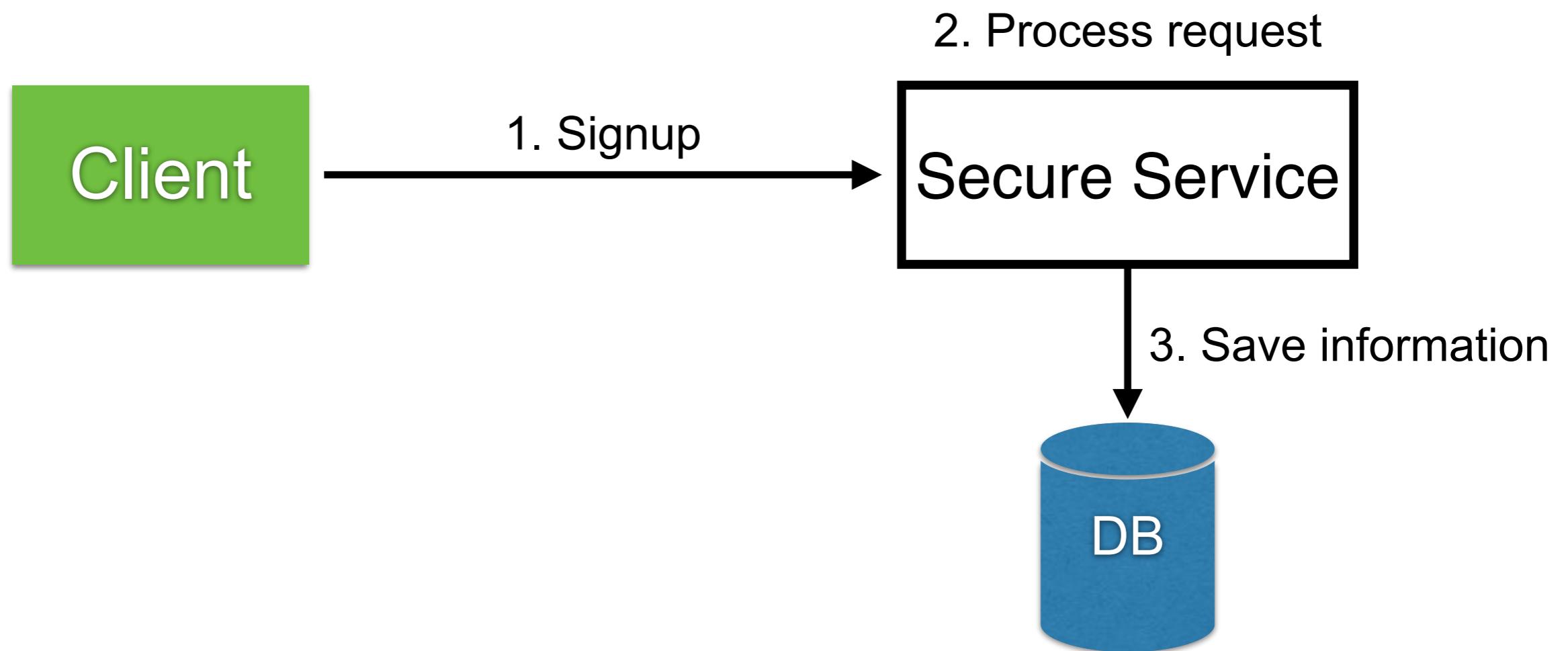
JDK 17

<https://spring.io/projects/spring-security>

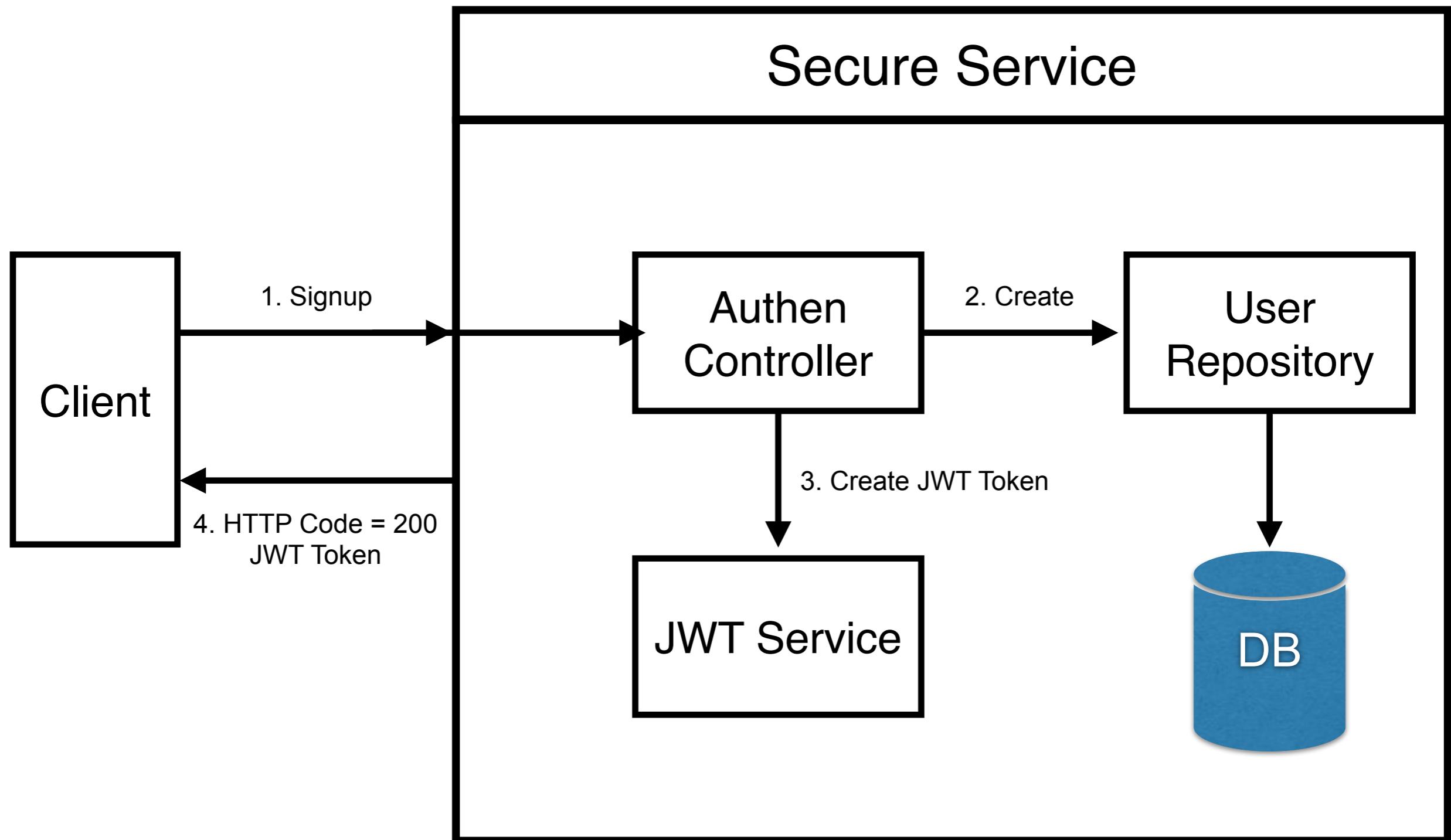


Simple Flow of Secure Service

Step 1 :: Signup process

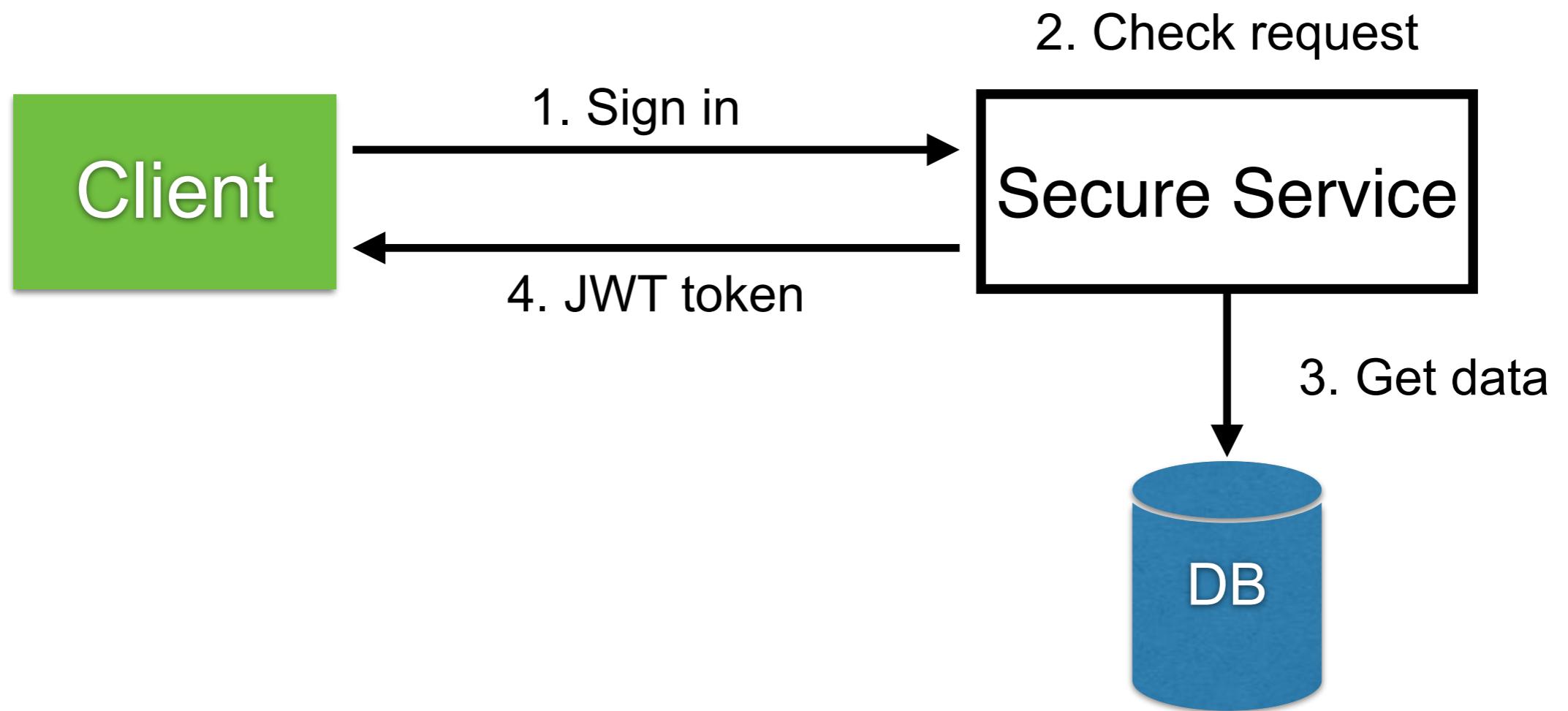


Flow diagram of Signup

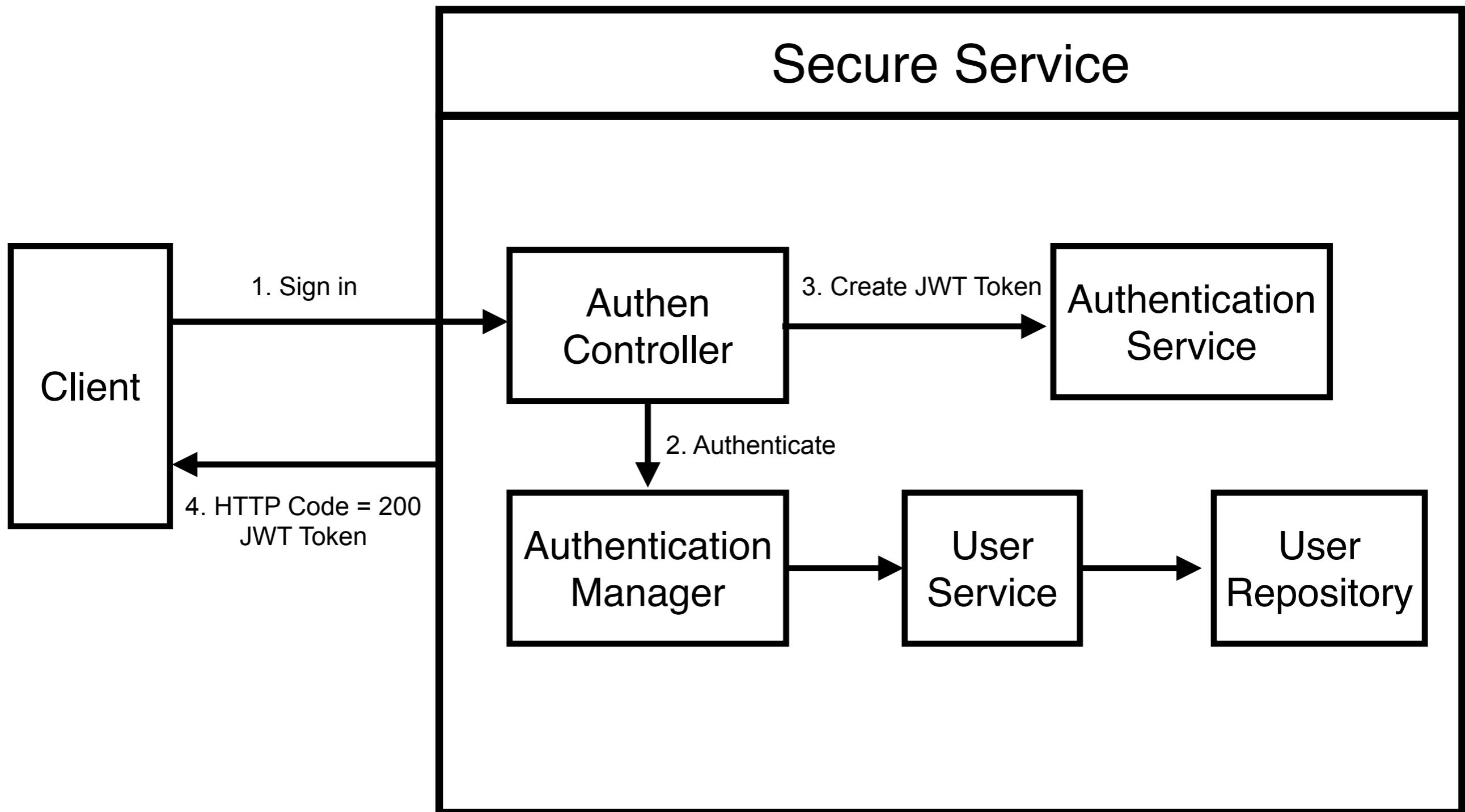


Simple Flow of Secure Service

Step 2 :: Sign in process

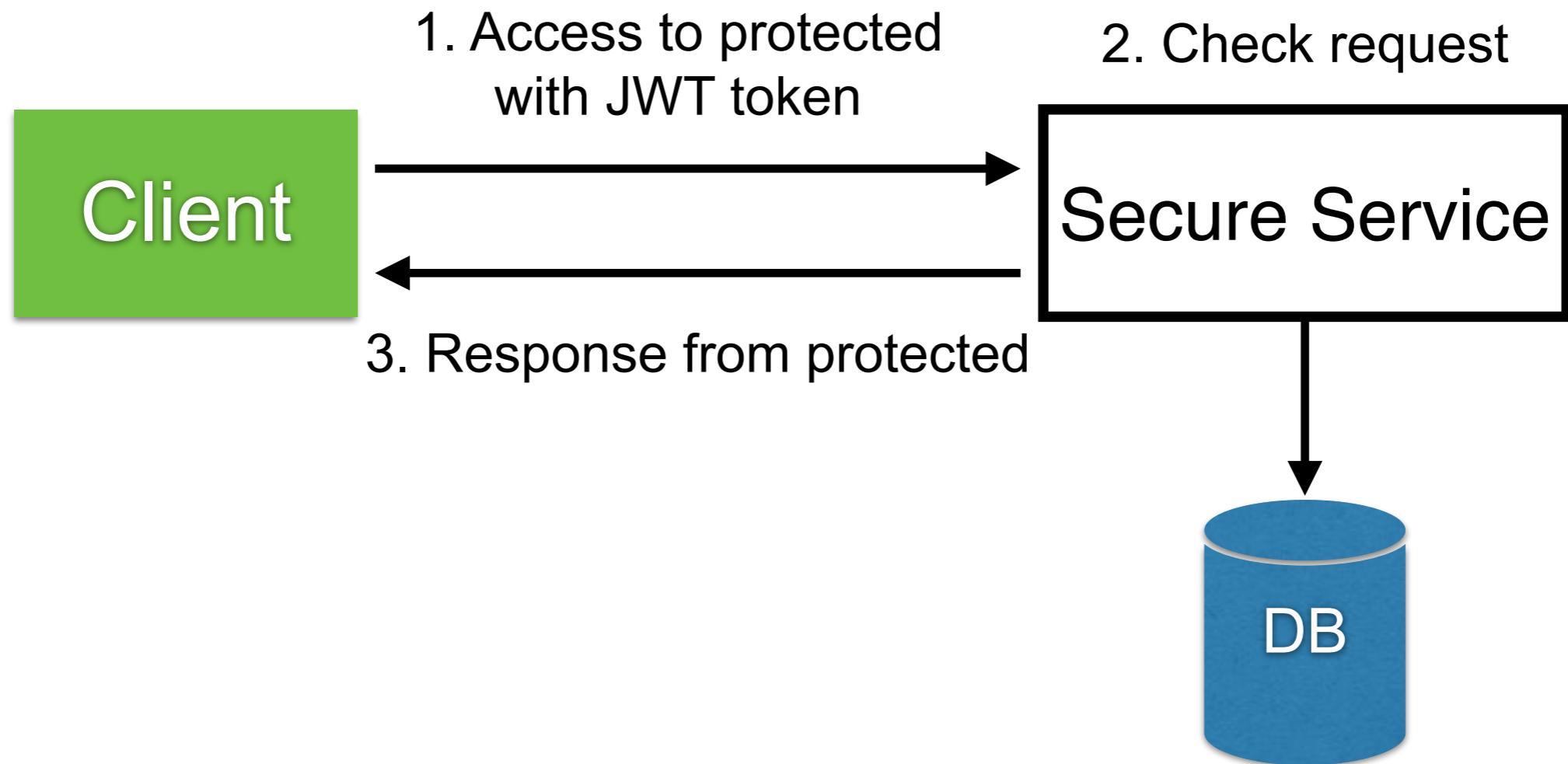


Flow diagram of Sign in

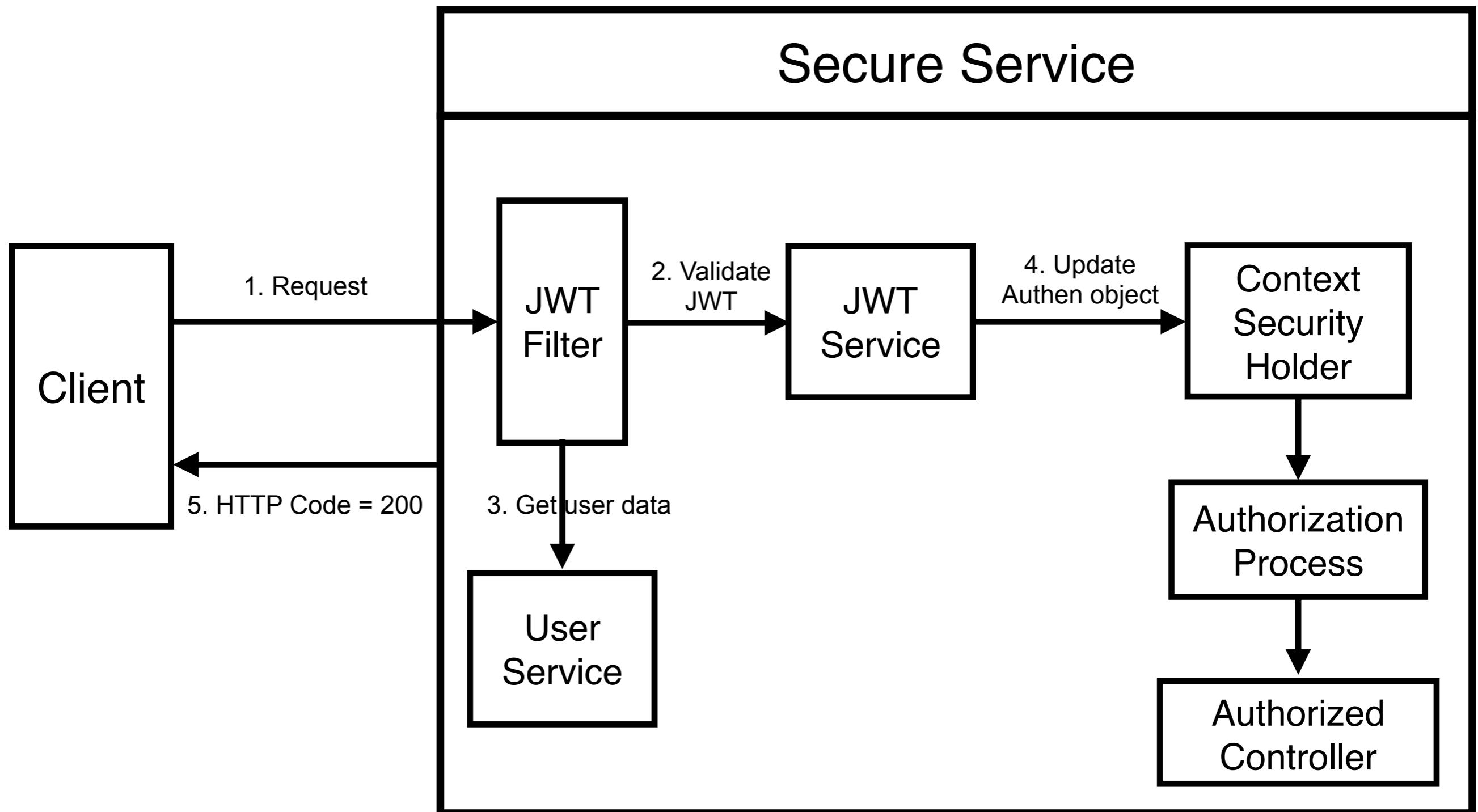


Simple Flow of Secure Service

Step 3 :: Access to protected services



Flow diagram of call service



JSON Web Tokens (JWT)

Encoded PASTE A TOKEN HERE

```
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJzdWIiOiIxMjM0NTY3ODkwIiwibmFtZSI6IkpvG4gRG9lIiwiaWF0IjoxNTE2MjM5MDIyfQ.Sf1KxwRJSMeKKF2QT4fwpNeJf36P0k6yJV_adQssw5c
```

Decoded EDIT THE PAYLOAD AND SECRET

HEADER: ALGORITHM & TOKEN TYPE

```
{  
  "alg": "HS256",  
  "typ": "JWT"  
}
```

PAYLOAD: DATA

```
{  
  "sub": "1234567890",  
  "name": "John Doe",  
  "iat": 1516239022  
}
```

VERIFY SIGNATURE

```
HMACSHA256(  
  base64UrlEncode(header) + "." +  
  base64UrlEncode(payload),  
  your-256-bit-secret  
)  secret: base64 encoded
```

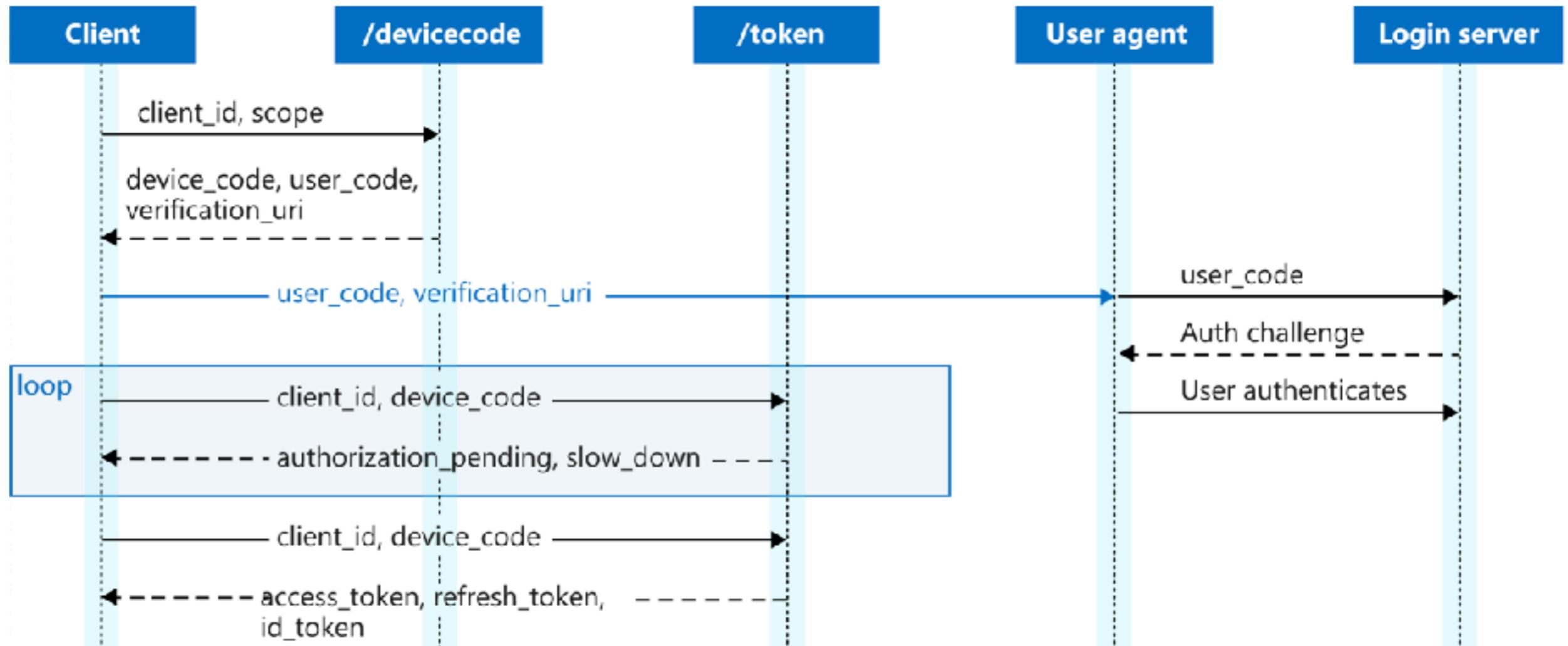
 Signature Verified

[SHARE JWT](#)

<https://jwt.io/>



Example



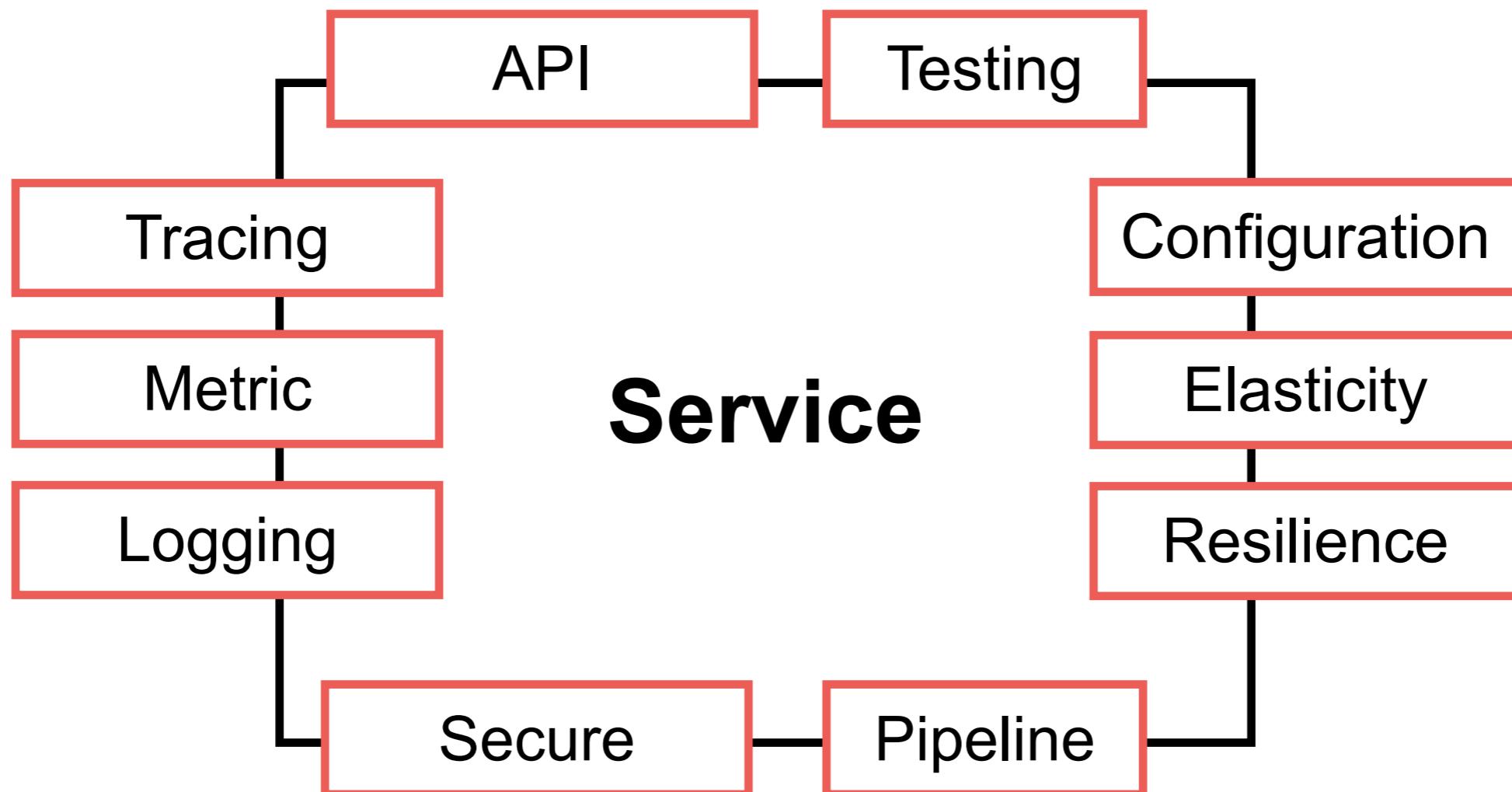
<https://learn.microsoft.com/en-us/azure/active-directory/develop/v2-oauth2-device-code>



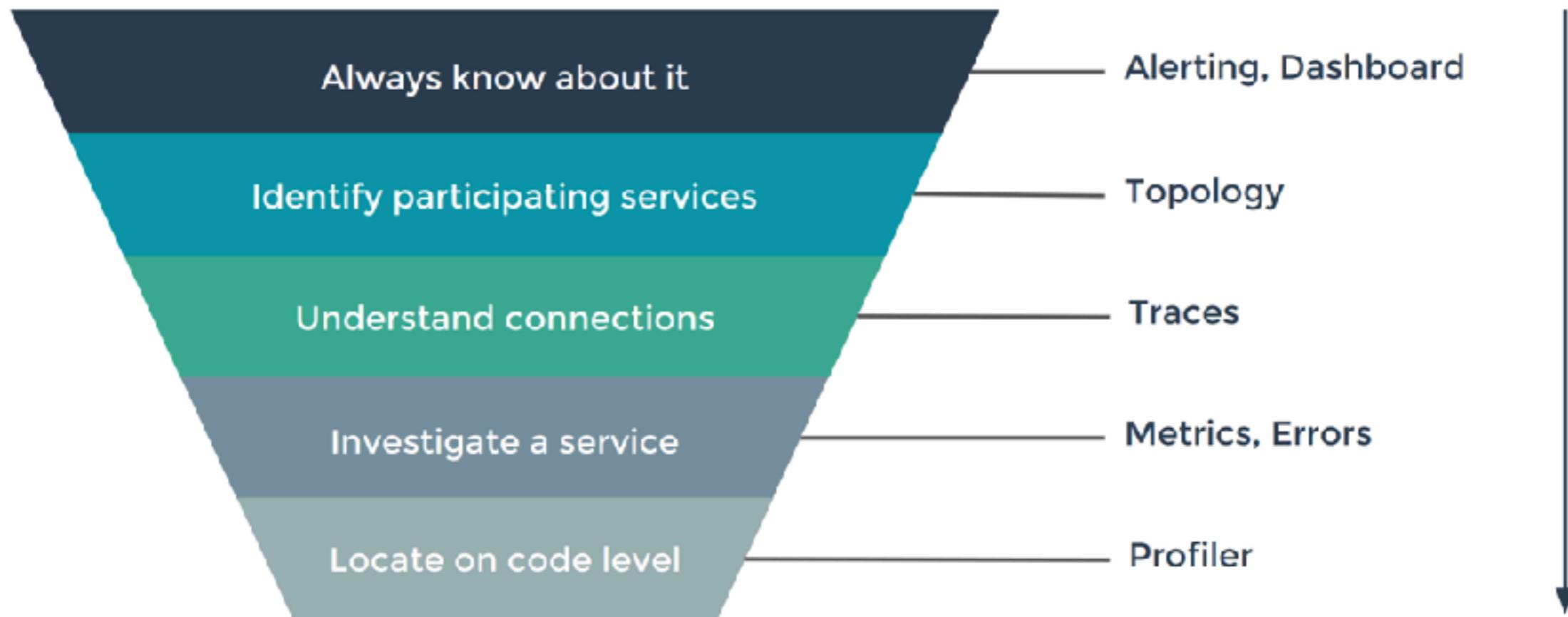
Observable Service



Properties of Service



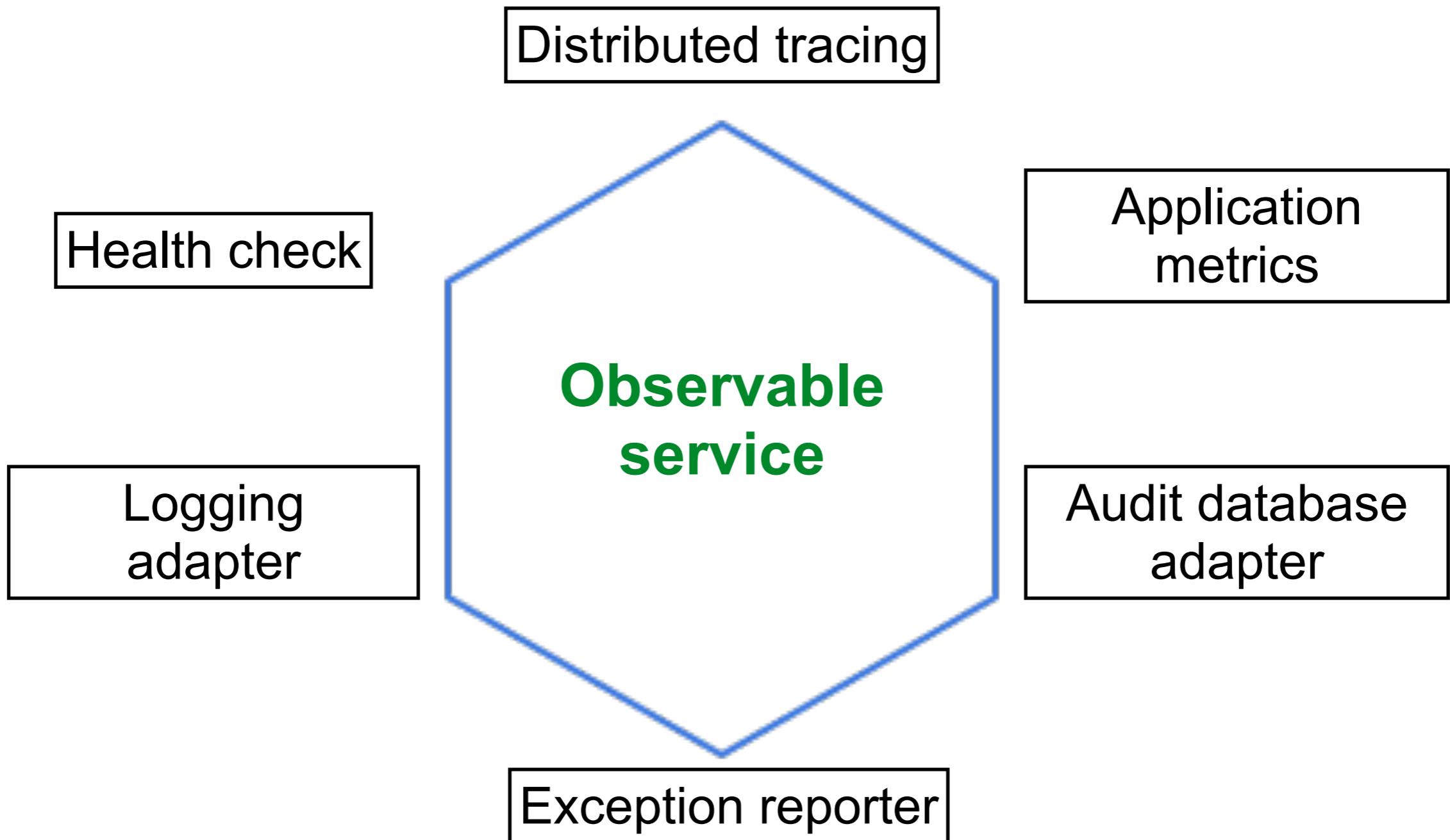
How to find an issue ?



Observability vs Monitoring

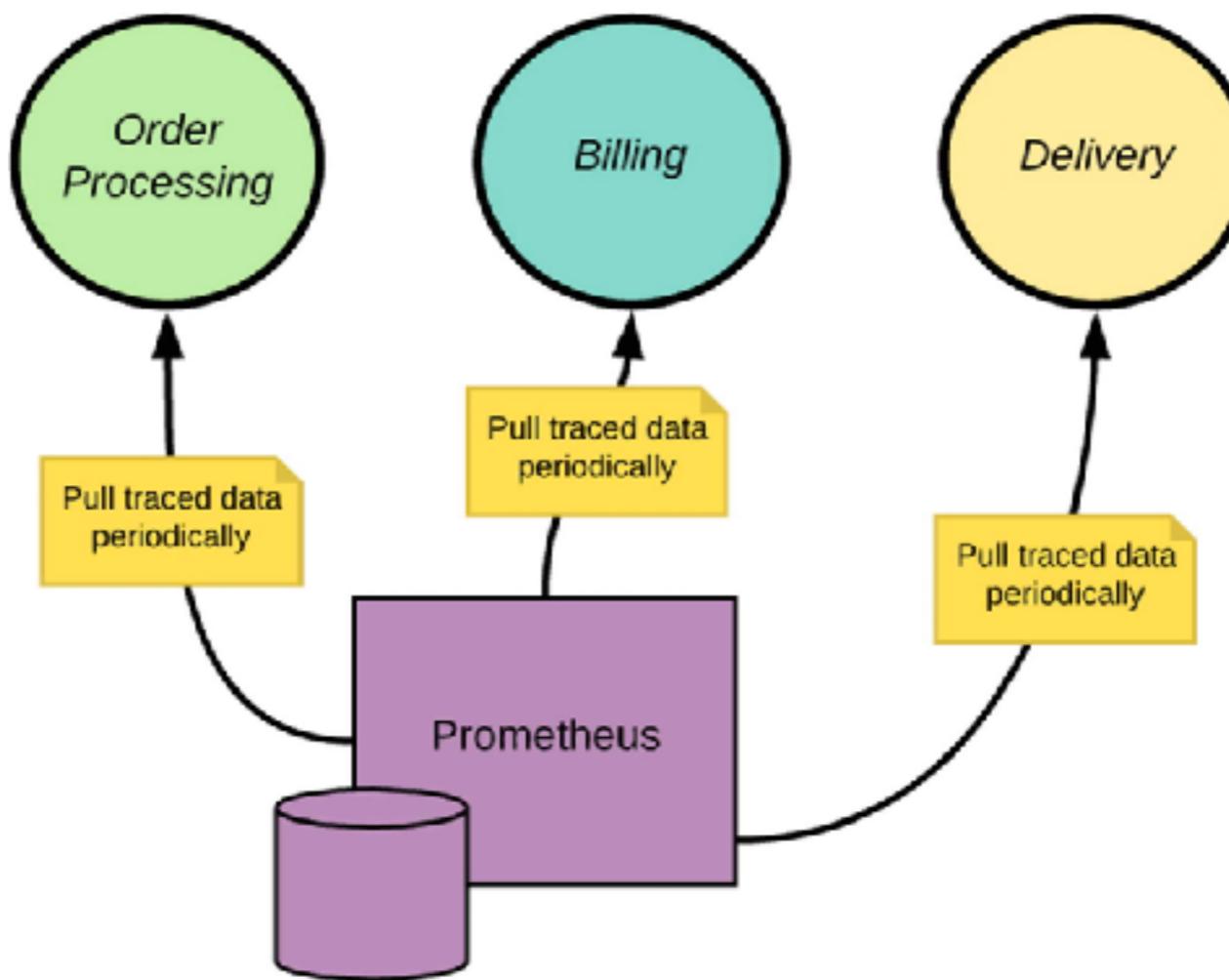


Observable services



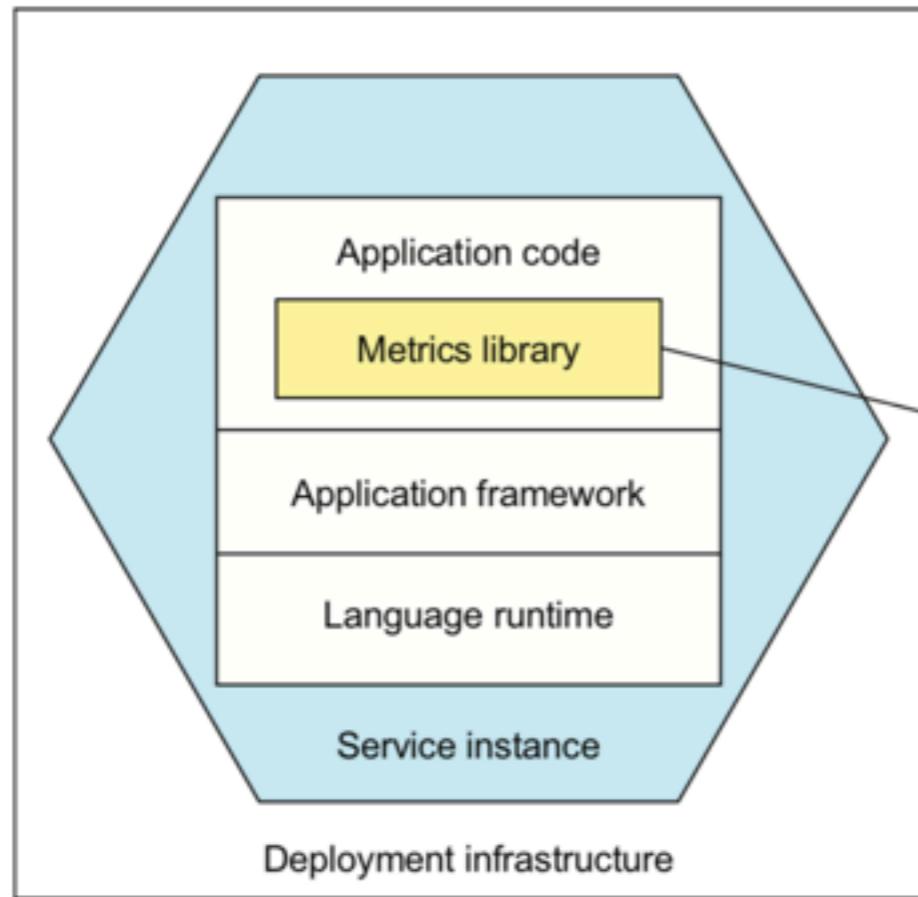
Application metrics

Services maintain metrics and expose to metric server (counters, gauges)

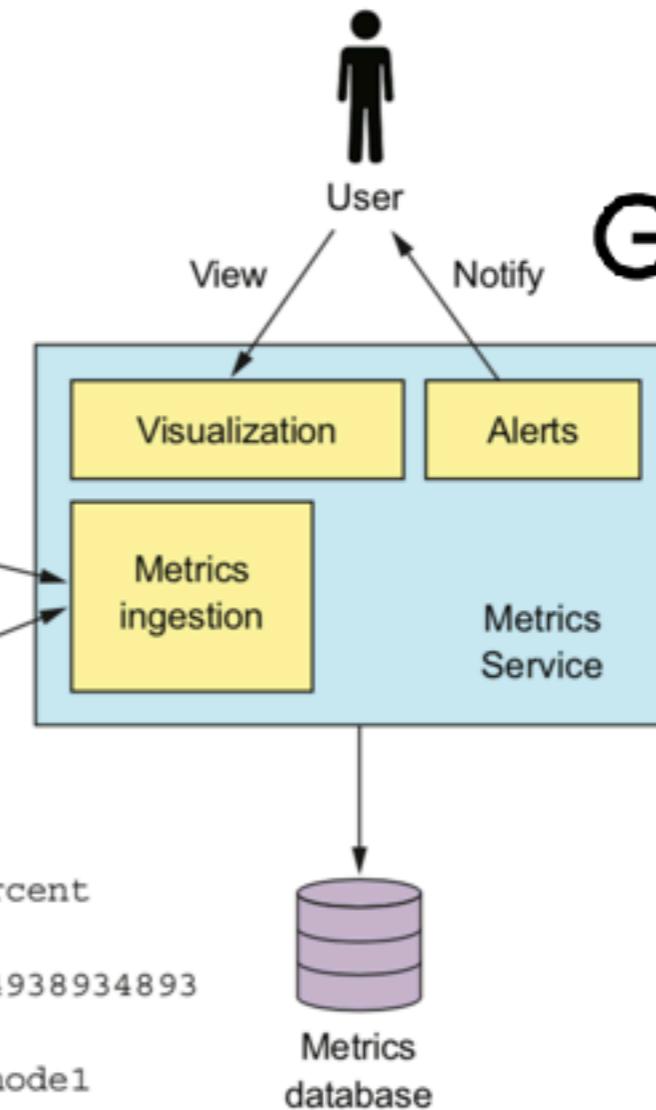


Application metrics tools

Spring Boot Actuator



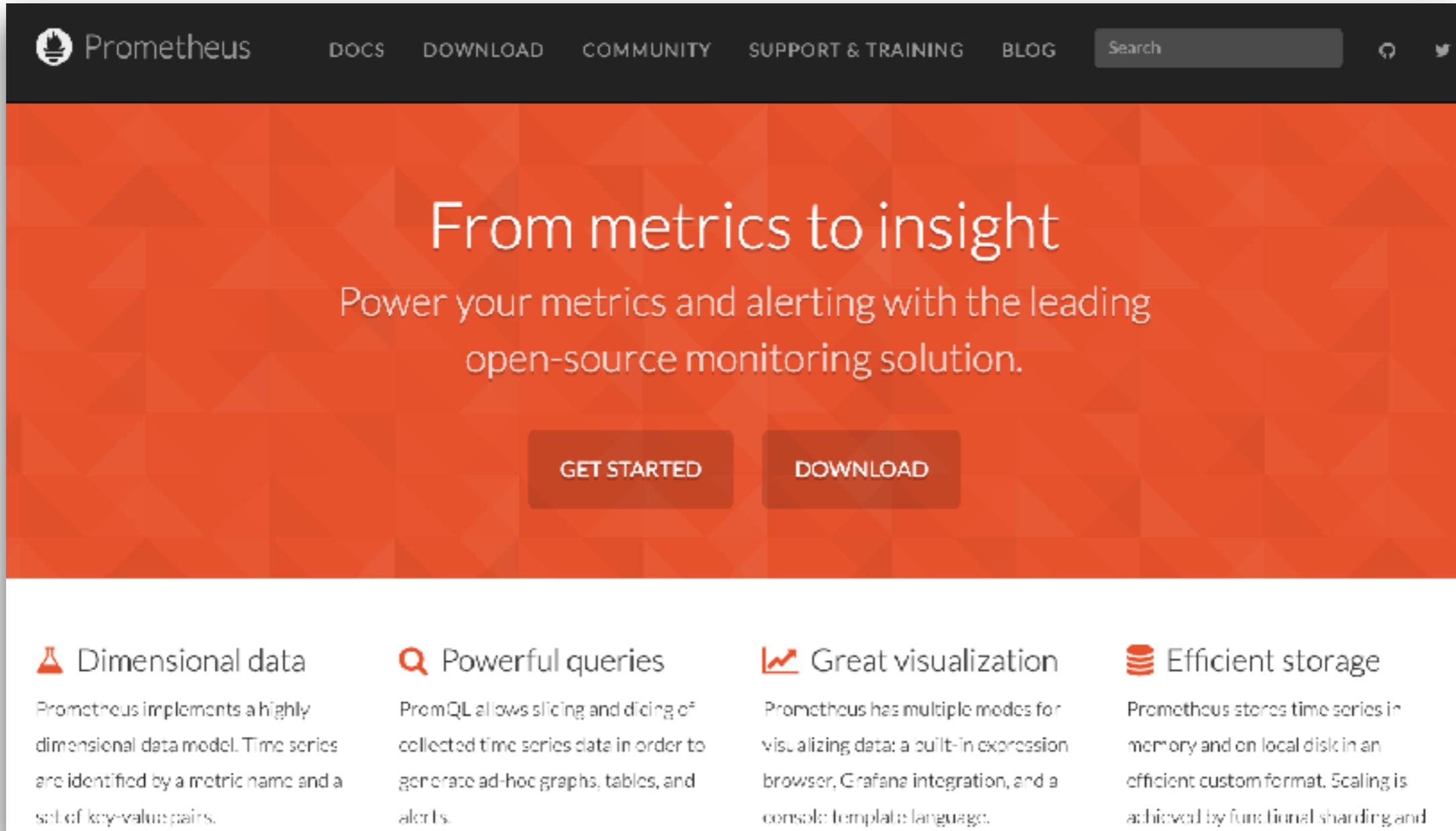
Metrics sample:
name=cpu_percent
value=68
timestamp=34938934893
dimensions:
machine=node1
...



Prometheus



Prometheus



The screenshot shows the official Prometheus website. At the top, there's a dark navigation bar with the Prometheus logo, a search bar, and social media links for GitHub and Twitter. The main heading "From metrics to insight" is prominently displayed in white on an orange background. Below it, a sub-headline reads "Power your metrics and alerting with the leading open-source monitoring solution." Two large buttons, "GET STARTED" and "DOWNLOAD", are visible. The bottom section features four cards with icons and descriptions: "Dimensional data" (Prometheus implements a highly dimensional data model), "Powerful queries" (PromQL allows slicing and dicing of collected time series data), "Great visualization" (Prometheus has multiple modes for visualizing data), and "Efficient storage" (Prometheus stores time series in memory and on local disk in an efficient custom format). Each card also includes a short explanatory paragraph.

Dimensional data

Prometheus implements a highly dimensional data model. Time series are identified by a metric name and a set of key-value pairs.

Powerful queries

PromQL allows slicing and dicing of collected time series data in order to generate ad-hoc graphs, tables, and alerts.

Great visualization

Prometheus has multiple modes for visualizing data: a built-in expression browser, Grafana integration, and a console template language.

Efficient storage

Prometheus stores time series in memory and on local disk in an efficient custom format. Scaling is achieved by functional sharding and

<https://prometheus.io/>



Grafana

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Compose and scale observability with one or all pieces of the stack

Your observability wherever you need it

Cloud

Self-managed

Grafana

API

Plugins

Dashboards

Alerts

Usage insights

Reports

Governance

Metrics

Logs

Traces

Applications

Infrastructure

Cloud

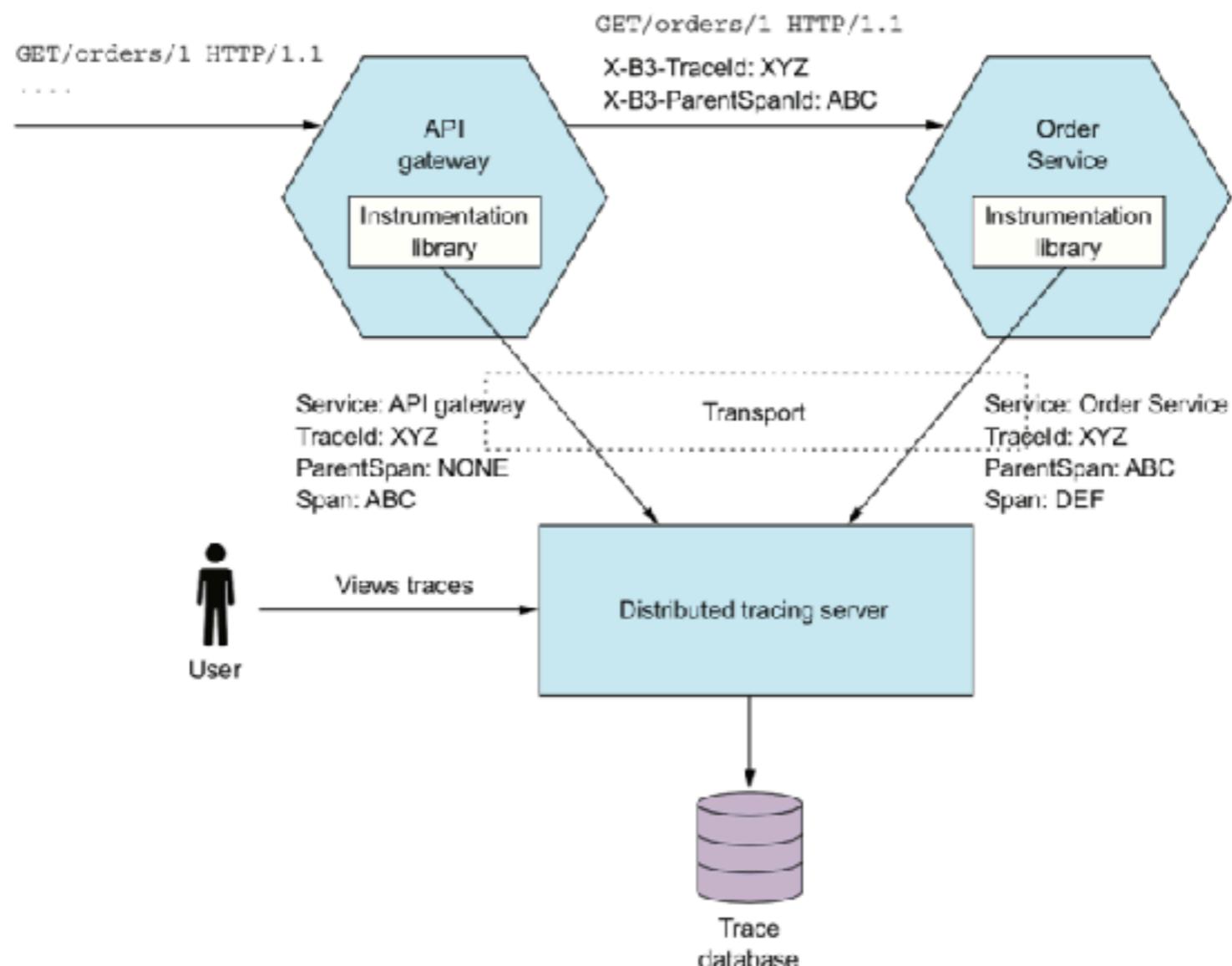
Self-managed

<https://grafana.com/>



Distributed tracing

Assign each external request a unique ID and trace requests as flow between services



Distributed tracing tools

Format standard with OpenTelemetry
Zipkin, Jaeger, Tempo, AWS X-Ray, Elastic APM



JAEGER



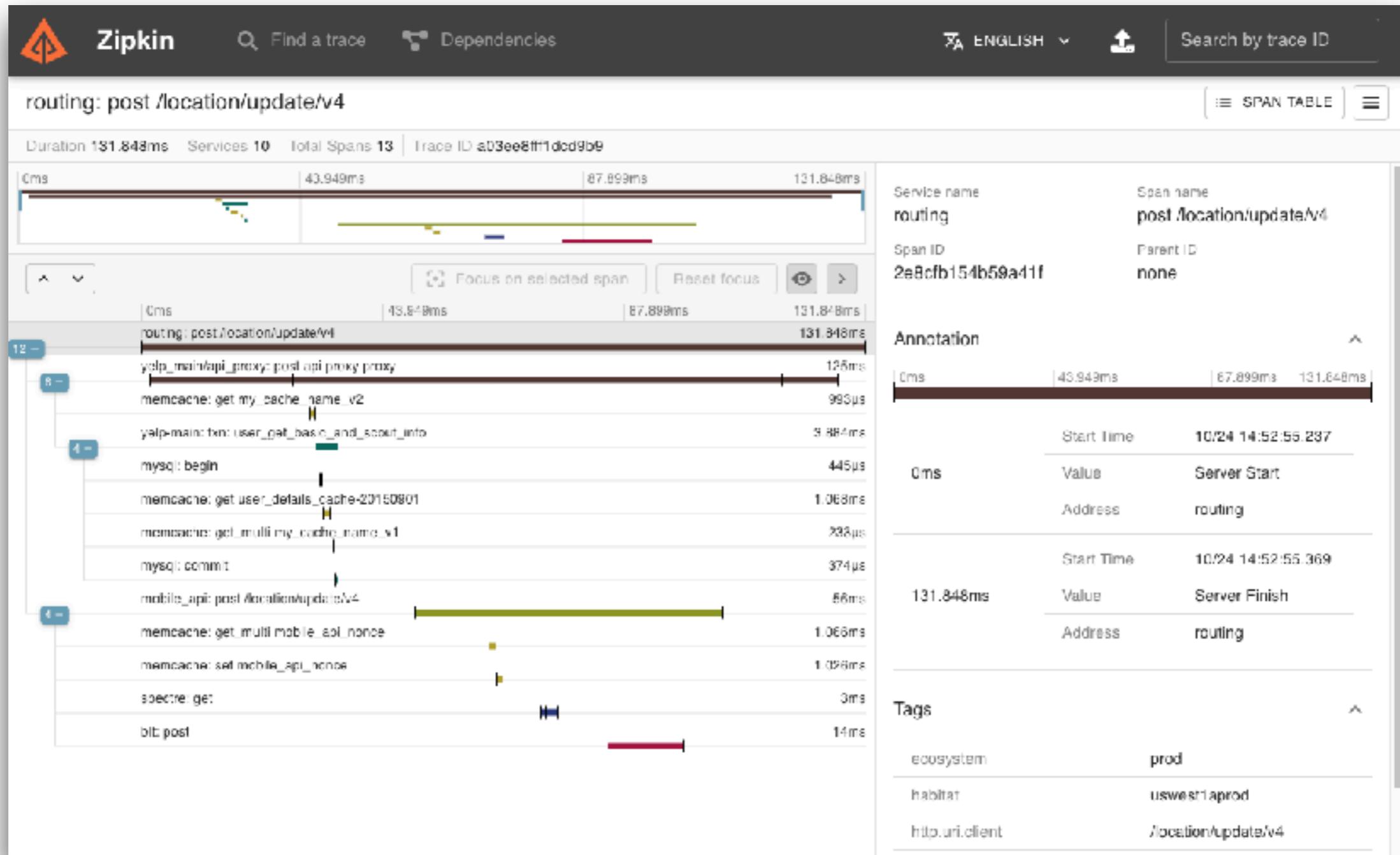
Grafana Tempo



OpenTelemetry



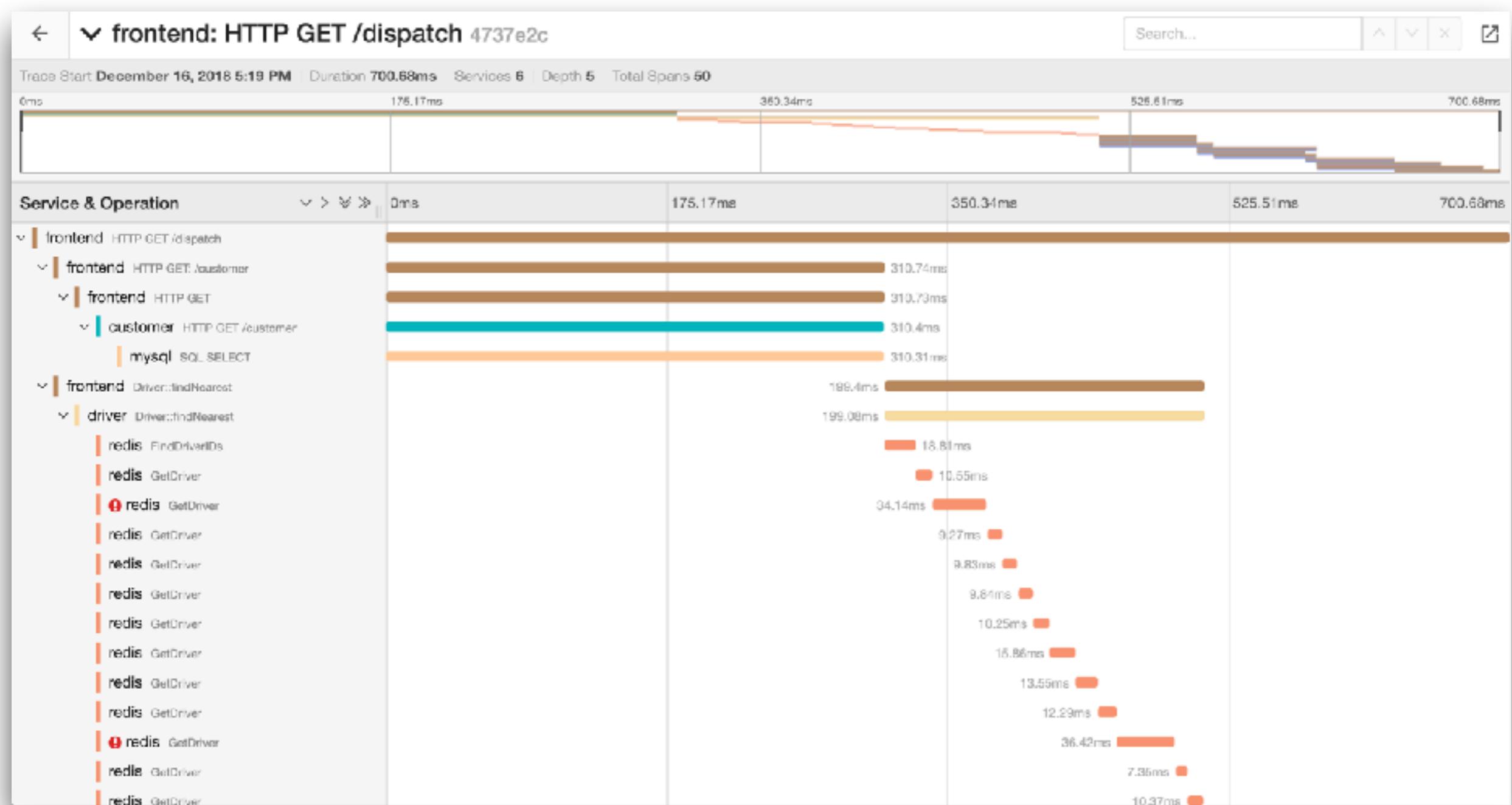
Zipkin



<https://zipkin.io/>



Jaeger

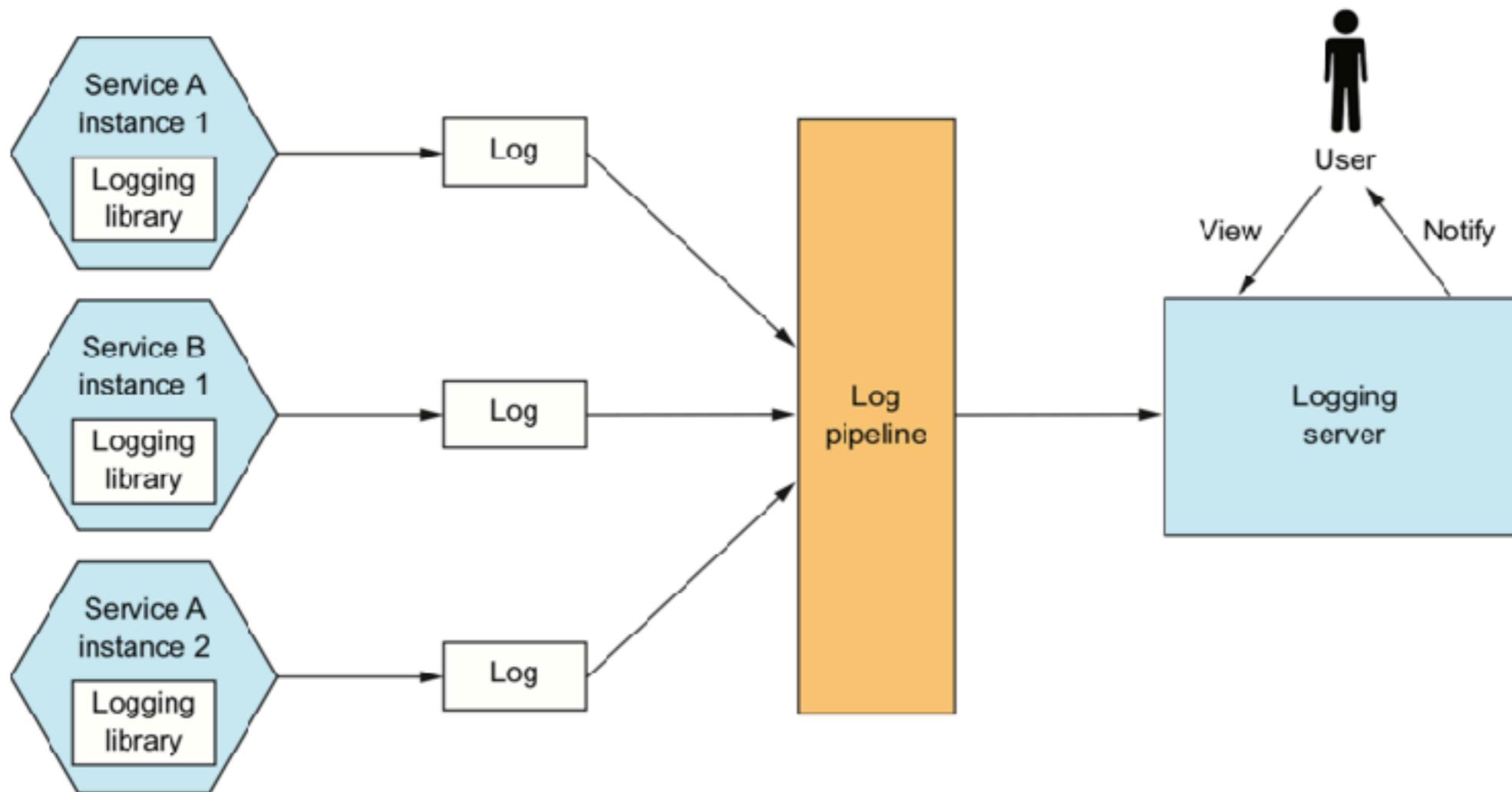


<https://www.jaegertracing.io>



Centralized logging

Log service activity and write logs into a centralized logging server. (searching, alerting)



Effective Logging

Define event to log

Use structured logging

Exclude sensitive information

Log at the correct level

Be specific in your message

Don't log large message

Make sure you keep trace Id in the log

https://github.com/OWASP/CheatSheetSeries/blob/master/cheatsheets/Logging_Cheat_Sheet.md



Consistent Structure across all logs

Property	Description	Example
Timestamp	Date and time of the log	2023-07-01
Log level	DEBUG, INFO, ERROR	
Trace Id or Correlation Id	Unique identifier that refer to other logs from all services	
Event/Action Name	Identify to event or action of log	Authentication fail
Service ID/ Name	Identify to service	
Request path	Path for the request	/api/products

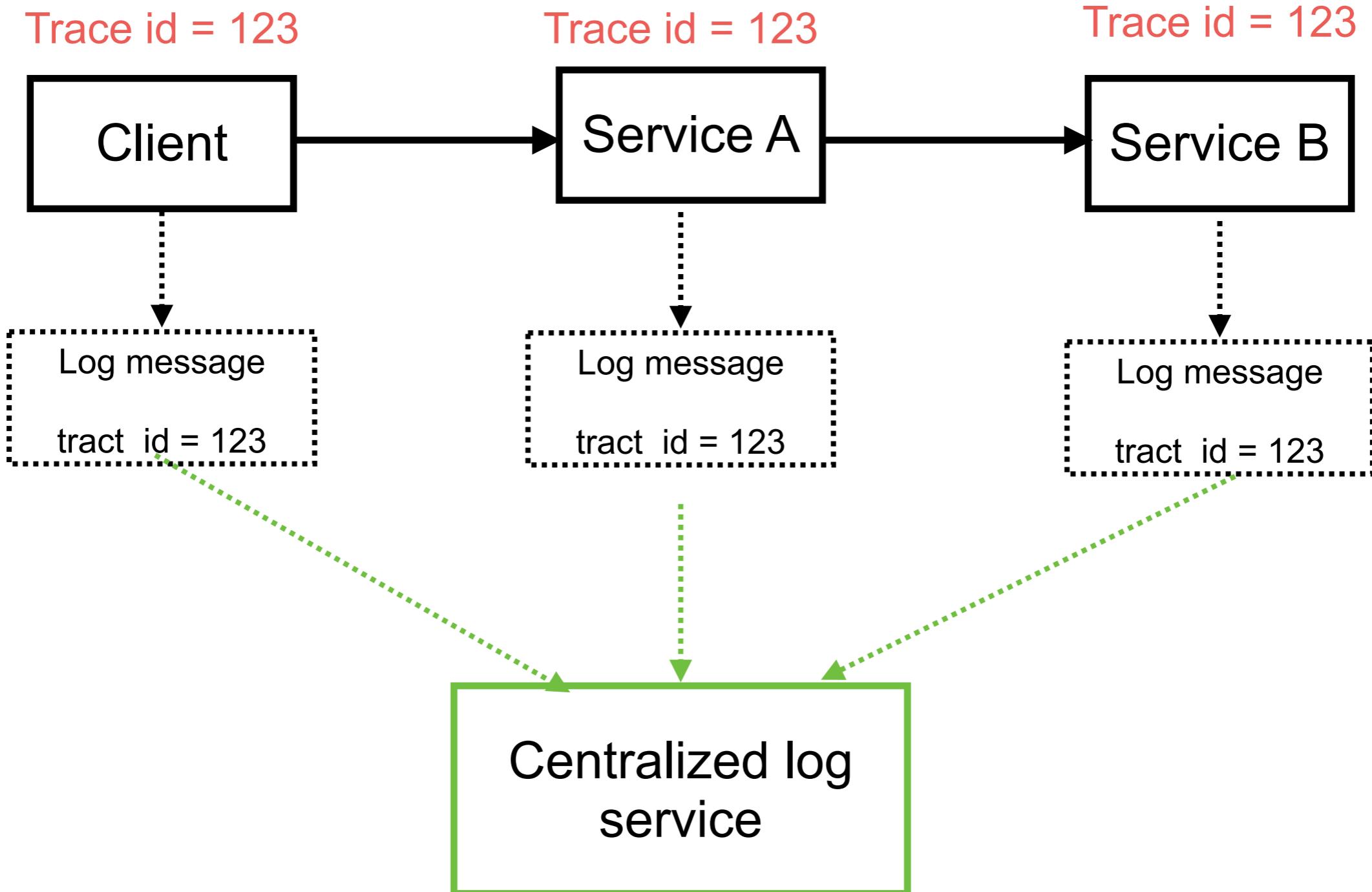


Don't keep !!

```
com.framework.FrameworkException: Error in web request
  at com.framework.ApplicationStarter.lambda$start$0(ApplicationStarter.java:15)
  at spark.RouteImpl$1.handle(RouteImpl.java:72)
  at spark.http.matching.Routes.execute(Routes.java:61)
  at spark.http.matching.MatcherFilter.doFilter(MatcherFilter.java:134)
  at spark.embeddedserver.jetty.JettyHandler.doHandle(JettyHandler.java:50)
  at org.eclipse.jetty.server.session.SessionHandler.doScope(SessionHandler.java:1568)
  at org.eclipse.jetty.server.handler.ScopedHandler.handle(ScopedHandler.java:144)
  at org.eclipse.jetty.server.handler.HandlerWrapper.handle(HandlerWrapper.java:132)
  at org.eclipse.jetty.server.Server.handle(Server.java:503)
  at org.eclipse.jetty.server.HttpChannel.handle(HttpChannel.java:364)
  at org.eclipse.jetty.server.HttpConnection.onFillable(HttpConnection.java:260)
  at org.eclipse.jetty.io.AbstractConnection$ReadCallback.succeeded(AbstractConnection.java:305)
  at org.eclipse.jetty.io.FillInterest.fillable(FillInterest.java:103)
  at org.eclipse.jetty.io.ChannelEndPoint$2.run(ChannelEndPoint.java:118)
  at org.eclipse.jetty.util.thread.QueuedThreadPool.runJob(QueuedThreadPool.java:765)
  at org.eclipse.jetty.util.thread.QueuedThreadPool$2.run(QueuedThreadPool.java:683)
  at java.base/java.lang.Thread.run(Thread.java:834)
Caused by: com.project.module.MyProjectFooBarException: The number of FooBars cannot be zero
  at com.project.module.MyProject.anotherMethod(MyProject.java:20)
  at com.project.module.MyProject.someMethod(MyProject.java:12)
  at com.framework.ApplicationStarter.lambda$start$0(ApplicationStarter.java:13)
  ... 16 more
Caused by: java.lang.ArithmaticException: The denominator must not be zero
  at org.apache.commons.lang3.math.Fraction.getFraction(Fraction.java:143)
  at com.project.module.MyProject.anotherMethod(MyProject.java:18)
  ... 18 more
```



Centralized logging



Observable Service Workshop

Metric

Tracing

Logging

<https://github.com/up1/demo-spring-observability>



Distributed Tracing



<https://zipkin.io/>



Create project with Tracing

org.springframework.boot:spring-boot-starter-actuator
io.micrometer:micrometer-tracing-bridge-otel
io.opentelemetry:opentelemetry-exporter-zipkin

Actuator

Micrometer
Tracing Otel

Opentelemetry
zipkin exporter

<https://docs.spring.io/spring-boot/docs/3.2.0/reference/html//actuator.html#actuator.micrometer-tracing>



Spring Boot 3.2.0

Virtual Threads

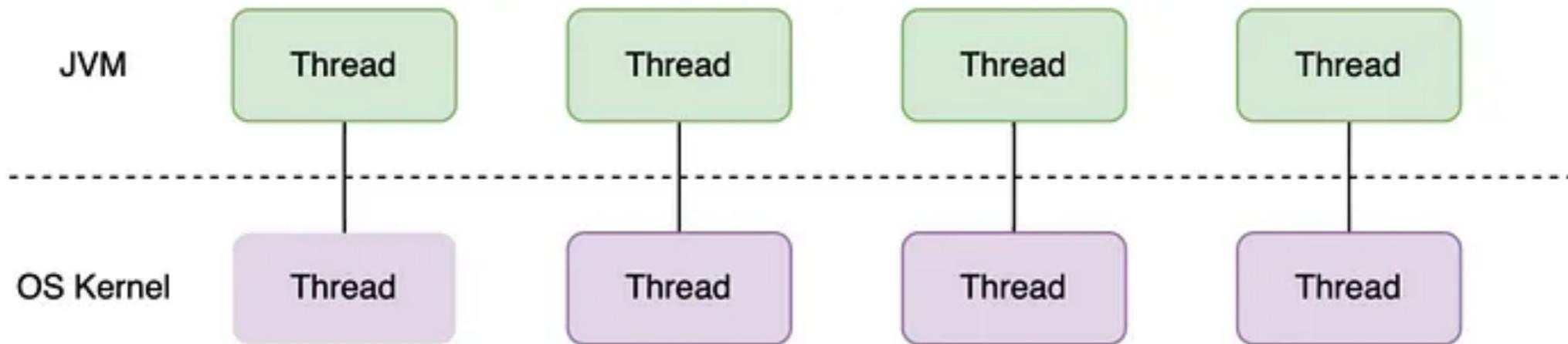
<https://openjdk.org/jeps/425>

<https://spring.io/blog/2023/09/09/all-together-now-spring-boot-3-2-graalvm-native-images-java-21-and-virtual>



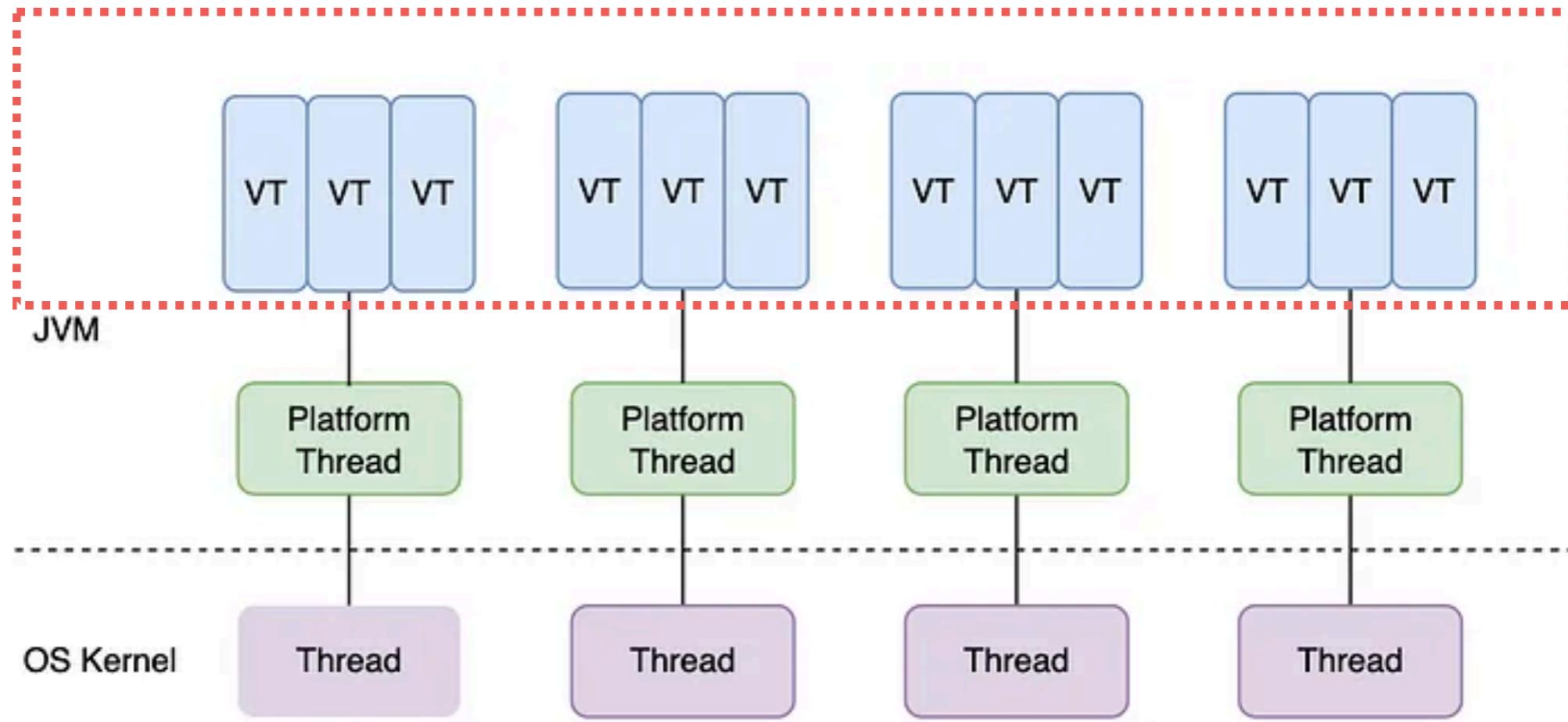
Java Threads

Thread pools



Support Virtual Threads

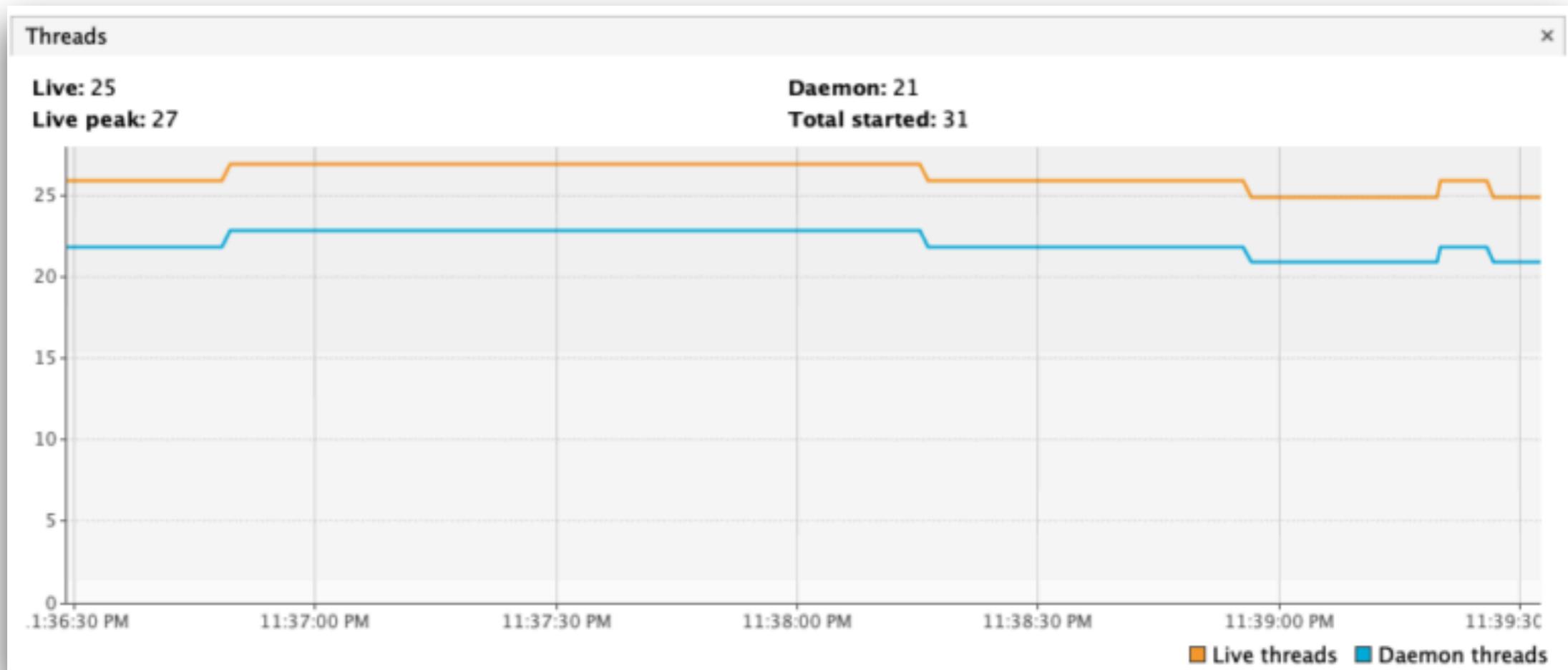
Thread pools



Enable Virtual Thread in Spring Boot

application.properties

```
spring.threads.virtual.enabled=true
```



Spring Boot 3.2.0

GraalVM native image support

<https://www.graalvm.org/>

<https://docs.spring.io/spring-boot/docs/current/reference/html/native-image.html>





Project

Gradle - Groovy Gradle - Kotlin Maven

Language

Java Kotlin Groovy

Spring Boot

3.2.1 (SNAPSHOT) 3.2.0 3.1.7 (SNAPSHOT) 3.1.6

Project Metadata

Group: com.example

Artifact: demo

Name: demo

Description: Demo project for Spring Boot

Package name: com.example.demo

Packaging: Jar War

Java: 21 17

Dependencies

[ADD DEPENDENCIES...](#) ⌘ + ⌘

Spring Web WEB

Build web, including RESTful, applications using Spring MVC. Uses Apache Tomcat as the default embedded container.

GraalVM Native Support DEVELOPER TOOLS

Support for compiling Spring applications to native executables using the GraalVM native-image compiler.

<https://start.spring.io/>



Spring Boot 3.2.0

Docker compose

<https://docs.spring.io/spring-boot/docs/current/reference/htmlsingle/#features.docker-compose>





Project

Gradle - Groovy Gradle - Kotlin
 Maven

Language

Java Kotlin Groovy

Spring Boot

3.2.1 (SNAPSHOT) 3.2.0 3.1.7 (SNAPSHOT) 3.1.6

Project Metadata

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Name: demo

Description: Demo project for Spring Boot

Package name: com.example.demo

Packaging: Jar War

Java: 21 17

Dependencies

[ADD DEPENDENCIES... ⌘ + B](#)

Docker Compose Support DEVELOPER TOOLS

Provides docker compose support for enhanced development experience.

Testcontainers TESTING

Provide lightweight, throwaway instances of common databases, Selenium web browsers, or anything else that can run in a Docker container.

<https://github.com/up1/demo-spring-docker-compose>



Spring Boot 3.3.0

SBOM (Software Bill of Materials)

<https://spring.io/blog/2024/05/24/sbom-support-in-spring-boot-3-3>



Enable SBOM in project

The screenshot shows the 'Dependencies' section of a Spring Boot application's build configuration. At the top right is a button labeled 'ADD DEPENDENCIES... ⌘ + B'. Below it, there are two dependency entries:

- CycloneDX SBOM support** OPS
Creates a Software Bill of Materials in CycloneDX format.
- Spring Boot Actuator** OPS
Supports built in (or custom) endpoints that let you monitor and manage your application - such as application health, metrics, sessions, etc.

application.properties

```
management.endpoints.web.exposure.include=health,sbom
```

https://github.com/OWASP/CheatSheetSeries/blob/master/cheatsheets/Logging_Cheat_Sheet.md



Build project

\$mvnw clean package

```
localhost:8080/actuator/sbom/application

2
4  {
5      "bomFormat": "CycloneDX",
6      "specVersion": "1.5",
7      "serialNumber": "urn:uuid:95933afb-5c32-3d63-b28f-cff74821ede9",
8      "version": 1,
9      "metadata": {
10         "timestamp": "2024-08-14T15:46:41Z",
11         "lifecycles": [
12             {
13                 "phase": "build"
14             }
15         ],
16         "tools": [
17             {
18                 "vendor": "OWASP Foundation",
19                 "name": "CycloneDX Maven plugin",
20                 "version": "2.8.0",
21                 "hashes": [

```



Q/A



Spring Boot 3.4.0

Next ...

