A Priority Packet Dissemination Scheduling Mechanism in Vehicular Ad-Hoc Networks

Jeffry¹, S Usman² and F Aziz³

¹,²,³Faculty of Mathematics and Natural Sciences, Universitas Pancasakti Makassar, Indonesia. 90132
1E-mail: jeffryfikom19@gmail.com

Abstract. One of the vehicle communication technologies in the Intelligent Transport System is the Vehicular Ad-Hoc Networks (VANETs). VANET is a communication technology between one vehicle with other vehicles so as to reduce the impact of traffic accidents. Quality of Service requirements in VANETs communications has been supported by the standard protocol, IEEE 802.11p WAVE (Wireless Access in Vehicular Environment) protocol. The mechanism used in this protocol is CSMA/CA that divides four access categories in the selection of channel access by ensuring the success of more priority packets compared to the low priority ones. However, if another vehicle has the same priority packet to send, then a collision might happen. This paper proposes a packet deployment mechanism based on priority. Priority packets are estimated based on location and traffic conditions of vehicles, and then the AODV protocol is used for data deployment. Experimental results showed that priority based channel access perform better than CSMA/CA with an increasing PDR average about 24%, throughput of about 0.25 Mbit/sec and delay of about 0.0969 seconds.

1. Introduction
Transportation accidents become a frightening spectre for every driver and rider in the world. according to WHO, Indonesia is in the third position after China and India for traffic accident cases in 2015 with a total death of 38,279. [1]. To cope with or reduce the number of traffic accidents, it is necessary to apply the wireless network technology that can communicate with each other between vehicles [2]. In the Intelligent Transport System, this communication has been supported by the communication between vehicles using VANETs (Vehicular Ad-Hoc Networks) technology that can communicate between V2V (vehicle to vehicle) and V2I (vehicle to infrastructure) [3], [4], [5]. The technology is based on local area network so the driver can aware immediately about potential accident by vehicle due to this communication technology.
In general, message communications that related to vehicular safety in VANETs consist of two messages, i.e., stated messages such as CAMs (Cooperative Awareness Messages) and emergency messages such as DENs (Decentralized Environmental Notifications) [6], [7]. In supporting both of communication messages, VANETs has provided the standard protocol used for the QoS (Quality of Service) requirement of the IEEE 802.11p WAVE (Wireless Access in Vehicular Environment) protocol using Enhanced Distributed Channel Access (EDCA) based on the IEEE 802.11e. The EDCA mechanism of the IEEE 802.11p protocol defines four ACs (access categories), i.e., voice (AC_VO), video (AC_VI), best effort (AC_BE) and background (AC_BK). This mechanism gives the highest priority AC_VO and the lowest is AC_BK. Parameters to determine access are categorized as CW_min (Minimum Contention Window), CW_max (Maximum Contention Window) and AIFSN (arbitration interframe space number) [8], [9].

The selection of priority packages that are deployed first into the network is an important determination of access categories. According to research [10], messages that are considered emergency are categorized as AC_VO access. To determine the access category using the IEEE 802.11p protocol with the standard CSMA/CA mechanism (Carrier Sense Multiple Access/Congestion Avoidance). This mechanism works by calculating the contention window and back-off [11]. However, if another vehicle has the same packet priority to be transmitted then the possibility of a collision will occur. When compared to the standard CSMA/CA scheme, the application of traffic types and TTL (Time to Leave) for each vehicle in accessing channels can increase throughput [12]. However, routing protocol to disseminate the packet after the channel access selection has not implemented in this research. This research is also conducted only with the maximum node condition of 30 nodes. Research [2] proposed an algorithm by selecting clusters to deal with delayed packages. In the deployment of packet using MAC scheme, research [13] implemented data dissemination in SUMO and NS3. The results show that the AODV protocol has better performance compared to other protocols. Even in conditions of high density [14].

Research [15] proposed priority packet data dissemination in VANET with determining TTL (Time to Leave) and distance for each vehicle. The results show that the proposed schema increase throughput, packet delivery ratio and also reduce the delay.

The purpose of This paper is to analyse the performance of CSMA/CA standard schemes and priority based on control channel access schemes under high-density conditions for packet prioritization based on category access selection. Then the packet with the highest access category will be disseminated first using AODV routing protocol.

the overall of this paper is section 1 : Introduction. Section 2 : preliminary. Section 3 contains proposed methods detailed. Section 4 contains experimental results through simulations carried out as well as performance metrics and in section 5 concludes our proposed research.
2. Preliminaries

2.1. IEEE Protocol
IEEE 802.11p has supported WAVE (Wireless access in the vehicle environment) in transmission [16], [17]. EDCA mechanism (enhanced distributed channel access) is used to improve quality by choosing package categories that have priority over other packages (access categories).

Table 1. EDCA access in IEEE 802.11p protocol

| Access Category | AIFS N | CW_min   | CW_max   |
|-----------------|--------|----------|----------|
| Background      | 9      | aCW_min  | aCW_max  |
| Best Effort     | 6      | aCW_min  | aCW_max  |
| Video           | 3      | (aCW_min+1)/2 - 1 | aCW_min  |
| Voice           | 2      | (aCW_min+1)/4 - 1 | (aCW_min+1)/2 - 1 |

2.2. AODV (Ad-hoc On-demand Distance Vector)
The use of traditional ad-hoc protocols in VANET includes proactive protocols, reactive protocols, and hybrid routing protocols [18]. AODV (ad-hoc on-demand distance vector) is one of the reactive routing protocols that requests routes when only needed [19]. AODV protocol mechanism there are two types of route discovery, namely RREQ (Route Request) and RREP (Route Reply). in AODV there is also a route maintenance mechanism, namely RERR (Route Error Requests). the way the route discovery works is when the destination node information has been found when making a route request, the node will send the packet back to the initial source. but when a failed data transmission occurs, route maintenance is used by sending a packet to the neighboring node to send back the initial source packet [20].

2.3. Performance Measurements

2.3.1. Packet Delivery Ratio
Is the number of data packets sent to the destination node divided by the number of data packets sent by the source node or it can be said that PDR is a comparison of packets received and sent successfully in the network [21]. PDR can be calculated as follows:

\[
PDR = \frac{\text{Sum of the data packets received}}{\text{Sum of the data packets sent}}
\]  

(1)

Network performance will improve if this metric is upgraded.

2.3.2. Throughput
Throughput is actual bandwidth using certain time unit measurements with certain network conditions when transferring file. According to [21], this metric can be calculated as follows:

\[
\text{Throughput} = \frac{\text{Number of received packet in bits}}{\text{Simulation time}}
\]  

(2)

2.3.3. Delay.
According to [21], delay defined as the time needed for transmitting data to reach the destination from the initial node to the destination node. This metric is calculated by subtracting “time at which first packet was transmitted by source“ from “time at which first data packet arrived to destination".
3. Proposed Priority Packet Dissemination Scheduling

3.1. Overview

The focus of this research is to proposing a priority packet dissemination scheduling mechanism in Vehicular Ad-Hoc Networks. Selection of priority packet based on the existing EDCA mechanism of the IEEE 802.11p protocol for selecting access category. The selection of categories is determined based on the location of the vehicle and traffic conditions. Packet dissemination is done first for packets that have the highest access category.

Figure 2. Illustration of the proposed mechanism

Figure 2, illustrates the proposed data dissemination mechanism, which gives priority to the position and traffic of the vehicle. The vehicle's priority calculations according to the study [12] are estimated as:

\[ TTL(i) = \frac{\sqrt{\text{max}(x-x(i)^2) + \text{max}(y-y(i)^2)}}{\text{Velocity}(i)} \]  \tag{3} \]

TTL is calculated from the range of vehicle distance and speed, so distance is calculated by:

\[ \text{Dis} = \sqrt{\left(\text{max} x - x(i)^2\right) + \left(\text{max} y - y(i)^2\right)} \]  \tag{4} \]

Next to calculate vehicle priorities related to TTL and type of traffic use the following calculation:

\[ V(i) = TTL(i) \times \frac{\text{Traffic type}(i)}{\text{Total traffic types}} \]  \tag{5} \]

Then based on equation (3), the traffic priority is calculated as follows:

\[ T(i) = V(i)/150\mu s \]  \tag{6} \]
increase priority package to AIFS value. Waiting time of each vehicle is determined when accessing the control channel with 'T (i)' and Short Interframe Space (SIFS) time. Time slot determined '13 µs'. WT (i) 'vehicle waiting time is given as follows:

\[ WT(i) = \frac{T(i)}{13 \mu s} + \alpha SIFS Time \]  

(7)

The data packet is then organized into a specific order by predicting the predetermined priority of the vehicle where the packet with the highest priority will be sent first. If packets with high priority have been determined, then the next packet will be disseminated using the AODV protocol.

3.2. Scenario

Scenario in this research is taking the actual condition in the Makassar city, Province of South Sulawesi, Indonesia. Accordingly, vehicle density volumes have been determined on the arterial roads of Makassar city including the roadway in accordance with predetermined scenarios, in which there are three lane roads in the simulation area, i.e., A.P. Pettarani street, Boulevard street, Pengayoman street and Hertasning street. The volume of vehicles divided into passenger cars unit (pcu) on A.P. Pettarani street as many as 7.860 pcu/hour, Boulevard street as many as 2.737 pcu/hour, Pengayoman street as many as 493 pcu/hour, and Hertasning street as many as 1.332 pcu/hour. So, the total number of vehicles in the simulation area as much as 12.422 pcu/hour.

In this paper, the simulation time is done for 60 seconds. Thus, the number of vehicles (nodes) will be adjusted according to the simulation time. To calculate the number of vehicles during the simulation period using the following calculation:

\[ n = \frac{(N \times t)}{60} \]  

(8)

Where:

- \( n \) = number of vehicles corresponding to the simulation time
- \( N \) = number of vehicles per hour that is 12.422 pcu/h
- \( t \) = is the simulation time for 60 seconds or 1 minute. So, obtained:

\[ n = \frac{12422 \times 1}{60} = 207 \]  

(9)

Thus, the number of nodes used in simulators is 207 nodes. Then to find out the re-liability of the transmission and see the performance measurement of the scheme, the number of nodes is raised above 207 nodes and subtracted below 207 nodes.

4. Sections, subsections and subsubsections

4.1. Simulation and Results

In this paper, simulations using OMNeT++ are integrated with SUMO to show a better visualization of VANET, as SUMO supports the use of real-world maps from the Open Street Map. We used C++ codes to generate Priority Based Channel Access mechanism in VANET architecture. Simulation parameters in accordance with real conditions on the arterial roads of Makassar city are given in Table 2.
4.2. Results

Performance measurement of the proposed scheme uses PDR, Throughput, and Delay which are part of Quality of Service.

In figure. 3, Performance improvement in PDR shows that Priority based channel access has better performance than CSMA/CA with average increase of 24%. Priority based channel access succeeded in increasing CSMA/CA performance by 33% at 100 nodes, 19% at 150 nodes, 17% at 200 nodes, 22% at 207 nodes, 24% at 250 nodes and 30% at 300 nodes. With the addition of the number of nodes, Priority-based channel access provides a varied increase that depends on the number of nodes. The main reason behind the average fluctuation of PDR is due to random movements of nodes and large areas with actual traffic conditions.

giving points to numbers must follow the numbers and be separated by one space:

![Figure 3. Packet Delivery Ratio](image)

In Fig. 4, Increased throughput is very significant when the number of users is higher. Priority based channel access succeeded in improving CSMA/CA performance about 0.18 Mbit/sec at 100 nodes, 0.15
Mbit/sec at 150 nodes, 0.18 Mbit/sec at 200 nodes, 0.23 Mbit/sec at 207 nodes, 0.30 Mbit/sec at 250 nodes and 0.45 Mbit/sec at 300 nodes.

Priority based channel access successfully decreases the average delay of CSMA/CA as shown in Fig. 5. Simulation using number of node 100 succeeded in decreasing delay 0.01386 s, 150 node decreasing delay 0.09401 s, 200 node decreasing delay 0.14917 s, 207 node decreasing delay 0.12471 s, 250 node decreasing delay 0.11826 s and 300 node decreasing delay 0.08158 s. The most significant delay occurs when the number of nodes is about 200.

5. Conclusions

In this research, a scheduling mechanism for packet data dissemination based on the vehicle priorities is proposed. Location and traffic condition of the vehicle is used to determine the priority of the packet being disseminated. Furthermore, the AODV protocol is used for dissemination. The comparison of schemes between standard CSMA/CA and the proposed mechanism for priority based on channel access is performed in accordance with the proposed mechanism on the high density. Both of these schemes are tried to be implemented according to real condition scenario of Makassar city. The proposed mechanism increased throughput, packet delivery ratio, and decreased the delay. The mechanism in VANET for packet priority based on channel access selection has better performance than CSMA/CA with an average PDR 24%, throughput is 0.25 Mbit/sec and delay is 0.0969 second. For future research, it is interesting to investigate and analyse protocols on some real condition scenario in highway and urban areas.
References

[1] World Health Organization, “Global Status Report on Road Safety 2015,” WHO Libr. Cat. Data Glob., p. 340, 2015.

[2] A. Upadhyay, M. Sindhwani, and S. K. Arora, “Cluster head selection for CCB-MAC protocol by implementing high priority algorithm in VANET,” in 2016 3rd International Conference on Electronic Design, ICED 2016, 2017, pp. 107–112.

[3] V. Kumar, S. Mishra, and N. Chand, “Applications of VANETs: Present & Future,” Commun. Netw., vol. 05, no. 01, pp. 12–15, 2013.

[4] J. A. Sanguesa, M. Fogue, P. Garrido, F. J. Martinez, J.-C. Cano, and C. T. Calafate, “A Survey and Comparative Study of Broadcast Warning Message Dissemination Schemes for VANETs,” Mob. Inf. Syst., vol. 2016, 2016, pp. 1–18, Mar. 2016.

[5] S. Ur Rehman, M. A. Khan, T. A. Zia, and L. Zheng, “Vehicular Ad-Hoc Networks (VANETs) - An Overview and Challenges,” J. Wirel. Netw. Commun., vol. 3, no. 3, pp. 29–38, 2013.

[6] W. Zhu, D. Gao, C. H. Foh, W. Zhao, and H. Zhang, “A collision avoidance mechanism for emergency message broadcast in urban VANET,” in IEEE Vehicular Technology Conference, 2016, vol. 2016-July, pp. 1–5.

[7] R. Stanica, E. Chaput, and A. L. Beylot, “Properties of the MAC layer in safety vehicular ad hoc networks,” IEEE Commun. Mag., vol. 50, no. 5, pp. 192–200, May 2012.

[8] 1999 Edition (Reaff 2003) IEEE Std 802.11e-2005 (Amendment to IEEE Std 802.11, IEEE Standard for Information technology--Local and metropolitan area networks--Specific requirements--Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications - Amendment 8: Medium Access Control (MAC) Quality of Service, vol. 2005, no. Reaff 2003. 2005.

[9] A. F. M. S. Shah and N. Mustari, “Modeling and performance analysis of the IEEE 802.11P Enhanced Distributed Channel Access function for vehicular network,” in FTC 2016 - Proceedings of Future Technologies Conference, 2017, pp. 173–178.

[10] C. Suthaputchakun, Z. Sun, and M. Dianati, “Trinary Partition Black-Burst based Broadcast Protocol for Emergency Message dissemination in VANET,” in IEEE Wireless Communications and Networking Conference, WCNC, 2013, pp. 2244–2249.

[11] A. T. Giang and A. Busson, “Modeling CSMA/CA in VANET,” in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2012, vol. 7314 LNCS, pp. 91–105.

[12] C. Tripti, M. G. J. Kumar, and R. Manoj, “Priority based control channel access scheme for throughput improvement in VANET,” in Proceedings on 2015 1st International Conference on Next Generation Computing Technologies, NGCT 2015, 2016, pp. 139–142.

[13] G. Sallam and A. Mahmoud, “Performance Evaluation of OLSR and AODV in VANET Cloud Computing Using Fading Model with SUMO and NS3,” in 2015 International Conference on Cloud Computing, ICCC 2015, 2015, pp. 1–5.

[14] T. E. Ali, L. A. Khalil Al Dulaimi, and Y. E. Majeed, “Review and performance comparison of VANET protocols: AODV, DSR, OLSR, DYMO, DSDV & ZRP,” in Al-Sadiq International Conference on Multidisciplinary in IT and Communication Techniques Science and Applications, AIC-MITCSA 2016, 2016, pp. 189–194.

[15] S. Syarif, A. Lawi, and Jeffery, “Proposed priority packet data dissemination scheduling mechanism,” in Proceedings of the 2017 4th International Conference on Computer Applications and Information Processing Technology, CAIPT 2017, 2018, pp. 1–5.

[16] IEEE Vehicular Technology Society, IEEE Draft Guide for Wireless Access in Vehicular Environments (WAVE) Architecture, no. July. 2012.

[17] IEEE, IEEE Standard for Information technology -Telecommunications and information exchange between systems Local and metropolitan area networks IEEE Std 802.11-2016, vol. 2007, no. June. 2016.

[18] S. Benkirane, S. Mostafa, M. L. Hasnaoui, and A. Beni-Hssane, “A new comparative study of ad hoc routing protocol AODV and DSR in VANET environment using simulation tools,” in
International Conference on Intelligent Systems Design and Applications, ISDA, 2016, vol. 2016-June, pp. 458–461.

[19] J. Lorincz, N. Ukić, and D. Begušić, “Throughput comparison of AODV-UU and DSR-UU protocol implementations in multi-hop static environments,” in Proceedings of the 9th International Conference on Telecommunications, ConTEL 2007, 2007, pp. 195–201.

[20] O. Eo, “A Review of Black Hole Attack on AODV Routing in MANET,” Int. J. Comput. Sci. Technol., vol. 4333, no. March, pp. 57–60, 2011.

[21] A. Al-Maashri and M. Ould-Khaoua, “Performance analysis of MANET routing protocols in the presence of self-similar traffic,” in Proceedings - Conference on Local Computer Networks, LCN, 2006, pp. 801–807.