Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 11, No. 1, November : 2023

# IOT BASED SMART STREET LAMP CONTROL SYSTEM

**Adicherla Gagana[1], Adumulla Manusha[2], Solleti Sowmika[3]**
[1,2,3] UG Scholars, ECE Dept, CMRIT, JNTUH University, Hyderabad
**P. Pavan Kumar** Asst Prof, ECE Dept, CMRIT, JNTUH University, Hyderabad

## I. Abstract
This project is a cutting-edge solution designed to revolutionize traditional street lighting systems. Unlike conventional setups that operate without considering actual lighting needs, this system integrates IoT devices to create a responsive and intelligent network. In this system, each street lamp is connected to a central server, forming a network that enables real-time monitoring and control. Various IoT devices such as light sensors, motion sensors, and communication modules are deployed to gather data on ambient light levels, traffic conditions, and weather[2]. This information is then processed by a central control unit, either cloud-based or a local gateway. The system's key features include adaptive lighting control, allowing street lamps to adjust brightness based on real-time conditions. Remote monitoring and control capabilities enable efficient management from a centralized location.[1]

**Keywords:**
Arduino node mcu (ESP8266), IR Sensor, LDR sensor, bylnk application

## II. Introduction
The overview of traditional street lighting systems identifies key issues such as energy wastage, lack of adaptability, high maintenance costs, and light pollution. This sets the stage for the emergence of IoT technology as a game-changer in urban infrastructure[1]. The introduction emphasizes how IoT devices and connectivity can facilitate smart and automated control systems, leading to enhanced energy efficiency, optimized maintenance, and improved functionality. The significance of energy efficiency and sustainability is underscored, drawing attention to the environmental impact of energy wastage and the potential cost savings achievable through optimized energy usage. The advantages of intelligent control mechanisms are outlined, with a focus on adaptive lighting control based on real-time data, remote monitoring, and troubleshooting capabilities[2]. The safety and security aspect is highlighted, emphasizing the system's ability to optimize lighting levels in real-time, contributing to accident reduction and crime deterrence. The environmental impact is addressed, with a focus on mitigating light pollution through dynamic brightness adjustments and targeted illumination.

## III. Existing system
The current street lighting paradigm relies heavily on traditional methods, marked by manual control, basic timers, and photocells. Municipal workers often manually operate street lamps based on fixed schedules, resulting in inefficiencies as lighting may not align with actual needs. Systems employing timers or photocells lack adaptability, unable to adjust to real-time conditions or specific requirements. Monitoring and maintenance are limited, relying on reactive approaches that lead to delayed responses and increased costs. Energy inefficiency is a notable drawback, with fixed brightness levels throughout the night contributing to unnecessary energy consumption and environmental impact. Integration with other urban infrastructure components is lacking, hampering coordinated control and intelligent decision-making. In response to these limitations, the emergence of IoT-based smart street lamp control systems becomes crucial. These systems aim to revolutionize urban lighting by providing intelligence, adaptability, and connectivity. By leveraging IoT technology, they offer real-time monitoring, adaptive lighting control, and integration with various urban systems. The shift from the

conventional to IoT-based systems promises to optimize energy usage, reduce maintenance costs, and enhance overall urban lighting efficiency. These systems aim to address the challenges posed by the existing system by offering advanced functionalities that enhance urban lighting infrastructure.

**IV. Proposed system**

The proposed system is an IoT-based Smart Street Lamp (SSL) Control System that leverages the power of IoT technology to create a more intelligent, efficient, and sustainable street lighting infrastructure. The system incorporates various components and features to overcome the limitations of the existing system. Here are the key aspects of the proposed system:

- IoT Devices and Connectivity: The proposed system utilizes IoT devices, such as smart street lamps equipped with sensors and communication modules, to create a connected network of street lights. These devices are capable of collecting and transmitting real-time data, enabling seamless communication between the lamps and a central control system.
- Remote Monitoring and Control: The proposed system enables remote monitoring and control of street lamps through a centralized control system. This allows city authorities or maintenance personnel to monitor the performance of individual lamps, detect faults or malfunctions, and remotely adjust lighting settings as required. Real-time data on energy consumption, lamp status, and maintenance needs can be accessed, facilitating proactive maintenance and reducing response times.
- Smart Maintenance and Fault Detection: The proposed system incorporates smart maintenance features, such as real-time monitoring of lamp performance and fault detection. It can automatically identify and report faulty lamps, enabling timely repairs or replacements.

**4.1 Block diagram**

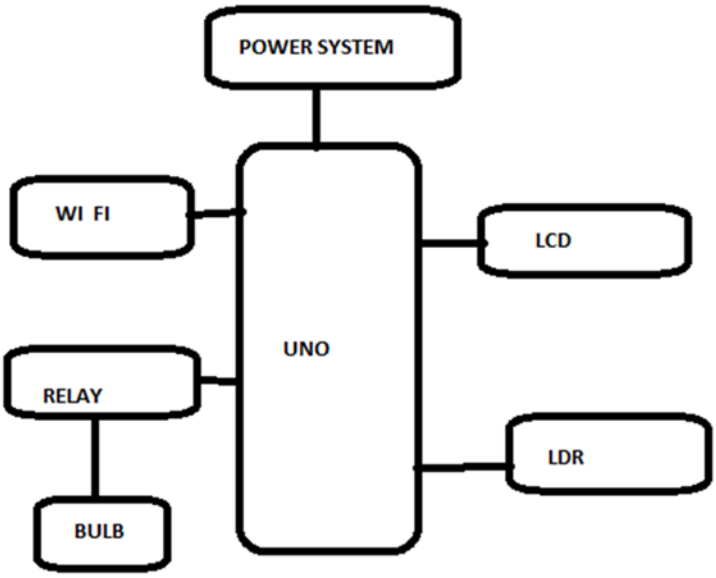



**Fig 1.** Block diagram of proposed system

**4.2 Arduino UNO**

The Arduino Uno is a popular and versatile microcontroller board widely used in the field of electronics and programming. Developed by Arduino.cc, it is based on the ATmega328P microcontroller. The board features digital and analog input/output pins, providing a platform for connecting various sensors, actuators, and other electronic components. Arduino UNO is known for its simplicity and ease of use, making it an excellent choice for beginners and hobbyists. It can be programmed using the Arduino IDE (Integrated Development Environment), which supports a simplified version of C++.


**Fig2.** Arduino UNO

### 4.3 NodeMCU (ESP8266 module)

The core of NodeMCU is the ESP8266 Wi-Fi module, providing wireless communication capabilities. It operates on the 2.4 GHz frequency and is known for its low cost and power consumption. The NodeMCU typically features a Tensilica L106 32-bit microcontroller, which can be programmed using the Arduino IDE or Lua scripting language. It comes equipped with a USB-to-serial converter, allowing easy programming and communication with the computer. This eliminates the need for an external programmer. The key feature is its built-in Wi-Fi capability, making it suitable for IoT projects. It can connect to Wi-Fi networks, allowing for remote monitoring and control.

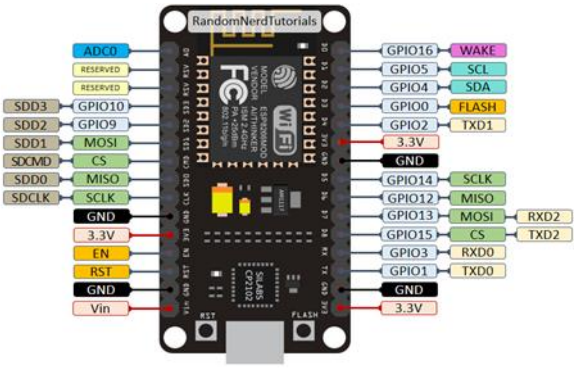



**Fig3.** ESP8266 module

| Pin Names on NodeMCU Development Kit | ESP8266 Internal GPIO Pin number |
|---|---|
| D0 | GPIO16 |
| D1 | GPIO5 |
| D2 | GPIO4 |
| D3 | GPIO0 |
| D4 | GPIO2 |
| D5 | GPIO14 |
| D6 | GPIO12 |
| D7 | GPIO13 |
| D8 | GPIO15 |
| D9/RX | GPIO3 |
| D10/TX | GPIO1 |
| D11/SD2 | GPIO9 |
| D12/SD3 | GPIO10 |

**Fig4.** Pin numbers on NodeMCU and ESP8266

### 4.4 LDR Sensor (Light Dependent Resistor)

LDRs are typically made of semiconductor materials that conduct more electricity when exposed to light. The resistance of an LDR decreases as the light intensity increases and vice versa. LDRs have two key resistance values—dark resistance (resistance in the absence of light) and light resistance (resistance when exposed to light). The ratio of these resistances determines the sensitivity of the LDR.

**Fig5.** LDR Sensor

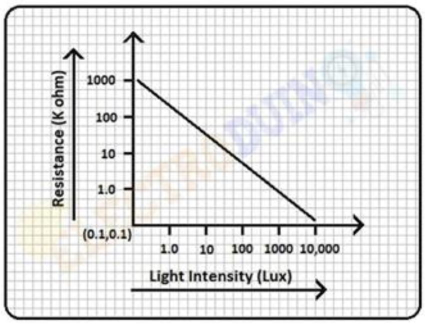



**Fig6.** Light Intensity vs resistance graph

**4.5 IR Sensor**

IR sensors work based on the principle of detecting infrared radiation, which is emitted by all objects with a temperature above absolute zero. They typically consist of an infrared source and a detector. IR sensors usually require a clear line of sight between the emitter and the receiver. Obstacles or interference can affect their performance.

**Fig7.** IR sensor

**4.6 Relay**

A relay consists of a coil, an armature, a set of contacts, and a spring. When a current flow through the coil, it generates a magnetic field that attracts the armature, causing the contacts to close or open, depending on the relay type. Relays can switch electrical circuits on or off, either opening or closing the contacts, based on the application's requirements. Relays provide electrical isolation between the control circuit and the load, allowing low-voltage control to switch high-voltage loads. They also offer durability and can handle high currents.

**Fig8.** Relay

| 2 Relay Module Input Pins Description | |
|---|---|
| Pin Name | Description |
| IN1 | Input pi for 1st relay |
| IN2 | Input pin for 2nd relay |
| GND | Ground (0V) |
| Voltage supply | Voltage supply of 5V |
| Voltage supply | Voltage supply of 12V |

**Fig9.** Pin number of relay module

**V. Execution**

The adaptive system architecture presented features key components such as LDR sensors, NODEMCU ESP8266, relays, and bulbs, operating in synchrony to create an efficient and responsive lighting system[4]. The NODEMCU ESP8266 microcontroller serves as the central intelligence of the system, orchestrating the interactions between various elements. The pivotal role of the LDR sensors, or Light Dependent Resistors, is to sense ambient light conditions. During daylight, when sunlight falls on the LDR, its resistance decreases, signaling the microcontroller to switch off the lights. Conversely, in low light or nighttime conditions, the increased resistance of the LDR triggers the microcontroller to activate the lights, ensuring an adaptive response to the environmental illumination. From the fig1. the relay, acting as an automatic switch, plays a crucial role in this architecture. It is connected to the microcontroller through a relay driver, providing a reliable and efficient means of controlling the lights. The electromagnetic switch nature of the relay facilitates automatic switching on and off of the lights based on the signals received from the microcontroller [5][6]. Overall, this adaptive system leverages the capabilities of the NODEMCU ESP8266 as the central controller, integrating LDR sensors and relays to create an intelligent lighting solution that dynamically responds to changing light conditions, promoting energy efficiency and operational reliability.

## VI. Result

The result is enhanced energy efficiency, proactive maintenance, and a more sustainable, intelligent, and responsive street lighting infrastructure in smart cities.

### 6.1 Power Consumption Graph:

- A line graph depicting the power consumption of the street lamps over time.
- X-axis: Time (hourly, daily, or monthly intervals).
- Y-axis: Power consumption in watt-hours.
- Result: Visualization of power usage patterns, helping in identifying peak and off-peak periods.

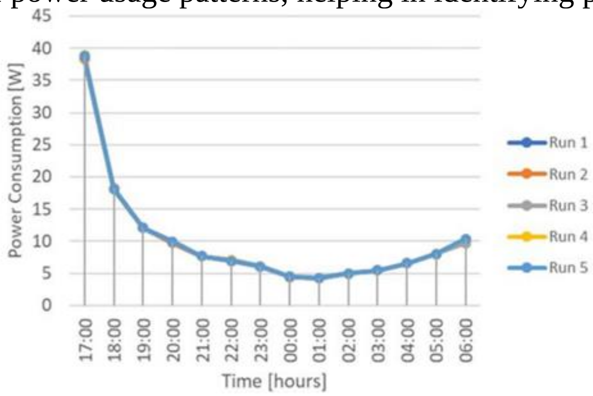



**Fig 10.** Time v/s Power consumption

### 6.2 Adaptive Lighting Control Impact Graph:

- A comparison graph showcasing lighting levels before and after system implementation.
- X-axis: Time.
- Y-axis: Light intensity.
- Result: Demonstrates the effectiveness of adaptive lighting control in optimizing illumination based on real-time conditions.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 11, No. 1, November : 2023

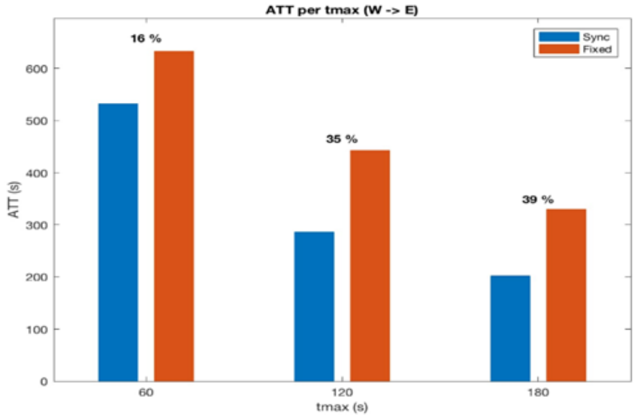
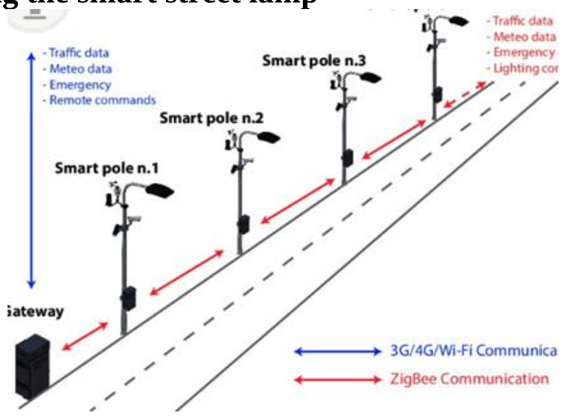



**Fig 11.** Time v/s Light intensity

### 6.3 Example of representing the smart street lamp




## VII. Conclusion

In conclusion, the adaptive lighting system, driven by the NODEMCU ESP8266 microcontroller, harmonizes LDR sensors and relays to create an intelligent street lighting solution. Responding dynamically to ambient light, the LDR sensors guide the microcontroller to switch off lights in daylight and activate them in low light. The relay, functioning as a reliable switch, enables seamless control over bulbs. This orchestrated interplay optimizes energy usage, enhancing operational efficiency. The system exemplifies a sophisticated integration of technology, offering an intelligent and responsive lighting infrastructure that not only prioritizes energy efficiency but also contributes to the creation of a sustainable and adaptive urban environment.

## VIII. References

[1]Soledad Escolar, Jesus Carretero, Maria-Cristina Marinescu and Stefano Chasse “Estimating Energy Savings in Smart Street Lighting by using an Adaptive Control System” International Journal of Distributed Sensor Networks Volume 2014, Article ID 9715.
[2] 2017 IEEE Region 10 humanitarian Technology conference (R10-HTC)
[3] http://espressif.com/en/products/esp8266/ and N. Kolban, Kolbans Book on ESP8266, an introductory book on ESP8266, 2015.
[4]https://www.mifratech.com/public/online-courses/course/1398
[5]https://www.javatpoint.com/iot-project-controlling-light-using-nodemcu-relay-wifi
[6]https://www.electronicshub.org/automatic-room-lighting-system-using-microcontroller/