Fair Scheduling of Priority Message or Vehicle (FSPMV) in Vehicular Ad-hoc Network

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Abstract Improving road safety is one of the primary goals of smart transportation systems. Vehicle accident alert systems broadcast collisions to automobiles in an ad hoc vehicle network. Emergency vehicles must respond promptly in order to offer emergency services and must have clear clearance on roadways. A little lag in the transit period of an emergency vehicle might result in the loss of important lives. The system requires faster broadcast of safety and emergency notifications in order to minimize additional effect. Regarding priority to cars and messages, our suggested strategy of fair scheduling of priority messages or vehicles aids in the speedier distribution of emergency messages by broadcasting with a reduced number of backoff timeslots and giving fair channel access to priority messages, indicating improved reliability.

Index Terms— **Vehicular communications, reliability, relay vehicle, emergency messages, ad-hoc networks**

I. Introduction

VANET is intended to deliver many roads safety services [1]. This aim may mainly be realized by utilizing effective safety apps that are able, through wireless broadcasting, to notify the drivers of a risky scenario such as an accident. For safety and traffic efficiency, message propagation is critical. Specific routing protocols [2] for the delivery of messages in VANET are categorized according to topology, initiator location, geocast, cluster-based, broadcast, platoons etc. Delays must be as minimum as possible because messages are to be transmitted quicker. As a consequence, there is a strong need for reliable message propagation in terms of faster dissemination of messages in emergencies and reducing network load, which in turn will help to reduce accidents and impact of accidents thus saving many lives.

Emergency vehicles must respond quickly in order to provide emergency services, hence they must have unobstructed passage on the highways. A minor delay in an emergency vehicle's transit time might result in the loss of valuable lives as well as financial loss [3]. It is vital to guarantee that network passage for emergency services makes its destination in the lowest period of time possible. The impetus for this effort stems from the vital importance of this need. This involves the creation of a rapid and impeccable mobility infrastructure for emergency services in vehicle networks. Our objective is to reduce the journey time of a distinguishing vital vehicle, such as an ambulance, from a point of origin to a point of destination. We would want to deliver an automobile that is Absolute Priority. To provide the lowest possible route time to an emergency vehicle such as an ambulance, all available network capabilities are used in absolute priority. The messages are prioritised depending on their relevance for timely transmission.

The following is how the paper is organised: Section 2 presents pertinent related work. Section 3 focuses on the model that has been suggested. Section 4 discusses the results, and Section 5 wraps things up.

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II. Related Work

The technique proposed in [4] takes into consideration the following parameters: (1) vehicle speed, (2) vehicle direction in regard to the RSU, and (3) emergency services. The first two parameters are used to establish the earliest deadline first (EDF) value for each car, while the third parameter is used to break ties, such that if many vehicles have the same EDF value, the vehicle with emergency service gets served first. Cars with a moderate or low EDF value, on the other hand, are considered high priority, whilst vehicles with a high EDF value are considered low priority.

The authors of this research [5] devised a unique priority assignment strategy to decrease transmission time. Each transmission was prioritised adopted on static and dynamic characteristics, together with the size of the message. The message content and application type define the Static Factor. In contrast to static variables, which are determined by the content of messages and the kind of applications, dynamic factors are determined by the VANET's conditions. The parameters used to calculate the dynamic factor include vehicle velocity, message usefulness, message validity, sender and recipient vehicle directions, meteorological conditions, and geographic position. The article determines message priority by employing novel metrics for instance weather and geographical location. The message's priority was used to determine the dynamic scheduling order.

For some applications, such as a travelling ambulance, even a second of delay is critical. The authors of this work [6] offer a fully infrastructure-free solution for determining the shortest path and managing traffic lights in order to guarantee 100% precedence for an emergency vehicle. The notion of automobile ad hoc networking is being researched in order to reduce required journey time. The vehicle's destination must be known. Based on the destination, the shortest path is estimated by taking into account the velocity and speed of all intermediary vehicles along the route between the origin and the destination

In [7], during an emergency, the approach utilized assesses the remoteness of priority vehicles from the junction and informs motorists to the impending arrival of the emergency vehicle, allowing greater priority vehicles to route through the junction ahead of lower priority vehicles. These networks seek to cause driving safer and more dependable, as well as to minimize the time it takes for life-saving vehicles to arrive at junctions. The suggested approach calculates the shortest distance between junctions and emergency vehicles using the Euclidean distance theorem and prioritizes the vehicles with the shortest distance to pass through the intersection.

A unique priority-based algorithm as stated in [8], is used to control junction traffic via vehicle-to-vehicle communication, with vehicles forming coalitions depending on their priority. Higher priority cars are allowed to pass through the intersection ahead of lower priority vehicles thanks to the algorithm. Vehicles travelling to a place may reach many crossroads, and beyond one route to the same site may exist. A vehicle will await at a juncture based on the priority and load of all cars in the entrance of that juncture. Several factors, including priority, distance from the juncture, vehicle direction, and density, were considered while calculating vehicle waiting time. In [9], authors have prediction system in real time using Big Data to improve the VANET network.

Daxin et al. [10] presented a position-based protocol for broadcasting emergency messages in VANETs. These messages are aired in order to decrease traffic accidents. When a vehicle is involved in an accident, it can send warning signals to other cars, allowing them to make proper judgments to evade the accident zone. The proposed approach aids in the avoidance of needless rebroadcasting of emergency signals. Because the protocol is spread in nature, it may be employed not just on roads but also in urban environments. The protocol sends communications across specific locations with little lag and delivery latency. It also eliminates unwanted re-transmissions and obviates emergency message broadcast collisions. The disadvantage is that maintaining real-time data is challenging due to message collisions caused by the rapid exchange of beacon signals. The authors in [11] have assigned priority to messages in an attempt to avoid congestion for critical messages.

In this work, the authors of [12] put forward a multi-hop message broadcast approach for time-critical emergency services in VANETs. This method's trinary partitioned black-burst-based broadcast protocol (3P3B) is made up of two main approaches. The first solution employs a framework known as micro distributed interframe space (DIFS) at the MAC layer to prioritise emergency signals in communication channels for time-critical distribution above other communications. The second method divides the communication range into tiny parts using a trinary partitioning approach. The purpose of this strategy is to permit the sender node in the faraway sector of the communication range to transmit emergency messages in order to enhance message dissemination speed by lowering the number of hops to the destination. Aside from that, the proposed protocol significantly drops jitter in the contention window irrespective of traffic volume, resulting in a stable contention period. The disadvantage of this strategy is that considerable network latency occurs during simultaneous transmissions and due to heavy competition. Authors in [13] present a unique Autonomic Dissemination Method (ADM) for delivering messages based on priority and density levels. Jingtao Du et al. in [14] have proposed an adaptive backoff algorithm based on the number of vehicle nodes but the priority of the message is not considered. Priority of message is calculated based on the size of the message [15].

From the literature focused on priority of messages and vehicles we explored; we can conclude that few research work focused to manage traffic at intersections. Vehicle needs to maintain too many parameters for priority calculation which increases processing time. Focus of some of the research work is on fast passage of emergency vehicles at intersection.

III. Proposed Approach – Fair Scheduling of Priority Message or Vehicle

The use of priority for emergency message distribution is beneficial in addressing the delays and latency that occur between nodes while communicating.

Considering the diverse nature of VANETs, and the traditional problems in message dissemination, our proposed Fair Scheduling of Priority Message or Vehicle (FSPMV) scheme consists of 1) calculating priority of message and 2) Scheduling of message. For calculating the priority, the proposed scheme considers the following factors 1) category of vehicles 2) application of message 3) speed of vehicle.

A. Priority Calculation

For calculating the priority, the proposed scheme considers the following factors: 1) category of vehicles 2) application of message 3) speed of vehicle.

Priority is calculated as in equation 1.

Finally, vehicle V computes $Priority_{assigned}$ as in equation 1.

$$Priority_{assigned} = \alpha * Veh_{cat} + \beta * Appl_{cat} + \gamma * \Delta S(v,z) \quad (1)$$

where α, β and γ are the different weights assigned Veh_{cat} indicates the different category of vehicles types $Appl_{cat}$ indicates the different category of application messages ΔS(v,z) is the speed difference.

Vehicle Priority

Vehicles are prioritized according to their roles. They can be high priority vehicles as indicated in figure 1.

High Priority Vehicles: Priority vehicles include police, gendarmerie, customs, fire departments, private ambulances, intervention vehicles of mobile medical units, automobiles used to transport detainees, and vehicles escorted by police or gendarmerie. These vehicles must use a two-tone siren as well as a flashing blue light at the same time to be designated a priority. They may break the rules of the road. This is due to the mission's urgency, which warrants it without risking other cars' safety. When approaching a priority vehicle, slow down or come to a complete stop. To allow the intervention units to proceed, the causeway must be cleaned as much as possible. The priority vehicle is further subdivided into three sub-categories: police, medical, and emergency service. All police service vehicles, patrolling vehicles, custom vehicles, etc., are under police category. Private ambulance and vehicle of mobile hospital come under medical category. Fire brigade, transport detains, etc., come under emergency service.

Easy Pass Vehicles: Vehicles needing easy passing have considerable, but limited, running privileges. Indeed, there is no legal requirement to signal the necessity for them to pass. When one of them approaches, it is still a matter of applying common sense and not obstructing the road needlessly. Medical association, Vehicles carrying blood products and human organs, Cash transportation from the bank, sanitary transport vehicles, etc., are some of the examples of easy pass vehicles.

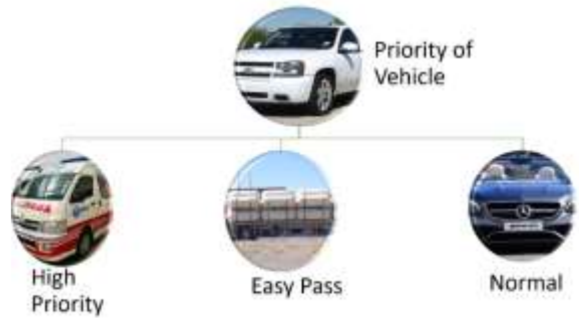

Fig. 1. Priority of Vehicles

Normal Vehicles: Transport vehicles with no distinguishing features such as goods transport vehicles, passenger carrying vehicles and even personal vehicles comes under this category.

High priority vehicles have high value of 3, easy pass vehicles have value 2 and normal vehicles have value 1.

Application Priority

Georgios K. et al.'s [16] classification of vehicular networking applications is as follows: 1) Active road safety applications, 2) Traffic efficiency and management apps, and 3) Infotainment applications. 1. Applications for Active Road Safety The primary goal of active road safety applications is to reduce the likelihood of traffic accidents and the loss of life among vehicle occupants. Cooperative collision warning, pre-crash sensing, lane change, traffic violation warning, and other active road safety applications assist to reduce the likelihood of automobile accidents. 2. Applications for Traffic Efficiency and Management Applications for traffic efficiency and management attempt to improve traffic assistance, traffic flow, and coordination among linked cars. This type of application delivers up-to-date maps, local information, and relevant messages that are limited in place and/or time. Applications include improved route guidance/navigation and traffic management. This programme delivers up-to-date maps, local information, and relevant messages that are limited in space and/or time. Applications such as improved route guidance/navigation, traffic optimum scheduling, lane merging aid, traffic signal assistance, and so on attempt to optimise vehicle flows. 3. Applications for comfort and information Such apps place a premium on information from locally based providers. Applications such as point of interest notification, media downloading, map download and update, parking access, media streaming, multiplayer gaming, online surfing, social networking, and so on provide the driver with information and amusement.

VANET applications present heterogeneous requirements (Figure 2). Reliability, low-latency, and efficient message dissemination are the requirements of safety applications and so high value of 3 assigned to it. Non-safety applications have varying communication requirements, ranging from assured Quality-of-Service requirements in multimedia and interactive entertainment apps to no particular real-time requirements in traveller information support applications with a value of 2. The value 1 will be allocated to comfort and infotainment apps, indicating the lowest importance.

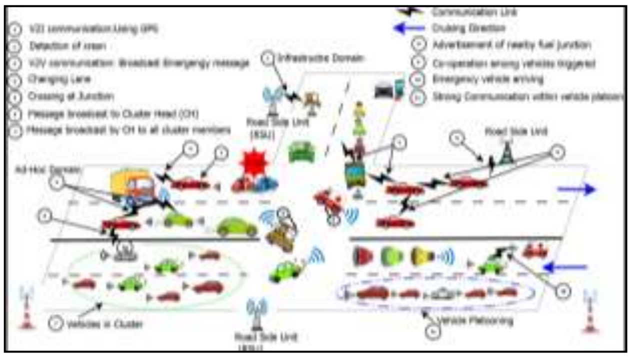

Fig. 2. Applications of VANET

Speed Difference

The vehicle after receiving the message will check for the speed of the vehicle that generated message. Consider $Speed_v$ is speed of vehicle that received message and $Speed_z$ is speed of vehicle that generated message. If the originator of the message vehicle is arriving with high speed, then it indicates the need to give the approaching vehicle clear passage to make their way. If the speed of the approaching vehicle is greater than the vehicle itself that received the message, the difference in speed is calculated. The difference in speed between V and the approaching vehicle Z is: ΔS(v,z)

If one of the vehicles out of M, successfully transmit after DIFS, then equation 6 will be modified as equation (2).

$$\Delta S(v, z) = |Speedv - Speedz| \qquad (2)$$

Depending upon the situation, different weights are assigned to α, β and γ in equation 1.

B. Scheduling of Message

M. Torrent-Moreno et al., investigate several strategies for dynamic intervals in MAC protocols in [17]. We employ the IEEE 802.11e EDCA MAC protocol, which is broadcast-based [18]. EDCA examines three important priority ways for channel access: contention window (CW), backoff parameters (CWmin and CWmax), and idle time after which transit of message may proceed (Arbitration Interframe Space, AIFS). When a station acquires access to a channel, EDCA allows it to specify the time period for which it is allowed to use the channel. EDCA presents the construct of access categories (ACs), individually of which has queue. An AC is allocated to each datagram that enters from the top layer and is generally associated with a certain kind of service or application. Depending on the application, voice traffic, video traffic, background traffic, and best effort traffic are all assigned to access categories 3, 2, 1, and 0.

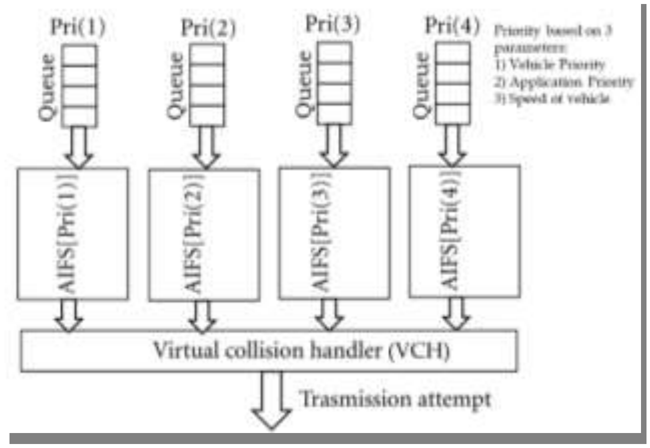

Fig. 3. Access Control Queues of AIFS indicating Priority Based

Parameters Contention parameters (CWmin[AC] and AIFS[AC]) are used by each access category AC. Priority traffic is distinguished from non-priority traffic (AC = 0) by the use of interframe spacing AIFSD[AC] and CWmin[AC] rather than conventional DIFS and CWmin. In equation 3, the AIFSD is determined as follows:

$$AIF\ SD[AC] = SIF\ S + AIF\ S[AC] * SlotT\ ime \qquad (3)$$

where SIFS is Short Interframe Space.

Each AC calculates its own random backoff time (CWmin[AC] <= backoff time <= CWmax[AC]) after detecting the medium idle for a time interval of AIFS[AC]. The intention of employing different contention levels for separate queues is to make a low priority AC wait prolonged than a high priority AC, so that the high priority AC may access the carrier well before lower - priority AC.

It is worth noting that the backoff timings of different ACs are spawned at random and may all approach zero all together at the same time. This might lead to an internal collision. As shown in Figure 3, a virtual scheduler built in each node permits only the highest-priority AC to broadcast first.

IV. Results and Discussion

In the proposed Fair Scheduling of Priority Message or Vehicle (FSPMV) scheme, the three parameters to consider priority are application of message, category of vehicle and speed of vehicle. Then proper scheduling of message for fair channel access is proposed. High priority messages have shorter backoff period and hence are scheduled earlier than low priority messages. The proposed work Fair Scheduling of Priority Message or Vehicle (FSPMV) is compared with Traffic Management for Priority Vehicles TMPV [7]. TMPV mainly focuses to reduce the waiting time of life saving vehicles at intersections.

For simulating the suggested, the experimental set-up is veins. The suggested system, including which integrates OMNET++ with SUMO road traffic simulator, is implemented under veins. The simulation parameters are: OMNET++ integrated in Veins supports the network simulation part whereas SUMO integrated with veins provides traffic simulation. The transmission range specified is 500 and the MAC protocol used is IEEE 802.11p within a frequency of 5.9 GHz with a 10Mhz band. These are the standard parameters for VANET.

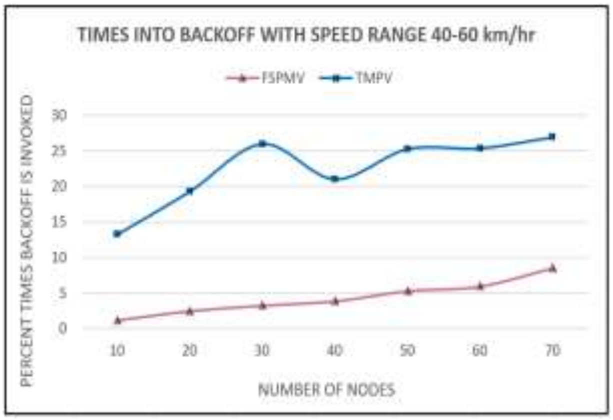

Fig. 4. Times into Backoff with Vehicles Speed Ranging Between 40 km/hr to 60 km/hr

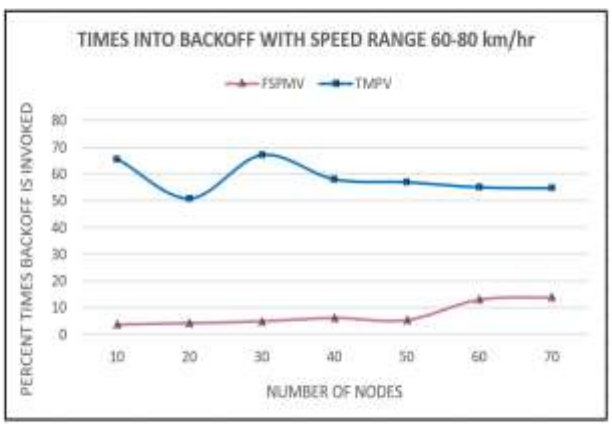

Fig. 5. Times into Backoff with Vehicles Speed Ranging Between 60 km/hr to 80 km/hr

The parameter times into backoff of priority messages for comparisons is considered. When there is an attempt to send the received packet but due to some reason, the packet is not sent and random backoff is initiated. The number of times the random backoff is initiated is equal to the times into backoff. Random Backoff is initiated during the following two conditions: (1) The channel was busy when new packet arrived from upper layer, and so random backoff is initiated and (2) Attempting to send the packet when the backoff reduces to zero (backoff == 0), but at the same time when guard is active. According to 1609, the packet cannot be transmitted when guard is active. So again, random backoff is initiated. In the simulation, 30% of the total messages as priority messages considering application and vehicle priority is taken. The percent times into backoff is initiated with respect to generated priority messages are plotted in the graphs.

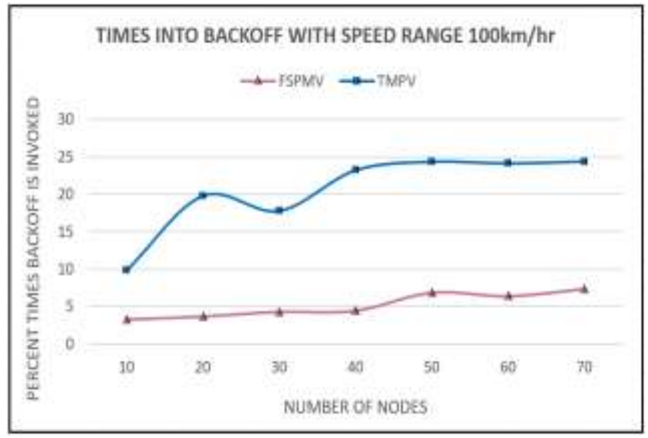

Fig. 6. Times Into Backoff with Vehicles Speed Ranging Between 100 km/hr

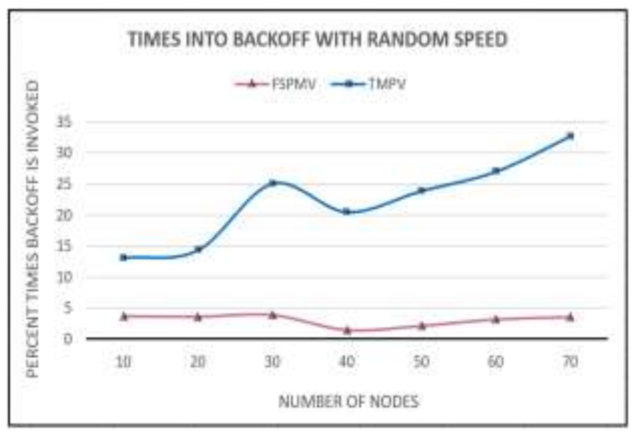

Fig. 7. Times Into Backoff with Vehicles Speed as Random Speed

Figure 4 to 7 represents the percent of times into backoff of a priority message, considering the different speed of vehicles. As indicated, our proposed FSPMV approach schedules all the priority messages faster as compared to Traffic Management for Priority Vehicles TMPV approach.

V. Conclusion

Deploying local warning systems in vehicles through vehicular communications can greatly help reduce accidents, manage traffic and provide a way for emergency service vehicles. Faster dissemination of safety and emergency messages is need of the system to reduce further impact. Considering priority to vehicles and applications, our proposed FSPMV approach helps faster dissemination of emergency messages by broadcasting with a smaller number of backoff timeslots by allowing fair channel access to priority messages and thus indicates improvement in reliability.

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