IOT based Electrical Device Surveillance and Control System

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***Abstract*—with every enhancement in Internet in terms of speed and bandwidth, IOT (Internet Of things) is taking the market on a new node and knocking the door with new opportunities of inventions.This paper talks about an energy saving electrical device Surveillance and Control system based on IOT.A large amount of energy is consumed by lighting appliances, so making improved efficiency and quick fault detection is a significant challenge.In this work, two different model approaches is followed depending on the nature of application.For 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, wired configuration is used to avoid range issue.**

Keywords—Street light; Traffic Signal, Signal Control; Wireless Communication; IEEE 802.11; Node MCU; ESP8266;Energy efficiency; Node Red; Raspberry Pi; MCP23008;

I. INTRODUCTION

IOT is system of related sensors, computing and digital devices spread across the globe over the internet which can communicate amongst them to share and transfer information using unique id which is assigned to each and every device, as UIDs (Unique Identifiers).With the growing of different commercial premises and societies, the focus to automate these premises have increased drastically. Also the growing traffic mess in the cities has pushed everyone towards a better and more reliable electrical control system. A user friendly web application and mobile based surveillance & control system connected to IOT cloud server is used here formore energy conservationand early resolution in case of any fault detection. In this new growing era where smart cities are taking into shape, the effort for optimal energy based traffic signal and light control system has gained pace. So effort has been taken to provide a reliable and user friendly application for easy to use and monitor the electrical devices.

II. APPLICATIONS OF IOT

IOT has great application in many of the fields, for example:

1) Smart Exam based on IOT to access student difficulty and disability to attempt exam questions [1]. This system allows analyzing the ability of student to understand a given topic or subject area

2) Patient health monitoring application from remote place based on IOT [2].

3) Now days, vehicle monitoring system is developed to get the live feedback of vehicle movement and track its performance [3].

IOT has also given opportunity for criticizers for an open debate on security on using IOT, as it transfer data into an open cloud system. Proper care and precaution needs to be taken in order to implement IOT [4].

III. LITERATURE SURVEY

ESP module [5] and Wi-Fi based remote control automatic surveillance system is intelligent and provides a safe, secure and economical way for indoor and outdoor electrical device control and monitoring.

Majority of the street lamps have used LDR based control system [6] which turns on the street lights in night and turns off the street lights in day. Street lamp or the on premise light system still consumes lotof electricity when there are few vehicles around or no people in the office, as the new design is better in providing the option to manually monitor and control through mobile or web based portal. Simultaneously, providing feedback of the faulty devices through sensors to the concerned authority to quickly fix the issue may be convenient to the end user.

Many systems have been developed based technologies like GSM [7] and Zig bee[8]. GSM modem which needs an active SIM to send/receive SMS through microcontroller. Here the street controller 89C51 is connected to GSM modem through its UART port (Serial Ports).Sim card used in the GSM module may be compromised with certain risk and also the cost of developing such system is quite high. Securityalgorithmadopted in GSM (e.g. A3, A5) is all not 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. So there is an overhead maintenance cost included. Zig bee module is costlier in nature as compared to Node MCU which is very lesser as compared.

Severalarchitectures have been developed to implement wireless system. Comparison chart is given in Table I.

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TABLE I. DIFFERENT WIRELESS ARCHITECTURE

Criteria	Different Wireless				
	NodeMCU	***ZigBee***	***802.11 (Wi-Fi)***	***Bluetooth***	***IR Wireless***
Data Rate	Max. 300 kbps	Max. 250 kbps	Max. 54 mbps	Max. 25 mbps	Max. 4 mbps
Range	225 meters	10-100 meters	32 meters indoor and 95 meters outdoor	5-30 meters	10 meters
Networking Topology	Ad-hoc	Ad-hoc	Point to hub	Ad-hoc, very small network	Point to Point
Frequency of operation (Ghz)	2.4	2.4	2.4 5	2.4	800-900nm
Complexity	Low	Low	High	High	Low
Power Consumption	Very low	Very low	High	Low	Low
Security	WPA/WPA2	128 AES		64 and 128 bit encryption	

NodeMCU Wi-Fi chips are a quite lesser in cost than compared to other contemporary chips. This chip ismanufactured by Chinese company [5]which has in built MCU and TCP/IP layer.The key focus area of this is cheap cost, lesser power consumption than other controllers and reliable performance. There are various application of NodeMCU like home automation, electronic product and medical equipment.

The proposedSurveillance and control system in this paper is divided into two categories

1) On premise

2) 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 wired communication through its Master Controller (Raspberry Pi) [9]. This pi has several input/output pins which are connected to devices. Further pi is connected to Cloud server 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.

TABLE II. NODEMCU AND WI-FI COMPARISION

Criteria	NodeMCU and Wi-Fi Comparison	
	NodeMCU	***Wi-Fi***
Standard	IEEE 802.11 Wi-Fi	IEEE 802.11 series
Network type	WPAN(Wireless Personal Area Network)	WLAN(Wireless Local Area Network)
Frequency Band (GHz)	2.4	2.4 and 5
Channel Bandwidth (MHz)	1	[0.3, 0.6, 2]
Data rate	upto 250 Kbps low data rate	upto 54 Mbps using 802.11a/g
Distance coverage (Meters)	200	30 to 100
Managed by	IEEE	wifi alliance and IEEE
Data protection	16 bit CRC is used	32 bit CRC is used
Applications	Industrial Automation, Medical Equipment	ExtendInternet connection in office or home
ESPchip manufacturers	Espressif Systems	Redpine, broadcom
Number of RF channels	1 (868MHz band), 10(915MHz band), 16(2.4GHz)	14 (2.4GHz band)

Here for this project I have used Raspberry Pi as a Master controller for its slave (electrical device). Raspberry Pi Model B specification [10] are ATmega328 microcontroller, input voltage 7 to 12v,DC current 40mA, operating voltage at 5v, 20v limit of input supply voltage, 40 GPIO pins, 32Kb flash memory. Raspberry Pi can be powered through USB connection or external power supply, with the range 7 to 12

volts. Raspberry Pi has input and output pins which may be used as power source for various device. A Software Serial library allows for serial communication on any of the input/output digital pins. The Arduino provides an IDE for programming the Raspberry Pi board, this Arduino IDE can be downloaded from the Arduino official website which is license free. This IDE is supported for every product of Arduino components.

Fig. 2. Raspberry Pi- Microcontroller development board

The GPIO pins are further expanded using multiplexer MCP23008. This comes handy in case where hundreds of street lamps need to be connected to Master Controller raspberry Pi.

Fig. 3. MCP23008 Multiplexer

Master controller is connected via Cloud serverto Mobile application with graphical representation or a Web application which can accessed from anywhere. The application is developed using Node RED. Node Red provide feature to drag and drop connection to connect different devices on application. This help in speedy development of the application.

IV. SYSTEM OVERVIEW

As mentioned earlier the whole system is divided in two categories.

On premise System: - Fig.4shows the block diagram of proposed ESP module based surveillance and control system. It consists of street lamps, sensors to detect flow of current, relay to control the on/off of the device and a 5 v power supply converter and node MCU at the slave end (electrical device). Sensors are used to control electrical appliance and send the analog signal of the environment to the system and perform the related task. Master end consists of Raspberry Pi 3 controller connected to Internet connection. The purpose of microcontroller is to take the data from all the street lamps through Wi fi connection and convert them into serial communication. The signal is transferred through the sensors to NodeMCU which in turns transmit the signal wirelessly to master control terminal. Master controller detects the signal and perform appropriate task in case there is detection of failure of street lamps. The transmission system comprises of NodeMCU at electrical device end which receives information though sensors attached to the device. At the other end, master controller (Raspberry Pi) which receives information wirelessly and send the data to a central monitoring system. Web application presents thegraphical representation of the received data from the electrical devices.

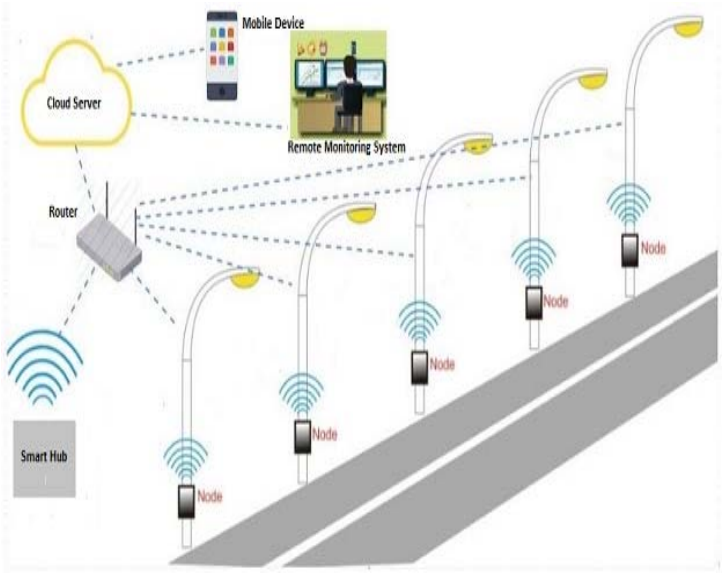

Fig. 4. Block diagram of Wi-Fi based survilience and control system (On Premise)

One directional: - This is the case of traffic street lamps [11] which grow in number in one direction. So this is different from the on premise as here we have challenge of communication range. As wireless connection range (router or Node MCU) is in meters, so it is not possible to use in cases where Wi Fi connection is require in Kilometers. Moreover, to make the system reliable wired connection is used to connect Master Controller Raspberry Pi to the street lamp device. This Pi is turn is connected to Cloud server and web application. - Fig.5 shows the block diagram of proposed surveillance and control system for one directional system.

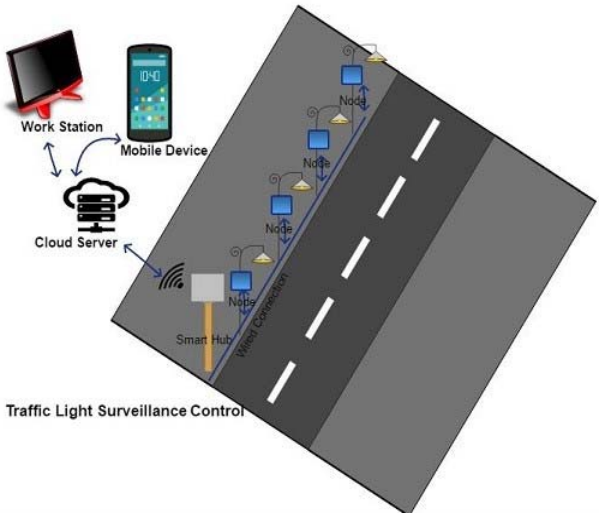

Fig. 5. Block diagram of Wi-Fi based survilience and control system (One directional)

A. Master Controller: It acts like brain for the whole device control and monitoring system. Raspberry Pi receives and transmits signals to and fro slave nodes over wired connection. At the same time it sends the feedback to a central monitoring application for visual display of the status of different electrical devices.

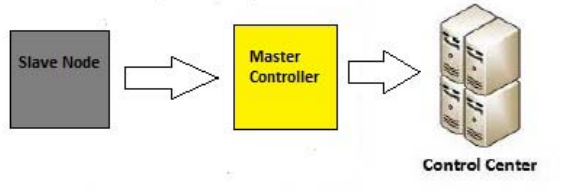

Fig. 6. Receiver Block Diagram

B. Slave Node: Each lamp controller is connected to master controller to send and receive information about the status of the device. Based on the current sensor detector which is connected to electrical device, signal is send to the Master controller about the working status of the device. If any signal is send from the master to the slave then the relevant action is performed based on the data received.

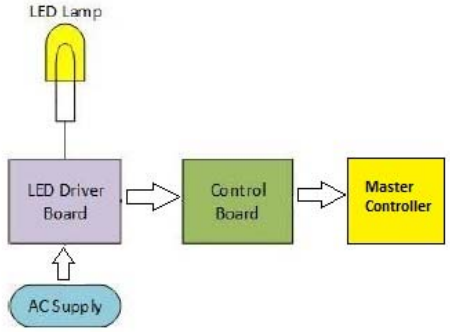

Fig. 7. Transmitter Block Diagram

C. Web Application: Web application is used to display the status of the electrical device in a user friendly way. User can also send signal from this web application to the device so that it can be controlled remotely. This application can communicate with the master controller via HTTP protocol.

D. Software used:AVR studio and Node Red are the two development tools that are used in this project. Embedded level programing is done through AVR studio and Node Red is used to develop web based application.

V. ALGORITHM

Algorithm 1: Controlling Electrical device from Web application
Notation Pub: Publisher Sub: Subscriber
Trigger: Switch on the lamp from web application
1. MQTT server on Raspberry Pi controller receives message from web application through Subscriber (Sub) message.
2. Pi reads the message for the client id of the target electrical device
3. Node Red (pub) finds the client id of the target device and publishes the message to particular device over Wi Fi signal

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Algorithm 2: Sending fault alert from Device to web application

Notation

Pub: Publisher

Sub: Subscriber

Trigger: Send fault signal from device

1. ACS712 current sensor senses the fault in electric current flow and alerts the Node MCU (Pub) to publish message to Subscriber for the fault.

2. Master Controller Pi receives this message from device over HTTP protocol using MQTT message.

3. Controller then sends the fault signal to other Subscriber over HTTP protocol.

4. Web application receives this fault signal and displays on the web portal.

Flowchart of the algorithm for the system is as depicted in Figure 8:

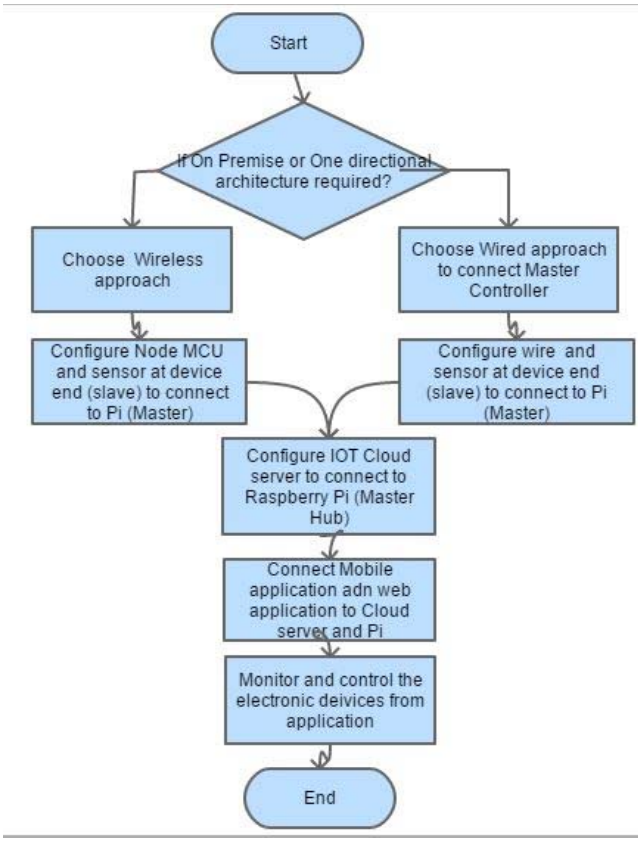

Fig. 8. Flowchart of the algorithm

VI. CONCLUSION

This IOT based device surveillance and control system 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.

Future Scope

The system can be further used to enhance to monitor the complete traffic system like:

- Reading Number plates of vehicles: - MATLAB or Open CV can be used to further enhance this system to automatically read Number plates of Vehicles.
- Challan the vehicles for over speeding :- In case of traffic violation or over speeding, challan can be automatically issued via camera monitoring and recording clips can be saved for future reference.
- Trespassers detection: - Trespassers can be traced if found guilty.
- Real time deployment of sensors to design and implement HMIS[HealthCare Management Information System]
- Live video feedback to traffic control center: - Live video streaming can be screened on to the application to a central monitoring team.

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