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Web Based Management Structure for Smart City with The Model of Smart LED Streetlight Structure

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ABSTRACT

Smart LED streetlight structure helps both vehicle users and pedestrians by providing low cost and low power outdoor lighting. For personal area networks, to provide low power digital radio signals, an open global standard named ZigBee is used. Smart LED's are used to increase energy savings and to provide better maintenance. For a creative LED streetlight application, ZigBee based wireless sensor modules are used. Proposes a combination of public weather data alertness, ZigBee based wireless communications and vital web-based management structure for the smart LED streetlight system appropriate for smart city. Central web server design is considered that receives weather information from each LED streetlights and facilitates flexible web interface for approved users. Real-time execution of the proposed structure shows flawless transmission-reception parameters like throughput and signal strength, which satisfies the wireless communication area and quality of the signal between each LED streetlights.

Keywords:LED, smart city, smart streetlight structure, wireless sensor networks, web server, wireless communication, ZigBee

1. INTRODUCTION

THE streetlight technology plays a major role in the development of smart city. LED (Light Emitting Diode) is a light source which is mainly used for indication and illumination [1]. To improve the safety of pedestrians and drivers, Streetlights are used to provide light at night-time to the streets and to avoid accidents. An LED streetlight uses light emitting diode as its light source. LED streetlights have advantages such as low energy consumption, longer lifetime and more accurate colour rendering [1]. LED streetlight also yields minimum heat, which makes the physical model simpler and is eco-friendly. To bring an extensive energy savings, streetlight LED lamps are made smart using web-based management system.

Emission of blue light in LED's can be minimized and can be measured using Correlated colour temperature(CCT) [2]. CCT provides a raw measure of the balance of energy in a spectrum, with lower values signifying relatively less blue content. For building a user-friendly platform for smart cities, the use of weather data aware CCT based smart LED's are used [2]. Wireless Sensor Network is a set of specialized transducers that includes communication infrastructure for monitoring conditions at diverse locations.

ZigBee is managed on IEEE 802.15.4 specification and is used to build networks that require a lower data transfer rate, energy efficiency and secure networking [4]. Smart city makes use of different types of electronic data collection to effectively manage resources. It provides various facilities such as smart health, smart building and smart streetlight system [5]. Flexibility is provided through remote access for avoiding blind spot traffic accidents. Smart LED streetlight system provides more efficient, simple Remote Mirroring. Remote mirroring usually takes place between storage arrays, for providing data protection. DALI (Digital Addressable Lighting) protocol has been proposed for controlling LED Streetlights. DALI network is made up of controller and slave devices that have DALI interface. Responsibility of controller is to monitor and control each device bi-directional exchange of data [6].

2. PROPOSED SYSTEM

Streetlight systems are established on different areas. Each Streetlight group includes several Streetlight Group Members(SGM's) and one Streetlight Group Coordinator(SGC). SGC is used as Network coordinator and these streetlight systems are connected in Tree Topology. SGC also behaves as Gateway streetlight Web Server(SWS) and Streetlights. SWS issues the web-based user interface for the authorized user. SWS acts as storage medium for storing all data from Streetlights [1]. By using the user interface, the authorized user can introduce requests to a particular streetlight. Fig 1 depicts design of smart streetlight system.

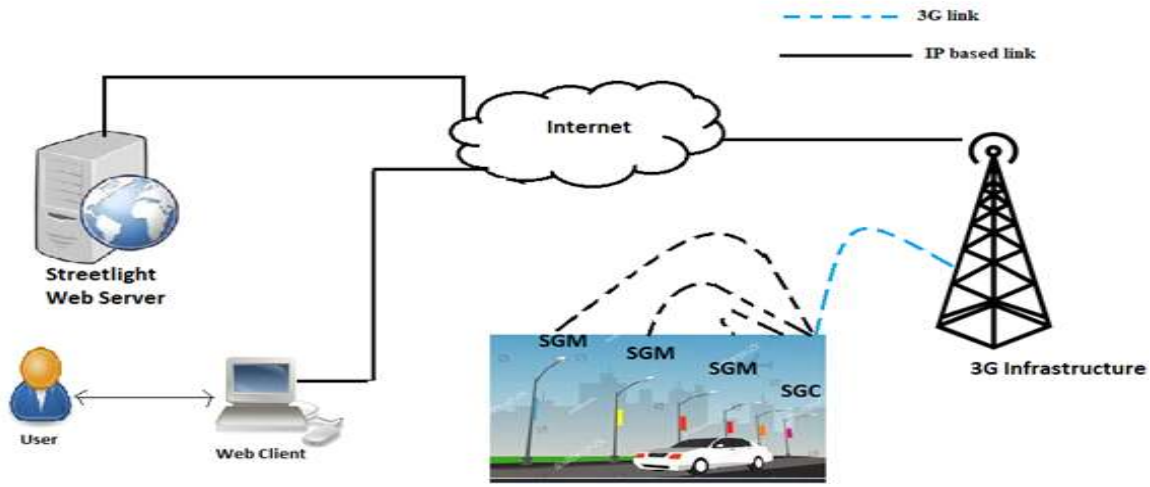

Fig 1: Smart Streetlight System Design

Zigbee network is used for communication between streetlights. Zigbee was initiated by ZigBee Alliance and is a wireless communication protocol [5].ZigBee Networks are mainly used for home automation such as smart lighting, smart energy which are mainly used with low bandwidth. ZigBee network consist of:

- **ZC:** Takes care of security keys and access which acts as Trust Center and stores information on the network. Example include modems of Assured systems.

- **ZR:** ZRs can execute a function within the network and also receive and forward data to and from other devices on the network. Examples include water meter, reading usage.

- **ZED**: ZED executes a function for an application. It can accept and respond to its coordinator. This link allows the node to preserve its battery life. Example include Light switch.

One form of ZigBee network is Star, which consists of one coordinator that manages several end nodes [6].

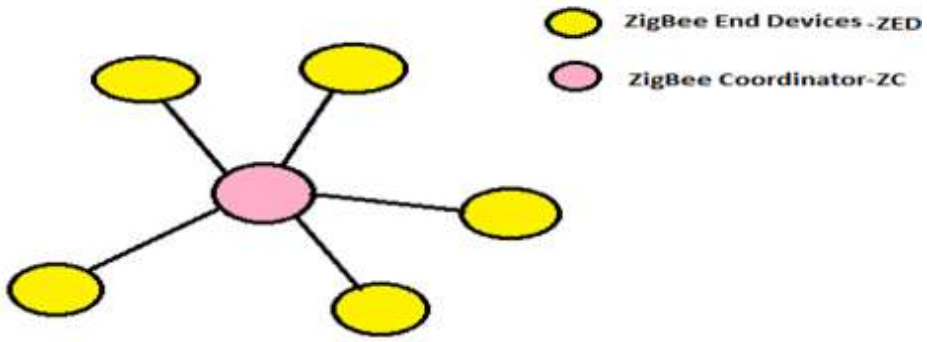

Fig 2. ZigBee Network- Star

Second form of ZigBee network is Cluster Tree, where parent routers have children end devices connected to the coordinator. Hence, this family becomes a cluster.

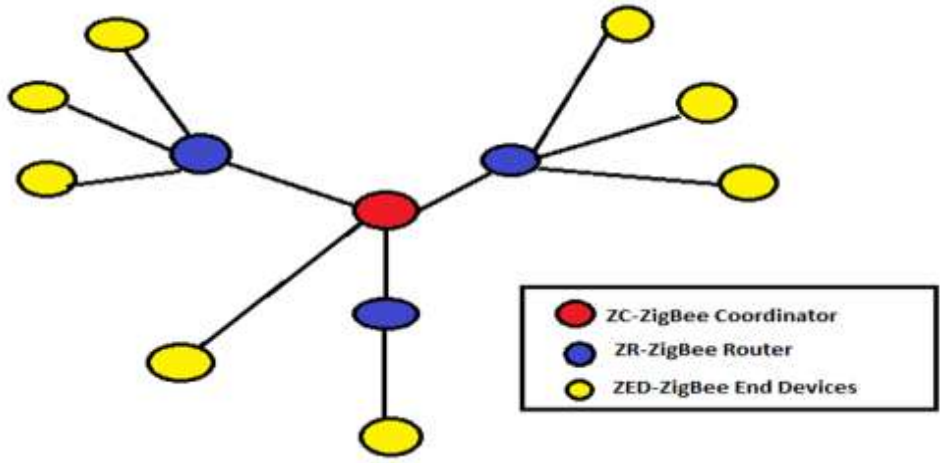

Fig 3. ZigBee Network- Cluster Tree

2.1 ZigBee Protocol

ZigBee is a high-level communication protocol used for creating personal area networks for home automation.

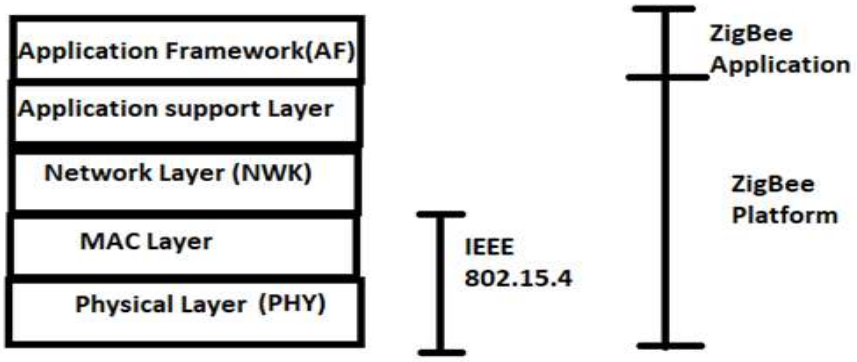

Fig 4. ZigBee Protocol

ZigBee Protocol consists of following layers:

- **Physical Layer:** Performs modulation and demodulation operations on transmitting and receiving signals.
- **MAC Layer:** Concerned with reliable transmission of data along with Carrier Sense Multiple Access with Collision Avoidance(CSMA).
- **Network Layer:** Responsible for network associated operations like network setup, routing.
- **Application Support Sub-Layer:** Provides the services mainly for ZigBee device and application objects to interface with network layers.
- **Application Framework:** Key value pair and generic message services are the two types of data services. Key value pair is responsible for getting attributes. Generic message services are a developer defined structure.

2.2 Transmission of data between Streetlight and Server

SGC acts as gateway for every streetlight to communicate with SWS. Every streetlight group is provisioned with 3G module in SGC. 3G module takes care of downlink and uplink data rates to support High-Speed Downlink Packet Access(HSDPA) protocol. Transmission Control Protocol/Internet Protocol(TCP/IP) is used for transmission of data packet from SGC to SWS [6]. At the start, every streetlight group establishes connection to SWS from each SGC.

2.3 Streetlight System Components

The smart streetlight system includes LED lights, brightness sensors and motion sensors. The lights are equipped with automatic switching on or off of the streetlights as and when the pedestrians pass by. Figure 4 depicts the components used in smart streetlight system.Components include:

- **Lamp Unit:** This unit includes power-adjustable LED's, motion sensors, communication device such as ZigBee module and the controller. Motion is detected for few minutes by sensors. If no motion is detected in particular area, then it turns off or reduces brightness to save electric power.
- **Sensor Unit:** This unit includes motion sensor, communication module and the controller. When the motion is detected, it sends out the message to other units. It is usually placed at house gates, at house fence and at electric poles to make sure that streetlight turns on before pedestrians or when vehicles notice the lights.
- **Access point:** This unit includes communication unit and the controller. It is mainly used when the distance between lamp and sensor units are too large.

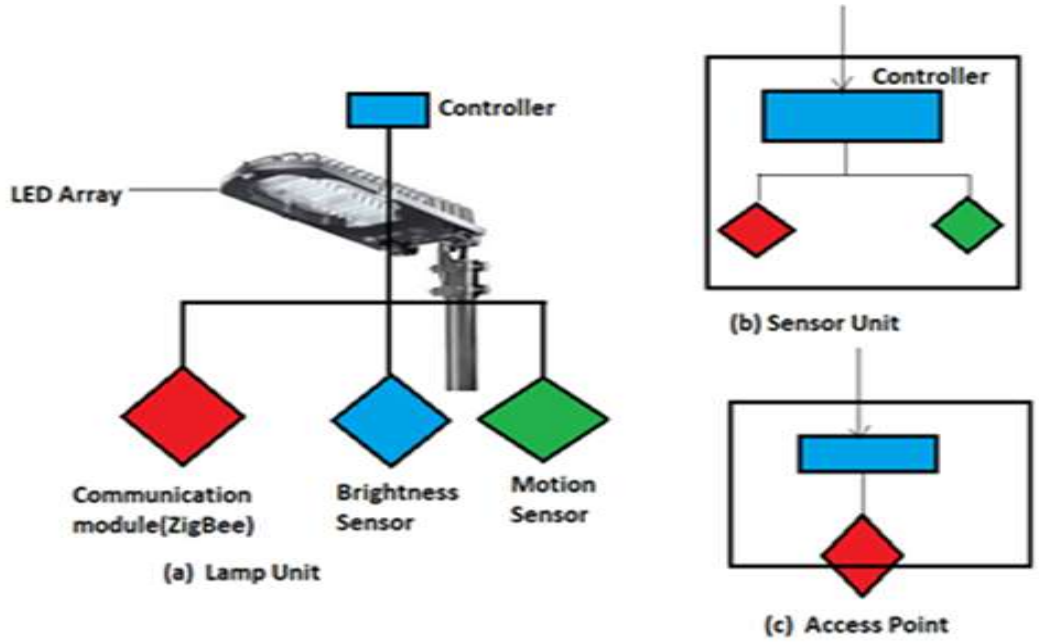

Fig 4. Components of Streetlight System

In streetlight system, every streetlight can be controlled by SWS. To control a streetlight, SWS will send a request to the streetlight system. Firstly, SGC receives the request and is processed. SGC gets data from its sensors and then sends the data to SWS [7].

SGC will send the data packets whenever the timer goes off. When data is received from its sensors to SWS, then it resets the timer. SGC will directly forward the data periodically to SWS, when SGC receives a request that has been forwarded by SGC.

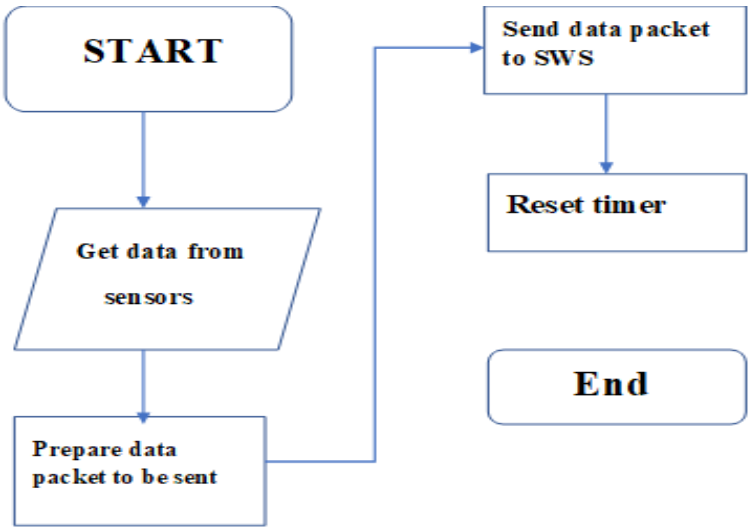

Fig 5. Flowchart of SGC when the timer goes off

3. Proposed Streetlight System Design

Fig 5 shows the block diagram of smart streetlight system. It consists of a central MCU (Microcontroller unit) that is responsible for storing larger program. MCU operates with a frequency of 16MHz. MCU design is based on architecture such as RISC (Reduced Instruction Set Computing) and is responsible to improve the power usage [1].

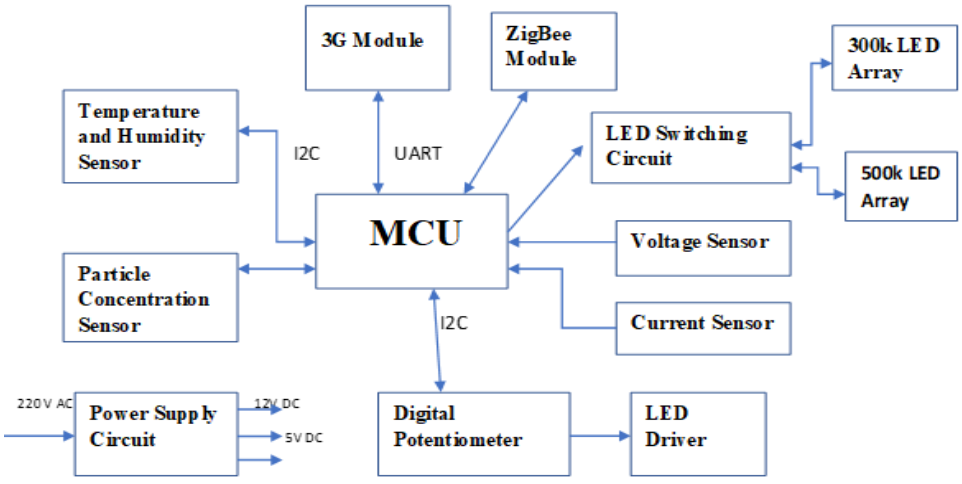

Fig 5. Block Diagram for Proposed system

To control the streetlight platform independently, 300k and 500k LED array are combined with separate power line. ZigBee module is used for communication among streetlights and 3G module is used for communication with SWS from SGC. Universal Asynchronous Receiver/Transmitter (UART) interface provides interface

where communication modules are connected to MCU [6].Voltage and current sensor are designed from the combination of resistors, capacitors, which are mainly used to measure the voltage and current of LED arrays.

4. MVC Architecture

SWS is developed using Java application based on Tomcat 8. SWS is equipped with database to record all the data, which is managed by MySQL. The purpose of SWS include:

- To accept sensors data from streetlights
- To accumulate all data in databases
- To issue web interface for authorized user
- To transmit control request from authorized user to the streetlight group
- To seek weather information from several APIs

MVC architecture is based on a server design pattern that splits all software parts inside the server. It includes:

- **Model component:** Consists of java objects that is used to update database directly or seeking data from database for providing dynamic content to client.
- **View component:** Includes Java Server Pages (JSP) to issue static content when requested by web client.
- **Controller component**: Includes servlet container, where servlets are responsible for translating the request from client to a particular operation, which can invoke java object to update the database.

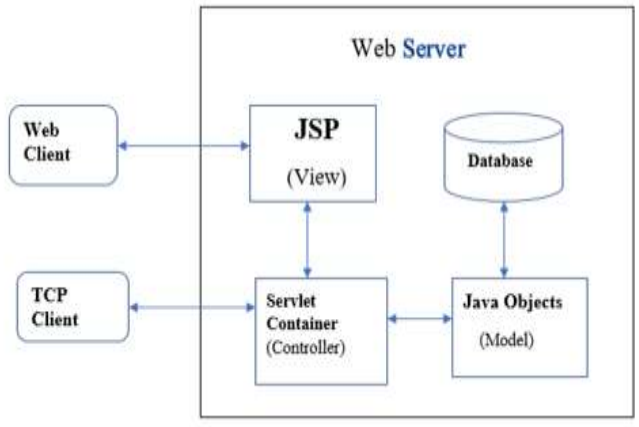

Fig 6. Structure of Model View Controller

The structure uses 2 types of clients such as Web client and TCP client. The Web client makes requests and receives responses using the View component, as the requests and responses are accessed from web interface.

TCP client directly communicate through Controller component. The web browser being used by an authorized user is the Web client and SGC's are used as TCP clients [7]. Before getting into the main page, the authorized user has to specify his/her username and password that has been already registered in SWS.

The switching of the CCT (Correlated color temperature) of streetlights is controlled from the SWS side. To switch the CCT to 5000k or 3000k, SWS uses the weather condition from weather APIs as input.To enhance the visibility in foggy condition, SWS will automatically request all LED lights to switch the CCT to 3000k. SWS will request the LED lights to switch the CCT to 5000k when the weather is clear. Fig 7 represents the automatic CCT switching operation in SWS. Automatic switching is equipped with failure recovery mechanism that is usually referred to as Distributed Replicated Volume(DVR). DVR is responsible for maintaining high-reliability of server and also to enhance read performance of server [8].

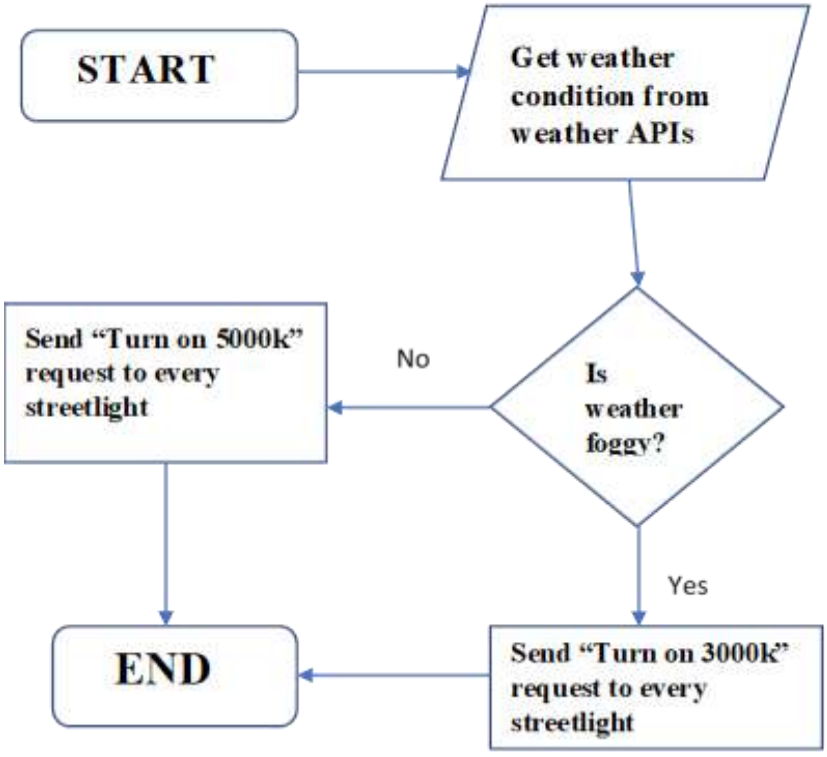

Fig 7. Flowchart of CCT switching in SWS

5. Conclusion

The proposed architecture consists of group of LED streetlights, which are basically connected to web based management system to provide authorized user with an interface. Streetlight network is established in such a

way that each streetlight can be monitored by a central web server, where control signals goes through the coordinator and then to each router based on their IDs.

Smart LED streetlight structure helps both vehicle users and pedestrians by providing low cost and low power outdoor lighting. For personal area networks, to provide low power digital radio signals, an open global standard named ZigBee is used. Real-time execution of the proposed structure shows flawless transmission-reception parameters like throughput and signal strength, which satisfies the wireless communication area and quality of the signal between each LED streetlights.

Smart LED streetlight system provides more efficient, simple Remote Mirroring. Remote mirroring usually takes place between storage arrays, for providing data protection.

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