Comparison of AODV, DSR, and DSDV Routing Protocols in a Wireless Network

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Abstract —In this paper, we analyzed DSR, AODV, and DSDV routing protocols in wireless ad-hoc networks. For comparison purposes, we have taken average throughput, normalized routing load, and End to End (E2E) delay as matrices. We assumed here that node mobility is very low in the network. In respect of simulation time, we have analyzed performance of proactive (DSDV) as well as reactive (DSR, AODV) routing protocols. Varying the simulation times, we analyzed for three protocols. Network-Simulator (NS)-2 is used as a simulation tool.

***Index Terms*—**AODV, DSR, DSDV, average throughput, WMN, MANET

I. Introduction

Wireless mesh network and mobile ad-hoc networks are examples of wireless ad-hoc networks. Routing is one specific process in these networks through which data is send from source to destination using some routing algorithms/protocols. In which network environment which routing protocol is well suited depends upon condition to condition like topology type, number of nodes, routing overhead, types of data to be send etc. Analysis of ad-hoc routing protocols in different network scenarios have been done in various research articles [1]-[3].

A. WMN

WMN is an inherited technology from many existing schemes, thus offers combined merit from generation from these network architectures in supporting next generation wireless communication.

These days, people use cell phone in a server-client mode supported by a Base Station (BS) like WLAN Access Point (AP), the coverage of a single BS is limited and if MH gives out of the service region, the wireless link becomes too weak to maintain. Therefore, a multilink network is built with many BSs to cover a wider region whose combined coverage makes ubiquitous access to MHs, thereby supporting MH's mobility. Leaving from cellular system, WMN employs AP known as IGW (Internet Gateway) to provide network access service for MHs. The IGW does have Internet access that allows useful information for work or leisure; exchange e-mails, talks or chat with friends or update recent events on Facebook or LinkedIn

Thus, MHs access the Internet connection by requesting and creating connection to an IGW, which is installed at a fixed location. IGW receives and accepts multiple connection requests from MHs. Different from point to point communication, the connections between a serving IGW and multiple MHs are simultaneously active, which forms a star like network topology. This kind of mode is very popular and used in many other applications in our daily life.

- WMN uses relay stations known as Mesh Routers (MRs) in ad-hoc mode. A modern relay station (MR) operates like a beacon tower using modulated wireless signals and is able to carry mesh rich information.
- WMNs have heavily inherited characteristics from the ad-hoc networks as on ad-hoc wireless network is formed between MRs that primarily act as a backbone.
- The backbone of a WMN uses ad-hoc routing and self-organization.
- Mesh Routers (MRs) deployment, Internet Gateway (IGW) deployment, channel assignment etc. are the major issues in implementing a WMN.

B. MANET

- Dynamic topologies, energy-constrained operation, limited bandwidth; security threads are the major characteristics of a MANET.
- Some well-known ad-hoc network applications are: collaboration work, crisis-management applications, vehicular area network, personal area networking.
- The challenges in ad-hoc networks that need to be resolved are: scalability, QoS (Quality of Service), client server model shift, security, interoperation with the Internet, energy conservation, node cooperation.
- A MANET environment is characterized by energy-limited nodes, bandwidth-constrained, variable capacity wireless links and dynamic topology, leading to frequent and unpredictable connectivity changes.
- Routing in a MANET depends on many factors including topology, selection of routes request initiator's location, and specific underlying characteristics that could serve as a heuristic in finding the path quickly and efficiently.
- One of the major challenges in designing a routing protocol for MANETs is that a node at least needs to know the reachability information to its neighbours

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for determining a packet route, while the network topology can change quite often in a MANET. Furthermore, as the number of network nodes can be large, finding route to a destination also requires frequent exchange of routing control information among the Mobile Hosts (MHs). Routing protocols can be classified on the basis of topology: proactive routing and reactive routing as shown in Fig. 1. DSDV comes under proactive while DSR and AODV come under reactive category.

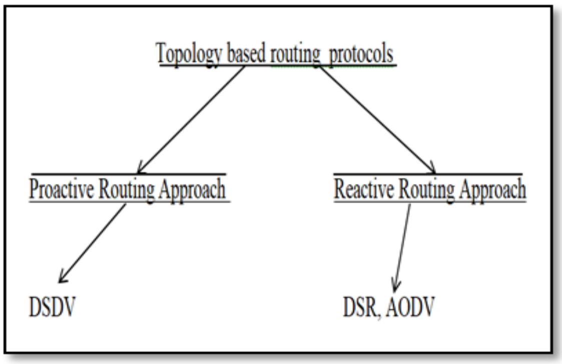

Fig. 1. Classification of routing protocols

DSDV: In this routing protocol, every mobile host in the network maintains a routing table for all possible destinations within the network and the number of loops to each destination. Each entry is marked with a sequence number assigned by the destination mobile host. The sequence numbers enable the mobile nodes to distinguish stable routes from new ones, thereby avoiding the formation of routing loops. Routing table updates are periodically transmitted throughout the network in order to maintain consistency in the tables.

DSR: The DSR algorithm is an innovative approach to routing in a MANET in which nodes communicate along paths stored in source routes carried by the data packets.

In DSR, mobile hosts maintain route caches that contain the source routes which the mobile host is aware of entries in the route cache are continually updated as new routes are learned. The protocol consists of two major phases: route discovery and route maintenance.

When a mobile host has a packet to send to some destination, it first consults its route cache to determine whether it already has a route to the destination. If it has a route to the destination, it will use this route to send the packet. If the mobile host does not have such an unexpired route, it initiates route discovery by broadcasting a route request packet containing the address of the destination along with source mobile host's address and a unique identification number. Each node receiving the packet checks whether it knows of a route to the destination. If it does not, it adds its own address to the route record of the packet and then forwards the packet along its outing links.

A route reply is generated when the route request reaches either the destination itself; or an intermediate node that in its route cache contains an unexpired route to the destination. By the time the packet reaches either the destination or such an intermediate node, it contains a route record with the sequence of hops taken.

Route maintenance is accomplished through the use of route error packets and acknowledgements. When a route error packet is received, the hop in error is removed from the node's route cache and all routes containing the hop are truncated at that point. In addition to route error messages acknowledgements are used to verify the correct operation of the route links.

DSR also supports multi-path in its design as a built-in feature with no need for extra add-ons.

AODV:

- AODV is basically a combination of DSDV and DSR.
- It borrows the basic on-demand mechanism of route discovery and route maintenance from DSR, plus the use of hop-by-hop routing, sequence numbers, and periodic beacons from DSDV. AODV minimizes the number of required broadcasts by creating routes only on-demand basis, as opposed to maintaining a complete list of routes as in the DSDV algorithm.
- AODV supports only symmetric links with two different phases:
  - ✓ Route discovery, Route Maintenance and
  - ✓ Data forwarding.

When a source mobile host desires to send a message and does not already have a valid route to the destination, it initiates a path discovery process to locate the corresponding mobile host. It broadcasts a route request (RREQ) packet to its neighbors, which then forwards the request to their neighbors, and so on, until either the destination or an intermediate mobile host with a fresh enough route to the destination is reached.

- 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 which is incremented for every RREQ the node initiates.
- During the process of forwarding the RREQ intermediate nodes record in their route tables the address of the neighbour from which the first copy of the broadcast packet was received, thereby establishing a reverse path. If additional copies of the same RREQ are later received, they are discarded. Once the RREQ reaches the destination or on intermediate node with a fresh enough route, the destination/intermediate node responds by unicasting a route reply (RREP) packet back to the neighbour from which it first received the RREQ.
- AODV is designed for unicast routing only and multi-path is not supported. In other words, only one route to a given destination can exist at a time.

We have structured this paper into five sections. Overview of related work is discussed in section II. Section III describes the simulation methodology with parameters. Simulation environment and results are discussed in section IV. Finally, a conclusion is summarized in section V.

II. Literature Survey

In [4], the performance of TORA, DSR, and AODV has been analyzed in a wireless sensor network. The presence of energy holes problem is assumed. Average energy consumption, End-to-End delay, PDR (Packet Delivery Ratio) of each protocol has been demonstrated under different node density. The simulation work is implemented using network simulator NS-2.34. AODV and DSR maintained higher packet delivery ratio due to their on demand nature and their fast recovery when the nodes were depleting their energy.

In [5], on account of varying the number of holes, speed and pause time, a comparison of DSR, DSDV, and AODV is carried out. Performance matrices for comparing were considered as packet delivery fraction (PDF), E2E delay (End to End delay) and NRL (normalized routing load). Number of nodes and pause time were taken as variable parameters. Random way point was used as a node movement model. In this work, AODV is declared as a faster protocol as compared to DSDV and DSR.

In [6], a comparison work for AODV, DSDV, and DSR is carried out. Considering different parameters like number of nodes vs throughput, number of nodes vs packet drop, packet received vs propagation delay, throughput vs simulation, the best protocol was declared as AODV. In case of number of nodes vs packet drop, DSR was declared the best routing protocol.

Performance analysis of DSDV, AODV, and DSR is taken-out in wireless ad-hoc network in [7]. A simulation work for 30 nodes (using OPNET) is carried out. Varying the number of nodes, the performance analysis of three protocols (based on throughput, packet dropped) is done.at the high mobility mode, AODV and DSR performs the best as comparison to DSDV.

In [8], varying the queue size, the comprehensive comparison of AODV, DSR is taken out.

For simulation, AODV routing protocol is declared as best as it is loop free. Step by step simulation work (using optimized network engineering tool) is explained and finally results are declared.

In [9], varying the simulation times, performance of Ant Hoc Net are examined at different metrics like data rates, loss rate, jitter, throughput, speed, pause time, packet delivery ratio.

In [10], Asma Tuteja *et al*. evaluated the comparison of three routing protocols AODV, DSDV, and DSR using NS-2.34. In this article, Asma Tuteja etc. identified that throughput for DSDV is very low as compared to AODV and DSR routing protocols. In case of E2E delay, DSR performs better than AODV. But performance of all three protocols is degrading as the mobility of nodes is increased.

In [11], three routing protocols (DSR, DSDV, and AODV) have been simulated using NS2. E2E delay, throughput, packet loss are the main metrics which were considered for performance comparison purposes.

Kapang Lego *et al*. described applications, challenges, classification of routing protocols in MANET. At last of this article, performance of AODV, DSR, and DSDV is evaluated in network simulator environment. Packet delivery ratio, average end-to-end delay and throughput metrics are used as performance metrics. This work concluded that end-to-end delay of DSDV is very high at the lowest pause time. As compare to DSDV and AODV, DSR outperform in terms of end-to-end delay. At last, DSR is identified as identified as best routing protocol in different network scenarios [12].

A comparison work analysis is carried out on the basis of varying the number of nodes in [13]. Performance of DSR and AODV evaluated on the basis of performance metrics like packet delivery ratio, packet drop ratio, end-to-end delay, throughput, false packet. Different quantities of nodes (30 nodes, 40 nodes, 50 nodes, 60 nodes, and 70 nodes) were taken at different network scenarios. AODV routing protocol is identified as best routing protocol than DSR.

Fan-shuo KONG *et al.* [14] analyzed the performance of DSR, AODV and DSDV in a mobile ad-hoc network. At the different values of pause times (0,150, 300, 450, 600, 750, 900), simulation is carried out. AWK script, setdest, cbrgen, tcl methodologies are used for preparing the evaluation setup. The performance metrics like packet delivery ratio, average end-to-end delay of data packets, normalized routing overhead were used for comparison purposes, this work is concluded that AODV got the similarly better packet delivery ratio than DSDV. The routing overhead of DSR is less than DSDV and AODV.

K. Natarajan *et al*. [15] analyzed the performance evaluation of AODV, LAR, FSR, ZRP, DSR, and DSDV under different scenarios of the network. Performance metrics used for simulation are used: throughput, packet delivery, routing overhead, end-to-end delay. Three types of network scenarios were used: low mobility, medium mobility, and high mobility. In TCP and UDP scenarios, DSDV and LAR outperforms respectively. Considering the traffic type TCP and metrics as PDR, throughput, overhead, delay, the routing protocols AODV, DSR, LAR, and DSDV performs the best, but at some conditions ZRP gives the low performance.

S. Mohanpatra *et al*. [16] evaluated the performance analysis of DSR, OLSR (optimized link state routing), and DSDV using the some performance metrics like end-to-end delay (EED), throughput, control overhead, packet delivery ratio (PDR). Varying the number of nodes, pulse time and simulation area, simulation work is carried out in MANETs. OLSR routing protocol is identified as outperformance protocol at high mobility conditions as compared to DSR and DSDV routing protocols.

Sukhdev Singh Ghuman [17] analyzed the design, performance evaluation, working principal of DSR, advantages, disadvantage of dynamic routing protocol (DSR) in a wireless ad-hoc network as well as multi-hop wireless ad-hoc networks.

III. Simulation Setup

We have used network simulator NS-2 [18], [19] in our work. NS-2 is a suitable simulator for analyzing the routing protocols in a wired as well wireless environment. Simulation parameters setup is depicted in Table I and Table II. We simulated three routing protocols AODV, DSR, and DSDV in network simulator version 2.34as shown in Fig. 3. We used 9 nodes and layout topology for nodes is grid topology i.e. 3×3(as shown in Fig. 2). We used two udp connections with udp packet size 1500 bytes. Network area for simulation is taken as 200×200. We simulated AODV, DSR, and DSDV at different simulation times from 25s to 175s. Traffic type is cbr with cbr packet size 512. The layout of nodes is shown in figure. TCL scripts are written for AODV, DSR, and DSDV routing protocols. Mobile node parameter setup in tcl scripts are depicted in Table II.

To calculate the performance metrics such as NRL, PDR, E2E delay, and throughput, awk scripts [20] were written. Mobile node parameters setup in tcl scripts is depicted in table. Two ray ground is used as a radio-propagation model. We run tcl scripts in ns2 varying the simulation time for each protocol keeping other parameters as constant. Finally we recorded all results in tabular forms and graphs were designed using jtaran, gnuplot, xgraph softwares.

TABLE I: SIMULATION PARAMETERS SETUP

Description	Parameters
Channel/WirelessChannel	Channel type
Propagation/TwoRayGround	Radio-propagation model
Phy/WirelessPhy	Network interface type
Mac/802_11	MAC type
Queue/DropTail/PriQueue	Interface queue type
LL	Link layer type
Antenna/OmniAntenna	Antenna model
50	Max packet in ifq
9	Number of mobile nodes
AODV,DSR, DSDV	Routing protocol
867	X dimension of topography
561	Y dimension of topography
25s,50s,75s,100s,125s,150s,175s	Time of simulation end

TABLE II: MOBILE NODE PARAMETER SETUP IN TCL SCRIPTS

$ns node-config -adhocRouting	$val(rp)
-llType	$val(ll)
-macType	$val(mac)
-ifqType	$val(ifq)
-ifqLen	$val(ifqlen)
-antType	$val(ant)
-propType	$val(prop)
-phyType	$val(netif)
-channel	$chan
-topoInstance	$topo
-agentTrace	ON
-routerTrace	ON
-macTrace	ON
-movementTrace	ON

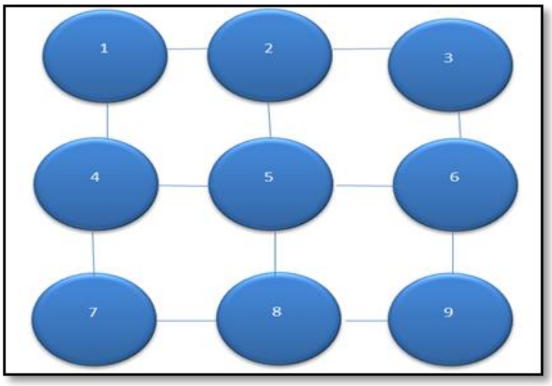

Fig. 2. Layout of nodes

IV. Results and Discussion

We analyzed individually AODV (Table III) as the simulation time is increased, the PDR is decreased slightly, but numbers of received packets are increased. In case of DSR, as simulation time is increased, PDR is slightly increased and also numbers of packets received are increased (as shown in Table IV. In case of DSDV (Table V), as the simulation time is increased, the PDR value is decreased, but numbers of packet received are increased.

TABLE III: AODV SIMULATION DATA

Simulation Time	Packet sent	Packet received	PDR	PACKET Forwarded
25	12208	713	1712.20	3506
50	24416	1431	1706.22	7007
75	36622	2156	1698.61	10501
100	48830	2889	1690.20	13990
125	61036	3618	1687.01	17473
150	73244	4363	1678.75	20948
175	85450	5108	1672.85	24427

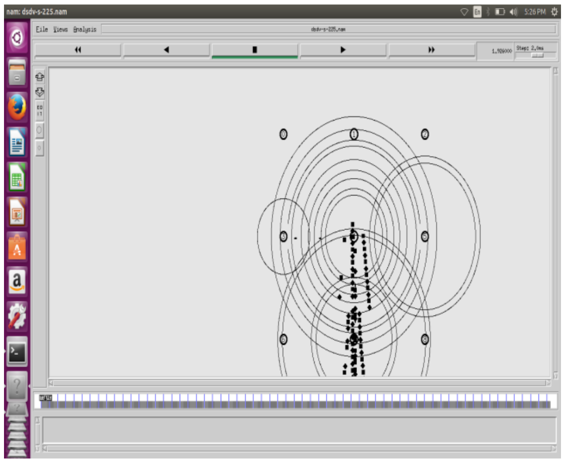

Fig. 3. Nam window

When we analyzed about the throughput of three protocols (AODV, DSR, DSDV), the throughput is slightly increased (little bit) in case of AODV, but it decreased in case of DSR. Throughput of DSDV routing protocol is decreased as the simulation time is (as depicted in Table VI, Fig. 6 and Fig. 10).

TABLE IV: SIMULATION DATA FOR DSR

Simulation time	Packet sent	Packet received	PDR	Packet forwarded
25	12208	976	1250.82	3233
50	24416	1916	1274.32	6497
75	36622	2835	1291.78	9783
100	48830	3765	1296.95	13059
125	61036	4693	1300.58	16336
150	73244	5618	1303.74	19621
175	85450	6550	1304.58	22898

TABLE V: SIMULATION DATA FOR DSDV

Simulation time	Packet sent	Packet received	PDR	Packet forwarded
25	12208	125	7154	872
50	24416	397	6150.13	1779
75	36622	768	4768.49	5585
100	48830	1536	3179.04	9004
125	61036	2501	2440.46	12241
150	73244	3485	2101.69	15439
175	85450	4520	1890.49	18606

TABLE VI: AVERAGE THROUGHPUT (KBPS)

Simulation time	AODV	DSR	DSDV
25	114.11	156.45	25.67
50	114.49	153.31	31.82
75	114.99	151.25	41.29
100	115.58	150.65	61.45
125	115.78	150.21	80.03
150	116.35	149.83	92.94
175	116.77	149.73	103.32

TABLE VII: NORMALIZED ROUTING LOAD

Simulation Time	AODV	DSR	DSDV
25	0.034	0.047	0.21
50	0.017	0.024	0.191
75	0.011	0.016	0.121
100	0.008	0.012	0.070
125	0.007	0.010	0.051
150	0.006	0.008	0.041
175	0.005	0.007	0.036

TABLE VIII: E2E DELAY (MS)

Simulation time	AODV	DSR	DSDV
25	2323.83	2442.25	1981.74
50	2387.25	2829.09	1981.74
75	2423.63	2961.97	2210.73
100	2435.29	3025.91	2543.01
125	2454.6	3064.43	2811.11
150	2458.72	3087.23	2882.68
175	2454.67	3133.38	3014.98

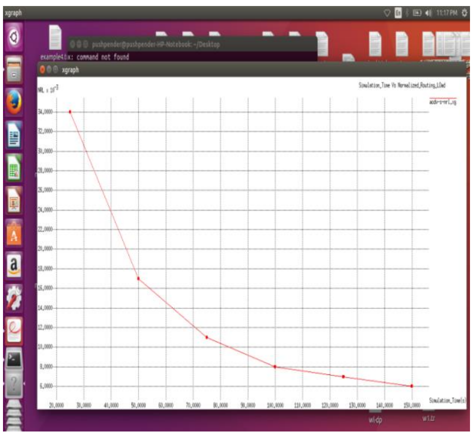

Fig. 4. Simulation time Vs NRL (AODV)

In case of AODV, DSR, and DSDV (Table VII, Fig. 4 and Fig. 9), normalized routing load is decreased as the simulation time is increased. E2E delay for AODV, DSR, and DSDV is increased as simulation time is increased (as shown in Table VIII and Fig. 5 and Fig. 8).

The comparison of packet delivery fraction for AODV and DSDV routing protocols is shown in Fig. 7. PDF is gradually increased as simulation time is increased.

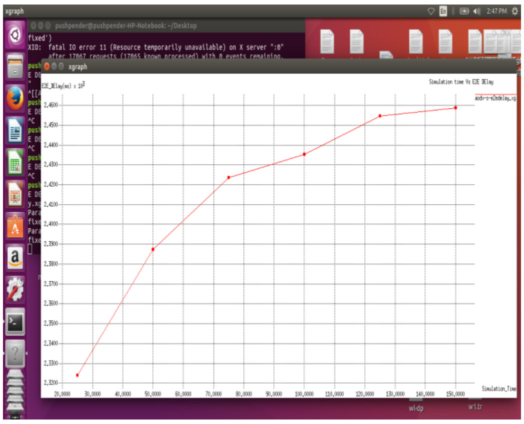

Fig. 5. Simulation time Vs E2E delay (AODV)

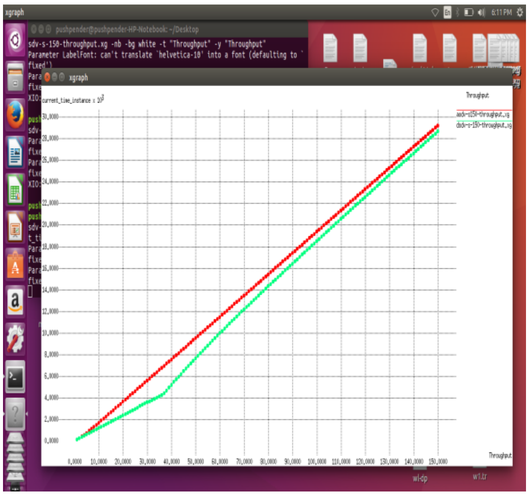

Fig. 6. Simulation time Vs throughput(AODV & DSDV) at 150s simulation time

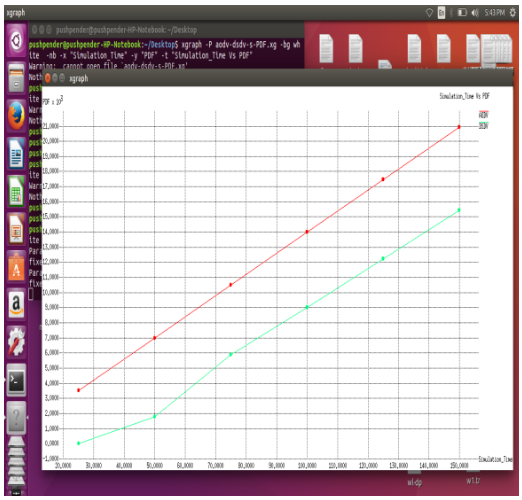

Fig. 7. Simulation time Vs PDF (AODV &DSDV)

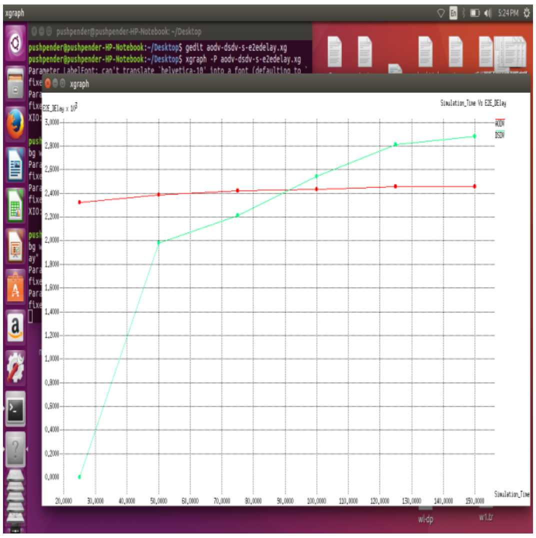

Fig. 8. Simulation time Vs E2E delay (AODV &DSDV)

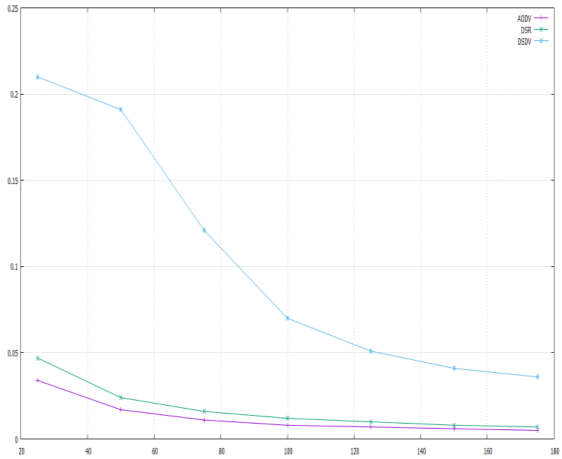

Fig. 9. Normalized routing load (AODV, DSR, DSDV)

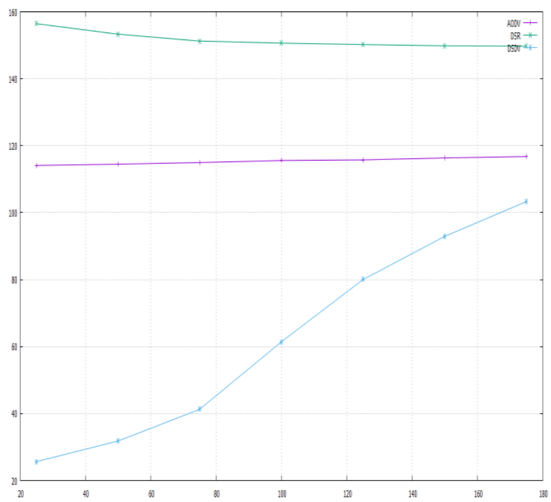

Fig. 10. Average-throughput

V. Conclusion

In this paper, we have simulated three routing protocols named as DSR, AODV, and DSDV. Taking number of performance matrices like average throughput, end-to-end delay, we analyzed the comparison at different simulation times. In our future work, we will consider other performance metrics at different network scenarios like number of nodes and pause time. At the assumption that node mobility is very low, the PDR for AODV and DSDV is decreased but increased for DSR. Throughput for AODV and DSDV is better as compared to DSR, at higher values of simulation times.

For all three protocols, NRL is slightly low as the simulation time values are higher. But E2E delay value is high as the simulation time high.

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