Design and Implementation of an Iot-Based Faculty tracking system using RFID and Mobile Application

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Abstract

In the present day learning institutions, student faculty communication is very crucial to academic achievement. Nonetheless, students have a challenge of finding faculty members in the campus as a result of changing schedules, meetings and unavailability of allotted cabins. The classical systems like set schedules, search by hand, or inquiring other students are not efficient and take time. The issues result in time wastage and low productivity.

In order to address these issues, this study suggests a Smart Faculty Finder System that employs RFID and IoT technologies to enable real-time monitoring of faculty members. The system is aimed at enabling the students to locate faculty members and consult their availability easily without making such effort. The system under proposal incorporates both hardware and software so that the system can operate smoothly and accurately.

The hardware component of the system comprises of RFID tags given to every faculty and RFID readers placed in various points on the campus. In case a faculty member shifts to the specific location, the RFID reader reads the tag and identifies the faculty member. The scanned information is then sent with an ESP32 microcontroller that can send information through a wireless network.

The software part of the system consists of a mobile application developed using Flutter and a backend server developed using Spring Boot. The data sent to the ESP32 is processed by the backend server where it is stored in a MySQL database. The application links the real-time location and availability of faculty members to the students with the backend through the REST APIs and presents the information in a convenient format to the users.

The system is created based on the Agile methodology, according to which the requirements are specified using a product backlog and realized in the form of several sprints. Every sprint is dedicated to certain features like authentication, dashboard creation, tracking system, and improvement of the user interface. This will result in constant development, testing and improvement of the system.

The system outcomes demonstrate that it saves a lot of time that the students need to spend to find faculty members. It also facilitates the interaction between students and teachers, and the overall efficiency of the academic environment is improved. The system is user friendly, scalable and can be used in different institutions of learning.

To sum up, the Smart Faculty Finder System is a good solution to a widespread issue in colleges. The system will allow real-time tracking by combining RFID, IoT, and mobile technologies and enhance productivity. GPS tracking, notification alerts, and AI based scheduling are the features that can be added to the system in the future and make it more efficient.

Introduction

In the contemporary learning setting, communication between students and the faculty members is a crucial element to academic achievement. Students often have to communicate with faculty in other ways including clarification of doubts, project advice, discussion of academic issues, and administration. Nonetheless, the other issue that most students have encountered is the challenge of finding faculty members in the campus.

Most of the institutions have students who use the traditional approaches, including fixed schedules, visiting the staff rooms or requesting other students to locate the faculty members. These techniques are not very stable since the faculty members usually have a busy timetable, go to conferences, or shift between various places in the

campus. This would result in students wasting much time in search of the faculty, hence, inefficiency and loss of productivity.

As the technological development is rapid, particularly in the area of Internet of Things (IoT) one can come up with intelligent solutions to these issues. The IoT is the technology that allows real-time data gathering and communication between devices that can be utilized efficiently in terms of tracking and monitoring.

The current study presents a Smart Faculty Finder System, based on RFID and IoT, which can be used to track faculty members in real-time in an educational institution. The system shall strive to ease the burden of finding faculty members by giving them the correct and updated location information via a mobile application.

The proposed system comprises hardware and software implementation. Faculty members are equipped with RFID tags, and RFID readers are located in different places. In this case, a faculty member walks through an area and the RFID reader reads the tag and the information is sent to the backend server via an ESP32 microcontroller. The data is processed by the backend which in turn updates the database which is consumed by a Flutter-based mobile application utilized by students.

The system is developed based on Agile methodology and requirements are specified in a product backlog and developed in several sprints. This methodology will provide flexibility, constant improvement, and effective project management.

The primary aim of the study is to develop and establish a system that will shorten the time needed to find faculty members, increase communication, and improve efficiency in the academic environment in general.

Literature Review

Literature review is a significant aspect of the research since it assists in knowing the work done in the related field. Faculty tracking systems, RFID technology, IoT-based applications and mobile-based solutions are the focus in this project.

Most educational facilities continue using the old systems like set schedules, notice boards and manual search to find faculty members. These techniques are not effective as they fail to give real-time

information and will most likely result in time wastage [1].

There are systems that are in existence that utilize Global Positioning System (GPS) in tracking. GPS is commonly applied to the outdoors, but it cannot be applied in the indoors because of the low signal accuracy within the buildings [2]. GPS cannot be used to give reliable results since faculty tracking primarily involves indoor positioning.

Other works have delved upon Bluetooth and Wi-Fi tracking system. The technologies are able to identify proximity and bare location, but they are limited to signal interference, range, and network conditions. This decreases their precision in big campuses or busy locations [3].

A better remedy that has been reported by research study is the Radio Frequency Identification (RFID) technology. The applications of RFID systems are mostly in identification and tracking applications due to the fact that it has a very high detection speed, is more effective in indoor use and is very cheap to implement. RFID enables automatic data capture, where manual records are not needed and therefore it is very much befitting faculty tracking system [4].

The Internet of Things (IoT) has facilitated the creation of smart systems in the recent years through linking hardware devices with software applications. IoT-based systems enable real-time data transfer and monitoring, a feature that can be used to monitor applications in smart campuses. Different researchers have revealed that IoT can enhance efficiency in learning institutions by automating and sharing information in real time [5].

Moreover, mobile applications have entered the realm of the modern systems as a necessity. It has been found out that mobile-based solutions enhance user experience since they allow easy access to real-time information. Programs created with the help of frameworks such as Flutter are cross-platform and user-friendly [6].

Based on the analysis of the current systems, it is noted that despite the existence of numerous technologies that can be used in tracking and monitoring, there are only a few systems that are particularly concerned with real-time tracking of the faculty in learning institutions. Lots of systems lack accuracy, are

not user-friendly, or fail to integrate hardware and software.

Thus, the proposed study is a Smart Faculty Finder System based on RFID, ESP32, IoT, Flutter, Spring Boot, and MySQL as a comprehensive and effective solution. The proposed system will be able to address the shortcomings of the current techniques by providing real-time, precise and readily available data about the location of the faculty.

Problem Statement

In learning institutions, proper communication between learners and the faculty members is a key to academic success. However, learners are usually challenged to a large extent when trying to identify faculty members on campus. This issue is caused by changing schedules of faculties, the possibility of constant movement between classes, laboratories, offices, and meetings, and the lack of any real-time tracking system.

In the majority of institutions, the most common approach is the use of the old system which includes fixed schedules, in-person search or visiting the staff rooms to get faculty members. These methods cannot be trusted since they are not in line with the existing availability or location of the faculty. Consequently, the students take a lot of time to find the teachers, therefore, causing inefficiency, academic activities are delayed and productivity is low [1].

Current technology like GPS-based tracking is not applicable in indoor settings, because of signal constraint and less precision within buildings [2]. On the same note, the Bluetooth and Wi-Fi-based systems have disadvantages like signal interference, poor coverage, and reliance on network conditions, rendering them less favorable when it comes to making exact indoor tracking [3].

Despite the extensive use of RFID technology in identification and tracking, little is known about the use of this technology in real time tracking of faculty in educational institutions. Moreover, most of the current systems do not have an appropriate integration of hardware and software architecture that renders incomplete or inefficient solutions [4].

So, it is required to have a smart, reliable and efficient system that could handle the real-time tracking of faculty members on campus. The system must be user friendly, precise, economical, and able to

enhance the interaction between students and faculty.

This study seeks to resolve these issues by introducing a Smart Faculty Finder System that combines RFID and IoT with a mobile app to help display the real-time faculty location and availability.

Objectives

The key aims of the planned Smart Faculty Finder System are as follows:

1. To create a system that will allow real-time monitoring of faculty members on the campus based on RFID and IoT technologies.

2. To save time and effort that students have to spend on searching faculty members to use their services academically.

3. To enhance student faculty communication by offering precise and current location data.

4. To create a mobile application that provides students with easy access to faculty information by making it user-friendly.

5. To deploy a stable backend server with Spring Boot and MySQL to perform efficient data processing and data storage.

6. To combine hardware components like RFID and ESP32 with software components that can easily operate the system.

7. To build the system based on the Agile methodology, having the appropriate product backlog and sprint planning to manage the project effectively.

8. To build a scaled system that is capable of expansion in the future to support smart campus applications.

Proposed System

The system under proposal is a Smart Faculty Finder System which will help in tracking the faculty members in real-time in an educational institution. The system combines RFID and IoT technologies with a mobile application to provide an effective and convenient solution to students.

The system comprises the hardware and software elements, which collaborate to give correct location details.

A. System Overview

The system will be set to monitor the movements of the faculty members in the campus automatically. A faculty member will be given a special RFID tag that will be scanned by RFID readers

located in various places like classroom, laboratory, and staff room. The scanned data is transmitted to the backend server using an ESP32 microcontroller.

The Spring Boot gained backend server receives the data and puts it in a MySQL database. This data is acquired with the help of the REST APIs and shown on the mobile application created with Flutter where the real-time location and availability of faculty members to students are displayed.

B. Major Characteristics of the Proposed System.

1. Real-Time Faculty Tracking:- The system gives real-time faculty location in the campus.
2. User Authentication System:- Provision of secure login by various users like students, faculty and administration.
3. Role-Based Access Control:- Distinct dashboards are also availed depending on user roles.
4. Search Functionality:- Faculty members can be easily searched by name or department by the students.
5. User-Friendly Interface:- The mobile app is an easy to use and simple application.
6. Data Management System:- Effective storage and retrieval of data with MySQL database.

C. Technologies Used

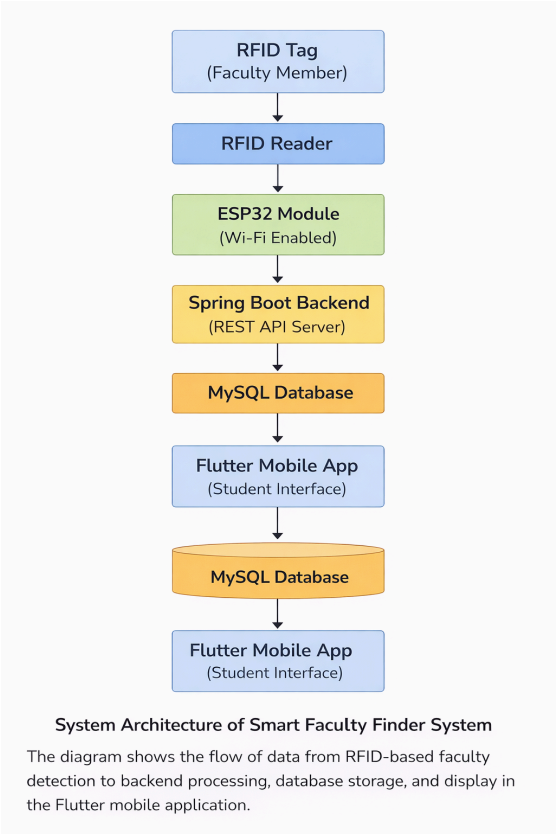
- RFID – To identify and track.
- ESP32 – In wireless transmission of data.
- Flutter- To develop mobile applications.
- Spring Boot - To build API on the backend side.
- MySQL - To manage databases.

D. Advantages of Proposed System Over Existing Systems

- Offers live tracking rather than as a static information.
- Performs well in the indoors.
- Reduces manual effort
- Enhances user-to-user communication.

The proposed Smart Faculty Finder System has a system architecture that is adopted to establish a seamless communication between the hardware and software components. The system will be split into three primary layers Hardware Layer, Backend Layer, and Frontend Layer

A. Architecture Diagram



System Architecture of Smart Faculty Finder System

The diagram shows the flow of data from RFID-based faculty detection to backend processing, database storage, and display in the Flutter mobile application.

B. Description of Architecture

1. Hardware Layer

The hardware layer comprises of RFID tags, RFID readers as well as ESP32 microcontroller. Every faculty is given a special RFID tag. The RFID reader reads the tag when the faculty member gets into a location and identifies their presence. This data is in turn transmitted to the backend server via Wi-Fi by the ESP32 module.

Backend Layer

Spring Boot is used to develop the backend layer. It takes the data that the ESP32 module transmits and processes it. The processed information is saved in the MySQL database. The mobile application is also able to access the data stored in the backend through the use of REST APIs.

Frontend Layer

The mobile application that is created with Flutter is the frontend layer. The app retrieves information on the server via API and shows the current position and status of faculty members. The interface is user friendly and straightforward.

C. Architectural working.

1. RFID tag on faculty.
2. The tag is scanned by the RFID reader.
3. ESP32 transmits information to backend.
4. Store and Backend processes data.
5. Flutter application retrieves information.
6. Faculty location is viewed by students.

Methodology

The Smart Faculty Finder System has a methodology that explains the working process of the system step by step. It describes the movement of data between the hardware

elements and the mobile application and the interaction between the systems and the users.

The system is systematic and has a process that would ensure real-time tracking and provision of accurate information.

A. Step-by-Step Working

1. RFID Tag Assignment

Every faculty is given a special RFID tag, which is filled with identification details.

2. RFID Tag Detection

As a faculty member steps into a particular facility like classroom, lab or staff room, the RFID reader scans the tag and identifies the presence of the faculty.

3. Transmission of data with ESP32.

The scanned data is transmitted to ESP32 microcontroller which sends the data to the backend server via a Wi-Fi connection.

4. Backend Data Processing

The data is sent to the backend system, which is created with Spring Boot, and the information is processed. The system recognizes the faculty member and changes his or her present location.

6. Database Storage

The processed data is stored on MySQL database such that the most recent location information is always available.

7. API Communication

The backend will offer REST APIs to enable the mobile application to make fresh data requests.

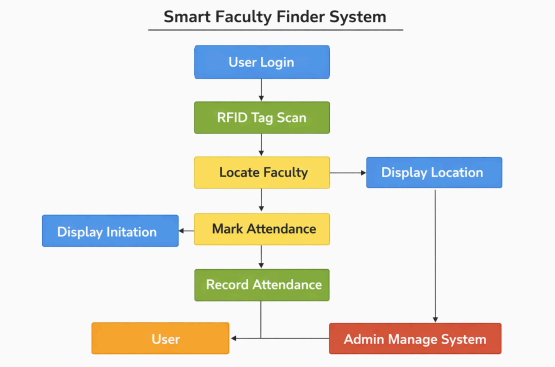
8. Mobile Application Display

The mobile application using Flutter gets the information in the backend and informs the students of the real-time position and accessibility of the faculty members.

9. User Interaction

Students can search for faculty members, view their details, and track their current location easily through the application.

B. Methodology Flow (Flowchart)



C. Agile-Based Development Methodology

The system is developed using Agile methodology, which includes:

- Product backlog creation
- Sprint planning
- Task execution
- Continuous testing and improvement

Each sprint focuses on specific features such as authentication, dashboard, tracking system, and user interface.

Implementation

The implementation of the Smart Faculty Finder System involves the integration of hardware components, backend services, and a mobile application. The system is developed using modern technologies to ensure efficiency, scalability, and real-time performance.

A. Hardware Implementation

The hardware part of the system includes RFID tags, RFID readers, and an ESP32 microcontroller.

- Each faculty member is assigned a unique RFID tag.
- RFID readers are installed at different locations within the campus.
- When a faculty member enters a location, the RFID reader scans the tag.
- The scanned data is sent to the ESP32 module.
- ESP32 transmits the data to the backend server using Wi-Fi.

This setup enables real-time data collection without manual input.

B. Backend Implementation

The backend system is developed using Spring Boot, which provides RESTful APIs for communication between hardware and the mobile application.

- APIs are created for login, data update, and data retrieval.
- The backend processes incoming data from ESP32.
- Faculty location is updated in real time.
- Authentication and role-based access control are implemented.
- The backend ensures secure and efficient data handling.

C. Database Implementation

The system uses MySQL database to store all required data.

- Faculty details (name, designation, cabin number)
- Login credentials
- Location data (latitude, longitude or location name)

The database is designed to ensure fast retrieval and proper data management.

D. Frontend Implementation

The frontend is developed using Flutter, which allows cross-platformmobile application development.

- User-friendly interface for students and faculty
- Dashboard for different user roles
- Search functionality for faculty
- Display of real-time location

The application communicates with the backend using REST APIs.

E. Integration of System

All components are integrated to work as a complete system:

- RFID detects faculty
- ESP32 sends data
- Backend processes data
- Database stores data
- Flutter app displays data

This integration ensures smooth communication between hardware andsoftware.

F. Tools and Technologies Used

Component	Technology Used
Frontend	Flutter
Backend	Spring Boot
Database	MySQL
Hardware	RFID, ESP32
Communication	REST APIs

Results and Discussion

The Smart Faculty Finder System was successfully developed and tested to evaluate its performance, accuracy, and usability. The system integrates RFID, ESP32, backend services, and a mobile application to provide real-time tracking of faculty members within the campus.

A. System Results

The implemented system produced the following results:

- The RFID-based tracking system successfully detected faculty presence at different locations.
- The ESP32 module transmitted data to the backend server without significant delay.

- The backend system processed and stored data efficiently in the MySQL database.
- The Flutter mobile application displayed real-time faculty location accurately.
- Users were able to search for faculty members easily using the application.

B. Performance Analysis

The performance of the system was evaluated based on different parameters:

Parameter Observation

Response Time Fast and real-time

Accuracy High (indoor tracking)

Usability Easy to use

Efficiency Improved significantly

The system showed good performance in real-time tracking and data handling. The response time was minimal, and the system was able to update faculty location quickly.

C. Discussion

The results indicate that the proposed system effectively solves the problem of locating faculty members within the campus. Compared to traditional methods, the system provides a faster and more reliable way of tracking faculty.

The integration of RFID and IoT technologies ensures accurate indoor tracking, while the mobile application provides a convenient interface for users. The Agile development approach also helped in improving the system step by step through multiple sprints.

However, the system depends on proper hardware setup and internet connectivity. Despite this, the overall performance of the system is satisfactory and suitable for real-world implementation in educational institutions.

Advantages

The proposed Smart Faculty Finder System offers several advantages over traditional methods:

1.Real-Time Tracking

The system provides live updates of faculty location within the campus, allowing students to find them quickly.

2.Time Saving

It reduces the time and effort required by students to search for faculty members manually.

3.Improved Communication

The system enhances communication between students and faculty by providing accurate location information.

4.User-Friendly Interface

The mobile application is simple, easy to use, and accessible to all users.

5.Efficient Data Management

The backend system ensures proper storage and quick retrieval of data.

6.Cost-Effective Solution

RFID and ESP32 are relatively low-cost technologies, making the system affordable for institutions.

7.Scalability

The system can be expanded to support a larger number of users and additional features.

8.Indoor Tracking Capability

Unlike GPS-based systems, the proposed system works efficiently in indoor environments.

Limitations

The proposed Smart Faculty Finder System has limitations in spite of its benefits:

RFID Infrastructure Reliance.

RFID readers must be installed correctly in various places, and this may add to the set-up workload in the early stages.

Restricted to Indoor Environment.

The system is primarily intended to be used indoors and it might not be effective in outdoor applications.

Network Dependency

The system will require connecting to a stable internet connection to transmit data between ESP32, backend and mobile application.

Hardware Maintenance

RFID devices and ESP32 modules should be maintained on a regular basis to maintain optimal operation.

Accuracy based on Reader Placement

RFID readers should be located in the right places to allow accuracy in tracking. Poor positioning can result in wrong location detection.

Large Campus Scalability Issues.

More hardware devices may be needed in extremely large campuses and this can lead to complexity.

Future Scope

To increase the functionality and usability of the proposed Smart Faculty Finder System, the system can be improved in a number of ways:

GPS Technology Integration.

The system can also be expanded to accommodate GPS that will track the faculty even outside the building.

Termination and Alert System.

Push notifications may be included to notify students about the availability of faculty or changes in location on-the-fly.

AI-Based Schedule Prediction

Faculty availability can be predicted by using Artificial Intelligence on previous data and schedules.

Cloud-Based Deployment

To enhance scalability, reliability and accessibility of the data, the system can be implemented on cloud platforms.

Attendance System Integration.

The attendance management can be combined with the system to automatically monitor faculty attendance.

Multi-Campus Support

The system may be extended to work across campuses or institutions.

Enhanced Security Features

State-of-the-art authentication and data security systems may be put in place to guarantee data privacy.

Improved User Interface

The mobile application will also be improved in terms of design, maps and more features.

Conclusion

The Smart Faculty Finder System is a practical way of solving the most common issue of finding faculty members within the educational institutions. The system effectively unites RFID and IoT technologies and a mobile application to provide a real-time facility to track faculty members.

The proposed system will save on time and effort that students need to spend to locate faculty, hence enhancing communication and overall academic efficiency. RFID is used to provide the correct indoor tracking, whereas ESP32, Spring Boot, and MySQL make it easy to process and manage data. The mobile application designed in Flutter offers the user-friendly

interface, and this simplifies the system to be used by every user.

Agile methodology was used to develop the system and ensured that the development was structured into product backlog and sprint implementation. This method guaranteed flexibility, continuous improvement and effective execution of project.

Despite these limitations that are embodied by the fact that the system requires the hardware configuration and network connectivity, it remains a reliable and scalable solution to real-life applications. The findings indicate that the system is effective and can be used in learning institutions to improve communication and efficiency.

Finally, the Smart Faculty Finder System is a good move in the right direction of coming up with smart campus solutions. As the system is further developed with addition of GPS integration, notification features and AI-powered functionalities, it can be scaled to offer even more enhanced functionality in the future.

References

1. A. Kumar and R. Singh, Traditional vs Smart Campus Systems, International Journal of Computer Applications, vol. 182, no. 12, pp. 25–30, 2019.[2]

2. P. Misra and P. Enge, Global Positioning System: Signals, Measures, and Performance, 2nd ed. Ganga-Jamuna Press, 2012.

3. J. Hightower and G. Borriello, Location Systems in Ubiquitous Computing, IEEE Computer, vol. 34, no. 8, pp. 57–66, 2001.

4. K. Finkenzeller, RFID Handbook: The Fundamentals and Applications of Contactless Smart Cards, 3 rd ed. Wiley, 2010.

5. L. Atzori, A. Iera and G. Morabito, The Internet of Things: A Survey, Computer Networks, vol. 54, no. 15, pp. 2787–2805, 2010.

6. [6] Google, “Flutter Documentation,” [Online]. Available: https://flutter.dev

7. 7] H. Liu, H. Darabi, P. Banerjee and J. Liu, Survey of wireless indoor positioning techniques and systems of IEEE Transactions on Systems, Man, and Cybernetics, vol. 37, no. 6, pp. 1067–1080, Nov. 2007.

8. R. Want, An introduction to RFID Technology, IEEE Pervasive Computing, vol. 5, no. 1, pp. 25–33, Jan.–Mar. 2006.

9. The paper by M. A. Razzaque, M. Milojevic-Jevric, A. Palade, and S. Clarke, Middleware Internet of Things: A Survey, IEEE Internet of Things Journal, vol. 3, no. 1, pp. 70–95, Feb. 2016.

10. S. K. Datta, C. Bonnet, and N. Nikaein, An IoT Gateway Centric Architecture to Provide Novel M2M Services, IEEE World Forum on Internet of Things, pp. 514–519, 2014.

11. N. Patil and S. Patil, IoT Based Smart Campus System in Educational Institutions, International Journal of Engineering Research and Technology (IJERT), vol. 8, no. 5, pp. 345–349, 2019.