Assignment #02 - Software Architecture and Platforms - a.y. 2024-2025

Description

Consider the "EBike application" seen in the first assignment. The objective of the second assignment is to design and develop a distributed version based on microservices and microservices patterns - as discussed in modules 2.X and in Lab Notes about microservices patterns, and adopting DDD as reference method for the analysis and development stage.

In particular:

- A knowledge crunching process must be enacted so to gather and represent architectural drivers, defining (following DDD) a proper Ubiquitous Language, structured around a domain model, and using it to define artifacts useful to both define requirements and quality attributes (user stories, use cases, domain stories, quality attribute scenarios), as well as bounded contexts and context map.
- Moving from strategical to tactical design, a model-driven design should be adopted, applying -- when useful -- DDD domain model pattern.
- The architecture should be based on microservices and hexagonal/ports & adapters/clean architecture style, for the design of the individual service.
- The architecture should integrate microservices patterns that are considered relevant, given the case study, considering the different examples and categories seen in the course:
    - Application-level patterns
    - Testing patterns
    - Deployment patterns
    - Runtime Configuration pattern
    - Observabilty Patterns
- A strategy for validating the proposed architecture should be devised and enacted, given the requirements and the quality attributes defined in the analysis stage.

Deliverable

A zipped folder `Assignment-02-<Surname>` including a maven-based or gradle-based project, with sources and the report in PDF. The deliverable can be submitted using a link on the course web site.

Deadline

November 29, 2024 - 9:00 AM

Usage

Running from the build tool (automatically assembles the jars):

```
sbt composeUpDev
```

Otherwise with the jars already built:

```
docker compose -f ./docker-compose.yml -f ./docker-compose.dev.yml --env-
file ./development.env build
docker compose -f ./docker-compose.yml -f ./docker-compose.dev.yml  --env-
file ./development.env up --force-recreate
```

Otherwise you can pull the images from dockerhub:

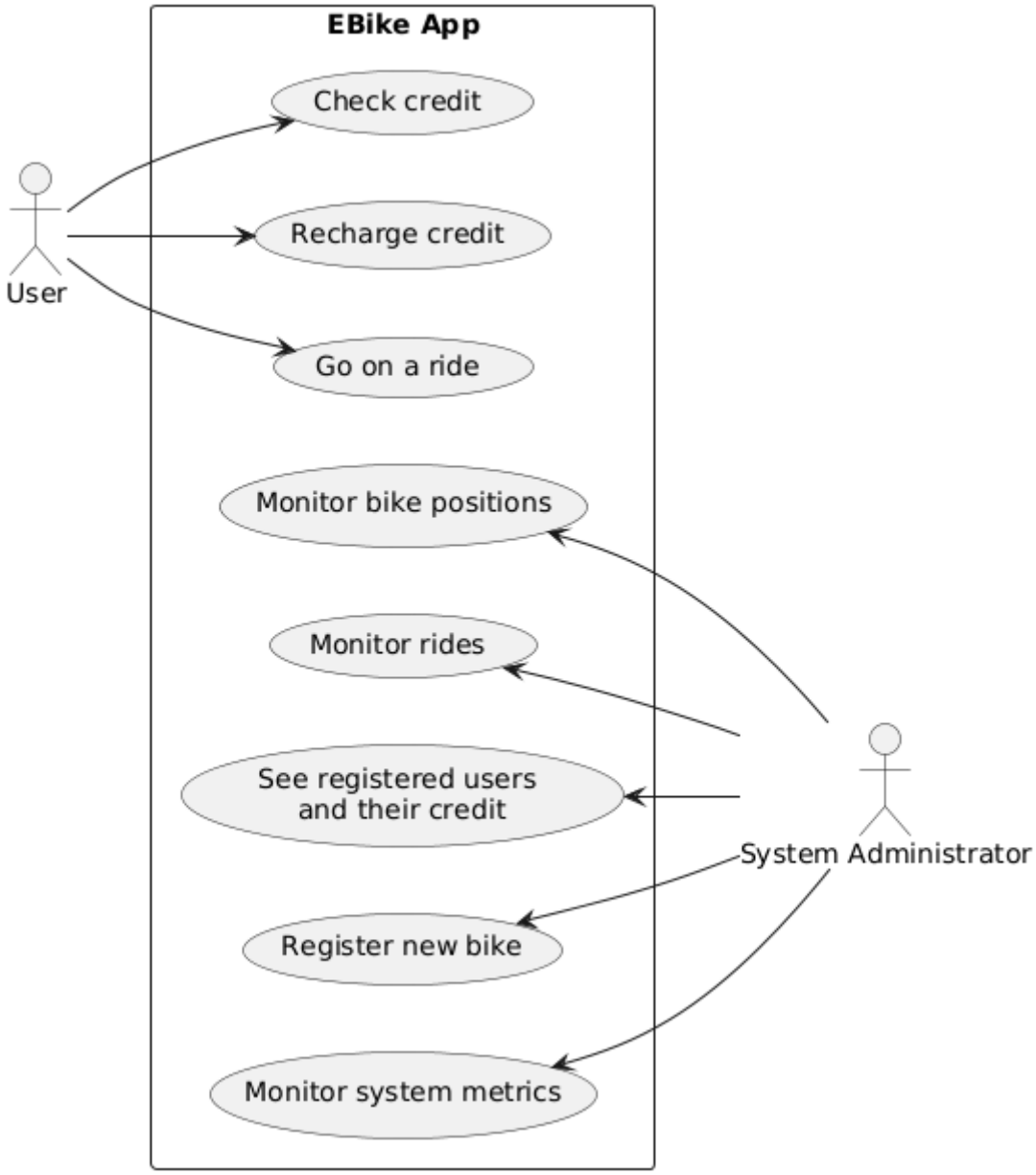
```
docker compose -f ./docker-compose.yml -f ./docker-compose.dev.yml -f
./docker-compose.hub.yml --env-file ./development.env up --force-recreate
```

Requirements

User Stories

As a	I want to	so that I can
user	go on a ride with a rented bike	leave it wherever i want
user	check my credit	understand if it needs to be recharged
user	recharge my credit	go on a ride
system administrator	see the current location of every bike	check if was left too far
system administrator	see which users are currently riding a bike	spot any anomaly if present
system administrator	see all the registered users and their credit	spot any anomaly if present
system administrator	add new bikes to the system	increase the number of bikes in the future
system administrator	be able to monitor metrics of the system (like health status of each component or the amount of request that were served)	spot any anomaly if present

Use cases



Scenarios

- Go on a ride:

    1. The user chooses an available bike and selects "Start ride"
    2. The user can see his credits updating while he's riding
    3. The user selects "End ride"

- Check credit:

    1. The user sees his credit right in the home screen

- Recharge credit:

    1. The user selects a "recharge credit" button
    2. The user inserts how much credits he wants to deposit
    3. The user confirms

- Add new bike:

    1. The system administrator chooses an id for the new bike and confirms
    2. The system checks that the id is valid, and if it's not it fails the operation
    3. The system register the new bike with the given valid id

- See registered users and their credit:

    1. The system administrator interface shows always every registered user alongside his credit

- Monitor rides

    1. The system administrator interface shows user usernames that are on a ride alongside the bike their riding

- Monitor bike positons

    1. The system administrator interface shows a graphical representation of the bike locations on a 2D space

- Monitor system metrics

    1. The system administrator interface shows for every component if it's running or not and the total amount of served requests

Business requirements

- The credit of the user must be decreased by 1 unit every second

Quality attribute scenarios

Quality attribute	**Source**	**Stimulus**	**Artifact**	**Environment**	**Response**	**Response measure**
Availablilty	User/Admin	Interacts with the system causing a component crash	System component	Normal conditions	The component is restarted	in 10 seconds
Observability	User/Admin	Sends a request	System	Normal conditions	Keeps a request counter	An updated requests counter is somehow exposed

Quality attribute	Source	Stimulus	Artifact	Environment	Response	Response measure
Observability	User/Admin	Interacts with the system causing a component crash	System component	Normal conditions	Tracks the current state of the crashed component	Updated information about the component state are somehow exposed

Analisys

Bounded contexts

Given the requirements multiple bounded contexts were identified:

- System administrator interactions
- User interactions
- Users management
- E-bikes management
- Rides management
- User authentication (emerged due to the need of storing users credit)
- Metrics monitoring

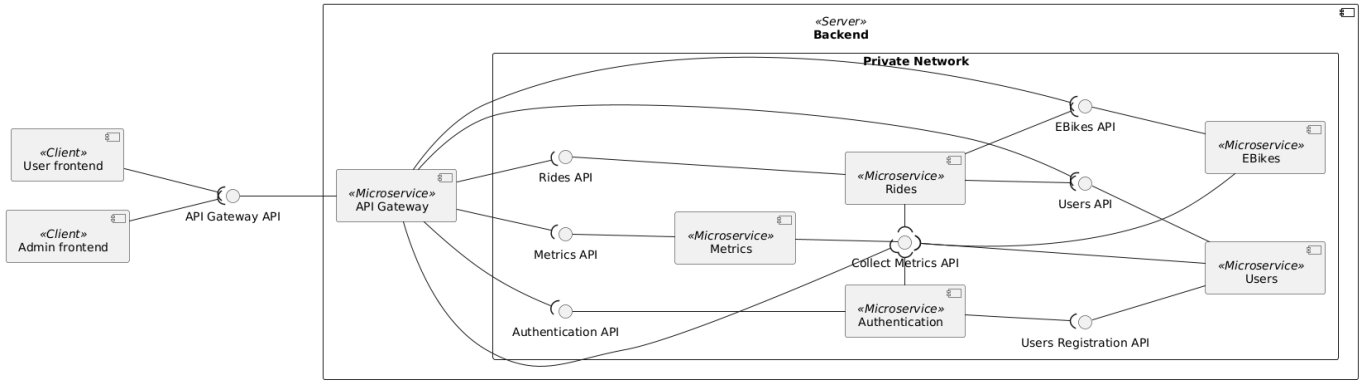
Ubiquitous language

Word	Definition	Synonyms
User	The actual app customer one which rents bikes to ride	Customer
Username	A text chosen by the user which uniquely identifies him inside the system	User id
Admin	An employee of the organization whose responsibility is to monitor the system and to take actions to let the system work as expected	System administrator
E-bike	An electric bike which can be rented by the users	Ebike, bike
E-bike location	The geographical location of the bike	E-bike position
Ride	The rental of a bike from a user which aims to use it to move from one place to another	
Credit	An internal currency that the users exchange with bikes rental time	
Recharge credit	Process executed by the user by which his credit is increased by the requested amount	
Register new ebike	An action taken by the admin which has the outcome of making the system aware of a new bike which can then be rented	Create new ebike

Word	Definition	Synonyms
Monitor ebikes/rides	Admin's capability to check the location of each bike and which users are riding them	
Authentication	Process by which the user provides enough data to the system to identify him	Login
Metric	A measurement relative to a specific characteristic	Measurement

Design

The system is designed follwing a microservice architecture where each bounded contexts is mapped to a single microservice or frontend.

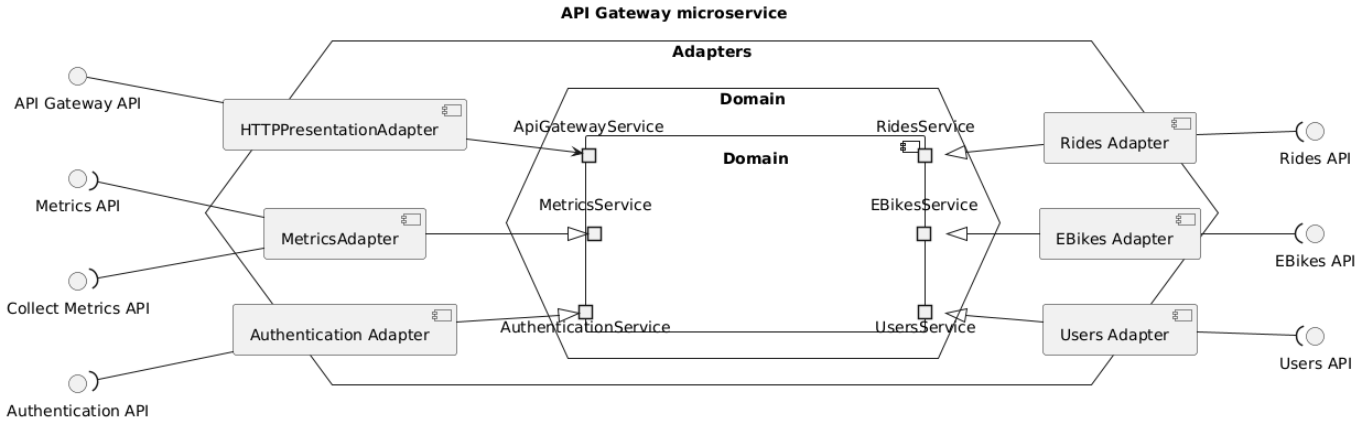


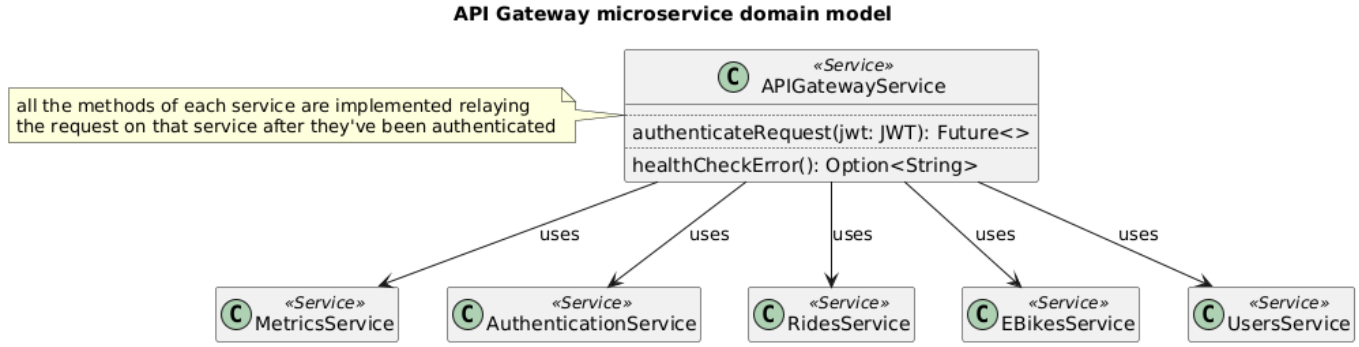
* The metrics service actually runs an healthcheck on every microservice and therefore it is loosely dependant on them, these dependencies are not shown in the diagram for the sake of simplicity

API Gateway

The API Gateway microservice is the only service exposed to the internet.

It has the responsibility to relay the client requests to the appropriate services.





A choice regarding security

Given the fact that the API Gateway is the only exposed access point it will be resposible for validating (through the Authentication microservice) every request before relaying it.

This allows to keep the token validation logic centralized letting every other microservice assume that the requests they receive are authenticated.

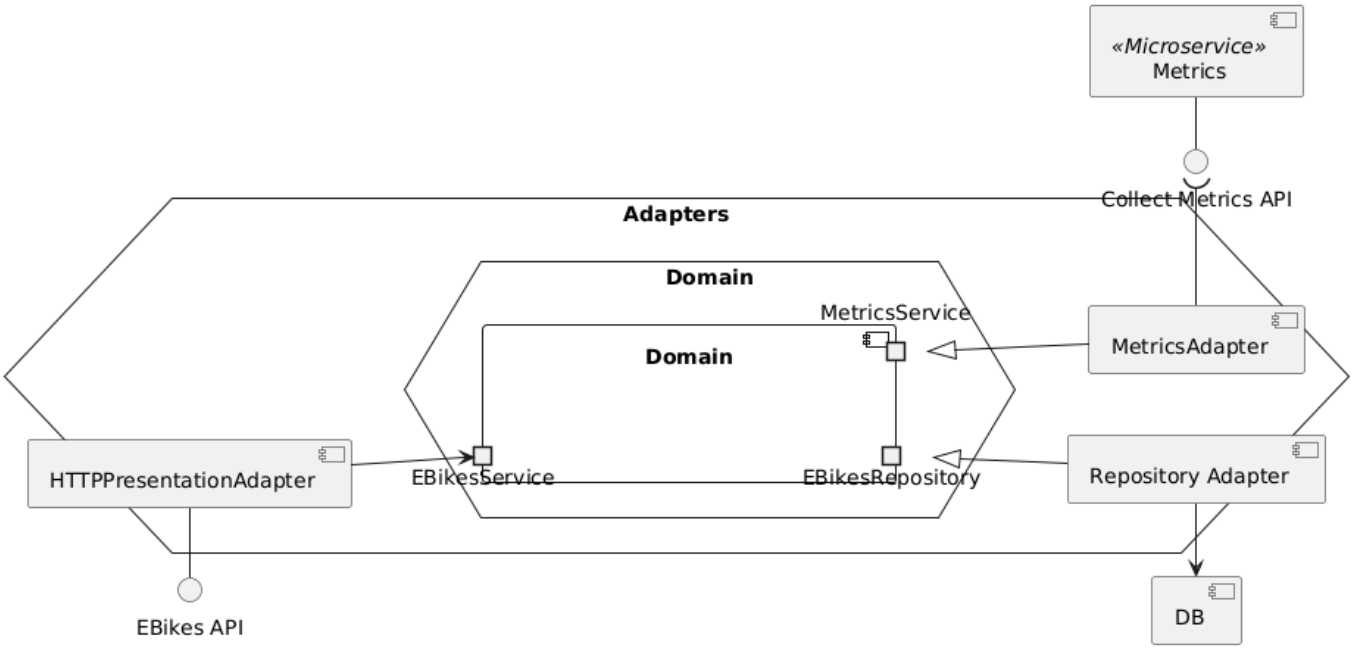
This is by far not a much secure solution but for the purpose of this project it allows to reduce overall complexity.

EBikes and Users microservices

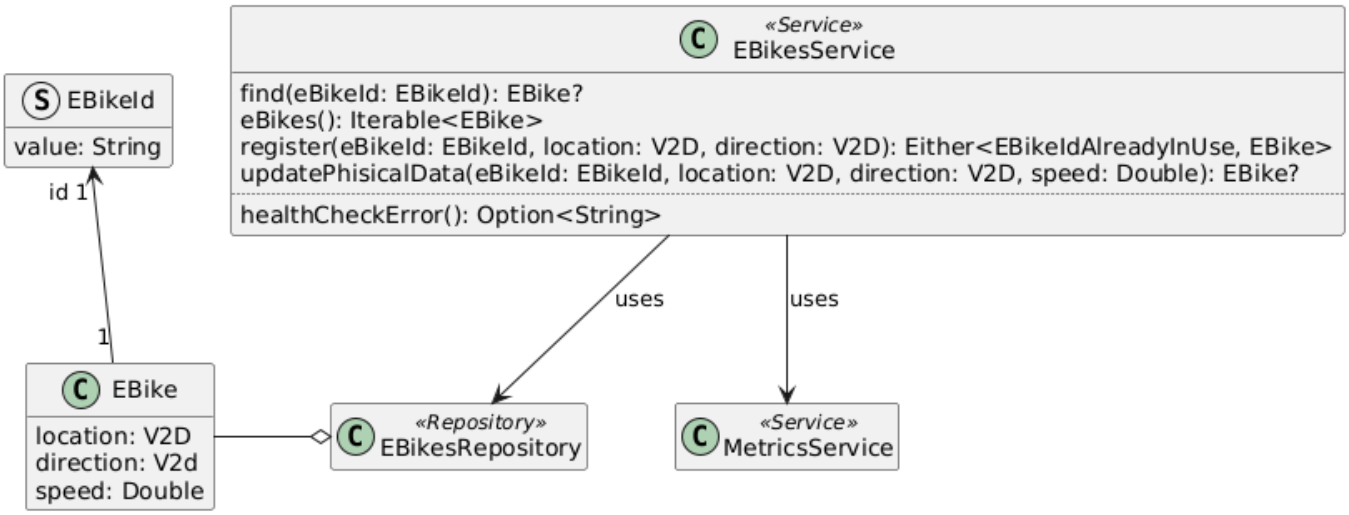
The EBikes microservice and the Users microservice are both built follwing the hexagonal architecture.

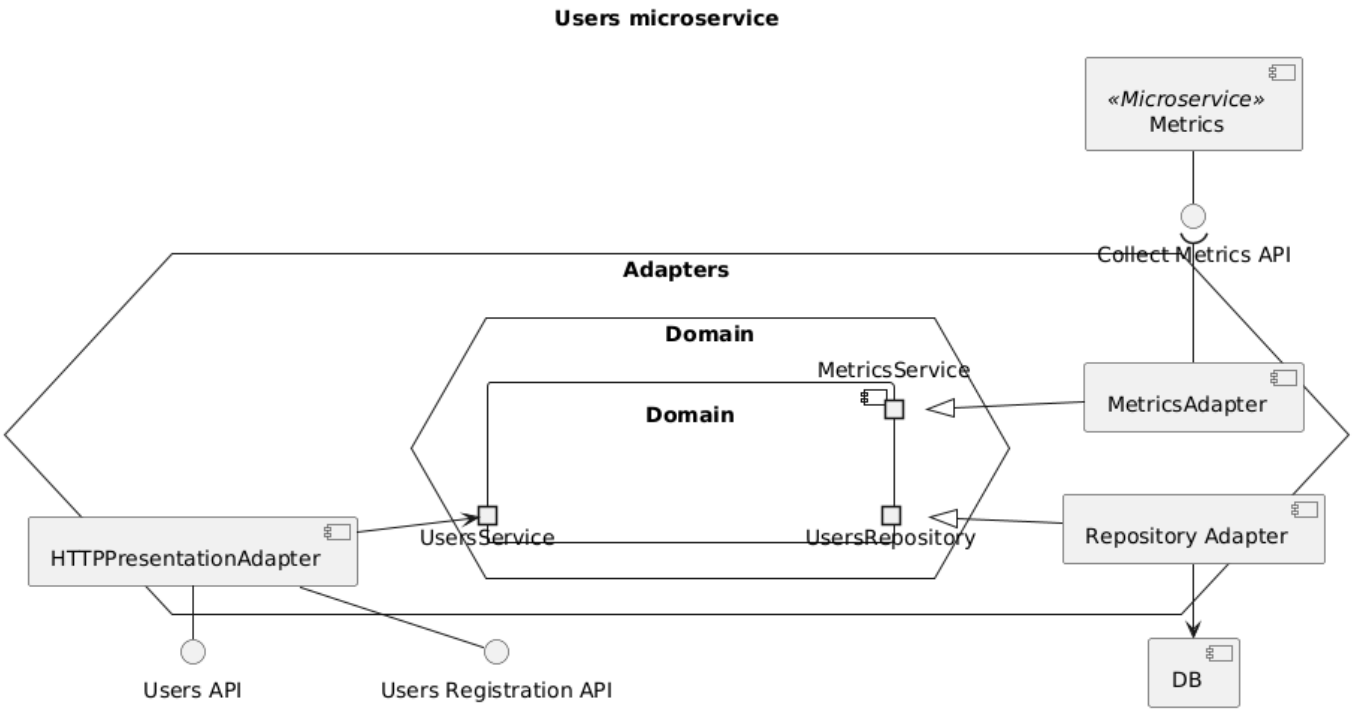
They don't depend on any other microservice (except the Metrics microservice but they can work perfectly even it that's down).

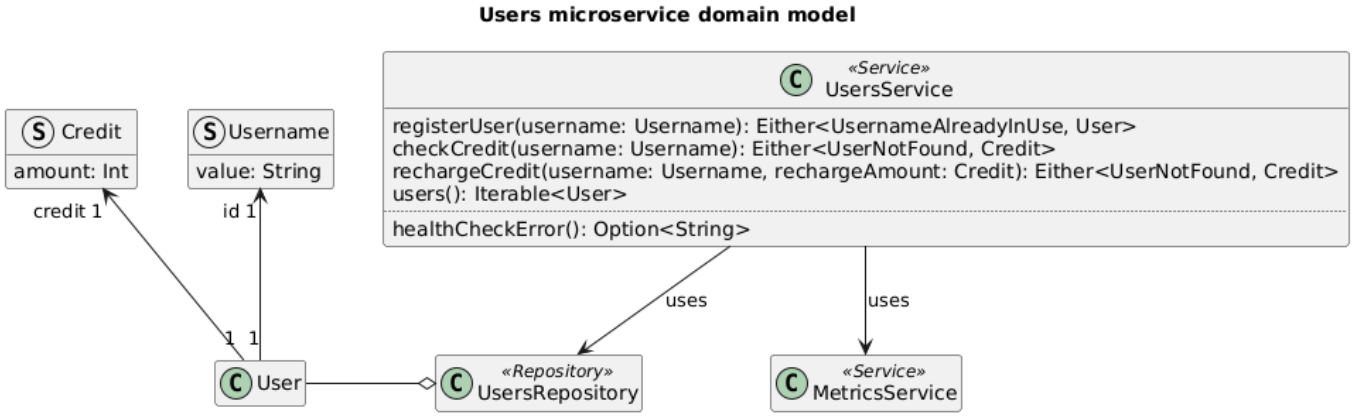
EBikes microservice



EBikes microservice domain model



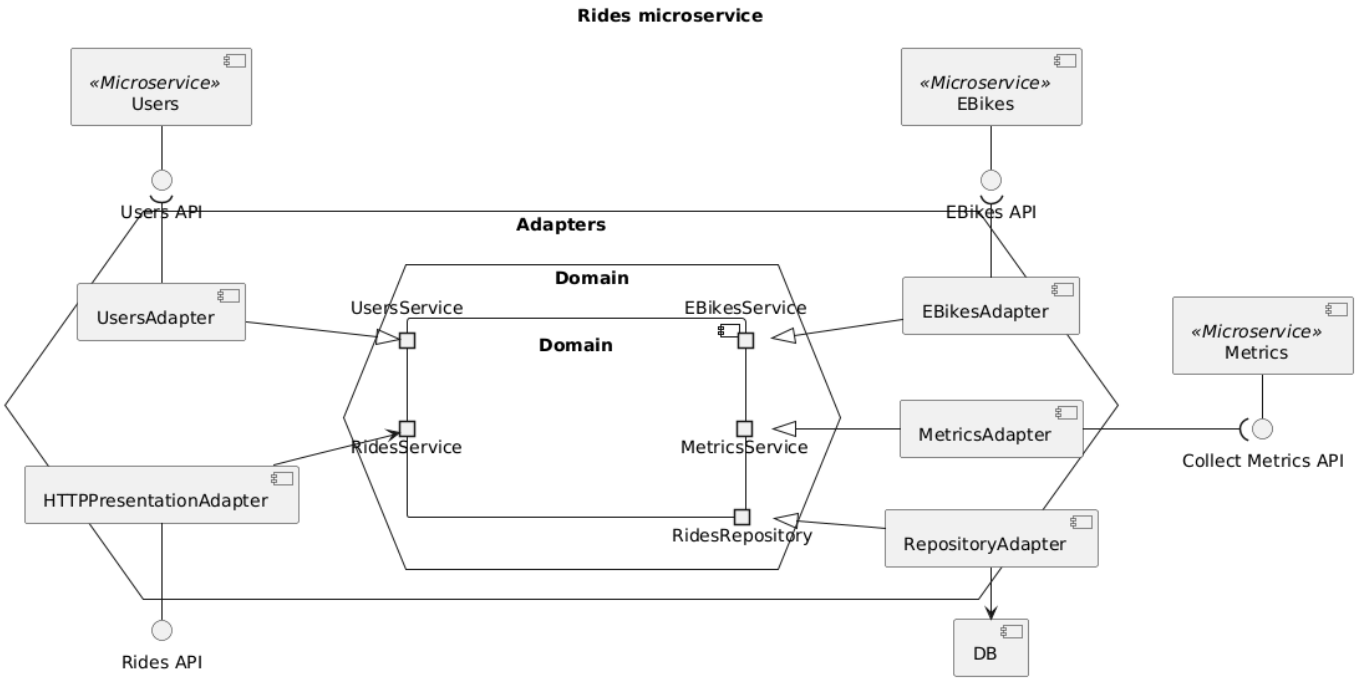


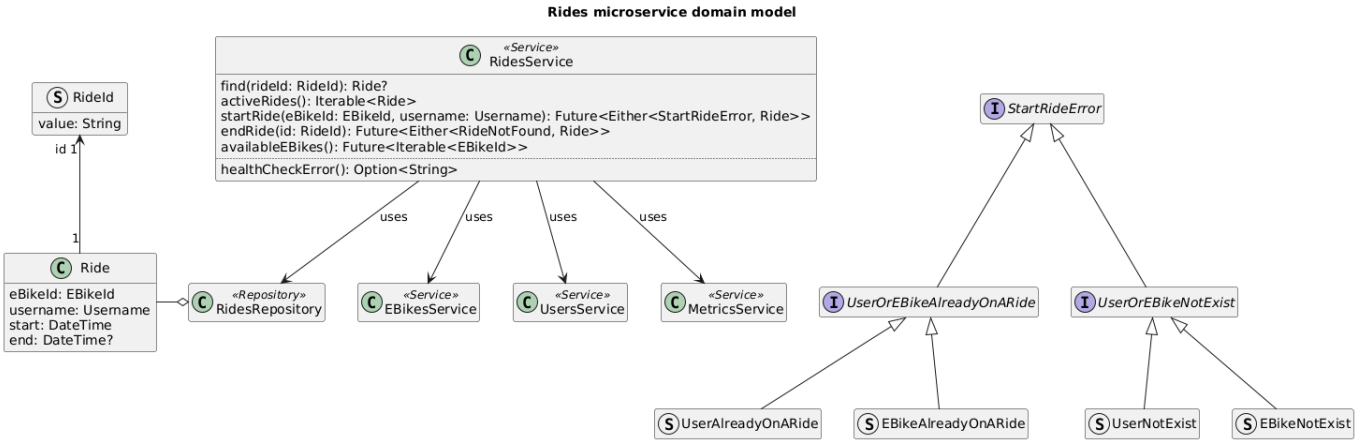


Rides microservice

The Rides microservice is built follwing the hexagonal architecture.

It depends on both the other microservices (EBikes and Users).

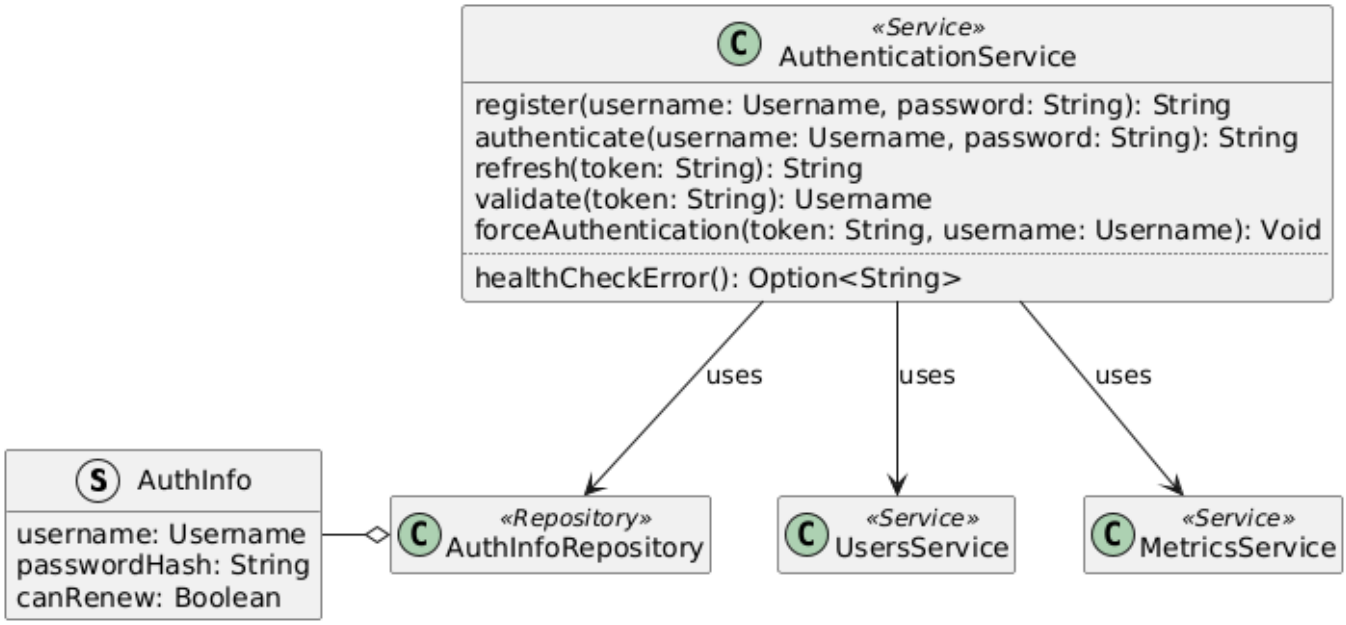




Authentication microservice

The Authentication service is responsible for every aspect regarding user authentication.

In fact the user password is not stored in the user microservice but it's stored in this one.



Bounded context language

Word	Definition	Synonyms
Password	The user's secret string that lets him authenticate himself	
PasswordHash	An hashed password, it allows to not store passwords in clear text format	
JWT	A token signed by the system that authenticates a user	JSON Web Token
AuthInfo	A data structure that holds the user's passwordHash and a flag regarding automatic token renewal	

Operations offered by this service are handled in this way:

Register new user

Registering a new user is the most complex operation as it requires interaction with the Users microservice.

The service:

1. will check that a user with that username does not already exist.
2. will send a request of registering a user to the Users service
3. if the operation succedes then will proceed by inserting a new AuthInfo into its AuthInfoRepository.
4. will issue and return a JWT token

In case of failure of the operation after successfully completing point 2 the system may be in an unconsistent state (a user has been created but has no AuthInfo).

To achieve eventual consistency this edge case is handled as it follows:

1. Once the service will try to create the (same) user (point 2) it will receive an error saying that the user is already registered but since it was already checked that no AuthInfo existed then the service will

proceed like no error has happened.

Authenticate existing user

Given a username and password the service checks if they're valid and if so it issues a JWT with relatively short expiration time (like 15 minutes). Also ensures that the `canRenew` flag is set to true.

Validating a JTW token

Given a JWT token the service verify it has a valid signature and that it's not expired.

Refreshing JWT token

Given a non-expired token the service will issue a new one only if the `canRenew` flag of the relative AuthInfo is set to true.

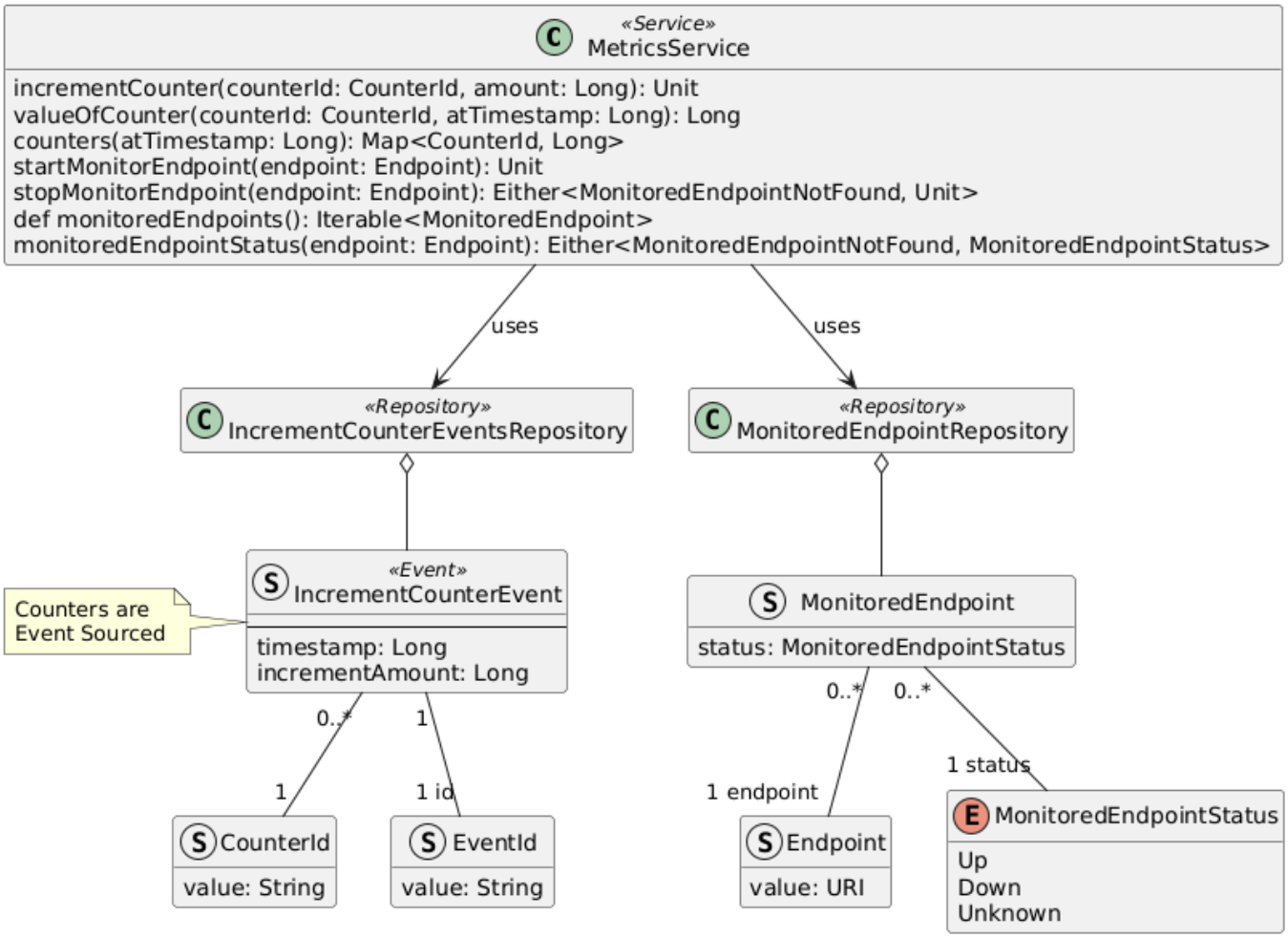
Force authentication

The `canRenew` flag of the user with the given username will be set to false so that it cannot renew his tokens until he authenticates again.

> **Note:**
>
> This mechanism allow to easily renew tokens while still keeping the possibility of forcing a user to re-authenticate. (For example in case he changes his password or strange behaviors are detected)

Metrics microservice

The metrics service is responsible for storing metrics data of the whole system.



The required metrics are:

- health status of each microservice
- total amount of requests served by each microservice

The health status will be tracked by polling each service at a fixed interval (Pull strategy)

The amount of requests will be reported by every microservice to the Metrics service (Push strategy)

Deployment

Each microservice will be deployed as a standalone Docker container while the two frontends will be deployed as standard GUI apps.

In order to achieve an effective and simple deployment a docker compose file has been written.

Fault tolerance / recovering

The system will exploit the underlying deployment platform (Docker / Docker compose) to restart services in case of failure.

Service discovery

A service discovery mechanism has to be implemented due to the subsequent reasons:

- Each microservice could be restarted in case of failure and as a consequence it could change it's network address
- Future versions of the software may require to create multiple instances of the same service due to heavy workloads and therefore the network address may change at runtime.

Given these requirements the built-in DNS service provided by Docker can be exploited to achieve the desired behavior.

Configuration

Since the microservices configuration does not need to be changed at runtime the simplest way to provide an externalized configuration is through enviornment variables that will be passed at deploy-time.

Testing

It is required to provide at least one test for each layer in the testing pyramid

Test type	Amount	Complexity	Examples
End-to-end	Low	Very high	End to end tests were made manually through Postman
Component	Medium	High	EBikesComponentTests
Integration	High	Medium	EBikesFileSystemRepositoryAdapterTests, HttpPresentationAdapterTests
Unit	Very high	Low	EBikesServiceTests, V2DTests

Issues

Incompleteness

Due to time constraints the system lacks these features:

- Differentiation between users and admins
- Proper authorization checks
- Incomplete API gateway (it only relays to EBikes and Authentication microservices)
- The user credit is not decreased when riding
- The GUI is really ugly
- The admin interface is missing the ability to register a new bike

  In order to register a bike to test the system you can run

  ```
  curl --location 'localhost:8081/ebikes' \
  --header 'Content-Type: application/json' \
  --data '{
  ```

```
    "id": {
        "value": "bike1"
    },
    "location": {
        "x": 0,
        "y": 0
    },
    "direction": {
        "x": 0,
        "y": 0
    }
}'
```