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Advanced Park Lightning System with Real Time Fault Monitoring

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Abstract **- The automatic remote switching of lightning system is based on the comparison with the intensity of light and motion of heat emitting objects (living things). This paper discusses the centralized monitoring and detection of faults in lightning system. The proposed model discusses a novel way of advanced lightning system using nRF, array of sensors in Internet of Things ecosystem for unique identification and data transmission and receiving at physical layer. The project has the capability of finding fault in led array used for lightning. The paper discusses the power consumption per head and suggests alternate ways to maintain power supply in the system. Designed with administration perspective and also serves as environmental check by aggregating key environment parameters.**

Index terms – IOT, smart lightning system, MQTT, fault detection, ELK, nRF

I. INTRODUCTION

Fundamentally, the lighting system is one of the imperative parts of a city's foundation where principle work is to lighten city's avenues in dark hours of the day. Present lighting methods are ineffectively planned and are not consistently kept up. In previous times, the population of town and city was less. With the advancement of urbanization, advancement in running systems is also needed. There are a few elements which should be considered keeping in mind, the objective to outline a decent lighting framework. For example, evening time security for group individuals and street clients is to be considered. In present methods, lights are controlled by the manual toggling switch which wastes the labour power. As it is a human task, it is prompt to mistakes also. So there should be some considerations to outline a first-rate avenue street lighting frameworks.

An improved lighting system is required to consummate national standards in terms of safety [7]. It is not only used to establish better safety in the country but also it increases the quality of life. The quality of life is directly cognate to stretching of activity hours. Power consumption is one of the crucial factors of this world because the availability of power is still unreachable to each and every district of the country. Researchers and scientists are trying best to develop an economically stable system and deploy a structure of maximum power efficiencies in the world. So, due to less availability of resources and management system, the consumption of power needs to be much more optimized. Perpetual techniques for the lighting system of parks utilize some inefficient procedures as more than 35 percent of the absolute electrical power is consumed by street and park lights.

Detection of faults is also needed to make the present system more reliable. Generally, faults in the lighting system are unnoticed till they affect badly. So, every time user has to step forward for reporting fault to the authority. Therefore, we need a system which can automatically detect and report that fault to the concerned ascendants. A fault detection circuit is needed to gather the faulty state of the lamps. Malfunctioning of lighting structure is one of the major loopholes in the system because these types of faults are not easily reachable [9],[10]. Automation in park lights will surely preserve the power. In addition, improvements in lighting standards will improve safety conditions of pedestrians. Therefore, this paper highlights the techniques to alleviate human burdens and reduce human errors with effective consumption of power. The street Light system with administration as an stake holder is discussed in the paper. For greater visibility of faulty needs and alarm triggering and management for the same is discussed in a practical approach in terms of data storage (ElasticSearch) ,log parsing (Logstash) and visualization for understanding at a glance (Kibana).

II. RELATED WORKS

In recent years , new research aided by improved technology has been done in improving existing systems for automatically switching light based on light intensity and human detection[3],[4],[5].The array of sensors utilized in previous works include LDR,IR sensor, motion sensor, human (living body)detection. Also a good amount of effort is done in reliable and cost effective relay of information(ZigBee , GSM module,ESP8266 module) through network via centralized and distributed control of nodes in network[6],[7],[8]. The previous work have been devoted on automatic toggling of switch and intensity adjustment .The modern systems are now able to reproduce arbitrary spectra, colour temperatures,

intensities and pivot on smart sensors and actuators incorporating Information and Communication Technologies (ICT)[9],[10],[11]. The mentioned work presents an interoperable smart lighting solution that combines multiple lighting technologies enabling intelligent functionalities[12],[13]. Theses system shift light intensity to increase visual comfort by considering human centric approach. These systems follow the guidelines defined by the ISO/IEC/IEEE 21451 standards and ZigBee Light Link (ZLL) [14] , [15] .The subsequent work have tried employing Computer vision and AI algorithms for object detection and cost cutting. The error detection in array of LEDs is discussed in our previous work[1],[2] and concepts of Dashboarding data is introduced in our previous work.[1]

III. PROPOSED SYSTEM

The system is arranged in three modules based on DNA(Device ,Network Application) which are outlined below:

Device: The device part is arranged in the hierarchical fashion, first objective is discussed ,under it the components used is elucidated and their organization.

A. Automatic switching of lights:

LDR:Switching of lights is to be done according to the intensity of surrounding light detected by using LDR. It is detected by measuring the values of current and voltage to ascertain intensity of light at certain instant of day.

Solar panels :They are not only utilized as an electricity generation sources for the system but also these work as sensing device to sense the intensity of surrounding light. This switching is automated and this decision is made per head, so less data is to be transmitted. The intensity of light can also be varied to save power based on human detection which is elaborated below.

Motion Sensor, IR Proxy sensor unit: Human detection is possible by using sensors which detects motion on the substructure of heat emitted by the body.After detecting motion of the living beings, variation in light intensity is to be governed in order to save power and inform the predecessor and successor nodes(that is immediate nodes) to increase their light intensity as well.

LED: Array of LEDs is used as a lamp for lightning purpose.

Servo: To handle the tilt of lamps to cover a greater radius. This part was introduced as an experiment and gave us good results. But a trade off on deploying extra device is to be decided.

B. Controller:

ESP8266: It is used as a micro-controller and Wi-Fi module for transmitting signals wirelessly. It is discussed in detail in Network part. Arduino/RPi could also be used for greater control as a controller.

C. Fault detection module:

The fault detection module can be utilized to detect fault in the lights by quantifying the amount of current/voltage passed. When faults like open circuit or short circuit occur or even both in LED matrix, this module is capable of detecting the same. Also, the faulty node can be detected remotely by monitoring the status of nRF module in wireless network cluster.

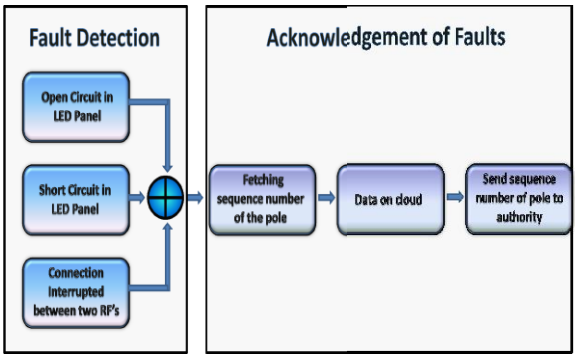

Fig. 1. Fault Detector Module

D. Environmental Conditions:

DHT11 Sensor: The sensor makes use of a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin. It is a low power consumption sensor and capable of transmitting up to 20m thus making a good choice for our system. Single-bus data format is used for communication and synchronization between MCU and DHT11 sensor is necessary.

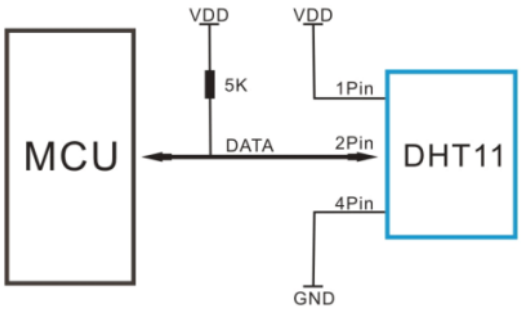

Fig. 2. DHT11 connection block diagram

DSM501 Sensor: It is capable of measuring the presence of fine particles in atmosphere according to PM2.5 and PM10 standards. It does not transmit its measurement directly but instead uses PWM system. The measurements are based on the ratio between the time spent in the high state (+ 4.5V) and the time spent in the low state (0V) and based on the curve AQI is measured.

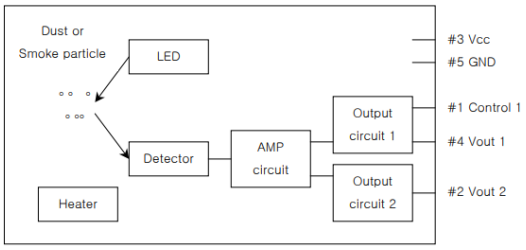

Fig. 3. DSM501 connection block diagram

Network: The intercommunication between nodes and transmitting information over gateway to cloud for centralized analytic capabilities is discussed below.

nRF module: nRF is a radio transceiver chip which works on 2.4-2.5 GHz band. It can be operated as both host as well as station. The power consumption of nRF is even lower a sin le LED. It can transmit up to 125 channels therefore; it can connect with 125 different nodes at the same time.

ESP8266 Wi-Fi module: It is a low cost Wi-Fi Microchip with inbuilt full stack of TCP/UDP .It comes under IEEE 802.11 b/g/n Wi-Fi. It has inbuilt RAM and supports SPI,I2C(for software implementation) and I2S(for interface with output pins) communication with 16 GPIOs. In our system it works as client as well as a master with adjoining nodes connected via authenticated password saved on individual nodes and information transmission is only possible after authentication. It supports WPA/WPA2 authentication,we have used WPA2 authentication for our system.It can store upto 32 allowed device ips with their password for transmitting concurrently. The architecture for Master-Client has been carried from our previous paper[] for secure communication over MQTT(Message Queuing Telemetry Transport).It uses the pub-sub pattern and translates messages between devices, servers, and applications. Along with message, QoS is also sent on a topic(broker) to which client(node) publish and other authenticated node subscribe(other node) on same topic.

Cloud:We made use of GCP cloud to host our application to which the edge(node) transmits data periodically.

Application: This part discusses the storage, log parsing ,aggregation and visualization aspects of system. The centralized view of all nodes arranged in network, real-time monitoring of network status and performance with predictive capabilities is outlined.

ElasticSearch employed as storage is an open source search and analytics tool for all types of data (structured and unstructured).It is built on Apache Lucene and is well known for its simple REST APIs, distributed nature, speed, and scalability, Elasticsearch is the central component of the Elastic Stack, a set of open source tools for data ingestion, enrichment, storage, analysis, and visualization. Commonly referred to as the ELK Stack (after Elasticsearch, Logstash, and Kibana). We chose elastic search for its fast indexing capabilities and an easy interface with JSON type querying supported. It supports textual search using Grok filter. Log Parsing is done using Logstatsh. It is a server side data processing pipeline used extensively for collecting logs from different sources and transforming them. We make use of input output and filters to ingest data dynamically into the system for analyses .The document is updated on the same index. Multiple pipelines are maintained for ingesting different streams of data concurrently. It transforms our unstructured textual logs into structured csv format which are then visualized using Kibana. Kibana provides an interface with the application. The inbuilt charts and aggregation methods are utilized to present a complete picture of the system. We use time series for our visualization. Since time provides an imperative picture and also is later utilized for predictive analysis of fault occurrence in correspondence with time using linear regression (this part is not discussed in the paper).

Alarm and Trigger Management: For alarm management we used alerting plugin(called X-pack) in Elasticsearch. It is based on the breach of a predetermined value by an event on an index. We can select the action to be taken based on the alert.

IV. SYSTEM ARCHITECTURE

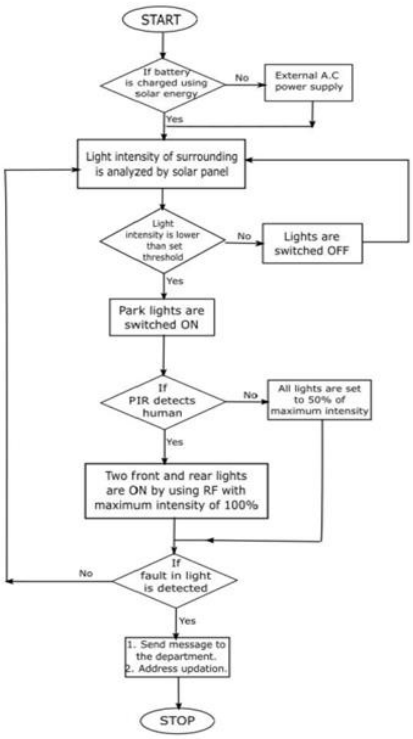

Fig. 4. System architecture and process flow block diagram

The automatic intensity variation of park lights is broadly dependent upon light incident on the solar panel attached to the top of light pole and motion of living beings. The decrease in light intensity below threshold level toggles LED panel to ON state. In addition to this, the solar panel is connected to the system in order to charge batteries of the pole. Failure to which, the external AC power supply will be consumed at the time of usage. For the purpose of intensity variation, motion of living beings should be detected. This can be achieved by installing occupancy sensors like Passive Infrared (PIR) sensors to the individual pole as PIR sensors measures infrared (IR) radiation emitted from objects in its region of view. When the motion is detected near a particular pole, the light intensity of that particular pole, two poles ahead of that pole and two poles behind that goes to the highest peak consuming maximum power. Otherwise, the light panel should consume 50% power of maximum input in order to save energy .Faulty conditions of the LED array panel must be detected by continuously monitoring the state of individual LEDs connected in the panel. Faults must include every permutation and combination of state of LEDs that can occur i.e. open circuit, short circuit, connection loosening, etc. This must be detected and sent to the data collection end. By utilizing gateway and cloud, data of faults can be wirelessly transferred and collected at the centralized hub. Analysis of that data can be done in the ways so as to get updated about faults. Regular servicing of complete arrangements should be done in order to avoid frequent failures. To reduce the consumption of power, solar panels are used with light detecting resistors (LDR). The light detecting resistor is used to quantify the intensity of surrounding light. Solar panels not only convert light energy into electrical energy

but it can quantify the intensity of surroundings also. In this system, lights will be switched ON/OFF only when they are needed. Also, the intensity of lights is variably controlled so as to utilize power more efficiently. The temperature, humidity and AQI aggregated information is also transmitted. The actions are taken at node level and only periodic logs are transmitted over network thus reducing congestion in network. The data once transmitted to the cloud is then further used to analyze and derive insights.

V. RESULT & DISCUSSION

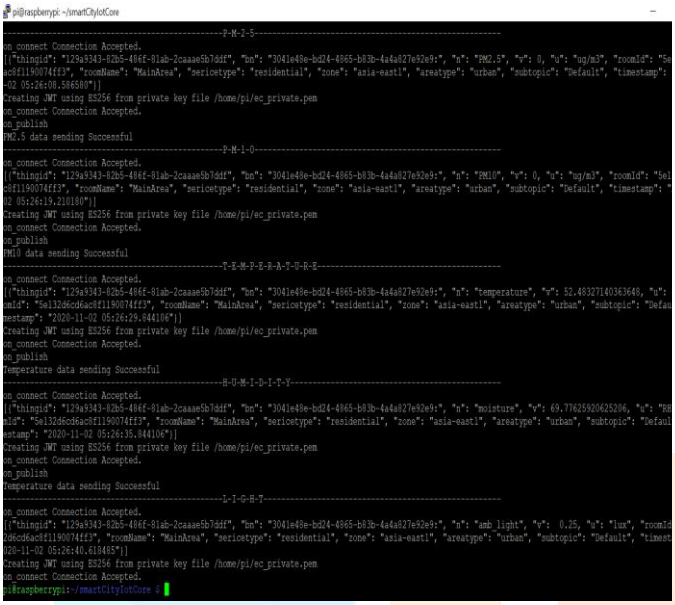

Fig. 5. Sensor value log

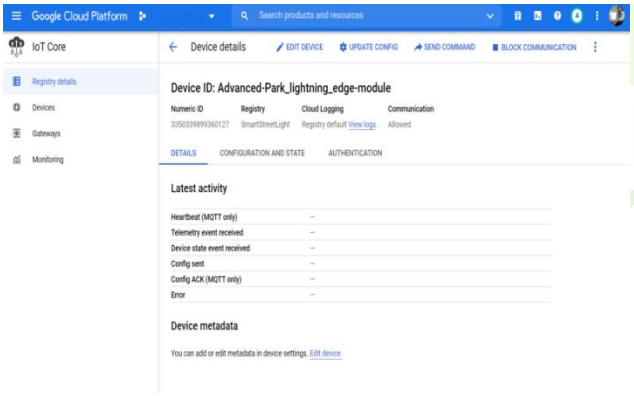

Fig. 6. GCP dashboard and connection overview

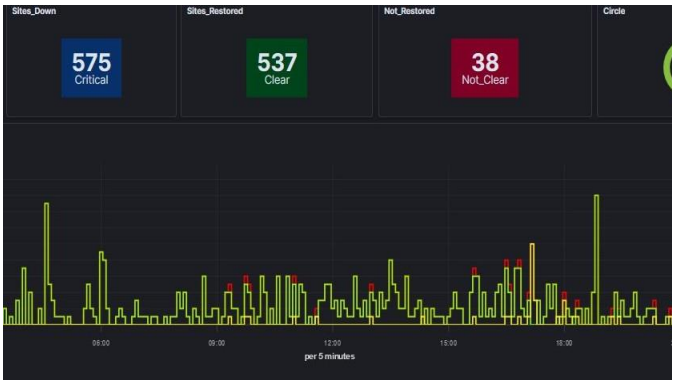

Fig. 7. Dashboard for count of stimulated streetlights in on/off state

VI. CONCLUSION

A smart street light arrangement has been proposed in the paper which is not only capable of toggling lights automatically but also has the competency to vary the intensity of light with respect to congestion of living beings surrounding light poles. It is the application to obtain maximum benefit by utilizing technology in an efficient way. This includes high-efficiency fixtures and automated controls that make adjustments predicated on conditions like occupancy or daylight availability. Consequently, this system will be adequate to announce fault to the authority. The fault might be of any type whether it is due to the open-circuited network or it is due to the closed circuited network. Fault detection and reporting have been proposed in addition to automation which includes continuous real-time monitoring of LEDs' status in the LED panel in order to detect the fault. This system is capable of handling most of the faults which may occur accidentally. In the occurrence of any faulty condition, reporting of that fault with a particular pole number is handled by alarm and triggers management and sends the email to authorized representative. The system aggregates key environmental parameters (such as temperature, humidity and AQI),thereby reducing the need for installing poles for such aggregation in cities and account for viscitude in weather conditions. Additionally, the predictive analysis could be carried out by identifying the patterns and training the model with simple Linear Regression. The future scope of this paper includes installing only the Docker image of model and system intelligence so that more secure network could be maintained .The study of lower latency and higher QoS(Quality of Service) with introduction of EDGE in 5G framework.

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