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Technical Note

Improving the Quality of Service in the VANET by Detecting and Removing Unused Messages

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***Abstract* — in the past, traffic safety was addressed by traffic awareness and passive safety measures like solid chassis, seat belts, air bags and etc. Thanks to the ongoing progresses in the concept of vehicular ad hoc networks (VANET), propitious conditions for finding efficient solutions for traffic safety are meeting. Safety messaging is the most important aspect of VANETs where the passive safety (accident readiness) in vehicles was reinforced with the idea of active safety (accident prevention). In safety messaging vehicles message each other over wireless media and update each other on traffic conditions and hazards. Owing to the importance of the QOS in safety messaging, many researchers have focused on this topic. Earlier related works have scrutinized the aspect of increasing the service rate by changing the properties and parameters of scheduler algorithms but this paper with a new look at the issue of quality of service tries to increase the performance of VANET by removing the useless or unused packets.**

***Keywords*- VANET, Safety message, Service ratio, unused messages**

I. Introduction

Traffic safety is a major challenge recognized by the major players in the automotive industry and by many governments. According to [1], thousands of road accidents are reported in any country. For example during the same year, Europe reported number of accidents with fatalities of 42,000. Similar situations exist in other parts of the world like United States [2].

Traffic incidents are often a result of the driver's inability to assess quickly and correctly the driving situations. Normally drivers have incomplete information about road conditions, speed and location of vehicles around them, and usually are forced to make decisions like breaking and lane changing without the benefit of whole data. Real time communication between vehicles or between vehicles and road-side infrastructure can improve traffic safety and efficiency [2]. For example, if a vehicle was required to slow down due to an accident ahead, it would broadcast warning messages to neighboring vehicles. The vehicles behind it will thus be warned before they actually see the accident, helping the drivers react faster, thereby avoiding rear ending of vehicles. In another scenario, if vehicles can transmit traffic congestion information to other vehicles in its range, it can help other vehicles that receive the information to chose alternate routes and avoid traffic congestion.

Vehicular Ad Hoc Networks (VANETs), an extension of mobile ad hoc networks (MANET) [3], were developed to enable real-time communication between mobile nodes (either vehicles or road side infrastructure) over wireless links, primarily to enable traffic safety and efficiency. The communication between nodes in a VANET faces many unique challenges [4]. This is especially true for safety-critical applications like collision avoidance, pre-crash sensing, lane change and etc [5]. Factors like high vehicle speeds, low signal latencies, varying topology, total message size, traffic density and etc induce challenges that make conventional wireless technologies and protocols unsuitable for VANETs [5, 6].

II. RELATED WORKS

A. MESSAGE DISSEMINATION IN THE VANETS

There are several approaches for efficient and reliable data dissemination in VANETs. However, most of these approaches cover specialized problems, such as contention based forwarding (CBF) by F¨ußler et al. [7]. CBF is a greedy position-based forwarding algorithm in unicast scenarios that uses a contention process based on the positions of the neighbor network nodes. Forwarding nodes that are likely to bridge the greatest distance to the destination are favored by the distributed contention process such that they may send first. Other nodes with a smaller distance to the destination are suppressed simultaneously. Another methodology going into the same direction is MDDV [8]: Forwarding of packets is carried out along a so-called forwarding trajectory, representing the path from the source to a destination region that has been specified by the sender. Another approach was made by Lochert et al. [9] using a digital street map to enhance the routing decision. This approach exploits the fact that connectivity in city scenarios is higher at street junctions. Thus, nodes at junctions should be chosen as forwarders. Like CBF and MDDV, the approach does not reflect the interest of the receivers in the message and does not take into account the changing utility of messages when the information that is transported gets older and stale. Further progress is made by Kosch in [10]. His methods uses a dissemination algorithm based on Geocasting and the interest in the message that nodes probably have (a first approach to utility estimation). Now, the receiver of a message is able to use his own knowledge to decide whether to forward a message immediately, to store it and forward it at a later time, or to discard it. Message forwarding is no longer a sender-driven process, but a receiver driven one.

Other efforts were made by Wischhoff et al. in [11], trying to reduce the network load by data aggregation. Additionally, nodes tried to measure the relevance of a received message by examining message age and reducing the spatial resolution of information when no change in the situation within a certain area was observed, thus implicitly trying to measure the utility of a packet. Another approach by Wischhof and Rohling also aimed at measuring the utility of a message [12].

Utility is calculated on a per byte basis, using a recursive algorithm that takes the current data rate into account. Then, a new data rate proportional to this utility is chosen by applications, thus ensuring a fair use of the channel. However, the paper did not suggest any metrics for the utility of a packet.

B. QOS IN THE VANETS

Much effort and research in the literature is spent on the factors that influence the QOS of wireless vehicle communication systems. In [13], the dissemination of safety-related information in a VANET is studied. Assuming a layered protocol design, it is argued where and how functions related to data dissemination and transport could be implemented. In [14] the decomposition of the VANET functionality into a combination of the typical OSI layered approach and an architecture tailored to the specific needs of VANETs is discussed. The result is a cross-layered architecture in which dependencies among parameters can be observed. Also in [15] a cross-layered architectural design is used, this time in safety/comfort-related applications, and the involved networking challenges are discussed. The results outline the main challenges for VANETs to be medium access control (MAC) and routing protocol related issues. The challenges in ad hoc networks obtained from the construction of a test bed are described in [16]. Here a set of scenarios are used to characterize an ad hoc network environment. Issues such as wireless technologies, routing protocols, security and signal propagation constraints are addressed. Examples of parameters are the type of routing protocol used, the adopted addressing

mode (e.g., Geocasting, broadcasting), the system latency or the transmission error rate. Our selection of parameters was driven by the characterizing features of VANETs on the one hand and the desired applications on the other hand, much the same way as the selection done in, e.g., [17].

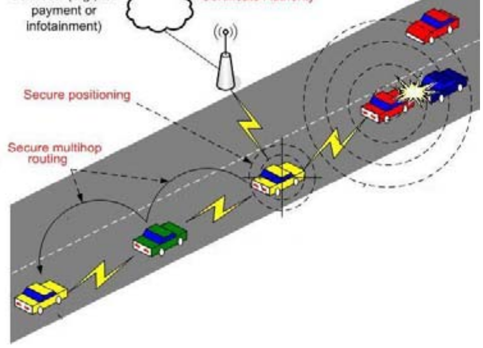


Figure1. Message dissemination and safety application

C. SAFETY CRITICAL APPLICATIONS

There are numerous in which VANET applications can be classified. In this section we focus on V2V safety-critical applications.

Pre-crash sensing can be used to prepare for imminent, unavoidable collisions. Based on position information obtained by beaconing, the car can determine whether a crash is about to occur. This application could use communication in combination with other sensors to mitigate the severity of a crash. [19, 20]

Cooperative collision warning collects surrounding vehicle locations and dynamics and warns the driver when a collision is likely. The vehicle receives data regarding the position, velocity, heading, yaw rate, and acceleration of other vehicles in the vicinity. Using this information along with its own position, dynamics, and roadway information (map data), the vehicle will determine whether a collision with any vehicle is likely. In addition, the vehicle will transmit position, velocity, acceleration, heading, and yaw rate to other vehicles. [19,20]

When a vehicle brakes hard, the Emergency Electronic Brake light application sends a message to other vehicles following behind. This application will help the driver of following vehicles by giving an early notification of lead vehicle braking hard even when the driver's visibility is limited e.g. a large truck blocks the driver's view, heavy fog, rain). This information could be integrated into an adaptive cruise control system. [19,20]

Blind spot: This application warns the driver when he intends to make a lane change and his blind spot is occupied by another vehicle. The application receives periodic updates of the position, heading and speed of surrounding vehicles via V2V communication. When the driver signals a lane change or turn intention, the application determines the presence or absence of other vehicles/pedestrians/bicyclists in his blind spot. In case of a positive detection, a warning is provided to the driver. Lane change: This application [19,20] provides a warning to the driver if an intended lane change may cause a collision with a nearby vehicle. The application receives periodic updates of the position, heading and speed of surrounding vehicles via V2V communication. When the driver signals a lane change intention, the application uses this communication to predict whether or not there is an adequate gap for a safe lane change, based on the position of vehicles in the adjacent lane. If the gap between vehicles in the adjacent lane will not be sufficient, the application determines that a safe lane change is not possible and will provide a warning to the driver. [19,20]

Table1. Identifying V2V Safety-Critical Applications

Application Category	Applications Name
Intersection Collision Avoidance	Traffic Signal Violation Warning · Stop Sign Violation Warning · Left Turn Assistant · Stop Sign Movement Assistance · Intersection Collision Warning · Blind Merge Warning · Pedestrian Crossing Information at Designated Intersections
Public Safety	Approaching Emergency Vehicle Warning · Emergency Vehicle Signal Preemption · SOS Services · Post-Crash Warning
Sign Extension	In-Vehicle Signage · Curve Speed Warning · Low Parking Structure Warning · Wrong Way Driver Warning · Low Bridge Warning · Work Zone Warning · In-Vehicle Amber Alert
Vehicle Diagnostics and Maintenance	Safety Recall Notice · Just-In-Time Repair Notification
Information from Other Vehicles	Cooperative Forward Collision Warning · Vehicle-Based Road Condition Warning · Emergency Electronic Brake Lights · Lane Change Warning · Blind Spot Warning · Highway Merge Assistant · Visibility Enhancer · Cooperative Collision Warning · Cooperative Vehicle-Highway Automation System (Platoon) · Cooperative Adaptive Cruise Control · Road Condition Warning · Pre-Crash Sensing · Highway/Rail Collision Warning · Vehicle-To-Vehicle Road Feature Notification

III. Influence of the Distance Among Vehicles and Their Positions on QOS

As we saw in the previous section, in the researches presented in scheduling in the VANET, many factors is considered and afterwards each of them has been tried to increase the transmission rate. Differences among VANET and other networks have led us to consider new factors and their impact on quality of service in the VANET. Several parameters in the VANET such as car velocity, dynamic topology, etc make the response time be an important issue because when a packet is received by a car it has limited time for response and reaction. Therefore if the amounts of packets transmitted in the network increased, queue of packets might be created in the car and response time of some packets would be expired before being processed and finally, the service rate would come down.

In previous works it has been tried to increase the service rate by changing the properties and parameters of scheduler algorithms. In This section we will examine two important factors and looking at the issue of quality service we try to increase the performance of the VANET by removing the useless or unused packets. For this purpose, consider the following scenarios:

A. Scenario1

Consider a highway that has at least two lines for car traffic. (Figure2).

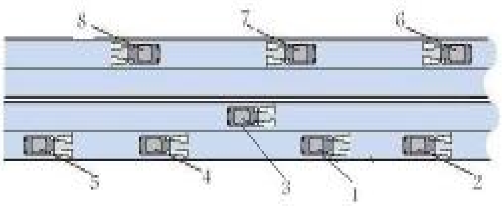


Figure2. Impact of vehicles position

Suppose that car 1 brake abruptly. In this vehicle, Emergency Electronic Brake Light Application sends a message in its area. In this way other vehicles that receive the message, must have a proper reaction. Vehicles that are in the same line and are behind the car1- such as 4 and 5- after receiving and processing of the received message from car1 they must reduce their speed.

Although car 3, 6, 7, 8 and 2 receive these messages, owing to their position to the car1, these vehicles don't need to process this message and after receiving the safety message they can remove it. In this special safety application, the position of vehicles has influential effect on their reactions.

From this standpoint even some other applications may be found that are different with Emergency Electronic Brake Light Application. Table2 shows some affected safety applications by this factor. In this idea each vehicles must be able to identify the position of itself to another.

According to this scenario if car 3 brakes and sends a safety message, car 1 4 and other cars receive this message, but according to their position they do not have to do any reaction. So all cars which receive this message do not need to process it and without any processing they can drop it.

In this figure suppose that car 1 wants to change its lane and go to another lane. When it starts changing, a safety application must send a message to inform this change to other vehicles. Cars which are in its area may receive that message and because of the type of the message they have to have a quick and proper reaction. But according to their position only car 3 needs to reduce its speed and has a proper reaction. This means that car 1 and car 4 do not need to process this message and they can drop it.

If we do not have this idea, each car which receives the safety message should process it and according to the type of that message, each car should do a reaction, for example it should brakes and tries to reduce its speed when a car change its lane. This is reasonable because of traffic common rules and on the other hand it leads to produce new messages which increase the congestion and response time. This means that when car 1 change its lane, only car 3 must brake and reduce its speed so other cars drop that message and process other important messages. On the other hand car 4, 2 and 7 do not need to brake because they drop that message and then they do not produce new unused messages.

B. Scenario2

In this scenario as shown in Figure2, suppose that car 1 brakes abruptly and sends a safety message over its area.

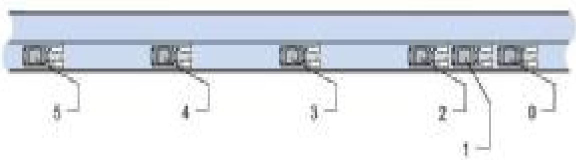


Figure3. Impact of distance between vehicles

Each car which receives the sent message will be forced to react and send a safety message according to its condition. This will be reiterated for throughout the highway. If we review the scenario, we'll see that the received safety message for vehicles far from the source vehicle such as 4 and 5 is less important than closer ones. In this scenario all of the cars are in the same lane and according to the previous scenario all of them must process the message after receiving and then show a proper reaction according to the type of the received message. But we know that when car 1 braked, car 2 which is the nearest car behind to it must react quickly. Car 3 which is so far away from car 1, does not need to do any reaction because of its distance to car 1.

In this idea each vehicles must be able to compute the distance between itself and another. This may increase the computational overhead but by this idea we can decrease the number of reactions and unused messages and this leads to increase the quality of service in the network.

Table2.influence of distance and position in the safety applications

Communication	Distance	Position
Emergency Electronic Brake light	Yes	Yes
Pre-crash sensing	No	Yes
Cooperative collision warning	No	No
Blind spot	Yes	Yes

These scenarios show that we can determine the position or the distance of a car by adding any overhead information or processing and then according to these factors we can reduce the number of unused messages and network congestion. Decreasing the length of queues in the cars and the average of the response time, increasing the quality of service and the speed of driver reaction in accident are the final result of this idea.

IV. IMPLEMENTATION

In this section we evaluate the performance of the idea that proposed in previous section in large scale network. by means of GloMoSim simulator. In this simulation we fix the length of the road to 2000 meters with 2 lanes on each side. We use 802.11b as the wireless media with a transmission range of 250 meters. During a simulation run, vehicles haphazardly send safety message in its area.

Table3. Simulation setup

Communication	
Mobility Model	Tow-way ground
Mac Model	IEEE 802.11b
PHY Data Rate	1Mbit/sec
Transmit Range	250m
Vehicular Traffic Model	
Road Length	2km
Number of lanes	2 per direction
Desired velocity	90km/h
Average number of vehicles	25

In this implementation we have used a 2 bits data field to show the lane and direction of the car which have produced that message. (Table4)

Table4. Lane and direction field values

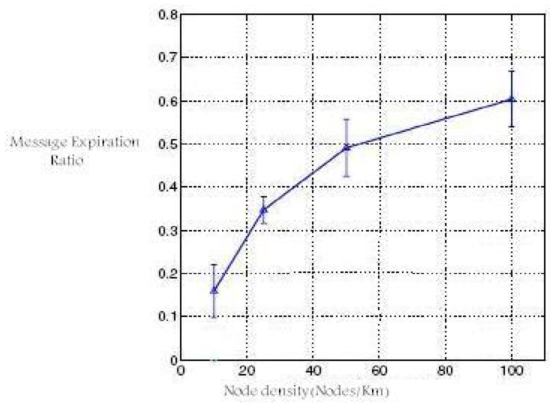
Lane and direction field	
00	Lane1- left to right
01	Lane2- left to right
10	Lane1-right to left
11	Lane2-right to left

In [18] the Formula for calculating distance between two nodes at time t has been proposed and base on this formula we propose the simulation result.

In this simulation we study the number of messages that their response time was expired. Figure4, 5 shows it.

We believe that some of messages which were received and processed in the network before applying the idea are unused and must have been dropped. So each application according to its type, use the direction and the distance of the source of the message to show this message must be processed or must be dropped. This means some of the messages in this simulation dropped intentionally. So be careful that the diagram of service ratio does not improve because the rate of messages which are dropped doesn't decrease. But some of these messages dropped by algorithm before processing. Indeed by this algorithm we can manage and determine which message should be processed and which message should be dropped. With a simple comparison we can say that in this idea, the rate of messages which were removed after their response time expiration was decreased.

Figure4. Simulation result before applying the idea



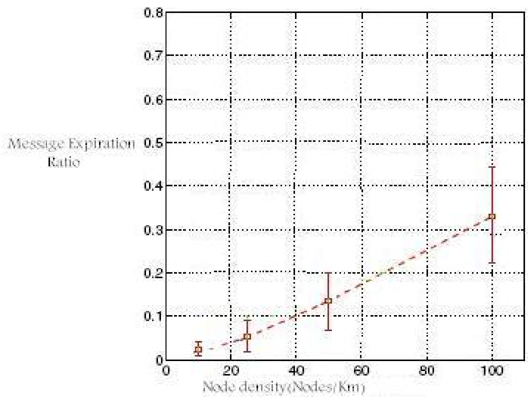


Figure5. Simulation result after applying the idea

This is important that in the past, an important message has been removed because of network congestion and waiting time for processing in the vehicles. Sometimes because of VANET restrictions an important message should be processed in a very short time but because of the unused message and prolonging waiting time that message is ineffective. So by detecting and removing the unused message we can increase the rate of the delivery and processing of those messages which are important and should be considered by vehicles.

V. CONCLUSION

In this paper we are looking for a way to reduce the work load of vehicles shown as Network nodes. First of all, the safety applications and their properties were reviewed and also the quality of service in the VANET was scrutinized. Then the foundation of our work was laid on the unused message sent by vehicles. Although the functionality of the vehicles won't be affected by unused messages but owing to the lengthening of the message processing queue they have influential effect on messages response time.

Therefore we propose a scenario by considering two factors: (1) distance among vehicles and (2) their positions. Removing unused messages before their queuing and processing, the extraordinary amount of time for other messages will be saved.

In overall, it can be concluded that none of the QoS solutions presented in the past can satisfy all the QoS criteria. In the future, more research should be done on finding new methods, standards, protocols and architectures which satisfy the QoS criteria. Moreover, comparisons using quantitative performance evaluations are needed, in order to quantify the performance differences between the QoS solutions.

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