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Smart Street Lighting System using LoRa For Smarter Kolkata City

Aakriti Mittal, Abhijit Bhowmick

Abstract: ***With increasing population and the corresponding increase in road's there has been a significant increase in the number of street light requirements, thereby, increasing the energy and investment costs [2]. However, with the advancement in technology, many new different energy efficient and smart street lighting solutions approaches proposed. The conventional systems prove to be without purpose on most days as they are manually operated which thus leads to huge amounts of meaningless power and human-power wastage [4]. In this project, I have designed an automated IOT based street lighting framework with integrated sensors and controllers communicating with each other using the LoRa technology which requires low power and cost thereby making the system more secure, cost and power effective solution. The LoRa end nodes(streetlights) send sensor data over the air to the LoRa gateway using LoRa WAN protocol, placed at a maximum distance of 5km. The gateway in turn forwards the data to the cloud server which processes it and communicates with the sensors for required actions.***

Keywords: Smart streetlight, IoT, LoRa technology, Lora WAN

I. INTRODUCTION

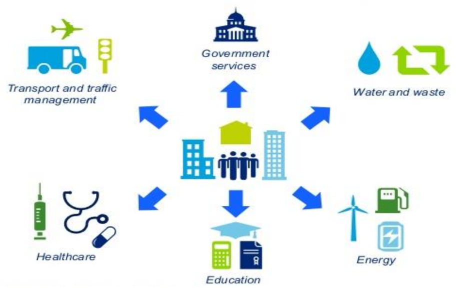

Fig 1: Key areas of focus for Smart Urbanization

The latest trend of global urbanization over the past decade or two, has brought about tremendous technological advancements in the field of automation, and streetlight technology is one of them [3]. According to the English Dictionary, streetlight is defined as a light that is usually mounted on a pole and consists of a series spaced at regular intervals along a street or a highway [2].

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However, it is one of the most expensive but important responsibilities for the Government which accounts for about 10-38% of the total energy bill in typical cities [1]. Thus, there is a dire need for investing in smart street lighting solutions as it will simulate economic and social stability. In addition, improved lighting quality and the expansion of such services would also improve the safety conditions for both vehicle traffic and pedestrians by allowing them a safe travel at night with better visibility [5]. As an alternative to the existing solutions, light emitting diode aka LED lamps have been used for this project as compared to the traditional technologies such as High-Pressure Sodium Vapor (HPS) Lamps and metal halide lights, as it provides considerable advantage in terms of energy efficiency and optical luminescence [6]. To make the entire process secure, standardized and low power and cost effective, I have also used the LoRa technology for wireless communication.

II. SYSTEM DESIGN

The entire system can be broadly classified into four major blocks: LoRa End Node, LoRa Gateway, The Firebase Network and an application system consisting of a website mockup and SMS API. The streetlight with embedded sensors and microcontroller acts as an end node which sends the sensor data signals to the LoRa gateway which acts as a data bridge located at an approximate distance of 5kms which is the practical distance for lossless communication through the LoRa WAN protocol. The gateway then forwards the data packets to the Firebase network via MQTT. The server which is a Python script, then executes the Firebase database queries and stores the data there. Our messaging API system which acts as the end-user application requests for specific logic using set coded logic using the Firebase database and the web pages on the website.

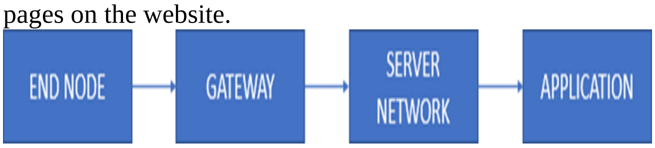

Fig 2: System Diagram [1]

II. LORA TECHNOLOGY

LoRa aka long range is a very new age spread spectrum modulation technique derived from Chirp Spread Spectrum (CSS) technology. It is aimed for the machine-to-machine and IoT market for providing low power, low data rate connectivity, real-time analysis, and additional features like geo-location over significant distances. Its key feature is that it provides end-to-end AES-128 encryption, thereby ensuring data privacy and protection and also significantly reduces upfront infrastructure and operating mode costs [2].

III. HARDWARE SPECIFICATIONS

In this section, I have outlined about the major hardware components utilized for our system design.

A. STM32F1038C8T6 Development Module

STM32 is a family of 32-bit microcontroller which integrated circuits by ST Microelectronics. It consists of a processor core, static RAM, flash memory, debugging interface and various other peripherals. Its key features include low power requirements, up to nine communication interfaces and up to 80 fast I/O ports, which makes it quite versatile for industrial usage.

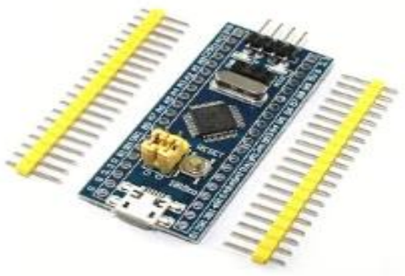

Fig 3: STM32 Module

B. SX1278 LoRa Module

This module is a transceiver which features the LoRa long range modem that provides ultra-long range spread spectrum communication and high interference immunity by minimizing current consumption. It operates at a operating voltage of 3.3V with an operating frequency of 433MHz in India and a programmable but rate of up to 300kbps. It can even send data signal up to a maximum distance of 10 kms which makes it quite efficient for long distance, secure data transfer.

Fig 4: SX1278 LoRa Module

C. ACS712 Current Sensor

This current sensor which can measure both AC and DC current values up to 30A depending on the module. It is a very easy to integrate sensor and provides good isolation from the load. It consists of three pins namely: Vcc (Input voltage of +5V for application), GND (connected to ground of the circuit), Output (outputs analog voltage proportional to the current) and a Wire in and Wire out portion where the wires through the current is connected here for measurement.

Fig 5: ACS712 Current Sensor

D. ZMPT101B Voltage Sensor

It is a voltage transform sensor which is ideal for measuring AC voltage. It has very high accuracy, good consistency for voltage measurements of up to 250V AC. It consists of four pins namely: Vcc (Input voltage of +5V), Out (Output reading), and two GND. It also has two opening namely neutral and phase for the wires of the AC voltage to be connected for measurement.

Fig 6: ZMPT101B Voltage Sensor

E. Light Dependent Resistor (LDR)

It is a special type of resistor having no polarity which can be used to sense light intensity. Its property to change its resistance based on the intensity of light is its key working principle. Its symbol is similar to a resistor with an extra inward arrow indicating the light signals.

Fig 7: Light Dependent Resistor

IV. METHODOLOGY

Our system consists of four major components namely the **LoRa end node, LoRa gateway, Network** and the **application** as shown in Fig 8.

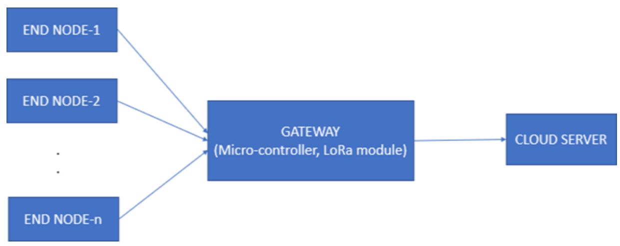

Fig 8: Block Diagram of the project

The node which is mainly the streetlight is embedded with a STM32 microcontroller, ACS712 current sensor, ZMPT101B voltage sensor, LDR and a SX1278 LoRa module as shown in Fig 9.

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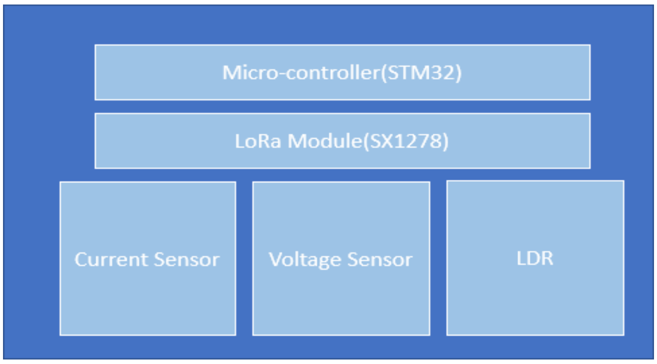

Fig 9: Block Diagram of the End Node

There will be multiple nodes in a single or multiple lane and all of them which are at a distance of 5kms to the central gateway, will communicate with it through the LoRa WAN protocol. The distance of 5km has been selected to ensure practically no data-loss during data signal transmission through the protocol in an urban setting. The sensors in the node continuously sends the data to the LoRa gateway using LoRa WAN protocol. The aggregated data sent by all the nodes consists of the node voltage reading, node current reading and node light intensity reading along with the node address which is unique and acts as a node identification parameter for the gateway. The data signals are then forwarded to the database server which in our case is Firebase Database server, wherein database queries are executed to store in the respective node data in JSON format. This data is also analyzed by the mockup website for any variations in the safe voltage or current data in real-time above the permissible range. In such a situation, in order to centralize and smoothen out the governance and orchestration of maintenance and repair work, a SMS would be sent to the controlling authority for quick governance. The messaging service API used for our project is SMS4YOU, which is integrated with our Python script.

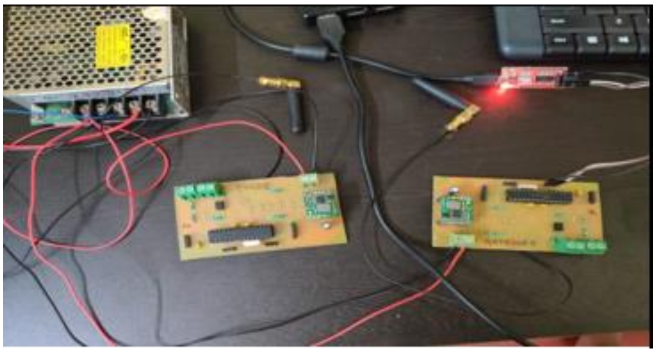

Fig 10: Circuit connection for the system

V. CALCULATIONS

In India, for household applications, the standard AC voltage is set around 220V(AC). The streetlight lamp used for the designing and testing of the project consists of a 60W power rating LED bulb which makes the entire system more energy and cost effective compared to the traditional methods.

We know, **Power(in W)=Voltage(in V) * Current(in A)**

Thus, 60W = 220V * I(A)

So, I = 60W/220V = **0.273A**

This is the maximum current or the safe current for the street light. If a current more than this is drawn by the light, it will fuse and there will be a short circuit.

VI. FLOWCHART

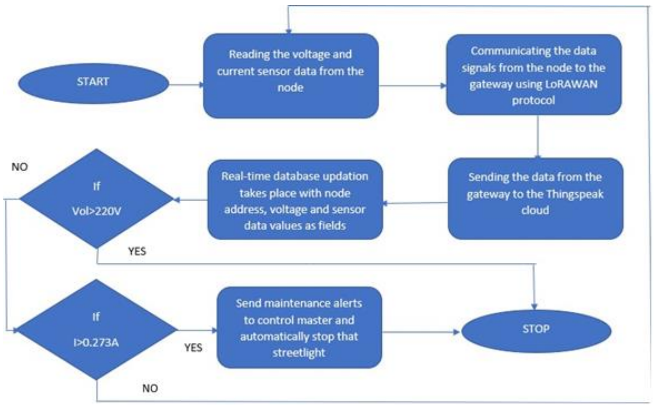

Fig 11: Flowchart of the system

VII. RESULTS

The proper connection establishment between the LoRa node and the STM32 microcontroller is checked as shown in Fig 12. After successful connection establishment, the sensor data is sent to the gateway which ensures lossless error free communication between the nodes and the gateway. For the demonstration purpose, we have taken two nodes which are sending data to the gateway as shown in Fig 13. The gateway then routes all the data and queries the Firebase Database server which results in the data being stored in the JSON format in the database as shown in Fig 14. For improving operational efficiency, there is also a SMS API which sends messages to using coded logic in Python script in case of abnormalities in the sensor data as shown in Fig 15.

There is also, a mockup website whose access will be granted to the control master for real-time analysis of the sensor data for each node as shown in Fig 16.

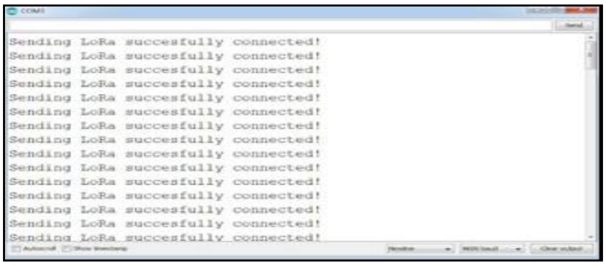

Fig 12: Connection between LoRa Module and MCU

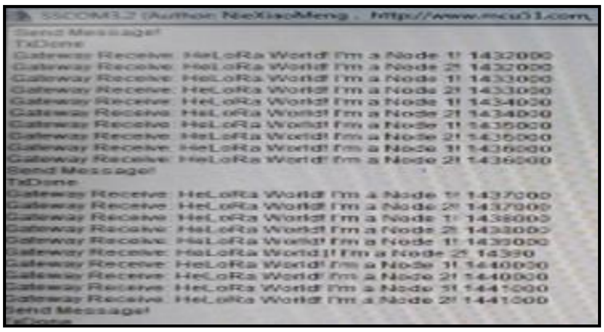

Fig 14: Communication between the node and gateway

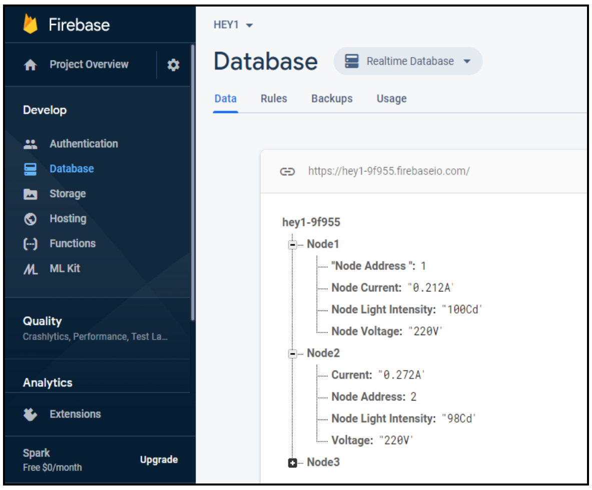

Fig 14: Firebase Database

Fig 15: SMS Alert System

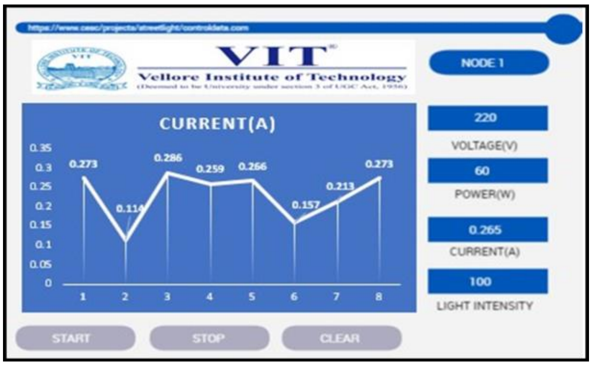

Fig 16: Mockup Website

VIII. CONCLUSION

This paper studied and designed one of the new ways of implementing smart street light system using LoRa wireless communication. The LoRa end node was successfully built and was efficiently communicating with the gateway. However, testing results of LoRa node shows that the coverage range is much smaller than that provided in the data-sheet. However, still undoubtedly, it is better than all the currently existing wireless protocols. The proposed method ensures that the energy and set-up cost wastage in the streetlight gets reduced up to almost 50-60% and all the functionalities get automated for making the streetlights smart [9]. The use of LoRa protocol for communication greatly changes the billing and maintenance and also additionally provides long distance wireless communication. The work can further be extended by applying the LoRa technology for the future of the smart city application together with the Internet of Things. Anti-theft monitoring, Air-quality monitoring, fire detection in the neighborhood etc., can also be implemented by integrating sensors in the streetlight nodes which can open up multiple possibilities for smarter cities and thereby, a better governance system [10]. There can also be further research work for optimizing the location of the gateway and on the analysis of the influence of the weather and other activities in the area that might affect the network performance.

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