Design and Implementation of Message Communication to Control Traffic Flow in Vehicular Networks

Senthilkumar Mathi, Eric Joseph, Dharini S, Mohan Karthik V, Harishkiran S

Abstract*: Nowadays on the road, the number of vehicles has been increasing rapidly. The road traffic congestions are posturing severe hitches owing to the inadequate ability of road networks and irregular on-route procedures in most of the towns and ensuing in a substantial number of losses. To address these problems, advanced traffic monitoring methods are being commonly used in major towns. Nevertheless, owing to increasing traffic on roads, additional methods remain desired to avoid traffic bottlenecks. The emergent of vehicle communication technologies, and particularly vehicle to vehicle and vehicle to infrastructure would be of great support. These technologies help in improving the ride duration of the traveller and alleviating the congestion problems in road traffic. The vehicles could communicate with each other and thus the traveller can be alerted about the vehicles around him. Therefore, this paper explores the message passing mechanisms between vehicles that collaboratively determine the optimal speed of the approaching vehicles and other suitable actions to take on to crossroad junctures with least delays but eventually evading stoppings. This exploration helps in achieving a substantial improvement in terms of the reduction in the travellers' average trip time.

***Keywords:* Vehicular networks, Routing, Vehicle-to-Infrastructure, Vehicle-to-vehicle.**

I. INTRODUCTION

Urbanization plays a major role in human's communication and living style in smart cities. The emergence of smart cities would be resulting in smart mobility, smart planning and building, smart hospitals, smart people, smart technology etc., as mentioned in Fig. 1 through vehicular ad-hoc networks the person can send a message to other drivers who are on the same road within a particular radius and these are independent of structure to achieve broadcasting and transmission of the data packets [1].

Currently, vehicles are fortified with smart methods intended to avert accidents such as collision warning or lane-keeping aid. The subsequent stage in decreasing accidents and managing traffic flow in road networks is to manage such vehicles in prior not only to evade accidents but to improve the flow of the traffic [2]. Using ad-hoc mode and infrastructure mode, vehicles can perceive the location and movement of other vehicles up to a quarter of a kilometre away and can communicate.

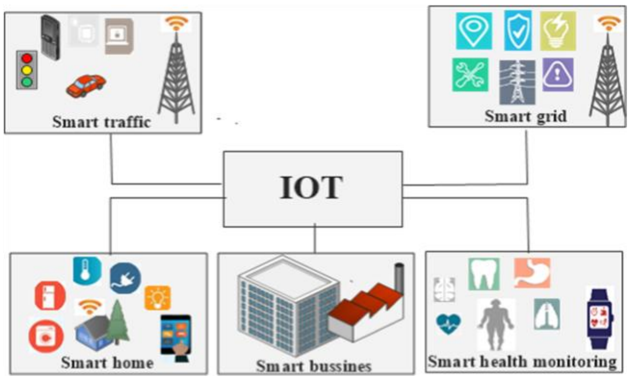

Fig. 1. Smart IoT for various applications

Recently, the smart vehicles are furnished with a simple antenna, a computer chip and GPS aid in preventing the collision [3]. Since nowadays the number of vehicles has been increasing rapidly, road safety has become one of the important things to focus on and it is also expected that the vehicles should communicate through wireless technology. Also, Internet-of-Things (IoT) and sensor technology-based applications are rising progressively [4]. Through vehicular networking, it has now become possible to create smart automobiles, smart cities etc., it could be implemented using some IoT techniques too [5].

II. RELATED WORKS

Vehicular ad-hoc network (VANET) supports vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications that establish periodic messages namely beacons in V2V used for both status and position updates of the vehicle, sending safety messages [6]. It is very important to check how far or the radius in which the messages can be sent and received and the also the

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time taken for the message delivery since these factors would acknowledge the driver about the traffic, distance to be maintained between two vehicles etc., the information is conceded by different channels defined for various determinations [7]. In this paper, they considered the transmission of messages between vehicles travelling in the same direction which can be used in highways and not in any urban areas but there is no limit on the number of vehicles in the transmission range. Using roadside units (RSUs), message delivery is more effective as they can work together to increase the throughput of the network [8].

Based on the urgency of the priority for load balancing, a supportive solution is suggested in [9]. The primary sources of delay in message delivery are considered to be the physical and MAC layer properties. The work in [10] provides a solution to regulate the messages lifetime for ensuring that under a certain radius to obtain the message by all the vehicles. Assuming that all the vehicles have a constant speed and deterministic propagation model is used with the arrival of the vehicles being in a Poisson distribution. The model uses the clustering process where each cluster consists of vehicles which are less than a certain distance and for the traffic jam caused after an accident; the queuing model is used for the vehicles entering the queue. The message propagation depends again on two factors – length of the queue and the last vehicle that is present in the queue (to know the distance) involved the derivation of the immobile and transitory solutions of the message propagation distance.

One of the current problems faced by the growing population is road traffic congestion which leads to the loss of both time and money. The reason behind this could be damaged roads, rush hours, increased four-wheelers, bad weather etc., Clustering techniques such as centroid-based k-means etc., are used to reduce the congestion in networks [11].

Due to the motion of the vehicles fuzzy techniques are more preferable: traffic management control unit based congestion detection involves the usage or installation of various sensors and also respective action should be taken on the data that is sensed by the sensors [12]. In the clustering techniques when the distance between the centres of the clusters reduces it indicates that there is a high chance for the vehicles to lead to congestion [13]. An unsupervised clustering algorithm - Fuzzy clustering technique is preferred over k-means though it has a higher cluster formation speed since in k-means each vehicle belongs only to one cluster whereas in fuzzy, each vehicle belongs to many clusters i.e. overlapping is allowed [14]. The disadvantage of the fuzzy technique is costlier and requires more execution time when compared to k-means [15].

Under control uncertainties of vehicles, collisions may occur for which priority-based control is chosen [16]. The prioritization is done to decide which vehicle should cross the juncture first. Here, the collision avoidance is established for communicating vehicles using the feedback control law. In this system, the vehicle obtains a deadlock-free and collision-free system [17]. The use of traffic light to communicate with human drivers is for each lane green light would be given successively for a small period of time so as to let the legacy vehicles going through that lane can cross the intersection [18]. The assumption is the legacy vehicles maintain a certain amount of distance with the vehicles ahead. It is better to have a range of collision area and can be achieved by prioritizing the vehicles.

A priority preserving control law could be used which defines that only after the passage of higher priority vehicles the other vehicles can pass without a collision [19]. Fig. 2 shows the pictorial representation of the priority-based framework. The vehicles are usually expected to slow if there is any chance in the collision risk. This system gathers and processes the needs as per the assignment policy of priority in random order and allocates priorities successively. In every step, the right-of-way is allocated to the vehicle that crosses the juncture and given the lowest priority. The admitted vehicles get notified based on their priorities and the rest are requested to halt in front of the stop lines [20]. There are two factors that affect this framework to reduced traffic – lack of advanced devices and unpredictable control.

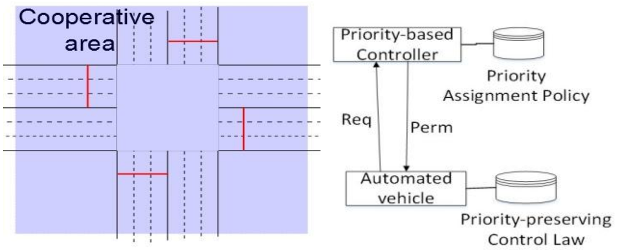

Fig. 2.Priority-based framework

At the intersection range or the collision region, it is assumed that no vehicle should be overtaking the other. All the vehicles with higher priority have previously passed the accident zone or the vehicles stay on the same path [21]. The concept of the virtual platoon is used that a sequence of vehicles is on the same path [22]. Any other vehicle which lies outside the group is considered to either have low priority than those in the group or higher priority (they would have already crossed the group) than all those that are in the group. Use of traffic lights leads to high node density i.e. the vehicles gather around and wait for the signal to turn green. In [23], traditional vehicles are needed to follow the time-based allocations. During this, there is a high chance for the packet collision to take place since there are several vehicles that are transmitting data at the same time. Hence, it is assumed that legacy vehicles do not overtake and follow a single path but yet to consider the work involving driver's behaviour.

The moving vehicles require passing contacts with one to another in diverse directions which can be used to build the connectivity [24]. In VANET, the framework is based on the groups that are intended by the self-directed mediator and it keeps making new groups based on those vehicles that are present in VANET but does not take into consideration about the topology modification-related choices. This mediator's methods motto in VANET is to have minimal overheads, effortless and adjustable routing schemas [25]. For forwarding messages, the related data is collected and the optimal paths are identified by the mediators.

III. DESIGN AND IMPLEMENTATION

The paper is intended to design a network model to improve the traffic flow for vehicular communication by sending an alert message to the driver. Here, the area of consideration is to implement the message passing scenario using Simulation of Urban Mobility (SUMO) simulator [26]. The proposed design also updates the driver about the surroundings to reduce the collisions of vehicles that improve traffic safety. The imminent incorporation of such supportive designs is in urban locations with interesting proliferation situations, which uses RSUs for V2I communication.

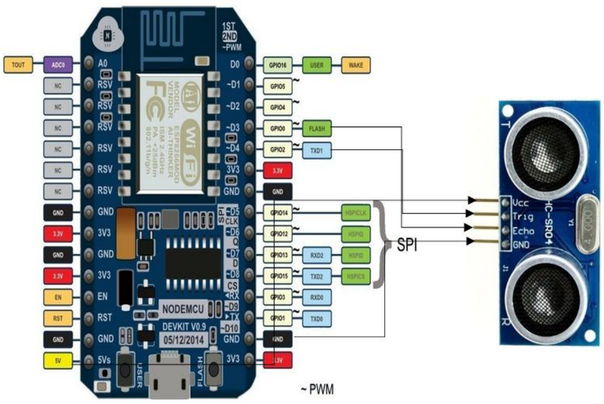

Fig. 3.Integrating nodemcu and ultrasonic sensor

The proposed design provides a computationally inexpensive modeling approach that lets to produce representative packet error patterns for urban locations. In V2I technology, the vehicles communicate with each other by initially communicating with the RSUs which would then send the messages received from one vehicle to the other set of vehicles that are present within its range. This would reduce the collisions and also traffic congestion on roads. The moment the vehicle leaves a particular RSU range it stops receiving messages from the vehicles belonging to that particular range but simultaneously another RSU would detect the vehicles' entry into its range and starts to communicate with it.

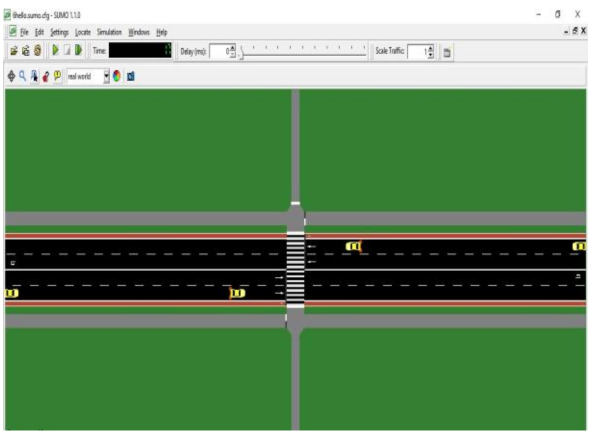

Fig. 4.SUMO representation of vehicular communication

For the representation of the real-time scenario, one could use various simulators and one among which is SUMO simulator. This helps us to understand the way in which vehicles communicate with others which are done by considering the position (coordinates) of the vehicles. The proposed design is also executed using a hardware platform with IoT.

The component integration of the proposed approach is shown in Fig. 3. The result obtained from SUMO simulator is a graphical representation of the communication between vehicles considering to and fro directions. It illustrates how the vehicles send messages to each other to alert the drivers to avoid them from colliding into each other. The red light behind the car is to indicate that the two cars moving in opposite lanes are communicating with each other when they get closer at the intersection shown in Fig. 4.

Fig. 5.Representation of vehicular communication along with obstacles

The red dots in Fig. 5 indicate that there are a few obstacles (people, cycle etc.) on the road and hence the vehicles are waiting for them to clear but at the same time the alert messages are sent to the vehicles about the vehicle waiting in the opposite direction.

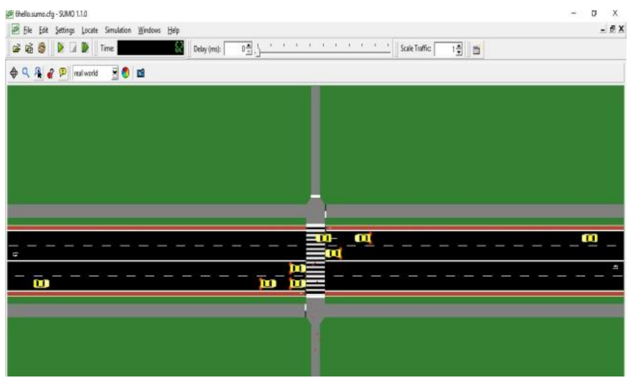

Fig. 6.Vehicle movement after obstacle clearance

The moment a part of the road is cleared the vehicles start moving instead of waiting for the clearance of the entire set of obstacles as shown in Fig. 6.

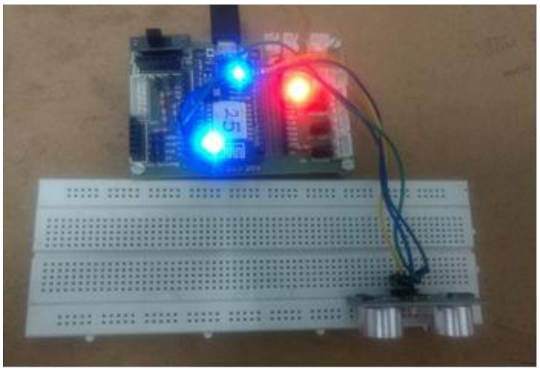

Fig. 7.Working of nodemcu and ultrasonic sensor

IV. RESULTS AND DISCUSSIONS

This section discusses the results obtained from the design and implementation. In Fig. 7, the nodemcu is connected to the ultrasonic sensor which measures the distance by sending ultrasonic signals which when reflected back would be used in the formula, distance = speed * time. There is also a condition specified that when the distance is below 10 cm then the built-in LED present in nodemcu would glow which would serve as an alert to the driver. Since the waves go to and fro the value is to be divided by 2 and then multiply by 0.034 to get the distance.

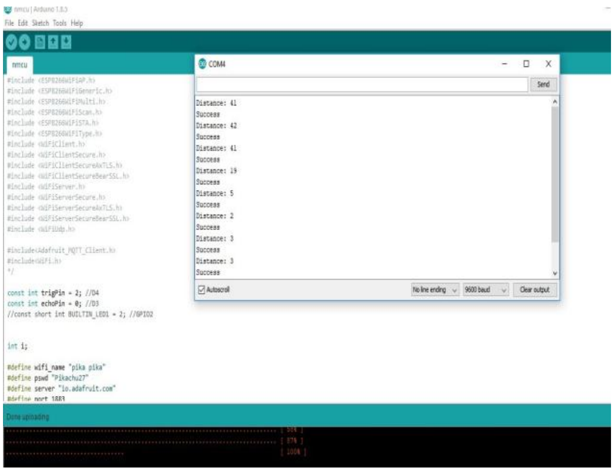

Fig. 8.Value display on the serial monitor of Arduino IDE

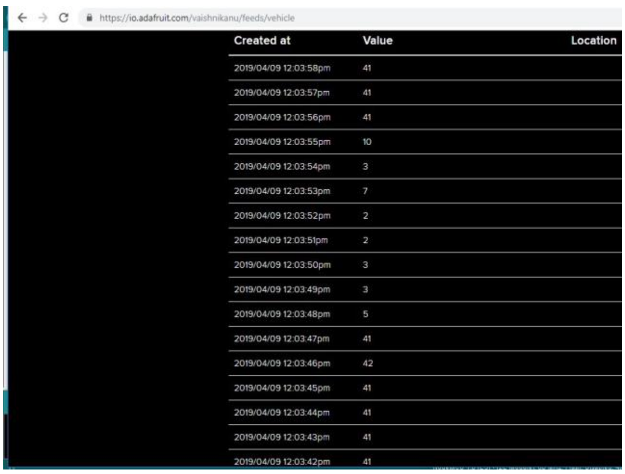

Fig. 9.Adafruit feeds

The calculated distance is then displayed on the serial monitor as shown in Fig. 8 and then uploaded to adafruit as shown in Fig. 9 using the Wi-Fi module present in ESP8266. MQTT Client and MQTT Publish help us to send the data. There is a graph generated for the values sent to adafruit as depicted in Fig. 10.

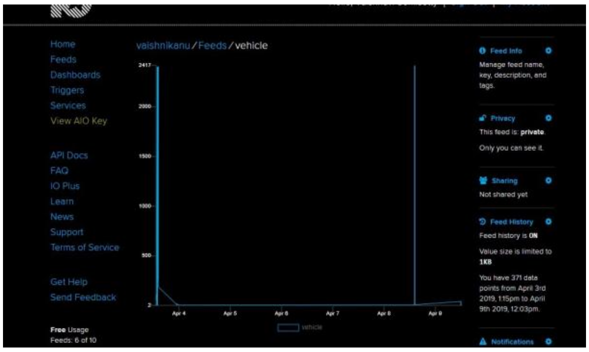

Fig. 10. Graphical representation of adafruit feed

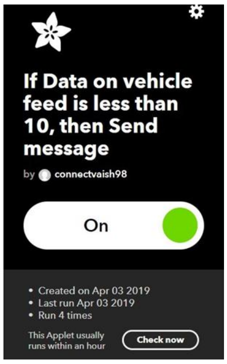

Fig. 11. Working applet created using IFTTT

Fig. 11 shows an IFTTT applet created which get the values from adafruit and verifies it against the user given condition which here is the distance is less than 10 cm and then sends an alert message to the drivers' facebook messenger as shown in Fig. 12. The driver is alerted (using LED and messenger), the chances for the collision to occur is reduced hence reducing the traffic.

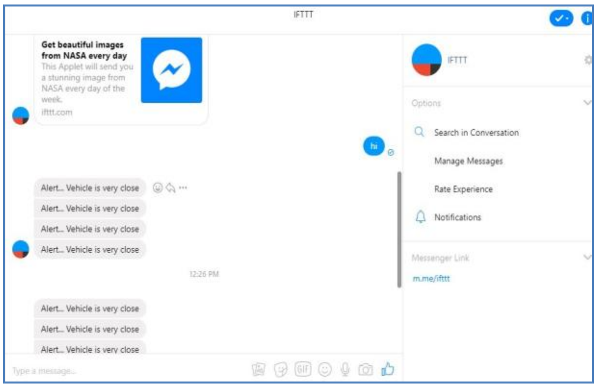

Fig. 12. Sending an alert message through messenger

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V. CONCLUSION

The proposed approach provides a solution for regulating traffic flow in urban areas, in which various circumstances may exist and can also be implemented in case of an intersection. It contributes to avoiding accidents by notifying the driver in advance of possible collisions by either sending them an alert message to their mobile or can also give the driver an alert by turning on an LED that should be inbuilt in the vehicle which glows when one vehicle approaches the other vehicle. Using SUMO simulation, the scenario can be visualized graphically where the vehicles communicate with each other so as to avoid collisions. This work if extended can be implemented in real-time by taking open street map which can take the real world map. Hence by using this architecture, every vehicle would be able to communicate with the other and collisions can be reduced and there can also be a reduction in the sudden stoppage of vehicles at intersections since it takes into consideration the position and speed of the vehicle. Thus, the traffic congestion can be prevented to some extent and the proposed idea is a computationally inexpensive modeling approach.

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