Performance Simulation Evaluation of Various Routing Protocols in Mobile Ad-Hoc Networks Using ns-2 Simulator

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Summary
The mobile ad-hoc network (MANET) is a system of wireless mobile nodes, that can freely and dynamically self-organized in arbitrary and temporary network topologies, without the need of wired backbone or centralized administration, that why need for efficient dynamic routing protocols plays an important role. A variety of routing protocols targeted specifically at this environment have been developed and some performance simulations are made on numbers of routing protocols like Dynamic Source Routing (DSR), Ad-hoc On-Demand Distance Vector Routing (AODV) and Destination Sequenced Distance-Vector (DSDV) routing algorithm has been implemented. To the best of our knowledge, few published work is available in the literature, which compares as many criteria as we have done to evaluate the performance of the considered routing protocols. In this paper we perform extensive simulations on differences in the protocol mechanics can lead to significant performance differentials using ns-2 simulator. The performance differentials are analyzed using varying network load, mobility, simulation times, connectivity sources and network size under performance metrics. These simulations are carried out based on the observations; we make recommendations about when the performance of either protocol can be best.

Key words:
Mobile ad-hoc, wireless networks, ns-2 simulator, metrics, routing protocols and performance evaluation.

1. Introduction

MANET is an autonomous system of mobile routers (and associated hosts) connected by wireless links. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a stand-alone fashion, or may be connected to the larger Internet[1].

Because nodes in a MANET normally have limited transmission ranges, some nodes cannot communicate directly with each other. Hence, routing paths in mobile ad-hoc networks potentially contain multiple hops, and every node in mobile ad-hoc networks has the responsibility to act as a router[2] to discover and maintain routes to other nodes in the network[3].

MANETs are becoming the crucial medium of present day communication owing to their self configuring, easily deployable and infrastructure-less nature. These networks are particularly suitable for emergency situations like warfare, floods and other disasters where infrastructure networks are impossible to operate. Since mobile nodes move in various directions causing existing links to break and the establishment of new routes, routing in such networks is a challenging task. Routing protocols used in these dynamic networks should be designed in such a way that they can adapt fast and efficiently to unexpected changes in network layout[3]. Most people carry and use laptop computers, cellular phones, and pagers that support nomadic computing of network users[4]. Many protocols have been proposed for MANETs, with the goal of achieving efficient routing[5][6][7], whereas most of the conventional routing protocols are designed either to minimize the data traffic in the network or to minimize the average hops for delivering a packet[8]. However, the ad-hoc networks have to suffer many challenges at the time of routing protocol. Dynamically changing topology (due to Brownian motion of the nodes of the network) and no centralized infrastructure are the biggest challenges in the designing of an Ad-hoc network. The main challenges in mobile ad-hoc networks are (Limited power supply, dynamically changing topology, limited bandwidth, security, mobility-induced route changes or packet losses, battery constraints)[9]. From these challenges there are many published papers of comparison routing protocols that is simulated using network simulator[4][10][11][12].

The organization of the rest paper is as follows: In section.2, the related works of routing protocol. In section.3, methodology described simulation model, setup and performance metrics. In section.4, evaluation results using ns-2 simulator. In section.5, performance analysis described effect of mobility and routing load effect of routing protocols. Finally, conclusion and future works.

2. Related Works in MANETs

In this section, studied an overview of mobile ad-hoc routing protocols, that is many routing protocols have been proposed for MANET's[5][6][7], with the goal of achieving efficient routing. The classification of routing protocols in MANETs can be done in many ways, but most of these are done depending on routing strategy and network structure. According to the routing strategy, the routing protocols can be categorized as table-driven and

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source initiated, while depending on the network structure these are classified as flat routing, hierarchical routing and geographic position assisted routing[13]. There is a number of routing protocols have been developed for mobile ad-hoc networks as shown in Fig.1[13], that DSDV[7] belongs to the table-driven protocols. The most popular protocols nowadays are the AODV[5] and DSR[6] protocols. Both of them belong to the source-initiated on-demand protocols. We will briefly describe these protocols in the following, thus motivating the study, analysis and compared three routing protocols (DSR, AODV and DSDV) and performance analysis, which aim at achieving routing stability.

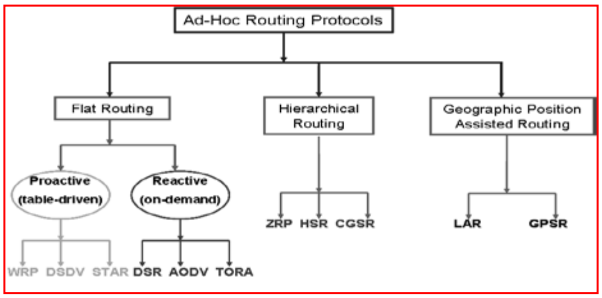

Fig.1: Classification of mobile ad-hoc routing protocols

A. DSR

The DSR routing protocol[6] is an on-demand routing protocol that is based on the concept of source routing Mobile nodes are to perform a Route Discovery, the source node S broadcasts a Route request packet with the Time-to-Live field of the IP header initialized to 1. This type of Route request is called a non-propagating route request and allows node S to inexpensively query the route caches of each of its neighbors for a route to the destination. If no reply is returned, node S transmits a propagating route request that is flooded through the network in a controlled manner and is answered by a route reply packet from either the destination node or another node that knows a route to the destination. To reduce the cost of route discovery, each node maintains a cache of source routes it has learned or overheard, which it aggressively uses to limit the frequency and propagation of route requests. Route Maintenance is the mechanism by which a packet's sender S detects if the network topology has changed such that it can no longer use its route to the destination D because two nodes listed in the route have moved out of range of each other. When Route Maintenance indicates a source route is broken, S is notified with a route error packet. The sender S can then attempt to use any other route to D already in its cache or can invoke route discovery again to find a new route. Since the Wave LAN-I radios do not provide any link-layer acknowledgment that a transmitted packet was successfully received. The Fig.2 show the basic operation of the DSR protocol, which consists of two mechanisms: Route discovery and route maintenance. Route discovery is the mechanism by which a node S wishing to send a packet to a destination D obtains a source route to D[14].

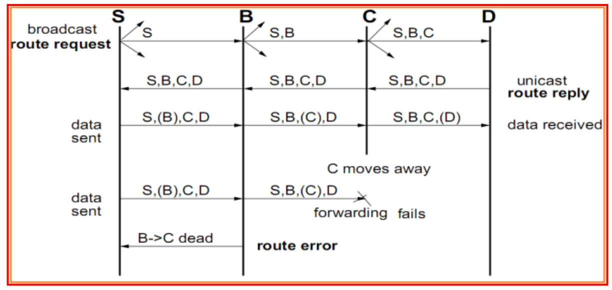

Fig.2: Basic operation of the DSR protocol.

B. AODV

The AODV routing protocol described in[5] builds on the DSDV algorithm[7] previously described. AODV is an improvement on DSDV because it typically minimizes the number of required broadcasts by creating routes on a demand basis, as opposed to maintaining a complete list of routes as in the DSDV algorithm. The authors of AODV classify it as a pure on-demand route acquisition system, since nodes that are not on a selected path do not maintain routing information or participate in routing table exchanges. When a source node desires to send a message to some destination node and does not already have a valid route to that destination, it initiates a path discovery process to locate the other node. It broadcasts a route request (RREQ) packet to its neighbors, which then forward the request to their neighbors, and so on, until either the destination or an intermediate node with a "fresh enough" route to the destination is located. The Fig.3:(a)[15] illustrates the propagation of the broadcast RREQs across the network. AODV utilizes destination sequence numbers to ensure all routes are loop-free and contain the most recent route information. Each node maintains its own sequence number, as well as a broadcast ID. The broadcast ID is incremented for every RREQ the node initiates, and together with the node's IP address, uniquely identifies an RREQ. Along with its own sequence number and the broadcast ID, the source node includes in the RREQ the most recent sequence number it has for the destination. Intermediate nodes can reply to the RREQ only if they have a route to the destination whose corresponding destination sequence number is greater than or equal to that contained in the RREQ. During the process of forwarding the RREQ, intermediate nodes record in their route tables the address of the neighbor from which the first copy of the broadcast packet is received, thereby establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. Once the RREQ reaches the destination or an intermediate node with a fresh enough route, the destination/intermediate node responds by uncasting a route reply (RREP) packet back to the neighbor from which it first received the RREQ as shown in Fig.3:(b)[15]. As the RREP is routed back along the reverse path, nodes along this path set up forward route entries in their route tables which point to the node from which the RREP came. These forward route entries indicate the active forward route. Associated with each route entry is a route timer which will cause the deletion of the entry if it is not used within the specified lifetime. Because the RREP is forwarded along the path established by the RREQ, AODV only supports the use of symmetric links. Routes are maintained as follows. If a source node moves, it is able to reinitiate the route discovery protocol to find a new route to the destination. If a node along the route moves, its upstream neighbor notices the move and propagates a link failure notification message (an RREP with infinite metric) to each of its active upstream neighbors to inform them of the erasure of that part of the route. These nodes in turn propagate the link failure notification to their upstream neighbors, and so on until the source node is reached. The source node may then choose to reinitiate route discovery for that destination if a route is still desired. An additional aspect of the protocol is the use of hello messages, periodic local broadcasts by a node to inform each mobile node of other nodes in its neighborhood. Hello messages can be used to maintain the local connectivity of a node. However, the use of hello messages is not required. Nodes listen for retransmission of data packets to ensure that the next hop is still within reach. If such a retransmission is not heard, the node may use any one of a number of techniques, including the reception of hello messages, to determine whether the next hop is within communication range. The hello messages may list the other nodes from which a mobile has heard, thereby yielding greater knowledge of network connectivity.

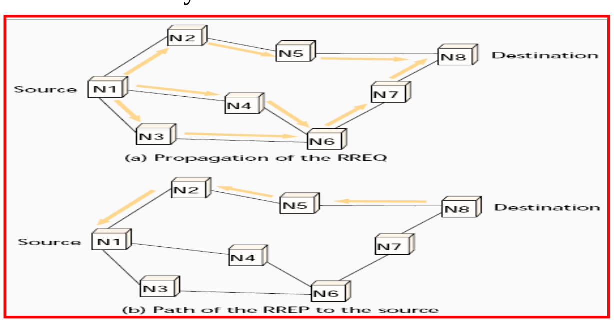

Fig.3: AODV route discovery.

C. DSDV

The DSDV routing protocol[7] based on the classical bellman-ford routing mechanism. Every mobile node in the network maintains a routing table in which all of the possible destinations within the network and the number of hops to each destination are recorded. Each entry is marked with a sequence number assigned by the destination node. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops[11]. Routing table updates are periodically transmitted throughout the network in order to maintain table consistency. In order to reduce the amount of information carried in these packets, two types will be defined. One will carry all the available routing information, called a "full dump". The other type will carry only information changed, called an "incremental". First the full dump. This type of packet carries all available routing information. Second Smaller incremental packets are used to relay only that information which has changed since the last full dump. Each of these broadcasts should fit into a standard-size, thereby decreasing the amount of traffic generated. The mobile nodes maintain an additional table where they store the data sent in the incremental routing information packets. New route broadcasts contain the address of the destination, the number of hops to reach the destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast. The route labeled with the most recent sequence number is always used. In the event that two updates have the same sequence number, the route with the smaller metric is used in order to optimize shorten the path[12].

3. Methodology

3.1. Simulation Model and Setup

A detailed simulation model based on network ns-2 simulation[16][17][18][19] is used in the evaluation and attempting to measure the performance analysis of three routing protocols under a range of four metrics. The parameters used for our simulation are given in Table.1.

Table.1: Scenario for the simulator ns-2 experiments

Parameter	Value
Number of nodes	10, 20, 30, 40, 50
Area size of the topography (x,y) meter	(500, 500) m
Traffic type	cbr
Node transmission range (Wireless range)	150 meter
Number of traffic sources	8, 15
Send rate of traffic	'1' pkt/sec
Mobility (Movement speed node)	Lower movement speed (1 m/sec and 5 m/sec), medium movement speed (10 m/sec and 15 m/sec), and higher movement speed (20 m/sec and 25 m/sec)
The mobility model used	Random waypoint model
Simulation time (second)	'200'sec, '500'sec and '900'sec
Pause time (s) at simulation time 200sec	10,30,50,70,100,200 second
Pause time (s) at simulation time 500sec	0,100,200,300,400,500 second
Pause time (s) at simulation time 900sec	0,100,300,500,700,900 second

The routing protocols are evaluated on the simulation of '10, 20, 30, 40, 50' wireless nodes forming an ad-hoc network, with varying movement patterns of mobility model used random waypoint model[20] as shown the movement node and the connectivity of network in Fig.4

and two files traffic model loads, using Constant Bit Rate (cbr) service is used for connections.

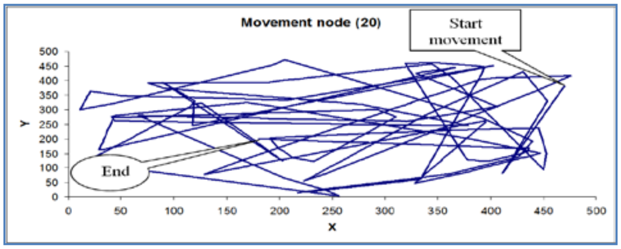

Fig.4: Movement node 20 at pause time 0 sec speed 20 m/s.

So that, we chose a space in order to force the use of longer routes between nodes over a rectangular (500m×500m) flat space for different simulation time (SIMT) with movement patterns generated for '5' different pause times: 10,30,50,70,100, and '200' seconds for SIMT 100s, and '6' different pause times: 0,100,200,300,400, and '500's for SIMT '500's, and '6' different pause times: 0,100,300,500,700, and '900's for SIMT '900's a pause time of '0's corresponds to continuous motion, and a pause time of '100' (the length of the simulation) corresponds to end of stop motion at SIMT 100s and as the same of SIMT 500s and 900s, because the performance of the protocols is very sensitive to movement pattern. In order to enable direct, fair comparisons between the protocols, it was critical to challenge the protocols with identical loads. From running simulator ns-2, we are generated output trace files and animator files, for each routing protocol, whereas the output trace file formats[19] are most important file in our experiment, which are analysis the outputs to record the packets and compute the performance metrics graphs, and the output animator files can be visualized in network animator[17].

3.2. Performance Metrics

Four important performance metrics are evaluated, which are quantitatively measured the performance and activities that are running in ns-2 simulation.

- Packet Delivery Fraction: it is called packet delivery ratio is important as it describes the loss rate that will be seen by the transport protocols, which in turn affect the maximum throughput that the network can support. This metric characterizes both the completeness and correctness of the routing protocol, which defined the ratio of the data packets delivered to the destinations to those generated by the CBR sources, so the higher value is better result[12][21]:

$$PDF = \frac{Number\ of\ packet\ received\ by\ destination}{Number\ of\ packet\ received}$$

- Average End-to-End Delay: It is defined the all possible delays caused by buffering during route discovery, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times[11][12][21]:

$$AED = \frac{\sum_{i=0}^{n} Time\ packet\ received - time\ packet\ sent}{Total\ number\ of\ packet\ received}$$

- Routing Packet Overhead: It is the total number of transmissions routing packets[12].
- Normalized Routing Load: The number of routing packets transmitted per data packet delivered at the destination[11][12][22].

$$NRL = \frac{Number\ of\ routing\ packets\ sent}{Total\ number\ of\ packets\ received}$$

4. Evaluation Results Using ns-2 Simulator

This section reports the results of the three routing protocols, undergone through simulation compared with the DSDV, DSR and AODV routing protocols. The results are summarized by measuring the performance metrics.

4.1. Packet delivery comparison

First, at simulation run time 200 sec, from the simulation results as shown in Fig.5. It could be noticed that, the DSR and AODV performed particularly well, delivering over 98% of the data packets regardless of mobility rate. Moreover, as shown in Fig.5:(a) the successful delivery rate of DSR and AODV is obviously higher than DSDV. But in Fig.5:(b) it could conclude that, if the node speed increase, the DSDV protocol loss of data packet about 60% that’s means some node are sleep. If the pause time increases to end of SIMT, all packets delivered correctly in case of the DSDV protocol as shown in Fig.5:(c) with the mobility speed of 25m/sec, 15 number of sources and 50 nodes in the network, as we seen the DSR routing protocol delivery of all data packet at end of SIMT, but when the decrease the number of sources equal 8 at the beginning of SIMT the DSDV loss about 40%, AODV loss about 20% and DSR loss about 10% of data packet at end of SIMT. Second, at simulation run time 500 sec, in Fig.6 the packet delivery ratio is independent of offered traffic load, with both protocols DSR and AODV delivering between 98% and 99%. It could be noticed that in Fig.6:(a) DSR and AODV outperforms DSDV by about 2%.

However, in Fig.6:(b) shows when a node speed increased as 40 m/sec the DSDV protocol loss of data packet about 2% that’s means some of nodes are sleep. But in Fig.6:(c) with the mobility speed of 25m/sec, 15 number of sources and 50 nodes in the network, as illustrates that the performance of delivered data packet of AODV routing protocol gets much worse than DSR routing protocol with larger number of sources at the beginning of SIMT, the DSDV do the good performance at higher pause time.

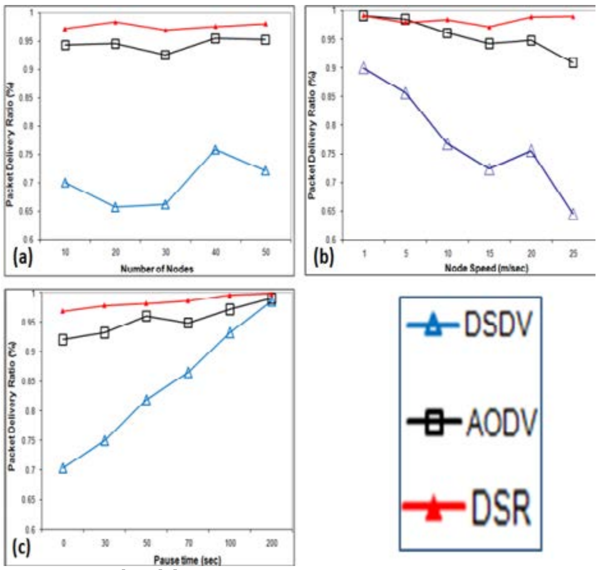

Fig.5: Packet delivery ratio comparison, at SIMT 200sec, as a function of: (a): Number of node. (b): Node speed. (c): Pause time.

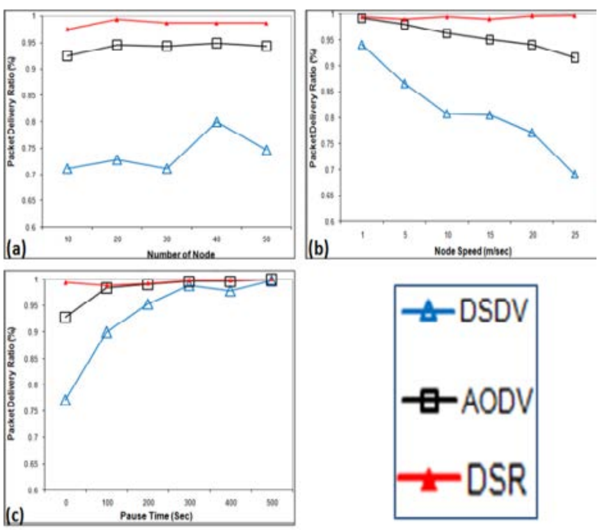

Fig.6: Packet delivery ratio comparison, at SIMT 500 sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time.

Third, at simulation run time 900 sec, in Fig.7 shows the packet delivery ratio for the three routing protocols as functions of node number, node speed and pause time at SIMT 900 sec. However, in Fig.7:(a) shows the rate of DSR and AODV is approach to 95% under the light load of 8 service sources, then DSDV loss about 2% to 3% of data packets, as well as, in Fig.7:(b) illustrates the rate of DSDV descends obviously when the node speed increases because the routing change is frequent and the routing discovery of DSDV become more difficulty. Whereas in Fig.7.(c) with the mobility speed of 25m/sec, 15 number of sources and 50 nodes in the network, at higher pause times the DSR do the best performance of data packets than AODV. However, DSR approach to a good performance when the numbers of sources are increased.

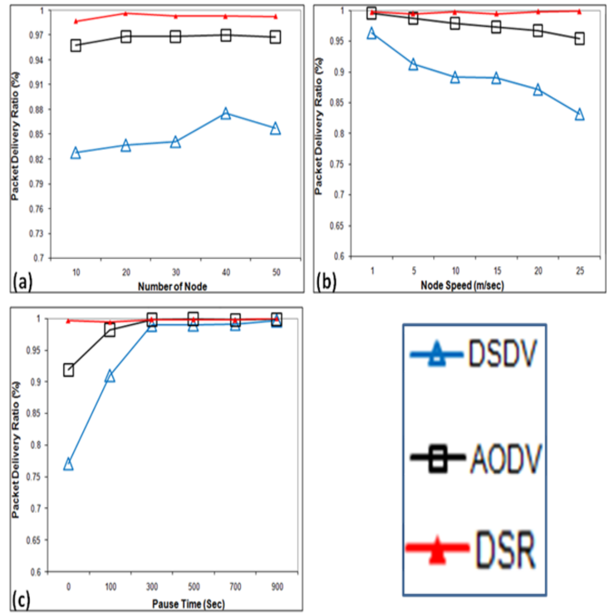

Fig.7: Packet delivery ratio comparison at SIMT 900sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time with 10 sources.

4.2. Average end to end delays comparison

First, at simulation run time 200 sec, the delays for DSDV are lower than DSR and AODV, and the delay of DSR decrease when number of node increase from 20 to 50, It could be noticed that in Fig.8:(a). But in Fig.8:(b) shows when use the 50-node experiments, we have used 8 service source when lower speed to higher speed the delays of DSDV is shortest then DSR and AODV. However, If increase in a pause time at end of SIMTs with the mobility speed of 25m/sec, 15 service source and 50 nodes in the network, the DSDV and DSR protocols are shortest delays then AODV it could be noticed that in Fig.8.(b).

Second, at simulation run time 500 sec, in Fig.9:(a) shows when a number nodes as a parameter, the delays of DSDV is the shortest and the delay of AODV is the longest. The DSDV shows the smaller delay than DSR and AODV, when the node speed is bigger than 30 m/sec, the delay of all protocols are degreasing it could be noticed that in Fig.9:(b). But, when increase in pause time at end of SIMT (decrease in mobility) the DSDV, DSR and AODV are the shortest delays at the 15 service sources, mobility speed of 25m/sec, and 50 nodes in the network, it could be noticed that in Fig.9:(c).

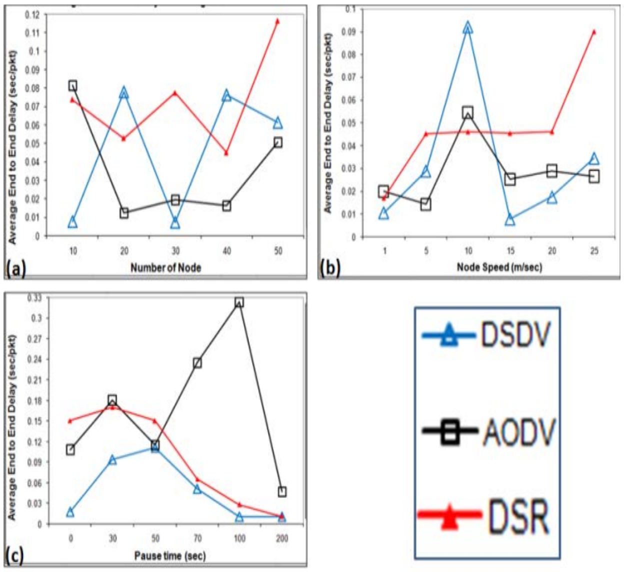

Fig.8: Average end-to-end delay, at SIMT 200sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time.

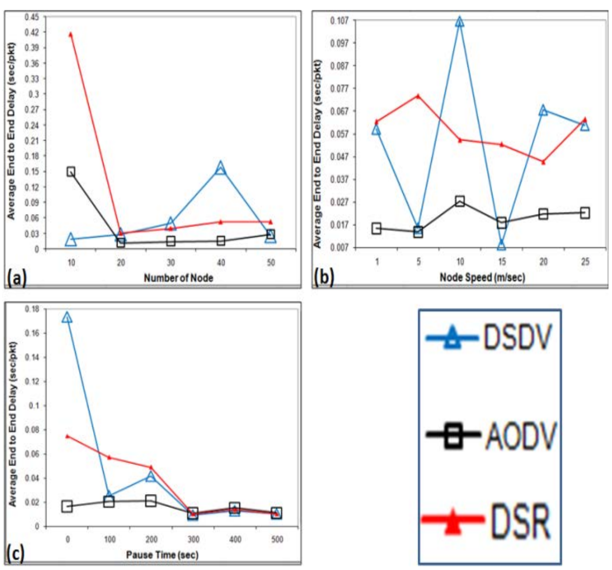

Fig.9: Average end-to-end delay, at SIMT is 500 sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time.

Third, at simulation run time 900 sec, in Fig.10:(a) shows when change of node numbers the delays of DSDV protocols is shortest then DSR and AODV at higher of number nodes equal 60. But in Fig.10:(b) illustrates when node speed as a parameter are change from low to high at 8 service source and SIMT is equal 900sec, the delays of DSDV is shortest and the delay of AODV is a longest. Hence, the AODV is the shortest delay and the DSR is the longest delay it could be noticed that in Fig.10:(c).

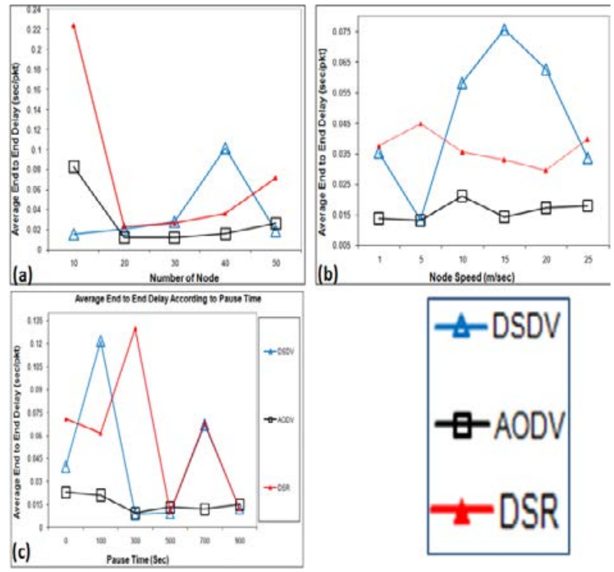

Fig.10: Average end-to-end delay, at SIMT 900sec, as a function of: (a): Node of number. (b): Node speed. (c): Pause time.

4.3. Normalized routing load comparison

First, at simulation run time 200sec, in Fig.11:(a) shows the AODV and DSR are increase dramatically with the number of nodes, where is increasing than DSDV, it is

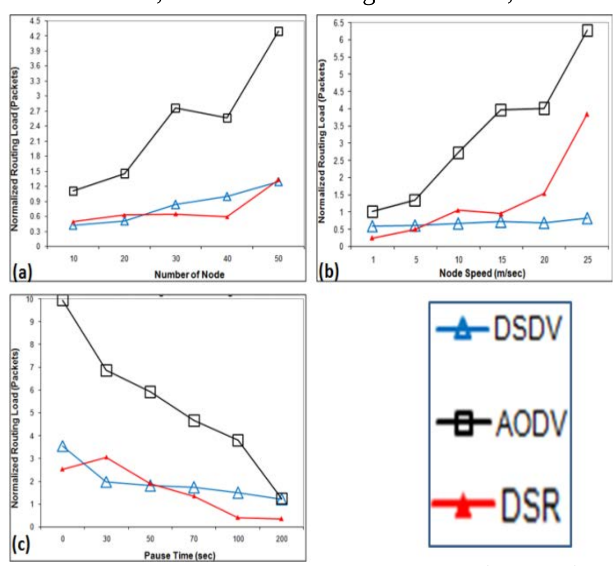

Fig.11: Normalized routing load, at SIMT 200sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time.

decrease when increase the number of nodes. However, when the node speed is increased as shown in Fig.11:(b), the DSDV increasing routing load and the DSR demonstrates significantly lower routing load. But, in Fig.11:(c) illustrates the DSDV routing load fairly stable with an increasing of a pause time; the DSR demonstrates significantly lower routing.

Second, at simulation run time 500 sec, in Fig.12 shows the normalized routing load for the three routing protocols as functions of number of nodes, mobility speed and pause time. The AODV has a higher normalized routing load then DSR and DSDV, when increase of node number and node speed. It could be noticed that in Fig.12: (a, b and c.).

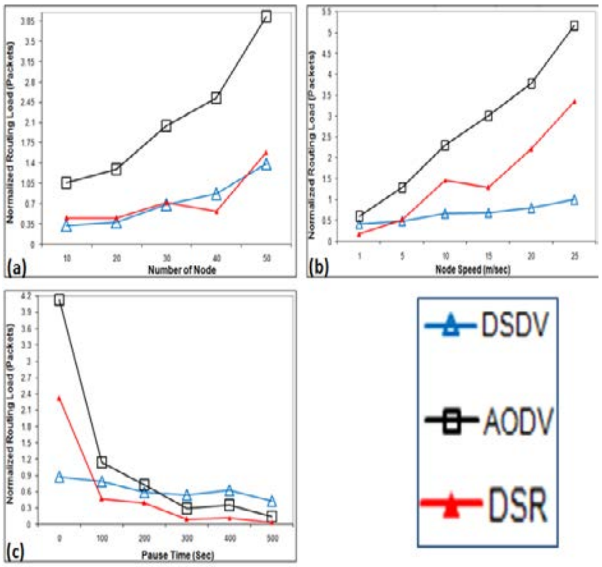

Fig.12.Normalized routing load, at SIMT 500sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time.

Third, at simulation run time 900sec, in Fig.13 as shown when are increasing a number of nodes and mobility speed, it is dramatically increase routing load. It could conclude from Fig.13:(a and b). But, when pause times are increased with decrease mobility at end of SIMT decrease the routing load. It could be noticed that in Fig.13:(c).

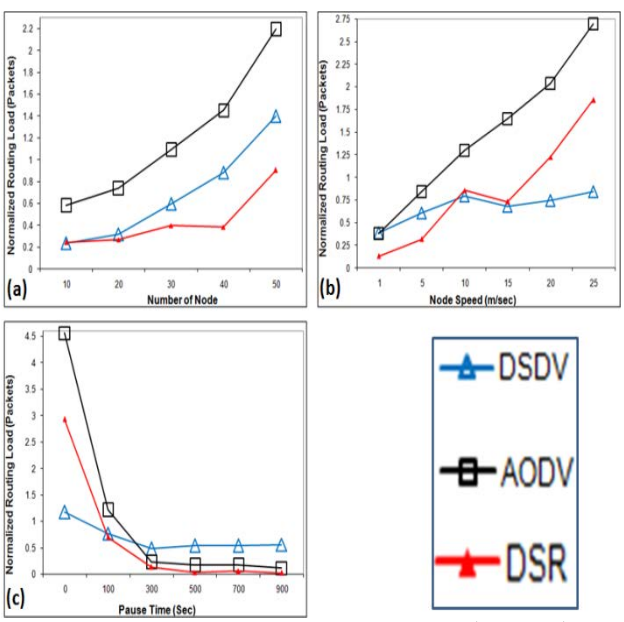

Fig.13. Normalized routing load, at SIMT 900sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time.

4.4. Routing overhead comparison

First, at simulation run time 200 sec, From Fig.14 as shown when a number of nodes as a parameter, the DSR and DSDV are very similar scale plotted has lower overhead then AODV. It could be noticed that in Fig.14:(a). The DSDV are plotted the lower overhead when change of mobility speed as shown in Fig.14:(b). All protocols DSR, DSDV and AODV have lower overhead at end of SIMT equal 200sec. It could be noticed that in Fig.14:(c).

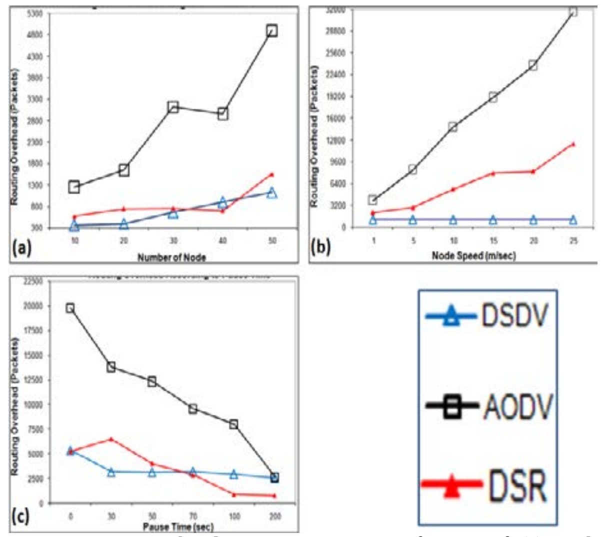

Fig.14: Routing overhead, at SIMT 200sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time.

Second, at simulation run time 500 sec, the DSR and AODV as shown in Fig.15 are increasing routing overhead dramatically, when change of mobility speed as shown in Fig.15:(b) to high, but DSDV has stable routing overhead as shown in Fig.15:(a, b and c).

Third, at simulation run time 900sec, in all cases it could conclude from Fig.16:(a, b and c) the DSDV is increasing routing overhead. Then from Fig.(14, 15 and 16), we concluded that the periodical update process is carried out to maintain the routing information in the table-driven protocols. The table-driven routing protocols are shortest and will not change until the next update process. So the even route length is shorter. In the on-demand routing protocols, the route will be rebuilt when the topology of the network changes. Even if the shortest route is found during the original process of routing discovery, it cannot be maintained because of the nodes are moving all the time. So that the even route length of DSR and AODV is longer than that of DSDV.

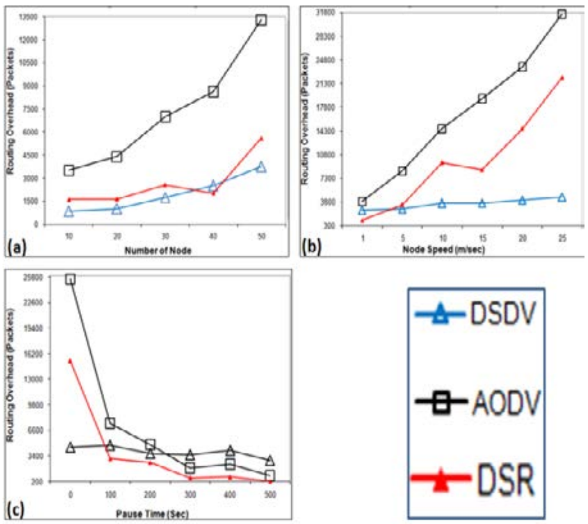

Fig.15: Routing overhead, at SIMT 500sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time.

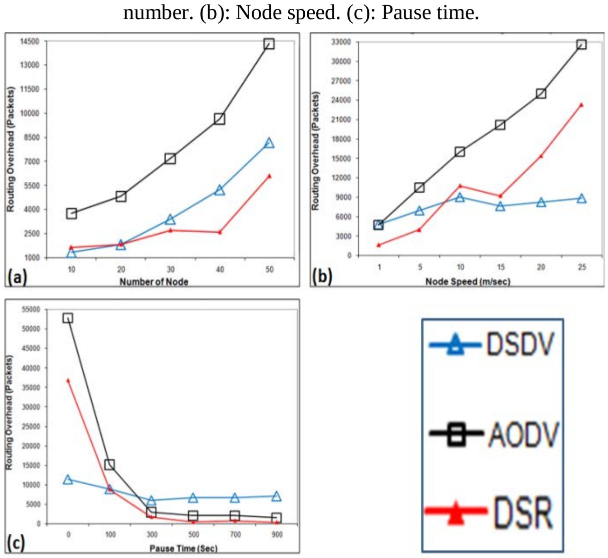

Fig.16: Routing overhead, at SIMT 500sec, as a function of: (a): Node number. (b): Node speed. (c): Pause time.

5. Performance Analysis

The simulation results bring out some important characteristic differences between the routing protocols. The presence of high mobility implies frequent link failures and each routing protocol reacts differently during link failures. The different basic working mechanism of these protocols leads to differences in performance. The lower and higher movement speeds of 10m/s and 25m/s, with differences SIMT (200s, 500s and 900s), when the number of sources is lower equal 8, the performance of DSR and AODV is similar regardless of mobility. But, with the large number of sources equal 15, the AODV starts outperforming DSR for higher mobility scenarios. As the data from the varying sources demonstrate, the AODV starts outperforming DSR at a lower load with a larger number of nodes, but the DSR always demonstrates a lower routing load than AODV. So that, the major contribution of the AODV routing overhead is from route requests, while route replies constitute a large fraction of DSR routing overhead. Furthermore, AODV has more route requests than DSR. Hence, at the higher movement speed of 25 m/s, the DSR is plotted a lower routing overhead packets generated to achieve this level of data packet delivery at 8 sources with comparison of routing overhead of (DSDV and AODV protocols). The DSDV fails to converge below lower SIMTs. So that, at higher rates of mobility (at lower pause time), the DSDV does poorly, dropping to a 4% packet delivery ratio at the lower movement speeds of 10m/s and 6% packet delivery ratio at the higher movement speed of 25m/s and SIMT 200s, whereas at the SIMT 900s dropping to a 2% packet delivery ratio at the lower movement speed of 10m/s. Nearly all of the dropped packets are lost because a stale routing table entry directed them to be forwarded over a broken link. The DSDV maintains only one route per destination and consequently, each packet that the MAC layer is unable to deliver is dropped since there are no alternate routes. For DSR and AODV routing protocols, the packet delivery ratio is independent of offered traffic load, with both protocols delivering between 96% and 100% of the packets in all cases at SIMT 200s and 500s. But when are increasing the number of source equal 15 the DSR delivering between 99% and 100% at SIMT 900s with the medium movement speed equal 10m/s, both protocols delivering between 99% and 100% of the packets in all cases and with the higher movement speed of 25m/s, both protocols delivering between 99.5% and 100% of the packets for 8 sources when a number of node as a parameters. But DSR is delivered between 100% at SIMT 200s. Since DSDV uses the table-driven approach of maintaining routing information, it is better in (lower average end-to-end packet delays), it is not as adaptive to the route changes that occur during high mobility. In contrast, the lazy approach used by the on-demand protocols, the AODV and DSR build the routing information and when they are created make them more adaptive, where the result is better performance (high packet delivery fraction and lower routing overhead).

5.1. Effect of Mobility

In the presence of high mobility, link failures can happen very frequently. Link failures trigger new route discoveries in AODV since it has at most one route per destination in its routing table. Thus, the frequency of route discoveries in AODV is directly proportional to the number of route breaks. The reaction of DSR to link failures in comparison is mild and causes route discovery less often. The reason is the abundance of cached routes at each node. Thus, the route discovery is delayed in DSR until all cached routes fail. But with high mobility, the chance of the caches being stale is quite high in DSR. Eventually when a route discovery is initiated, the large number of replies received in response is associated with high MAC overhead and causes increased interference to data traffic. Hence, the cache staleness and high MAC overhead together result in significant degradation in performance for DSR in high mobility scenarios. In lower mobility scenarios, DSR often performs better than AODV, because the chances of finding the route in one of the caches are much higher. However, due to the constrained simulation environment (lesser simulation time and lesser mobility models), the better performance of DSR over AODV couldn't be observed, where in higher mobility scenarios the routing overhead of DSDV perform better than AODV and DSR.

5.2. Routing Load Effect

DSR has a lower routing load in all cases of sources than AODV and DSDV protocols. This can be attributed to the caching strategy used by DSR, which is more likely to find a route in the cache, and hence resorts to route discovery less frequently than AODV and DSDV.

6. Conclusion

The main objective of this paper is using ns-2 simulator to compare the performance of three routing protocols (DSDV, AODV and DSR) for ad-hoc networks with different SIMTs and connectivity sources.

First, the simulation results bring out some important characteristic differences between the routing protocols, the presence of high mobility implies frequent link failures and each routing protocol reacts differently during link failures. The different basic working mechanism of these protocols leads to the differences in the performance. In the lower and higher mobility speeds of 1m/s and 25m/s, with differences SIMTs (200s, 500s, and 900s), when the number of sources is low, the performance of DSR and AODV is similar regardless of mobility. But, with the lower number of sources the AODV starts outperforming DSR for high-mobility scenarios. As the data from the varying sources demonstrate, AODV starts outperforming DSR at a lower load with a higher speed. DSR always demonstrates a lower routing load than AODV.

Second, the major contribution to AODV routing overhead is from route requests, while route replies constitute a large fraction of DSR routing overhead. Furthermore, AODV has more route requests than DSR. Moreover, at the lower and higher mobility speed of 1m/s and 25m/s, the DSDV is plotted a low routing overhead packets generated to achieve this level of data packet delivery at 8 sources with comparison of routing overhead for DSR and AODV routing protocols. DSDV fails to converge below lower pause times. Whereas, at higher rates of mobility (lower pause times), DSDV does poorly, dropping to a 70% packet delivery ratio and 60% packet delivery ratio at the higher speed of 25m/s for SIMTs (200s and 500s), but at SIMT 900s dropping to a 80% packet delivery ration. Nearly all of the dropped packets are lost because a stale routing table entry directed them to be forwarded over a broken link. DSDV uses table-driven approach of maintaining routing information; it is not as adaptive to the route changes that occur during high mobility. In lower mobility scenarios, DSR often performs better than AODV, because the chances of find the route in one of the caches is much higher. The better performance of DSR over AODV couldn't be observed, were in higher mobility scenarios the routing overhead of DSDV routing protocol perform better than AODV and DSR.

Third, Routing Load Effect DSR has a lower in normalized routing load in all cases of sources than AODV and DSDV protocols. This can be attributed to the caching strategy used by DSR. The DSR is more likely to find a route in the cache, and hence resorts to route discovery less frequently than AODV.

Finally, In the future works, extensive complex simulations could be carried out using this paper code, like comparison with different mobility models. In order to gain a more in-depth performance analysis of secure routing protocols in MANETs, for instance as SAWDV: Secure Authentication Watermarking in Ad-hoc Destination-Sequenced Distance-Vector and SEAD: secure efficient ad-hoc distance vector routing protocols.

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