Vehicle Density Estimation using GPS and Zigbee Networks to Control Traffic Signals

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***Abstract*— In India a few developed cities have traffic signal control based on the vehicle density. But even though all other cities that have the same traffic density, time based traffic signal control is used till then. As a part of globalization, time management and time consumption means a lot. The fast moving world does not want to wait at any cost and does not want to wait in midst of the time consuming traffic signals. As a result of this urge on people, safety measures are also discarded intentionally. Thus a need of time saving traffic signal control unit based on density aroused. The proposed technique of density based system would be better than the time based system as it scans the density of vehicles on road based on GPS and Zigbee wireless communication protocol (IEEE 802.15.4), also time is not a major constrain. More accurate and easily maintainable system is our needful system. This proposed work would compensate the drawbacks of the existing systems. This system can be implemented in all frequently congested road junctions. Traffic density estimation can be done in many ways by using IR sensors, image capturing method, surveillance method etc. The proposed system has two units; the Traffic Signal Control Unit (TSCU) and the Vehicle Unit (VU). Thus green signal can be lighted on the road which has the more number of vehicles and the congestion on the roads can be reduced. Besides the traffic signal management, the same system also refers about the priority given to the emergency vehicles on the road. The paper mentions four cases of algorithms based on the density variation on the roads.**

***Keywords*—- ZigBee network, GPS, Vehicle Density, RFD, FFD, TSCU, VU.**

I. INTRODUCTION

The traffic signal system in almost all cities in India is based on the time that results in time wastage, more fuel consumption and more congestion on roads. Many methods and systems were already proposed for the traffic management using the density of the vehicles on the road. This paper is proposing a method to estimate vehicle density using GPS and ZigBee network. Location coordinates from GPS is used for the density estimation [9], [6]. ZigBee network is used as the communication wireless network. All TSCU should have a Microcontroller Unit (MCU) and a ZigBee coordinator to create a network. The MCU in TSCU is given a range of location coordinates that defines the all paths or roads converging to the traffic signal post. The vehicles should contain a GPS modem, a MCU together with a ZigBee transmitter. The MCU routes the latitude and longitude coordinates / location from the GPS to the TSCU when the ZigBee transmitter in the vehicle is activated by the ZigBee network in the TSCU. The traffic signal control unit receives the location coordinates from all the vehicles and vehicle densities at all the paths are to be estimated based on the location ranges stored in the MCU. Firstly we have to identify the more crowded junctions. Find the range of location coordinates of all the roads using GPS or Google map. The range or distance from the traffic control unit should be within the transmitting range of ZigBee unit in the vehicles. Thus a minimum of 100m to150m radius can be covered by this system.

II. THE ZIGBEE NETWORK

The ZigBee is a WPAN IEEE 802.15.4 protocol, with a data rate of 250Kpbs at 2.4 GHz and a range of 10 to 100m. The MAC layer of the IEEE 802.15.4 introduced two types of physical devices, the full-function-device, FFD and the reduced-function-device, RFD.

FFD - These devices perform network management functions such as routing, coordination, networking formation, and other management functions [1], [2].

RFD - These devices interact directly with the application processes and sensors i.e. they perform data capture, control functions, and other application specific functions. They can also be mobile, depending on application, and therefore they need only low power and memory space [1], [2].

This project needs a star topology based network in the TSCU. The coordinator is responsible for the formation of network. A FFD ZigBee device can create a network which has the ability to create the network, assigning network channel and adding other nodes to the network [1], [2].

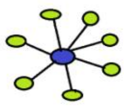

Fig. 1. Star Topology

Figure 1 shows a star topology created by one coordinator (blue color) device and seven end devices (green color). One network can be created by using only one coordinator. Each TSCU thus has a ZigBee network and the coordinator is powered using the electricity mains since it needs to wake up all the time and it consumes more power and memory space than the end devices. ZigBee transmitter in each VU acts as the end device. The end device is chosen as the RFD since it has only the reduced function of sending the GPS location coordinates to the coordinator. End devices talk only to the network coordinator (FFD).The coordinator is set in such a manner to ensure that only one GPS location is received from one end device or VU at a time. The star network topology allows equal access to all the end devices and it is called multi access. The star topology in our paper uses beacon access mechanism. A node in a beacon enabled network can transmit only in its designated time slot. This reduces collisions of data from other end devices. The coordinator periodically generates a super frame, identified as a beacon frame [1], [2], [3]. All nodes in the network should synchronize their on-board clocks to this frame. Each node is allocated a specific time-slot within this super frame and during which only it is allowed to transmit its data. In a beacon-based network, an end device node will wake up just before this super frame is generated, will transmit / receive data at the appropriate time and then go back to sleep. End devices search active channels and select the strongest channel. It then sends a ‘can I join?’ message to the coordinator. The network uses the MAC addressing scheme. Each ZigBee node comes with its own unique 64-bit MAC address, assigned by the IEEE that gives no information about the location of the node [2]. The coordinator scans the MAC address of the node wanting to join a network with the help of a list of permitted MAC addresses, it then allow or deny access to that node.

III. GLOBAL POSITION SYSTEM

The Global Positioning System (GPS) is a satellite-based navigation system. It consists of 24 orbiting satellites, each of which makes two revolutions around the Earth every 24 hours [4]. These satellites transmit– the satellite's number, its position, and the time the information is sent. These signals are received by the GPS receiver and calculate the distance between it and the GPS satellites. GPS satellites transmit two low power radio signals, L1 and L2. The signals travel by line of sight. The GPS module continuously transmits serial data according to NMEA_standards [5]. NMEA has a lot of sentences like GPGLL, GPGSV, and GPRMC etc. NMEA sentences start with ‘$GP’ for GPS devices, has about 80 characters, each data separated by comma and ends with ‘*checksum digits’. A GPRMC sentence contains the latitude, longitude, time, date and speed values of the receiver [5].

Table 1 .GPRMC Information

Field Name	Index	Format
Header	0	$GPRMC (fixed)
Timestamp	1	hhmmss.ss
Latitude	3	DDMM.MMM
Longitude	5	DDDMM.MMM
Velocity	7	VVV.V

In this paper, the GPRMC sentence is received by the microcontroller through serial communication port and extracting the latitude, longitude and speed by comparing the sentence with the previously loaded NMEA format.

IV. THE TRAFFIC SIGNAL CONTROL UNIT (TSCU)

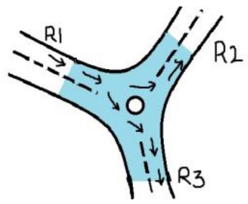

Fig. 2. ZigBee network in a TSCU

The main function of the unit is to estimate the vehicle density. This unit has a ZigBee receiver and a Microcontroller unit (MCU). The ZigBee receiver is a coordinator device. The microcontroller AT89xxx which has the flash memory of 4kb or the other advanced controllers can be used [8].

Fig.2. shows a junction of three ways R1, R2 and R3. Our plan is to place the traffic signal unit at the centre of the junction. Find the nearest and the farthest end location coordinates of each road that is under the ZigBee network. The area under the network is shown in blue shade in figure. The range in a road can be mostly in wider rectangular shape and a minimum of six/four location coordinates are required to clearly define a rectangular and a wider road. The number of location coordinates may vary based on the accuracy of GPS using and also based on the width of the road. Save the coordinates in the ROM of the microcontroller by using Assembly language programming. When the TSCU is activated a ZigBee network is created by the coordinator after scanning the received addresses from the various end devices or Vehicle Units. The ZigBee module receives the location coordinates from the vehicles and the data is given to the MCU through the serial interface. The microcontroller sorts the roads using location coordinates from the vehicles. Based on the number of vehicles the microcontroller unit gives control to light the green signal to the road that has more number of vehicles. The program can be written in C language.

V. THE VEHICLE UNIT

This unit consists of a MCU, a ZigBee transmitter (End device) and a GPS. As the vehicle reaches in the range of ZigBee beacon enabled network it sends the MAC address to the coordinator to get the communication link. The MCU checks whether the vehicle speed is zero using GPS data and also checks the ZigBee device whether it is activated or not. When both the conditions are met the GPS data or the current location coordinates are transmitted to the coordinator [6], [7].

VI. TSCU BLOCK DIAGRAM

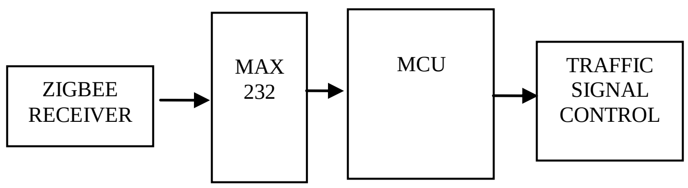

Fig. 3. TSCU Block Diagram

VII. VU BLOCK DIAGRAM

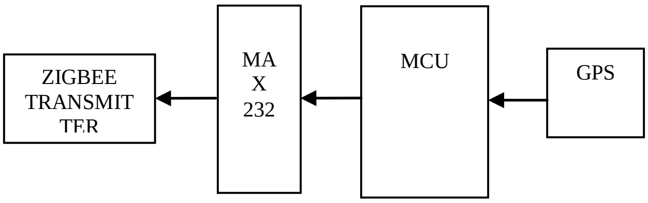

Fig. 4. VU Block Diagram

VIII. PSEUDO ALGORITHM

While writing the algorithm we have to consider some cases viz,

1. All roads are with more or less the same densities.
2. Two roads denser than the other road.
3. One road denser than the other two roads.
4. Clearance of roads with heavy vehicles like truck or to give priority to ambulance, police vehicles, fire brigade etc [9].

All these cases can be handled in different ways. This paper explains a method to clear the above cases.

A. Case 1

1) TSCU algorithm for vehicle density estimation:

a) Load the location coordinates of the three roads R1, R2 and R3 in the microcontroller unit that defines the range of the network.

b) Three registers in MCU are allocated to store the number of vehicles in each road. The value in each register gives the count of vehicles in each road.

c) Sort the location coordinates received by the coordinator based on the data already saved in the MCU to get the road number that the vehicle possess and increment the corresponding register value.

d) Compare register values and generate green signal to the road with maximum number of vehicles, generate red signal to the other two roads and clear the particular register.

e) Give a delay to pass all the vehicles in 100m or the vehicles in the last row at that time.

f) At this same time vehicle density estimation (step 3) is calculated in the other two roads parallely.

g) Repeat the steps (d), (e) and (f) continuously.

2) VU algorithm for location coordinates transmission:

a) Write the interfacing program for ZigBee and GPS module.

b) Continuously check whether the ZigBee is activated or not.

c) If the ZigBee is activated check the speed of the vehicle using GPS' data.

d) Load GPS data or location coordinates to the ZigBee when the speed of the vehicle is zero.

B. Case 2

1) TSCU algorithm

a) Calculate the distance of the farthest vehicle in that road using location coordinates from VU and already saved coordinates that defines the range of network.

b) Calculate time to cross the road.

c) Give green signal to that road only for the calculated time.

C. Case 3

a) Neglect the high density road and estimate the densities for the other two roads.

b) Give green signal to denser road for a time to cross the farthest vehicle in the range calculated using the 1 and 2 steps in case 2.

c) Then give green signal to the lowest density road for a time calculated using the 1 and 2 steps in case 2.

D. Case 4

1) VU

a) Heavy vehicles and priority required vehicles' MCU is loaded with a label to indicate the type of the vehicle.

b) This label will be transmitted to the TSCU along with the coordinates when the vehicle enters the network.

2) TSCU

a) This unit will sort out the road with emergency vehicles using coordinates and the label sent by the VU; it will set green signal to the road till these vehicles cross the signal

IX. CIRCUIT DIAGRAMS

1) Vehicle Unit

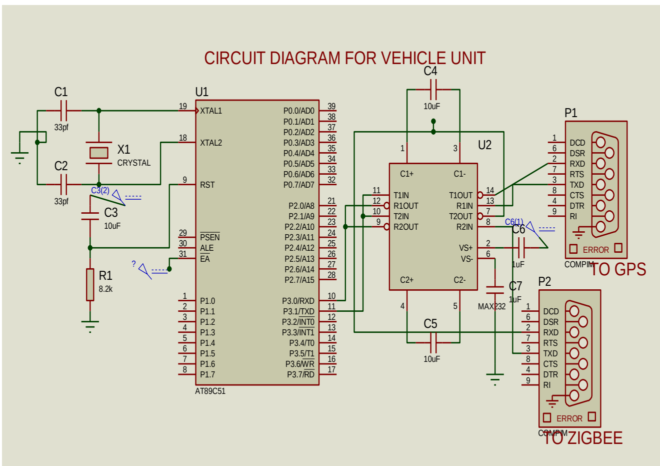

Fig 5: Vehicle unit – circuit diagram

2) TSCU

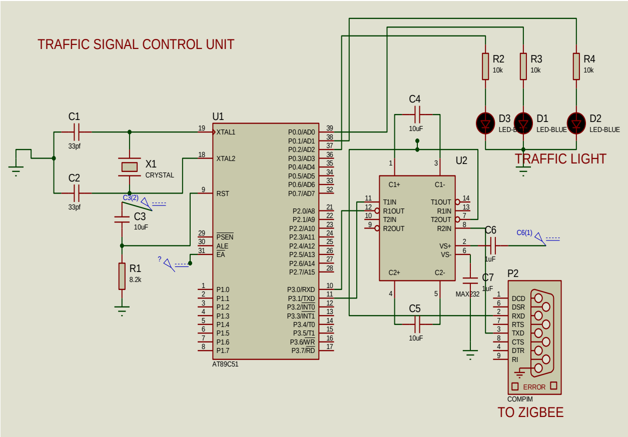

Fig 6**:** TSCU circuit diagram

X. CONCLUSION AND FUTURE SCOPE

This paper covers the methodology of implementing the traffic signal control system based on the density of vehicles in road. The main objective of this paper is to estimate the density of vehicles using GPS and ZigBee network. The paper thus gives a method to reduce congestion on road, saves fuel and valuable time. GPS based density estimation is very accurate and ZigBee network implementation is easier and less expensive than other wireless technologies.

The paper provides priority to emergency vehicles along with the density estimation of vehicles. The same paper can be modified to regulate the traffic of all roads through inter vehicular communication and density estimation with GPS details can be used by transportation authority for checking the individual vehicle records, for checking any violation of traffic rules, to maintain a record of vehicle density in an area etc.

REFERENCES

[1] Shahin Farahani **, "**ZigBee Wireless Networks and Transceivers" 1st Edition, Ed.PAP/COM, Butterworth-heinemann, 2008, pp. 9, 19, 20, 90.

[2] Fred Eady, "Hands-On ZigBee: Implementing 802.15.4 with Microcontrollers", Newness, USA, 2007, pp. 5_7, 29-33, 93-95.

[3] Stefano Tennina, Anis Koubâa, Roberta Daidone, Mário Alves, Petr Jurčík, Ricardo Severino, Marco Tiloca, Jan-Hinrich Hauer, Nuno Pereira, Gianluca Dini, Mélanie Bouroche, Eduardo Tovar, " IEEE 802.15.4 and ZigBee as Enabling Technologies for Low-Power Wireless Systems with Quality-of-Service Constraints", Subseries: Springer Briefs in Cooperating Objects Series: Springer Briefs in Electrical and Computer Engineering, 2013, pp. 4-6, 114,115.

[4] James Bao-Yen Tsui, "Fundamentals of Global Positioning System Receivers: A Software Approach", 2000, John Wiley & Sons, Inc.Print ISBN 0-471-38154-3 Electronic ISBN 0-471-20054-9, pp. 31-33.

[5] Shai Vaingast, "Beginning Python Visualization: Crafting Visual Transformation Scripts", 2009, USA, Franh Pohlmann, Michelle Lowmann, pp.13-15.

[6] Clement A. Ogaja, "Applied GPS for Engineers and Project Managers", ASCE Publications, 01-Jan-2011 - Technology & Engineering, pp. 23.

[7] Natarajan Meghanathan, Dhinaharan Nagamalai, Nabendu Chaki, "Advances in Computing and Information Technology:" Proceedings of the Second International Conference on Advances in Computing and Information Technology (ACITY) July 13-15, 2012, Chennai, India - Volume 3, Springer, 22-Sep-2012 – Computers.

[8] Muhamed Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems.", 2nd Edition, Pearson publications, 2006.

[9] Farheena Shaikh1, Dr. Prof. M. B. Chandak2, "An Approach towards Traffic Management System using Density Calculation and Emergency Vehicle Alert", IOSR Journal of Computer Science (IOSR-JCE) e-ISSN: 2278-0661, p-ISSN: 2278-8727 PP 24-27, www.iosrjournals.org International Conference on Advances in Engineering & Technology – 2014 (ICAET-2014).