Analysis and Scope of Automation in available Street Light Architecture

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Abstract- Automation of street light and the energy losses occurring in them is an important issue because it requires a large manpower and also leads to increased energy expenses for a city due to which system becomes less efficient. This research paper deals with survey and analysis of system architecture of street light and scope of automation in street light. Automated systems can be employed to make the street lighting system very efficient. This article helps the research community in designing better architecture of street light which helps in reducing the manpower, eliminating the errors which occur due to manual operation and saving in energy consumption of street light.

Keywords: Street lighting control, Monitoring, Fault detection,theft protection,Energy saving.

1. INTRODUCTION

Street light are the essential part of human life and city's infrastructure as their main purpose is to illuminate the city's street during the night time. Street lights have been used by almost every country across the world. The lamps being used in street lights are generally incandescent lamps, mercury vapour lamps, induction light, sodium vapour lamps and LED lights. The energy consumption for street light for overall world will be 80% higher by 2030 than in 2005 as indicated by International Energy Agency [1]. The switching of lights can be performed in two ways:

1. Manual switching - In manual switching, the street lights are operated using a single manual switch. The street lights are switched ON every evening and are switched OFF next morning after there is enough light outside. But these lights should be ON only when there is absolute darkness.

Automatic switching - Automation plays an important **role in industries, world's economy and also in day to day life** activities. Automation system provide greater performance as compared to manual systems as automatic systems are not prone to human errors resulting in higher accuracy, fast operation, etc. Industrial automation can be achieved using various controlling devices such as PLC (Programmable Logic Controller), micro-controller, Arduino, NodeMCU, GSM (Global System for Mobile), etc. While the automatic switching is accomplished by using the timer switch, Internet of Things devices, etc. Although the automation has been introduced in the current scenario of street light but still there is a gap between automation system and manual operation. This motivates to perform rigorous analysis of existing street light architecture and scope of automation in diverse street light architecture. Hence, this research paper deals with the investigation and scope of automation in existing system architecture of street light.

1. The various problems associated with the street lighting system are that the power is getting wasted up to a certain extent due to improper switching mechanism of street lights.Also all the lights are operated manually by a single switch only and there is no mechanism for the individual controlling and monitoring of street light. So, this article provides the possible solution for the maintenance of electrical power thus helps to regulate the wastage of power and the operation is completely automatized i.e. eliminating the manual operation with the help of IoT.

☐ This article is useful for the researchers as follows: To find the ways to control all the street lights using automation with focus on IoT (Internet of Things) architecture. Hence, the flexibility will be increased as it can be operated from anywhere and can be switched ON/OFF according to our requirement.

☐ The actual location of fault can be detected and diagnosed easily as the longitudinal and latitude address of every street light will be available on server in case of IoT automation. Hence, enhances the life of street light lamps and overall electricity distribution architecture.

☐ Also, the overloading (due to short circuit fault) and the under loading (faulty street

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lights) conditions can be detected easily as there will be energy monitoring systems.

☐ Optimized framework for street light automation is a good scope of research for street light automation.

2.LITERATURE SURVEY

Parkash et al. [2] have designed and executed an advance embedded system which provides a solution of electrical power wastage. The proposed system comprises of sensors, IR transmitter and IR receiver couple. These sensors detect the presence of any vehicle or obstacle and then transmit the data to microcontroller which switches the lights ON/OFF also the information can be access from anywhere and anytime via internet. However, this project has some drawbacks which provide a research gap as to minimise the initial cost and reduce the maintenance in terms of periodic checks. Also, the system develop can be used for surveillance purpose in corporate campuses and industries.

B.Meena et al. have designed a lightning system which provides automatic control and monitoring of street lights. [3] They have also designed an energy monitoring system which records and account on energy saving of a particular area. The street lights can be operated from central control room hence, manual errors can be eliminated. They have also implemented an accident avoidance mechanism which gets activate when the distance between the vehicles reduces less than 50-70 mts.

Fabio Leccese [4] has proposed a system which was remote control and can optimize management and improves the efficiency of street lightning system. The system has used a ZigBee technology which uses a wireless device and sensors to control the system parameters, the information is transferred using ZigBee transmitter and receiver which transmit point to point data. The data is then transferred to control unit, which check the status of lamps and take appropriate steps in case any fault occur. However, there is still a research gap to prevent the system blackout.

F. Marinoa et al. [5] have developed an adaptive control
system that uses a smart camera has been carried out. It has **high capability to save energy. Also it doesn't affect the**

security. Various experiments were carried out and the results of those were that the energy expenditure with and without the requisition of adaptive scheme for the established power minimization were

evaluated. Finally it was found that these supervisions will lead to a proper regulation system for real smart city.

Y. Jagadeesha et al. [6] have proposed a present day advanced technology which allows the street light to calibrate its own based on existent time traffic control. It defines about the low cost perspicacious system using various sensors for curtailment in electrical energy by using the IR and PR sensors.

Archana.G et al. [7] have developed a circuit that detect the motion of vehicles and switches the street light accordingly. This intelligent lightning system consist of various features such as it controls the light automatically using LDR sensor, PIR sensor is used for controlling the intensity of light, has camera for security reasons and automatic fault detection mechanism using GSM technology. There is still a gap of research in increasing the life of HID lamp. As reigniting of hot HID lamp will shortens the lamp life.

A. Lavric et al. [8] have design and implemented a light monitoring and control system which helps in reducing the energy consumption about 20% and minimises the maintenance nearly about 5% by adjusting the intensity of light by detecting vehicles presence or absence. As the energy consumption of street lightning of Romanian city is about 20% of total energy consumption. The system is enacted on a WSN (Wireless Sensor Network) communication protocol. There is still left a considerable scope in making system energy efficient, decrease pollution level and improve traffic conditions.

S. Bhosale et al. [9] have proposed a special control system used for street lights which uses wireless technology and client server mechanism. The main purpose of this technology is to increase the efficiency and accuracy with less energy consumption. Using this user can easily detect the street lights of any place from a particular location by interacting with web based applications. However, there is still scope of research in standardizing the solar-powered street lights and make sure that traffic safety and intercepts crime in opposition to night walking.

Nabil Ouerhani et al. [10] have proposed a system that consists of software that enables the connection of a profusion of actuators and sensors to create beneficial services. It provides a platform to qualify easy consolidation of range of communicating objects. The outdoor light controller used will receive the level of intensity that is calculated by the decision making module which is measured in percent. The total energy saved using the system is 56%. Also various tests have been carried out that showed the

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concernment of provisions. There are many opportunities for continued advance gave further scope like system can be used to control the luminaries accordingly and it can bring solutions towards low carbon cities of the future also provides safe operation of the system.

G. Yao et al. [11] have proposed an Automatic Meter Reading (AMR) system. In this system they are using ZigBee and 3G technology for data transmission. This system was mainly design for residential building by using Digital Image Processing template matching method to get meter data which reduces man power and human error. This made the process faster by using Digital Image Processing and data transmission through 3G network and ZigBee.

This system comprises of a camera used to capture the image of meter display and immediately send it to microcontroller, ZigBee Module and then to Image processor or next meter immediately. This system uses the MAC layer and IEEE 802.15.4 which offers star tree, cluster tree and mesh topology. All the received data was send to the remote data centre for data storage and processing. This system reduces the security issues by using Internet Protocol Security (IPSec). These articles have used a 3G wireless network. And offered scope so that 4G network can also be used for fast data transfer to image processing system.

Prasad Babu et al. [12] have designed a system which provides the exact location of every street light by getting its Longitudinal and Latitudinal value from Google maps as connecting device to every street light will become costly so they take value from Google maps and write it in their program. This will also help in data privacy and reduce the cost of device. GPS location is used in case if any fault occurs in street light then on their website the user will be able to see the status of light i.e. whether it is ON/OFF, where the light is located and also the pole number which is currently used by electricity companies for keeping record of maintenances of street lights done by them this month/year.

S. Das et al. [13] have developed a technology to monitor home appliances through GSM technology using cell phones and sms service. The device allows user to remotely control and monitor multiple home appliances using cellular network and receiving sms again. This system will be a flexible tool that will offer this service at any time and from anywhere with the constraints of the technologies being applied. This system is cost effective, cheap and adaptable and together with statement of scope that we can control the household devices using app over a mobile phone,

through the app the user can check the status off/on and off devices.

T. Ramachandran et al. [14] have proposed that street lights are integrated with wireless technology so as to improve the management and maintenance system. The street lighting system will consist of automated switching mechanism to further reduce their electricity Consumption. The design of the smart street light system comprises of three major aspects which is the implementation of smart street light control system, the use of an environment friendly energy resource and a surveillance security system. The system will be able to provide energy measurement to determine the efficiency of street lights. The opportunities for regular growth gave various scopes that we can also check the status of the street lights through the app whether they are on or off. Simultaneously we can also monitor the amount of current flowing through to check the case of theft in device and control it through mobile application.

Andrea Zanella et al. [15] have proposed that Internet of things helps us to get connected to the different systems and devices around the globe. But building architecture of IOT is quite difficult and makes things difficult for user. Urban IOT can be used to realize the smart city mission programme of India. This paper provides the detailed information of how the user can build the architecture of IOT and how they can get connected to different devices present in this world. IOT has currently become popular due to its vast scope and future of IOT is quite immense due to easy availability of internet. IOTs can be used in different applications to get connected to different devices with the help of simply using an internet. IOTs can be used to provide better services to the people by minimizing the role of public administrations. There is still left a considerable scope which provides the automate stuff in home to make faster decision,, communicate instantly, monitor the stuff which is most important – human being can be more effective automating non-value added activities and spend more time where they want to focus.

J. Baviskar et al. [16] have proposed a system for Designing of Home Automation and Power Monitoring System. In this system they used a ZigBee emerging technology. ZigBee is an efficient short range wireless technology in terms of power consumption, scalability. It consists of two modules transmitter and receiver and is controlled via Radio Frequency (RF). It works on both Wi-Fi and Wireless Sensor Network (WSN) based home automation system with the implementation of CC2430 Chip. A fresh scope can be given to this paper that can provide novel approach for connecting the outer home

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network with the inner ZigBee network using home gateway.

Sakthi Preetha et al. [17] have used the wireless technology systems to transmit vital signals and analysed how to implement these techniques through routing protocols. Vital signals can be transmitted with better management and width. Data transmission can be categorized into four nodes, unicast, multicast, broadcast and any cast. This wireless technology first found full scope for usage of a multichip Wi-Fi network and system use broadcast or multicast scheme to increase the reliability of the signals transmission and broadcast and multicast routing id used for routing purpose in AODV protocol to improve the reliability of sensitive medical, which are sent to the receiver.

Sindhu A.M et al. [18] have implemented a smart street light architecture which uses IR sensors. The main reason behind this implementation is to decrease the power consumption which arises due to unnecessary switching ON of street light when then is no vehicle. So, this IR sensor detects the vehicle movement and control the lightning system hence, improves efficiency and can surplus amount of power. The future research work is that the existing system can be extended to make it two-way traffic, also to increase the flexibility during rainy days and to control the lights using GSM technology.

A. J.Manekar et al. [19] have an idea of switching the system dynamically ON and OFF depending on light intensity and traffic. The dynamic switching is carried out using FPGA and IR sensors also it releases the manual operation up to 100%. The system can be made more efficient by reducing the power consumption which can be obtained using LED lights and this is the research work also by increasing safety by installing cameras. Another scope is that the traffic signal can be interfaced with the FPGA and can perform the dynamic operation such as calculating the ON and OFF time depending on the strength of traffic.

In above section literature survey is performed of conventional street light architecture. For better understanding the concept of construction, working and the energy consumption of conventional architecture is explained in section III with the help of conventional block diagram.

3. CONVENTIONAL ARCHITECTURE

Street lighting is considered as one of the largest energy expenses for any department. An intelligent lighting system can reduce the energy of street lighting cost up to 50-70%

[10]. The lamps which are being used in the street light are the incandescent lamps, mercury vapour lamps, induction light, sodium vapour lamps and LED lights. Generally Sodium vapour lamps are used as street lights. The ratings of these lamps are 150W, 70W, 40W respectively.

street light. Every evening a person has to came to every power supply box and switch ON the street lights and then next morning again came to switch OFF the street lights and the lamps which are generally being used for the lightning purpose are Sodium Vapour lamps
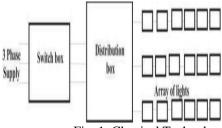

Fig. 1. Classical Technology

The problem associated with this system is that the consumption of sodium vapour lamp is high and there is wastage of energy as well as increase in manpower as a person has to come and switch ON the street light and if the street lights need to switch OFF early then it is not possible as the person will come according to his/her time. Another problem associated with classical technology is that if the street light

gets faulty then until a person/customer raises a complaint till then **it didn't come to notice** that street light is faulty in that area.

In **Modern Technology** LED lamps are used due to which energy consumption is saved up to 40-50%. The modern technology consists of Sub-Station, Transformer, Distribution Box, Timer and Arrays of Street Light. The working of modern technology is almost same as that of classical technology with an up gradation in modern technology is that a Timer is used with a switch. Fig. 2. Shows the timer technology in which, timer is programmed in such a way that it automatically switches ON/OFF the street lights according to the program feed in it. For example- the time feed in the timer according to summer is that at 7:00 p.m. it will automatically switches ON the street light and switches OFF at 5:00 a.m. The advantage of using timer is that manpower is reduced and energy is saved.

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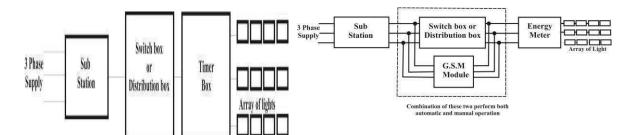*Available online at www.ijrat.org*

Fig. 2. Timer Technology

Fig. 3. GSM Technology

The problem associated with timer technology is that they are still not able to find the faulty street light until someone raises the complaint.

Another type of **Modern Technology** is that by using the GSM module instead of using Timer. This type of technology is made up of Sub-Station, Transformer, Distribution Box, GSM Module and Arrays of Street Light. IN Fig. 3 the G.S.M technology.In this type of technology GSM module is used and with the help of this module the workers of company can send or receive message whether the system or street lights are ON/OFF on phone and also on server. The main difference in this technology as compared with other technology is that it can work as both automatic and manual operations.

In this technology first a supply of 440V will come from Sub-station then a step down transformer is connected which steps downs the 440V to 220V and then this supply will go to Distribution box connected for street light operation after that a GSM module is connected which sends or receives data via SMS and with server also. A GSM module receives command for ON/OFF via SMS and Internet also as in case if internet

The technology being used in conventional street light architecture can be broadly classified in two categories:

☐ Classical Technology
☐ Modern Technology

The **Classical Technology** which is used for operation of street lighting system is made up of Sub-Station, Transformer, Distribution Box (Switch Box) and Arrays of Street Light. Fig.1. implies the classical technology, the operation of street lights is carried out from the supply of 440V coming from sub-station to transformer which step down the voltage to 220V which is input for distribution box.The distribution box is basically a switch which is used for switching operation of speed is coming slow we can send command via SMS also. It also sends data of energy consumption via sms and through internet also.

The advantages of this technology are as follows:-
☐ Energy is saved.
☐ Manpower is reduced.
☐ Data of energy consumption can be received any time.
☐ Work as both automatic and manual system.
☐ Real time monitoring is possible.

Limitations of GSM Technology are:-
☐ Problem of network connectivity - As if in some area there is issue of network connectivity then the system will not work as automatic system.
☐ If system reset by fault then messaging will get block-also if the system gets reset due to any fault then the messaging service will get block or the commands and data will not be received via sms.

Thus, to analyse the existing street light system and to study the nature of fault occurring in them various case studies has been conducted which are listed in rest section:

4. CASE STUDY OF COMMERCIAL STREET LIGHTS

A. Case Study 1

After investigating TPDDL (Tata Power Delhi Distribution
Limited) office located with GPS location 28.704300,

77.157230. Havel's Timer box panel is used as a controlling unit for the automation of street light. Currently, 3 Panels are used Energy Meter, Switch Box and Timer Box.
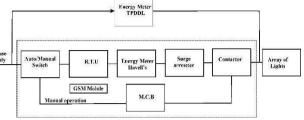

Fig. 4. Block Diagram of Case Study

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Fig. 4 shows the block diagram of case study 1 where energy meter is used for measuring the load greater than 100Amps which is coming on the Street Lights from the

Distribution Centre of TPDDL office. The Energy Meter's input is connected with the Switch box and the output of the Energy Meter is connected with the Timer box. Specifications of Energy Meter are as follows:-

- Dimensions:- 480mm*300mm
- Voltage:- 440V
- Maximum permissible current- 250A

Switch box is connected with the Energy Meter and Pole where Street lights are connected. When the System has to be used automatically then the Dial in the switch box was changed and with the help of MCB connected in the Timer

box, the Energy Meter gets connected with the Timer box. And the output of the switch box gets connected with the pole in case when the system is used manually. The Specification of Main Switch box in terms of amperes is 125A- 400A.

Mostly the manual system is used when the maintenance of street lights is being done otherwise the timer box is used for the automatic operation.

Timer box is used for automatic operation. Timer box is connected with the Energy Meter and the output of timer box is connected with the pole where street lights are connected. A program in the timer is already saved according to winter and summer season. In winter season the Street lights will operate at 5:15 pm (ON status) and in summer the street lights will operate at 7:00pm (gets ON). The time gets disconnected with the help of MCB (Miniature Circuit Breaker) present in the Timer Box for manual operation; this MCB forms an open and closed loop with the Energy Meter.

The feature of this Timer box is that it will automatically switch on and off the street lights according to the program feed in it. It will also tell whether there is any kind of fault or theft in the street lights connected in 3 phases and will also send a SMS to the respective mobile number feed into it.

If there is any kind of theft of supply from street light then they came to know by seeing the difference in value of input and output load of street light.

In timer they are using Contactors, Timer IC, PLC system, auto manual switch, RTU (Remote Terminal Unit) (consisting of Wi-Fi, Bluetooth and GSM), the readings of energy meter are transmitted to GSM Module Via RTU, Maxwell energy meter, 40 Amp MCB switch, and 40Amp surge arrester.

B. Case Study 2

After investigating TPDDL office situated at 28.685165,

77.156412, the system installed in their area is operating manually i.e. a switch box is being used at a pole from where there is connection of 90 street lights and at every evening a person from office goes to all switch boxes and make the lights ON and at morning again the person came to all switch box and make the lights close. Also the road lights in that region are operated with the same method.

If there is any kind of fault which occurs in the street light then until someone registers a complaint to customer care the fault is not detectable. As there are no such features which helps in detecting fault or which street light needs to be repaired, and the additional details like where the street light is and other necessary information is gathered from the person who is raising the complaint. Fig. 5 shows the block diagram of case study 2.
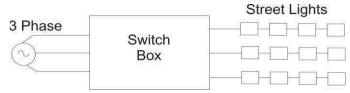

Fig. 5. Block Diagram of Case Study 2

C. Case Study 3

After investigating BSES (Bombay Suburban Electric Supply) office situated at 28.629557, 77.080189. The system

used is of EESL (Energy Efficiency Services Limited) is **connecting Smart LED's in the street lights. The LED used is** of 70W. The purpose of using **LED's is to save energy and the Smart LED's also helps in greater efficiency and monitoring** of street lights. Fig. 6 shows the block diagram of case study 3. **The features of EESL Smart LED's is to monitor** continuously the status of street light and also protects from theft of supply from street lights by telling the difference in

the input and output load of street lights connected in series **although the connection of LED's and Sodium vapour lights** are same, but now with the lesser wattage rating the number of

LED lamps are increased to approx. 90 to 150 LED's in 3

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Phase with a total current of 100Amp. Hence, power losses **are reduced using LED lamps. In the EESL's panel a GSM**

module is used for controlling of Street lights. For ON and OFF operation of street lights, both the methods are used i.e. automatic operation by sending signal from mobile or office or either by manual operation with the help of MCB present in the panel.

The specifications of BSES Energy Meter and Switch box are as follows:-
  - Dimensions:- 480mm*300mm
  - Voltage:- 440V
  - Current Rating:- 250A
  - Switch Box:- 125A – 400A

The problem associated with this system is that it contains an automatic and manual switch which provides power supply to the control unit of the module and MCB (Miniature Circuit Breaker). Initially system is operated on automatic mode in which it works on the signal or instructions obtain from the

operator. When the system is operating at auto mode then no **manual operation can be performed or lights can't be switch**

3off through a manual switch. To use the system manually then we switch to manual mode but it disconnect the power supply of control unit of the system, it reset the GSM module which stop receiving and sending of data. In that case operator has to program the GSM again which is a cumbersome task for operators.
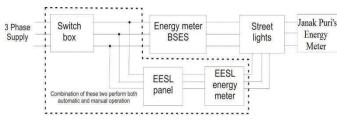

Fig. 6. Block Diagram of Case Study 3

The various features of EESL's panel are that:-

  - **GPRS location of LED's**

  - Theft Protection
  - Both Automatic and Manual Operation
  - Approx. 50% of Energy Saving

In the EESL's panel a GSM module is used for controlling purpose and Contactor. The specification of EESL panel is as follows:-

  - Contactor:- 32A – 100A

  - Smart meters which are used for energy metering for their own purpose.

V. ANALYSIS AND LIMITATION OF CONVENTIONAL STREET LIGHT

The major problem of street lighting is its high consumption. Every year in the world, several billion or we can say trillion KWh are disbursed on street lightning and also
the very high consumption means a high amount of energy generated, which results into an emission which is very poisonous.
There are the following problems:
First problem is fault detection and location of fault is a

major problem with conventional architecture street light and **which part is faulty can't not be determine.**

Another problem is related to the billing of the street lights energy consumption. The other name for street lightning that can be used is the unmetered load. Imprecise bills are paid by the municipalities also these are based on certain calculation like the parameter utilization and their working hours.

Also there are several proposals for all these issues occurred. As the LED based lamps is one of them. It expends twice less energy and utmost twice as long as the ordinary high intensity discharge lamps and this really solves the problem of high consumption of energy that generally occurs. Also the use of some sensors like the photoelectric sensors makes the light of lamp only throughout the night time and not the day time. Although, now and then, these sensors become out of order and also they can get grimy too and as a result the lamp either will not turn on, or it will work the whole day.

Now when we consider the maintenance problem, people are accusing inoperative lights. Also for this almost each and every municipality or we can say the street lightning network possessor has a web page, which helps people to interface with the shattered lamps, it can be done using a unique way or throughout the telephone. Although, the information generated will be properly circulated to the dispatcher instantly after the lamps become out of order and the delay between that time the lamp is smashed and it is restored can be altogether lengthy.

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But also all these provisions also have a noteworthy **drawback which can't be ignored that is these are**

unaccompanied and shattered, so we consider and also treat each and every problem individually and not the system completely.

6. SCOPE OF AUTOMATION IN STREET LIGHT

As the existing street light architecture has many flaws such as there is lot of energy wastage due to inappropriate switching method which uses manual switching. Also, the use of sodium vapour lamps in street light results in high power consumption leading to large energy expenses. Thus all these issues in existing street light architecture leads to future scope. There are lots of scope for street light automation by using IOT devices, ZigBee, wireless network etc. They can use LED lights to reduce the energy consumption. Commucation between IOT device and cloud server it still a problem for current system and has wide scope of research for the research community. Street light data can be monitor on the internet and store it on cloud server to provide access to everny concern person to analys the consupton and losses toprovide better solution to reduce the losses. It will aslo help to comtrol the street light from the internet ti reduce the human error and provide better maintenece by sending location of stret light via sms or notification to the concern technical staff.

Fig. 7 implies the proposed framework in which, the proposed panel gets connected with the 3 phase supply coming from the distribution center and there is an embedded system present in the panel which performs both automatic
and manual operation of street light. The automatic operation is as when the supply comes in the IOT device connected gets activated and starts sending data to the server and when it receives the ON signal from the server then it will send a high signal to the street lights and the lights will get ON.

For the manual opration there should be a manual switch to oprate the steet light for maintence and update the status of street light to the cloud server.

The main features of proposed system will be:-

 - It will help in detecting overload and under load.
 - Both Manual and Automatic operation simultaneously.

 - Send the status of every street light i.e. whether it is ON/OFF.

 - Variable load handling capability is there.

 - It is like an optimized system which stores data of meters on Cloud.

 - It helps in detecting the faulty Street light.
 - Energy is saved as manpower used is reduced.

The use of LED avoids unnecessary wastage of electricity, **caused due to manual switching of streetlights when it's not**

required. The automatic street light system is versatile, economic, less energy consumption, extendable and completely adjustable to user needs.
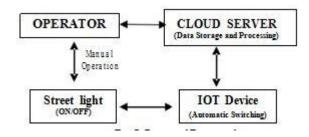

Fig. 7. Proposed Frameworks

7. CONCLUSION

In this paper, a rigorous survey has been accomplished. By means of the case study the existing structure of street light system have been investigated and studied. This is found that there is still need of improvement in the existing structure of street light over the worldwide. The improvement in the structure must be in both terms that is for the case of light technology (e.g. led) and in terms of intelligent and interconnected switching technology. This paper provides new ways for the researchers in the era of development of automation of street light and to find new technologies to improvement in the saving of energy from street lights. There is overall an eco-friendly, affordable, pollution free, cost effective and the safest way to save the energy by means of automation.. Also, the light status (ON/OFF) information, various readings of energy meter, fault location can be accessed from anywhere and anytime which is investigated in this paper. A framework is also proposed which may tackles with the two major problems i.e. saving of energy and eliminates the error which occurs due to manpower.

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