A delay-efficient channel allocation scheme for disseminating alert messages using WBAN and VANET

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***Abstract*—Vehicular Ad hoc Networks (VANETs) provide an extensive number of services through a collection of applications for intelligent transportation. It mainly reduces the difficulties for the drivers of vehicles by generating alerts for any unforseen road accidents, warnings and road congestions in real time. Wireless Body Area Network (WBAN) facilitates remote health monitoring for patients and elderly people in healthcare sector. This paper proposes an architecture which combines WBAN and VANET — WBAN is used for patient monitoring while travelling and VANET takes the charge of delivering the alert message generated from abnormal physiological data of the patient to its destination. A Road Side Unit (RSU) allocates distinct channels to the On Board Units (OBU) of vehicles that ask for it. However, allocation scheme taking the priority of the OBUs into account allocates the channels. An OBU will send the emergency messages using the assigned channel. In this work, we develop a novel technique to compute the priority of vehicles using three important criteria such as severity of the message, vehicle speed, and channel occupancy time. The technique utilized two multi-criteria based decision making schemes — Analytic Hierarchy Process (AHP) for finding a weight for individual criterion, and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for computing normalized priority values of vehicles. The main aim of this work is to minimize the End-to-End delay of alert messages. Our simulation study shows that our proposed scheme provides better results as compared to standard scheme.**

***Index Terms*—WBAN, VANET, channel assignment, TOPSIS, prioritization, RSU, multi-criteria**

I. INTRODUCTION

Over the last decades, there has been a significant rise in the number of applications of wireless technology in Intelligent Transportation [1]. The wireless technology, named as VANET, which is an innovative concept facilitated public safety enormously through a number of road safety applications. In VANET, each vehicle attempts to disseminate safety and non-safety messages to other vehicles and public facilities. For dissemination of these messages, two major types of vehicular communications in VANETs are used — Vehicle-to-Vehicle (V2V) communications and Vehicle-to-Infrastructure (V2I) communications [2], [3]. VANETs provide nominal delay in sending emergency messages in V2I and V2V communications [1], [4], [5]. In V2I communication, the vehicles are able to receive or send data using downlink or uplink from or to the RSUs with minimal delay. RSU may take the responsibility of allocating channels to vehicles in V2I communication, and vehicles broadcast messages to their neighbours using the allocated channel through V2V communications. Presently, the standard for VANETs is prescribed by IEEE 802.11p, popularly known as Wireless Access in Vehicular Environment (WAVE) as well as Dedicated Short Range Communication (DSRC).

On the other hand, demerits of traditional healthcare services can be subdued with the help of remote and pervasive healthcare [6], and healthcare data analytics [7]. The imminent health issues draw the attention of researchers and scientists to look for "eHealth" in which healthcare was provided using electronic means, and presently healthcare services are provided by means of mobile technology termed as mHealth. Eventually, in healthcare sector, a new kind of network has emerged termed as Wireless Body Area Network (WBAN) [8] in order to fully exploit the benefits of wireless technologies. It aims to improve the health care services with minimal cost but with fast and accurate response. Traditional medical systems in hospitals are benefited through these technologies. Moreover, the mobility of patient and remote health monitoring are also supported by them. In this context, the authors in Ref. [9] have discussed that WBAN can be used to diagnose complex diseases easily by means of uniterupted supervision of patient using physiological sensors. The network protocols for WBAN are prescribed by IEEE 802.15.6.

In this paper, considering a situation where a person travelling in a vehicle needs to send an alert message to near by hospitals or some medical practitioners to get immidiate medical emergency services, we propose a network architecture for health monitoring of a person on board. For this purpose, our proposed architecture will be of great help if it includes the benefits of the VANET and WBAN together. Though authors in Ref. [10] coined this idea specifically for elderly people living in Europe by proposing an emergency alert system, we propose to extend the work which can be a generalized solution for any person who needs to send an alert message while travelling in a vehicle.

The following are the significant contributions of the paper.

- We develop an integrated architecture of WBAN and VANET considering vehicles with OBU equipped with two interfaces that can serve for both.

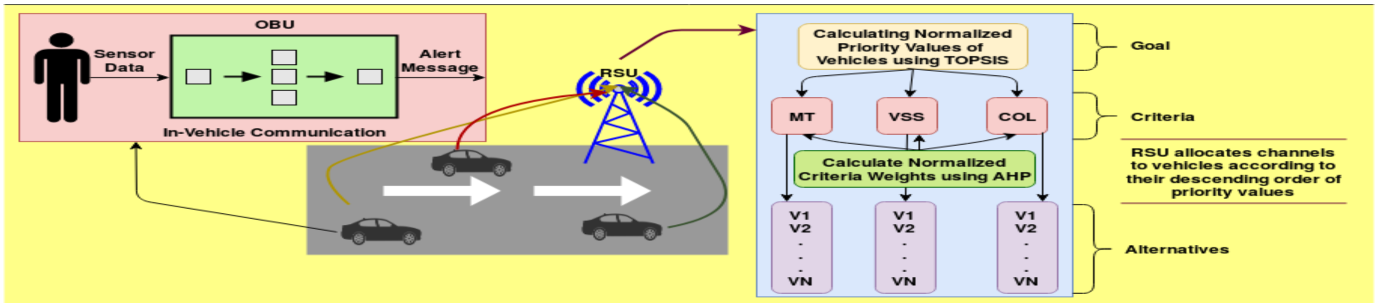


Fig. 1: Overall framework of our proposed scheme

- We implement a multi-criteria based decision making scheme for computing priority values of the vehicles and rank them for channel allocation.
- We analyze the outcome of our proposed scheme in terms of *End-to-End Delay*, *Channel Access Delay*, PDR, and $Throughput$. We also compare it with the standard scheme. It has been observed that the our proposed algorithm defeats the standard scheme regarding *End-to-End Delay*, *Channel Access Delay*, PDR, and $Throughput$.

The rest of this paper is presented as follows. We discuss some related works in VANET and WBAN in Section II. In Section III, we have described our proposed mechanism in detail. Section IV presents the simulation settings, simulation metrics and result anlysis. Finally, Section V concludes the paper.

II. Literature Review

Though VANET is scalable, its performance degrades rapidly with the increase in load and traffic density. Authors in Ref. [11] proposed a Decentralized Location Based Channel Access Protocol (DLCAP) which discusses the issue of channel reuse for V2V communication in VANETs. This protocol aims at a channel allocation to the vehicles without taking any help from the RSU. Channel allocation is done based on a vehicle's geographic location. However, the protocol's performance is poor in terms of throughput as compared to existing ones. In Ref. [12], a protocol named as "Cluster Based MAC (CMAC)" [12] was proposed for reliable delivery of messages in which the RSU has a responsibility to allocate channels to the vehicles. The throughput of the CMAC protocol is little higher than the other protocols even in densed networks. Their studies using a simulated VANET environment shows that this protocol outperforms the existing ones in terms of PDR and delay. Authors in Ref. [13], [14] proposed an "RSU centric channel allocation protocol" [13] for VANETs. It is a centralized single criterion based channel allocation strategy. However, it also makes an effort to minimize the end-to-end delay to deliver safety messages and to maximize the throughput. An RSU-based efficient channel access scheme is proposed in Ref. [15] for VANETs under highly densed network and mobility. It is a centralized cum distributed scheme. In which, contention window is varied dynamically according to the dwelling time of the vehicle in the RSU's region. The vehicles with less dwelling time are catered first and vice versa. However, in this scheme, no channel is allocated deterministically to any vehicle by the RSU. With the modified contention window size each vehicle contends for the channel which makes the scheme distributed as well. In healthcare sector, there exists two very important technologies which include Wireless Sensor Network (WSN) and Wireless Body Sensor Network (WBSN). These technologies provide us a huge variety of applications in healthcare and also ease the deployment with mobility. Some applications of WBAN can be found in Ref [16]–[18]. The authors in [19] coinded the idea of using wireless devices instead of wired devices to monitor health. These devices are easier to carry by every one all the time. These devices are capable to transmit real-time physiological data to a central hub so that the doctors can access the data for further diagnosis. The e-health monitoring system has evolved eventually [20] with its prompt services. In recent times, this monitoring system is proposed for a vehicular environment for security. Seeded cloud [21] and V-Cloud [22] are the examples of these kind of systems. The proposed schemes concentrate only on monitoring the health of vehicular users [23] which offers extra benefits to drivers and therapeutic experts. Benefits of these wearable devices are utilized in the field of Internet of Things as well, as discussed in Ref. [24].

III. Proposed Scheme

We make one realistic assumption that every vehicle carries physiological sensors like pulse, blood-pressure and temperature sensors. Whoever travel in such vehicle, specifically elderly people, should wear those sensors. Local Processing Unit (LPU) receives the data from WBAN sensors to analyze them for generating alarm message for medical practitioners, if needed. Unlike WBAN sensors, LPUs are equipped with better computation capability and with better power backup. The responsibility of the LPU is to analyze the sensed data to identify whether an alert message should be generated or not. If an alert message is generated, it is disseminated using VANET to caregivers or hospitals for medical help. The whole framework can be understood from Fig. 1. Our proposed mechanism has four phases and they are as follows: Data collection from sensors, Data analysis and generation of alert message, Channel allocation and message dissemination.

A. Data collection from sensors

Usually an architecture of an OBU includes Human-Machine Interface Module, Global Positioning System (GPS) module, Wireless Communication Module, and Central Control Module as described in Ref. [25]. Khaliq et al. in Ref. [10] have proposed an extended design of an OBU where WBAN is incorporated. With some meaningful addition to that architecture, we have assumed that in each vehicle OBU is equipped with two interfaces — One is IEEE 802.15.6 interface which is used for data collection from the sensors and the other one is IEEE 802.11p interface which is used for alert message dissemination through VANET as shown in Fig. 2.

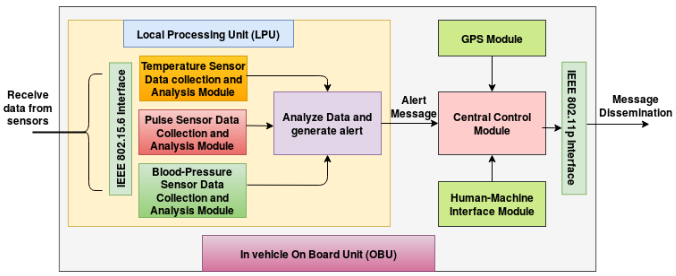


Fig. 2: In-vehicle OBU design

With the help of sensor modules, physiological data are collected by the OBU.

B. Data analysis and generation of alert message

In WBAN, sensors that are deployed on human body are autonomous. They transmit sensed physiological data to the LPU for further processing. We have assumed that OBU contains LPU as well for data processing as shown in Fig. 2. Since in our proposed scheme three types of sensors are used, there are three different data analysis algorithms are required for alert message generation. Fig. 3a, 3b and 3c show the work flow of three sensor modules in LPU, respectively.

C. Channel allocation by the RSU

We consider a VANET consisting of vehicles and an RSU. The RSU being the hub allocates channels to vehicles that ask for it. Each vehicle is equipped with only one transceiver. A periodic beacon message is broadcasted by the RSU which contains its identity and its location. After entering into the region of an RSU a vehicle receives its beacon message. Then it sends an association request message to get registered with the RSU. A number of vehicles among all the present vehicles in VANET want to access channel to send some safety/non-safety messages. When an enrolled vehicle of the RSU needs to transmit any message, it initially sends a Channel Allocation Request Message over the control channel [26] to the RSU mentioning for a channel.

After getting the alert message, OBU tries to send this message to its destination. To accomplish this, it first send a Channel Allocation Request Message to the RSU. After receiving such requests from different vehicles RSU ranks them in order to serve the most deserving vehicle as early as possible. We have used a multi-criteria decision making mechanism named as TOPSIS [27] for prioritizing the vehicles.

1) Criteria for prioritization: We have considered three criteria for prioritization — Message Type (MT), Vehicle Speed Status (VSS) and Channel Occupancy Level (COL), and there are a number of alternatives in terms of vehicles, as illustrated in Figure. 1. The MT is defined as Definition 1.

Definition 1 - *The Message Type (MT) corresponding to a safety or non-safety message generated by a vehicle is the measure of extremity of that message, which it intends to transmit at a certain instant of time.*

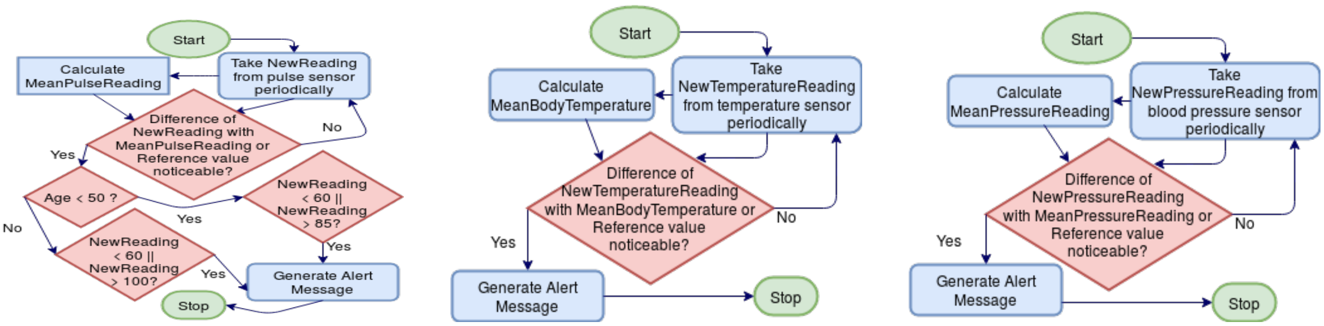
In case of DSRC, there exists only two message types — safety and non-safety. In our model, depending on the criticality of the application, the safety messages are further divided into three categories, and the categories along with their binary representations are — Extremely critical (11), very critical (10) and critical (01). Another category is considered for non-safety application which is, not critical(00). Alert messages generated from abnormal physiological data fall under the category "Extremely critical". However, a vehicle's speed is also an important criteria. Let us explain why it is so important by considering a situation as follows. If two vehicles want to send messages of same criticality and one of them does not get the opportunity to send the message during its dwelling time in that RSU coverage area due to its high speed, then it will lead to lethal results. Thus, understanding the potency of vehicle speed, the next criteria vehicle speed status (VSS) is described below.

Definition 2 - *The Status of Speed of a Vehicle (VSS) corresponding to each vehicle is a two bit value that portrays the four-levelled speed status. The levels along with their binary implications are as follows — very slow (00), slow (01), fast(10), and very fast (11).*

From the received channel allocation request, RSU extracts the speed value and finds out which level the vehicle's speed falls in. RSU first determines the dwelling time of that vehicle in its coverage area and also inspects the value of channel occupancy time (which is described below) for broadcasting the message. The deviation from the pre-decided threshold of the difference between channel occupancy time and dwelling time helps the RSU to determine the level. This threshold is determined based on the topological data at some point of time by the RSU. The last important criteria is channel occupancy level which is elaborated below.

Definition 3 - *The Channel Occupancy Level (COL) corresponding to each safety or non-safety message generated by a vehicle is again a binary value of two bit that portrays the 4-levelled channel occupancy time. The levels along with their binary implications are as follows — high (00), average (01), low (10), and very low (11).*

The channel occupancy time is the total time during which the control channel will be occupied by that particular vehicle which includes transmission delay as well as propagation delay. The Federal Communication Commission recommends that the transmission time of a safety message over control



(a) Pulse Sensor Module (b) Temperature Sensor Module (c) Blood Pressure Sensor Module

Fig. 3: Work Flow of Three Sensor Modules [10]

channel should be less than 200 μs. If the message takes more than 200 μs to be transmitted then another channel must be used [28]. Depending on this value the RSU determines the level.

2) Criteria Weights: TOPSIS requires wight for each criterion for calculating priority values for each vehicle. Since priority values will be calculated dynamically in each turn by the RSU, RSU must have criteria weights beforhand. During the procedure of priority calculation, if criteria weights are also calculated dynamically, it will take a significant amount of time which may deteriorate the efficiency of our scheme. That is why, weight of each criteria is calculated beforehand using another algorithm named as AHP [29] and remain same for each turn of priority calculation. From the working principle of AHP, it can be noted that AHP needs a criteria preference matrix (CPM) which contains mutual preference values among criteria. The CPM should be validated by calculating consistency ratio as described in the working principle of AHP. After getting a valid CPM, weight for each criteria is calculated. These weights are fed to TOPSIS as inputs. After computing the normalized priority values of vehicles, RSU allocates a channel to the vehicle with highest priority by broadcasting a clear message along with the Vehicle Id, Channel Number and Duration of the channel occupancy. In this way, RSU goes on allocating channels till the last vehicle in the list. After receiving the clear message from the RSU, the vehicle whose identity was mentioned in the message, starts disseminating its safety/non-safety message and other vehicles that have safety/non-safety messages to send wait till their turn come.

D. Message dissemination

After getting the channel assigned, a vehicle may disseminate its message in three ways — either it may broadcast or multicast or unicast depending on the targeted recipients of the message that it wants to send.

IV. Performance Evaluation

A. Simulation Settings

We have assumed that all the vehicles can carry maximum of 5 passengers including driver. We consider a star-based WBAN with a single LPU that is placed in the OBU for our simulation. We have considered alert message is generated only for one person at a time in a particular vehicle. We have simulated in MATLAB using the following simulation setting as described in Table I.

TABLE I: Simulation Settings

Number of Vehicles	5 — 40
Number of Lanes	2
Data Rate	1Mbps
Packets Type	UDP
Traffic Type	Constant Bit Rate (CBR)
Packet Size	512Byte
Traffic Load	1 packet/ms
RSU Transmission Range	1000m
Vehicle Transmission Range	250m
Vehicle Speed Range	36 km/h — 144 km/h
Propagation Model	Nakagami-3 [30]
Simulation Time	500s

We consider that communications between sensors and LPU occur using MAC protocol prescribed by IEEE 802.15.6 standard. The vehicles contend for the channel using MAC protocol as specified by IEEE 802.11p standard while communicating with the RSU (i.e., V2I communication), but for V2V communication each vehicle gets deterministic channel access by the RSU for data dissemination.

B. Simulation Metrics

The outcome of the proposed mechanism is analyzed in terms of *priority*, *End-to-End Delay* and *Channel Access Delay* specifically for those vehicles who have alert message to send. Also, we have evaluated PDR and $Throughput$ for the network as well. We compare the values of these metrics calculated by the proposed scheme with the standard scheme that is, the communications between sensors and LPU use MAC protocol prescribed by IEEE 802.15.6 standard and communications among vehicles use MAC protocol specified by IEEE 802.11p standard without any RSU.
End-to-End Delay: It is measured as the time duration between the time when abnormal physiological data collected from the

sensor and the time when the alert message gets transmitted. *Channel Access Delay*: It is measured as the time duration between the time when the vehicle which has alert message to send tries to contend the channel for transmission and the time when it finally gets it.
PDR: It is calculated as the percentage of the fraction between the number of messages/packets actually deliverd and the number of messages/packets which are intended to be delivered.
Throughput: It is calculated as the number of bits transmitted per unit time from source to destination.

C. Result Analysis

Different criteria levels of 5 vehicles are considered corresponding to the criteria as — V(1): [1 0 3], V(2): [1 0 3], V(3): [0 3 3], V(4): [3 1 3] and V(5): [2 1 0], where the first, second and third column represents the levels of MT, VSS, and COL, respectively, for a particular allocation turn. The CPM considered in our simulation is as follows:

$$CPM = \begin{array}{c} \\ MT \\ VSS \\ COL \end{array} \begin{array}{c} \begin{array}{ccc} MT & VSS & COL \end{array} \\ \begin{pmatrix} 1 & 3 & 7 \\ \frac{1}{3} & 1 & 5 \\ \frac{1}{7} & \frac{1}{5} & 1 \end{pmatrix} \end{array} \tag{1}$$

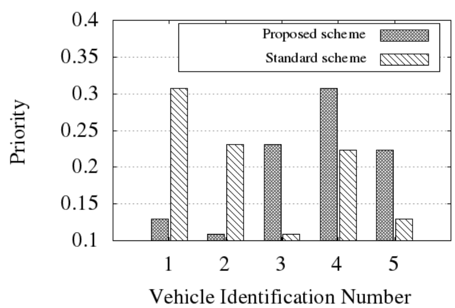


Fig. 4: Priority values for 5 vehicles

With this CPM the three criteria MT, VSS and COL get individual weight as 65%, 28% and 7% of total wights, respectively with the help of AHP. Fig. 4 shows that the priority values of 5 vehicles as computed by our proposed algorithm for this allocation turn. The vehicle V(4) secures the highest priority value among all the 5 vehicles and the priority order starting from highest to lowest priority for all the vehicles is as follows: V(4), V(3), V(5), V(1) and V(2). The most important one of all the features of the proposed algorithm is that it considers the mutual preferences among multiple criteria. As mentioned earlier, we compare our result with the standard scheme which considers single criterion (message type) for prioritization. From the values of three criteria, it can be observed that V(4) is a fast vehicle as well as it has an extremely critical message (i.e., alert message) to disseminate, and it requires moderate channel occupancy time for this allocation turn. Our algorithm assigns V(4) the highest priority for channel allocation whereas standard scheme assign the third-highest priority, that seems the priority assignment is not fair, as compared to our mechanism. We also run the simulations to study the priority order for 10, 15 and 20 vehicles with different allocation turns. Each time our proposed mechanism gives highest priority to the most deserving vehicle.

We are mainly concerned about the earliest dissemination of the alert message generated from the abnormal physiological data of a patient in a vehicle. Fig. 5 shows the *Channel Access Delay* of the vehicle V that has an alert message i.e. extremely critical message to send with respect to number of vehicles that want to access the channels for transmission. It is evidently seen that with the increase in number of vehicles, *Channel Access Delay* of V increases. Still our scheme shows less delay as compared to the standard scheme. Fig. 6 shows the *End-to-End Delay* of V with respect to number of vehicles that want to access the channels for transmission. For obvious reasons, increasing number of vehicles wanting to access the channel causes the delay a little more for V. Our scheme shows better result than the standard scheme.

Fig. 7 and 8 show the effect of PDR and $Throughput$, respectively. It can be distinctly observed that our proposed mechanism shows better network performance in terms of PDR and $Throughput$ than that of the standard scheme due to the fact of reduced message retransmission, collision and to some extent confirmed message delivery.

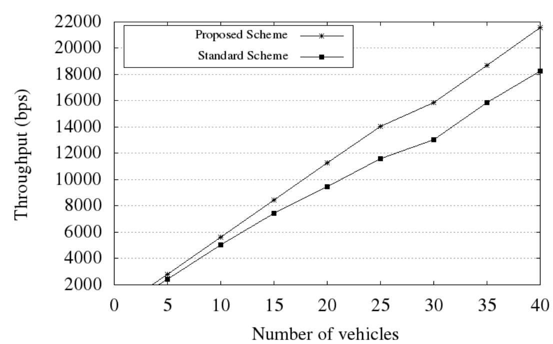


Fig. 8: Number of vehicles vs. Throughput

V. Conclusion

Being a promising technology VANET facilitates the emergency services like accident warnings, traffic information dissemination, and road condition awareness. The new era of eHealth and mHealth compels WBAN to development applications which support mobility for better medical assistance. As a solution, we have designed an architecture by integrating these two technologies, VANET and WBAN, in a vehicular environment to disseminate alert messsage for those people who need immediate medical help. We also try to solve the channel allocation problem in IEEE 802.11p MAC by proposing a mechanism, in the environment of VANETs under saturated data traffic condition. Unlike the existing works, we try to take the advantage of a multi-criteria based decision making strategy like TOPSIS and AHP in order to rank the vehicles by computing priority values. We have also elaborated

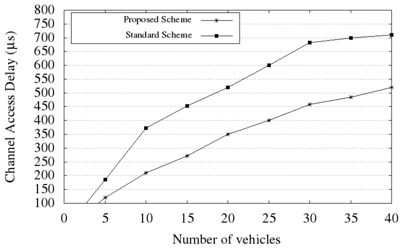


Fig. 5: Channel Access Delay for the vehicle that have an alert message to send

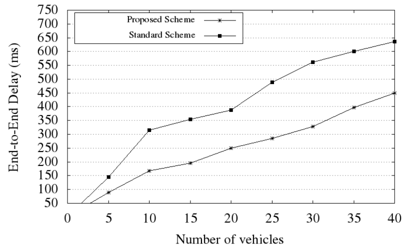


Fig. 6: End-to-End Delay for the vehicle that have an alert message to send

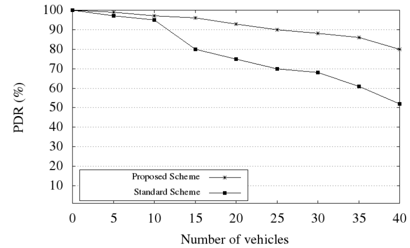


Fig. 7: Number of vehicles vs. Packet Delivery Ratio (PDR)

how the various important parameters considered as criteria influence the prioritization process. As the purpose of result analysis, we compare the output of our scheme with the standard scheme. We also show that our proposed scheme is capable of reducing substantially the delay of deserving vehicles. And it also became successful in maximizing the PDR and $Throughput$ distinctly.

REFERENCES

[1] H. Hartenstein and L. Laberteaux, "A Tutorial Survey on Vehicular Ad hoc Networks," IEEE Communications magazine, vol. 46, no. 6, 2008.

[2] R. Tomar, H. G. Sastry and M. Prateek, "Establishing Parameters for Comparative Analysis of V2V Communication in VANET," Jour. of Scientific and Industrial Research Vol. 79, January 2020, pp. 26-29.

[3] A. M. Vegni, M. Biagi and R. Cusani, "Smart Vehicles, Technologies and Main Applications in Vehicular Ad hoc Networks," Book Chapter in Vehicular Technologies - Deployment and Apps., IntechOpen, 2013.

[4] M. S. Akbar, M. S. Khan, K. A. Khaliq, A. Qayyum, and M. Yousaf, "Evaluation of IEEE 802.11n for Multimedia Application in VANET," Procedia Computer Science, 2014, vol. 32, pp. 953-958.

[5] K. A. Khaliq, M. S. Akbar, A. Qayyum, and J. Pannek, "Suitability of IEEE 802.11 ac/n/p for Bandwidth Hungry and Infotainment Applications for Cities," in proceedings of SAI Intelligent Systems Conference, Springer, 2016, pp. 903-921.

[6] P. K. D. Pramanik, B.K. Upadhyaya, S. Pal, and T. Pal, "Internet of things, smart sensors, and pervasive systems: enabling the connected and pervasive health care," in: N. Dey, A. Ashour, S.J. Fong, C. Bhatt(Eds.), Healthcare Data Analytics & Management, Elsevier, 2018, pp. 1-58.

[7] P. K. D. Pramanik, S. Pal, and M. Mukhopadhyay, "Healthcare Big data: a comprehensive overview," in: N. Bouchemal (Ed.), Intelligent Systems for Healthcare Management and Delivery, IGI Global, 2018, pp. 72-100.

[8] M. Lont, D. Milosevic, and A. V. Roermund, "Wake-up Receiver Based Ultra-low-power WBAN," Springer, 2014, pp. 7-28.

[9] S. Sindhu, S. Vashiath, and S. Chakarvarti, "A Review on Wireless Body Area Network (WBAN) for Health Monitoring System, Implementation Protocol," Communication on Applied Electronics, Foundation of Computer Science, Newyork, USA, vol. 4, no. 7, 2016.

[10] K. A. Khaliq, O. Chughtai, A. Qayyum and J. Pannek, "An emergency alert system for elderly/special people using VANET and WBAN," 13^{th} Inter. Conf. on Emerging Technologies(ICET), Islamabad, 2017, pp. 1-6.

[11] S. Katragadda, C.N.S. Ganesh Murthy, M.S. Ranga Rao, S. Mohan Kumar and R. Sachin, "A Decentralized Location-Based Channel Access Protocol for Inter-Vehicle Communication," in Proc. of 57^{th} IEEE Semiannual Vehicular Technology Conf., 2003, Vol. 3, pp. 1831-1835.

[12] N. C. Rathore, R.S. Tomar, S. Verma and G.S. Tomar, "CMAC: A Cluster Based MAC Protocol for VANETs," in Proceedings of 6^{th} IEEE International Conference on Next Generation Web Services Practices, 2010, Poland, pp. 563-568.

[13] R. S. Tomar and S. Verma, "RSU Centric Channel Allocation in Vehicular Ad-Hoc Networks," in Proc. of 6^{th} Inter. conf. on Wireless Comm. and Sensor Networks, 2010, Allahabad, India, pp. 1-6.

[14] R. S. Tomar and S. Verma, "RSU Assisted Channel Allocation in VANETs," International Journal of Contemporary Research in Engineering and Technology, vol. 1, no. 1, 2011, pp. 25-36.

[15] S. A. Hussain, M. Iqbal, A. Saeed, I. Raza, H. Raza, A. Ali, A.K. Bashir and A. Baig, "An Efficient Channel Access Scheme for Vehicular Ad Hoc Networks," Mobile Information Systems, Vol. 2017.

[16] S. Mukherjee, K. Dolui, and S.K. Datta, "Patient Health Management System using e-health Monitoring Architecture," in IEEE International Advanced Computing Conference (IACC). IEEE, 2014, pp. 400-405.

[17] S. Misra, S. Sarkar, "Priority-Based Time-Slot Allocation in Wireless Body Area Networks During Medical Emergency Situations: An Evolutionary Game Theoretic Perspective," IEEE Journal of Biomedical and Health Informatics, vol. 19, no. 2, Mar. 2015, pp. 541-548.

[18] S. Misra, S. Moulik, H.-C. Chao, "A Cooperative Bargaining Solution for Priority-based Data-rate Tuning in a Wireless Body Area Network," IEEE Trans. on Wireless Comm., vol. 14, no. 5, 2015, pp. 2769-2777.

[19] T. Gonnot, W.-J. Yi, E. Monsef, P. Govindan, and J. Saniie, "Sensor Network for Extended Health Monitoring of Hospital Patients," in IEEE Healthcare Innovation Conference (HIC), IEEE, 2014, pp. 236-238.

[20] N. Kumar, K. Kaur, S. C. Misra, and R. Iqbal, "An intelligent RFID-enabled Authentication Scheme for Healthcare Applications in Vehicular Mobile Cloud," P2P Net. and Apps., 2016, vol. 9, no. 5, pp. 824-840.

[21] C. Baru, N. Botts, T. Horan, K. Patrick, and S. S. Feldman, "A Seeded Cloud Approach to Health Cyber infrastructure: Preliminary Architecture Design and Case Applications," in 45^{th} Hawaii International Conference on System Science (HICSS), IEEE, 2012, pp. 2727-2734.

[22] H. Abid, L. T. T. Phuong, J. Wang, S. Lee, and S. Qaisar, "V-Cloud: Vehicular Cyber-physical Systems and Cloud Computing," in Proceedings of the 4^{th} International Symposium on Applied Sciences in Biomedical and Communication Technologies, ACM, 2011, pp. 165.

[23] J. Barrachina, P. Garrido, M. Fogue, F. J. Martinez, J.-C. Cano, C. T. Calafate, and P. Manzoni, "VEACON: A Vehicular Accident Ontology Designed to Improve Safety on the Roads," Journal of Network and Computer Applications, 2012, vol. 35, no. 6, pp. 1891-1900.

[24] S. Misra, A. Roy, C. Roy, A. Mukherjee, "DROPS: Dynamic Radio Protocol Selection for Energy-Constrained Wearable IoT Healthcare," IEEE Journal on Selected Areas in Communications, vol. 39, no. 2, 2021, pp. 338-345.

[25] Q. Yang, L. Wang, W. Xia, Y. Wu and L. Shen, "Development of on-board unit in vehicular ad-hoc network for highways," Inter. Conf. on Connected Vehicles and Expo (ICCVE), Vienna, 2014, pp. 457-462.

[26] S. A. M. Ahmed, S. H. S. Ariffin and N. Fisal, "Overview of Wireless Access in Vehicular Environment (WAVE) Protocols and Standards," Indian Jour. of Sc. and Tech., 2013, vol. 6, no. 7, pp. 4994-5001.

[27] R. A. Krohling, and A. G. C. Pacheco, "A-TOPSIS - An approach Based on TOPSIS for Ranking Evolutionary Algorithms," Information Technology and Quantitative Management (ITQM 2015), Procedia Computer Science, Elsevier, vol. 55, 2015, pp. 308-317.

[28] J. Guo and N. Balon, "Vehicular Ad Hoc Networks and Dedicated Short-Range Communication," VANET chapter, University of Michigan - Dearborn, 2006, pp. 1-56. Available: http://www.nathanbalon.net

[29] T. L. Saaty, "How to make a decision: The Analytic Hierarchy Process," European journal of operational research, 1990, Elsevier, vol. 48, no. 1, pp. 9-26.

[30] M. Nakagami, "The m-distribution - A General Formula of Intensity Distribution of Rapid Fading," in Statistical Methods in Radio Wave Propagation, W. G. Hoffman, Ed. Oxford, U.K.: Permagon Press, 1960, pp. 3-36.