IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 3, March 2017

Development of Street Lighting System with Vehicular Sensing at Low Light Intensity based on Zigbee Intelligence

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Abstract: A new method is proposed here for the automation of the street lighting system using the wireless zigbee module. This module provides a perfect scheme for the operation of alternate street lighting systemthat is both automatic and manual. LDR and IR sensor are the backbone of this project. The LDRSensors are used here to detect the day and night andthe sensors to detect any obstacle (vehicle/mobile) passing by and accordingly the lights will be switched on and off.The Graphical User Interface (GUI) is created on MATLAB and can be used to manually operate the lights from the base station. Considerable amount of energy will be saved by the application of this module. The scheme was implemented, and a small scale-working model was developed.

Keywords: LDR, GUI, IR, MATLAB, Zigbee.

I. INTRODUCTION

The world is making progress by leap and bounds and so is the technology. The present era is all about automation and urbanization. From the water purifying system in home to the large systems running in industries, all are automated. This brings the concern for certain systems that are left behind. One of them is our street lighting system. Due to lack of automation in this system it has become more prone to human error and power consumption. The challenge, which concerns the nation most, is the rise in the demand of power supply.In rural India the type of lamps used for the street lighting system are sodium vapour lamps and mercury lamps [1], the former being the prominent. The annual electricity power consumption of a sodium lamp is 217674 KWh that means approximately 25 KW per hour [3]. As the demand is increasing day by day, the nation not only needs to fulfill the demand of the power needs but should also provide energy efficient technology that will lead to improve the efficiency of power consumption with the main objective of saving energy. The gap between the demand and supply will relate to the contribution of the nation towards its development. From the past ten years it has been observed that there is an increase in the number of people who work at night and return home late night.

So there is a need to implement safety measures on the highways to a greater extent, which can be achieved with a proper street lighting system along with its efficient monitoring. The existing system is a manual control system, which has high chances of power loss and human error during failure of proper maintenance. Taking into consideration all of the mentioned, it can be concluded that the street lighting system needs a major attention. The following Zigbee-based street light control is aimed at finding a solution to these sometimes-fatal predicaments.

The present street lighting system is inefficient due to the following reasons:

In complex cable networks currently being used in thestreet light system, it has been observed that during short-circuiting of the power lines, the control of the whole system is lost. Coming to the GSM technology, though its wireless but requires a mobile phone communication which is prone to disruptions and has high operation cost. Here we propose a ZigBee-based street light network that transfers the effective control to a PC running a MATLAB Graphical User Interface application at the Base Station. An optional manual control is also present.Centralization of Control aids in effective and meticulous maintenance due to the constant update of the street light status on the base station PC. It also reduces the human error by facilitating an automatic mode of operation. Moreover, an energy saving scheme is implemented to reduce the energy consumption of the street light system.As the traffic is low in rural areas. If the application of the proposed module leads to the lights being switched-off for at least 4 hours a day then there will be a power saving of 100 KWatts per day and ultimately 36500 KWatts per year. The details about the zigbee technology, the prototype development and the proposed methodology are given in the below sections.

II. CHOOSING THE WIRELESS MODULE

There are many wireless modules present like the Bluetooth, Wi-Fi and Zigbee. Our project aims low data rate which is few Kbps, low power consumption, high coverage area and connectivity to more number of devices and the wireless module of communication should be smaller in size. Apart from the high coverage area, Zigbee

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satisfies all the above. It makes it the most desirable module for the project. It can be best understood by the given comparison of the specifications of different wireless modules[4]. Zigbee is an IEEE 802.15.4-based specification [2]. It suites high-level protocol and is used to create personal area networks with low-power, small digital radios. The technology defined by it is intended to be simpler and is not as expensive as another wireless personal area networks (WPANs), such as Bluetooth or Wi-Fi. Applications of Zigbee include wireless light switches, electrical meters, devices that aim low data rate and less range. It passes data through a mesh network of intermediate devices and can transmit data over long distances.

Table I. Comparisons of various Wireless Modules

Modules / Parameters	Wi-Fi	Bluetooth	Zigbee
Power Consumption	80 m.W	50 m.W	60 m.W
Date Rate	10 Mbps	1 Mbps	250 Kbps
Range	100m	10m	10-100m
Max. No. of Nodes Connected	8	8	>65000

Devices that need low range of networking, secured networking and long battery life, zigbee is the best option for them.(ZigBee networks are secured by 128 bit symmetric encryption keys.)The defined rate of zigbee is 250 Kbit/s, and is best suited for intermittent data transmissions from a sensor or any other input device [2].ZigBee was developed by ZigBee alliance comprising many members (Chipcon, Mitsubishi, Ember, Free scale, AMI Semiconductor, Invensys, CompXs). In this project we prefer zigbee, as the project does not need high data transmission rate. Given below is the comparison of zigbee with other wireless modules. Because of its application focus, more battery life and greater network size zigbee is preferred over other modules. The maximum data transfer rate of Zigbee devices is 250 Kbps with an oscillator of 2.4 GHz. The approximate power consumption is of 60 mW [2]. Zigbee devices use the technique of Direct Sequence Spread Spectrum (DSSS), and thus ensure the reliability of signal transmission, avoiding interference from other signals.It has the maximum operating range of up to 100m. Zigbee network can have up to 65336 devices [2], and each node can interact with every other node, resulting in a very big network.

Due to the advantages highlighted in the following passage, ZigBee networks are a powerful alternative and can be used effectively to control an intelligent street lighting system. Zigbee devices are of two types, Full Function Devices (FFD) and Reduced Function Devices (RFD). FFDs are devices that help in the further propagation of signals into the network. The RFDs being unable to route the signal further in the network are used as network end points.

ZigBee devices are of three kinds:

- ZigBee Coordinator (ZC): It's the most capable device, the coordinator is the root of the network tree and it acts as a bridge to other networks. Only one Zigbee coordinator is present to start a network. There are certain Zigbee specifications, which do not a coordinator like the Light Link, making it more usable for certain home products. The coordinator stores the information about the network. It also acts as the Trust Center & repository for security keys.
- ZigBee Router (ZR): The router acts as an intermediate between the Zigbee coordinator and the end devices. It forms the link to transfer information between the other devices, which are present in the network. While running an application function, a Router works as an intermediate router, passing on data from other devices.
- ZigBee End Device (ZED): It is a Reduced Function Device (RFD). It cannot relay data from other devices and contain just the minimum functionality to talk to the parent node that is either a coordinator or a router. Because of this reason the end device remains idle for most of the time, thus giving a long Battery life. This relationship enables the node to be idle for a significant amount of the time thereby giving long battery life. The end device requires lesser amount of memory when compared to the router and the coordinator. Due to this its cost efficient.

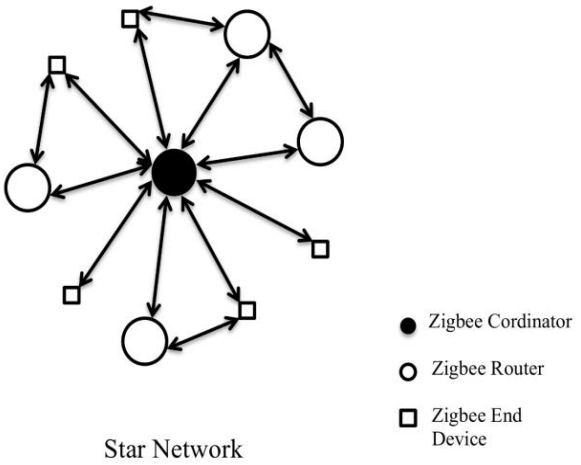

Figure.1.Diagram of a star network

ZigBee is used in 3 modes of operation namely Star-structured, Mesh -structured and Cluster Tree network [2]. In the proposed method we use the Star Network. The star network has a single coordinator. Both routers and the end devices can be directly connected to the coordinator.

III. PROPOSED METHODOLOGY

The main blocks involved in the proposed module are:

Transmitter section:

The receiver unit is responsible for the mode of operation of the module. The basic function of the transmitter

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section is to carry the commands required for the functioning of the module.These commands are generated using the graphical user interface (GUI) and are carried to the receiver via Zigbee, i.e. it forms a channel to carry the commands using comports. The GUI is created using the MATLAB software. There are certain other sources for creating GUI like the Microsoft Visual Basic, JAVA and the .NET.

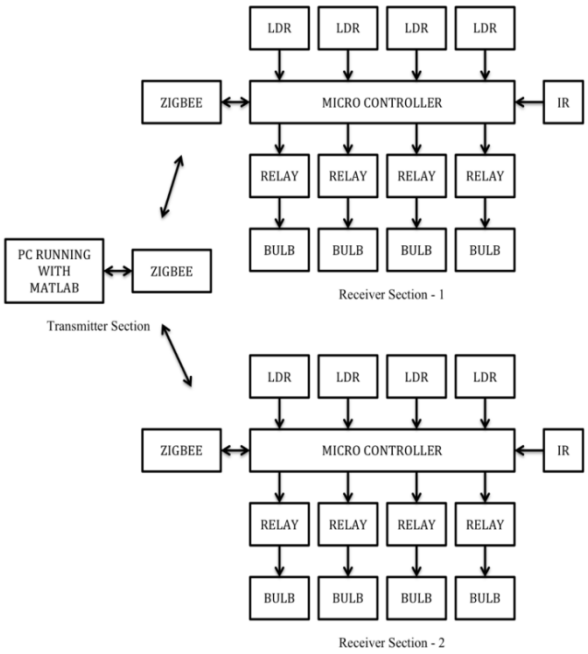

Figure.2. Block Diagram of the proposed system

Receiver section:
The receiver unit is responsible to act according to the commands of the transmitter as the mode of operation depends on the transmitter, the receiver unit works accordingly. For example if the mode of operation is automatic then the control unit present in the receiver section activates the sensors i.e. the Light Dependent Resistor (LDR) and the infrared (IR) sensors. To operate in the automatic mode two conditions are checked. Firstly the LDR checks whether its day or night. It is activated when its night then the module checks for the motion using the IR sensor. If both the conditions are met then the lights are switched ON. If the mode of operation is manual then the street lights are controlled manually from the base station using the individual switches in the GUI.

IV. PROTOTYPE DEVELOPMENT

The street light system based on the ZigBee intelligence can be operated in both the modes i.e. automatic mode as well as manual mode. In the Manual Mode of operation street lights are switched ON or OFF manually, either over the wireless ZigBee network from the base station PC or by the switches provided at the respective nodes. Whereas, after the system is turned into the Automatic Mode of operation, street lights are controlled automatically with the help of the light sensing unit and the microcontroller present at each node. The whole module is developed on the board (Plastic/wooden). There are 8 posts, each one with array of LED depicting the street light (lamp). Each streetlight has one LDR sensor fixed at the top. The IR sensor is fixed in such a way so that it can detect any obstacle (mobile/vehicle in real time) that passes. Here relays are used as switches for each post.
The zigbee wireless network acts as a link/interface between the PC running with a MATLAB GUI at the base station and the street lights (control module at the nodes). The PC interacts with the wireless network with the help of GUI developed on MATLAB. The commands are transmitted to the control modules by the network coordinator (Transmitter section). The control module executes the command. It includes the microcontroller AT89S52 and the sensors (LDR, IR) .

Figure.3. GUI application built on MATLAB

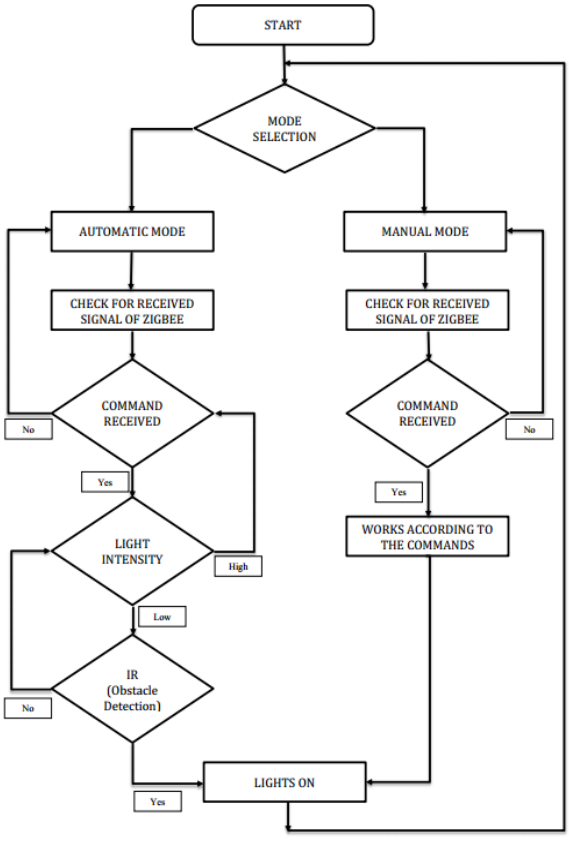

Figure 4. Flow Chart of the street light control system

DOI10.17148/IJARCCE.2017.63175

IJARCCE

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V. CONCLUSION

The paper proposes a novel method to control and effectively manage a street light system using ZigBee, and this provides for better maintenance and management of street lightstechnology. Why it's preferred over other modules has been made clear. This project will lead to a huge power saving as well as reduction of errors. It provides both automatic and manual controls which makes it an appropriate choice for today's need. The ZigBee technology is a relatively ingenious way of communication and this technology can be integrated with other wireless and wired networks. The use of ZigBee technology, which employs low power rating devices that facilitate a longer battery life and require low maintenance, offers the energy efficient way of control that is being sought these days. A small scale working model of the proposed method was successfully developed, and the various modes of operation and control were demonstrated. The system was found to respond efficiently to the various commands sent from the base station PC using the ZigBee technology and the MATLAB graphical user interface. The scope of further enhancements in the project, in terms of the addition of more features is being looked at.

VI. RESULT

By using the proposed methodology, the amount of power saving contributed by the street lighting system will be considerable. In rural India the type of lamps used for the street lighting system are sodium vapour lamps and mercury lamps, the former being the prominent. The annual electricity power consumption of a sodium lamp is 217674 KWh that means approximately 25 KW per hour. As the traffic is low in rural areas. If the application of the proposed module leads to the lights being switched-off for at least 4 hours a day then there will be a power saving of 100 KWatts per day and ultimately 36500 KWatts per year. Apart from the rural areas the application of this module in certain isolated streets will add to the power savings.

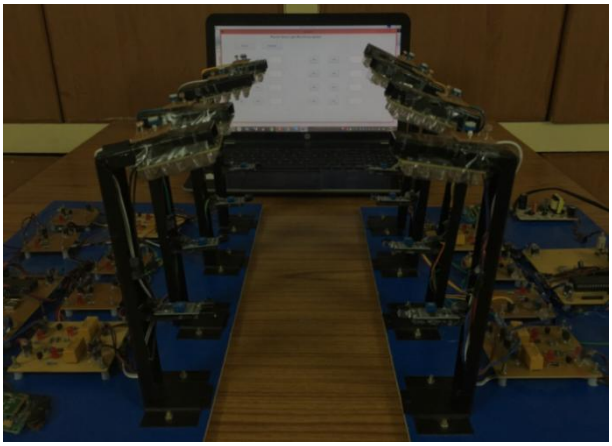

Figure 5. The small scale-working model developed

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