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Performance evaluation of ad-hoc on-demand distance vector protocol in highway environment in VANET with MATLAB

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ABSTRACT

Vehicular ad-hoc network (VANET), the development of this network in recent years has become one of the most important areas of research. The primary goal of using the VANET network is to reduce the number of deaths and enhance road safety. VANET network faces some problems when routing packets between vehicles, due to the high-speed movement of vehicles. Therefore, researchers have begun to develop routing protocols in the VANET network to overcome these problems when routing packets between vehicles. In this study, the effect of changing the number of vehicles on the performance of ad-hoc on-demand distance vector (AODV) protocol will be studied in the highway environment and in the case of vehicle movement at variable speeds between (40-120 km/h) and the simulation time is 200 sec. The ad-hoc on-demand distance vector protocol performance was evaluated by three performance measures (end-to-end delay, dropped packets, overhead and packet delivery ratio).

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1. INTRODUCTION

Mobile ad- hoc network (MANET) is one of the wireless networks and MANET network contains mobile nodes and is self-organizing and does not contain a base station, so there is no central administration [1]. The nodes in MANET network move randomly and every node within the network acts as a router that directs the packets from the source node to the interface using intermediate nodes [2]. Vehicular ad-hoc network (VANET), is a subclass of MANET, but it differs from it with some characteristics as the nodes in VANET move at high speed and speedy topology amendment.

VANET network enhanced the intelligent transportation system (ITs) as it embodied many applications such as comfort, entertainment and road safety. The growth of wireless networks has not stopped due to imposed restrictions such as bandwidth restrictions, power limitations and high error rate [3]. The VANET network allows communication between vehicles (V2V) or among vehicle and infrastructure (V2I) and uses the multi-hop concept when the vehicle is outside the range of the wireless connection. The communication performance of the vehicles in the VANET network depends on the routing protocols. Figure 1 shows the connection model in the VANET network [4]. This study will focus only on vehicle-to-vehicle (V2V) communication in VANET. Other types of communication are outside the scope of this paper. According to previous researches, we note that research efforts focused on providing new routing protocols for the VANET network, but only a small number were subjected to standardization as mentioned in [5]. VANET network routing protocols are classified into three groups according to their mechanism of operation. The first group is the reactive protocols in this type of protocols. The nodes search for the path only upon request. The second group of proactive routing protocols, these protocols work in contrast to the reactive protocols where the path is discovered and maintained regardless of whether the path is required or not, where a routing table is built through the exchange of messages between the nodes and the routing table is updated at the end or periodically. A node searches for the path in its routing table in case it wants to contact the other node. The third group is the hybrid protocols. This type of protocols combines the advantages of reactive and proactive protocols. This algorithm is designed to reduce path detection time by allowing nodes close to each other to form a proactive group and reduce routing expenses by using a path detection mechanism to locate the paths of distant nodes [3]. The importance of this work lies in measuring the effect of the number of nodes on the performance of ad-hoc on-demand distance vector (AODV) protocol in the highway scenario and calculating the (end-to-end delay, dropped packets, overhead and packet delivery ratio).

The remainder of the research is organized as follows. The second section is a literature review. The third section is the novelty of the work. The fourth section is the VANET applications. The fifth section is routing protocols. The sixth section describes the simulation environment. The seventh section is the simulation results. The eighth section is the conclusion.

2. LITERATURE REVIEW

Haerri *et al.* [6] studied the optimized link state routing protocol (OLSR) and ad-hoc on-demand distance vector (AODV) protocol was implemented in a city environment the speed of the car ranged from 72 to 126 km/s, and the number of cars from 40 to 80 The performance of the two protocols was evaluated in terms of packet delivery ratio and E2E delay. The results of the comparison showed that the AODV protocol has the lowest percentage of packet delivery ratio (PDR) than OLSR at low density, while the PDR of in AODV increases when the density of vehicles increases. While the OLSR protocol has the lowest percentage in terms of routing overhead and E2E delay.

Khan and Qayyum [7] the performance of AODV and OLSR protocol in an urban environment was compared using Nprobabilistic Nakagami radio propagation model with the change in vehicle density between (30, 50, 70, 90, and 120) vehicles. The simulation was carried out by the NS-2 program, and the performance of the two protocols was evaluated in terms of PDR and E2E delay. The results of the comparison showed that OLSR protocol is better than AODV.

Lage *et al.* [8] the AODV, dynamic source routing protocol (DSR), and destination-sequenced distance vector (DSDV) protocols were implemented on the vehicle-to-vehicle in VANET, where the speed of vehicles was changed from 50 km/s in the city environment to 108 km/s in the highway environment and the performance of the protocols was evaluated by changing the vehicle density between 10, 20 and 40 vehicles. The simulation was carried out by simulation of urban mobility (SUMO) and network simulator (NS2). The performance of the protocols was evaluated in terms of dropped packets, routing packets, PDR, received packets, routing load, and E2E delay. The comparison results showed that the AODV protocol is better than DSR and DSDV.

Singh *et al.* [9] the performance of the DSR, AODV, and OLSR protocol was compared in the city and highway environment. The performance of the protocols was evaluated in the case of a change in vehicle density between 152, 340, 767, and 1216 vehicles in the highway environment and 20, 102, 254, and 610 in a city environment. The protocols were simulated by NS-2.34. The performance was evaluated in terms of PDR and E2E delay. The results of the comparison showed that the OLSR protocol is not suitable in the two environments because of its average performance, while the DSR protocol has a high packet loss rate, so it is not suitable in the two environments. As for the AODV protocol, it is better than DSR and OLSR in terms of PDR, but it has a high E2E delay, so it is considered unsuitable in cases where information needs to be delivered at a specific time.

Waddy and Mohammed [10], a comparison was made between the maximum distance on-demand routing algorithim MDORA MDORA and AODV protocol in two cases, the first is the movement of vehicles in several directions and the second is the movement of vehicles in one direction. The protocols were simulated by MATLAB. The performance of the protocols was evaluated in terms of the PDR, end-to-end (E2E) delay, and overhead. The results of the comparison are shown in the first case, the AODV protocol is the best, while in the second case, the MDORA protocol is the best.

3. THE NOVELTY OF THE WORK

In this paper, the AODV protocol is simulated in a highway environment. The protocol was simulated through vehicle-to-vehicle communication using MATLAB. Where the effect of vehicle density on the performance of the AODV protocol was studied at 10, 20, and 30 vehicles, and the speed of vehicles varies between 40-120 km/h. The performance of the protocol was evaluated in terms of PDR, overhead, dropped packets, and E2E delay.

4. APPLICATIONS OF VANETS

- Safety applications: safety applications are used for the purpose of monitoring the vehicle environment, avoiding road accidents and improving road safety. Examples of this application are (post crash notification [11], cooperative message transfer, real-time traffic information, information on other vehicles traveling on the roads [12], vehicle maintenance and diagnostics, sign extension, maintaining public safety and intersection collision avoidance.
- Entertainment and convenience applications: this application aims to share multimedia files, electronic toll plaza, the location of the nearest restaurant, availability of parking lots, traffic, and provide comfort for passengers and drivers by providing them with information related to weather conditions [13].
- Commercial oriented: this application provides value-added advertisement, real-time video transmission, digital map download, internet access for services and entertainment, and remote vehicle diagnosis [11].
- Productive applications: this type of application looks for fuel saving, time utilization and environment benefits [11].

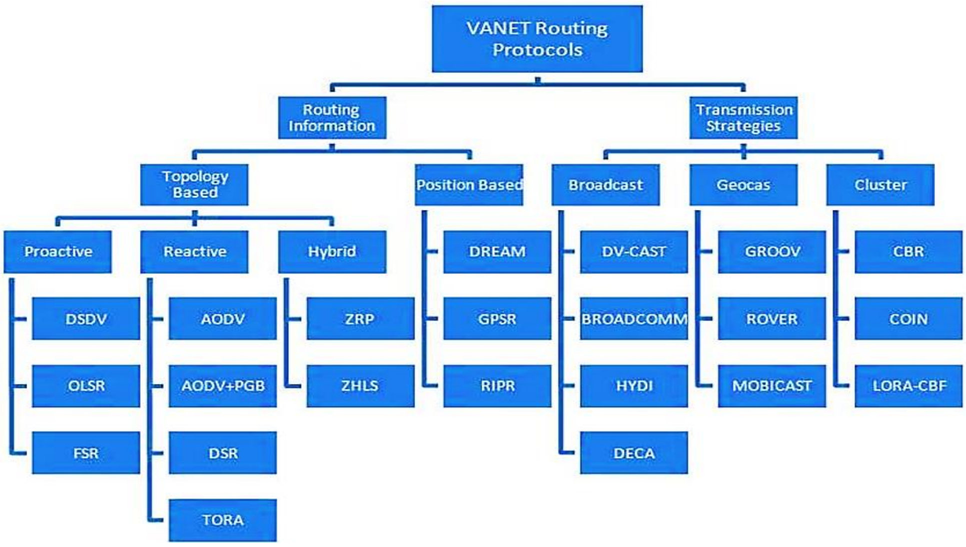

Figure 1. Classifications of routing protocols [14]

5. ROUTING PROTOCOLS

The primary responsibility of protocols in VANET network is to forward packets, route establishment, and restore route, route management and control of communication between two devices [15]. In VANET Network, many protocols have been developed and can be classified on the basis of quality of service, routing technique, protocol characteristics and network architecture [16]. Routing protocols can be classified on the basis of the information received for routing into two categories (geographic based and topology-based). The protocols can be divided, on the basis of path detection, into three divisions: predictive, mixed, reactive and proactive. Finally, the protocols in VANET can be classified into hierarchical, perceptual and flat when we consider the quality of service (QoS) [14]. By looking at various points we find many ways to classify the protocols in VANET. The routing protocols based on characteristics and routing techniques have been categorized into five classes: cluster -based, broadcast, Geo cast, position-based and topology-based routing protocols [17]. Figure 1 shows the classification of routing protocols.

5.1. Topology -based routing protocols

In topology based protocols, the packets are transferred of source vehicle to interface using link information within the network. In current network, the link data is used to implement packet forwarding. This type of protocols is assorted into reactive (interactive) protocols such as (AODV, DSR and temporally ordered routing algorthem (TORA)) [18], proactive protocols such as (DSDV, OLSR and fisheye state routing (FSR))

[19], and hybrid protocols such as (zone routing protocol (ZRP) and zone based hierarchical link state routing protocol (ZHLS)) [15], [18], [20], [21]. In this paper, AODV protocol will be studied and implemented.

5.1.1. Ad-hoc on-demand distance vector (AODV)

It is one of the reactive routing protocols. AODV protocol detects tracks between vehicles on demand and the mechanism work this protocol is to detect and maintain the path [21]. The AODV protocol starts working when the source vehicle sends a route request message (RREQ) after which the source vehicle waits for a route reply message (RREP) from the interface vehicle. If the source vehicle does not receive a message (RREP) within the specified time, this means that there is no route.

Using unicast, the path information will be passed to the source vehicle of the specified node when a message RREQ arrives at the specified target [16]. When the source vehicle sends RREQ to the neighboring vehicles, it will either receive a message RREP from the neighboring vehicles in case they have a path to the target, or the neighboring vehicles send RREQ again to their neighbors with an increase as the number of vehicles. To maintain free communication with the loops, the vehicles ignore the duplicate RREQ messages that contain the same broadcast ID as the previous request [16]. When a message RREQ arrives at the destination vehicle, it responds to the request message and sends RREP via the reverse path to the source vehicle. The reverse path is created by keeping the path of all intermediate nodes, and each node maintains for a specified period the path within the routing table [22]. Figure 2 shows the mechanism of the work of AODV protocol.

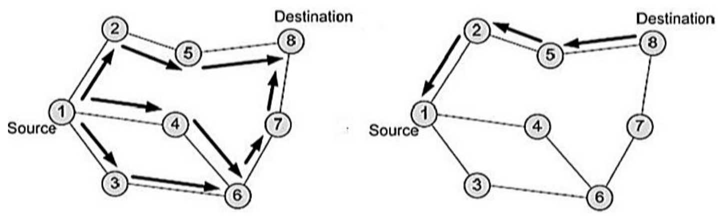

Figure 2. The mechanism of the work of AODV protocol [22]

6. SIMULATION ENVIRONMENT

Matlab program was used to simulate the AODV protocol in a highway environment. Initially, the highway environment was designed in terms of (road lanes, vehicle movement direction and vehicle speed), then the AODV protocol was simulated in the environment that was designed. Protocol performance was compared in two cases that differed in the number of compounds and the duration of simulation. Table 1 shows the parameters that were applied in this simulation.

Table 1. Simulation environment

Parameter	Value
Protocol	AODV
Number of Vehicles	10, 20, 30
Simulation Time	200 s
Simulation Area	5 km*5 km
Variable Speed	40/120 (km/h)
Data Rate	5 Packet/s
The Size of Control Messages	64 Bytes
The Size of Packet	512 Bytes

7. SIMULATION RESULTS

In this paper, three types of performance measures were used, namely, end-to-end delay, packet delivery ratio and number of dropped packets:

7.1. End-to-end delay

Delay is the time the beam is created in the source vehicle to the time the interface vehicle receives the packet, and the delay is measured in seconds [23]. The performance of AODV protocol was compared via E2E delay in the case of change in the number of vehicles between (10, 20 and 30 vehicles) and the simulation time of 200 sec. Figure 3 shows the comparison result and the result showed that the best performance of AODV Protocol is in the case of the number of vehicles 30. This means that the protocol performs better in an environment with high vehicles density.

7.2. Packet delivery ratio (PDR)

It is the number of packets that the interface vehicle has successfully received by the number of packets sent by the source vehicle. The PDR is measured in percentage [24]. The performance of AODV protocol was compared via the packet delivery ratio in case of change in the number of vehicles between (10, 20 and 30 vehicles) and during the simulation time of 200 sec. Figure 4 shows the comparison result and the result showed that the highest rate of PDR is in the case of the number of vehicles 30. This means that the protocol performs better in an environment with high vehicles density.

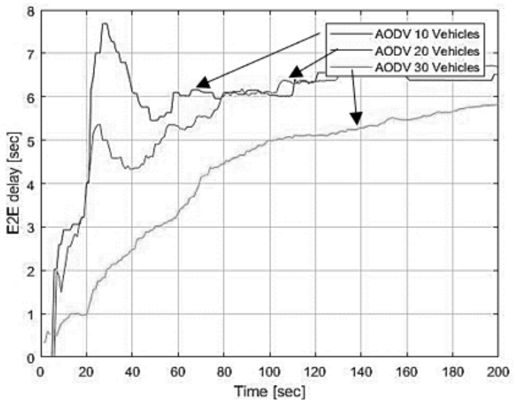

Figure 3. E2E Delay

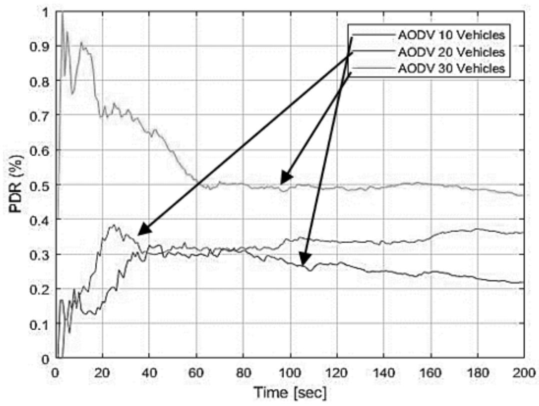

Figure 4. Packet delivery ratio

7.3. Overhead (OH)

It is defined as the number of messages the protocol sends to construct and maintain routes [25]. When comparing the performance of the protocol in terms of communication overheads, the result of the comparison showed that the lowest proportion of communications overheads are in the case of low vehicle density, and the proportion increases with increasing vehicle density as shown in Figure 5. This is because at lower density AODV spends fewer request and response messages, and thus lower communication overhead (OH). Lower indicates better network performance.

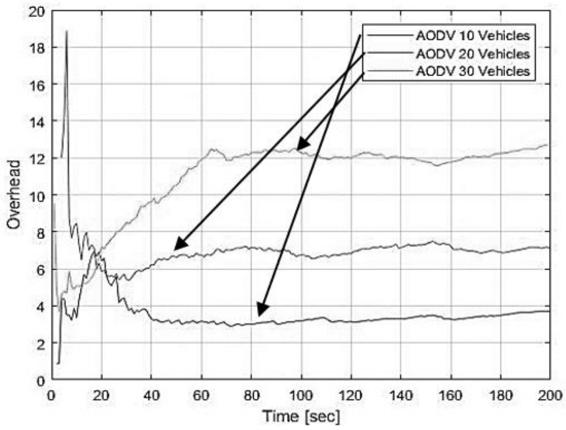

Figure 5. Communication overhead

7.4. Dropped packets (DPs)

It is the number of packets that are dropped during the simulation. In this simulation, the number of DPs was calculated due to (packet lifetime, data buffer overflow, path breaking). The Table 2 shows the number of DPs during the simulation. The results showed that the lowest number of DPs is in case of the number of vehicles 10, while the number of DPs increased in case of 20 and 30 vehicles, this means that the number of dropped packets increased with the increase in the number of vehicles. Finally, Table 3 summarizes the performance comparison of the AODV protocol.

Table 2. Number of DPs

Number of vehicles	Dropped packet due to packet lifetime	Dropped packets due to data buffer overflow	Dropped packet due to path break
10	301	0	0
20	457	0	0
30	516	0	1

Table 3. The performance comparison of AODV protocol

References	Protocols	Simulation	Results
Haerri *et al.* [6]	OLSR and AODV	NS-2	AODV outperforms OLSR as density rises, whereas OLSR outperforms AODV at low densities.
Khan and Qayyum [7]	AODV and OLSR	NS-2	At low densities, OLSR is preferable, whereas as density rises, AODV is superior.
Lage *et al.* [8]	AODV, DSR, and DSDV	NS-2	AODV has proven to be more effective than other methods.
Singh *et al.* [9]	DSR, AODV, and OLSR	NS-2.34	The results proved that the AODV protocol is better than DSR and OLSR.
Waddy and Mohammed [10]	MDORA and AODV	MATLAB	AODV protocol is best in the case of vehicles moving in several directions while MDORA protocol is best in the case of vehicles moving in one direction.
This paper	AODV	MATLAB	The results proved that the AODV protocol has the best results in the case of low density.

8. CONCLUSION

In this work, AODV protocol was implemented in a highway environment and the protocol's performance was evaluated through three measures (end to end delay, packet delivery ratio, overhead and number of dropped packets). The protocol was simulated in the case of a change in vehicles density, where the protocol's performance was compared in three cases that differ in the number of vehicles (10, 20 and 30) vehicles during a simulation time of 200 sec. The results of the comparison showed that the AODV protocol, in the case of using 30 vehicles, has the lowest delay rate and the highest packet delivery ratio. This means that AODV in the highway environment has the best performance at high node density, while in terms of the overhead and the number of dropped packets, the proportion of overhead and the number of dropped packets increases with the increase in vehicles density.

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