Remotely Controlled Automated Street Lights: A Novel Approach towards IoT (Internet of Things)

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Abstract: ***Internet of Things (IoT) is widely being accepted as a disruptive technology business opportunity, with standards emerging primarily for wireless communication between sensors, actuators and gadgets in day-to-day human life, all in general being referred to as "Things". This offers the capability to measure for understanding environment indicators. This paper addresses the internet of things (IoT) and presents automated street lighting prototype using LEDs which controls the brightness intensity of street light and thus saving power by switching it based on time and ambient light of the environment. IoT as envisioned is innumerous sensors connected to the internet that would generate large amount of data which need to analysed, interpreted and utilized. As quite a potential technology, the Internet of Things is bound to experience a widespread application in a few years. This paper also discusses on Internet oriented applications, services, visual aspect and challenges for Internet of Things. Smart cities advocate future environments where sensor pervasiveness, data delivery and exchange, and information mash-up enable better support of every aspect of (social) life in human settlements but also poses infrastructural and architectural constraints because of the heterogeneous nature of different "things" and the varied type of data being collected. This paper concludes by comparing the traditional lighting system and the new LED based street lighting system which also takes the ambient light of environment into consideration to save power.***

Keywords: Internet of Things, street lighting

1. Introduction

The street lighting system of a city plays an important role on its infrastructure. It is responsible to guarantee the society: security and living during nighttime, traffic safety, and city appearance. In the beginning, the control of the oil lamps was performed manually. With the invention of the electric lamps, the control of the street lighting started to be carried on automatically, by means of photocells, according to the light levels or timers. Light sources and their respective control gears are being constantly developed since their invention. As smart cities are investing in intelligent LED street lighting and traffic monitoring systems, new applications of distributed automation technology are possible. LED luminaires may be quickly dimmed and adjusted back to full power to provide the optimum level of light at the right time even reacting to the movement of individual road users without damage to the luminaire, as is indicated by recent patents (e.g. by Philips).

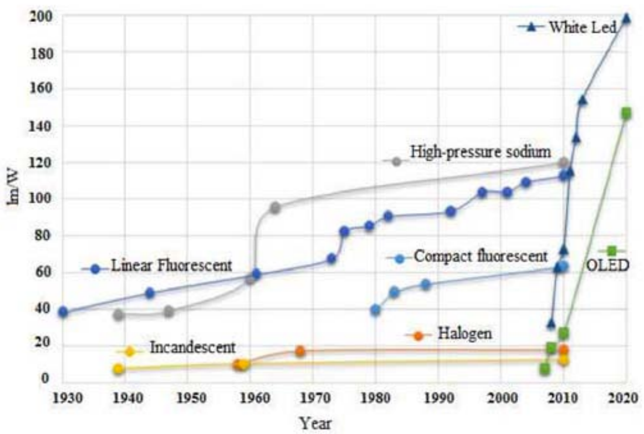


Figure 1: Comparison of luminous efficacy between main lighting techonologies and LED (Adapted from 2020 projection)[1]

In the last years, light-emitting diodes (LEDs) are gaining much interest for street lighting applications, since they can provide high luminous efficacy (over 150lm/W), long lifetime (50-100kh), high color rendering index (CRI) (70-90), high reliability and energy saving. Studies expect a reduction from 42% of energy consumption with street lighting, from the year 2010 until 2030, by use of LED technology.

Regarding the lamp types used in street lighting, light emitting diodes (LEDs) are being presented as an alternative to replace the conventional lighting systems. Despite of their widespread use as signaling systems, LEDs are not commonly used as lighting systems. However, recent technology is improving gradually the LEDs' efficiency and color quality, which allows their application in lighting systems. The conventional luminaires applied to street lighting system are not able to perform communication, control and management features. Furthermore, the system is also not capable to measure useful information from the luminaire, i.e. energy consumption and detection of possible failures in the luminaire. In this sense, it is possible to notice that the large majority of street lighting systems were designed using old equipments and techniques. However, due to the advance in science as well as the increased number of industrial researches regarding the development of modern devices and computational processes, the application of smart and communication technologies in the conventional street lighting systems provide prospects for monitoring, management and automation, allowing the interconnection of different intelligent devices.

The traditional lighting street lamp on-off control is based on chronological time, which many times is insufficient and even inflexible. For an increased efficiency, a modern street lighting control system must be able to adapt the light level intensity in order to determine an optimum energy consumption level. After taking these factors into consideration, such a system should also adequately adjust the luminosity level so as to ensure the safety of road traffic and maintain an optimum energy consumption level. The traditional street lamp control systems have photoelectric cells that may malfunction and thus endanger the proper functioning of the entire lighting system, most likely because of improper installation, calibration or impurity build-up. The emerging LED technology enables intelligent street lighting that is based on sensing individual vehicles and dimming street lights accordingly. The potential energy savings are considerable, exceeding 50% on roads with low traffic. A possible reason why such applications are not yet emerging are financial uncertainties about the size of the savings, which are needed to motivate the investment. Another barrier to adoption are uncertainties about whether proposed approaches meet standards and regulations for traffic safety.

The paper is organized as follows: Section II presents the mains concepts of IoT (Internet of Things) and Smart Cities.. Section III consists of Economic Analysis of LED Street Lights with traditional lighting systems. Section IV includes the Proposed System architecture of LED Street Lighting. Section V focusses on the Future Works and Challenges.

2. Internet of Things (IoT)

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

"Things," in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, electric clams in coastal waters,automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen, monitoring field operation devices that assist firefighters in search and rescue operations. Automated Street Lights can be a very useful ‘thing’ by sharing its data on the cloud for further analysis and development. Street Lighting can also be integrated with Security Systems using CCTV cameras having night vision in the dark.

The individual's trust in the IoT should be fundamental and complete, knowing that information will not impact negatively on any individual or society.

Any IoT system consists of a Wireless Sensor Network whose components are:

- *Wireless Sensor Networks hardware* - Typically a WSN node contains interfaces to sensors, computing and processing units, transceiver units and power supply.
- *Wireless Sensor Networks Communication Stack* (WSNCS) – The nodes will be deployed in an adhoc manner. Communication topology will be an important factor for communication through the system of WSN nodes. There is this communication stack at one central node which will be able to interact with the connected world through the Internet and which will act as a gateway to the WSN subnet and the Internet.
- *Middleware*–This is associated with the internet infrastructure and the concept of service oriented architecture (SOA) for access to heterogeneous sensor resources.

One significant aspect in IoT is the large number of things being connected to the Internet, each one providing data. Finding ways to reliably store and interpret the masses of data through scalable applications which remain a major technological challenge.

From the narrative in this section, we draw a number of key challenge areas:

a) *Privacy, Identity Management, Security and Access control:*
IoT presents significant challenges in terms of who can see what with which credentials (recalling that the entities are no longer only people, but might be any form of IoT “appliance”. The recent Stuxnet worm presents an excellent example of a malicious “software actor” that has the potential to effect major physical changes in industrial processes.

b) *Standardisation and Interoperability*:
How do we make sure that the hugely diverse technology platform continues to act in a platform manner i.e. ensuring that we do not have to re-invent the wheel every time we develop a new application or, indeed, a sensor that needs to plug into the IoT.

c) *Data deluge*:
The IoT shares many of the key challenges similar to large scale data initiatives as identified in the e-Infrastructure domain. How do we deal with the data stream of billions of “actors”? How do we ensure the data remains usable for future generations?

Smart Cities

A **smart city** is an urban development vision to integrate multiple information and communication technology(ICT) solutions in a secure fashion to manage a city’s assets – the city’s assets include, but not limited to, local departments information systems, schools, libraries, transportation systems, hospitals, power plants, water supply networks, waste management, law enforcement, and other community services. The goal of building a smart city is to improve quality of life by using technology to improve the efficiency of services and meet residents’ needs. ICT allows city officials to interact directly with the community and the city infrastructure and to monitor what is happening in the city, how the city is evolving, and how to enable a better quality of life. Through the use of sensors integrated with real-time monitoring systems, data are collected from citizens and objects - then processed and analyzed. The information and knowledge gathered are keys to tackling inefficiency.

3. Economic Analysis of LED Street Lights with traditional lighting systems

With the insertion of smart devices in street lighting system as well as the integration of LED lamps, it is important to perform a deep analysis to ensure both technical and economic feasibility of these types of prototypes.

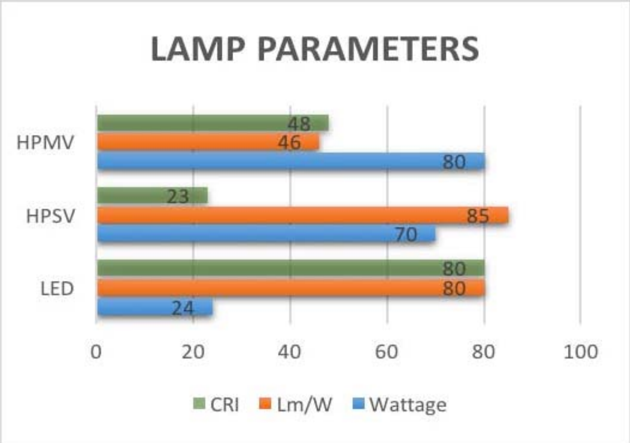


Figure 2: Lamp parameters of HPMV,HPSV and LED

Lamp Parameters

PARAMETERS	*LED*	*HPSV*	*HPMV*
Wattage	24W	70W	80W
Lamp(lm/W)	80lm/W	85lm/W	46lm/W
Lifetime	Upto 50000h	28000h	16000h
CRI	>80	23	48
Luminosity	1920lm	6000lm	3700lm
Model	Philips BRP 320	Bajaj HPSV70W	HPLN80W

These are the parameters of the sample street lights studied. LED street light has lesser power consumption with nearly same lm/W and nearly double the lifetime.

Figure 3: PHIILPS BRP 320

	LED	HPSV	HPMV
HOUR	0.144	0.42	0.48
DAY	1.728	5.042	5.76
MONTH	51.84	151.2	172.8
YEAR	622.2	1814.2	2073.6

This cost analysis concludes that that the LED street light would be the most economically feasible solution as it costs least when electricity charges per street lamp is calculated.

Figure 4: Cost Analysis of LED,HPSV,HPMV

Comparative Analysis of Led in INR

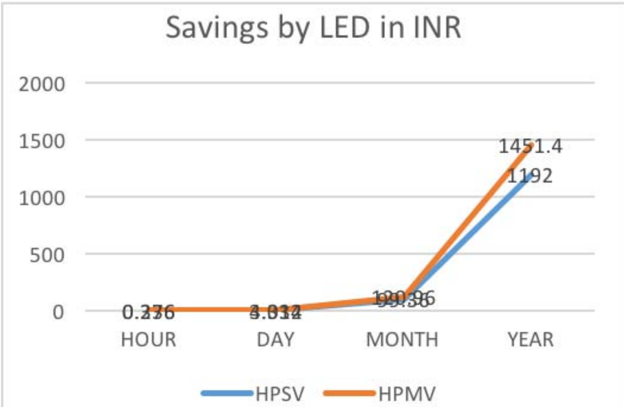


Figure 5: Savings with respect to HPMV and HPSV

Above graphs conclude that initial investment on LEDs may seem a lot but the output realized over a time span exceeds its production cost and provides a long term solution for controllable street lighting system.

SAVINGS	HPSV	HPMV
HOUR	0.276	0.336
DAY	3.314	4.032
MONTH	99.36	120.96
YEAR	1192	1451.4

Each LED Street Light saves about INR 1500/- in a year which exceed its production cost and thereby can be considered for replacing the existing conventional street lighting systems.

Moreover, with the growing researches related to the development of efficient designs for LED drivers, the relative cost of manufacturing is reducing quickly.

4. Proposed System

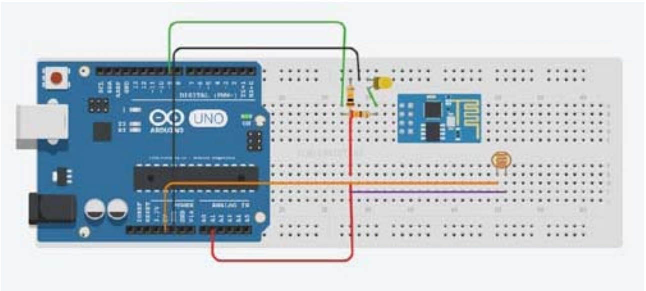


Figure 1

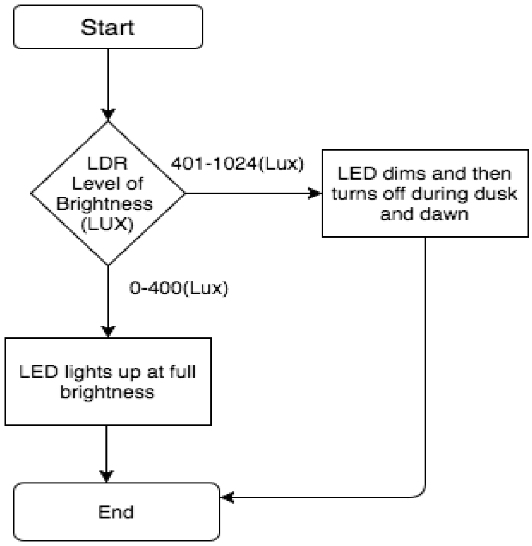
Figure 1 shows the components, by which our smart street light system is realized.

1) Lamp unit
It consists of power-adjustable LED to emulate a led street light , the brightness sensor is used to vary the brightness or light intensity of a street light to save power and energy. The LED is connected across 5V digital output and ground . It uses PWM (Pulse Width Modulation) to vary the brightness intensity of the street light.

2) Ambient Light Intensity Sensor
A photoresistor (or light - dependentresistor, LDR, or photocell) is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits. Photoresistors can be placed in streetlights to control when the light is on. Ambient light falling on the photoresistor causes the streetlight to turn off. Thus energy is saved by ensuring the light is only on during hours of darkness.

The ambient Light Intensity Sensor is designed using an LDR (Light Dependent Resistor). A small experiment was conducted to determine the value of the resistance of LDR at the threshold value of ambient light intensity shown in Table I. The threshold value of the light intensity is the value at which artificial lighting is required.

3) Arduino Board as the Controller Unit and the circuit
Depending on the LDR values, which is supplied as input to Port A1, the Arduino board modulates the LED light intensity accordingly. It ensures that light is dimmer at dawn and dusk to ensure clear visibility of roads and also makes sure that it behaves like usual street lights at night and turns off automatically in the day time. Arduino board also is able to transfer its values to cloud when interfaced with ESP8266 wifi module. The data on cloud is available for further analysis and the whole module can be turned on and off wirelessly using a TCP client mobile app or internet browser. The circuit consists of 230 ohms and 10k ohms respectively as shown in the figure.



The LED light intensity is controlled according to to light sensor's input to save power during dawn and dusk by dimming the light accordingly.

5. Software Implementation

Arduino IDE is used to interpret the signals given by the sensors and appropriately drive the loads (LED). The fade amount, brightness is declared appropriately to ensure proper working of the Module.
Python libraries are used to plot the real time brightness intensity and compare with the constant standard output of traditional street lighting system. The power saving exceed 50% when compared with traditional street light considering Indian weather and other parameters.

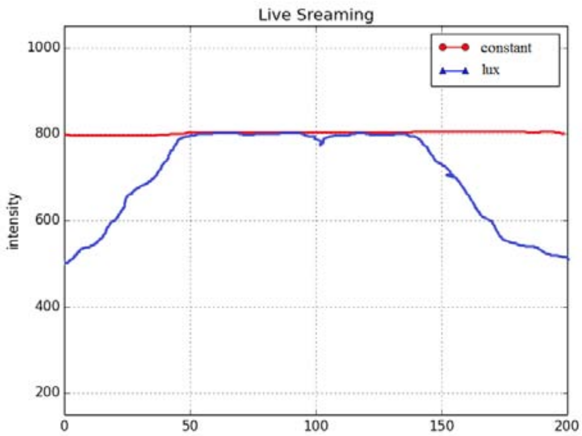


Figure 8: Live Data from Prototype depicting the Luminance

When the Arduino LED module is interfaced with ESP8266 wireless transmitter, the state of the street light can be communicated with cloud and even can be controlled and managed wirelessly provided it is connected to a wireless network.

Figure 9: Freeboard.io representing input of dweet.io

Fig. represents that the acquired sensor data and information related to status of the street light can be made available on cloud when the street light establishes connection. The acquired data can be used for further analysis and monitoring purposes.

6. Future Works & Challenges

- Solar panel and motion sensor integration
- Possibility of integrating the street lights with telephone lines to provide them with internet access.
- Practical application and economic feasibility to be checked for.
- Designing appropriate driver architecture for the lamp that consists of the LEDs.
- Designing a distributed as well as centralized control system for the automation of street lights.
- Effects of varying weather conditions on the functioning of lighting system.
- Developing an application that keeps a log and monitors the functioning of the street lights.
- Checking the quality of lighting(illuminance).
- Examining the integration with existing power circuitry.
- Develop a separate network for communication with wireless sensors.

7. Conclusion

This paper has presented a brief review of an economic analysis for dimming control of LED lamps applied to public lighting systems. By comparing the LED with conventional lighting systems.

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