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PERFORMANCE EVALUATION OF ROUTING PROTOCOLS IN MOBILE AD-HOC NETWORKS

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Abstract

Mobile ad-hoc network (MANETs) is a collection of mobile nodes used to create an open network; nodes are self configured and connected by wireless links as per the defined routing protocol. Each node in the MANET shares the wireless medium and the topology of the network changes erratically. In MANET, breaking of communication link is very frequent, as nodes are free to move. The paper attempts to provide an overview of MANET protocols and their comparison on the basis of throughput, packet delivery ratio, end to end delay and normalized routing load. The simulation is carried out using the NS-2 simulator. The comparison result explores that AODV performs optimally better among its category protocols considered in the paper.

1. Introduction

MANET is a type of ad-hoc network that can change locations and configure itself. This can be a standard Wi-Fi connection or another medium, such as a cellular or satellite transmission. A big challenge in the design of ad-hoc network is the selection and modification of dynamic routing protocols that can efficiently find the routes between the communicating nodes.

Gulati et al. [3] explores that MANET is a self configuring network of mobile routers connected by wireless links with no access point. Every mobile device in a network is autonomous and infrastructure less. Kumar et al. [4]

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includes that inside the ad-hoc networking field, wireless sensor networks take a special role. A sensor network is composed of a large number of small sensor nodes, which are randomly deployed inside the area in which a phenomenon is being monitored. Wireless ad-hoc networking techniques also constitute the basis for sensor networks.

Wireless network consist of nodes having dynamic energy are running various software versions and different hardware component. Establishing communication between these heterogeneous components become a bigger challenge due to its restricted communication range, within this range intruder can easily attack with malicious intentions. If routing protocol using the cryptography in MANET routing protocols degrades the performance due to additional routing load along with dynamic topology. Security has always been a key issue with MANET since there are no physical boundaries. As compared to wired network, the routing in MANET differs in the aspects like: architecture, cabling, centralized access point etc. MANET does not require a pre-existing architecture for communication purpose and do not rely on any type of wired infrastructure. MANET comprises a special subset of wireless networks since they do not require the existence of a centralized message passing device. MANET is infrastructure less and is best suited for decentralized operations. It possesses dynamic topology, mobility and heterogeneity. MANET is the only solution for various applications such as emergency response network which is mainly used in areas like investigation and rescue, crowd control, disaster area network and military emergency applications.

Kumar et al. [4] explores that regardless of the variety of applications and the long history of mobile ad-hoc network there are still some issues and design challenges that have to be overcome. MANET is one of the elementary research fields. MANET is a wireless network of mobile nodes which is self organized network and every device can communicate with every other device. Kumar et al. [4] highlighted the MANETs characteristics viz-network does not depends on any fix infrastructure for network having dynamic topology, ease of deployment, each node is working as intelligent node, not any mediator networking device is required for communication.

The rest of this paper is organized in four sections. In section 2, we discuss MANET Routing Protocols. Performance metrics and simulation

result are discussed in section 3 and section 4 respectively. Finally, the conclusion is in section 5.

2. MANET Routing Protocols

Routing is the process of information exchange from one host to the other host in a network. Routing is the mechanism of forwarding packets towards their destination using most efficient path. Efficiency of the path is measured in various metrics like number of hops, traffic, security etc. In Ad-hoc network each host node acts as specialized router itself. There are three categories of routing protocols which are as follows

Table 1. Classification of Routing Protocols.

S. No.	Characteristics	Reactive Protocol	Proactive Protocol	Hybrid Protocol
1	Definition	Routes are established whenever it is required	Routes established in advance at the time of initialization of the network	When nodes are communicating in intra zone, they follow reactive protocol while in case of inter-zone communication they follow proactive protocol
2	Routing Information	Is generated whenever required	It is always available.	Is always available and generated whenever required based on protocol selection.
3	Scalability	Some of the protocols are not suitable for large networks.	These are not at all suitable for large networks	Design hybrid protocol gives better results for large networks.
4	Example	Ad-hoc on Demand Distance Vector (AODV), Dynamic Source Routing (DSR)	Destination Sequence Distance Vector (DSDV), Optimized Link State Routing (OLSR)	Zone Routing Protocol (ZRP)

Mostly used MANET reactive protocols are AODV, DSR and reactive protocol is DSDV which are described as follows-

(A) Reactive Routing Protocoli)

(i) Ad-hoc On-Demand Distance Vector Routing (AODV)

Mohapatra et al. [10] explores that, AODV is a routing protocol for ad hoc mobile networks with large numbers of mobile nodes. AODV create routes between nodes only when the routes are requested by the source nodes, giving the network flexibility to allow nodes to enter and leave the network at will. Routes remain active only as long as data packets are traveling along

the paths from the source to the destination. When the source stops sending packets, the communication will disconnect.

(ii) Dynamic Source Routing (DSR)

DSR determining source routes requires accumulating the address of each device between the source and destination during route discovery. The accumulated path information is stored by nodes processing the route discovery packets. The known paths are used to route packets. To accomplish source routing, the routed packets contain the address of each device, the packet will traverse.

(B) Proactive Routing Protocoli)

(i) Destination Sequence Distance Vector (DSDV)

Destination Sequence Distance Vector (DSDV) is a hop-by-hop vector routing protocol where each node is required to periodically broadcast routing updates. It is a table driven algorithm based on modifications made to the Bellman-Ford routing mechanism. Each node in the network maintains a routing table that has entries for each of the destinations in the network and the number of hops required to reach each of them. Each entry has a sequence number Simulation is performed in network simulator NS-2. Performance analysis of MANET routing protocols AODV, DSR and DSDV on the basis of throughput, packet delivery ratio, end to end delay and routing load are evaluated with following network specifications-associated with it that helps in identifying stale entries. The mechanism allows the protocol to avoid the formation of routing loops.

3. Performance Metrics

Table 2. Network Specification for Simulation.

Simulator	Max packet in Queue	No. of nodes	protocol	(x, y) m	Simulation time (ms)
NS-2 version-2.35 Channel-802.11	50	10, 20, 30	AODV-DSR AODV-DSDV DSR-DSDV	(1500,1500)	100,200,500,1000 1500, 2000

The comparison is done by measuring the following performance parameters:

Throughput- The amount of data transmitted successfully from one place to another in a given time period. It is measured in bits per seconds and mbps. Throughput is a crucial indicator of performance of a network connection. i. e. a larger value of throughput indicates better performance. It is calculated using following formula-

$$\text{Throghput} = \sum npr/T.$$

Where, np_r = number of packets received, np_s = number of packets sent, T = time and $np_s >= np_r$.

Packet Delivery Ratio. It is defined as the ratio of the number of data packets sent by the source node and the total number of data packets received by destination node. For any network it is desirable that the packet delivery ratio is high. It is calculates as-

$$\text{Packet Delivery Ration} = (\sum np_r / \sum np_s) * 100.$$

Where np_r = number of packets received np_s = number of packets sent.

Average End to End Delay –It is time taken by the packet to travel from sender's application layer to receiver's application layer. It includes all the delay in the network. The average end to end delay for a network should be least. It is measured as-

$$Average\ End\ to\ End\ Delay = \sum D_i / N.$$

Where D_i is the duration of delay i, N is the total number of delay, $0 < i < N$ and $N \neq 0$.

Normalized Routing Load- Normalized routing load is defined as the total number of routing packet transmitted per data packet. It is the ratio of total number of routing packets sent to the total number of data packets received. It is calculated as follows-

$$\text{Normalized Routing Load} = \sum nRps / \sum nDpr.$$

Where, $nRps$ is number of routing packets sent and $nD\,\mathrm{Pr}$ is number of data packets received.

QOS VALUES FOR MANET ROUTING PROTOCOLS

The objective of the paper is to compare the performance of AODV, DSR and DSDV protocols on the basis of parameters throughput, packet delivery ratio, end to end delay and normalized routing load. The performance is analyzed on the basis of varying number of nodes and simulation time (ms). The performances is analyzed with the help of NS-2 simulator as follows-

1. AODV Protocol Values

Table 3. Comparison of QoS for AODV Protocol.

S. No.	No. Of Nodes	Simulation Time (ms)					
		100	200	500	1000	1500	2000
Throughput(kbps)	10	682.74	683.27	683.27	683.27	683.27	683.27
	20	679	679.59	679.59	679.59	679.59	679.59
	30	663.76	668.44	668.44	668.44	668.44	668.44
PDR (%)	10	98.79	98.60	97.98	96.88	95.82	94.78
	20	96.70	96.09	88.40	88.40	84.33	80.53
	30	94.41	94.29	91.37	86.68	82.67	79.13
E2E Delay (ms)	10	37.7826	38.4042	38.37	38.30	38.24	38.19
	20	47.72	48.4612	48.46	48.46	48.46	48.46
	30	49.64	47.59	47.59	47.58	47.5986	47.59
NRL(Overheads)	10	0.013	0.016	0.030	0.053	0.075	0.098
	20	0.46	0.059	0.125	0.237	0.345	0.455
	30	0.097	0.102	0.169	2.286	0.396	0.503

Table 3 shows that the value of throughput for varying nodes is constant at simulation time 200ms and above. The value of packet delivery ratio is decreasing continuously as simulation time increases. The end to end delay does not show any significant changes with respect to the simulation time as the number of node increases the value of end to end delay increasing. The

value of normalized routing load is minimum for 100 ms simulation time or lesser.

2. DSR Protocol Values

Table 4. Comparison of QoS for DSR Protocol.

S. No.	No. Of Nodes	Simulation Time (ms)					
		100	200	500	1000	1500	2000
Throughput (kbps)	10	108.70	108.70	248.32	248.32	248.32	248.32
	20	248.32	248.32	248.32	248.32	248.32	248.32
	30	71.86	71.86	71.86	71.86	71.86	71.86
PDR (%)	10	57.25	57.25	61.93	61.93	61.93	61.93
	20	61.93	61.93	61.93	61.93	61.93	61.93
	30	33.00	33.00	33.00	33.00	33.00	33.00
E2E Delay (ms)	10	183.875	183.875	55.46	55.46	55.46	55.46
	20	55.4613	55.4613	55.46	55.46	55.46	55.46
	30	108.187	108.187	108.187	108.187	108.187	108.187
NRL(Overheads)	10	1.001	1.001	0.896	0.896	0.896	0.896
	20	0.896	0.896	0.896	0.896	0.896	0.896
	30	6.001	6.001	108.187	108.187	108.187	108.187

From table 4, it can be seen that; at simulation time 100 ms and 200 ms for 10 nodes, value of throughput was minimum. After increasing the simulation time for 20 nodes, throughput was maximum as compared to throughput of 10 nodes, but in this scenario the value of throughput was constant at different simulation time. Similarly for 30 nodes the value of throughput is also constant for different simulation time and value of throughput was decreased as compare to throughput of 20 nodes. The value of packet delivery ratio is constant at different simulation time and fixed number of nodes. There is no significant value of end to end delay and normalized routing load were found because simulation time and number of nodes insignificantly affect the result of both factors.

3. DSDV Protocol Values

Table 5 depicts that the value of throughput and packet delivery ratio

decreases with respect to the simulation time. The value of end to end delay is least at 10 nodes and as simulation time and number of nodes increases, value of end to end delay also increases. The value of normalized routing load is constant for different number of nodes and simulation time i.e. 0.001 overheads.

Table 5. Comparison of QoS for DSDV Protocol.

S. No.	No. Of Nodes	Simulation Time (ms)					
		100	200	500	1000	1500	2000
Throughput (kbps)	10	679.77	680.18	647.99	680.18	671.84	674.00
	20	678.95	680.31	670.82	663.63	658.46	638.39
	30	674.21	674.56	626.96	637.60	644.37	624.17
PDR (%)	10	98.74	98.51	98.17	98.51	98.01	98.06
	20	97.39	97.01	96.46	96.07	95.87	94.43
	30	95.91	95.42	95.38	92.97	93.73	95.19
E2E Delay (ms)	10	36.0527	36.5309	36.47	36.53	35.91	35.93
	20	40.9808	41.1953	41.427	42.411	45.23	53.87
	30	44.4099	43.724	71.55	67.1036	62.43	73.667
NRL(Overheads)	10	0.001	0.001	0.001	0.001	0.001	0.001
	20	0.001	0.001	0.001	0.001	0.001	0.001
	30	0.001	0.001	0.001	0.001	0.001	0.001

The simulation result of QoS for protocols AODV, DSR, and DSDV as compared above, explores that mobility affects the performance of QoS for various nodes. In the presence of high mobility of source and destination node, link failure can happens more frequently. Link failure triggers new route discoveries in protocols i.e. with low mobility, the possibilities of link failure is low and value of QoS parameters will be constant.

A. Comparison of Routing Protocols on various QoS Parameters

1. Throughput for the 10 node model at different Simulation Time

Figure 1 shows the comparison of routing protocols like AODV, DSR and DSDV on the basis of throughput and simulation time for 10 nodes. The simulation time is taken in millisecond and throughput is measured in kbps.

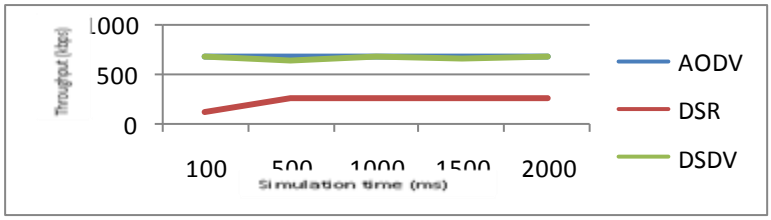

Figure 1. Throughput at different simulation time.

The simulation result for throughput measured for the three routing protocols as described above. Figure 1 shows that the throughput of AODV and DSDV are almost equal and better than DSR at various simulation time. In this scenario the number of nod constant. Based on the simulation results, throughput value of DSR is increases as increasing the simulation time but there is no significant changes observes on AODV and DSDV protocols of simulation time.

2. Packet Delivery Ratio (PDR) for the 10 nod model at different Simulation Time

Figure 2 shows the comparison of routing protocols like AODV, DSR and DSDV on the basis of packet delivery ratio and simulation time for 10 nodes. The simulation time is taken in millisecond and packet delivery ratio is measured in percentage.

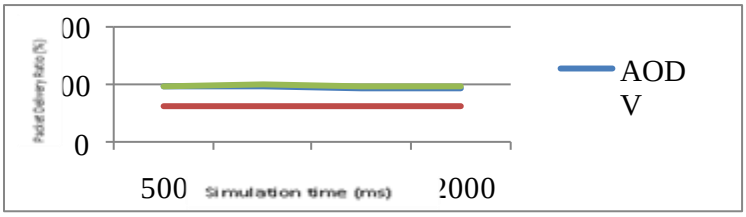

Figure 2. PDR at different simulation time.

The figure 2 shows that the value of packet delivery ratio in DSDV protocol is higher than all other protocols. The PDR value of DSR is directly proportional to the simulation time, as we increase the simulation time, we will observe that the value of PDR is also increases with insignificant ratio.

3. End to End Delay for the 10 node model at different Simulation Time

The objective of figure 3 is to compare routing protocols like the basis of end to end delay and simulation time for 10 nodes. The simulation time is taken in millisecond and end to end delay is measured in milliseconds.

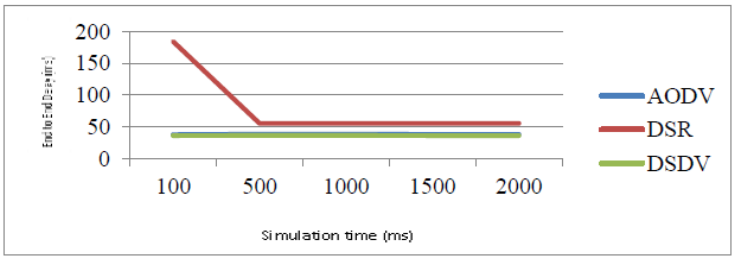

Figure 3. End to End Delay at different simulation time.

Figure 3 describes that DSR has higher end to end delay while the DSDV has the shortest delay due to its proactive features because all the routing information are already stored in table. Hence it takes lesser time. End to End delay of DSDV is inversely proportional to the simulation time, as shown in table 5.

4. Normalized Routing Load for the 10 node model at different Simulation Time

In figure 4 we compare routing protocols like AODV, DSR and DSDV on the basis of normalized routing load and simulation time for 10 nodes. The simulation time is taken in millisecond and NRL is measured in overheads.

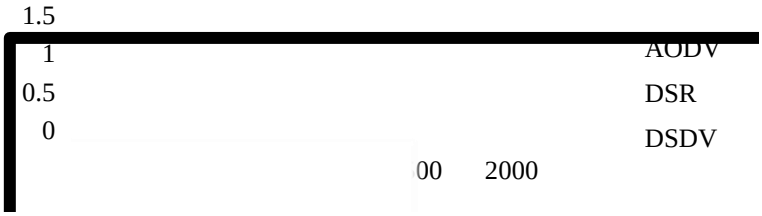

Figure 4. NRL at different simulation time.

Figure 4 shows that the NRL value of DSR is higher than AODV and DSDV protocol. The table 5 explores that the NRL value of DSDV protocol is constant with respect to simulation time i.e. if we increase the simulation time, the NRL value will never change.

4. Result Analysis

Performance in mobile ad-hoc network is major concern for the functionality of the networks. After the simulation process, the comparison result shows that AODV performs well not the best among all the studied protocols. DSDV is best suited for small networks and AODV is well for general ad-hoc networks. DSR shows the lowest performance as compared with AODV and DSDV.

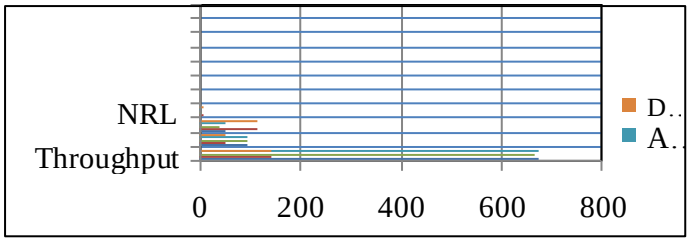

Figure 5. QoS Comparison Chart.

In figure 5, research explores that the performance of routing protocols does not depends on the time. If we vary the time and nodes, the variations in QoS parameters of routing protocols is insignificant.

5. Conclusion

The paper compares the performance of MANET routing protocols AODV, DSR and DSDV on the basis of QoS metrics (throughput, PDR, end to end delay, NRL) using NS-2 simulator. Simulation shows that in different scenario, performance of AODV and DSDV is almost same except DSDV protocol has minimum delay as compare to AODV protocol. The throughput of DSR protocol is very low as compare to other two in all the scenarios which indicates that the performance of DSR is poor for all type of networks. In networks with a dynamic topology, DSDV faces difficulties in maintaining valid routes and loses many packets. With increasing mobility DSDV strives to maintain routes continuously to every other node which results increase in network load.

After investigation of different scenarios it is accomplished that when the network is small, DSDV performs well while in case of general ad-hoc

network AODV is the finest protocol. Hybrid protocols are best suited for large networks. The performance of DSR is worst in case of small and large network so one should avoid using this protocol unless and until there is some hardware and software limitation.

The routing protocols use different mechanism for route discovery. MANET administrators usually don't have any idea about selecting routing protocols. Wrong selection of routing protocol degrades the performance of network. The paper is helpful for MANET administrators to select appropriate routing protocol.

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