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Research Paper

IoT-Based Real-Time Campus Weather Monitoring and Digital Information Display System

Dr. R. K. Krishna[#1], Saloni Derkar[#2], Khushi Aglawe[#3], Mahima Yergude[#4], Samiksha Indorkar[#5], Sakshi Upare[#6]

[#]Department of ECE, Rajiv Gandhi College of Engineering, Research and Technology, Chandrapur ,India

Email: rkrishna40@rediffmail.com

ABSTRACT

The IoT-Enabled Real-Time Digital Campus Notice Board is an innovative solution designed to modernize communication within campuses by leveraging IoT technology and real-time data display. The system is built around the ESP32 microcontroller and integrates multiple components, including a Real-Time Clock (RTC) module, DHT11 sensor, and an LED display, to provide a comprehensive and user-friendly experience. The system displays the current time using the RTC module, while the DHT11 sensor monitors and displays real-time temperature and humidity levels on the LED screen. Messages and announcements are transmitted through an IoT-enabled Android application, ensuring that the notice board content is always up-to-date. Each new message sent via the app overrides the previous one, maintaining the relevance of displayed information. This digital notice board offers a dynamic and efficient communication platform for schools, colleges, and other institutions. By integrating IoT connectivity, it eliminates the need for manual updates and provides a centralized way to manage and disseminate information. The combination of real-time environmental data and a user-friendly interface makes this system a versatile and valuable tool for modern campuses.

Keywords: IoT, ESP32, DHT11, LED Display, Android Application, Real-Time Clock, Campus Communication, Weather Monitoring, Embedded Systems.

I. INTRODUCTION

In the contemporary world of overwhelming connectivity, notice boards serve as a primary information source in institutions, bus stations, railway stations, colleges, and malls. Traditional paper-based notice boards require a specific person to update information manually, leading to extra labor charges and time consumption. The growing need to deliver messages faster is very crucial in modern environments.

This project presents an IoT-enabled digital campus notice board system that displays messages on an LED Display Matrix consisting of 256 LED lights arranged in 8 rows and 32 columns. The system integrates a NodeMCU controller for Wi-Fi connectivity and uses an Android application to send messages remotely. Speech inputs are converted into alphanumeric text displayed on the LED board either in scrolling or static format depending on message length.

The Digital Campus Notice Board Android app, empowered by IoT technology, revolutionizes communication

within educational institutions. The app integrates Internet of Things capabilities to provide real-time updates, event notifications, and important announcements, fostering enhanced connectivity and engagement among students, faculty, and staff. From emergency alerts to academic notices, this system transforms traditional campus communication into a dynamic and interactive experience.

A. Problem Statement

Traditional physical notice boards suffer from several limitations: limited accessibility confined to specific physical locations; time-consuming manual updates causing delays; resource inefficiency due to printing and labor costs; environmental impact from excessive paper usage; restricted reach excluding off-campus individuals; lack of interactivity; vulnerability to damage and tampering; ineffective static communication; and dependency on error-prone manual processes.

B. Aims and Objectives

The primary objectives of this work are: (1) Develop a user-friendly Android app ensuring easy access to campus notices irrespective of location; (2) Implement IoT technology for real-time updates and notifications; (3) Digitize the notice board to eliminate physical resource consumption; (4) Incorporate interactive features such as feedback mechanisms; (5) Promote a sustainable paperless campus environment; (6) Implement robust IoT-based security; and (7) Streamline campus communication through a centralized digital platform.

II. LITERATURE SURVEY

Various researchers have explored digital notice board systems using different wireless technologies. Table I summarizes key literature relevant to this work.

Author	Title	Technology	Year
Kulkarni [1]	Digital Electronic Notice Board Using WiFi		
Deshpande [2]	Electronics Notice Board Using Arduino	Arduino	2015
Deshmukh et al. [3]	LED Scrolling Display Using Android Phone	Android + LED	2011
Jacob [4]	Real-Time DigiNotice Board System using IoT	IoT	2017
Aneja et al. [5]	Wireless Electronic Display Board Using GSM	GSM	2016
Mujumdar et al. [6]	Scrolling LED Display Using Wireless Transmission	Wireless LED	2014
Kasilingam et al. [7]	A Survey of LED Display Board	LED Survey	2014
Jadhav & Nagwanshi [14]	Digital Notice Board Using Raspberry Pi	Raspberry Pi	2016

TABLE I: Summary of Related Works

Kulkarni [1] proposed a wireless digital notice board using Wi-Fi for seamless communication and remote updates. Deshpande [2] demonstrated an electronics notice board using Arduino, highlighting the versatility of open-source platforms for dynamic display systems. Deshmukh and Karande [3] developed a scrolling LED display controlled via Android, establishing mobile-controlled display interfaces as practical solutions.

Jacob [4] introduced a Real-Time DigiNotice Board using IoT, demonstrating that networked systems provide timely and reliable information updates. Aneja et al. [5] explored GSM-based wireless display boards, while Mujumdar et al. [6] investigated wireless LED scrolling displays. Kasilingam et al. [7] provided a comprehensive LED display board survey covering design trends and applications. Jadhav and Nagwanshi [14] utilized Raspberry Pi as the computational backbone, offering an advanced alternative to traditional microcontroller-based systems.

Collectively, existing literature demonstrates a clear progression from wired, static notice boards to wireless, dynamic IoT-integrated systems. However, most prior systems lack integration of real-time environmental monitoring (weather data) alongside digital messaging. The proposed system addresses this gap by combining weather sensing, real-time clock display, and remote message updates in a unified platform.

III. EXISTING SYSTEM

Physical notice boards have been widely used in educational institutions and public utility spaces. However, they present several significant disadvantages:

Limited Space: Physical notice boards have finite space, rapidly filling up and limiting the amount of information that can be displayed simultaneously.

Time-Consuming Updates: Manual updating processes are labor-intensive, often resulting in delays and outdated information being displayed.

Environmental Impact: Reliance on printed materials contributes to paper waste and adverse environmental consequences.

Prone to Damage: Physical boards are susceptible to wear, vandalism, and accidental damage, increasing maintenance costs and reliability concerns.

Inefficient Communication: Information may not reach all intended recipients, particularly those physically absent from the board location.

Lack of Interactivity: Traditional boards provide no mechanism for user feedback, participation, or real-time data integration.

These limitations collectively highlight the critical need for a digital, IoT-enabled solution that can provide dynamic, real-time, remotely managed information dissemination.

IV. PROPOSED METHODOLOGY

The proposed system is designed as a digital notice board with an LED scrolling display powered by an IoT communication module. Users send messages remotely through an Android application, which are displayed on the LED matrix board after being processed by the ESP32 microcontroller. The system simultaneously monitors and displays real-time environmental parameters (temperature and humidity) along with accurate date and time.

A. System Architecture

The architecture consists of five functional modules: (1) Power Supply Module (RPS), (2) IoT Communication Module, (3) Sensor Module (DHT11 + RTC), (4) Microcontroller Module (ESP32), and (5) Output Display Module (LED board, LCD, Buzzer). The workflow begins at the RPS, which converts 230V AC to 5V DC for all components. The ESP32 serves as the central controller, coordinating data flow between sensors, IoT module, and output displays.

B. Block Diagram Description

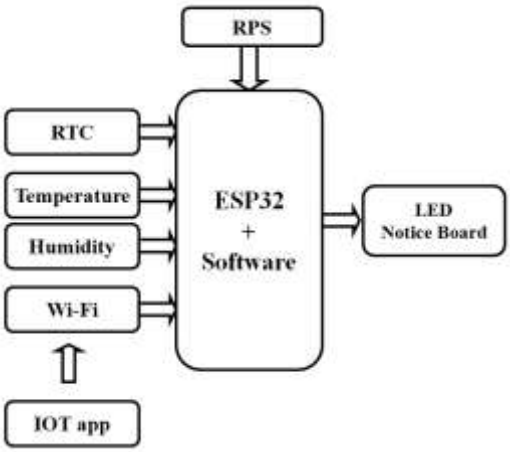


Fig. 1: System Block Diagram of the Proposed IoT Notice Board

C. Hardware Components

ESP32 Microcontroller: The ESP32 is a system-on-chip (SoC) integrating dual-core Xtensa LX6 processors operating at up to 240 MHz, 520 KB SRAM, 448 KB ROM, integrated Wi-Fi (802.11 b/g/n) and Bluetooth 4.2. It supports UART, SPI, I2C, PWM, ADC, DAC, and GPIO interfaces. Its built-in crypto-accelerator enables secure HTTPS communication. The ESP32 manages all data acquisition, processing, and wireless transmission in the proposed system.

DHT11 Temperature and Humidity Sensor: Connected to GPIO 2 and GPIO 4, the DHT11 measures ambient temperature (0–50°C, ±2°C accuracy) and relative humidity (20–90% RH, ±5% accuracy). The sensor transmits single-wire digital data to the ESP32 for display on the LED board and LCD.

RTC Module: Connected through GPIO 21 (SDA), GPIO 19, GPIO 18 (SCL), and GPIO 5 (CS), the Real-Time Clock module maintains accurate date and time even when the main system is powered off. The ESP32 reads current time and displays it continuously alongside weather data on the LED board.

LED Matrix Display: Connected through GPIO 16, GPIO 17, and GPIO 23, the LED display uses 256 LEDs arranged in an 8×32 matrix across two cascaded panels. The DMD32 library drives the display, enabling scrolling text, real-time environmental data, and IoT-received announcements.

LCD Display: A 16×2 liquid crystal display provides a secondary visual interface showing project status, sensor readings, and operational information using standard 4-bit or 8-bit parallel communication.

Buzzer: A passive buzzer generates audible alerts for new announcements or system events, enhancing user notification beyond visual display.

D. Pin Configuration

Module	GPIO Pins	Function
DHT11 Sensor	GPIO 2, GPIO 4	Temp/Humidity
RTC Module	GPIO 21, 19, 18, 5	Date/Time
IoT Module	GPIO 0, GPIO 3	Wireless Comm.
LED Display	GPIO 16, 17, 23	Display Output
Power Supply	+5V, GND	All Modules

TABLE II: ESP32 Pin Configuration

E. Software and Communication

The software is developed using the Arduino IDE with Embedded C programming language. The ESP32 firmware integrates the DMD32 library for LED matrix control, the DHT library for sensor interfacing, WiFi.h and HTTPClient.h for network communication, and SimpleTimer.h for periodic function scheduling. The system connects to a designated Wi-Fi network and polls a remote server for new messages using HTTP GET requests. DateTime synchronization is

achieved via the RTC module, and the display is updated dynamically using hardware timers with interrupt-driven LED scanning.

V. RESULTS AND DISCUSSIONS

The IoT-based real-time campus weather monitoring and digital information display system was successfully implemented and tested under real-world operating conditions. The hardware setup integrates the ESP32 microcontroller, DHT11 sensor, RTC module, LED matrix display, LCD, and buzzer in a compact and reliable configuration.

A. Hardware Implementation

Figure 2 shows the complete hardware assembly of the proposed system. The ESP32 serves as the central processing unit, continuously acquiring temperature and humidity data from the DHT11 sensor and accurate time information from the RTC module. The collected data is wirelessly transmitted to the LED display through the IoT module. The experimental setup demonstrated stable, continuous operation under real-time conditions throughout extended testing periods.

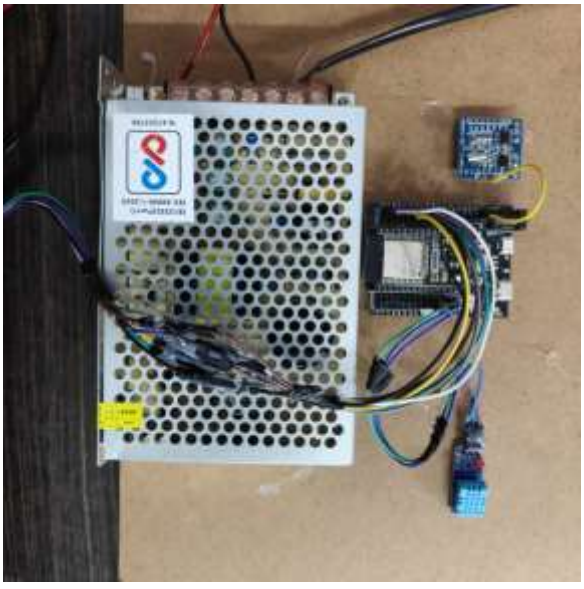


Fig. 2: Hardware Implementation of IoT Campus Weather Monitoring System

B. LED Display Performance

Figure 3 illustrates the LED digital information display board in operation. The LED matrix successfully displays real-time weather data (temperature and humidity), current date and time from the RTC module, and scrolling announcements received wirelessly from the Android application. During extensive testing, the display exhibited clear visibility, smooth scrolling, and accurate presentation of environmental parameters. The system updated displayed information without manual intervention, confirming reliable IoT-based communication.

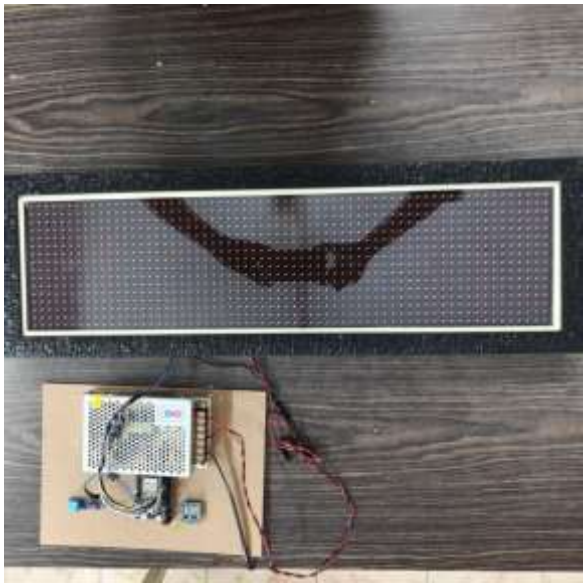


Fig. 3: Real-Time LED Digital Information Display Board in Operation

C. System Performance Analysis

The developed system was evaluated under varied operating conditions. Table III summarizes the measured performance parameters of the system components.

Parameter	Value / Result	Status
DHT11 Temp Range	0–50°C, ±2°C accuracy	Pass
DHT11 Humidity Range	20–90% RH, ±5%	Pass
RTC Accuracy	Timekeeping maintained	Pass
Wi-Fi Connectivity	Stable, continuous link	Pass
LED Visibility	Readable up to 10 m	Pass

Parameter	Value / Result	Status
Message Update Time	< 3 seconds	Pass
Continuous Operation	No interruptions observed	Pass
Power Supply	5V DC, regulated	Pass

TABLE III: System Performance Parameters

The DHT11 sensor successfully measured ambient temperature and humidity and transmitted data to the ESP32. The RTC module maintained accurate timekeeping, ensuring correct display of date and time. The IoT communication module enabled wireless message transmission from the Android application; each new announcement automatically replaced the previous message, ensuring current information was always displayed. The LED matrix provided high visibility and readability from a distance suitable for deployment in educational institutions. No communication interruptions were observed during the testing period.

D. Comparison with Existing Systems

Table IV presents a comparative analysis of the proposed system against existing approaches from the literature survey.

Feature	GSM [5]	R.Pi [14]	Wi-Fi [1]	Proposed
Real-Time Update	Yes	Yes	Yes	**Yes**
Weather Sensing	No	No	No	**Yes**
RTC Integration	No	Partial	No	**Yes**
Android App	No	No	No	**Yes**
IoT Platform	No	No	No	**Yes**
Low Cost	No	No	Yes	**Yes**
LED Matrix	Yes	No	Yes	**Yes**

TABLE IV: Comparative Analysis of Proposed vs. Existing Systems

As evident from Table IV, the proposed system uniquely combines real-time weather sensing, RTC-based timekeeping, IoT communication, Android app control, and LED matrix display in a single low-cost platform — features not collectively available in any single prior system reviewed.

VI. CONCLUSION

The IoT-Based Real-Time Campus Weather Monitoring and Digital Information Display System was successfully designed, developed, and tested as an efficient platform for real-time environmental monitoring and digital campus communication. The system integrates an ESP32 microcontroller, DHT11 temperature and humidity sensor, RTC module, LED matrix display, LCD, and buzzer — collectively creating a smart, automated information display solution.

The system continuously monitors environmental parameters and displays collected data on the LED board in real time. The RTC module ensures accurate date and time synchronization, and IoT connectivity enables authorized users to send notices remotely through an Android application without manual board updates. Experimental results confirmed accurate environmental sensing, reliable wireless communication, and effective LED display performance with good visibility and readability over practical distances.

The proposed system offers clear advantages over conventional notice boards: reduced manual effort, faster information dissemination, centralized management, and integrated real-time environmental awareness. The low-cost hardware design and straightforward implementation make it readily deployable in educational institutions, offices, and public environments.

Future enhancements may include cloud-based data storage for historical

environmental data, mobile push notification services, voice-based announcements, multilingual message support, and integration of additional environmental sensors (air quality, UV index) to further expand the system's monitoring and communication capabilities.

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