Wireless Voting System

Adrián Hložný, Michal Hodoň, Lukáš Formanek

***Abstract*—** This paper presents the development and implementation of a wireless voting system utilizing ESP32 technology. The system comprises a voting device powered by a Li-Pol battery and a collector device connected via the ESP-NOW protocol. The voting device processes user inputs for multiple-choice questions and transmits responses wirelessly to the collector device. Collected data is visualized as a bar graph on a web page managed by the collector device. The system aims to provide an efficient, cost-effective, and environmentally friendly alternative to traditional voting methods. Results from prototype testing demonstrate the system's functionality and highlight its potential applications in educational and organizational settings.

***Keywords*—** ESP32, ESP-NOW, Li-Pol battery, micro-USB, web page.

I. INTRODUCTION

Voting systems play a critical role in decision-making processes across various domains, including legislative assemblies, corporate environments, educational institutions, and public referendums. Traditional voting methods, such as paper-based ballots or manual tallying, are often inefficient, prone to errors, and environmentally unsustainable due to significant resource consumption. As the demand for more efficient and reliable systems grows, technological advancements in electronics and wireless communication offer promising solutions to modernize these processes [1], [2].The integration of Internet of Things (IoT) technologies into voting systems has the potential to address many of the limitations of traditional approaches. IoT-enabled voting systems can provide real-time communication, secure data processing, and enhanced user convenience. Among the various IoT platforms available, the ESP32 microcontroller has emerged as a cost-effective and versatile solution for wireless applications [3], [4]. Its ability to support multiple communication protocols, such as WiFi and ESP-NOW, makes it particularly suitable for building scalable and efficient systems [5]. This paper focuses on the development of a wireless voting system utilizing ESP32 technology and the ESP-NOW protocol. ESP-NOW, a proprietary communication protocol by Espressif Systems, enables low-latency and reliable peer-to-peer data transmission without requiring an active WiFi network. This feature allows the system to operate independently of external network infrastructure, increasing its flexibility and reducing setup complexity [6] [7]. The system's primary components include a voting device that captures user inputs and a collector device that aggregates and visualizes the results. The design emphasizes ease of use, low power consumption, and environmental sustainability, making it suitable for a wide range of applications. In addition to addressing operational inefficiencies, this study aims to explore the feasibility of implementing a compact, portable, and user-friendly voting system for educational and organizational settings. Such systems could enhance participation rates, streamline decision-making processes, and provide real-time feedback to users. By leveraging modern microcontroller technologies and efficient communication protocols, the proposed system seeks to deliver a reliable and scalable solution that aligns with the needs of contemporary users. This paper outlines the methodology for designing the system, discusses the results of performance evaluations, and highlights its potential applications and limitations. The proposed solution contributes to the growing body of research on IoT-enabled voting systems and their role in improving organizational and institutional decision-making.

Adrián Hložný, University of Zilina, Zilina, Slovakia (e-mail: hlozny3@stud.uniza.sk)
Michal Hodoň, University of Zilina, Zilina, Slovakia (e-mail: michal.hodon@fri.uniza.sk)
Lukáš Formanek, University of Zilina, Zilina, Slovakia (e-mail: lukas.formanek@fri.uniza.sk)

II. Integration

The methodology for the wireless voting system encompassed a comprehensive approach to integrating hardware, software, and communication protocols to create a robust, scalable, and user-friendly solution. The system comprises two primary components: voting devices and a collector device. Each voting device is designed to capture user input through tactile buttons that represent multiple-choice options and is powered by a rechargeable Li-Pol battery to ensure portability and independence from external power sources. The core of the voting device is the ESP32-WROOM-32D microcontroller, selected for its dual-core processing capability, low power consumption, and compatibility with the ESP-NOW protocol. This protocol allows for direct, low-latency wireless communication between devices without relying on an external WiFi network, simplifying deployment and enhancing reliability. The voting device encodes user inputs into compact data packets that include the device's unique identifier, the selected option, and a timestamp. These packets are then transmitted to the collector device using the ESP-NOW protocol. The collector device, also built around the ESP32 microcontroller, acts as the central processing unit of the system. It aggregates the data received from multiple voting devices and organizes it into an in-memory data structure that tracks the number of votes for each option. The collector device is configured to function as a web server, leveraging MicroPython's lightweight uHTTP library to host a dynamic and interactive user interface. This interface, developed using HTML, CSS, and JavaScript, provides real-time visualization of voting results in the form of bar graphs. The system's web interface is optimized for accessibility and responsive design, ensuring compatibility with various devices such as smartphones, tablets, and desktops. AJAX requests enable seamless updates to the displayed data without requiring manual page refreshes, further enhancing the user experience.

The hardware design incorporated several additional components to ensure stable and efficient operation. A TP4056 charging module manages the safe recharging of the Li-Pol battery, while an LM2596 DC-DC step-down converter regulates voltage to provide consistent power to the ESP32 module. This setup ensures reliable performance and extends the operational lifespan of the system. During the design phase, significant attention was given to the placement and configuration of components to minimize power consumption and maintain the compactness of the devices. The development process involved iterative testing and optimization to validate the system's functionality and performance. Reliability was tested by simulating simultaneous inputs from multiple voting devices, ensuring accurate data transmission and aggregation without packet loss. Latency was measured to confirm that the time between casting a vote and updating the visualization remained within acceptable limits for real-time operation. The energy efficiency of the voting devices was evaluated by monitoring battery performance under continuous use, confirming that the Li-Pol battery could sustain operation for extended periods. Scalability was another critical consideration, addressed by assigning unique identifiers to each voting device, allowing the system to accommodate additional devices without significant changes to its architecture.

The overall system architecture was designed with three functional layers: the input layer, comprising the voting devices; the processing layer, managed by the collector device; and the visualization layer, represented by the web-based user interface. These layers work in tandem to provide a seamless and intuitive voting experience. The input layer captures user selections, the processing layer ensures accurate aggregation and storage of data, and the visualization layer presents the results in a clear and accessible format. By integrating reliable hardware components, efficient communication protocols, and a responsive user interface, the methodology reflects a well-rounded approach to developing a practical and scalable wireless voting system that meets the needs of modern electronic voting scenarios.

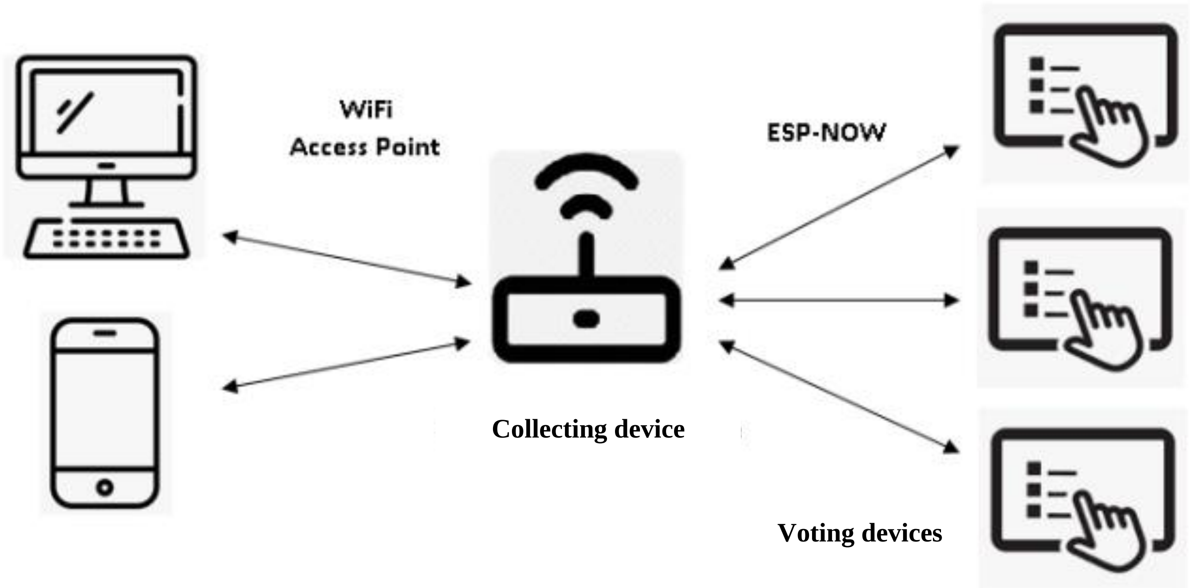

Fig. 1 System block schematic

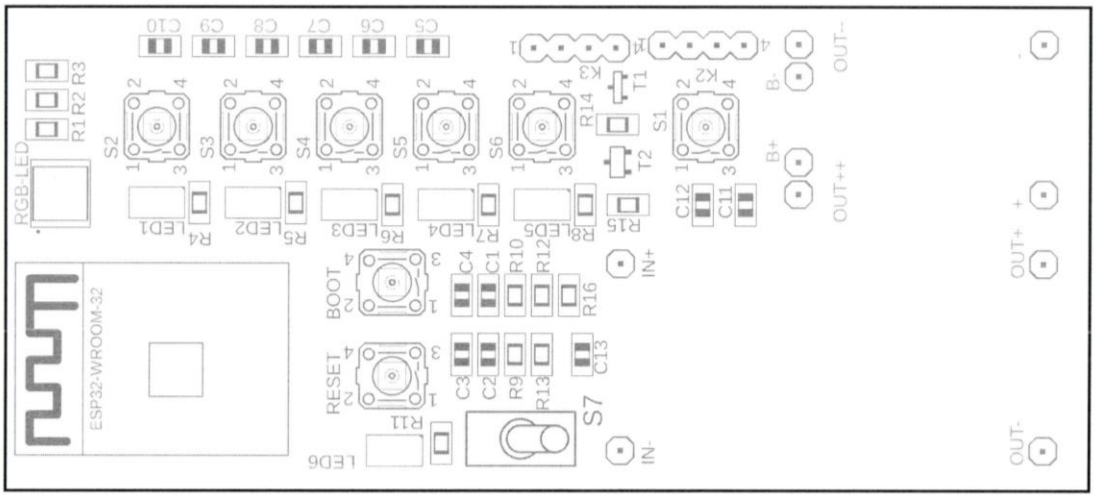

Fig. 2 Voting module

III. CONCLUSION

The system was tested in a controlled environment to evaluate its performance in terms of reliability, latency, and usability. The voting device successfully transmitted user selections to the collector device, which accurately processed and displayed the results. The bar graph visualization provided clear and immediate feedback on voting outcomes. Additionally, the system demonstrated low power consumption, with the Li-Pol battery sustaining extended operation under typical usage conditions. The ESP-NOW protocol proved effective, maintaining a stable connection between devices within the specified range. The proposed system offers several advantages over traditional voting methods, including faster data processing, reduced environmental impact, and enhanced user engagement. However, challenges such as signal interference and scalability limitations in larger environments highlight areas for improvement. Future enhancements could include integrating advanced encryption for data security, expanding the system's range, and developing a mobile application for easier access to the web interface. This study successfully implemented a wireless voting system using ESP32 technology. The system provides an efficient and cost-effective solution for electronic voting, with potential applications in education, business, and other domains.

Further research and development could explore scalability and additional features to enhance its utility in diverse settings.

References

[1] J. Bowen, "Digital solutions for transparent voting systems," *Journal of Electronic Governance*, vol. 8, no. 4, pp. 220-231, 2020.

[2] S. Smith and A. White, "Sustainability challenges in modern voting practices," *Environmental Management Journal*, vol. 15, no. 2, pp. 112-119, 2021.

[3] Espressif Systems, "ESP32 Technical Reference Manual," 2020. [Online]. Available: https://www.espressif.com/en/support/documents. [Accessed: Dec. 6, 2024].

[4] R. Gupta and M. Singh, "IoT-based voting systems: A comprehensive review," *International Journal of Electronics and Communication*, vol. 12, no. 3, pp. 345-357, 2022.

[5] A. Kumar, "Microcontroller innovations in wireless communication," *IEEE Micro*, vol. 34, no. 2, pp. 42-51, 2019.

[6] Espressif Systems, "ESP-NOW protocol overview," 2022. [Online]. Available: https://www.espressif.com/en/products/software/esp-now. [Accessed: Dec. 6, 2024].

[7] D. Wilson and L. Brown, "Low-latency communication for IoT applications," *IoT Journal*, vol. 9, no. 1, pp. 55-65, 2021.