Evaluation of the performance of the vehicular ad hoc network protocols in the case of V2I and EV2I communications

Dania Mohammed[1], Muhamad Mansor[1,2], Goh Chin Hock[1]
[1]Department of Electrical and Electronics Engineering, College of Engineering, Universiti Tenaga Nasional, Kajang, Malaysia
[2]Institute of Power Engineering, College of Engineering, Universiti Tenaga Nasional, Kajang, Malaysia

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ABSTRACT

Vehicular ad hoc network (VANET) is an intelligent technology that enables efficient communication, secure data transmission, and traffic management. The purpose of routing protocols in the VANET network is to route data between vehicles (V2V) and vehicles-to-infrastructure (V2I). Recently, researchers have shown interest in designing effective routing protocols for the VANET network, as not all existing protocols are suitable for all traffic scenarios. Electric vehicles (EVs) are increasingly being adopted and integrated into intelligent transportation systems (ITS). Developed countries are actively promoting sustainable transportation solutions to increase energy efficiency and reduce carbon emissions. Therefore, this research presents an EV charging station (CS) management scheme based on communication between EVs and RSUs, with performance evaluation simulated using VANET network protocols. In this study, the G-MDORA, MDORA, and geographical routing protocol (GRP) protocols were modified to accommodate V2I communication, and RSUs were distributed along the roadmap. Additionally, a scheme for managing electric vehicle CS was presented, focusing on the communication between electric vehicles and RSUs in the EV2I context. Performance was evaluated using the G-MDORA, GRP, and MDORA protocols, considering factors such as throughput, communication overhead, packet delivery ratio, and end to end delay.

Corresponding Author:

Dania Mohammed
Department of Electrical and Electronics Engineering, College of Engineering, Universiti Tenaga Nasional
Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia
Email: daniahmohammed94@gmail.com

1. INTRODUCTION

The development of intelligent transportation system (ITS) continues worldwide due to the low cost of electronics and the spread of technology, the need to reduce air pollution, improve passenger safety, provide entertainment information to cars, and reduce traffic congestion. Wireless technology provides a medium for interconnection between vehicles and the outer circumference [1]. ITS consist of electronics based on information and mobile and fixed communications; these electronics and information are integrated into vehicles. These technologies enhance productivity, reduce congestion, and improve road safety in transportation infrastructure. Among the applications of intelligent transport systems that have been expanded are navigation systems inside vehicles, accident management systems, and electronic road fee collection [2].

One of the most prominent developments in ITS is their incorporation into electric vehicles (EVs), so EVs have become the critical building block for reducing carbon emissions [3]. There is an urgent need to reduce global warming, and some countries are also trying to find an alternative to foreign oil. Therefore, Evs are used because they provide a sustainable solution to achieve those goals [4], [5]. The communication between EVs and the smart grid vehicle-to-grid (V2G) depends on the standard (IEC 61850), and the communication between them V2G is an essential step for achieving the internet of things (IoT) [6]. As for the communication between EVs and the infrastructure (V2I), it depends on the standard (IEEE 1609 WAVE) [7]. Vehicles are provided with an onboard unit (OBU) to provide wireless communication that allows the exchange of information in the case of communication (V2I) [8], [9]. The communication process between the EV, the infrastructure roadside unit (RSU), and the charging station (CS) is shown in Figure 1.

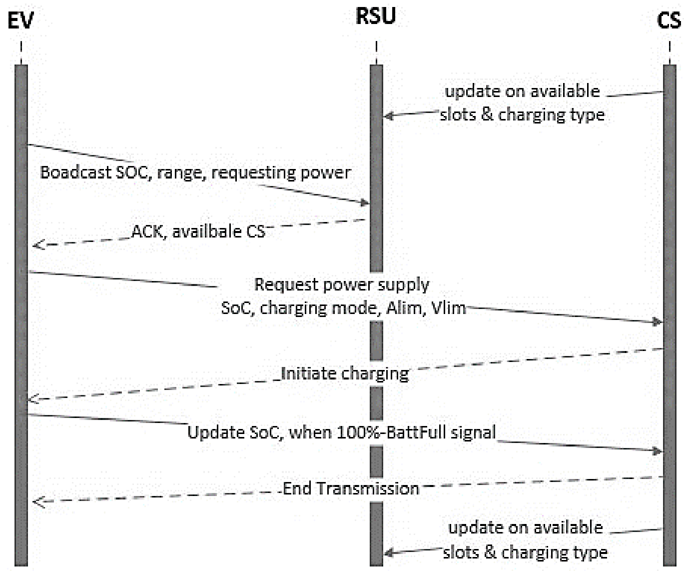

Figure 1. Communication between EV-RSU and CS [10]

According to Zhiyuan [11] the two protocols, geographical routing protocol (GRP) and optimized link state routing (OLSR), were compared to reduce routing flooding in the ad hoc routing protocol. The GRP routing protocol uses regional and hierarchical methods to improve flooding. The simulation showed that the GRP routing protocol could limit routing flow and make network resources available.

Tamizhselvi and Banu [12] proposed to study the GRP performance under various multimedia loads, such as video data and voice. When comparing video traffic and voice traffic, it was discovered that video traffic has a minor delay. However, compared to voice data, data loss in the network is more than 5.5 times greater. However, GRP outperforms ad hoc on-demand distance vector (AODV) for video data throughput and end-to-end (E2E) delay.

Zhang *et al.* [13] created a more realistic simulation environment based on VanetMobiSim and OPNET. They have evaluated and compared the performance of several traditional routing protocols, including dynamic source routing (DSR), AODV, GRP, and OLSR in various network conditions. Different node densities are used to mimic network latency and packet loss. According to the simulation findings, DSR is not suited for dense vehicular ad hoc networks (VANETs), but AODV and OLSR have superior network adaptability in dense VANETs. GRP's performance is inferior to that of AODV and OLSR.

Yang *et al.* [14] suggested an enhancement to the technique of next-hop selection with joint consideration of distance factor and hierarchical quadrant based on an in-depth examination of the GRP and next-stage selection. This study also proposes an improved geographic routing protocol (IGRP) based on the next-hop selection technique, which is more likely to deliver packets to their destinations. The simulation results demonstrate that IGRP can significantly enhance the average delay, total backtracking number, average number of hops, and average delivery ratio.

Yousaf and Majeed [15] compared AODV, OLSR, and GRP routing protocols under various VANET settings with high congestion and high mobility. This VANETs research aims to analyse the performance of routing protocols in urban and highway VANET scenarios so that cars may connect for voice and video applications for human safety. They chose four VANET scenarios based on congestion and speed; in these VANETs scenarios with increasing the number of mobile nodes and mobility of nodes, performance evaluation of AODV, OLSR, and GRP routing protocols based on performance metrics load throughput and E2E delay of the network. In terms of delay, throughput, and load, OLSR was shown to be the most effective.

In terms of delay, GRP performs best. AODV performance is poor in a high-congestion environment, and the maximum delay grows as the number of nodes increases.

According to Al-Mayouf *et al*. [16], the changing structure of the network is one of the biggest challenges in a network VANET because it is challenging to direct packets from the source to the destination successfully, so the protocol maximum distance on-demand routing algorithm (MDORA) was used in this work because it uses wireless communication to communicate between vehicles and it depends on the site. Hence, it determines the optimal path by locating the specific site vehicles that help reach the destination. In this work, the MDORA protocol was compared with greedy perimeter stateless routing with lifetime (GPSR-L), high level aminoglycoside resistance (HLAR), and AODV protocols in terms of E2E delay, packet delivery ratio, and throughput, where results showed that the MDORA protocol is the best.

According to Rivoirard *et al*. [17], GRP, DSR, AODV, and OLSR were all evaluated considering both vehicular safety application requirements and mobility models based on real-world traffic traces. Even though proactive routing strategies perform better in this context, the four routing protocols fail to meet the safety application criteria on the delay metric for enough cars, according to the results. As a result, the protocols given in this paper are unsuitable for this application and need to be modified.

According to Taha and Alhassan [18], from a single node perspective within a highway mobility pattern, the performance of three GRP, OLSR, and AODV protocols were compared with voice traffic in terms of routing sent and received traffic, E2E delay, and throughput. According to the simulation results, GRP performed better than other protocols regarding routing sent and received traffic. At the same time, OLSR outperformed other protocols for time-sensitive applications.

Hussain *et al.* [9] implemented a freight management plan in EV based on communication between EV, RSU, and CS, which will aid in better managing the load in EV. The performance was evaluated by simulating network protocols VANET includes, including temporally-ordered routing algorithm (TORA), AODV, DSR, OLSR, and GRP in terms of E2E delay. The results showed that the GRP protocol is better than AODV, OLSR, DSR, and TORA protocols because it has the lowest E2E delay.

According to Mohammed and Wadday [19], MDORA protocol simulated an urban environment in the event of vehicle movement at a constant speed. The results were shown for two cases in which the nodes' sites differed, and the performance was evaluated in terms of "communication overhead, packet delivery ratio (PDR), and E2E delay". In addition, the drop rate due to the broken path or beam age was calculated.

According to Wadday and Mohammed [20], MDORA protocol simulated the event of vehicle movement at variable speeds. Two random cases were chosen for the node's sites, and the performance was evaluated in terms of delay, PDR, and communication overhead. In addition, the dropped packets were calculated for two cases: the first is the movement of the nodes at a fixed speed, and the second is the movement of the nodes at a variable speed.

Abualola *et al.* [21] suggested an ad hoc-based vehicle to vehicle (V2V) charging method that uses VANET for information distribution and charging pair allocation. To achieve this, a decentralized V2V protocol is suggested at the VANET application layer. This protocol has two phases: provider announcement, in which consumers in the network learn about nearby providers, and provider-consumer allocation, in which providers choose the best customer based on the OFFERs received. Quality of service-optimized link state routing (QoS-OLSR) is utilized at the network layer to determine routing pathways utilizing multi-point relays (MPRs). The protocol uses these MPRs to transmit the providers' announcements throughout the network. The simulation results suggest that the proposed protocol performs well in packet delivery ratio and E2E delay. Furthermore, in the presence of unconnected EVs, the suggested protocol outperforms centralized allocation in terms of pay-out and allocation rate.

In this research, two protocols were selected from the VANET network: the first protocol, the MDORA [8], and the second, the GRP [9]. A geographical-maximum distance on-demand routing algorithm (G-MDORA) was proposed that combines the advantages of MDORA and the GRP protocol. The three protocols were simulated in a virtual environment designed by MATLAB, a comparison was made between G-MDORA and MDORA, GRP in the case of vehicle to infrastructure (V2I) communication, performance was evaluated in terms of E2E delay, PDR, overhead (OH), and throughput. Finally, the communication between electric vehicles to infrastructure (EV2I) and EVs to the smart grid, such as CS V2G, has been coordinated, and the protocols were implemented between EV2I to evaluate performance in terms of E2E delay, PDR, OH, and throughput and to clarify which protocol is the best.

2. METHOD

This section will cover the state of V2I and EV2I communication. A detailed explanation of the MDORA, GRP, and G-MDORA protocol simulation process will be presented as these protocols are simulated in the V2I and EV2I communication cases.

2.1. Vehicle to infrastructure communication

In this part, the MDORA, GRP, and G-MDORA protocols have been modified to suit the communication situation from vehicle to infrastructure. Simulation environments like the city environment with RSU distribution in some intersections were designed to simulate the G-MDORA, GRP, and MDORA protocols in the case of V2I communication. The simulation environment was designed in MATLAB.

2.1.1. Maximum distance on-demand routing algorithm in the case of vehicle to infrastructure communication

In this part, the MDORA algorithm has been modified to suit communication from a vehicle to infrastructure (V2I), where the algorithm starts working when the RSU publishes a request message (hello_message) to nearby vehicles (that are within its communication range (CR) with (timer) operation, the vehicles that it receives a hello_message comparing its direction with the direction of the RSU contained in the hello_message. If the vehicle's direction is different from the direction of the RSU, the vehicle will ignore the hello_message. While if the vehicle's direction is equal to the direction of the RSU, the vehicle will send a response_message. If the timer expires before the RSU receives a response_message from nearby vehicles, the RSU resends (hello_message) to the nearby vehicles.

The distance factor is then calculated by (1) for all vehicles that have sent a response message to RSU. After calculating the distance, a neighbor_table is created. The distance of the vehicles is stored and ordered from the farthest distance to the closest to the RSU. The communication lifetime (CLTf) is computed by (2) (the communication expiration time between RSU and the vehicle) for the first vehicle in the neighbor_table to ensure that the vehicle remains in the CR of the RSU. CLTf determines how long the vehicle remains in the RSU's communication radio range. A scale is defined as the communicative language teaching (CLT) _threshold (the minimum time required for the data transfer) from the RSU to the vehicle. In this work, the value of the CLT _threshold was taken as (0.01 sec).

The CLT _threshold is used to evaluate the communication life of the next-hop vehicle. The CLT _threshold is compared with CLTf, and if CLTf is less than the CLT _threshold, this vehicle is removed from neighbor_table. The second vehicle is chosen from neighbor_table, and the previous steps are recalculated from CLTf. If CLTf exceeds the CLT _threshold, RSU starts forwarding the packet to the vehicle. Finally, the ID of the neighbour vehicle that received the packet neig_ID is compared with the ID of the target vehicle D_ID. The algorithm will be terminated if the identifiers are identical because it is the target vehicle.

$$Distf = (〚Distf〛 \hat{}2(S,D) + Distf\hat{}2(S,n) - Distf\hat{}2(n,D))/(2 \times Distf\hat{}2\ (S,D)) \quad (1)$$

where (S) is source vehicle, (D) is destination vehicle, (N) is neighbour vehicle, and (t) is transmission.

$$CLTf = (-(ab+ac) + \surd(\ 〚(a)〛 \hat{}2\ t\hat{}2 - \ 〚(ac-ab)〛 \hat{}2\ ))/a\hat{}2 \quad (2)$$

2.1.2. Geographical routing protocol in the case of vehicle to infrastructure communication

At GRP, every mobile vehicle is supported by GPS to locate the vehicle. Hello_messages from the vehicles are transmitted to the RSU to identify their neighbours and location. GRP divides the network into quadrants to reduce the broadcast of hello_messages. The vehicle sends a hello_message in two cases. The first is when the vehicle moves for a distance longer than a predetermined distance; for example, a condition is set (when the vehicle travels 100 meters, it must broadcast a hello_message to inform the neighbouring vehicles of its current location). The second is when the vehicle crosses the quarter's boundaries. In this case, the vehicle sends a hello_message to inform RSU of its current location. Each RSU in the GRP maintains a neighbor_table, whereby each RSU in the network maintains a list of neighbour vehicles in its neighbor_table.

Furthermore, the neighbour table is updated when RSU receives a hello_message. Hello_messages are broadcast periodically by each vehicle to its neighbours to exchange location information and update the neighbour table. The time interval between hello_messages can be specified based on network traffic. Vehicles broadcast hello_messages in three cases:

- The vehicle sends a hello_message with its new location as soon as it has moved more than a specified distance or crossed the quarter boundary.
- A vehicle that has moved more than the specified distance within the same quadrant sends a hello_message (only RSUs in the same quadrant will receive a hello_message).
- If the vehicle crosses the boundary of the quadrant, in this case, it will send a hello_message, and the RSU in the same quadrant but at a higher level will receive a hello_message.

In GRP, the process of selecting the next hop to transfer the packet from RSU to the interface takes place in two cases: i) if RSU and the neighbour vehicles are in the same quadrant, RSU will select the vehicle in the same quadrant from the neighbour table, and the RSU sends the packet to it; and ii) if the RSU and the neighbour vehicles are in different quadrants, and no vehicle is in the same quadrant of the RSU, GRP will select the adjacent node closest to the RSU quadrant from the neighbour table and send the packet to it.

2.1.3. Geographical-maximum distance on-demand routing algorithm in the case of vehicle to infrastructure communication

At G-MDORA, every mobile vehicle is supported by GPS to locate the vehicle. Hello_messages from the vehicles are transmitted to the RSU to identify their neighbours and location. G-MDORA divides the network into quadrants to reduce the broadcast of hello_messages. The vehicle sends a hello_message in two cases. The first is when the vehicle moves for a distance longer than a predetermined distance. The second is when the vehicle crosses the quarter's boundaries. In this case, the vehicle sends a hello_message to inform RSU of its current location. Each RSU in the G-MDORA maintains a neighbor_table, whereby each RSU in the network maintains a list of neighbour vehicles in its neighbor_table.

In G-MDORA, to transfer a packet from RSU to the target, the distance factor is calculated by (1) between RSU, and the neighbouring vehicles stored in the neighbor_table. After calculating the distance, a distance_table is created. The vehicles are stored and ranked from the least distance from the RSU to the farthest. Then the CLTf is computed by (2) (the communication expiration time between RSU and the vehicle) for the first vehicle in the neighbor_table to ensure that the vehicle remains in the CR of the RSU. The CLTf determines how long the vehicle remains in the RSU's communication radio range. A scale is defined as the CLT _threshold (the minimum time required for the data transfer) from the RSU to the vehicle. In this work, the value of the CLT _threshold was taken as (0.01 sec).

The CLT _threshold is used to evaluate the communication life of the next-hop vehicle. The CLT _threshold is compared with CLTf, and if CLTf is less than the CLT _threshold, this vehicle is removed from neighbor_table. The second vehicle is chosen from neighbor_table, and the previous steps are recalculated from CLTf. If CLTf exceeds the CLT _threshold, RSU starts forwarding the packet to the vehicle. Finally, the ID of the neighbour vehicle that received the packet Neig_ID is compared with the ID of the target vehicle D_ID. The algorithm will be terminated if the identifiers are identical because it is the target vehicle.

2.2. Electric vehicles to infrastructure communication

EVs are being adopted and integrated into ITS as developed countries push for sustainable transportation solutions that deliver higher energy efficiency and lower carbon emissions. EVs can communicate with RSUs in ITS and smart grid using OBU placed in the vehicles so that wireless transmission between EV2I is done. This work demonstrates an EV charging management scheme using EV2I communications.

2.2.1. Communication model

The CS shares its information with RSU in terms of the number of slots available for charging and the type of charge AC and DC. RSU broadcasts "WSAs" messages over the control channel (CCH). These messages contain information about available and nearby charging slots and the accessible service channel (SCH) on which RSU is available. The communication model is illustrated in Figure 2. When EV receives the message, it joins RSU through the SCH indicated in the message. EV then starts sending data to RSU in SCH about (range, charging status, and state of charge (SoC)). RSU will respond with the appropriate information for these messages. All SCH exchanges contain the TCP/IP protocol. When the EV reaches CS, it begins connecting the charging connector from the CS to the charging port, and the EV sends the power delivery request message to CS. CS responds with a power delivery response message and begins charging. To find out information about the charging process, the CS sends the charge parameter discovery request message to the EV, and the EV responds with the charge parameter discovery response message that contains information about the charging status, information about the SoC, information about the voltage limit, and current entrance (Vmax and Amin). EV (Battfull) will be sent to CS when the battery is fully charged or at the required level. The battery is ultimately charged, SOC will update, and then CS will terminate transmission, and CS transmits an update around an available blank opening for RSU.

2.2.2. Vehicular ad hoc network routing protocols for electric vehicle charging simulation

The performance of the proposed VANET for EV charging is evaluated in terms of E2E delay, PDR, OH, and throughput. The communication performance is not very limiting because EVs are immobile at CS. RSUs, on the other hand, construct an ad hoc communication network with mobile EVs all around them, which is extremely resource heavy. The ability of RSU to communicate seamlessly with EVs and alert CS will be influenced by the quantity of EVs in the ad-hoc network. To ensure the quality of service, the first WSA message exchanges between EVs and RSUs over the CCH channel in VANETs should not be delayed beyond a critical level. Because these WSA messages include essential information, they must be delivered on time. As a result, the E2E delay measure is significant and widespread in EV-RSU communication. VANETs employ various routing protocols, each contributing significantly to the latency. As a result, several VANET protocols are simulated to ensure they comply with the E2E delay, PDR, OH, and throughput. Different existing protocols considered in this study are the MDORA, GRP, and G-MDORA. The following sections describe the simulation environments implemented to evaluate the performance of the protocols.

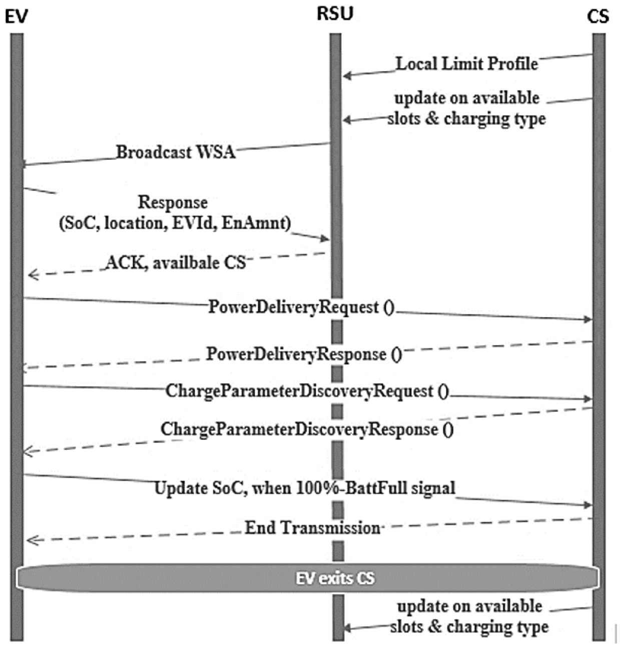

Figure 2. Message exchange during charging request

3. PERFORMANCE EVALUATION METRICS

This section will simulate G-MDORA, MDORA, and GRP protocols in two cases. The first case is V2I communication. The second case is EV2I communication. The following cases will explain V2I and EV2I communications cases in detail.

3.1. Performance evaluation metrics in the case of vehicle to infrastructure communication

In this case, a simulation environment like the city environment was designed with the distribution of RSU on the roads to simulate the MDORA, GRP, and G-MDORA protocols in the case of V2I communication. The simulation environment was designed in MATLAB. Furthermore, the performance of the MDORA, GRP, and G-MDORA protocol was compared in the V2I communication state. MDORA, GRP, and G-MDORA protocol performance were evaluated regarding E2E delay, PDR, OH, and throughput. Figure 3 shows the simulation environment. Table 1 shows the simulation parameters that were used in the case of communication between V2I. This system can calculate the E2E delay, PDR, OH, and throughput in GRP, MDORA, and G-MDORA protocol through (3) to (6) [20], [22]–[25]:

$$E2E = \frac{Time\ of\ transmission\ packet}{\sum Number\ of\ received\ packets} \tag{3}$$

$$PDR\ (data\ Counter) = \frac{number\ of\ Received\ Packets}{number\ of\ Generated\ Packets} \tag{4}$$

$$OH\ = \frac{no.of\ Hello\ Message +\ no.of\ Response\ Message}{no.Of\ Received\ Packets} \tag{5}$$

$$Throughput = \frac{\sum SizePackagesReceived}{TimeReception - TimeSending} \tag{6}$$

3.2. Performance evaluation metrics in the case of electric vehicles to infrastructure communication

In this case, a simulation environment like the city environment was designed with the distribution of CS and RSUs on the roads to simulate the MDORA protocol in the case of electrical vehicle to infrastructure communication. The simulation environment was designed in MATLAB, and the same parameters as those in Table 1 were used. Furthermore, the performance of the MDORA, GRP, and G-MDORA protocols was compared in the electrical vehicle to infrastructure communication state. MDORA, GRP, and

G-MDORA protocol performance were evaluated in terms of E2E delay, packet delivery ratio, communication overhead, throughput, and packet loss ratio. Figure 4 shows the simulation environment.

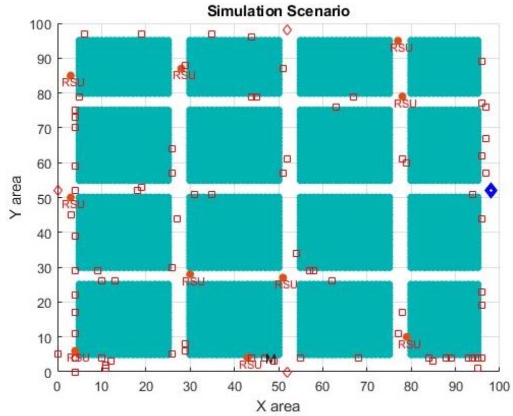

Figure 3. G-MDORA, MDORA, and GRP simulation environment in the case of V2I communication

Table 1. Simulation parameters used in the case of communication between V2I and EV2I

Parameter	Value
Simulation tool	MATLAB
Protocol	G-MDORA, GRP, MDORA
Number of lines	Two bidirectional
Number of RSU	10
Number of CS	16
Number of vehicles	100
Variable velocity	40-120 (km/h)
The size of the packet	5 packet/s

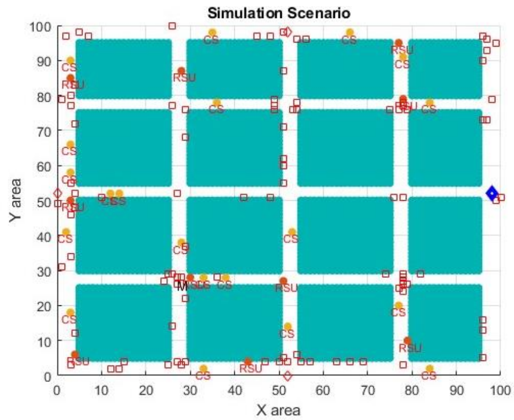

Figure 4. G-MDORA, MDORA, and GRP simulation environment in the case of EV2I communication

4. RESULTS AND DISCUSSION

This section presents the results of the comparison between GRP, MDORA, and G-MDORA protocols, where the performance of the protocols was evaluated in terms of E2E delay, OH, PDR, and throughput in the case of V2I and EV2I communication. Figures 5 and 6 show the result of the comparison between MDORA, GRP, and G-MDORA protocols in terms of E2E delay. The comparison result showed that the G-MDORA protocol has the lowest average delay, which means it performs better than the MDORA and GRP protocols. This is due to the short path and the few hops that the packet is transmitted from the source to the interface, unlike in the GRP protocol, where the delay rate is high due to the number of hops and the high backtracking. As for the MDORA protocol, the delay is high because the protocol only communicates with those on the same path and direction, so the delay rate is high in MDORA.

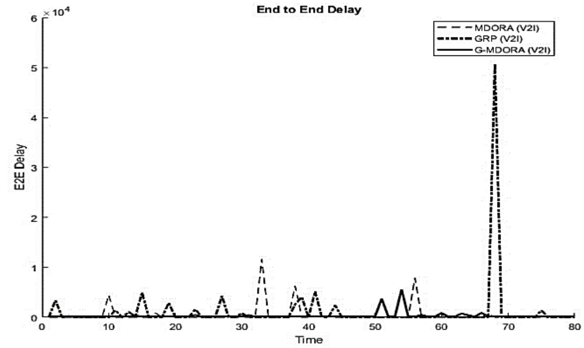

Figure 5. E2E delay, comparison of G-MDORA, MDORA, and GRP protocol in the case of V2I communication

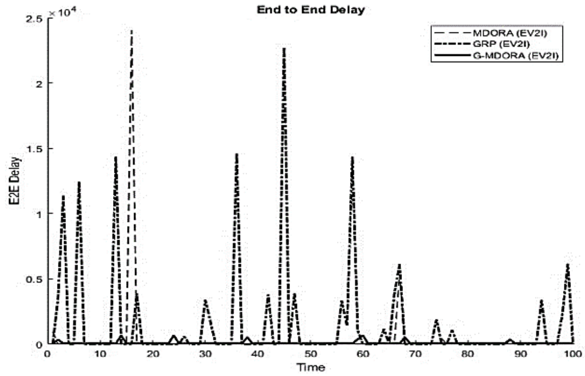

Figure 6. E2E delay, comparison of G-MDORA, MDORA, and GRP protocol in the case of EV2I communication

Figures 7 and 8 compare MDORA, GRP, and G-MDORA in terms of PDR. The protocols are simulated in the case of communication from V2I and EV2I. The comparison result showed that the GRP protocol has the highest packet delivery ratio, which means it performs better than the MDORA and GMDORA protocols. This is due to the GRP protocol, which has a backtracking path, meaning that if it does not find a vehicle to which it sends the packet, it resends the packet a step back to search for another vehicle that takes it to the target. If it does not find a vehicle, it returns the packet to the source, and the source begins to search for another path until the packet arrives at the interface, thus ensuring successful packet access without loss. The opposite of what it is in the MDORA and G-MDORA protocols.

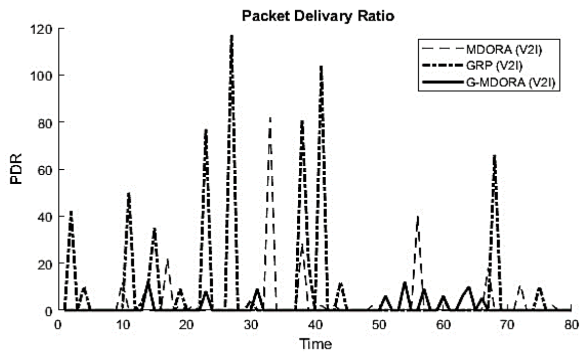

Figure 7. PDR, comparison of G-MDORA, MDORA, and GRP protocol in the case of V2I communication

Figures 9 and 10 compare MDORA, GRP, and G-MDORA protocols regarding OH. The protocols are simulated in the case of communication from V2I and EV2I. The comparison showed that the G-MDORA protocol has the lowest communication overhead compared to the MDORA and GRP protocols because the packet in G-MDORA is delivered to the destination with the fewest possible control messages (hello_messages).

Thus, the communication overhead expenses are lower in GMDORA than in GRP and MDORA. At the same time, the GRP protocol exhausts more control messages to maintain and create a path, as in the backtracking path. As for the MDORA protocol, the communication overhead is high because the protocol sends the packet in the forward direction, so if it does not receive a response, it resends the control messages, which leads to an increase in communication overhead.

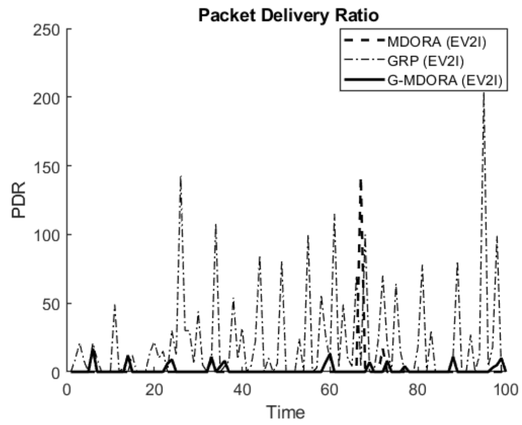

Figure 8. PDR, comparison of G-MDORA, MDORA, and GRP protocol in the case of EV2I communication

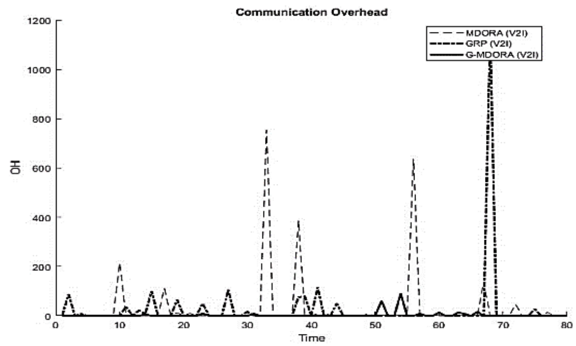

Figure 9. OH, comparison of G-MDORA, MDORA, and GRP protocol in the case of V2I communication

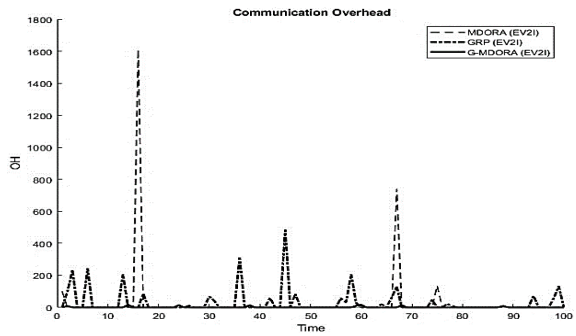

Figure 10. OH, comparison of G-MDORA, MDORA, and GRP protocol in the case of EV2I communication

Tables 2 and 3 present the comparison results between MDORA, GRP, and G-MDORA protocols regarding throughput in V2I and EV2I communication cases. The comparison shows that the G-MDORA protocol has the highest throughput rate compared to the MDORA and GRP protocols. Because quality strongly affects the probability of packets being successful for a particular link. In the G-MDORA protocol, the link with the highest connection probability is selected to forward packets, resulting in higher link quality per hop than MDORA and GRP. Therefore, the throughput of G-MDORA is the highest.

Table 2. Comparative analysis of throughput for MDORA, GRP, and G-MDORA protocol in case of V2I communication

Header	MDORA	GRP	G-MDORA
Throughput	0.89797	0.89895	0.9873

Table 3. Comparative analysis of throughput for MDORA, GRP, and G-MDORA protocol in case of EV2I communication

Header	MDORA	GRP	G-MDORA
Throughput	0.89674	0.8981	0.97283

5. CONCLUSION

In this paper, GRP, MDORA, and G-MDORA protocols were simulated in two different cases through MATLAB, and from this simulation, the following conclusions can be drawn: the G-MDORA, MDORA, and GRP protocols were modified to accommodate V2I communication, and RSU was distributed on the roadmap. The three protocols were compared regarding E2E delay, OH, PDR, and throughput. The comparison results showed that the G-MDORA protocol has a minor delay, communication overhead, and the highest throughput, while the GRP protocol has a higher rate in terms of packet delivery ratio.

Finally, a scheme for managing EV CS based on the communication between EVs and RSU is presented. Several RSU and CS were distributed in the simulation environment, and the G-MDORA, GRP, and MDORA protocols were simulated. The performance of the protocols was evaluated by E2D delay, OH, PDR, and throughput. The comparison results showed that the G-MDORA protocol has the best throughput and the slightest delay and communication overhead, while the GRP protocol has a higher rate in terms of PDR.

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BIOGRAPHIES OF AUTHORS

Dania Mohammed received the Bachelor of Engineering. Degree in Computer Technical Engineering from Madenat Alelem University College, in 2016. The masters degree in Computer Technical Engineering from College of Electrical and Electronic Technology, the Ph.D. degree from Universiti Tenaga Nasional, in 2019. She is currently working as an employee in the Iraqi Ministry of Water Resources. She can be contacted at email: Daniahmohammed94@gmail.com.

Muhamad Mansor received the B.Sc. degree in Electrical Engineering from Universiti Teknologi Malaysia, in 2000, the M.Sc. degree in Electrical Power Engineering from Universiti Tenaga Nasional in 2006, and the Ph.D. degree in Power Electronics from Universiti Malaya in 2012. He is currently an associate professor and the head of the Department of Electrical Power Engineering, College of Engineering, Universiti Tenaga Nasional. His research interests include power electronics, converter controller, and railway engineering. He can be contacted at email: Muhamadm@uniten.edu.my.

Goh Chin Hock received the bachelor’s degree in Electrical and Electronics Engineering in 2004 as well as master and Ph.D in Electrical Engineering in 2008 and 2012 respectively from Universiti Tenaga Nasional, Malaysia. He is currently a senior lecturer with the Department of Electrical and Electronics Engineering, Universiti Tenaga Nasional. He is the professional engineer of BEM, energy professional of MEPA, and corporate member of IEM. Besides that, he is certified energy manager (CEM), certified professional in measurement and verification (CPMV) as well as registered electrical energy manager (REEM). His work and research interest includes, advanced material and energy, electromagnetic technology, and smart cities solution. He can be contacted at email: chinhock@uniten.edu.my.