



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 5, May 2025

IoT-Driven Real-Time Seat Availability System for Inclusive Urban Mobility

Dr.I.Kathir*, Brindha G**, Thrisha P**, Divyadharshini S**, Prathisha S**

Professor, Department of Electrical and Electronics Engineering, VSB Engineering College, Karur, Tamil Nadu, India*

U.G. Student, Department of Electrical and Electronics Engineering, VSB Engineering College, Karur,
Tamil Nadu, India**

ABSTARCT: People with disabilities often face challenges while using public transport, especially when it comes to find and access the seats that are reserved for them. Many times, these seats are already occupied or misused, and there's no way for the passenger to know this in advance. To solve this real world problem, we've developed a smart system that helps monitor and show the availability of reserved seats in real-time. The system is built around an ESP32 microcontroller and uses load cell sensors under each reserved seat to detect if it's taken or free. This information is then sent to a cloud platform (Firebase) using Wi-Fi or GSM and shown on a screen inside the bus or on a mobile app. The idea is to make bus travel more inclusive by giving differently-abled passengers the confidence and clarity to travel without worry. The proposed system presented in this paper not only improves accessibility but also encourages fair use of reserved spaces and supports independent commuting.

I. INTRODUCTION

For most people, catching a bus is just another part of daily life. But for differently-abled individuals, using public transport often comes with unexpected difficulties. One of the biggest issues is that they do not know whether the seats specially reserved for them are actually available. In many cases, these seats are either occupied by general passengers or not easily accessible, which creates discomfort and inconvenience for the people who need them the most [1]. Despite efforts by transport authorities to make public systems more inclusive, there's still a lack of real-time information that can truly assist differently-abled commuters during their journey [2]. Even though reserved seating policies exist, without a system to monitor and enforce them, they don't always serve their purpose [3]. The objective of this proposed system is to design and develop a smart, real-time seat monitoring solution that ensures fairness and accessibility on public buses. Our idea is simple but effective: install sensors beneath the reserved seats that can detect whether someone is sitting there or not. These sensors are connected to an ESP32 microcontroller, which collects the data and sends it to a cloud-based database like Firebase using Wi-Fi or GSM [4]. This information is then displayed on a screen inside the bus and can also be accessed via a mobile app. This way, differently-abled passengers can immediately know which seats are free and where to go without having to rely on others or guesswork [5].

Additionally, an alert system notifies the bus driver when all reserved seats are taken, so that they can take appropriate steps to assist the passenger. It's a small technological step, but it can make a big difference in someone's travel experience [6]. The proposed work doesn't just aim to build a system it aims to give people more confidence, comfort, and independence while using public transport [7].

II. LITERATURE SURVEY

Sharma emphasizes the importance of inclusive smart mobility systems, focusing on public transport accessibility for differently-abled individuals [1]. Tan et al present a real-time monitoring system for bus seat occupancy using IoT-enabled sensors, enhancing travel experiences through accurate seat availability updates [2]. Nair and Thomas explore wireless sensor networks in public transportation, highlighting the significance of real-time communication and data reliability [3]. Singh and Jadhav propose an IoT-driven seat monitoring solution with embedded systems and cloud integration, offering a foundational framework for smart seat systems [4].

Zhang and Wang address power continuity through battery backup systems in autonomous IoT applications for transport, which is critical for system reliability [5]. Quadros et al design a smart seat for differently-abled passengers, showcasing ergonomic considerations and sensor-based integration for safety and comfort [6]. Mohammed and

Alkurawy contribute a model featuring automation and emergency controls, supporting accessible infrastructure in transit systems [7]. Rajalakshmi et al implement a real-time IoT-based seat tracking system, providing insights into data flow and system architecture for public buses [8]. The Ministry of Social Justice and Empowerment offers essential national guidelines under the Accessible India Campaign, reinforcing the ethical and policy-aligned basis for the proposed system's inclusivity and usability for all passengers [9].

III. DESIGN CONSIDERATION

Designing a smart seat availability system for differently-abled passengers involves careful integration of electrical hardware, mechanical structure, and data communication. The system must be lightweight, durable, and capable of functioning reliably in a mobile environment such as a public transport bus. The objective is to enable accurate, real-time monitoring of reserved seats without interfering with passenger comfort or bus operations.

1. Electrical Design

The electrical subsystem is responsible for collecting data from the seats and transmitting it to a central system. Each seat is equipped with a load cell sensor, which detects pressure changes when someone sits down. These sensors are highly sensitive and offer the necessary accuracy for this application [1]. Since load cells generate low voltage analog signals, an HX711 amplifier is used to amplify and convert these signals into digital form, which can then be processed by the microcontroller. The ESP32 microcontroller is the central processing unit that reads the digitized values and determines whether a seat is occupied or available. ESP32 also supports both Wi-Fi and Bluetooth connectivity, making it ideal for IoT-based applications where real-time data transfer is needed [2]. Power is managed using an LM2596 buck converter, which steps down the 12V supply from the bus to 5V or 3.3V for the sensors and controller. This ensures stable operation without damaging the components. In areas without reliable Wi-Fi, a SIM800L GSM module provides cellular internet connectivity to maintain cloud synchronization [3]. To alert the driver when all reserved seats are full, a DF Player Mini audio module is included. This module plays a pre-recorded voice alert through a connected speaker, providing a simple and effective way to communicate seat status to the driver [8].

2. Mechanical Integration

From a mechanical perspective, the goal is to ensure that sensors can be installed on standard bus seats with minimal modification. The load cells are mounted below the seat cushions so they remain hidden and protected from wear and tear. Care is taken to position the sensors in areas where they can detect body weight reliably without triggering false readings due to vibrations or bus motion [9]. The installation also accounts for environmental challenges such as humidity, dust, and temperature changes. By encasing the components securely and using heat resistant materials, the system is made robust enough for everyday transport use.

3. Control & Communication Design

Data collected from the sensors is processed by the ESP32 and uploaded to a Firebase real-time database. This database stores the current status of each reserved seat, which is displayed via an onboard LED display and a user friendly mobile application. The LED display is placed at the entrance of the bus so that passengers can instantly see whether any reserved seats are available. This helps differently-abled individuals make quick decisions without having to navigate through the entire bus [10]. The control logic also includes an automated audio alert. If all reserved seats are occupied, the system triggers the DF Player Mini to play a voice notification for the driver. This ensures that the driver is aware of the situation and can take appropriate action, such as assisting the passenger or informing them about the next bus stop with availability [11].

IV. METHODOLOGY

The methodology for developing the Smart Bus Seat Availability System involves several key steps, each designed to ensure that the system is reliable, efficient, and accessible for differently-abled passengers. The functional units of the proposed system are:

1. Signal Conditioning Unit

The output from each load cell is in the form of an analog signal, which is not directly usable by the microcontroller. To convert this signal into a digital form that can be processed by the ESP32, the signal passes through

an HX711 amplifier. This module amplifies the small signals from the load cells and converts them into a digital format. The ESP32 then reads the digitized data to classify whether a seat is occupied or available [6].

2. Data Processing Unit

Once the digital signals are received, the ESP32 microcontroller processes the data. It uses a pre-set threshold value to determine whether a seat is occupied or not based on the amount of pressure detected by the load cell. If the pressure exceeds the threshold, the system classifies the seat as "Occupied." If the pressure is below the threshold, it is considered "Available." This real-time data processing is critical for ensuring that passengers receive up-to-date seat availability information [7].

3. Data Communication Module

The processed seat status data is then sent to a Firebase real-time database. The ESP32 uses either Wi-Fi or GSM for data transmission, depending on the available network. Wi-Fi is typically used for urban areas with stable internet coverage, while the GSM module ensures connectivity in areas with limited or no Wi-Fi access. The cloud database updates seat availability in real-time, enabling passengers and bus operators to access the most current information [8].

4. User Interface Module

The seat availability information is displayed for passengers in two ways: an LED display at the bus entrance and an optional mobile app. The LED display shows a simple, easy-to-understand status of available and occupied seats. The mobile app provides a more detailed, real-time seat map, offering enhanced visibility and allowing differently-abled passengers to easily check for available seats before boarding [9]. This dual approach ensures accessibility for both on-site and remote users.

5. Driver Notification Module

To help the bus driver maintain an organized seating plan, the system includes an audio alert system. If all the reserved seats are occupied, the ESP32 triggers the DFPlayer Mini audio module, which plays a pre-recorded voice alert notifying the driver. This ensures that the driver is always aware of the seat status, making it easier for them to manage seating arrangements for differently-abled passengers [10].

V. ALGORITHM

Step 1: Start the system.

Step 2: Initialize the ESP32 microcontroller and set-up the Wi-Fi/GSM module for cloud connectivity.

Step 3: Activate the load cell sensors beneath each bus seat to detect weight.

Step 4: Continuously monitor the data from each load cell sensor.

Step 5: If the seat is occupied (weight detected above the threshold), mark it as Occupied.

Step 6: If the seat is not occupied (weight below the threshold), mark it as Available.

Step 7: Send the seat status (Occupied/Available) to the Firebase cloud via Wi-Fi/GSM.

Step 8: Update the LED display at the bus entrance with the seat availability status.

Step 9: If all reserved seats for differently-abled passengers are occupied, trigger an audio alert to notify the bus driver.

Step 10: Continue monitoring the seat status and update the data every few seconds.

Step 11: Stop the system.

FLOW CHART

Figure 1 shows the flowchart of the Smart Seat Availability System, outlining the process of seat occupancy detection, data processing, and real-time seat status updates for passengers.

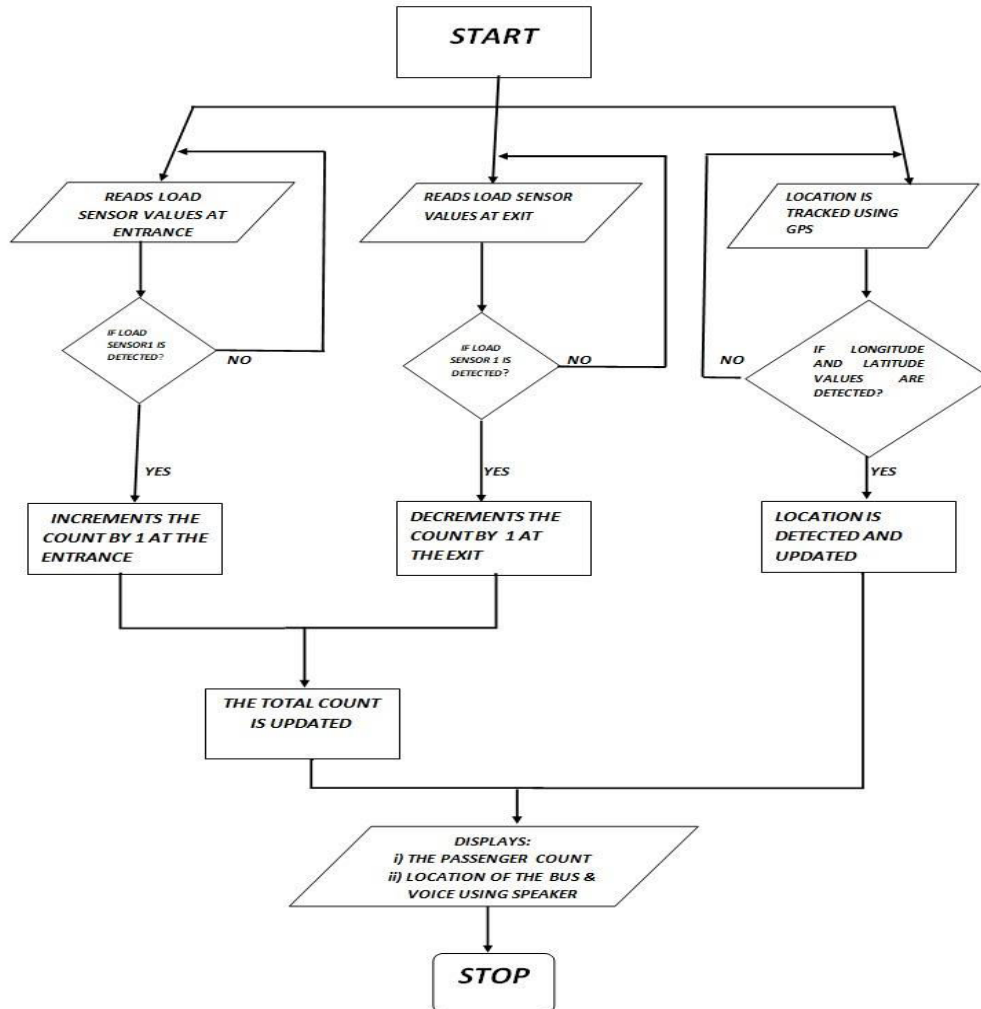


Fig.1: Flowchart for Real-Time Seat Availability System

BLOCK DIAGRAM

Figure 2 illustrates the block diagram of the Smart Seat Availability System, incorporating an ESP32 microcontroller, load cells, GSM module, LED display, DFPlayer Mini, and a battery backup for efficient seat monitoring.

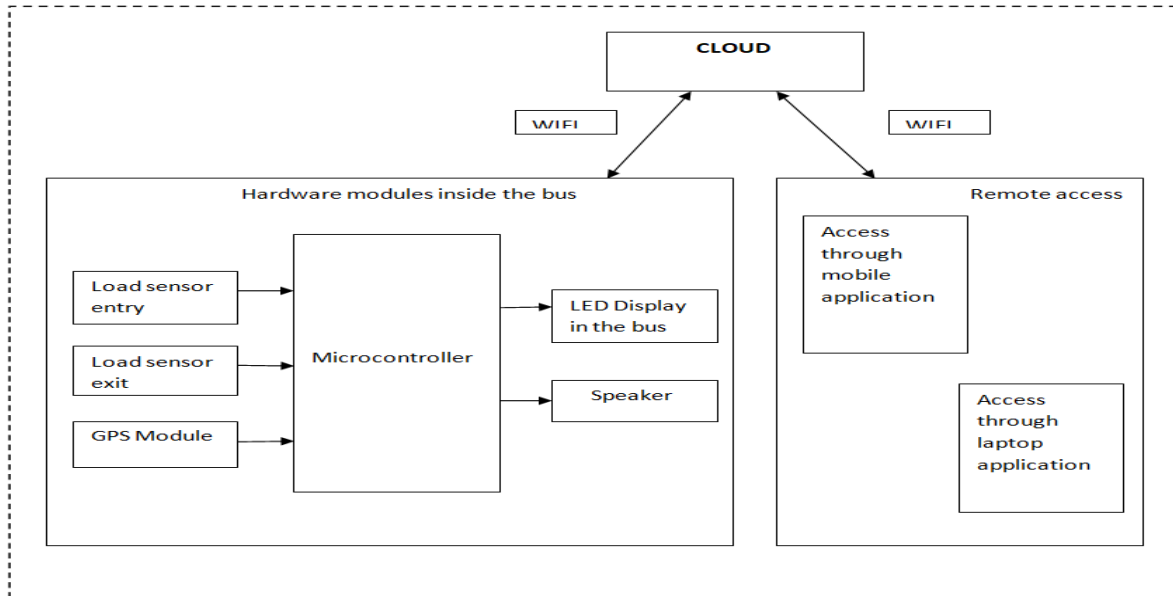


Fig.2: Block diagram for -Time Seat Availability System

VI. HARDWARE COMPONENTS

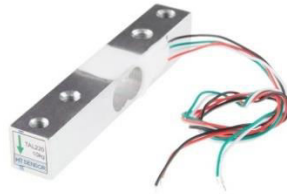
The following hardware components are essential for the development of the Smart Bus Seat Availability System. Each component plays a crucial role in ensuring accurate seat occupancy detection, communication, and overall system functionality.

ESP32/NodeMCU



Fig.3: ESP32

The ESP32 microcontroller serves as the brain of the Smart Bus Seat Availability System. With built-in Wi-Fi and Bluetooth capabilities, it enables seamless communication with cloud databases and mobile applications. The ESP32 receives signals from the load cells (via the HX711 amplifier) to determine whether a seat is occupied or vacant. It then sends this data to the Firebase cloud database in real-time, which is subsequently displayed on the LED screen on the bus or via a mobile app. This microcontroller is highly energy-efficient and supports various IoT applications, making it ideal for this real-time system [11].

Volume 14, Issue 5, May 2025**|DOI: 10.15680/IJIRSET.2025.1405202|****Load Cell + HX711****Fig.4: Load cell**

A load cell is a pressure sensor used to detect if a passenger is seated. It converts weight into an electrical signal, which is then amplified by the HX711 module. The ESP32 processes this signal to determine seat occupancy in real-time. This setup ensures accurate detection with minimal wiring. Load cells used in such systems typically support a weight range of 0 to 200 kg, ideal for identifying seated passengers. The HX711 boosts the signal for clear data processing by the microcontroller [12].

GSM Module (SIM800L)

The GSM Module helps the system stay connected when Wi-Fi is weak or unavailable. It allows the ESP32 to send data to Firebase using mobile networks. This makes the system more dependable, especially for buses traveling through remote or low-connectivity areas. [3]

LED Display (I2C)

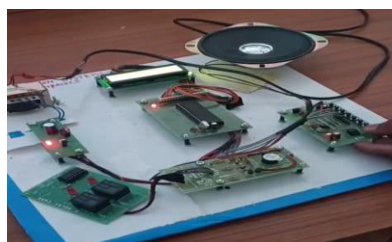
The LED display at the bus entrance shows real-time seat availability for differently-abled passengers. It receives data from the ESP32 via I2C, ensuring quick updates and clear visibility. This helps passengers know the seat status before boarding, improving accessibility and convenience [13].

Speaker (DFPlayer Mini)

The DFPlayer Mini module provides audio alerts to the bus driver when all reserved seats for differently-abled passengers are occupied. It ensures the driver is promptly informed, helping maintain organized and accessible seating arrangements [14].

VII. WORKING

The system works by placing load cell sensors beneath each reserved seat on the bus to detect whether the seat is occupied or free. These sensors send data to the ESP32 microcontroller, which acts as the central unit for processing the input. Based on the sensor readings, the ESP32 determines the seat status and sends this information in real-time to a cloud database like Firebase using either Wi-Fi or GSM, depending on the available network. The live seat availability is shown on a display inside the bus so that passengers can easily see which reserved seats are available. To make it even more accessible, especially for visually impaired passengers, a speaker announces how many reserved seats are currently free. Additionally, a digital display is also placed outside the bus near the entrance, so differently-abled individuals can know the seat status before boarding. This real-time monitoring setup helps ensure that reserved seats are used fairly and gives confidence to those who rely on them for a more comfortable and independent journey.

**Fig.5: IoT-Driven Real-Time Seat Availability System**

VIII. CONCLUSION

The Smart Bus Seat Availability System for Disability is a step forward in making public transportation more inclusive, accessible, and user-friendly for differently-abled individuals. By combining real-time seat monitoring with audio announcements and visible displays both inside and outside the bus, the system ensures that passengers can travel with greater confidence and independence. It not only helps prevent the misuse of reserved seating but also supports a fair and respectful environment for everyone. Through simple yet effective technology, this solution addresses a real-world problem and promotes equal access to mobility something that is essential in building a truly inclusive society.

REFERENCES

1. Tan W, et al "Real-Time Monitoring Systems for Public Transport: A Case Study of Bus Seat Occupancy," Journal of Transportation Engineering and Technology, vol. 9, no. 2, pp. 112–118, 2021.
2. Sharma V, "Designing Inclusive Smart Mobility Systems: Public Transport Accessibility for All," Urban Mobility Journal, vol. 5, no. 1, pp. 33–38, 2020.
3. I.Kathir, Thrisha P, Brindha G, Divyadharshini S, Prathisha S, "Design and Implementation of Automatic Fire Extinguisher," in Proceedings of the 5th International Conference on Innovation in Electrical, Information and Communication Engineering (ICIEICE'25), 28, March, 2025.
4. Nair A & Thomas J, "Wireless Sensor Networks in Public Transportation for Real-Time Monitoring," IEEE Access, vol. 8, pp. 106522–106530, 2020.
5. Singh R & Jadhav P, "Smart Public Transportation using IoT for Seat Monitoring," International Research Journal of Engineering and Technology (IRJET), vol. 7, no. 10, pp. 1089–1092, Oct. 2020.
6. Zhang Y & Wang X, "Battery Backup Systems for Autonomous IoT Applications in Public Transport," Energy Technology, vol. 8, no. 6, pp. 950–957, 2022.
7. Quadros J, Pereira S, Noronha S, & Prasad S, "Smart Seat for Differently Abled," Journal of Emerging Technologies and Innovative Research (JETIR), vol. 6, no. 6, pp. 746–749, June 2019.
8. Mohammed K G, & Alkurawy L, "Design and Implementation of a Smart Seat for Handicap People," ARPN Journal of Engineering and Applied Sciences, vol. 14, no. 9, pp. 1741–1746, May 2019.
9. Rajalakshmi P, Gopalakrishnan V, & Abinaya M, "IoT Based Real-Time Public Transport Seat Tracking System," International Journal of Scientific Research and Engineering Trends (IJSRET), vol. 7, no. 3, pp. 201–205, 2021.
10. Sharma V, "Designing Inclusive Smart Mobility Systems: Public Transport Accessibility for All," Urban Mobility Journal, vol. 5, no. 1, pp. 33–38, 2020.
11. Nair A, & Thomas J, "Wireless Sensor Networks in Public Transportation for Real-Time Monitoring," IEEE Access, vol. 8, pp. 106522–106530, 2020.
12. Ministry of Social Justice and Empowerment, Government of India. "Accessible India Campaign (Sugamya Bharat Abhiyan): Guidelines and Implementation," 2016.
13. Rashvand N, Hosseini S S, Azarbayjani M, & Tabkhi H, "Real-Time Bus Departure Prediction Using Neural Networks for Smart IoT Public Bus Transit," IoT, vol. 5, no. 4, pp. 29–45, 2025.
14. Patra S S, & Vanajakshi L, "Application of Low-Cost IoT Sensors for Smart Public Transportation," Transportation in Developing Economies, vol. 10, no. 2, article no. 25, 2024.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details