INTERACTIVE REAL-TIME OFFICE PRESENCE INDICATOR DISPLAY SYSTEM WITH MOBILE APP INTEGRATION

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF STUDY

Our world continues to become increasingly complex, interconnected, and dynamic: There are more people and institutions; they engage in more relationships and exchange; and the rates of change continue to grow, largely because of developments in technology and the importance of information to human and technical development.

Human existence is a series of interactions with the environment. Most of humankind's early history was surviving these interactions, and the purpose of our science and technology is to control the environment so that we can choose the interactions that serve our personal or social objectives. We master and value interactions with other people through a variety of natural communication mechanisms that have evolved.

Interactivity - the propensity to act in unison with external objects or other people - is a basic human characteristic. The complexity of modern society forces us to interact with more institutions and systems, using limited and cumbersome communication mechanisms that we generally characterize by phrases such as bureaucratic protocol.

We live in an information society in which more people must manage more information, which in turn requires more technological support, which both demands and creates more information. Electronic technology and information are mutually reinforcing phenomena, and one of the key aspects of living in the information society is the growing level of interactions we have with this complex and increasingly electronic environment.[1]

In an academic environment where the presence and availability of a lecturer are not properly communicated to outsiders, one will have to knock to enter. It aims to provide real-time information about a lecturer's presence, availability, and office hours within a school environment.

Efficient communication and collaboration are essential for both students and staff. However, a persistent challenge is the lack of readily available information about individuals' presence and availability.

The current challenge of obtaining this information promptly is a persistent issue, not just in academic environments but also in modern offices, where employees may need to access

shared spaces. By leveraging technology, this system bridges the gap between traditional methods of obtaining permission to enter an office and the need for efficient communication.

With the display system in place, individuals can quickly determine whether a lecturer or employee is occupied, busy, or available, reducing the need for unnecessary interruptions and improving overall productivity.

1.2 PROBLEM STATEMENT.

The persistent challenge of obtaining real-time information about office or lecturer presence poses significant obstacles to both academic and professional environments. Current methods for accessing shared spaces are often inefficient and prone to interruptions, hindering productivity and workflow efficiency. There is a critical need for a technological solution that can bridge this gap and provide timely information about the availability of individuals in official settings.

1.3 AIMS AND OBJECTIVES

The aim is to develop an Interactive Real-Time Office Presence Indicator Display System that leverages technology to streamline communication and improve productivity in academic and professional environments.

The objectives are

1) To design and implement a real-time presence detection system capable of accurately identifying the occupancy status of offices and shared spaces.

2) To develop an interactive display system that provides visual indicators of office occupancy, availability, and busy status in a user-friendly interface.

3) To integrate mobile application functionality that enables remote access and interaction with the office presence display system.

4) To evaluate the effectiveness of the system in reducing interruptions, improving communication, and enhancing overall productivity in academic and professional settings.

1.4 SCOPE

This project's scope encompasses designing and deploying a real-time presence detection system, creating an interactive display interface for visual indicators of office occupancy and availability, and integrating mobile application functionality for remote access. The project will focus on academic and professional environments where efficient communication and collaboration are paramount.

1.5 SIGNIFICANCE

This project aims to tackle a longstanding issue in academic and professional settings by leveraging technology to enhance communication and productivity. The proposed system has the potential to bolster workplace efficiency, minimize interruptions, and optimize resource utilization.

By providing seamless access to real-time information on office presence, the project contributes to the creation of a more cohesive and collaborative work environment. The findings and results of this project have far-reaching implications for the adoption of smart office technologies and their impact on organizational performance.

1.6 LIMITATIONS

The system's functionality may be affected by various factors, including network connectivity, sensor precision, and the limitations of microcontrollers. The project may encounter constraints related to budget, timeline, and available resources for development and deployment. Moreover, the project scope may not account for all scenarios or requirements across diverse academic and professional settings, which could result in suboptimal performance.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 GENERAL OVERVIEW

The efficient management of office spaces and presence is essential for fostering productivity and collaboration in modern work environments. This literature review explores existing research and studies related to **"INTERACTIVE REAL-TIME OFFICE PRESENCE INDICATOR DISPLAY SYSTEM WITH MOBILE APP INTEGRATION".** The important keywords related to the project are office presence management systems, real-time communication technologies, and smart office solutions to provide a comprehensive understanding of the context and challenges addressed by the proposed project.

2.2. PRESENCE IN THE ENVIRONMENT

If "presence" in the workplace is no longer a one-dimensional idea, but an increasingly multi-faceted one, then a stable, effective, and discreet digital infrastructure is needed to underpin all the emerging considerations around hybrid ways of working. Software and systems architecture needs to seamlessly plug into the physical workplace and connect to other systems to work effectively and create the safest, most flexible, and collaborative work experience. Smart systems should be modular and scalable so that companies can test the principles of the connected office at a basic level and be future-ready to scale up. In this context, the use of LED-connected lighting with embedded IoT (Internet of Things) sensors makes a lot of sense from an operational and design perspective.[2]

2.3 REAL-TIME COMMUNICATION SYSTEMS

Real-time communication systems play a crucial role in modern workplaces, enabling instant communication and collaboration among team members. Research has shown that effective

communication is essential for maximizing productivity and minimizing disruptions in any official setting[4]. However, existing communication tools may not always provide real-time visibility into individuals' availability, leading to delays and inefficiencies in information sharing[5]. Integrating real-time office presence indicators into communication systems can help address this challenge and enhance the effectiveness of workplace communication.

2.4 SMART OFFICE SUB-SYSTEM AND COMPONENTS

The concept of Smart Office, as an application type belonging to the Internet of Things (IoT) domain, typically covers features supporting intelligent behavior of the work environment, namely office rooms [6], [7].

A network of dedicated sensors, actuators, and various specialized devices is employed to adjust the settings of temperature, light intensity, humidity, vibrations, noise level, and other in-room environment parameters in accordance with the preferences of users and office employees [8].

In line with the IoT principles [9], the networked sensors and devices are acting as autonomous and adaptable entities that exchange produced and consumed data by means of Internet-like protocols, provide services embedded directly in the devices, update their inner status, and generate events as responses to changes in the outside context [10]

2.4.1 Examples of Smart Office Technology

2.4.1.1 Internet of Things

The Internet of Things (IoT) refers to the interconnected network of devices and objects that are linked to the internet, enabling communication and data exchange[11][12]. This technology has revolutionized various industries by connecting everyday objects like appliances, vehicles, and gadgets to the internet, allowing for automated data collection and interaction between objects and humans[13][14]. IoT systems have digitized daily life,

leading to the development of smart homes and smart cities through the connection of devices and vehicles to the internet.

2.4.1.2 Machine learning

Machine learning is a crucial component of smart office technology, as highlighted in various research papers. In the context of smart offices, machine learning is utilized to predict situations, analyze data, and enhance efficiency[15]. Specifically, machine learning is employed to forecast faults in IoT devices, ensuring real-time monitoring and maintenance of office equipment[16].

2.4.1.3 Interconnectivity and Control

Interactive and control features are prominent in smart office technologies. For instance, smart office desks utilize machine learning algorithms to learn from users[17]. These desks collect data on user postures, habits, and interactions with software applications to provide personalized recommendations and implement actions accordingly[18]. Additionally, IoT-based smart office models enable remote control of office devices via smartphones, enhancing efficiency and security[19].

2.4.1.4 Improved communication tools

Smart offices also feature technologies that improve human-to-human communication for both in-person and remote employees. These tools can include digital whiteboards for easily syncing notes and facilitating brainstorming sessions, improved conference rooms featuring high-definition cameras and microphones for productive video conferencing calls, and high-quality document management systems hosted in the cloud.

2.5 IMPACT OF THE INTERNET OF THINGS (IOT) ON EDUCATION

The introduction of the Internet of Things (IoT) in education, which allows Internet-based communications to happen between physical objects, sensors, and controllers, has changed educational institutions massively.

By embedding sensors in objects and integrating cloud computing, augmented reality, wearable technologies, and big data in this platform, different parameters of the educational environment can be measured and analyzed to provide useful information.

It also has created a new interaction between people and the environment in educational organizations. Data will be gathered by embedded sensors and actuators, which are then sent to specialized applications to create actionable information.[20]

Governments and educational institutions are using IoT to streamline processes, leverage data, and promote sustainability. The use of smart objects and wearable devices is well-established in any number of universities.[21]

Enabling technologies such as sensors, chips and other wearable devices which are all well understood, easily mass-produced, and inexpensive have become ubiquitous in education and used extensively in classrooms due to the potential to change the existing industrial and business processes.[22]

2.6 COMPONENTS OVERVIEW AND FUNCTIONALITY

By integrating mobile app functionality and interactive display systems, smart office solutions offer users greater flexibility and control over their workspace environment, leading to higher levels of satisfaction and engagement.

The indicator display would contain different parts. Each of these parts is fundamental and is itself made up of a series of small devices assembled to perform a certain function.

These components also include indicator lights. Devices designed for a wide variety of application needs, beacons, or indicator lights are optimal for reliable indication of the operating status of a device.

Indicator lights are used to make the operating status (on, off, fault) of the device on which they are installed visible from the outside using a small light. The colour of the light emitted will therefore be associated with a precise status of the application, making it instantly understandable and easy to use for the end user.

2.7 SUMMARY

The literature review highlights the significance of real-time communication systems, and smart office solutions in modern organizations. While existing research has identified the importance of these factors, there is a clear need for innovative solutions that integrate real-time office presence indicators with communication technologies to address the challenges faced in official school settings.

The proposed project aims to fill this gap by developing an Interactive Real-Time Office Presence Indicator Display System with Mobile App Integration, which has the potential to significantly improve school workplace efficiency and productivity.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This project aims to develop an interactive real-time office presence indicator display system integrated with a web application. The system will provide a convenient and efficient way for office users to indicate their presence status, which can be displayed on dedicated devices inside and outside the office.

It consists of two electronic devices placed on the door: an indoor device with buttons for indicating presence situated at the back of the door, and one device placed on the outside of the door with LEDs for displaying the presence status. Both devices are equipped with an LCD screen for displaying additional information.

The web application component allows users to remotely update their presence status without the need for physical interaction with the devices. This necessitates the need for communication between devices, which calls for the integration of a microcontroller.

The project's implementation will involve the precise integration of components, ensuring dependable and effective operation. The design procedures for each of the modules that make up the entire project system are discussed in the following sections.

3.2 SYSTEM ARCHITECTURE

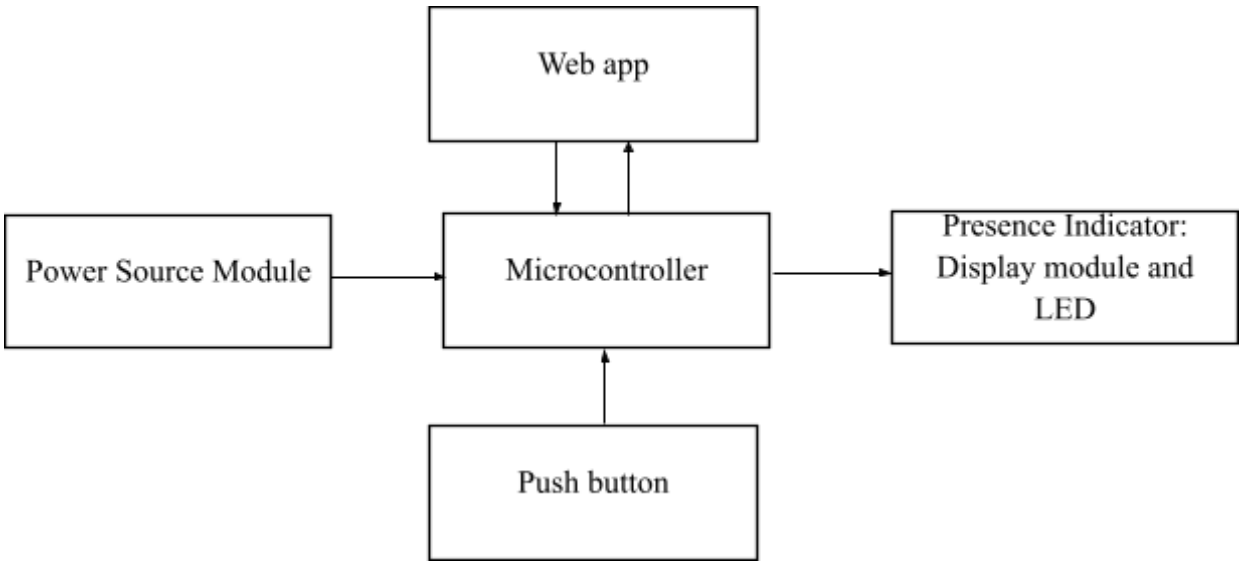
The proposed system consists of two main components: hardware devices and a web application to provide the desired simplicity and functionality. The hardware devices are responsible for collecting and displaying presence status information, while the web application facilitates remote access and updates.

The hardware components include ESP32 modules, LCD screens, push buttons, and LEDs, while the software components consist of programming code for the ESP32 modules and a web application for remote presence activation and logging. The device placed indoors is

equipped with buttons that office users can press to set their presence status. The ESP32 module in this device processes the button input and updates the presence status accordingly.

The outdoor device receives the presence status from the indoor device and displays it using LEDs and an LCD screen. Both devices have an LCD screen for displaying additional information.

A web application is integrated into the system for more ease and simplicity, allowing users to log their presence remotely without the need for physical button presses, making it faster and easier. The web application communicates with the ESP32 modules to update the presence status, which is then reflected on the indoor and outdoor devices. Essentially, the web application serves as a remote control for the status display devices.



This shows a block diagram illustrating the system components

3.3 HARDWARE IMPLEMENTATION

3.3.1 POWER SOURCE MODULE

A power bank is selected as the power supply module for the system due to its portability, high energy density, and ease of use. The chosen power bank has a capacity of 10,000mAh and an output voltage of 5V, which is compatible with the power requirements of the ESP32 module and peripherals.

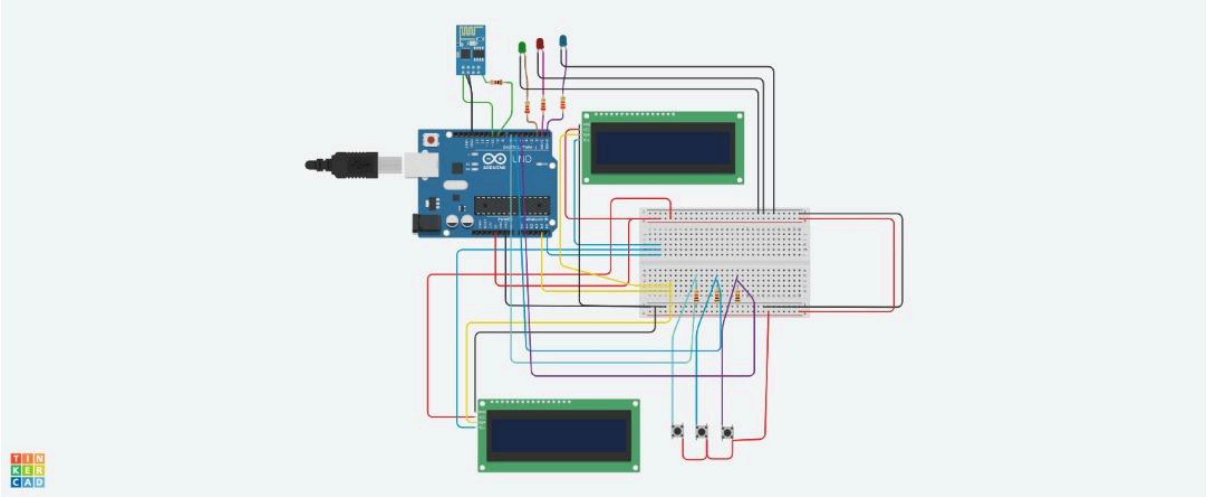
When the main discharging port of the station is electrically connected to an electronic device, the charging-discharging control circuit receives electric power from the rechargeable batteries of the battery modules to provide electric power to the electronic device.

The power bank is connected to the ESP32 module via a USB cable, providing a reliable and efficient power source for the entire system.

3.3.2 ESP32 MICROCONTROLLERS

The ESP32 microcontroller is chosen for its powerful processing capabilities, integrated Wi-Fi and Bluetooth connectivity, and a wide range of peripherals. The ESP32 module used in this project is the ESP32-WROOM-32D, which features a dual-core 32-bit processor running at 240MHz, 520KB of SRAM, and 4MB of flash memory. The ESP32 module is programmed using the Arduino IDE and the ESP32 core for Arduino.

The firmware is developed in C++ and utilizes various libraries for interfacing with the LCD screens, push buttons, and LED indicators, as well as for Wi-Fi connectivity and communication with the web application.



An image showing the ESP32 microcontrollers connections

3.3.3 PUSH BUTTONS

For the indoor device, three push buttons are implemented to allow office users to indicate their presence status. The push buttons are connected to the ESP32 module via GPIO pins, with appropriate pull-up or pull-down resistors to ensure stable operation.

The firmware implements debouncing techniques to prevent false button press detection due to mechanical bouncing. When a button is pressed, the corresponding presence status is updated and displayed on the LCD screen.

The button press event is also transmitted to the web application for synchronization. The logic for processing button presses involves updating the presence status variable based on the button pressed (e.g., "Available," "Busy," or "Out-of-Office").

3.3.4 LCD (LIQUID CRYSTAL DISPLAY) SCREENS

Both the indoor and outdoor devices are equipped with 16x2 character LCD screens for displaying presence status information.

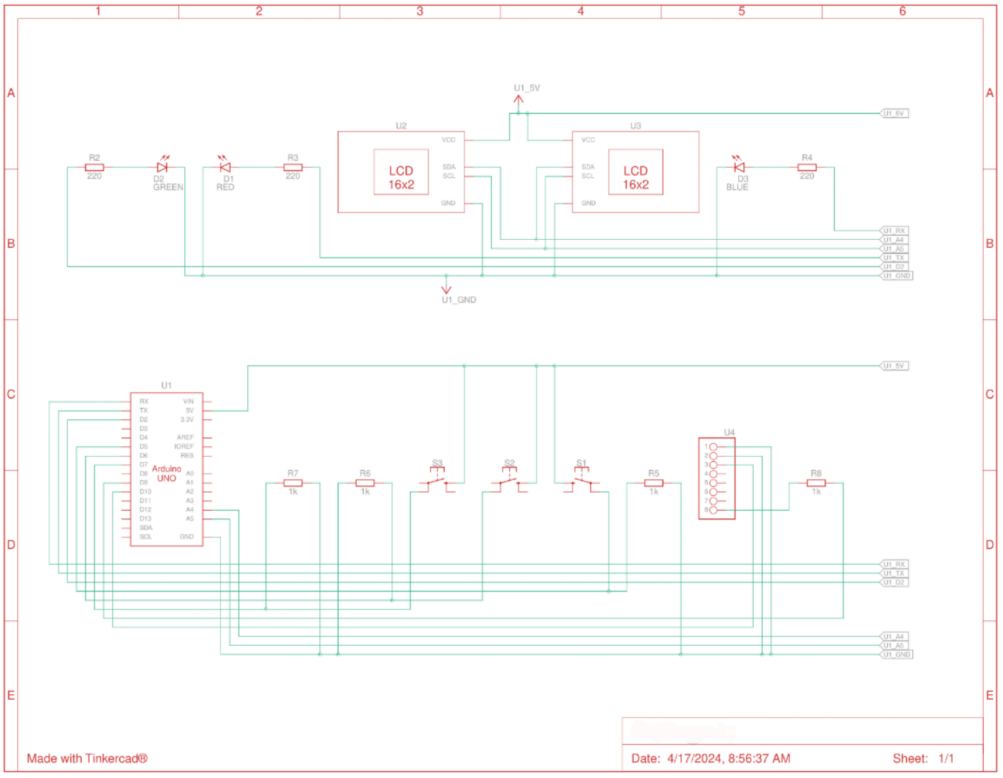
The LCD screens are interfaced with the ESP32 module using the I2C communication protocol, which simplifies the wiring and allows for future expansion with additional devices.

The firmware includes functions to initialize and control the LCD screens, displaying the current presence status and any additional information as required.

3.3.5 LED (LIGHT EMITTING DIODE) INDICATORS

For the outdoor device, a set of three LEDs (red, green, and yellow) are implemented to provide a visual indication of the presence status. The LEDs are connected to the ESP32 module via GPIO pins, with appropriate current-limiting resistors to prevent damage.

The firmware controls the LED indicators based on the received presence status data from the indoor device or the web application. For example, a green LED may indicate presence, a red LED may indicate absence, and a yellow LED may indicate an unknown or busy status.



A circuit diagram of the proposed system

3.4 SOFTWARE IMPLEMENTATION*

3.4.1 ESP32 Firmware

The firmware for the ESP32 module is developed using the Arduino programming language and the ESP32 core for Arduino. The program structure includes the following main components:

- Setup Function: Initializes the ESP32 module, configures Wi-Fi connectivity, sets up the LCD screen, and registers the necessary callbacks or interrupts for button presses and data reception.
- Loop Function: Handles the main program loop, including checking for button presses, updating the presence status variable, and transmitting the presence data to the external device or the web application.

- Button Press Handling: Implements debouncing and processes button presses to update the presence status variable accordingly.
- Data Communication: Utilizes the Arduino WebSocket Client library to establish communication with the web application and exchange presence data in real-time.

3.4.2 WEB APPLICATION

The web app was built using modern web technologies, such as HTML, CSS, and JavaScript, with a responsive design to ensure compatibility across different devices and screen sizes.

The web app features a user-friendly interface where users can log their presence status. Upon submitting the presence status, the web app communicates with the ESP32 modules using a secure protocol, such as HTTPS or WebSockets, to update the presence status on the indoor and outdoor devices.

The web app development process involved designing the user interface, implementing the necessary functionality, and integrating with the ESP32 modules for seamless communication and data exchange.

3.4.2.1 Front-end Development

The web application's user interface is developed using HTML, CSS, and JavaScript, with the React framework for building the interactive components. The user interface consists of the following components:

- Login Page: Allows the user to authenticate and gain access to the presence status update functionality.
- Presence Status Update Form: Provides a user-friendly interface for the user to update their presence status remotely, without the need for physical buttons.
- Presence Status Display: Visually represents the user's presence status, potentially using icons or color-coding for easy recognition.

3.4.2.2 Back-end Development

The back-end of the web application is developed using Node.js and the Express.js framework. The server-side logic includes the following components:

- User Authentication: Implements secure user authentication mechanisms, such as password hashing and JWT token-based authentication.
- Presence Status Update Handling: Processes the presence status updates received from the client-side application and transmits the updated status to the ESP32 module.
- WebSocket or MQTT Integration: Establishes a real-time communication channel with the ESP32 module using either the WebSocket protocol or the MQTT messaging protocol, facilitating bi-directional data exchange.
- Database Integration (Optional): If required, a database management system (e.g., MongoDB, PostgreSQL) can be integrated to store user information and presence status logs for future reference or analysis.

3.4.2.3 Integration with ESP32 Module

The web application is integrated with the ESP32 module to enable remote presence status updates. This integration is achieved through the following steps:

- WebSocket Client Implementation: The ESP32 firmware includes a WebSocket client library to establish a connection with the web application server.
- Data Exchange Protocol: The web application server and the ESP32 module communicate using a predefined data exchange protocol, which specifies the format and structure of the presence status data.
- Presence Status Update Handling: When the web application receives a presence status update from a user, it transmits the updated status to the ESP32 module, which then updates the LCD screen and LED indicators accordingly.

The methodology employed in developing the interactive real-time office presence indicator display system with mobile app integration involved a combination of hardware and software components.

The ESP32 modules served as the central processing units, interfacing with various peripherals such as LCD screens, buttons, and LEDs. The firmware development for the ESP32 modules handled the processing of user input, presence status updates, and communication between the indoor and outdoor devices.

The web app development process focused on creating a user-friendly interface for remote presence logging and ensuring seamless integration with the ESP32 modules. Extensive testing was conducted to validate the system's functionality and performance, addressing any issues or challenges encountered during the integration phase.

This methodology aimed to create a robust and reliable system that meets the desired requirements, allowing office users to conveniently indicate their presence status through physical buttons or remotely via a web app.

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