



INTELLIGENT TRAFFIC CONTROL SYSTEM FOR URBAN AREAS USING WIRELESS SENSOR NETWORKS AND GSM WITHOUT DIRECT COMMUNICATION WITH ON ROAD VEHICLES

Wazir Ur Rahman¹, Majid Ashraf², Amjad Iqbal³

Wazir Ur Rahman is currently pursuing Master degree program in Electrical Engineering major in communication and electronics from University of Engineering and Technology (UET) Peshawar, Pakistan, Email: engineer2290@gmail.com

Majid Ashraf is an Associate Professor in the department of Electrical Engineering in University of Engineering and Technology Peshawar holding Master Degree from Denmark, Email: majid@uetpeshawar.edu.pk

Amjad Iqbal is currently pursuing PhD from Universiti Tunku Abdul Rehman (UTAR) Malaysia in Wireless Communication. Email: amjad.iqbal68@hotmail.com

Keywords:: V2V, V2I, GSM, mixed-integer linear program, WSN, TCS, ITCS

Abstract

The increasing number of vehicles on road has resulted in traffic jams, accidents and many other issues that need to be resolved. The world of automation and computerized intelligent control has revolutionized modern world. Both coordinated-actuated signal control systems and signal priority control systems have been widely deployed for the last few decades. However, these two control systems are often conflicting with each due to different control objectives. For this reason, this research aims to introduce an intelligent traffic control system that is able to sense the vehicles and traffic density on a junction and reduce it in an efficient way in order to decrease the overall density of traffic on a specific junction. This article aims to address the conflicting issues between actuated-coordination and multi-modal priority control. The simulation experiments show that the proposed control model is able to reduce average bus delay, average pedestrian delay, and average passenger car delay, especially for highly congested condition with a high frequency of transit vehicle priority requests.

1. 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. Many techniques have been used including, aboveground sensors like video image processing, microwave radar, laser radar, passive infrared, ultrasonic, and passive acoustic array. However, these systems have a high equipment cost and their accuracy depends on environment conditions [2]. Another widely used technique in conventional traffic surveillance systems is based on intrusive and non-intrusive sensors with inductive loop detectors, micro-loop probes, and pneumatic road tubes in addition to video cameras for the efficient management of public roads [3, 4]. However, intrusive sensors may cause disruption of traffic upon installation and repair, and may result in a high installation and maintenance cost. On the other hand, non-intrusive sensors tend to be large size, power hungry, and affected by the road and weather conditions; thus resulting in degraded efficiency in controlling the traffic flow. As such, it is becoming very crucial to device efficient, adaptive and cost-effective traffic control algorithms that facilitate and guarantee fast and smooth traffic flow that utilize new and versatile technologies. An excellent potential candidate to aid on achieving this objective is the Wireless Sensor Network (WSN) [5]. Many studies suggested the use of WSN technology for traffic control [4, 6, 7, 9-11]. In [7], a dynamic vehicle detection method and a signal control algorithm to control the state of the signal light in a road intersection using the WSN technology was proposed. In [11], energy efficient protocols that can be used to improve traffic safety using WSN were proposed and used to implement an intelligent traffic management system. In [10], Inter-vehicle communication scheme between neighboring vehicles and in the absence of a central base station (BS) was proposed.

In this research, we propose a technique that uses WSN to manage the traffic control without any direct communication with the vehicles. The collected data would be measures using the WSN nodes. The reason why any direct communication with the vehicle for measuring density and other such parameters is avoided because in underdeveloped countries most of the cars do not have any on board communication device that can be integrated with WSN. Since it is not feasible to install such a device on every vehicle, a technique that does not require any such integration is modeled in this research.

By implementing the proposed system, the traffic lights can be controlled and be used to reduce the overall traffic of the area or a junction. Additionally, further enhancement of the system can make sure that other traffic related scenarios such as in time arrival of emergency vehicles, avoiding traffic jams and safety of vehicles is prioritized and entertained in an efficient way. This research aims to address the conflicting issues between actuated-coordination and multi-modal priority control. Enabled by vehicle-to-infrastructure (v2i) communication in Connected Vehicle Systems, priority eligible vehicles, such as emergency vehicles, transit buses, commercial trucks, and pedestrians are able to send request for priority messages to a traffic signal controller when approaching a signalized intersection. A queue-based mixed-integer linear program (MILP) is formulated that explicitly accommodate multiple priority requests from different modes of vehicles and pedestrians while simultaneously considering coordination and vehicle actuation. Signal coordination is achieved by integrating virtual coordination requests for priority in the formulation. The simulation experiments show that the proposed control model is able to reduce average bus delay, average pedestrian delay, and

average passenger car delay, especially for highly congested condition with a high frequency of transit vehicle priority requests

In our modeling we take in account a standard dual ring as in figure 2 4-leg intersection and 8-movements presented. Usually, every ring in controller is four phased that is shown in figure 3. To cross two rings there is a barrier in groups of differing movements hence all phases of a group have to end prior to every phase in subsequent group started.

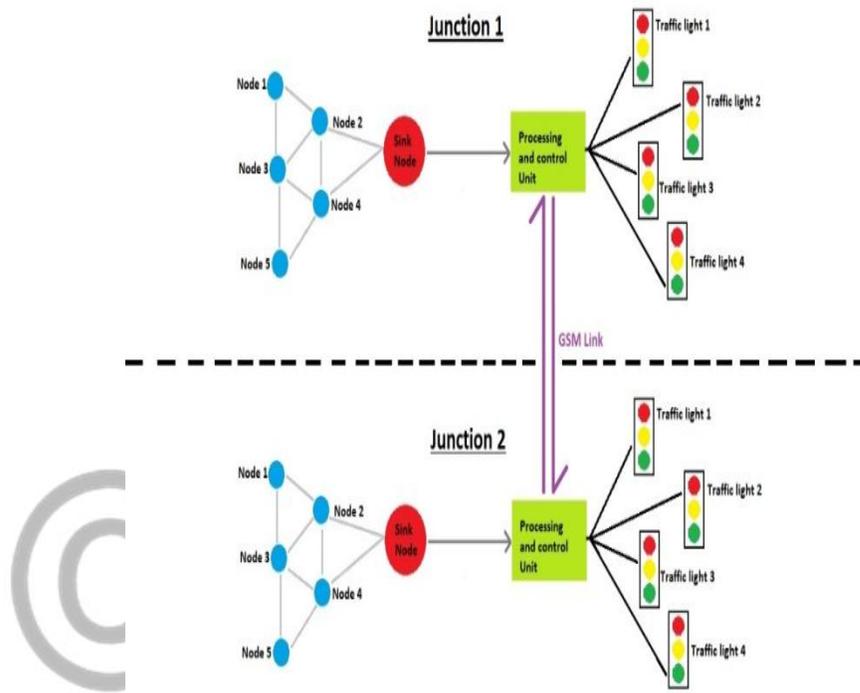


Figure 1: Network link architecture of Intelligent Traffic Control System

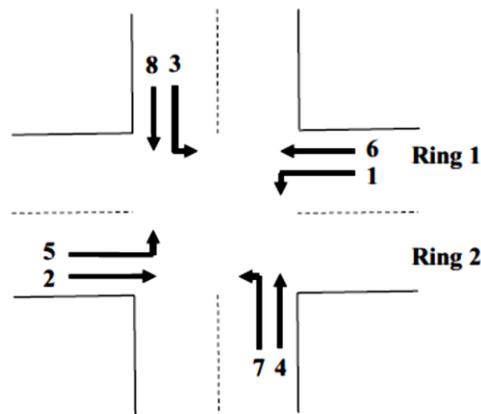


Figure 2: Layout of 4 phases

We have considered here three different scenarios of ordinary Traffic Control System (TCS) in which the behavior of Ordinary TCS, Semi-adaptive TCS and Adaptive TCS environments are considered. In each scenario, we have considered 200 cars at a time and the time of simulations taken is 200 minutes.

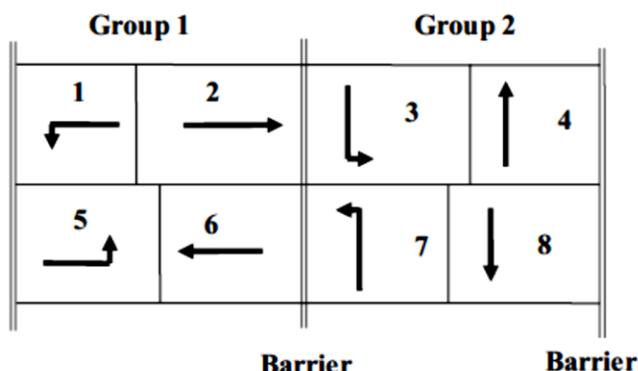


Figure 3: Ring Model with 8 phased controller

2. Traffic density analysis using typical TCS

According to Figure 4 that showing the traffic density by using TCS, in 200 minutes about 90 to 95 cars reached at junction 0, 145 cars at junction 1, 150 cars at junction 2, 155 cars at junction 3 and approximately 162 cars at junction 4. Hence this figure showing that the density of traffic is low at junction 0 while at junction 4 the traffic density is higher. At junction 1, 2, 3 and 4 the density of traffic is almost very close to each other while comparatively these junctions at junction 0 the density is quite low. At the start, up to 20 to 25 minutes the density at all junctions are almost same or very near to each other which is about 20 to 30 cars but the difference starts after 40 minutes in which at junction 1, 2, 3 and 4 the density of traffic is increased continuously.

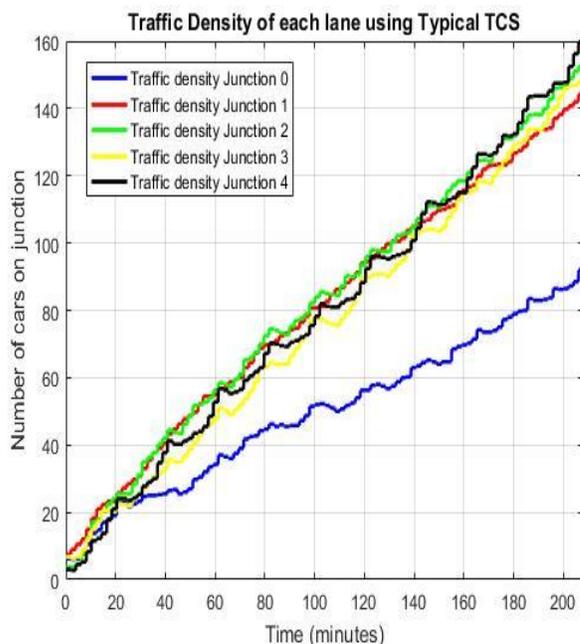


Figure 4: Analysis of Traffic Density By Typical TCS

3. Traffic density analysis using Semi-adaptive TCS

The Figure 5 shows the traffic density by using Semi Adaptive TCS. According to this figure in 200 minutes just 40 to 50 cars reached at junction 0 but at junction1 about 145 to 148 cars reached that is quit higher difference as compare to the traffic density at junction 0. Similarly at junction 2, 3 and 4 about 90, 130 and 110 cars reached respectively in 200 minutes. Hence this figure also shown that density of traffic is enough low at junction 0 while at junction 1 the traffic density is higher than all other junctions. At junction 1 the traffic density is higher from the start as compare to other junctions and at the duration after 50 to 110 minutes, the density of junction 1 remains almost very close to the density of junction 3 which is 40 to 75 cars. At the time of start till 30 minutes the density at junction 0, 2, 3 and 4 are almost near to each other that is about 10 to 20 cars but after 30 minutes the density is increased at junction 2, 3 and 4 while the density of traffic at junction 1 is higher from the starts is almost very close from start to end of our observed time that is 200 minutes. At the start, up to 40 minutes the density at 0, 2, 3 and 4 junctions are close to each other which is about 5 to 15 cars but the difference starts after 40 minutes in which at junction 2, 3 and 4 the density of traffic is increased continuously while the density of traffic at junction 1 is higher from the start.

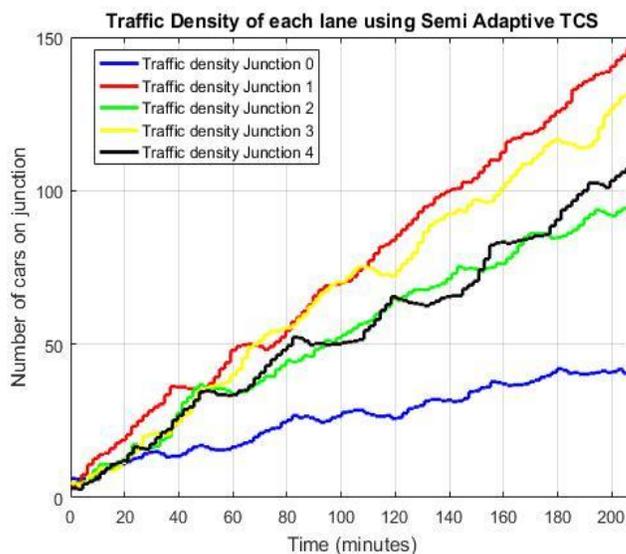


Figure 5: Analysis of Traffic Density By Semi Adaptive TCS

4. Traffic density analysis using our proposed scheme ITCS

The Figure 6 shows that the traffic density by our proposed ITCS scheme for the traffic management. In Figure 6 we considered three scenarios of ITCS for comparative analysis that are Typical ITCS (TITCS), Adaptive ITCS (AITCS) and Semi-adaptive ITCS (SITCS). The traffic density by ITCS of TITCS showing very high from the start and after 200 minutes the density increased up to 175 points while the traffic density by ITCS of AITCS is quite low after 200 minutes that is just 115 points. The density of SITCS is almost close to AITCS from 1st minute up to first 85 minutes, but the density of SITCS is increased continuously and goes to 135 points in 200 minutes. Hence the AITCS showing best performance as the traffic density of AITCS is low as compare to SITCS and TITCS.

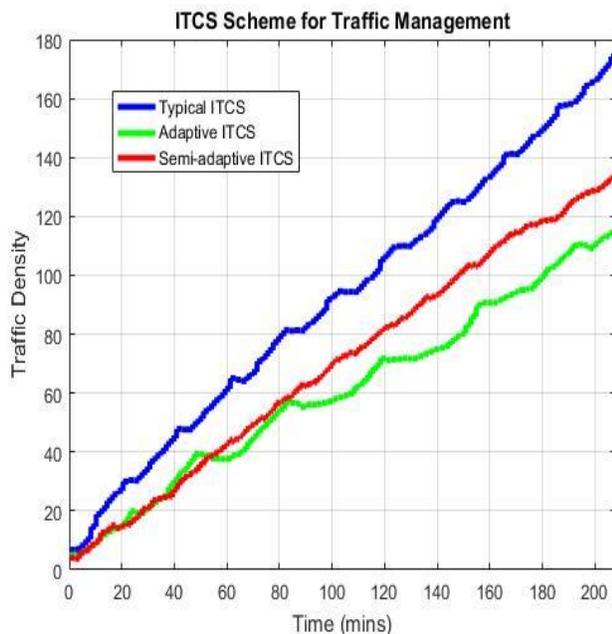


Figure 6: Analysis of Traffic Density By ITCS

5. Conclusion

The increasing number of vehicles on road has resulted in traffic jams, accidents and many other issues that need to be resolved. The world of automation and computerized intelligent control has revolutionized modern world. In this work we control the traffic without having any direct contact with the vehicles. The sensors is located on the sides of a road would approximate the number of vehicles and would be able to sense the presence or absence of a vehicle without having a communication device within the vehicle. We have considered three different scenarios for ordinary Traffic Control System (TCS) in which the behavior of Ordinary TCS, Semi-adaptive TCS and Adaptive TCS environments are considered. In each scenario, we have considered 200 cars at a time and the time of simulations taken is 200 minutes.

6. Future work

In last few years VANETs network gain much attention of the researchers. VANETs has enormous capacity in the network growth and research area to enhance V2V and V2 RSU traffic safety, driver and passengers comforts. These days Flying Ad Hoc Networks (FANETs) also gain attention of researchers. In our future work we are planning to implement our ARV2V scheme for establishing a secure communication link among FANETs and VANETs using satellite and GPS assistance.

7. REFERENCES

1. X.Han, C.Guangjie, Y.Dong,H.Guo, L.Shu, and D.Wu. "Cross-layer optimized routing in wireless sensor networks with duty cycle and energy harvesting". *Wireless communications and mobile computing* 15,vol no.16 issue#5 (2015) pp 1957-1981.
2. A.Sheeraz, N.Javaid, F.A.Khan, M.Y. Durrani, A.Ali, A.Shaukat, M.M. Sandhu, Z.A.Khan, and U.Qasim. "Co-UWSN: Cooperative energy-efficient protocol for underwater WSNs." *International Journal of Distributed Sensor Networks* issue 11, vol# 4 (2015), pp 89-95.
3. A.Sheeraz, M. R. Baig, M. Ahsan, and F.Hadi. "Cooperation vs. Non-Cooperation Based routing Protocols in WBAN." *International Research Journal of Electronics and Computer Engineering* 2, no. 4, 2017,pp 1-6.

4. I.ullah, M.masjid, S.Ahmad, and A.Salam. "Optimized QOS protocols for small-sized manets." In *Emerging Technologies, 2016. ICET'06. International Conference on*, vol 4,issue 4 pp. 525-531. IEEE, 2016.
5. K.Lin, C.Hung, F.Y.Dong, and K.Hirota. "Common driving notification protocol based on classified driving behavior for cooperation intelligent autonomous vehicle using vehicular ad-hoc network technology." *Journal of Artificial Intelligence and Soft Computing Research* vol 5, no. 1 (2016): pp 5-21.
6. L.L.D.Wen, and D.Yao. "A survey of traffic control with vehicular communications." *IEEE Transactions on Intelligent Transportation Systems*”vol 15, no. 1 (2014): pp 425-432.
7. X.Moretti, K.Fabio, T.Stefano R.Pizzuti, N.Stefano G.Panzieri, and M. Annunziato. "Urban traffic flow forecasting through statistical and neural network bagging ensemble hybrid modeling." *Neurocomputing* vol.5, issue no.1 (2015): pp.3-7.
8. M.Osigbeme, K.Michael, M.Onuu, and O.Asaolu. "Design and development of an improved traffic light control system using hybrid lighting system." *Journal of traffic and transportation engineering Vol.4*, issue no. 1 (2017): pp.88-95.
9. W.Thomas, and J.Harding. "Influence of dynamic traffic control systems and autonomous driving on motorway traffic flow." *Transportation Research Procedia* vol. 15, issue.4 (2016): PP.176-186.
10. C.Baiyu, Z.Yang, S.Huang, X.Du, Z.Cui, J.Bhimani, X.Xie, and N.Mi. "Cyber-physical system enabled nearby traffic flow modelling for autonomous vehicles." In *Performance Computing and Communications Conference (IPCCC), 2017 IEEE 36th International*, pp. 1-6. IEEE, 2017.
11. H.Qing, K. L.Head, and J. Ding. "Multi-modal traffic signal control with priority, signal actuation and coordination." *Transportation research part C: emerging technologies* Vol.46 issue.4 (2015): pp. 65-82.
12. G.Ros, B.Victor L.Knoop, T.Takahashi, I.Sakata, B.V.Arem, and S.P. Hoogendoorn. "Optimization of traffic flow at freeway sags by controlling the acceleration of vehicles equipped with in-car systems." *Transportation Research Part C: Emerging Technologies* 71 (2016): pp. 1-1