GSM Based Autonomous Street Illumination System for Efficient Power Management

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Abstract: **This paper efficiently defines the control of street lightning system and thereby saving electricity which is a major concern worldwide. It also describes the use of wireless sensor networks using GSM for streetlight monitoring and control. This system would provide a remote access for streetlight maintenance and control. It also discusses an intelligent system that takes automatic decisions for luminous control (ON/OFF/DIMMING) considering surrounding light intensity and time of the day both at the same moment. The system also senses various parameters like surrounding temperature, fog, carbon emissions, and noise intensities and suggests corrective measures. Power theft control is also integrated in the same system. The efficiency of the system is designed such that it can be readily installed in present on road conditions with extra cost of only a single controlling computer. The system is compatible to solar cell installation.**

I. INTRODUCTION

Due to the increase of environmental concerns, lighting control systems will play an important role in the reduction of energy consumption of the lighting without impeding comfort goals. As mentioned the energy is the single most important parameter to consider when assessing the impacts of technical systems on the environment. Energy related emissions are responsible for approximately 80% of air emissions and central to the most serious global environmental impacts and hazards, including climate change, acid deposition, smog and particulates. Lighting is often the largest electrical load in offices, but the cost of lighting energy consumption remains low when compared to the personnel costs. Thus its energy saving potential is often neglected. According to study global grid based electricity consumption for lighting was about 2650 TW in 2005, which was an equivalent of 19% of total global electricity consumption. European office buildings dedicate about 50% of their electricity for lighting, whereas the share of electricity for lighting is around 20-30% in hospitals, 15% in factories, 10-15% in schools and 10% in residential buildings. Intelligent lighting control and energy management system is a perfect solution for energy saving, especially in public lighting management. It realizes remote on/off and dimming of lights, which can save energy by 40%, save lights maintenance costs by 50%, and prolong lamp life by 25%. The system application in streetlight control for each lamp will reduce in streetlight electricity and maintenance cost, and increase availability of street light [8][10][11].

Main Functions:

•Remote on/off, Dimming and on-site Status Check
•System Fault Detection/Alarm;
•Anti-theft Detection/Alarm;
•Date Management (energy consumption report);
•24-hours online Monitoring;
• Reduce energy use by up to 40%;
• Reduce maintenance by up to 50%.

Public lighting in streets, tunnels, city centers, ports and squares etc. can account for about 30% of the urban energy consumption. And the maintenance costs are very high. India is facing a huge energy crisis which has to be addressed to at the earliest using devices that are energy efficient. Based on environmental and economic factors, cities need smart energy management systems urgently for energy saving, maintenance costs reduction and CO2 emission reduction. This project consist of spatially using autonomous devices embedded along with sensors which monitor the environmental parameters like sound ,fog ,temperature ,carbon monoxide emission.

The system compromises of server, GUI to display and nodes which are micro controlled processed with embedded sensors measuring different parameters. Each node in the network is linked to the main server via a protocol. The analog data sensed by the sensor is converted in digital form, processed by microcontroller and then sent to the server. The master controls all the slaves .The other nodes sends the data to master and the master collects the data and further sends to concentrator and server where the data is monitored and on necessary alterations process it to switch On/Off the nodes devices. This scenario increases life of streetlights, reduces power consumption, ease of monitoring and controlling and less installation cost are the various advantages achieved [1][2][3].

II. LITERARY SURVEY

A. *Similar IEEE Reference Papers*

- WSN for intelligent street lighting system
- Design of new intelligent street light control system

- An intelligent driver for Light Emitting Diode Street Lighting
- Integrated System for Intelligent Street Lighting

B. Companies working on similar technology

- IoTcommTechnologies, China

IoTcomm Technologies develops communication technologies for the Internet of Things (IoT), including but not limited to Power Line Communication (PLC), GPRS, Zigbee and WIFI. By integrating PLC and wireless communication technologies seamlessly, Dotcom has developed an intelligent street lighting control and management system, which provides its customers with the least expensive and the most reliable solution to significantly reduce power consumption, operating costs and environmental impacts. IoTcomm also offers power line communication modules and wireless communication modules, which are readily to be integrated into smart automation systems including lighting, heating and cooling, security, fire detection, access control, or energy monitoring equipment for both commercial and residential buildings.

- Echelon International,USA

Echelon's Smart Street Lighting Solution transforms streetlights into intelligent, energy efficient, remotely managed networks that deliver dependable lighting at 30% less cost than low-energy luminaries alone. Over the long term, Smart Street Lighting serves as a foundation for building a Smart City. Nearly 500 cities have started and know the value of it is field-proven and reliable smart street lighting solution. It has proven track record to provide safer, more affordable lighting that reduces carbon footprint.

- Instruments Universal, India

Instruments Universal, an Industrial Automation & System Integration major in Gujarat, was established in 1980 in Vadodara. With a strong foundation of technical expertise and 30-year experience in Effluent Sampling Automation, it has emerged as one of the leading torchbearers in the Automation Industry. The company specializes in MCS51 series, ST7 series of microcontrollers, assembly languages, visual basic, Java, effective 32 bit ARM processor operations and PIC microchip controllers. The company is serving in the field of street light automation, street light monitoring and controlling and street light management since 2000.

III. FIELD SURVEY

A. In Vasai-Virar Mahanagarpalika

TABLE I
STREET LIGHT EXPENDITURE

Sr.No	Identity	Quantity	Expenditure
1.	G.I pole	1	4200INR
2.	Foundation(erection of pole)	1	2100INR
3.	Foundation(erection of pole)	1(9m)	1100 INR
4.	Junction Box	1(6m)	620INR
5.	Cable41*6	35	7700INR
6.	Internal wire	1	500INR
7.	Bracket	1	800INR
8.	Sodium fitting	1	5500INR
9.	Sodium Lamp	1	800INR
10.	Earthing	1	850INR
11.	Evacuation for Laying cable	N/A	3000INR
Total			27120INR

BULBUSED:

- Mostly sodium vapor bulb of 250W or 150W.
- 250W is used for main roads.
- 150W is used for internal roads.

TYPES OF BULB:

1. Sodium-yellow color- Steady nature
2. Mercury-white color- Not used usually
3. Metal halide-white color- Power consumption is quite high, hence not normally used.

B. From MSEB Pune

Current Scenario of Street Light System
(Data Collected From M.S.E.B. –Pune, (M.S.), India)

- Height of Street Light:

7m, 8m, 9m, 10m

- Power:

70 Watts for 7m & 8m poles
150Watts for 9m pole
250 Watts for 10m pole

- Distance between successive street lights:

19-20m (between 7-7m and 8-8m poles)
24-25m (between 9-9m and 10-10m poles)
(Distance between poles depends on width of the roads.)

- Phase :

Single phase (230V) and Three Phase (440) Used together

- Lamps :

Sodium Vapor Lamps

- Network :

Arranged in parallel network

- Linear control :

No linear control available on lamps.

- Timer :

Use of Intelligent Timer
Lamps/Timer 3Kw-5Kw load per timer (20 -30lamps)

- Number of Timers :

2500

- Number of Lamps :

62500(25 Lamps per Timer)

- Number of Energy units Utilized:

4166000 per month approximately

- Monthly Bill of 1.25 crores (Rs.3 per unit)

IV. SOFTWARE REQUIREMENT

- Microsoft visual Basic.NETfor user interface.
- SQL.
- Embedded C for microcontroller chip.
- Eagle software for circuit layout.

V. HARDWARE REQIREMENTS

A. *On road*

1. GSM SIM300 module for wireless communication.
2. Microcontroller C8051F350 for controlling various sensors.
3. PLC module.
4. A PC for observation and running of controlling software.
5. Various sensors for sensing external parameters.
6. Beta-LED fixtures.
7. Camera for street surveillance.

B. *Prototype*

1. GSM SIM300 module for wireless communication.
2. Microcontroller C8051F350 for controlling various sensors.
3. A PC for observation and running of controlling software.
4. Various sensors for sensing external parameters.
5. LED's as street-light lamp.
6. Power supply unit.
7. PCB
8. Thermacol for visualization of streets and street light vicinity.
9. Five small rods as a street light poles

- GSM SIM300 module for wireless communication

Fig.1 GSM module

- Microcontroller C8051F350

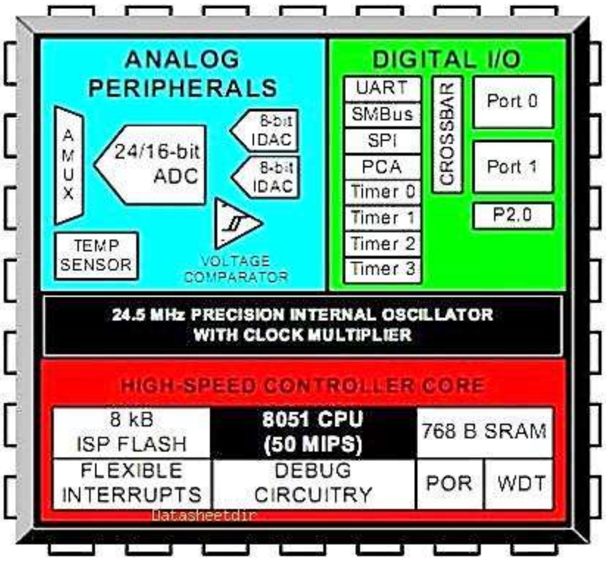

Fig. 2 Microcontroller

- Sensor nodes

The main challenge of Hardware is to produce low cost and tiny sensor nodes. With respect to these objectives, our system sensor nodes are mainly prototypes. It includes different sensors for various parameters and a LED light fixtures i.e. LDR, CO2 gas sensor, Sound sensor (microphone) and Fog sensors. The envisaged size of a single sensor node can vary from shoebox-sized nodes down to devices the size of grain of dust. [12]

VI. SYSTEM STATEMENT

- To create near to real time environment for working of WSN based Street Light Control System and test performance and working of that application.

- To sense real time light intensity by the ambient lights sensor and depending upon the sensed light intensity take appropriate control action on the Street Light (End Device).
- To create library of several modules to simulate the network condition parameters.

- To provide graphical user interface to control and monitor the status of street lights.
- To give graphical simulation of light intensity to the user.

VII. ARCHITECTURE

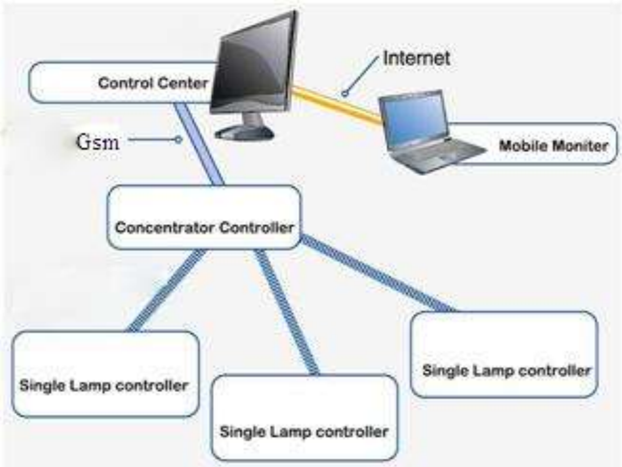

Fig. 3 Architecture

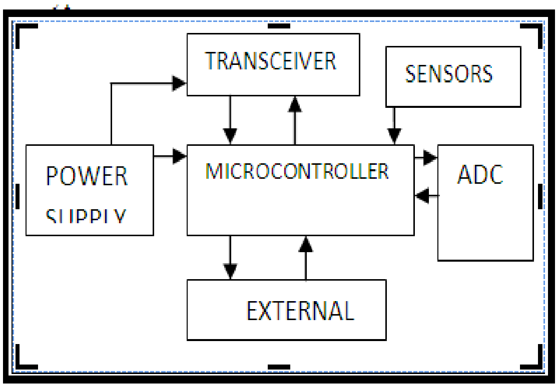

Fig. 4 Block architecture

BASICSYSTEM BLOCK DIAGRAM

Transmission Side

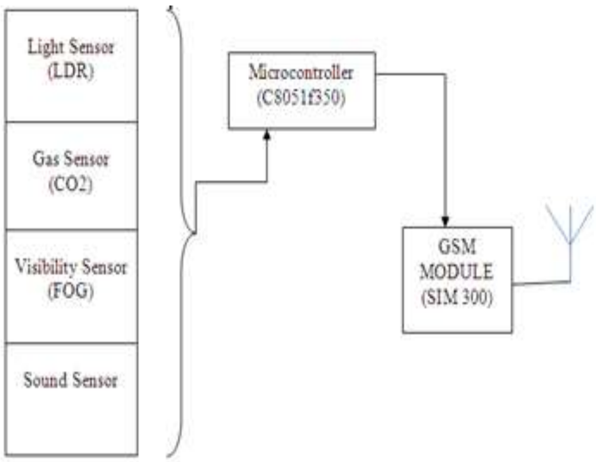

Fig.5 Transmission side

Reciever side

Fig. 6 Reciever side

VIII. SYSTEM FLOW CHART

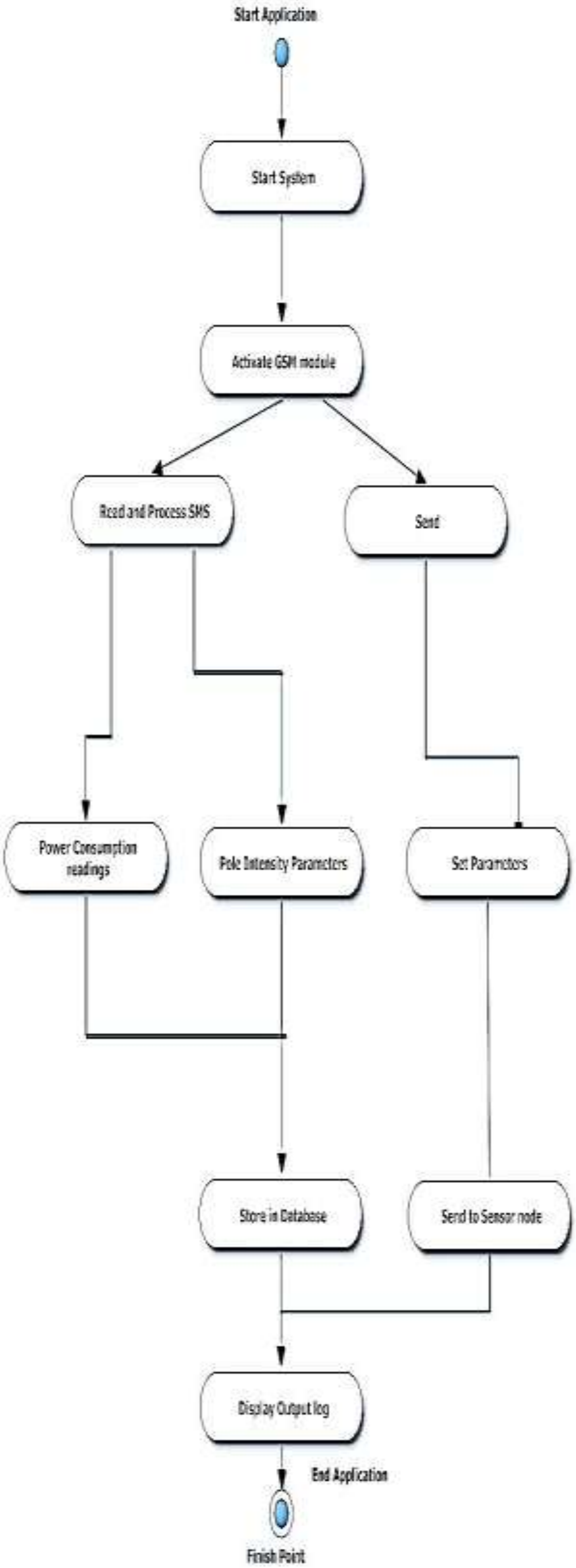

Fig.8 Flow chart

IX. IMPLEMENTATION DETAILS

- User Sets all the required parameters for a particular Sensors on a Street Light Modules for different Areas on the Server.
- All the information is sent to the Street Light Modules using the GSM / GPRS Module.
- Microcontroller then controls the street light based on the Sensor parameters and performs the required action received from the server using GSM / GPRS MODULE.
- The control center will monitor and control all streetlight real times [9]. It compares these values with the threshold value and appropriately decides whether to vary intensity of light. The GUI gives us a representation of the streetlights i.e. their status (ON/OFF) [3][5][6][7].
- Street Light Module can operate in Manual or Automatic Mode as configured from the server by the user.
- Street Light Module also measures the amount of visibility and Carbon Dioxide present in the environment using the respective FOG and Gas Sensor and controls the Fog Lights if Necessary. All This information is sent to the server on request. It takes account of environment and safety standards needed in all traffic conditions [2][4][6].
- Firstly, microchip would be required to be installed on the pole lights. These chips will consist of a micro-controller along with various sensors like CO2 sensor, fog sensor, light intensity sensor, noise sensor and GSM modules for wireless data transmission and reception between concentrator and PC.
- The data from the chips would be received on a remote concentrator (PC) and the PC would also transmit the controlling action to the chip.
- Separate automatic mode will be provided that will have timing considerations in addition to surrounding light conditions.

Highlighting Features:
1. Multicolor LED
2. Light sensor
3. Fog Sensor
4. Carbon emission sensor
5. Noise Sensor

Modes of Operation:

- Auto mode
- Manual mode

A. Auto mode

In auto mode, according to the light intensity, slot of times and also monitoring the weather conditions the nodes are being switched on/off .It monitors the complete locality and thus saving power.
It has following four cases:

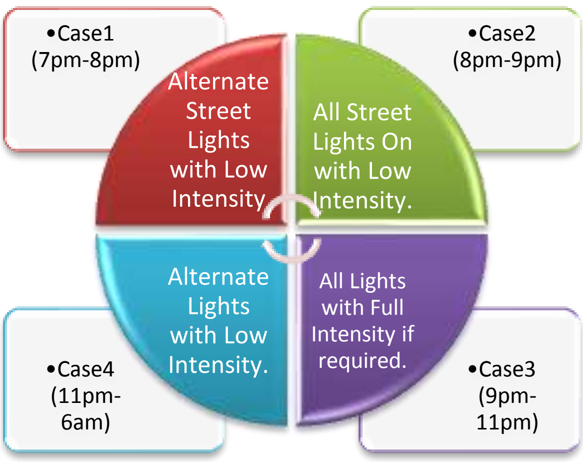

Fig. 9 Four cases

B. Manual mode

In Manual mode, system stores the parameters in computer about changes in environmental conditions continuously like heavy rain visibility, faults ,more or less traffic congestion or during foggy conditions. User can manually define each node with specific intensity factor as per the requirement and can take any suitable corrective measure.

X. ENERGY UTILIZATION

- Works on profile basis i.e. all street lights are ON from 6:30pm to 6:30 am, in other words street lights are functioning completely for 12hrs a day. Assuming 20 nodes to be working power consumed by them will be given as:
    - Bulb used =150 W=0.150 Kw
    - Number of nodes = 20 nodes
    - Number of working hours per day = 12hrs
    - Power Consumed/day = 20 * 12 * 0.150= 36 kWhr i.e. 36 * 30 = 1080 kWhr/month
    - Monthly Bill for 20 nodes (Rs3/kWhr) = 1080 * 3= 3240Rs per month

<u>Comparison with the intelligent system:</u>

- System operates on Sun rise and sunset timing – saves 4% to 8% of energy
- In normal functional time system corrects voltage if goes beyond certain limit– saves additional 7% to 10% energy
- At low traffic time (programmable) system enters in to energy saving mode – saves additional 45% to 50% of energy
- At mid night or very low traffic time staggering starts (programmable) – additional 7% to 10% energy saving.

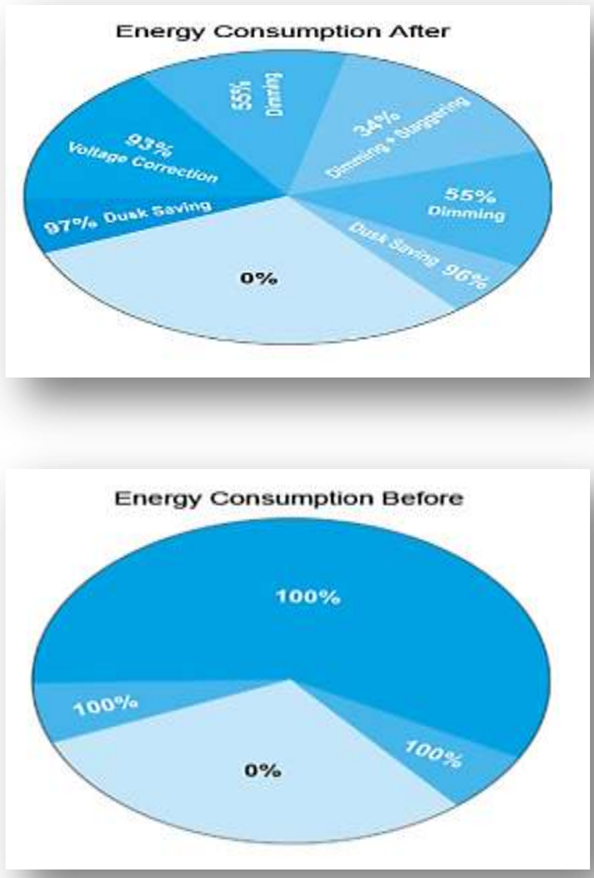

Fig. 10 Pie chart

XI. CONCLUSION

The main issue for the success of integrated solutions in street is to define appropriate communication protocol and the media for the information transfer. Wireless Sensor networks may present a new solution to bring the installed cost down and to ensure energy efficiency. Over the past 10years many new RF solutions have been developed into our every-day life. It is expected that soon a reliable, robust, easy-to-install and secure wireless network technology for connecting devices on streets and in buildings will gain market acceptance and substantial shares of new and retrofit installations. GSM is heading in this direction. Nevertheless it is still not well defined on a semantic point of view.

XII. FUTURE SCOPE

After having implemented this Intelligent System, what remains is the scope for improvements. Firstly, we could directly go for Wireless Power Transmission which would further reduce the maintenance costs and power thefts of the system, as cable breaking is one of the problems faced today. In addition to this, controlling the Traffic Signal lights would be another feature that we could look into after successful implementation of our system. Depending on the amount of traffic in a particular direction, necessary controlling actions could be taken. Also emergency vehicles and VIP convoys can be passed efficiently. Moreover, attempts can be made to ensure that the complete system is self-sufficient on non-conventional energy resources like solar power, windmills, Piezo-electric crystals, etc. We hope that these advancements can make this system completely robust and totally reliable in all respects.

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