INNOVATIVE DESIGN METHODOLOGY FOR IOT-BASED SMART CAMPUS SOLUTIONS

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Abstract—
Research in the smart campus domain is still evolving, with each researcher offering unique perspectives that haven't yet converged into a unified concept. Education is a fundamental need, and managing a college with seamless communication among students, parents, and faculty on a single platform would greatly benefit everyone involved. This system addresses the essential requirements of a college. The main contribution of developing a smart campus with advanced technology is to simplify campus life. Contactless technology facilitates easy data entry when accessing classrooms or equipment, while IoT enables real-time environmental status reporting. Cloud computing organizes various information effectively and provides data services. The purpose of a smart campus is to address current challenges faced by schools, campuses, and educational institutions. This system utilizes the Internet of Things (IoT) and incorporates web and Android applications for campus operations. Cloud computing is used to store information and facilitate communication with users.

Keywords— Networking, Internet of Things, Sensors, Smart Campus, virtualization technology.

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DOI: 10.53555/ecb/2023.12.11.98

I. INTRODUCTION

In today's digital era, our college campus must integrate a variety of IoT technologies to create a sophisticated environment that leverages secure and modern tech for an e-campus in academic processes. The application of advanced technologies has revolutionized the development of smart campus networks, transitioning from basic network access services to intelligent network application services. The primary goal of developing a smart campus using new technologies is to simplify campus life. By utilizing advanced technologies such as the Internet of Things (IoT), cloud computing, facial recognition, virtualization, and networking, smart campuses transform how students and faculty interact. Various objects like computers, printers, projectors, as well as complex entities like buildings and parking areas, can be made smart by incorporating sensors and QR tags like RFID, endowing them with a significant level of operational intelligence. While the primary focus of a smart e-campus is on education, it also enhances management, safety, and environmental protection. Many college administrators seek comfortable and convenient methods to manage their institutions, driven by the desire to control and monitor the campus environment remotely. Smart campuses address current challenges faced by educational organizations, improving the quality of education and saving time. The continuous emergence of new technologies influences how processes are performed in the rapidly changing digital landscape. This initiative aims to create a smart campus where students, parents, and faculty can communicate seamlessly on a single platform. Information and communication technology (ICT) plays a crucial role in enhancing the quality of higher education in developed countries, benefiting learning, libraries, research, information services, and university administration. One ICT application is IoT, where objects and people have unique identifiers, allowing data transfer over a network without direct human interaction. IoT has advanced smart homes, campuses, buildings, and cities. The concept of a smart campus has been prevalent in industrialized countries for years, with smart campuses being a popular IoT application. Building a smart campus means using advanced ICTs to monitor and control all campus facilities automatically. The design and implementation of a smart campus vary based on the specific needs of each campus, and although the infrastructure is expensive, its implementation enhances campus efficiency and effectiveness. Creating a smart campus requires developing a digital infrastructure that provides services to the community. IoT combines various information sensing, identification, and processing devices, such as RFID, GPS, GIS, JIT, EDI, and more, with the internet to create an extended network, enabling information and intelligence for entities..

II. SMART CAMPUS INFRASTRUCTURE

One key focus in developing a smart campus is the infrastructure, which is modeled after current smart city systems. The infrastructure is crucial to the success of the smart campus initiative, allowing information about the campus to be accessible via mobile phones or other devices if properly implemented. The "smart campus" system aims to address issues like security and college administration by using advanced Internet of Things (IoT) technology to monitor the campus. This project highlights several smart campus applications, including:

Smart street light system
Biometric-based attendance tracking system
Smart gardening
Smart car parking system

III. PROPOSED METHODOLOGY

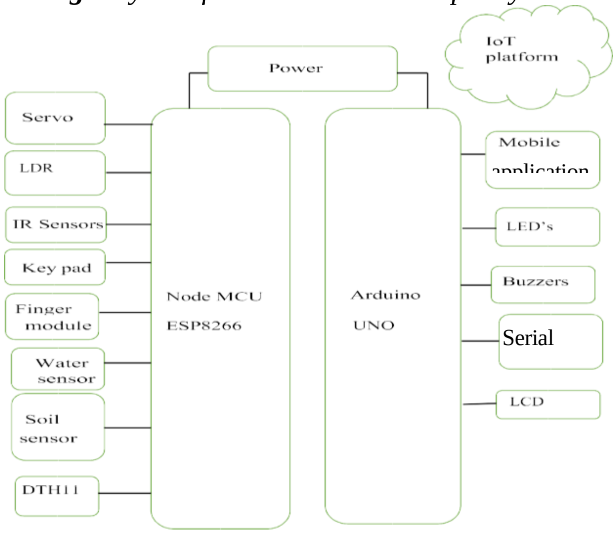
The Smart Street Light System is a crucial element of smart city infrastructure, designed to illuminate city streets using sensors to conserve energy. Traditional street lamps consume more power and require extensive maintenance, whereas LED lamps are more efficient, consuming less power and costing less. By integrating IoT technology, these systems become even more effective.

Attendance systems are commonly used in offices and schools to monitor presence. These systems have evolved significantly, from manual entries in attendance registers to utilizing high-tech applications and biometric technologies. In our project, we use a fingerprint module and Arduino to collect and store attendance data, enhancing security for users.

The fingerprint attendance system uses a Fingerprint Sensor module to authenticate individuals by capturing their fingerprint input. Four push buttons are used for enrolling, deleting, and navigating options, with specific functions assigned to the ENROLL and DEL keys.

Mobile computing effectively supports IoT in developing practical systems. Gardening enthusiasts often struggle with maintenance, leading to plant loss over time. Smart gardens offer a solution, optimizing water usage and simplifying maintenance and monitoring. Our expandable, low-cost, and easy-to-construct planter design is ideal for adding greenery to terraces or backyards.

Fig. *Layout of iot based smart campus system*



Automation aims to provide comfort by reducing manual labor and enhancing system performance without user interaction. This approach offers cost-effective and optimal solutions for farmers with minimal manual intervention.

With the rising number of four-wheeler vehicles, the demand for proper parking spaces has increased. People often waste time finding parking spots, and managing parking data manually can lead to errors. A smart car parking system optimizes the use of time and ensures error-free data management. It simplifies finding parking spaces and allows for monitoring via the internet, showing available slots and tracking entry and exit times.

IV. COMPONENTS DESCRIPTION

NodeMCU ESP8266:

The core component of the project is NodeMCU, an open-source Lua-based firmware and development board designed for IoT applications. It runs on the ESP8266 Wi-Fi SoC from Espressif Systems and features hardware based on the ESP-12 module.

LEDs (Light Emitting Diodes) are small light bulbs that can easily be integrated into circuits. They illuminate through the movement of electrons in a semiconductor material.

LDR (Light Dependent Resistor), also known as a photoresistor, changes its resistivity based on the electromagnetic radiation it receives, making it sensitive to light in a manner similar to human eyes.

An IR Sensor (infrared sensor) detects infrared radiation to identify specific properties in its environment, such as motion detection and temperature measurement, even though infrared wavelengths are invisible to the human eye.

The Arduino IDE (Integrated Development Environment) includes a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to Arduino hardware to upload programs and communicate with them.

ThingSpeak API is a cloud-based IoT analytics platform that allows for the aggregation, visualization, and analysis of live data streams. It supports sending data from devices, creating real-time visualizations, and setting up alerts.

Arduino UNO is a microcontroller board based on the ATmega328P microcontroller, featuring digital and analog input/output pins, 14 digital pins, and 6 analog pins. It can be programmed via the Arduino IDE using a USB Type-B connector.

The Fingerprint Module is a TTL UART interface optical biometric sensor (R305) used for direct connections to a microcontroller UART. It stores fingerprint data for identification in 1:1 or 1
mode and can connect directly to 3.3V or 5V microcontrollers, requiring a level converter/serial adapter for PC connection.

A Push Button switch completes an electric circuit when pressed, using a metal spring inside to make contact with two wires, allowing electricity to flow. Releasing the button breaks the contact, stopping the current flow. The switch's body is made of non-conducting plastic.

The 1K Resistor serves as a pull-down resistor to pull the base of a transistor to ground when the control signal is absent, reducing leakage current when the Arduino is unpowered.

The 2.2K Resistor works with an LDR to create a voltage divider, turning variable resistance into variable voltage, which is compared to a reference voltage controlled by a potentiometer.

A Buzzer, or beeper, is a signaling device used in alarm clocks, timers, and to confirm human input like mouse clicks or keyboard strokes.

The 16x2 LCD operates on 4.7 to 5.3 volts with a current consumption of 1mA without illumination. It is an alphanumeric display module that shows letters and numbers, with two rows each capable of displaying 16 characters.

The RTC (Real Time Clock) Module keeps accurate time and date with a battery backup, communicating via the I2C interface.

The DHT11 Temperature and Humidity Sensor is an affordable digital sensor that uses a capacitive humidity sensor and a thermistor to monitor ambient air, providing a digital signal on the data pin.

A Water Level Sensor measures water levels, monitors sump pits, detects rainfall, or identifies leaks.

The Soil Moisture Sensor determines soil water content by measuring its dielectric permittivity using capacitance.

The Relay Module is an electrically operated switch that controls circuits with higher voltage and current than a microcontroller can handle.

Breadboard and Jumper Wires are used for prototyping, allowing quick circuit changes without soldering. Jumper wires have connector pins on both ends for easy connections.

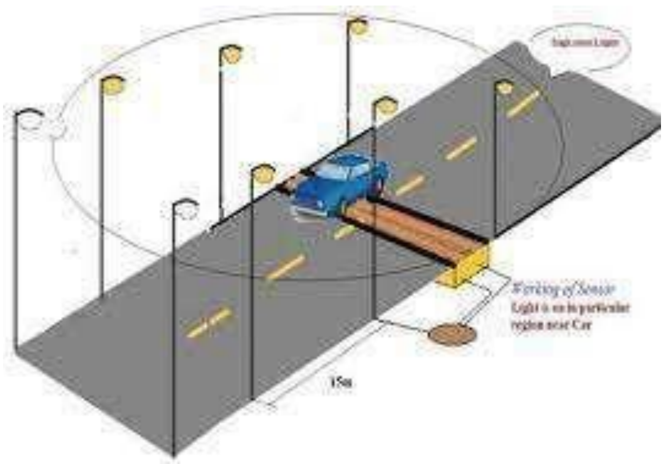
The Blynk app is a platform for creating interfaces to control and monitor hardware projects via iPhone or Android devices, using a digital dashboard for building graphical interfaces with drag-and-drop widgets.

Adafruit IO is an open data platform for aggregating, visualizing, and analyzing live data in the cloud. It enables uploading, displaying, and monitoring data over the internet, making IoT objects internet-enabled.

V APPLICATIONS

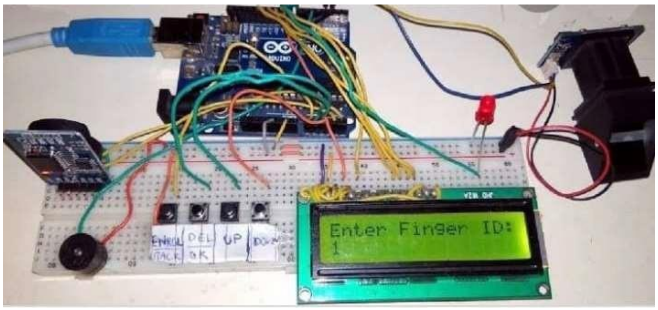
i. SMART STREET LIGHT SYSTEM

The lighting is provided by LED bulbs, which are activated by multiple IR sensors when an object or vehicle approaches. As vehicles pass by, the IR sensors detect them, triggering the corresponding street lights to turn on. Once the vehicle has moved past, the lights turn off as the sensors no longer detect any signals. IR LED light-dependent devices have a resistance that decreases in the presence of light and increases in darkness. When a light-dependent resistor (LDR) is in the dark, its resistance is very high.



ii. BIOMETRIC BASED ATTENDANCE SYSTEM

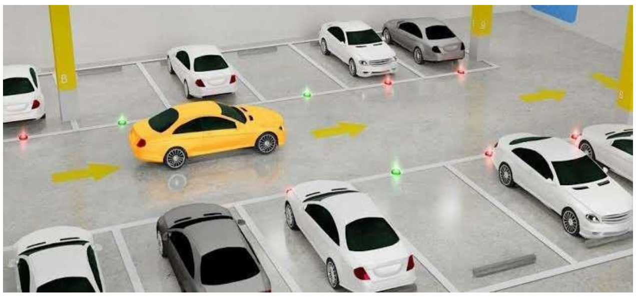
First, the user must enroll their fingerprints using the push buttons. The user starts by pressing the ENROLL key, and the LCD will prompt them to enter an ID for the fingerprint to store it in memory. Using the UP/DOWN buttons, the user selects an ID and then presses the OK key (DEL key). The LCD will then prompt the user to place their finger on the fingerprint module. The user places their finger on the module, which captures an image of the fingerprint. The LCD will instruct the user to remove and then replace their finger on the module to capture another image. The module converts these images into templates and stores them in memory under the selected ID. The user is now enrolled and can record attendance by placing their finger on the fingerprint module. All users will be registered in the system using this same method.or remove any of the saved IDs or fingerprints, he or she must press the DEL key. When the delete key is pushed, the LCD prompts you to choose which IDs you want to erase. Now the user must select ID and press the OK key (same DEL key). The LCD will now inform you that your fingerprint has been successfully removed. When a user places his finger on the fingerprint module, the module records the image of the finger and searches the system for any IDs connected with that fingerprint. If a fingerprint ID is identified, the LCD will display Attendance registered and the buzzer will sound once, followed by the LED turning out until the system is ready to accept input again. We used an RTC module fortime and date in addition to the fingerprint module. In the system, the time and date are constantly updated. So, anytime a genuine user lays his finger over his fingerprint, Arduino records the time and date and saves it in the EEPROM at the assigned memory slot.



iii. SMART GARDENING SYSTEM

In this project, to determine the volumetric water content of the soil, we employ a soil moisture sensor. The temperature and humidity levels in the plant's environment will be measured by the DHT11 sensor, and the water level in a tiny tank will be measured by the water level sensor. We keep trackof sensor data and use a relay module to operate high-voltage devices like motors and lighting. We can remotely monitor numerous metrics in our garden and trigger equipment using the Blynk app. We can remotely turn on a motor to replenish the water level in the tank falls below a certain threshold, we can activate the lighting to raise the temperature to a specified level if it drops below the minimum requirement. If your plants need more water, you can remotely water them by opening a valve. Next, create a new Blynk account. After creating the account, you need to create a new project and select the required hardware. The Blynk app will automatically send a unique authentication code for each new project. This code is necessary to connect your smartphone to the hardware and will be emailed to the address you provided during registration. To monitor temperature, water level, humidity, and soil moisture, we will need to install four gauge widgets.

iv. SMART CAR PARKING SYSTEM



In this project, the parking system is managed using sensors and a NodeMCU module. Through a mobile application, users can view which parking spaces are occupied and which are available. We use the Adafruit IO platform over the internet to access parking space details. Each user is assigned a unique ID and password for their specific parking space, enabling them to check its status. When a vehicle enters the parking area, IR sensors detect it, and the servo motor opens the gate. Once the vehicle is parked in a slot, sensors in that slot detect it and update the cloud to indicate the slot is occupied, including the time the car was parked. Similarly, when the car leaves the sensors presents at that particular slot detects it and updates the time at what the car left the space and shows that the particular slot is free. When the car leaves the parking facility the sensors at the exit gate detects the vehicle and the servo motor opens the gate forthe car to leave the parking facility. Here the entry and exit gates can also be opened by the user through their mobiles over the internet.

VI CONCLUSION

IoT technology has diverse applications, one of which is the development of a smart campus. Implementing a smart campus is a complex and innovative concept. The design of this system includes smart street lighting, smart parking, smart gardening, and a biometric-based attendance system. This report outlines research on a concept that could be instrumental in building a smart campus.

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