Reactive and Proactive Route Evaluation in MANET

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Abstract —Ad hoc networks are established in small local areas and need very low infrastructure**.** There is no centralized control system for data communication. Due to frequently changing the position of the nodes create so many challenging issues like throughput, data loss and increase the packet delivery fraction. In this paper, An Ad Hoc On-Demand Distance Vector, Ad hoc On demand Multipath Distance Vector, and Multi-path dynamic address routing protocols have been analyzed based on various data rates. The evaluation parameters are taken as: average throughput, average delay, packet delivery ratio, packet delivery fraction and latency. Implementation research work has been simulated on network simulator 2.35. It is analyzed that Ad hoc On demand Multipath Distance Vector routing protocol performs better in terms of packet delivery ratio and received packets as compared to Ad Hoc On-Demand Distance Vector and Multi-path dynamic address routing protocols.

Index Terms—Throughput, delay, latency, ad hoc networks, packet delivery ratio

I. Introduction

Wireless ad hoc networks are more frequently used due to its short time deploy-mentation. In wireless ad hoc networks, nodes can communicate to each other in the network inside as well as outside [1]. Frequently changing of topology is one feature of mobile ad hoc networks. Fast speed of mobile nodes in ad-hoc networks is one reason due to which performance of networks during communication through various routing protocols has been degraded up to certain limit. To achieve a better performance, confusion has been created that which one of the routing protocols should be used and at what data rates so that maximum throughput can be achieved without losing data packets. Different routing protocols performs different depends upon the nature of network, type of network scenario and time for which data communication have to be performed. We cannot declare that a particular routing protocol will perform well in all network conditions. A lot of research work has been conducted in respect of performance evaluation of routing protocols for wireless networks. Some researchers investigated for proactive routing protocols while others worked for reactive and hybrid routing protocols. Evaluations of three routing protocols (AODV, AOMDV, and MDART) have been carried out in this research work based on certain performance parameters. AODV and AOMDV both routing protocols are reactive protocols while MDART having proactive routing capacity. AOMDV is the enhanced version of AODV routing protocol while MDART is designed over DART (Dynamic Address Routing). MDART uses the hop by hop routing approach [2]. AOMDV and MDART have so many similar features for data transmission like multipath [3], [4]. Varying the data rates, performance has been observed and results are tabulated for analysis purpose. Rest of this paper is organized in V sections. Section II presents the related research work performed by researchers in terms of network scenarios, different performance parameters. Research methodology and simulation parameters (with their values) applied for this work is elaborated in Section III. For all results and discussion part is presented in Section IV. This paper is concluded by Section V.

II. Literature Survey

Ad hoc on demand multipath distance vector (AOMDV) routing protocol in respect of its multi path routing capacity in a high speed wireless network is elaborated and discussed in [5]. Also a comparison work has been carried out based on performance parameters like throughput, delay, and normalized routing load. By varying the speed, simulation time, pause time, performance has been evaluated. It was concluded that in respect of high speeds of nodes, packet dropped rate for AOMDV is very less and also throughput achieved by it is excellent [5].

A.A.A. Radwon, *et al*. [6] evaluated AODV, DSR (Dynamic Source Routing), and location aided routing (LAR) protocols based on 18 performance metrics like throughput, average end to end delay, data packets retransmitted. A comparative study is performed on GloMoSim simulator. By varying the network size and pause time, different network scenarios have been generated. N terms of normalized routing overhead, LAR protocol performs better while AODV routing protocol outperforms LAR and DSR in respect of throughput and packets retransmission.

In [7], research work has been carried out for health care applications by considering ad hoc wireless local area network. AODV and DSDV (Destination-Sequenced Distance-Vector Routing) routing protocols have been evaluated based on throughput, packet delivery ratio, and end to end delay. By varying the pause time and node density, different network scenarios have been generated. All type of simulation work is simulated on network simulator NS-2 (Network Simulator -2). This research work concludes that AODV shows better results as

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compared to DSDV routing protocols. AODV is strongly recommended for communication purposes in healthcare applications.

In [8], a comparison work has been carried out for AODV, DSR, and zone routing protocol (ZRP). Based on performance metrics like average end to end delay, average jitter, energy consumption, packet delivery ratio, and throughput, protocols are evaluated. All the simulation work is conducted on Qualnet network simulator. It was concluded that in small area networks, DSR performs well as compared to AODV. For higher scalability area networks, AODV routing protocol is strongly recommended. In terms of energy consumption, AODV produces better results as compared to ZRP and DSR routing protocols.

An evaluation work is conducted in [9] for TORA (Temporally Ordered Routing Algorithm), AODV, and OLSR (Optimized Link State Routing Protocol) routing protocols. Performance parameters in this research work are considered as PDR, E2E delay, and throughput. It was observed that proactive routing protocol OLSR outperforms than TORA and AODV routing protocols in dynamic changing network topology.

Srinivas Kanakala *et al*. [10] proposed an enhanced version of COPE (Cooperative Power and Energy-efficient) protocol for reducing the energy consumption using software coding at cluster head side and incorporating the best features of cluster based routing protocol (CBRP), COPE routing protocol is enhanced. The proposed energy saving ECCRP (energy-efficient coding aware cluster based routing protocol) has the capability to make network lifelong. A weighted clustering algorithm has been applied to design the proposed protocol which makes it saving the energy consumption. Also a comparison work has been carried out for CBRP and ECCRP with performance parameters like nodes, number of packets delivered, and energy consumption.

Based on routing overhead and route optimality, a performance evaluation framework has been proposed by Muhammad Saleem [11] that is capable to evaluate AODV-LL (AODV-Link Layer), DSR, Gossiping, and DSDV algorithms. Simulation work is conducted on network simulator NS-2. Also a comparison work for AODV-LL, DSR, and DSDV routing protocol in terms of proposed frame has been carried out.

By considering the network load, route evaluation work is presented for wireless mesh networks [12]. Also an enhanced version of MAODV routing protocol is proposed. The proposed protocol is simulated and evaluated in network simulator NS-2. By considering the performance metrics like throughput, end to end delay, delivery ratio, a comparison work for proposed protocol and existing MAODV (Multicast Ad hoc On-Demand Distance Vector) routing protocol has been performed. By varying the traffic load 5-30 packets/s, network scenario has been generated. In terms of network performance, proposed protocol selects an appropriate route for data transmission.

Jeevaa *et al*. proposed an energy efficient routing protocol in wireless ad-hoc networks [13]. The proposed protocol has been designed by considering the concept of discovering routes based on energy level and the link quality. By varying the pause time and considering the performance metrics like end to end delay, total energy consumption, average residual energy, packet delivery ratio, normalized routing load, packet drop ratio, proposed protocol has been evaluated. The proposed protocol shows better results in respect of quality of service (QoS) metrics as compared to existing routing protocols like AODV which considers only single metric for route chosen.

In [14], bandwidth based evaluation study has been carried out in wireless ad hoc networks having multi-hop routing process. Bandwidth measurement techniques have been studied deeply in respect of methods, implementation process, metrics, and calculations. Self-loading periodic streams technique (SLoPS) is used to measure the bandwidth from end to end. This technique is more popular in a current research scenario. By varying the pause time 0-900 seconds, the above discussed measurement technique is analysed with AODV, DSR, and DSDV routing protocols. It was declared that SLoTS technique shows better results in terms of all mobility rates, when used with DSR routing protocol. SLoTS outperforms when used with AODV in terms of all mobility rates and movement speeds.

Qualitative as well as quantitative route evaluation has been presented for AODV routing protocol [15]. Routing protocols such as AODV, DSR, and TORA have been evaluated by considering performance parameters like end to end delay, packet delivery ratio, network life time and scalability. Each protocol have its own capacity to perform depends upon network scenario. Overall AODV routing protocol was recommended as compared to DSR and TORA routing protocols.

By varying node density and send data rate, in different network scenarios AODV and DSDV routing protocols have been evaluated [16]. Performance metrics are considered as: throughput, average end to end delay, and packet delivery ratio. All the results are generated using network simulator NS-2. At lower data rates, AODV routing protocol performs well, but as data rate is gradually increased, DSDV outperforms AODV.

A detailed survey has been conducted in [17] for mobile ad hoc networks. Quality of service (QoS) parameters for evaluating the performance of routing protocols has been analysed. Especially throughput has been observed for TORA, AODV, and DSR routing protocols. Behaviour of proactive and reactive routing protocols has been changed depends upon network scenarios. It has been summarized that at higher node density, TORA shows better results while at low node mobility in small networks, DSR outperforms the AODV routing protocol.

Insaf Sassi *et al*. [18] presented a detailed study and analysis work for networked robots in wireless networks.

Evaluation work was carried out in terms of quality of service parameters with the help of Markov model. Also a detailed study and investigation work is carried out for Markov model.

Bellmanford, FSR, and AODV protocols have been investigated on GloMoSim simulator in MANET environment [19]. The main evaluation metrics were used as: normalized application bytes received and application byte delivery ratio. AODV outperforms the Bellman ford algorithm and FSR. At lower node densities, LAR performs well while AODV shows better results at higher node density. Both AODV and LAR perform well at higher speeds of nodes.

To ensure the packet delivery, a stable backup scheme has been introduced by Fan Zhang [20]. The proposed scheme is evaluated and compared in terms of average delay, packet delivery ratio. Based on simulation results conducted in network simulator NS-2, it has been declared that proposed stable backup scheme works better as compared to existing routing mechanism.

Chansu Yu *et al.* [21] proposed a study on energy efficient routing protocols for MANETs. A detailed survey has been conducted for FAR (flow argumentation routing), OMM (online max-min), RAR (retransmission energy aware routing), GAP (Geographic adaptive fidelity), PEN (Prototype embedded network), MER (Minimum energy routing) protocols. Basic criteria for survey as considered as: classification, features, drawbacks, similarities, and architectural working principles.

III. METHODOLOGY

Three routing protocols have been simulated at network simulator NS-2.35 for simulation time of 100 seconds. Network simulator NS-2 is more appropriate simulator to simulate the mobile ad hoc network and most likely by the researchers [22]. Randomly network topology is generated for 50 nodes. UBUNTU 16.4 operating system was used to run network simulator. For simulation work, 6 tcl scripting files were written by varying the data rates from 2 Mb to 12 Mb. For calculating the average throughput, average end to end delay, normalized routing load, PDF (packet delivery fraction), PDR(packet delivery ratio), total number of packets dropped, received packets, awk script [23] files were used and results were tabulated. For visualizing the resulted data into graphical form, XGRAPH tool was used. TCP (Transmission Control Protocol) and UDP(User Datagram Protocol), both types of connections were created for TCP connections and UDP connections; packet size is kept as 512 Mb. Cbrgen tool is used for traffic scenario generation and connection generation of TCP, CBR (Constant bitrate). Setdest tool is applied for node movements in wireless scenarios. Wireless network with 20 TCP and 20 UDP connections is established for 50 moving nodes having maximum speed of 60 m/s.

Simulation Setup:

All the simulation parameters are depicted in Table I. Network size (X=1171 m, y=590 m) is created with 40 TCP and UDP connections. Two Ray Ground and Omni Antenna models have been applied as radio propagation model and antenna model respectively. Mobility model is designed with maximum speed 60 m/s and pause time as 0s. Data packets are settled as 512 Mb both for TCP and UDP connections. Different network scenarios are simulated by varying the data rates from 2 Mb to 12 Mb. All routing protocols (AODV, AOMDV, and MDART) have been simulated for 100 seconds as simulation time. All the wireless channels are established with 25Mb bandwidth and 1Mb basic rate.

TABLE I: SIMULATION PARAMETERS

Parameter type	Value
Operating system	Ubuntu 16.5
Simulator type	Network Simulator NS-2.35
Routing protocols	AODV, AOMDV, MDART
Channel type	Wireless
Bandwidth	25 Mb
Basic rate	1 Mb
Radio propagation model	Two Ray Ground
Mac Type	802.11
Interface Queue type	Priority Queue
Link layer type	LL
Antenna model	Omni Antenna
Queue length	50 packets
No. of mobile nodes	50
Network topology size	X=1171m, y=590m
RTS Threshold value	4000
Data rate	2, 4, 6, 8, 10, 12 Mb
Pause time	0s
Max. Speed	60 m/s
Maximum connections	40(TCP=20, UDP=20)
Packet size	512 Mb(both for TCP, UDP)
Total sources in TCP connections	14
Total sources in UDP connections	13
Send rate(in UDP connections)	0.1
Seed (in UDP connections)	1.0
Max. packets(in UDP connections)	10000
Interval(in UDP connections)	0.1
Simulation Time	100s

IV. RESULTS AND DISCUSSION

Performance evaluation and result analysis work has been conducted for AODV, AOMDV, and MDART routing protocols. Performance metrics such as normalized routing load, latency, dropped packets; received packets, average throughput, and average end to end delay are verified for above protocols. By varying the data rates, in different network scenarios, graphs are generated and results are discussed in this section.

Total Dropped packets: Total dropped packets with respect to data rate, is presented in Fig. 1. In case of AODV routing protocol, as data rate is increased, total number of dropped packets are also increased. But it is different in case of AOMDV and MDART routing protocols. Here total dropped packets are fluctuating as the data rate is varying. Overall dropped packets are very less for MDART as compared to AODV and AOMDV routing protocols.

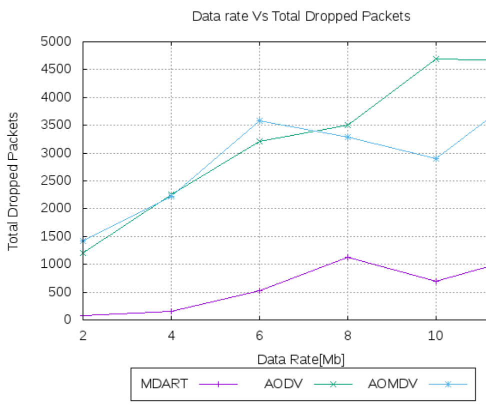

Fig. 1. Total dropped packets

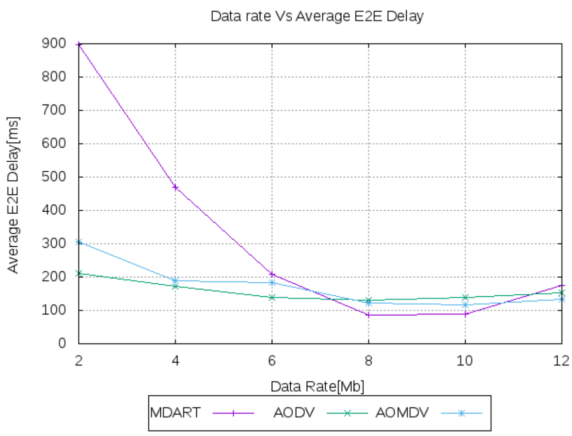

Fig. 2. Data rate Vs average E2E delay

Average E2E delay: Average end to end delay has been depicted in Fig. 2. Graph clearly indicates that as data rate from 2 Mb to 10 Mb is increased, average end to end delay is decreased for AOMDV, but in case of AODV and MDART, it is fluctuating. When data rate is increased 2Mb-12Mb, for all routing protocols (AODV, AOMDV, and MDART), average end to end delay is suddenly increased. In this evaluation work in respect of average end to end delay, MDART comes under worst case, while it is better for AODV routing protocol.

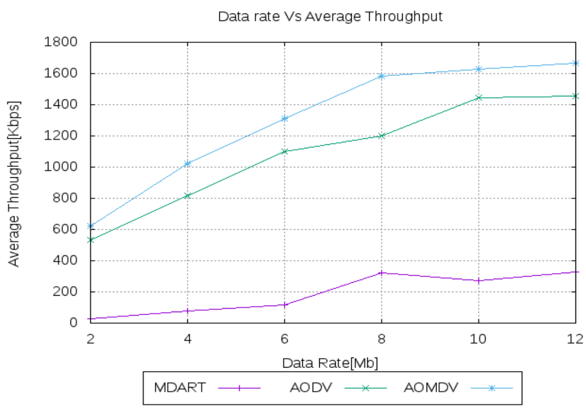

Fig. 3. Data rate Vs average throughput

Average throughput: Average throughput is presented in Fig. 3. Average throughput for AODV, AOMDV, and MDART routing protocols has been evaluates in respect of data rate 2Mb-12Mb. For AODV and AOMDV, as data rate is increased, average throughput is also increased. Same case is repeated in case of MDART, when data rate is increased from 2Mb to 10 Mb. But suddenly, it is decreased from 10 Mb to 12Mb data rates. AOMDV shows better average throughput as compared to AODV and MDART routing protocols. In this evaluation work, MDART comes under worst case in respect of average throughput.

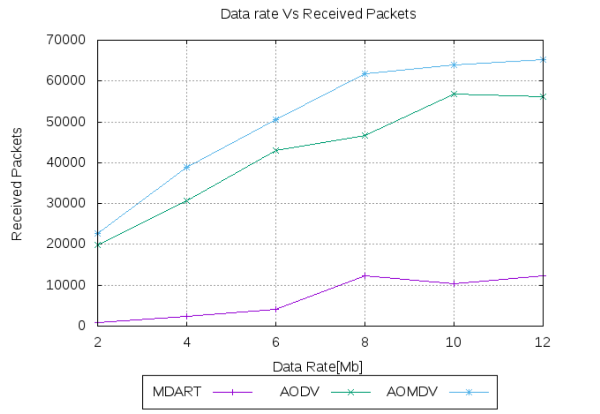

Fig. 4. Total received packets Vs data rates

Received Packets: Total received packets are shown in Fig. 4. Received packets for MDART are very less at all data rates from 2 Mb to 12 Mb. In case of AODV and MDART, received packets are increased as data rate is increased, but suddenly it decreased from data rate 10 Mb to 12 Mb. In case of AOMDV, as data rate is increasing, received packets are fluctuating. It is lowest at 2 Mb, while at date rate 2Mb, received packets are at peak stage.

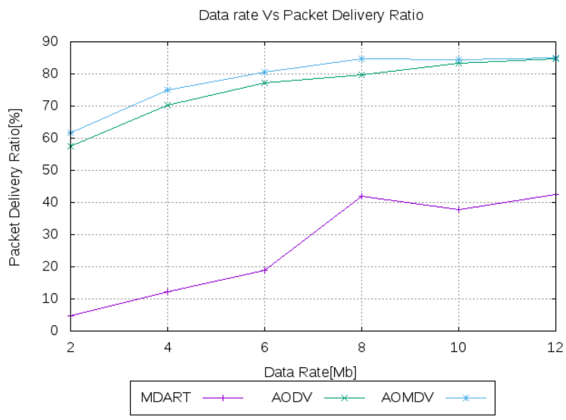

Fig. 5. PDR Vs data rate

PDR: packet delivery ratio is depicted in Fig. 5. Graph shows clearly that for AODV and AOMDV routing protocols, packet delivery ratio is increasing as date rate from 2 Mb to 12 Mb is increased. But in case of MDART, packet delivery ratio is fluctuating by varying the data rates. AOMDV routing protocol outperforms the AODV and MDART in terms of packet delivery ratio. MDART shows very poor performance in respect of packet delivery ratio.

PDF: Packet delivery fraction is observed from 2Mb to 12Mb data rates (see Fig. 6). For AODV, Packet delivery fraction is increasing as data rate is varying from 2 Mb to 12 Mb. It is fluctuating for AOMDV and MDART routing protocol. From data rate 2 Mb to 8 Mb, PDF is increasing for AOMDV routing protocol. PDF is suddenly decreased from data rate 6 Mb to 8 Mb for MDART. In terms of PDF, AOMDV outperforms the AODV and MDART routing protocols. MDART comes under worst case in respect of packet delivery ratio.

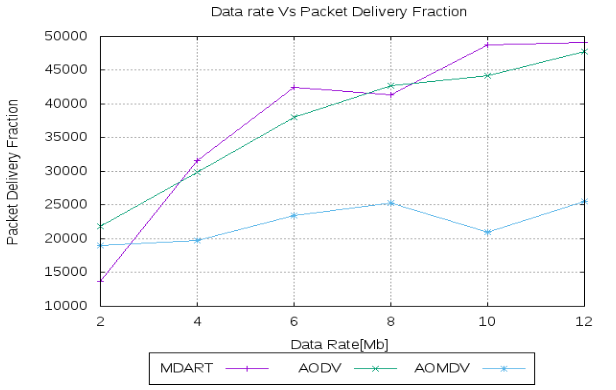

Fig. 6. Packet delivery fraction Vs data rate

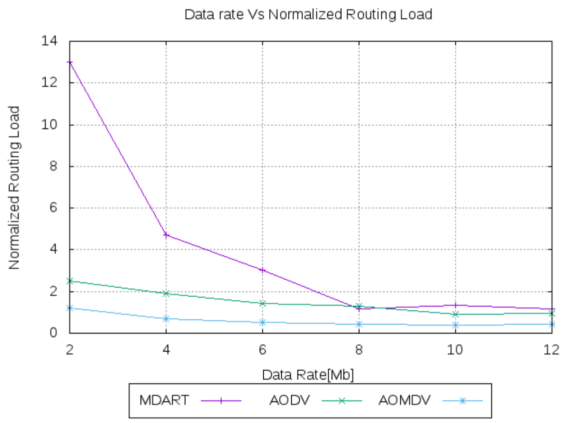

Fig. 7. NRL Vs data rate

NRL: Normalized routing load is evaluated in Fig. 7. Normalized routing load has been analysed in respect of data rates for AODV, AOMDV, and MDART routing protocols. AOMDV shows better results as data rate is increased. MDART produce very high normalized routing load. As data rate is increased, NRL for AODV decreased. Normalized routing load is fluctuating in case of AOMDV and MDART routing protocols. Initially from data rate 2 Mb to 8 Mb, NRL is decreasing. After that it is fluctuating for all data rates.

Latency: Fig. 8(a), Fig. 8(b), and Fig. 8(c) presents the latency results in terms of data rates for AODV, AOMDV, and MDART. Latency is simulated for data rates from 2 Mb to 12 Mb for all above protocols. As shown in graphs, it has been observed that as data rates are increasing gradually from 2Mb to 12Mb, latency is also increased in case of AODV, AOMDV, and MDART routing protocols. Latency is at lowest level for 2Mb data rate while it is at highest level at 12Mb data rate. Results show that MDART outperforms as latency is very low while AODV having very poor performance because it produces very high latency.

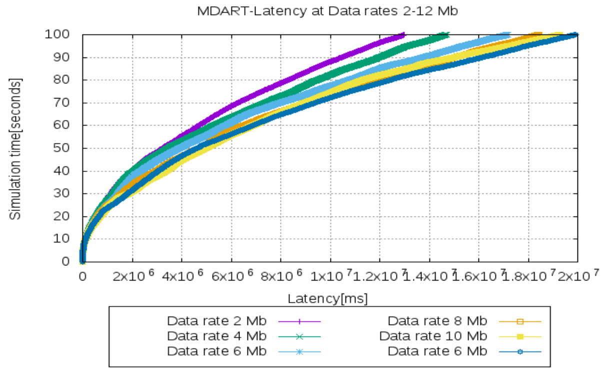

Fig. 8. (a): Latency for MDART

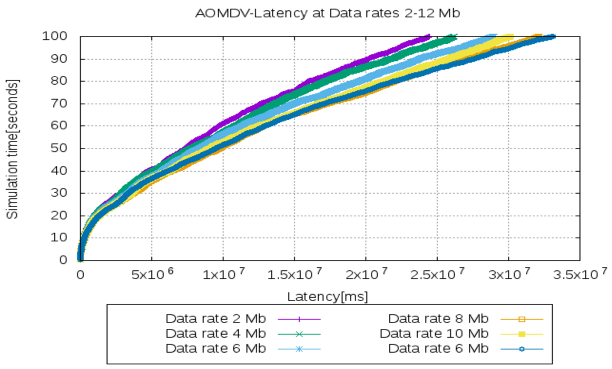

Fig. 8. (b): Latency for AOMDV

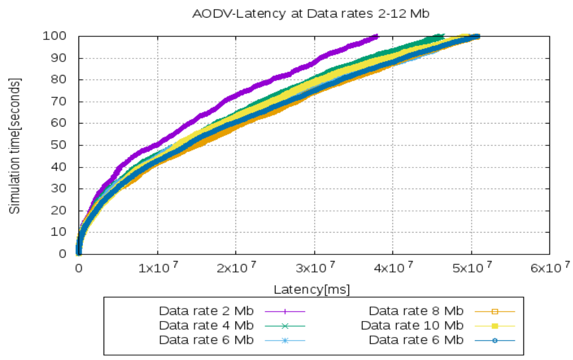

Fig. 8(c): Latency for AODV

TABLE II: OVERALL AVERAGE RESULTS

Overall Summarise Results			
	AODV	**AOMDV**	**MDART**
Total dropped packets	3255	2918	618
Average E2E Delay[ms]	156.87	174.80	312.375
Average Throughput[kbps]	1092.487	1307.935	1082.86
Received packets	42242	50532	7088
PDR(%)	75.48	78.58	26.32
PDF	37430	21820	37825
NRL	1.505	0.6126	4.0835

Table II shows the average summarize results for all performance parameters. In case of total packet loss, MDART outperforms the AODV and AOMDV routing protocols while AOMDV shows better results in terms of average throughput, received packets, packet delivery ratio, packet delivery fraction, and normalized routing load. In other aspects AODV presents better performance in respect of average end to end delay as compared to AOMDV and MDART routing protocols. Also AODV works well as compared to MDART in terms of average end to end delay, average throughput, received packets, packet delivery ratio, and normalized routing load. In most of the cases, AOMDV can be recommended for better performance in wireless ad hoc networks as compared to AODV and MDART routing protocols.

V. Conclusion and Future Work

Proactive and reactive routing protocols have been verified in terms of performance metrics in mobile ad hoc networks. After observation from the simulation results, it has been identified that AOMDV performs well as compared to AODV and MDART routing protocols. In some exceptional cases like total number of packet dropped, MDART shows better results. In terms of normalized routing load, AODV works well as compared to MDART routing protocol. In most of the cases, if we consider latency for data communication, MDART presents better results while AODV comes under worst case. AOMDV outperforms the AODV and MDART routing protocols. For better network performance and time saving without data loss, AOMDV routing protocol can be recommended in wireless networks for data transmission. In future evaluation work for TORA and MAODV with more quality of service parameters will be conducted.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Pushpender Sarao conducted the research; Mahendra Sharma analyzed the data; Pushpender Sarao wrote the paper; all authors had approved the final version.

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