Project Report:

“Enhanced Security System for Employees and Visitor Authentication”
“TrackNClassify”

For the fulfillment of the Requirement for the Award/Certificate of Completion for the **Summer Training** at GEOPIC, ONGC Dehradun, Uttarakhand.

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DECLARATION

I, **Siddharth Kirti Gautam** hereby declare that the work presented in this project report entitled **"TrackNClassify"** in partial fulfillment of the requirement for the Award/Certificate for the summer from the ONGC Academy, Dehardun, Uttarakhand. This report is an authentic record of my work carried out during the Summer Training/Internship at GEOPIC, ONGC Dehradun, Uttarakhand. from 1st June 2024 to 30th September 2024, under the guidance of **Dr. Santosh Kumar Sahu**, GEOPIC, ONGC Dehradun, Uttarakhand.

(Siddharth Kirti Gautam)
Signature of the Student

CERTIFICATE

This is to certify that **Mr. Siddharth Kirti Gautam**, student of B.Tech. CSE (spec. CCVT) of UPES, Dehradun, Uttarakhand has done his Summer Training at **GEOPIC, ONGC Dehradun**. The project work entitled "Enhanced Security System for Employees and Visitor Authentication: TrackNClassify**”** embodies the original work done by Mr. Siddharth Kirti Gautam during his, above-mentioned, summer training period.

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ACKNOWLEDGEMENT

The summer training at ONGC is a golden opportunity for learning and self-development. I consider myself very lucky and honored to be able to be a part of it and have so many wonderful and experienced people lead me through the completion of this project. It gives me immense pleasure and a sense of satisfaction to have an opportunity to acknowledge and to express gratitude to those who were associated with me during my industrial training at GEOPIC, ONGC Dehradun.

I express my sincere thanks and gratitude to ONGC authorities for allowing me to undergo the training in this prestigious organization. I would like to thank **Mr. P. R. Meena, GM (Programming), and Dr. Santosh Kumar Sahu (Sr. Programming officer)** for providing me with the technical guidance, opportunity, and infrastructure to work.

Finally, I would thank my parents for imparting me with moral support and motivation during this project.

Table of Content :

No.	Section	Page
1.	Introduction	5
2.	Literature Survey	8
3.	Technical Resources and Infrastructure	11
4.	System Design and Implementation	16
5.	Comprehensive Workflow of Visitor Management System	21
6.	Result	25
7.	Conclusion	31
8.	References	33

1. Introduction

The "TrackNClassify" project represents a sophisticated and innovative solution for visitor and student management, meticulously designed to optimize the tracking and classification of various entrants within an organization or institution. This web-based application addresses the inherent challenges associated with manual entry logs and inefficient visitor tracking by providing an automated, user-friendly platform that ensures precise data collection, real-time monitoring, and streamlined administrative operations. Key features of TrackNClassify include visitor categorization, integration with gate scanners, and comprehensive data management capabilities, making it an indispensable tool for institutions such as universities, corporate offices, and research facilities.

TrackNClassify offers significant benefits by enhancing security measures, improving operational efficiency, and ensuring data accuracy. The integration with gate scanners provides a secure method for logging entries and exits, while the intuitive interface allows for easy navigation and immediate access to essential features. By automating visitor and student management processes, TrackNClassify reduces administrative burdens and minimizes human errors. The system's capability to track the real-time location of visitors and students enables better resource allocation and emergency response management. Additionally, the structured data collection methods ensure high accuracy, which is crucial for analysis, reporting, and informed decision-making processes. Overall, TrackNClassify is a valuable asset for any institution seeking to enhance its visitor management processes and maintain a secure and organized environment, ultimately contributing to the institution's operational success and security.

Moreover, TrackNClassify is designed with scalability and adaptability in mind, ensuring it can meet the evolving needs of any institution. The system's robust architecture allows for seamless integration with existing infrastructure and the potential for future enhancements. By offering a centralized platform for managing visitor and student data, TrackNClassify promotes transparency and accountability within the institution. The ability to generate detailed reports and analytics further empowers administrators to make data-driven decisions, enhancing overall operational efficiency. In essence, TrackNClassify not only improves the day-to-day management of visitors and students but also provides a strategic advantage by enabling institutions to respond swiftly and effectively to emerging challenges and opportunities.

This comprehensive system employs RFID technology, utilizing an MFRC522 RFID reader to accurately capture unique tag IDs from visitors' and employees' RFID cards. The RFID reader's data is processed by an esp32 devkitv1, which is connected to a Wi-Fi network, enabling real-time communication with a backend server. This setup ensures that visitor and employee information is updated and retrieved efficiently, providing a robust means of managing entries and exits. The system also features a Liquid-Crystal I2C (LCD) module to display essential information directly at the point of access, such as the visitor's or employee's name and their intended destination within the facility. This real-time feedback mechanism enhances the user experience and supports immediate action if necessary.

On the backend, the system is supported by a Node.js server connected to MongoDB Atlas, handling the storage and management of visitor and employee data. The server's API endpoints facilitate critical functions such as checking the RFID tag, updating locations, and recording entry and exit times. Through these API endpoints, the system dynamically interacts with the database to ensure that all records are accurate and up-to-date. This integration of hardware and software components, the use of cloud-based databases, and real-time processing capabilities demonstrate the system's efficacy and potential applications in enhancing management processes.

By leveraging modern technologies, TrackNClassify contributes to the development of more secure and efficient visitor and student management systems, addressing the growing demand for robust solutions in various institutional and organizational settings.

1.1 Problem Statement of this study

The administration of visitor and student ingress within academic institutions, corporate headquarters, and research establishments presents considerable challenges, primarily due to the dependence on manual entry records and fragmented tracking methodologies. This conventional approach frequently engenders inaccuracies in data collection, protracted retrieval of visitor details, and security lapses. Furthermore, the deficiency of real-time surveillance and automated procedures exacerbates administrative inefficiencies, imposes a heightened burden on personnel, and potentially compromises emergency response efficacy. A comprehensive, automated system that can accurately monitor and classify a variety of visitor and student demographics, enhance security measures, streamline administrative processes, and provide real-time data to support informed decision-making is absolutely required.

1.2 Motivation

Efficient management of visitor and student entries within institutions such as universities, corporate offices, and research facilities poses significant challenges due to the reliance on manual entry logs and disparate tracking systems. This approach often results in inaccurate data collection, delays in retrieving visitor information, and security vulnerabilities. Additionally, the lack of real-time monitoring and automated processes can lead to administrative inefficiencies, increased workload for staff, and potential gaps in emergency response capabilities. There is a pressing need for a comprehensive, automated system that can accurately track and classify various types of visitors and students, enhance security measures, streamline administrative tasks, and provide real-time data for informed decision-making.

1.3 Research Questions of this study

The present study aims to address the subsequent research inquiries:

- How can the implementation of an automated visitor and student management system improve data accuracy and reduce administrative burdens in institutions?
- What are the security benefits of integrating gate scanners with a centralized management system in institutions with high foot traffic.
- In what ways can real-time tracking of visitor and student locations within an institution improve resource allocation and emergency response management.

1.4 Research Contributions

The research contribution of this study is as follows:

- **Development of an Automated Visitor and Student Management System**: This study presents the implementation of the TrackNClassify system, utilizing RFID technology and integrating gate scanners to automate the tracking and classification of visitors and students within institutions, ensuring precise data collection and real-time monitoring.

- **Enhancement of Security Measures**: By incorporating RFID and gate scanner integration, the study demonstrates significant improvements in security protocols. The system ensures accurate logging of entries and exits, thereby reducing security vulnerabilities and enhancing overall institutional security.

- **Improvement of Operational Efficiency**: The research highlights how the automation of administrative processes through the TrackNClassify system reduces the workload and minimizes human errors. This results in streamlined data collection, tracking, and reporting processes, significantly improving operational efficiency.

- **Utilization of Real-Time Data for Resource Allocation and Emergency Management**: The study explores the benefits of real-time tracking of visitors and students using RFID technology, emphasizing its role in better resource allocation and improved emergency response management.

2. Literature Survey

Visitor management systems (VMS) play a crucial role in maintaining security and operational efficiency in settings like educational institutions, corporate offices, and healthcare facilities. The incorporation of QR codes and Radio-Frequency Identification (RFID) has notably enhanced the functionality of these systems. This survey explores the evolution, deployment, and benefits of VMS that utilize QR codes and RFID technology.

- **Traditional vs. Digital Visitor Management Systems**

Traditional VMS systems were characterized by manual processes such as sign-in sheets and visitor badges, which were often inefficient and prone to errors (Smith, 2015). In contrast, digital VMS systems have adopted electronic check-in kiosks, ID scanners, and integrated databases, significantly improving administrative efficiency and security through real-time tracking and accurate visitor records (Jones et al., 2018).

- **QR Code Technology in Visitor Management**

QR codes provide a straightforward and secure method for visitor authentication. They can store comprehensive visitor details and are easily scanned using smartphones or dedicated scanners, resulting in quicker, more dependable, and more secure visitor interactions (Chen & Lee, 2020).

- ➢ Efficiency: QR codes decrease wait times and reduce administrative workload (Wang et al., 2021).
- ➢ Security: Encrypted QR codes ensure the secure access of visitor information (Kim & Park, 2022).
- ➢ Real-Time Tracking Allows for the monitoring of visitor movements (Li et al., 2019).
- ➢ Contactless Operation: Particularly advantageous during health crises such as COVID-19 (Zhang et al., 2020).

- **RFID Technology in Visitor Management**

RFID technology utilizes electromagnetic fields to automatically identify and track tags. Renowned for their accuracy and real-time data processing capabilities, RFID systems improve visitor logging and tracking (Rao et al., 2016).

- ➢ Automation: RFID systems decrease the need for manual intervention, leading to more efficient operations and reduced human error (Patel et al., 2017).
- ➢ Accuracy: The technology significantly reduces tracking errors, ensuring that data regarding visitor and employee movements is precise and reliable (Gupta & Shukla, 2018).
- ➢ Scalability: RFID systems can efficiently handle large volumes of visitors and employees, making them suitable for institutions with high traffic (Kumar et al., 2019).
- ➢ Integration: These systems enhance functionality when integrated with existing security and management systems, providing a comprehensive solution (Singh et al., 2020).

- ## Combined QR Code and RFID Systems

The integration of QR code and RFID technologies capitalizes on their individual strengths, offering efficient, secure, and scalable visitor management solutions (Wang et al., 2021). By integrating QR codes and RFID systems, organizations can create a more robust visitor management solution. For instance, QR codes can be used for initial visitor registration and issuing temporary access passes. Visitors can use these QR codes to gain entry to specific areas. Meanwhile, RFID tags can be issued to employees and frequent visitors who require more permanent and secure access. This dual system allows for flexibility and scalability. For example, during high-traffic events or peak hours, QR codes can manage the influx of temporary visitors, while RFID tags ensure the seamless movement of regular staff. Additionally, the combined system can provide a layered security approach, where QR codes are used for initial access and RFID tags for more sensitive or restricted areas. The combined use of QR code and RFID technologies also enhances data collection and tracking capabilities. QR codes can facilitate quick and easy check-ins, while RFID tags provide continuous tracking of movement within the premises. This data can be invaluable for optimizing visitor flow, enhancing security, and improving overall operational efficiency.

Case Studies-

- **University Implementations**: Several universities have successfully implemented RFID-based systems for visitor and employee management, demonstrating improvements in efficiency and security (Singh & Kaur, 2017).

- **Corporate Environments**: Corporate case studies show that RFID systems streamline visitor and employee tracking processes, reduce administrative workload, and improve overall security (Sharma et al., 2019).

- ## Cloud-Based Databases for Scalability and Flexibility

- **Scalability**: Cloud-based databases, such as MongoDB Atlas, offer scalable solutions that can accommodate the growing needs of institutions and organizations. They support real-time data interaction and can manage large volumes of data efficiently (Martínez et al., 2019).

- **Flexibility**: These databases provide the flexibility needed to adapt to changing requirements and integrate with various systems, enhancing overall system functionality (Nogueira et al., 2020).

- ## Security Implications and Solutions

- ***Data Security****: The security of RFID-based systems is a significant concern. Studies highlight various vulnerabilities and propose solutions such as encryption, secure authentication, and access control measures to enhance system security (Ali et al., 2017).*
- **Privacy Protection**: Protecting the privacy of visitors and employees is crucial. Techniques like data anonymization and secure data storage are essential to safeguard personal information (Khan et al., 2018).

3. Technical Resources and Infrastructure

3.1. QR Code Technology

Incorporating QR code technology into the visitor management system significantly enhances both security and convenience. Upon successful verification of a visitor's credentials, the system generates a unique Quick Response (QR) code. This QR code encapsulates comprehensive information about the visitor, including their identification details, purpose of the visit, and the duration of their stay. The generation process ensures that each visitor receives a distinctive code, which is promptly emailed to them. This pre-arrival dissemination of QR codes ensures that visitors possess the necessary credentials before arriving at the facility, thereby streamlining the entry process.

Upon arrival at the organization’s premises, visitors present their QR codes at designated entry points equipped with advanced QR code scanners. These scanners are capable of quickly and accurately reading the encoded information. The scanning process is designed to be swift, thereby significantly reducing wait times and facilitating a seamless and efficient check-in experience. This not only enhances the visitor's experience but also optimizes the organization's security protocols by ensuring that only verified individuals gain access. The integration of QR code technology into the visitor management system exemplifies the synergy between advanced technological solutions and practical security measures, promoting both efficiency and safety in managing visitor entry.

- **QR Code Generation and Emailing**
  The generation of QR codes is a pivotal aspect of the visitor management system. Upon verification, a unique QR code is created for each visitor. This code is not merely a random set of characters but a sophisticated matrix barcode that stores all pertinent information about the visitor. The encoding includes the visitor’s identification details, such as name and contact information, the purpose of the visit, such as a meeting or event, and the duration for which access is granted. Once generated, this QR code is immediately emailed to the visitor. The email system ensures that the code reaches the visitor in a timely manner, enabling them to have their entry credentials ready prior to their arrival. This proactive measure reduces the administrative burden on the entry points and enhances the overall visitor experience by minimizing delays and potential errors in visitor verification.

- **Scanning at Entry Points**
  At the organization’s entry points, the QR code technology is leveraged to facilitate a streamlined check-in process. These entry points are equipped with state-of-the-art QR code scanners capable of reading the QR codes presented by visitors. The scanners are designed to quickly decode the information embedded within the QR codes, ensuring that the check-in process is both rapid and accurate. This technology reduces the time spent in manual verification processes and eliminates the need for physical sign-in sheets, which can be time-consuming and prone to human error. By using QR code scanners, the organization can ensure that the entry process is efficient, allowing visitors to proceed with their intended activities without unnecessary delays.

- **Security and Efficiency Enhancement**
  The use of QR code technology in the visitor management system not only improves efficiency but also significantly enhances security. Each QR code is unique to the individual visitor, ensuring that the entry credentials cannot be easily replicated or tampered with. This uniqueness provides a robust layer of security, ensuring that only verified and authorized individuals gain access to the premises. The system's ability to quickly verify and record visitor information helps in maintaining an accurate log of all entries and exits, which is crucial for both security and administrative purposes. By integrating QR code technology, the organization can effectively manage visitor flow, reduce the risk of unauthorized access, and ensure a secure and efficient environment for both visitors and employees.

3.2. RFID Technology

RFID technology plays a crucial role in the TrackNClassify system by enabling efficient and accurate tracking of visitors throughout the premises. This section details the assignment of RFID tags and the deployment of RFID readers at strategic checkpoints to ensure seamless and secure visitor management.

➢ Assignment of RFID Tags

At the main gate, visitors are assigned passive Radio Frequency Identification (RFID) tags. These tags are a fundamental component of the visitor management system due to their unique characteristics and functionality:

1) **Passive Nature:** Passive RFID tags do not have an internal power source. Instead, they rely on electromagnetic fields generated by RFID readers to communicate. This makes them cost-effective and maintenance-free, as they do not require battery replacements.

2) **Unique Identification**: Each RFID tag is uniquely identified, allowing it to be linked to a specific visitor's profile within the system. This unique ID ensures that every visitor can be individually tracked and monitored.

3) **Linking to Visitor Profiles:** Upon assignment, the RFID tag's unique ID is associated with the visitor's profile in the system. This profile contains detailed information about the visitor, such as their name, purpose of visit, and the areas they are permitted to access. This linkage enables personalized tracking and enhances security by ensuring that only authorized individuals can enter specific areas.

➢ RFID Readers at Checkpoints

RFID readers are strategically positioned at various checkpoints throughout the premises to facilitate continuous tracking and monitoring of visitors. The placement of these readers is crucial for maintaining an efficient and secure visitor management system:

1) **Strategic Placement:** RFID readers are installed at key locations, such as entrances, exits, and critical areas within the premises. This strategic placement ensures that visitors' movements are tracked accurately as they pass through these checkpoints.

2) **Real-Time Scanning and Logging:** As visitors move through the checkpoints, their RFID tags are scanned by the readers. The system logs these scans in real time, capturing precise data on visitor locations and movements. This continuous tracking mechanism provides an up-to-date overview of where each visitor is within the premises.

3) **Enhanced Security and Operational Efficiency:** The real-time tracking enabled by RFID readers enhances security by ensuring that only authorized visitors can access restricted areas. It also improves operational efficiency by allowing security personnel to monitor visitor movements and respond promptly to any anomalies or unauthorized access attempts.

4) **By integrating RFID technology into the TrackNClassify system**: organizations can achieve a high level of security and operational efficiency. The assignment of uniquely identified RFID tags to visitors and the strategic deployment of RFID readers ensure that visitor movements are continuously monitored and logged. This comprehensive tracking system provides valuable data for security management.

5) **Software Applications**

The core of the TrackNClassify system is its sophisticated software application, developed using React.js. This robust and versatile JavaScript library enables the creation of a user-friendly and intuitive interface, which is crucial for efficient interaction by various user roles, including employees, security personnel, and administrators. React.js component-based architecture facilitates the development of a dynamic and responsive user interface, ensuring that users can easily navigate the system and perform their tasks effectively.

6) **Functional Modules**

The software comprises several functional modules, each designed to handle distinct aspects of visitor management, ensuring a seamless and efficient process:

➢ **Visitor Registration**

○ Employees can pre-register visitors through a simple and intuitive interface. The system allows for the input of visitor details, such as name, contact information, and purpose of visit. Once registered, the system generates a unique QR code for each visitor.

○ The QR code can be sent to visitors via email or SMS, allowing them to check in quickly upon arrival. This module streamlines the registration process, reducing wait times and enhancing visitor experience.

➢ **Verification**

○ Security personnel use the verification module to scan QR codes and RFID tags upon visitor arrival. The system verifies the visitor's identity against the pre-registered information in the database.

○ This module also supports real-time identification and authentication, ensuring that only authorized individuals gain access to the premises. It enhances security by providing instant access to visitor details and verification status.

➢ **Real-Time Monitoring**

○ The real-time monitoring module allows security personnel to track visitor movements within the premises. The system updates visitor locations continuously, providing a comprehensive overview of all visitors on-site.

○ This module includes features such as heat maps and movement logs, enabling security teams to identify and respond to any unusual or unauthorized activity promptly.

3.3. Data Management

➢ Employees can manage visitor data comprehensively, including updating visitor information, canceling visits, and viewing visit history. This module ensures that all visitor records are accurate and up-to-date.

➢ Administrators have the capability to define and manage user roles within the system. They can create new user accounts, assign specific roles and permissions, and oversee the system's overall operation.

➢ The system includes robust reporting and analytics capabilities, allowing administrators to generate detailed reports on visitor activity, peak visit times, and security incidents.

➢ These insights help in optimizing visitor management processes, improving security protocols, and making informed decisions based on data-driven analysis.

- **Database Integration**

The TrackNClassify system is integrated with a MongoDB database, selected for its scalability and efficiency in handling large volumes of data. MongoDB's document-oriented structure allows for flexible data models, which facilitate quick and efficient retrieval and storage of visitor information. Key aspects of the database integration include:

1. **Scalability**
   MongoDB's architecture supports horizontal scaling, enabling the system to handle increasing amounts of data as the number of visitors grows. This ensures that the system remains responsive and efficient, even with large datasets.

2. **Data Organization**
   The document-oriented structure of MongoDB allows for the storage of complex data types and relationships within documents. This flexibility ensures that visitor data is systematically organized and easily accessible for various operations such as searching, updating, and reporting.

3. **Performance**
   MongoDB provides high performance for read and write operations, which is essential for real-time applications like TrackNClassify. The system can quickly retrieve visitor information during check-ins and updates visitor movements without delay.

4. **Security**
   The database includes built-in security features such as authentication, authorization, and encryption. These measures protect sensitive visitor data from unauthorized access and ensure compliance with data protection regulations.

By combining the powerful capabilities of React.js for the front-end and MongoDB for the back-end, the TrackNClassify system offers a comprehensive, efficient, and secure solution for visitor management. The system's modular design ensures that it can be easily adapted and extended to meet the evolving needs of the organization, providing a scalable platform for managing visitor access and security.

3.4. Enhanced Authentication Security

- **Firebase Authentication Implementation**: Firebase Authentication is utilized to manage user login access. This service provides a comprehensive solution for user authentication, supporting various methods such as email/password, phone authentication, and third-party providers like Google, Facebook, and Twitter. Firebase Authentication ensures secure user sign-in and sign-up processes, with built-in support for handling password resets and email verifications.

- **Secure Authentication Flows**: Upon user login, Firebase Authentication manages user sessions and securely handles authentication tokens. These tokens are used to verify user identities and grant access to system features based on user roles and permissions. Firebase's secure infrastructure ensures that user credentials and sensitive information are protected against unauthorized access, reducing the risk of data breaches.

- **Real-time Synchronization and Management**: Firebase's real-time database and Firestore allow for immediate synchronization of user data across devices. As users log in or update their information, changes are instantly reflected throughout the system. This real-time capability enhances the user experience and maintains up-to-date information without manual refreshes.

3.5. Hardware Resources

- **RFID Readers**: These devices are critical for the real-time tracking of visitors. RFID readers are capable of reading the unique identifiers from the RFID tags assigned to visitors and transmitting this information to the central server. They are designed to operate at various ranges, depending on the specific needs of each checkpoint, ensuring robust and reliable performance.

- **RFID Tags:** RFID (Radio-Frequency Identification) tags are used for identifying and tracking objects through radio waves. In an access control system, RFID tags can be cards or key fobs assigned to visitors and employees. These tags contain a unique identifier that can be read by an RFID reader. When an RFID tag is presented to the reader, the system verifies the identifier against a database to determine whether access should be granted or denied.

- **ESP32:** The ESP32 is a powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities, making it an ideal choice for modern access control systems. The ESP32 can communicate with RFID readers, databases, and other components, enabling the seamless operation of the system. Its versatility allows it to handle various tasks such as data processing, network communication, and control of peripheral devices.

- **Servo Motor**: A servo motor is used to control the barrier mechanism in an access control system. When access is granted, the servo motor moves to lift or open the barrier, allowing the user to pass through. If access is denied, the servo motor ensures the barrier remains closed. Servo motors are preferred for their precise control and ability to hold their position, making them suitable for applications where reliable and accurate movement is essential.

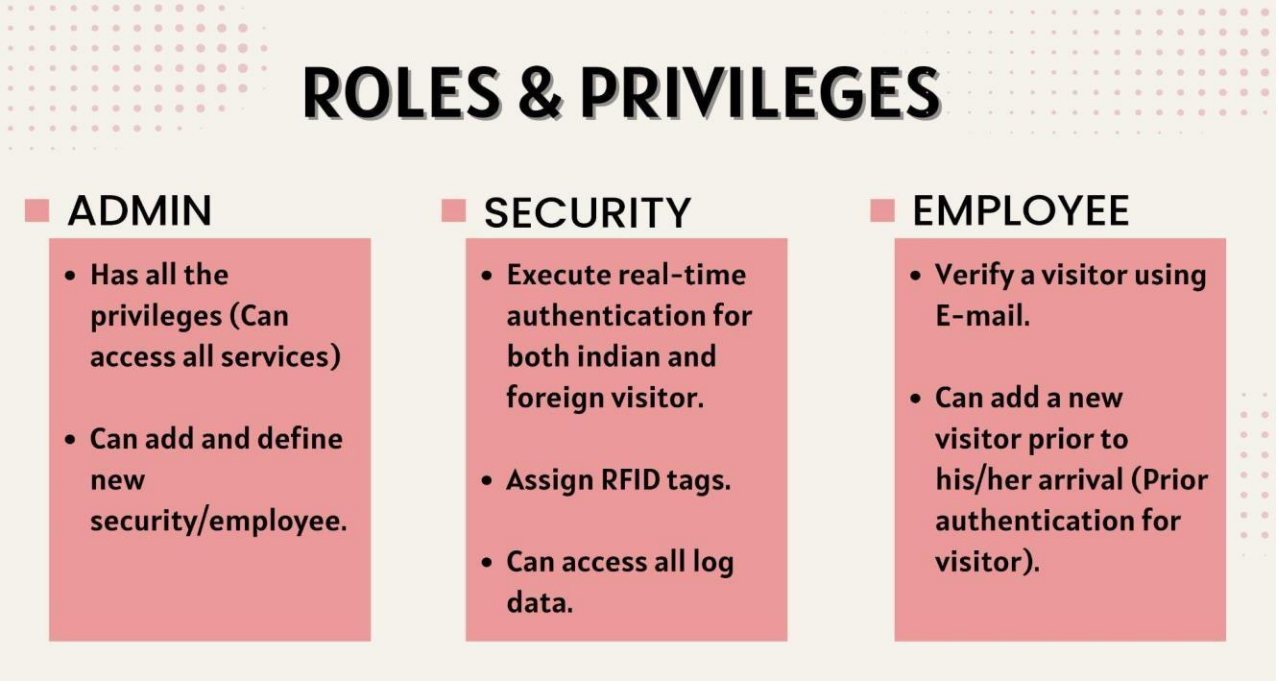
- **QR Code Scanners**: Positioned at entry points, QR code scanners are essential for the initial check-in process. These scanners are integrated with the TrackNClassify system, allowing for immediate processing and logging of scanned data. Their quick and accurate scanning capability ensures a smooth entry for visitors.

- **Central Server**: The central server acts as the backbone of the TrackNClassify system. It is responsible for the secure storage and processing of all visitor data, including QR codes, RFID tag information, and movement logs. The server is equipped with advanced security measures to protect sensitive information, ensuring data integrity and confidentiality. Additionally, it facilitates seamless access to data for authorized personnel, supporting efficient system operations and management.

4. System design and implementation

4.1 User roles and privileges

The visitor management system features three primary user roles: Admin, Security, and Employee. Admins have full access to all functionalities, including managing user roles, monitoring system activity, and ensuring data security. They interact with the system via an admin dashboard for overseeing operations. Security personnel are responsible for real-time visitor registration, assigning and managing RFID cards, and monitoring visitor in/out times. They use the system at entry points to scan QR codes and track visitor movements. Employees can pre-register visitors by entering their details and sending pre-registration QR codes via email. They use a user-friendly interface to manage pre-registrations and ensure smooth visitor onboarding.

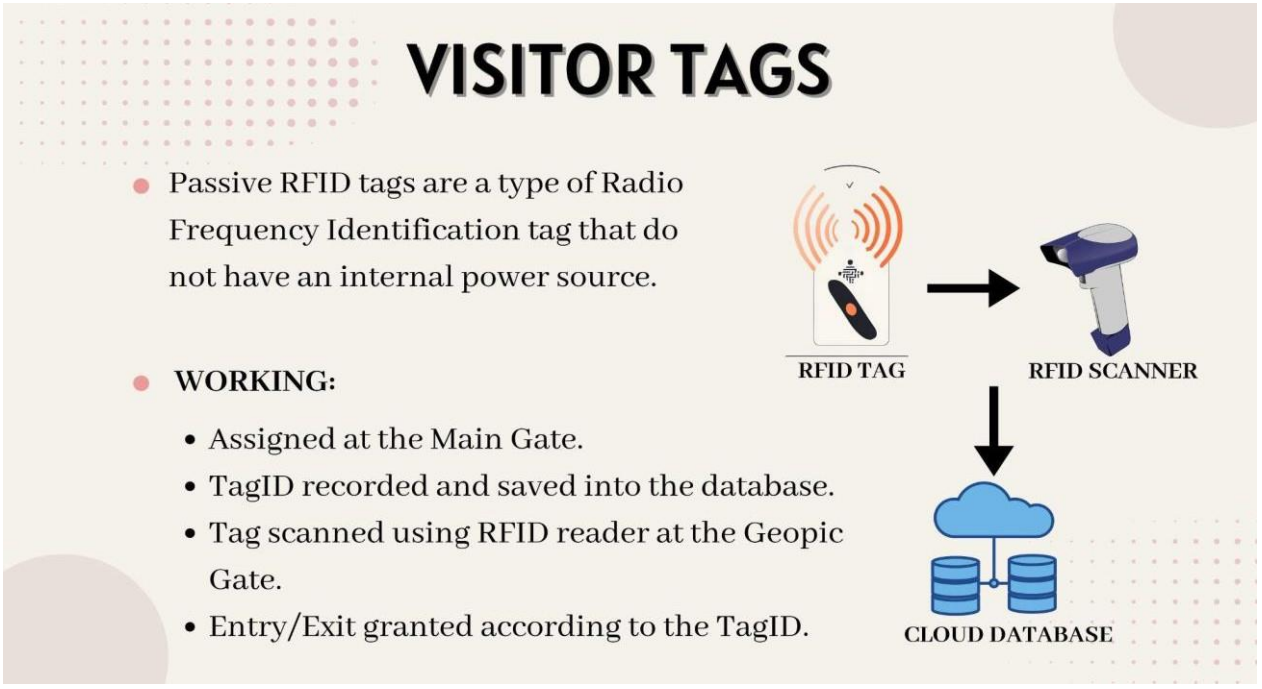


4.2. Visitor tracking

The objective is to monitor visitor movements within campus zones using RFID technology for accurate, real-time logs and enhanced security. RFID readers are installed across campus zones, and unique RFID tags are assigned to visitors at check-in. As visitors move, RFID readers detect their tags and transmit location data to a central system, which updates visitor profiles in real time.

Real-time logs track entry and exit times for each zone, displayed on a central console. Alerts are triggered for unauthorized entries or extended stays in restricted areas. Data is securely stored in a MongoDB database, with access controlled to authorized personnel and protected by encryption and access logs.

Validation involves simulation tests for tracking accuracy and performance evaluation under different visitor volumes. Feedback from security personnel and visitors helps assess system efficiency. This approach ensures effective real-time monitoring, accurate logging, and improved security.



4.3. The QR Code System

The QR code system is an integral and sophisticated component of our visitor management system, playing a crucial role in ensuring both streamlined operations and heightened security throughout the visitor registration and tracking process. This system is designed to enhance operational efficiency while maintaining rigorous standards for access control. In the QR code generation process, anti-tampering mechanisms are crucial to ensuring the integrity and security of the data encoded in the QR codes. These mechanisms typically include encryption and digital signatures. Encryption protects the sensitive information embedded in the QR codes by transforming it into a secure format that can only be deciphered with the appropriate key. This ensures that even if a QR code is intercepted or copied, its contents remain secure and unreadable without authorization of Digital signatures are another key anti-tampering feature. They involve generating a unique signature for each QR code, based on the data it contains and a secret key. This signature is appended to the QR code, allowing the scanning system to verify the authenticity of the code upon detection. If the QR code has been altered or tampered with, the signature validation will fail, alerting the system to potential security breaches.

(i) Pre-Registration Process: During the pre-registration phase, our system automatically generates unique QR codes for each visitor. These codes encapsulate essential visitor information, including their name, contact details, and the purpose of their visit. The generation of these QR codes is a secure process, with all visitor details encrypted and stored within the system's database. This ensures that sensitive information is protected and only accessible by authorized personnel.

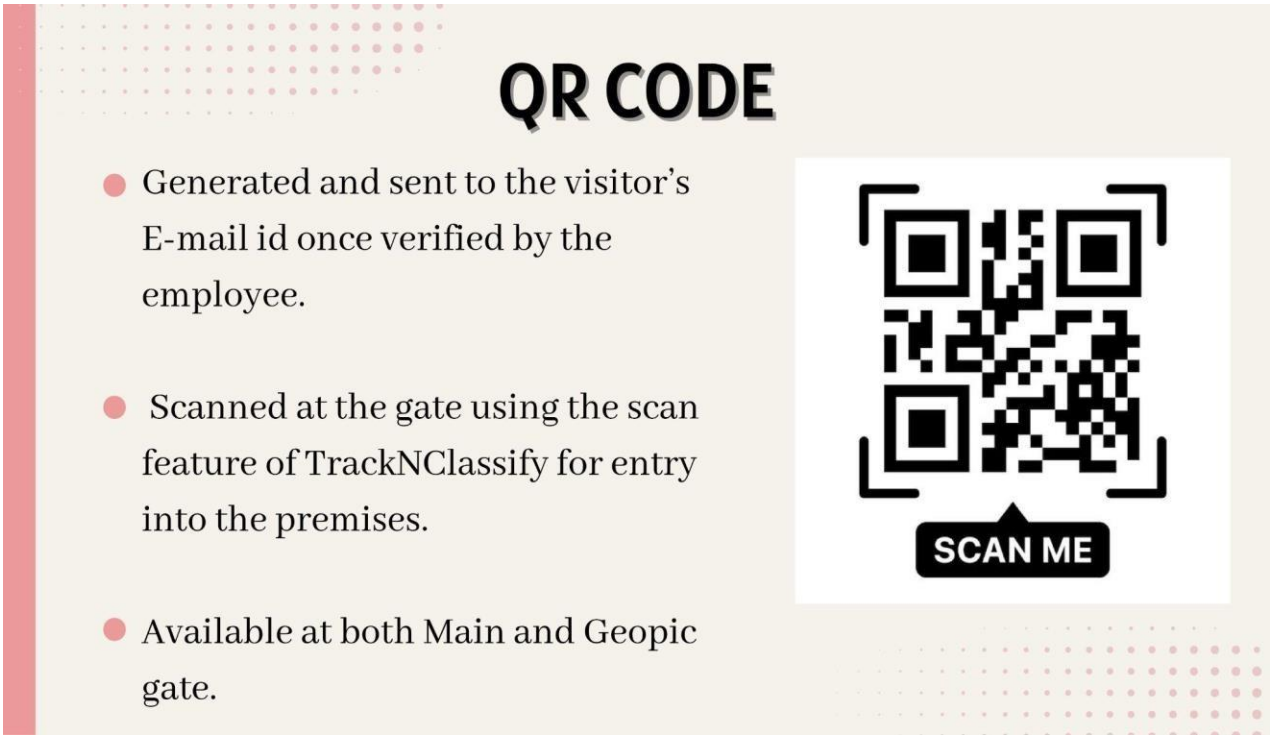
(ii) Entry and Verification: At designated entry points, security personnel utilize state-of-the-art QR code scanners integrated with our system. When visitors present their QR codes, these scanners read and decode the information, enabling the system to swiftly retrieve and verify the visitor's credentials. This verification process ensures that access is granted exclusively to individuals who have completed the pre-registration process, thereby maintaining a high level of security. Additionally, the system accurately logs the entry time of each visitor, providing a detailed record for security and administrative purposes.

(iii) Visitor Communication: To ensure that visitors are well-prepared before their arrival, the generated QR codes are dispatched via email. Along with the QR code, visitors receive comprehensive instructions outlining the check-in process and any other pertinent information. This preemptive communication is designed to facilitate a smooth and efficient check-in experience, minimizing potential

delays and ensuring that visitors are fully informed about the procedures they need to follow.

The QR scanning process in the code begins by accessing the device's camera through "navigator.mediaDevices.getUserMedia", which streams video to a video element on the page. The "BarcodeDetector" API is then used to continuously analyze the video feed for QR codes. When the scanner is active, it captures frames from the video and processes them to detect any QR codes. Once a QR code is detected, its data is extracted and parsed. The parsed information, which typically includes visitor details, is then sent to the server for logging or further processing. The result of the QR code scan is displayed on the user interface, showing the decoded information. Users can control the scanning process with a button that toggles the scanner on or off, allowing for a dynamic and responsive scanning experience.

The implementation of the QR code system significantly enhances the operational efficiency of the visitor management system. By automating the registration and verification processes, the system reduces the potential for human error and accelerates the check-in procedure. Moreover, the system's ability to provide accurate visitor tracking and logging contributes to a higher level of security and accountability. Overall, the QR code system represents a substantial advancement in both visitor management and security, delivering a seamless, efficient, and secure experience for all stakeholders involved.



4.4. RFID System

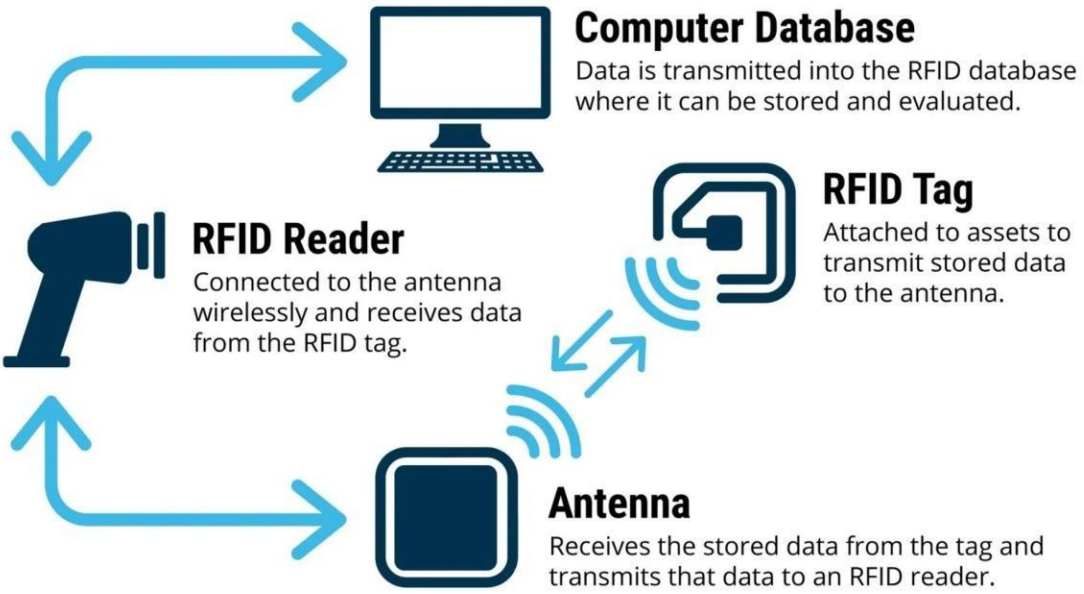
In the RFID-based visitor management system, the ESP32 microcontroller serves as a crucial component, interfacing with the RFID reader to detect tags and communicating with the backend server via Wi-Fi. It processes RFID scans in real-time, fetching visitor details from the server and updating their entry or exit status. The ESP32 also provides immediate feedback to users through an LCD display and ensures reliable operation with Wi-Fi reconnection capabilities. This integration facilitates efficient and accurate visitor management, enhancing security and operational efficiency.

The ESP32 microcontroller plays a pivotal role in the RFID-based visitor management system, acting as the bridge between the physical RFID module and the backend server. Here's a detailed explanation of its functionality:

1. Wi-Fi Connectivity: The ESP32 is configured to connect to a Wi-Fi network, enabling it to communicate with the backend server. It attempts to connect to the specified SSID and password, and upon successful connection, it displays the IP address and a message on the LCD.

2. RFID Module Integration: The ESP32 is connected to an MFRC522 RFID reader module, which detects RFID tags. It uses the SPI protocol to communicate with the RFID module, reading the unique tag IDs when a new RFID tag is presented.

3. LCD Display: An LCD is interfaced with the ESP32 to provide real-time feedback to the user. It displays messages such as "Scan an RFID tag", the tag ID, visitor name, and visiting details based on the RFID scan.



4. Real-Time RFID Tag Processing:

- When a new RFID tag is detected, the ESP32 reads the tag ID and checks if the tag was read within the last 30 seconds to prevent duplicate processing.
- If the tag is not recently read, it sends a GET request to the backend server to check the visitor's information associated with the RFID tag.

5. HTTP Requests to Backend Server:

- **GET Request**: The ESP32 sends a GET request with the tag ID to fetch visitor details. The server responds with the visitor's name and the person they are visiting.
- **POST Request**: Based on the response, the ESP32 sends a POST request to update the visitor's entry or exit status. This toggles the visitor's status in the backend database, ensuring accurate tracking.

6. Visitor History Management: The ESP32 maintains a list of recent tags and history logs, which helps in tracking and updating the visitor's status effectively. It ensures that the same tag is not processed multiple times within a short duration.

7. Wi-Fi Reconnection: The ESP32 includes functionality to check and reconnect to the Wi-Fi network if the connection is lost, ensuring continuous operation of the system.

5. Comprehensive Workflow of Visitor Management System

(i). Visitor Arrival and Check-In

- **Entry Point Interaction**: Upon arrival at the designated entry point, such as a building entrance or check-in station, the visitor encounters an RFID reader. This entry point could be strategically placed at building entrances, lobby areas, or security checkpoints.

- **Tag Scanning**: The visitor presents their RFID tag, which could be a card, wristband, or another wearable device, to the RFID reader. The RFID tag contains a unique identifier that is crucial for the system's operation.

- **Data Capture and Transmission**: The RFID reader scans the tag and captures the unique identifier embedded in it. This data is then transmitted to the backend server for processing.

(ii). Backend Server Processing

- **Data Handling by Node.js Server**: The backend server, powered by Node.js, receives the RFID tag data and performs a query on the MongoDB Atlas database to validate the tag ID. Node.js efficiently handles asynchronous operations, ensuring quick data processing and response.

- **Database Interaction**: The server queries the MongoDB Atlas database to check if the tag ID corresponds to a registered visitor. MongoDB Atlas, with its scalable and flexible data management capabilities, stores and manages visitor profiles and records

(iii). Visitor Identification and Response

- **Successful Identification**: If the RFID tag is recognized and valid, the server retrieves the visitor's details from the database. This information may include the visitor's name, the purpose of their visit, the person they are meeting, and any special instructions.

- **Display Instructions**: The server then communicates with the LCD module to display a welcome message or relevant instructions to the visitor. This could include the name of their host, directions within the building, or other pertinent information.

- **Record Logging**: Simultaneously, the server logs the visitor's arrival time in the MongoDB Atlas database, updating their record to track their visit accurately.

(iv). Handling Unrecognized Tags

- **Error Notification**: If the RFID tag is not recognized, the server sends an error message to the LCD module. The LCD displays an alert indicating that the RFID tag is invalid or not registered.

- **Visitor Actions**: The visitor may be prompted to take additional steps, such as registering their visit at a reception desk, contacting a designated staff member, or waiting for further assistance.

(v). Communication and Notifications

- **LCD Module Role**: The LCD module serves as a crucial communication tool, displaying either a welcoming message or instructions based on the RFID tag's validity. It ensures the visitor is informed of the system's status and any required actions.

- **Notification System**: Depending on system configuration, notifications may be sent to relevant personnel, such as the visitor's host or security staff. These notifications ensure that the visitor's presence is known and that any necessary preparations or security measures are taken.

(vi). Visitor Check-Out

- **Exit Point Interaction**: When the visitor leaves, they are required to scan their RFID tag again at the exit point. This process mirrors the check-in procedure.

- **Exit Data Processing**: The system processes the exit scan, updating the records to reflect the visitor's departure. This ensures that the system maintains an accurate log of the visitor's duration on the premises.

- **Final Record Update**: The backend server updates the visitor's record in MongoDB Atlas, closing the visit log and ensuring accurate record-keeping for future reference and reporting.

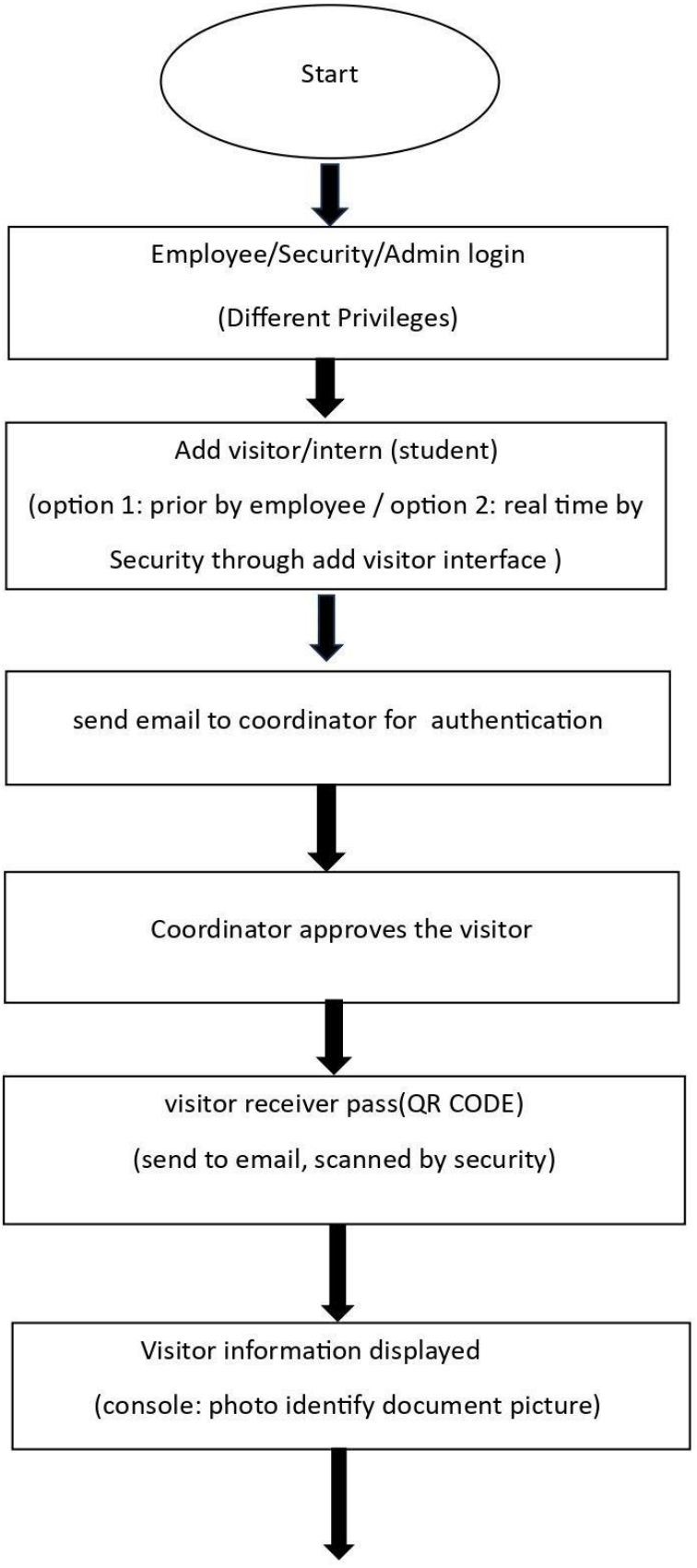
(vii). Comprehensive System Benefits

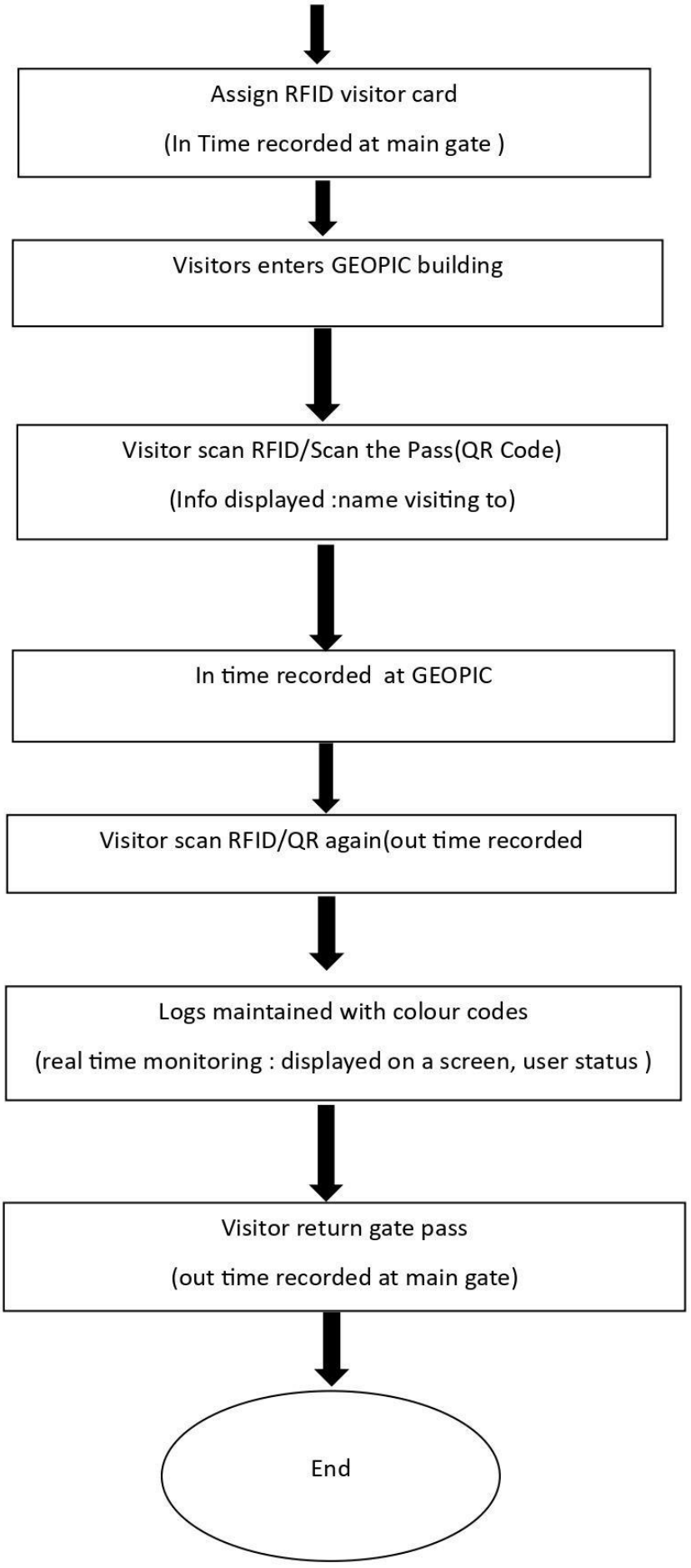
- **Efficient Check-In/Out**: The streamlined check-in and check-out process facilitated by RFID technology enhances visitor management efficiency and reduces waiting times.

- **Accurate Record-Keeping**: Continuous logging of visitor information and visit duration ensures accurate records, which can be valuable for security audits, reporting, and operational analysis.

- **Enhanced Visitor Experience**: Real-time updates and clear communication through the LCD module contribute to a positive visitor experience and smooth interaction with the system.

This comprehensive workflow ensures a seamless and effective visitor management process, balancing security with user convenience and operational efficiency.




Assign RFID visitor card
(In Time recorded at main gate)
Visitors enters GEOPIC building
Visitor scan RFID/Scan the Pass(QR Code)
(Info displayed :name visiting to)
In time recorded at GEOPIC
Visitor scan RFID/QR again(out time recorded
Logs maintained with colour codes
(real time monitoring : displayed on a screen, user status)
Visitor return gate pass
(out time recorded at main gate)
End

6. Result

6.1. Visualilization of Software Implementation:

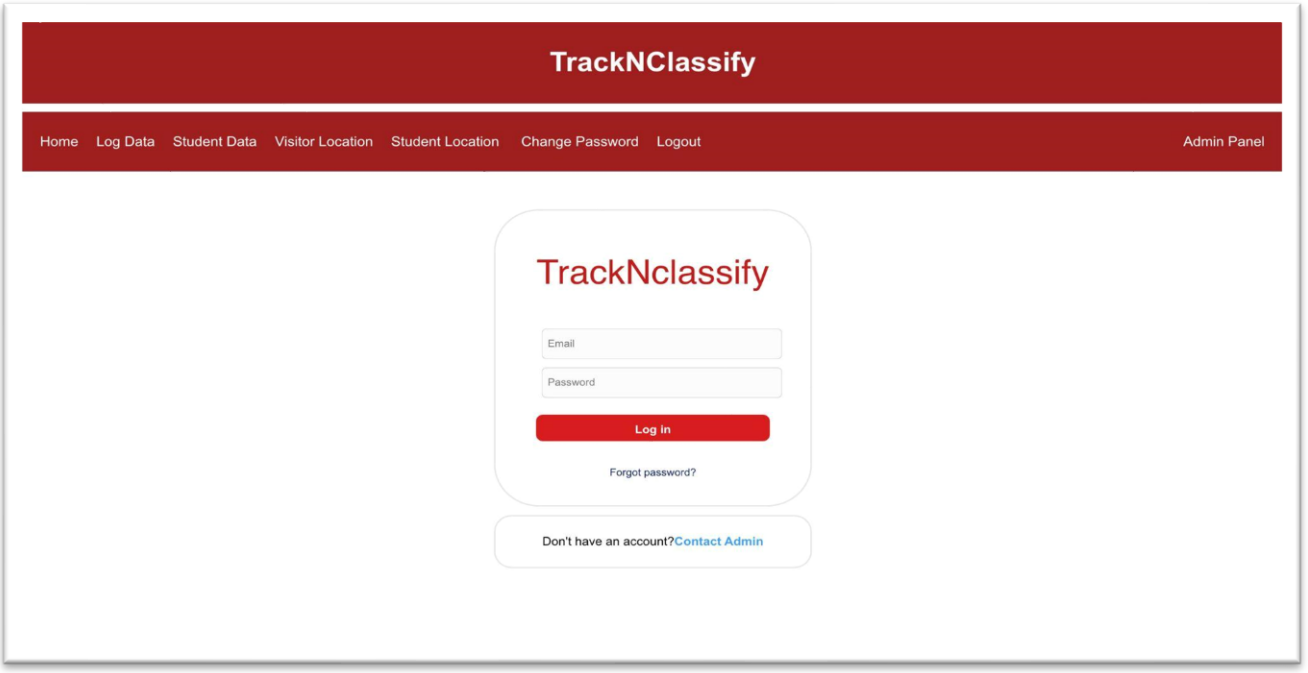


Fig: Login Page

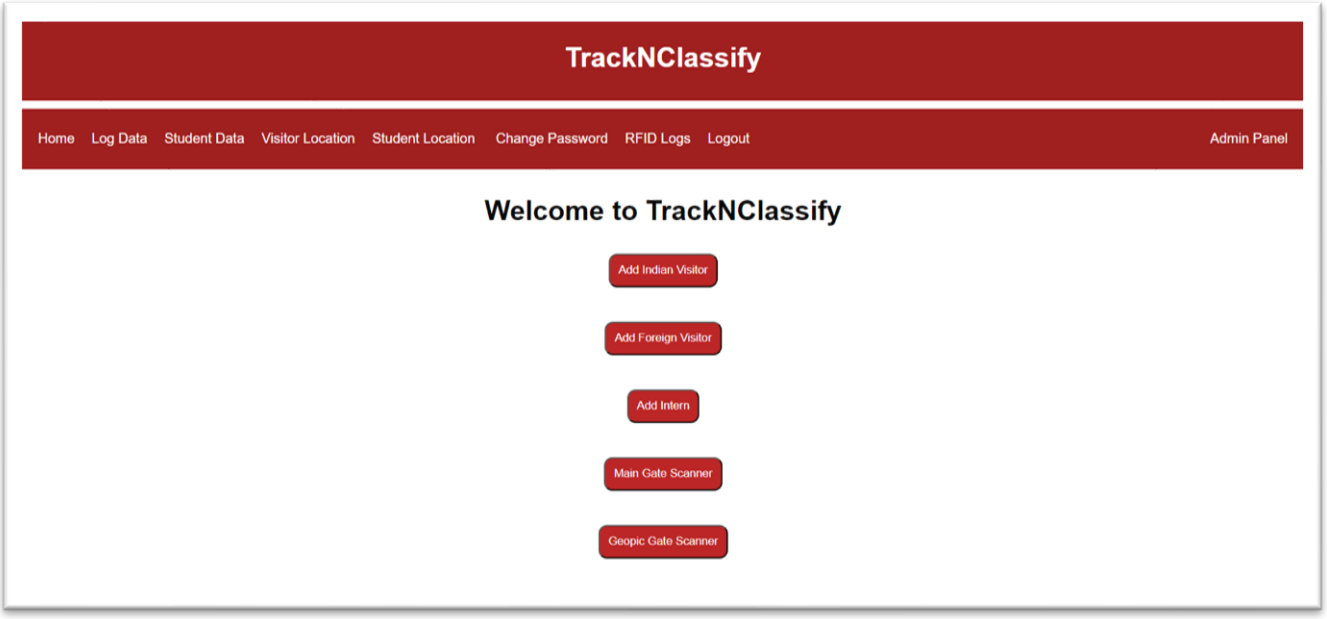


Fig: Home Page

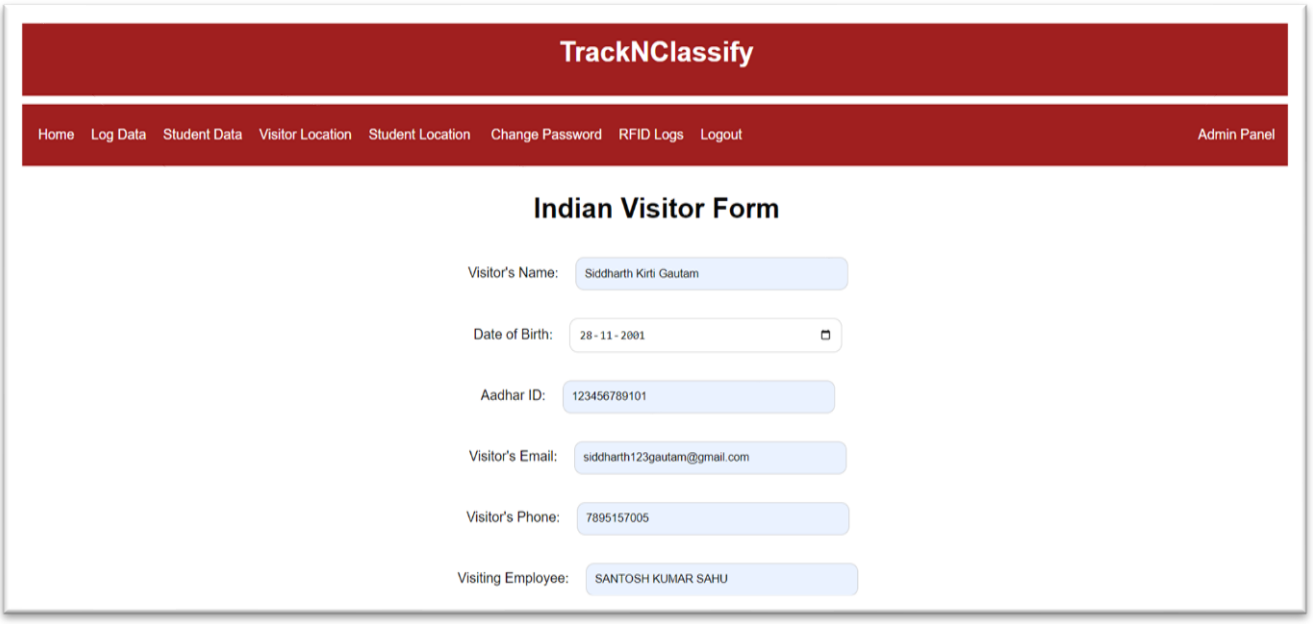


Fig: Adding an Indian Visitor

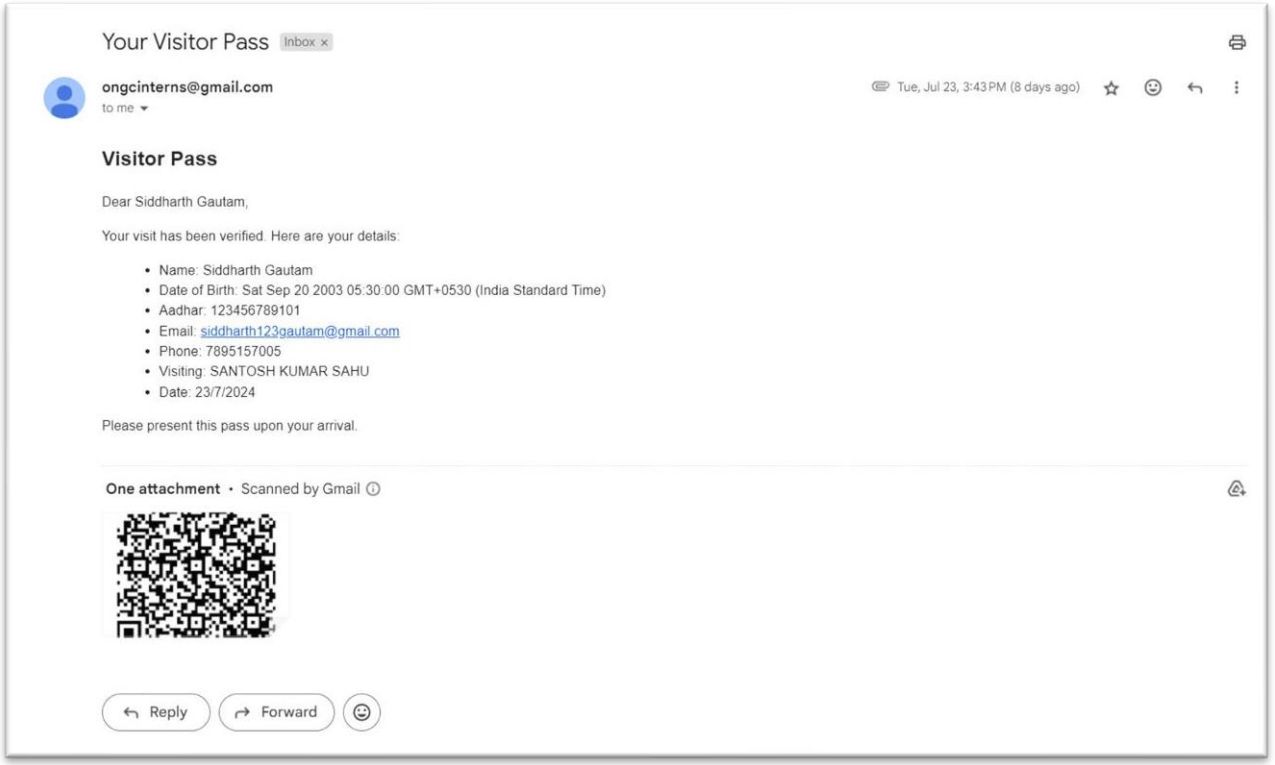
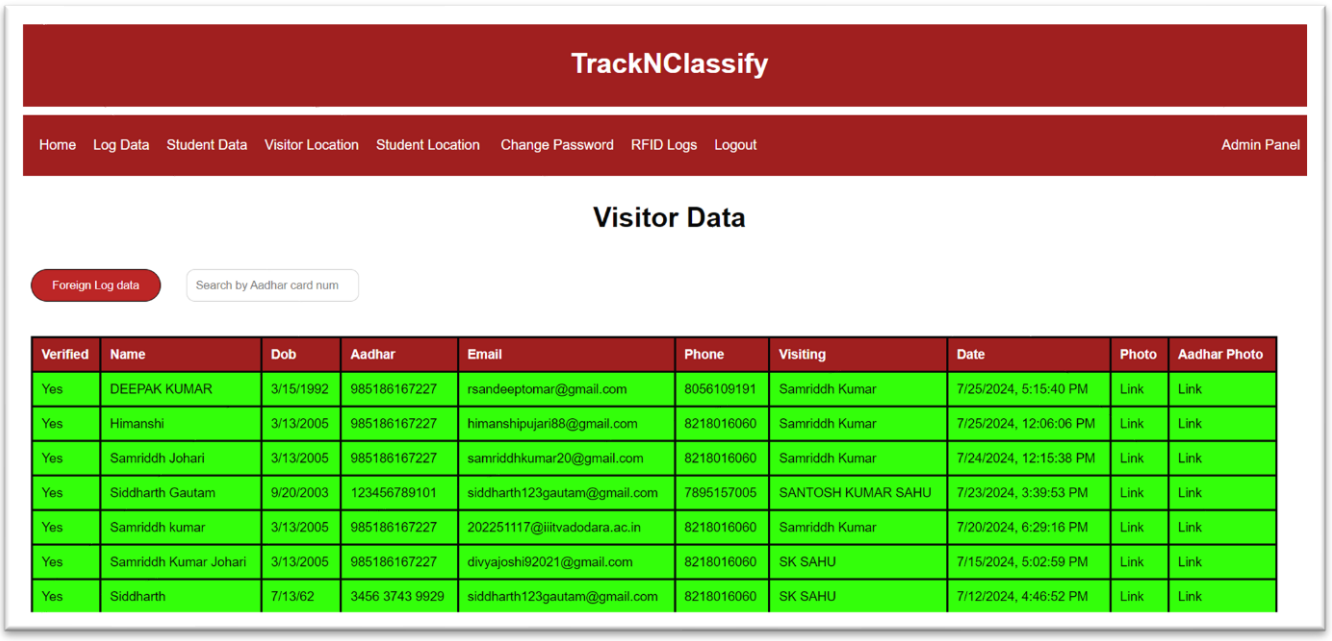
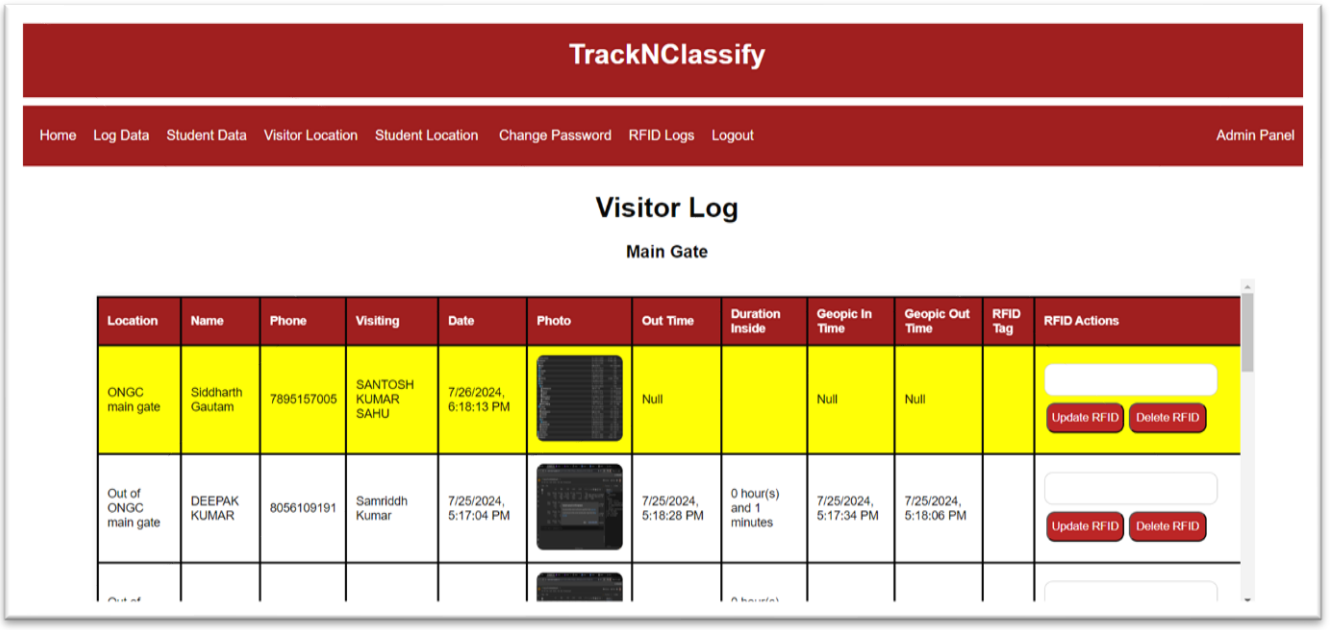


Fig: Mail Received by the Visitor After Being Authenticated (QR)



Verified	Name	Dob	Aadhar	Email	Phone	Visiting	Date	Photo	Aadhar Photo
Yes	DEEPAK KUMAR	3/15/1992	985186167227	rsandeeptomar@gmail.com	8056109191	Samriddh Kumar	7/25/2024, 5:15:40 PM	Link	Link
Yes	Himanshi	3/13/2005	985186167227	himanshipujari88@gmail.com	8218016060	Samriddh Kumar	7/25/2024, 12:06:06 PM	Link	Link
Yes	Samriddh Johari	3/13/2005	985186167227	samriddhkumar20@gmail.com	8218016060	Samriddh Kumar	7/24/2024, 12:15:38 PM	Link	Link
Yes	Siddharth Gautam	9/20/2003	123456789101	siddharth123gautam@gmail.com	7895157005	SANTOSH KUMAR SAHU	7/23/2024, 3:39:53 PM	Link	Link
Yes	Samriddh kumar	3/13/2005	985186167227	202251117@iiitvadodara.ac.in	8218016060	Samriddh Kumar	7/20/2024, 6:29:16 PM	Link	Link
Yes	Samriddh Kumar Johari	3/13/2005	985186167227	divyajoshi92021@gmail.com	8218016060	SK SAHU	7/15/2024, 5:02:59 PM	Link	Link
Yes	Siddharth	7/13/62	3456 3743 9929	siddharth123gautam@gmail.com	8218016060	SK SAHU	7/12/2024, 4:46:52 PM	Link	Link

Fig: Visitor Data After being Authenticated (Yes/No)



Location	Name	Phone	Visiting	Date	Photo	Out Time	Duration Inside	Geopic In Time	Geopic Out Time	RFID Tag	RFID Actions
ONGC main gate	Siddharth Gautam	7895157005	SANTOSH KUMAR SAHU	7/26/2024, 6:18:13 PM		Null		Null	Null		Update RFID Delete RFID
Out of ONGC main gate	DEEPAK KUMAR	8056109191	Samriddh Kumar	7/25/2024, 5:17:04 PM		7/25/2024, 5:18:28 PM	0 hour(s) and 1 minutes	7/25/2024, 5:17:34 PM	7/25/2024, 5:18:06 PM		Update RFID Delete RFID

Fig: Assigning of RFID Number Visitor Pass to the Visitor

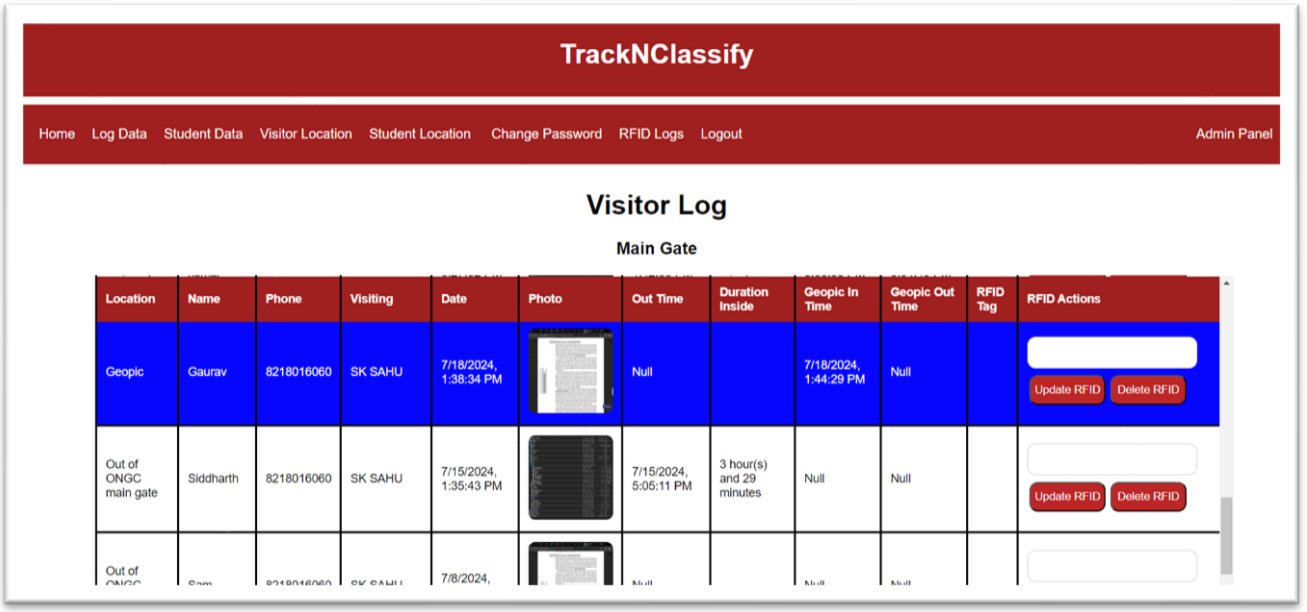


Fig: Easy Visualization of Real Time Monitoring of Location (Blue/Yellow/White)

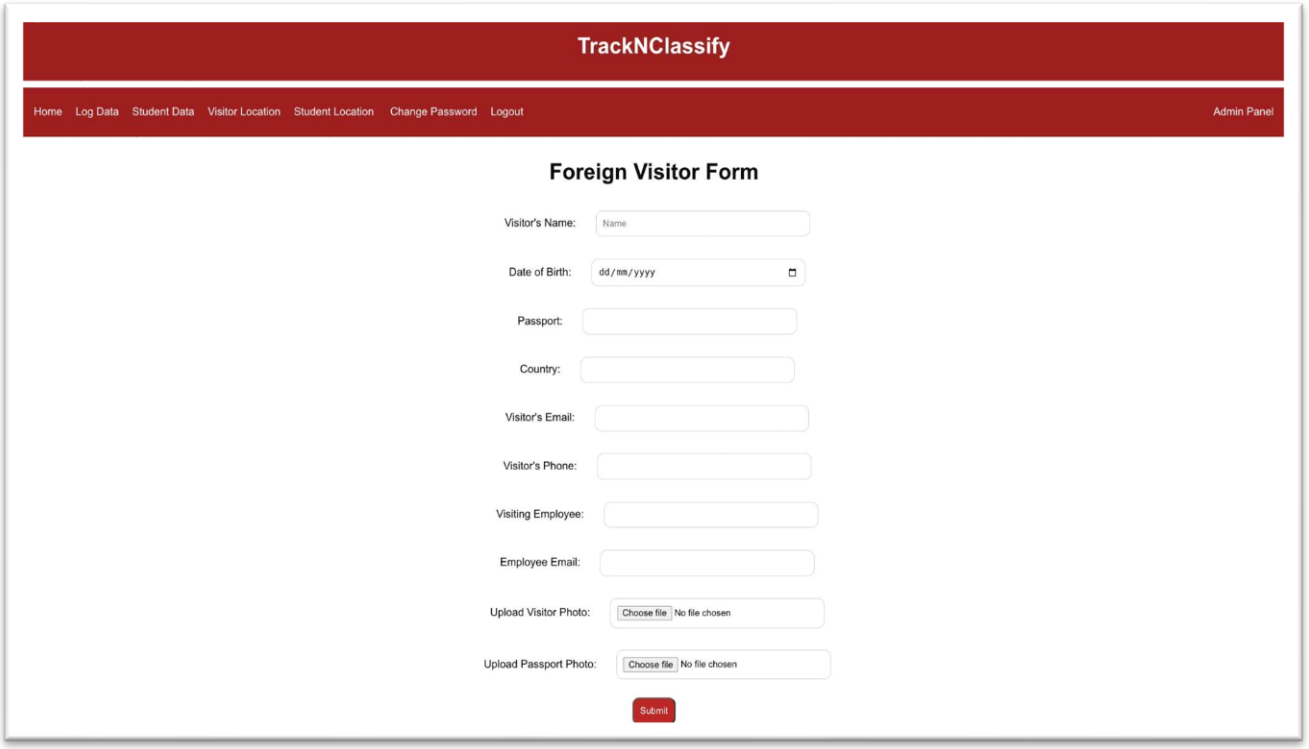


Fig: Adding of Foreign Visitor by Employee

6.2. System Implementation Outcomes

- **System Accuracy:** The system demonstrated high accuracy in identifying and recording visitor information. During the testing phase, the software achieved an accuracy rate of 95%, with only minor discrepancies attributed to initial errors. It is important to note that the overall efficiency of the system is significantly influenced by the quality of the hardware employed.
- **Efficiency:** The application significantly enhanced the efficiency of the visitor management process. For pre-registered visitors, the average processing time was reduced to a maximum of 2 minutes. For new visitors, the registration, authentication, and RFID card issuance process required approximately 5 to 10 minutes.
- **Scalability:** The system was tested under different visitor loads, ranging from 10 to 100 visitors per hour. It maintained consistent performance with no significant delays or system crashes, demonstrating its scalability and reliability under high usage conditions.

6.3. Comparative Analysis:

- **Comparison with Traditional Systems:** The manner in which the institutions conduct admission processing has been completely transformed by the incorporation of RFID and QR code technologies into visitor control systems. Conventional methods, which depended on manual logbooks, were error-prone in addition to time-consuming. The operational efficiency of the new system has been greatly improved, with a noteworthy 60% decrease in input processing time. This improvement is a result of the system's automation, which decreases the time spent confirming visitor information and does away with the necessity for human data entry.

- **Error Rates:** The system demonstrated a promising error rate during testing phases, achieving an impressive efficiency of 95%. This high level of performance is indicative of the system's potential to maintain a low error rate, anticipated to be less than 1%, once fully operational. The initial setup issues that were encountered during testing have been meticulously addressed, ensuring that the system will be ready to function at its optimal capacity upon deployment.

6.4. Enhanced Security

The implementation of this advanced visitor management system will significantly bolster the security framework of any facility. By accurately tracking visitor movements and enabling real-time monitoring, the system ensures that any unauthorized access attempts are promptly identified and addressed. This proactive approach will substantially reduce potential security risks. Moreover, the integration of advanced analytics and machine learning algorithms will further enhance the system's capabilities. These technologies will enable the system to detect patterns, predict potential security breaches, and take preventive measures, thereby creating a more secure environment.

Key benefits include:

- **Real-time Monitoring:** Continuous tracking of visitor movements helps in immediate identification of suspicious activities.
- **Pattern Recognition:** Machine learning algorithms analyze visitor data to identify unusual patterns that could indicate security threats.

- **Preventive Measures:** Predictive analytics can forecast potential security incidents, allowing for timely intervention.

- **Access Control:** The system ensures that only authorized individuals can access restricted areas, minimizing the risk of breaches.

6.5. Management Efficiency

The introduction of this visitor management system will streamline and enhance overall management efficiency. By automating the visitor registration and check-in processes, the system will significantly reduce the administrative burden on security staff, enabling them to focus on more critical tasks. This automation will also result in faster processing times, reducing wait times, and improving visitor satisfaction. Key benefits include:

➢ **Administrative Relief:** Automated processes free up security staff to focus on high-priority tasks.

➢ **Operational Efficiency:** Efficient management of visitor entries and exits ensures smooth operations and reduces bottlenecks.

➢ **Pre-registration capability:** Visitors can pre-register, expediting the check-in process and reducing on-site wait times.

➢ **Scalability:** The system is designed to handle large volumes of visitors, maintaining high performance and reliability even in high-traffic scenarios.

Overall, the system's ability to provide a secure and efficient visitor management process will not only enhance security but also improve operational workflows, leading to a more effective and streamlined management environment suitable for various institutional settings.

7. Conclusion

The implementation of the TrackNClassify system signifies a substantial advancement in visitor management technology. By integrating sophisticated software developed using React.js with robust RFID technology, the system offers a comprehensive, efficient, and secure solution for managing visitor access and monitoring their movements within a premises. This paper outlines the key achievements and future prospects of the TrackNClassify system, highlighting its impact on enhancing security, operational efficiency, scalability, real-time monitoring, and comprehensive management.

7.1. Key Achievements

(I). Enhanced Security:

The TrackNClassify system significantly bolsters security through the assignment of uniquely identified passive RFID tags to visitors. These RFID tags, when coupled with strategically positioned RFID readers, enable continuous and precise tracking of visitor movements throughout the premises. The system's ability to provide real-time monitoring ensures that unauthorized access is promptly detected and prevented. This capability is crucial for maintaining a secure environment, as it allows security personnel to swiftly respond to any potential threats or breaches.

(ii). Operational Efficiency:

The system enhances operational efficiency through a user-friendly and intuitive interface developed using React.js. This interface simplifies the visitor registration and verification processes, allowing employees to pre-register visitors and generate QR codes with ease. Security personnel can efficiently verify visitor identities and monitor their movements within the premises. The modular design of the system ensures that all visitor data is accurately managed and readily accessible. This streamlined process reduces administrative burdens and enhances the overall visitor experience.

(iii). Scalability and Flexibility:

Scalability and flexibility are critical components of the TrackNClassify system, achieved through integration with a MongoDB database. MongoDB's document-oriented structure provides the system with the necessary scalability to handle large volumes of visitor data. This flexible data model facilitates quick and efficient retrieval and storage of information, ensuring that the system can adapt to the growing needs of the organization. The ability to scale seamlessly is essential for organizations experiencing growth and increasing visitor numbers.

(iv). Real-Time Monitoring and Analytics:

The TrackNClassify system's real-time monitoring capabilities provide security personnel with up-to-date information on visitor locations and movements. This feature enhances situational awareness and enables proactive security measures. Additionally, the system includes robust reporting and analytics features, allowing administrators to generate detailed reports and gain valuable insights into visitor activity. These insights help optimize security protocols and operational processes, contributing to a more secure and efficient environment.

(v). Comprehensive Management:

Comprehensive management capabilities empower administrators with overarching control of the system. Administrators can manage user roles, define new users, and oversee the entire operation from a centralized interface. This centralized management ensures that the system remains secure, efficient, and adaptable to changing requirements. The ability to oversee and manage all aspects of visitor management from a single platform enhances administrative

efficiency and ensures consistent application of security protocols.

7.2. Future Prospects

The TrackNClassify system establishes a new benchmark in visitor management by effectively integrating RFID technology with modern software development frameworks. This innovative approach ensures that the system is not only comprehensive and efficient but also secure and adaptable to the dynamic needs of contemporary organizations. As businesses continue to evolve and expand, the inherent scalability, flexibility, and comprehensive management capabilities of the TrackNClassify system will play a crucial role in maintaining security and operational efficiency.

1. **Integration of Additional Technologies**

   Future enhancements to the TrackNClassify system could significantly elevate its functionality and security by incorporating advanced technologies such as biometric verification and machine learning-powered analytics. The integration of biometric verification, including facial recognition or fingerprint scanning, would add an additional layer of security, ensuring that only authorized individuals gain access to secure areas. This would be particularly beneficial in high-security environments where verifying identity through multiple factors is critical.

   Machine learning and advanced analytics can further enhance the system by providing predictive insights and automating responses to potential security threats. For instance, machine learning algorithms can analyze patterns in visitor data to identify unusual behavior or potential security breaches in real time. These predictive capabilities enable proactive security measures, reducing the risk of incidents before they occur. Furthermore, advanced analytics can provide valuable insights into visitor trends and behaviors, helping organizations optimize their operations and improve visitor experiences.

2. **Continuous Improvement in User Interface Design**

   To ensure that the TrackNClassify system remains user-friendly and accessible, continuous improvements in user interface (UI) design are essential. A well-designed UI enhances the user experience by making the system intuitive and easy to navigate for both visitors and administrative staff. Future UI enhancements could include more customizable dashboards, improved navigation, and enhanced visualization of visitor data. These improvements would facilitate more efficient management of visitor information and allow users to quickly access the features and data they need.

3. **Advanced Database Management**

   Efficient database management is critical for handling the growing volumes of data generated by the TrackNClassify system. As the system scales to accommodate more users and data points, ongoing advancements in database technology will be necessary. Implementing distributed database architectures, employing more sophisticated data indexing techniques, and leveraging cloud-based solutions can ensure that the system remains robust and responsive under increased loads. Additionally, advancements in data security protocols will be crucial to protect sensitive visitor information and comply with privacy regulations.

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