QoS Performance Analysis of Some Routing Protocols in MANET

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***Abstract*—Mobile Ad Hoc Network (MANET) is introduced for vital situations where the infrastructure of wireless networks fails to provide a connection during natural disasters and wars. This is because MANET is an independent network that relies on its own battery power for routing packets. In this paper, we examined the Quality of Service (QoS) parameters for two types of routing protocols; namely reactive and proactive protocols. In this study, we handled the Ad Hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) protocols as the reactive protocols. On the other hand, we used the Destination-Sequenced Distance Vector (DSDV) and Optimized Link State Routing (OLSR) protocols as the proactive protocols. We considered the throughput, end-to-end delay and packet delivery ratio as the QoS parameters. We carried out different scenarios where the network area size, network density, speed, and pause time were changed. We run the NS2 simulator to execute the performance of these scenarios through some numerical results.**

I. INTRODUCTION

A Mobile Ad hoc NETwork (MANET) is composed of wireless and mobile nodes that work together to forward packets in a multi-hop way. The network is independent of any fixed infrastructure, thus it requires robust and dynamic routing protocols. Since there is no centralized administration, MANET does not own base stations. Also, their costs are more economical compared to other networks, because of having infrastructure-less structure. In MANET, the communication of a node can be done either directly with other nodes that are in its wireless range or indirectly through multi-hop routes. Every node can be considered as either normal node and/or router that forwards packets within the topology [1], [2].

In MANET, ensuring Quality of Service (QoS) is a difficult task because of the mobility of nodes and the shared wireless medium nature. To be able to support service requirements of multimedia and real-time applications, the routing protocol of MANET has to ensure QoS especially with the parameters that are related to end-to-end delay, throughput, and packet delivery ratio [2].

It is obvious that routing functionality is the most important one in MANET since the survivability of the network depends on it. Accordingly, several routing protocols were proposed for MANET, they can be classified depending on some criteria such as routing information update approach [2]. MANET routing protocols are composed of three main types which are Proactive, Reactive and Hybrid protocols as illustrated in Fig. 1 Reactive protocol is known as on-demand protocol because it does not depend on a routing table but Proactive protocol is table-driven and nodes update their routing table permanently [3]. Hybrid protocol includes the advantage of proactive and reactive protocols because it is constituted by combining both types of protocols [4]. In this paper, we attempt to show the differentiation between two Reactive routing protocols (DSR and AODV) and two Proactive routing protocols (DSDV and OLSR) in terms of QoS parameter studies.

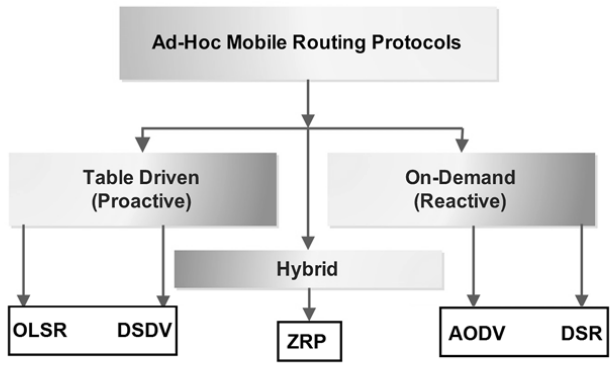

Fig.1. Routing Protocols Categories in MANET

The rest of the paper is organized as follows: Section II introduces the categories of different routing protocols. Section III presents the performance evaluation of these protocols through several simulation results. Section IV concludes the paper.

II. MANET ROUTING PROTOCOLS CATEGORIES

A. *Reactive routing protocols*

Reactive routing protocol is known as on-demand protocol, because the routing table of every node is not updated with the newest routing path. The node utilizes a mechanism which is called as Route Discovery in the routing process. It does not depend on the prior information of the network topology. To constitute a routing path from a sender to a destination, it sends a query packet to the network that is Routing Request (RREQ). When the destination node receives the (RREQ) packet, it detects that a node attempts to connect. Then it sends a Route Reply (RREP) packet as a reply to the sender. As a result, a routing path between the source and the destination is formed [5]. In [6], the reactive routing protocol is presented as a better protocol than the proactive one. Because this kind of protocol operates only on those nodes that are presently utilized. The rest of the nodes do not retain the unused routes, this operation has effect on controlling the network traffic. The delay in the reactive class is better than the other one. In [7] it is stated that, due to the sensitivity to the traffic load, the reactive routing protocol is proper for low connectivity and small number of network loads [7]. Further, a comparison is done between Reactive routing protocols (DSR and AODV) and Proactive routing protocol (DSDV) in [8]. The result of the comparison indicates that reactive routing protocol consumes less power than proactive routing protocol. In our study, two protocols are considered as sample. These are Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR). The main reason about choosing these protocols refers to their usability in many applications.

- Ad-hoc On-demand Distance Vector (AODV)

Ad-hoc On-Demand Distance Vector was formed as a combination between on-demand and distance vector protocol [3]. It is similar to DSDV protocol but better in many ways and not proactive. AODV depends on hop by hop routing method. It starts with forming Route Request (RREQ) packet then sending it to all neighbors. The neighbors forward the (RREQ) to the others or satisfy it by sending back Route Reply (RREP) packet to the sender. When (RREQ) is sent from the sender to the destination, it forms a reverse path through all intermediate nodes to the sender. Route Request packet (RREQ) includes the following information.

- Source address
- Source sequence Number
- Broadcast ID
- Destination Address
- Destination Sequence Number
- Hop count

Source address and broadcast ID work together as a composite key in every (RREQ) packet and they are private and unique. Every node can drop a (RREQ) packet when the same copy of the (RREQ) with the same source address and Broadcast ID are already received. Hop count increases while forwarding (RREQ) by each node. Broadcast ID works as a counter. Source sequence number is utilized for representing the newest information about reverse path. The destination sequence number is formed by the destination node to show the freshness of the route. The Route Reply packet contains the following information:

- Source address
- Destination Address
- Destination Sequence Number
- Hop count
- Lifetime

The common problem in AODV is removing destination node or any intermediate node from the network. To solve this, Route Error (RERR) packet is utilized in [9]. With receiving a (RERR) packet, the sender detects that an intermediate node or a destination node is removed. Then, it can discover a new path or stop broadcasting. In [10] it is stated that AODV has many advantages and disadvantages. The basic advantages of this protocol are decreasing broadcast overhead and multicasting which is not compulsory [10]. Additionally, the delay is the weakness of this protocol. It is attempted to find out the parameters in every protocol that are acting on power consumption. It is stated that the interference and noise directly affect the power, in order to reduce these influences, it is suggested that AODV protocol should be modified properly to provide an efficient power awareness [11]. A new on demand routing protocol, which is called as Power-aware Source Self-contained, was presented in [12]. This protocol plays a great role in minimizing power consumption by the nodes in MANET. The protocol guarantees that no route will be overworked and a route with the minimum energy cost will be chosen.

- Dynamic Source Routing (DSR)

Dynamic Source Routing is one of the on-demand routing protocols. In DSR, nodes can discover the routes from a source to any destination in the network. The basic characteristic of DSR is that the header of the data packet has the whole nodes' addresses that the packet will pass to arrive to the destination [3]. Two mechanisms are utilized in DSR protocol, the first one is Routing Discovery Mechanism. This is similar to the discovery mechanism in AODV. But before broadcasting Route Request (RREQ) packet, the node checks its route cache to find out whether the requested route is already available there, if not, it sends (RREQ) packet to its neighbors. Thus the process continues until the (RREQ) packet reaches the destination node. The destination confirms the route and informs the sender node with sending Route Reply (RREP) [13]. The second mechanism is Maintenance Route Mechanism. It is used when a disconnection is detected during the packet transmission from a sender to a destination. This condition occurs when the network topology changes by the movement of an intermediate node or the destination. When the Maintenance Route notices that a source route link is no longer active, the sender node iimplements the first mechanism again [3]. The main point in DSR protocol is the way of storing the route information. It stores the whole information about the routing in the source. It is not preferred by the other on-demand protocols. For example, AODV stores the routing information in the intermediate nodes and does not rely on only the source node [14]. DSR protocol does not keep routing table, but it is not very active and capable to be utilized for a large network [6].

B. Proactive routing protocol

This type of protocol is called Table-Driven. Because the nodes in the network carry a routing table that maintain information for sending packets to any node in the network. Every node updates its routing table to keep its stability and maintains the latest network topology. This class utilizes the sequence number that is formed by the destination node. The critical information needed by a node for establishing a new route is the destination address, the number of nodes that should be accessed until reaching the destination node and the new sequence number tagged by the destination [3]. Proactive routing protocols own some advantages and disadvantages. As an advantage, the sequence number is utilized for avoiding the network from facing an infinite count loop problem. The problem emerges when a node is removed from the network but its neighbors do not notice this situation and count it as an existing one. On the other hand, the main weaknesses of this type are incapability to apply in a big network, having routing overhead issues, low throughput and bandwidth power consumption [15].

- Optimized Link State Routing (OLSR)

OLSR is a proactive protocol that depends on the routing table. Unlike reactive protocols, its routing information table is maintained. OLSR protocol is an advanced version of the traditional Link State protocol. It can control the broadcasting by any node in the network. Thus, the broadcasting flooding that causes overhead in the network can be minimized. Also, OLSR depends on Multipoint Relay (MPR) technique. Every node in the network selects one of its neighbors as (MPR) for re-transmitting its messages. The nodes that are not selected as MPR are capable to receive messages but they do not have the same ability as MPR. MPR uses Hello message to find information about neighbor nodes and Topology Control message for sending information to the neighbors of MPR Selector [16]. The delay in OLSR is not long but when a link is broken, it needs time for re-discovering [6]. It is stated that OLSR owns high throughput performance with low data drop and delay as well as it is suitable and efficient for a large network with high number of nodes [17].

- Destination-Sequenced Distance Vector (DSDV)

Destination-Sequenced Distance Vector is an advanced version of the classical shortest-path routing protocol [18]. It owns a technique for improving routing performance that depends on the sequence number which is formed by the destination. In the protocol, every node includes a routing table with the following fields in every entry.

- Destination address.
- Next hop address.
- Metric of the routing to the destination.
- Destination sequence number.

The advantage of using sequence number is to make a differentiation between the old and the new routes and preventing from creating route loops. Routing table in every node is updated according to time change or event occurrence. There are two ways of updating a routing table. The first one is known as full-dump which updates all table entries and the second one updates only those entries that witness changes (Partially update) [3]. DSDV protocol works properly in small networks but for large networks its performance is not convincible and since the nodes need to update their routing tables frequently, this protocol will use more battery power [19].

III. SIMULATION RESULTS

We evaluated the performance of the above-mentioned routing protocols in MANET in terms of QoS parameters using NS2 simulator. The scenarios that we chose for measuring the performance of these protocols involve the following context while (i) Network area size is changing; (ii) Network density is changing; (iii) Pause time is changing and (iv) Node speed is changing. Table I shows the parameters of simulations.

TABLE I. SIMULATION PARAMETERS

Parameters	Values
Propagation model	Two-Ray Ground Reflection
Density	(14, 20, 30, 40, 45, 50, 60) nodes
Pause Time	(0, 5, 50, 100, 150, 200, 250) sec
Speed	(1, 10, 20, 30, 40, 50) m/sec
Network Area size	(250x250,500x500,750x750,1000x1000, 1250x1250,1500x1500) m
Mobility model	Random Waypoint Mobility
Traffic Type	Constant Bit Rate

For each context, we evaluated the following parameters for QoS (i) Throughput, (ii) End-to-End Delay and (ii) Packet Delivery Ratio only since they are the most popular and essential parameters in the performance evaluation of routing protocols.

A. *Throughput*

Fig. 2 presents the performance of the chosen protocols in terms of throughput corresponding to different network area sizes. Throughput performance of all protocols is declined with increasing the network area size. Throughput values of the reactive protocols are very close to each other, they decline in the same way. In proactive protocols, a sharp decrease in the throughput values for DSDV protocol is noticed unlike OLSR.

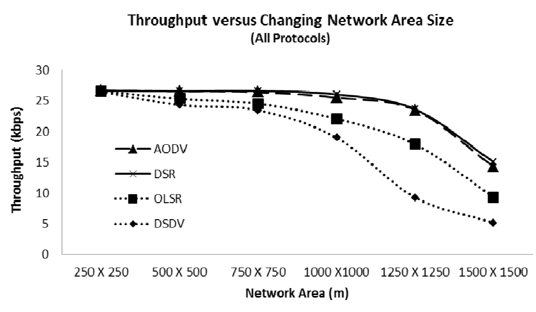

Fig.2. Throughput vs Changing Area Size

Fig. 3 illustrates throughput performance of the protocols for different network density. The throughput of reactive protocols is higher than that of the proactive protocols because once the reactive protocols find the path between a sender and a receiver, it no longer utilizes the remained nodes. So the rest of the nodes remain unused. And there is a variation between the proactive protocols: OLSR and DSDV, as OLSR has better throughput performance than DSDV since OLSR depends on MPR technique.

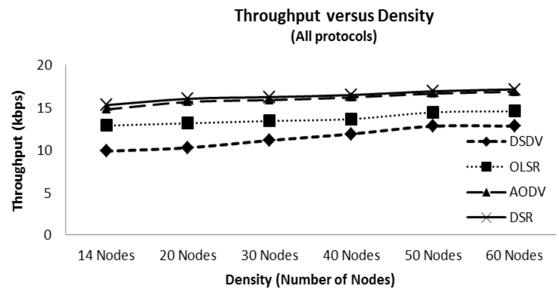

Fig.3. Throughput vs Density

Fig. 4 demonstrates the performance of the protocols in terms of the throughput with varying pause time. The reactive protocols have better throughput performance than proactive protocols because proactive protocols need to update their routing table properly. In small pause duration the proactive protocols have small throughput value but by increasing the pause duration their behavior can be improved after a pause (200 seconds). The reactive protocols have stable behavior in all pause durations. The proactive protocols have stability at pause time (200 seconds and 250 seconds) because these pause times are a little smaller or equal to the simulation time which means that the nodes in these pause times are motionless and the network is quite static.

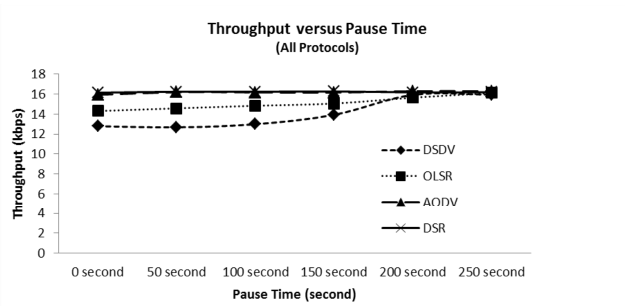

Fig.4. Throughput vs Pause Time

Fig. 5 demonstrates the impact of speed on throughput for all protocols. Proactive protocols: OLSR and DSDV are more sensitive to the speed because their throughput performance decreases when the node's speed increases. And, the reactive protocols own better throughput and their performance is quite stable in all speed cases.

B. *End-to-end delay*

Fig. 6 presents the results of the average End-to-End delay for all protocols according to the changes in the network area size. Proactive protocols: DSDV, OLSR perform better than reactive protocols: AODV, DSR. Because slight increases are seen from proactive protocols, but reactive protocols have an obvious increase with the increases in the area size. This is because when area size becomes larger, reactive protocols need more time for creating an on demand routing path between the source and destination nodes.

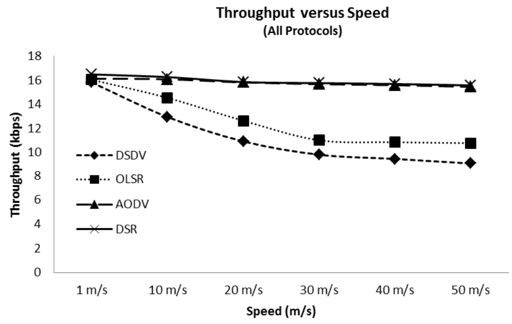

Fig.5. Throughput vs Speed

Fig. 7 shows the latency for different ranges of the network density. There is an opposite behavior between reactive protocols and proactive protocols. Because the latency in proactive protocols increases with increasing the density while in reactive protocols latency decreases with increasing the density. Because, adding node to the network leads to decrease the distance between the nodes and since reactive protocols depend on the hop by hop connection, the delay from a source node to a destination node decreases.

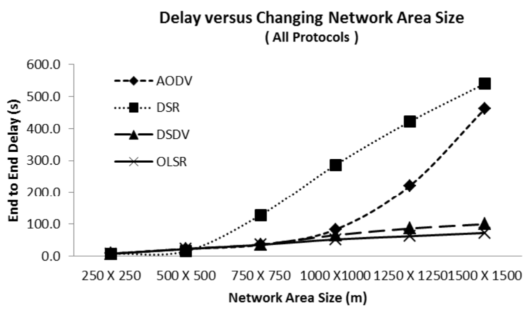

Fig.6. E2E Delay corresponding to Network Density

In contrast, increasing the density causes increase in delay in proactive protocols due to updating the routing information table continuously. As shown in Fig. 7, AODV protocol has strange behavior because it has higher latency in small density when compared with DSR. AODV depends on the routing discovery mechanism for finding routing path therefore it spends a lot of time for determining a routing path especially for large network area (750 x 750 meter) with a small density. DSR is a reactive protocol but unlike AODV, it does not depend on the routing discovery mechanism but it depends on the routing catch mechanism hence DSR does not spend too much time to find a routing path. In general reactive protocols are better than proactive protocols for small network density while for high network density proactive protocols have better behavior.

Fig. 8 illustrates the variation of the delay with varying pause duration for all protocols. Reactive protocols decline sharply by increasing the pause duration but after a pause duration of 150 seconds they reach a stability level. Proactive protocols have a kind of stability in all pause duration values however DSR decreases at the duration of 150 seconds.

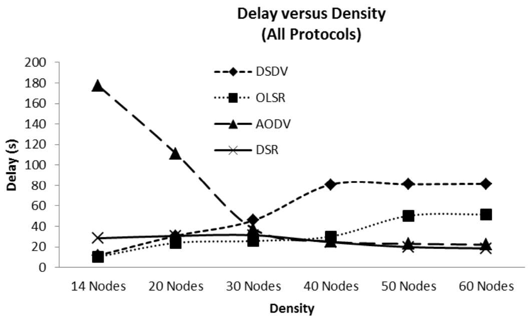

Fig.7. E2E Delay corresponding to Density

Fig. 9 demonstrates the relation between the delay and the node speed for all protocols. The speed effects the end-to-end delay. Increasing the speed of the nodes leads to increasing the delay but the amount of such increase is different. In proactive protocol, the delay increases when the speed increases but at 40 m/s and 50 m/s they tend to be steadier. Reactive protocols own diverse behaviors. The delay for DSR protocol increases slowly at the beginning then it increases sharply with the increase in the speed while AODV has stability but after 40 m/s it starts to increase.

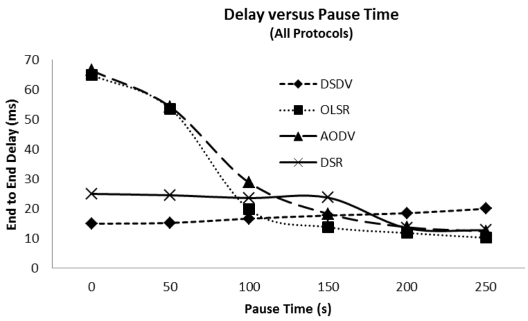

Fig.8. E2E Delay corresponding to Pause Time

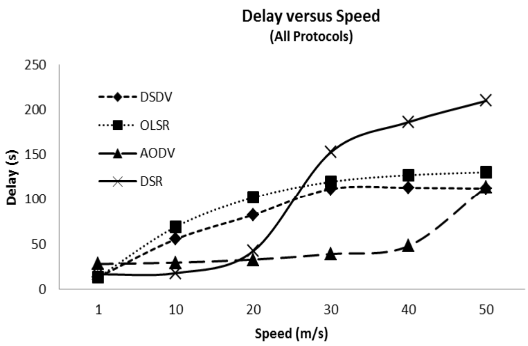

Fig.9. E2E Delay corresponding to Speed

C. *Packet delivery ratio*

Fig. 10 shows Packet Delivery Ratio (PDR) for all protocols: AODV, DSR, OLSR and DSDV corresponding to the change of the network area size. PDR can be obtained by dividing sending packet over receiving packets. With increasing the area size of the network, PDR values of protocols decrease. DSR has the highest PDR value which is PDR = 1 in small network area size (250 x 250) meter, this means that DSR protocol has no loss in small network area. Other protocols cannot reach this value as all other protocols loose some packet even in small network area size. The PDR values of reactive protocols: AODV and DSR are close to each other and they are better than Proactive protocols: OLSR and DSDV. Because in all network area sizes, the PDR values of the reactive protocols are greater than those of the proactive protocols and they do not decrease sharply like the proactive protocols.

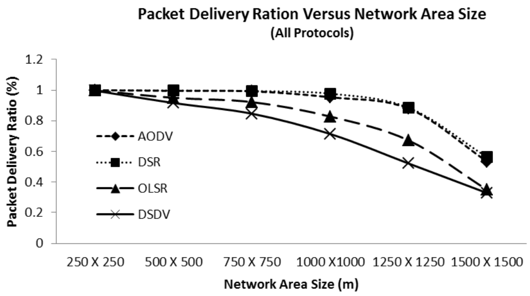

Fig.10. PDR vs. Changing Area Network Size

Fig. 11 illustrates the PDR for all protocols with variable number of nodes. Reactive protocols: AODV and DSR own well performance with increasing number of nodes but proactive protocols: OLSR and DSDV do not reach the top value of PDR. OLSR provides better performance than DSDV, but all reactive protocols have less packet loss rates than the proactive protocols and the increase of the number of nodes does not affect their performance.

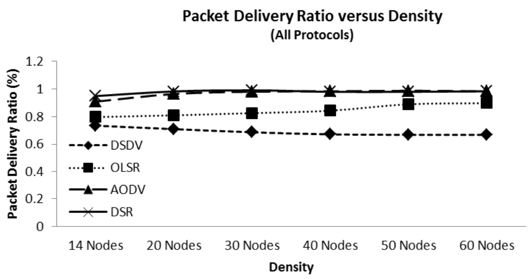

Fig.11. PDR vs. Density

Fig. 12 shows the values of PDR in distinct pause durations for all protocols. Reactive protocols provide higher values than proactive protocols and their values are very close and stable. The proactive protocols present lower value in small pause duration but their values ascend with increase in the pause durations. So, it is predictable that both protocol classes have close values of PDR in higher pause duration.

Fig. 13 demonstrates the influence of the node speed on PDR for all protocols. PDR for reactive protocols: AODV and DSR is approximately (100%) when nodes have slow mobility with 1 m/s and 10 m/s. In both protocol classes, PDR values decrease when the node speed increases but in proactive protocols these values decrease with increasing in the speed. So, the speed has a small impact on the reactive protocols while it has a great impact on the proactive protocols.

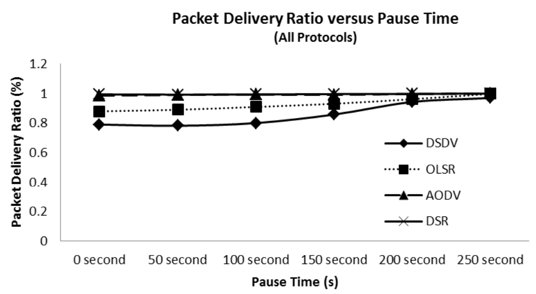

Fig.12. PDR vs Pause Time

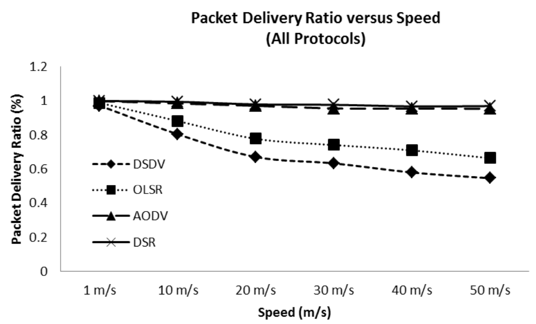

Fig.13. PDR vs. Speed

TABLE II. OVERALL RANKING OF THE PROTOCOLS

Simulation Parameters	Protocols	Performance Parameters
Varing Network Area Size (m)	DSR > AODV > OLSR > DSDV	Throughput (kbps)
	DSR > AODV > DSDV > OLSR	End-to-End Delay (s)
	DSR > AODV > OLSR > DSDV	Packet Delivery Ration (%)
Varing Network Density	DSR > AODV > OLSR > DSDV	Throughput (kbps)
	DSDV > OLSR > AODV > DSR	End-to-End Delay (s)
	DSR > AODV > OLSR > DSDV	Packet Delivery Ration (%)
Varing Pause Time (s)	DSR > AODV > OLSR > DSDV	Throughput (kbps)
	AODV > DSR > OLSR > DSDV	End-to-End Delay (s)
	DSR > AODV > OLSR > DSDV	Packet Delivery Ration (%)
Varing Speed (m/s)	DSR > AODV > OLSR > DSDV	Throughput (kbps)
	DSR > OLSR > DSDV > AODV	End-to-End Delay (s)
	DSR > AODV > OLSR > DSDV	Packet Delivery Ration (%)

IV. CONCLUSION

In this paper, we investigated the performance of different routing algorithms in MANET in terms of Quality of Service. We studied some scenarios depending on (network area size, network density, pause duration, speed) for all selected protocols (DSDV, OLSR, AODV and DSR). The results about QoS concern mainly throughput, end-to-end delay and PDR. According to the obtained results, Reactive protocols (AODV and DSR) present higher performance than proactive protocols (DSDV and OLSR) in terms of throughput. Regarding end-to-end delay, behavior of the protocols, it varies according to the scenario. Reactive protocols have excellent performance in PDR in all scenarios because their performance is a kind of steady and approximately equal to one, but PDR performance of the proactive protocols declines in all scenarios and is not in a good condition like the reactive protocols. The main reason behind such a behavior of the reactive protocols is related to their operation mechanism used in routing. Table 2 illustrates overall ranking of the protocols for each performance parameter. As a future work, we intend to study the performance of those protocols in terms of power consumption.

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REFERENCES

[1] Md. M. Morshed, F. I. S. Ko, D. Lim, Md. H. Rahman, Md. R.R. Mazumder, J. Ghosh, "Performance Evaluation of DSDV and AODV Routing Protocols in Mobile Ad-hoc Networks," 2010 *4th International Conference on New Trends in Information Science and Service Science (NISS),* 11-13 May 2010, Gyeongju, pp. 399 – 403.

[2] C. Fathy, M. T. El-Hadidi, M. A. El-Nasr, "Fuzzy-based Adaptive Cross Layer Routing Protocol for Delay Sensitive Applications in MANET," *IEEE ICC* 2012 - Ad-hoc and Sensor Networking Symposium.

[3] S. K. Sarkar ,T. G. Basavaraju, C. Puttamadappa, "Ad Hoc Mobile Wireless Networks Principles Protocols and Applications," *New York. Auerbach Publications,* 2007.

[4] A.Kumaravel and M.Chandrasekaran, "A Complete Study on Power Aware Routing Protocol For Mobile Adhoc Network," *IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE),* pp. 71-75, 2014, India.

[5] M. Maleki, M. Pedram, "Power-Aware On-Demand Routing Protocols for Mobile Ad Hoc Networks," Available online http://www.mpedram.com/Papers/crc_chap_nofigs.pdf

[6] N. Kumar, "Power Aware Routing Protocols in Mobile Adhoc Networks-Survey," *International Journal of Advanced Research in Computer Science and Software Engineering*, Vol. 2, 2012, India.

[7] T. Lin, "Mobile Ad-hoc Network Routing Protocols: Methodologies and Applications," Phd Thesis, *Faculty of the Virginia Polytechnic Institute and State University Computer Engineering,* 2004, Virginia.

[8] V.P. Patil, "Reactive and Proactive Routing Protocol Energy Efficiency Performance Analysis in Wireless Ad Hoc Networks," *International Journal of Electronics and Computer Science Engineering*, 2013, India.

[9] D. Kaur, N. Kumar, "Comparative Analysis of AODV, OLSR,TORA, DSR and DSDV Routing Protocols in Mobile Ad-Hoc Networks,"*Computer Network and Information Security*, 2013, India .

[10] R. Kumar, P. Singh, "Performance analysis of AODV, TORA,OLSR and DSDV Routing Protocols using NS2 Simulation,*" International Journal of Innovative Research in Science, Engineering and Technology* ,Vol. 2, Issue 8, 2013, India .

[11] J. Deepthy, N. Krishnan,."Performance Improvement of Energy Aware and Adaptive Routing Protocols For Manets?A Survey," *International Journal of Research in Engineering and Technology,*Vol 3, 2014, India.

[12] M. Maleki, K. Dantu, M. Pedram, "Power-aware Source Routing Protocol for Mobile Ad Hoc Networks," *Proceedings of the 2002 International Symposium on Low Power Electronics and Design*, 2002 (ISLPED '02), pp. 72-75, IEEE.

[13] S. S. Kaushik, P.R.Deshmukh, "Comparison of Effectiveness of AODV, DSDV and DSR Routing Protocols in Mobile Ad Hoc Networks," *International Journal of Information Technology and Knowledge Management,* Vol. 2, No. 2, pp. 499-502, 2009, India.

[14] A. Aggarwal, S. Gandhi, N. Chaubey, "Performance Analysis of AODV,DSDV and DSR in MANETS," *International Journal of Distributed and Parallel Systems*, Vol. 2, No. 6, 2011, India.

[15] B. D. Shivahare, C. Wahi, S. Shivhare, "Comparison of Proactive and Reactive Routing Protocols in Mobile Adhoc Network Using Routing Protocol Property," *International Journal of Emerging Technology and Advanced Engineering*, Vol. 2, Issue 3, 2012, India.

[16] K. Shamekh, E. E. Elfakharany, "Comparative Study of AODV and OLSR Protocols in MANET Network under the Impact of Black Hole Attack,"*International Journal of Computer Science and Telecommunications*,Vol. 4, Issue 9, 2013, Egypt.

[17] G. S. Aujla, S. S. Kang, "Comprehensive Evaluation of AODV, DSR, GRP, OLSR and TORA Routing Protocols with varying number of nodes and traffic applications over MANETs," *Journal of Computer Engineering*, Vol. 9, Issue 3, 2013, India.

[18] H. Bakht, "Survey of Routing Protocols for Mobile Ad-hoc Network, " *International Journal of Information and Communication Technology Research*,Vol. 1, No. 6, 2011, UK.

[19] A. Aggarwal, S. Gandhi, N. Chaubey,"Performance Analysis of AODV, DSDV and DSR in MANETS," *International Journal of Distributed and Parallel Systems (IJDPS),* Vol. 2, No. 6, 2011, India.