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Smart Street Lighting System with Adafruit Cloud

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Abstract: ***Street Lights consume a lot of power overnight, even though they do not appear to. This paper describes a way to reduce that power consumption while also storing the data in the cloud. In a fast trending world, storing data on the cloud is good for better maintenance and monitoring. This paper also gives a method to control the lights remotely, if required. The lights will be ON in the evening from dusk, and will remain ON in high density traffic areas, till late night. Then, the time when traffic reduces, lights will start working autonomously. This traffic intensity and timings will vary from place to place. These street lights communicate via the fields in the cloud, and will ON the lights before the vehicle even reaches the next area, for a safe margin and to prevent accidents. The main aim of this proposal is to not only reduce power consumption of unused street lights at night, but to also implement it with the help of a cloud to get data for future implementations, which will help make a better cloud-based system in the future.***

Keywords: ***Adafruit Cloud, IR Sensors, Node MCU or ESP8266, MQTT (Message Queuing Telemetry Transport).***

I. INTRODUCTION

Power production and consumption has become a big deal. There are very few renewable power sources, and all the non-renewable power sources have become tougher to obtain. So, power wastage is a big problem and it is required to reduce it. There are many areas of wastage which can be focused on to overcome this problem.

One such area is wastage due to street lights being left ON the whole night even when there is little to no traffic. Street lighting system is the most noticeable feature depicting the urbanization of a city [12]. According to estimates, around 5% of the energy used in lighting is consumed by public lighting, which is the most important component of a city or town’s energy consumption [10]. Street lights are left ON for safer pedestrian movement and the little traffic that moves at that time.

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The power consumption of each light varies depending on its type. Incandescent lamps typically range from 25- 150 watts, fluorescent lamps range from 18-95, metal halide lamps range from 50-400 watts, and high-pressure sodium lamps range from 50-400 watts [1]. In addition to this the emission of CO_2 gas causes environmental pollution to the large extent. The system application for street light control for each lamp will require small amount of electricity and availability of street light will also increase [5].

So, for better utilization, lights can be made based on traffic. This traffic is different in different places and times. In cities the peak traffic time on busy or main roads is generally till around 10p.m. – 11p.m. While some of the streets might not be busy after 8pm.

Whereas, in villages the peak traffic time is generally till 9pm at the most on main roads. The timings on others streets might be less at all times during the day. The traffic on each street can determine the type of automated street light required in that street.

Highways are the most unsafe areas so turning the lights OFF completely can be quite dangerous. The lights can be made to work based on intensity so as to minimize safety hazards while also saving power to a certain extent. In this case there has to be a trade-off between safety and power consumption.

Street lights at night can be made ON with IR sensors alone, but sometimes it may be dangerous if vehicles travel at higher speeds. So, when one IR sensor detects the movement, a series of lights can be made ON and also “Alert” the next series of lights. With this idea we have made a prototype with the above features.

II. LITERATURE SURVEY

There are many mechanisms and papers which are previously published by different authors for making this street lightning system much more energy efficient using different components and methodologies.

Keeping in mind the long-established and ordinary approaches of smart street lighting system as a sense following articles are considered for review.

Siddarthan et.al. proposed a system in this paper which is an efficient way of implementing a smart street light. It is mainly based on 3 main parts: Lamp Unit, Communicator, Back End. The Lamp Unit consists of 2 sensors i.e. the LDR and Camera. The LDR is to detect the amount of sunlight at a time, while the camera is to detect pedestrians and vehicles moving, to activate the light. The Communicator is mainly used to collect information and send it to the “Backend”. Device such as ZigBee can be used to achieve such a task.

The Back End consists of code to act according to the outputs from the sensors. This is done in such a way that the intensity of the light will be determined from there. After the code is executed the output of the code is carried with the help of the communicator to the lamp unit to control the intensity of light in real time.

M. Caroline Viola Stella Mary et al [2] proposed a smart street lightning system for an entire city using renewable power sources. The street lights work in a way to control brightness and switching efficiently according to pedestrians and vehicles thereby resulting in minimal power consumption. The motion and brightness of the LED (Light Emitting Diode) is identified and Node MCU is used to connect and monitor all these lights via the cloud. ZigBee network is used for communication. This results in saving 35% to 42% of daily energy expenditure than that of conventional street lightning system.

A prototype was made by Bilam Roy et al [3] to optimize the street light intensity while detect the vehicles to save power and switch the street lights accordingly. Here, Arduino was used as the controller and LDR's for the detection of ambient light and DS1307 module was also used detect the vehicles in order to compare the real time clock and maintain the street light intensity. Street Lights are automatically turned ON or OFF based on the intensity of the sun light from the LDR sensor input. When the intensity of sunlight decreases, the resistance of LDR increases. Based on the resistance value of LDR lights are switched ON or OFF. During night time the LDR's resistance is high, hence lights a are switched ON and turned OFF after the pre-set value of real time clock set by DS1307 is reached.

Omkar Rudrawar et al [4] also made a prototype to optimize the light intensity similar to the paper, but used Node MCU as the controller and also involved some latest Internet of Things trends such as connectivity and real time monitoring, to reduce energy consumption of street lights. Here they have included an intensity control unit TRIAC and an ultrasonic sensor to identify vehicles. At first, sunrise and sunset time is retrieved from the internet then compared to the present time. When it is around sunset time, it triggers the intensity control unit and the switches are turned ON and TRIAC device is used to continuously monitor the light intensity and whenever it is sun rise time it automatically switches OFF the street lights. Using the Node MCU the system generates required data regarding light intensities and are uploaded to the cloud for further processing.

Sunayna. S. Badgelwar et. Al. [5] has proposed a system in which the street lights are turned ON, OFF according to sunset, sunrise respectively and during night time using Object Level Frame Comparison. It detects the vehicles and people passing by, the images of them are taken and then the street lights are turned ON else, turned OFF automatically. Raspberry Pi was used in order to make this proposed system work. First the pi cam continuously takes images from the live video and converts them to grey scale images and a binarized image is obtained and by applying contour mapping the existing image from the background is extracted. The methodology involves capturing the video, processing the video frames, determining the state of the street lights, activating the sensor array and wireless communication for the status.

Fares S. El-Faouri et al [6] proposed a prototype to use solar energy instead of photovoltaic sources such as batteries. In addition to this an additional battery was attached to the pole in order to store the additional power obtained from the solar energy. Also, they added motion sensing control design which consists of a PIR motion sensor and a relay module. So, whenever it detects motion the PIR sensor triggers the relay module to switch the street light. They have also done various comparisons of how the solar energy is obtained during various weather conditions and also, they have included a PV panel to show the details of various parameters.

A system was proposed by Revathy. M et al [7] in which automation of street lights is done for a smart city using highly efficient LED lights instead of discharge lamps with which, intensity of the street lights can be altered and thereby save energy. Here they have used a microcontroller and PWM to vary the intensity of the LEDs.

At first initialization of RTC, serial ports and PWM duty cycles is done. Then, based on the time, the LEDs are switched by using input from LDR sensors. Based on the input from the first LDR PWM duty cycle is changed. Then current is measured using ACS 712 sensor and the base station is informed if fault is detected in it, using GSM module. Thomas Novak et al [8] proposed a design based on flow of traffic. The volume of traffic is continuously monitored by the sensors fixed on the road. Communication of the lights takes place through the ZigBee modules and they are controlled discretely. This system design is based on detection of human and vehicle. Each light is controlled separately, while having data modem communication modules. On the first light pole, a camera is installed, which sends data to the Raspberry-Pi. This system reduces usage of multiple sensors. LDR and camera are used to detect the movement of pedestrians or vehicles. GSM module is used to send an alert or message of malfunction to the authority, which is done by the public with a button.

III. DESIGN

The smart street lighting can be made in various ways depending on the area it will be used in. The two main types are:

A. Motion Based

Motion based street light systems can be placed in places where traffic intensity at night is not so high, generally within cities or villages. This type of street light will detect motion and then ON the street light. After a certain delay or duration, the light will OFF automatically. This can in certain situation be unsafe, but since the traffic is mostly non-existent at late hours it can be non-problematic.

B. Intensity Based

Generally, it should be preferred to have an intensity-based light on highways, since keeping the light OFF when there is less or NO traffic is not an option. Instead, lights can be made to work based on the environmental lighting. As the dusk time starts light intensity of the street light can start to increase slowly as the environmental light decreases. After a point the light will be in its full intensity.

So essentially, the light will be ON for its duration from that point in night till dawn, rendering our idea not so useful.

So, a better solution than an intensity-based light will be a mix of intensity based and motion-based lights on as mentioned by Vijay Barve in [11].

There can also be another solution that is proposed in this paper which will not only enable safer movement at night but also lesser power consumption.

With proper design, street lights can be made to "communicate" with each other. As mentioned by Caroline et. Al. in [2]. The design in this paper is similar in the thought that the street light will communicate, but the method in which it is done is different.

With the world entering an era of Internet of Things and 5G, having cloud usage and data monitoring can be useful to improve services later on. Though the idea is "costly" in terms of expectations to be able to implement the project, it can hopefully be done with introduction of 5G.

The street lights will be working on and ON-OFF based system based on input from the IR sensors of the street light before and after it. The input from the IR sensor is taken by the Node MCU and the status of that light is updated in the Adafruit cloud, while also controlling the street lights "Next in line", to be made ON. Each Node MCU is subscribed to its own feed and the feed of the next Node MCU. This subscription will help it to check the data from the other Node MCU and will also help in sending the ON signal to the next Node MCU if motion is detected.

IV. WORKING

Node MCU (ESP8266) is the controller used here. The IR sensor for each unit is connected to its Node MCU. Each Node MCU has an LED light (street light) connected. The Node MCU is connected to the cloud via the internet connection. The basic expectation is that the devices have proper internet connection, considering the upcoming 5G Network. These are connected to the cloud where the status of the IR sensor of each Node MCU is available in "feeds" of the user. These feeds can be visualized in the form of switches, graphs etc. on the dashboard in the cloud.

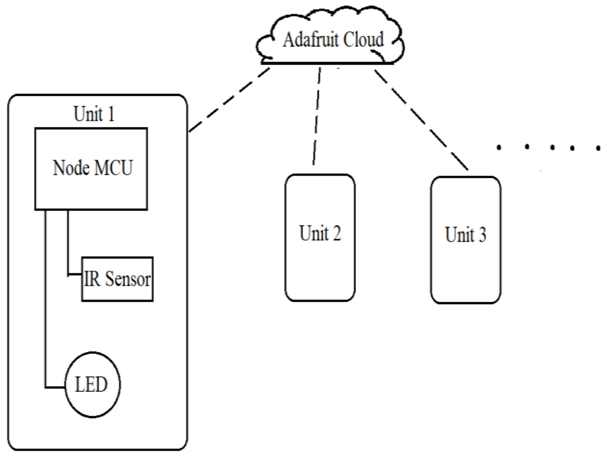

Fig. 1. Block Diagram of the System

Each individual Node MCU works based on the input from its IR sensor. The Node MCU publishes the data from the IR sensor to the cloud. It is subscribed to its own feed channel. While also being able to publish to the feed of the next Node MCU. Whenever the IR sensor of a Node MCU detects an object, status data ON is published to its own feed and also the feed of the next Node MCU. In order to be able to react to the upcoming vehicle, the status of the IR from the previous Node MCU is reflected onto the next Node feed in order to make the next light ON. To achieve this, each Node MCU has to be subscribed to its own feed, while being able to publish the data to its own feed as well as to the next Node feed.

We are considering the concept of "next" Node MCU assuming these lights are present on roads with two ways, which means direction determination of the vehicle is not necessary.

So, first motion is detected in a Node MCU (say Unit 1) from the IR sensor, which is subscribed to its own feed. The Unit 1 will send the ON signal to the cloud to its own feed and to the feed of next Node MCU (say Unit 2). The Unit 2 is "alerted", i.e., the feed of Unit 2 is made ON which will affect the status of the light of Unit 2, since the Node MCU of Unit 2 is subscribed to its own feed. This pattern is continued down the lane till a junction is reached, in which case all the first lights on each turn of the junction is activated when the IR of the last unit detects the vehicle. When the vehicle turns into a lane the IR of the first Unit in that lane detects motion and the same process is continued.

This way the system works synchronously to detect motion and turn lights ON and OFF accordingly.

V. ALGORITHM

The algorithm can be written as steps as below. Each sub-step represents the block which is executed once the condition is satisfied.

Step 1: Read the IR sensor input
Step 2: If IR input is HIGH
  Step 2.1: Turn ON the light
  Step 2.2: Publish ON to the feed of its own and the next unit
  Step 2.3: Delay (to leave the light ON only for some time).
  Step 2.4: Turn OFF the light
  Step 2.5: Publish OFF to the feed of its own and the next unit
Step 3: If IR input is LOW
  Step 3.1: Monitor own feed
  Step 3.2: If the feed value is ON
    Step 3.2.1: Turn ON the light.
    Step 3.2.2: Delay (to leave the light ON only for some time).
    Step 3.2.3: Turn OFF the light.
  Step 3.3: If the feed value is OFF, go to Step 4.
Step 4: Go to Step 1.

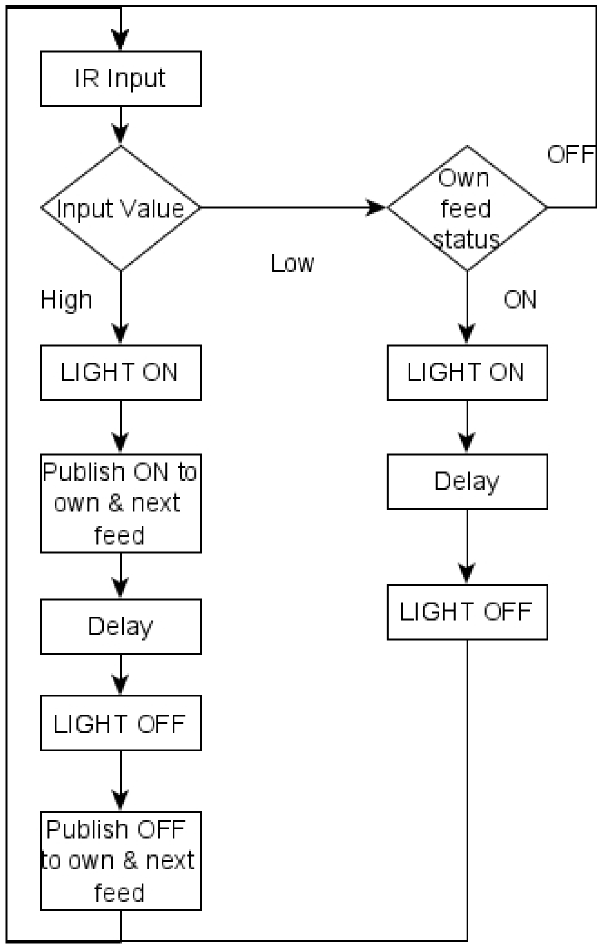

Fig. 2. Flowchart of the System

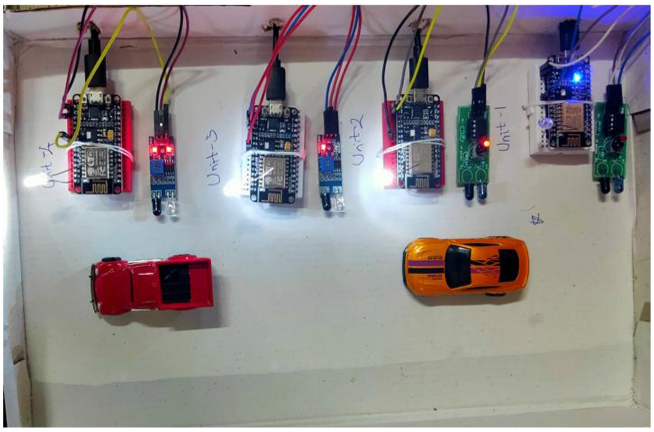

Fig. 4. Two Vehicles near light 2 and light 4 showing changes in light status

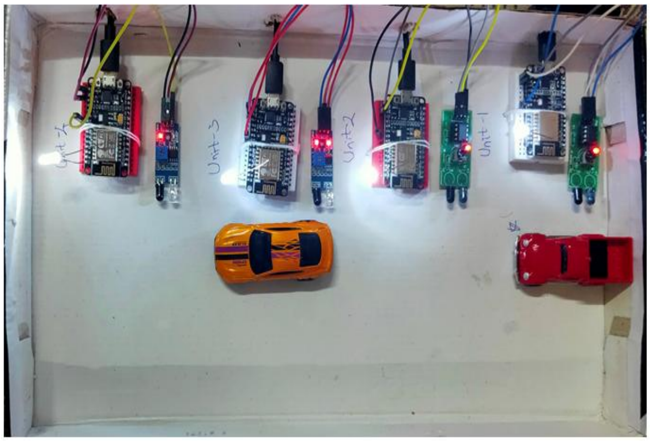

Fig. 5. Two Vehicles near light 1 and light 2 showing changes in light status

VI. RESULT AND DISCUSSION

With the help of this system, we are able to monitor the status of the switches live, on the dashboard as well as the mobile app, which is MQTT (Message Queuing Telemetry Transport) based.

The output of the demo can be seen as follows:

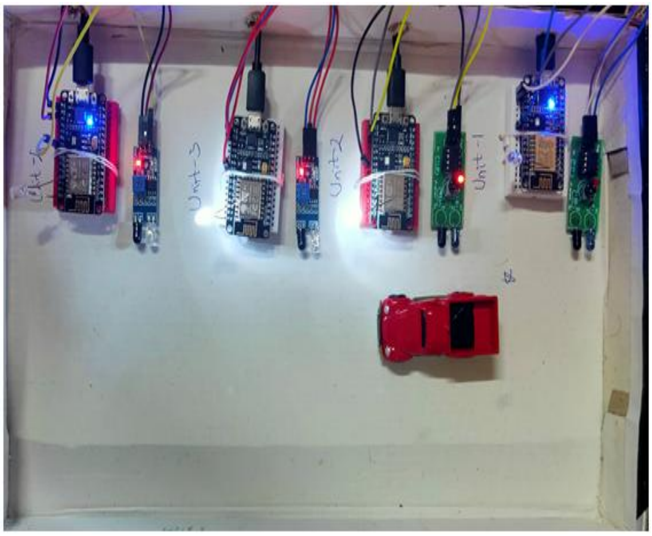

Fig. 3. Vehicle near street light 2 showing changes in state of the lights

The proposed model gives output based on the input from IR sensors of not only its own unit, but also from the IR sensor input from the previous unit in order to turn ON the light before the vehicle reaches the next light for better and safer driving. This is achieved by the status of the switches in the Adafruit dashboard.

Some of the results can be seen as follows:

Fig. 6. Status of switches in cloud as shown by situation in Fig.3

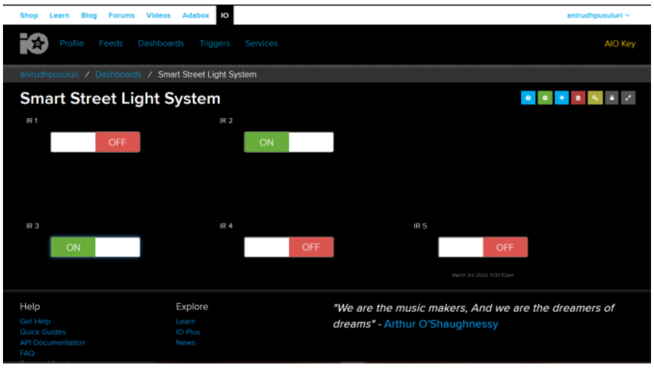

Fig. 7. Status of switches in cloud as shown by situation in Fig.4

The condition of the street lights can be changed as per will, by the management from not only the dashboard of the cloud but also a mobile App – MQTT. The pictures can be shown as follows:

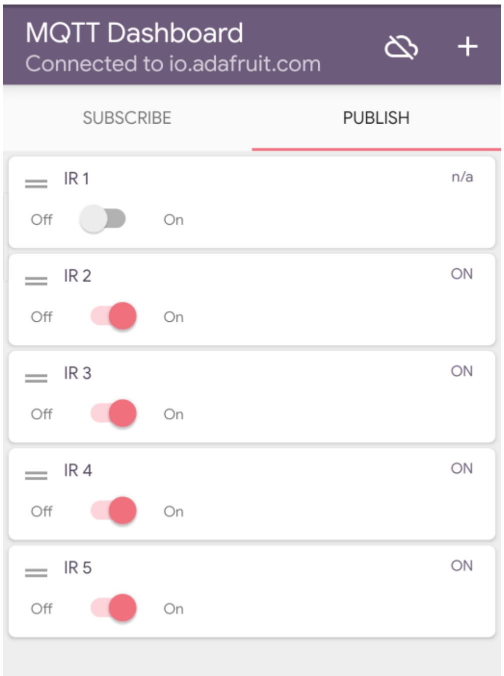

Fig. 8. Mobile app status of switches showing situation in Fig. 4

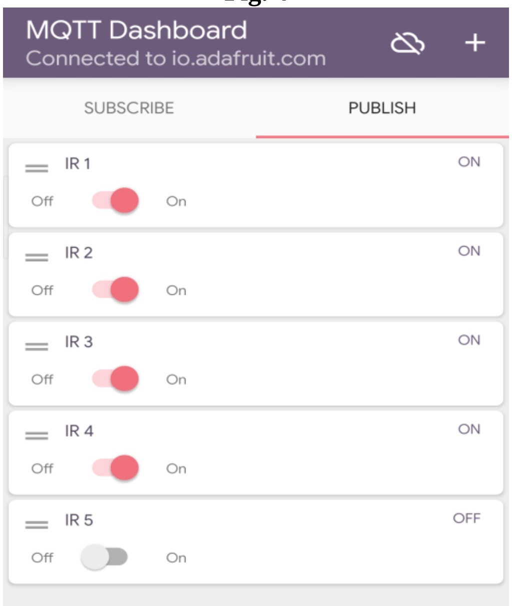

Fig. 9. Mobile app status of switches showing situation in Fig. 5

VII. CONCLUSION

With the help of the Adafruit cloud the smart street light system was made. This was done to not only test the feasibility and viability of the approach but also to learn improvements for it.

The system here is highly dependent on the internet connection. Not having a proper internet connection might lead to some problems. So, designing the system to work efficiently to a certain extent even without proper internet connection is a key factor in this model, which includes having localized decision making for individual light rather than from the status of the cloud switch. This will ensure that the lights are ON when there is vehicle detected but the factor of "safe margin" for driving is limited.

Considering the upcoming technologies, this proposed model can be improved upon. Technologies such as 5G can make this model a reliable one. Also, the dashboard can be improved to make it user readable, using different cloud platforms.

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