Monitoring Street Light Using IoT Technology to Detect Fault Automatically

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Abstract: India facing one of the major problems is maintenance of street lights. In India Street lights are maintained manually, it is found that there is wastage of power by operating the street lights due to manual operations like switch on the lights at day time. Due to that wastage of electricity will be occurred. The methods that are working on the maintenance of street lights are not effective. We all may notice that the street light illuminates continuously. Also light is glowing in some unnecessary areas for about 12 hours. It glows very brightly in the area during absence of person or vehicle. And the main thing we noticed was there will belots of defective bulbs in the street light and it take some time to repair that problem. And also it is difficult to find which street light is in defective state. And man power is required to identify that problem. By that man power also lots of confusion in identifying the defective bulbs. Our idea will give solution for all the above mentioned problems. The Objective of the project is to provide the Smart Street Light Monitoring using IoT. Monitoring means it focus on automatic control, intensity variation and fault detection. a smart and energy-efficient street lighting system that not only reduces energy consumption and operating costs but also provides immediate information about any faults in the street lamps. Such systems are becoming increasingly popular as cities look for ways to improve energy efficiency and overall infrastructure management.

Keywords: Street light, Electricity, IoT, Smart, Fault detection, Efficiency, Automatic Control

1. Introduction

Street light automation is used to control street light automatically using GSM module (global system for mobile communication).It is constructed to perform and increase the efficiency of street light during in nights. It is implemented by 89C51 microcontroller which on setting of time delays switches ON/OFF the street lights and sends the updated messages through a phone [1]. Smart lighting gives remote lighting control by adjusting the amount of time the lights are turned-on. Inorder to reduce energy costs without sacrificing public safety. It will also be named as adaptive street lighting which dims when not needed or any movement is detected [2]. Nowadays, a manual system is considered to switch ON in the evening before the sunsets and switch OFF in the next day morning after sunrise. From this, the power will be wasted to some extent [3]. Hence, this leads to electricity wastage and manual operation. The street lights turn on before pedestrians and vehicles will come and turn off when there is no one in the street. The system is automatically programmed to turn off during day hours and only operate, its need to be operated during the night time and heavy raining or bad weather [4]. All over the world, 70% of electricity is generated to burn fossil fuels, a source of air pollution and green house gases, and globally there are approximately 300 million street lights are using the electricity [5]. Most of them all controlled by manually. The cost spent is so high that all the lights are sodium vapor lamps which consume more power. The street light is one of the big expenses in a city. Nowadays [6], population density shifts towards to urban cities and have resulted in the constant rise of energy consumption in all cities. This study implies a street lighting system consumes minimum energy from the city network. Here the street lights are switched via IoT technologies. The street light can be operated to turn ON or OFF at any time and any place through web server. Added to that on top of the street light we are placing a camera [7] inorder to keep track the activities performed on the street and where they are recorded and stored in a server. Also with, a panic button is placed on the pole, If there is any emergency occurred like harassment, robbery and any one can press the button to make alarm to reach rescue. The rapidly evolving field of IoT [8] stands out as a high-impact technology sector, particularly in managing extensive real-time data. IoT takes the lead in the market due to its adaptable structure, with two distinct approaches being pursued based on the specific nature of the applications in question. Across the globe [9], a significant amount of electrical energy is currently being utilized by street lamps that operate automatically by switching on during darkness and off when it's bright, without regard to the presence or absence of people on the streets. This automated operation conserves both manual effort and power to some degree. Furthermore, due to the extensive quantity of lamps in use [10], street lighting constitutes a considerable portion of total energy consumption, thereby imposing significant costs on utility providers. Smart street lighting solutions empower control, monitoring, and automatic fault detection, effectively converting these systems into intelligent, energy-efficient networks, leading to substantial savings in electricity expenditures.

2. Hardware Requirements

2.1 Node MCU

Node MCU is an economical, open-source IoT platform that was initially designed with firmware compatible with the ESP8266 Wi-Fi System-on-a-Chip (SoC) from Espressif Systems, paired with hardware based on the ESP-12 module. Subsequently, it expanded its support to include the ESP32 32-bit MCU. Node MCU encompasses open-source firmware, and corresponding open-source prototyping board designs are readily available. The name "Node MCU" derives from the fusion of "node" and "MCU" (microcontroller unit). It's worth noting that "Node MCU" primarily pertains to the firmware itself rather than the specific development kits, and both the firmware and prototyping board are open source. The Node MCU is shown in Figure 1.

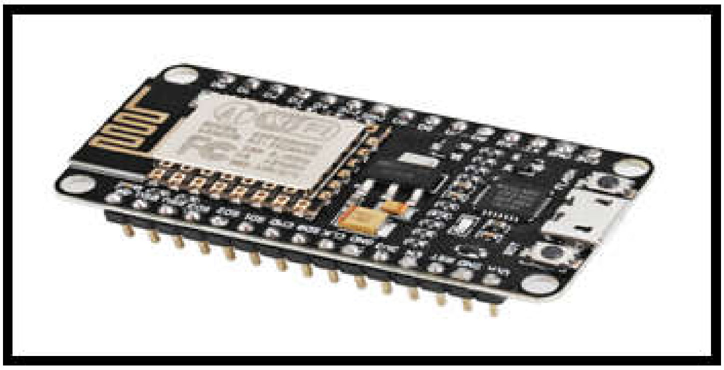

Figure 1. Node MCU

2.2 Arduino

Arduino is a company, project, and community centered around open-source hardware and software. They specialize in crafting single-board microcontrollers and microcontroller kits for constructing digital devices. Their products are released under licenses such as the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), which grants permission for anyone to manufacture Arduino boards and distribute the associated software. Arduino boards can be obtained in preassembled form through commercial outlets or as do-it-yourself (DIY) kits and it is depicted in Figure 2.

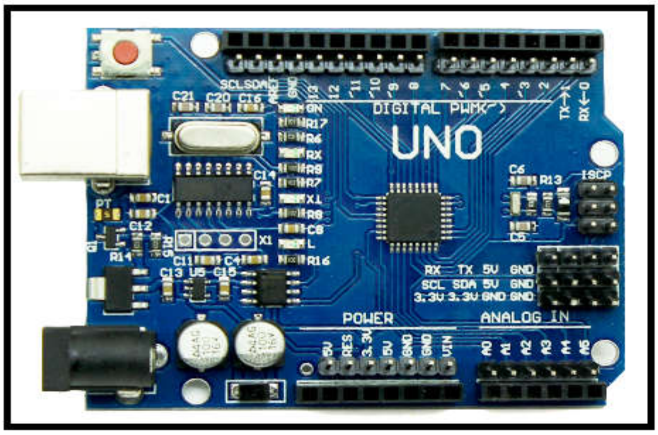

Figure 2. Arduino

Arduino board designs employ a variety of microprocessors and controllers. These boards come equipped with sets of digital and analog input/output (I/O) pins that can be connected to various expansion boards known as 'shields,' as well as breadboards for prototyping and other circuits. Additionally, these boards include serial communication interfaces, with some models featuring Universal Serial Bus (USB) ports that allow for program loading from personal computers.

The microcontrollers within these boards can be programmed using the C and C++ programming languages. To facilitate this process, the Arduino project offers an integrated development environment (IDE) based on the Processing language project. This IDE serves as a user-friendly platform for both novices and professionals, providing an accessible and cost-effective means to create devices that interact with their surroundings through sensors and actuators. Examples of such devices designed for hobbyists and beginners encompass simple robots, thermostats, and motion detectors.

2.3 LED

A light-emitting diode (LED) represents a semiconductor-based light source that radiates light when an electric current passes through it. Within the semiconductor material, electrons rejoin electron holes, liberating energy in the form of photons. The specific color of the emitted light, which correlates with the energy level of the photons, is determined by the energy necessary for electrons to traverse the band gap within the semiconductor material. To produce white light, a combination of various semiconductors or a layer of light-emitting phosphor is applied onto the semiconductor device. The Symbol of LED is illustrated in Figure 3.

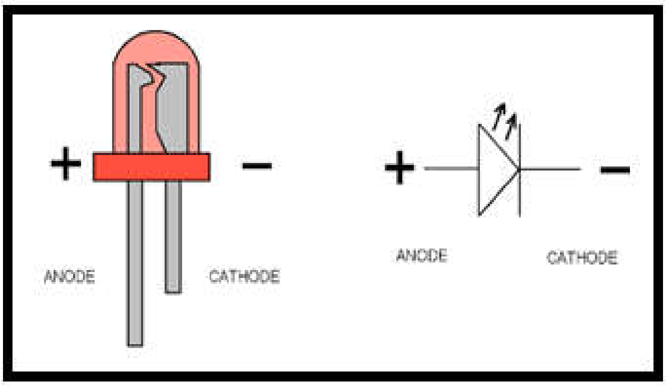

Figure 3. LED

2.4 Zigbee

The XBee S2C is an RF module specifically engineered for wireless communication and data exchange. It operates on ZigBee mesh communication protocols, which are built on top of the IEEE 802.15.4 PHY (Physical) layer. This module serves as a means of wireless connectivity for end-point devices within ZigBee mesh networks, accommodating devices from various manufacturers. It's important to note that the XBee is a module developed by the company 'DiGi,' while ZigBee refers to the protocol used by XBee modules to establish wireless communication.

With just a handful of these modules, users can swiftly establish their own ZigBee network, typically in a matter of minutes. The XBee RF Module is compatible with a range of other devices employing ZigBee technology. This includes, but is not limited to, other XBee modules, ConnectPortS gateways, XBee and XBee-PRO Adapters, XBee Sensors, and other products bearing the "ZB" designation in their product name and it is viewed in Figure4.

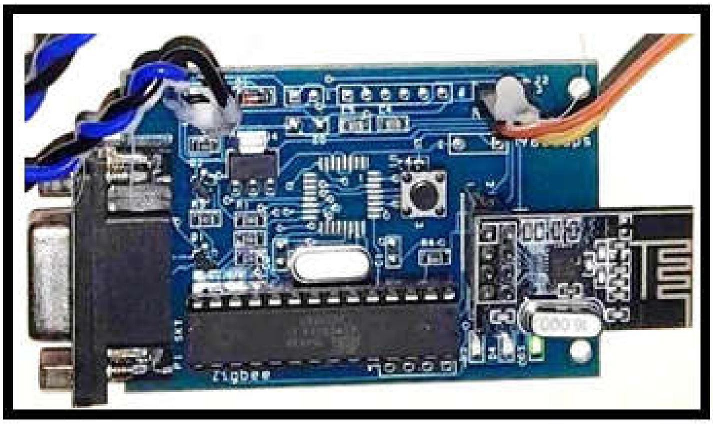

Figure 4. Zigbee

3. System Operation and Results

3.1 Working

In this setup, an LDR sensor is employed to determine whether it's daytime or nighttime. The LDR sensor's resistance varies based on the amount of light it detects, akin to a potentiometer. One terminal of the LDR sensor is linked to a 5V source, while the other end connects to a fixed resistance, which is further grounded. The NodeMCU has a designated ADC pin (A0), which interfaces with the point between the fixed resistance and one terminal of the LDR sensor, as indicated in the circuit diagram. As the LDR sensor's resistance changes in response to varying light levels, this configuration generates a variable voltage at A0. The fixed resistance has a value of approximately 10K ohms. IR sensors, on the other hand, are used to identify the presence of individuals or objects crossing the street. They function by emitting IR rays, which, if they encounter an object such as a person, animal, or vehicle, are reflected back to the sensor. The receiving diode detects the reflected IR rays, thereby confirming the presence of an object, and subsequently activates the corresponding LED. This approach conserves a significant amount of electricity, as the street lights only activate when someone is detected in the vicinity.

Each IR sensor typically has three pins: Vo, Gnd, and Vcc. The Gnd pins of all the sensors are interconnected with the Gnd pin of the NodeMCU. Similarly, the Vcc pins are all connected to the A0 pin. One terminal of the LDR sensor is also connected to the A0 pin, with the other end linked to the fixed resistance. The other terminal of this resistance connects to the Gnd pin. The Vo pins from the IR sensors and the positive terminals of the LEDs are linked to digital pins. The negative terminals of the LEDs are connected to the Gnd pin. The system working models are displayed in Figures 5, 6 & 7.

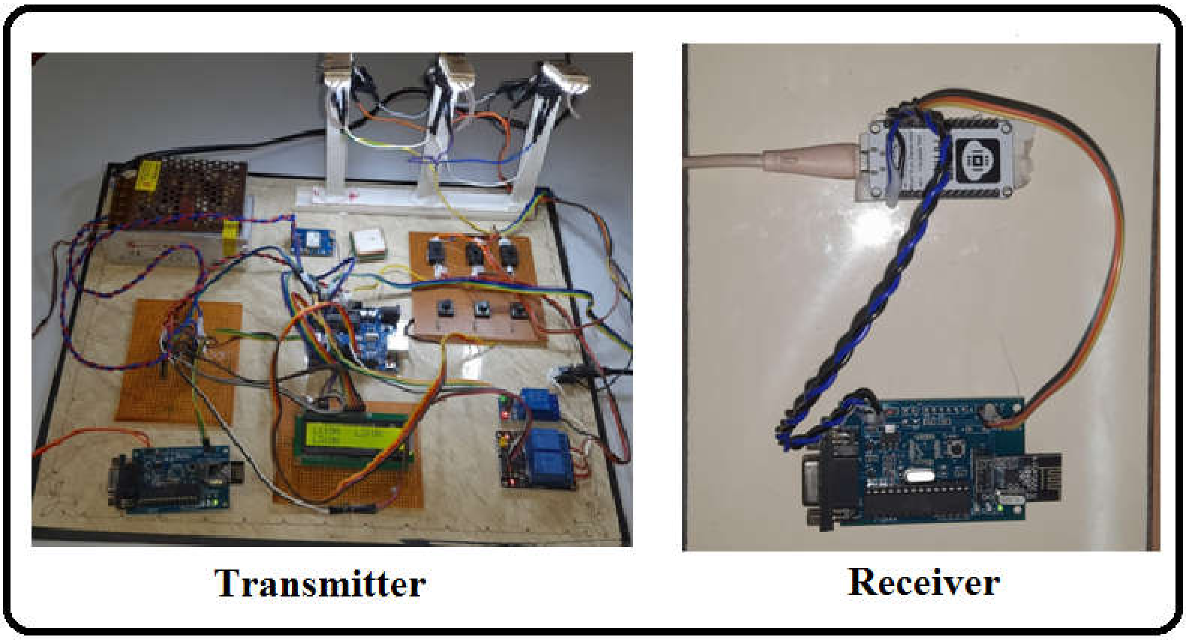

Figure 5. System Working Model

3.2 Server

The IoT server in use is ThingSpeak, a versatile platform designed for the Internet of Things (IoT). ThingSpeak serves as an open data platform and API, offering the capability to gather, store, assess, visualize, and take action based on data originating from various sensors. This platform serves as an IoT analytics service that streamlines the aggregation, visualization, and analysis of real-time data streams within a cloud-based environment.

ThingSpeak is particularly popular for the initial stages of IoT system development, aiding in the creation of prototypes and proof-of-concept projects that require comprehensive analytics. For smaller, non-commercial ventures, ThingSpeak is available as a complimentary service, accommodating projects with message volumes totaling less than 3 million messages per year, or approximately 8,200 messages per day. For larger-scale applications, ThingSpeak is offered in units, with each unit allowing the processing and storage of up to 33 million messages within a one-year timeframe, equating to approximately 90,000 messages daily. This scalable approach caters to diverse IoT projects, whether they are small in scope or require substantial data processing and storage capabilities. Thingspeak server is displayed in Figure 6.

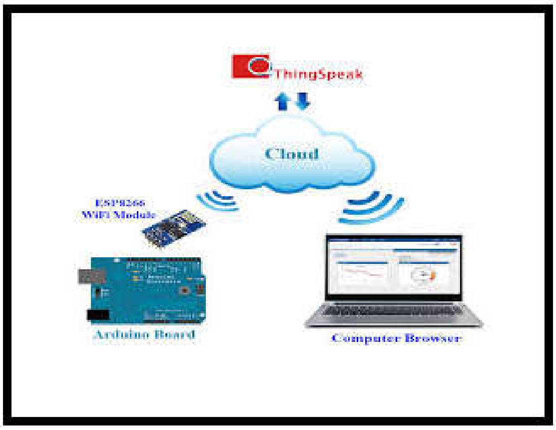

Figure 6. Thingspeak

3.2.1 Installing Thingspeak Library In Arduino IDE

Step 1: To open Arduino, navigate to the "Sketch" menu. Next, select "Include Libraries," and then click on "Manage Libraries" and it is displayed in Figure 7.

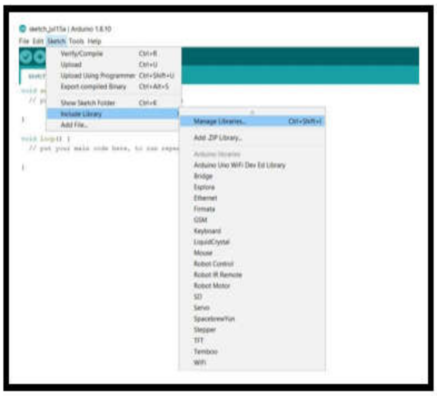

Figure 7. Arduino IDE Software

Step 2: Once you click on "Manage Library," the Library Manager dialog box will open. Inside the Library Manager, you can install the required files. To do this, simply search for "ThingSpeak" in the Library Manager, and then proceed to install the ThingSpeak library as indicated below in Figure 8.

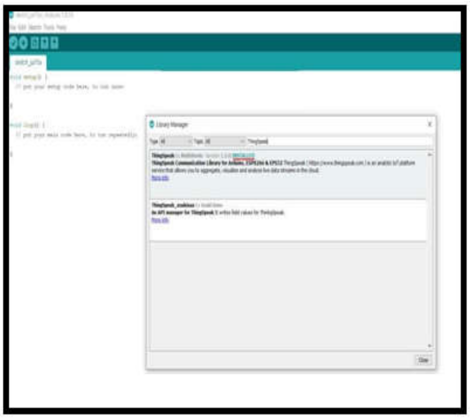

Figure 8. Installation of Thingspeak Library

3.2.2 Data Uploading

Step 1: First create Thingspeak account.

Step 2: Next, navigate to the channel setting option and complete the necessary fields. The channel ID will be generated automatically, and you can provide the name and description before saving it. Within the fields box, enter the names of the components responsible for measuring both input and output data. The Channel setting dialogue box is shown in Figure 9.

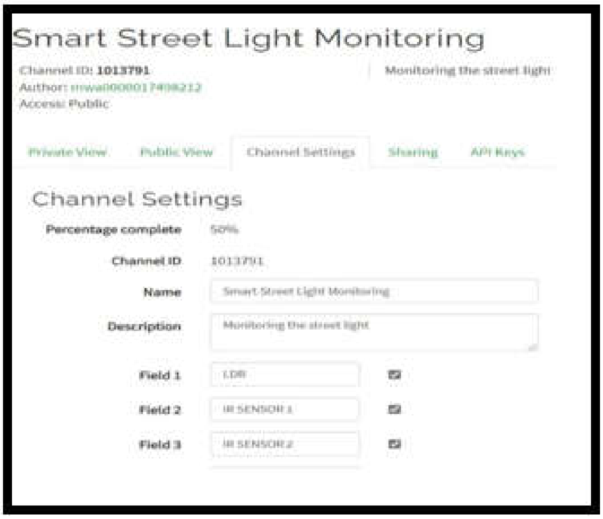

Figure 9. Channel Setting

Step 3: The next essential step for updating data on the server involves working with API keys. It's crucial to note that both the write and read API keys are automatically generated upon channel creation. Below are the API keys provided and it is displayed in Figure 10.

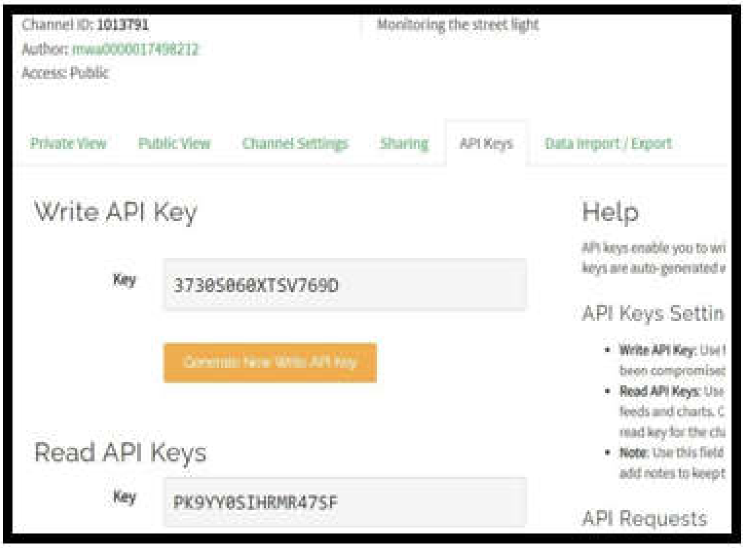

Figure 10. API Keys

Step 4: By incorporating the API keys into the code, the data is visualized in graphical format, making it easier to interpret and analyze. In this section, the LED is turned to 1 with giving some delay. Figure 11 is API Requests and Application Window, respectively.

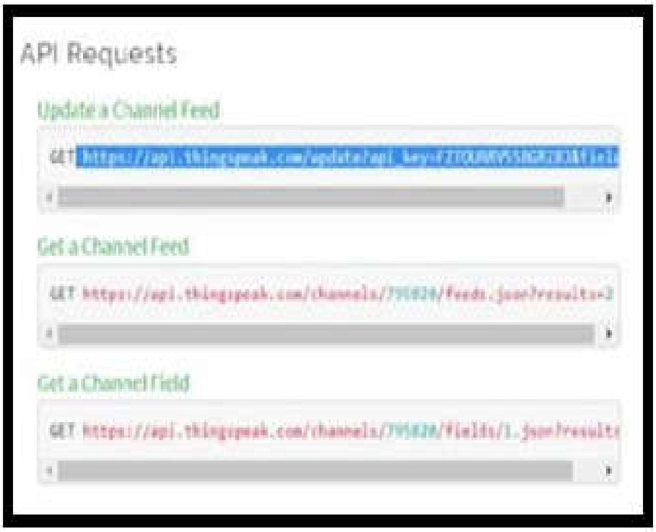

Figure 11. API Requests

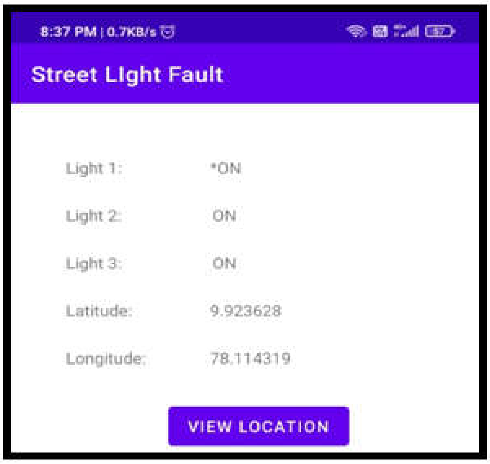

Figure 12. Output displayed in Application Window

4. Conclusion

Utilizing IoT for Smart Street Light Monitoring is a cost-effective, practical, environmentally friendly, and secure solution for conserving energy. This system enables remote access to real-time information on light statuses from anywhere, effectively addressing two pressing global challenges: energy conservation and the identification of faulty lights. While the initial setup cost and ongoing maintenance may present challenges, leveraging technological advancements and efficient resource management can substantially reduce project costs. Furthermore, the use of high-quality equipment can minimize the need for frequent maintenance checks. LED technology, known for its long lifespan, cool light emission, absence of toxic materials, and rapid switching capabilities, plays a pivotal role in this project. Moreover, this innovative approach holds promise for various other applications, such as providing efficient lighting solutions in industrial settings, educational campuses, and the vast parking lots of large shopping complexes.

5. Future Work

Integrating a LoRaWAN (Long Range Wide Area Network) technology for long range communication and to attain low power consumption. The LoRa process unfolds in a sequence, commencing with the presence of a node, followed by the deployment of a gateway, and ultimately connecting to a server. Subsequently, data is regularly monitored and accessible through mobile devices or computers for long range communication.

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