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POLITECNICO
MILANO 1863

DD: Design Document

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1 Introduction

1.1 Scope

Traditional software programming education often lacks of hands-on experience and continuous evaluation. CodeKataBattle addresses these issues by providing a platform for competitive programming challenges which promotes teamwork and emphasizes the test-first approach in software development. It allows students to apply theoretical knowledge in tournaments with an automated scoring system. Instructors benefit from closer mentorship through code reviews and manual evaluation, creating a cycle of learning through practice, feedback, and community engagement.

CodeKataBattle's platform will employ a microservices architecture, emphasizing the decomposition of the system into small, independently deployable services. Each microservice will be dedicated to a specific business capability, promoting modular development and ease of maintenance. The architecture facilitates scalability, allowing individual services to be scaled independently based on demand. Other important design choices include:

- **Service Discovery:** A service registry will be used to allow services to locate each other without prior knowledge of their location. This enables efficient communication between services by providing up-to-date information. Service discovery enhances fault tolerance and load balancing, contributing to the overall reliability of the system.
- **API Gateway:** An API gateway will be used to provide a single entry point for clients to access the system. This simplifies the client interface by abstracting the underlying microservices and provides a centralized location for authentication and authorization. The API Gateway enhances security measures, ensuring controlled and secure access to the microservices.
- **Hybrid Communication Framework:** While most services exploit synchronous communication via REST api calls, an event-driven communication framework is also used to facilitate communication between specific microservices, allowing them to be loosely coupled and promoting both modularity and scalability. This framework enhances the

reliability of these services by providing a mechanism for asynchronous communication between them (i.e. queues).

- **Data Management Strategies:** The system employs tailored data management strategies, utilizing databases suitable for microservices. Both relational and NoSQL databases are considered for each specific service in order to provide flexibility and scalability.

Incorporating these key properties into the CodeKataBattle system should provide a robust and scalable architecture, ensuring modularity, responsiveness, security, reliability, and effective data management.

1.2 Definitions, Acronyms, Abbreviations

TODO: remove unused ones

1.2.1 Definitions

- **User:** anyone that has registered to the platform
- **Student:** the first kind of users and, basically, the people this product is designed for. Their objective is to submit solutions to battles
- **Team:** students can decide to group up and form a team to participate to a battle. The score assigned to the submission of a team will be assigned also to each one of its members
- **Educator:** the second kind of users. They create tournaments, set-up battles, and eventually, evaluate the solutions that teams of students have submitted during the challenge
- **Tournament:** collection of coding exercises (battles). Interested students can subscribe to it and participate to its battles as soon as they are published
- **Code Kata Battle (or battle):** the atomic unit of a tournament. Usually students are asked to implement an algorithm or to develop a simple project that solves the task. Each battle belongs to a specific tournament: students submitting solutions for a battle will obtain a score that will be used to compute both the team's rank for the battle and the members' tournament rank

- **Code Kata:** description and software project necessary for the battle, including test cases and build automation scripts. These are uploaded by the educator at battle creation time
- **Tournament collaborator:** other educator that is added by the tournament creator to help him in the management of the tournament. He can create battles and evaluate their submissions
- **GitHub:** web-based hosting service for version control, mostly used for programming. It offers both distributed version control and source code management functionalities
- **GitHub repository:** a repository is a storage space where some project files are stored. It can be either public or private. In the context of the platform, each battle is associated with a GitHub repository that is created by the system and shared with the teams
- **GitHub collaborator:** person who is granted access to a GitHub repository with write permission
- **GitHub Actions:** GitHub feature that allows to automate tasks directly on GitHub, such as building and testing code, or deploying applications. In the context of the platform, GitHub Actions is used to automatically notify the system when a new submission is pushed to the repository of a team
- **Test cases:** each battle is associated with a set of test cases, which are input-output value pairs that describe the correct behavior of the ideal solution
- **Static analysis:** is the analysis of programs performed without executing them, usually achieved by applying formal methods directly to the source code. In the context of the platform this kind of analysis is used to extract additional information about the level of security, reliability and maintainability of a battle submission
- **Functional analysis:** measures the correctness of a solution in terms of passed test cases
- **Timeliness:** measures the time passed between the start of the battle and the last commit of the submission

- **Score:** to each solution is assigned a score which is computed taking into account timeliness, functional and static analysis and, eventually, manual score assigned by the educator that created the challenge. The score is a natural number between 0 and 100 (the higher the better)
- **Rank:** during a battle, students can visualize the ranking of teams taking part to the battle. Moreover, at the end of each battle, the platform updates the personal tournament score of each student. Specifically, the score is computed as the sum of all the battles scores received in that tournament. This overall score is used to fill out a ranking of all the students participating to the tournament which is accessible by any time and by any user subscribed to the platform
- **Notification:** it's an email alert that is sent to users to inform them that a certain event occurred such as the creation of a new tournament and battle or the publication of the final rank of a battle

1.2.2 Acronyms

- **DD:** Design Document
- **RASD:** Requirements Analysis and Specification Document
- **CKB:** Code Kata Battles
- **API:** Application Programming Interface
- **UML:** Unified Modeling Language
- **HTML:** HyperText Markup Language
- **CSS:** Cascading Style Sheets
- **JSON:** JavaScript Object Notation
- **OS:** Operating System
- **REST:** REpresentational State Transfer
- **URL:** Uniform Resource Locator
- **HTTPS:** HyperText Transfer Protocol Secure

1.2.3 Abbreviations

- **Gn**: Goal number “n”
- **Dn**: Domain Assumption number “n”
- **Rn**: Requirement number “n”
- **UCn**: Use Case number “n”

1.3 Revision History

- December 21, 2023: version 1.0 (first release)

1.4 Reference Documents

- Specification document: "Assignment RDD AY 2023-2024"
- DD reference template: "04e.QualitiesAndCreatingDD.pdf"
- UML official specification <https://www.omg.org/spec/UML>
- GitHub API official documentation: <https://docs.github.com/en/rest/guides/getting-started-with-the-rest-api?apiVersion=2022-11-28>

1.5 Document Structure

- **Section 1: Introduction**

In this section a general description of the document and the system to be developed is provided, also including a glossary of terms used and a list of reference documents.

- **Section 2: Architectural Design**

Here the high-level structure of the software is outlined. This includes the identification of major components, their interactions, and the overall flow of data within the system. Dependencies on external factors or third-party integrations are also detailed, offering a comprehensive view of the software’s architecture.

- **Section 3: User Interface Design**

Focused on the end-user experience, this section describes the layout, interactivity, and visual elements of the software's user interface. It includes mockups of the main pages of the web application.

- **Section 4: Requirements Traceability**

Here the relation between software requirements and design elements is highlighted. This is achieved through the use of a traceability matrix.

- **Section 5: Implementation, Integration and Test Plan**

This section is a comprehensive guide that covers the main aspects of the software development lifecycle. It outlines the details of implementation and integration plan, as well as the testing strategy.

- **Section 6: Effort spent**

The sixth and last chapter contains the time spent by each contributor of this document.

2 Architectural Design

2.1 Overview

The following diagram represents the high level architecture of the system, including the external entities that will interact with it.

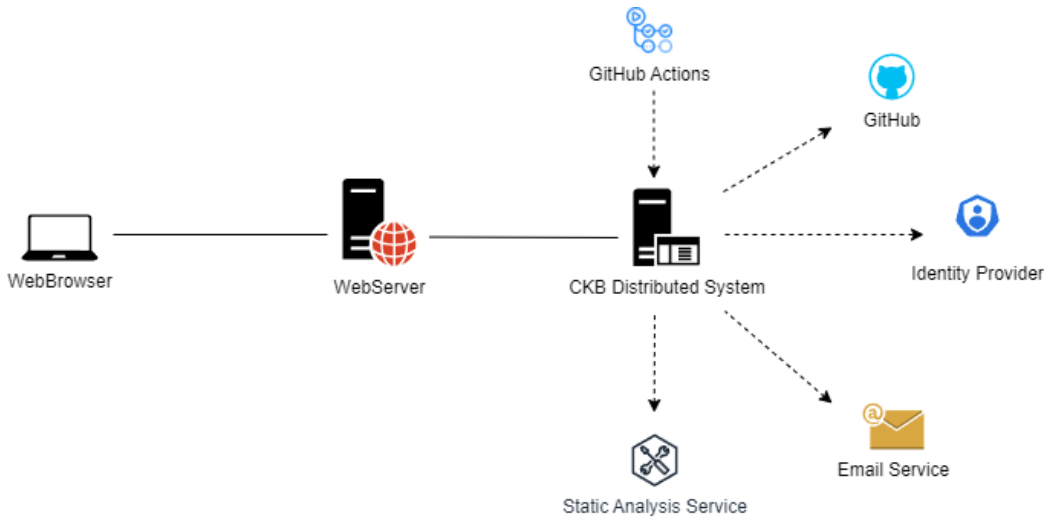


Figure 1: CKB system diagram

The main elements contained in Figure 1 are:

- **WebBrowser** used by students and educators to access the system functionalities through the web application.
- **WebServer** whose functions are:
 - Serving static assets (HTML, CSS, JavaScript) to the client, necessary for handling the initial rendering of the UI.
 - Managing the client-side application and routing.
 - Generating requests directed to the backend system.
- **CKB Distributed System** which is the distributed system composed of multiple microservices that implement the core functionalities of the

system. Its in charge of the data management, application and integration logic of the whole CKB platform.

- **External Entities** the CKB Distributed System must be able to integrate with to accomplish its functionalities. The arrow in the diagram highlights the direction of the interaction between the system and the external entities.

2.2 Component view

The following component diagram highlights the main components of the system and their interaction with external entities and services. In the diagram, the components have been organized to highlight the logical grouping of the system elements.

The WebApplication component represents the presentation layer of the system, being the only entry point for the users. The application and integration logics are represented together due to their tight interaction, while the data layer contains the databases accessed by the respective microservices. Different colors are used to highlight components that share similar roles in the system.

Orange components represent the system's microservices. Some complex microservices have been further decomposed into subcomponents, for a more fine grained representation.

Yellow components represent the model of the database accessed by its microservice. The model offers to the microservice an abstraction of the database, allowing it to access the data without knowing the underlying database implementation technology.

The **violet** has been used to highlight components or services that cover an important role for the communication between microservices. It has been used for the queues subcomponents, which are used to implement the asynchronous and concurrent communication between specific microservices. Also the ServiceRegistry has been represented with the this color, since it enables the communication in the system. Some microservices have an important role in the integration and communication with external entities as well, but have been depicted with their orange color used for microservices. This aspect will be clarified in the detailed description of the components that follows the diagram.

Red components represent the external services that interact with the sys-

tem.

Finally, the **green** color has been used to highlight the databases components that are used to store the data of the system.

It's important to notice that for the sake of simplicity and readability, the interface offered by the ServiceRegistry has been depicted with some dotted arrows that connect all the microservices to it.

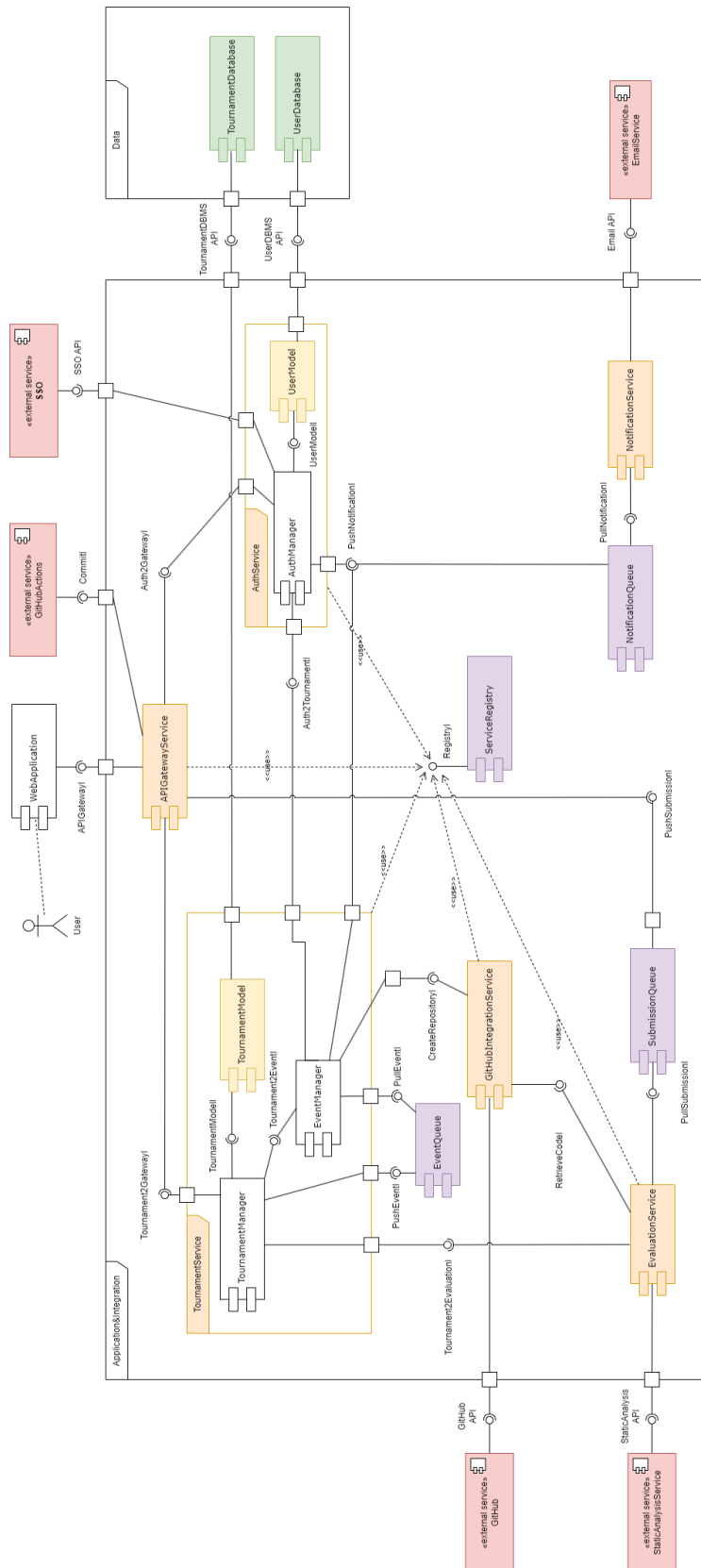


Figure 2: Component diagram

The components in Figure 2 are :

- **WebApplication:** the web app to which users of the CKB platform (students and educators) connect through a modern web browser. It is the front end of the system, and thanks to the interface offered by the **APIGatewayService**, allows users to manage and access the most important aspects of tournaments and battles.
- **APIGatewayService:** this component is the microservice that exposes the REST API used by the WebApplication. Indeed, it allows the implementation of the main functionalities needed by the users of the web application by orchestrating the microservices. It also offers a REST API, used by the GitHub Actions Service, to notify a submission of a student on the Github repository. It's also responsible for the following functionalities:
 - Acts as a single entry point for client requests.
 - Handles authentication, authorization through the interaction with the AuthService.
 - Routes requests to the appropriate microservices that provide the required business functionality.
 - Aggregates responses from multiple microservices if needed.
 - Load balancing and API rate limiting.
- **AuthService:** this component is the microservice that handles the authentication and authorization of the users of the system. To accomplish this task, it may be required to interact with external identity providers, depending on the user preferences. It is responsible also for all the data related to the users of the system, such as their personal information and their roles. It includes the following subcomponents:
 - **AuthManager:** implements the main logical functionalities of the AuthService, exposing APIs used by other microservices to authenticate, authorize users and to retrieve their information.
 - **UserModel:** represents the model of the database used by the AuthService to store the data related to the users of the system.
- **TournamentService:** this component is the microservice that implements most of the functionalities needed by the users. It handles:

- Management of tournaments and battles: it allows the creation of battle and tournaments, enrollment of students to tournaments and battles.
- Management of events regarding tournaments and battles.
- Management of the ranking of the students.
- Management of data related to tournaments, battles and submissions
- Manual evaluation of the submissions of the students.

It is composed of the following subcomponents:

- **TournamentManager**: implements the main logical functionalities of the TournamentService, exposing APIs used by other microservices to manage tournaments and battles and their data.
 - **TournamentModel**: represents the model of the database used by the TournamentService to store the data related to tournaments and battles.
 - **EventQueue**: implements the queue used by the TournamentService to manage the events related to tournaments and battles.
 - **EventManager**: periodically checks the EventQueue for events and processes them once the deadlines are reached.
- **GitHubIntegrationService**: this component is the microservice that handles the integration with GitHub. It is responsible for the following functionalities:
 - Creation of the GitHub repository of the battle.
 - Retrieval of the code of the submission from the GitHub repository.
 - **EvaluationService**: this component is the microservice that handles the evaluation of the submissions of the students. It is responsible for the following functionalities:
 - Evaluation of the submissions, in terms of timeliness and functional analysis

- Integration with external static code analysis tools to evaluate the quality of the code of the submissions.

It is composed of the following subcomponents:

- **EvaluationManager**: implements the main logical functionalities of the EvaluationService, periodically checking the EvaluationQueue for submissions to evaluate and processing them.
- **EvaluationQueue**: queue that stores notifications about new pending submissions, appended by the GitHubActionsService through the REST API exposed by the APIGatewayService, yet to be evaluated.
- **NotificationService**: this component is the microservice that handles the notifications of the users of the system. To perform this task, the NotificationService interacts with the external email service provider to send notifications to the users. It is responsible for the following functionalities:
 - Dispatch of confirmation email to new registered users.
 - Dispatch of email notifications to users in case of events related to tournaments and battles.

It is composed of the following subcomponents:

- **NotificationManager**: implements the main logical functionalities of the NotificationService, periodically checking the NotificationQueue for notifications to send and processing them.
- **NotificationQueue**: queue that stores new notifications to be dispatched.
- **ServiceRegistry**: this component is the microservice that handles the registration of the microservices to the system. It offers to all the other microservices the following:
 - Registration of the microservices instances to the system.
 - Discovery of the microservices instances by the other microservices.
 - Availability check of the microservices instances, by receiving periodic heartbeats from them.

- **TournamentDatabase:** this component is the database used by the system to store the data related to tournaments and battles, including also scores and ranks.
- **UserDatabase:** this component is the database used by the system to store the data related to the users of the system, such as kind of user, email and usernames.

The Figure 2 contains also some external entities the system interacts with:

- **GitHub:** used by the system to retrieve the code of GitHub repositories and to create new repositories.
- **GitHubActions:** configured by the students on their GitHub repository to automatically notify the system when a new submission is pushed to the repository.
- **StaticAnalysisService:** used by the system to evaluate the quality of the code of the submissions.
- **EmailService:** used by the system to send emails to the users of the system.
- **SSO:** used by the system to offer the users the possibility to signup and login with their preferred identity provider.

2.3 Deployment view

The following diagram represents the deployment architecture of the system, highlighting the physical nodes on which the system will be deployed and the communication channels between them.

In Figure 3 the nodes have been colored according to the color scheme defined in the component view exception, with the only difference that the **red** color has been used to identify the user's web browser and the **yellow** one to represent the system's web server.

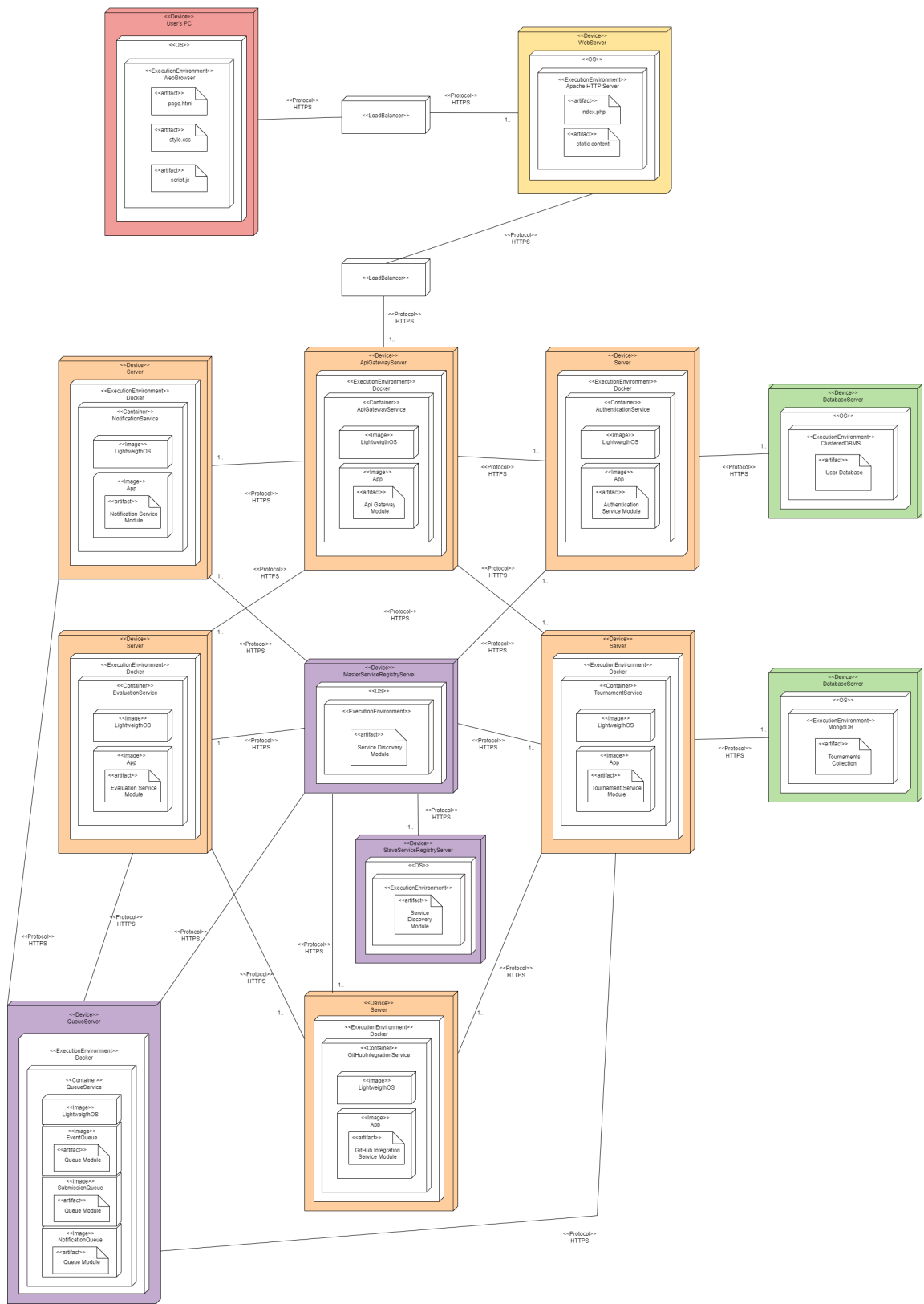


Figure 3: Deployment diagram

The most important aspects that are worth noticing are:

- Queues are deployed on a single physical node. As we can see from the artifacts, all queues are built over the same code but replicated in a way that each type of microservice uses its own: this should increase modularity and maintainability of the system. Moreover these queues are logged (i.e. also persisted in secondary memory) so that, in case of failure, a new service can be deployed and the previous state of the queue can be restored: this allows the system to be fault tolerant by ensuring that no communication data is lost.
- Most of the microservices are deployed in a containerized environment, using Docker containers. This allows them to be easily deployed on necessity, allowing the system to scale out according to the current load. The Service Registry instead is deployed in a non-containerized environment, since it is a critical component of the system and it is important to ensure its availability. In particular, in order to achieve this, a master-slave approach has been chosen. The master instance is deployed on a physical node, while slave instances are deployed on different nodes: the latter ones have the task of monitoring the master instance and to copy its logs. In this way, if the master instance fails, one of the slave instances (e.g. chosen through a consensus algorithm) can be promoted to master so the system can continue to work from the point the master left without any interruption.

2.4 Component interfaces

2.5 Runtime view

2.6 Selected architectural styles and patterns

2.7 Other design decisions

3 User Interface Design

TODO: check impagination and write about sequence of mockups instead of interaction diagrams

3.1 Signup and Login

The signup page asks to the unregistered user to provide some personal information like name, surname, email address and password. Moreover, the user has to specify if he is a student or an educator by flagging the corresponding checkbox. In case he is a student, he is also asked to provide his GitHub's username. Alternatively, users can choose to sign up using third party services like Google or GitHub.

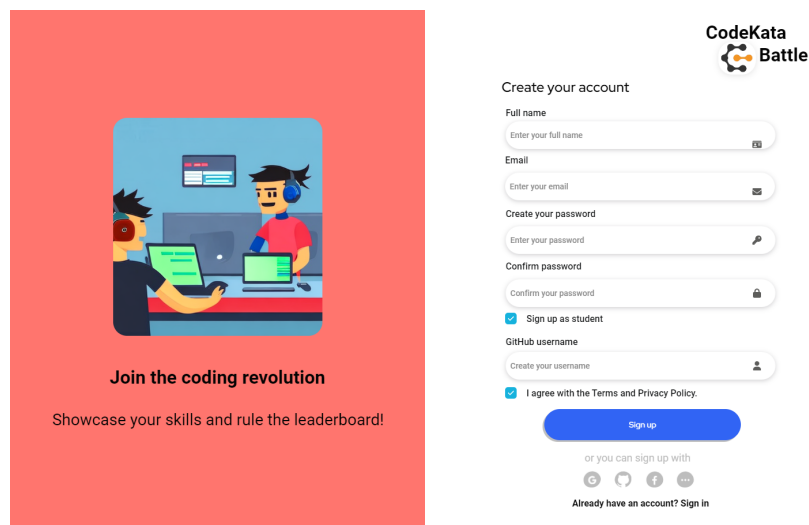


Figure 4: Signup page

The login page asks to the registered user to provide his email address and password. Alternatively, users can choose to login using the same third party services.

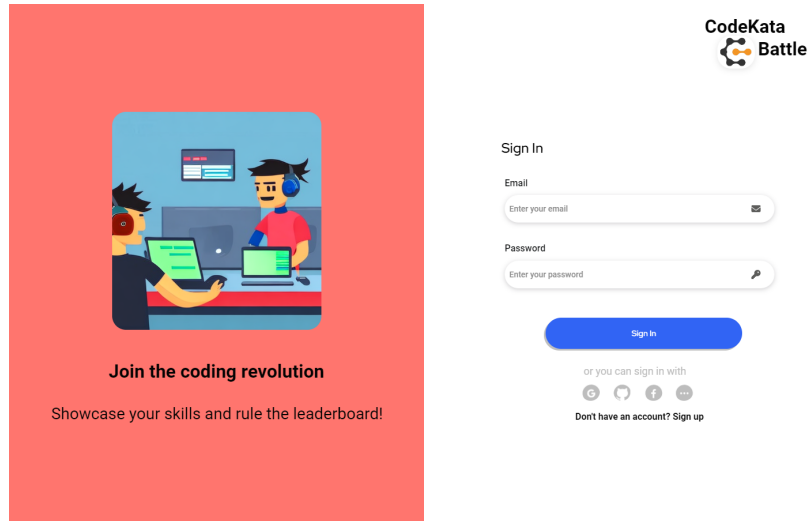


Figure 5: Login page

3.2 Home page

The home page is the first page that the user sees after logging in. If the logged user is a student, the homepage contains a brief overview of platform's ongoing tournaments, battles the user is participating in, a calendar with upcoming deadlines and some statistics of past battles. Educator's homepage is similar, but will include some information about tournaments and battles he is responsible of.

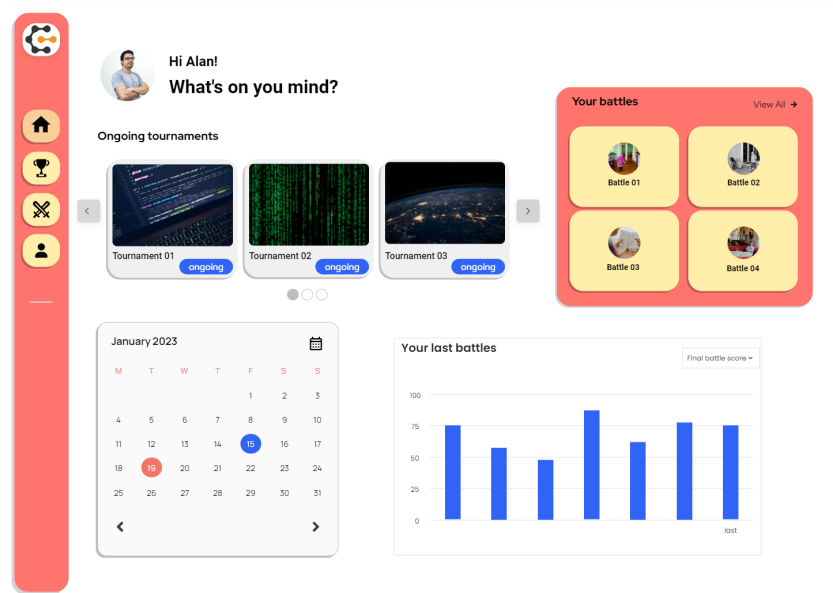


Figure 6: Home page from the perspective of an user logged as student

3.3 Tournaments

The tournaments section will provide to the student a list of all ongoing tournaments in the platform and a list with all tournaments the student is enrolled in. The page will contain also some collections, to access for example popular tournaments or all past tournaments. By clicking on a tournament, the user will be redirected to the tournament page.

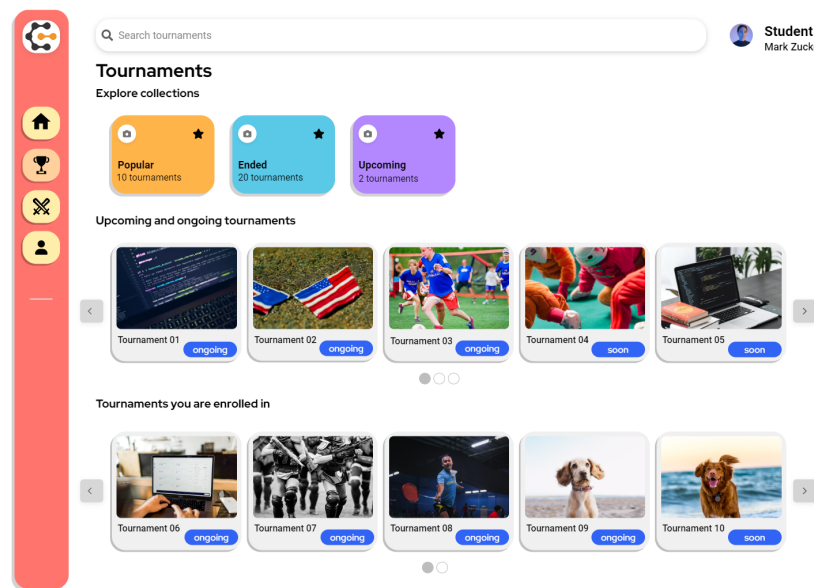


Figure 7: Tournaments page from the perspective of a user logged as student

The corresponding page for educators will show basic similar information about tournaments, but will also provide a button to create a new tournament.

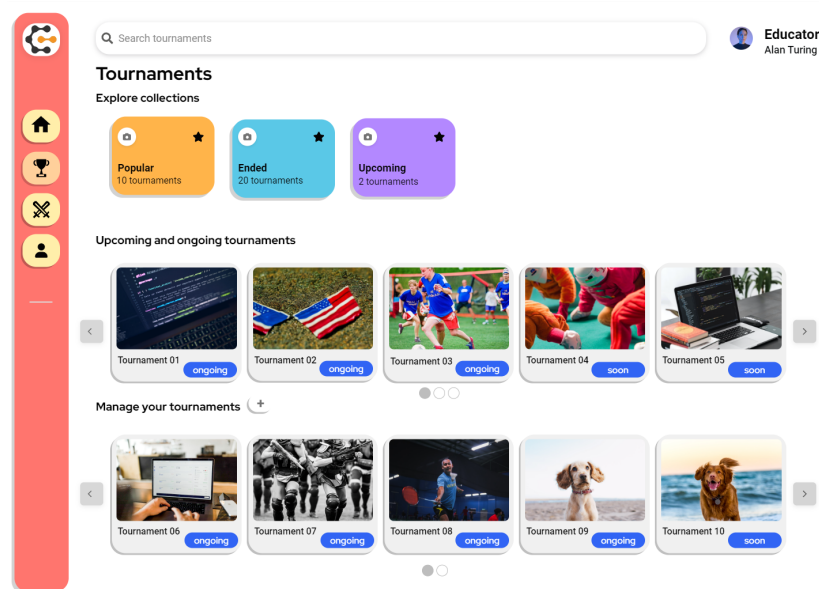


Figure 8: Tournaments page from the perspective of a user logged as educator

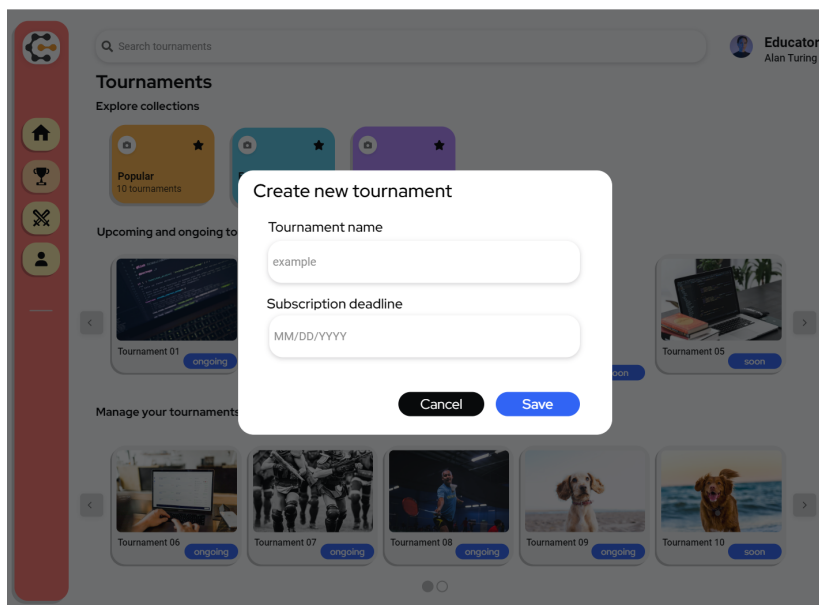


Figure 9: Page used from educators to create a new tournament

The tournament page offers to the educator owning the tournament the possibility to manage it. He will be able to click the "Add collaborator" button to add another educator to the tournament by email address. Moreover, the page offers the "collaborators" tab that can be used to check and manage the list of collaborators. The last tab called "leaderboard" allows the educator to check the ranking of the students enrolled in the tournament. The main tournament page contains the list of all the battles created within the tournament. By clicking on a specific battle, the educator will be redirected to the battle's page. Most importantly, the educator can create a battle by clicking on "Create battle" button.

The student's tournament page will share most of the content, but the options to manage the tournament. The same page, if the tournament is not started yet, offers the possibility to the student to subscribe to the tournament and by default shows a list of participants.

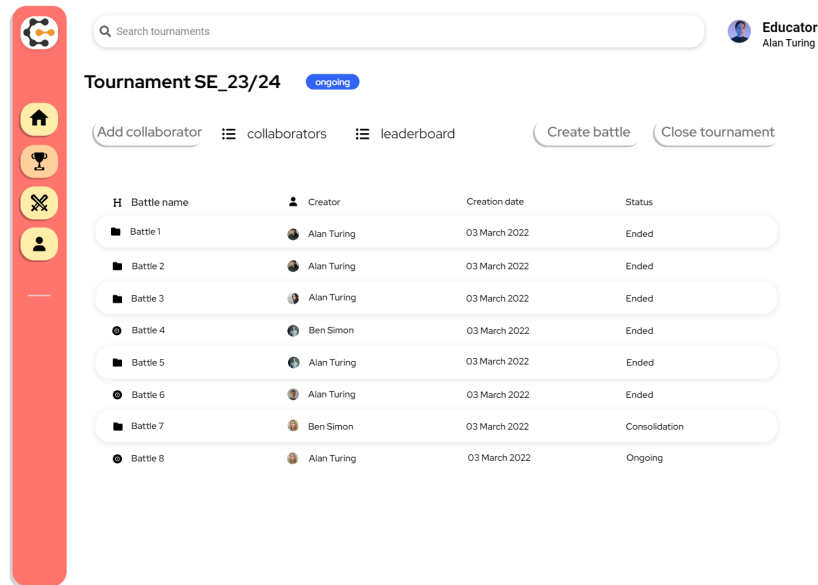


Figure 10: Page used from educators to manage the main settings of an ongoing tournament

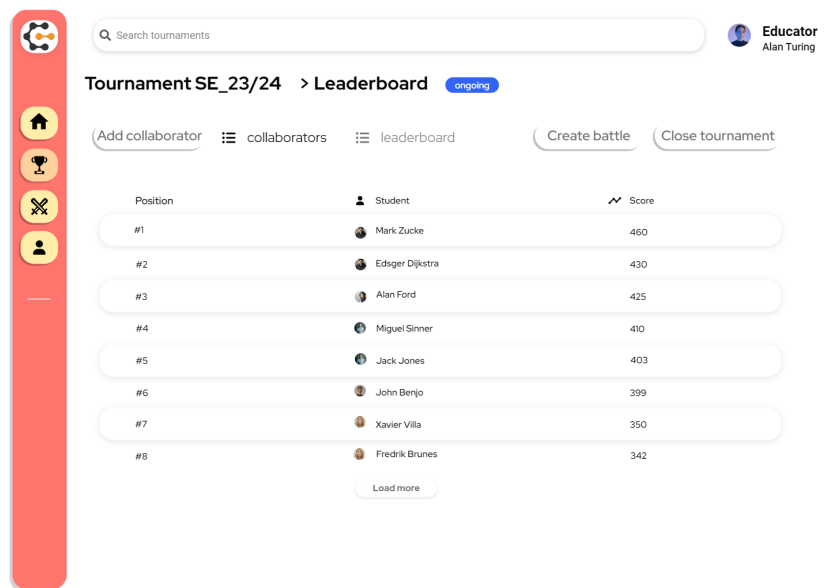


Figure 11: "Leaderboard" tab available to both educators and students to check the ranking in tournament

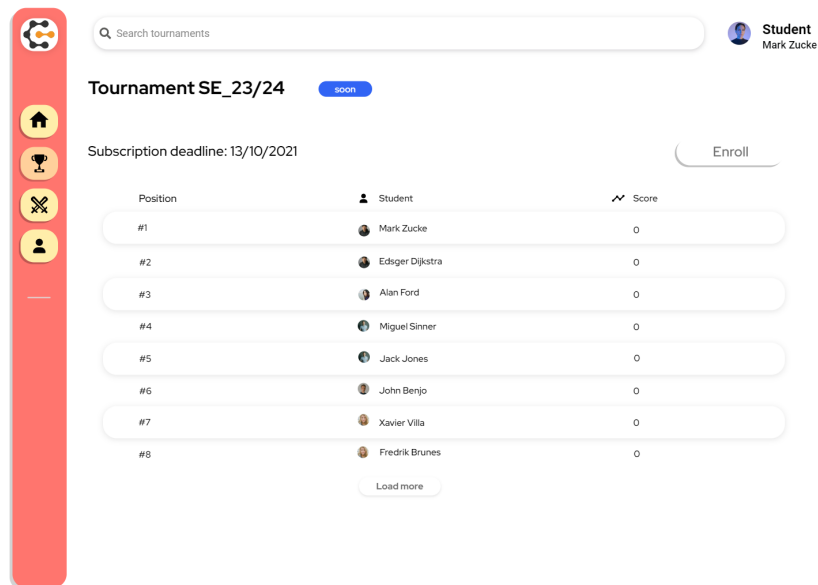


Figure 12: Page used from students to subscribe to a tournament

3.4 Battles

After selecting the option to create a battle, the educator will be redirected to the page used to create a new battle. The page will ask the educator to provide the name of the battle, the description, the deadline for the registration and the deadline for the submission. Moreover, the educator will be able to select the minimum and maximum number of students per group allowed for the battle. The educator will be able to set some information about the battle and to configure the battle settings for the evaluation. He will be required to upload the Code Kata files of the battle, which contain the test cases and the basic template of the project that students will have to complete with their solutions.

Set-up your next battle

Educator
Alan Turing

Title
your title

Description
this is a coding battle

Minimum team members

2

Maximum team members

4

Subscription deadline

MM/DD/YYYY

Submission deadline

MM/DD/YYYY

Upload CodeKata Python

Static analysis settings

☒ Security ☒ Maintainability ☐ Reliability

☐ Enable Manual Evaluation How to upload

Confirm

Figure 13: Page used from educators to create a new battle

When a battle is in subscription phase, the battle's page will offer to the student the options to subscribe to it by creating a new team or joining an already existing one. If the student decides to create the team, he will be asked to input the name of the team and its privacy setting. Instead, if the student want to join a team, the system will ask him to insert the name of the team (if public) or the invite code (if private). The page will also show the list of all the teams enrolled in the battle, to facilitate the team formation.

Teams can be clicked in the leaderboard and a small pop-up with the list of members will be shown.

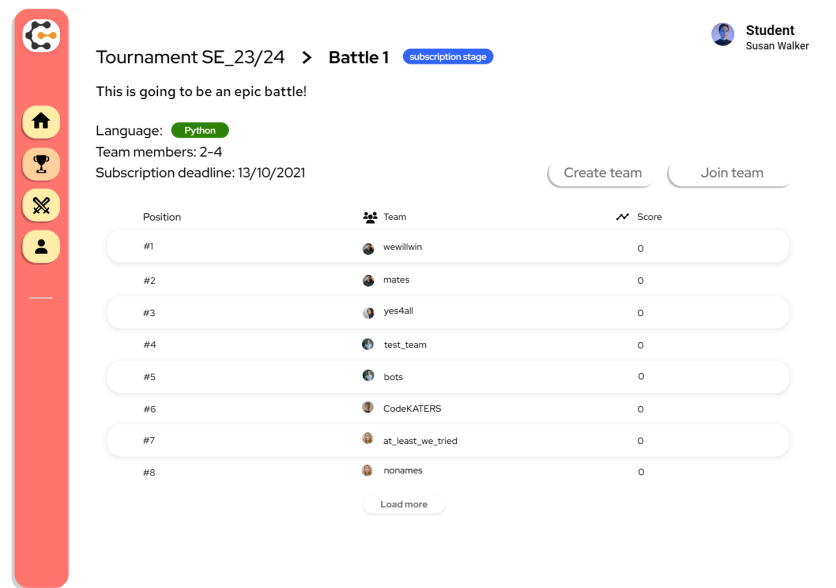


Figure 14: Page used from students to subscribe to a battle

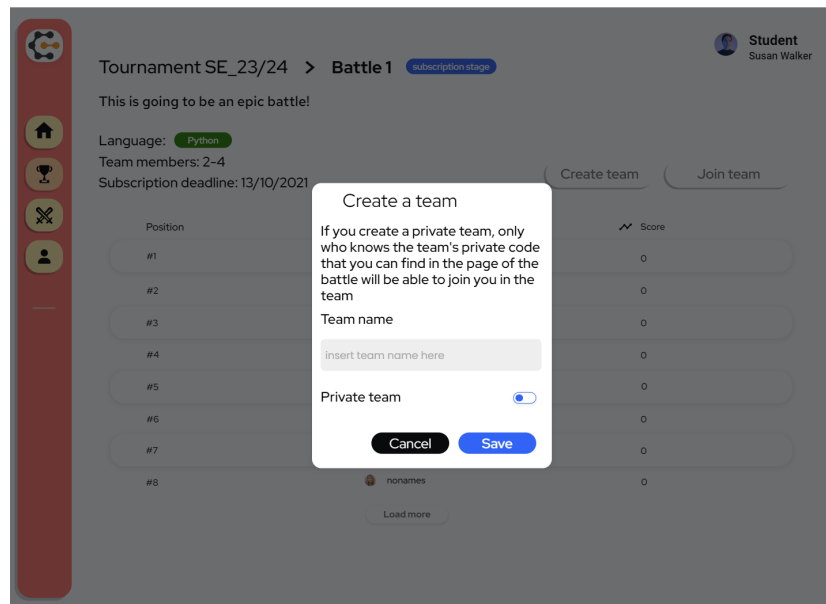


Figure 15: Page used from students to create a new team

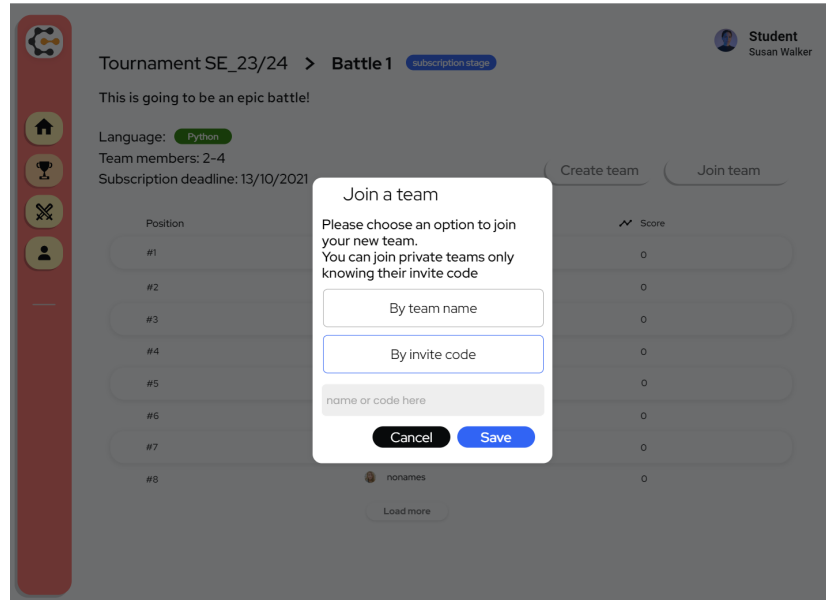


Figure 16: Page used from students to join a team

The page of a battle which is in the submission phase, will show by de-

fault the leadeboard of the teams. By clicking on "Your team" button, the student will be able access a section that contains important team settings and the information related to the submissions.

In case the manual evaluation is not enabled, this page will have similar content for both educators and students, but the team settings button.

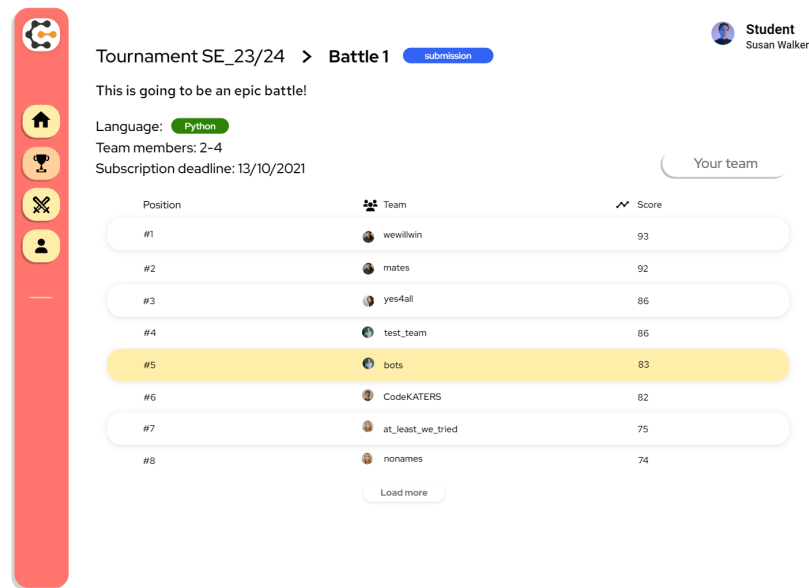


Figure 17: Page used from students when a battle is in submission phase

The team page, accessible only to students of team, will contain all important settings needed to properly setup the GitHub repository and evaluation information about the team's last submission. It will show also some statistics about past submissions to facilitate the tracking of the team's performances. By clicking on "Team members" box, the list of teammates will show up, with related commits count.

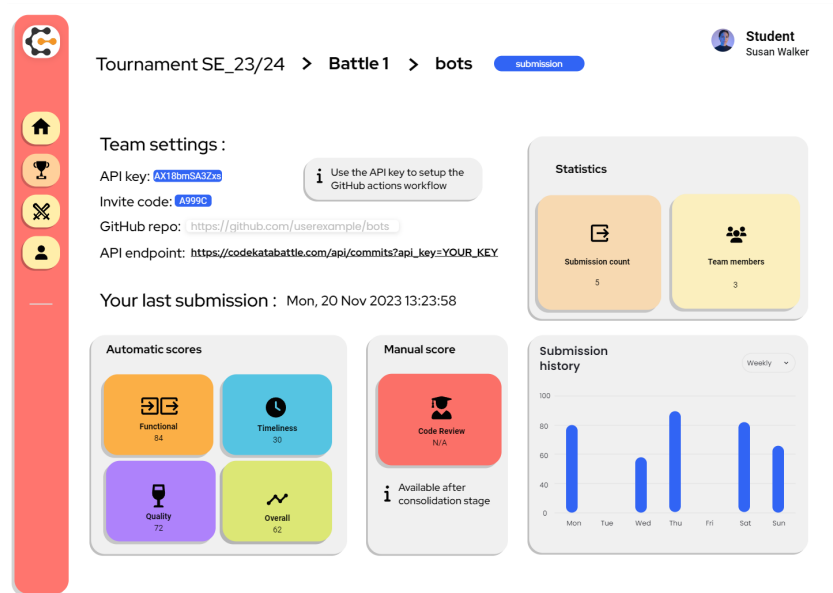


Figure 18: Page used from students to manage the settings of their team and to check submissions information

3.5 Evaluation

The battle page, during the optional consolidation stage, will offer a special team leaderboard, with an overview of both manual and automatic scores. By clicking on a specific team, the educator has access to the evaluation page of the team. The page also contains a button to close the consolidation phase once the educator has evaluated all the teams.

In the evaluation section, the educator is able to access the GitHub repository of the team to check the code of the last submission. Finally, he is provided with a field to input the manual score.

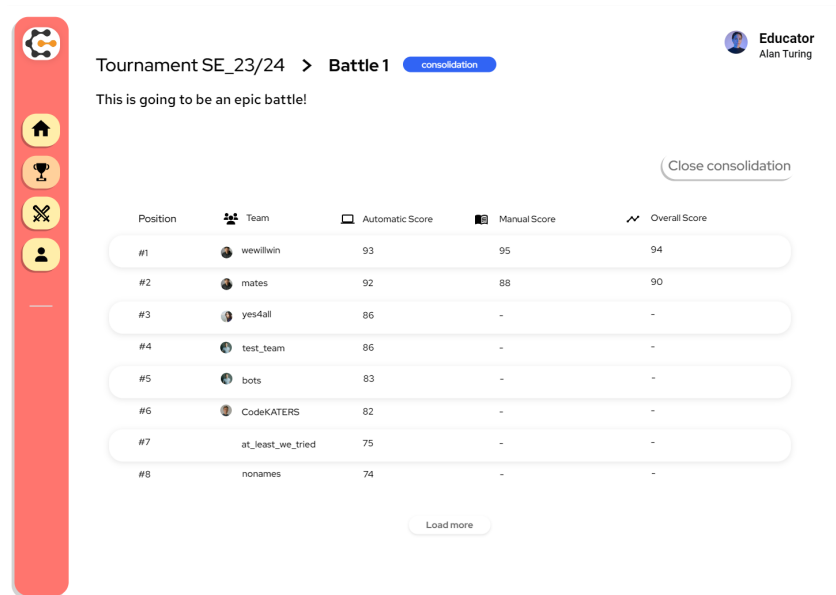


Figure 19: Page used from educators to manage the consolidation stage of a battle

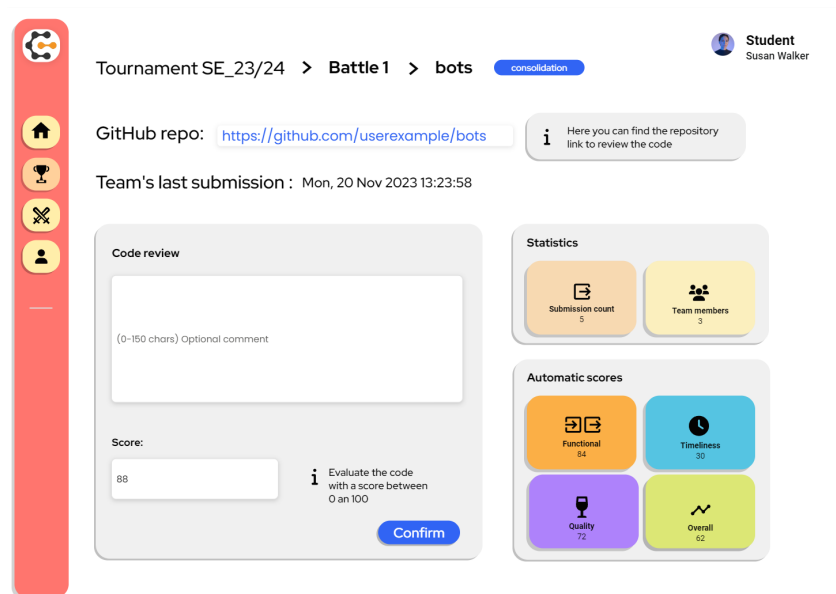


Figure 20: Page used from educators to manually evaluate a submission

4 Effort Spent

Name and Surname	Section 1	Section 2	Section 3	Section 4
Tommaso Capacci	10	10	10	10
Gabriele Ginestroni	10	10	10	10