System Design for SFWRENG 4G06

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April 4, 2023

1 Revision History

Date	Version	Notes
February 18, 2023	1.0	Initial Version
April 3, 2023	1.1	Added higher quality diagrams. Updated introduction tests for Scope, Component Diagram and User Interfaces sections. Added explanation for why HTTPS is preferable in Communication Protocols section.

2 Reference Material

This section records information for easy reference.

2.1 Abbreviations and Acronyms

symbol	**description**
SFWRENG 4G06	The Software Engineering Capstone Project Course at McMaster University
Figma	A collaborative web application for interface design
HTTP / HTTPS	Hypertext Transfer Protocol, a communications protocol for network interactions
Web Socket	A communications protocol used for two-way interaction
MDN Web Docs	A documentation repository for web developers
AWS	Amazon Web Services, a cloud computing platform
Angular	A web framework for building web applications.
Node.js	A JavaScript run-time.
MongoDB	A database program.
Google Oauth	An authentication service by Google.
Docker	A container engine.

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3 Introduction

This document describes the design for the CodeChamp system. The design document is split up into three documents, the Module Interface Specification, Module Guide and the system design document. Other relevant documentation is listed below:

1. Development Plan
2. System Requirements Specification
3. Hazard Analysis
4. Validation & Verification Plan

4 Purpose

This document is written to describe the architecture and the design decisions in the CodeChamp system. Primarily, it introduces the scope of the system to demonstrate the possible interactions with the outside world. Moreover, it gives an overview of the project, recounting the important components from a high level and describing the normal behavior of the system. Additionally, it gives a high-level overview of the event handling mechanisms in place for undesired behavior. Since the CodeChamp system is user-centric, the document also describes mock-ups for the user interface design of the system. Finally, a timeline is given for the implementation of the system.

5 Scope

Figure 1 demonstrates the context of the CodeChamp system by showing the interactions between the system and external actors. The behavior of the systerm as well as details for its intended interactions are further detailed in Section 6.1.

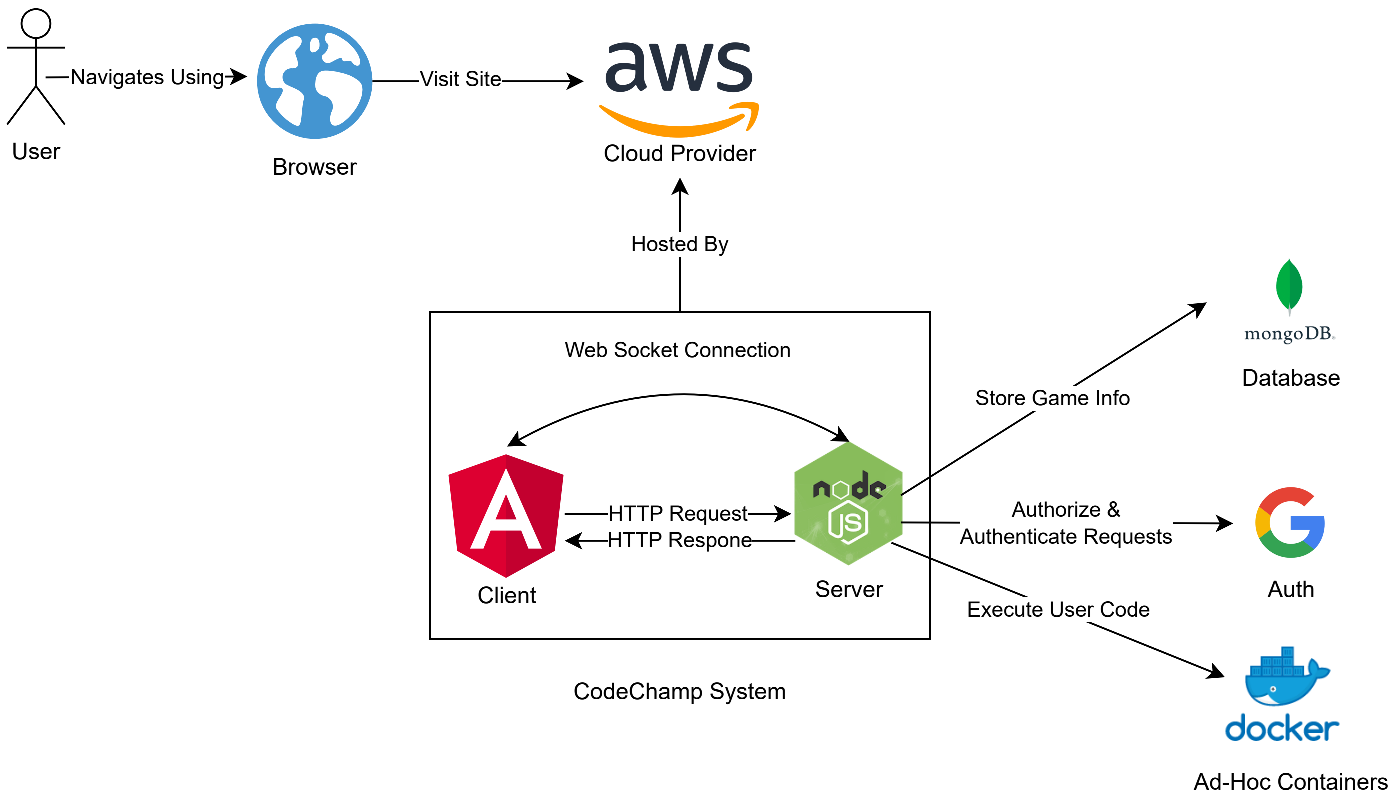


Figure 1: Context Diagram for the CodeChamp System

6 Project Overview

6.1 Normal Behaviour

The CodeChamp system is seperated into an Angular front-end and a Node.js backend. Normally, the user will access the front-end throw a web browser on a desktop application. The client will send network requests using HTTPS to the back-end and successfully receive a response. For parts of the application which require bidirectional connectivity, such as live updates during a game or in the lobby, a WebSocket connection will be used. Additionally, the CodeChamp system will interact with various external services. For storing and retrieving items from the database, a MongoDB cluster will be used. When needed, the backend will query MongoDB to retrieve and/or store an object when a client requests it. Furthermore, for authentication purposes, such as for signing in users, Google Oauth will be queried. Finally, when a user submits code to be executed, a docker container will be created to execute and evaluate the submission.

The following user journey specifies the average expected experience for a user of the CodeChamp system:

1. User navigates to the site using web browser

2. User logs into the application
3. User creates/joins a game
4. The game starts once the lobby is ready
5. User plays the game by attempting to solve the problem
6. User proceeds to the next round upon successfully completing a round
7. User loses after being unable to complete a round / user wins by winning all the rounds
8. User checks their personal statistics and match history by going to the Home Page and clicking on the personal profile button
9. User checks the leaderboard by going to the Home Page and clicking on the leaderboard button

6.2 Undesired Event Handling

Exceptions which occur in the Backend APIs will be propagated as HTTP status codes. The engineers will ensure to follow the conventions established in the MDN Web Docs in order to distinguish client error responses and server error responses. Furthermore, internal server errors will be logged and will be made accessible for developers through the AWS portal in production. This ensures that developers can quickly identify and debug issues that arise. The front-end will use the Angular error interceptor in order to detect error responses and will forward them to the pages to handle accordingly. In the case of errors, the front-end will display a dialog mentioning the event in natural language to the user and suggesting an solution. For example, for client errors, this may be to take a different action. For internal server errors, it may suggest for them to retry the action at a different time. Additionally, errors occurring on the front-end will also be made accessible for developers through the AWS portal in production .

6.3 Component Diagram

Figure 2 showcases the major components in the CodeChamp system and groups them by their common functionality. Additionally, it showcases the use relation at a high-level.

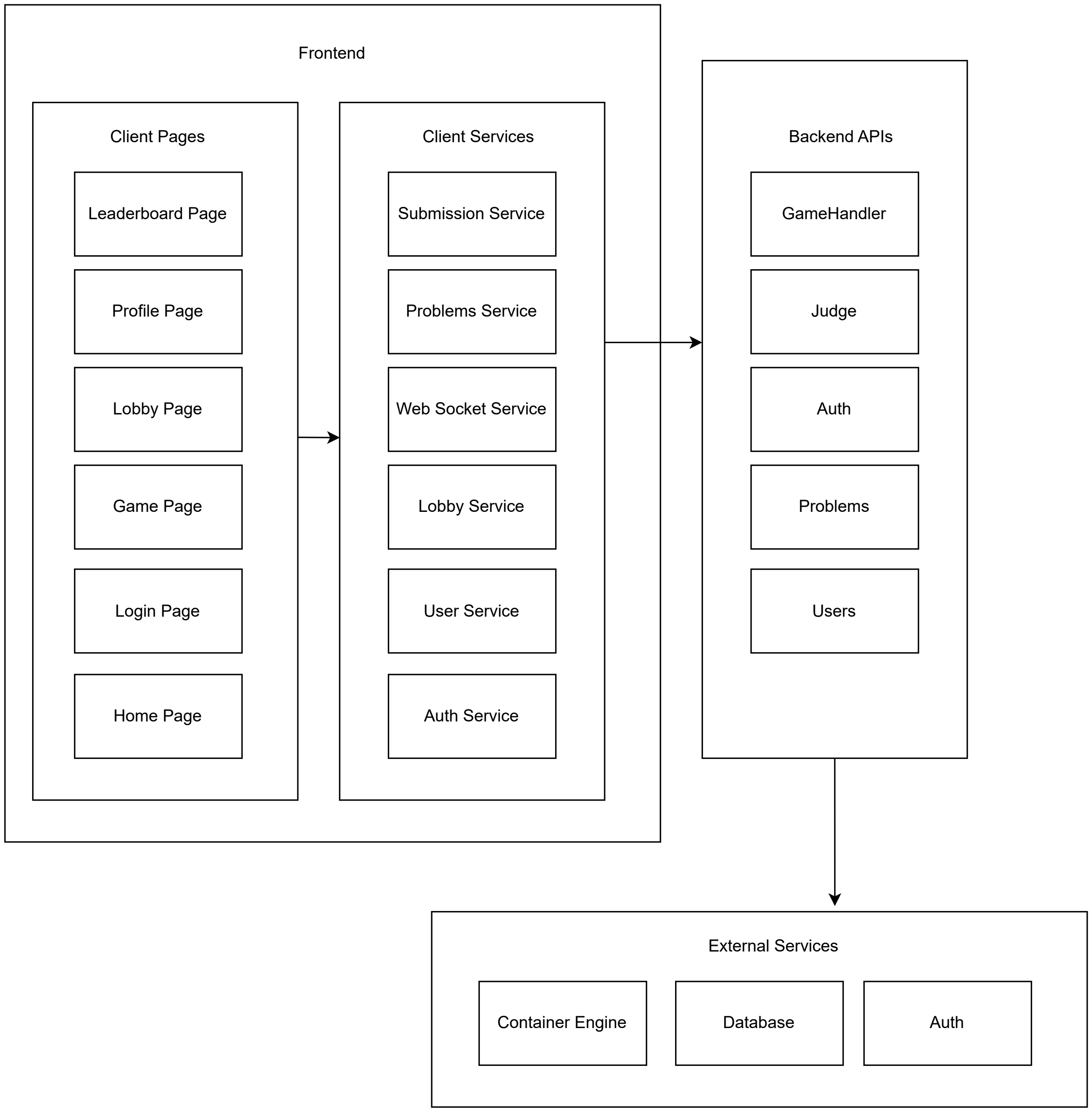


Figure 2: Component Diagram for the CodeChamp System

6.4 Connection Between Requirements and Design

Req.	**Decisions**
NFR11	Users use username, password and email to create accounts. Google Oauth is used as part of the implementation.
FR6, FR14, FR15	Using Docker as the containerized engine to run and compile code to avoid the effects of running malicious code.
FR3	Game cuts player count in half in each round to have at most 4 rounds.
FR.23	Using unique yet human readable IDs/lobby codes for ease of joining.
FR.13	The system allows developers to create/modify tests through network calls.
FR.1	System uses random matchmaking instead of the other option, skill based match making.

Table 1: Requirements and Design Decisions made

7 User Interfaces

The following mock-ups (Figure 3-8) were produced using Figma for the CodeChamp user interface:

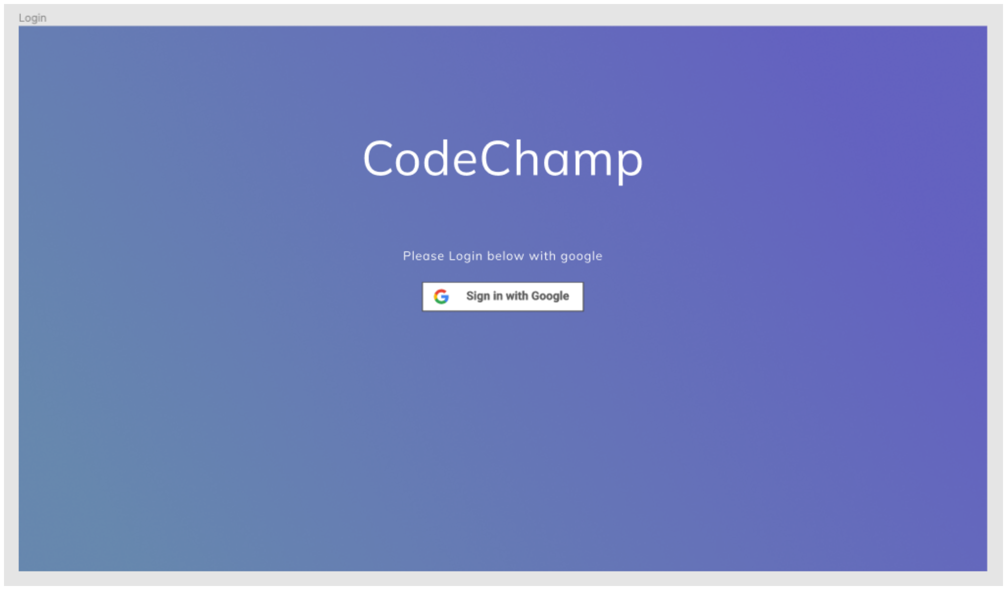


Figure 3: Mock-up for CodeChamp's Login Page

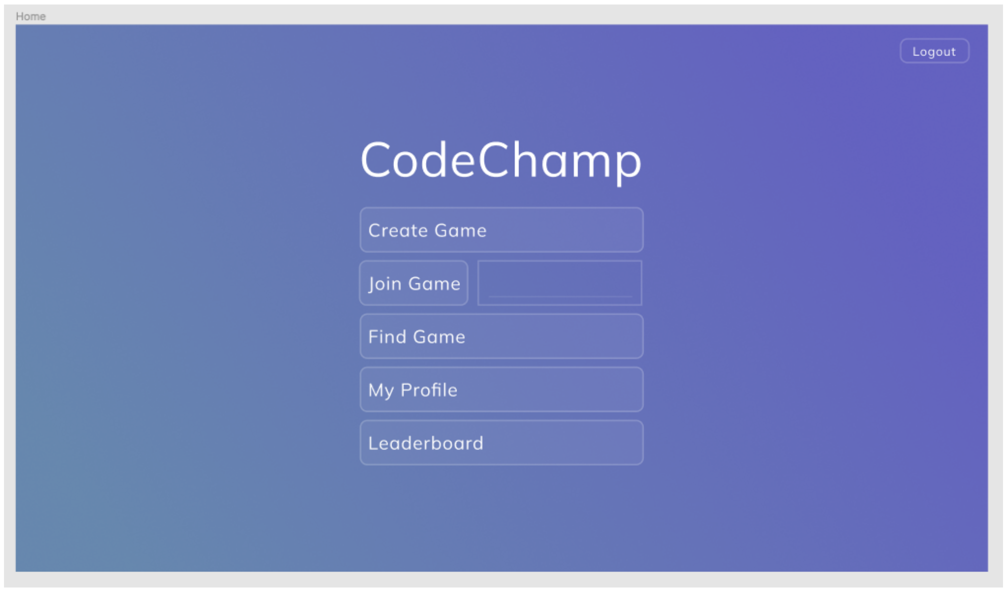


Figure 4: Mock-up for CodeChamp's Home Page

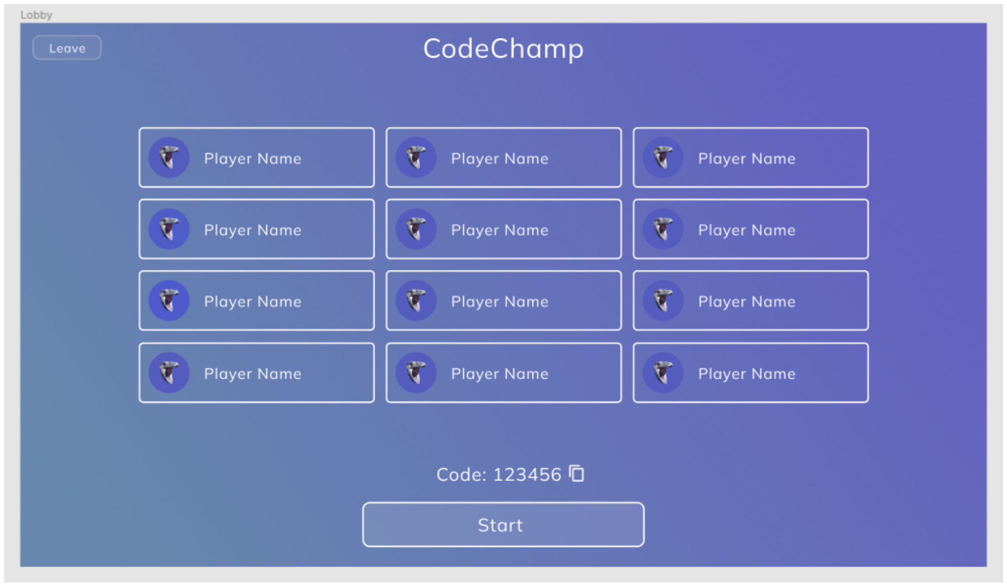
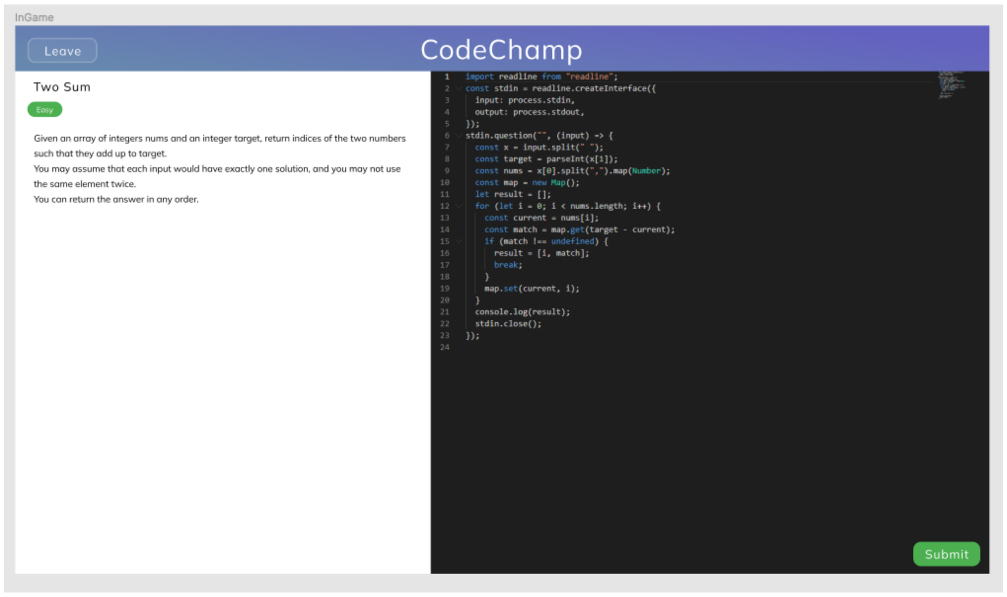


Figure 5: Mock-up for CodeChamp's Lobby Page



Two Sum

Given an array of integers nums and an integer target, return indices of the two numbers such that they add up to target.
You may assume that each input would have exactly one solution, and you may not use the same element twice.
You can return the answer in any order.

```
import readline from "readline";
const stdin = readline.createInterface({
  input: process.stdin,
  output: process.stdout,
});
stdin.question("", (input) => {
  const x = input.split(" ");
  const target = parseInt(x[1]);
  const nums = x[0].split(",").map(Number);
  const map = new Map();
  let result = [];
  for (let i = 0; i < nums.length; i++) {
    const current = nums[i];
    const match = map.get(target - current);
    if (match !== undefined) {
      result = [i, match];
      break;
    }
    map.set(current, i);
  }
  console.log(result);
  stdin.close();
});
```

Figure 6: Mock-up for CodeChamp's Game Page

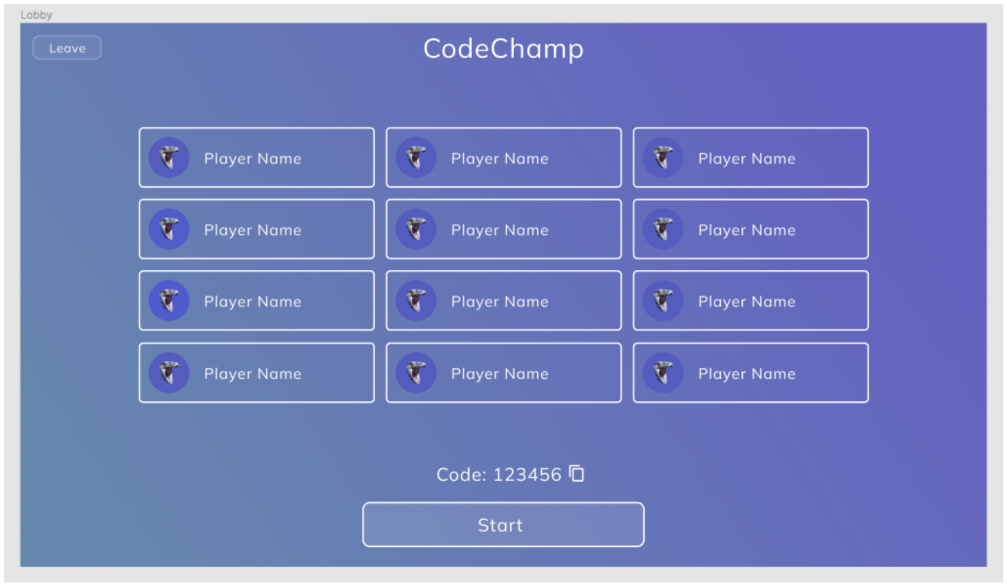


Figure 7: Mock-up for CodeChamp's Leaderboard Page

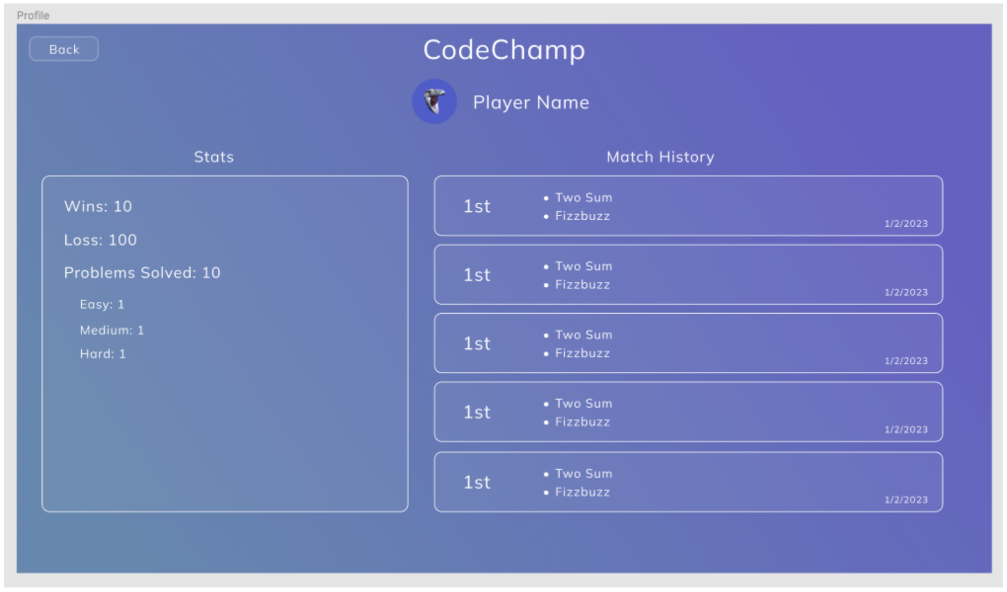


Figure 8: Mock-up for CodeChamp's Profile Page

Figure 9 illustrates the state of the user interface along with the various events that have the ability to transition between pages.

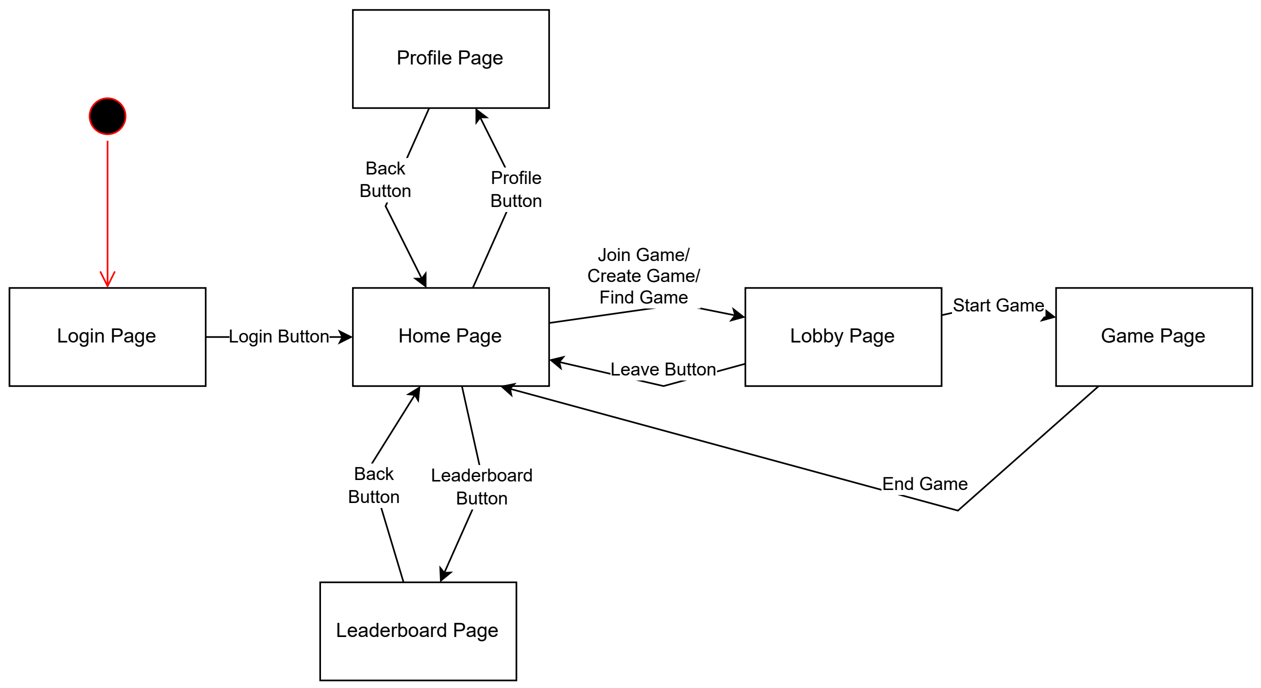


Figure 9: State Machine for front end pages

8 Design of Hardware

N/A

9 Design of Electrical Components

N/A

10 Design of Communication Protocols

WebSockets are used for parts of the application which require bidirectional connectivity, such as live updates during a game or in the lobby. Otherwise, HTTPS will be used by client will send network requests using HTTPS to the back-end and successfully receive a response. This is preferable to using HTTP, as HTTPS uses Transport Layer Security (TLS) which is a cryptographic protocol used to secure information exchanged over the network. This is essential when handling sensitive information but is also a web-standard for any modern application. HTTPS and WebSockets are standard technologies and are not implemented by the CodeChamp team.

11 Timeline

Module	Completion By Date	Responsible Engineer(s)
ClientT Module	2022-12-30	Anton
GameT Module	2022-12-30	Anton
MatchT Module	2023-02-11	Zhiming
UserT Module	2023-02-11	Zhiming
UserStatsT Module	2023-02-11	Zhiming
ProblemT Module	2022-11-14	Tamas
Difficulty Module	2022-11-14	Tamas
TestCaseT Module	2022-11-14	Youssef
SubmissionT Module	2022-11-14	Youssef
JudgeResultT Module	2022-11-14	Youssef
JudgeVerdict Module	2022-11-14	Youssef
TestCaseVerdictT Module	2022-11-14	Youssef
HomePage Module	2023-1-21	Zhiming, Dipendra
ProfilePage Module	2023-1-21	Zhiming, Tamas
LeaderboardPage Module	2023-1-21	Zhiming
LobbyPage Module	2023-1-10	Dipendra, Anton
GamePage Module	2023-1-10	Dipendra, Anton, Tamas
LoginPage Moudle	2023-1-3	Dipendra, Tamas
SubmissionService Module	2022-11-14	Dipendra
ProblemsService Module	2022-11-14	Dipendra
UserService Module	2023-02-11	Tamas, Zhiming
AuthService Module	2023-1-3	Tamas
LobbyService Module	2023-1-14	Anton, Dipendra
WebSocketService Module	2022-12-30	Anton, Tamas
GameHandler Module	2023-1-10	Anton, Tamas
Judge Module	2023-01-28	Youssef
Auth Module	2023-1-3	Tamas
Problems Module	2022-11-14	Dipendra, Youssef
User Module	2023-02-11	Dipendra

Table 2: Timeline for CodeChamp Module Implementation

Module	Tested By Date	Responsible Engineer(s)
LoginPage Moudle	2023-1-18	Dipendra, Tamas
AuthService Module	2023-1-18	Tamas
Auth Module	2023-1-18	Tamas
HomePage Module	2023-1-21	Zhiming, Dipendra
LobbyPage Module	2023-1-21	Dipendra, Anton
LobbyService Module	2023-1-21	Anton, Dipendra
GamePage Module	2023-1-23	Dipendra, Anton, Tamas
GameHandler Module	2023-1-23	Anton, Tamas
ProblemT Module	2023-1-27	Tamas
Problems Module	2023-1-27	Dipendra, Youssef
ProblemsService Module	2023-1-27	Dipendra
TestCaseT Module	2023-1-28	Youssef
TestCaseVerdictT Module	2023-1-28	Youssef
SubmissionT Module	2023-1-30	Youssef
SubmissionService Module	2023-1-30	Dipendra
JudgeResultT Module	2023-1-31	Youssef
JudgeVerdict Module	2023-1-31	Youssef
Judge Module	2023-01-31	Youssef

Table 3: Timeline for CodeChamp Module Testing

All team members will participate in creating features all around the tech stack. The roles are intended for each member to have a focus-area, which can later change depending on the team's needs. If a team member finishes early, they can help other team members with a module's implementation or testing. In the above table, important modules were chosen to be tested in order to have confidence in the system's first revision. In addition to the module testing, all team members will manually verify that CodeChamp behaves as expected for the system's first revision. Finally, the remainder of the modules and the system will be tested in accordance with the Validation & Verification Plan.

A Interface

UI design of CodeChamp

B Mechanical Hardware

None

C Electrical Components

None

D Communication Protocols

HTTPS & WebSockets are used to communicate between the front-end and back-end.

E Reflection

The information in this section will be used to evaluate the team members on the graduate attribute of Problem Analysis and Design. Please answer the following questions:

1. What are the limitations of your solution? Put another way, given unlimited resources, what could you do to make the project better? (LO_ProbSolutions)

   The current design is centered around a static lobby size, which was chosen to consist of twenty players. In the future, it would be beneficial to support different game modes as well as larger lobby sizes. This would improve the game experience by increasing the amount of variety available, as well as increasing the competition by allowing for a larger pool of competitors in one game. The system would have to support different scaling mechanisms to make this possible, since currently it is designed to cut the lobby in half each time, which may result in very long matches if we increase the lobby size. Likewise, employing a skill based matchmaking system would increase the competitiveness as well as lower the barrier to entry, which are two traits of a successful game. The system would have to track statistics such as win rate, types of problems solved and the difficulty of the problems solved for each user in order to evaluate a skill rating for them. Furthermore, the developers would have to design a match-making algorithm to group similarly skilled players in a lobby. Finally, the game page can only currently be accessed in a game, meaning that any problem must be solved within the time limit for a round. Additionally, the players are not able to view previously attempted problems or their own solutions to the problems. It would be useful to track problems which have been attempted by the players, and to allow them to re-try them in a practice environment in-dependant of the game. With this system, the game system would have to ensure that players are not given a problem they have seen before toe ensure competitive integrity. However, it would be a beneficial trade-off, as players would have an opportunity to review their solutions and re-attempt problems that they have failed before, improving the learning experience.

2. Give a brief overview of other design solutions you considered. What are the benefits and tradeoffs of those other designs compared with the chosen design? From all the potential options, why did you select documented design? (LO_Explores)

   The current design consists of a completely separate back-end and front-end, implemented using Node.js and Angular respectively. An alternative design could use a monolith application which serves the HTML from the server. For instance, many frameworks such as Razor Pages use the MVC pattern to achieve this design. The main advantage this presents is an easier implementation, as we can re-use types across the system and not spend time implementing abstraction layers for communication protocols. Another advantage is that a multi-page application will have better search engine optimization. However, we opted for this design as the usage of a Single Page Application framework for the front-end allows for better performance, as all rendering can be done on the client. Furthermore, it allows for a separation of concerns by hiding the implementation logic on the server-side from the display and layout logic on the client-side. This also reaps other benefits, as it allows developers outside of the CodeChamp team to develop tools which interact with our backend APIs, as they are not reliant on a specific client-side implementation and can be communicated with using HTTP and Web Socket protocols. Finally, our application will not benefit from better search engine optimization, as most pages of the client-side pertain to temporary game information and interactions, rather than information typically picked up by web crawlers.

   We also considered different authentication methods. For example, using a security package to hash and salt passwords and storing these in our database. The main advantage of this is that there is no reliance on a third party service, which can improve the performance of the application as well as its reliability in case of downtime of the third party service. We opted to use Google Auth as it is a widely accepted security solution, with essentially zero historical downtime. Furthermore, the vast majority of users will already have an account, reducing the sign-up process on CodeChamp to a single click. Finally, this prevents possible errors in our security integration which can result in compromised accounts and passwords, as with this approach we never process or store the user's password using our own service.

   Different lobby systems were considered when designing CodeChamp. Initially, the idea was to hide the concept of a lobby from the players, and instead match-make them and place them in a game. We did not choose this system as it relies on the existence of a skill-based matchmaking system. However, skilled based matchmaking requires a large player-base in order to have meaningful results, as wait time for a game will be too large with a small player-base. Thus, we opted for this system as it allows users to invite friends and start a lobby whenever they wanted, reducing the friction and wait-time in the early stages of CodeChamp. With a growing player-base, we may be able to implement a skill-based lobby system in the future by tracking several statistics about the players, as described in the previous section.