Project Report (Part I)
on

ClassConnect: A Real-Time Attendance Management System Empowering Education Through Broadcasting Technology

Submitted in partial fulfillment for the award of the degree
of
BACHELOR OF ENGINEERING
In
COMPUTER ENGINEERING

Submitted by
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(Academic Year. 2024-25)

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CERTIFICATE

This is to certify that the project entitled **"ClassConnect: A Real-Time Attendance Management System Empowering Education Through Broadcasting Technology"** is a bonafide work of **Urmil Pawar (Roll No. 42), Prabhat Pankaj (Roll No. 43), Shlok Prajapati (Roll No. 44)** submitted to the Thakur College of Engineering and Technology, Mumbai (An Autonomous College affiliated to University of Mumbai) in partial fulfillment of the requirement for the **Project-I** for award of the degree of **"Bachelor of Engineering"** in **"Computer Engineering"**.

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PROJECT APPROVAL CERTIFICATE

This project report entitled "***ClassConnect: A Real-Time Attendance Management System Empowering Education Through Broadcasting Technology***" by ***Urmil Pawar (Roll No. 42), Prabhat Pankaj (Roll No. 43) Shlok Prajapati (Roll No. 44)*** is approved for the degree of **"Bachelor of Engineering"** in **"Computer Engineering"**.

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It would be unfair if I do not acknowledge the help and support given by Professors, students, friends etc.

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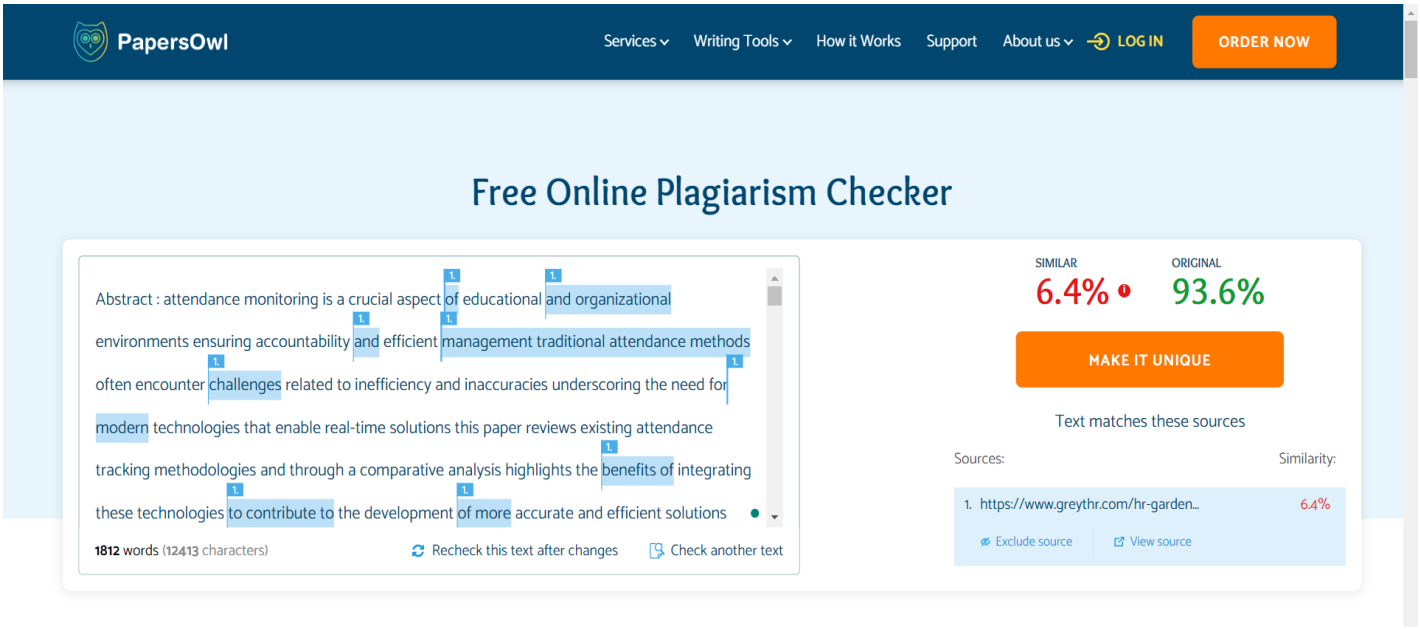
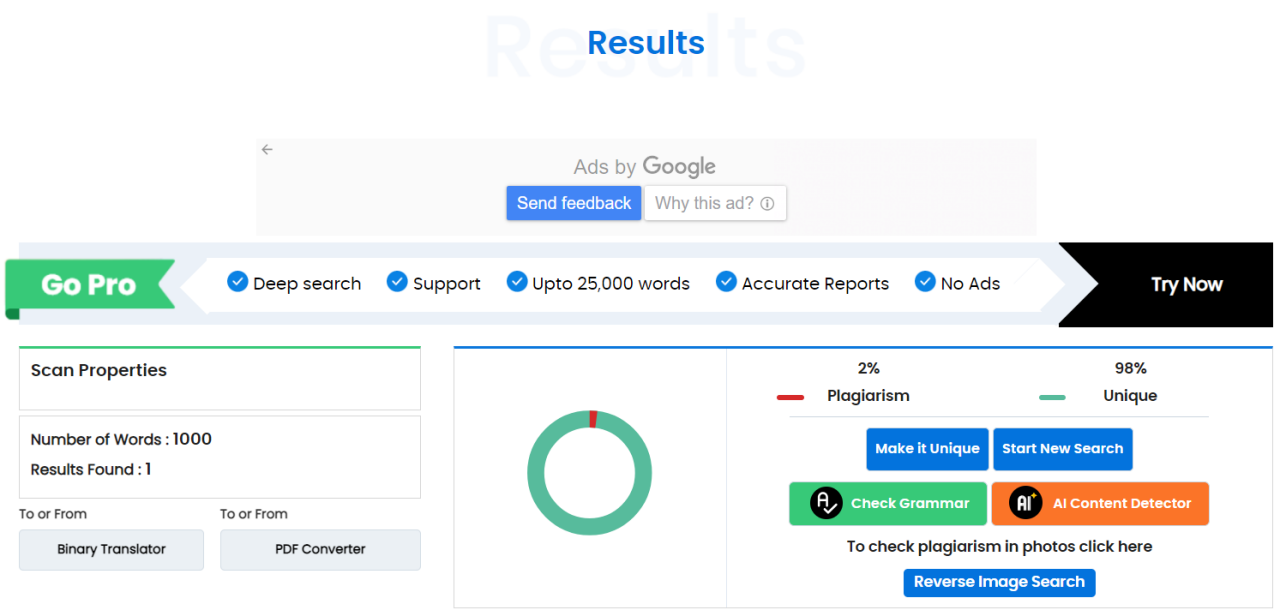
Plagiarisms Report





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Abstract

ClassConnect is a real-time attendance tracking and management system that leverages modern technology to enhance and accelerate attendance processes across educational institutions and corporate environments. It enables precise and efficient attendance tracking with minimum manual intervention and significantly reduces the time and effort required to track attendance. Conventional systems, like manual roll calls and paper-based tracking, are prone to human error, manipulation, and time wastage, making it difficult for institutions to maintain accurate records and prevent proxy attendance. Despite the advances made in attendance technologies like QR codes, RFID, Bluetooth, face recognition, or voice recognition these systems still face challenges related to high setup costs and time consumption which can be efficiently tackled by 'ClassConnect'

The ClassConnect system is designed using WebSocket for real-time communication, ensuring seamless interaction between teachers and students. The methodology incorporates biometric authentication through mobile devices and geolocation tracking to verify a student's identity and location, ensuring they are present within the classroom radius. The system is built with a combination of frontend technologies such as HTML, CSS, and JavaScript, and backend technologies like Flask and MySQL for data management. With cloud hosting on Azure, the system is scalable and secure. The outcome of the project is a highly efficient attendance management solution that eliminates manual processes, prevents proxy attendance, and provides real-time, accurate attendance reports.

Chapter 1

Introduction

1.1 Introduction

Attendance management is a critical aspect of organizational operations, particularly in educational institutions, where accurate record-keeping and accountability are essential. Traditional methods, such as manual roll calls and paper-based systems, are often inefficient, prone to errors, and susceptible to manipulation, leading to issues like proxy attendance and time wastage. In response to these challenges, modern technologies such as QR codes, RFID, Bluetooth, biometrics, and voice recognition have been introduced to improve the process. However, these systems still face limitations, including high setup costs, security concerns, and high time consumption that hinder their effectiveness.

To address these gaps, ClassConnect presents a real-time attendance tracking and management system designed to overcome the shortcomings of existing solutions. By integrating cutting-edge technologies like biometric authentication and geolocation tracking, ClassConnect ensures secure, accurate, and efficient attendance tracking with minimal manual intervention. This system not only streamlines attendance processes but also significantly reduces the potential for errors, enhancing accountability and transparency in educational environments.

1.2 Motivation

The motivation for this project arises from the limitations and challenges posed by traditional attendance systems, such as manual roll calls and paper-based tracking method. These outdated methods are prone to inefficiencies, human error, and manipulation, leading to significant issues in attendance management.

Manual roll calls can be time-consuming, taking away valuable time from lectures or meetings. Additionally, the chances of missing records or inaccurate data are high, often due to human oversight or mishandling of paper records. Another major concern is the prevalence of proxy attendance in paper-based attendance tracking, where one individual marks the presence of another, compromising the integrity of the system. This makes it difficult for institutions to accurately monitor attendance and enforce accountability.

Given these challenges, there is a pressing need for a more reliable and efficient. By leveraging modern technology, such as automated and real-time monitoring systems, we aim to create a system that ensures accurate attendance tracking while eliminating the risks of manipulation and error. The goal is to streamline the attendance process, enhance accuracy, and ensure transparency, ultimately improving the overall efficiency of attendance management in educational and professional settings.

1.3 Problem Definition

Traditional attendance systems, such as manual roll calls and paper-based tracking methods, are inefficient, prone to human error, and susceptible to manipulation. These methods are time-consuming and there is a potential for proxy attendance, where individuals mark attendance on behalf of others. Additionally, the chances of missing records or inaccurate data are high, often due to human oversight or mishandling of paper records. This undermines the accuracy and integrity of attendance management, making it difficult for institutions to monitor and enforce accountability. There is a need for a modern, reliable solution that can address these challenges by leveraging technology to automate and ensure accurate, real-time attendance tracking, thus enhancing overall efficiency and transparency in attendance management.

1.4 Objectives of the Project

1. To design and develop a real-time attendance tracking and management system.
2. To leverage GPS and biometric authentication for secure and accurate attendance tracking.
3. To develop an efficient system that minimizes manual intervention, eliminates time wastage, ensures accurate records and prevents proxy attendance.
4. To enhance the reliability of attendance monitoring in educational settings.

1.5 Scope of the Project

This project is primarily focused on educational institutions, focusing on attendance monitoring within classrooms or during events or seminars, where efficient tracking is crucial for both students and teachers. By automating the attendance process, the system eliminates the need for manual roll calls or paper-based attendance tracking, reduces errors, and prevents proxy attendance. It allows teachers to track student participation in real-time, ensuring that attendance records are both accurate and secure. The system can generate reports that help educational administrators monitor attendance trends, identify issues, and improve accountability.

Beyond educational institutions, the solution can be extended to other organizational environments where attendance and participation tracking are equally critical. For instance, corporate settings, conferences, seminars, and government offices can benefit from real-time monitoring and secure attendance logging. The system's flexibility allows it to be adapted for various use cases, providing organizations with a reliable and scalable attendance management tool.

By securely linking participants (such as teachers and students or employees and supervisors) and automating record-keeping, the project ensures that attendance data is accurate and easily accessible. The overarching goal is to create a robust system that enhances the efficiency of attendance tracking and management across multiple sectors.

1.6 Application of the project

The primary application of this project is within educational institutions, where it automates attendance tracking for students and teachers. By replacing manual methods with an efficient, technology-driven system, the project aims to streamline attendance management, reduce errors, and improve accountability.

In addition to its use in education, the system can be adapted to various other sectors, including:

1. **Corporate Organizations**: The system can track employee attendance, ensuring timely and accurate records for HR and payroll management. It can also be implemented in government offices for similar purposes.
2. **Event Management**: For events such as conferences, seminars, and workshops, the system can monitor participant attendance in real-time. This ensures that organizers have reliable records of participant engagement, facilitating post-event reporting and analysis.

The project's flexibility allows it to serve a wide range of environments where accurate, real-time attendance monitoring is critical.

1.7 Expected Outcome of the Project

The expected outcomes of the project include:

1. A fully automated attendance system with real-time attendance tracking.
2. Secure attendance validation through biometric and geolocation checks.
3. Complete elimination of time wastage and proxy attendance, significantly ensuring the accuracy of attendance records.
4. Minimum manual intervention

1.8 Organization of the Project Report

1. **Abstract:** Overview of the project, addressing traditional attendance problems and proposing a new solution using GPS and biometric technologies.
2. **Introduction:** Briefing the need for efficient attendance systems by addressing existing problems and fallbacks in traditional techniques.
3. **Literature Survey:** Review of existing attendance systems, outlining their methodologies, strengths, and weaknesses.
4. **Literature Review**: A detailed explanation of the methodologies employed by current systems, with a deeper focus on their effectiveness and challenges.
5. **Methodology**:
    - A comprehensive description of the system workflow.
    - Presentation of the system's mathematical model.
    - Overview of the system architecture.
    - Detailed data flow diagram.
    - Explanation of database design.

- Outline of servers, server routes, and request formats.
- Explanation of hosting strategies.
- Discussion on load balancing algorithms.
- Outline of future system upgrades.

6. **Conclusion**: Summarizing the proposed system and its potential future

Chapter 2

Proposed System

2.1 Survey of Literature/Existing System

1. **Mobile and Web-Based Attendance System**: This system uses mobile devices for students to register attendance via selfies or digital signatures. Attendance records are stored in a database, making it easy to track absentees.
2. **Voiceprint and Location-Based System**: This system captures students' voiceprints and verifies them against stored templates for authentication. It also calculates the student's location relative to the classroom to validate attendance. Records are stored in a database and presented via a web portal for analysis.
3. **Bluetooth and RFID-Based System**: Bluetooth technology, combined with RFID cards, is used for efficient student attendance tracking. The system offers low power consumption and is suitable for mobile devices. It also employs fingerprint biometric authentication for staff attendance.
4. **Biometric Attendance System**: This system uses fingerprint biometrics for secure and accurate attendance tracking. Students' fingerprints are matched with stored templates, and attendance is automatically recorded in the database, generating reports for each course.
5. **QR Code and Face Recognition-Based System**: QR codes combined with face recognition offer a simple and cost-effective solution for automated attendance recording. However, mobile dependency and connectivity issues may limit effectiveness in certain situations. RFID and biometric systems are also discussed, highlighting their pros and cons, such as high costs and privacy concerns.

Each system offers different technologies to improve accuracy, security, and efficiency in attendance management, but also comes with challenges like high cost, privacy issues, and dependence on mobile infrastructure.

2.2 Limitations of Existing System/Gap Analysis

A review of current attendance management systems reveals several limitations:

1. **Mobile Device and Web Application-Based System**: Lacks functionality for interactive feedback between lecturers and students, which could hinder engagement. Additionally, storing personal data (selfies, signatures) raises **privacy concerns**, necessitating strong security measures.
2. **Voiceprint and Location-Based System**: **Privacy concerns** arise due to the storage of biometric data (voiceprints). The system also heavily relies on **stable internet connectivity**, making it less effective in areas with poor network coverage.
3. **Bluetooth and RFID-Based System**: The possibility of **proxy attendance** is a significant issue, allowing one person to mark attendance for another. It also lacks interactive features for **constructive feedback**, limiting lecturer-student engagement.

4. **Biometric-Based System**: While it offers high security and accuracy, the **cost** of setting up fingerprint scanners and database infrastructure can be prohibitive for institutions with limited budgets.
5. **QR Code and Face Recognition-Based System**: The system relies on **mobile devices** and **internet connectivity**, meaning that poor network coverage or lack of access to a device could hinder its functionality in certain contexts. Also, a lack of accuracy in face recognition techniques can hinder the attendance process.

The following is a overview of all the papers:

Paper	Methodology	Advantage	Drawbacks
[1]Attendance Management System Using a Mobile Device and a Web Application	Utilizing a mobile device and web application for students to register attendance using selfies or signatures with data stored in a database for reference in the future.	**Enhanced Efficiency** **Real-time Monitoring** **Digital Record Keeping**	**Feedback Limitations:** The system lacks functionality for facilitating feedback from participants, hindering interactive engagement and potentially limiting opportunities for lecturer-student interaction and improvement. **Privacy Concerns:** Collection and storage of personal data (e.g., facial images, signatures) raise privacy considerations, indicating the requirement of robust security measures
[2]An automated student attendance tracking system based on voiceprint and location	Students use one app to submit attendance via voiceprints, while lecturers manage sessions through another. Servers handle attendance collection, verification, and database storage.	**Enhanced Efficiency** **User-Friendly Interfaces** **Digital Record Keeping**	**Privacy Concerns**: Voiceprint verification raises privacy concerns related to the collection and storage of biometric data. It should be highly secured. **Reliance on Internet Connectivity:** The system relies on stable Internet connectivity for communication between devices and servers. In environments with poor or unreliable internet access, the system's functionality may be compromised.
[3] Bluetooth Based Attendance Management System	Bluetooth and RFID technology	**Timesaving** **Independent Redesign** **Efficiency**	**Reduced Constructive Feedback:** The system lacks functionality for facilitating feedback from participants, hindering interactive engagement, and potentially limiting opportunities for lecturer-student interaction and improvement. **Proxy Attendance:** One of the drawbacks of the Bluetooth attendance system is the possibility of proxy attendance, where someone else can mark attendance on behalf of another individual.

[4] Development of Attendance Management System using Biometrics.	Biometric technology	**Enhanced Security** **Accuracy** **Adaptability**	**Cost Considerations:** While fingerprint technology offers security benefits, the initial setup costs might be higher due to the need for fingerprint scanners and database infrastructure.
[5] Online Attendance Monitoring System Using QR Code (OAMS)	QR Code, Face Recognition, RFID, Biometric (Fingerprint)	F**ast, Automated** **Accurate** **Cost-effective** **User-friendly**	**Relies on mobile devices and internet connectivity:** poor network coverage or lack of access to a device could hinder its functionality **Inaccuracy:** Lack of accuracy in face recognition techniques

Table 2.1 : Literature Survey

Overall, the existing systems suffer from issues such as **privacy concerns**, **costs**, **proxy attendance**, **internet dependency**, and a lack of **interactive feedback**, highlighting areas for improvement in future developments.

2.3 Proposed System

ClassConnect leverages modern technologies to streamline the process of student attendance in educational institutions. The system utilizes WebSocket connections for real-time communication between teachers and students, ensuring seamless attendance tracking through biometric authentication and geolocation verification. The following subsections detail the system's workflow and key components.

The workflow of the proposed System is as follows:

1. **Teacher Connection:** The teacher fills in the required information on the interface form, such as user type, name, initials, department, division, and year, and connects to the WebSocket server.
2. **Session Creation:** Upon the teacher's connection, a new session map is created with the teacher's initials as the key.
3. **Student Connection:** Students fill out their details, including user type, name, roll number, branch, division, year, and the teacher's initials (who is currently

taking the lecture) on their interface form. They then connect to the WebSocket server.

4. **Mapping Students to Teachers:** Students are mapped to the session based on the teacher's initials. This ensures that each student is linked to the correct session for attendance tracking.
5. **Attendance Start:** When the teacher clicks the 'start' button, a message indicating that attendance has started is sent to the students' devices. The message also includes the teacher's location, and the session map on the WebSocket server is cleared.
6. **Student Authentication:** Upon receiving the attendance message, the students' devices will open an interface prompting biometric authentication. Simultaneously, the system checks if the students are within a specific radius of the teacher's location (geolocation check).
7. **Data Validation:** Students who successfully authenticate and are within the required radius will have their data sent to the 'validation server' to be stored in the database.
8. **Attendance Stop:** When the teacher clicks the 'stop' button, a request is sent to the report generation server. The server will fetch and display a detailed list of the students present in the session.

2. Use of Teacher Initials for Session Management

In scenarios where lectures or practicals are conducted in batches, the teacher's initials serve as a unique identifier for the session. Despite multiple batches within a class, the teacher remains the constant entity to correctly map students to their respective sessions. This ensures clarity and accuracy in tracking attendance across multiple sessions.

3. Mobile OS Biometric Authentication

The proposed system eliminates the need for external authentication devices by utilizing the **mobile device's built-in biometric authentication** feature. When prompted for attendance, the student's mobile phone requests verification through its operating system, which checks the device's stored biometric data. This process mimics the phone's unlocking mechanism, returning a simple yes/no response to confirm whether the device owner is attempting to mark attendance. This method enhances both security and convenience without requiring additional hardware.

Chapter 3

Requirement Gathering, Analysis and Planning

3.1 Requirement Specification

Following are the functional and non-functional requirements necessary for implementing the proposed Attendance Tracking and Management System as a web application.

3.1.1 Functional Requirements:

1. **Teacher Login:** Teachers must be able to log in, and fill in session details such as initials, department, division, and year.
2. **Student Login:** Students must be able to log in, and input personal details such as name, roll number, branch, division, year, and teacher initials to join the session.
3. **WebSocket Server:** Real-time communication between teachers and students for attendance tracking must be established through WebSocket connections.
4. **Biometric Authentication:** Students must authenticate using their mobile device's biometric system during attendance submission.
5. **Geolocation Verification:** The system must verify that students are within a specific radius of the teacher’s location before allowing attendance to be marked.
6. **Session Management:** The system should manage the start and stop of sessions initiated by teachers and generate detailed reports after the session concludes.
7. **Attendance Reports:** After the session ends, the system must generate and display a report of students who attended the session.

3.1.2 Non-Functional Requirements:

1. **Minimum latency:** The system should allow teachers to take attendance swiftly, with minimal delay, ensuring that the process of taking attendance is quick.
2. **Scalability:** The system should handle multiple teachers and students simultaneously without performance degradation.
3. **Usability:** The interface must be user-friendly for both teachers and students, minimizing the learning curve for usage.
4. **Reliability:** The system must ensure that attendance data is accurately captured and stored with no errors.
5. **Security:** Biometric and location data must be securely used and communication should occur over secure communication protocols like HTTPS.

3.2 Feasibility Study

3.2.1 Technical Feasibility:

- The required technologies, such as WebSocket for real-time communication and mobile OS-based biometric authentication, are well-established and compatible with modern web browsers.
- Available libraries for biometric authentication (like Android/iOS Web APIs) and geolocation (HTML5 Geolocation API) make it feasible to implement the system without additional hardware.
- Hosting the system on cloud platforms provides scalability and supports high availability.

3.2.2 Operational Feasibility:

- The system can integrate easily with educational institutions as it automates attendance tasks and eliminates manual procedures, making it highly operationally feasible.
- Students and teachers are familiar with using mobile devices, so adoption of the system should be straightforward with minimal training required.

3.2.3 Economic Feasibility:

- The initial development cost includes cloud hosting, database management, and development tools but it can be efficiently managed by taking advantage of various student subscriptions like Azure for students or GitHub student pack, along with this long-term maintenance costs are also nearly low due to the use of cloud platforms.
- Since the system reduces administrative overhead and attendance errors, it provides value by streamlining operations and improving data accuracy.

3.2.4 Schedule Feasibility:

- The project can be developed incrementally, with a prototype available within 1–2 months, depending on time.

3.3 Methodology

This project employs the **Incremental Model** of software development to construct the Attendance Tracking and Management System. The following steps outline the methodology:

1. **Incremental Development**: The system will be developed in a series of increments, each focusing on specific functionalities of the overall system. Each increment will add some value to the last, allowing for the gradual addition of features and capabilities.
2. **Increment Breakdown**:
    - **Increment 1:** Basic Teacher and Student login interface with real-time communication over WebSocket.

    - **Increment 2:** Server Implementation for data storage, inserting the attendance of authenticated students, report generation, and adding new student data.
    - **Increment 4:** Load balancers implementation using round-robin and least connections algorithm in order to manage heavy loads.
    - **Increment 3:** Biometric and Geolocation Verification implementation.
    - **Increment 4:** Proper dynamic UI implementation for students and Teachers.
    - **Increment 6:** Notification System and Report Manipulation implementation *(based on Pending Time Availability)*
3. **Internal Testing**: After the completion of each increment, internal testing will be conducted to ensure the system is working as expected
4. **Documentation**: Comprehensive documentation will be maintained throughout the development process. This includes design decisions and testing results.
5. **Deployment**: Deploying each component immediately after it is built allows for incremental releases to effectively test it against the new components efficiently.
6. **User Feedback**: Although feedback will not be collected after every individual component, structured user testing sessions will be conducted after substantial increments are completed. This feedback will be used to make necessary adjustments and improvements in subsequent increments, ensuring that the system aligns with user expectations.
7. **Maintenance**: Post-deployment, the system will be continuously monitored for performance and user satisfaction. Regular updates and improvements will be implemented based on system performance metrics and user feedback gathered during the user testing sessions.

3.4 Technology

The following technologies are proposed for the implementation :

Frontend:

- **HTML5/CSS3/JavaScript**: For creating respective user interfaces for teachers and students.
- **React.js or Angular**: For building dynamic and scalable front-end applications, enhancing user experience.
- **HTML5 Geolocation API**: For obtaining the geolocation of students during attendance.
- **Mobile OS APIs (Android/iOS)**: To integrate biometric authentication features directly from mobile devices.

Backend:

- **Node.js**: For handling WebSocket communication and load balancing in real-time.
- **Flask**: For building APIs for data storage, inserting the attendance of authenticated students, report generation, and adding new student data.
- **WebSocket Protocol**: To enable real-time communication between teacher and student devices during attendance tracking.

Database:

- **MySQL** : For storing student data, lecture records, and attendance data securely.

- **Redis**: For managing session data and ensuring quick access to frequently queried information during real-time attendance tracking.

Cloud Infrastructure:

- **Azure**: For hosting the web application and databases, providing high availability, scalability, and security.

Security:

- **HTTPS and WebSocket over TLS (WSS)**: For encrypted communication between the server and users, ensuring data privacy.
- **Biometric APIs (Fingerprint/FaceID)**: Integrated with the mobile OS to handle secure biometric authentication without storing sensitive data.

3.5 Gantt Chart and Process Model

3.5.1 Gantt Chart:

ID	Task Name	Start	End	Duration	Progress %
1	Login & WebSocket	2024-09-24	2024-09-27	4 days	60
2	Flask Server Implementation	2024-10-01	2024-10-07	5 days	80
3	Load Balancer Imlementation	2024-10-28	2024-10-31	4 days	25
4	Biometric and Geolocation Verification System	2024-12-02	2024-12-06	5 days	0
5	Dynamic UI implementation	2024-12-09	2024-12-11	3 days	0
6	Research Paper and Report Completion	2024-12-12	2024-12-20	7 days	0
7	Real Time Testing	2024-12-23	2024-12-23	1 day	0
8	Enhancement and Upgradation	2024-12-24	2024-12-30	5 days	0

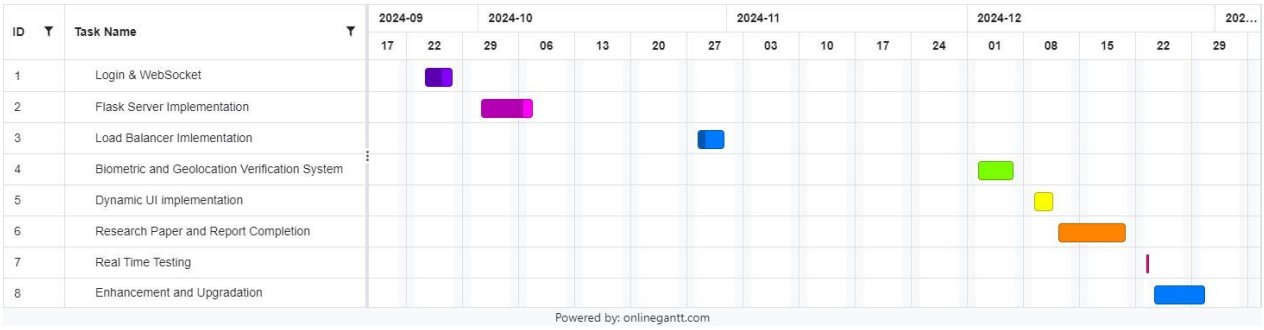


Fig. 3.1 : Gantt Chart

3.5.2 Process Model:

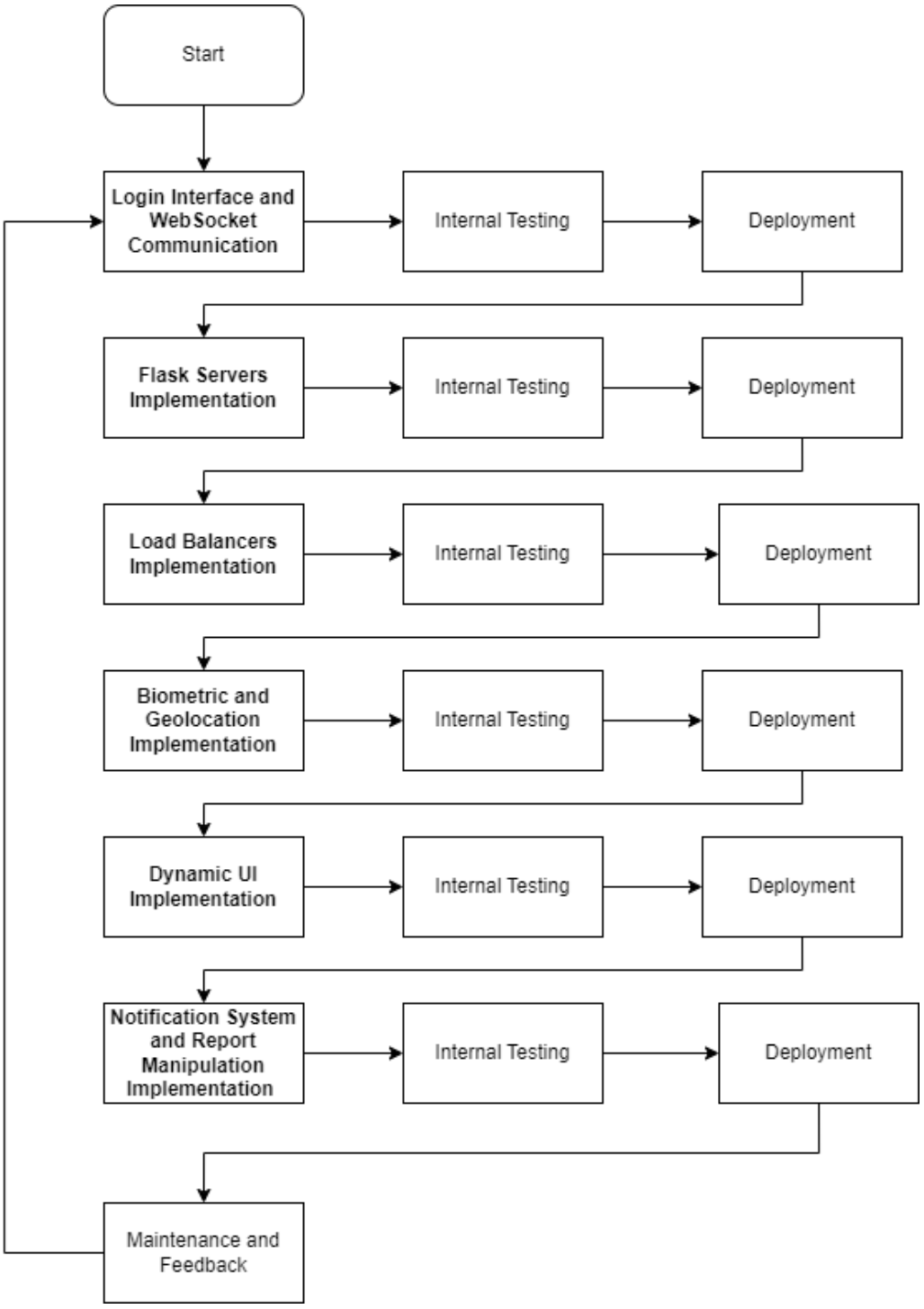


Fig. 3.2 : Process Model

3.6 System Analysis

3.6.1 Functional model

The following is the **Use Case Diagram** for our project:

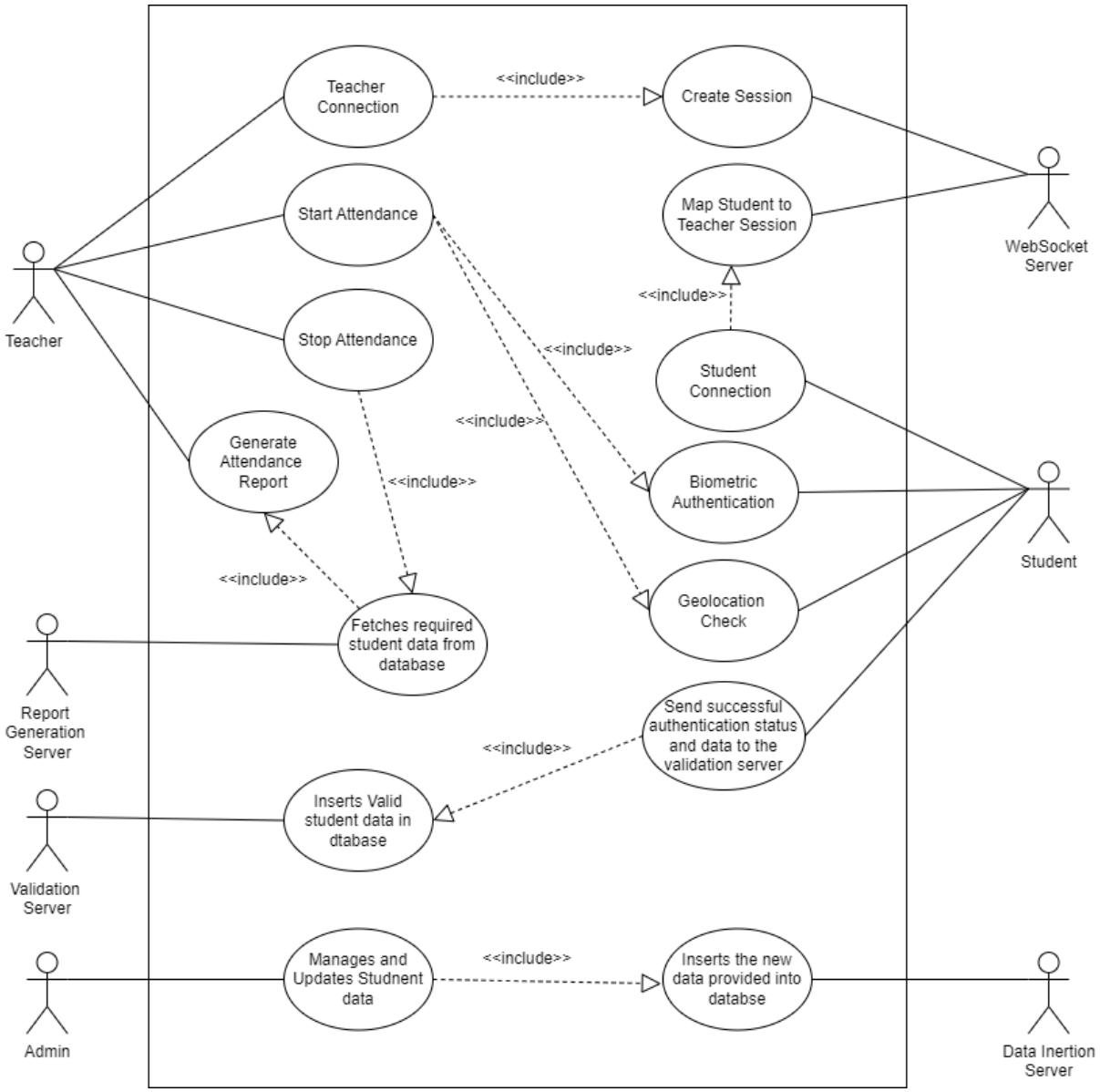


Fig. 3.3 : Use Case Diagram

3.6.2 Structural model

The following is the **Component Diagram** for our project:

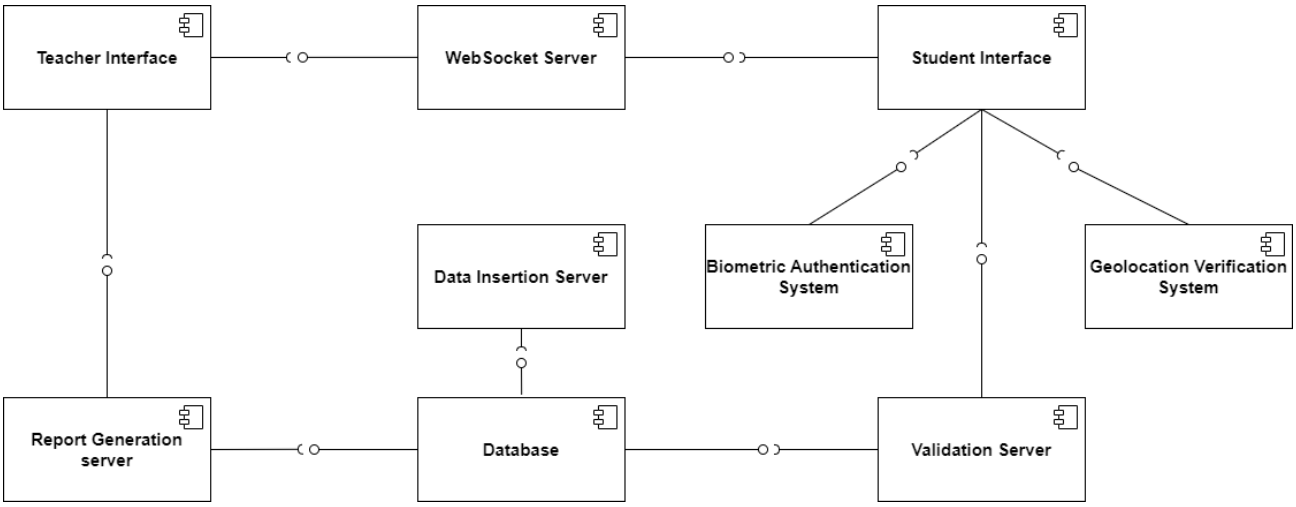


Fig. 3.4 : Component Diagram

3.6.3 Behavioral model

The following is the **Sequence Diagram** for our project:

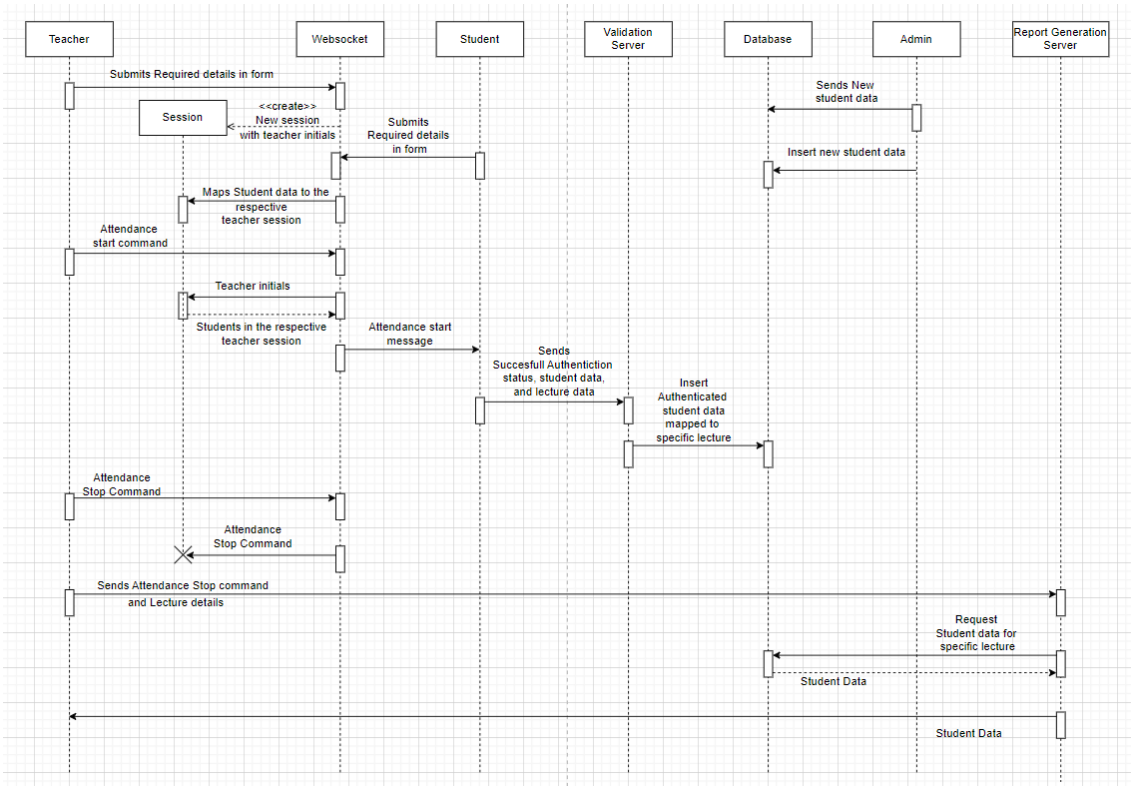


Fig. 3.5 : Sequence Diagram

Chapter 4

System Design and Experimental Set up

4.1 Data Flow Diagram/ Physical layout/ Block diagram

4.1.1. Data Flow Diagram

Following are the three major components of our DFD
External Entities:

1. **Teacher**: Fills in session details and starts/stops the attendance.
2. **Student**: Fills in details and participates in the attendance session to mark their presence.
3. **Admin**: Updates new or existing student data.
4. **WebSocket Server**: Holds the mapping of students with their respective teachers.
5. **Validation Server**: Receives student attendance data to insert into the database.
6. **Report Generation Server**: Generates attendance **Admin**: Updates new or existing student data.
7. **Data Insertion Server**: Inserts the data of new students or updates existing student data.

Processes:

1. **Teacher Connection**: The teacher submits details and connects to the WebSocket server.
2. **Student Connection**: Students submit their details and connect to the WebSocket server.
3. **Mapping Students to Teachers**: Students are mapped to their teacher's session.
4. **Attendance Start**: Attendance begins and students receive the attendance message.
5. **Student Authentication**: Marks the student's attendance as 'present' whose Biometric authentication and geolocation check are successful.
6. **Attendance Stop**: Attendance ends and the report is generated.
7. **Student Data Insertion** : Insertion of new student data into the database.

Data Stores:

1. **MySQL Database**: Contains data about the student, lectures and mapping or present student to the lectures.

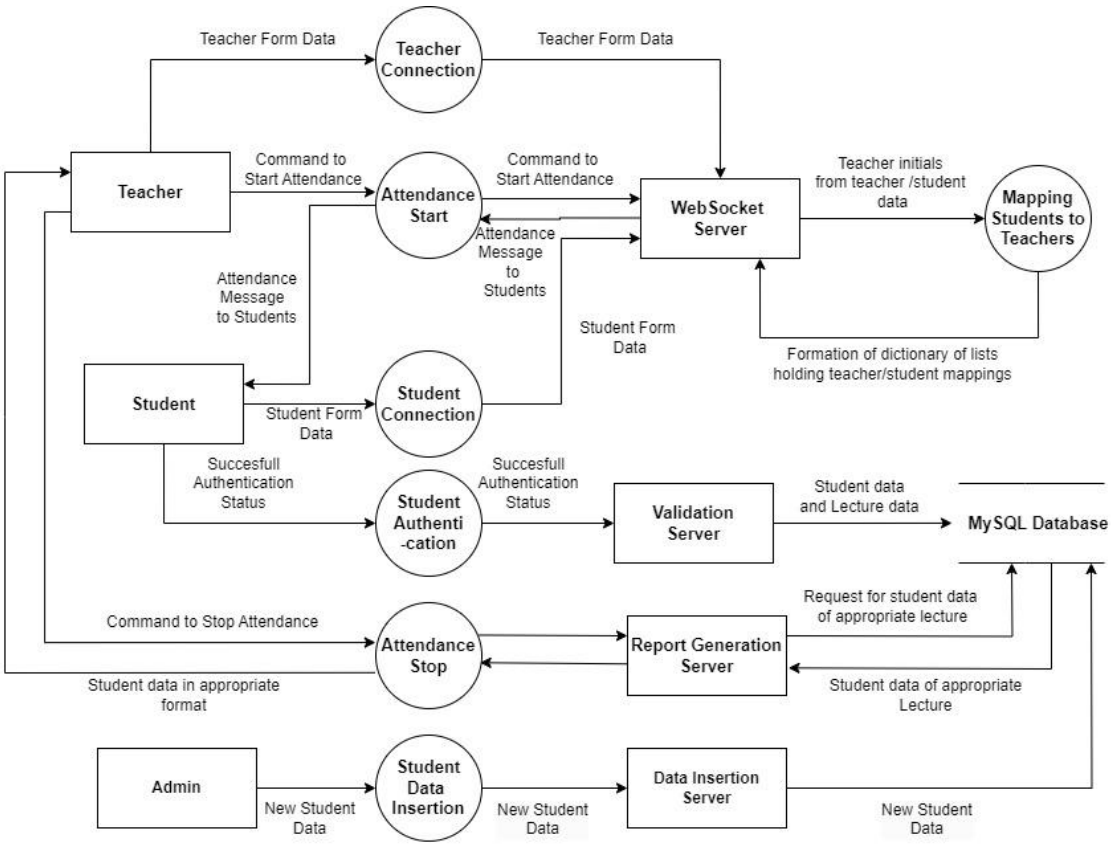


Fig. 4.1 : Data Flow Diagram

4.1.2. System Architecture

The working of our project consists of three major phases:

1. Client Connection and Session Initialization

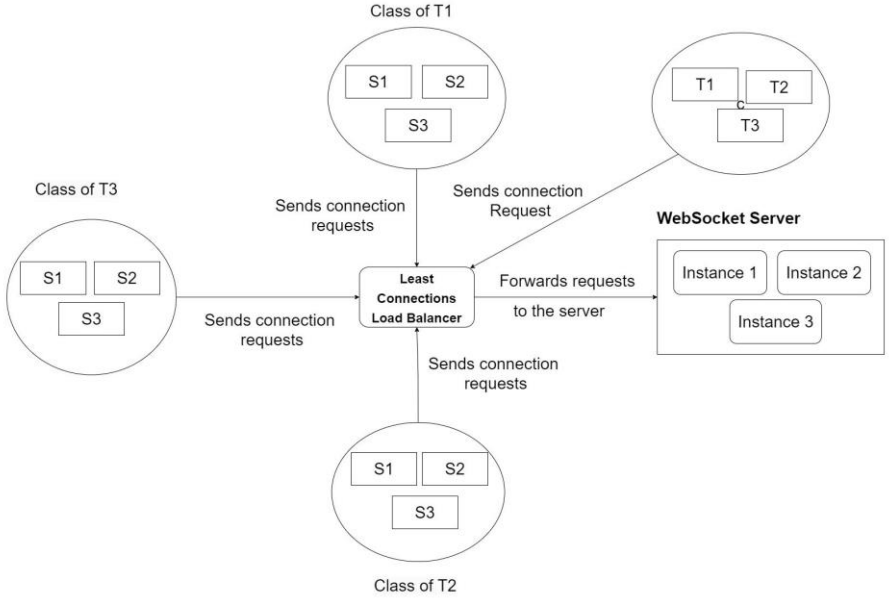


Fig. 4.2 : System Architecture Phase 1

2. Attendance Verification and Marking

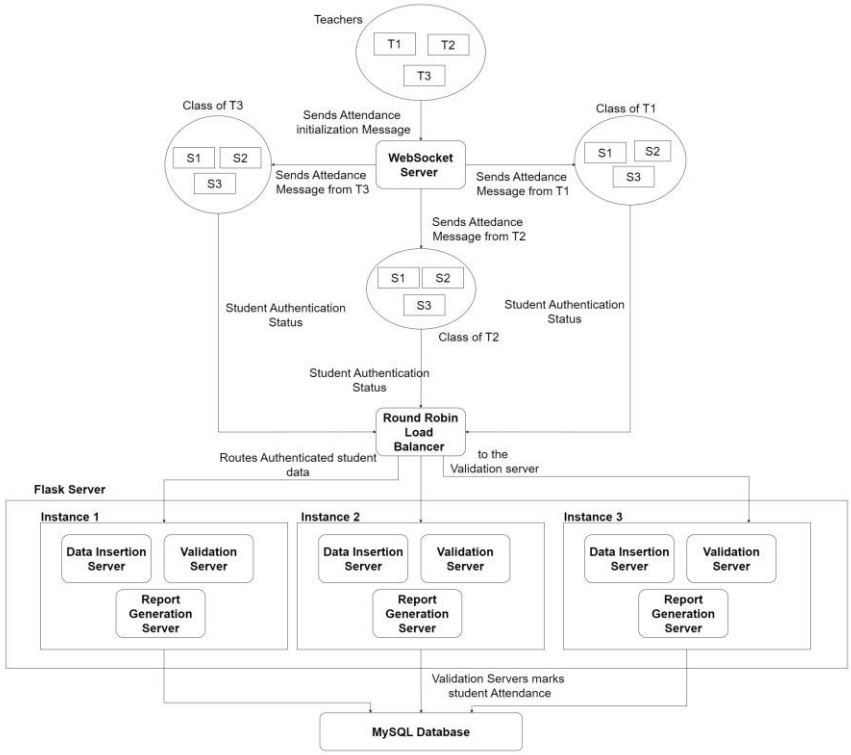


Fig. 4.3 : System Architecture Phase 2

3. Session Closure and Report Generation

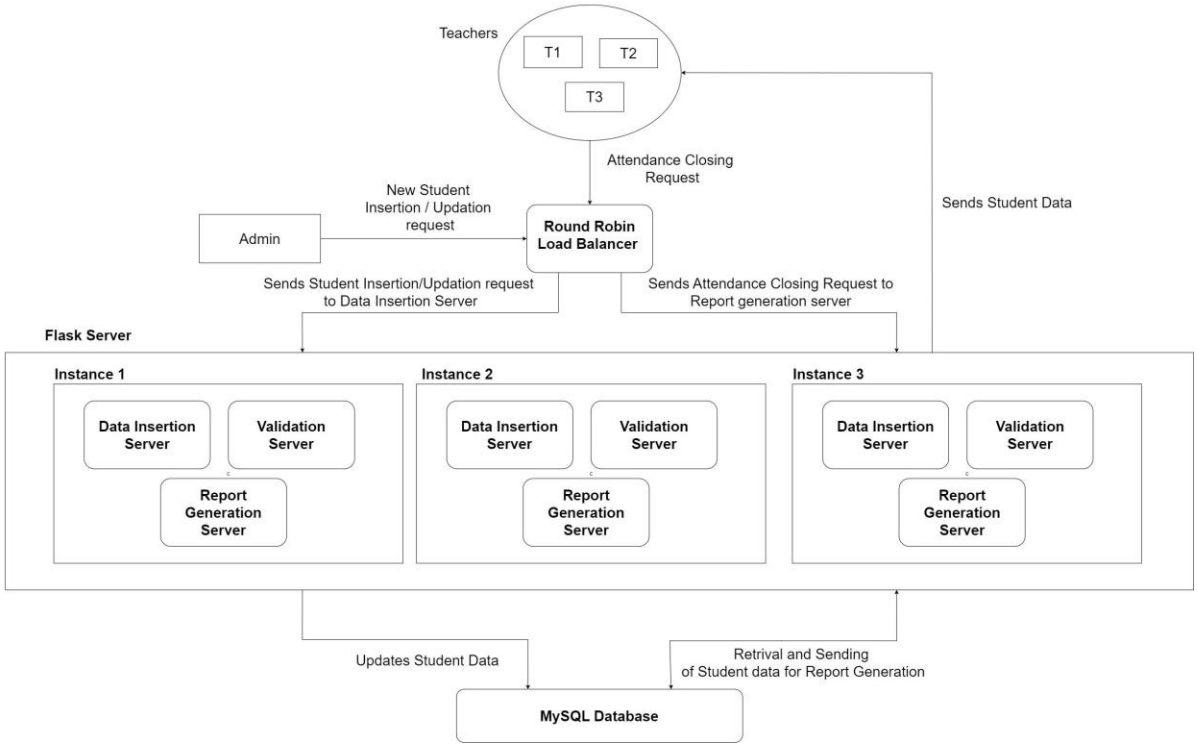


Fig. 4.4 : System Architecture Phase 3

4.2 Algorithm/Flowchart/Pseudo Code Design/ UML Diagrams

4.2.1 Mathematical Model

The working of our project consists of three major phases:

4. Client Connection and Session Initialization
5. Attendance Verification and Marking
6. Session Closure and Report Generation

1. Set Definitions

a. Let T represent the set of all teachers:
$T=\{t1,t2,\ldots,t_n\}$

b. Let L represent the set of all sessions created by teachers:
$L=\{L1,L2,\ldots,L_k\}$

c. Let S represent the set of all students:
$S=\{s1,s2,\ldots,s_m\}$

d. Let A represent the set of students who are successfully authenticated for attendance:
$A=\{a1,a2,\ldots,a_j\} \subseteq S$

2. *Variables and Functions*

a. $t \in T$: A teacher in the system.

b. $s \in S$: A student in the system.

c. *L(t):* The lecture created by teacher t.

d. *bio(s):* A function that returns 1 if the student s successfully passes biometric authentication, otherwise 0.

e. *loc(s):* A function that determines the location of the teacher or student

f. *geo(s,t):* A function that checks if the student s is within the required geolocation radius of teacher t.

$$geo(s,t) = \begin{cases} 1 \text{ if } d(loc(s), loc(t)) \leq r \\ 0 \text{ if } d(loc(s), loc(t)) > r \end{cases}$$

where *d(loc(s), loc(t))* is the distance between the location of student s and teacher t, and r is the required radius.

g. *auth(s,t):* A function that returns 1 if student s is authenticated (biometrically and geographically) for teacher t's session, otherwise 0.

$$auth(s,t) = bio(s) \wedge geo(s,t)$$

h. *att(s,t):* A function that represents whether a student is marked as present in a teacher t's session:

$$att(s,t) = \begin{cases} 1 \text{ if } auth(s,t) = 1 \\ 0 \text{ if } auth(s,t) = 0 \end{cases}$$

3.Conditions

a. The distance between the student and the teacher must satisfy:
$d(loc(s),loc(t)) \leq r$

b. The student must pass biometric authentication:
$bio(s)=1$

c. If both conditions are satisfied, the student's attendance is marked:
$att(s,t)=1$

Otherwise:

$$att(s,t)=0$$

4. *Workflow Representation*

$$L(t)=\{s \in S \mid auth(s,t)=1\}$$

4.2.2 Algorithms

In a real-time environment, multiple users may attempt to access the server simultaneously. To prevent server overload and enhance availability, load balancers are employed to efficiently distribute traffic among the servers.

1) The load balancer managing traffic on the WebSocket server uses the **'Least Connections' algorithm**, which directs traffic to the server with the fewest active connections.
2) For the 'Validation' and 'Report Generation' servers, the load balancer uses the **'Round Robin' algorithm** to evenly distribute traffic, sequentially sending requests to each server in turn.

Round Robin Algorithm

The Round Robin algorithm is one of the simplest and most widely used load balancing algorithms. It operates on a cyclical basis, distributing client requests equally across a group of servers without considering the current load on each server. Here's a detailed explanation:

Working:

- Cyclic Distribution: The load balancer assigns each new request to the next server in the list, in turn. When it reaches the end of the list, it starts again from the first server.
- Equal Share: Each server is assigned an equal number of requests, regardless of its current load, processing power, or other factors.

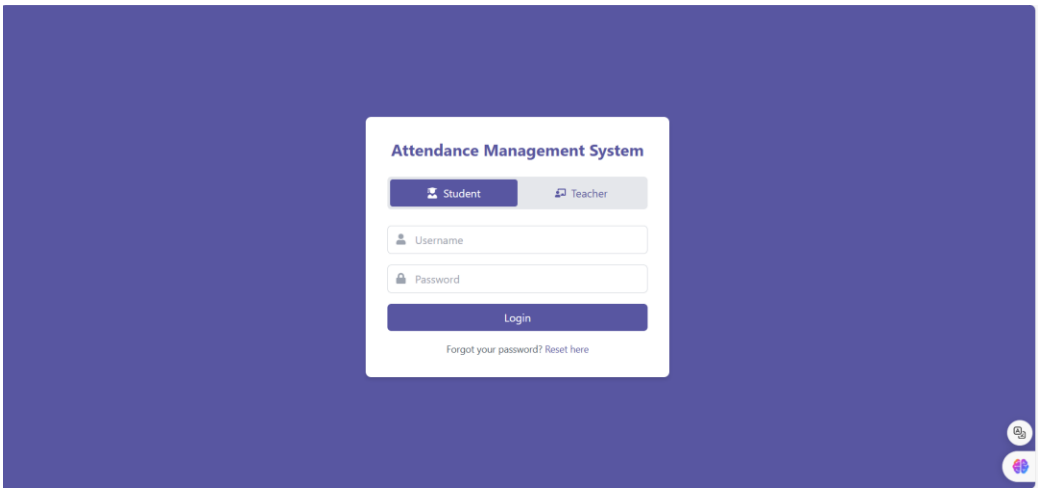
Least Connections Algorithm

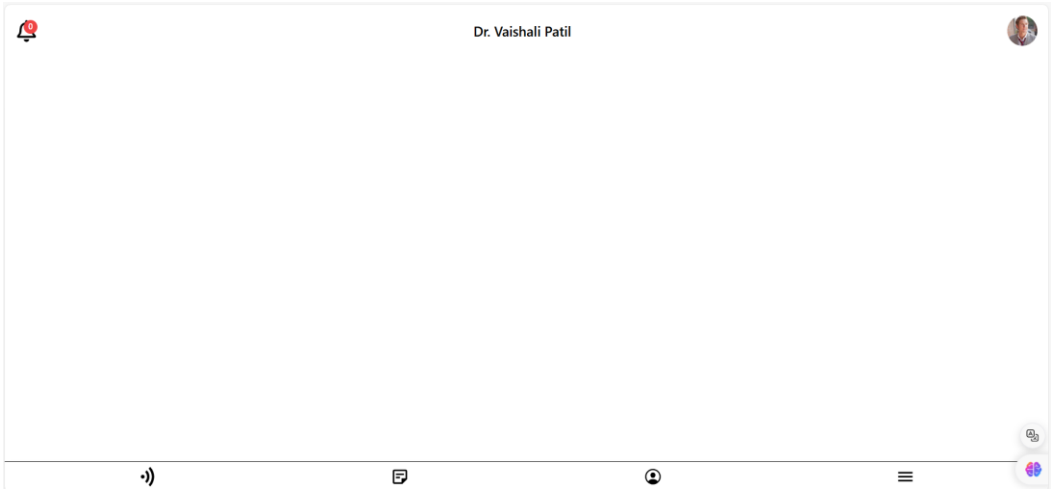
The Least Connections algorithm is a more dynamic and intelligent load-balancing technique. It distributes incoming requests based on the number of active connections each server currently has, aiming to send requests to the server that is handling the fewest connections at any given moment.

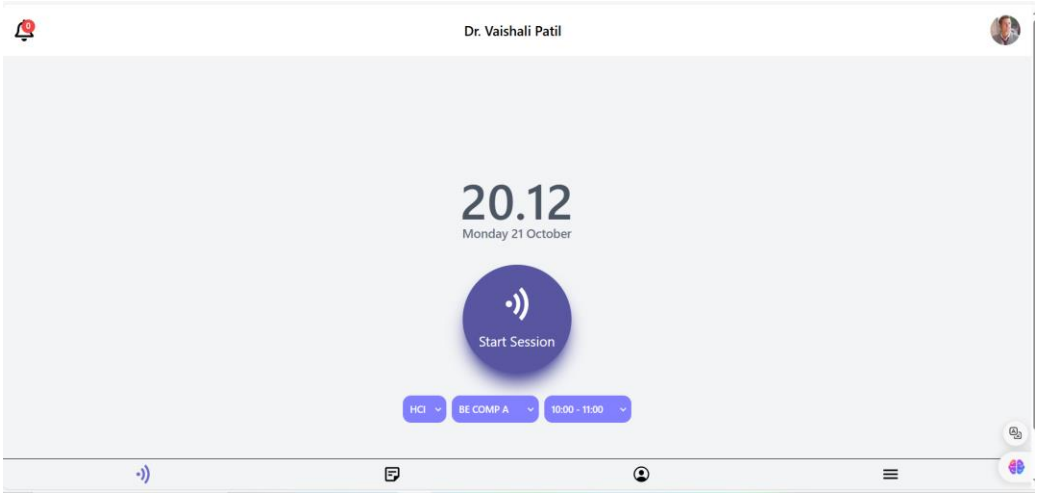
How It Works:

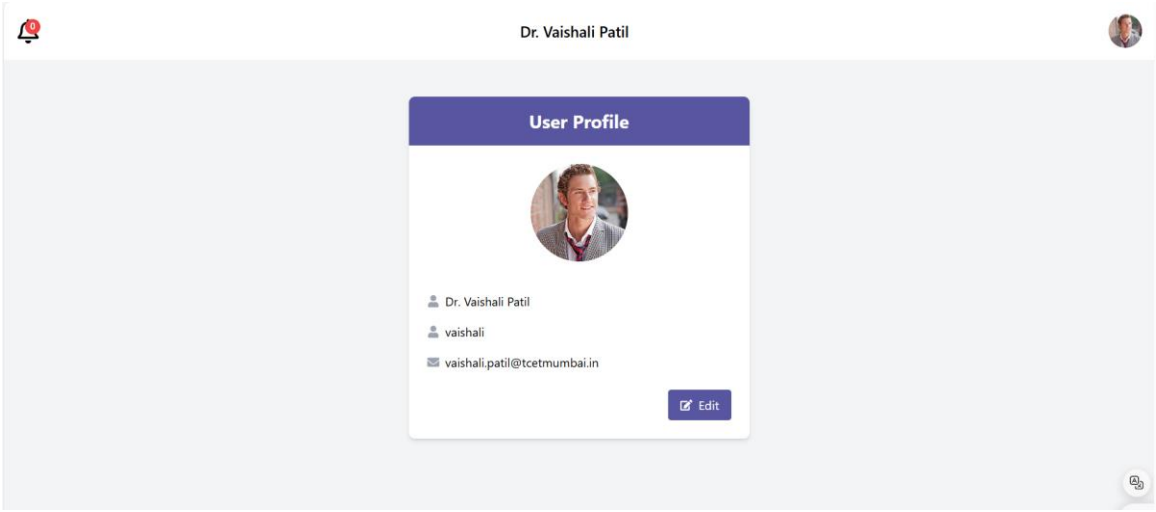
- Connection Monitoring: The load balancer continuously monitors how many active connections each server is managing.
- Load Balancing: New requests are sent to the server with the least number of active connections. This ensures that no single server gets overloaded while others remain underutilized.

4.3 User Interface Design (Snapshots)









4.4 Details about input to systems or selected data

4.4.1. User Inputs:

- **Login Credentials:** Username and Password for authentication.
  - Student Login details:
  - User Type
  - Name
  - Roll No.
  - Branch
  - Division Year
  - Teacher Initials
- **Teacher Login details:**
  - User Type
  - Name
  - Initials
  - Department
  - Division
  - Year
- **Biometric Data:** Student Fingerprint images through the scanners on their mobiles.
- **Geolocation Data:** Latitude and Longitude coordinates from the user's device (using GPS).

4.4.2. Data Management Inputs:

- **Student Information:**
  - Schema

u_id	roll_no	name

- Input Format

- **Lecture Information:**
  - **Schema**

l_id	lecture -name	branch	division	teacher_ initials	date

  - **Input Format**

- **Attendance Information:**
  - Schema

U_id	l_id

  - Input Format

4.4.3. System Configuration Inputs:

- **WebSocket Connection:** URL for the WebSocket server.
- **Database Connection:**
- Database type (MySQL), URL, and credentials for connecting to the database.

4.5 Performance Evaluation Parameters (for Validation)

1. Response Time:
- **Attendance marking Time:** Time taken to mark the student present after successful authentication.
- **Data Fetch Time:** Time taken to retrieve attendance data from the database for report generation.

2. System Throughput: Measure of number of attendance marked per minute or hour.
3. Scalability: Evaluate the system's performance under increased load.
4. User Satisfaction: Gather feedback from users (students and teachers) regarding system usability and performance.

4.6 Software and Hardware Set up

4.6.1. Software Setup:

1. **Frontend Technologies:**
    - **HTML/CSS/JavaScript** for web interface development.
    - **Frameworks:** (if used): **React.js** or **Angular** for dynamic UI.
    - **WebSocket Library: 'ws'** library in **Node.js** for real-time communication.
2. **Backend Technologies:**
    - **Flask** (Python) for developing the backend API.
    - **Database Management System: MySQL** (Azure MySQL Database).
3. **OS Biometric API:** To capture and process fingerprint data.
4. **Geolocation API: HTML5 Geolocation API** or **Google Maps API** for retrieving location data.
5. **Version Control: Git** for source code management and collaboration.
6. **Deployment: Azure** for hosting the backend server and database.

4.6.2. Hardware Setup:

1. **Server: Azure Virtual Machine** and **App Service** configured with appropriate resources.
2. **Client Devices:**
    - Desktop or laptop computers for accessing the web application.
    - Mobile devices for geolocation and biometric verification.
3. **Network Infrastructure:**
    - Reliable internet connection to ensure smooth WebSocket communication and data transfer.
4. **Development Environment:**
    - Local development setup with IDEs i.e. **Visual Studio Code**.

Chapter 5

Conclusion

5.1 Summary of Work Completed

In this project, significant progress has been made towards developing an Attendance Tracking and Management System that integrates real-time communication and biometric authentication. Below is a summary of the work completed so far:

1. **Login Interface & WebSocket Communication**:
   The basic login interfaces for both teachers and students were developed, allowing users to input essential session and general details. A real-time WebSocket communication system was implemented, enabling dynamic interaction between teachers and students during attendance marking.
2. **Flask Server Implementation:**
   The backend infrastructure was set up using Flask and MySQL to store student and session data securely. This allows the system to record student attendance in real-time, store new student data, and generate attendance reports at the end of each session.
3. **Load Balancing Setup:**
   A load-balancing system design was established for both WebSocket and Flask servers and partial implementation is completed.

5.2 Implementation Plan for Next Semester

Looking forward to the next phase of the project, the following implementation tasks have been outlined:

1. **Biometric Authentication**: Implementation of mobile biometric authentication, enabling students to verify their identity via fingerprint or face recognition before marking their attendance.
2. **Geolocation Verification**: Implementation of a Geolocation Verification System that verifies that students are within a specified radius of the teacher's location, using the HTML5 Geolocation API, before attendance submission is permitted.
3. **Complete Load Balancing Setup**: A load balancing system implementation using both the **Round-Robin** and **Least Connections** algorithms, ensuring the system can manage higher traffic by distributing loads across multiple servers effectively.
4. **Notification System and Report Manipulation:**
   - Notifications: Develop a notification system to inform students about their current attendance status. This system will allow teachers to send reminders and updates in real-time.
   - Report Manipulation: Implement functionality for teachers to review and modify attendance reports, allowing them to make corrections if any errors are found after the session ends.
5. **User Feedback Integration:**

- After initial deployment and testing, collect feedback from users (students and teachers) to improve the system based on real-world usage. Incorporate suggestions related to UI/UX improvements and additional features as needed.

6. **Scalability Testing:**
   - Conduct extensive scalability testing to ensure the system can handle larger numbers of concurrent users (teachers and students). Fine-tune the load balancing algorithms to distribute requests efficiently under varying traffic loads.

By the end of the next semester, the project is expected to have a fully functioning attendance tracking system with enhanced performance, security, and user experience, ready for deployment at scale in educational institutions.

References

[1] Mishra, S., Kumar, C., Ali, A., & Bala, J. (2021). Online Attendance Monitoring System using QR code (OAMS). 2021 2nd International Conference on Intelligent Engineering and Management (ICIEM).

[2] Mb, S., & Roy, R. (2015). A web enabled secured system for attendance monitoring and real time location tracking using Biometric and Radio Frequency Identification (RFID) technology. 2015 International Conference on Computer Communication and Informatics (ICCCI -2015), Jan. 08 – 10, 2015, Coimbatore, INDIA.

[3] Lodha, R., Gupta, S., Jain, H., & Narula, H. (2015). Bluetooth Smart Based Attendance Management System. Procedia Computer Science, 45, 524–527.

[4] Idowu, O. J. (2012). Development of Attendance Management System using Biometrics. Department of Electrical and Electronics, University of Benin, Edo State, Nigeria.

[5] Yang, S., Song, Y., Ren, H., & Huang, X. (2016). An automated student attendance tracking system based on voiceprint and location.

[6] A. K. Jain, A. Ross, and S. Prabhakar, "A Biometric Attendance Management System Based on Fingerprint Recognition," *International Journal of Computer Science and Information Technologies*, vol. 4, no. 5, pp. 647-652, 2021.

[7] S. Kumar, M. A. Patil, and P. G. Khot, "Smart Attendance System using GPS and Facial Recognition," *IEEE Access*, vol. 9, pp. 34321-34328, Mar. 2021.

[8] L. Zhang and H. Wang, "A Comparative Study on QR Code, Biometric, and RFID Technologies for Automated Attendance Systems," *Journal of Education and Information Technologies*, vol. 25, no. 6, pp. 1234-1245, Dec. 2020.

[9] M. S. Alkahtani, "RFID and Bluetooth based Attendance System for Improved Accuracy and Automation," *IEEE Transactions on Education*, vol. 64, no. 4, pp. 311-319, Nov. 2020.

[10] N. Ratha and R. Bolle, "Privacy and Security Issues in Biometric Attendance Systems: A Review," *ACM Computing Surveys*, vol. 53, no. 2, pp. 1-33, Apr. 2021.

Propose Conference Paper

ClassConnect: A Real-Time Attendance Management System Empowering Education Through Broadcasting Technology

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Abstract—**Attendance monitoring is a crucial aspect of educational and organizational environments, ensuring accountability and efficient management. Traditional attendance methods often encounter challenges related to inefficiency and inaccuracies, underscoring the need for modern technologies that enable real-time solutions. This paper reviews existing attendance tracking methodologies and, through a comparative analysis, highlights the benefits of integrating these technologies to contribute to the development of more accurate and efficient solutions. Based on the research, the paper proposes a novel system that leverages GPS and biometric authentication to overcome the limitations of conventional approaches. By utilizing these technologies, the system improves accuracy, automates attendance processes, ensures real-time tracking, reduces manual intervention, saves time, and paves way for more robust attendance management in modern institutions.**

Keywords— Attendance monitoring, Efficient management, Real-time solutions, Attendance tracking methodologies, Comparative analysis, GPS authentication, Biometric authentication, Accuracy, Automated attendance, Real-time tracking, Time-saving

I. Introduction

Attendance management is a crucial aspect of organizational operations, ensuring compliance, participation tracking, and accountability. Traditional methods, such as manual roll calls or paper-based systems, are prone to inefficiencies, errors, and even manipulation, often resulting in distractions, missed attendance records, and proxy attendance, undermining the process's reliability. This has rose interest in exploring modern technologies to enhance and streamline attendance monitoring.

Recent advancements in technology have given rise to various automated attendance systems, including QR code scanning, RFID tagging, GPS tracking, and biometric authentication. While these methods improve accuracy and speed compared to traditional approaches, they also come with challenges, such as infrastructure costs, privacy concerns, and technical limitations.

In this context, our paper surveys existing attendance marking methodologies and introduces a novel solution based on GPS and biometric authentication to address the limitations of conventional methods. By combining location-based tracking with biometric identity verification, the proposed system aims to provide a secure and automated attendance monitoring solution across diffAerent environments. Our GPS- and biometric-based solution aims to contribute to the development of reliable, efficient, and secure attendance monitoring systems tailored to diverse organizational needs.

II. Literature Survey

Through a detailed comparative analysis of various attendance systems, this paper seeks to shed light on the evolving landscape of attendance management technologies, highlighting both their strengths and shortcomings.

Paper	Methodology	Advantage	Drawbacks
[1]Attendance Management System Using a Mobile Device and a Web Application	Utilizing a mobile device and web application for students to register attendance using selfies or signatures with data stored in a database for reference in the future.	**Enhanced Efficiency** **Real-time Monitoring** **Digital Record Keeping**	**Feedback Limitations:** The system lacks functionality for facilitating feedback from participants, hindering interactive engagement and potentially limiting opportunities for lecturer-student interaction and improvement. **Privacy Concerns:** Collection and storage of personal data (e.g., facial images, signatures) raise privacy considerations, indicating the requirement of robust security measures

[2]An automated student attendance tracking system based on voiceprint and location	Students use one app to submit attendance via voiceprints, while lecturers manage sessions through another. Servers handle attendance collection, verification, and database storage.	**Enhanced Efficiency** **User-Friendly Interfaces** **Digital Record Keeping**	**Privacy Concerns**: Voiceprint verification raises privacy concerns related to the collection and storage of biometric data. It should be highly secured. **Reliance on Internet Connectivity**: The system relies on stable Internet connectivity for communication between devices and servers. In environments with poor or unreliable internet access, the system's functionality may be compromised.
[3] Bluetooth Based Attendance Management System	Bluetooth and RFID technology	**Timesaving** **Independent Redesign** **Efficiency**	**Reduced Constructive Feedback**: The system lacks functionality for facilitating feedback from participants, hindering interactive engagement, and potentially limiting opportunities for lecturer-student interaction and improvement. **Proxy Attendance**: One of the drawbacks of the Bluetooth attendance system is the possibility of proxy attendance, where someone else can mark attendance on behalf of another individual.
[4] Development of Attendance Management System using Biometrics.	Biometric technology	**Enhanced Security** **Accuracy** **Adaptability**	**Cost Considerations**: While fingerprint technology offers security benefits, the initial setup costs might be higher due to the need for fingerprint scanners and database infrastructure.
[5] Online Attendance Monitoring System Using QR Code (OAMS)	QR Code, Face Recognition, RFID, Biometric (Fingerprint)	**Fast, Automated Accurate Cost-effective User-friendly**	**Relies on mobile devices and internet connectivity**: poor network coverage or lack of access to a device could hinder its functionality **Inaccuracy**: Lack of accuracy in face recognition techniques

III. Literature Review

In this literature review, we will look into a comprehensive exploration of the methodologies and approaches adopted by key research papers in our domain of study. Building upon the foundational information presented in the literature survey section, we now shift our focus to a detailed examination of each selected paper's unique contributions and techniques. The review is sorted with the names of the paper

1)Attendance Management System Using a Mobile Device and a Web Application: The proposed system for attendance management combines the use of mobile devices and web services to address the challenges typically encountered in traditional attendance tracking methods. During lectures, a mobile device equipped with a custom application is passed among participants, allowing them to register their attendance individually. Participants can choose to register using either a selfie or a signature. If they opt for a selfie, a photo is taken and stored for attendance purposes. If they choose a signature, they digitally sign the screen, and the attendance record is stored with identification by the signature. Once registration is complete, the participant's name is removed from the list of available participants on the device's screen, facilitating easy identification of absentees for the lecturer. The system also allows for the storage of facial images or signatures as evidence of participation. These records are stored in a database, accessible for administrative purposes.

Fig. 1.Proposed System Architecture. Adapted from [2]

2) An Automated Student Attendance Tracking System Based on Voiceprint and Location: This system architecture outlines a approach to attendance tracking using smartphone applications and voiceprint verification. Both students and lecturers use smartphone applications for attendance tracking. The student version captures voiceprints and submits attendance records, while the lecturer version controls the lifecycle of attendance and checking.

The Voiceprint Recognition server verifies students' voiceprints to authenticate their identity. When a student submits their presence, the server compares the captured voice clip with the stored voiceprint template to confirm the match. The Attendance Collecting Server receives attendance submissions from students and controls the primary logic of attendance tracking. It communicates with both student and lecturer applications, coordinating the beginning and ending of attendance activities. It also validates the submissions and calculates the distance between the student's location and the classroom.

All attendance records are stored in the database server. Each record contains essential information such as student ID, course ID, and submission time. Additionally, course-related information like lecture time and location is stored, linking attendance records with specific courses. The Data Presentation Server provides functionalities for accessing attendance data through a web-based portal. It retrieves course information and attendance records from the database and presents them in the portal. The portal includes interactive plots for statistical analysis and allows users to export attendance data.

Security measures include token-based security to prevent forgery during attendance submission. A dynamically generated token is retrieved after successful voiceprint verification and used to authenticate submission requests.

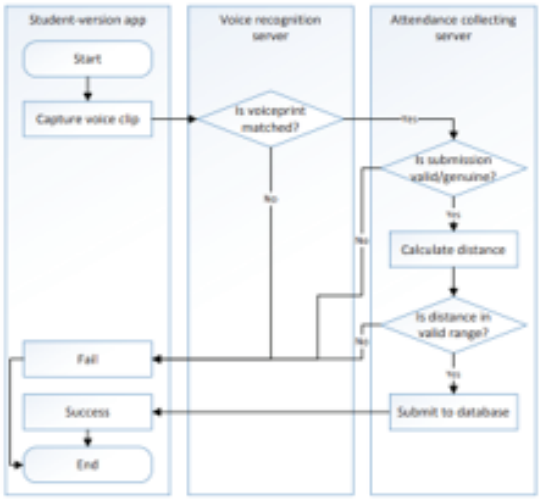

Fig. 2. The process of students attendance submission. Adapted from [2]

3) Bluetooth Based Attendance Management System: The proposed system for attendance management combines the use of Bluetooth and RFID technology to track student attendance efficiently. Student information is collected through RFID cards, sent to the computer, and then to the lecturer's mobile phone for attendance records. Communication architecture within the system employs heterogeneous protocols like TCP/IP, Bluetooth, NFC, and USB. Bluetooth technology is chosen for its range, low power consumption, and suitability for cell phones and battery-operated devices. The system aims to enhance staff attendance through fingerprint biometric authentication and automated class attendance recording, ensuring reliable data transmission and efficient communication between components. Once registration is complete, the participant's name is removed from the list of available participants on the device's screen, facilitating easy identification of absentees for the lecturer. The approach includes a 'Top-Down' analysis and design method with 'Bottom-Up' integration and testing process.

Fig. 3. Bluetooth based Attendance Management System. Adapted from [3]

4) Development of Attendance Management System using Biometrics: This system aims to streamline the process of recording and managing student attendance in educational institutions.. Both students and lecturers use smartphone applications for attendance tracking. During this administrative phase, the system administrator logs in to the system. Student biometric data, including fingerprints, is captured and stored in the database for registration. Course, lecturer, and exam details are also registered at this stage to facilitate attendance tracking. When a lecture begins, the lecturer selects the course code and attendance type. Students then place their fingerprints on the biometric reader. The system compares the captured fingerprint features with the stored templates in the database to verify attendance.

All attendance records are stored in the database server. Each record contains essential information such as student ID, course ID, and submission time. Additionally, Reports are generated for each course, listing the total number of students present and their attendance status. The system automatically records students for the lecture, mid-semester test, or semester exam upon successful fingerprint verification. A message confirms the attendance recording to the user.

The system utilizes biometric authentication to prevent impersonation and ensure accurate attendance tracking. Rather than traditional methods like paper sheets, the biometric system enhances security and efficiency in managing student attendance.

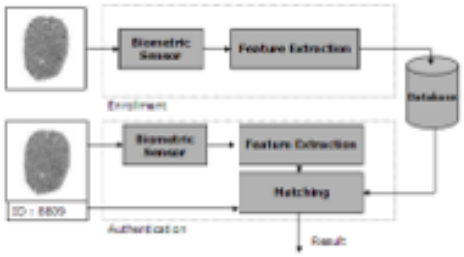

Fig. 4. General Architecture of a Biometric System. Adapted from [4]

5) Online Attendance Monitoring System Using QR Code (OAMS): QR code-based systems offer a promising solution for attendance monitoring due to their simplicity, cost-effectiveness, and ease of implementation. Mishra et al. propose an Online Attendance Monitoring System Using QR Code (OAMS), which combines QR codes with face recognition technology for automated attendance recording. This approach provides advantages such as speed, automation, accuracy, and user-friendliness. However, reliance on mobile devices and internet connectivity may pose limitations in certain contexts.

RFID-based systems are another option for automating attendance tracking through radio frequency data communication between RFID tags and readers. Despite offering scalability and automation, RFID systems have drawbacks such as high initial costs and susceptibility to interference from metal and liquids. Nevertheless, RFID remains a viable choice for institutions investing in advanced attendance management solutions.

In contrast, biometric fingerprint systems offer high accuracy in identifying individuals but are often accompanied by significant costs, data breach risks, and biases in results. The need for specialized hardware and concerns regarding privacy and security make biometric systems less feasible for widespread adoption in educational settings.

IV. Methodology

Working of the System

Workflow:

The workflow of the Attendance Tracking and Management System is as follows:

1. **Teacher Connection**: The teacher fills in the required information on the interface form, such as user type, name, initials, department, division, and year, and connects to the WebSocket server.
2. **Session Creation**: Upon the teacher's connection, a new session map is created with the teacher's initials as the key.
3. **Student Connection**: Students fill out their details, including user type, name, roll number, branch, division, year, and the teacher's initials (who is currently taking the lecture) on their interface form. They then connect to the WebSocket server.
4. **Mapping Students to Teachers**: Students are mapped to the session based on the teacher's initials. This ensures that each student is linked to the correct session for attendance tracking.
5. **Attendance Start**: When the teacher clicks the 'start' button, a message indicating that attendance has started is sent to the students' devices. The message also includes the teacher's location, and the session map on the WebSocket server is cleared.
6. **Student Authentication**: Upon receiving the attendance message, the students' devices will open an interface prompting biometric authentication. Simultaneously, the system checks if the students are within a specific radius of the teacher's location (geolocation check).
7. **Data Validation**: Students who successfully authenticate and are within the required radius will have their data sent to the 'validation server' to be stored in the database.
8. **Attendance Stop**: When the teacher clicks the 'stop' button, a request is sent to the report generation server. The server will fetch and display a detailed list of the students present in the session.

Use of Teacher Initials : In cases where lectures or practicals are conducted in a batch-wise mode (with a single class split into multiple batches), the teacher remains a unique identifier. Regardless of the number of batches, the teacher is the constant entity to identify which students belong to which session, ensuring clarity.

Authentication only Using Mobile OS Verification: The system does not require external authentication devices. When students are prompted for biometric authentication, a request is sent to their mobile phone's operating system to use the stored biometric data. This method is similar to how the phone unlocks itself via biometrics. The mobile OS simply verifies whether the user attempting to mark attendance is the owner of the device, returning a yes/no response after authentication.

Mathematical Model

The working of our project consists of three major phases:

1. Client Connection and Session Initialization
2. Attendance Verification and Marking
3. Session Closure and Report Generation

1. Set Definitions

a. Let T represent the set of all teachers:
$$T=\{t1,t2,\ldots,t_n\}$$
b. Let L represent the set of all sessions created by teachers:
$$L=\{L1,L2,\ldots,L_k\}$$
c. Let S represent the set of all students:
$$S=\{s1,s2,\ldots,s_m\}$$
d. Let A represent the set of students who are successfully authenticated for attendance:
$$A=\{a1,a2,\ldots,a_p\} \subseteq S$$

2. *Variables and Functions*

a. $t \in T$: A teacher in the system.
b. $s \in S$: A student in the system.
c. $L(t)$: The lecture created by teacher t.
d. $bio(s)$: A function that returns 1 if the student s successfully passes biometric authentication, otherwise 0.
e. $loc(s)$: A function that determines the location of the teacher or student
f. $geo(s,t)$: A function that checks if the student s is within the required geolocation radius of teacher t.
$$geo(s,t) = \begin{cases} 1 \text{ if } d(loc(s), loc(t)) \leq r \\ 0 \text{ if } d(loc(s), loc(t)) > r \end{cases}$$
where $d(loc(s), loc(t))$ is the distance between the location of student s and teacher t, and r is the required radius.
g. $auth(s,t)$: A function that returns 1 if student s is authenticated (biometrically and geographically) for teacher t's session, otherwise 0.
$$auth(s,t) = bio(s) \wedge geo(s,t)$$
h. $att(s,t)$: A function that represents whether a student is marked as present in a teacher t's session:
$$att(s,t) = \begin{cases} 1 \text{ if } auth(s,t) = 1 \\ 0 \text{ if } auth(s,t) = 0 \end{cases}$$

3.Conditions

a. The distance between the student and the teacher must satisfy:
$$d(loc(s),loc(t)) \leq r$$
b. The student must pass biometric authentication:
$$bio(s)=1$$
c. If both conditions are satisfied, the student's attendance is marked:
$$att(s,t)=1$$
Otherwise:
$$att(s,t)=0$$

4. *Workflow Representation*

$$L(t)=\{s \in S \mid auth(s,t)=1\}$$

System Architecture:

Phase 1 : Client Connection and Session Initialization

Phase 2 : Attendance Verification and Marking

Phase 3 : Session Closure and Report Generation

Dataflow Diagram(DFD)

Following are the three major components of our DFD

External Entities:

1. **Teacher**: Fills in session details and starts/stops the attendance.
2. **Student**: Fills in details and participates in the attendance session to mark their presence.
3. **Admin**: Updates new or existing student data.
4. **WebSocket Server**: Holds the mapping of students with their respective teachers.
5. **Validation Server**: Receives student attendance data to insert into the database.
6. **Report Generation Server**: Generates attendance **Admin**: Updates new or existing student data.
7. **Data Insertion Server**: Inserts the data of new students or updates existing student data.

Processes:

1. **Teacher Connection**: The teacher submits details and connects to the WebSocket server.
2. **Student Connection**: Students submit their details and connect to the WebSocket server.
3. **Mapping Students to Teachers**: Students are mapped to their teacher's session.
4. **Attendance Start**: Attendance begins and students receive the attendance message.
5. **Student Authentication**: Marks the student's attendance as 'present' whose Biometric authentication and geolocation check are successful.
6. **Attendance Stop**: Attendance ends and the report is generated.
7. **Student Data Insertion** : Insertion of new student data into the database.

Data Stores:

1. **MySQL Database**: Contains data about the student, lectures and mapping or present student to the lectures.

The diagram is as follows:

Database Design

The database consist of three tables:

a) Students: Contains data about individual student
b) Lecture: Contains details about the lecture
c) Attendance: Contains mappings of students to the respective lectures

The Structure of the tables is as follows:

a) Students

u_id	roll_no	name

b) Lecture

l_id	lecture_name	branch	division	teacher_initials	date

c) Attendance

U_id	l_id

The 'Attendance' table is created separately to eliminate redundancy and the data insertion process is also optimized for duplicate entries such that no additional entry will be added for the same student

Server Routing

There are two major servers implemented :

1. WebSocket Server (websocket_server.js): Responsible for connecting clients (mapping students to their respective teachers)
2. Flask Servers (app.py): Flask servers are further classified in multiple functionalities based on routes:
   a) /attendance_data: Route for handling Lecture Insertion and mapping student Database
   b) /student_details: Route for Inserting Student details for college authorities
   c) /report_data: Route for retrieving the data for report generation

Working:

1. If the college authorities want to insert or change their student data then they can send a POST request to /student_details with following example JSON content as the body:

2. Whenever the the teacher closes the session a request will be sent to /report_data to retrieve the names of the students who attended the session. The following data about the students will be retrieved

3. Whenever the student authentication will be successful a request will be sent to /attendance details for mapping them with the lecture and inserting a new lecture with following details.

Hosting

The deployment of both servers is done on Microsoft Azure using the Azure App service. The MySQL server which holds the database is also created using the Azure MySQL server. Following are the FQDN for the same:

1. WebSocket server: https://www.postman.com/avionics-astronomer-74847053/workspace/google-solution-challenge/ws-raw-request/66eff66035488341439b692c
2. Flask servers: https://flask-servers-gqazghgmg7hnbsgv.centralindia-01.azurewebsites.net

A virtual network is created in azure in which all the servers (MySQL, WebSocket and flask) are connected. A private endpoint is being created only between the flask and MySQL server to secure the data for external access.

Load Balancing

In a real-time environment, multiple users may attempt to access the server simultaneously. To prevent server overload and enhance availability, load balancers are employed to efficiently distribute traffic among the servers.

1) The load balancer managing traffic on the WebSocket server uses the 'Least Connections' algorithm, which directs traffic to the server with the fewest active connections.
2) For the 'Validation' and 'Report Generation' servers, the load balancer uses the 'Round Robin' algorithm to evenly distribute traffic, sequentially sending requests to each server in turn.

Future Upgrades

1) Teachers will have the ability to manually edit the list of present students after clicking the 'stop' button, allowing for corrections.
2) A notification system will be available for students, providing real-time updates on their attendance percentage.

V. CONCLUSION

In this paper, we tried to analyze the existing research going on in the field of Attendance Tracking and Management Systems and implemented a solution incorporating GPS and biometric authentication to ensure accurate and secure attendance tracking.

Our literature review has provided a thorough examination of key research papers in the domain of Attendance Management Systems. Each paper contributed unique methodologies and approaches, shedding light on diverse techniques to address challenges in this field.

Our methodology proposes a system that streamlines attendance processes by utilizing WebSocket connections, biometric authentication, and geolocation verification, eliminating proxy attendance. It efficiently manages sessions using teacher initials and mobile OS biometrics, ensuring security and ease of use. With scalable architecture and potential upgrades, the system enhances performance and user experience.

In the future, we are planning to include manual attendance edits for teachers after report generation and real-time attendance notifications for students, enhancing flexibility.

VI. REFERENCES

[1] Mishra, S., Kumar, C., Ali, A., & Bala, J. (2021). Online Attendance Monitoring System using QR code (OAMS). 2021 2nd International Conference on Intelligent Engineering and Management (ICIEM).

[2] Mb, S., & Roy, R. (2015). A web enabled secured system for attendance monitoring and real time location tracking using Biometric and Radio Frequency Identification (RFID) technology. 2015 International Conference on Computer Communication and Informatics (ICCCI -2015), Jan. 08 – 10, 2015, Coimbatore, INDIA.

[3] Lodha, R., Gupta, S., Jain, H., & Narula, H. (2015). Bluetooth Smart Based Attendance Management System. Procedia Computer Science, 45, 524–527.

[4] Idowu, O. J. (2012). Development of Attendance Management System using Biometrics. Department of Electrical and Electronics, University of Benin, Edo State, Nigeria.

[5] Yang, S., Song, Y., Ren, H., & Huang, X. (2016). An automated student attendance tracking system based on voiceprint and location.

[6] A. K. Jain, A. Ross, and S. Prabhakar, "A Biometric Attendance Management System Based on Fingerprint Recognition," International Journal of Computer Science and Information Technologies, vol. 4, no. 5, pp. 647-652, 2021.

[7] S. Kumar, M. A. Patil, and P. G. Khot, "Smart Attendance System using GPS and Facial Recognition," IEEE Access, vol. 9, pp. 34321-34328, Mar. 2021.

[8] L. Zhang and H. Wang, "A Comparative Study on QR Code, Biometric, and RFID Technologies for Automated Attendance Systems," Journal of Education and Information Technologies, vol. 25, no. 6, pp. 1234-1245, Dec. 2020.

[9] M. S. Alkahtani, "RFID and Bluetooth-based Attendance System for Improved Accuracy and Automation," IEEE Transactions on Education, vol. 64, no. 4, pp. 311-319, Nov. 2020.

[10] N. Ratha and R. Bolle, "Privacy and Security Issues in Biometric Attendance Systems: A Review," ACM Computing Surveys, vol. 53, no. 2, pp. 1-33, Apr. 2021.

Appendix A

Abbreviation and Symbols

1. UI: User Interface
2. API: Application Programming Interface
3. WSS: WebSocket Secure
4. HTTPS: HyperText Transfer Protocol Secure
5. DB: Database
6. RAM: Random Access Memory

Appendix B

Definitions

1. WebSocket: A communication protocol that allows full-duplex communication between the client and server, facilitating real-time data exchange.
2. Biometric Authentication: A security process that uses unique biological characteristics (fingerprint or face recognition) to verify an individual's identity.
3. Geolocation Verification: The process of determining a user’s geographical location to validate their proximity to a specific point.
4. Load Balancing: The process of distributing incoming network traffic across multiple servers to ensure no single server bears too much demand.
5. Round-Robin Algorithm: A load balancing method where incoming requests are distributed sequentially across servers in a rotating order.
6. Least Connections Algorithm: A load balancing algorithm that directs new requests to the server with the fewest active connections.

Appendix C

No prior publications.