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SIMULATION AND COMPARISON OF AD HOC NETWORKS ROUTING PROTOCOLS BASED ON OPNET

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***Abstract*- Ad-Hoc routing algorithm has always been a core problem in research of Ad-Hoc networks. To deal with various routing protocol problems on an ad-hoc network like poor validity and large control overhead, this paper classifies and compares ad-hoc network routing protocols through the OPNET simulation tool and focuses on testing two routing protocols' performance namely, table-driven and on-demand routing protocol. The DSDV Destination Sequenced Distance Vector routing protocol is the most used table-driven routing protocol, while AODV (Ad Hoc On-Demand Distance Vector) and DSR (Dynamic source routing) routing protocols are the most used on-demand routing protocols. The performance of these three protocols are simulated with a variety of packet delivery ratio, average end-to-end delays, and routing loads are also been analyzed and compared using different movement speed (from 0 to 25 m/s) and a constant bitrate source traffic model. The results obtained from 20 network nodes distributed randomly showed that the on-demand routing protocol is the best option for a high mobility environment.**

***keywords:* Ad-hoc, AODV, DSR, DSDV (Destination Sequenced Distance Vector), OPNET, Simulation.**

I. INTRODUCTION

A mobile self-organizing wireless multi-hop network is known as an Ad Hoc network. It does not need infrastructure that is fixed to support also all the network's nodes are mobile which can be maintained dynamically with other connections of the node. Network nodes can move anywhere, also be turned on and off at any time, all of which will change the topology of the network at any moment. Two end-users who cannot communicate directly can use other nodes for packet forwarding. Every mobile node may act as a router and a host at the same time. Because of the Ad Hoc network's features, the traditional routing protocols (such as distance vector and link-state) are not applicable. Many routing protocols have been suggested for the Ad Hoc network and may be divided into two categories: proactive, reactive, and hybrid routing protocols. Also, another name for the prior routing protocol is the table-driven routing protocol can be given in [1]. In this routing protocol, each node has a routing table that contains information about how to go to other nodes. When a topological change in the network is identified, the node broadcasts an update message to the network, so the routing table of the node that receives the update message will be updated to ensure that routing information is consistent, instantly, and correct, so the topology of the network can be accurately reflected in the routing table. When a message is sent from a source node, It can obtain the destination node's arrival route immediately, so the delay of this routing protocol is small, but the overhead of the routing protocol is large. When data needs to be transferred, on-demand routing (reactive routing protocol) searches for a route, in this routing protocol, the node does not need to maintain up-to-date and correct routing information. When a message is sent to a destination node, the source node initiates a network route search and finds the appropriate path. When compared to the prior routing protocol, the reactive routing protocol has a lower overhead and a longer datagram transmission latency than other hybrid routing methods that incorporate the benefits of both the prior and reactive routing protocols [2]. The characteristics of ad hoc routing algorithms put forward special requirements, the development, and research of routing protocol that gradually become a hot spot. In general, many articles been attempted to simulate proactive and reactive protocols and analyze their performance. Analytic methods faced difficulty since protocols like DSR, DSDV, and AODV were complicated and have been set in a variety of ways to obtain high performance in a variety of scenarios [3]. Over the last few years, many research institutions have successively proposed different ad hoc routing protocols, such as DSDV AODV, DSR, OLSR, MAODV, FSR, etc. Literature [4] presented a comparison between LAR and OLSR routing protocols using a Matlab simulator to detect fires in the forest, The results showed that LAR was more efficient in the detection of fires and used less energy than OLSR. Literature [5] presents a comparison between DSR and AODV routing protocols applying TCP and UDP traffic sources in a mobility model, the result showed that AODV has higher mobility than DSR. Literature [6] uses Matlab to compare DSDV performance with WRP (Wireless Routing Protocol) and OLSR (Optimized Link State Routing) protocols in terms of throughput, overhead, and packet delivery ratio. the simulation result showed that DSDV had better performance than WRP while the performance of the OLSR protocol was the best among other protocols. Literature [7]-[10] simulate various routing protocols in ad-hoc networks, which has certain reference significance for the research of ad-hoc network routing protocols, but they did not conduct horizontal comparison and comprehensive analysis of different routing protocols. Literature [11]-[15] simulated and compared several on-demand routing protocols, but the performance indicators used did not reflect fully the realization of routing protocol goals, and the impact of the number of communication source nodes on routing performance were not properly considered. Literature [16] proposed an improved AODV protocol, to improve the route discovery and local repair to establish new routes. The route repair function was improved, the successful delivery rate of packets reduces, the end-to-end delay of nodes, and reduces routing Overhead. However, not all nodes in the network have two-way links, and no one-way links have been studied. Literature [17] proposed an improved DSR protocol by setting a backup route, so route reconstruction can be effectively avoided, the packet transmission success rate is improved, the average end-to-end delay was significantly reduced, and the routing overhead was also reduced. However, due to the provision of alternate routes, the routing space overhead was increased, and the improvement of network performance was relatively limited. literature [15] compared protocols (AOMDV, LAMR, LAR, and AODV) with different times and speeds, the simulation results showed that AOMDV gives the best performance in the end-to-end delay and packet delivery ratio. In this paper three major ad hoc routing protocols namely (DSR, AODV, and DSDV) have been evaluated, the performance is analyzed and compared using speed packet delivery function, delay, and routing load implementing OPNET simulation platform, This study may serve as motivation for further research towards improving existing conventions or developing new ones to solve the challenges faced by MANETs.

II. Introduction to Three Routing Protocol Algorithms

A. DSDV

DSDV is a proactive routing protocol, which is based on the traditional Bellman-Ford routing algorithm, and its characteristic is to use the destination node serial number to solve the routing loop of the digital beamforming algorithm (DBF) and the infinite counting problem. Each node in DSDV maintains a routing table with the number of hops between the accessible destination node and the destination node, in addition to the destination node's routing sequence number.

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The routing sequence number of the destination node is used to differentiate outdated routes and avoid loops. When the network topology and link quality change, periodic help messages are sent out, and the routing table is changed[18].

B. DSR

B. DSR DSR is an on-demand routing protocol based on source routing. The full routing information from the source to the destination node is contained in the header of each packet. It stores source route information using routing cache technology. Once a new route is learned, the route cache content is modified. The DSR protocol is divided into two phases: route discovery is used when data must be sent from a source node to a destination node, It initially determines if the route cache has an unexpired route to the destination end. If so, use this route to send data. If not, broadcast a route request message containing the source and destination node addresses and unique identifiers to neighboring nodes to initiate the route discovery process. Route maintenance is achieved through routing error packets and confirmation packets. When the node's data link layer detects that the link is interrupted, it will send a routing error packet, and any node that receives or hears the routing error message will delete the route containing the error code. Confirm that the packet verifies the correct operation of the routing connection by monitoring if the data packet that is sent is forwarded by the next-hop node [7].

C. AODV

The AODV protocol is developed from the DSDV algorithm. It is divided into two stages: route discovering and route maintaining. In route discovery first searches the routing table when a node wants to send data. If the route to the destination node exists, It will be transmitted according to the routing table's next hop. If not, A route request message RREQ will be sent from the source node to neighboring nodes. The node that receives the non-duplicate RREQ will establish or update the reverse route and then broadcast the RREQ until it is received by the destination node or an intermediate node that has a valid route to the destination node, then responds with an RREP along the reverse path to the source node. When the reverse route returns, the forward route is established, so that the path from the source to the destination node is created when the source node gets RREP. Route maintenance AODV monitors the link status by periodically broadcasting Help messages. While using a link, a node may find that the link has been disconnected, The route containing the link will be deleted from the routing table by the node, and the route will be sent. The error message RRER (Route Error Message) informs those nodes that are unreachable as a result of link disconnection to remove the refer route from the routing table, and the node forwarding the RRER along the way also deletes the corresponding route in its routing table [8].

III. Ad Hoc Network Routing Protocols Simulation Environment

OPNET was used as a simulation platform for ad hoc network routing protocol performance analysis, randomly placing 20 nodes as shown in Fig. 1 while Table I lists the simulation parameters that were utilized. The MAC layer adopts Distributed Coordination Function (DCF) in the IEEE 802.11b media access control (MAC) protocol, and the transport layer adopts the UDP protocol.

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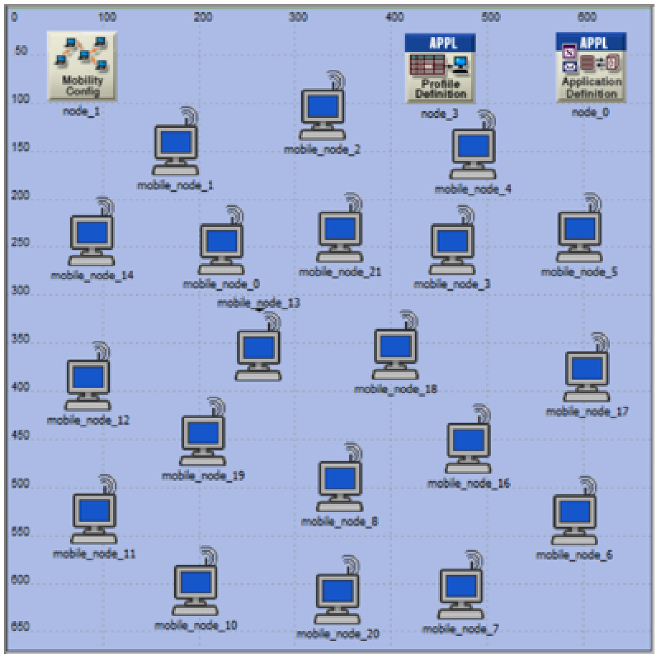

Figure 1: Ad hoc network topology diagram

TABLE I
Simulation Parameters

Parameters	Value
Simulation Area	670 × 670 sq. m.
Transmission Rate	11 Mbps
No. of Mobile Nodes	20
Movement Node Speed	3, 5, 10 m/s
Packet Size	512 byte
Coverage Radius	250 m
Traffic Type	Constant bitrate (CBR)
Hop Limit	7
Simulation Time	300 s
Protocols	AODV, DSR, DSDV

A. *Performance Indicators*

According to the RFC2501 evaluation criteria for ad hoc network routing, the following three metrics are selected for performance evaluation:

1) Packet delivery rate: the proportion of data packets supplied by the CBR source node to data packets received by the destination node.
2) The average end-to-end delay: Comprises the route search time delay, the packet waiting for time delay in the interface queue, the transmission time delay, and the MAC layer retransmission time delay.
3) The routing overhead: can be divided into the protocol packet overhead caused by each transmission of a data packet and the protocol byte overhead caused by each transmission of a data byte

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Fortunately, packet delivery is an important parameter for evaluating routing protocols. It can represent the network's maximum throughput, thereby portraying the integrity and correctness of the protocol to a certain extent. The average end-to-end delay reflects the effectiveness of routing. The routing overhead is a measure of how congested the network is and how powerful the nodes are. When the efficiency of the protocol is high, the probability of congestion is large, and the data packets transmitted in the interface queue will be delayed. It is worth noting that these parameters are not completely mutually independent. For example, high routing overhead will lead to lower throughput and longer delay, and a smaller delay does not mean higher throughput, because the calculation delay only counts those packets that are successfully transmitted.

B. Simulation Results Analysis and Comparison

The network is running for 5 minutes using OPNET to simulate the packet delivery rate, average end-to-end delay, and routing overhead in the case of AODV, DSDV, and DSR. Fig. 2 showed that the packet delivery rate of the three routing protocols is very high under the condition that the node is completely static, and can reach more than 98%. The node's speed increased, while the packet delivery rate of the three protocols began to decline, and DSDV sharply dropped. When the average moving speed is 3m/s, the packet delivery rate is 92% for DSR, and when the average moving speed increases to 10m/s, the packet delivery rate is only 72% for DSDV. Although the packet delivery rates of AODV and DSR have declined, they remain at a relatively high level, both above 92%, which is nearly 20% higher than DSDV. The reason is that DSDV is a proactive routing protocol and requires periodicity. Broadcast routing information is therefore expensive, occupies part of the link bandwidth AODV and DSR are on-demand routing protocols, there is no redundant routing information transmission problem, so there will be a better packet delivery rate. Fig. 2 also shows that for AODV and DSR when the node is moving slowly, the packet delivery rate is comparable, and as the node moves faster, AODV surpasses DSR. This is because DSR relies too much on routing cache. When DSR faces multi-hop routing selection, it only selects the shortest from the cache instead of the latest. In this way, an invalid route may be selected, and the selection of an invalid route may cause network bandwidth consumption or may bring incorrect information to the routes of other nodes. As seen in Fig. 3, when it comes to average end-to-end delay, DSDV has the smallest delay, which is better than the two on-demand routing protocols. Because DSDV is a proactive routing protocol, it assumes the probability of going to all other nodes. Similarly, The routing table keeps a list of all node routing information and updates it regularly. Therefore, routing information to any node is available at any time, so the transmission delay of data packets is small, while in the on-demand routing protocol the route request process starts when the required route is not in the routing table, and the route request process requires broadcast route request packets. The time required is proportional to the length of the path, so it is very time-consuming. Fig. 4 and Fig. 5 show that the routing overhead increases when the node's movement speed increases, which means that the changing of network topology will accelerate, and the routing overhead will increase accordingly. Fig. 4 also shows that the packet overhead of the two on-demand routing protocols is higher than that of the proactive routing protocol DSDV, and this increase is particularly obvious with the node's movement speed increase, and it could be observed from Fig. 5 that AODV and DSR are lower than DSDV in byte overhead. This is because on-demand

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routing initiates a new routing request process every time it reaches all nodes in the path. The route length represents the number of protocol packets transmitted., and the cost of the proactive routing protocol is proportional to the routing request frequency and path. Therefore, the packet overhead of the on-demand routing protocol is larger than that of the proactive routing protocol. At the same time, the periodic routing update message of the proactive routing protocol includes all nodes' routing information, while the routing of the on-demand routing protocol pulls packets. The information carried is only related to one route, and its packet length is small, so in terms of byte overhead on average, on-demand routing is less than proactive routing. Therefore, from the perspective of the efficiency of routing protocols, the overhead of on-demand routing protocols is less than that of proactive routing protocols.

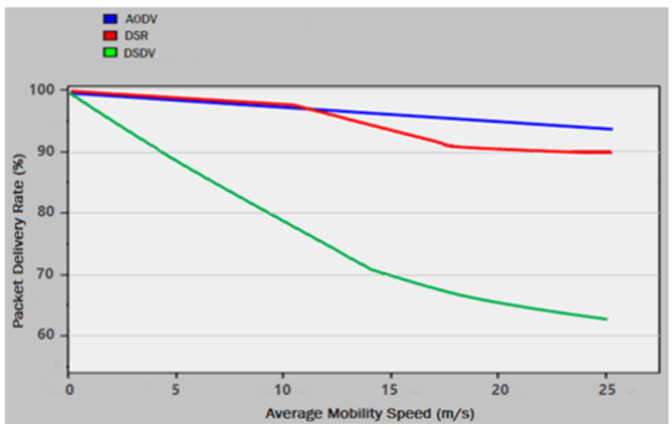

Figure 2: Comparison of packet delivery rate under different speeds

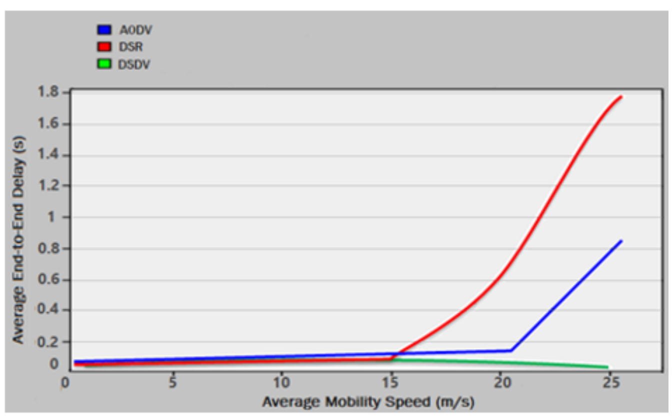

Figure 3: Comparison of end-to-end delay under different speeds

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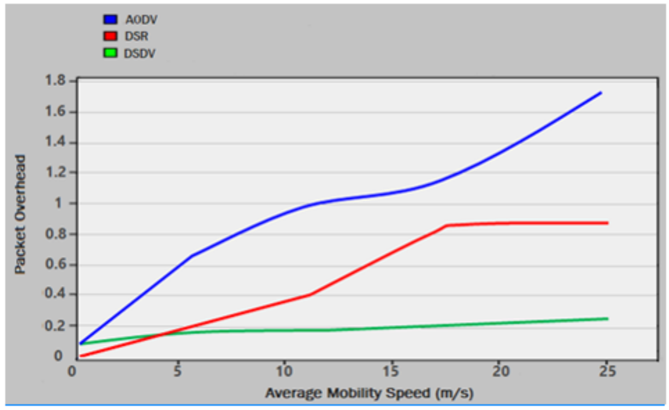

Figure 4: Comparison of protocol packet overhead under different speeds

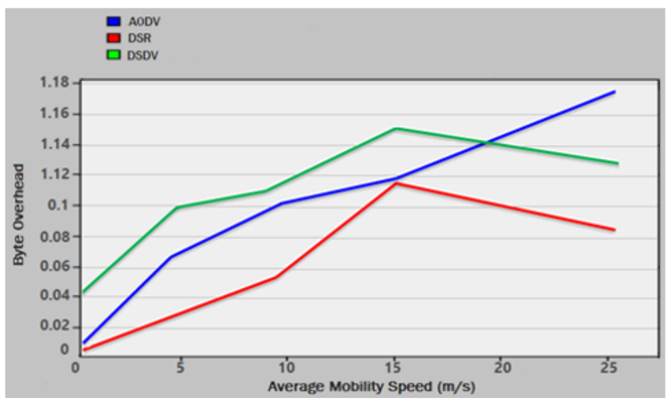

Figure 5: Comparison of protocol byte overhead under different speeds

IV. Conclusion

This paper presents an evaluation study for three major ad hoc routing protocols. Such study is required to assist network operators and mobile application developers in determining which ad hoc routing protocols algorithm can aid them in improving the end-user experience. Following a quick introduction to the principles of three typical ad hoc routing protocols, the three routing protocols are simulated using the network simulation platform OPNET. Under the same network environment, changing the average moving speed of the nodes, counting the simulation results, and comparing the three routing protocols from the three performance indicators of packet delivery rate, average end-to-end delay, and routing overhead, It concluded that the overall performance of the on-demand routing protocol is better than that of the proactive routing protocol. The on-demand routing protocol is more suitable for networks with medium-scale and higher mobility requirements, while the proactive routing protocol is only suitable for small-scale and low-mobility requirements.

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