International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 11 | Nov 2019 www.irjet.net p-ISSN: 2395-0072

IOT BASED STREET LIGHT MONITORING & CONTROL WITH LoRa/LoRaWAN NETWORK

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Abstract – *IoT is one of the fast growing fields in technology which handles high date in real time applications. IoT leads the market with its ergonomic structure. In this study, two different approaches followed depend on the nature of application. Small areas or confined premises IEEE 802.11 wireless technology is used where all the appliances is connected to a common Wi-Fi network. In the second model like street lamp pole where number of appliances grows only in one direction, instead of wired configuration LoRa used. This study covers the area of energy saving electrical device Surveillance based on IOT along with the help of wifi & LoRa for effective communication between users & control devices LoRa uses radio frequency transmission for data transfer which is free of cost & long range of operation which can replace the wired network infrastructure of higher cost. LoRa operates in different frequency bands 433MHz, 915MHz and 868MHz for different regions*

Key Words: *Electrical Power, LPWAN, LoRa, LoRaWAN, IoT, wifi, network server*

1. INTRODUCTION

IOT meant to transmit data from the devices to master controller through gate ways & existing network structure. IOT market developments and analysis implies that unlicensed and licensed spectrums are essential. IOT system[1]operates with field sensors and data analyzing on the internet which can communicate them to share and transfer information using unique id assigned to every device. Automation plays an important role in the modern society and where IOT along with LoRa can help to fulfill the needs. For the Street lighting & Electrical systems due to the conventional on/off system there is a huge loss of electrical power noted and studies conducting in the area to minimize the power loss by various technology. Mobile based surveillance with web uses IOT cloud server used here for more energy conservation and early resolution in case of any fault detection. Lot of research is conducting in this field to minimize energy loss in remote locations by implementing user friendly applications.

The main idea of this research is to develop an automated and controlled street light according to requirement the roads, pedestrians & Vehicles. A user friendly control system to monitor & control the lighting systems from remote locations with using IOT & LoRa can fulfill the requirements with minimal infrastructure cost by using the existing networks & un licensed radio frequencies. From remote locations, Field Sensor data can be transmitted to the master control stations through LoRa gateways, after reaching gateways signals will be transferred to the User end through existing network server & vice versa. Every gateway forwards the received packet from the end-node to the cloud-based network server via some backhaul either cellular, Ethernet, satellite, or Wi-Fi. Hence the power consumption can be cut down by switching off the circuit when there is no requirement of lighting in particular area.

Successful implementation of IOT & LoRa systems can bring lot of benefits in the fields of Home automation [2], Temperature Monitoring, patient health monitoring, Vehicle monitoring etc.

2. RELATED WORK

A public Street Lights & Electrical system in remote city locations consumes a lot of energy due to the unavailability of control devices due to the large setup cost. Presently most of street lamps turn on the street lights in night and turns off the street lights in day using LDR based control system [3]. Street lamp or Electrical systems still consumes a lot of electricity when there are few vehicles around or no people in the office due to the lack of monitoring and controlling based on the actual requirements [4]. For a wireless control monitoring system each street light must be equipped with different types of sensors that are connected to a microcontroller to monitor its environment with regards to its working needs like light intensity, current capacity, voltage load and temperature which are collected and transferred by the means of radio frequency communication

ESP module and Wi-Fi/LoRa[5] based remote control automatic surveillance system can provides a safe, secure and economical way for indoor and outdoor electrical device control and monitoring. Electricity consumption in remote locations can be minimized using IoT devices with the help of LoRa & Network servers. Sensor data can be transmitted to the master control stations through LoRa gateways, after reaching gateways signals will be transferred to the User end through existing network server & vice versa. Every gateway forwards the received packet from the end-node to the cloud-based network server via some backhaul either cellular, Ethernet, satellite, or Wi-Fi. New design will provide

the option to manually monitor and control through mobile or web based portal. Also by providing feedback of the faulty devices through sensors to the concerned authority to quickly fix the issue may be convenient to the end user.

Table -1: DIFFERENT WIRELESS STANDARDS

Wireless Std	Power	Transmission range	Data Rates
Bluetooth	Medium	1 to 100m	1to3Mbps
Blutooth LE	Lower	>100m	125kbps to 2mbps
LoRa WAN	Low	10Km	0.3 to 50 kbps
NB-IoT	Low	<35Km	20 kbps to 5 Mbps
NFC	Low	>10cm	106 to 424 kbps
sigfox	Low	3 to 50Km	100 to 600bps
6LoWPAN	Low	100m	0 to 250kbps
802.11/Wi-Fi	Medium	100m to Kms	10 to 100Mbps
Zigbee	Low	10 to 100m	20 to 250kpbs
Z-wave	Low	15 to 150m	9.6 to 40 kpbs

Many systems have been developed based on technologies like GSM [6] and Zig bee [7]. GSM modem needs an active SIM to send/receive SMS through microcontroller where Street controller 89C51 is connected to GSM modem through its UART port (Serial Ports).Sim card used in the GSM module has some risk and also the cost impact of developing such system infrastructure is high. Also not all Security algorithm adopted in GSM (e.g. A3, A5) is disclosed algorithms. The researchers have proved that these algorithms cannot prove 100% security. Lastly, every time, the GSM module sends a signal through SMS a minimum balance has to be maintained in each individual GSM module of the connected network using an extra cost impact. Zig bee module is costlier in nature as compared to Node MCU which is very lesser as compared.

NodeMCU Wi-Fi chips are a quite lesser in cost than compared to other contemporary chips which has in built MCU and TCP/IP layer. This is cheap cost, lesser power consumption than other controllers and reliable performance. Several automation systems in Electrical & medical make use of NodeMCU Wi-fi Chips.

The proposed Surveillance and control system in this paper is divided into two categories, premise & one directional Though both the categories have same purpose but differ in the system design. One directional focuses mainly on long distance control like traffic signals which works on LoRa through its Master Controller (Raspberry Pi) [9]. This pi has several input/output pins which are connected to devices. Further pi is connected to Cloudserver to process the data and send information to end user in mobile or web application. On premise uses NodeMCU module to communicate to Master controller over the HTTP protocol through internet to detect the faulty devices in the system

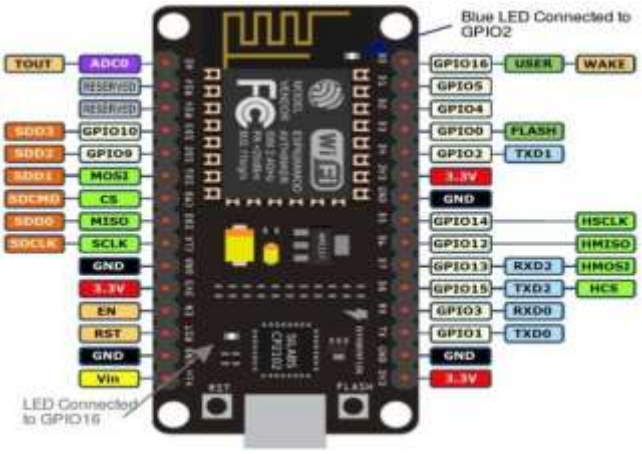
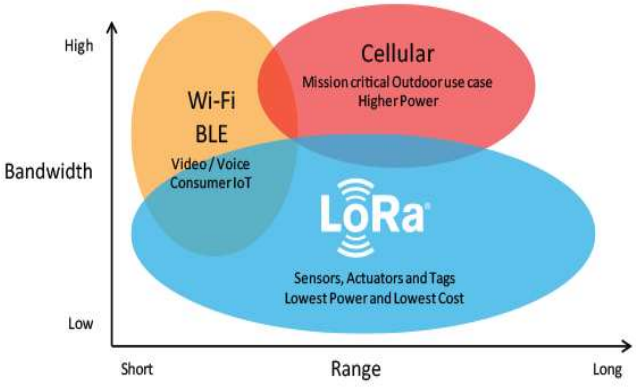


Fig-1: NodeMCU Module

The NodeMCU as shown in Fig.1 has assimilated TCP/IP protocol that can give any microcontroller entrance to the Wi-Fi network that supports 2.4 GHz Wi-Fi (802.11 Wi-Fi standards). NodeMCU is capable of either connecting to an existing wireless connection or hosting an application over http protocol. Each NodeMCU module comes pre-programmed with an AT command set firmware which means one can simply link this up to your Raspberry Pi device and get about like Wi-Fi shield.

3. LoRA/LoRaWAN ARCHITECTURE

The proposal here to make use of LoRa & LoRaWAN[8] to achieve very-long-range transmissions (more than 10 km in rural areas) with low power consumption. Below Graph shows that LoRa achieves long rang communication with less Bandwidth requirements



Graph 1: Range of Different Communication techniques

LoRa as the name implies Long range communication technique which uses radio frequency. LoRa technology can be used for bi-directional transmission of datas in long distances without investing in infrastructure. This property

of the LoRa is used in Control system application as most of the sensor datas transferring are of low bandwidth. IoT solution for field monitoring there will hundreds of Sensors nodes deployed on the field which will monitor the vital parameters and transmits it to the cloud for processing. Sensors should be wireless and should operate on a small battery power so that it is portable. Wireless solutions like RF can send data to long distance but requires more power, while BLE on the other hand can work with very little power but not capable of sending data to long distance. Here LoRa plays a vital role

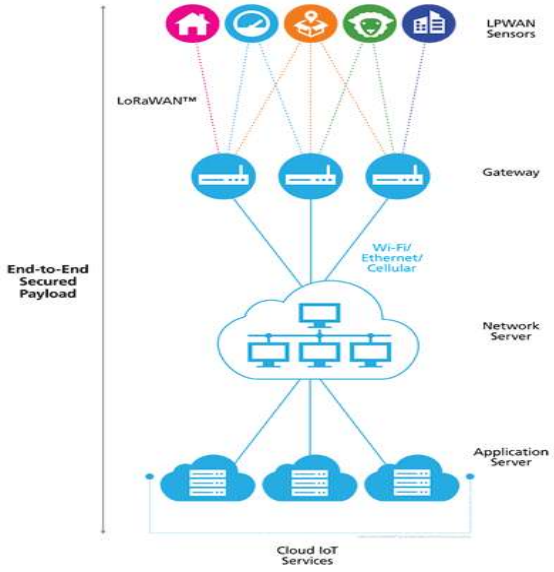
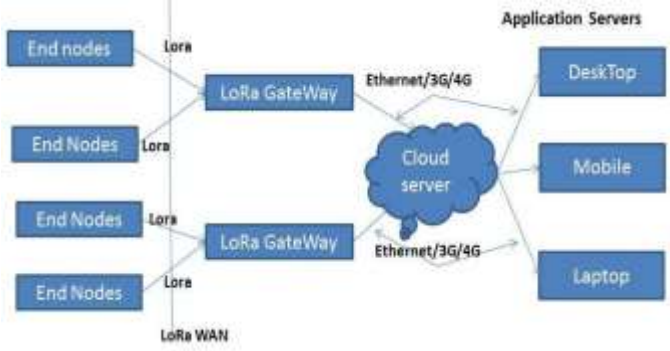


Fig-2: System Overview of LoRaWAN

Fig:2 Explains how LoRa works in a network. Signal from one LoRa Node reached other node through a gate way known LoRa gateway. LoRaWan is a Low power wide Area networking protocol designed to connect IoT devices which requires bi-directional communication. LoRaWAN is the media access control (MAC) layer protocol above the physical layer that defines the communication protocol and system architecture of a device. In short, the network upon which all LoRa devices operates



Block Diagram-1: LoRa/LoRa WAN

LoRaWAN link-layer specification is the same across all regions. Each region may differ in the attributes of the physical layer of the device. Connected devices are not gateway-specific. Consumers can grab any certified LoRaWAN device to perform necessary tasks like filtering out redundant messages and maintaining low power consumption. LoRaWAN, operates with LoRa technology. LoraWAN powers LoRa Alliance member ecosystem to provide a wide range of supplier options from chips to the cloud. Plenty of LoRaWAN devices are already on the market and ready to work with the cloud. Main two reasons LoRaWAN catches the attention of the market: First, it is the strongest technology available for LPWAN applications now. Second, it is widely available and has 100 operators in over 100 countries.

4. SYSTEM OVERVIEW

The LoRaWAN® network architecture is deployed in a star-of-stars topology in which gateways relay messages between end-devices and a central network server. Gateways are connected to the network server via standard IP connections and act as a transparent bridge, simply converting RF (radio frequency) packets to IP packets and vice versa. The wireless communication takes advantage of the long-range characteristics of the LoRa® physical layer, allowing a single-hop link between the end device and one or many gateways. All modes are capable of bidirectional communication, and there is support for multicast addressing groups to make efficient use of spectrum during tasks such as Firmware Over-The-Air (FOTA) upgrades or other mass distribution messages. The capability to receive the same message by multiple gateways increases the network SLA and prevents to manage "hand-over" between networks cells.

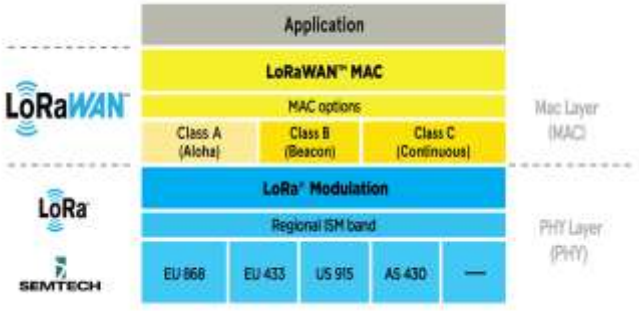


Fig-3: LoRa/LoRa WAN Architecture

Class A stands for Low power Bi-directional end devices. Class B stands for Bidirectional end-devices with deterministic downlink latency. Class C stands for Bidirectional end-devices with deterministic downlink latency. In addition to frequency hopping, all communication packets between end-devices and gateways also include a variable "Data rate" (ADR) setting. The selection of the DR allows a Class A stands for Low power Bi-directional end

devices. Class B stands for Bidirectional end-devices with deterministic downlink latency. Class C stands for Bidirectional end-devices with deterministic downlink latency. In addition to frequency hopping, all communication packets between end-devices and gateways also include a variable "Data rate" (ADR) setting.

AES algorithms are used to provide authentication and integrity of packets to the network server and end-to-end payload encryption to the application server. By providing these two levels, it becomes possible to implement multi-tenant shared networks where network operators not having visibility of the user payload data. Keys can be Activated By Personalization (ABP) on the production line or while Commissioning or Over-The-Air Activated (OTAA) in the field.

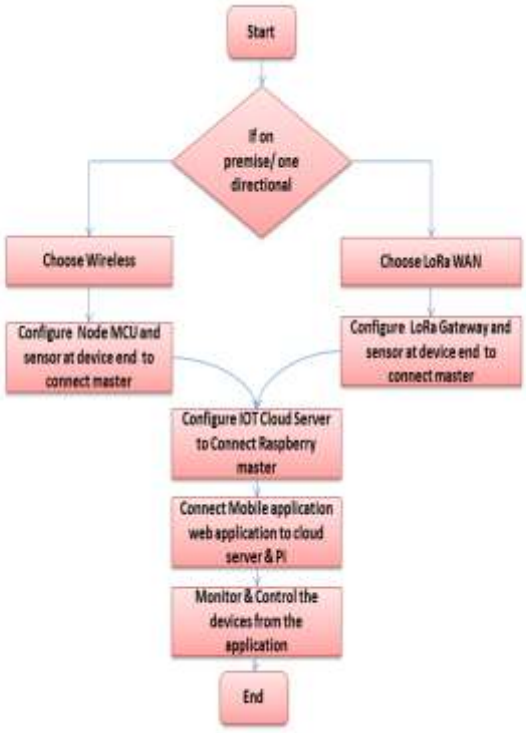
4a. Street Light Control & monitoring using IOT & LoRa

In general working of a regular street light system is to ON the light when it is night and OFF the light when it becomes morning. Further comes a improvement to street light system with a sensor detecting the presence of vehicle/pedestrian so that the light turns ON automatically and turns OFF when there are no road user using the road. But in some cases, it completely may not be successful also. Here when it comes to working of smart street light system, it has a transmitter and a receiver. Where transmitter is almost placed 500m away from receiver, so that first the transmitter detects the presence of road user and sends data to receiver then light will ON and in case transmitter fails to detect the road user the receiver detects the road user by itself and the light will be ON. Then light will go to OFF position when there are no road users using the road.

Fig-4: Street Control with IOT & LoRa Network

Initially the transmitter side of street light system is constructed using Raspberry pi, LoRauart module and Ultrasonic sensor. Firstly Raspberry pi 3 is made to initialized. If Ultrasonic sensor detects the any vehicle or living being then it sends data to Arduino. Here Ultrasonic sensor has an average detecting range of 4m. Then Raspberry pi make the LoRauart module communicate with other LoRauart module on the other side (receiver side). When the LoRa module on the receiver side receives data through LoRa module on the transmitter side then light tend to ON. This is how transmitter does its work

The receiver side of street light system is constructed using Raspberry pi, LoRauart module, Lidar Lite V3, PIR sensor and a LED light. Here Raspberry pi is made to initialize. Here if Lidar Lite V3 or PIR sensor tend to detect the vehicle/ living being then it sends data to Arduino[9]. Here Lidar Lite V3 has detecting range of 30-40m and PIR sensor has 6-8m. Then Arduino tend to make the light ON at the proper time. In case Ultrasonic sensor detects the vehicle before then with the LoRa, light tend ON before.



Flowchart-1: Flowchart of Street Control

5. CONCLUSION

This IOT based device surveillance and control system with LoRa/ LoRaWAN is exclusively used to keep surveillance on the electrical devices working condition and also to control the on/off functionality from a central remote location. The designed system works efficiently for both indoor and outdoor lighting. On the one hand it improves efficiency of the system by sending alert signal in case of any defect and on the other hand it drastically reduces the electric energy consumption by providing central control over the appliances. The graphical App based mobile controlling gives a user friendly and easily accessible platform to the user. This system can be installed as energy

efficient system to control street lamp that requires a lot of energy and needs manual intervene

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