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Improved maximum distance on-demand routing algorithm routing protocol for vehicular ad hoc network network in an urban environment

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ABSTRACT

Vehicular ad hoc network (VANET) is a modern technology that has received great attention in the modern era due to daily road accidents. In VANET network it is difficult to design effective routing protocols due to the speed of movement of nodes and the rapid change in network architecture, and the purpose of routing protocols in the VANET network is to route data between vehicles (V2V), and between vehicles to infrastructure (V2I). Recently researchers have been interested in designing effective routing protocols for the VANET network because not all existing protocols are suitable for all traffic scenarios. Therefore, the focus of this paper will be on the maximum distance on-demand routing algorithm (MDORA) protocol and work on improving the protocol algorithm so that it is compatible with the urban environment. After that, the improved performance of the MDORA-without direction (MDORA-WD) protocol will be compared with the ad-hoc on-demand distance vector (AODV) protocol in terms of communication overhead, packet delivery ratio (PDR) and end to end (E2E) delay. The protocols will be simulated by MATLAB.

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1. INTRODUCTION

The Vehicular ad hoc network (VANET) is one of the elements of the intelligent transportation system (ITS). VANET is considered one of the most active fields of research [1], and the vehicular ad hoc network aims to provide wireless communication between roadside units (RSU) and vehicles [2]. In the VANET network, vehicles while moving along the road can create an automatic network, because all vehicles in the VANET network are equipped with wireless capabilities and data sharing. There are two types of communication in VANET which is vehicle-to-vehicle communication (V2V) and vehicle-to-infrastructure communication (V2I). While the vehicles are moving along the road, the vehicle can communicate with another vehicle, and this is called V2V communication. Where, data is exchanged between nearby vehicles by wireless technologies such as wireless fidelity (Wi-Fi), while in V2I communication the vehicle can communicate with roadside units by technologies worldwide interoperability for microwave access (Wi-MAX), Wi-Fi, and general packet radio service (GPRS)/3G.

Vehicular ad hoc network has some characteristics such as no power restrictions, stringent delay restrictions, frequent interruption, the nodes moving at a high/random rate, making it difficult to forecast their position and network structure, wireless channels are used to link the nodes and exchange data. As a result, secure communication is required and VANET can be developed for a single city, a group of cities, or even a whole country. As a result, security needs necessitate collaboration and supervision [3]. VANET network provides many applications, the most important of which is to provide safety during travel [4], and there are other applications such as providing restaurant locations, providing traffic information, providing weather information to increase the comfort of passengers, road condition warning, warning against violating traffic lights, pedestrian crossing warnings, intersection collisions, and collision alerts are among the safety applications in VANETs that aim to prevent and reduce the incidence of road accidents [5]. VANET network needs efficient routing protocols for the accurate and timely transfer of data and information, but due to network characteristics, it is not easy to design a protocol that fits all network scenarios. There are some challenges that the VANET network faces, including collaborative communication between vehicles and network security, designing robust scalable routing algorithms and quality of service (QoS) requirements with retransmission, and minimal delay, data storage and management, geographical addressing, and variable network density [6].

This paper aims to improve the performance of the the maximum distance on-demand routing algorithm (MDORA) protocol and compare MDORA-without direction (MDORA-WD) with ad-hoc on-demand distance vector (AODV) protocol in terms of communication overhead, packet delivery ratio (PDR) and end to end (E2E) delay. The remainder of the paper is broken down as follows: the second section describes related works, the third section is the routing protocols, the fourth section is the scenario implementation, the fifth section is the simulation results, and the sixth section is the conclusion.

2. RELATED WORKS

VANET network uses the capabilities of the new generation of vehicle wireless networks and is a subtype of the mobile ad-hoc network (MANET) network [7], [8]. In the previous studies, the routing protocols of the MANET network were studied and discussed, and they found that the routing protocols of the MANET network cannot be used in the VANET network because the nodes in MANET move at a constant speed and the structure of the random network, while in VANET the movement of nodes is at high speeds and changing network topology quickly. Accordingly, MANET network protocols are not suitable for the VANET network. VANET routing protocols are classified into the broadcast, multicast, geocast, position and topology-based routing protocols. This study will focus on 2 types of protocols which are topology and position-based routing protocols.

2.1. Topology-based routing protocols

In this type of protocol, the data is transferred from the source vehicle to the destination vehicle depending on the information in the routing table. This type of protocol depends on the routing table that maintains the link information. This type of protocol contains three sections: hybrid such as zone routing protocol (ZRP) [9], [10], reactive such as AODV [11]-[13] and proactive such as destination-sequenced distance vector (DSDV) and optimized link state protocol (OLSR) [14]-[17]. AODV is a topology-based routing protocol [12]. When a source node wants to create a path to an interface node it broadcasts a route request (RREQ) packet across the network. The node that receives this packet updates its information in the routing schedule. When the RREQ reaches the interface, the interface replies with a route reply (RREP) message on the same path from which the RREQ message came from, and when the source receives the RREP message, it begins to send data to the interface because the path is ready to direct the packets.

2.2. Position-based routing protocols

This type of protocols depends on a locator such as global positioning system GPS to locate neighboring nodes. Based on the information obtained from GPS routing decisions are made. This type of protocols includes three sections which are hybrid routing protocols [18], delay-tolerant network routing protocols (DTN) [19] and non-delay-tolerant network routing protocols (non-DTN) [20]-[23].

MDORA [24] is a position-based routing protocol. This protocol relies on communication age, distance, and direction to determine the optimal next hop. This protocol also calculates the path towards the interface with the fewest jumps, to decrease load control and reduce delay.

Mohammed and Wadday [25], MDORA protocol was simulated in 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, PDR and E2E delay. In addition, the number of dropped packets due to broken path or because of the beam age was calculated.

Wadday and Mohammed [26], MDORA protocol was simulated in the event of vehicles movement at variable speed, two random cases were chosen for the node’s sites, and the performance was evaluated in terms of delay, the 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. This paper presents the improvement of the performance of the MDORA-WD protocol by modifying the algorithm of the MDORA protocol, where the direction condition has been removed from the algorithm. MDORA-WD is one of the position-based routing protocols, MDORA-WD was compared with AODV, a topology-based routing protocol. The two protocols were compared in terms of communication overhead, PDR and E2E delay in the event of vehicles moving at variable speeds in a simulated environment like an urban environment, the environment was designed by MATLAB.

3. MDORA-WD

MDORA-WD is one of VANET network protocols. In this paper, the performance of this protocol has been improved by eliminating the directional condition from the protocol algorithm, so that the protocol is more effective in the urban environment. Figure 1 shows the flowchart of the MDORA-WD protocol after making modification to the algorithm. The protocol goes through two stages, the path detection phase, and the path creation phase.

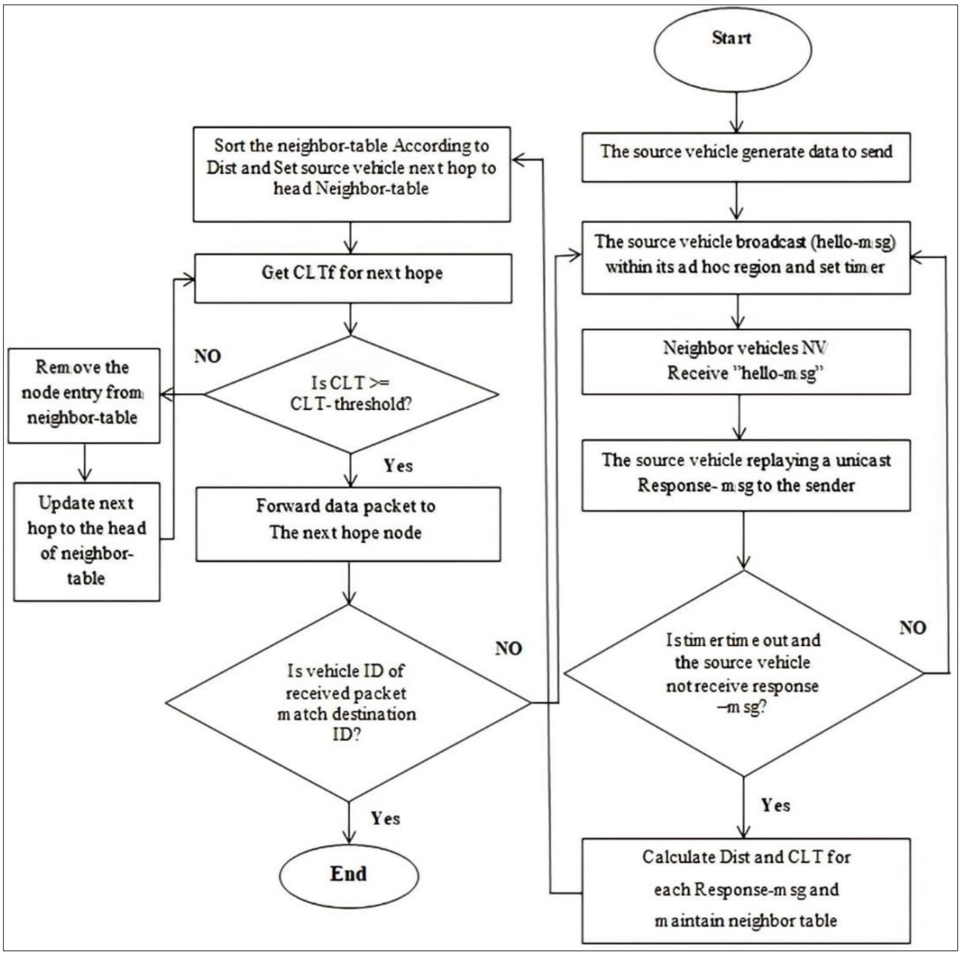

Figure 1. Flowchart of MDORA-WD

3.1. The path detection phase

The phase starts when the source vehicle (SVeh) sends a "hello message" to the neighboring. When the neighboring vehicle receives the "hello message", it is returned with a response message to SVeh, as shown in the Figure 2. If the source does not receive a response message within the specified time, the source vehicle will re-transmit the hello message to the neighboring vehicles. If the source vehicle receives a response message from the neighboring vehicles, it creates a routing table for the neighboring vehicles and then begins to calculate the communication lifetime and distance through the latitude and longitude present in the response message. The purpose of calculating the distance is to determine the next jump, where the node that is furthest of the source and closest to the Interface is chosen to reduce the delay.

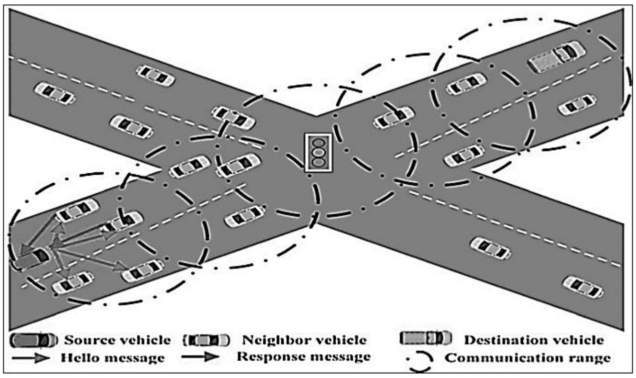

Figure 2. The path detection phase

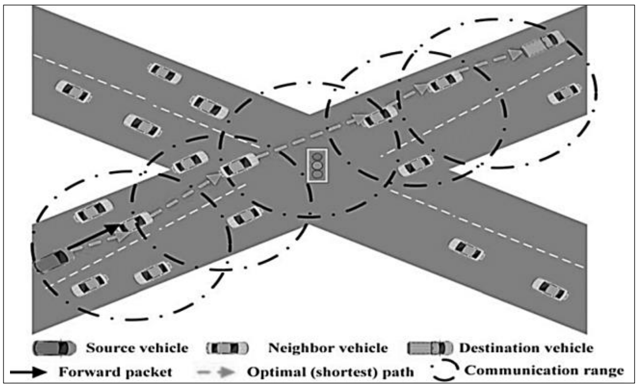

Figure 3. The path creation phase

3.2. The path creation phase

This stage occurs after calculating the distance for all the vehicles from which a response message was received, then a table is created, and the vehicles are arranged in ascending order depending on the distance factor. After that, the communication lifetime factor is calculated for the first vehicle in the table and the communication life is compared with the (threshold) factor which is the time required to transmit packets if the communication lifetime is greater than (threshold), the source vehicle starts directing the packet to the next vehicle and the identification (ID) of the vehicle that received the packet is compared with the ID of the destination vehicle. If the ID is identical, the algorithm is terminated, and if they do not match, the algorithm is returned until the packet reaches the destination vehicle as shown in Figure 3.

4. SCENARIO IMPLEMENTATION

The VANET network simulation environment was designed using MATLAB, and the movement of vehicles at variable speeds between 40 to 120 km/h. MATLAB program was used for simulation. And three parameters were used which are communication overhead, PDR and E2E delay. Table 1 shows the parameters that were used in the simulation.

Table 1. Simulation parameters

Parameter	Value
Protocol	MDORA-WD, AODV
Simulation area	5 km×5 km
Number of lines	2 Bidirectional
Number of vehicles	80
variable velocity	40-120 (km/h)
Transmission rate	5 Packet/S
Simulation time	10 s, 20 s, 50 s, and 100 s

5. RESULTS ANALYSIS

Figure 4, Figure 5, Figure 6, and Figure 7 shows the end-to-end delay with different simulation time 10 s, 20 s, 50 s and 100 s, the (1) was used to calculate the delay, and a comparison was made among MDORA-WD and AODV protocol.

$$\text{E2E Delay Average (data Counter)} = \text{mean (End} - \text{to} - \text{End Delay (1: E2ECounter))} \quad (1)$$

The results showed that the MDORA-WD protocol after the improvement became better than the AODV protocol in the case of its application in an urban environment where the percentage of delay in MDORA-WD less than AODV. This result is due to the fact that the MDORA-WD protocol uses the least number of hops to get the packets to the interface, while in the AODV protocol the delay is higher because the packet delivery speed is slower.

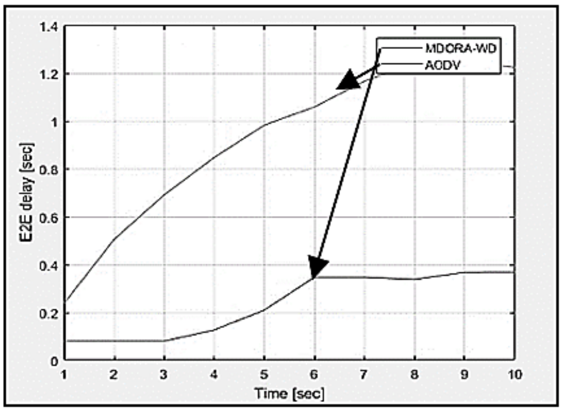

Figure 4. End to end delay 10 sec simulation time

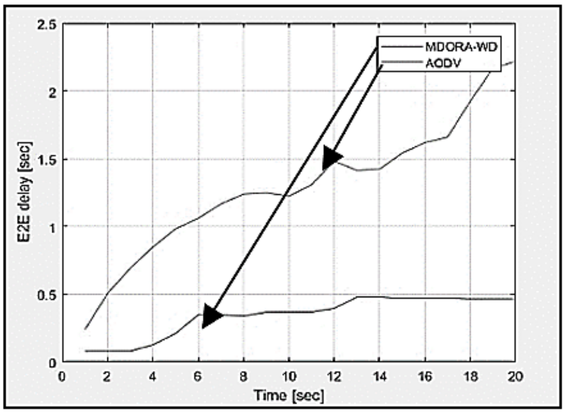

Figure 5. End to end delay 20 sec simulation time

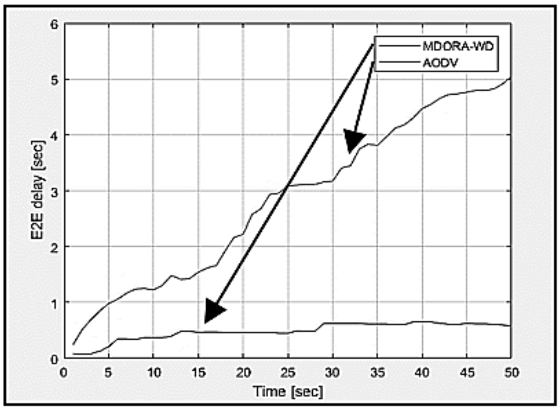

Figure 6. End to end delay 50 sec simulation time

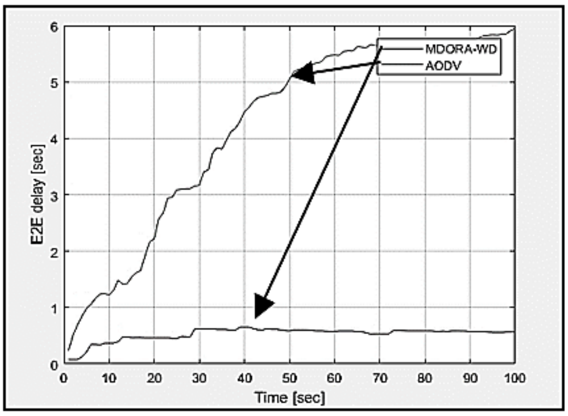

Figure 7. End to end delay 100 sec simulation time

Figure 8, Figure 9, Figure 10, and Figure 11 shows the packet delivery ratio with different simulation time 10 s, 20 s, 50 s, and 100 s. The (2) was used to calculate of packet delivery ratio, and a comparison was made among MDORA-WD and AODV protocol.

$$\text{PDR (data Counter)} = \text{number of Received Packets/ number of Generated Packets} \quad (2)$$

The results showed that MDORA-WD protocol had the highest of packet delivery ratio than AODV protocol in the case of its application in the urban environment. This result is attributed to the AODV protocol suffers from higher packets loss than MDORA-WD protocol due to route interruption, in addition to that it cannot maintain the route if vehicles are moving at high speeds.

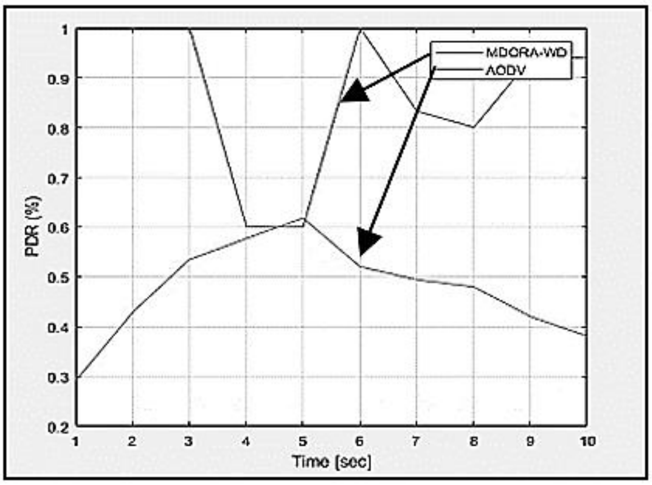

Figure 8. Packet delivery ratio 10 sec simulation time

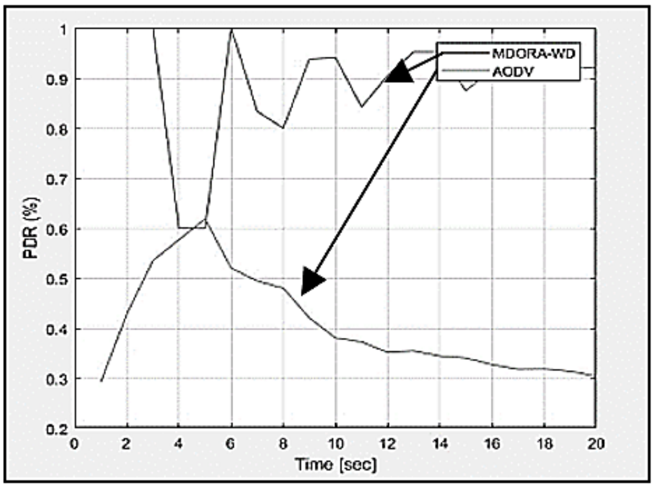

Figure 9. Packet delivery ratio 20 sec simulation time

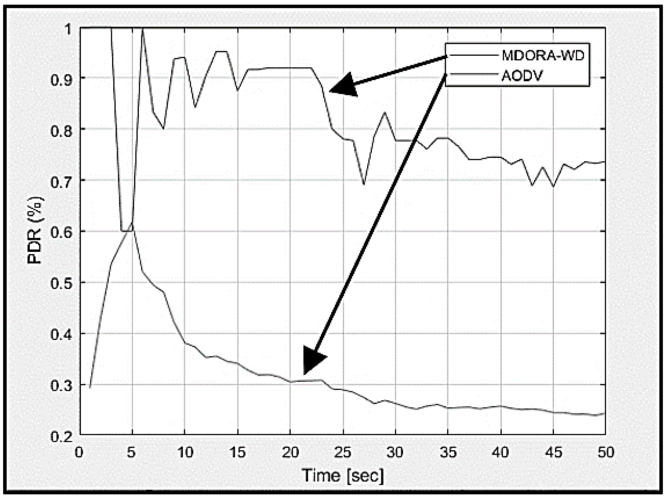

Figure 10. Packet delivery ratio 50 sec simulation time

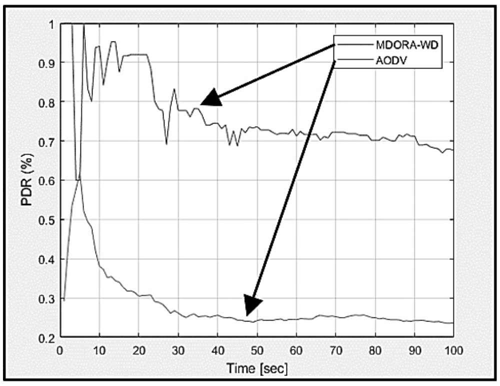

Figure 11. Packet delivery ratio 100 sec simulation time

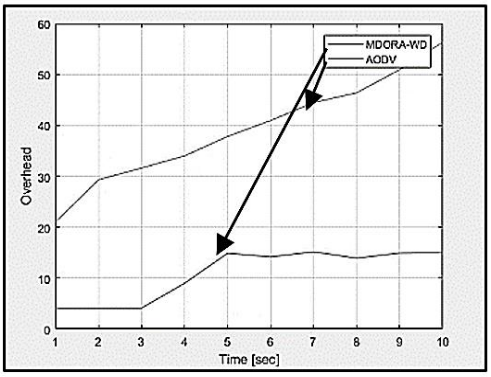

Figure 12. Communication overhead 10 sec simulation time

Figure 12, Figure 13, Figure 14, and Figure 15 shows communication overheads with different simulation time (10, 20, 50, and 100) sec. The (3) was used to calculate the ratio of communication overheads, and a comparison was made among MDORA-WD and AODV protocol.

$$\text{Overhead} = ((\text{no. of Hello Message} + \text{no. of Response Message}) / (\text{no. Of Received Packets})) \quad (3)$$

The results showed that the MDORA-WD protocol had the lowest rate of communication overheads than the AODV protocol in the case of its application in the urban environment. This result is attributed to the that the MDORA-WD protocol uses the least number of hops to get the packets to the interface, and this means that it uses the least number of (hello and response) messages. Therefore, the percentage of communication overheads is less than the AODV protocol.

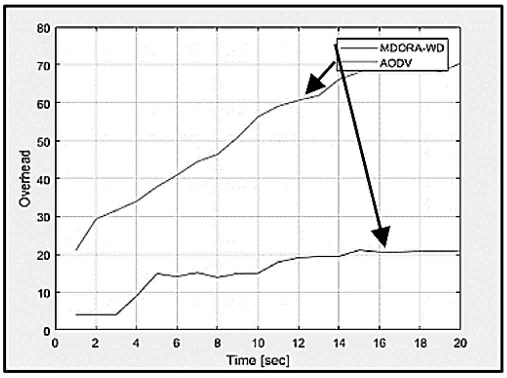

Figure 13. Communication overhead 20 sec simulation time

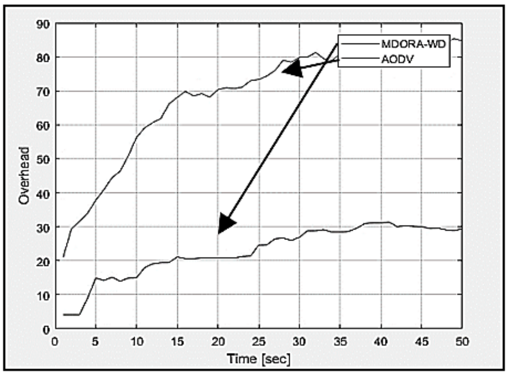

Figure 14. Communication overhead 50 sec simulation time

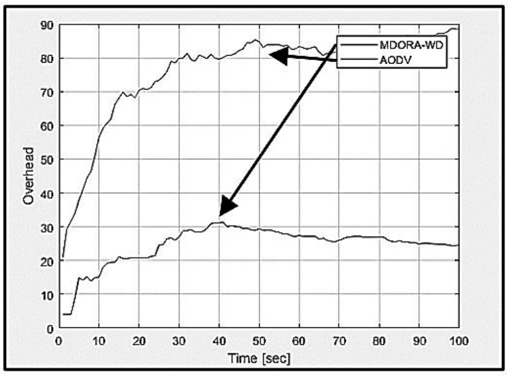

Figure 15. Communication overhead 100 sec simulation time

6. CONCLUSION

In this study, the performance of the MDORA protocol was improved by canceling the directional condition in the protocol algorithm so that the protocol would be more effective in the urban environment. The maximum distance on-demand routing algorithm without direction (MDORA-WD) protocol depended on the distance and the communication lifetime. MDORA-WD Protocol was compared with AODV protocol in terms of communication overhead, PDR and E2E delay. The simulation took place in (10 s, 20 s, 50 s, and 100 s) simulation time. The simulation results showed that MDORA-WD protocol is better than AODV protocol.

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