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Intelegent Smart Lighting System

"An evolutionary IOT application"

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Abstract : *Intelligent Smart lighting system is the pillar of Home automation as well as the Street lighting system. Typically, IoT is offers advanced inter connection of devices. To technically expand the IOT concept, every single user must know the concept, working procedure and benefits of smart lighting system. This paper entitled Intelligent Smart lighting system focuses on the designing aspect of sensors used at home for lighting in UML scenario, hardware required and it's functioning. Sensors are major part of its working process and functioning. It highlights on the Street lighting system and various communication media used for smart lighting system as well as its protocol stack. It also shows a comparison of traditional lighting system and current day lighting system. It provides a landscape view of the devices, technology and application required for smart lighting system. The evolution of smart lighting system phenomena is growing faster which is also a commercial reality in the field of IOT.*

Keywords : *Design, Street Lighting system, Sensors, , Communication media, Power of illumination*

I. INTRODUCTION

Smart lighting is an energy saving illumination technology which includes automatic controls of the lighting system and sensors. This system can save up to 35% of the energy compared to conventional lighting system. Home lighting systems nowadays are referred as Domotics. Domatica is fusion of Latin words used for home and robots. "Domo" prefix originates from Domus which means home and suffix "tics" originates from Robotics Domotics are smart lighting system used at homes which requires internet and sensors for its functioning. Smart lights can be controlled without touching the switches; it is intangible in nature. Street Lighting System is automatic now days as it uses sensors for its functioning. All the switches are connected to central gateway. Messages are broadcasted by the use of WIFI or a protocol stack. The central hub provides user interface, which is machine device mounted at wall or an application installed in the mobile which displays all the features and function for operations of lights at homes. There is a master to slave relationship between devices eventually readings can also be taken from the parent device (Access point). Smart lighting system can be used in areas such as home, lawn, offices and streets. Cost of maintaining street light and Power consumption can be significantly reduced with "Smartification of Street Lights". Lighting infrastructure and maintenance can also be easily controlled by Intelligent Smart Light Systems.

II. LITERATURE REVIEW

1. According to Thomas Little, a BU professor of electrical and computer engineering and associate director of the LESA ERC, luminaries (LED) are designed to be energy efficient, enhanced productivity, and improve health by responding to the needs of people in the room. Sensors embedded in the luminaries, called "time-of-flight" sensors, can detect people and objects in a room and change lighting intensity, turn lights on and off, and even adjust color.
2. According to research there are two approaches for energy saving in lighting system, namely the use of high efficiency light sources, and the development of smart lighting techniques.
3. LED has Luminous efficacy of 80 – 160 Im/W and it has a very good color rendering feature.
4. As per a survey, Lighting consumes one fifth of world energy so use of sensors can reduces the need of hundreds of power station
5. According to SLNP Programme Converting India's 30 million conventional lights to LED, can save 5 billion KWh every year which is equals to US$ 480 million.
6. According to IEEE 802.15.4 standard, ZigBee is a short range, low power, communication protocol with a low transmission rate which leads to ZigBee lighting system
7. Smart Cities use recent and latest digital technologies and communication sources, data sharing and analysis, and intelligent design to make cities more livable, resilient, economically sound, and sustainable. Smart sensors are embedded with devices to from street lights to power meters to traffic signals.
8. San Diego has replaced 4,000 lights around the city, saving an estimated $250,000, or 60 percent of the lights' energy costs, per year

9. A survey last year of 204 cities conducted by the U.S. Conference of Mayors found 82 percent of those responding had already adopted higher-tech street lighting, like LEDs. That topped the list of all technologies cities had adopted, including the ever-popular low-energy building.
10. In Ajmer, over 33 thousand lamps have been replaced, with an investment of over 14 crore by EESL. The project here has benefited Ajmer with reduction in peak load of 58% which translates to over 4.6 million units of energy saved per annum and over 3.7 crore in monetary savings.

III. SMART LIGHTING SYSTEM DESIGN (HOME)

Use case diagrams are also called as behavior diagram; as they are used to relate the set of actions also refer as use cases, with external users of the system. It is dynamic in nature. Each use case must provide remarkable readings. The use case diagram for smart lighting system represents the relationship between actor and its use cases within a system. Every actor must participate or interact with at least one use case. In the diagram besides, Owner or main user is the primary actor and Technician is the secondary actor. Main user or owner interacts with the device directly or via remote for day to day activity. He is responsible for operating the device, checking the readings and controlling the system. Technician which is also the secondary actor interact with the system when it requires maintenance or some problem and hang out occur. Technician is responsible for fixing and repairing of the system. Here the system represents the device used for Smartification of lighting system. The device provides automatic monitoring of the lighting environment. The device is switched on; reading is checked by actor (user) and adjusted accordingly as per requirement.

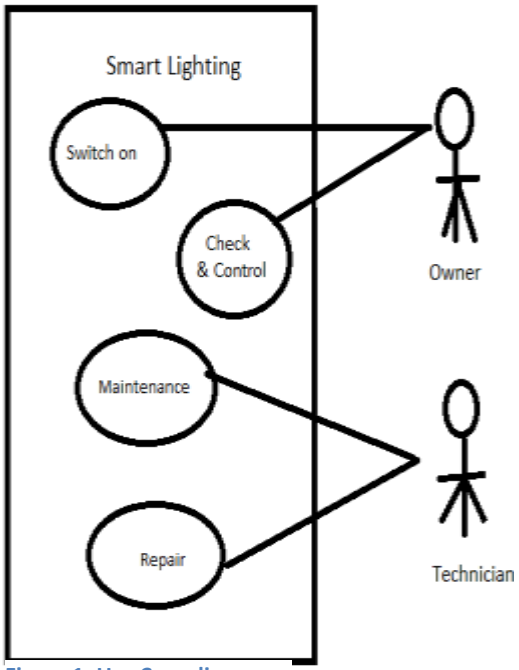

Figure 1: Use Case diagram

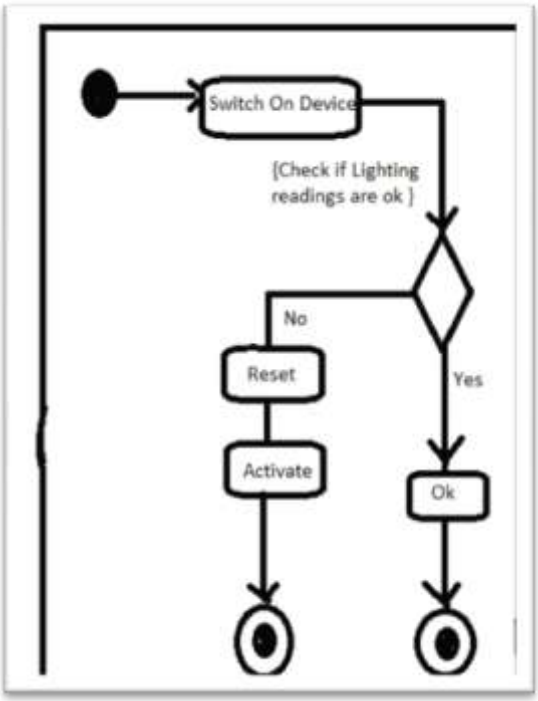

Figure 2 : Activity diagram

Activity diagram of smart Lighting system represents the activity performed by the system in the form of flow chart. Operation initiates with the black circle and ends with black circle surrounded by a circle (encircled). Flow of control of the operation is from one activity to other activity. Rectangles denote the activity of the device, diamond shape reflects the decision, taken and managed by user. After the device is switched on, it displays the current reading of the device. Decision leads to the option whether to reset the system monitoring reading or to leave in the current state. Depending on the selected option the operation is performed. Data flow is represented by arrows which start with the first node and terminates at end node. It represents the dynamic aspects of the system. It does not reflect the flow of messages between objects. Behavior of objects depends on its input from the upper operation.

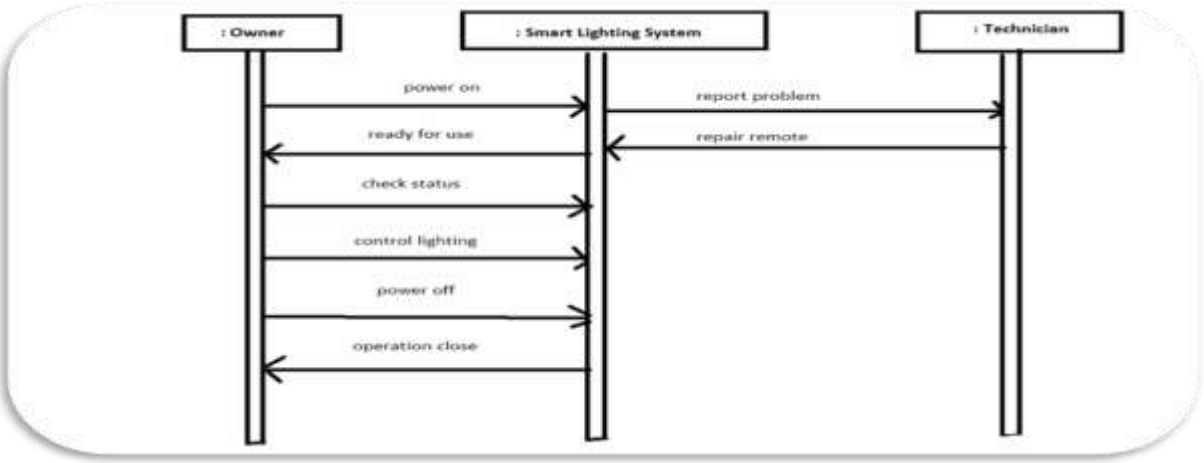

Figure : 3 Interaction diagram

Actors are considers are objects (entity) in the interaction diagram, which is external to the area, Interaction diagrams represents the interaction and operations of objects in a sequence. Interaction starts with the top level and ends at the bottom level. Phase by phase every orders are justified and arranged in sequence. The functionality of use cases are briefly elaborated in the interaction diagram. Sequence diagrams represent the event scenarios of the entities. In sequence diagram of smart lighting system, objects are represented by parallel lifelines or lines, vertical lines represent the messages (events) occurring, transmitted or processed between objects. The events are sequential arranged as per order. It represents the runtime scenario of the objects.

The above design is applicable to smart lighting system for home automation. It shows a user interface design in unified modeling approach with the smart lighting system (device).

IV. STREET LIGHTING SYSTEM

Intelligent street lighting system is the proposed energy saving technique for smart cities. It is the recommended customized solution to instill countries economy. Smart lighting solutions vary for one area to another. It requires several hardware components for its electrical installations.

Solar street lights consist of solar cells which transform ultrasonic lights to electrical energy. Batteries are used to stored the electrical energy. It is controlled by a charge controller which consists of LDR. An LDR is a semiconductor device made up of cadmium Sulphide (CDs) that evince photoconductivity and has a mutable resistance with the light intensity that falls on it. Light levels (intensity) are inversely proportional to résistance. When intensity of light decreases, the resistance of the LDR increases, causing a voltage drop which finally affect the transistors to turn on. According to the principle of current "**the current always flow in the low resistance path**". The LDR does not get enough supply to get energized. Hence, the load is switched off during the daylight.

Figure 4: Intelligent Street Lighting Sys

All street lights lamps (LED) has a light controller which is connected to central control room via network. Central control rooms have dashboard, central light controllers and systems for operating street lights. Street lights are connected by means of cables and a Dashboard is used to show the location of lights on the wall map. It gives provision to control the light by intelligent street light controllers. It also display light mode (On/off). This light status is shown by color indicator. Smart Lighting Controllers integrate its component into the network framework. The lighting is controlled via decentralized switches which based on small control programs. Switches help to control Street Lighting system over the network. Street light controllers have GPRS & GSM facility to provide average data transfer speed and support cellular transmission. It works on relay circuit and LDR. It also has traffic sensors to manage light intensity of the LED.

V. SENSORS

A **Sensor** maps different form of energy, frequency and waves into electrical signals which can further transformed into scalable readings. A sensor works according to the signal input it receives. It has physical parameter such as light intensity, pressure, temperature, humidity, speed, etc. which are converted into a signals that can be measured electrically. Each sensing node has its own communication and reading (sensing) capabilities. A group of sensors works in a wireless sensor network for monitoring the desired function.. The main components of sensors are micro controller, a GPS, radio transceiver, power plug-in/battery and memory. All sensors have its own microcontroller for operation. Radio transceiver is responsible for transmitting to and from information from one to other node. GPS provide facility for time and space location of a sensor. All the data's are stored in its database and its works on power source. Deterministic sensors are deployed with a possible site selection. Sensors transmit data directly or indirectly via multihop communication. The deployed collection of sensors finally forms a connected network. Network thus formed can be based on any topology and works on wireless protocol stack for communication in various layers as defined by OSI model. WSN are resilience, heterogeneous and scalable for future up gradation. Data access rates and bandwidth of network depends on the type of sensors node it is using.

Sensors uses photo resistor which work according to the level of light it detects to obtain amount of current pass through the circuit. So, if the sensor is in unlighted area, it only lets a small amount of current to pass through. If it detects a lighted area, it lets a larger amount of current to pass through. Street lighting system uses LDR (Light Dependent Resistor). LDRs use photo resistors which are convenient electronics component to use. They provide large change in resistance for changes in light level.

TABLE 1: Day & Night Light Effects

Night Time			
Light intensity (Flux)	**Resistance (Ohms**	**Current Flow**	**Approximately**
low	high	less	20MΩ
Day Time			
Light intensity (Flux)	**Resistance (Ohms**	**Current Flow**	**Approximately**
High	low	high	100Ω

5.1. How a sensor senses

Sensors accept input and delivers output in a digital format which can be easily accessed by the user. According to usage, sensors can sense data in analog mode as well as in digital mode. Most of the sensors are analog in nature. Analog sensors uses digital circuit controller to acquire input in the form of signals and deliver output after conversion in the form of binary representation. The input electrical signals can be in the form of motion, pressure, light intensity, humidity, gravity, sound wave e.t.c. The input value of analog signal is transformed or converted into its equivalent digital values and pass on to central station. It also supports audio and video transmission. Analog sensors can produces infinite set of results. In comparison to analog sensors, digital sensors have limited range of possibilities; therefore they are discreet in nature. Data transform is in digital mode. It basically works in wires medium, transmitter is part of it .Sensor and cable (length limited) are detached with each other for its operation.

5.2 Sensors can be classified based on power or energy supply requirement of the sensors:

· Active Sensor - Sensors that require power supply are called as Active Sensors.

Example: LiDAR (Light detection and ranging), photoconductive cell.

· Passive Sensor - Sensors that do not require power supply are called as Passive Sensors.

Example: Radiometers, film photography.

a. Benefits of using sensors

Benefits of sensors are representated by Figure 5 below with certain parameters.

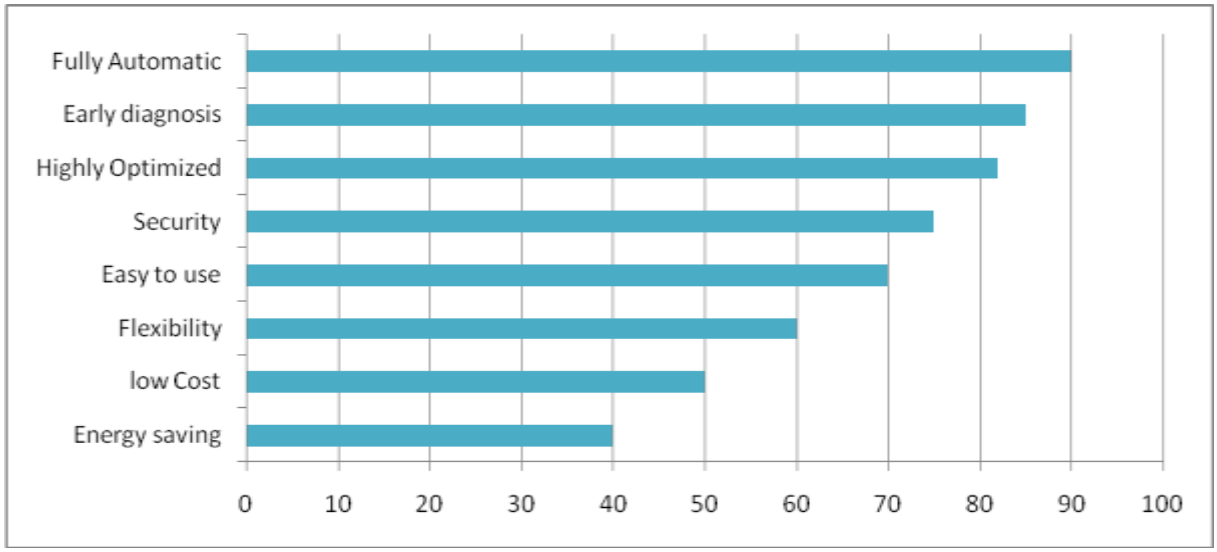

Figure 5: Benefits of Sensors 1

VI. COMMUNICATION MEDIA

According to Zhang and Lou, "**When the sensor density (i.e., number of sensors per unit area) is finite, c □ 2r is a necessary and sufficient condition for coverage to imply connectivity**".
Sensors can be connected via guided and unguided media. To interconnect a set of sensors devices though guided media, we can use an array element of n - 1 wire, each connecting at least two sensors node. Of all such possible design, the one that uses least amount of wires is usually considered.

Suppose V is the set of sensors devices, E is the possible interconnections between sensors, For each interconnections (x, y) ε E, We have a weight w(x,y) determining the amount of wires required to connect x,y.

So the overall total weight,

$$: w(0) = \sum_{(x,y \varepsilon 0)} w(x,y) \text{ ,} \quad \text{(equation 1)}$$

is reduced or minimized

To interconnect a sensor through an unguided media, sensors are allocated in a distributed fashion to scan and detect the environment. They are not connected with each other via wires, indeed they communicate in an open space through wifi or power of net. Sensors are usually attached to sensor gateway (microcontroller device) and are powered by battery, usually known as access points and they are connected by a distribution system. Whenever the system controller (user) desires a piece of information, the client program uses SNMP to request the information from the node. An SNMP running on that node receives the request, and returns it to the client program, from where the user can finally read it. Various communication protocols are available nowadays based on seven OSI layer model for home automation such as X10, DECT, C- BUS, Z-Wave , ZigBee

6.1 ZigBee

It is an application used for managing and controlling in house lighting system such as occupancy sensors, access points and dimmers. It is an IEEE 802.15.4 standard for wireless personal area networks (WPANs), ZigBee provides an option of sleep mode which reduces the battery consumption. It is based on star, cluster, and mesh topology and very cost efficient. The operating mode consumes less power. It has limited coverage area which makes it suitable for home automation system. It consists of three physical devices, end node, access point (device) and router. Access point is the master node and end node or end device are the slave node. Access point is the coordinator which is responsible for storing and managing data's and information. It is also responsible for data transmission operation and passing of control information. End node or device on the other hand is responsible for communicating with the parent node and transmitting up to date data. Router is responsible for data packets to and fro through it. For sending data from master node to slave node it has to pass

through the intermediate router. When there is no transmission of data then the routers and master node automatically goes is sleep mode. Also known as beacon mode. It also periodically monitors the incoming and outgoing of data. ZigBee provides a stack of protocol working in OSI layers. The Physical layer is responsible for managing data access rate, frequency band, channel allocation and coverage area. The **MAC layer** is responsible for message passing across a shared channel (terminals). Network Layer is responsible forwarding data packets through intermediate routers and device synchronization. Application Support sub layer is responsible for access point (device) interface with the network which includes linking and correlating two nodes (master – master or master slave) for data managing services. Application framework layer is responsible for scanning, validating and detecting other nodes for providing object level interface by linking other devices to the network.

VII. POWER OF ILLUMINATION

Earlier coal and petroleum gas are used to illuminate streets which were further replaced with arc lamp also called as carbon lamp. Later on arc incandescent lamps are used in spite of arc lights which consumes power near about 100 watt, therefore also refers as 100 watt light bulbs. 100 watt bulbs are replaced by low pressure and high pressure sodium bulbs. Earlier halogen light lamps are also a source of lights for illuminating streets and are used to lighten the roads which consume much power near about 100 – 500 watt lamps Then comes florescent and LED bulbs into picture which have a life line of 10000 hrs and 100000 hours. Compact fluorescent lamps (CFLs) replace incandescent lamps/bulbs that are roughly four times their wattage, saving up to 80% energy. Although CFLs cost 5–10 times more than comparable incandescent bulbs, they work for a longer period. When lights are used for longer durations, then CFL are productive, cost effective, and energy saving products. The LED solar street lighting systems are designed to operate for dim environment lights under average daily insulation of 6 kWh /Esq. on a horizontal surface. The lifeline of LED depends on quality design, operating environment. LED has Luminous efficacy of 80 – 160 Im/W and it has a very good color rendering feature . It has a lifeline of 100000 hours which is highly energy saving, low maintenance. But it has high installation cost. LED has a lifetime of 15 years. TABLE 2 represents the comparison of traditional bulbs and modern days bulbs.

Energy(E) = Power(P) * Time(T) , where

$100 \leq P \leq 500$ for halogen lamps

$50 \leq P \leq 400$ for Sodium Lamps

$20 \leq P \leq 80$ for Florescent Lamps

$50 \leq P \leq 100$ for LED lamps

TABLE 2: Comparison Chart

Feature	Incandescent bulb	CFL bulb	LED bulb
Avg Life Span	1200 hr	10,000 hr	30,000 hr
Power Consume	60 - 100 W	10 – 15 W	2 – 15 W
Requirement	10 bulbs/year	1 bulb/year	1 bulb in 2 year
Cost	Less	High	Expansive
Durability	Less	High	Very High

India's Prime Minister Narendra Singh Modi launched SLNP scheme for replacement of conventional lights to intelligent LED street light for efficient energy saving. The target of this programme is to install 15 lakhs conventional lights. LED consumes 7W power, with better light intensity & brightness, which saves energy in comparison to other conventional lights. According to Streetlight National programme (SLNP)

TABLE 3: Energy Acquisition

Average Energy Saving single light/day	Average Energy Savings/day	GHS Emission Reduction	Avoided Capacity
0.385kWh	1062834.85 kWh	882.15 t CO_2	96.62 MW

VIII. FUTURE WORKS

In future smart lighting system can be expanded to the use of voice sensors. Voice can be used to control lights in home automation.

Environmental conditions such as rain, humidity, foggy can affect the use of sensors , so Street lights system must increase its capability to cope with environmental hazards.

IX. CONCLUSION

This paper entitled "Intelligent Smart lighting system" is an IOT application for better future. Due to sensor it is possible to detect and scans the environment readings. Use of sensors and communication media provides a significant impact on light management system. Street lights are best solution for energy saving, with the use its various components it is possible to trace and adjust light intensity levels . Lighting controllers are the base to provide network communication also. Wireless communication between devices is an added advantage. When adding the network layer on top of the IEEE 802.15.4 stack, it gives phenomenal success of wireless communication. It can also be concluded that with knowledge of the wireless network structure and use of LDR it is easier to know its functioning. Comparison chart of various illumination models are also an efficient and fruitful knowledge for shifting to smart lighting system.

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