

A REPORT OF FOUR WEEK TRAINING

at

SENSATION SOFTWARE SOLUTIONS PVT. LTD. AJITGARH, PUNJAB

**SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD
OF THE DEGREE OF BACHELOR OF TECHNOLOGY**

BACHELOR OF TECHNOLOGY

(Computer Science and Engineering)



JUNE-JULY, 2025

SUBMITTED BY:

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GURU NANAK DEV ENGINEERING COLLEGE LUDHIANA

TRAINING CERTIFICATE

This is to certify that Navneet Saini, a student of Bachelor of Technology (B.Tech.) in Computer Science and Engineering, has successfully completed a four-week industrial training program titled "MERN Stack" during the period from 19th June 2025 to 18th July 2025 at Sensation Software Solutions Pvt. Ltd., Mohali. During this training, she demonstrated sincerity, enthusiasm, and a keen interest in learning various aspects of Mern Stack. The training was undertaken in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (Computer Science and Engineering).

Full Stack Development

AI & Machine Learning

Data Science

Digital Marketing


Web/Graphic Designing

Human Resources

Finance

Quality Assurance

Business Analytics



CERTIFICATE OF COMPLETION

The Training Division of
Sensation Software Solutions Pvt. Ltd.

do hereby
Recognises that


Navneet Saini


has successfully completed the training
from 19 June 2025 to 22 July 2025

He/She has successfully completed the project on
Blogging Platform

in MERN Stack

He/She attained Grade A+


Faculty Member


Director

A+	A	B+	B	C
Outstanding 100-90%	Excellent 89-80%	Very Good 79-70%	Good 69-60%	Satisfactory 59-50%

Sensation Software Solutions Pvt. Ltd.

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GURU NANAK DEV ENGINEERING COLLEGE, LUDHIANA**CANDIDATE'S DECLARATION**

I “NAVNEET SAINI” hereby declare that I have undertaken four week training “Sensation Software Solutions Pvt. Ltd. Ajitgarh, Punjab” during a period from 19th June 2025 to 18th July 2025 in partial fulfillment of requirements for the award of degree of B.Tech. (Computer Science and Engineering) at Guru Nanak Dev Engineering College, Ludhiana. The work which is being presented in the training report submitted to Department of Computer Science and Engineering at Guru Nanak Dev Engineering College, Ludhiana is an authentic record of training work.

The four week industrial training Viva–Voce Examination of _____ has been held on _____ and accepted.

Signature of Internal Examiner

Signature of External Examiner

ABSTRACT

This report presents a detailed account of the technical knowledge and practical skills acquired during the B.Tech summer training on **Web Development using the MERN Stack (MongoDB, Express.js, React.js, and Node.js)**. The primary objective of the training was to gain hands-on experience in modern full-stack web development and to understand the integration of frontend, backend, and database technologies in a practical environment.

During the training, significant emphasis was placed on learning Node.js and Express.js for server-side programming, including the creation of RESTful APIs, handling HTTP requests, and implementing middleware for secure and efficient server operations. The use of MongoDB provided exposure to NoSQL database design, document-based data modeling, query optimization, and database connectivity with the backend.

On the frontend, React.js was used to develop dynamic, component-based interfaces, providing practical experience with state management, routing, and asynchronous data handling using API calls. Additional exposure included integration of frontend and backend, debugging techniques, error handling, and implementation of authentication and authorization mechanisms.

The training also offered insights into software development life cycle practices such as requirement analysis, system design, testing, and deployment. Throughout the program, emphasis was placed on problem-solving, debugging, version control using Git, and collaborative project management.

Overall, the training significantly enhanced technical competence in full-stack development, improved understanding of modern JavaScript frameworks, database operations, and API integration. It provided a strong foundation for future academic and professional pursuits in software engineering and web application development.

ACKNOWLEDGEMENT

I take this opportunity to express my sincere gratitude to all those who guided and supported me during my summer training on Web Development using the MERN Stack.

First and foremost, I would like to thank [Mentor's Name / Training Instructor] for their invaluable guidance, technical support, and encouragement throughout the training period. Their insights and suggestions greatly helped in understanding complex concepts of full-stack development and implementing them effectively in practical scenarios.

I am also thankful to the faculty of the Department of Computer Science & Engineering, Guru Nanak Dev Engineering College Ludhiana, for providing me with the opportunity to undertake this training and for their continuous motivation and academic support.

I extend my gratitude to my friends and colleagues who assisted me during the project, offering valuable advice, constructive feedback, and collaborative support during problem-solving and debugging.

Finally, I would like to acknowledge my family for their encouragement and moral support, which enabled me to complete this training successfully.

This training experience has been instrumental in enhancing my technical knowledge, practical skills, and understanding of modern web development practices, and I am sincerely grateful to all those who contributed to this learning journey.

About the Company

Sensation Software Solutions is a leading IT services and software development company based in Mohali, Punjab, specializing in providing innovative and reliable digital solutions to clients across various industries. Established with a vision to deliver high-quality and cost-effective technology services, the company has earned a strong reputation for its commitment to excellence, professionalism, and customer satisfaction.

The organization offers a wide range of services including web and mobile application development, UI/UX design, digital marketing, software testing, and enterprise solutions. It leverages modern technologies and frameworks such as MERN Stack (MongoDB, Express.js, React.js, Node.js), Python, PHP, and JavaScript to deliver scalable, secure, and user-centric solutions tailored to client needs.

Sensation Software Solutions fosters a culture of continuous learning and innovation, encouraging interns and employees to develop practical industry-oriented skills. The company provides a supportive and collaborative environment where trainees gain exposure to real-world projects, agile development practices, and modern software engineering tools.

During my training at Sensation Software Solutions, I had the opportunity to work with experienced developers and mentors who guided me in learning full-stack web development using the MERN stack. This experience not only enhanced my technical skills but also gave me valuable insights into teamwork, project workflows, and the professional standards followed in the IT industry.

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CHAPTER 1 INTRODUCTION

1.1 Background

Web development has become a critical component of modern software engineering, enabling the creation of interactive and responsive applications that are accessible over the internet. Over the last decade, web applications have evolved from static pages to dynamic platforms that allow user interaction, data storage, and real-time updates. Blogging platforms are one such application that enables users to share content, ideas, and experiences online.

Traditional web development often involved using separate technologies for frontend and backend development, which led to complexities in integration and maintenance. The MERN stack — consisting of MongoDB, Express.js, React.js, and Node.js — provides a unified JavaScript-based approach to full-stack development. This integration simplifies development by allowing the same language, JavaScript, to be used on both client and server sides, improving efficiency and maintainability.

The MERN stack is widely adopted in the industry for developing scalable and high-performance web applications. It supports modular design, RESTful API integration, and asynchronous operations, which are essential for modern dynamic applications such as social media platforms, e-commerce websites, and blogging platforms.

The focus of this training was to gain hands-on experience in full-stack web development and to understand the practical implementation of a blogging platform using the MERN stack. This included learning about frontend design, backend server management, database design, API integration, authentication, authorization, and deployment.

1.2 Theoretical Overview of MERN Stack Components

1.2.1 MongoDB (Database Layer)

MongoDB is a NoSQL, document-oriented database that stores data in a flexible, JSON-like format called BSON (Binary JSON). Unlike traditional relational databases, MongoDB does not require a predefined schema, which allows developers to easily modify the database structure as the application evolves. This flexibility makes MongoDB particularly suitable for modern web applications that deal with dynamic and heterogeneous data. Its architecture is designed for horizontal scalability, enabling it to efficiently manage large volumes of data by distributing it across multiple servers. Furthermore, by storing data in collections of documents, it allows for rich, hierarchical information to be nested within a single record, closely mirroring how objects are used in application code.

Key concepts learned:

- **Collections and Documents:** In MongoDB, data is organized into collections and documents, which are analogous to tables and rows in relational databases. Each document represents a single record and can have varying fields, providing high flexibility in data modeling.
- **CRUD Operations:** MongoDB supports Create, Read, Update, and Delete operations. These operations were performed using queries through Mongoose to manage users, blog posts, and comments effectively within the application.
- **Database Connectivity:** The Node.js backend was connected to MongoDB using **Mongoose**, an Object Data Modeling (ODM) library. Mongoose provides a schema-based solution to model application data, perform validation, and execute queries in an organized manner. This integration ensured seamless interaction between the backend server and the database.

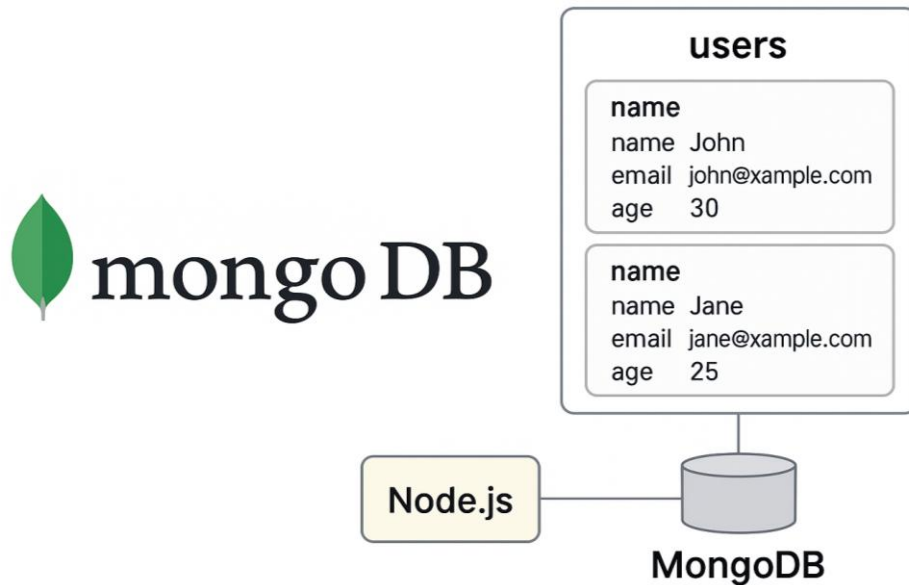


Figure 1.1 MongoDB

1.2.2 Express.js (Backend Framework)

Express.js is a lightweight and flexible web application framework for Node.js that simplifies server-side development by providing robust features for building web applications and APIs. It streamlines the process of handling HTTP requests, managing middleware, and integrating with databases, making backend development more structured and efficient. Express.js is widely used for developing RESTful APIs, enabling seamless communication between frontend and backend components of web applications.

Key topics learned :

- **Routing:** Express.js allows defining URL paths (routes) and mapping them to specific backend functions. This ensures organized handling of different client requests, such as fetching blog posts, submitting comments, or updating user profiles.
- **Middleware Functions:** Middleware in Express.js provides a mechanism to execute code between the request and response cycle. It was used for tasks such as logging request details, handling errors, validating inputs, and implementing security features like authentication and authorization.

- **RESTful API Design:** Express.js was used to design RESTful APIs for CRUD operations (Create, Read, Update, Delete). Each API endpoint corresponded to a specific function, allowing structured and predictable communication between the frontend and backend.
- **Integration with MongoDB:** The backend routes were connected with MongoDB operations using Mongoose. This integration allowed storing, retrieving, updating, and deleting data such as users, blogs, and comments efficiently, ensuring the application functions correctly in real-time.

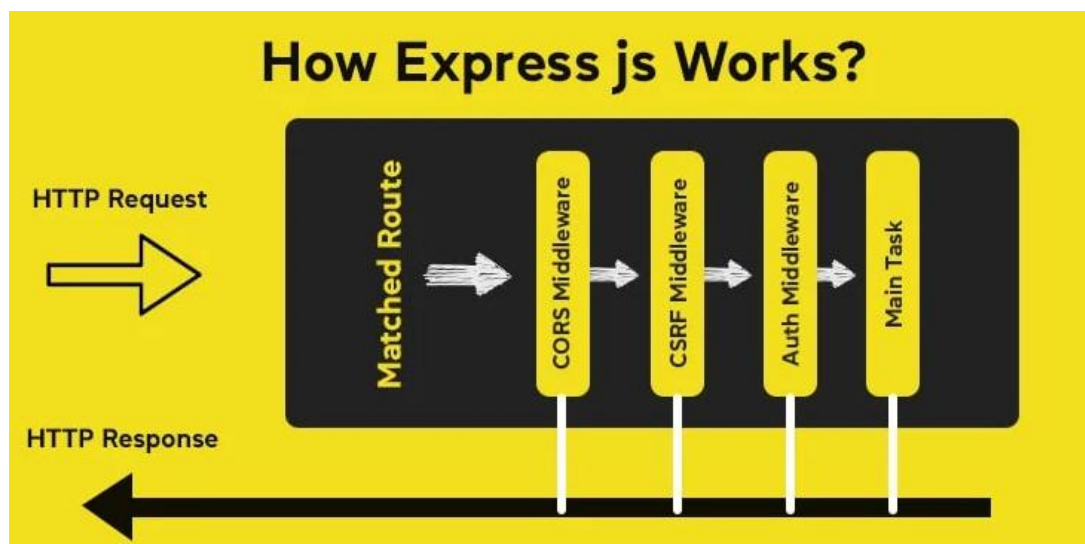


Figure 1.2 Express.js

1.2.3 React.js (Frontend Framework)

React.js is a component-based frontend library that enables the development of interactive and dynamic user interfaces for web applications. It allows developers to break the UI into reusable components, improving modularity, maintainability, and scalability of the application. React efficiently manages application state and provides a virtual DOM for optimized rendering, ensuring high performance even for complex interfaces.

Key concepts learned:

- **Components and Props:** React encourages modular design by dividing the UI into independent, reusable components. Props (properties) are used to pass data from parent components to child components, enabling dynamic rendering of content.
- **State Management:** State represents dynamic data within a component. Hooks like `useState` and `useEffect` were used to manage component state, handle side effects, and update the UI efficiently in response to user interactions.
- **Routing:** The `react-router-dom` library was used to implement client-side routing, allowing smooth navigation between different pages such as Home, Blog Details, and User Profile without reloading the browser.
- **API Integration:** `Axios` and `Fetch` APIs were used to communicate with the backend server. Data such as blogs, user profiles, and comments were fetched and displayed dynamically, demonstrating real-time interaction between frontend and backend.
- **Form Handling and Validation:** React forms were implemented for user registration, login, and blog creation. Validation techniques ensured accurate and secure user input, improving data integrity and user experience.

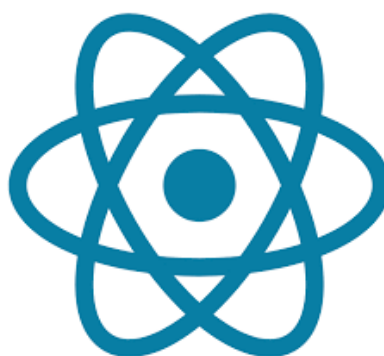


Figure 1.3 React.js

1.2.4 Node.js (Server-Side Runtime)

Node.js is a JavaScript runtime environment that allows the execution of JavaScript code outside the browser, enabling server-side programming. Its non-blocking, event-driven architecture

allows handling multiple client requests simultaneously without waiting for one task to complete before starting another. This makes Node.js particularly suitable for scalable, high-performance, and real-time web applications, such as chat systems, blogs, and APIs.

Key concepts learned:

- **Server Setup:** Node.js allows creating HTTP servers capable of handling incoming client requests and sending appropriate responses. Setting up a server is the foundation of any web application, and it was essential for connecting the frontend with backend services.
- **Package Management:** Node.js uses npm (Node Package Manager) to install and manage libraries, frameworks, and dependencies. This facilitated the inclusion of essential packages like Express.js for backend routing, Mongoose for database operations, and Axios for API calls.
- **Asynchronous Programming:** Node.js supports asynchronous operations using callbacks, promises, and async/await, which allows multiple operations (like reading from a database, processing requests, or calling APIs) to run simultaneously without blocking the server. This improves performance and responsiveness in web applications.
- **Integration with Express.js and MongoDB:** Node.js served as the runtime environment for the Express.js framework and enabled seamless communication with the MongoDB database through Mongoose. This integration was crucial for implementing complete backend services, including user authentication, blog management, and API endpoints for CRUD operations.



Figure 1.4 Node.js

1.3 Software Tools and Development Environment

During the training, various software tools and development environments were employed to facilitate the design, development, and deployment of the MERN stack blogging application. The choice of tools was guided by the need for efficiency, scalability, and ease of integration between frontend, backend, and database layers.

Table 1.1 Project Technology Stack

Tool	Purpose
Visual Studio Code	Code editor for writing frontend and backend code.
Node.js & npm	Backend runtime environment and package management.
MongoDB Atlas / Local	Database for storing users, blogs, and comments.
Postman	API testing and debugging.
Git & GitHub	Version control and project collaboration.
Browser (Chrome / Firefox)	Testing and running frontend interfaces.

1.4 Hardware Requirements

The successful execution of the MERN stack project also relied on appropriate hardware resources. The hardware requirements were defined to ensure smooth operation of development tools, efficient database handling, and optimal application performance.

Table 1.2 Hardware Specifications

Component	Specification
Processor	Intel Core i5 or equivalent
RAM	8 GB or more
Storage	250 GB SSD or more
OS	Windows 10/11 or Linux

1.5 Project Overview and Objectives

The primary objective of this project was to design and develop a full-stack web application using the MERN stack (MongoDB, Express, React, Node.js) that facilitates the creation, management, and interaction of blog content. The project aimed to provide a practical platform to apply the theoretical concepts of modern web development learned during the training program, while also addressing real-world requirements for user engagement, content management, and secure access.

1.5.1 Purpose and Motivation: With the increasing popularity of digital content, blogging platforms have become essential for knowledge sharing, personal expression, and professional communication. The motivation behind this project was to create a web-based blogging platform that allows users to share ideas and information in a structured, interactive, and secure manner. The project also sought to demonstrate practical application of the MERN stack technologies in building scalable, maintainable, and responsive web applications. By implementing this project, the objective was to enhance proficiency in frontend and backend development, database management, API integration, and user authentication mechanisms.

1.5.2 Core Features: The blogging website incorporates several key features to provide a comprehensive user experience:

- 1. User Registration and Authentication:** Secure user registration, login, and logout functionalities using JWT (JSON Web Tokens) to manage authentication and authorization.
- 2. Blog Creation and Management:** Authenticated users can create, edit, and delete blog posts with text content and multimedia support.
- 3. Commenting System:** Users can post comments on blogs, fostering interaction and engagement within the platform.

4. **User Profile Management:** Users can manage their profile information, including updating personal details and profile picture.
5. **Responsive Design:** The frontend is designed using React to ensure compatibility across multiple devices, including desktops, tablets, and mobile phones.

1.5.3 Scope of the Project: The project focuses on building a functional and secure web application that demonstrates the integration of frontend, backend, and database components in a real-world scenario. While the primary scope includes core blogging functionalities, authentication, and user management, additional features like search functionality, pagination, and real-time updates can be considered for future enhancements. The project emphasizes practical learning in software development, including project planning, coding, testing, and deployment, which collectively provide hands-on experience of the complete software development lifecycle.

1.5.4 Technologies Used:

- **MongoDB:** For storing and managing user profiles, blogs, and comments in a flexible, document-oriented database.
- **Express.js:** As the backend framework to handle server-side logic, routing, and RESTful API development.
- **React.js:** For building a dynamic, component-based, and responsive frontend interface.
- **Node.js:** To run the server-side JavaScript code and manage asynchronous operations efficiently.
- **Additional Tools:** Postman for API testing, Git and GitHub for version control, and VS Code as the development environment.

Overall, this project serves as a practical implementation of MERN stack development, allowing the integration of theoretical knowledge with hands-on skills in full-stack web application

development. It also provides a foundation for further exploration into advanced features such as cloud deployment, performance optimization, and enhanced security.

1.6 Learning Outcomes

The training provided exposure to:

- Full-stack application development using MERN stack.
- Integration of frontend, backend, and database.
- Implementation of RESTful APIs and secure authentication mechanisms.
- Understanding of software development life cycle (SDLC).
- Experience with debugging, testing, and deployment.

CHAPTER 2 TRAINING WORK UNDERTAKEN

2.1 Overview of Training Methodology and Learning Framework

The industrial training was undertaken to develop a comprehensive understanding of full-stack web development using the MERN (MongoDB, Express.js, React.js, Node.js) technology stack. The training followed a structured and sequential methodology, designed to progress from conceptual learning to practical implementation through systematic experimentation and iterative development. This hands-on approach focused on building the blogging platform incrementally, where each module was designed, coded, and rigorously tested before being integrated into the larger system, ensuring a stable and robust foundation.

The methodology was divided into progressive phases emphasizing conceptual clarity, environment setup, backend–frontend integration, authentication mechanisms, and deployment strategies. Each phase contributed to a deeper understanding of end-to-end web application architecture, ensuring both theoretical reinforcement and applied proficiency. This framework not only guided the technical implementation but also fostered critical problem-solving skills through direct engagement with real-world development challenges, such as debugging API endpoints, managing application state, and ensuring secure data transmission.

Table 2.1 Phased Learning Framework

Phase	Core Area	Learning Objective	Tools/Technologies Used
I	Web Development Fundamentals	Comprehend web architecture and RESTful communication	HTML, CSS, JavaScript
II	Environment Configuration	Establish development environment and tools	VS Code, Git, Node.js, MongoDB
III	Backend Implementation	Design and implement RESTful APIs	Express.js, Mongoose
IV	Frontend Development	Develop responsive user interfaces	React.js, Axios, Tailwind CSS
V	Authentication and Security	Implement secure access and authorization mechanisms	JWT, Middleware, bcrypt.js
VI	Testing and Deployment	Validate and host complete web application	Postman, Render

2.2 Web Development Fundamentals

Web development in modern software engineering involves creating interactive, dynamic, and data-driven applications that provide end-users with seamless access to information and services. A strong understanding of foundational concepts is critical to ensure the development of efficient, scalable, and secure applications. The initial stage of the training focused on the theoretical and practical understanding of these concepts, which serve as the backbone for full-stack development.

2.2.1 Client-Server Architecture

The client-server model defines the interaction between the user interface (client), the application logic (server), and the data storage system (database).

- **Client (Frontend):** Responsible for presenting data and user interface elements. It sends requests to the server based on user actions, such as submitting a form or fetching content.
- **Server (Backend):** Handles business logic, processes requests, validates data, and communicates with the database.
- **Database:** Persistent storage layer that stores structured or unstructured data. The server interacts with the database using queries to retrieve, create, update, or delete information.

The model ensures separation of concerns, improving maintainability and scalability. Proper client-server interaction is crucial for handling multiple concurrent users efficiently, minimizing latency, and ensuring data consistency. The communication between these tiers is typically managed through a well-defined API (Application Programming Interface), which acts as a contract for how data is requested and exchanged, often using the HTTP protocol. This architectural decoupling allows the client and server to evolve independently, enabling specialized teams to work on each part without disrupting the others.

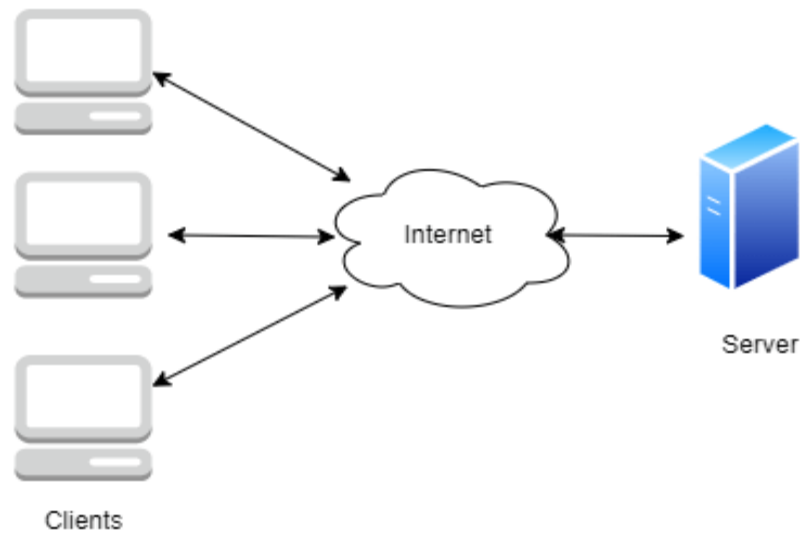


Figure 2.1 Client-Server Architecture

2.2.2 HTTP Protocols

Hypertext Transfer Protocol (HTTP) is the foundation of communication between clients and servers on the web. As a request-response protocol, it defines the rules for how messages are formatted and transmitted across the internet. When a user interacts with a website, their browser sends an HTTP request to the server hosting the site. The server then processes this request and sends back an HTTP response, which might contain an HTML page, an image, or data.

- **Request Methods:**
 - **GET:** Retrieve resources from the server.
 - **POST:** Submit data to create new resources.
 - **PUT/PATCH:** Update existing resources.
 - **DELETE:** Remove resources from the server.
- **Status Codes:** Indicate the result of HTTP requests, e.g., 200 (OK), 201 (Created), 400 (Bad Request), 401 (Unauthorized), 404 (Not Found), 500 (Internal Server Error).
- **Headers:** Carry metadata such as content type (Content-Type: application/json), authorization tokens (Authorization: Bearer <token>), and caching directives.

Table 2.2 HTTP Methods and Their Use Cases

HTTP Method	Purpose	Typical Use Case
GET	Retrieve data	Fetch list of blogs
POST	Create resource	Submit a new blog
PUT	Update resource	Edit existing blog
DELETE	Remove resource	Delete a comment

2.2.3 RESTful API Principles

Representational State Transfer (REST) is an architectural style, or a set of design principles, for designing networked applications. Think of it not as a strict protocol, but as a set of guidelines that, when followed, lead to scalable, reliable, and easy-to-use web services. It leverages the existing standards of the web, primarily the HTTP protocol, to enable communication between a client and a server.

- **Stateless Communication:** Each HTTP request contains all the necessary information, allowing the server to process it independently.
- **Uniform Resource Identification:** Resources are identified using URLs, e.g., `/api/blogs/123` refers to a blog with ID 123.
- **CRUD Operations:** RESTful APIs use standard HTTP methods for Create, Read, Update, and Delete operations.
- **Response Formatting:** JSON is the standard format for transmitting data between client and server due to its lightweight and easily parsable structure.

2.2.4 JSON Data Interchange

JavaScript Object Notation (JSON) is a lightweight, text-based format used to exchange data between frontend and backend.

- **Structure:** Key-value pairs, arrays, nested objects.

- **Advantages:** Human-readable, language-independent, compatible with JavaScript natively.
- **Use Case in Training:** All APIs for the blogging platform (users, blogs, comments) exchanged request and response data in JSON format, enabling seamless integration between React frontend and Node.js/Express backend.

2.3 Development Environment Setup and JavaScript Fundamentals

A structured development environment has been established to facilitate efficient coding, debugging, version control, and integration with databases and APIs, ensuring consistency across development and production stages.

2.3.1 Integrated Development Environment (IDE) and Tools: Visual Studio Code (VS Code)

served as the primary IDE, offering extensive support for multiple programming languages and frameworks. Its features, including intelligent code completion, integrated terminal, and debugging capabilities, enhance productivity and code quality. Version control employed Git, with repositories hosted on GitHub, enabling collaborative development, tracking of changes, and maintenance of code history.

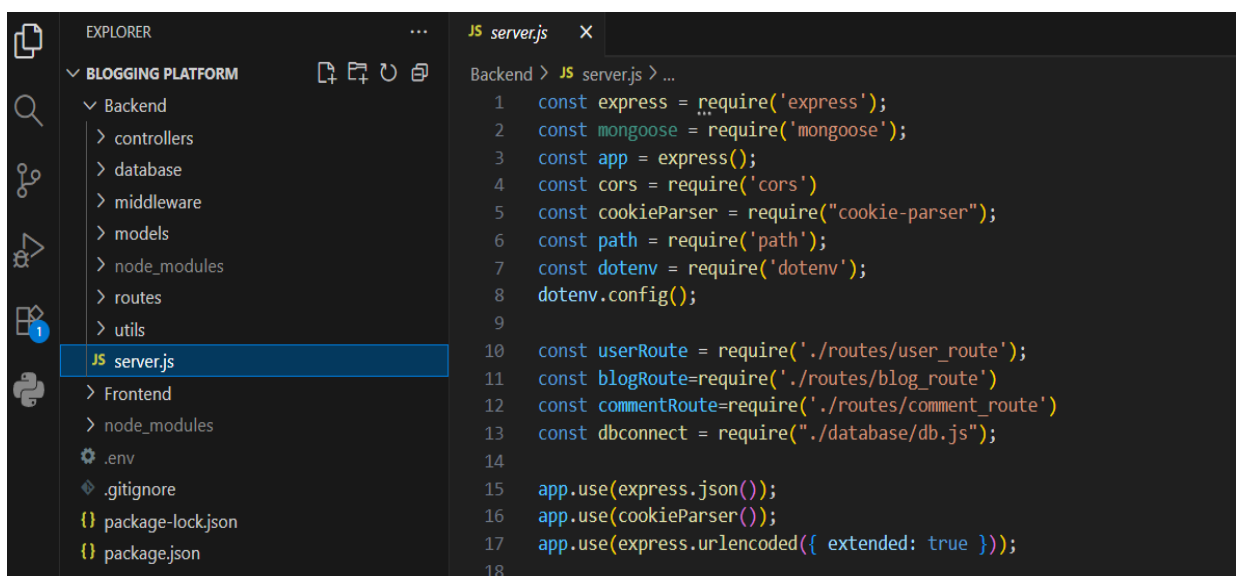
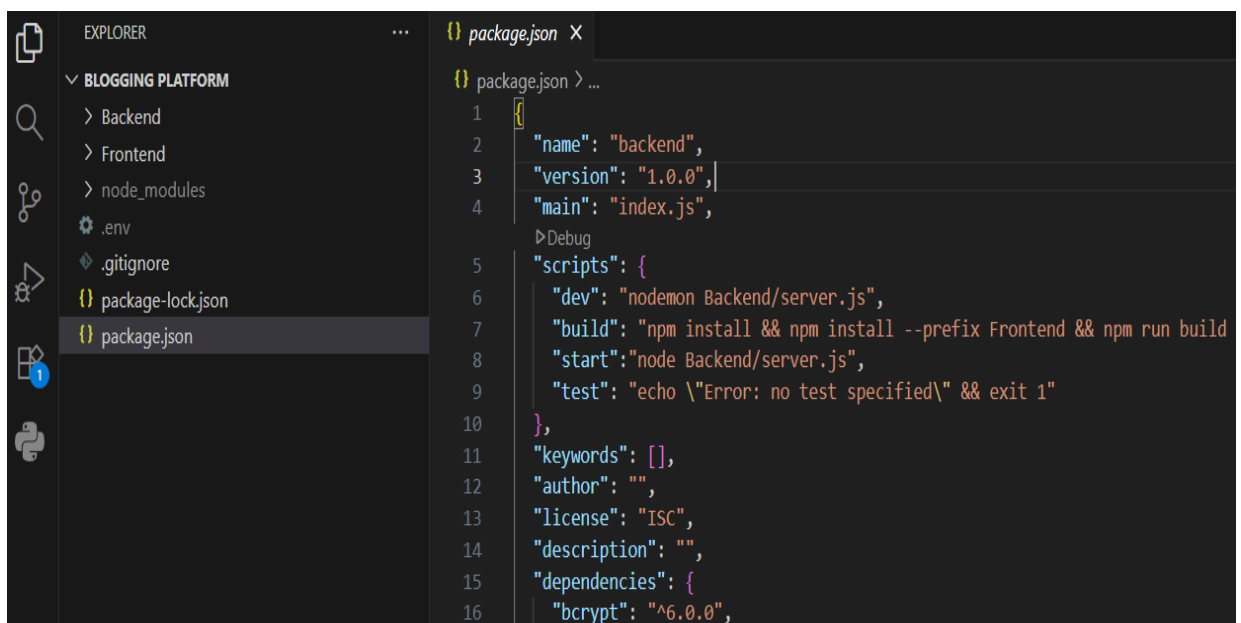


Figure 2.2 VS Code Project Setup

2.3.2 Runtime Environment and Package Management: The project leveraged Node.js as the server-side runtime environment, which facilitates the execution of JavaScript code outside the confines of a web browser. Its non-blocking, event-driven architecture is a key feature, enabling the backend to handle numerous concurrent connections with high efficiency and low latency—a critical requirement for modern, data-intensive applications. This allows for the creation of scalable network applications that can process requests asynchronously without impeding the main execution thread.



The screenshot shows the Visual Studio Code interface. On the left, the Explorer sidebar displays a file tree for a project named 'BLOGGING PLATFORM'. The files listed are 'Backend', 'Frontend', 'node_modules', '.env', '.gitignore', 'package-lock.json', and 'package.json'. The 'package.json' file is selected and its content is displayed in the main editor area. The code is as follows:

```

1  {
2    "name": "backend",
3    "version": "1.0.0",
4    "main": "index.js",
5    "scripts": {
6      "dev": "nodemon Backend/server.js",
7      "build": "npm install && npm install --prefix Frontend && npm run build",
8      "start": "node Backend/server.js",
9      "test": "echo \"Error: no test specified\" && exit 1"
10   },
11   "keywords": [],
12   "author": "",
13   "license": "ISC",
14   "description": "",
15   "dependencies": {
16     "bcrypt": "^6.0.0",

```

Figure 2.3 NPM Scripts

2.3.3 Database Integration: The project employs MongoDB as its data persistence layer, a decision driven by the database's inherent schema flexibility and horizontal scalability. To support the complete development lifecycle, a dual-environment strategy is implemented. For production, MongoDB Atlas provides a fully-managed, cloud-hosted database, which handles operational complexities such as security and backups. A local MongoDB instance complements this by supporting all development and testing phases, offering a high-speed, offline-capable environment for rapid iteration. This configuration ensures a seamless and reliable transition between the local development workspace and the cloud-hosted production environment..

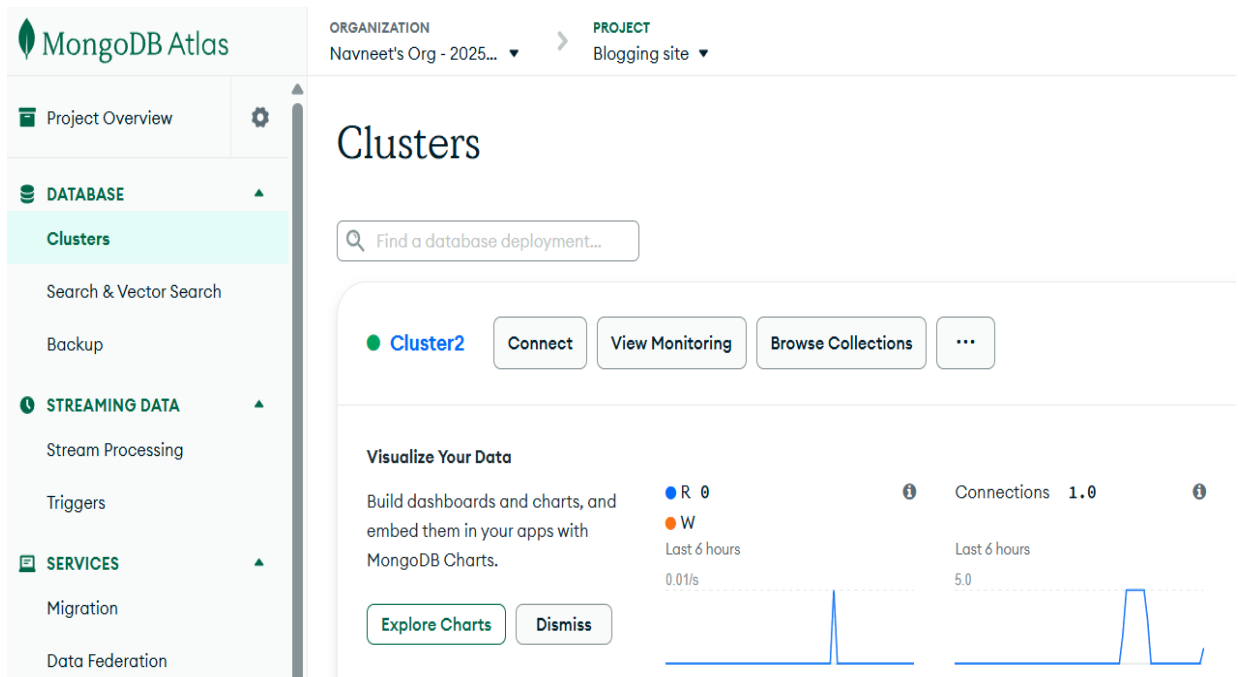


Figure 2.4 MongoDB Atlas Cluster

2.3.4 API Testing and Debugging: Postman facilitated API testing and endpoint validation, ensuring proper functionality of HTTP requests, responses, and integration with frontend components.

2.3.5 JavaScript ES6 Concepts Applied: Modern JavaScript (ES6) features enhanced code readability, maintainability, and efficiency:

- **Arrow Functions:** Simplified function expressions for concise syntax.
- **let and const:** Enabled block-scoped variable declarations.
- **Template Literals:** Facilitated string interpolation and multi-line strings.
- **Modules:** Promoted modular and reusable code via export and import.
- **Async/Await:** Streamlined asynchronous operations for database and API interactions.
- **Destructuring and Spread Operators:** Enabled efficient extraction, merging, and manipulation of objects and arrays.

2.4 Backend Development and Database Integration

The backend and database layers were systematically implemented to ensure reliable data management, secure communication, and efficient API performance. The development process was architected around principles of modular design, maintainability, and strict adherence to RESTful conventions, establishing a robust foundation for the application's server-side logic.

2.4.1 Express.js Server Configuration: The backend architecture employed Express.js, a minimalist and high-performance Node.js framework, to manage HTTP requests and responses. Dedicated routes were configured for major endpoints:

- **/api/users** – Handling user registration, login, and profile management.
- **/api/blogs** – Managing blog creation, retrieval, updating, and deletion.
- **/api/comments** – Processing user comments associated with blogs.

These routes enable a structured API design that supports separation of concerns and maintainable routing logic.

```
const express = require('express');
const app = express();
const dotenv = require('dotenv');
dotenv.config();

const userRoute = require('./routes/user_route');
const blogRoute = require('./routes/blog_route');
const commentRoute = require('./routes/comment_route');

app.use("/api/user", userRoute)
app.use("/api/blog", blogRoute)
app.use("/api/comment", commentRoute)
const PORT = process.env.PORT || 5000;
app.listen(PORT, () => console.log(`Server running on port ${PORT}`));
```

Figure 2.5 Express.js API Route Configuration.

2.4.2 Middleware Implementation: Multiple middleware functions were incorporated to enhance security, reliability, and performance.

- **Input Validation:** Ensured incoming data met defined format and schema requirements.
- **JWT-Based Authentication:** Implemented secure user authentication through JSON Web Tokens (JWT), allowing authorized access to protected routes.
- **Error Handling:** Managed exceptions and ensured uniform error responses across the API.
- **Request Logging:** Recorded client requests using middleware such as *morgan*, facilitating debugging and monitoring of system activity.

2.4.3 Database Design Using Mongoose: The database layer for the application was constructed using MongoDB in conjunction with Mongoose, an Object Data Modeling (ODM) library specifically designed for Node.js environments. Mongoose serves as a crucial abstraction layer, imposing a structured, schema-based framework on top of MongoDB's inherently flexible, schema-less architecture. This approach simplifies schema definition by allowing developers to define a blueprint for their data directly within the application code. Three primary collections were designed:

- **Users Collection:** Contained credentials, roles, and authentication data.
- **Blogs Collection:** Stored blog titles, content, timestamps, and author references.
- **Comments Collection:** Maintained user comments linked to corresponding blogs.

Schema relationships were established through object references, enabling population of related documents and ensuring data consistency across collections. Validation rules and default values were also defined to maintain data integrity.

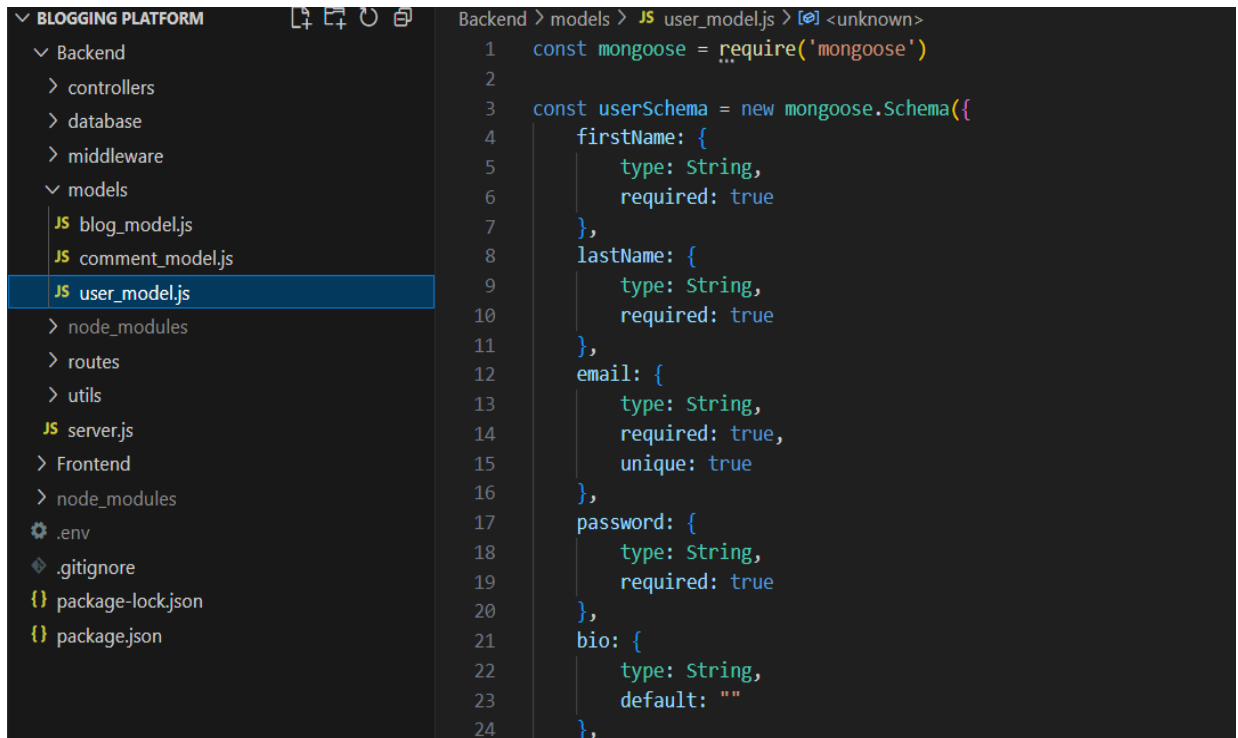


Figure 2.6 Database Schema

2.4.4 API Implementation: The backend incorporated CRUD (Create, Read, Update, Delete) functionalities for all major entities, adhering to RESTful API design conventions. Additionally, aggregation pipelines were developed to efficiently retrieve blogs along with their associated comments and author information. These pipelines improved data processing performance by reducing multiple database queries into optimized operations.

2.5 Frontend Development with React.js

The frontend segment of the system employed React.js, a modern JavaScript library facilitating the development of dynamic, modular, and responsive user interfaces. The design followed structured architectural principles emphasizing reusability, component hierarchy, and seamless interaction with the backend through APIs.

2.5.1 Component-Based Architecture

The user interface adhered to a component-driven design, wherein individual interface elements were developed as independent and reusable modules. This approach promotes maintainability, consistency, and scalability within the application.

The primary components of the interface are outlined below:

Table 2.3 Overview of Primary UI Components

Component Name	Primary Function	Description
Navigation Bar	Facilitates user movement across application routes.	Provides links to sections such as Home, Blogs, and Profile.
Blog Listing Component	Displays all available blogs retrieved from the backend database.	Implements pagination and summary views of each post.
Blog Detail Component	Renders detailed information about a selected blog post.	Integrates a comment display and input system.
Create/Edit Blog Form	Enables authenticated users to create or update blog content.	Implements controlled input fields with real-time validation.
Comments Section	Displays and manages user-generated comments associated with blogs.	Ensures dynamic rendering and submission of comments via API.

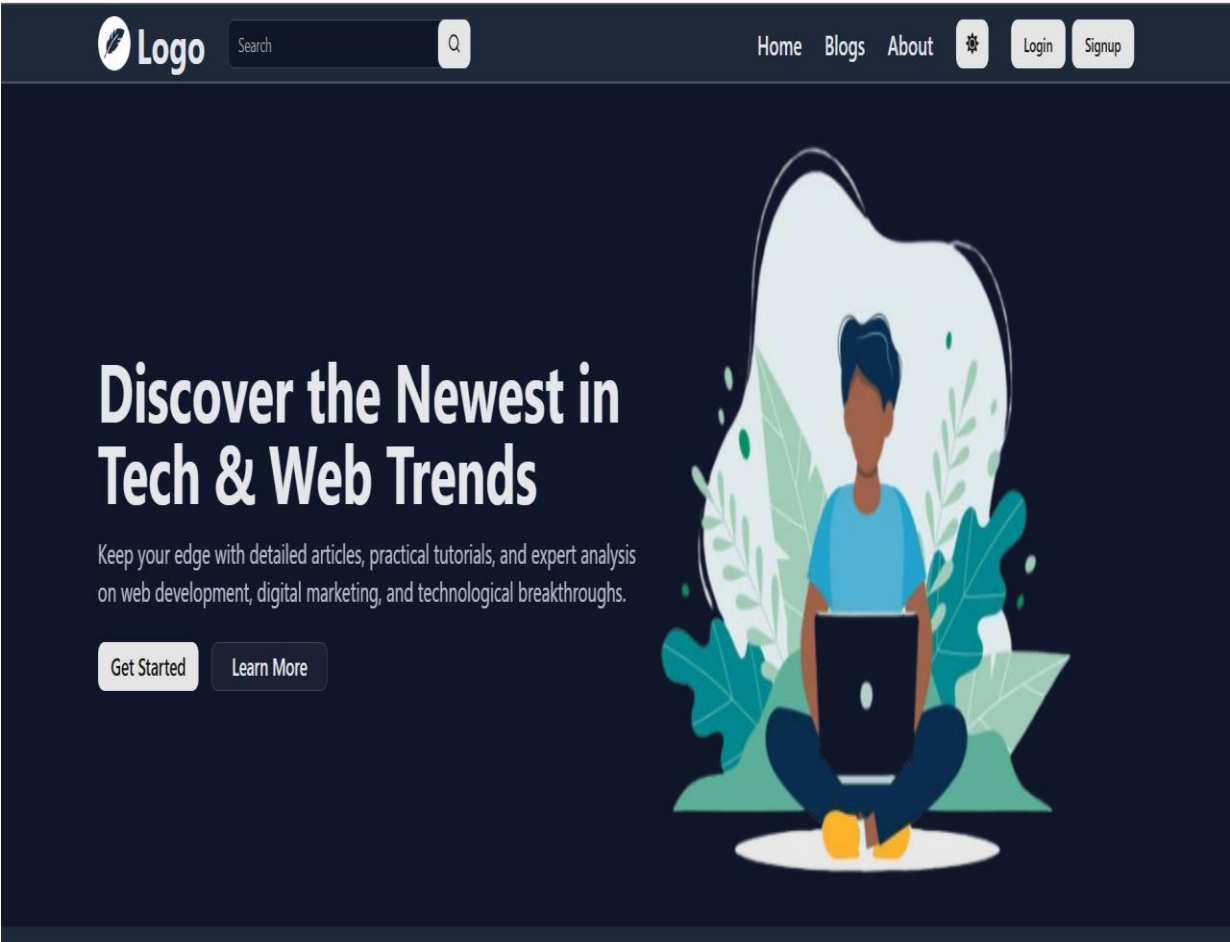


Figure 2.7 Homepage Interface

2.5.2 Routing Configuration

Routing functionalities were established through react-router-dom, enabling smooth transitions between distinct application views without requiring complete page reloads. Each route corresponds to a specific component, thereby ensuring structured navigation and improved performance.

Table 2.4 Frontend Routing Table

Route Path	Associated Component	Purpose
/	Homepage Component	Displays all published blogs.
/login	Login Component	Manages user authentication.
/register	Register Component	Handles new user creation.
/create	CreateBlog Component	Facilitates blog submission.
/blogs/:id	BlogDetail Component	Displays a single blog with comments.
/edit/:id	EditBlog Component	Provides interface for modifying existing blogs.

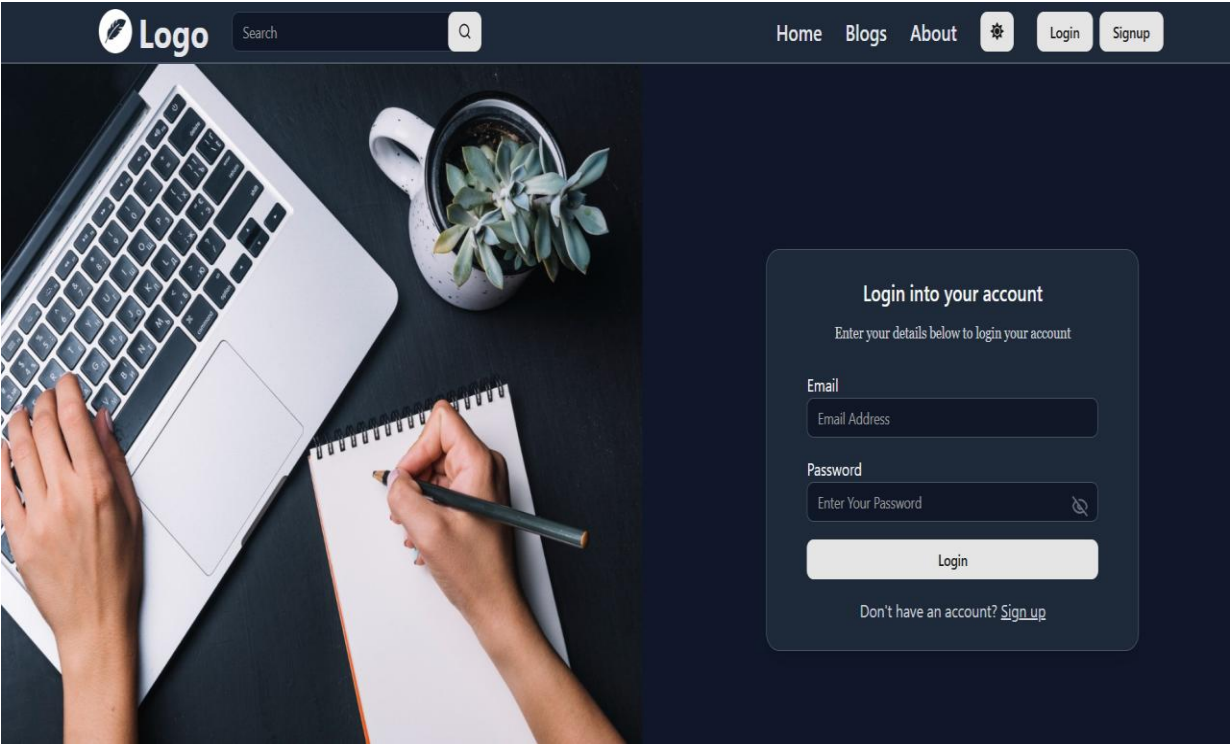


Figure 2.8 Login page interface

2.5.3 State Management and API Integration

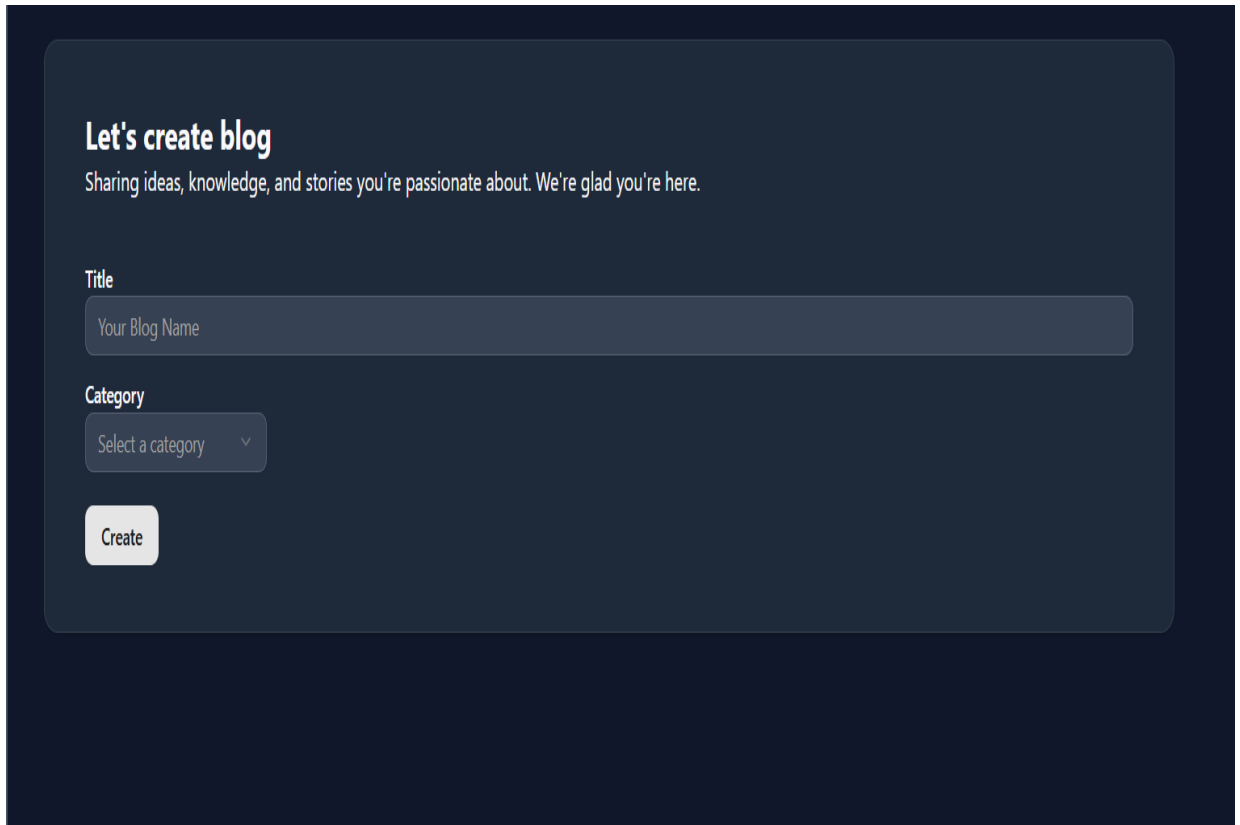
State and lifecycle management were achieved through React Hooks, specifically `useState` and `useEffect`.

- **useState Hook:** This hook was fundamental for introducing state into functional components, enabling them to manage and react to changing data. It provides a state variable and a dedicated setter function. When this setter function is called with a new value, React automatically triggers a re-render of the component and its children, ensuring the user interface remains synchronized with the underlying data.
- **useEffect Hook:** The `useEffect` hook was employed to manage all side effects—operations that interact with systems outside of the React component tree. Its primary application was for handling asynchronous data fetching. Upon component rendering, a `useEffect` hook would execute an API call to the backend. The hook's dependency array was carefully configured to control when the effect would re-run, optimizing performance by preventing unnecessary network requests.

Axios, a promise-based HTTP client, established secure communication with backend APIs, enabling real-time retrieval and manipulation of data. Error responses from APIs were intercepted and handled gracefully within the UI layer to maintain robustness.

Table 2.5 Frontend State and API Hooks.

Hook / Library	Purpose	Example of Implementation
<code>useState</code>	Maintains dynamic data within components.	Stores blog lists or form input values.
<code>useEffect</code>	Manages lifecycle events and side effects.	Fetches blogs upon component rendering.
Axios	Facilitates RESTful API communication.	Performs CRUD operations for blogs and comments.

The image shows a 'Create Blog' interface on a dark blue background. At the top, the heading 'Let's create blog' is in white, followed by the subtitle 'Sharing ideas, knowledge, and stories you're passionate about. We're glad you're here.' Below this, there are two input fields: 'Title' with a placeholder 'Your Blog Name' and 'Category' with a dropdown menu labeled 'Select a category'. A white 'Create' button is positioned at the bottom left of the form area.

Let's create blog

Sharing ideas, knowledge, and stories you're passionate about. We're glad you're here.

Title

Your Blog Name

Category

Select a category ▼

Create

Figure 2.9 Create Blog Interface

2.5.4 Form Validation and Error Handling

All input forms incorporated client-side validation to ensure submission of accurate and complete data. Validation rules were defined for mandatory fields, character limits, and permissible formats.

Dynamic error messages were rendered conditionally, providing immediate feedback to users without reloading the page. Additionally, API error responses were captured and displayed through standardized notification components to maintain interface uniformity. This dual-layer approach improves the user experience by providing instant guidance while enhancing system integrity by preventing invalid data from reaching the server.

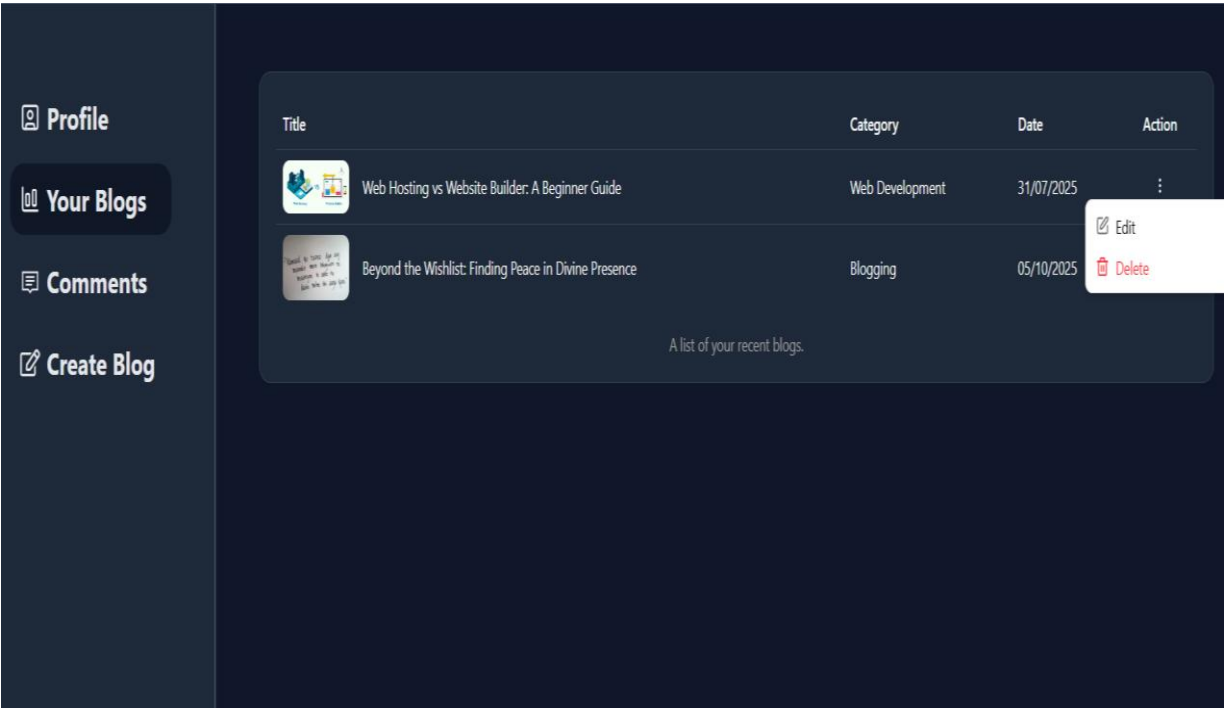


Figure 2.10 Edit Blog Interface

2.5.5 Summary of Frontend Implementation

The React.js frontend ensured modular development, optimized rendering, and responsive user interaction. Integration with backend APIs allowed consistent synchronization of data across components. The systematic combination of component-based architecture, routing mechanisms, state management, and validation strategies provided a scalable and maintainable frontend solution.

Table 2.6 Frontend Technology Stack

Feature	Technology / Concept Applied	Objective
User Interface Development	React.js Components	Modular and reusable UI design
Navigation and Routing	React Router DOM	Smooth transition between application views
State Management	React Hooks (useState, useEffect)	Efficient handling of dynamic data
API Integration	Axios	Reliable data communication with backend
Form Validation	Custom Validation Logic	Improved data accuracy and user experience

2.6 User Authentication and Security

The authentication and security subsystem was implemented to ensure controlled access to application resources, enforce user verification, and maintain data integrity throughout all communication channels. The design incorporates JSON Web Tokens (JWT) as the core mechanism for authentication and session management, combined with a structured authorization framework.

2.6.1 JWT Token Generation and Validation: During the authentication process, a unique JWT is generated for each verified user. The token is cryptographically signed using a secure secret key to prevent tampering and unauthorized modification. It encapsulates essential user credentials, including the user identifier and role attributes. Each subsequent request from the client includes this token within the HTTP authorization header, enabling the backend to validate the session before executing any operation.

2.6.2 Access Control and Route Protection: The backend system enforces strict protection mechanisms on API routes through middleware validation. Tokens are examined for authenticity and expiration prior to granting access. Routes associated with data modification, administrative actions, or sensitive information retrieval are accessible exclusively to authenticated and authorized users. This structure ensures role-based differentiation, restricting non-administrative users from executing privileged operations.

2.6.3 Frontend Security Integration: On the client interface, tokens are securely retained within the browser's protected storage environment and are appended automatically to outbound API requests. The frontend architecture ensures session continuity, token-based request verification, and systematic invalidation upon logout or session expiry. This prevents reuse of expired or invalid tokens, thereby strengthening overall security compliance.

Table 2.7 JWT Security Implementation.

Security Element	Purpose	Implementation Detail
Token Generation	Establishes authenticated session representation for verified users.	Generated using the jsonwebtoken library on successful user login.
Token Validation Middleware	Ensures that only authorized requests are executed on protected routes.	Implemented as an Express.js middleware verifying signature and expiry.
Role-Based Authorization	Restricts access to specific operations based on assigned user roles.	Role attributes encoded within the JWT payload and verified on access.
Secure Client Integration	Maintains integrity of authentication tokens during client-server exchange.	Tokens appended to HTTP headers using Axios interceptor configuration.

2.7 API Testing, Integration, and Deployment

The integration and deployment phase constituted the final validation stage of the application, ensuring functional accuracy, data consistency, and operational stability across all modules. The process encompassed systematic API testing, frontend-backend synchronization, and optimized deployment of the system on cloud-based environments. This critical phase bridges the gap between the controlled development setup and a live production setting. It serves as the ultimate verification of the system's readiness to handle real-world user interactions and data reliably.

2.7.1 API Testing and Validation

All RESTful API endpoints underwent comprehensive testing using Postman to verify CRUD (Create, Read, Update, Delete) operations. Each request was evaluated for proper status code responses (e.g., 200 OK, 201 Created, 400 Bad Request, 401 Unauthorized, and 404 Not Found), adherence to input validation rules, and enforcement of authentication protocols. This rigorous process involved testing both successful "happy path" scenarios and edge cases with invalid data to ensure the API behaves predictably under all conditions.

Automated test cases were developed within Postman to confirm accurate error responses and the correct enforcement of authorization on restricted routes. The testing process validated the

logical integrity of the request-response cycles between the client and server components. This meticulous validation was crucial in establishing a reliable and secure backend foundation, ensuring that the frontend components could interact with the API with a high degree of confidence.

Table 2.8 Backend API Validation Cases.

Testing Parameter	Description	Validation Tool
CRUD Operations	Verified creation, retrieval, updating, and deletion of blogs/comments.	Postman
Authentication & Tokens	Confirmed proper handling of JWT tokens and protected endpoints.	Postman
Input Validation	Ensured appropriate error messages for invalid inputs.	Postman
Status Code Accuracy	Verified expected response codes for all possible request outcomes.	Postman

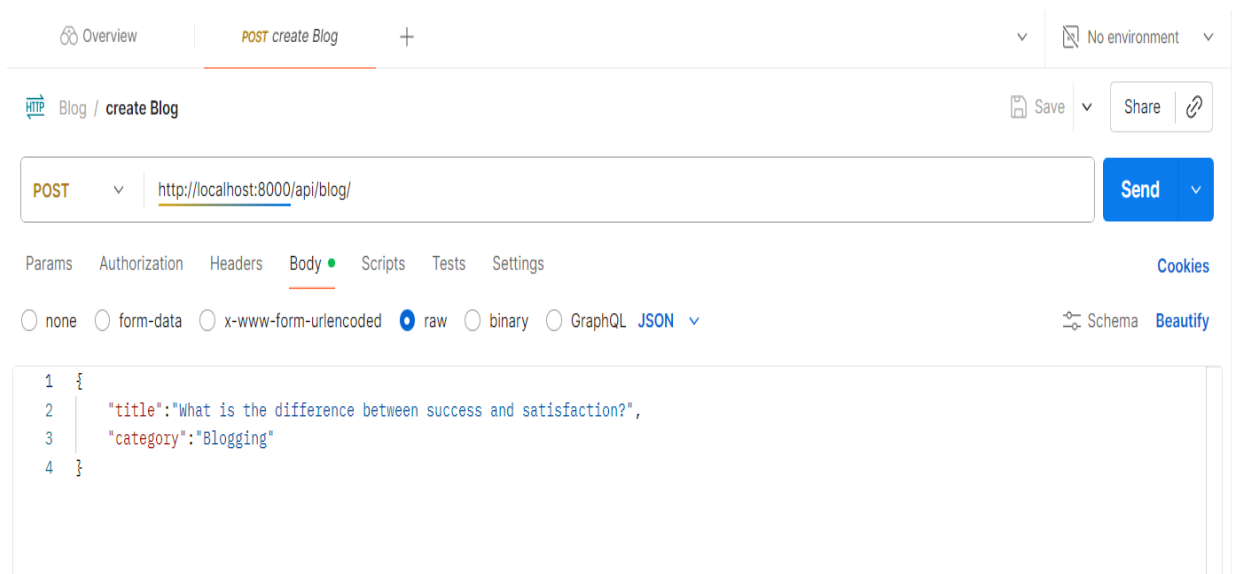


Figure 2.11 Postman API for creating blog

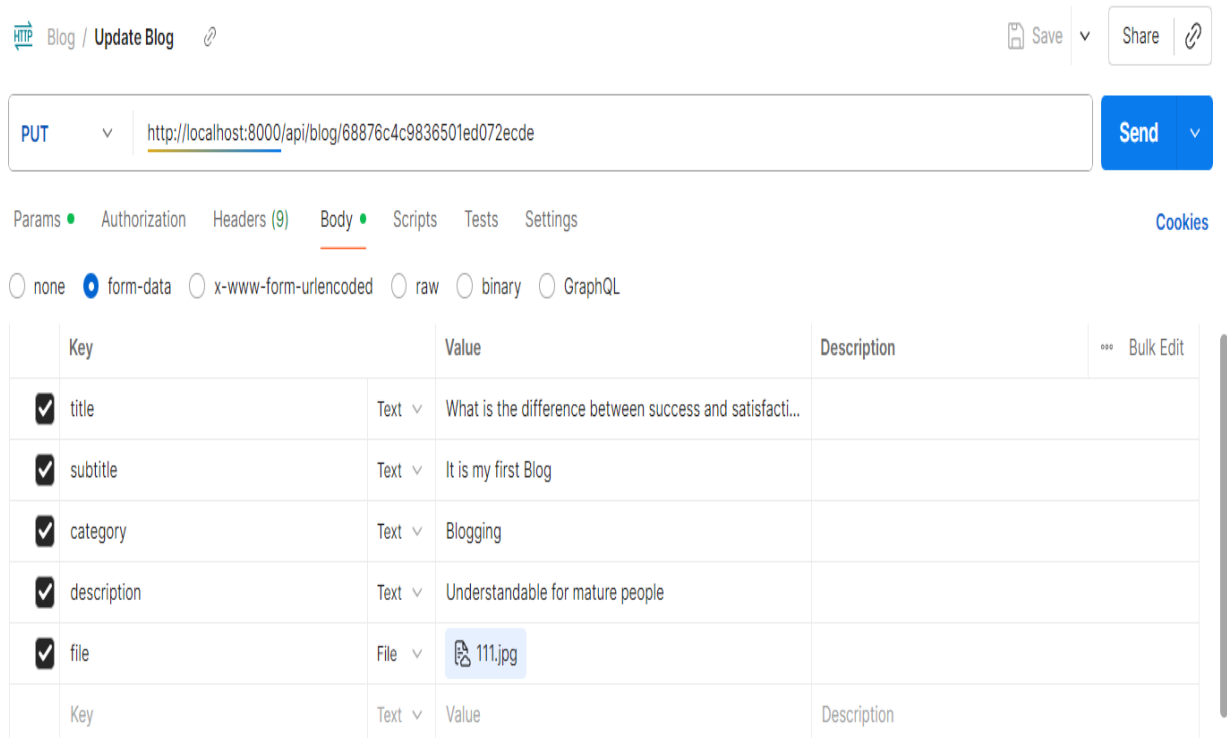


Figure 2.12 Postman API for updation of blog

2.7.2 Frontend–Backend Integration

Following validation, the React.js frontend was fully integrated with the Express.js backend to create a cohesive single-page application. The Axios library was employed as the primary HTTP client for all API communication, configured with interceptors to automatically attach the JWT to authorization headers, ensuring secure and structured data transmission for protected routes.

Dynamic rendering of blogs, user profiles, and comments was implemented using React's state management hooks. The `useEffect` hook initiated API calls to fetch data upon component mount, while the `useState` hook stored the server's response, triggering a re-render to display the retrieved information.

To permit requests from the frontend's domain to the backend server, Cross-Origin Resource Sharing (CORS) middleware was configured in the Express.js application. This crucial step enabled the decoupled architecture to function correctly. This tight integration guaranteed synchronized operation of all major modules, providing a fluid user experience where client interactions immediately and reliably reflected data manipulation on the backend.

```
import axios from 'axios';
const getPublishedBlogs = async () => {
  try {
    const token = localStorage.getItem("token");

    const response = await axios.get(
      "https://my-blogging-site-pqws.onrender.com/api/blog/get-published-blogs",
      {
        headers: {
          Authorization: `Bearer ${token}`,
        },
      },
    );
    console.log("Fetched Blogs:", response.data.blogs);
  } catch (error) {
    console.error("Error fetching blogs:", error.message);
  }
};
getPublishedBlogs();
```

Figure 2.13 Axios API Call with Token Authorization.

2.7.3 Debugging and Performance Optimization

Performance enhancement measures were systematically implemented across the full stack to ensure a highly responsive application. On the backend, this included minimizing redundant API calls, optimizing database query execution using Mongoose aggregation pipelines, and strategically ordering middleware to reduce server response latency. These strategies were crucial for reducing the server's computational load and ensuring that data-intensive requests were processed with maximum efficiency.

Frontend performance was improved through techniques such as lazy loading for components, React memoization to prevent unnecessary re-renders, and the use of centralized error boundary components for fault isolation. This holistic approach, addressing both client-side rendering and server-side processing, contributes to a significantly faster initial page load and a more fluid user experience. Furthermore, robust server-side logging and structured exception handling were established to ensure consistent runtime diagnostics, which proved invaluable for rapid debugging and proactive monitoring of the application's health in the production environment.

Table 2.9 Performance Enhancement Techniques

Optimization Technique	Purpose	Implementation Detail
Query Optimization	Reduce database access latency.	Aggregation pipelines and indexed queries.
Middleware Sequencing	Enhance request–response efficiency.	Ordered authentication and logging middlewares.
Lazy Loading & Memoization	Improve client rendering performance.	Applied to React components with high re-renders.
Centralized Error Handling	Streamline exception processing.	Unified middleware-based error management.

2.7.4 Deployment and Live Verification

For deployment, a decoupled strategy was employed, hosting the backend service on a Platform as a Service (PaaS) like Render and the frontend interface on a specialized static hosting provider such as Netlify or Vercel. This separation allows each part of the application to leverage an environment optimized for its specific needs. Environment variables were configured securely through the hosting provider's dashboard for production, ensuring that sensitive credentials like database connection strings and JWT secret keys were never hard-coded or exposed in the codebase. The local `.env` file was used exclusively for development and was included in the `.gitignore` file to prevent accidental version control commits.

Post-deployment validation involved a comprehensive suite of tests to ensure operational integrity in the live environment. This included systematically testing all live API endpoints with Postman to confirm they were accessible and functioning correctly. Database connectivity was verified by monitoring the backend service's logs for a successful connection to the MongoDB Atlas cluster. Finally, the application's complete user workflow—from registration and login to creating and commenting on a blog post—was manually inspected on the live URL to ensure stable, end-to-end performance in a production setting.

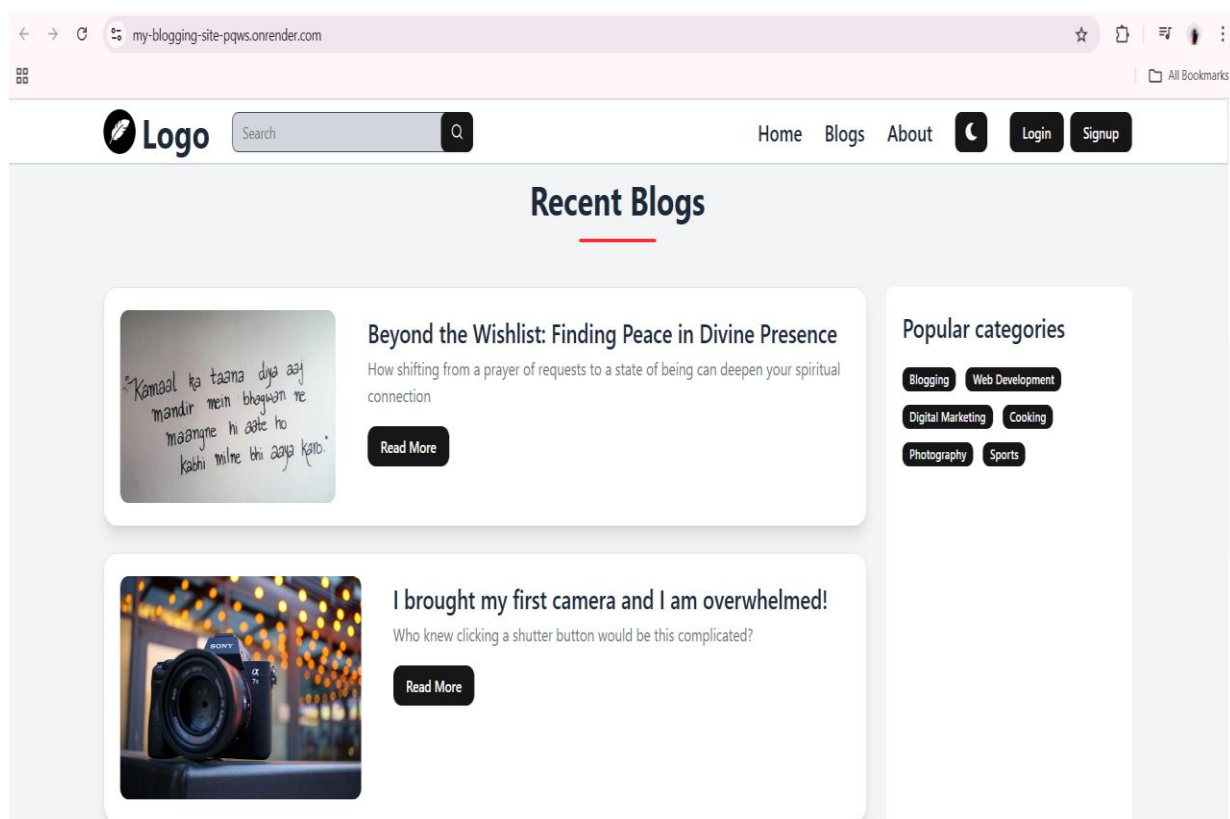


Figure 2.14 Screenshot of the deployed web application

CHAPTER 3 RESULTS AND DISCUSSIONS

This chapter provides a comprehensive analysis of the MERN stack blogging platform project, moving from the technical implementation to a critical evaluation of the final outcomes. It presents the empirical results derived from systematic testing and validation, which confirm the operational success and functional integrity of all core features. Following this, the chapter offers an in-depth discussion of the architectural and technological decisions, critically assessing their impact on key software engineering metrics like scalability and maintainability. The application's performance is also evaluated, considering both backend API response times and frontend rendering efficiency. Finally, it examines the challenges encountered during development and acknowledges the project's limitations, culminating in a clear, actionable roadmap for future enhancements.

3.1 Verification of Functional and Non-Functional Requirements

The project's primary objective—to develop and deploy a functional, full-stack blogging platform—was successfully achieved. The final application artifact is a deployed, operational system that satisfies all core functional requirements outlined in the project scope. Non-functional requirements, including responsiveness and security, were also addressed, resulting in a robust and user-centric platform. The systematic application of the MERN stack technologies resulted in a cohesive system where the frontend, backend, and database layers are seamlessly integrated.

3.2 Analysis of Core System Functionality

Each module of the application underwent rigorous testing to validate its operational correctness. The results confirm that all features perform as designed.

3.2.1 User Authentication and Authorization Subsystem

The security model, centered on JSON Web Tokens (JWT), was validated as both secure and efficient. The authentication workflow proceeds as follows:

- A user submits credentials to the `/api/users/login` endpoint.
- The Express.js backend validates the credentials against the Users collection in MongoDB.
- Upon successful validation, the jsonwebtoken library generates a signed token containing a payload with the `userId` and user role.
- This token is returned to the client, where it is stored securely (e.g., in `localStorage`).

For protected routes, such as `POST /api/blogs` or `DELETE /api/blogs/:id`, the token validation middleware is executed first. It extracts the token from the `Authorization: Bearer <token>` HTTP header and uses `jwt.verify()` to check its signature and expiration. Any request lacking a valid token is rejected with a 401 Unauthorized status code, effectively preventing unauthorized access to protected resources. This mechanism proved highly effective in implementing both authentication and role-based authorization.

3.2.2 Content Management and CRUD Operations

The RESTful API for managing content demonstrated full compliance with CRUD principles. Mongoose was instrumental in translating HTTP requests into database commands.

- **Create:** A POST request to `/api/blogs` with a valid JWT and request body triggers a new `Blog({ ... })` instance, followed by a `.save()` command, successfully creating a new document in the Blogs collection.
- **Read:** GET requests to `/api/blogs` utilize the `Blog.find()` method to retrieve all posts. For `/api/blogs/:id`, the `Blog.findById()` method is used, along with `.populate('author')` and `.populate('comments')` to dynamically include related data from other collections in a single, efficient query.

- **Update:** A PUT request to `/api/blogs/:id` is handled by the `Blog.findByIdAndUpdate()` method, allowing authenticated users to modify their own content. Authorization logic within the controller ensures a user can only edit their own posts.
- **Delete:** A DELETE request to `/api/blogs/:id` triggers the `Blog.findByIdAndDelete()` method, successfully removing the specified document from the database.

3.2.3 Dynamic and Interactive User Interface

The React.js frontend provided a fluid and intuitive user experience. The component-based architecture allowed for a clean separation of concerns on the client side.

- **Data Fetching and State Synchronization:** The `useEffect` hook was pivotal for fetching data upon component mount. For instance, the `BlogListingComponent` executes an Axios GET request inside a `useEffect` hook to retrieve all blog posts. The response is then stored in the component's state using the `useState` hook, which triggers a re-render to display the data.
- **Component Reusability:** Components like form inputs, buttons, and loading indicators were designed to be reusable across the application, which significantly accelerated development and ensured UI consistency.
- **Client-Side Routing:** The `react-router-dom` library provided seamless, single-page application (SPA) navigation. This prevented full-page reloads when navigating between views like the homepage, a blog detail page, and the create-blog form, leading to a much faster and smoother user experience.

3.3 Discussion of Architectural and Technological Strategy

The project's architecture was designed to be modular, scalable, and maintainable.

- **Benefits of the MERN Stack:** The decision to use a unified JavaScript ecosystem was highly beneficial. It eliminated the context-switching required when working with different languages for the frontend and backend. Furthermore, the native handling of

JSON by all components of the stack—from MongoDB's BSON storage to Express.js request bodies and React's state objects—created a frictionless data pipeline.

- **Advantages of a Decoupled (Headless) Architecture:** Separating the frontend and backend into two distinct applications provided immense flexibility. This architecture allows for independent scaling; the frontend can be deployed on a global CDN for fast asset delivery, while the backend API can be scaled on a PaaS provider based on computational needs. It also facilitates parallel development, where frontend and backend teams can work concurrently against a shared API specification.
- **Robustness of the Middleware Pattern:** The middleware pattern in Express.js was a cornerstone of the backend's design. It created a clean, linear request-processing pipeline (e.g., Logging -> CORS Handling -> JSON Parsing -> Authentication -> Route Handler). This approach makes the code highly modular and easy to reason about, as each middleware function has a single, well-defined responsibility.

3.4 Performance, Optimization and Scalability Analysis

Several optimization techniques were implemented to ensure the application is performant.

- **Database Performance:** By creating indexes on frequently queried fields in MongoDB (e.g., the author field in the Blogs collection), database read operations were made significantly more efficient. This practice avoids slow, full-collection scans and is critical for maintaining performance as the amount of data grows.
- **Frontend Rendering Optimization:** To prevent unnecessary re-renders in the UI, techniques like React memoization (React.memo) can be applied to components that receive props but do not need to update unless those props change. For larger applications, code-splitting with React.lazy would further improve initial load times by only loading the JavaScript needed for the current view.

- **Scalability Considerations:** While the current deployment is suitable for a moderate user base, the application is architected for future scalability. The backend can be scaled horizontally by running multiple instances behind a load balancer. The use of a managed database service like MongoDB Atlas allows for database scaling with minimal operational overhead.

3.5 Challenges and Limitations

The project, while successful, presented several challenges and has identifiable areas for future improvement.

3.5.1 Challenges Encountered

- **Asynchronous Operations Management:** Effectively managing the asynchronous nature of JavaScript, especially with nested database queries and dependencies between API calls, required careful use of `async/await` syntax to ensure code remained readable and predictable.
- **Cross-Origin Resource Sharing (CORS):** Configuring CORS policies correctly on the backend was a critical challenge in the decoupled environment to allow the frontend domain to make secure requests to the backend API.

3.5.2 Identified Limitations

- **State Management Complexity:** The reliance on component-level state with `useState` is sufficient for this application's scope. However, it does not scale well for features requiring complex, shared state across many components.
- **Lack of Real-Time Features:** The application operates on a standard request-response model. There is no mechanism for pushing real-time updates to clients, such as new comments appearing instantly for all users viewing a post.

- **Basic Security Hardening:** The current security model is foundational. It lacks advanced features like rate limiting to prevent brute-force attacks, comprehensive input sanitization to mitigate XSS risks, or measures against CSRF attacks.

CHAPTER 4 CONCLUSION

This project successfully culminated in the design, development, and deployment of a full-stack blogging application using the MERN (MongoDB, Express.js, React.js, Node.js) stack. The final artifact validates the implementation of all primary objectives, including a secure JWT-based authentication system, comprehensive CRUD functionalities for content management, and a dynamic, component-based user interface.

The investigation confirmed the efficacy of a unified JavaScript ecosystem and a decoupled client-server architecture in modern web development. This architectural choice enhanced modularity, simplified the development workflow, and established a scalable foundation. The project provided a practical synthesis of theoretical concepts, bridging the gap between academic knowledge and applied software engineering by addressing real-world challenges such as asynchronous data flow and API security.

While the application meets all initial requirements, this study acknowledges avenues for future enhancement. These include the integration of an advanced state management library (e.g., Redux) to handle greater complexity, the implementation of real-time communication protocols (e.g., WebSockets) for live user interaction, and the containerization of the application using Docker to optimize deployment and portability.

In conclusion, this project serves as a definitive validation of the MERN stack's capabilities for building robust, data-driven web applications. It successfully demonstrates the practical application of the full software development lifecycle and provides a strong empirical foundation for further academic and professional work in the field of full-stack engineering.

REFERENCES

- [1] MongoDB, Inc. (2025, October 16). MongoDB Documentation [Online]. Available: <https://www.mongodb.com/docs/>
- [2] OpenJS Foundation. (2025, October 16). Express.js - Node.js web application framework [Online]. Available: <https://expressjs.com/>
- [3] Meta Inc. (2025, October 16). React Documentation [Online]. Available: <https://react.dev/>
- [4] OpenJS Foundation. (2025, October 16). Node.js Documentation [Online]. Available: <https://nodejs.org/en/docs/>
- [5] V. Karpov. (2025, October 16). Mongoose ODM - Elegant MongoDB object modeling for Node.js [Online]. Available: <https://mongoosejs.com/docs/guide.html>
- [6] M. Jones, J. Bradley, and N. Sakimura, “JSON Web Token (JWT),” Internet Engineering Task Force, IETF, Report No. RFC 7519, May 2015.
- [7] Auth0. (2025, October 16). JWT.IO - Introduction to JSON Web Tokens [Online]. Available: <https://jwt.io/introduction/>
- [8] Mozilla Developer Network. (2025, October 16). JavaScript Guide [Online]. Available: <https://developer.mozilla.org/en-US/docs/Web/JavaScript/Guide>
- [9] Postman, Inc. (2025, October 16). Postman Learning Center [Online]. Available: <https://learning.postman.com/>
- [10] OWASP Top Ten, OWASP Foundation, 2021.