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Leveraging IoT to Enhance Real-Time Lecturer Accessibility in Higher Education

Norzaila Mohamad Nor, Shifa' Zubir, Muhammad Shahrizan Shahrudin

Kulliyyah of Islamic Finance, Management Science & Hospitality, Universiti Islam Antarabangsa Sultan Abdul Halim Mu'adzam Shah (UniSHAMS), Kedah, Malaysia

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Abstract

The Internet of Things (IoT) technology has introduced transformative shifts across various sectors, including academia. By integrating IoT devices with a user-friendly web interface, higher education institutions can address the challenge of lecturer availability. The Synced Information on Lecturer Availability (SILA) notification system aims to enhance facilitator accessibility in academia. Utilizing ESP32 development boards, this system allows lecturers to update and broadcast their availability status in real-time, providing students with seamless access to this information. The system undergoes thorough testing for usefulness, user satisfaction, and usability. Ultimately, the SILA project significantly enhances communication, accessibility, and operational efficiency in educational settings.

Keywords: Internet of Things (IoT), Lecturer, Notification System.

Introduction

In recent years, the Internet of Things (IoT) has become a disruptive force in higher education institutions (HEIs), offering innovative solutions to longstanding challenges. This impact is particularly evident in Malaysia, where IoT technology is increasingly being integrated into academic environments. As highlighted by Muhamad et al (2023), IoT has influenced various industries, including education, by providing creative solutions and promoting a more connected and efficient learning environment. By revolutionizing educational practices and enhancing connectivity, IoT is fostering more dynamic and responsive academic settings.

The increasing reliance on digital solutions in higher education underscores the importance of studying IoT integration. Not only does IoT offer an innovative way to address the communication gap between students and lecturers, but it also aligns with global trends in the modernization of educational infrastructure. IoT technologies enhance both operational efficiency and academic support systems, making them crucial in creating more responsive and dynamic educational environments. By exploring the potential of IoT to streamline

communication and improve lecturer availability, this study addresses a fundamental need in higher education, effective student-lecturer interaction which has been shown to positively influence academic performance and student satisfaction.

By incorporating IoT devices with user-friendly web interfaces, higher education institutions (HEIs) can develop dynamic systems to address significant issues such as educator availability, a concern highlighted by (Madni et al., 2022). The ability of IoT technology to provide real-time information on educator availability enhances student-educator interactions and streamlines the process of accessing educator assistance, as emphasized by (Amasha et al., 2020). This advancement has the potential to greatly improve the accessibility and transparency of educator availability, fostering more dynamic and engaging educational environments.

The significance of this study lies in its ability to offer practical, scalable solutions for institutions seeking to enhance accessibility and communication between students and lecturers. The proposed Synced Information on Lecturer Availability (SILA) system has the potential to reduce the time students spend attempting to contact lecturers, thereby increasing academic engagement and satisfaction. Moreover, by providing real-time availability information, the system addresses existing inefficiencies in student-lecturer interaction and enhances overall productivity in academic settings. Effective communication and accessibility between students and lecturers are crucial in contemporary academia.

Students frequently require guidance, clarification, and academic discussions with their lecturers, yet navigating the intricate schedules of lecturers can pose significant challenges. This often leads to frustration among students and disrupts the learning process. Traditional methods of determining lecturer availability, such as office hours and manual appointment scheduling, are fraught with challenges, including miscommunications and inconveniences. The lack of real-time information regarding lecturers' schedules exacerbates these issues, leaving students uncertain about the appropriate times to approach their lecturers.

To address these challenges, this study proposes the design and implementation of a notification system named Synced Information on Lecturer Availability (SILA). The study has three primary objectives: first, to develop a notification system utilizing ESP32 development boards, enabling lecturers to update and broadcast their availability status in real-time; second, to create an intuitive web interface specifically designed for students, offering straightforward access to real-time information about their lecturers' availability; and third, to incorporate a notification mechanism that alerts students to any changes in their lecturers' availability status, ensuring timely updates and improved communication. By integrating ESP32 development boards with an intuitive web interface, the SILA system aims to facilitate and optimize the student-lecturer interaction process. The implementation of this advanced IoT technology is anticipated to foster a more accessible and responsive learning environment, thereby enhancing students' overall academic experience.

Problem Statements

The current methods for determining lecturer availability present several inefficiencies and frustrations, significantly impacting the academic environment. Meehan and Howells (2018) note that students frequently need to physically visit their lecturers' offices to check for

availability, only to find the lecturer absent. This inefficient use of students' time and effort results in considerable frustration and may discourage students from seeking assistance altogether. Such recurring inconveniences lead to missed opportunities for valuable academic interactions and guidance, thereby decreasing overall productivity and heightening student dissatisfaction.

The absence of real-time information regarding lecturer schedules constitutes a significant barrier. According to Uzorka, Namara, and Olaniyan (2023), the lack of readily accessible availability data inhibits students from knowing when lecturers are available for consultations or meetings. This uncertainty may lead to reluctance in approaching lecturers or result in students missing out on crucial academic support, thereby impeding their learning and performance. Moreover, without real-time updates, students are often left guessing about when to approach their lecturers, which undermines the effectiveness of academic communication.

Furthermore, the communication gap between students and lecturers worsens these issues. Brown (2019), highlights the inefficiency of current communication channels for scheduling appointments and notifying students of changes in availability. This communication deficit complicates the process of accessing necessary guidance and support, thereby increasing student frustration. If a more systematic and real-time solution is not implemented, students will continue to face difficulties in getting academic assistance in a timely manner.

If these issues remain unsolved, the consequences could be considerable. The inefficiencies in accessing lecturer availability may lead to a persistent decline in student satisfaction and academic performance. Students might continue to waste valuable time attempting to contact lecturers, resulting in decreased productivity and potential disengagement from academic activities. Additionally, the ongoing lack of effective communication and real-time availability information may disseminate a cycle of frustration and missed educational opportunities, ultimately compromising the overall quality of education.

To address these challenges, a real-time solution like the proposed SILA system is crucial. By offering an intuitive interface and an automated notification mechanism, the SILA system aims to provide a streamlined process for accessing lecturer availability and facilitating academic consultations. Such a system is not only more efficient but also enhances the effectiveness of student-lecturer interactions, ensuring that students receive timely guidance when needed. As supported by Sulasula (2023), the SILA system intends to optimize academic processes by providing an intuitive web interface for students, facilitating straightforward access to real-time availability information, and incorporating a notification mechanism to alert students of any changes in lecturers' availability. By addressing the inefficiencies of existing methods, SILA aims to create a more effective and supportive learning environment, thereby enhancing the overall academic experience for students

Scope

This project is specifically developed for the Universiti Islam Antarabangsa Sultan Abdul Halim Mu'adzam Shah (UniSHAMS), targeting the entire student population of UniSHAMS. Given the campus's unique qualities and geographical location, the scope of this study is comprehensive and aims to address the specific needs of both students and lecturers within this academic

environment. The scope of the system is designed to address these needs by providing a comprehensive and user-friendly solution. In terms of user roles, the SILA system will cater to two primary user groups: students and lecturers.

Students will have access to a web interface that allows them to view real-time information about the availability status of lecturers. They will be able to search for specific lecturers to check their availability and receive notifications or alerts when a lecturer's availability status changes. On the other hand, lecturers will be able to authenticate themselves and create accounts for access. They will have a personalized dashboard to update their availability status in real-time, manage their office hours, location, or contact information, and receive notifications or alerts regarding student queries or appointment requests.

The system includes several key features and functions, such as real-time availability information, secure user authentication for both students and lecturers, and a user-friendly web interface designed to be visually appealing and easy to navigate. A dedicated lecturer dashboard allows for efficient management of availability and profiles, while automated notifications and alerts keep students informed of changes in lecturer availability and to notify lecturers of student inquiries. The study's focus on UniSHAMS allows for tailored solutions that address the specific needs of the campus's student and lecturer populations, providing valuable insights for potential broader applications.

Method and Tools

The system is developed using the Agile methodology, which includes five stages: requirements, design, development, testing, and implementation. This iterative approach allowed for continuous feedback and improvements throughout the development process, ensuring that the final product met the needs of its users effectively.

The initial stage involved gathering requirements from stakeholders, including students, lecturers, and administrative staff at UniSHAMS. This was accomplished through surveys and interviews to understand the specific needs and challenges faced by both students and lecturers regarding availability and communication. Based on the gathered requirements, the design phase focused on creating a system architecture and user interface that addressed these needs. The design included two primary user roles: students and lecturers. Students would access a web interface to view real-time information about lecturer availability, search for specific lecturers, and receive notifications when a lecturer's availability status changes. Lecturers would authenticate themselves, update their availability status in real-time, manage their office hours and contact information, and receive notifications regarding student queries.

The development phase involved coding and integrating various system components. The hardware requirements included ESP32 development boards and PIR motion sensors to detect lecturer presence and activity. The software stack comprised PHP, MySQL, JavaScript, and HTML/CSS for the web interface and backend services. The ESP32 boards and sensors collected availability data, which was transmitted to the web interface through a secure server setup. The system underwent rigorous testing to ensure its functionality, usability, and reliability. Testing methods included unit testing, integration testing, and user acceptance testing (UAT). A pilot group of students and lecturers at UniSHAMS participated in the UAT to

provide feedback on the system's performance and user experience. Metrics such as system responsiveness, accuracy of real-time updates, and user satisfaction were evaluated.

The materials and tools used in the project included ESP32 development boards, PIR motion sensors, and personal computers for development and testing. The software stack consisted of PHP for server-side scripting, MySQL for database management, JavaScript for client-side interactivity, and HTML/CSS for web design. Development tools such as IDEs (e.g., Visual Studio Code) and version control systems (e.g., Git) were also utilized. The SILA system was thoroughly evaluated for its usefulness, user satisfaction, and usability. Evaluation methods included surveys and questionnaires distributed to students and lecturers to gather feedback on the system's performance and user experience. Interviews were conducted with a select group of users to gain in-depth insights into their interactions with the system and any challenges faced.

Design and Development

This section explains the design and development process of the system, describing key stages and considerations. It starts with an overview of requirements gathering, which involved personal interviews and feedback from students and lecturers to determine the system's necessary features. This phase highlighted the need for a user-friendly interface and effective communication tools to enhance lecturer accessibility.

The system is designed with IoT integration using ESP32 and PIR motion sensors for accurate availability detection. Non-functional aspects emphasize reliability, scalability, real-time performance, and usability. The design includes secure user authentication, an intuitive interface, and effective notifications for both students and lecturers. System specification and UML diagrams provide a detailed view of user interactions, interface design, and database architecture. Use case diagrams illustrate interactions such as updating and broadcasting availability by lecturers and viewing and receiving notifications by students. The user interface is designed to be intuitive, offering real-time updates and clear visibility of lecturer availability through color-coded indicators.

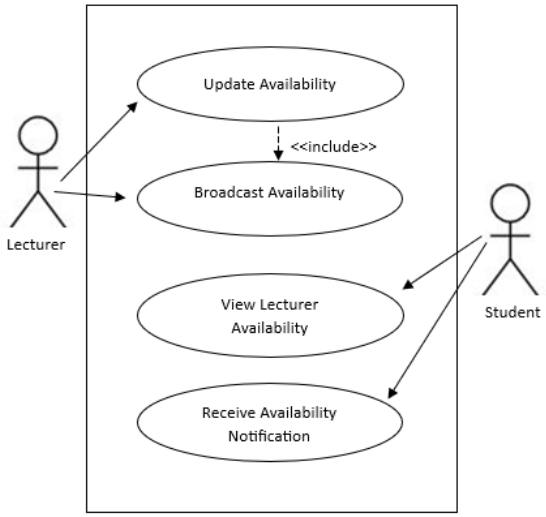

Figure 1. Use case diagram for the system

Database design is critical to ensure that tasks run effectively. It uses an event-driven architecture, with motion detection triggering real-time database updates that indicate the lecturer's current position. This structure enables efficient data management and quick information retrieval for students.

The 'Lecturer' table is designed to store essential information about each lecturer within the system. It includes several fields: Lect.ID, which serves as the unique identifier for each lecturer, ensuring different recognition; Name, which stores the lecturer's name for easy identification; Room, representing the office location associated with the lecturer; and Availability, which indicates the current availability status of the lecturer, crucial for students seeking to know if the lecturer is available for consultation.

Table 1
Table Lecturer

Fields	Explanation
Lect.ID	Unique identifier for each lecturer in the system
Name	Stores the name of the lecturer
Room	Represents the room associated with the lecturer
Availability	Indicates the current availability status of the lecturer

The Event table is used to record occurrences detected by motion sensors related to lecturer activities. It contains several fields: EventID, the unique identifier for each event triggered by the motion sensor, ensuring each event is clearly recognized; Timestamp, which records the date and time when the motion was detected, providing a chronological log of events; LecturerID, linking the event to the corresponding lecturer using the unique identifier from the Lecturer table, thus establishing a connection between the event and the lecturer; and EventType, which describes the type of event, possibly indicating motion detection, and helps in understanding the nature of the activity detected by the sensors.

Table 2
Table Event

Fields	Explanation
EventID	Unique identifier for each event triggered by the motion sensor.
Timestamp	Records the date and time when the motion was detected.
LecturerID	Links the event to the corresponding lecturer.
EventType	Describes the type of event, possibly indicating motion detection.

Together, these tables work to maintain and track the availability of lecturers by linking motion sensor events to specific lecturers, thus providing real-time information on their availability status.

Hardware and Software

The SILA system integrates physical devices and software to monitor lecturer availability in a kulliyyah environment in real-time using advanced IoT technologies. The main tools used are the ESP32 board and motion sensors, which detect lecturer presence. Alongside, software components like Microsoft Visual Studio, XAMPP, and Arduino IDE manage data processing, storage, and presentation. This collaborative approach ensures efficient motion data capture, accurate updates to a MySQL database, and presentation through a user-friendly web interface, facilitating quick access to essential information for managing academic sessions.

ESP32 Integration

The ESP32 development board, a microcontroller with Wi-Fi and Bluetooth capabilities, is crucial in the SILA system for interfacing with IoT technologies. It enables real-time monitoring of lecturer availability by communicating with various sensors and devices. A Passive Infrared (PIR) motion sensor detects human body heat and movement, strategically placed to determine lecturer presence. When motion is detected, it triggers an event signal to update the database with current availability information. The ESP32, integrated with the PIR sensor and programmed via Arduino IDE, handles motion data, manages local data, and transmits information to a server. This ensures efficient real-time monitoring and data transmission, making the lecturer accessibility system effective. The process includes the PIR sensor detecting motion, the ESP32 processing the data, updating the database, and a web application displaying real-time information to students. This integration creates an efficient system for monitoring lecturer presence in academic settings.

Web Interface Development

The web interface for the system is tailored to meet the informational needs of students at Kulliyyah, featuring a background image of the selected building and four main navigation buttons. The "Availability" button allows students to check lecturers' real-time availability, while the "About" section provides comprehensive background information on the Kulliyyah's history and mission. The "Programmes" button displays the courses offered, and the "Chart" button outlines the organizational structure, including positions like the Dean and Head of Department. Additionally, the logo and integrated gallery buttons offer visual narratives of the selected building, enhancing the online experience. This web interface not only provides essential real-time availability information but also offers a rich repository of information, fostering an engaging and informative online environment for students.

Result and Discussion

This section provides a discussion of the findings and results produced from the developed prototype. The important phase in the development process involved performing detailed fact-finding, evaluating current systems, and presenting the prototype to user testing. In order to define the functional requirements for the application, a fact-finding technique was utilized by examining similar existing systems. In this study, relevant hardware and software components were identified. Steps were made to integrate these components in order to make sure the system operated effectively.

Fact-Finding

During the fact-finding phase, researcher conducted a comprehensive review of existing systems to understand the current approaches to lecturer availability management. This

review highlighted key functionalities and components that were integrated into the system. By studying these systems, researcher identified the essential hardware components, such as ESP32 development boards and PIR motion sensors, and the necessary software tools, including PHP, MySQL, JavaScript, and HTML/CSS.

System Integration and Development

The integration of these components was executed to ensure seamless operation. The ESP32 development boards and PIR motion sensors were configured to detect and transmit lecturer availability data in real-time. The software stack was developed to process this data and present it through a user-friendly web interface. The iterative nature of the Agile methodology allowed for continuous testing and refinement, ensuring the system's reliability and usability.

Prototype Evaluation

The prototype was assessed based on the effectiveness of the system. The evaluation focused on two main aspects: the overall effectiveness of the system and its system usage and accessibility. Questionnaires were distributed to students to gather feedback. The results indicate that the majority of respondents agreed on the system's effectiveness, reliability, and accuracy. According to Debevc and Bele (2008), system usability is considered satisfactory with scores greater than 50. All evaluated aspects of the SILA system received scores above this level, indicating high levels of perceived impact, usefulness, user satisfaction, and usability.

User Feedback and System Performance

The survey results showed that 97% of respondents experienced a significant increase in their awareness of lecturer availability with the system. This suggests that the system successfully enhances users' awareness and access to crucial scheduling information, proving its value and impact within the academic environment. In terms of reliability, 84.4% of respondents expressed high confidence in its reliability, demonstrating that the system is perceived as dependable and trustworthy by the majority of users.

In terms of speed and accuracy, all respondents confirmed that the system was faster and more accurate than traditional methods for determining lecturer availability, showing that SILA is extremely efficient and precise. This agreement among respondents highlights the system's superiority over traditional methods, reinforcing its effectiveness and reliability as a tool for quickly and accurately providing lecturer availability information. These performance improvements, as evidenced by user feedback, showcase SILA’s potential to be scaled up for wider institutional use.

Hypothetical Scenario

Consider a scenario in which a student urgently needs to meet a lecturer before an assignment deadline. Traditionally, the student might face uncertainty about the lecturer's availability, leading to frustration and delays. However, with the SILA system, the student can check real-time availability on the web interface, immediately seeing whether the lecturer is available for consultation. This timely information allows the student to schedule a meeting efficiently, avoiding unnecessary delays and increasing overall productivity. This hypothetical

case demonstrates how IoT-driven solutions like SILA can significantly improve the academic experience by reducing friction in student-lecturer interactions.

Scalability and Broader Impact

Looking ahead, the SILA system's scalability can be explored through its deployment at other institutions beyond Universiti Islam Antarabangsa Sultan Abdul Halim Mu'adzam Shah (UniSHAMS). As the system has been demonstrated to be effective in a pilot test, it can be adapted to other educational institutions, potentially improving lecturer accessibility across the board. Further improvements, such as integration with mobile apps or enhanced notification systems, could expand its functionality, making it more versatile and applicable in diverse academic settings.

By showcasing these results, the study illustrates the effectiveness of the SILA system not only as a proof-of-concept but also as a practical tool that can significantly enhance communication and operational efficiency in higher education settings. The combination of IoT technologies, real-time data processing, and user-friendly interfaces makes the system a compelling solution to one of academia's persistent challenges.

Conclusion

The Synced Information on Lecturer Availability (SILA) project has successfully tackled the persistent challenges associated with lecturer availability in higher education institutions. By leveraging the capabilities of Internet of Things (IoT) technology, the system delivers real-time updates on lecturer availability, thereby enhancing communication, accessibility, and operational efficiency within academic settings. The integration of IoT components, such as ESP32 development boards and PIR motion sensors, ensures accurate and timely information dissemination, which is critical for effective student-lecturer interactions.

The system's implementation has been met with positive feedback from users, with a significant majority reporting improved awareness and ease of access to lecturer availability information. This positive reception underscores the transformative potential of IoT technology in revolutionizing the academic experience. By providing a dynamic and responsive learning environment, SILA fosters more effective educational interactions and supports a more efficient use of time and resources for both students and lecturers.

The successful implementation of the SILA system offers a scalable solution for other educational institutions seeking to enhance student-lecturer interactions. Its real-time features and IoT integration ensure not only improved communication but also increased student engagement and institutional efficiency. Additionally, the adaptability of SILA demonstrates its potential to evolve with the changing needs of educational institutions, making it an invaluable tool in modern academic environments.

Looking ahead, future work will aim to expand the system's functionalities, incorporating additional features to further enhance user experience and operational efficiency. Additionally, there is considerable scope to explore other innovative applications of IoT technology in education, potentially addressing various other challenges faced by higher education institutions. The findings of this study highlight the promising role of IoT in shaping

the future of academic environments, paving the way for more intelligent and connected educational systems.

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