# PRIORITY BASED TRAFFIC LIGHTS CONTROLLER USING WIRELESS SENSOR NETWORKS

[1]SHRUTHI K R & [2]VINODHA. K

[1&2]The Oxford College Of Engineering Bommanahalli, Bangalore-68
E-mail : shruthi_krs@yahoo.co.in, mohan.vinodha@gmail.com

**Abstract** - Vehicular traffic is continuously increasing around the world, especially in large urban areas. The resulting congestion has become a major concern to transportation specialists and decision makers. The existing methods for traffic management, surveillance and control are not adequately efficient in terms of performance, cost, maintenance, and support. In this paper, the design of a system that utilizes and efficiently manages traffic light controllers is presented. In particular, we present an adaptive traffic control system based on a new traffic infrastructure using Wireless Sensor Network (WSN). These techniques are dynamically adaptive to traffic conditions on both single and multiple intersections. An intelligent traffic light controller system with a new method of vehicle detection and dynamic traffic signal time manipulation is used in the project. The project is also designed to control traffic over multiple intersections and follows international standards for traffic light operations. A central monitoring station is designed to monitor all access nodes..

## I. INTRODUCTION

The continuous increase in the congestion level on public roads, especially at rush hours, is a critical problem in many countries and is becoming a major concern to transportation specialists and decision makers. The existing methods for traffic management, surveillance and control are not adequately efficient in terms of the performance, cost, and the effort needed for maintenance and support. For example, The 2007 Urban Mobility Report estimates total annual cost of congestion for the 75 U.S. urban areas at 89.6 billion dollars, the value of 4.5 billion hours of delay and 6.9 billion gallons of excess fuel consumed. On smaller scale, the traffic engineering department in Jordan estimates that the total cost due to congestion in the year 2007 was around 150 million USDs [1]. As such, there is a need for efficient solutions to this critical and important problem.

Urban areas nowadays have a great deal of traffic jams especially when a number of junctions are taken into consideration. Air and noise pollutions, accidents, time wastage and so many other factors are of serious concerns in traffic [2]. The existing methods for traffic management, surveillance and control are not adequately efficient in terms of the performance, cost, and the effort needed for maintenance and support. There are many other methods of controlling traffic lights in junctions to minimize the amount of traffic.

In the proposed project, two junctions are discussed and brought into focus along with the use of wireless sensors as many studies suggest the use of sensors. If there is no traffic lights control system in these junctions, huge amount of traffic causes waiting time and accidents. As a result, physical existence of traffic police is always required there which is inappropriate due to availability of technology today. Also, due to heavy traffic in these two junctions, emergency vehicles face hardships when they pass from there. Sensors will be located at a specific distance before the junctions which will detect the speed and sound waves of siren at a particular threshold. Based on the speed, sensors will communicate wirelessly with the traffic control system of the two junctions while realizing their routes. On the basis of WSN traffic control systems of the two junctions will be able to minimize the traffic flow by inter communication thus assigning the right time for red and green lights so that emergency vehicles can pass quickly[3]. A WSN is used as a tool to instrument and control traffic signals roadways, while an intelligent traffic controller is developed to control the operation of the traffic infrastructure supported by the WSN. Simulation results show the efficiency of the proposed scheme in solving traffic congestion in terms of the average waiting time and average queue length on the isolated (single) intersection and efficient global traffic flow control on multiple intersections. The paper concludes with some future highlights and useful remarks.

Although the work in this paper adopts the WSN for traffic control as some previous studies did, it distinguishes itself from these studies in many aspects. *First*, our work introduces an intelligent traffic light controller system with a new method of vehicle detection and dynamic traffic signal time manipulation. In particular, the dynamic process of selecting the traffic flow sequences for all traffic directions and based on the traffic conditions is a genuine part of the proposed system. Moreover, the flow of the traffic stream will not be fixed such as the case in the current traffic control systems. *Second*, the proposed system can handle the case of controlling

traffic over multiple intersections, while other schemes can only handle the single intersection case. *Finally*, the proposed system follows the international standards for traffic light operation, which makes it easy to adapt or use in the international market[4].

The framework of this paper consists of: overview of priority based traffic lights controller in section II, in section III design model of fuzzy logic based traffic control system is discussed, in section IV design algorithm of fuzzy based traffic system is discussed, in section V, simulation results are discussed and in section VI conclusion results are discussed.

## II. OVERVIEW

For inputs, three agents have been taken that include police, ambulance and fire brigade vehicles. These vehicles when they are arriving near heavy traffic, they switch on their emergency lights and specific emergency siren. Sensors will be located at a specific distance before the junctions which will detect the speed and sound waves of siren at a particular threshold. Based on the speed, sensors will communicate wirelessly with the traffic control system of the two junctions while realizing their routes. On that basis traffic control systems of the two junctions will be able to minimize the traffic flow by inter-communication thus assigning the right time for red and green lights so that emergency vehicles can pass quickly. Fig.1 shows the block diagram of multi-agent based traffic control system. In case of more than one emergency vehicle coming from different directions, the traffic control system will be able to avoid collisions. The project uses fuzzy logic to define the direction of emergency vehicles to avoid collisions [5].

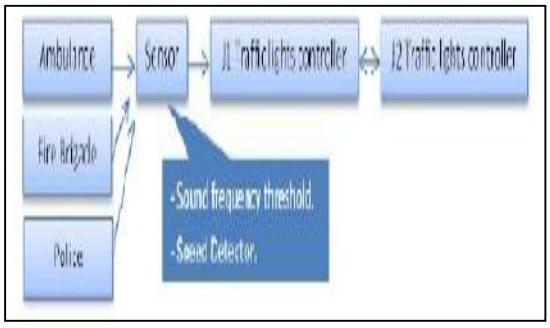


**Fig.1.Block diagram of the proposed system**

Lastly, the central monitoring station which collects information from all the access nodes is designed. It collects the information from each access point to analyze traffic conditions and take actions such as adjusting the traffic light durations. An example configuration for the system is given in Figure 2 for an urban intersection.

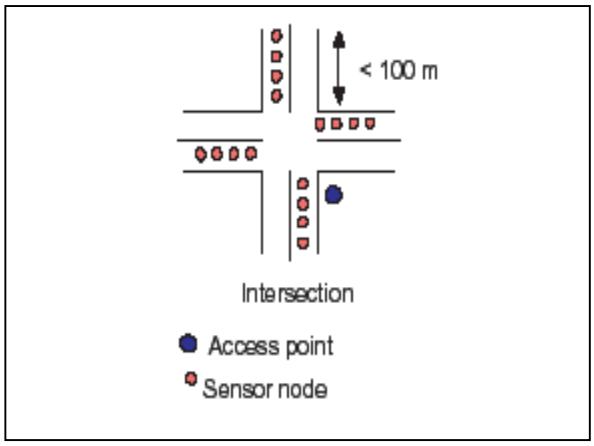


**Fig 2: Example Configuration of the system**

## III. DESIGN OF TRAFFIC WIRELESS SENSOR NETWORK

The design of WSN used as communication infrastructure in the proposed traffic light controller is discussed in this section. We have designed, built, and implemented a complete functional WSN and used it to validate my proposed algorithm [6].

The two junctions have been categorized as J1 and J2 as shown in Fig. 3a. Wireless sensors S1, S2 and S3 have been used which are installed 500m away from the junctions. We are considering three emergency vehicles, ambulance, police and fire brigade, coming from three different directions at the same time with different speed ratio. Based on their speed detected by the sensors, two actions are performed. One, traffic flow is minimized on their routes so that they can pass by with their maximum possible speed and secondly, their collisions are avoided. In this scenario, first we consider an ambulance coming from the left side of Junction J1 having its route defined straight ahead. It will pass through roadways w1 and w7 with road codes 00001 and 00004 respectively. Secondly, we consider a police vehicle coming towards junction J1 will pass through roadways w3 and w7 having road codes 00002 and 00004 respectively. Finally, we consider a fire brigade vehicle coming from the right side of junction J2 having its route defined and will pass through the road ways w1 and w5 having road codes 00006 and 00003 respectively. Each of these wireless sensors has been installed at 500m away from the junctions. However, the total distance between sensors S1 and S3 is 1.5 km [9]. The expected time of these emergency vehicles are found with the help of the following formula:

$$\text{Distance (s)} = \text{Velocity (v)} / \text{Time (t)}$$

or

$$\text{Velocity (v)} = \text{Distance (s)} / \text{Time (t)}$$

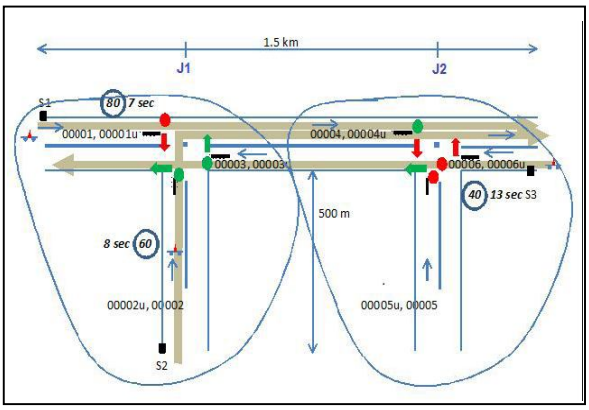


**Fig 3a: The proposed scenario of the two junctions**

The architecture of the Traffic Wireless Sensor Network is as shown in fig 3b. Sensors have been installed on the traffic lights. Sensors sense the RF signal emitted from emergency vehicles. After having being detected, the traffic lights controller change lights accordingly depending upon the priority that is assigned to emergency vehicles. As soon as vehicles pass through, the traffic lights resume back to their original position if there is no any other emergency vehicle in the queue [7].

The architecture of single traffic intersection is as follows:

- There are four paths marked as N (North), S (South), W (West) and E (East) leading to the road intersection and each path has three lanes in the incoming direction, which are turn-left (L), go-forward (F) and turn-right (R). So each passing vehicle can have a path P of {E, S, N, W} and a direction D of {L, F, R} [6].
- The sensors are placed at the traffic signal. For a single intersection road network, it needs at least four sensors. The monitoring station, the controller are shown in the fig. 3b.

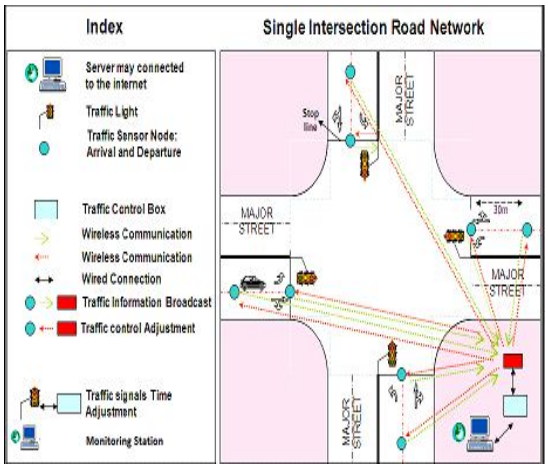


**Fig 3b: Single Intersection Road Network**

## IV. TRAFFIC CONTROL ALGORITHM FOR A SINGLE INTERSECTION

In this section, we present the details of the control algorithm for single intersection. The data at junction J1 containing sensors, traffic flow, road ways and traffic light status which is G for green and R for red are given in Table 1, however, yellow light has been ignored as it is marginal in this case and our main focus is on the green time to move the traffic as much as possible during the arrival of emergency vehicles [8]. An advantage of this scheme is that the simplicity of the control enables the use of simple and inexpensive equipment.

TABLE 1
DATA OF JUNCTION J1

| Junctions | J1 | | | | | |
|---|---|---|---|---|---|---|
| Sensors | S1 | | S2 | | S3 | |
| Traffic Flow | 100 | | 60 | | 95 | |
| Road ways | w1 | w2 | w3 | w4 | w5 | w6 |
| Traffic Light Status | G | G | R | G | R | R |
| | G | G | R | G | R | R |
| G=Green Y=Yellow R= Red | R | R | G | G | G | G |
| | R | R | G | G | G | G |

**Algorithm 1:** *Traffic Wireless Sensor Network Algorithm*

*Input: RF signal, Code*

Output: Guarantee successful communication between all the components of the traffic control system in order to set the time duration for all the traffic signals using the traffic control box.

Operations:

1. The vehicles transmits the RF signal and code
2. The sensor on traffic signal detects the signal and receives the code and communicates wirelessly with traffic lights controller.
3. Traffic lights controller senses the signal and receives request from all sensors.
4. It checks priority and changes the traffic lights accordingly.
5. The system resumes back to it original position after the emergency vehicle passes

The traffic lights controller is designed with the priority queue to store all the requests. Fig 4 demonstrates the traffic signal in the green time and also in red time. Emergency vehicles in different directions are stored in queue. They are allowed

according to their priority along their directions. Traffic lights controller is responsible to check priority and change lights accordingly.

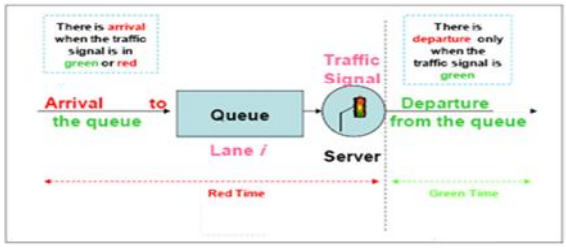


**Fig 4: Traffic signal queue flow**

## V. PERFORMANCE EVALUATION

Two surface views has been shown here that indicates the effect of output. Fig. 5a shows a graph between the inputs: Ambulance and Police vehicles and output: Green time for ambulance. Fig. 5bshows a graph between the inputs: Ambulance and Fire brigade vehicles and output: Green time for ambulance.

Results clearly say that highest priority is given to ambulance. Next it will be fire brigade and then comes police vehicles.

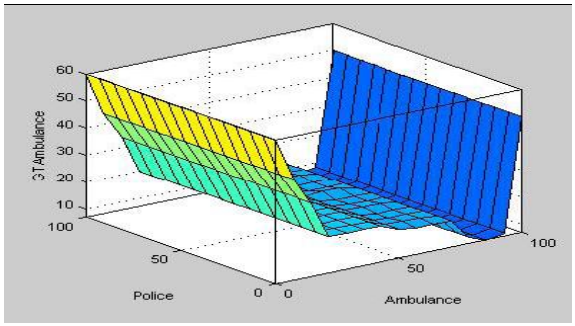


**Fig 5a: Surface view for Police and Ambulance vehicles**

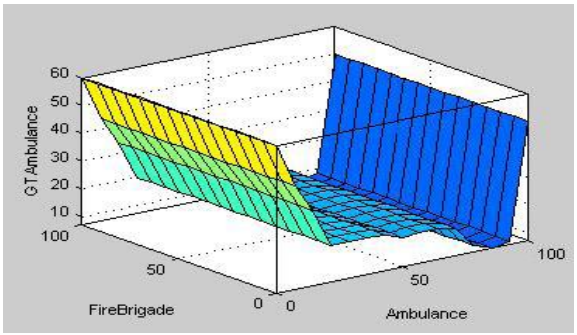


**Fig 5b: Surface view for fire brigade and ambulance vehicles**

## VI. CONCLUSION RESULTS AND DISCUSSION

Using proper data collection for the two junctions and proposing a traffic control system for multi-agents, the emergency vehicles passes from these two junctions quickly facing less traffic and at the same time collisions are avoided in case of multiple emergency vehicles coming from different directions. In case of new emerging algorithms and hardware technology, the proposed system will be flexible enough to be enhanced in order to handle future traffic aspects using FPGAs based Microelectronics chips to control traffic signals. The monitoring station will be helpful to know processing in all sensors installed at traffic lights.

The project can be extended further by-

- Using GPS navigation system installed in vehicle, the route can be fixed and informed to sensors in prior to their arrival
- Can be used to detect other VIP vehicles and send message to the appropriate according to their requirement
- Same system can be used for other applications like automatic gate opening

## REFERENCES

[1] Tzafestas et al. "Advances in Intelligent Autonomous Systems: Microprocessor based and Intelligent Systems Engineering" Kulwer Academic Publishers, 1999.

[2] Cheonshik Kim, You-Sik Hong. "Traffic signal using smart agentsystem" American Journal of Applied Sciences, 2008: 1487- 1493.

[3] S. Coleri, S. Y. Cheung and P. Varaiya. "Sensor networks for monitoring traffic" Proceedings of the 42nd Annual Allerton Conference on Communication, Control and Computing 2004, pp. 32-40.

[4] Skowronski, W., L. Shaw. "Self-learning fuzzy traffic controller for a traffic junction. I." European Congress on Intelligent Techniques and Soft Computing-EUFIT 93, Aachen, Germany, 1993: 751-761.

[5] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci. "A survey on sensor networks" IEEE Communications Magazine, Vol. 40, 2002, pp. 102-114.

[6] A. N. Knaian. "A wireless sensor network for smart roadbeds and intelligent transportation systems" Technical Report, Electrical Science and Engineering, Massachusetts Institute of Technology, June 2000.

[7] W. J. Chen, L. F. Chen, Z. L. Chen, and S. L. Tu, "A real time dynamic traffic control system based on wireless sensor network" Proceedings of the 2005 International Conference on Parallel Processing Workshops, Vol. 14, 2005, pp. 258-264.

[8] M. Tubaishat, Y. Shang, and H. Shi. "Adaptive traffic light control with wireless sensor networks" Proceedings of IEEE Consumer Communications and Networking Conference, 2007, pp. 187-191.

[9] Yousaf Saeed, M. Saleem Khan, Khalil Ahmed, Abdul Salam Mubashar, "A Multi-Agent Based Autonomous Traffic Lights Control System Using Fuzzy Control" International Journal of Scientific & Engineering Research Volume 2, Issue 6, June-2011 ISSN 2229-5518

◈◈◈