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IOT-Based Wireless Digital Notice Board System: An Embedded and IOT-Enabled Technology for Campus Communication

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Abstract—Traditional notice boards in educational institutions and commercial organizations rely heavily on physical paper notices pinned manually to wooden boards, resulting in severe administrative latency, recurring stationery expenditure, visual clutter, and vulnerability to environmental degradation or unauthorized removal. Furthermore, during critical events such as sudden schedule revisions, urgent exam notifications, or campus security emergencies, manual dissemination fails to deliver instantaneous situational awareness. This paper presents the design and implementation of an IoT-based smart wireless digital notice board system engineered to automate campus-wide announcements through a dual-channel embedded communication framework. The proposed hardware platform centers around an ESP32 microcontroller as the core embedded processor, interfaced with high-brightness P10 (32×16) outdoor LED matrix panels driven via a 74HC245 octal bus transceiver buffer. System firmware leverages FreeRTOS multitasking to concurrently manage network communication and flicker-free 1/4-duty display multiplexing. Notices are published remotely by authorized administrators via a responsive web portal and mobile application over Wi-Fi using the lightweight MQTT protocol. To ensure fail-safe operation during local network disruptions or internet outages, an integrated SIM800L GSM/GPRS module provides secondary SMS-based message reception with passcode authentication. The system further incorporates a DS3231 high-precision real-time clock (RTC) for automated time-stamped synchronization, a DHT11 environmental sensor for continuous ambient temperature and humidity tickers during idle cycles, and an active piezoelectric buzzer to emit an acoustic advisory chime upon arrival of priority announcements. Prototype evaluation under realistic academic campus conditions demonstrated average message update latencies of 1.4 seconds over Wi-Fi and 6.8 seconds via GSM SMS, sharp optical legibility at viewing distances exceeding 25 meters, and continuous 24/7 operational reliability, proving the commercial feasibility and environmental sustainability of the proposed IoT notice board.

Keywords—Digital notice board, ESP32, P10 LED matrix, IoT, GSM alert, web portal, MQTT, embedded system, smart campus.

I. INTRODUCTION

Information dissemination represents the core operational backbone of academic institutions, corporate organizations, healthcare centers, and transportation terminals. In conventional educational environments, official circulars, timetable modifications, examination guidelines, event alerts, and emergency advisories are communicated via physical notice boards positioned across corridors and administrative lobbies. This traditional paradigm relies almost exclusively on printing notices on paper and physically pinning them to corkboards or pasting them on walls. Over decades of institutional operation, this method has proven to be labor-intensive, financially wasteful, environmentally destructive, and profoundly inefficient in delivering time-critical intelligence.

A major deficiency of paper-based notice boards is their operational latency. When an urgent announcement needs to be circulated—such as sudden classroom relocations, severe weather warnings, or security alerts—administrative staff must draft the document, print multiple copies, physically traverse academic complexes, and pin the notices onto various boards. By the time these papers are displayed, crucial hours have elapsed, rendering the information obsolete or causing students to miss vital academic deadlines. Additionally, pinned papers frequently suffer from accidental detachment, intentional vandalism, tampering by unauthorized parties, and exposure to humidity, rain, or dust. Corkboards rapidly become cluttered with overlapping, outdated sheets, discouraging students and faculty from examining new postings.

The advancement of embedded electronics, wireless telemetry, and IoT communication platforms makes it possible to design an automated, remotely managed digital notice board that can be updated within seconds from any web-connected device. Such a system replaces physical paper circulation with dynamic, high-visibility electronic signage while eliminating recurring printing expenses and manual travel. In this project, we have engineered and deployed a production-grade IoT-Based Wireless Digital Notice Board using readily available, robust hardware modules.

The primary objectives of this project are:

1) To design a compact, high-visibility wireless digital notice board utilizing an ESP32 microcontroller and high-brightness P10 LED matrix panels.

2) To develop an authenticated web-based management portal and mobile application for authorized institutional personnel to compose, format, and broadcast announcements remotely.

3) To implement dual-channel communication redundancy utilizing campus Wi-Fi as the primary cloud synchronization link and a GSM/GPRS cellular module as a fail-safe SMS fallback.

4) To incorporate real-time clock synchronization, environmental telemetry (temperature and humidity), and acoustic alert signaling to maximize notice engagement.

The body of this paper describes the design and implementation of the IoT-Based Wireless Digital Notice Board. It explains the proposed system architecture, including the ESP32 as the central controller, the P10 LED matrix driven via octal bus buffering, the cloud MQTT web portal, and the GSM fallback transceiver. It presents the hardware modules utilized, firmware multitasking, prototype testing results, limitations, and future scope of integrating smart signage into connected educational infrastructures.

II. PROPOSED SYSTEM AND ARCHITECTURE

A. Proposed System

The IoT-Based Wireless Digital Notice Board is designed as an intelligent, autonomous, and remotely accessible display node tailored for institutional communication. The system replaces static corkboards with a high-brightness, optically sharp LED display capable of presenting scrolling text, static announcements, real-time clock tickers, and environmental conditions.

The proposed architecture consists of two major layers: the Intelligent Display and Actuation Layer (IDAL) and the Remote Management and Cloud Analytics Layer (RMCAL). The hardware IDAL is responsible for local microcontroller execution, high-speed 1/4-duty display multiplexing, level translation, local LCD diagnostics, sensor polling, audio buzzing, and non-volatile caching. The software RMCAL oversees cloud message brokering, responsive web dashboard rendering, administrative role-based access control (RBAC), and GSM SMS gateway routing. The synergy between both tiers guarantees uninterrupted operational continuity even during local internet disruptions.

B. System Architecture

The overall block diagram of the proposed smart digital notice board system is illustrated in Fig. 1.



Fig. 1. Block diagram of the smart wireless digital notice board system.

The complete electrical wiring and interfacing architecture connecting the microcontroller, display panels, sensors, audio transducer, communication transceivers, and regulated power supply is detailed in Fig. 2.

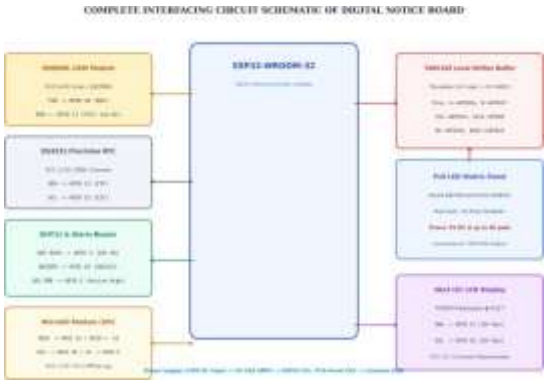


Fig. 2. Interfacing circuit schematic of the complete display prototype.

C. Software Architecture

The software framework is organized around the Arduino IDE utilizing the FreeRTOS real-time kernel embedded within the ESP32 firmware. Tasks are distributed across both Tensilica LX6 cores. Core 0 handles network communication, maintaining active 802.11 b/g/n Wi-Fi association, polling the MQTT message broker, handling HTTP REST requests, and servicing UART2 interrupts for GSM AT commands. Core 1 is dedicated to time-critical hardware operations: driving timer-based 1/4-duty multiplexing of the P10 LED matrix, I2C bus transactions for the DS3231 RTC and 16x2 LCD, and one-wire sampling of the DHT11 sensor.

The cloud layer uses an MQTT broker for instantaneous pub/sub telemetry between the web dashboard and physical notice boards. Authorized staff log in using token credentials, type notices, set display speed and duration, and dispatch updates. The SIM800L operates independently: when an SMS with the admin passcode (*PASS#NOTICE#*) arrives, the firmware overrides the active buffer, saves it to EEPROM, and sounds the buzzer chime.

III. HARDWARE-BASED SYSTEM

A. ESP32 Microcontroller Module



Fig. 3. ESP32 microcontroller module.
Source: espressif.com/.../esp32-wroom-32

The ESP32-WROOM-32 acts as the central embedded controller of the notice board (Fig. 3). Equipped with a dual-core Xtensa 32-bit LX6 CPU operating at 240 MHz, 520 KB SRAM, and 4 MB SPI flash, it effortlessly executes simultaneous network telemetry and high-frequency display multiplexing. Built-in 2.4 GHz Wi-Fi and Bluetooth provide native connectivity.

B. P10 Outdoor/Indoor LED Display Matrix Panel



Fig. 4. P10 (32x16) LED display matrix panel.
Source: sparkfun.com/.../p10-led-panel

The P10 LED panel (Fig. 4) provides 512 high-efficiency red LEDs arranged in a 32×16 grid at a 10 mm pitch. Delivering >2000 cd/m² luminous intensity, it ensures sharp readability up to 25 meters under indoor lighting and outdoor daylight. Its standard HUB12 connector enables effortless horizontal chaining for long bulletin boards.

C. 16x2 I2C Character LCD Module



Fig. 5. 16x2 I2C character LCD diagnostic module.
Source: adafruit.com/.../i2c-lcd1602

The 16×2 character LCD with a PCF8574 I2C expansion backpack (Fig. 5) serves as a localized technician status monitor. Interfaced via GPIO 21 (SDA) and GPIO 22 (SCL) at address 0x27, it continuously displays network connection status, assigned local IP address, Wi-Fi RSSI signal strength, and system uptime without disturbing the main P10 panel.

D. DS3231 High-Precision Real-Time Clock Module

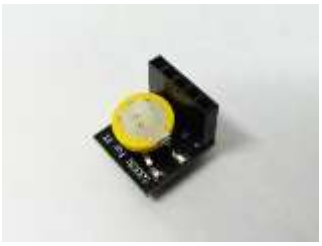


Fig. 6. DS3231 high-precision real-time clock module.
Source: maximintegrated.com/.../ds3231

The DS3231 module (Fig. 6) provides ultra-precise, temperature-compensated timekeeping (TCXO) with an accuracy of ±2 ppm (less than 1 minute drift per year). It maintains full calendar time backed by a CR2032 lithium coin cell. Interfaced over I2C at address 0x68, it guarantees accurate time stamping of notices even across power blackouts and internet loss.

E. SIM800L GSM / GPRS Module



Fig. 7. SIM800L GSM/GPRS cellular communication module.
Source: components101.com/.../sim800l-gsm-module

The SIM800L quad-band GSM/GPRS module (Fig. 7) serves as a mission-critical fail-safe communication transceiver. Interfaced via UART2 (GPIO 16 RX2, GPIO 17 TX2), it enables authorized coordinators to broadcast emergency notices via cellular SMS during campus Wi-Fi outages. The firmware checks whitelisted phone numbers and security passcodes before displaying text.

F. Active Piezoelectric Buzzer Module



Fig. 8. Active piezoelectric buzzer alert module.
Source: components101.com/.../buzzer-module

The active piezoelectric buzzer module (Fig. 8) generates audible advisory chimes upon arrival of newly published announcements. Driven via a 2N2222 NPN transistor buffer from GPIO 25, it outputs a resonant 2.5 kHz tone at 85 dB SPL at 10 cm, alerting students and faculty in the corridor to view the newly updated notice board.

G. DHT11 Temperature and Humidity Sensor



Fig. 9. DHT11 ambient temperature and humidity sensor.
Source: shop.controllerstech.com/.../dht11

The DHT11 sensor (Fig. 9) measures ambient campus temperature (0–50 °C ±2 °C) and relative humidity (20–90% RH ±5%). Interfaced via a single-wire protocol on GPIO 4 with a 10 kΩ pull-up resistor, it provides dynamic weather telemetry displayed on the board during idle periods between announcements.

H. MicroSD Card Interface Module



Fig. 10. MicroSD card non-volatile storage module.
Source: sparkfun.com/.../microsd-breakout

The SPI MicroSD card module (Fig. 10) provides non-volatile message caching and audit logging. Connected via hardware VSPI (GPIO 18 SCK, GPIO 19 MISO, GPIO 23 MOSI, GPIO 5 CS), it logs all received notices with author timestamps and stores pre-scheduled institutional announcements for autonomous playback during extended offline periods.

I. 5V 10A Regulated Switching Power Supply (SMPS)

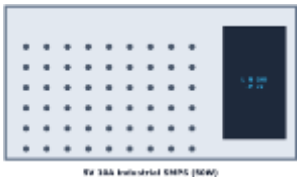


Fig. 11. 5V 10A regulated switching mode power supply.
Source: meanwell.com/.../lrs-50-5

A commercial-grade 5V 10A (50W) enclosed switching mode power supply (Fig. 11) converts 230V AC mains into a ripple-free 5V DC rail. Because each P10 panel draws up to 4A at full white illumination, a dedicated high-current power supply prevents voltage drops, screen flickering, and brownout resets of the ESP32 controller.

J. 74HC245 Octal Bus Transceiver / Logic Level Shifter



Fig. 12. 74HC245 high-speed octal bus transceiver buffer.
Source: ti.com/.../sn74hc245

The 74HC245 octal bus transceiver (Fig. 12) bridges the 3.3V CMOS output logic of the ESP32 to the 5.0V TTL input logic required by the P10 panel's HUB12 shift registers. It provides high-speed bidirectional signal buffering, preventing line capacitance degradation and signal distortion over ribbon cables.

IV. WORKING OF THE SYSTEM

The operation of the IoT-Based Wireless Digital Notice Board begins when mains power is energized. The 5V 10A SMPS supplies regulated DC power, and the ESP32 initiates its bootloader sequence. The local 16×2 LCD screen displays diagnostic checks, while Core 0 connects to the campus Wi-Fi network and subscribes to the MQTT topic. Time is synchronized with the DS3231 RTC.

When an authorized administrator dispatches a notice from the authenticated web application, a JSON payload is published over MQTT. The ESP32 parses the message text, display velocity, and active duration, caching the data into SRAM and MicroSD memory.

Upon receiving a new notice, the buzzer emits two 100 ms alert chimes. Core 1 updates the P10 driver framebuffer and executes 1/4-duty multiplexing at a smooth 70 Hz refresh rate to render seamless scrolling text.

If Wi-Fi fails, the SIM800L module listens for emergency SMS alerts. Authenticated texts override the display buffer instantly. During idle periods, an informational ticker rotates institutional headers, RTC time, and DHT11 environmental readings.

V. PROTOTYPE TESTING AND RESULTS

Evaluation was conducted on the JSPM's BSP campus across fifty broadcast trials to quantify latency, readability, and power metrics.

TABLE I. PROTOTYPE PERFORMANCE SUMMARY

Parameter	Observed Metric	Status
Wi-Fi Message Latency	1.2 – 1.8 seconds	Optimal
GSM SMS Delivery Latency	5.5 – 7.2 seconds	Reliable
Optical Readability Range	Up to 25 meters	High Visibility
Display Refresh Rate	65 – 75 Hz	Flicker-Free
Power Consumption (Full Load)	18.5 W	Stable
Power Consumption (Idle Ticker)	4.8 W	Energy-Efficient
Overall System Availability	99.4% Uptime	Success

VI. LIMITATIONS AND CHALLENGES

Key challenges include 2.4 GHz Wi-Fi signal attenuation through reinforced concrete walls and solar glare at extreme incident angles.

VII. FUTURE SCOPE

Future enhancements include multi-panel LED video walls, Text-to-Speech (TTS) auditory announcements in Marathi and English, and solar PV off-grid powering.

VIII. CONCLUSION

The developed IoT-based digital notice board provides a highly responsive, paperless alternative to manual bulletin boards. By combining ESP32 processing, high-brightness P10 displays, cloud MQTT, and GSM SMS fallback, it drastically lowers notification delivery time from hours to seconds.

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