

# MINI PROJECT

(2021-22)

VIBIN



Institute of Engineering & Technology

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Declaration

We hereby declare that the work which is being presented in the Bachelor of technology. Project “**VIBIN**”, in partial fulfillment of the requirements for the award of the **Bachelor of Technology** in Computer Science and Engineering and submitted to the Department of Computer Engineering and Applications of GLA University, Mathura, is an authentic record of our own work carried under the supervision of **Manoj Varshney, Technical Trainer, Dept. of CEA, GLA University.**

The contents of this project report, in full or in parts, have not been submitted to any other Institute or University for the award of any degree.

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*Certificate*

This is to certify that the project entitled “VIBIN”, carried out in Mini Project – I Lab, is a Bonafede work by Karan Chaurasia, Kinjal Varshney, Suraj Mishra, Sani Chaturvedi and Abhishek Yadav is submitted in partial fulfillment of the requirements for the award of the degree Bachelor of Technology (Computer Science & Engineering).

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Thanking You

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# Abstract

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In the past, web development was mostly based on the LAMP stack (Linux, Apache, MySQL, PHP or Perl) and Java-based applications (Java EE, Spring). However, those stacks comprise of various programming languages which can be a burden for a single developer to comprehend. With the advances in web technologies during the last few years, a developer can participate in both front-end and back-end processes of a web application.

The main goal of this bachelor's Mini Project was to study the basic components of the highly popular MERN stack and build a social platform application based on it. The MERN stack, short for MongoDB, Express.js, React.js and Node.js eases the developers with the idea of unifying web development under a single programming language: JavaScript.

After months of doing research, the application was successfully built and fully functional. The application has sufficient features and can either be used as a platform to connect people or a service to manage employees for a real company.

Keywords: MongoDB, Express, Node, React, JavaScript.

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## List of Abbreviations

API	Application Programming Interface
NPM	Node Package Module
MVC	Model-View-Controller
HTTP	Hypertext Transfer Protocol
NoSQL	Non- Structured Query Language
JSON	JavaScript Object Notation
BSON	Binary JSON
RDBMS	Relational Database Management System
HTML	Hypertext Markup Language
MVVM	Model-View-ViewModel
JSX	JavaScript XML
SPA	Single Page Application
URL	Uniform Resource Locator
UI	User Interface



# 1 Introduction

Nowadays, the demand for full-stack developers has rapidly increased than ever before. According to a survey taken by Indeed, the highest demand also comes with an impressive average salary of \$110,770 in the US. [1] The term full-stack developer refers to a person who can technically work on both front-end and back-end development of a dynamic website or web-based applications.

In the past, web development was mainly based on the LAMP stack (Linux, Apache, MySQL, PHP or Perl) and Java (Java EE, Spring), which consists of various programming languages. With the capabilities to work on both the client-side and server-side, JavaScript eases web development with the MERN stack's emergence. The stack comprises four primary technologies: MongoDB, Express.js, React.js, and Node.js. In this bachelor's thesis, the main goal was to study each component's nature in the stack and create a social platform that can connect people.

The thesis will primarily split into two main parts. The theoretical part focuses on giving a deep understanding of each component in the stack and related technologies to carry out the final project. Later it will dive into practical implementation of the social platform.

The outcome is a platform that has sufficient features to demonstrate the connections of each of the components in the MERN stack. Users can sign up, sign in and sign out. After signing in, users can create a post with upload photo functionality. Moreover, users can also like and comment on other user's posts and reset the password. Due to the limited scope of this thesis, a notification system was not implemented. The knowledge acquired from this thesis can be applied to build various kinds of applications.

## 2 Introduction to JavaScript

### 2.1 History of JavaScript

Brandan Eich, an employee of Netscape created JavaScript in September 1995. In 1996, JavaScript was officially named ECMAScript, which is a standard set by European Computer Manufacturer associations (ECMA). ECMAScript 2 was released in 1998, and ECMAScript 3 continued in 1999. [2] Since then, JavaScript has been steadily evolving, with a record of 95% of websites using JavaScript as of March 2021. [3]

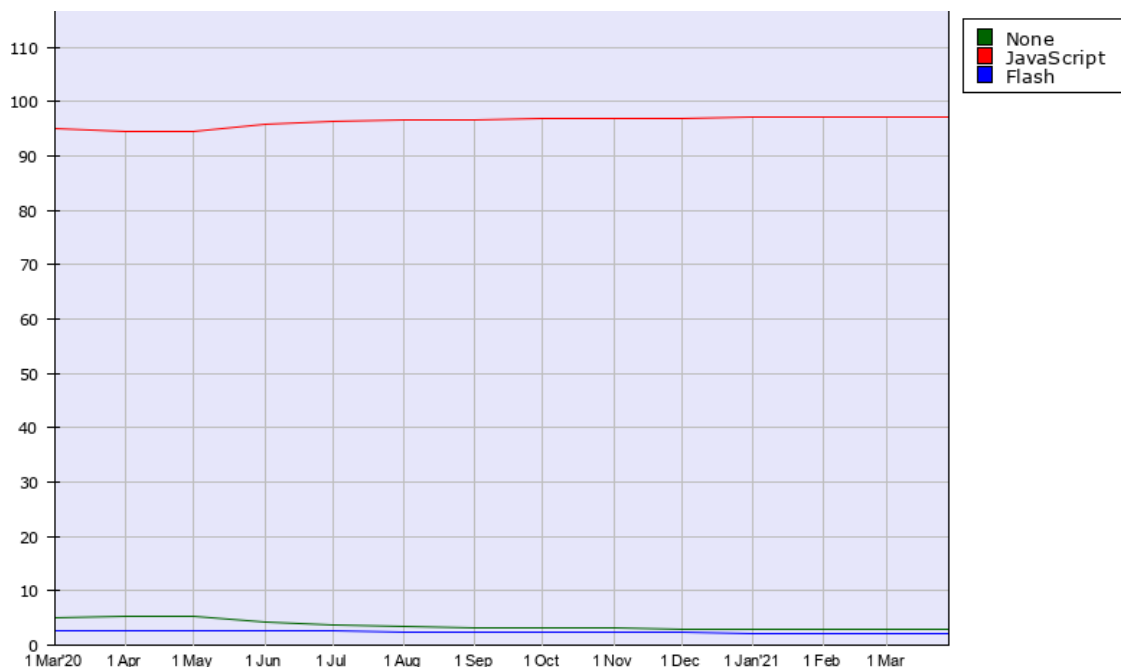


Figure 1. Usage of client-side programming languages for websites, 28 Mar 2021, W3Techs.com. [3]

## 2.2 What is JavaScript used for?

JavaScript is a lightweight, interpreted, cross-platform scripting language. Back in the day, JavaScript was only used in websites and run by the browsers to add effects or interactions to a website's front end. However, as with the existence of Node.js running by V8 engine since 2009, JavaScript can also be used to run on the server.

- **Client-side JavaScript:** An extension of core JavaScript language to control the browser and the DOM. It can also validate input, manipulate UI elements or perform some calculations without refreshing the page frequently.
- **Server-side JavaScript:** An extension of core JavaScript language to run on a server that can be seen as normal C#, C, Python, or any other server-side programming language code. For example, it can connect and modify the database or file system with back-end access. Moreover, with server-side code, a developer can handle JavaScript requests from the client-side. [4]

## 2.3 Modern JavaScript

ECMAScript 6, also known either as ES6 or ECMAScript 2015, released in 2016, was the second major revision to JavaScript. [5] Understanding ES6 is essential when adopting the React.js framework in any of the MERN-based projects. In React.js, developers will be writing plain-old JavaScript along with features added by ES6.

### 2.3.1 Creating variables using `let`

Using the `let` keyword allows developers to declare a variable with block scope. [5]

```
var x = 5;
// now x = 5
{
    var x = 20;
    // now x = 20
}
// finally x = 20
```

Listing 1. Declaring variable using `var`

Using `let` to re-declare a variable can solve the above problem.

```
var x = 5;
// right now x = 5
{
    let x = 20;
    //x = 20
}
// x is still 5
```

Listing 2. Declaring variable using `let`

### 2.3.2 Creating variables using `const`

The `const` keyword is used to declare a variable with a constant value. [5] A variable need to be assigned a value as soon as it is declared.

```
var x = 5;
// now x= 5
{
    const x = 20; // x = 20
}
// x is 5
```

Listing 3. Declaring variable using `const`

### 2.3.3 Arrow function

Arrow functions make it possible to write a function in a concise way. Developers can get rid of writing function and return keywords as well as the curly brackets.

[5]

```
// ES5
var minus = function(y, z) {
  return y - z;
}

// ES6
const minus = (y, z) => y - z;
```

Listing 4. Difference between normal function and arrow function

## 3 Explore the MERN stack

MERN stands for MongoDB, Express.js, React.js and Node.js. With MongoDB as Database, Express.js is a web server framework (integrated with Node.js), React.js is a web client library, and Node.js is a server-side platform. It helps developers to develop Web apps based solely on full-stack JavaScript.

MERN combines four cutting-edge technologies today, from the front-end to the back-end development, which Facebook strongly supports, so developers do not need to learn any other technology such as .NET, PHP, or Java. It saves developers time and effort to learn different technologies for application development. Due to the same JavaScript platform, the stack is supported by a vast number of open-source packages and a dedicated community for programmers to increase scalability and maintain software products.

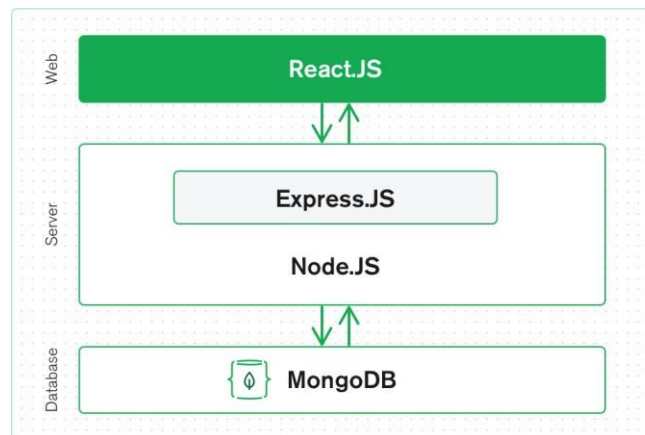


Figure 2. A 3-tier MERN architecture [6].

As depicted in Figure 2, the MERN stack starts with the core Node.js, a server-side technology with very high performance and fast response to all tasks, including large and complex data.

MERN does not need to use TypeScript, just the flexible foundation of React - the most popular and influential front-end technology today.

### 3.1 Node.js

#### 3.1.1 Background of Node.js

None of us are unfamiliar with the Google Chrome web browser, and there is nothing new that this browser can open web pages and run JavaScript on the websites. The JavaScript code's execution is thanks to a JavaScript engine located inside a Chrome browser called V8. V8 has proven to be a powerful engine, written in C ++; V8 can interpret and execute JavaScript very quickly. [7]

Faced with the apparent fact about the power of V8, the idea popped into the founders' minds to separate this V8 from Chrome and form an application capable of executing the JavaScript code on the server-side. In 2009, Ryan Dahl created Node.js to achieve that goal. [7]

It should be easy to understand when Node has the same role as JVM (Java Virtual Machine). Like the JVM, Node.js is considered a platform, an environment for the applications to run on. If JVM executes the byte code, Node.js executes the JavaScript code. Programmers always use high-level languages such as Java, Scala, Groovy, or Kotlin to write the source code on the application programming side when working on the JVM. This source code will be compiled into byte code. Nevertheless, Node.js itself can understand and execute JavaScript on the Node.js platform, so the language written on the application side can be JavaScript, or languages capable of compiling into JavaScript like Typescript.

The birth of Node.js brought a breath of fresh air into the programming world. It has gained popularity among developers' top server-side platform choices and is used in major systems such as Netflix, LinkedIn, and Uber. The following is a ranking of the most popular libraries/platforms according to a StackOverflow survey in 2020.

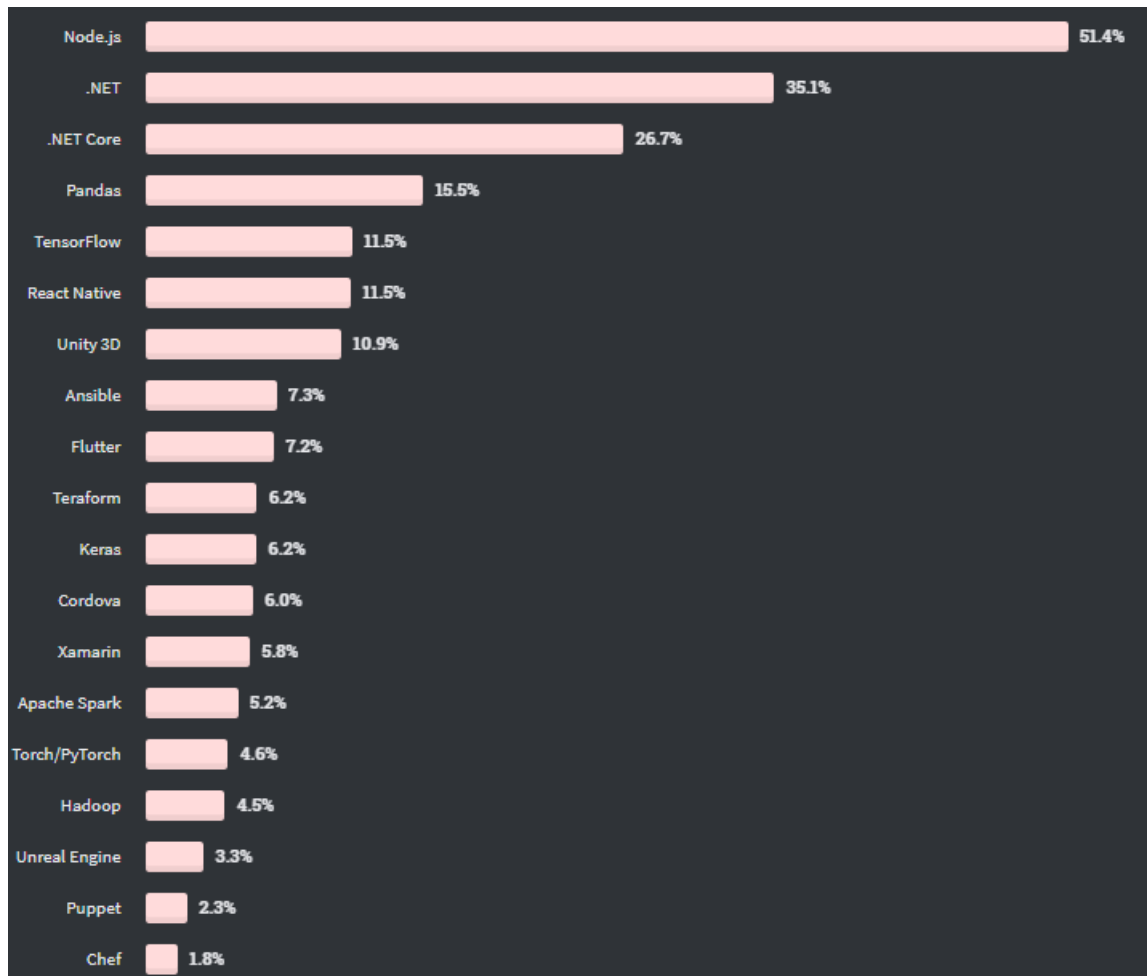


Figure 3. Node usage in 2020 [8]

### 3.1.2 Non-Blocking programming in Node.js.

The Node.js platform is versatile, perhaps not because of the V8 engine or the ability to support the JavaScript language, but in the Non-Blocking style of programming. Operations related to Non-Blocking in Node.js are mostly related to IO, such as reading and writing data to disk or calling Web APIs, for example. Furthermore, the use of Non-Blocking operations makes applications written on a Node.js platform capable of using computational resources (CPU) most efficiently.

In the creation of the Non-Blocking mechanism, Node.js applications operate according to the Event Loop design pattern. The illustration below explains this design in more detail:



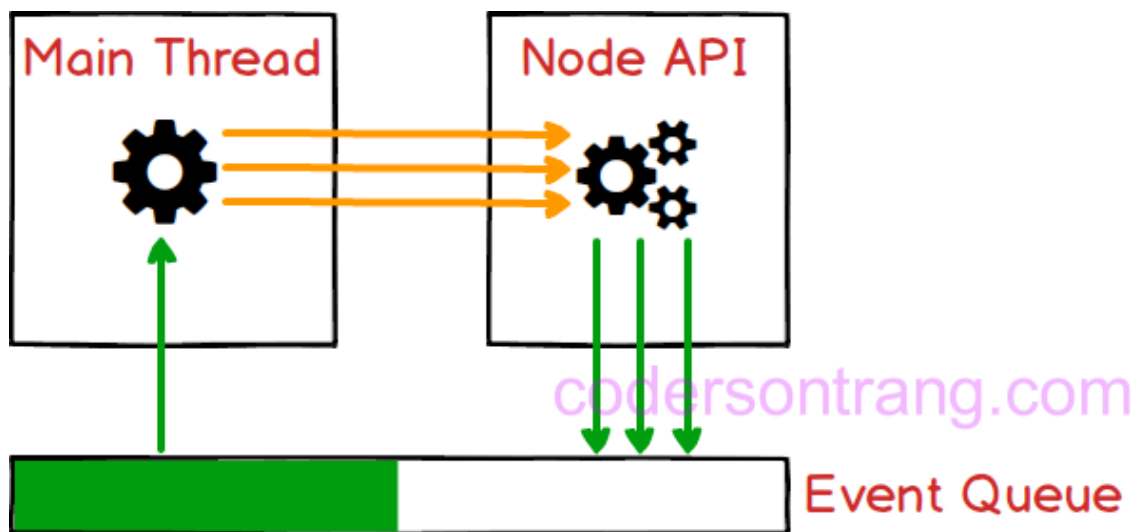


Figure 4. The Event Loop mechanism. [9]

- **Event Queue:** Considering as a repository to store Events (events). Event here can be understood as a particular process in the program. Each event contains information to classify what that event is and the accompanying data. Because it is a queue structure, the Event Queue will operate on the principle of First In First Out (FIFO). This ensures that the order in which the Events are retrieved for processing is the same as the order they are put into the Event Queue.
- **Main Thread:** Saying this is the Main Thread because it will be the source and the end of the program. This main Thread is responsible for processing computation when receiving Events from the Event Queue. This is also the only Thread of the Node application that the programmer has control over. That is also the reason why it is still said that a Node application is single-threaded. Because of that, programmers will not have a headache about concurrency problems between threads like in some other platforms like Java.
- **Node API:** The unit responsible for handling IO operations. IO operations will be handled here by the multi-threaded mechanism. Moreover, each IO operation after completion will return the result as an event, and this event will be put in the Event Queue.

With the above three components, the way a Node application behaves like this:

- The Main Thread will run the computation processing statements declared in the source code. Wherever IO manipulation is involved, the Main Thread will make a Non-Blocking call to the Node API and then continue to execute other commands without waiting for the other IO operation to complete.
- When receiving a request from Main Thread, Node API will directly handle IO manipulation by different Threads. Once the IO operation is completed, the Node API will wrap the result as an Event and place it into the Event Queue.
- Events in the Event Queue will be processed by the Main Thread one after another. In the Main Thread, the code used to handle Events is usually declared as callback.

The above process is repetitive, creating a cycle of events in the application. The programming will be imposed in a way that is geared towards event handling instead of the traditional sequential way of thinking. [9]

### 3.1.3 Node package manager (NPM)

NPM (short for Node Package Manager) is used and comes together to support each development of Node.js. [10] Most libraries are available on NPM, so it is relatively easy to include them just by running `npm install <package>` command line to download them.

NPM is being maximized and operating based on two prominent roles as follows:

- NPM is a Software Registry and is being used very extensively to publish open-source Node.js projects. One can understand that: it is an online platform that allows all users to publish and share several other tools

written in JavaScript. It has crossed over 1.3 million code packages as of April 2020. [11]

- NPM is one of the command-line tools that can help interact with other online platforms such as servers or web browsers. It is also a utility that can assist with package installation, package uninstallation, version management, and server-driven management. Also, NPM is used to manage the dependencies needed to run the projects.

#### 3.1.4 Applications of Node.js

- **Websocket servers:** Websocket is a protocol formed to support two-way communication between the client and the server to connect and exchange data with each other quickly and accurately. The protocol is implemented over TCP, and they are used for web applications.
- **Ad Server:** Running ads and controlling views will take time. Therefore, Node.js will be a platform that brings many benefits to customers. It is easier for ad servers to capture information.
- **Cloud Services:** Cloud services on electronic devices such as phones, iPad, etc.
- **RESTful APIs.**
- **Real-time applications.**
- **Microservices:** The idea of microservices is to split an extensive application into small services and connect them.

### 3.2 Express.js

#### 3.2.1 Introduction to Express.js

Express.js is released under an open-source license, has a large community of support, and used for commercial applications. Hence, developers can

completely rest assured to use this framework for their projects, from small projects to large projects.

Express.js has a ton of support packages and provides additional features for developers to a better program. Nevertheless, it does not slow down the speed of Node.js. The famous Node.js platform today is using Express.js as a core function.

According to the GitHub repository, Express.js was founded by TJ Holowaychuk and was first released on May 22, 2010, with version 0.12. In June 2014, project management rights were acquired by StrongLoop. IBM acquired StrongLoop in September 2015. In January 2016, Express.js was managed by the Nodejs Foundation. [12]

### 3.2.2 Structure of an Express.js application

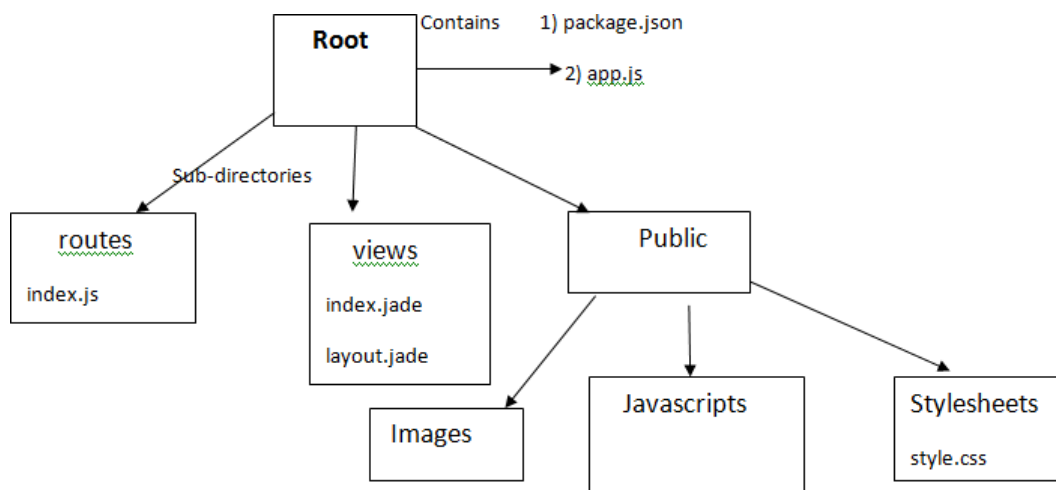


Figure 5. Structure of an Express.js app.

As illustrated in Figure 5, the project directory structure using Express.js is divided into three parts: Routes, Views, and Public. Express.js build web applications following the MVC (Model, View, Controller) design pattern.

- **Root.**

- **app.js:** contains all the logic setup for the applications to run.
- **package.json:** contains all the installed packages.
- **routes:** contains all the routing-related logic present in the application.
- **views:** contains the views/templates for the application.
- **Public:** contains static files such as images, JS codes and CSS settings for the application.

### 3.2.3 Understanding middleware

Middleware is computer software that connects software components or applications together. [13] Software of this type consists of services that allow interaction between processes running on one or more different machines. Middleware technology has been developed to provide interoperability, catering to commonly used distributed architectures to support and simplify complex distributed applications.

When working with Express.js, developers use various middleware functions with different functionalities:

- Functions receive the request, response of 1 cycle of HTTP request/response.
- Functions can correct requests and responses before sending them to the `next()` middleware function.
- Functions can update or terminate the request/response cycle. [14]

The middleware function in Express.js often takes three parameters: the request (`req`) object, the response (`res`) object, and the `next()` function. Figure 6 below illustrate a custom middleware used in the project.

```

125 //follow
126 exports.addFollowing = (req, res, next) => {
127   User.findByIdAndUpdate(
128     req.body.userId,
129     { $push: { following: req.body.followId } },
130     (err, result) => {
131       if (err) {
132         return res.status(400).json({ error: err });
133       }
134       next();
135     }
136   );
137 };

```

Figure 6. A custom middleware.

### 3.3 MongoDB

#### 3.3.1 Introduction to MongoDB

MongoDB was first born by MongoDB Inc. in October 2007. It was part of the PaaS (Platform as a Service) product like Windows Azure and Google App Engine. It was later made open source in 2009. [15]

MongoDB is a document-oriented database and a NoSQL database. Therefore, MongoDB will often avoid the relational database's table-based structure to adapt to all documents such as JSON, available in a very flexible schema called BSON. [16]

#### 3.3.2 Pros and Cons of MongoDB

The outstanding advantages of MongoDB convincing the choice of current users are:

- Since MongoDB uses data in the JSON form, each collection has different sizes and documents. Nevertheless, they are very flexible when it comes to archiving.

- MongoDB data is usually not bound to each other; it does not support `join` query like in RDBMS, so when users insert, delete or update, it will not spend too much time to check if it satisfies the constraints like in RDBMS or not.
- MongoDB is easy to scale. In MongoDB, the concept “cluster” refers to clusters of nodes containing data to communicate with each other. Adding a new node to the cluster helps users expand the system quickly.
- The unique identifier `_id` will always be indexed automatically, so the speed of querying information will consistently achieve the highest performance.
- Data query will be cached to RAM with little access to the hard drive so the read and write speed is faster.

In addition to many outstanding advantages as above, MongoDB still does have its drawbacks:

- It is not applicable to any transaction models that require a high degree of accuracy due to its non-binding nature.
- There is no transaction mechanism to banking service applications.
- Data takes RAM as the centre of the action, so it requires a large amount of RAM when operating.
- Any change to the default data is not written to the hard drive immediately, so the chance of losing data from the cause of an unexpected power failure is very high.

## 3.4 React.js

### 3.4.1 Introduction to React.js

React.js is a JavaScript library built by Facebook engineers, being used by many famous companies to develop their products such as Yahoo, Airbnb, Facebook,

Instagram. It is better suited for large, scalable projects rather than small projects. [17]

- Features of React.js

The React.js mindset is to build reusable components that make it easy to break down problems and test. It helps us quickly manage and extend the system; if it is Angular, it requires optimal structure and coding style.

React.js always keeps components stateless (as much as possible), making it easy to manage because it is like a static HTML page. It takes inputs from the outside and only displays it against those inputs, explaining why it is reuse and easy for testing.

- The strengths of React.js

React.js is a performance-minded view rendering framework. Many of the heavyweights on the MVVM (Model-View-ViewModel) framework take a long time to display large amounts of data, such as lists. However, with React.js, that is no longer an issue, as it just shows what changes.

One of React.js more strengths is the virtual DOM (Document Object Model) - which is hidden inside every view and is the reason why React.js achieves good performance. When a view requests a call, everything is included in a virtual copy of the DOM. React.js compares the virtual DOM and the real DOM after the call completes and makes the changes indicated in the above comparison. [18]

For example, if we are looking at a list of 20 products displayed by React.js and change the 2nd product, only that product is re-displayed, and the remaining 19 products remain the same (no need to display reload or reload the page). React.js used the so-called virtual DOM to increase performance by outputting a virtual view, then checking the difference between the virtual rendering and what is in the DOM and creating a patch.



### 3.4.2 Some concepts of React.js

- Component

React.js is built around components, not using templates like other frameworks. The user can create a component by extending the component as follows. [19]

```
class Welcome extends Component {  
  render() {  
    return <h1>Hello, {this.props.name}</h1>;  
  }  
}  
  
export default Welcome;
```

Figure 7. A component in React.js.

The most crucial method is render, which is triggered when the component is ready to be rendered on the page.

In that function, the user will return a description of what the user wants React.js to render on the page. As in the example above, the user renders an h1 tag containing the greeting and the name.

The render function is a specific description of the UI at any given time. If the data is changed, React.js will update the UI with the corresponding data. One can understand that React.js will automatically call the render function to update the UI when the data changes. [19]

- Prop

Props here are properties of a component; users can change the props of the component by passing data from the outside. Props can be an object, function, string, number, etc. [19]

```
import PropTypes from 'prop-types';
import React from 'react';

class Greeting extends React.Component {
  render() {
    return (
      <h1>Hello, {this.props.name}</h1>
    );
  }
}

Greeting.propTypes = {
  name: PropTypes.string
}
```

Figure 8. Prop in React.js.

When a prop is passed to the component, it is immutable. That is, its data is not changed like a "pure" function. [19]

Examples of "pure" and "not pure" function. We consider the function as below:

```
function sum(a,b) {
  return a + b;
}
```

Figure 9. Pure function.

The function is called "pure" because it does not change its input value and always returns the same result for the same inputs. [19]

We consider the second function as shown below:

```
function sum(sum, a) {  
  sum += a;  
}
```

Figure 10. Not pure function.

Here the above function changed its input sum value, and this makes it not a "pure" function.

All React.js components must act as "pure" function. [19]

- State

A React.js component has two ways to get props and state information. Unlike props, the state of a component is not passed from the outside. A component determines its own state. To create a state for the component, we will have to declare it in the constructor function. [20]

```
class Posts extends Component {  
  constructor() {  
    super();  
    this.state = {  
      posts: [],  
    };  
  }  
}
```

Figure 11. State in React.js.

## 4 Implementation of the project

The Social Platform implementation will be carried out into three separate steps: back-end creation, front-end creation, and finally testing of the application. Due to the limited scope of the thesis, it is not recommended to describe all the project's aspects in detail. However, it can be able to demonstrate all the necessary steps to implement the MERN application successfully.

## 4.1 Back-end creation

In creating the back-end of the application, the Express.js library on top of Node.js is used to build the server. After that, to store the data in JSON format, Mongoose library is installed to connect to the MongoDB database. Finally, the routing-related logic is introduced as they include the endpoints to interact with the front-end.

### 4.1.1 Server creation

First and foremost, a server is needed to compile the JavaScript code on the back-end.

```
npm init
```

Listing 5. Command to initialize a project.

The code above is used to initialize a new Node.js project. After answering fundamental questions regarding the project's description and user's information, a `package.json` file is automatically created. After the project's initialization, instead of using the core Node.js HTTP core modules to build the server, the Express.js framework is used to take advantage of existing `npm` packages:

```
npm install express
```

Listing 6. Command to create an Express.js server.

Afterward, an entry file called `app.js` is created. This file contains all the middlewares and node packages.

```

JS app.js > ...
1  const express = require("express");
2  const app = express();
3  // import mongoose
4  const mongoose = require("mongoose");
5  const morgan = require("morgan");
6  const bodyParser = require("body-parser");
7  const cookieParser = require("cookie-parser");
8  const expressValidator = require("express-validator");
9  const fs = require("fs");
10 const cors = require("cors");
11 // load env variables
12 const dotenv = require("dotenv");
13 dotenv.config();

```

Figure 12. app.js file.

The objectives of some middlewares and packages included in Figure 11 can be explained as follow:

- `mongoose` helps establish a connection between MongoDB database and the Express app.
- `morgan` shows the request details in the console.
- `bodyParser` parses the incoming request bodies under the `req.body` property.
- `dotenv` helps loading environment variable from a `.env` file into `process.env`.

#### 4.1.2 Database creation

To connect the MongoDB database to the Express.js app, a node package called Mongoose is installed. Mongoose is an Object Data Modelling tool to assist MongoDB in creating a schema. Based on that Schema interface, models are defined. The Schema allows users to define the fields stored in each document and their validation methods and default values. Essentially, the schema is a

blueprint for constructing the database. [21] There are two schemas in the application: user and post.

### User schema

```
7  const userSchema = new mongoose.Schema({
8    name: {
9      type: String,
10     trim: true,
11     required: true,
12   },
13   email: {
14     type: String,
15     trim: true,
16     required: true,
17   },
18   role: {
19     type: String,
20     default: "subscriber",
21   },
22   hashed_password: {
23     type: String,
24     required: true,
25   },
26   salt: String,
27   created: {
28     type: Date,
29     default: Date.now,
30   },
31   updated: Date,
32   photo: {
33     data: Buffer,
```

Figure 13. A user schema.

In the Social Platform app, the user schema will store all the information related to the users. This schema has many different fields within it, each with its type and properties, as shown in Figure 13 above. The three required fields that need introduction include `name`, `email`, and `hashed_password`.

- `name`: This field stores the user's name who is using the app and will be of String data type.
- `email`: This field stores the registered user's email and will also be of String data type.
- `hashed_password`: This field is designed to store the user's password in a hashed version.

The author does not store the password in plain text format but as a hashed version. As security concerns, the plain text version will be easily stolen if hackers perform breaching the database. Taking that into account, virtual fields and `Crypto` - a Node.js module are used to encrypt the password. Virtual fields are additional fields for a given model. Their properties can be set manually or automatically with defined functionality. Virtual properties do not persist in the database as they only exist logically and are not written to the document's collection. [22] A whole process of encrypting a password is illustrated in Figure 14 below.

As shown in Figure 14, a plain password, along with a generated timestamp, has been encrypted by the `encryptPassword` method and saved in the `hashed_password` variable between the setter and getter methods in the virtual fields. The actual process of encrypting a plain password occurs in lines 73-76 where the `encryptPassword` method takes the plain password as an argument and does the encryption.

In the `authenticate` method, the function receives the plain password, hashes it and check if it is the same as the encrypted version saved in the database to verify the user.

```

50  userSchema
51    .virtual("password")
52    .set(function (password) {
53      //create temporary variable _password
54      this._password = password;
55      //create a timestamp
56      this.salt = uuidv1();
57      //encrypt password
58      this.hashed_password = this.encryptPassword(password);
59    })
60    .get(function () {
61      return this._password;
62    });
63
64  //methods
65  userSchema.methods = {
66    authenticate: function (plainText) {
67      return this.encryptPassword(plainText) === this.hashed_password;
68    },
69
70    encryptPassword: function (password) {
71      if (!password) return "";
72      try {
73        return crypto
74          .createHmac("sha1", this.salt)
75          .update(password)
76          .digest("hex");
77      } catch (err) {

```

Figure 14. Virtual fields and methods in user schema.

## Post schema

Figure 15 below displays the structure of the post schema in detail. The schema has various fields related to the post, including title, body, photo, likes, comments, etc. One exceptional point is the appearance of a type of `ObjectId` and `ref` of "User" in the `likes`, `postedBy` and `comments` field. It illustrates the relationship between `Post` and `User` models in the database. For instance, when a user likes a post, his/her `userId` will be store in the post model to reflect the change.



```

3  const postSchema = new mongoose.Schema({
4    title: {
5      type: String,
6      required: true,
7    },
8    body: {
9      type: String,
10     required: true,
11   },
12   photo: {
13     data: Buffer,
14     contentType: String,
15   },
16   postedBy: {
17     type: ObjectId,
18     ref: "User",
19   },
20   created: {
21     type: Date,
22     default: Date.now,
23   },
24   updated: Date,
25   likes: [{ type: ObjectId, ref: "User" }],
26   comments: [
27     {
28       text: String,
29       created: { type: Date, default: Date.now },
30       postedBy: { type: ObjectId, ref: "User" },
31     },

```

Figure 15. A post schema.

#### 4.1.3 Authentication and Authorization process

Authentication is the process of identifying an account entering the system as that person and not anyone else. It is the initial step of any system with a user element.

After determining the account's identity, the system can only answer, "Who is that?". The next equally important step, that is, to answer the question, "What can that person do in the system"? Hence, Authorization comes into play to define the permissions of the current account that has just been authenticated.

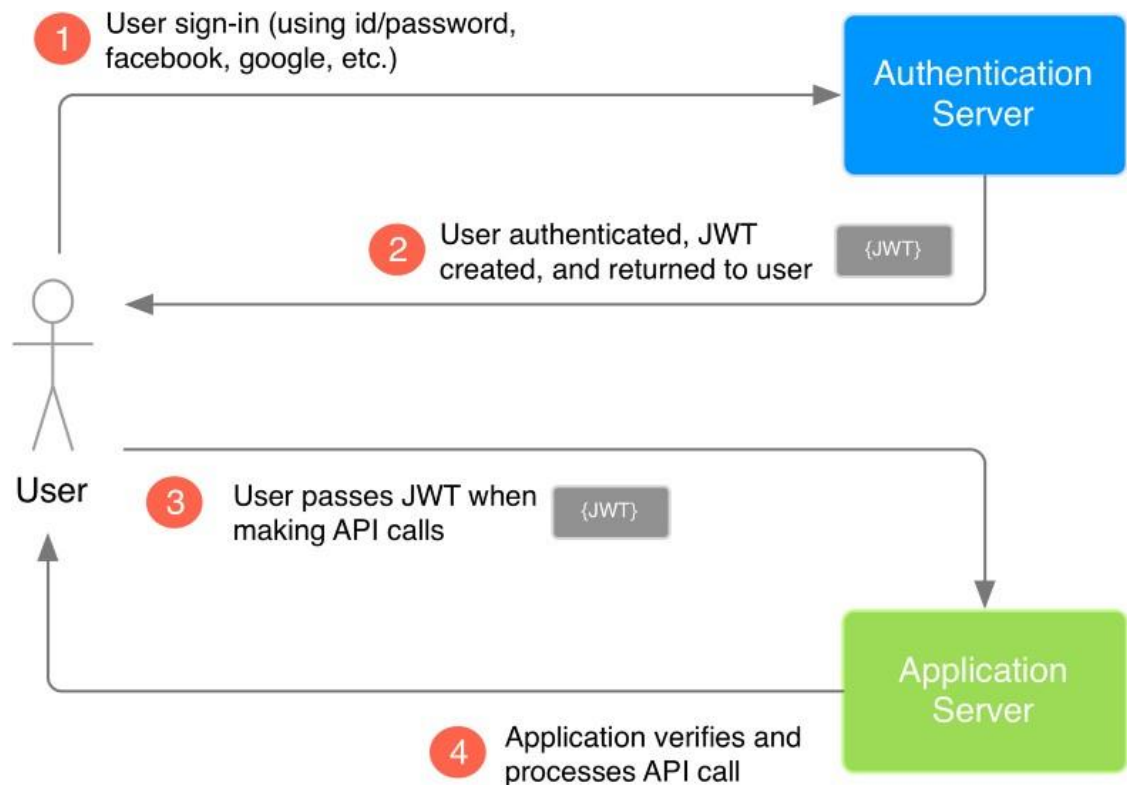


Figure 16. Authentication and Authorization with JWT.

JSON Web Token (JWT) is a JSON standard representation of the claim(s) transmitted between client and server. The token issuer digitally signs claims, and the recipient of this token can then use this digital signature to prove ownership of the claim. [23] Figure 16 above illustrates the flow of using JWT in authentication and authorization of a service:

- 1) A user performs login by sending id/password or using social network accounts on the Authentication Server.
- 2) The Authentication Server receives the data sent by the user for user authentication. In case of success, the Authentication Server will create a JWT and return it to the user via a response.
- 3) The user receives the JWT returned by the Authentication Server as the "key" to execute subsequent commands against the Application Server.
- 4) The Application Server before executing the request called from the user will verify JWT sent. If OK, continue to execute the called request.

```

21 exports.signin = (req, res) => {
22   // find the user based on email
23   const { email, password } = req.body;
24   User.findOne({ email }, (err, user) => {
25     // if err or no user
26     if (err || !user) {
27       return res.status(401).json({
28         error: "User with that email does not exist. Please signup.",
29       });
30     }
31     // if user is found make sure the email and password match
32     // create authenticate method in model and use here
33     if (!user.authenticate(password)) {
34       return res.status(401).json({
35         error: "Email and password do not match",
36       });
37     }
38     // generate a token with user id and secret
39     const token = jwt.sign(
40       { _id: user._id, role: user.role },
41       process.env.JWT_SECRET
42     );
43     // persist the token as 't' in cookie with expiry date
44     res.cookie("t", token, { expire: new Date() + 9999 });
45     // return response with user and token to frontend client
46     const { _id, name, email, role } = user;
47     return res.json({ token, user: { _id, name, email, role } });
48   });
49 };

```

Figure 17. Using JWT to sign in user.

The implementation of JWT in the `signin` controller method is depicted in Figure 17. When there is a POST request to the route `/signin`, the method `signin` is executed. First of all, email and password values are deconstructed from the request body. Then the database searches for the user using the email id. If the user does not exist, an error message indicates that the user does not exist will appear. When the user is found, the database will check the password if it is the same as the hashed version. Subsequently, a signed JWT token is generated along with the user id, the user's role, and a JWT secret (created in the `.env` variable). The token is sent back to the user in the Local Storage as a response with user details but without the password.

#### 4.1.4 Controllers and Routes

For the sake of clearness, the back-end folder will be split into three sub-folders: `controllers`, `models`, and `routes`. Folder `models` contains the mongoose schemas to define the models in the database. Folder `routes` include all the routing-related API endpoints. The `controllers` folder consists of the middleware functions to be executed when the front-end requests match the corresponding routes.

```
router.get("/users", allUsers);
```

Listing 7. An example of post-related API.

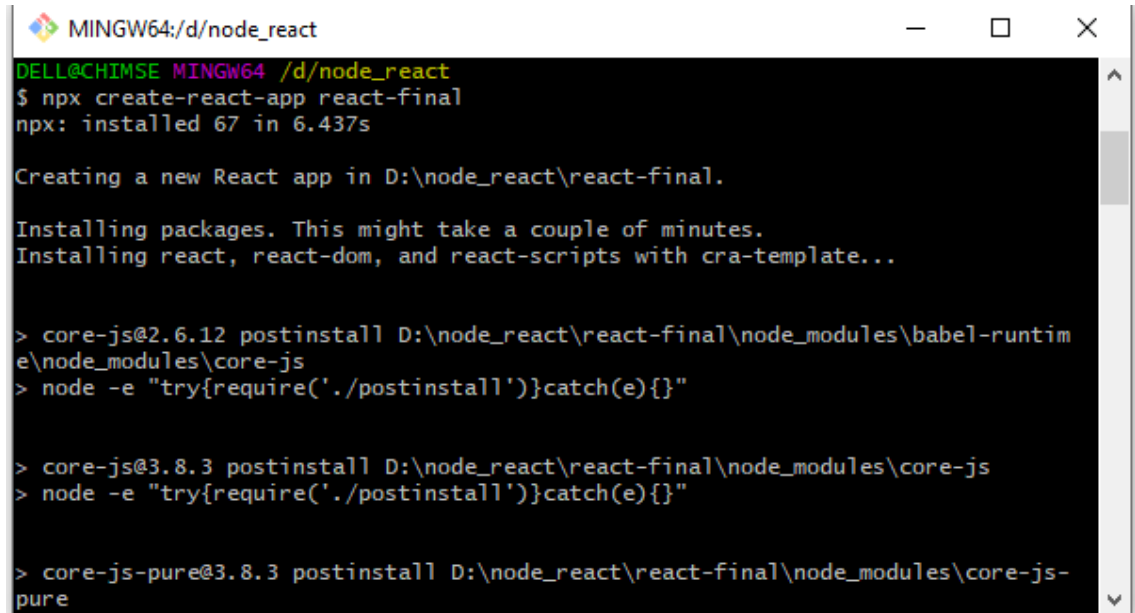
As can be seen from Listing 5, whenever a GET request from the front-end is sent to the back-end to the corresponding `"/users"` endpoint, the custom middleware function `allUsers` will be executed to retrieve all the users in the database and display them to the front-end.

## 4.2 Front-end creation

### 4.2.1 Setting up a React.js application

In the past, configuration and environment settings for new projects using React were sophisticated. The process included setting up Babel to convert JSX into browser-ready code and configuring Webpack to bundle all the application assets. Realizing this is a time-consuming and tedious process, Facebook has developed an app Node.js module named "create-react-app" to scaffold a React.js template quickly.

Figure 18 below shows the first step of creating a React.js application by running the command "npx create-react-app" with the application's name, in this case, "react-final" in the same folder that an Express.js was created.

A terminal window titled 'MINGW64:/d/node\_react' showing the execution of 'npx create-react-app react-final'. The output indicates that packages are being installed and lists postinstall scripts for 'core-js' and 'core-js-pure'.

```
MINGW64:/d/node_react
DELL@CHIMSE MINGW64 /d/node_react
$ npx create-react-app react-final
npx: installed 67 in 6.437s

Creating a new React app in D:\node_react\react-final.

Installing packages. This might take a couple of minutes.
Installing react, react-dom, and react-scripts with cra-template...

> core-js@2.6.12 postinstall D:\node_react\react-final\node_modules\babel-runtime\node_modules\core-js
> node -e "try{require('./postinstall')}catch(e){}"

> core-js@3.8.3 postinstall D:\node_react\react-final\node_modules\core-js
> node -e "try{require('./postinstall')}catch(e){}"

> core-js-pure@3.8.3 postinstall D:\node_react\react-final\node_modules\core-js-pure
```

Figure 18. Creation of a React.js app.

After successfully creating a React.js app, a command "npm start" was run to display the application in the user's default browser. The figure below shows how a React.js looks like in the browser.

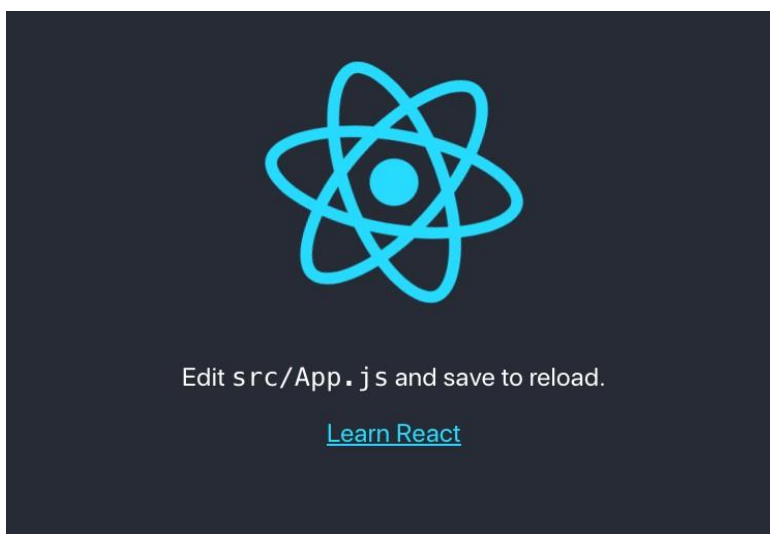


Figure 19. Initial look of a React.js app.

In the `src` folder, the `index.js` file is the entry point of the whole application. The figure below displays the flow of how a React.js app functions. Firstly, the `index.js` file imports all the necessary libraries, then it renders the root component `App.js` on the interface with the `ReactDOM.render()` method.

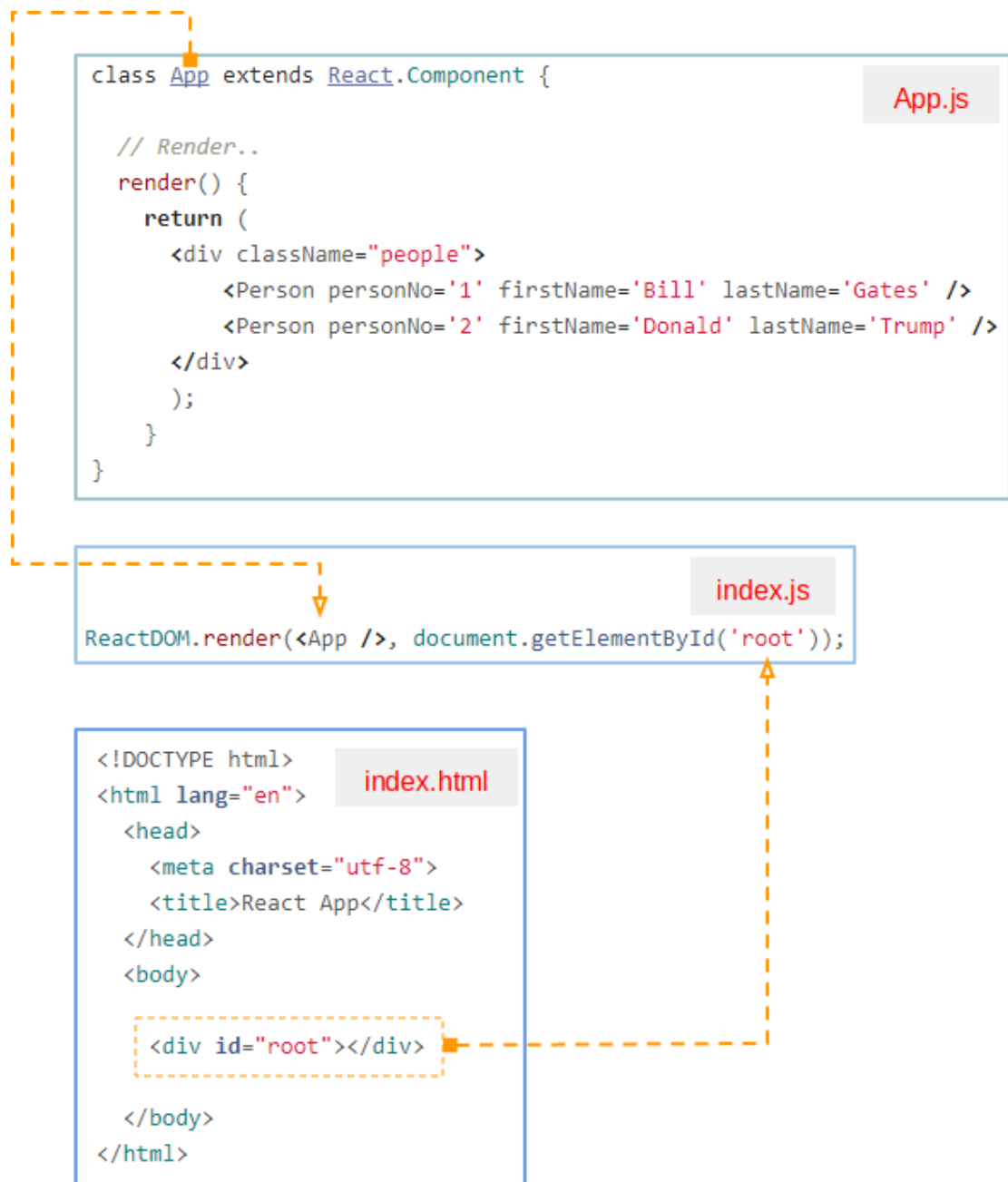


Figure 20. Flow of a React.js app.

#### 4.2.2 Setting up route in React.js app

SPA (Single Page Application) is now considered a trend to build web apps because of many outstanding features. When an app is created in the SPA philosophy, the UIs will be generated on a single page, depending on the case in which the component will be rendered.

Alternatively, users can use the URL as a condition considering which components will be rendered. In React.js, React Router is the library built to do this.

React Router is a library for standard URL navigation in React.js; it allows synchronizing UI with URL. It is designed with a simple API, which in turn allows solving problems of URLs quickly. Listing x above shows how to install React Router library in the project.

```
npm install react-router-dom
```

Listing 8. Install React Router library

```
src > JS App.js > ...
1  import React from "react";
2  import { BrowserRouter } from "react-router-dom";
3  import MainRouter from "./MainRouter";
4
5  const App = () => (
6    <BrowserRouter>
7      <MainRouter />
8    </BrowserRouter>
9  );
10 export default App;
11 |
```

Figure 21. A look of App component.

Figure 21 above shows a look of the `App` component. As discussed in section 4.2.1, `App` is the parent component of the application. For React Router to work,

minor adjustments need to be made on the `App` component. Firstly, a component named `MainRouter` was created. Then `BrowserRouter` will wrap and render everything that is inside `MainRouter`.

```
19  const MainRouter = () => (  
20    <div>  
21      <Menu />  
22      <Switch>  
23        <Route exact path="/" component={Home} />  
24        <Route exact path="/forgot-password" component={ForgotPassword} />  
25        <Route  
26          exact  
27          path="/reset-password/:resetPasswordToken"  
28          component={ResetPassword}  
29        />  
30        <Route exact path="/users" component={Users} />  
31        <Route exact path="/signup" component={Signup} />  
32        <Route exact path="/signin" component={Signin} />  
33        <PrivateRoute exact path="/user/:userId" component={Profile} />  
34        <PrivateRoute exact path="/user/edit/:userId" component={EditProfile} />  
35        <PrivateRoute exact path="/findpeople" component={FindUser} />  
36        <PrivateRoute exact path="/post/create" component={NewPost} />  
37        <PrivateRoute exact path="/post/:postId" component={SinglePost} />  
38        <PrivateRoute exact path="/post/edit/:postId" component={EditPost} />  
39        <PrivateRoute exact path="/admin" component={Admin} />  
40      </Switch>  
41    </div>  
  )
```

Figure 22. A look of `MainRouter` component.

The `MainRouter` component, as shown in Figure 22, contains all the components with their corresponding paths that will be rendered inside `BrowserRouter`. There are three primary types of components in React Router:

- Routers, such as `<BrowserRouter>` and `<HashRouter>`.
- Route matchers, such as `<Route>` and `<Switch>`.
- Redirects, such as `<Link>`, `<NavLink>`, and `<Redirect>`. [24]

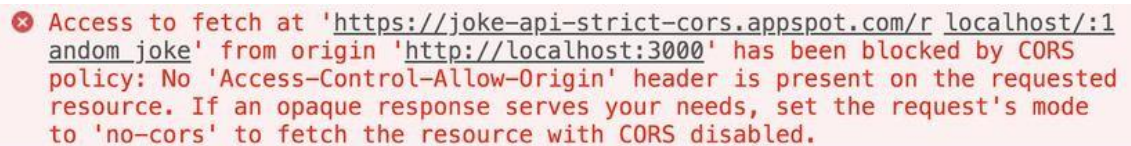
It can also be seen from Figure 22 that there are two kinds of the route in the application: public and protected. For instance, users go to the path `"/"` on the browser to access the home page but cannot go to the route `"/user/:userId"` to see a particular user's profile page, as it is a protected route.



### 4.2.3 Connection between the front-end and back-end

The CORS (Cross-origin resource sharing) error is a browser policy that prevents unauthorized access to resources from other domains. Besides, it also helps to protect users from malicious websites from unauthorized access to additional resources. [25]

If a request is called from the front-end to back-end API, an error will occur, as shown in figure 23 below. It is because both the front-end and part-end parts of the application are hosted on different domains.

A screenshot of a browser console error message. The message is in red text on a light orange background. It starts with a red 'X' icon. The text reads: "Access to fetch at 'https://joke-api-strict-cors.appspot.com/r localhost/:1 andom\_joke' from origin 'http://localhost:3000' has been blocked by CORS policy: No 'Access-Control-Allow-Origin' header is present on the requested resource. If an opaque response serves your needs, set the request's mode to 'no-cors' to fetch the resource with CORS disabled."

✖ Access to fetch at 'https://joke-api-strict-cors.appspot.com/r localhost/:1 andom\_joke' from origin 'http://localhost:3000' has been blocked by CORS policy: No 'Access-Control-Allow-Origin' header is present on the requested resource. If an opaque response serves your needs, set the request's mode to 'no-cors' to fetch the resource with CORS disabled.

Figure 23. An example of CORS error

To fix the error, a command `npm install cors` was run in the back-end directory. `cors` is a very convenient package, providing middleware that allows users to enable CORS with many options to customize and concise for MERN-based application.

### 4.2.4 Fetching data in React.js

Fetching data in React.js is an essential task as a MERN-based application is all about dynamic rendering. By using `fetch()` API, a built-in tool in most modern browsers on the window object (`window.fetch`), users can get resources from a server or an API endpoint.

```

31
32 export const list = () => {
33   return fetch(`${process.env.REACT_APP_API_URL}/users`, {
34     method: "GET",
35   })
36   .then((response) => {
37     return response.json();
38   })
39   .catch((err) => console.log(err));
40 };
41

```

Figure 24. Fetch API.

As shown in figure 24, a list of users from the database is retrieved by calling the `fetch()` API inside the `list()` method. The `fetch()` API takes in the path to the endpoint author wants to fetch, along with the method of "GET". When the request is fulfilled, it returns a promise that contains a response object. The response is just a typical HTTP response and not the actual JSON. Finally, the `json()` method is used to get the JSON body content from the response.

```

6 class Users extends Component {
7   constructor() {
8     super();
9     this.state = {
10       users: [],
11     };
12   }
13
14   componentDidMount() {
15     list().then((data) => {
16       if (data.error) {
17         console.log(data.error);
18       } else {
19         this.setState({ users: data });
20       }
21     });
22   }
23 }

```

Figure 25. Component Lifecycle.

The best place to fetch data in React.js is at the `componentDidMount()` lifecycle method as shown in figure 25. Using `componentDidMount()` will prevent data from being uploaded until the first render is complete. It reminds users to correctly state the data without getting an error. When the `Users` component has mounted, a list of users in the app will be displayed in the browser.

### 4.3 Testing the application

After successfully creating the back-end, front-end, and connection between them, it is time to test the result application. As expected, the application behaves as a fully functional social platform.

Figure 27 below displays the app's home page, which contains all the posts by the users. It is the only page that unregistered users can access the app excluded the sign-up and sign-in features. Conventionally, all the app pages will have a navigation bar at the top of the page, which helps users direct to different parts of the app.

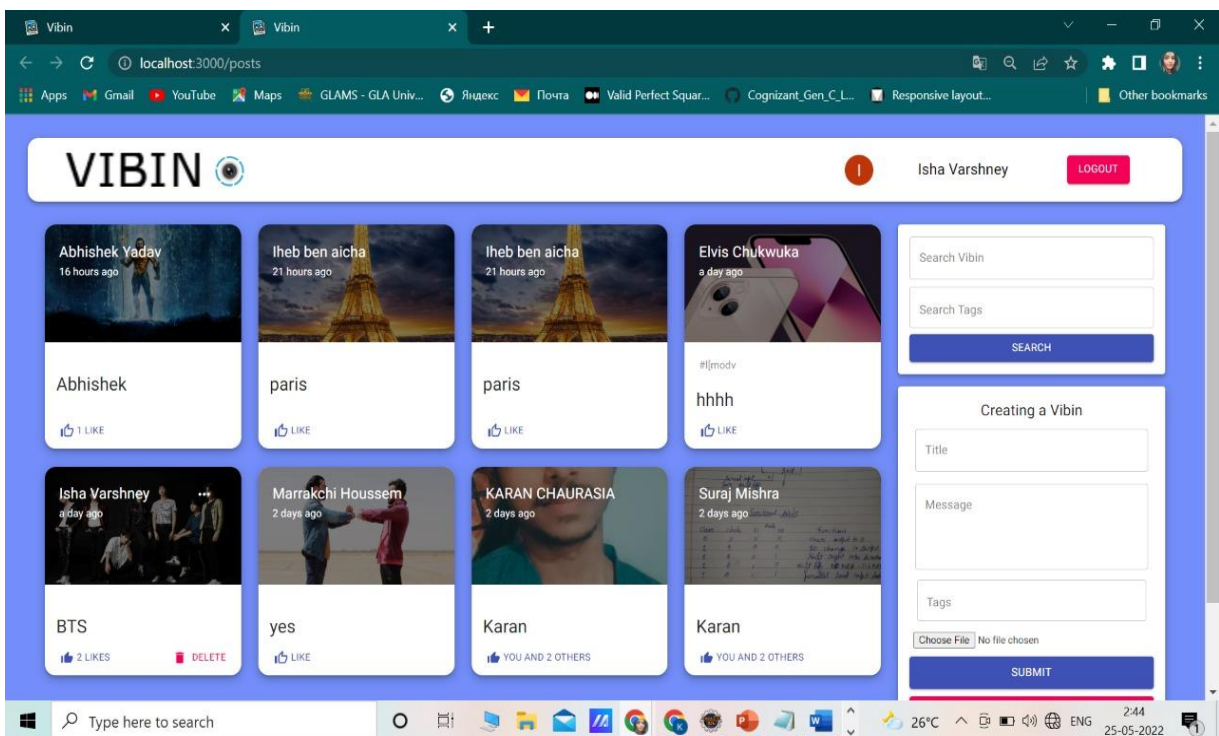


Figure 27. Initial look of homepage

To access all the app features, a visitor needs to register to the service by clicking the tab SIGN UP, filling all the required fields as figure 28 displays.

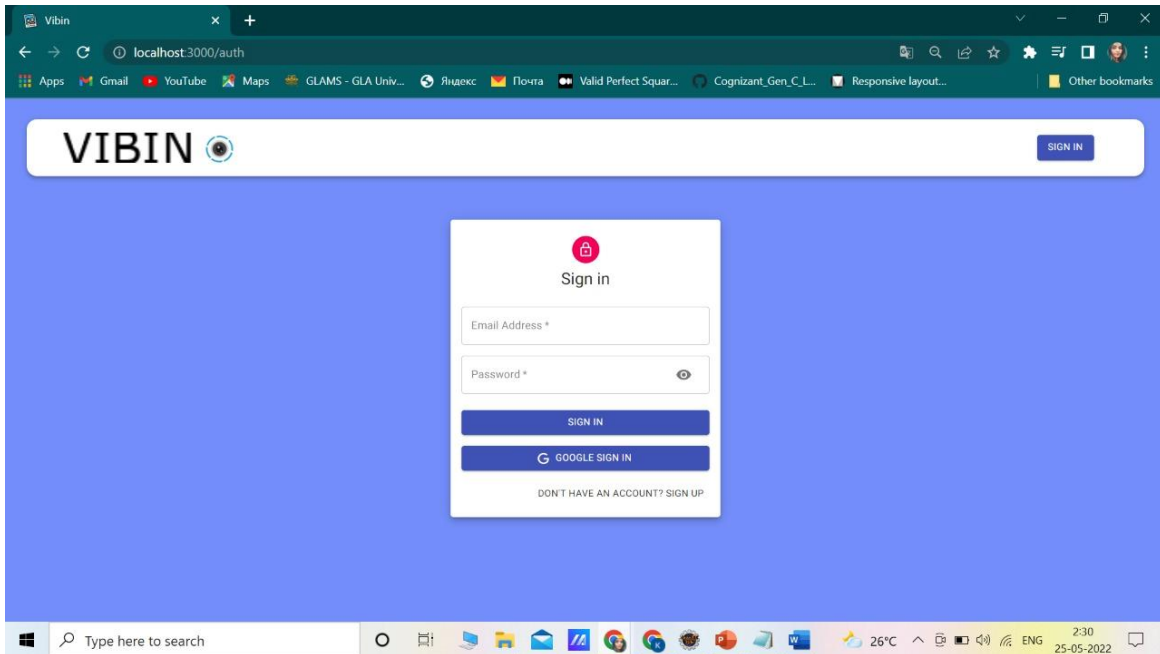
The screenshot shows a web browser window with the address bar displaying 'localhost:3000/auth'. The page has a blue background. At the top, there is a white header with the 'VIBIN' logo on the left and a 'SIGN IN' button on the right. In the center of the page, there is a white 'Sign in' form. The form contains two input fields: 'Email Address \*' and 'Password \*'. Below these fields are two buttons: 'SIGN IN' and 'GOOGLE SIGN IN'. At the bottom of the form, there is a link that says 'DON'T HAVE AN ACCOUNT? SIGN UP'. The browser's taskbar is visible at the bottom, showing various application icons and system information like '26°C' and '25-05-2022'.

Figure 28. Sign Up form

Subsequently, user can sign in with the provided email and password as shown in figure 29 below.

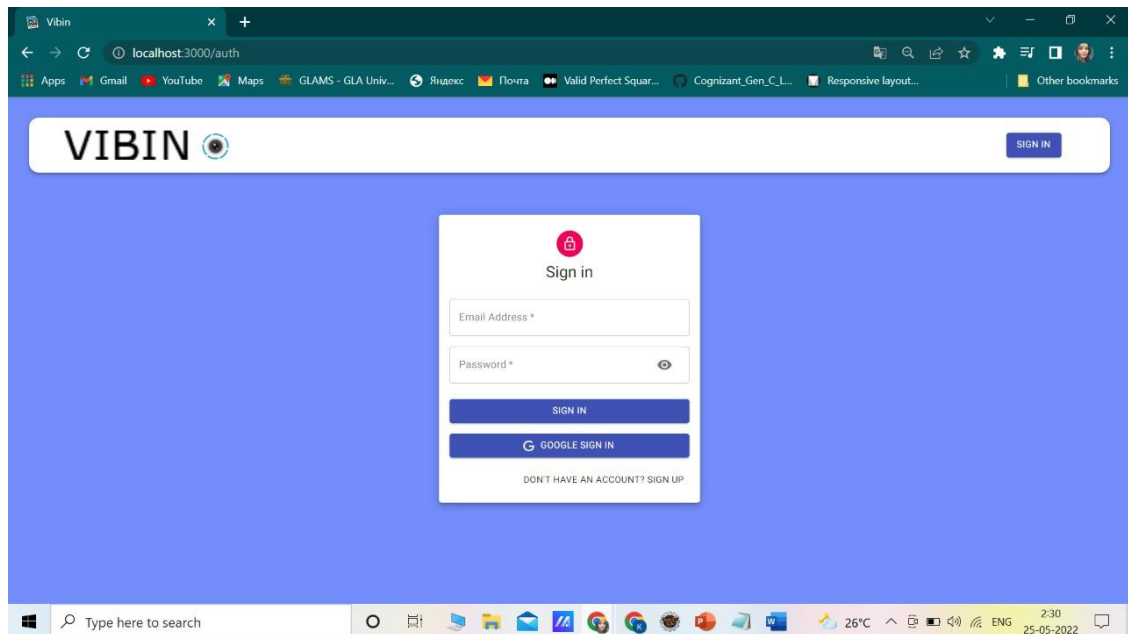


Figure 29. Sign In form

After successfully login, a user can have full access to the app, including creating post with photo upload functionality, editing his/her profile. The most interesting feature is that user can like or comment on other user's post as shown in figure 30.

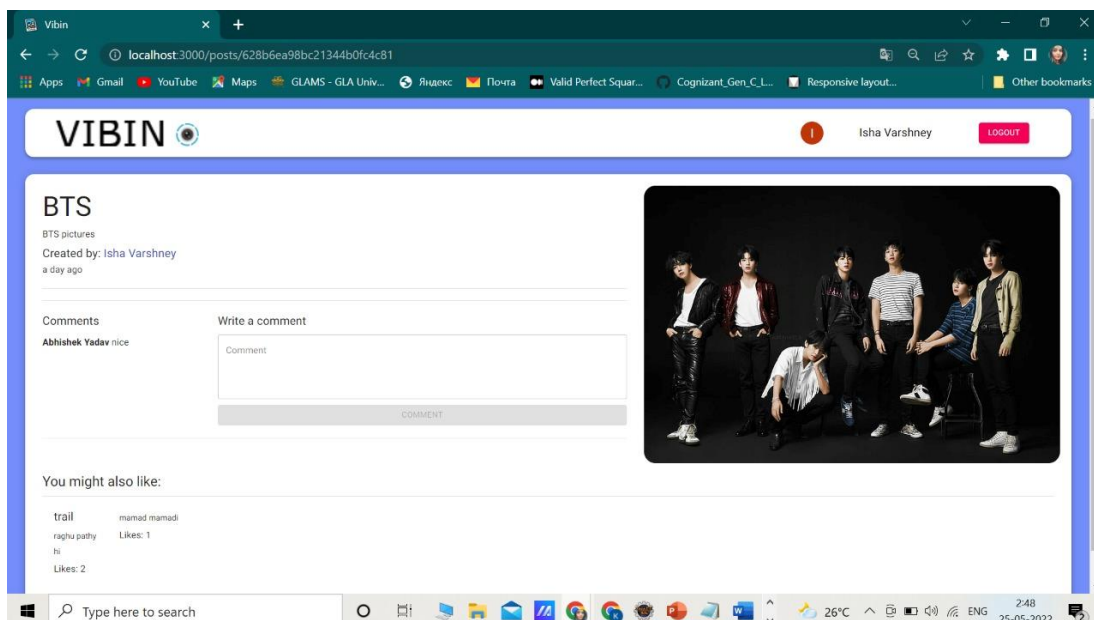


Figure 30. A single post in detail

## 5 Conclusion

In this bachelor's thesis, MERN stack and its characteristics are studied and applied to build an end-to-end social media web application. The paper has outlined comprehensively the history of JavaScript, which is the core of MERN stack, as well as the background theories, concepts, and important techniques of each technology in the stack itself. The author has demonstrated the advantages of those technologies and how they strongly unify to form an application with connected backend and frontend, aided by a NoSQL database engine.

Thereupon, detailed steps to implement the social media application have been described and thus have proven the feasibility of applying for a mentioned theories into a real-world problem. All things considered, all objectives have been accomplished and the outcome of the project can be considered successful. The application built during the project has fulfilled all minimum requirements of a social platform, given the time frame of the project. The users can share their own stories and interact with those from others through a graphical web user interface, while benefitting from a secure authentication and authorization model. This can become a strong foundation for a more sophisticated and refined product that is able of connecting people or even a more professional workplace communications system.

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