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Smart Traffic Light Control and Congestion Avoidance System During Emergencies Using Arduino and Zigbee 802.15.4

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Abstract*—In this paper we have proposed à smart traffic light control and congestion avoidance system during emergencies. The system consists of two parts: Smart traffic light control system and Smart traffic routing system. First part of the system controls the traffic light system smartly for emergency vehicles and second part of the system tries to avoid congestions caused by traffic jams. The overall system is based on Arduino. The Arduino used in the system is Arduino duemilanove atmega which is 328P family based. The system contains IR proximity sensor/distance sensor, Arduino and Xbee pro which are mounted on the either sides of roads and in emergency vehicles respectively. The IR system is activated whenever any vehicle passes on road between IR proximity sensor and Xbee pro. Arduino controls the IR system and counts number of vehicles passing on road. Arduino also store vehicles count in its memory. Based on different vehicles count, the Arduino takes decision and updates the traffic light delays. The traffic light is situated at a certain distance from the IR system. Thus based on vehicle count, Arduino defines different ranges for traffic light delays and updates those accordingly.

***Keywords*— Arduino, Ethernet Shield, IR proximity sensor, Xbee Pro, GSM Modem**

I. INTRODUCTION

Traffic Signal System or traffic monitoring is a vast domain where WSN can be applied to gather information about the traffic load on a particular road, incoming traffic flow, traffic load at particular period of time (peak hours) and in vehicle prioritization. Wireless Sensor Networks [1] deployed along a road can be utilized to control the traffic load on roads and at traffic intersections. Sensors are deployed on either side of roads at intersection points and in emergency vehicles respectively. These sensors run on both solar energy as well as battery. During bright and sunny conditions these sensors have the capability to draw solar energy from sun light and use battery power for functioning during night and cloud and foggy condition Consider a scenario of highly congested area where many vehicles such as personal transport, public transport and emergency vehicles (Ambulance, Fire brigade, VIP cars and other rescue vehicles) have to wait for long for the change of traffic signals at intersection points. Existing traffic light systems have timers that are set at regular intervals. This leads to the wastage of precious time especially in case of rescue vehicles for emergency conditions. In order to control this situation, we have proposed a system consisting of two parts: Smart Traffic Light Control System (STLC) and Smart Congestion Avoidance System (SCA) during emergencies. STLC System controls the change of traffic lights at intersection points giving high priority to emergency vehicles. SCA System is a smart traffic routing system that chooses the shortest routes having the least congestions. Sensors used in this system are mainly of two types: Simple proximity sensor [2] and Modulated IR sensor [3]. Simple Proximity sensor is a sensor used to detect nearby objects without any physical contact. A proximity sensor often transmits electromagnetic radiation (infrared) and looks for changes in the field or return signal. Modulated IR sensor is combination of Infrared sensor and 38KHZ Square Wave Generator. Unlike the simple IR proximity sensor, this sensor provides high immunity against normal sun rays and can be used for all indoor/outdoor conditions effectively. The processing module that has been used for the proposed system is Arduino duemilanove atmega which is 328P family based [4]. Xbee Pro Series 1[5] radios have been used for RF communication also a fixed directional antenna system has been used at each intersection. A GSM modem [6] and display unit has been embedded in the main controller system as well as in the vehicular system. The main controller system uses an Ethernet shield [7] to connect the server with Arduino via RS45 cable. The rest of the paper has been categorized as follows: Section II contains related work, Section III consists of the proposed system, Section IV presents the system implementation, and Section V includes conclusion.

II. RELATED WORK

The design for a smart traffic control system is one the most recent trend nowadays. Various systems have been proposed in the literature. Many techniques like SCADA & PLC, RFID, IR sensor & microcontroller, smart phones (Bluetooth, WIMAX, and WIFI), smart Cameras, Data acquisitions stations & inductive coils, Singposting systems, weather stations, Tele-Vigilance system and Smart-Signal (Systematic Monitoring of arterial road traffic signals) have been used. SCADA and PLC has been used to design smart traffic control system in [8]. This system is used to measure the traffic density by counting the number of vehicles in each lane and their weight then park in automated in parking or diverge them accordingly. RFID has been used to design intelligent traffic lights in [9]. This system provides quality of

service to Emergency vehicles and improves the accuracy of Automatic Traffic Light Violation Detection system as well as helps to trace out the stolen vehicles using RFID. IR sensors and microcontroller has been used to design Intelligent Traffic Light and Density Control in [10]. This system somehow reduces the possibility of traffic jams caused by traffic lights. Smart phones have been used to design an Efficient Real-Time Traffic Sign Recognition System for Intelligent Vehicles [11]. The traffic sign recognition system is one kind of driving assistance system (DAS) which is used to automatically inform the driver the traffic sign information by a head up display (HUD), monitor, or speaker device. Smart Cameras have been used to design Vehicles tracking and classification using traffic zones in a hybrid scheme for intersection traffic management in [12]. Data acquisitions stations & inductive coils, Singposting systems, weather stations, Tele-Vigilance system has been given in Wireless Sensor Network-based system for measuring and monitoring road traffic [13]. Data acquisitions stations have been used to get the data from stations and inductive coils has been used to detect the presence of vehicles on the roads. Singposting systems have been designed to give all information about what is happening along the road. They are made of digital panels and are connected to the central control with the help of optical fibre cables. Weather stations have been designed to prevent risky situations. In this system sensors are equipped with barometers, hygrometers and thermometers. Tele Vigilance system has been used to monitor the roads with the help of cameras deployed along the road and the emergency services are activated in a few minutes.

Smart Signal has been used to design Systematic monitoring of Arterial road traffic signals in [14]. This system has been used to collect and archive event-based traffic signal data simultaneously at multiple intersections. Using the event-based traffic data, SMART-SIGNAL can generate time-dependent performance measures for both individual intersections and arterials including intersection queue length and arterial travel time.

III. PROPOSED SYSTEM

We have proposed a system consisting of two parts: Smart Traffic Light Control System (STLC) and Smart Congestion Avoidance System (SCA) during emergencies. Fig. 1 (Smart traffic and congestion control system in emergency conditions) shows the architecture of whole system.

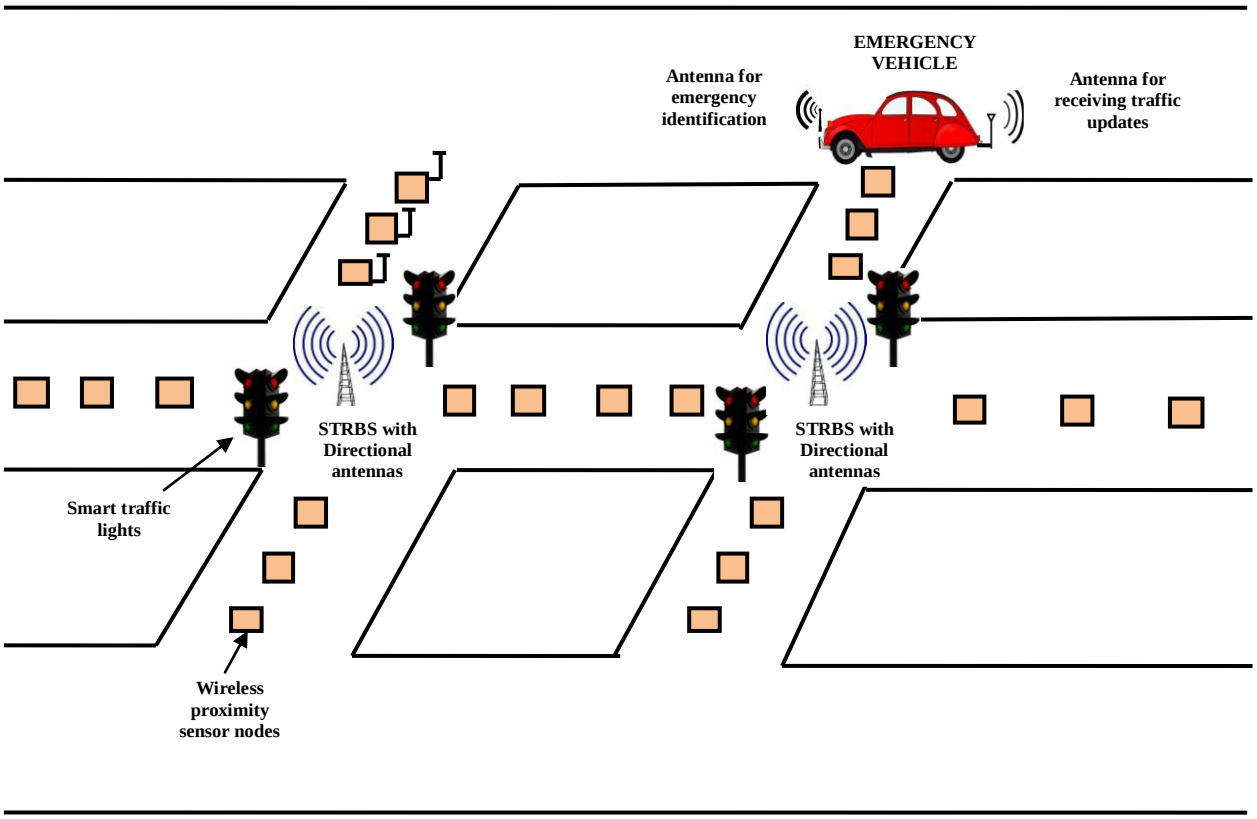


Fig. 1: Smart traffic and congestion control system in emergency conditions

A) Smart Traffic Light Control System (STLC)

STLC System controls the change of traffic lights at intersection points giving high priority to emergency vehicles. In this system when emergency vehicles approaches at intersection points our STLC give them higher priority. The block diagram of STLC system has been shown in Fig.2.In this system emergency vehicle contains IR source for detection of proximity of vehicle. This IR source continuously sends IR rays and IR sensors which are deployed along the road detect those IR signals. The IR sensor output are connected to pin 13 of Arduino which is connected to Xbee. Xbee communicates with directional RF antenna systems at traffic lights. Traffic light contains our STLC system which monitors and controls the whole traffic and gives priority to emergency vehicles so that they will not remain at

intersection points for a long. When there are emergency vehicles on all sides of road named as a, b, c and d towards the common intersection, at that time our system works smartly as shown in fig. 3

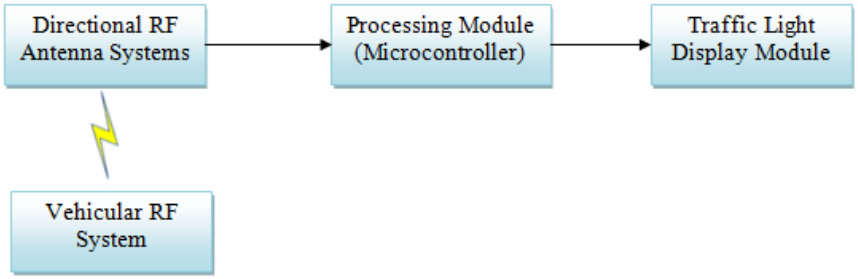


Fig. 2: Block diagram of Smart Traffic Light Control System (STLC)

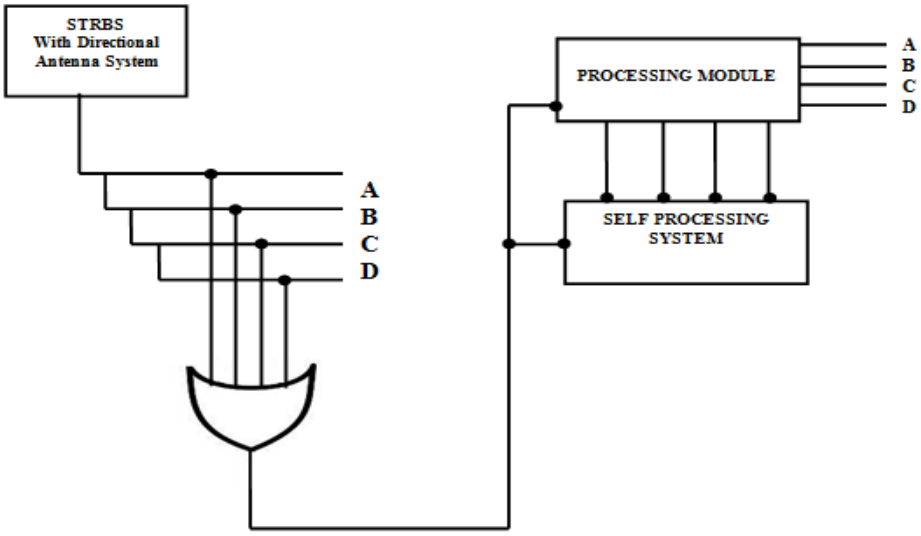


Fig. 3: STRBS communicating with Base Station processing module

B) Smart Congestion Avoidance System (SCA)

SCA System is a smart traffic routing system that chooses the shortest routes having the least congestions. In this case emergency vehicles contains antenna for emergency identification, antenna for receiving traffic updates from nearest STRBS (Smart traffic Routing Base Station), RF communication unit, Processing module and Display unit has been shown in fig. 4.

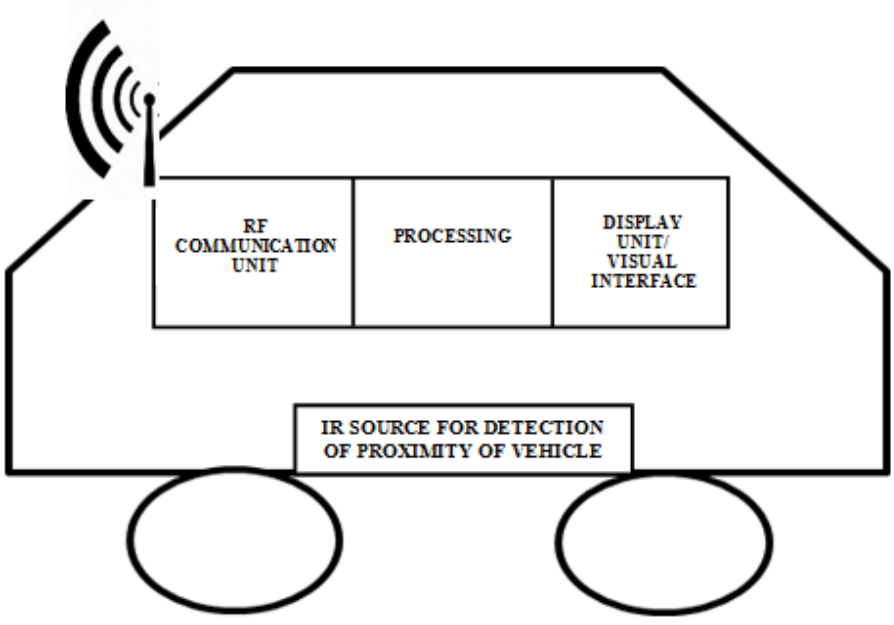


Fig. 4: Emergency Vehicle System

This emergency vehicle gets traffic updates from nearest STRBS and according to that information it takes the shortest routes with less traffic jams. The block diagram of SCA has been shown in fig. 5

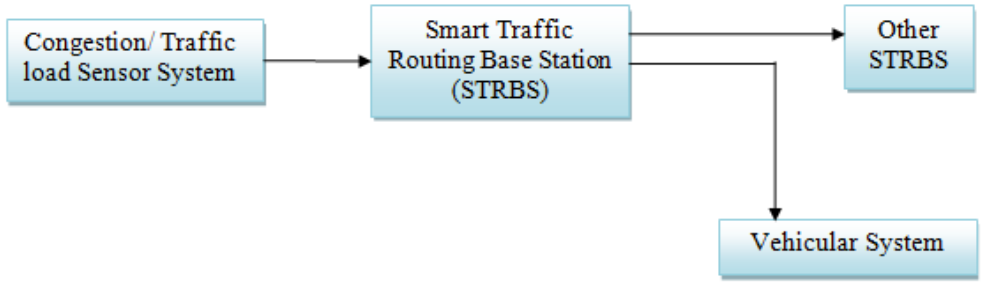


Fig. 5: Block diagram of Smart Congestion Avoidance System (SCA)

Communication of sensing system with vehicular system for routing has been shown in fig. 6. In this vehicle gets routing information form nearest STRBS with the help of GSM technology. Xbee Pro Series 1 radios have been used for RF communication also a fixed directional antenna system has been used at each intersection. A GSM modem [6] and display unit has been embedded in the main controller system as well as in the vehicular system. The main controller system uses an Ethernet shield to connect the server with Arduino via RS45 cable.

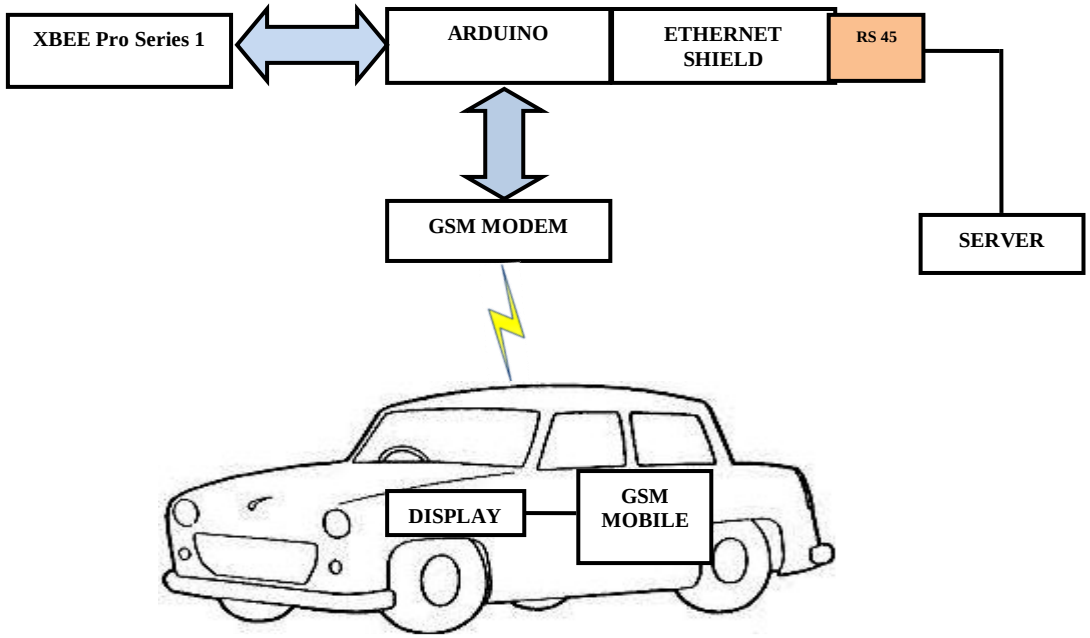


Fig. 6: Communication of Sensing System with Vehicular system for routing

C) *Algorithm*

We have proposed a new algorithm for smart traffic light control and congestion avoidance for the high traffic areas. We have named this algorithm as "Smart Traffic Light Control and Congestion Avoidance" (STLCA) algorithm. This has been given below.

STLCA Algorithm

STEPS:

Step 1: Sensor a1, b1, c1 and d1 sense the proximity, process it and send it through ZIGBEE or WSN to a2, b2, c2 and d2 receiver.

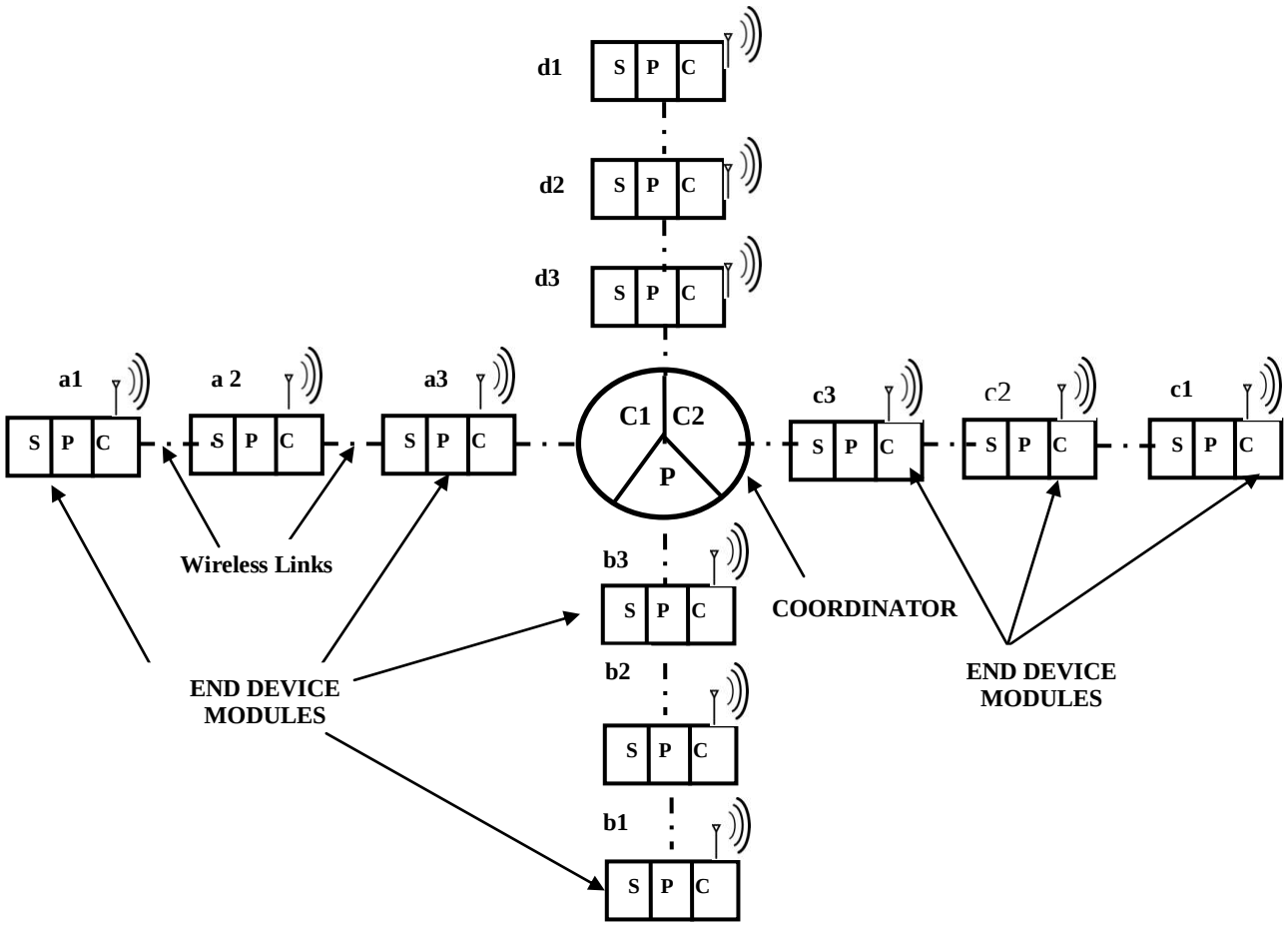
Step 2: Sensor a2, b2, c2 and d2 sense the proximity and add it to the received proximity from the last record sensors.

Step 3: Sensor a3, b3, c3 and d3 sense the proximity and add it to the received proximity from the last record sensor near coordinator.

Step 4: Sensor a4, b4, c4 and d4 sense the proximity and add it to the received proximity from the last record sensor near coordinator.

Step 5: Coordinator senses the total weight from the entire four peer to peer networks and routes the information to neighbouring coordinator.
Step 6: At the neighbouring coordinator all the steps 1 to 4 are repeated.
Step 7: Coordinator takes the decision and performs an action according to the information received.

The diagrammatic representation for the communication between the different end devices and coordinator has been depicted in fig.7. It uses multihop communication to transfer the packets from one node to another thus increases the communication range and saves time. End device a1 forwards data to end device a2, a2 in turn forwards the packet to a3 and so on until the packet reaches the coordinator which then takes the necessary action. Similarly the packet is transferred from b1, b2, b3, b4 and c1, c2, c3, c4 and d1, d2, d3, d4 to coordinator.



For END DEVICE:
S- IR Proximity Sensor/ Distance sensor
P-Arduino (328P Family)
C- RF Communication Module XBEE Pro series 1

For COORDINATOR:
P-Arduino
C1- XBEE for communication with the motes
C2- Ethernet/PPP RF link for communication with server/ vehicle

Fig. 7: Layout for Communication among the end device modules and Coordinator module

IV. SYSTEM IMPLEMENTATION

In this section we have explained hardware implementation of our system which consists of Arduino duemilanove atmega which is 328P family based Ethernet shield, RS45 cable, GSM Modem, Xbee Pro Series 1, IR proximity sensor, and Modulated IR proximity sensor. Arduino Duemilanove is a microcontroller board based on Atmega328 or Atmega168. It has 14 Input/ Output pins of which 6 can be used for analog inputs and 6 pins as PWM outputs, 16 MHz crystal oscillator, a USB connection, ICSP header, a power jack, an, and a reset button. It has same function as microcontroller we have to connect it to computer with a USB cable and give it power supply or battery to get started.

GSM Modem is just like a mobile phone accepting a SIM card and works like a mobile phone and is a specialized type of modem which operates over a subscription to a mobile operator. By connecting the GSM modem with computer allows us to use the GSM modem for communication over the network. GSM modem can be used for sending and receiving SMS and are frequently used for internet connection.

XBees Pro Series 1 is used for RF communication and its indoor range is 100m and outdoor range is 1500m Receiver sensitivity is 100dBm. XBees are configured with the help of X-CTU terminal.

Sensors used in this system are mainly of two types:

A) Simple proximity sensor
B) Modulated IR sensor.

Simple Proximity sensor is a sensor used to detect nearby objects without any physical contact. A proximity sensor often transmits electromagnetic radiation (infrared) and looks for changes in the field or return signal. In our system IR proximity sensor is connected with pin 13 of Arduino.D1 pin of Arduino transmits the data to Xbee and pin D0 is received data from XBees. Fig. 8 shows the circuit diagram of End device using Simple Proximity Sensor.

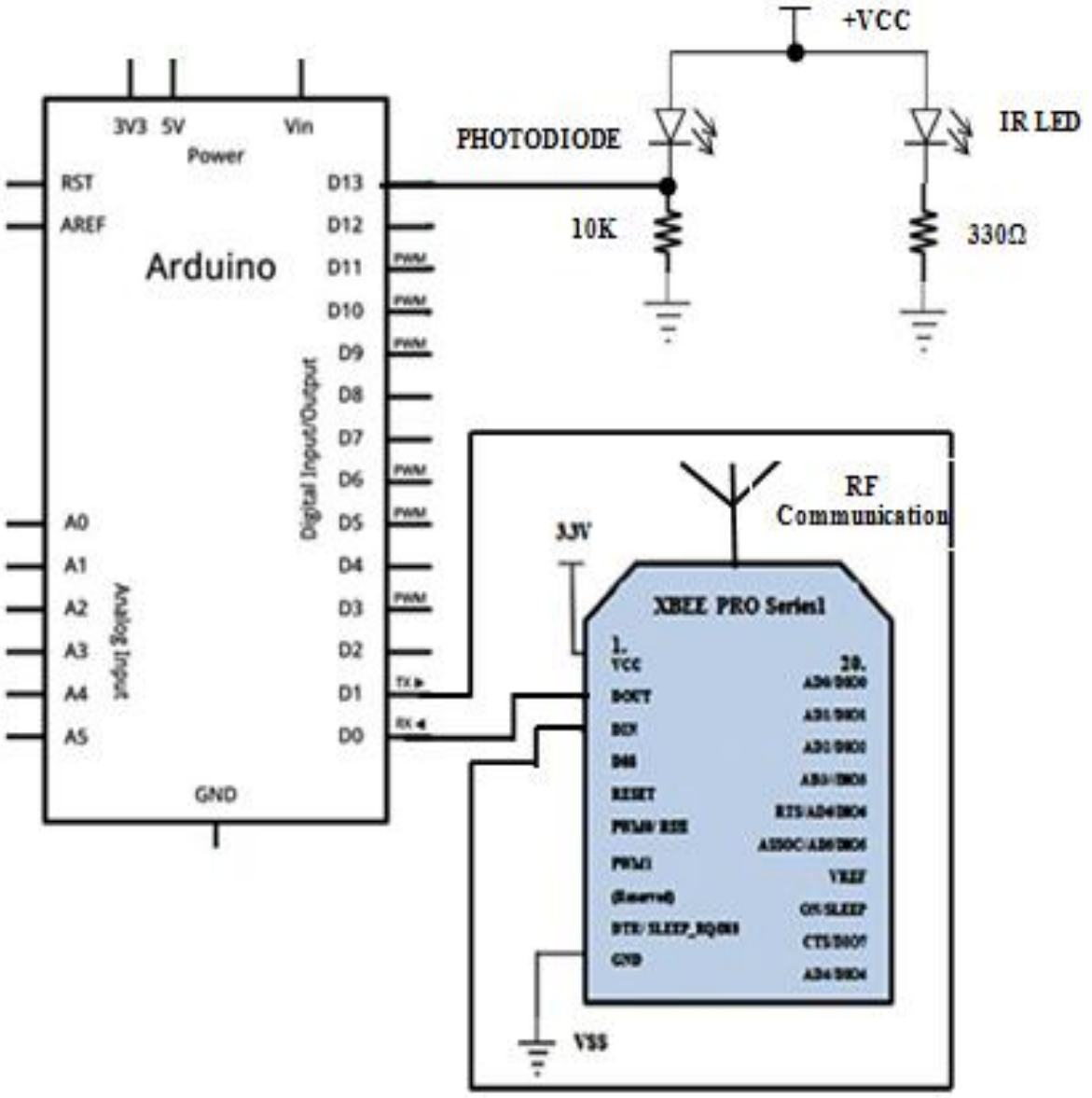


Fig. 8: Simple Proximity Sensor (End device)

Modulated IR sensor is combination of Infrared sensor and 38KHZ Square Wave Generator. Unlike the simple IR proximity sensor, this sensor provides high immunity against normal sun rays and can be used for all indoor/ outdoor

conditions effectively. In our system Modulated IR proximity sensor is connected with SCL and SDA pin of Arduino.D1 pin of Arduino transmits the data to Xbee and pin D0 is received data from XBees. Fig. 9 shows the circuit diagram of End device using Modulated IR Sensor.

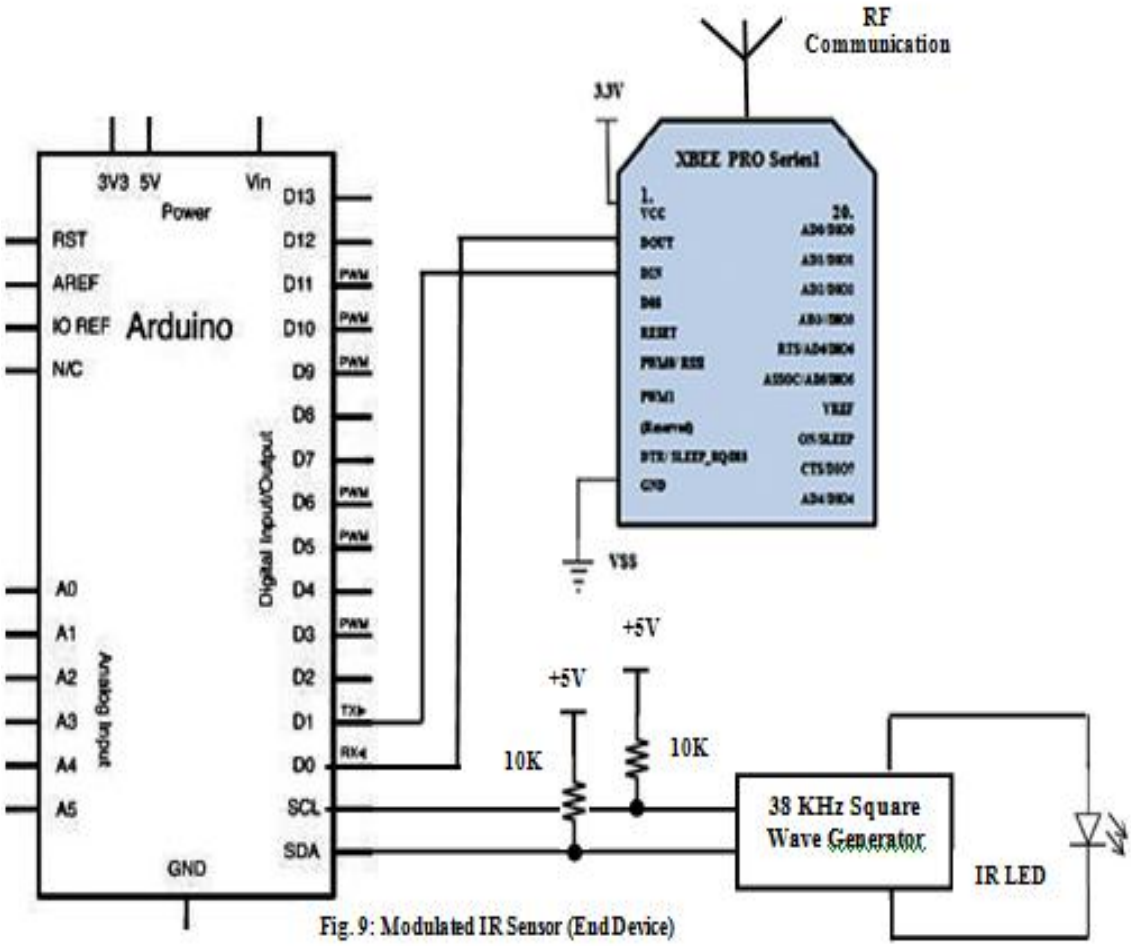


Fig. 9: Modulated IR Sensor (End Device)

Fig 10-14 depicts the various pictures of our system Fig. 10 shows the picture of Arduino with Ethernet shield, fig. 11 shows the picture of processing module with sensing module, fig. 12 shows the picture in processing module communicates with server through cable and fig. 13 depicts the picture of two XBees configured as two End devices.

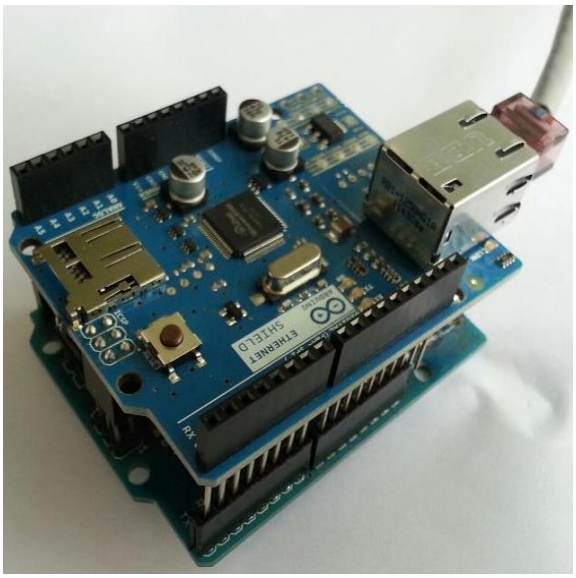


Fig. 10: Picture depicting the Arduino with Ethernet

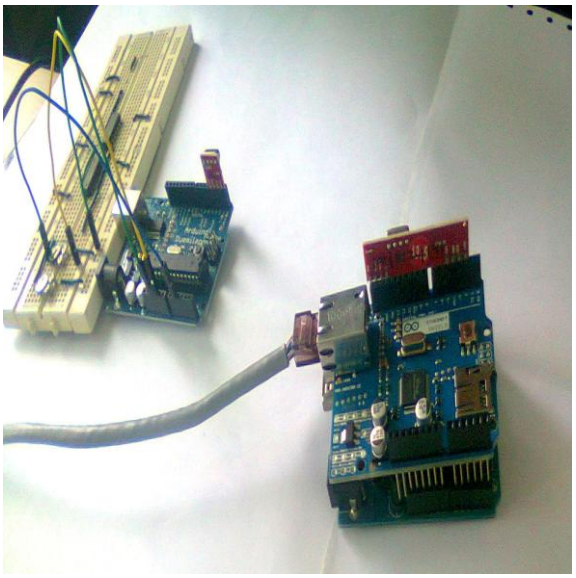


Fig. 11: Picture depicting the processing module with sensor module

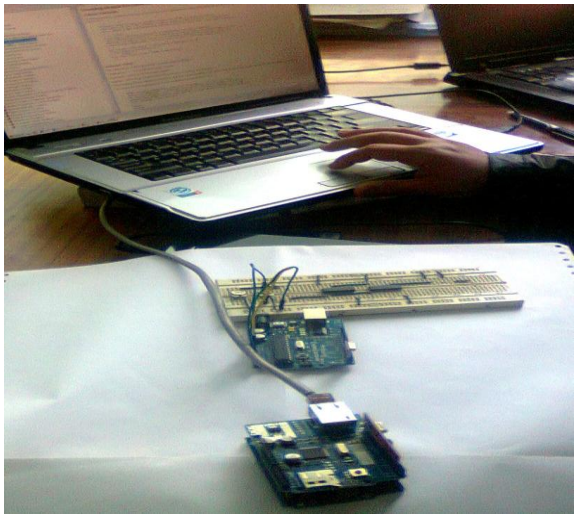


Fig. 12: Picture depicting the connection of Arduino to server through cable

Fig. 13: Picture depicting the two XBees configured as end devices

V. CONCLUSIONS

In this paper we have proposed and implemented Smart Traffic Light Control and Congestion Avoidance System using Arduino and Zigbee 802.15.4 in real time. This system controls the change of traffic lights at intersection points giving high priority to emergency vehicles. Furthermore this System provides smart traffic routing that chooses the shortest routes having the least congestions. Although previous approach represents efficient techniques to control the traffic light sequence but they use complex architecture which are very expensive. The use of Zigbee makes it economical, reliable and provides roader range for communication. In our system we have used Arduino which has already power and reset circuitry setup as well as circuitry to communicate and program with the microcontroller over USB. We have evaluated the feasibility of the system through rigorous experimentation and have obtained satisfactory results.

ACKNOWLEDGMENT

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