Eco Talk Smart Communication Board with Text -to-Voice Technology Empowering Green Innovation and Growth

Ajay Vishwakarma[1], Akanksha Sahu[2], Hariom Meena[3], Pintu Nayak[4] Prof. Siddharth Singh Parihar
Department of Electronics and Communication Engineering,
Sagar Institute of Science and Technology (SISTec)
Corresponding Author: ajayvishwakarma00005@gmail.com

Abstract—

The rapid growth of smart infrastructure has increased the demand for efficient, accessible, and eco-friendly communication systems in public and institutional environments. Traditional notice boards and announcement systems rely heavily on paper-based displays or manual updates, leading to delayed communication, increased maintenance, and environmental impact. This paper presents the design and implementation of an Eco Talk Smart Communication Board that integrates wireless communication, speech-to-text processing, and text-to-speech technology. The proposed system allows users to transmit messages through a mobile application using voice or text input, which are then displayed on a digital board and announced audibly through a speaker. The system is built using a ESP32 microcontroller, an LED panel , and a text-to-speech module. Experimental results demonstrate low response time, reliable operation, and improved accessibility for hearing-impaired users. The proposed solution offers a scalable, low- cost, and sustainable alternative to conventional communication boards.

Keywords—Smart Communication Board, ESP32, Text-to-Speech, IoT, Accessibility, Green Technology

I. INTRODUCTION

Communication plays a vital role in modern society, especially in public spaces such as educational institutions, hospitals, industries, transportation hubs, and community centers. Conventional communication boards often rely on printed materials, manual updates, or non- interactive display systems, which are neither eco- friendly nor inclusive for people with visual or speech impairments. Moreover, frequent paper usage contributes significantly to environmental waste.

With advancements in embedded systems, wireless communication, and assistive technologies, there is a growing demand for smart, sustainable, and accessible communication solutions. Text-to-Speech (TTS) technology has emerged as a powerful tool to bridge communication gaps by converting textual information into audible speech, thereby supporting visually impaired users and enhancing inclusivity.

The Eco Talk Smart Communication Board is designed to address these challenges by providing a paperless, energy-efficient, and accessible communication platform. The system enables users to send text messages from a mobile application via Bluetooth to an ESP32 microcontroller. The received message is simultaneously displayed on a P10 LED display panel and converted into speech using another ESP32 module integrated with Text-to-Speech processing, an audio amplifier, and a speaker.

This dual-mode communication approach— visual and auditory—not only ensures effective information dissemination but also promotes green communication by reducing paper dependency and enabling real-time updates.

II. Literature Survey

Several studies and systems have been proposed in the domains of smart display boards, wireless notice boards, and assistive communication technologies.

Wireless notice boards using Bluetooth and GSM technologies have been widely explored. GSM- based notice boards allow message transmission over long distances but incur recurring costs and higher power consumption. Bluetooth-based systems, on the other hand, offer low-cost, short- range communication suitable for indoor environments such as classrooms and offices.

LED display boards using microcontrollers like Arduino, Raspberry Pi, and ESP32 have been implemented for dynamic message display. Among these, ESP32 stands out due to its low power consumption, integrated Bluetooth/Wi-Fi, higher processing capability, and cost effectiveness.

Text-to-Speech systems have been extensively used in assistive devices for visually impaired individuals, public announcement systems, and smart home applications. Previous research demonstrates that TTS significantly improves accessibility; however, many systems focus only on audio output without visual display, limiting usability for hearing-impaired users.

Some recent works combine IoT-based displays with mobile applications, enabling remote updates. However, most existing systems lack a unified approach that simultaneously addresses eco-friendliness, accessibility, and affordability.

III. Methodology

The proposed Eco Talk Smart Communication Board is developed to enable efficient, eco- friendly, and accessible communication by integrating wireless data transmission, embedded processing, visual display, and text-to-speech technologies. The system architecture comprises a mobile application and two ESP32-based embedded modules that operate collaboratively to provide synchronized visual and audio outputs.

The mobile application acts as the primary user interface, allowing users to enter text-based messages. These messages are transmitted wirelessly to the embedded system using Bluetooth communication, which is selected due to its low power consumption, minimal latency, and suitability for short-range indoor applications. Upon reception, the transmitted text data is processed simultaneously by two ESP32 microcontrollers.

The first ESP32 functions as the display controller and is interfaced with a P10 LED matrix panel. The received message is decoded and rendered on the LED panel, providing a clear and high-visibility visual output suitable for public information display. The use of LED matrix technology ensures real-time updates while maintaining energy efficiency and eliminating the need for printed materials.

The second ESP32 is dedicated to audio processing and text-to-speech conversion. It receives the same text message and converts it into an audible speech signal using an embedded text- to-speech algorithm. The generated audio output is routed through an external audio amplifier to drive a speaker, ensuring sufficient volume and clarity for public announcements. The simultaneous generation of visual and auditory outputs enhances accessibility for visually impaired users.

Overall, the proposed methodology ensures synchronized communication, low operational cost, reduced environmental impact, making the system suitable for educational institutions, hospitals, and public environments.

IV. Block Diagram and Hardware Implementation

5.1 Block Diagram

The system consists of a mobile application, two ESP32 microcontrollers, and visual and audio output components. The mobile application acts as the user interface and sends control commands wirelessly to the system via Bluetooth. These commands are received by the primary ESP32, which processes the data and controls the LED panel to produce the required visual output. The primary ESP32 also communicates bidirectionally with a secondary ESP32 to share control or audio- related information. The secondary ESP32 is responsible for audio signal generation or processing and sends the audio signal to an external amplifier. The amplifier increases the signal strength to a suitable level, and the amplified signal is then delivered to a speaker, which produces the audible output. This architecture allows synchronized control of both visual and audio outputs based on user input from the mobile application.

This division of tasks between the two ESP32 modules improves system efficiency and reduces processing load on a single controller. Overall, the design ensures reliable wireless control and coordinated audio-visual output for the application.

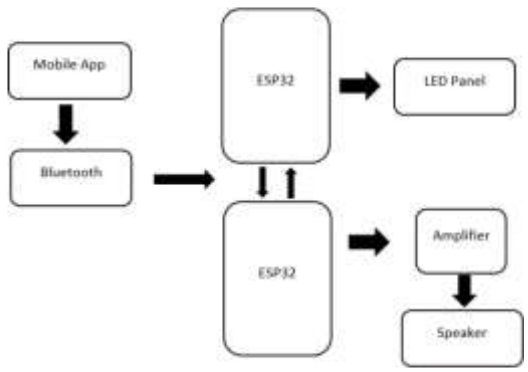

Fig.5.1 Block diagram of Eco Talk Smart Communication Board

5.2 Hardware Components Used

Table I. Hardware Components Used

Component	Operating Voltage	Function
ESP32	3.3V	Central controller for wifi communication and data processing
LED Panel	5 V	Display Received text message
Speaker	—	Audio output for announcement
Audio Amplifier	5-12 V	Amplifies low level audio signal
Power Supply	5 V / 3.3 V	Provides regulated power to all modules

5.3 Hardware Configuration

The system utilizes two ESP32 microcontrollers to ensure efficient and synchronized operation of visual and audio outputs. Both ESP32 modules operate at a logic level of 3.3 V and make use of the built-in Bluetooth functionality for wireless reception of text data from the mobile application.

The first ESP32 is configured as the display controller and is interfaced with a P10 LED matrix panel. The received text message is processed and displayed on the LED panel, which offers high brightness and wide viewing angles, making it suitable for public communication boards. Appropriate level shifting and power handling are implemented to meet the voltage and current requirements of the P10 display.

The second ESP32 is dedicated to audio processing and text-to-speech conversion. Upon receiving the same text message, the ESP32 converts the text into an audio signal using a text- to-speech library. The generated audio signal is fed to an external audio amplifier, to increase signal strength before driving the 8 Ω speaker. This configuration ensures clear and audible voice output suitable for indoor public environments.

A regulated 5 V switched-mode power supply (SMPS) is used to power the ESP32 modules, LED display, and audio amplifier. Onboard voltage regulation ensures stable operation and protects the components from voltage fluctuations. The overall hardware configuration is designed to be compact, energy-efficient, and reliable for continuous operation.

V. CHALLENGES & LIMITATIONS

Communication Limitations

- Bluetooth has limited range and bandwidth.
- Signal interference may affect data reliability.

Synchronization Issues

- Maintaining real-time synchronization between two ESP32 controllers is challenging.
- Delays can impact coordinated audio and visual output.

Hardware Constraints

- Limited processing power and memory of the ESP32 restrict complex algorithms.
- High power consumption when operating LED panels and audio amplifiers together.
- Heat generation during continuous operation may affect system stability.

VI. Performance Evaluation

Table II. Performance Metrics

Parameter	**Measurement Method**	**Observed Value**
Response Time	Voice input to LED panel Update Delay	1.5 – 2.0 sec
Panel Update Delay	Panel refresh time	< 500 ms
Wireless Range	Indoor Wi – Fi coverage	25 – 30 m
System Reliability	Sucessful message delivery rate	> 90 %
Power Consumption	Active mode power measurement	~ 1.2 W

VII. Future Scope

The Eco Talk Smart Communication Board provides a scalable foundation that can be further enhanced to meet evolving communication requirements. Future improvements may include the integration of Internet of Things (IoT) technologies by incorporating Wi-Fi and cloud- based platforms, enabling remote message updates and centralized monitoring of multiple communication boards. Such enhancements would significantly increase system flexibility and applicability in large-scale deployments.

Support for multilingual text-to-speech engines can be incorporated to improve usability in linguistically diverse environments. This enhancement would allow announcements to be delivered in multiple regional and international languages, thereby expanding the accessibility and reach of the system. Additionally, the inclusion of speech-to-text functionality would enable voice- based message input, facilitating hands-free operation and benefiting users with physical or motor impairments.

VIII. Conclusion

The Eco Talk Smart Communication Board with Text-to-Speech Technology presents an effective solution for sustainable and accessible communication. By integrating Bluetooth-based mobile communication, ESP32 microcontrollers, LED display technology, and audio output systems, the proposed system enables real-time dissemination of information in both visual and auditory formats.

Overall, Eco Talk contributes to the advancement of green technology and inclusive communication, aligning with modern sustainability and accessibility goals.

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