IJCSE International Journal of Computer Sciences and Engineering Open Access
Survey Paper Vol.-7, Issue-6, June 2019 E-ISSN: 2347-2693

A Survey on Traffic Control System for Emergency Vehicle Clearance

Jashvant Dave[1*], Shailesh Panchal[2]

[1]Gujarat Technological University, India
[2]Information Technology Department, Vishwakarma Government Engineering College, Ahmedabad, India

Corresponding Author: jashvant.phd@gmail.com

DOI: https://doi.org/10.26438/ijcse/v7i6.575580 | Available online at: www.ijcseonline.org

Accepted: 13/Jun/2019, Published: 30/Jun/2019

Abstract - Traffic congestion during peak hours is a critical issue worldwide. Due to increasing number of private vehicles, traffic jams primarily near cross roads results into significant delay in emergency services. Current surveys suggest that lives of many patients can be saved if emergency medical services could reach in time. With the evolution in sensor and communication technology, it is now possible to provide optimal solution to the problem of delay happening due to traffic related issues. Many researchers have proposed solutions for reducing delays and providing timely emergency services. Suggested solutions range from giving signaling priority to emergency vehicles to establishing a dedicated network to track the position of the emergency vehicle and ensuring an open rout to the destination. In this paper, we explore various mechanisms proposed for effective evacuation of vehicles creating traffic on the rout of emergency vehicle. The objective here is to provide clear view and state of the work done in the said area. This helps a researcher to easily understand and extend the capabilities of mechanisms according to the need.

Keywords- DSRC, ITS, Traffic Control System

I. INTRODUCTION

Very frequent changes in vehicle usage pattern have created a need of proper management of vehicular traffic. Number of on-road vehicles is increasing day by day due to urbanization which has given birth to traffic congestion problem. Traffic congestion cost in UK is more than 20.5 billion US$ [1], in United States it is more than 124 million US$ and in Australia, it will be 7.8 billion Australian dollar by 2020 [2]. A similar study has been made in developing countries like India. In New Delhi, at least about 300,000 US$ worth of fuel was being wasted everyday, by vehicles idling at traffic signals as early as in 1998 [2]. This figure jumped to approximately 1.6 million US$ per day as of 2010. Projected vehicular population in Delhi by 2020 is 10 million [2] which increase the response time of emergency vehicles.

In the year 2016, about 146, 133 people were lost their lives in road accidents within India. Unfortunately around 30% of deaths are caused because of ambulance delay [3] and hence during emergency response trips, it is very important that emergency vehicle must be passing through cross roads safely and efficiently to minimize ambulance delay. Proper traffic control system can increase the safety and efficiency of transportation system. Mostly traffic light control system uses static signaling approaches which does not give priority to emergency vehicles.

In the present scenario, with the help of proper sensors, appropriate communication mechanism and intelligent algorithms, a Traffic Control System can manage traffic effectively during emergency situations. Components of typical Traffic Control System (TCS) are depicted in Figure 1. TCS mainly performs three operations: (i) Data collection using various sensors (ii) Extracting traffic parameters and (iii) Determining proper green light phase. To carry out these operations autonomously, the TCS equipped with Sensors and Traffic light controller. Sensors collect traffic information like existence of emergency vehicle, speed of vehicle, current traffic density, vehicle type, etc. Traffic light controller is responsible for analyzing gathered traffic information and determining proper schedule of traffic light which ensures that emergency vehicles will be offered signaling priority. Generic process of TCS is depicted in Figure 2. This paper provides a review of existing Traffic Control Systems, discusses key challenges and identifies research directions. The remaining part of this paper is organized as follows: Section II, presents some related work on Traffic Control System for priority based signaling which reduces average trip time of emergency vehicle. Section III discusses about challenges of Traffic Control Systems and Section IV concludes the paper by providing future direction.

II. EXISTING TRAFFIC CONTROL SYSTEMS

In this section, several Traffic Control Systems are presented.

Kapileswar Nellore et al. [4] proposed a mechanism to minimize delay of emergency services by integrating sensors, traffic management center and traffic lights. System detects emergency vehicle by its siren frequency using acoustic sensors. Once emergency vehicle is detected, traffic analysis unit takes the real-time traffic video as input using camera sensors and extracts traffic information like distance of emergency vehicle from intersection, velocity, current traffic density, etc. Traffic management unit uses extracted traffic information and calculate green light sequence and green light duration. Upon detection of emergency vehicle, current sequence of traffic light will be stopped and newly calculated green light sequence will be adopted by traffic light until emergency vehicle left the intersection.

Veera Venkatesh et al. [5] proposed a mechanism to implement Intelligent Traffic Control System for

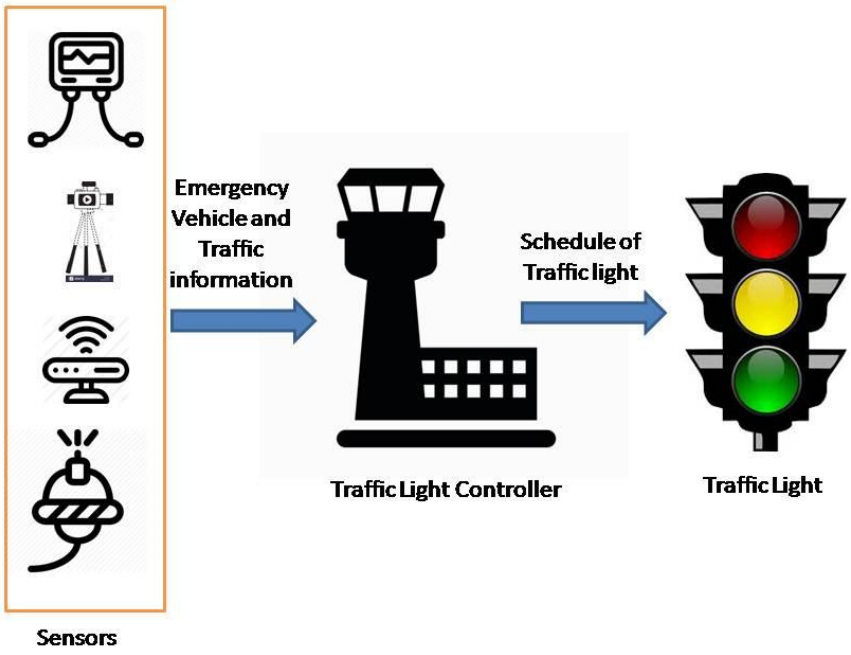

Figure 1. Schematic diagram of Traffic Control System

emergency vehicle clearance using video and image processing. Camera is fixed at traffic light and it captures images on regular time interval. For emergency vehicle detection, the concept of edge detection is used. The object counting mechanism counts the frames and subtracts the objects from the captured images. So the flow of traffic at signals can be identified. Green signal time period is calculated based on distance of emergency vehicle from intersection and current traffic density.

For fast and hindrance free movement of emergency vehicles, Rahul Pundir et al. [6] presented a system which uses RFID for emergency vehicle detection, ZIGBEE for wireless communication with the surrounding vehicles and audio-visual system for displaying warning message. RFID receiver is installed 1000m before the traffic light so early detection of emergency can be possible. All the emergency vehicles contain RFID tag which will be sensed by RFID receiver and emergency vehicle is detected. Once emergency vehicle is detected, using ZIGBEE, existence of emergency vehicle is notified to traffic light controller and the same is also conveyed to all the vehicles between emergency vehicle and traffic light so drivers of those vehicles can pull the car on left lane to give way to emergency vehicle. Traffic light schedule switch to normal mode once RFID receiver installed at intersection detects the emergency vehicle. In this proposed system, authors have used FIFO approach to break the tie between more than one emergency vehicles.

Asmaa Shaalan Abdul Munem et al. [7] developed a system which performs two different tasks: Optimal route suggestion for ambulance and Traffic light control. Whenever any emergency situation is detected, system calculates optimal path based on data collected from crowd sensors. System also tracks the location of ambulance using its GPS data and schedule the traffic light sequence when ambulance reaches nearer to traffic light.

Geetha.E et al. design an intelligent auto traffic signal control system [8] to reduce ambulance delay. Many researchers have used concept of video and image processing for detection of emergency vehicle and to determine vehicle density. But to minimize the weather effect, authors have used RFID to detect existence of ambulance and IR sensors to determine vehicle density. Location of ambulance and current traffic density is used to calculate the optimal time of green light phase.

Papa Rao Nalajala et al. [9] proposed system which consists of vehicle unit, ambulance unit, traffic unit and main server. Vehicle unit is deployed with sensors which are responsible to detect accident and communicate the same to server. The main server discovers the nearest ambulance to the accident place and also the shortest route between the accident spot, ambulance and the nearby hospital. Then the server sends this path to the emergency vehicle. The traffic controller controls the traffic signal automatically with the help of RF module. Whenever the emergency vehicle reaches near to the traffic signal (approximately 100m), the traffic signal will be made of green via RF communication. Thereby the ambulance is recommended to attain the hospital without delay.

Md Asaduzzaman et al. addressed the issue of traffic signal control by applying the concept of Transit Signal Priority (TSP) techniques (i.e. early green, green extension, phase rotation). The main objective of proposed work [10] is to minimize travel delay for normal traffic and emergency vehicle. Authors have also considered the case of multiple emergency vehicles and priority algorithm is proposed which will estimate arrival time and suggest traffic schedule which will minimize waiting time at crossing.

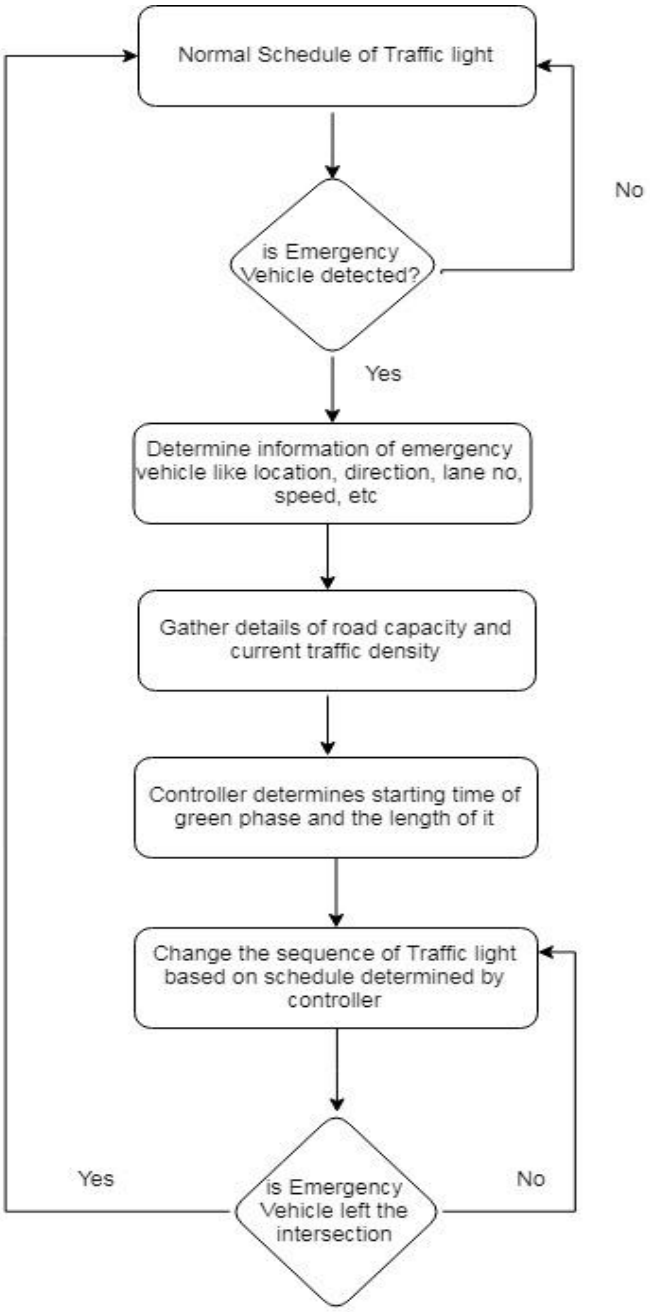

Figure 2. Flowchart describing generic mechanism of Traffic Control System

Mohamed Masoud et al. [11] proposed special purpose traffic light preemption protocol based on the Collection Tree Protocol (CTP) in Wireless Sensor Network (WSN). This protocol used to handle the emergency vehicle preemption request in a multi-hop tree-based topology spread across the traffic intersection. Sensors are deployed across the intersections and each anchor is only in the range with the Base Station (BS). The emergency vehicle periodically broadcast the WSN-EVP packet keeping emergency preemption request byte "ON". When request

is detected by any of the anchor, it will be forwarded to BS. BS extracts the payload, verifies it to ensure preemption is requested and grant the preemption request. Proposed protocol deals with multiple emergency preemption requests on FCFS basis.

Hanene Ben Yedder et al. presented approach [12] which is intended to help allocate emergency vehicles to urban emergencies and adjust their routes according to upcoming changes and unforeseeable events. System has three components namely Supervisor agent, Complex agent and Environment agent. Supervisor agent is responsible for event delegation, Complex agent process the events and Environment agent consist of vehicle agent and sensor agent which continually relay their status to Complex agent. When any emergency request arrives, most suitable emergency vehicle based on traffic condition will be assigned for that request. Assigned emergency vehicle will be tracked continuously for breakdown or congestion situation. If such situation occurred, controller will take the decision whether to send other emergency vehicle or not to minimize delay.

Hairuo Xie et al. [13] proposed VANET based approach for traffic light preemption. Emergency vehicle periodically broadcast message which contains its route information with clearance distance and its current lane. This information can be useful for normal vehicles to know whether they are impeding an emergency vehicle. When intersection controller receives the message from emergency vehicle, it adjust traffic light if emergency vehicle's route crosses intersection. For adjusting traffic light, current traffic volume, clearance distance of emergency vehicle and travel distance is considered.

The work proposed by A. El-Dalil et al. [14] would be presented in Communication architecture, Utility processing unit (UPU) and Game theory algorithm unit (GTAU). Communication architecture specifies number of roads and vehicles. UPU is responsible for calculating road utility on the basis of road capacity, distribution of vehicles in the intersection and emergency level of the vehicle. GTAU is responsible for selecting appropriate strategy to apply at intersection from a two player game using the concept of Nash equilibrium solution.

Abdullahi Chowdhury presented priority based secure traffic management system [15]. In proposed system, the concept of incident based priority assignment is adopted. Depending upon incident type, priority will be assigned to all the emergency vehicles (ambulance, fire truck and police van). To identify essential green signal phase, system finds the length of the traffic flow on the road using parameters like number of cars in the queue, length of the car and space between two cars. For hacking detection, an approach similar to statistical anomaly detection is used. If profile of particular traffic signal significantly deviates from its normal pattern, it can be interpreted as hacking situation and traffic controller restarts the normal traffic pattern.

III. DISCUSSION

Mechanism of Traffic Data Collection: Some of the TCSs discussed here [4, 5, 7, 10, 14, 15] uses different on-

Table 1. Summary of existing Traffic Control Systems

Proposed Approach	Outcome	Mechanism used for EV detection	Priority assignment to EV	Communication mechanism used
TMEVP [4]	Using PE-MAC protocol better end to end delay, throughput and energy consumption is achieved.	Acoustic sensor	Ambulance Fire Truck Police Car	DSRC
STCS-EVC [5]	Reduce the emergency trip time by giving priority of emergency vehicle.	Video and image processing	Ambulance	-
STSEV [6]	• Creating green corridor for emergency vehicle • Reschedule of traffic light to give way to emergency vehicle	RFID	FIFO	ZigBee
STLCEA [7]	• Optimal route between victim and hospital is suggested • Rescheduling of all the traffic lights on the way of ambulance	Crowd Sensor	Ambulance	Wi-Fi
IATSC [8]	Minimize travelling time of ambulance and vehicle of VIP personal.	RFID IR Sensor	Ambulance VIP Car	-

IRTCS-A [9]	Reduce trip time of emergency vehicle using the concept of early warning.	RFID	Ambulance	Radio Frequency
PACTS-EV [10]	Schedule traffic light such that average delay of emergency and normal vehicle will be reduced.	-	Scenario based priority	DSRC
WSN-EVP [11]	Tree based cost effective and secured approach for minimize ambulance delay.	Sensor Network	FCFS	Wi-Fi
REVD-RTID [12]	Assign emergency vehicle with minimum trip time to emergency situation.	GPS, Central server	Ambulance	DSRC
EVP-ITS [13]	Schedule traffic light to reduce trip time of emergency vehicle.	DSRC	-	DSRC
PLM-EV [14]	Using the concept of game theory, it minimizes travel time of both normal and emergency vehicles.	GPS, Central Server	Seven levels of priority based on situation	3G/4G
PSTMS-EV [15]	• Creating green corridor for different emergency vehicles • Statistical anomaly based detection of malpractices	GPS, Central Server	Three different scenario based priority allocation	Wi-Fi WiMAX

road sensors and GPS for gathering traffic and emergency vehicles' information. But accuracy of these sensors and GPS may be affected due to bad weather conditions. Deployment and maintenance of these sensors is also difficult due to constant vehicular movement. Another approach used in literature for detection of emergency vehicle is RFID [6, 8, 9] which suffers from the problem of limited coverage. Since few years, Vehicular Adhoc Network (VANET) [16, 17] becomes very prominent area of research. Researchers need to explore the scope of VANET for traffic data collection. Deployment and maintenance of on-board (in-vehicle) sensors may be easy with compare to on-road sensors.

Priority Mechanism: In literatures, vehicles considered in the category of emergency vehicle are ambulance, fire truck and police car. Most of the TCSs [5, 6, 7, 9, 11, 12] reviewed here have considered only ambulance for their proposed architecture. But many emergency situations require multiple types of emergency vehicles like ambulance, fire truck and police vehicle at the same time. In this type of scenario it may be the case that multiple emergency vehicles arrive towards intersection from different directions and there will a question that which emergency vehicle will get green corridor first. Very important and crucial thing for resolving conflict between more than one emergency vehicle requests is assigning priority to each of the emergency vehicle. Very few TCSs [4, 10, 14, 15] touched upon this crucial problem and assign priority to emergency vehicles based on scenario of emergency. But still researchers need to focus on problem of priority assignment and a proper mechanism is to be proposed with well-defined priority levels which will take care of all possible emergency scenarios and all classes of emergency vehicle.

Decision making authority: In most of the TCSs, local traffic light controller deployed at intersection is responsible for deciding efficient schedule of traffic light for safe and effective departure of emergency vehicle. Mostly there is no communication between two traffic light controllers deployed on the same road. Very few TCSs [12, 14, 15] have centralized control for deciding schedule of traffic light. It is always beneficial that traffic light control can get to about approaching of emergency vehicle well in advance and this may be possible by centralized control mechanism. One of the major concerns in centralized control mechanism is computing capacity [18]. Researcher needs to analyze both local and centralized approach by keeping computation delay and early warning in mind.

IV. CONCLUSION

Recent work in the area shows that delay in emergency services due to traffic related issues can be reduced. Literature review suggests that implementing proper traffic control system can achieve notable reduction in trip time of emergency vehicle. Predicting the location and possible rout of the emergency vehicle accurately is a real value-add to the challenge. Current state of the said research area promises to solve the problem effectively and efficiently.

This paper discusses about open challenges in the field of traffic data collection, assignment of vehicular priority and architecture of traffic control.

REFERENCES

[1] M. Carey and A. Srinivasan, "*Externalities, average and marginal costs, and tolls on congested networks with time-varying flows*" Operations Research, vol. 41, pp. 217-231, 1993. DOI: 10.1287/opre.41.1.217

[2] Neema Davis, Harry Raymond Joseph, Gaurav Raina, Krishna Jagannathan, "*Congestion costs incurred on Indian Roads: A case study for New Delhi*", In the Proceedings of the 2015 International Conference on Communication Systems and Networks (COMSNETS), held at Bangaluru, India, 2015.

[3] Anita Acha George, Arun Krishna, Toney Dias, Asheena Sara Vargheese, R S Divya, "*Golden aid an emergency ambulance system*" In the Proceedings of the 2015 International Conference on Networks & Advances in Computational Technologies (NetACT), held at Thiruvanthapuram, India, 2017.

[4] Kapileswar Nellore, Gerhard P. Hancke, "*Traffic Management for Emergency Vehicle Priority Based on Visual Sensing*", Sensors, 2016

[5] Veera Venkatesh, Nazneen Syed, "*Smart Traffic Control System for Emergency Vehicle Clearance*", IIRCCE, 2015

[6] Rahul Pundir, Vikash Kumar Yadav, Sunil Prakash Mandrawal, Deepak Kumar, "*Smart Traffic System for Emergency Vehicle*",IJSET, 2017

[7] Asmaa Shaalan Abdul Munem , Dr. Muayad Sadik Croock, "*Smart Traffic Light Control System for Emergency Ambulance*", IJARCET, 2016

[8] Geetha.E, V.Viswanadha, Kavitha.G, "Design of an Intelligent Auto Traffic Signal Controller with Emergency Override", IJESIT, 2014

[9] Papa Rao Nalajala, Rotala Umarani, Naroju Mounika, "*Design Of Intelligent Road Traffic Control System For Ambulance Using RF And GSM Technology* ", IJATCSE, 2016

[10] Md Asaduzzaman, Krishnamurthy Vidyasankar, "*A Priority Algorithm to Control the Traffic Signal for Emergency Vehicles*", IEEE, 2017

[11] Mohamed Masoud, Saeid Belkasim, "*WSN-EVP: A Novel Special Purpose Protocol for Emergency Vehicle Preemption Systems*", IEEE Transaction on Vehicular Technology, IEEE, 2018

[12] Hanene Ben Yedder, Ilham Benyahia, "*Reactive Emergency Vehicles Dispatching Based Real-time Information Dissemination*", IEEE, 2017

[13] Hairuo Xie, Shanika Karunasekera, Lars Kulik, Egemen Tanin, Rui Zhang, Kotagiri Rama mohana rao, "*A Simulation Study of Emergency Vehicle Prioritization in Intelligent Transportation Systems*", IEEE, 2017

[14] A. El-Dalil, Maha Sharkas, Mohamed Khedr, "*Priority Level Mutualism for Emergency Vehicle using Game Theory*", IEEE International Conference on Vehicular Electronics and Safety (ICVES), IEEE, 2017

[15] Abdullahi Chowdhury, "*Priority Based and Secured Traffic Management System for Emergency Vehicle using IoT*", IEEE, 2016

[16] Dave J R, Bhatia J B, "*Issues in Static Periodic Broadcast in VANET*", International Journal of Advances in Engineering & Technology, Vol.6, Issue.4, pp.1712-1717, 2013

[17] Kanwalprit Singh, Harmanpreet kaur, "*Evaluation of proposed technique for detection of Sybil attack in VANET*", International Journal of Scientific Research in Computer Science and Engineering, Vol.6, Issue.5, pp.10-15, 2018

[18] R. Bhavani, K. S. Suganya, D. Yazhini Priyanka, "*Autonomous PHR Sharing: A Patient Centric Scalable and Flexible e-Healthcare Framework*", International Journal of Scientific Research in Network Security and Communication, Vol.6, Issue.2, pp.11-14, 2018

Authors Profile

Jashvantkumar Rajnikant Dave received the degree of Bachelor of Engineering in Information Technology in 2005 from Hemchandracharya North Gujarat University and Master of Technology in Computer Science Engineering in 2013 from Nirma University. Currently he is pursuing his PhD from Gujarat Technological University. He is a Life Member of the Indian Society for Technical Education (ISTE). His current research interest includes Vehicular and Mobile Adhoc Network, Internet of Things and Software Defined Netwrok.

Dr. Shailesh Panchal received the degree of Bachelor of Engineering in Electronics and Communication in 1999 from Hemchandracharya North Gujarat University, Master of Technology in Computer Science Engineering in 2010 from Nirma University and PhD in 2017 from CHARUSAT university. Currently he is working as Associate Professor in Information Technology Department at Vishwakarma Government Engineering College, Ahmedabad. He has 19 years of teaching experience. His current research interest includes Image Processing, Adhoc Networks and Internet of Things.

