

Intelligent High Tech Street Lightning Pole for Smart City

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ABSTRACT

The alarming increase in energy price and maintenance cost results in significant increase in lighting budgets. With Smart Street lights, cities can save energy and minimize CO₂ emissions, limit light pollution & minimizes maintenance cost. Street light is the basic infrastructure of a city. Utilization of Sensors for data collection in Street light becomes the basic design of a Smart City. Smart Street light provide secure traffic situations and secure pedestrian environment resulting in better infrastructural improvement to Smart cities. The article elaborates on the design of Intelligent Street lightning pole towards energy efficient lightning management services and other emergency handling facilities. The features of the design covers to way finding, business advertisement, weather station, rain and flood monitoring and so on.

Keywords

Smart city;Secure solution;Intelligent street light; Light pole;Energy saving;Light pollution;EV charging;Embedded

Introduction

Street Light [1] plays a major role in current smart cities. Street light is the primary source of light on road and located in the intersections of roads. In majority of locations, traditional street lights are used, which uses heavy materials & more power. In current scenario of cost hike in materials & various social responsiveness to issues in environment leads to identifying the alternative technologies to save power and cost. LED Street lightning answers the issue towards environment friendly & reduction in cost. With the utilization of Embedded Sensors & Digital Networks, they gather and transfer data which help to monitor cities and respond to any situations. Intelligent Street lightning system can detect bottleneck in traffic and detects the vacant parking slots. Also, the networks can minimize the energy consumption by controlling the LED lights remotely to turn off and on, flash and dim. Smart lightning system results in saving energy, minimizing cost, reduction in maintenance and CO₂ emissions. The intelligent Street lightning [3-5] can be made as Smart Poles also, which caters combined smart services & amplify the business potentials. The Smart pole can cater as infrastructure for 5G, Wi-Fi hotspots, Surveillance cameras, Environmental sensors and Electric vehicle charging points.

The 3 significant force in developing the smart street lightning are regulatory policies, Internet of Things (IoT) convergence and LED prices drop [1].Figure 1 shows the key market drivers of smart street lightning. Across Globe, 320 million street lightning poles are present with Asia possessing 25%, North America and Europe 20% and South America for 10%. Figure 2 displays the top 10 cities implementing connected streetlights. Street lightning infrastructure has three potential parameters towards smart cities implementation comprising capillarity, electrification and connectivity. Smart Cities [6] uses various sensors, information technologies aligning with IoT to collect and supply from city infrastructure [2].Smart city results in more accessible, cleaner, healthier, safer and pleasant for its residents. Figure 3 displays the smart city components comprising home, transportation & mobility, farming, mobile payments and various other services.

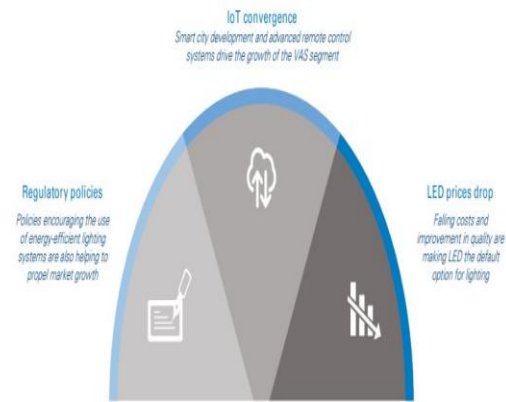


Figure 1. Key Market drivers of Smart Street Lighting

Rank	City	Connected streetlights	Country
1	Miami	500,000	United States
2	Paris	290,000	France
3	Madrid	225,000	Spain
4	Los Angeles	165,000	United States
5	Jakarta	140,000	Indonesia
6	Montreal	132,500	Canada
7	Birmingham	130,000	United Kingdom
8	Dongguan	120,000	China
9	Buenos Aires	108,500	Argentina
10	Milan	101,060	Italy

Figure 2. Key Market drivers of Smart Street Lighting

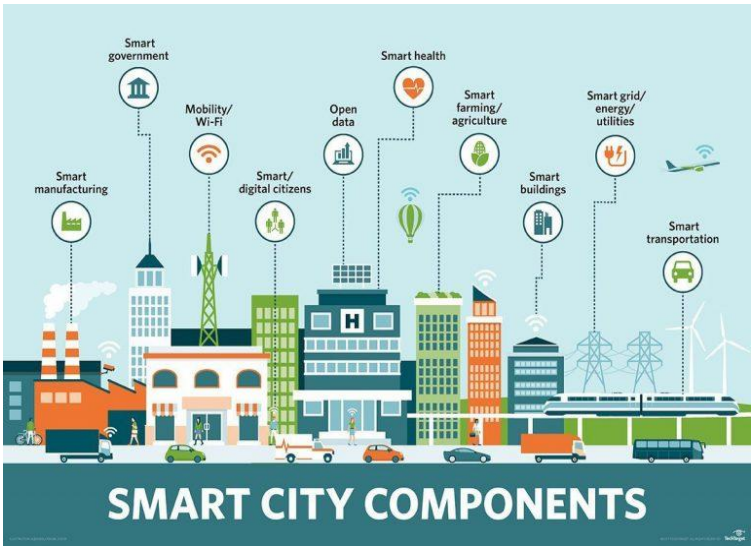


Figure 3. Smart City Components

Literature Review

B.C.Mishra [7], et al described that using Zigbee based Wireless devices optimization done in efficiency of street lighting systems. Using Embedded Internet Technology, a monitoring system design done for Street light. The results proves that the proposed system solves various essential applications such as street light management, real time access and so on pertaining to Embedded Internet applications. Eungha Kim[8], et al described a methodology where people can control certain devices utilizing Internet services in Smart Home. It proposes an integrated community service platform system architecture which provides solution for Smart city/home using a single integrated and intelligent community services. M.K.Sheu [9], et al, describes about Smart Street light which results in road safety and energy saving. Embedded System monitors the status of road and output control instruction. Low color temperature light is generated by embedded system when fog or rain is detected. Proposed LED Street light results in better ambience of intelligent city by improving the road safety for pedestrian and driver. E.Kougianos[10], et al, described that the Image or Video exchanges over the IoT is a requirement in various applications such as smart structures, intelligent health care and smart city planning.

A.Murtuza [11], et al, proposed a system which detects presence of vehicle for a certain distance and the light gets switched on during the vehicle passing the defined radius. Also, a prototype is incorporated to intimate the defect in street light if any identified. The proposed system results in consumption of power and also uses solar energy during day period. Also, the system elaborates on the minimum utilization of manpower for detecting the faulty street lights and intimation to the substation. S.Arslan [12], et al, discusses about significant application of IoT in designing a smart city for street lightning system. The designed system operates on the principle Light Dependent Resistor (LDR) which operates the bulb depending on the light intensity. Also, the discussed system is designed at economical prize with inclusion of various sensors to measure the atmospheric parameters with the aid of Android [20] operating system for effective utilization. N.Ouerhani [13], et al, elaborates on real time solution for street light control and utilization of IoT system. The design results in energy saving with respect to traditional street light control system.

M.S.A.Muthanna [14], et al, elucidates on the implementation concept of Smart City using a Wireless technology which caters long range and consumes low about power named LoRa. The system discusses with smart street lightning including the overall network organization with logical implementation. D.VijendraBabu [15], et al, discusses remote street light monitoring and controlled system. It results in conservation of power with the use of PIC Microcontroller.

Y.Yang [16], et al, proposes about efficient system for street light and utilization of sensors included to obtain the interface of data collection. The system details about Edge Computing services with high commercial value. RishikeshLohote [17], et al, exposes the conventional usage of Street lightning which results in wastage of electricity between 20 to 40% & proposed usage of Smart street light lamps which results in energy efficiency and assists in displaying various significant parameters such as weather forecast, water level sensor alerts & emergency notifications overcoming the drawbacks of conventional street light system.

Yoo S Song [18], et al, elaborates on smart lamppost composing of intelligent edge unit, camera, short range communication device, digital signage, etc. One of the main functions in the smart lamppost is to forward the safety information to the gateway node by an I2I communication system. The article analyses on the latency and throughput at each node during multi-hop data transmission to the gateway node. GunjanBhartiya [19], et al, elaborates on intelligent lightning control and energy management system. It describes about designing an efficient energy saving mechanism using microcontroller and sensors which turn on/off street lights automatically which results in energy consumption with the utilization of sensors. M.Suresh [20], et al, elaborates on utilization of reliable smart management proposal for minimizing the wastage of power in street light with the utilization of Wi-Fi module, Light Dependent Resistor (LDR), accelerometer and ultrasonic sensors are employed. Intelligent lightning control and energy management system. A Predictive model based on Improved Bayesian Neural Network (IBNN) model is applied which eliminates the power wastage during night time if there is no vehicle or trespassers passing.

System Design

The purpose is to design an Intelligent High Tech Street lighting pole which runs an embedded web server for Smart Web based services in addition to the energy efficient lighting management services and other emergency handling

facilities. The Block diagram displayed in Fig.4 and proposed Street Lightning pole sample is displayed in Fig. 5. STM32F429, Cortex-M4F Microcontroller [21-27] is used.

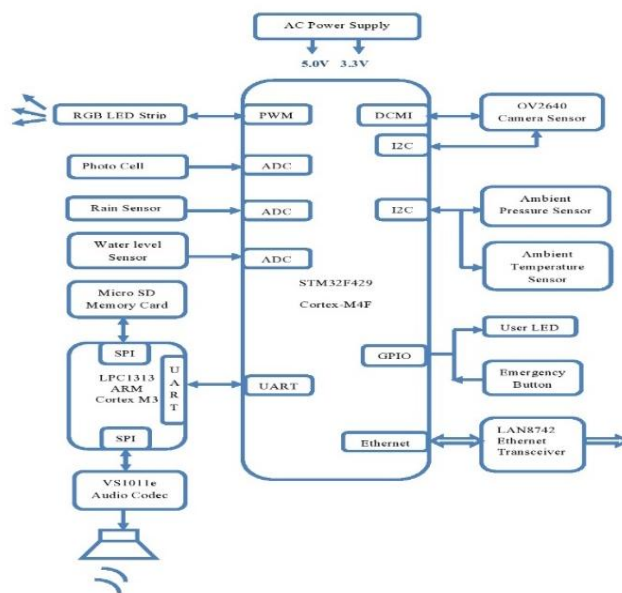


Figure 4. Prototype Block Diagram

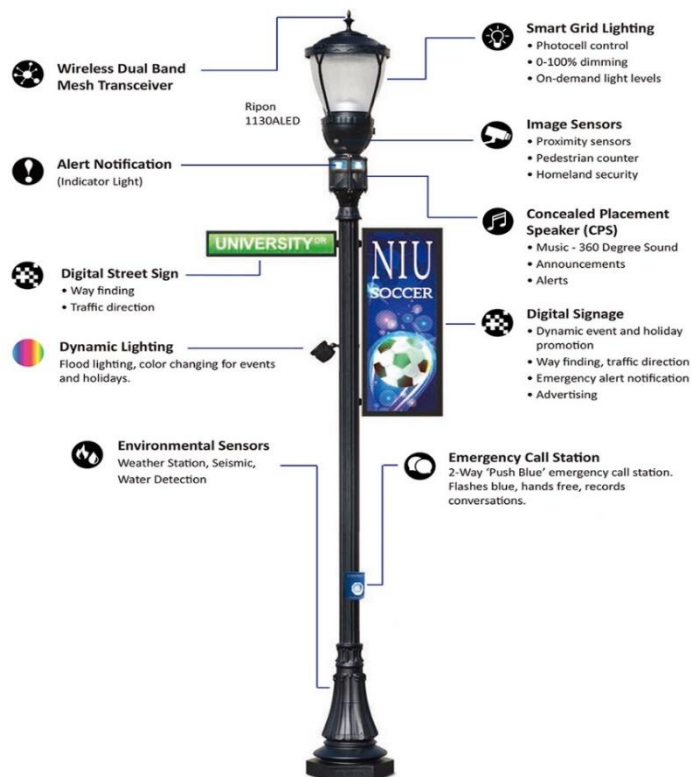


Figure 5. Proposed Street Lightning Pole

Atollic True STUDIO & ST-Link Debugger tools are used. The Street pole consists of various sensors, Transceivers,

Camera, LED Lights and connected to server. The unique features of the design are as follows

- Business advertising
- Weather station
- Rain and flood Monitoring
- Way Finding
- RGB LED light
- Festival lighting
- IP Surveillance Camera

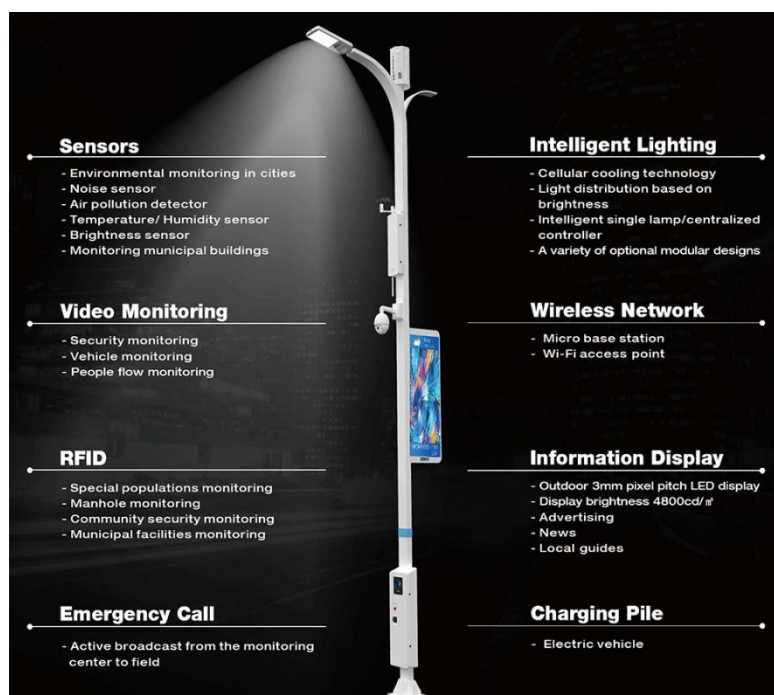


Figure 6. Features of Intelligent Street Pole



Figure 7. Snapshot of Hardware Module

Fig.5 displays the proposed Lightning pole consisting of Wireless dual band mesh Transceiver, Smart grid lightning, Image sensors, Digital street sign & Signage, Concealed placement speaker, Dynamic lightning, Environmental sensors & emergency call station. Fig.6 displays features of Intelligent Street Light Pole which consists of Sensors, Video monitoring, RFID, Wireless network, Intelligent lightning, Information display & charging pile. The snapshot of Hardware module is displayed in Fig. 7.

Results & Discussions

IP Surveillance camera helps in monitoring the street continuously, which helps in assisting the theft/robbery incidents if happens. The Way finding is used to determine the correct path. Weather parameters such as Pressure and Temperature are measured continuously and uploads to the Internet. Using Festival lightning mode, the color of the Street light can be varied to fit with the festival conditions. Emergency speaker provides mass notification services during an emergency situations. Using Photocell control, the Street light is automatically turned on and turned off depending upon the circumstances. The Street lightning pole can also be used for business advertising resulting in revenue generation for authorities. Fig.8 displays the snapshot of result which displays the various modules/features listed in intelligent street lightning system.

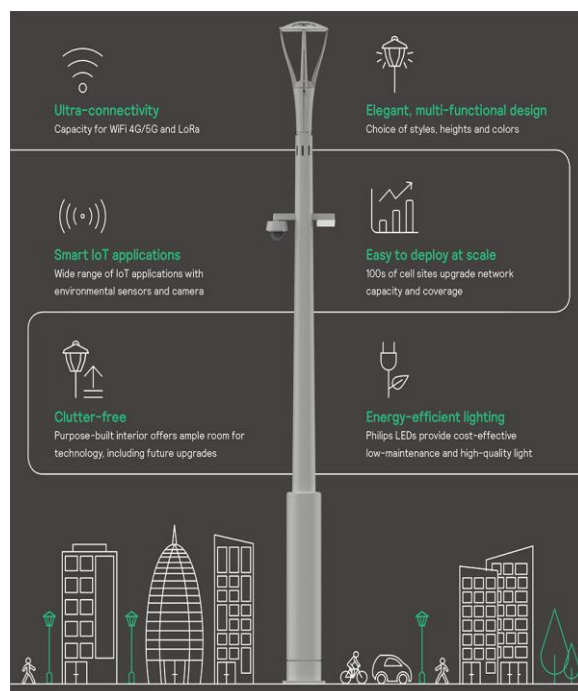


Figure 8. Intelligent Street Light

Conclusion

The article describes the concepts of an Intelligent High Tech Street Lighting Pole which caters the additional services along with essential services which runs on an Embedded Web Server This smart lighting system can be implemented in smart cities, parks, schools, educational institutions and common venues. It provides opportunity for revenue generation too & helps in emergency situations. Smart City journey starts with Smart Street lights which connects over 300-410 million streetlights worldwide with access with 24/7. The future ready systems becomes an open architecture with interconnected applications such as Traffic systems, Security systems, Environmental sensors, Weather systems, Emergency response, EV charging, etc. The overall result in implementing Intelligent Street Lightning results in Adequate Light always, Optimization of Operation & Maintenance, Increased Public Safety, Minimization of Environmental impact, Secure Data connection & Globally compatible.

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