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Wireless Bus Identification System for Visually Impaired Person

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ABSTRACT: The technology developed in the United States called ‘The Wireless Bus Identification System for Visually Impaired Persons’ assists a disabled individual in identifying the appropriate bus, boarding it with ease and without any help or assistance. The system consists of two components: one is placed on the bus and the other used by the disabled person. The Bus Unit includes Signal Switch, Node MCU ESP8266, and RF Transmitter. After their completion of bus check procedures, the driver uses the signal switch. As soon as it is pressed, input is processed by Node MCU. It also controls an RF Transmitter which has the capability of sending signals uniquely identifying the Buses. Therefore, its name or code will be sent via wireless connection. Transmitting signals can only be done when the bus is opened for entrance and boarding. The Blind Unit is built with a Raspberry Pi Pico W, RF Receiver, GPS Module, Buzzer, an Emergency Switch, and Audio Output. The RF Receiver searches for signals at all times. When in range, the signal is processed by the Raspberry Pi Pico W. If the signal corresponds with the desired ID of the bus, the system is notified using audio feedback. Users in dire situations have the choice to press the Emergency Switch which activates the buzzer, sends the user’s GPS location in real time to an IoT monitoring application, and empowers caregivers or authorities to act swiftly.

KEYWORDS: Raspberry pi pico, Node MCU, GPS Module, Blind Unit, Unique Bus Identification Code, Bus Unit, RF Receiver, Emergency switch.

I. INTRODUCTION

Public transport represents the backbone of urban existence, facilitating people to travel efficiently and affordably. For the visually impaired users, however, accessing public transport systems poses a massive problem. Everyday activities such as boarding a bus become cumbersome and in some cases hazardous due to a lack of ability to read bus destinations or numbers. Visually impaired users rely on the goodwill of passersby or drivers to inform them of the right bus, hence compromising their autonomy and prolonging the journey. For the instance of major cities where buses from various directions come at the same time, confusion increases and the possibility of boarding the wrong bus or missing the one in question becomes high. With the introduction of accessible technologies such as sound signals and tactile pavement at pedestrian crossing points, there has been a lack in efficient and real-time systems to guide the visually impaired to identify buses correctly. Realizing the need for a smart, affordable, and efficient solution, there arises a Wireless Bus Identification System for Visually Impaired Persons. This system will promote independence, accessibility, and security through the provision of direct and real-time information of incoming buses to the users through a wireless communication system.

The system we have proposed breaks down to two major components, the Bus Unit and the Blind Unit. The Bus Unit is housed in the bus and includes the Signal Switch, a Node MCU ESP8266 microcontroller, and the RF Transmitter. When the bus approaches a stop and is ready to pick up passengers, the driver presses the signal switch. This then directs the Node MCU to activate the RF Transmitter to broadcast a unique bus identification code. The code assigned to each bus makes the signal particular and identifiable to the Blind Unit. By only activating the signal when the bus has stopped and accepts passengers to be boarded, the system prevents duplicate RF transmissions that could otherwise overwhelm users. Sending out a unique identifier also enables the visually impaired users to tell apart many buses that

will arrive at the same stop at the same time. Such controlled, real-time communication enhances the clarity and reliability, where users could be more secure and assured in navigating without assistance.

The Blind Unit, to be worn by the visually impaired user, comprises a Raspberry Pi Pico W microcontroller and includes RF Receiver, GPS module, audio output (speaker or headphone jack), buzzer, and emergency switch. The RF Receiver continuously scans the environment for RF signals transmitted by surrounding Bus Units. On reaching a signal, the data from the signal is processed by the Raspberry Pi Pico W to verify whether the bus ID matches the user's pre-programmed preferred bus ID. If it finds a match, the system immediately provides the user with audio feedback in the form of the arrival of his/her bus. This sort of feedback advantageously avoids all visual identification. The audio feedback may be a voice prompt or pattern of beeps that the user recognizes as the recognition signal. This enables the users to travel confidently in the right bus without the need to ask others, promoting autonomy and dignity in the travel routine.

Apart from improved safety, especially in the event of emergencies, the Blind Unit also has an Emergency Switch. If the user feels in danger, confused, or in need of some urgent help, pressing the switch allows the GPS module to be enabled. The device will then capture the user's current location coordinates and send them over Wi-Fi to an IoT-based software for monitoring. The data may then be monitored by the caregiver, family member, or emergency service, and instant action can be taken. The incorporation of RF-based bus location and GPS-based emergency alert makes the system very practical for daily use and in urgent situations too. It connects assistive technology and real-time communication to offer a complete solution to mobility and safety.

This project not only addresses a specific accessibility need but also meets global developmental needs. More than 285 million individuals worldwide have some degree of visually impaired status, and most of them live in urban cities. Mobility in an easy and accessible manner is necessary to the empowerment of such citizens in terms of improvement in the overall standard of living and allowing them to participate in social, educational, and business processes to the fullest. The Wireless Bus Identification System directly serves the United Nations Sustainable Development Goal 11 to make the world's cities inclusive, safe, resilient, and sustainable. By allowing inclusive transport, the system helps create a more equitable world where every individual can travel easily and securely.

Technically, the choice of components makes the system viable and economical for mass deployment. The NodeMCU ESP8266 microcontroller is a Wi-Fi-enabled and economical microcontroller best suited for wireless data transfer. RF communication between the blind unit and the bus is simple and energy-efficient according to the short-distance communication at bus stops. The Raspberry Pi Pico W is selected due to its versatility, processing capability, and in-built wireless connectivity, allowing it to achieve tasks like signal processing and emergency location sharing. Additionally, the addition of the GPS and the IoT platform provides value to the system without affecting the system cost to any great degree, allowing it to be scaled to deploy in real-world applications.

Overall, the Wireless Bus Identification System for Visually Impaired Persons is affordable, user-friendly, and impactful in closing the pressing gap in public transport accessibility. The system empowers the visually impaired by providing them with a functional way to identify and get on the correct bus without the need for help while also ensuring their safety in the form of emergency location tracking. The system brings hardware and software together in a critical sense, using RF communication, GPS tracking, and the internet of things technologies to provide a stable and reliable experience. With cities competing to achieve a more efficient and inclusive urban space, the project marks a significant move in the direction of inclusive transport for all.

II. LITERATURE SURVEY

A number of innovative systems have been proposed over the years to support the public transport experience of visually impaired users with the incorporation of novel technologies like ZigBee, RFID, wireless sensor networks, GPS, and microcontrollers. A complete ZigBee-based bus guidance system was proposed in [1] to enhance the accessibility and convenience of blind and differently-abled users. The system comprises two primary subsystems: one to be carried by the blind user and the other to be placed on the bus. The user module assists in the identification of approaching buses and the route details to the blind users through voice announcements via a speaker. This enables the user to decide whether the incoming bus is the correct one or not. The module also has a confirmation button to tell the user's intention to take the particular bus, and it sends a message to the driver. This confirmation on the LCD screen

comes along with a voice alert within the bus to make the driver aware of the user's arrival and destination requirements. Another feature of the module includes a vibrator to the user module, activating it when a bus approaches, providing useful assistance to deaf and dumb users with tactile feedback. This provides multimodal interaction between the blind person and the bus system, increasing the safety and independence of the user.

In [2], another approach was presented, using RFID technology along with wireless communication to automate the transport process for blind individuals. The system consists of two major devices: a user module and a bus module. The modules exchange real-time information through a wireless network. One of the standout features of the system is the use of GPS to navigate users to the bus stop using audio directions, making it easier for them to navigate without assistance in outdoor areas. Additionally, the system provides the service of booking the bus service in advance and digital payment of the fare, lowering reliance on external assistance and manual transactions. This model successfully integrates the navigation, identification, and processing of transactions to provide a complete solution for blind commuters.

The research in [3] also employs ZigBee technology but with a different twist to tackle the issues of the visually impaired passengers. In this case, when the blind user reaches a bus stop and switches on his/her module, the system broadcasts a signal with the data relevant to the bus the user wishes to board. If there is a bus in the vicinity with a matching module, it detects the data and the system automatically initiates a feedback mechanism where the user receives the alert through a voice message via a playback module. Meanwhile, a buzzer is also enabled to show successful identification and recognition, increasing the user's confidence and lowering the anxiety of solo travel. This user-interactive communication between the user and the bus makes the system not just reactive but also efficient and secure.

In [4], there was the introduction of an ultrasonic sensor-based bus identification system that also divides the system into a bus driver module and a passenger module. When the user approaches the bus stop and turns on the device, the ultrasonic sensor becomes active in the detection of buses nearby. When the buses are detected, a signal is passed to the Arduino controller in the user module, and it activates a buzzer that indicates to the blind individual that the bus is near. To verify his/her presence and intention to get in, the user presses a switch that sends a signal to the bus driver module. This verifies that the driver knows that the visually impaired person has arrived at the stop and hence will have a smooth boarding process. Such a real-time communication assists in the coordination of the bus and the passenger while using affordable and reliable sensor technology.

In reference [5], a more sophisticated system merging RFID and wireless sensor network technologies was presented, designed to further enhance the public transport experience of visually impaired individuals (VIPs). The article highlighted the development of a mechatronic system with hardware and software components to support VIPs in real time. The user module of the system is programmed to deliver details of the nearby transit stop, bus estimated arrival times, and other schedule-related information. Such features are provided through an audio device and a tactile user interface, with the system being accessible for blind and partially deaf individuals. Data communication between the transmitter (user module) and the receiver (bus module) takes place over Wi-Fi to speed data exchange and enhance scalability in urban settings. The tactile interface provides the benefit of a different type of sensory input that comes in handy in crowded environments where audio cues may not be as useful.

Together, these systems represent a step forward in the ability of technology to close the gap between public infrastructure and accessibility for the visually impaired. Each system individually tackles different parts of the visually impaired traveler's commute—to the bus stop and to the identification of the right bus, to boarding and verification of the trip. Although [1] and [3] rely strongly on ZigBee-based signaling between devices, [2] and [5] utilize GPS and RFID to provide wider and more dynamic identification and navigation abilities. [4] highlights the simplicity and lower costs of ultrasonic sensors in determining bus arrival time and thus suits its deployment in rural or cost-limited areas. A commonality among all the systems includes the use of voice-based feedback for real-time human-system interaction, tactile or vibratory elements in silent alerting, and modular architectures to enable the system to be scaled and modified to fit into various environments. In conclusion, the research indicates a distinct trend towards the creation of assistive technologies that enable the visually impaired to navigate independently, confidently, and securely. Such systems not only address genuine challenges to accessibility in the real world but also open the door to more accessible public transport networks. By combining hardware like microcontrollers, sensors, and communicative outputs with software components like GPS routing and wireless networking, researchers have exemplified a sound and empathetic approach

to inclusive engineering. The selected studies create a sound basis for continued innovation and identify areas for improvement like miniaturization of systems, energy efficiency, multi-language support, and compatibility with smart city systems to achieve larger-scale effects.

III. METHODOLOGY

The new proposed system is an assistive device that will autonomously direct blind passengers to find and catch the correct bus using a low-cost and efficient wireless communication system. The proposed system has two components, which are the Bus Unit and the Blind Unit. The Bus Unit is mounted on public buses and contains a Signal Switch, NodeMCU ESP8266 microcontroller, and an RF Transmitter.

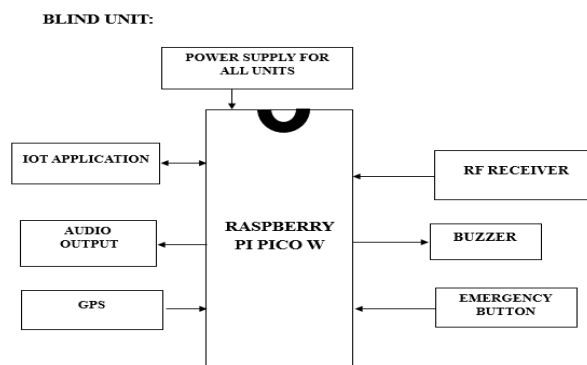
When the bus is approaching a stop and waiting for passengers, the signal switch is turned on by the driver, which activates the NodeMCU to prompt the RF Transmitter to transmit a unique bus identification code. This way, the proper NodeMCU signal is transmitted only when required and thus prevents unnecessary signals and becomes more convenient for passengers to use at crowded stops. On the other hand, the Blind Unit that is being carried by the visually impaired user has a Raspberry Pi Pico W microcontroller, RF Receiver, GPS module, buzzer, an audio output element (i.e., speaker or earphones), and an emergency switch.

RF Receiver continues to await the signals received, and on receiving a bus ID, microcontroller cross checks that it is the same as saved desired bus ID from the user side. If they match, the system immediately informs the user by a sound signal so that they may go ahead with certainty to and catch the correct bus without relying on other people for directions.

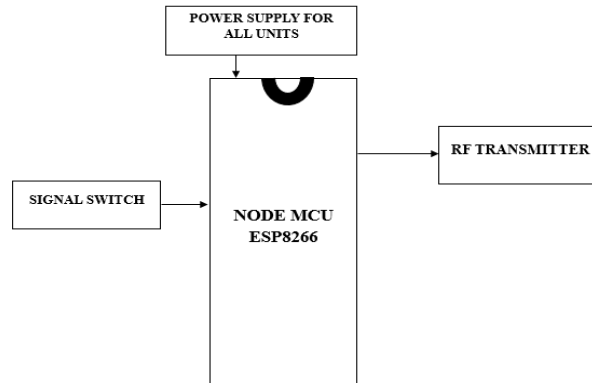
Apart from bus identification, the system also has a safety feature: in the event of an emergency, the user is able to use the emergency switch, where the GPS module captures the present location and transfers it over Wi-Fi to an IoT-based monitoring platform that is able to call caregivers or emergency services. The two-in-one solution not only provides increased mobility but also safety for the individual. Unlike the internet-based smartphone app that needs internet connectivity as well as touchscreen functionality, that is a low-priced, easily procurable stand-alone solution with the visual impaired individual's special needs at heart. Application of RF communication to facilitate real-time, proximity-based communication and integration with GPS for use in the event of an emergency adds to an effective and inclusive solution towards accessible public transport.

This system is economical using the equipment available and basic technology. It is not smartphone, app, or internet-based but standalone. Data transfer is made to be fast and reliable by RF communications. An audio feedback system is provided to provide instant commands and basic, easy-to-follow instructions to the user. Also incorporated is a GPS module to enable emergency alerts, wherein the user's location can be relayed to a remote monitoring terminal in the eventuality of a need.

BLOCK DIAGRAM



BUS UNIT:



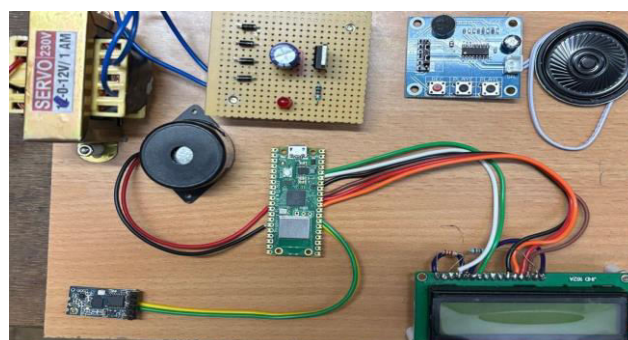
IV. EXPERIMENTAL RESULTS

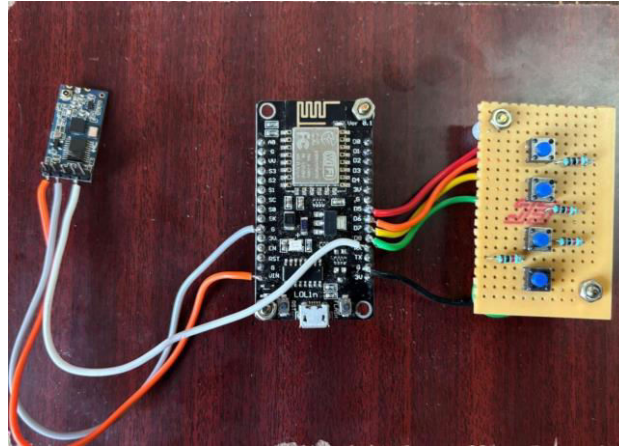
In order to simulate normal public transportation scenarios, the visually impaired bus identification system was tested in controlled and semi-realistic environments. Within 20 to 30 meters, the Blind Unit [fig2] was able to receive the pre-programmed bus ID that the RF Transmitter had successfully transmitted. Only when the bus ID matched the one stored on the user's device did the Raspberry Pi Pico W in the Blind Unit process the signal and start the audio output. When using traditional audible announcements or app-based tracking systems, visually impaired passengers faced significant confusion when multiple buses arrived at the same stop. This identification helped to clear uncertainty.

Since RF communication offered a wireless short-range data transmission system with low-power and latency-efficient capability, it was a reasonable substitute for other technologies including Bluetooth or Wi-Fi. Its simplicity helped to streamline deployment and maintenance, removing the need for sophisticated software or ongoing user intervention. The built-in emergency alert feature of the GPS module noted and sent the users' exact location coordinates to a cloud-based monitoring station when the emergency switch was pressed, so safeguarding them should an emergency arise.

From the user's perspective, the audio alert system was unambiguous, instantaneous, and simple, that is, without technical knowledge or past training. Reading the buses made the users more self-assured and independent, free from depending on people walking by or employees working in transit. Some negatives were observed, such as sporadic delays or signal collisions in areas with strong RF interference or where several buses emit signals simultaneously without a clear transmission protocol.

The audio alert system was clear, immediate, and easy to use from the perspective of the user; no technical knowledge or prior training was required. When reading the buses, the users felt less reliant on bystanders or transit employees and more independent and confident. Some disadvantages were identified, such as sporadic delays or signal collisions in areas with high levels of radio frequency interference or when multiple buses simultaneously emit signals without using a separate transmission protocol.





V. CONCLUSION

The Wireless Bus Identification System for Visually Impaired People is a technology that facilitates accessibility, mobility, and safety for the visually impaired people in public transportation systems. It applies low technologies such as RF communication, microcontrollers, GPS modules, and audio feedback to give real-time bus identification so that users can board independently in crowded or noisy surroundings without confusion.

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