T.C.
MARMARA UNIVERSITY
FACULTY OF ENGINEERING
COMPUTER ENGINEERING DEPARTMENT

CSE4197
Engineering Project I
Analysis and Design Document

GENETIC ALGORITHM LECTURES: *İSPİNOZ*

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1. Introduction

1.1 Problem Description and Motivation

There are different types of computational approaches like deterministic, random and evolutionary. Evolutionary techniques are also known as nature-inspired techniques. Genetic Algorithm (GA) is one of the most commonly used evolutionary techniques and it is an adaptive heuristic search algorithm based on genetics and the evolutionary ideas of natural selection. The famous quote by Charles Darwin is "*It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change*" and GA is laid on this "survival of the fittest" [1]. As in nature, there is a competition among individuals for limited resources and it results in the fittest individuals dominating over the weaker ones. Those individuals who cannot adapt are will not survive as we can see in Figure 1.

Figure 1: An example of natural selection [2]

Past research shows that GA has been effectively used to solve the different problems from the domain of computer science such as software cost estimation, task scheduling, clustering, natural language processing, image processing, etc. [3]. There are many applications of GA besides computer science. It has been also applied to many branches of medicine [4], environmental science [5], often with good results.

GA which is an advanced topic is used to solve different NP-hard computational problems and it is generally taught as one of the subjects in Artificial Intelligence course. Unlike older AI

systems, in searching a large state-space, multi-modal state-space, or n-dimensional surface, a GA may offer significant benefits over the more typical search of optimization techniques like linear programming, heuristic, depth-first, breadth-first [1]. Nevertheless, the GA is a biology-related algorithm that requires knowledge of genetic terms as well as fundamentals of programming. The requirement of the knowledge on the GA which is, for example, gene, chromosome, the population as in Figure 2 may make the algorithm difficult and complicated for the students.

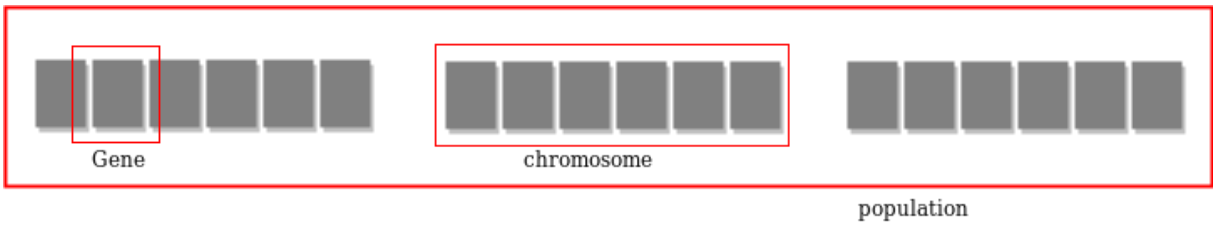

Figure 2: Gene, chromosome and population in GA [1]

We propose an interactive web-based application which makes the *GA* more understandable with providing fundamental knowledge, quizzes and solution of problems based on *GA*. It has some variables which affect efficiency and running speed and some do not. Users can change these values of variables i.e., probability of mutation, cross-over point interactively and can see which variables affect the result and which do not effect. This interactive working provides them persistent and fast learning of GA.

1.2 Scope of the Project

Our project is developing a web-based application on teaching GA, which is a web site called İspinoz and its development mainly consists of three phases which are software design, problem selection for GA and software implementation. Firstly, we design our website and database for the data required for the website. In this phase, we will create a logo and find a slogan for our website İspinoz. This phase includes preparing system diagrams, UML diagrams, ER diagrams and deciding on a view of the website and its colors. Our website will be a website with a login of the students and the information of the students.

After the software design phase finished, problem selection phase will start. This phase can be divided into two. One of two is preparing questions and their solution for quizzes. These will be stored in the database. The number of questions will be sufficient to measure whether a

student understand the algorithm or not. Another one is preparing problems and their solutions based on GA. The more problems İspinoz provides, the more understandable the GA is for the students. Therefore, our web site will provide many questions which are simple mathematical equality problems, Travelling Salesman Problem (TSP), Knapsack Problem (KP), N-Queen Problem and so on. These problems will be on a small scale and steps of problem solutions and outputs will be visualized so that GA will be easy to understand because visuality is at the forefront of our web site. In the implementation phase, we will develop our web site with new web technologies according to our software design phase.

When the students who want to learn GA sign up the web site, they will start to learn genetic-related terms of GA which are declared below.

- Gene
- Crossover
- Selection
- Genotype
- Chromosome
- Mutation
- Fitness
- Phenotype
- Population
- Generation
- Allele
- Offspring

After the students obtain knowledge about GA's terms and definition, they will continue practicing GA by solving quizzes and problems. Our project will only provide GA and problem solutions based on it. Any other algorithm is not in the scope of this project. We will develop our web site is only for the students who want to learn the GA and practice on it.

There is no sufficient number of Turkish-English web site on GA and our web site will support two languages Turkish and English so that Turkish people and any people who know English can use the web site to learn the algorithm.

The percentage of developers who have self-reported as being blind is about 1% in the 2017 survey of Stack Overflow which is an accessible web site [6]. Now, neither having visual impairment nor being blind is not an obstacle for the people who want to code. Therefore, our web site İspinoz will be accessible and blind people by using any existing screen reader can use the web site to learn and practice the GA. We provide it in the development phase by taking into consideration of accessibility requirements.

In this project, we assume that the students have a programming and algorithm knowledge from the past. The students who want to use the web site must internet connection and there are not any constraints to use website İspinoz.

1.3 Definitions, acronyms, and abbreviations

Abbreviation and Acronyms	Word in Meaning
GA	Genetic Algorithm
TSP	Travelling Salesman Problem
KP	Knapsack Problem
HTML	HyperText Markup Language
CSS	Cascading Style Sheets
NP-hard	Non-deterministic Polynomial-time Hard
UI	User Interface
PHP	Hypertext Preprocessor
JS	JavaScript

Table 1: Abbreviation and acronyms used in this document

2. Literature Survey

Like our project, there are many educational web sites on computer science. Three of the educational websites are W3Schools, VisuAlgo and Vitamin described below:

W3Schools [7] is an interactive website which provides tutorials and references on web development languages such as HTML, CSS, JS, PHP, Python and etc. The tutorials W3Schools start from the basic level and become increasingly difficult. W3Schools uses simple code explanations with simple illustrations which makes the learning easy and straight-forward. Similar to W3Schools, our project will provide quizzes and exercises that the students can practice. Unlike W3Schools, in our website İspinoz students have accounts and when they log in the website, they can see the progress of their learning and results of quizzes. In the development of W3Schools, HTML, CSS, ASP.Net were used as web technologies.

VisuAlgo [8] is a website to help students better understand data structures and algorithms such as Binary Search Tree, graphs, sorting algorithms and etc. For example, you can visualize the solution of Traveling Salesman Problem, website VisuAlgo shows iterations of code and its outputs step by step which makes VisuAlgo more interactive for students to understand. Similar to VisuAlgo, our website will provide quizzes and visualizations of problems and the students have accounts like VisuAlgo. The difference between VisuAlgo and İspinoz is that İspinoz will

focus only on GA and it will provide the solution of problems by using GA. VisuAlgo was developed by using HTML, CSS, JS and PHP.

Vitamin [9] is an interactive Turkish website which provides lectures for the students in primary school and high schools. Vitamin mainly consists of video lectures, 3-dimensional representation and experiments on subjects. Different from İspinoz, Vitamin is not a free website, the students who want to use Vitamin must pay price monthly. Unlike İspinoz, Vitamin has also video lectures for teaching. In the development of Vitamin, HTML, CSS and JS were used.

3. Project Requirements

3.1 Functional Requirements

a. Our website must have a registration service.

   Users can be registered as:

   - Student User
   - Teacher User

b. The website provides three types of users:
   - Students
   - Teachers
   - Admins

c. The website must provide a login system. Users can log in the website with a valid email address and password.

d. The website must provide a password recovery service.

e. Students must be able to:
   - Solve quizzes
   - View quiz results
   - Study solved NP-hard problems with GA
   - Practice GA with changing variables
   - View learning history
   - Rate quizzes and problems
   - Add a class code to be a student of a teacher

f. Teachers must be able to:
    - Act as a student
    - Suggest quizzes to the website
    - Create a class code to invite students
    - View results of his/her students' quiz results
g. Admins must be able to:
    - Add/remove/update lectures, quizzes, problems
    - Ban any student and teacher

3.2 Non-functional Requirements

3.2.1 Usability

- The interface of the website must be responsive.
- The website must be interactive to make learning progress understandable.
- Any page on the website must not have any unnecessary and useless content.

3.2.2 Performance

- The website must have a 20 minutes connection timeout for inactivity.
- For any action on the website, response time must not exceed 1 minute.
- The website must take backups daily.

3.2.3 Security

- The website must provide an authorization system.
- Passwords must be encrypted with well-known algorithms.
- The system must have a firewall for hazardous attacks.

3.2.4 Accessibility

- The content of the website must be designed for also blind users.
- A blind user can use the website by any existing screen reader.

3.2.5 Ethical

- Content of our GA lectures must be correct.
- References used in lectures must be specified in the web site.

4. System Design

4.1 UML Use case Diagram(s) for the main use cases

Diagram illustrated in Figure 3 shows which operations the user can access during main use cases.

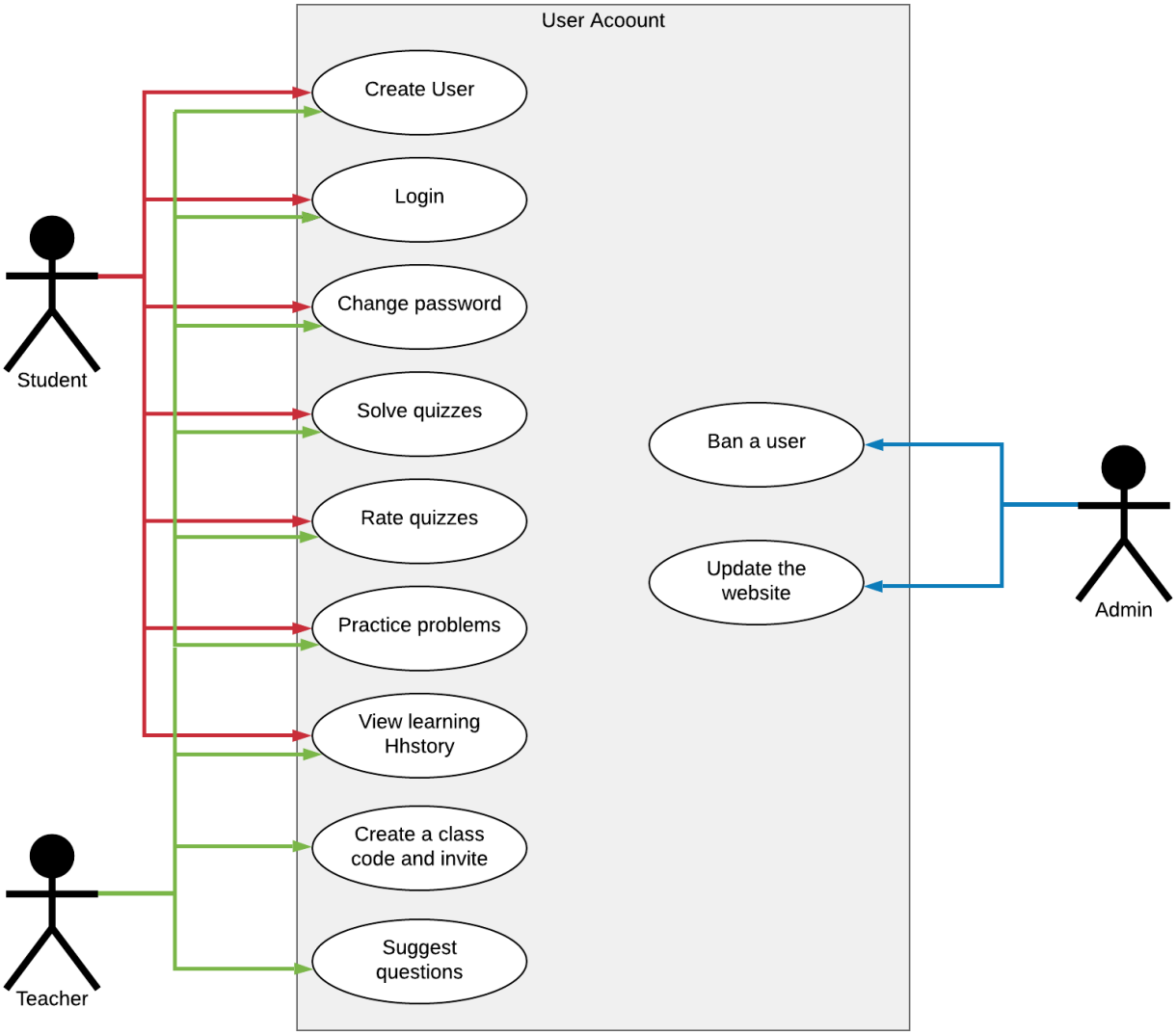

Figure 3: User Account UML Case Diagram

4.2 UML Class and/or Database ER diagram(s)

Entity relationship (ER) diagram which is shown in Figure 4 below demonstrates the information of relationships between entities in a database for our website.

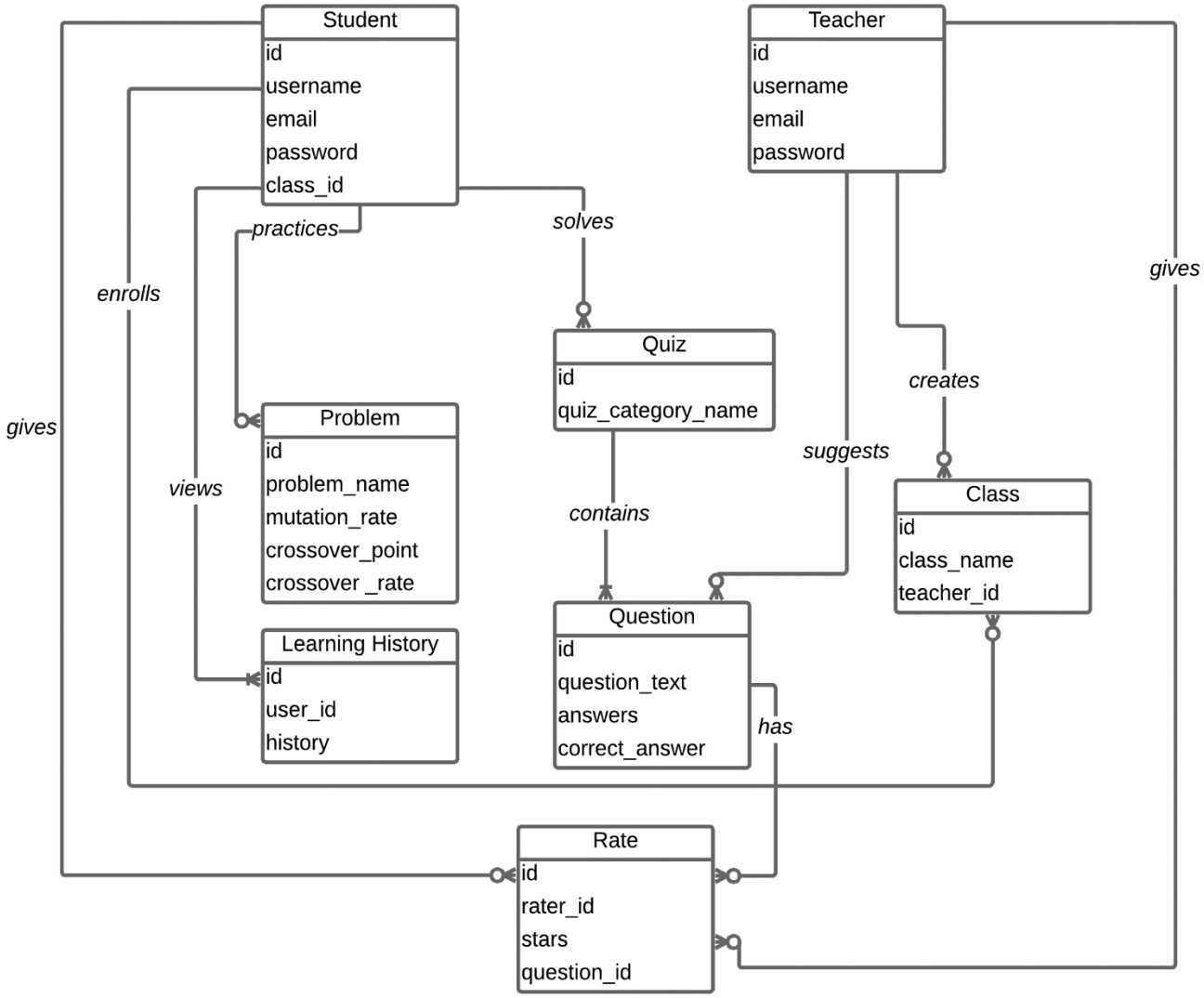

Figure 4: Database ER diagram

4.3 User Interface

The user interface of the website consists of a set of pages which are main page, sign-up page, login page, home page and etc. Users can interact the pages with data on the website. Completed pages are shown the Figure 5, 6, 7 and 8 below.

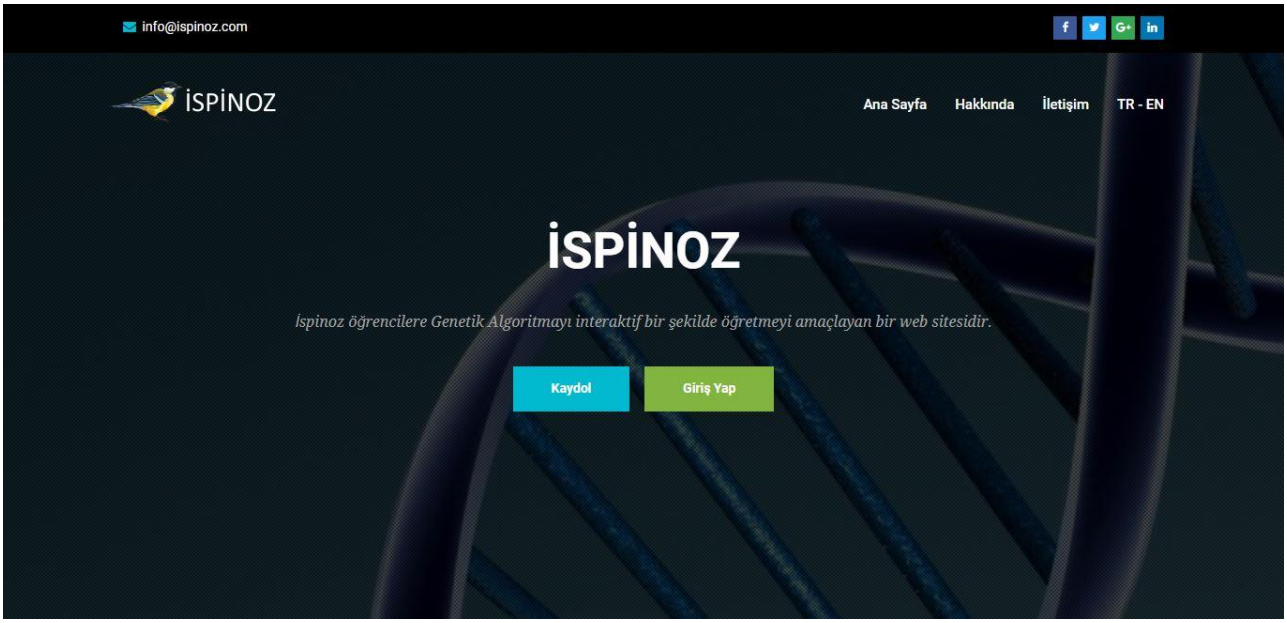

Figure 5: User interface of the main page

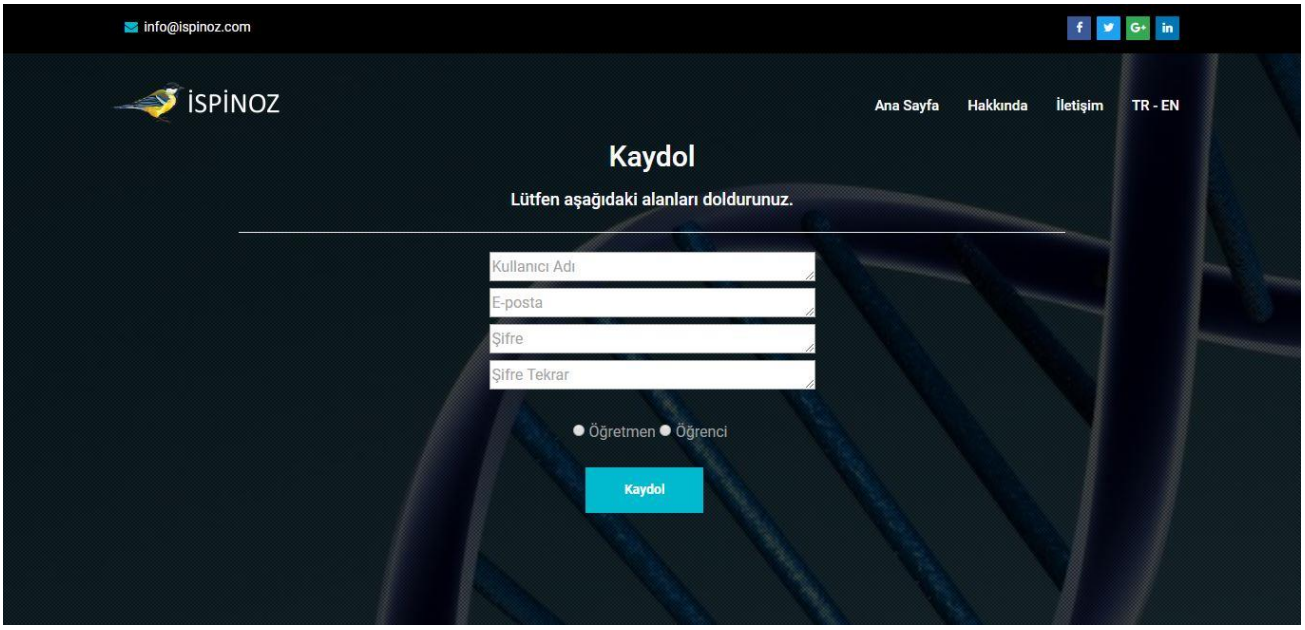

Figure 6: User interface of the registration page

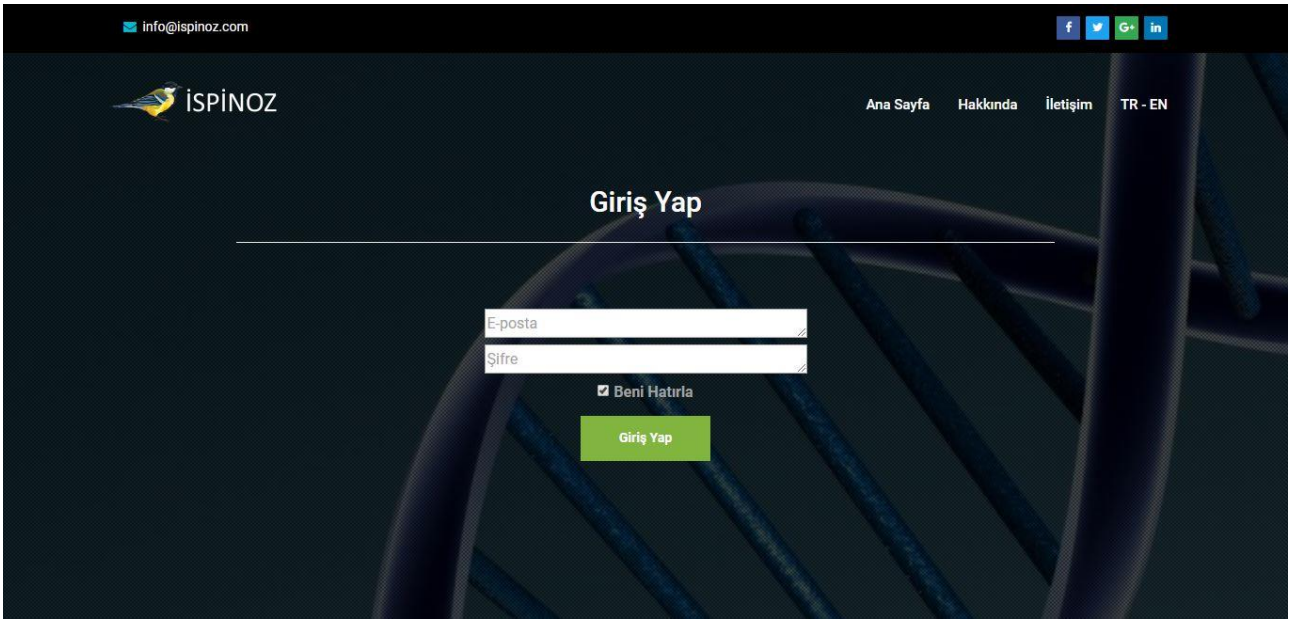

Figure 7: User interface of the login page

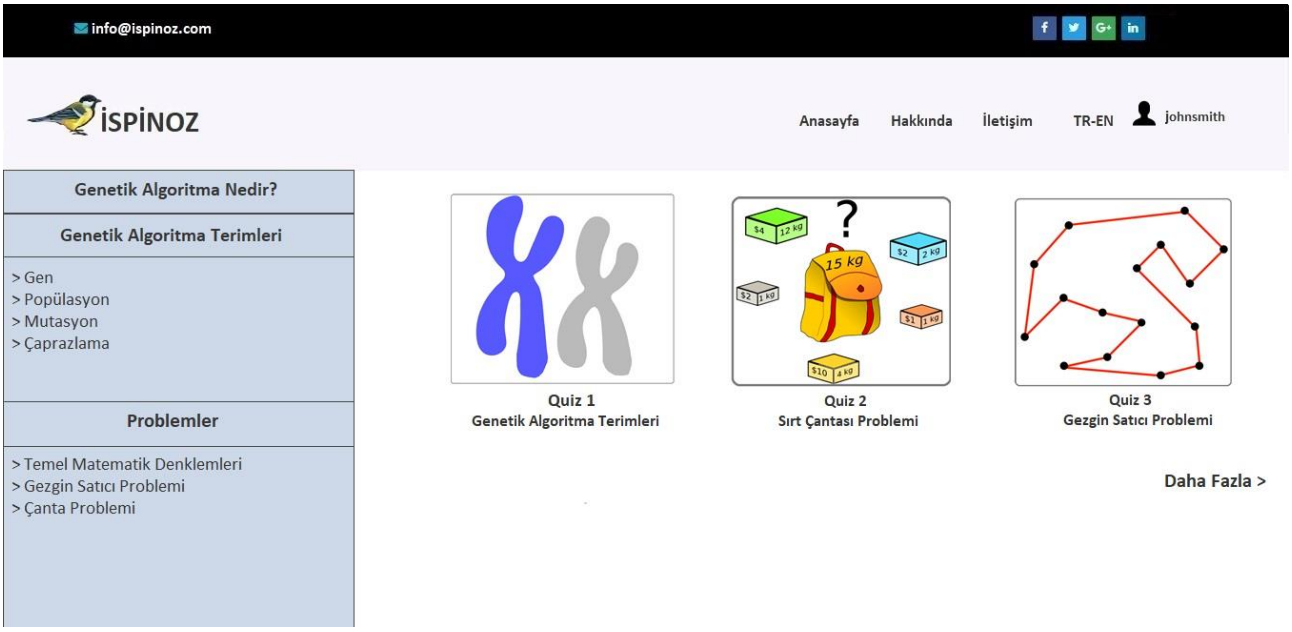

Figure 8: User interface of the home page

4.4 Test Plan

A test plan is enough to ensure the success and usefulness of our website deliverables. While our website development, testing will be performed at several points in the project life cycle. This section describes our test plan of the project and some test scenarios given in Table 2 below.

Test Case	Test Case Name	Description	Test Steps	Expected Results	Estimated Calendar
1	User Interface	Checking whether all UI components work properly	Click on all UI components and check if they are working properly	UI should work as expected	June
2	Sign Up Page	A new user can register to the website	1) Go to the Sign-up page 2) Enter a valid email address and a password 3) Click on the sign-up button	A new user should register to the website successfully	June
3	Login Page	A registered user can log in	1) Go to the Login page 2) Enter an email address and password 3) Click on the sign-up button	The registered user should log in successfully	June
4	Language Button	Users can change the language of the website	Click on the language button	Language must be changed from English to Turkish or Turkish to English when button clicked	September
5	Accessibility for blind people	The website must be accessible also for blind people	1) Go to website 2) Open an existing screen reader application	All components of UI and the texts are understandable for the blind people	November

6	Quiz Page	Users can solve quizzes in a defined time	1) Go to the Quiz page 2) Start a quiz 3) Solve the quiz in the defined time	• When quiz finished the correct answers and the score must be shown • The quiz should be finished when the time is up	October
7	Problem Practising	Users can practice the NP-hard problems with GA on a small scale	1) Go to the Problem page 2) Start practicing problem 3) Change the GA variable in an interactive way 4) See the result	• Users should be able to change the GA variables (probability of mutation, crossover and etc.) • The output of the problem should be shown to the user in a visualized way	November
8	Class Code by Teacher	A teacher can create a class code	1) Login with a teacher account 2) Click on the class code button	• The teacher should be able to create a class code successfully • When the class code created, students enroll the class and teacher can view their learning history	October
9	Question Suggestion by Teacher	The teacher can suggest a question for the quizzes	1) Login with a teacher account 2) Click on the suggest question button 3) Type the question, the correct and wrong answers	• The teacher should be able to suggest questions to the website • When admin accept the question, it will be visible to the users in quizzes	November

Table 2: Test scenarios for our website

5. Software Architecture

5.1 Data Flow

In this part, we look at the data flow of the website. It requires numbers of different databases to store particular data. Students do not have the same authority on lectures as Admins or quizzes as Teachers. Students can save their information with sign up the website and change the password, username after then. They can practice lectures, solve quizzes, rate quizzes and problems, only view their own quiz result, add class codes to join classes of teachers, only view their own learning history, practice on NP-hard problems. The website offers them a copy of problem solutions and chance to change problem variables to see the effects of the changes. Teachers and Admins can act as Students, it means they can do what students can do. In addition to them, Teachers can add new quizzes to the website, view learning histories and quiz results of their students which is defined with class codes, generate class codes to share with students. Admins are real owners of the websites. They can update lectures, add/delete/update quizzes and NP-hard problems, confirm new quiz offers of teachers, view/edit class codes, view all learning histories, rates, quiz results, class codes and also delete class codes, user information to ban students and/or teachers. Data flow of the website is shown in Figure 9 below.

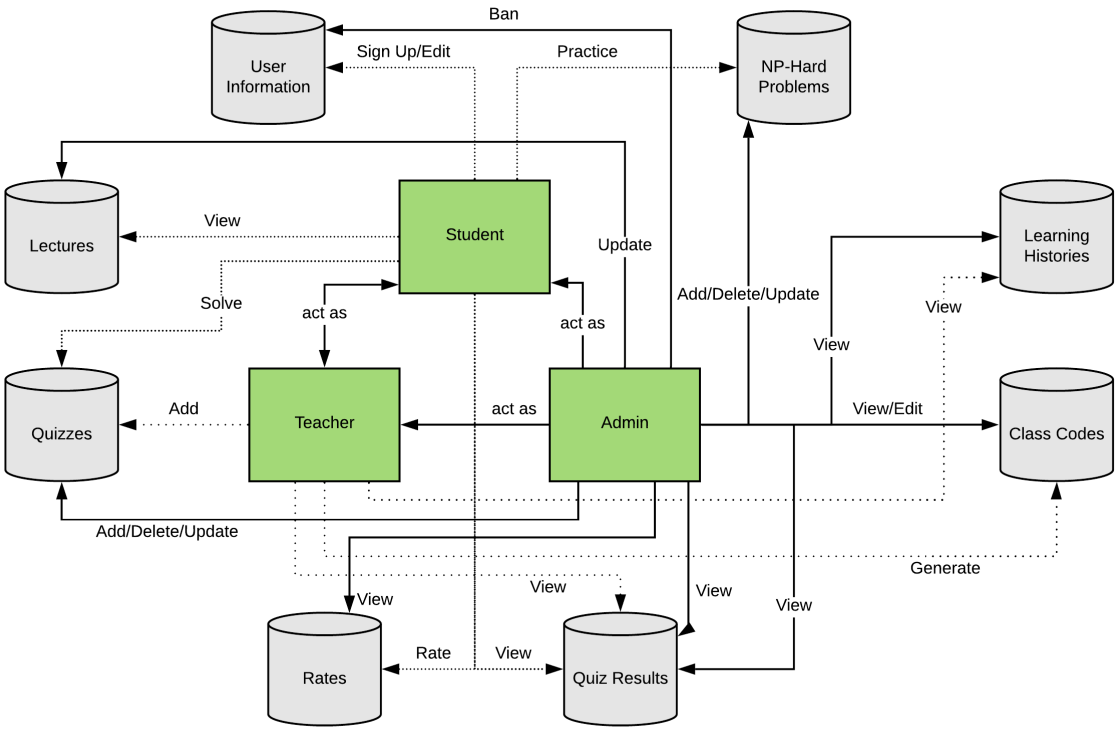

Figure 9: Data Flow of the Website

5.2 Control Flow

There is a specific scenario for each UI page, it starts with user interaction and continues at the system part. The system consists of three parts which are front-end, back-end and database. Database part is updated by the back-end system and a response is sent to the front-end part. Control flows of user registration system, quiz system, user login system and problem-solving system and main website are shown in Figure 10, 11, 12, 13 and 14 respectively.

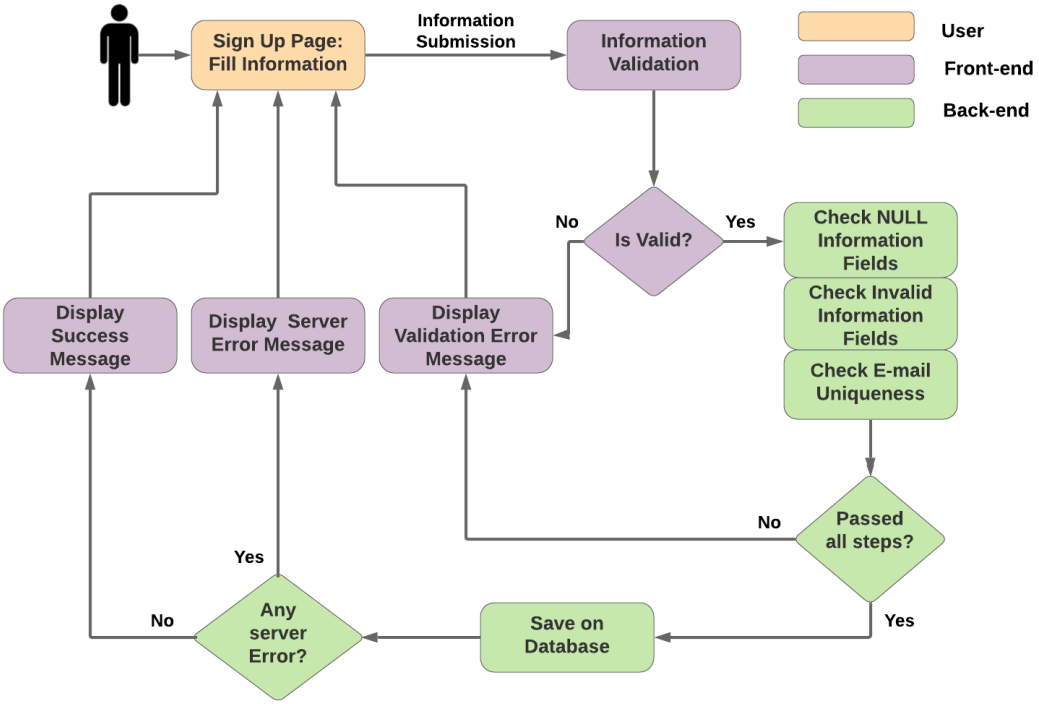

Figure 10: User Registration System

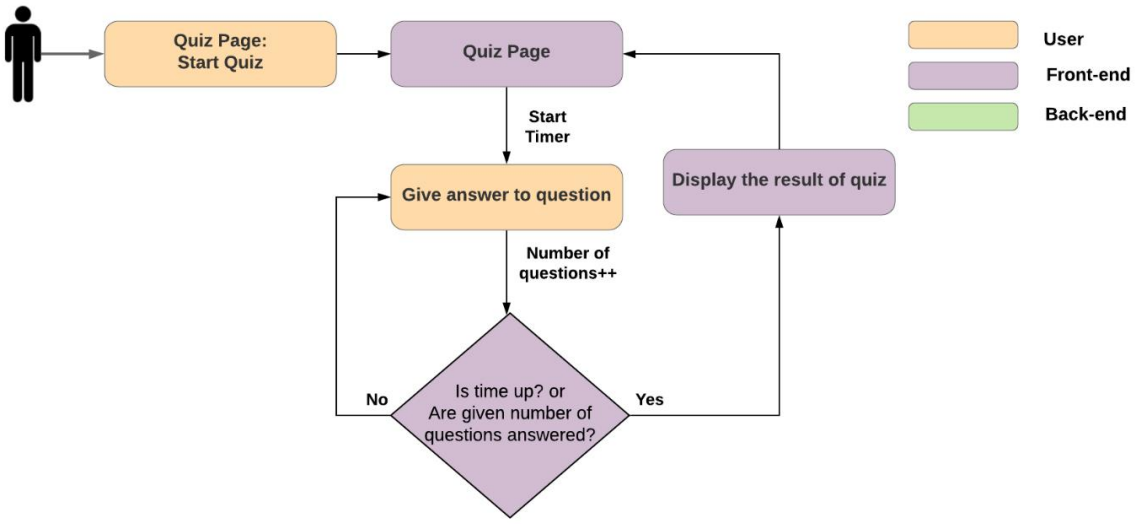

Figure 11: Quiz System

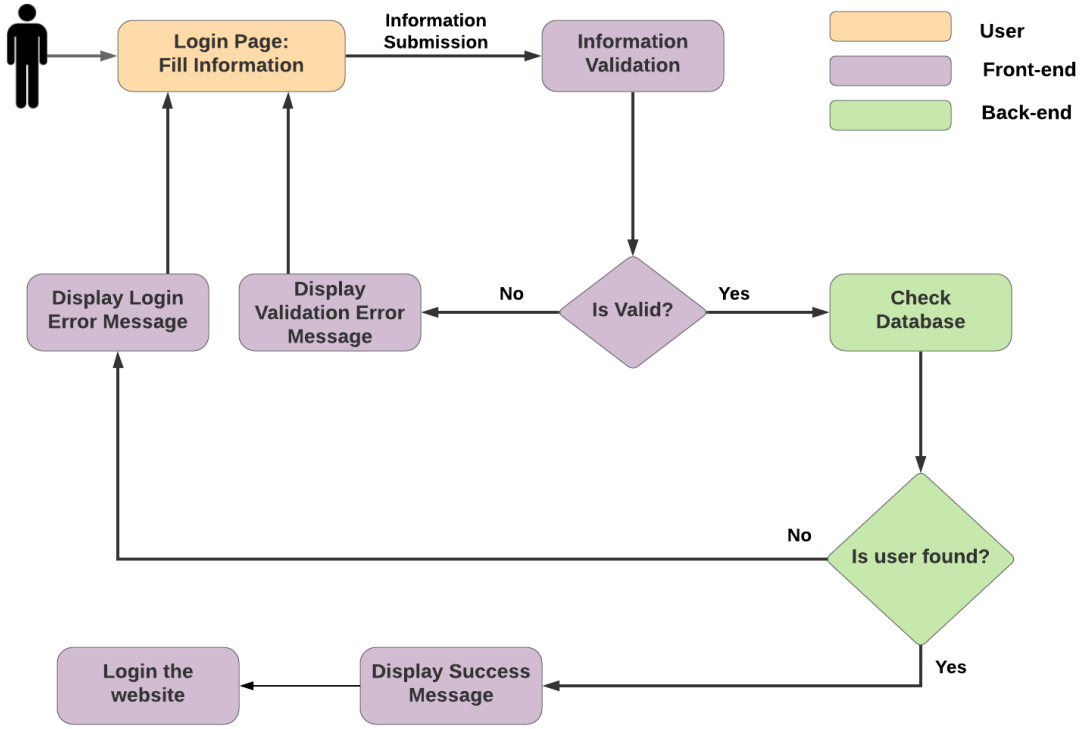

Figure 12: User Login System

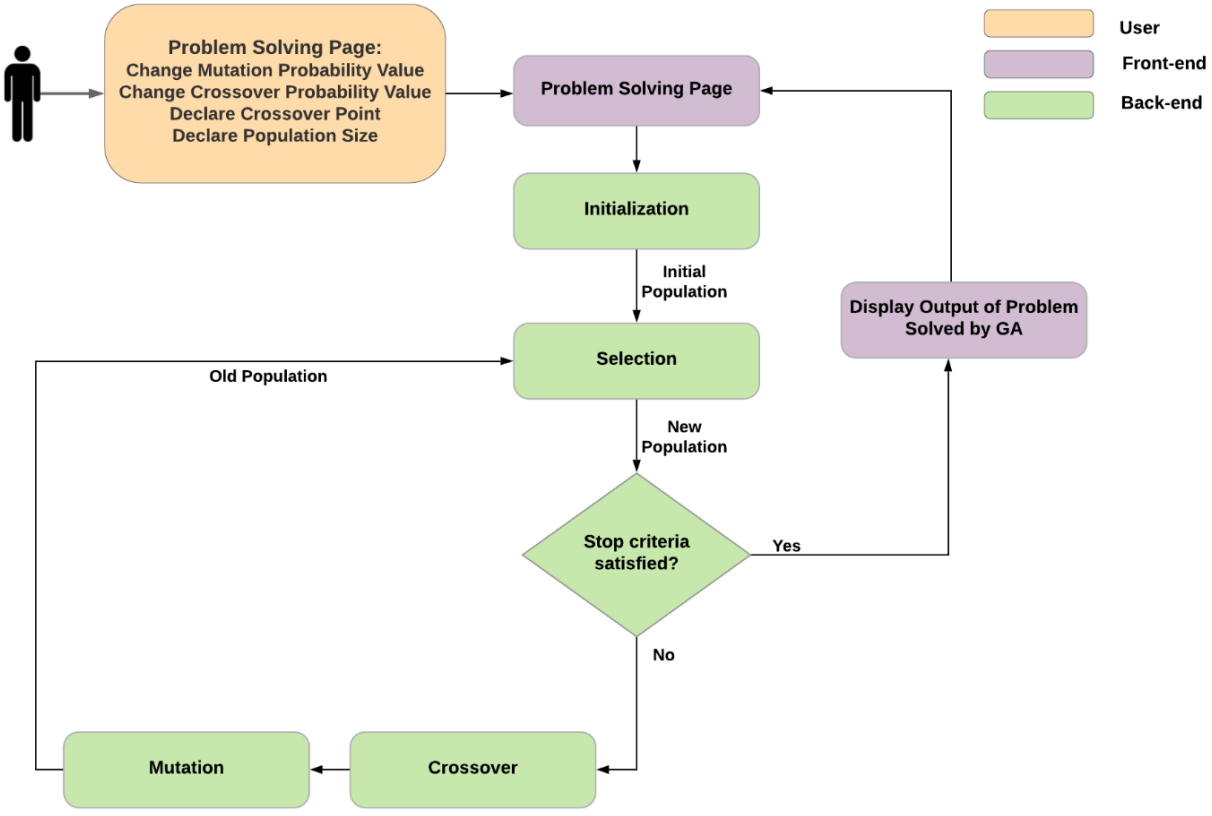

Figure 13: Problem Solving System

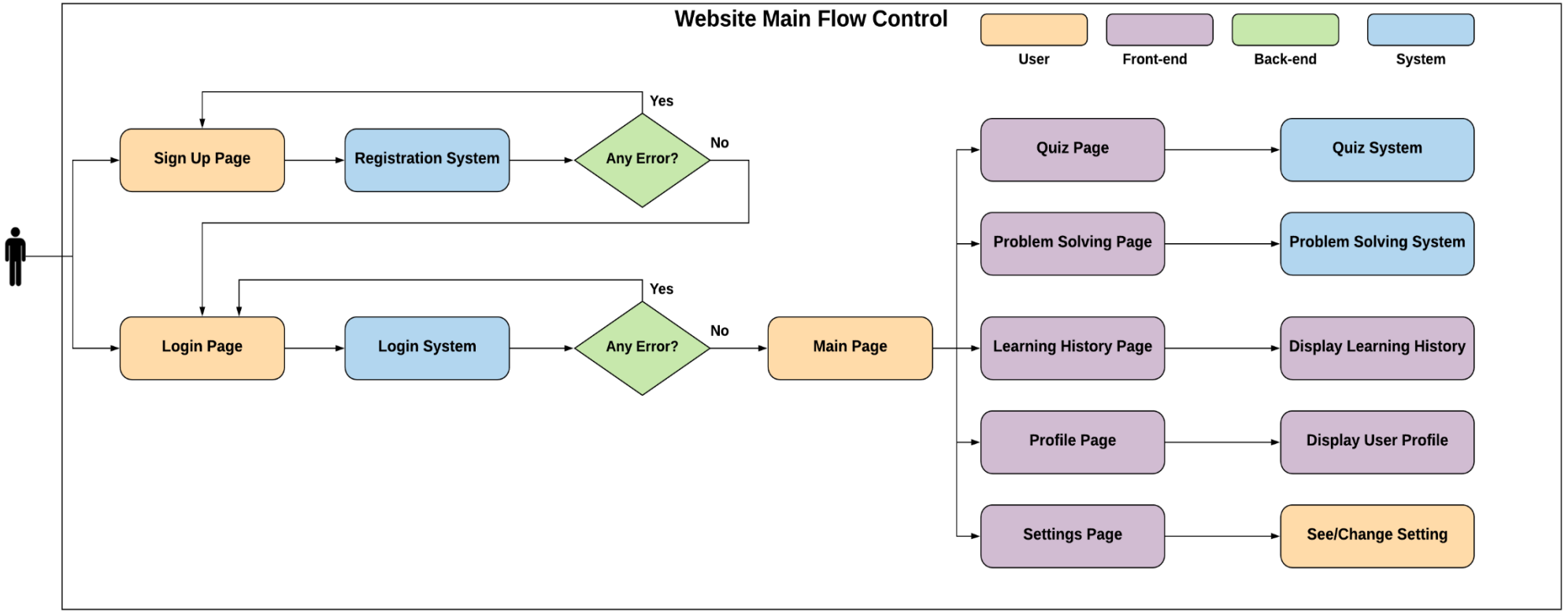

Figure 14: Website Main Control Flow

6. Tasks Accomplished

6.1 Current state of the project

Before we started the project, we divided our project into tasks, and we planned our tasks. Our task plan is shown in Table 3 of Section 6.3. According to the task plan of our project, we finished the phases:

- Phase 1: Literature survey on GA

In this phase, we researched GA and its concepts in detail. While our literature survey, we decided what information will be on our website and how we can give this knowledge to the students in the lectures.

- Phase 2: Survey on web application technologies

As we need to build an interactive educational website, which technologies will be used in this project was the main question for us. We searched for the disadvantages and advantages of web technologies. We made a huge effort in this phase and we decided the web technologies which will be used during the development of a website. We started to learn and practice them.

- Phase 3: Web application design

In this phase, we designed the user interface of our website. We decided which pages there will be on our website such as sign-up, login, home, quiz pages and etc. For each page, we worked on which UI components they will consist of. Then, we design a UML case diagram for user accounts.

- Phase 4: Database design

We decided which tables the database will contain and what attributes there will be in the tables. After that, we design an entity relationship diagram (ERD) for this phase.

After these phases finished, we started the phases:

- Phase 5: Web application implementation

After the web application design phase finished, we started the implementation phase. This phase will continue until the end of October 2020. UI of accomplished pages are shown in Section 4.3.

- Phase 7: Problem selection

In this phase, we started to decide which NP-hard problems will be on our website to practice for students. These problems are such as Knapsack Problem (KP) and Traveling Salesman Problem (TSP). We decided which GA variables are changeable by users and how the output will be demonstrated in a visualized way to the user.

6.2 Task Log

This section describes the meetings which we have arranged until today. Meetings are listed below including information of date, hour and description. In addition to these, we also used online applications to keep in touch about the process of our project.

13.02.2019 – Wednesday, 13.00 – 14.00: Meeting 1 in MB449 Marmara University

We talked about our project briefly and what we will do during project development.

21.02.2019 – Thursday, 13.00 – 14.00: Meeting 2 in MB449 Marmara University

We talked about our project design and we decided on how phenotype and genotype will be when we solve the problem using GA.

28.02.2019 – Thursday, 13.00 – 14.00: Meeting 3 in MB449 Marmara University

We prepared a user interface (UI) for our web site. We decided on the web technologies which we will use.

07.03.2019 – Thursday, 13.00 – 14.00: Meeting 4 in MB449 Marmara University

We talked about how web technologies we will use. We investigated some of the similar educational websites together.

14.03.2019 – Thursday, 13.00 – 14.00: Meeting 5 in MB449 Marmara University

We made task sharing for Project Specification Document (PSD). We talked about what the sections of PSD will contain together.

14.03.2019 – 22.03.2019, Group Meetings at Marmara University

We researched the related works and what web technologies used for them in detail. We decided on "what will be and what will not be in our project scope. "We prepared the Project Specification Document (PSD).

14.03.2019 – Thursday, 12.45 – 13.30: Meeting 6 in MB449 Marmara University

We talked about the functional and non-functional requirements of our project in detail. We planned the test phase of our project.

27.05.2019 – 12.06.2019, Group Meetings at Marmara University

We drew the UML Case and ER Diagrams. We planned what the task which will be done in the next semester and prepared Analysis and Design Document (ADD).

6.3 Task Plan with Milestones

Our project is divided into 10 phases described below. The task plan of our project for first and second semester is given in Table 3.

- Phase 1: Literature survey on GA
- Phase 2: Survey on web application technologies
- Phase 3: Web application design
- Phase 4: Database design
- Phase 5: Web application implementation
- Phase 6: Database implementation
- Phase 7: Problem selection
- Phase 8: Solving problems with Genetic Algorithm (GA)
- Phase 9: Implementation of visualizing inputs and outputs for problems on the web application
- Phase 10: Testing web application and database requirements

	1st Semester						2nd Semester						
	Feb	March		Apr	May	June	Sep	Oct	Nov	Dec	Jan		
Phase 1			Project Specification Document			Analysis and Design Document						Poster Presentation	Project Report
Phase 2													
Phase 3													
Phase 4													
Phase 5													
Phase 6													
Phase 7													
Phase 8													
Phase 9													
Phase 10													

Table 3: GANNT Chart for time plan of our project

7. References

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