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Faculty 2: Computer Science and Engineering

STUDYING WEB FULL-STACK TECHNOLOGIES AND APPLYING IN STUDENT LIFE SUPPORT SERVICE WEB APPLICATION DEVELOPMENT

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BACHELOR THESIS

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Declaration

I hereby declare that the research presented in this thesis, carried out at both the Vietnamese-German University and the Frankfurt University of Applied Sciences, is my own original work. The thesis was completed under the guidance and supervision of Dr. Tran Hong Ngoc and Dr. Truong Dinh Huy. I further affirm that no part of this thesis has been included in any previous submission for a degree and that it does not violate any intellectual property rights.

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Abstract

The Student Life Support Service is a web application developed to streamline student support processes at the Vietnamese-German University (VGU). The system addresses the needs of students, dormitory staff, and administrators by facilitating efficient communication and ticket management for daily student life issues.

The key objectives of this project are to enhance student-staff interaction, simplify ticket resolution, and improve the overall support experience. Students can create, view, and manage support tickets, while staff members handle ticket processing and communication with students. Administrators oversee the entire system, managing users, roles, and system reports.

The application is built using a modern technology stack. The frontend, developed with ReactJS, Material UI, and Vite, incorporates a responsive design that ensures compatibility with various devices, including desktops, laptops, tablets, and smartphones. This ensures that users have a seamless experience regardless of the device they are using. The backend is powered by NodeJS, ExpressJS, and SocketIO for real-time communication, with JWT-based authentication (utilizing access and refresh tokens stored in a Redis in-memory database). The system's data is managed using PostgreSQL for robust and scalable database management.

The project adopts a modular and RESTful API-driven architecture to facilitate scalability and maintainability. The methodology involves iterative development with thorough testing at each stage to ensure the system meets functional and performance requirements.

Preliminary results indicate that the Student Life Support Service significantly improves the efficiency of support ticket management and fosters better communication between students and university staff. The system's modular design and responsiveness enable future enhancements, making it adaptable to evolving requirements at VGU.

Contents

Acronyms

AI Artificial Intelligence

API Application Programming Interface

CSE Computer Science and Engineering

JWT JSON Web Token

REST Representational State Transfer

SQL Structured Query Language

UI User Interface

VGU Vietnamese-German University

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1 Introduction

1.1 Project Background

The Student Life Support Service is a web-based platform designed to enhance the efficiency and accessibility of student support services at the Vietnamese-German University (VGU). Universities typically handle a large volume of student inquiries and requests, ranging from dormitory issues to general student affairs, but the traditional systems in place often fall short of meeting modern student expectations. The current support mechanisms at many educational institutions are not streamlined, leading to delays in issue resolution, inefficient communication between students and staff, and lack of transparency in the handling of support tickets. Students frequently experience difficulty in tracking the progress of their requests, and support staff often lack the tools needed to manage tickets effectively.

This project aims to address these challenges by introducing an integrated system that automates the submission, handling, and resolution of student support tickets. In addition to providing students with a clear communication channel with the relevant university staff, the system also includes features such as real-time messaging, ticket status updates, and feedback mechanisms. The system will allow administrators to manage user roles, view comprehensive reports on ticket status, and optimize resource allocation.

Additionally, at VGU, students living in dormitories or dealing with other administrative issues often face challenges in receiving timely support. Current methods of submitting issues through email or in-person communication are prone to delays and mismanagement, leading to student dissatisfaction. This is exacerbated by the lack of real-time updates and the absence of a centralized platform where students can view the status of their requests. Similarly, staff members experience difficulty in managing the volume of requests, tracking the status of tickets, and effectively communicating with students.

The proposed Student Life Support Service will streamline these processes by creating a user-friendly, centralized system that not only tracks and manages support tickets but also fosters better communication between students and staff.

1.2 Problem Statement

The lack of a streamlined, accessible system for managing student support services at VGU has led to inefficiencies in communication and delayed resolution of student requests. Students often face prolonged waiting times, uncertainty about the status of their tickets, and difficulty in communicating with the responsible staff. On the other hand, staff members face challenges in managing multiple requests efficiently, tracking their progress, and prioritizing tasks.
The specific problem addressed by this project is the absence of an integrated platform that facilitates smooth communication, real-time ticket management, and timely issue resolution between students and university staff. The current system is fragmented, lacking automation, and fails to provide transparency in the support process.

1.3 Objectives of the Project

The primary objective of this project is to develop a web-based Student Life Support Service that enables students to submit, track, and manage their support requests efficiently. The system will provide several key features, including:

Key features	**Description**
Ticket Management	Allow students to submit support tickets related to dormitory issues or other university services. Students can track the progress of their tickets in real time.
Real-time Communication	Enable direct communication between students and staff handling the tickets using a real-time messaging system.
Role Management	Provide administrators with tools to manage user roles, such as students, dormitory staff, and student affairs personnel.
Feedback Mechanism	Allow students to give feedback on the support provided and rate the resolution of their tickets.
Notifications and Announcements	Provide students and staff with timely notifications and announcements related to their tickets or university activities.
Responsive Design	Ensure the system is fully compatible with devices of all sizes, including desktops, laptops, tablets, and smartphones.

Table 1: System key features

The focus of the system is to create an efficient, user-friendly, and responsive platform that can be accessed by students and staff across various devices, ensuring convenience and accessibility.

1.4 Scope of the Project

The Student Life Support Service project includes the development of a full-stack web application with several key components:

Key components	**Description**
Frontend	Built with ReactJS, Material UI, and Vite, the frontend will focus on providing a responsive, interactive interface that can be accessed from any device. Users will be able to submit support tickets, communicate with staff, and view ticket updates.
Backend	Using NodeJS, ExpressJS, and SocketIO, the backend will handle ticket processing, real-time communication, and manage user roles. JWT-based authentication will be used to secure the platform, with refresh tokens stored in Redis for session management.
Database	A PostgreSQL database will store user data, tickets, and related information. This will allow efficient querying and management of all system data.

Table 2: System key components

The system does not cover advanced analytics or AI-driven decision-making, as it is focused on the core functionality of ticket management and communication. Additionally, the scope does not include integration with third-party tools for external service management, though future expansions could allow for such features.

1.5 Thesis Structure

The thesis is organized into several sections, each addressing different aspects of the project:

- **Section 1: Introduction** – Provides an overview of the project background, objectives, problem statement, scope, and thesis structure.
- **Section 2: Literature Review** – Reviews existing solutions and technologies related to student support services, analyzing gaps in current systems that the Student Life Support Service aims to address.
- **Section 3: System Design** – Discusses the system's functional and non-functional requirements, architecture, database design, and API structure. It also covers the UI/UX design approach and how the responsive feature is implemented.
- **Section 4: System Implementation** – Details the step-by-step implementation of the frontend, backend, database, and security mechanisms. It includes code snippets, system flows, and real-time messaging features.
- **Section 5: Results and Discussion** – Analyzes the results of the project, discussing whether the initial objectives were met.
- **Section 6: Conclusion and Future Work** – Concludes the thesis by summarizing the project outcomes and discussing possible future enhancements, such as extending the system to other universities or integrating advanced analytics features.

2 Literature Review

2.1 Existing solutions

2.1.1 Group Chat-Based Systems (Current Solution at VGU)

Currently, many educational institutions, including VGU, rely on informal systems like social media group chats (e.g., Facebook or WhatsApp groups) for raising support tickets and contacting staff. While these systems are easy to set up and require minimal resources, they suffer from significant limitations:

- **Lack of Structure**: The conversation threads are disorganized, making it hard to track specific issues or prioritize them.
- **Absence of Accountability**: There's no formal ticketing system, leading to delays in responses and no mechanism to track whether an issue has been resolved.
- **Inadequate Historical Data**: It's difficult to retrieve past conversations or analyze data to improve service.
- **Lack of Privacy**: Group chats often expose personal information to all participants, which may raise privacy concerns.

2.1.2 Existing University and Open-source Ticketing Systems

Several universities have adopted formal ticket management systems for handling student support services. These systems are often integrated into larger university management platforms or custom-built web applications. Common examples include:

Systems	Features	Limitations
JIRA Service Management	Offers customizable workflows, automated prioritization, and detailed issue tracking.	Too complex for university needs, expensive, and difficult to adapt without major customization.
Freshdesk	Supports ticket management, multi-channel communication, and agent collaboration.	Feature-heavy and expensive for universities; lacks educational-specific tools.

Systems	Features	Limitations
Zendesk	Provides email, live chat, and ticketing, with automation and analytics.	Geared towards businesses; lacks flexibility for diverse student needs and real-time communication.
OSTicket	Open-source, customizable, with email-based ticketing and status tracking.	Requires customization for universities, not intuitive for non-technical users, lacks real-time communication.

Table 3: Existing University Ticketing Systems

2.1.3 Limitations of Existing Solutions in the University Context

- **Complexity**: Many existing solutions are designed for enterprise environments and are not tailored to the unique requirements of universities.
- **Lack of Customization**: Solutions like JIRA and Zendesk require extensive customization to meet university-specific needs, such as handling dormitory issues or academic support tickets.
- **Cost**: Proprietary solutions can be expensive, making them less viable for universities with limited IT budgets.
- **Lack of Real-Time Communication**: Most solutions offer asynchronous communication through email or message boards but do not provide real-time chat, which is essential for time-sensitive student support.

2.2 Technology Review

2.2.1 Frontend: ReactJS, Material UI, Vite

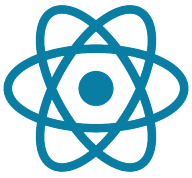

Figure 1: ReactJS Logo

ReactJS is a popular JavaScript library for building user interfaces, which provides a fast, scalable, and modular way to develop the frontend of web applications[2]. Its component-based architecture allows for reusability and efficient state management using hooks like `useState()` and `useEffect()`. This enables a responsive and dynamic user experience, ideal for handling real-time ticket updates.

```
const Profile = () => {

  return (
    <MainCard title="Personal Information">
      <Grid container spacing={gridSpacing}>

        <Grid item xs={12} sm={6}>
          <ProfileCard />
        </Grid>

        <Grid item xs={12} sm={6}>
          <SchoolDetailsCard/>
        </Grid>

      </Grid>
    </MainCard>
  );
}

export default Profile;

```

Code snippet 1: Example of a React component

Material UI is a React-based UI component library that implements Google's Material Design principles. Material UI ensures that the frontend is both visually appealing and functionally intuitive. Pre-built components like buttons, forms, and dialogs accelerate development while maintaining consistency in design.[4]

Figure 2: Material UI Logo

Figure 3: Vite Logo

Vite, a modern frontend build tool that offers faster development speed compared to older tools like Webpack. Vite optimizes the build process for React applications by providing instant hot module replacement (HMR), which is useful for a smooth developer experience during iterative development cycles.[3]

2.2.2 Backend: NodeJS, ExpressJS, SocketIO

Figure 4: NodeJS Logo

NodeJS is a runtime that enables JavaScript to be used for server-side scripting, making it possible to use a single language (JavaScript) throughout the stack. NodeJS is non-blocking and event-driven, making it ideal for handling I/O-heavy tasks like managing support ticket requests in real time.

ExpressJS is a minimalist web framework for NodeJS, Express simplifies routing, middleware management, and API handling. It serves as the backbone of the server, processing requests from the frontend, interacting with the database, and managing the business logic.

Figure 5: Expressjs Logo

Figure 6: SocketIO Logo

SocketIO is a JavaScript library that enables real-time, bidirectional communication between clients and servers. SocketIO is used to implement features such as real-time messaging between students and staff, making the system more interactive and responsive.[5]

2.2.3 Authentication: JWT, Redis

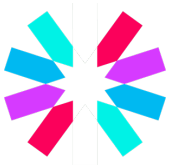

Figure 7: JWT Logo

JWT (JSON Web Tokens) is a token-based authentication system that provides secure stateless authentication for users. JWT is ideal for modern web applications because tokens can be stored on the client-side (in local storage or cookies) and are transmitted with each request, allowing for scalability.

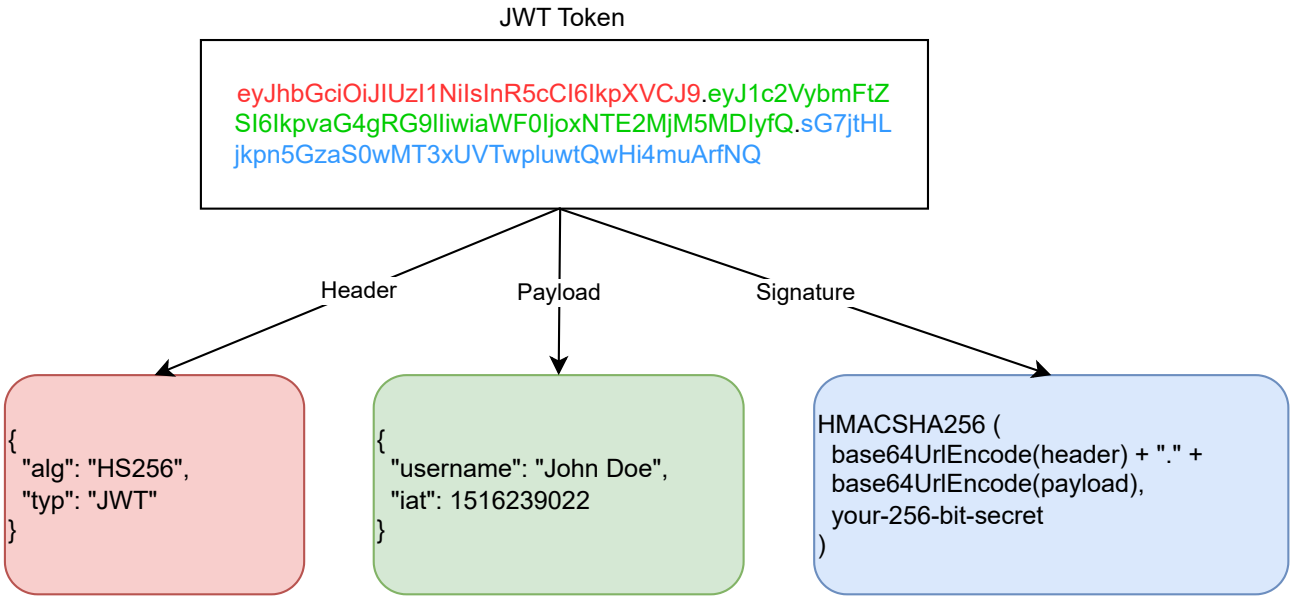

Figure 8: Detailed explanation of JWT-based authentication mechanism.

Figure 9: Redis Logo

Redis is an in-memory data structure store, Redis is used for session management, particularly in storing refresh tokens. By caching these tokens, Redis reduces the load on the database and enhances the system's performance.

2.2.4 Database: PostgreSQL

Figure 10: PostgreSQL RDBMS Logo

PostgreSQL is a powerful, open-source relational database that offers strong ACID compliance, making it suitable for managing critical data like user accounts, ticket information, and communication logs. Its support for advanced querying and indexing ensures the system can handle complex searches efficiently.

2.2.5 Responsive Web Design: Techniques and Tools

- **Media Queries**: CSS media queries are used to apply different styles based on device characteristics (screen size, resolution). This allows the frontend to automatically adapt to different devices, ensuring that the system is usable on desktops, laptops, tablets, and smartphones.
- **CSS Flexbox/Grid**: These CSS layout models allow for flexible, responsive layouts that adjust to different screen sizes. Flexbox is ideal for managing component positioning in small screens, while Grid is useful for creating complex layouts in larger screens.

2.3 Theoretical Background

2.3.1 Ticket Management Systems

A ticket management system is a tool designed to manage and track the progress of support requests, from the time they are submitted until they are resolved. The system typically assigns a unique identifier (ticket) to each request, enabling staff to monitor progress, prioritize issues, and provide timely responses. In a university context, ticket management systems are particularly useful for handling student issues, such as dormitory problems, academic inquiries,

and administrative requests. By assigning specific staff members to tickets, the system ensures accountability and reduces response time.

2.3.2 Real-Time Communication Tools

Real-time communication tools like SocketIO or WebSockets are essential in modern web applications. These tools allow for instantaneous data transmission between the server and client, enabling real-time messaging and live updates. For instance, in the Student Life Support Service, students and staff can exchange messages directly without having to refresh the page, ensuring efficient communication.

2.3.3 Web Application Development Best Practices

- **Modular Design**: Applications should be developed in a modular fashion, separating concerns into distinct components (frontend, backend, database). This allows for easier maintenance and scalability.
- **Security First**: With the increasing number of security breaches in web applications, implementing security best practices like JWT for authentication, HTTPS for communication, and proper data validation is essential.
- **Responsive Design**: Ensuring that the application works across different devices and screen sizes is a fundamental best practice, especially for a university setting where students and staff might use a wide variety of devices.

2.4 Gap Analysis

2.4.1 What is Missing from Existing Solutions

Existing solutions for university support systems face several shortcomings. Privacy concerns arise in social media-based group chats, where sensitive student information may be exposed, and even proprietary systems lack a strong focus on educational privacy needs. Role-specific functionalities are often missing, with few systems offering specialized tools for students, dormitory staff, or administrators, or including student-centric features like feedback collection, ticket rating, and public status views. Limited analytics is another issue; while general analytics are provided, they don't cater to the specific needs of student services, such as tracking recurring

issues or ticket performance. Additionally, many systems, like JIRA, are not user-friendly for students, requiring training and posing barriers in environments where simplicity is essential.

2.4.2 How the Student Life Support Service Fills These Gaps

The Student Life Support Service addresses the gaps in existing systems by offering a solution tailored specifically to university needs. Its customizable structure supports role-specific functionalities for students, dormitory staff, and administrators, making it ideal for managing university-specific scenarios like dormitory issues and academic inquiries. Real-time communication is enabled through SocketIO, allowing fast, interactive responses between students and staff. The user-friendly interface, built with ReactJS and Material UI, ensures easy navigation for non-technical users. As an open-source, cost-effective platform using NodeJS, PostgreSQL, and ReactJS, it avoids the high costs of proprietary software. The system also provides role-specific features, such as ticket creation, tracking, and rating for students, efficient ticket handling for staff, and detailed reporting tools for administrators. Enhanced privacy and security are ensured through JWT-based authentication and role-based access, preventing unauthorized access to sensitive information. Additionally, built-in data analytics offers administrators insights into ticket trends and areas for improvement in student support services.

3 System Design

3.1 Functional Requirements

The Student Life Support Service is designed to fulfill the specific functional requirements of three key user roles: Students, Dormitory Staff (or Student Affairs), and Administrators. Each role has its own set of features tailored to its needs within the system.
User Type: S-Student, DS-Dormitory Staff/Student Affairs, A-Admin (Operator)
Categorized: F-Functional, NF-Nonfunctional

No	Requirement	Description	Priority	User Type	Category
1	Manage personal info	Users can view and update their personal information.	Medium	S, DS, A	F
2	Support tickets	Users can create (raise), view support tickets.	High	S, DS, A	F
3	Contact through messages	Users can contact the staff or students handling the support ticket through text messages.	High	S, DS	F
4	Ticket rating	Students can rate their tickets which are marked as done.	Medium	S	F
5	View newsfeed	Users can view a newsfeed of public pending/in-process tickets.	Low	S, DS, A	F
6	View notifications	Users can view notifications and announcements.	Medium	S, DS, A	F
7	Feedback and suggestions	Users can give feedback and suggestions for the system.	Medium	S, DS, A	F
8	Handle support tickets	Dormitory staff can view and handle (mark as done, cancel) support tickets.	High	DS	F

No	Requirement	Description	Priority	User Type	Category
9	View past tickets	Dormitory staff can view all previously handled support tickets.	Medium	DS	F
10	Manage notifications	Dormitory staff and admins can create and manage notifications and announcements.	High	DS, A	F
11	Manage users	Admins can manage all users/roles (create, view, update, delete).	High	A	F
12	Manage tickets	Admins can manage all support tickets (view, delete).	High	A	F
13	Manage dormitories	Admins can manage all dormitories (create, view, delete).	Medium	A	F
14	Manage system logs	Admins can manage system logs (view, delete).	Medium	A	F
15	Manage feedback	Admins can manage system feedback (view, delete).	Low	A	F
16	View system report	Admins can generate and view system reports.	High	A	F

Table 4: Functional Requirements

For clearer comprehension, the table presented below provides a detailed visualization of the functional requirements, organized according to the different user roles within the system. This structure allows for a more precise understanding of how each role interacts with the system's features and capabilities.

User roles	**Functional Requirements**
Student	• can view, update his/her personal information. • can create (raise), view his/her support tickets. • can contact the staff who handles the support ticket through text messages. • can rate his/her tickets which are marked as done. • can view newsfeed (public pending/in process tickets). • can view notifications, announcement. • can give feedback and suggestions for the system.
Dormitory staff/ Student Affairs	• can view, update his/her personal information. • can view all available support tickets. • can handle support tickets. (mark as done, cancelled) • can view all past handled tickets. • can contact students who owns the ticket through text messages. • can view newsfeed (public pending/in process tickets). • can create, view notifications, announcement. • can give feedback and suggestions for the system.

User roles	Functional Requirements
Admin (Operator)	• can manage his/her personal information (view, update). • can manage all users/roles (create, view, update, delete). • can manage all support tickets (view, delete). • can manage all dormitories (create, view, delete). • can manage system logs (view, delete). • can manage system feedback (view, delete). • can view newsfeed (public pending/in process tickets). • can manage notifications, announcement (create, view). • can view the system report.

Table 5: Functional Requirements by User Roles

3.2 Non-Functional Requirements

Categorized: NF-Nonfunctional

No	Requirement	Description	Priority	Category	Functioning
1	Fast Response Time	The system should provide fast responses for user interactions such as submitting tickets, viewing statuses, and real-time messaging.	High	NF	Performance
2	Real-Time Communication	Messages between students and staff should be transmitted with minimal latency (under 100 milliseconds).	High	NF	Performance

No	Requirement	Description	Priority	Category	Functioning
3	Concurrent Users	The system must support up to 500 concurrent users without significant performance degradation.	High	NF	Performance
4	Database Query Optimization	PostgreSQL database should be optimized to handle high read/write volume efficiently even during peak load.	High	NF	Performance
5	JWT-Based Authentication	Secure authentication using JSON Web Tokens (JWT), with short-lived tokens and securely stored refresh tokens in Redis.	High	NF	Security
6	Role-Based Access Control	Enforce strict role-based access to ensure users only have access to the functionality appropriate for their role.	High	NF	Security
7	Encryption	All communications between the client and server must be encrypted using HTTPS to ensure data security.	High	NF	Security
8	Data Validation	Input from users must be validated and sanitized to protect against common vulnerabilities like SQL Injection and Cross-Site Scripting.	High	NF	Security
9	Audit Logs	Admins must have access to immutable and secure audit logs to track user actions such as login attempts and system modifications.	Medium	NF	Security
10	Database Scalability	The PostgreSQL database should scale efficiently as the number of tickets, messages, and users grows.	High	NF	Scalability
11	User-Friendly Interface	The interface should be intuitive and easy to navigate for users of varying technical abilities.	High	NF	Usability

No	Requirement	Description	Priority	Category	Functioning
12	Cross-Device Compatibility	The system should be responsive and function well on desktops, laptops, tablets, and smartphones.	High	NF	Usability

Table 6: Non-Functional Requirements

3.3 Use Case Diagrams

Figure 11: Student Use Case Diagram

3.4 System Architecture

The system follows a three-tier architecture, consisting of the following layers:

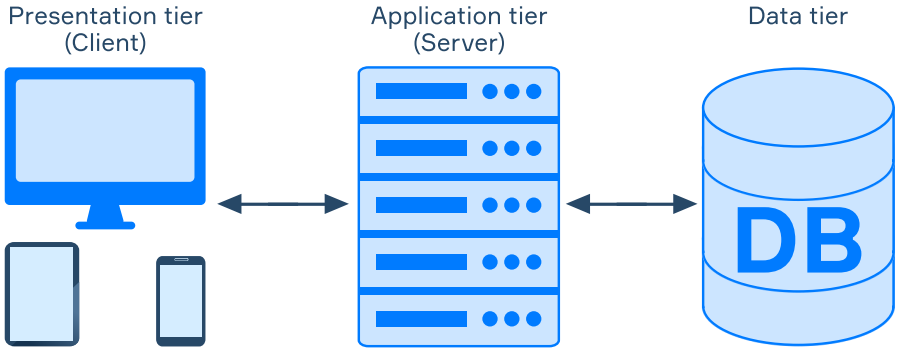

Figure 12: Three-tier Architecture[1]

1. **Presentation Layer (Client):**

   Handles all interactions with the user. Implements the user interface using ReactJS and Material UI. Communicates with the server through RESTful API calls and SocketIO for real-time features. Responsible for rendering components, collecting user input, and displaying data received from the backend.

2. **Business Logic Layer (Server)**:

   NodeJS and ExpressJS handle the core business logic, such as processing support ticket requests, authenticating users, managing roles, and communicating with the database. SocketIO is used to manage real-time messaging between students and staff. Implements security features like JWT-based authentication and session management using Redis.

3. **Data Layer (Database)**:

   PostgreSQL stores all persistent data, including user profiles, support tickets, messages, and system logs. The server communicates with the database using SQL queries to retrieve, create, update, and delete records. Ensures data consistency and integrity by enforcing constraints, foreign keys, and relationships.

3.5 Frontend Design

References

[1] Aryan Patil. Three-tier architecture, 2023. URL: https://hyperskill.org/learn/step/25083.

[2] Sanity. React.js overview, August 2023. URL: https://www.sanity.io/glossary/react-js.

[3] Eric Simons. What is Vite (and why is it so popular)?, September 2024. URL: https://blog.stackblitz.com/posts/what-is-vite-introduction/.

[4] Alesia Sirotka. What is Material UI?, March 2022. URL: https://flatlogic.com/blog/what-is-material-ui/.

[5] Socket.IO. Introduction, July 2024. URL: https://socket.io/docs/v4/.