Performance Evaluation of Routing Protocols in MANETs with Variation in Pause Time

Suresh Kumar, Deepak Sharma, and Payal

Abstract With the advancement in technology, there is a need for dynamically changing network applications for efficient, seamless, and last mile connectivity for a cost effective solution. In mobile ad hoc networks (MANETs), the function and location of the randomly connected mobile nodes keep on changing based on the user necessity. The seamless and longer duration network connectivity depends upon mainly on density of nodes, their mobility, speed, pause time, and transmission power. In this research work, three routing protocols (RP), i.e., (i) Ad hoc on demand distance vector (AODV) (ii) dynamic source routing (DSR) (iii) optimized link state routing (OLSR) have been evaluated on a designed MANET network scenario for 80, 100 and 120 nodes at different pause time. Throughput, average jitter, and average MAC delay have been taken as the performance metrics with random waypoint mobility model (RWMM) and constant bit rate (CBR) as the traffic application. With increase in pause time, the OLSR RP shows superior performance in terms of both throughput and average jitter. The average MAC delay of OLSR does not get affected much even with the increase in node density, and thus outperforms the other two RP.

Keywords AODV · Average end to end delay (AEED) · CBR · DSR · MANET · OLSR · Packet delivery ratio (PDR)

1 Introduction

MANET is a dynamic topology ad hoc network with random node placement, the position of which changes rapidly on need basis. These networks do not possess any pre-existing infrastructure like base stations or access points. Thus, each node

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behaves like a router that forwards the progressing data packets to its neighbors. The technique by which the nodes are connected is dependent on transmitted power parameter of the nodes and their location that may vary intermittently in the network. The communication between the nodes is maintained via transmission of packets containing data over a common wireless channel which thereby limits the radio coverage [1, 2]. The nodes in MANETs have limited power capabilities due to which the neighboring nodes get limited in terms of resources. The higher operating frequencies suffer from interference and fading in an urban environment, which uphold the links unreliable. Therefore, effective and accurate power aware routing techniques are required for effective network design in MANETs. The RP is the defined set of regulations and standards that provide a method of communication and mechanism of route selection among the nodes while maintaining high QoS standards [3]. The mobile nature of nodes results in random change of the network topology. Pause time in MANET signifies the duration during which the transmitting mobile nodes remain static at a place while communicating among themselves. As the pause time increases, the static behavior in dynamic mobile nodes increases. The present research work is related to enhancement of transmission range and lifetime, which is certainly a challenging task for researchers. Further the present research paper organization is as follows: The RPs are briefed in Sect. 2 followed by Sect. 3 containing related work. Section 4 describes the simulation parameters in MANET design. The results obtained have been analyzed in Sect. 5. The overall outcome has been summarized in Sect. 6.

2 MANET RP

Unipath RP and multipath RP are the two categories of well-known RP the performance of which depends on node density, mobility and behavior of mobile nodes, composite interaction of the protocol mechanisms, and their explicit parameter settings with traffic intensity. The former category of RP can be proactive, reactive, and hybrid. In proactive RP, i.e., DSDV, the nodes provide currently updated routing information about the network topology, and routes are created between them before they are required by the network. The reactive RP, i.e., AODV and DSR on the other hand have no predefined routes and the nodes establish their routes on demand dynamically. Once the route is established, the packets of data are communicated to all or its intermediate neighbor nodes. Hybrid RP is a non-uniform routing protocol which utilizes adaptive and minimal overhead control to optimize the network performance. With the mechanism of route discovery, the scalability of the network is also increased by proactive route management.

AODV RP provides broadcast, multicast, and unicast communication in MANETs. The path discovery process begins when a demand is displayed by the source and is terminated only when a route is found or all the routes are already investigated [4]. DSR is an on demand, path creating protocol that maintains path revelation and path preservation functions for effective and error free connectivity

[5]. Whenever there is data to be transmitted, this RP selects an accessible path from its own caches otherwise a path discovery process is initiated with a path request packet containing origin and end address, besides distinctive identification number. OLSR is a proactive, upgraded type of a pure link state protocol. When the delivery time of control messages is reduced, it uses more reactivity to the topological variance. Hello and topology control are the types of control messages operated with this protocol. Hello messages are operated for revealing data concerning the status of the link and host's neighbors while to convey data among its own advertised neighbors, the later type is used.

3 Related Work

The authors in [6] presented a packet level simulation of ad hoc networks under variable load distribution probabilities for different RP. Simulative results show that the performance of the proposed network improves significantly with incorporation of mobility conditions. The authors in [7] presented a modified AODV for evaluating the performance of designed MANET network for effective protection against black hole and gray hole attack by detecting misbehaving nodes in MANETs. The simulative result shows that the proposed algorithm works efficiently and was successful in minimizing misbehaving nodes effectively. The authors in [8] presented the evaluation of AOMDV, TORA, AODV, DSR, and DSDV RP in MANET under different network scenarios based upon PDR, throughput, and energy consumption. Simulative results show that former RP outperforms other RP being an energy efficient protocol in handling network resources. The authors in [9] presented a comparative evaluation of AODV, DSR, and DSDV routing protocols in MANETs. The simulative results show that AODV outperforms the two RP for all performance metrics. The authors in [10] presented modified versions of AODV and DSR using mean absolute deviation statistical approach and carried out a comparative evaluation for effective protection against wormhole attack in MANET. The simulative results show that the modified DSR protocol outperforms modified version of AODV in terms of performance metrics and was successful in minimizing Wormhole attack in MANET.

The authors in [11] evaluated the performance of hierarchical and cluster-based RP in FSO-MANET. Simulative results exhibit that the hierarchical-based optical sphere RP provides improved performance in terms of delay, number of packets dropped and throughput in comparison to cluster based RP. The authors in [12] presented the performance evaluation of AODV, OLSR, and DSDV protocol using PDR, routing overhead, AEED, and packet loss under variable network conditions in MANET. Simulative results show that DSDV and OLSR perform better in terms of AEED, whereas AODV outperforms DSDV in terms of routing overhead. The authors in [13] presented a comprehensive theoretical review of AWSN. The authors in [14] AODV and DSR routing protocol have been evaluated for their performance in AWSN networks using Zigbee traffic application. Simulative results show that AODV outperforms DSR in QoS parameters while using Zigbee as traffic application.

The authors in [15] evaluated the performance of (i) Generic, (ii) Micaz, and (iii) Micamotes energy conservation models over a designed AWSN network scenario for the two RP, i.e., AODV and DYMO using AEED, Throughput and energy consumed as the performance metrics. With AODV protocol, the Micamotes outperforms the generic and Micaz energy model due to lesser energy consumption both in transmit and receive mode.

All the earlier work reported in literature have evaluated the performance of designed network scenarios in isolation using several routing protocols for improved performance at a specified pause time. A few literary works have been reported recently having used variable pause time for AODV, DSR, and DYMO protocol. In this work, we aimed at evaluating the performance of a designed MANET scenario with variable node density in conjunction with random waypoint mobility model at two different pause times of 15 and 30 s using AODV, DSR, and OLSR protocols for optimum performance.

4 Simulation Setup

MANET scenario has been created with nodes (80, 100 and 120) randomly placed over 1500 * 1500 m terrain size using QualNet Simulator 7.3.1. The designed MANET performance with three different RP has been evaluated for the performance metrics—Throughput, average jitter, and average MAC delay for an increase in node density. The mobility model used in our network scenario is RWMM and CBR as the traffic application. The data packet size is of 512 bytes with 10 m/s speed per node and data rate of 2 Mbps. Table 1 provides a list of simulation parameters and their values used in the designed network scenario.

Table 1 Parameters and values used in simulation

Parameter	Value
No. of nodes	80, 100, 120
Terrain size	1500 * 1500 m
MAC protocol	IEEE 802.11
RP	AODV, DSR, OLSR
Model	RWMM
Pause time	15, 30 s
Maximum speed of node	10 m/s
Energy model	MICA motes
Data traffic	CBR
Traffic application	(10–27), (14–11), (46–30), (39–45), (73–12), (13–75), (58–43), (28–52), (16–60), (37–25)

The performance metrics chosen for evaluating performance are throughput, average jitter, and MAC delay.

Throughput: It is defined as the average rate of data successfully delivered using suitable communication channel and expressed in bits/s or packets/s. It is desired that the throughput remains higher.

Average Jitter: It is defined as the alteration in delay of various data packets that reaches the terminating nodes and a measure of volatility in latency in delivery of packets from source to destination. It is measured in seconds. For optimum performance of a network, the jitter has to be very less. Higher jitter might prompt the buffers to underflow or overflow and may lead to algorithm collapse.

MAC Delay: It is defined as the medium access delay for a packet including the time spent in collisions as well as the time spent in back off process. The dropped packet poses problem in delay calculation. MAC delay is calculated as the time elapsed between the moment a packet is put to service and its successful transmission or drop.

Mica Mote Energy Model: The Mica mote energy model uses second generation energy efficient WSN nodes utilizes TinyOS operating system at each node and incorporates an Atmel family based 8 bit microcontroller operating at a frequency of 4 MHz. The nodes also incorporate a 10 bit ADC for digitizing the output. The radio of MICA mote can transmit upto 40,000 bits per second over a distance of hundred meters.

5 Result and Discussion

In this present research, we have varied the pause time of nodes to create two different scenarios with 15 and 30 s pause time for evaluating network performance. The graph depicting throughput with nodes varying from 80 to 120 at a pause time of 15 s is shown in Fig. 1.

The value of throughput for AODV, DSR, and OLSR protocol increases as the number of nodes vary from 80 to 120 nodes. From Fig. 1, it is also evident that the average throughput increases with node density as AODV, DSR, and OLSR

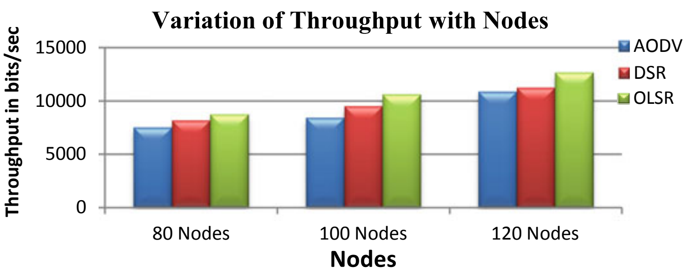

Fig. 1 Variation of throughput with nodes at a pause time of 15 s

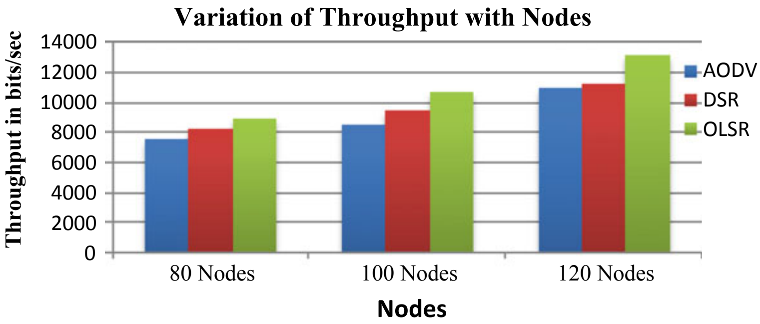

Fig. 2 Variation of throughput with nodes at a pause time of 30 s

protocols show an increase of 44.48%, 37.59%, and 45.51%, respectively, when the node density increases from 80 to 120 nodes. The bar plots in Fig. 2 show the variation in throughput at pause time of 30 s.

At 30 s pause time, AODV, DSR, and OLSR protocols show an increase of 44.44%, 37.59%, and 48.66%, respectively, when the node density increases from 80 to 120 nodes. From Figs. 1 and 2, the value of throughput is higher at pause time of 30 s as compared to 15 s. With increase in pause time, the static behavior of nodes increases, and they remain in their place for longer duration, thereby allowing an error free seamless transmission. OLSR provides higher throughput for both the pause time scenarios and outperforms AODV and DSR. Further OLSR shows approximately 4% increase in throughput with the increase in pause time form 15 to 30 s. Figures 3 and 4 depict the variation of average jitter with increasing node density for pause time scenarios of 15 and 30 s.

The bar chart in Fig. 3 shows the variation of average jitter for increasing node configuration for a pause time of 15 s. From Fig. 3, the values of average jitter for AODV, DSR, and OLSR vary from 0.16, 0.17, and 0.059 for 80 nodes to 0.22, 0.24, and 0.08 s for 120 nodes, respectively. At 15 s pause time, AODV, DSR, and OLSR protocols show an increase of 43.75, 41.17%, and 35.59%, respectively, in

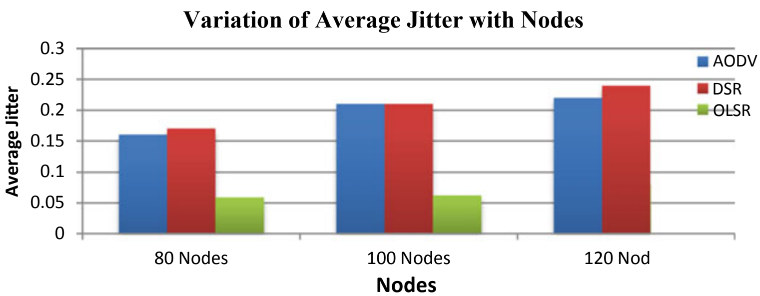

Fig. 3 Variation of average jitter with nodes at a pause time of 15 s

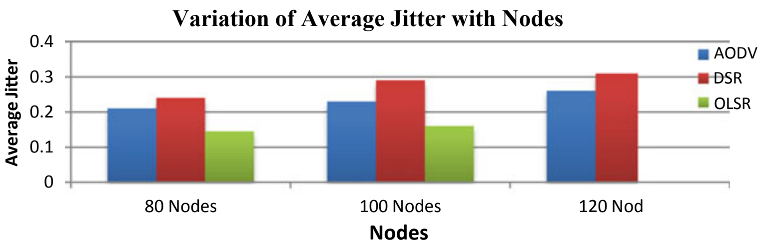

Fig. 4 Variation of average jitter with nodes at a pause time of 30 s

average jitter when the node density increases from 80 to 120 nodes. It is evident from the results that with node density, the average jitter increases and OSLR provide minimum jitter in comparison to both the RP, i.e., AODV and DSR. Figure 4 shows the variation of average jitter for a pause time of 30 s.

At 30 s pause time, AODV, DSR, and OLSR protocols show an increase of 23.80, 29.16%, and 17.24%, respectively, in average jitter when the node density increases from 80 to 120 nodes. However, OSLR provides minimum jitter in comparison to AODV and DSR. With increase in pause time from 15 to 30 s, the average jitter increases thereby limiting the performance. However, in both scenarios of different pause time, the OLSR RP shows optimum performance. The variation of MAC delay with node density for pause time of 15 and 30 s is shown in Figs. 5 and 6, respectively.

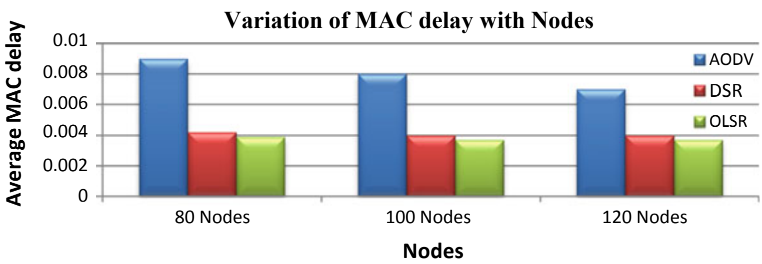

Fig. 5 Variation of average MAC delay with nodes at a pause time of 15 s

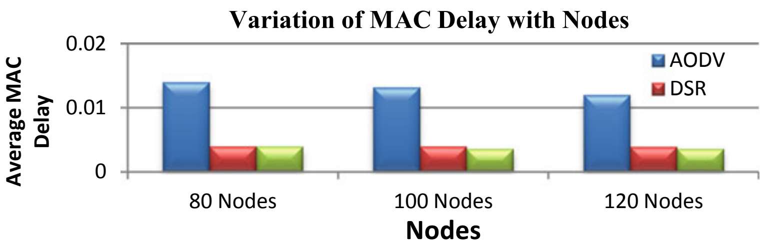

Fig. 6 Variation of average MAC delay with nodes at a pause time of 30 s

At a pause time of 15 s, the average MAC delay varies from 0.009, 0.0042, and 0.0039 to 0.007, 0.004, and 0.0037 for increase in node density from 80 to 120 nodes for AODV, DSR, and OLSR protocol, respectively. AODV, DSR, and OLSR protocols show variation of 22.22%, 14.7%, and 5.4%, respectively, in average MAC delay when the node density increases from 80 to 120 nodes. It is evident from the results that with node density, the MAC delay decreases and OSLR provides minimum MAC delay in comparison to AODV and DSR protocol.

At pause time of 30 s, the average MAC delay varies from 0.014, 0.004, and 0.004 to 0.0012, 0.0039, and 0.0038 for increase in node density from 80 to 120 nodes for AODV, DSR, and OLSR, respectively. From Figs. 5 and 6, it is evident that the average MAC delay decreases with increase in number of nodes. However, the MAC delay increases with increase in pause time from 15 to 30 s as the increase in pause time tend to increase static node behavior.

From the results, it is further evident that the designed MANET scenario works in consonance with the theoretical results. The average throughput and average Jitter increases and average MAC delay decreases for each of AODV, DSR, and OLSR routing protocol with increase in number of nodes from 80 to 120 nodes. Further with increase in pause time from 15 to 30 s, the static behavior of nodes increases, and they remain in their place for longer duration there by allowing an error free seamless transmission and increase in average throughput for all three routing protocols. However, OLSR provides higher throughput in both the pause time scenarios and outperforms AODV and DSR. Again in both pause time of 15 and 30 s, the OLSR RP shows optimum performance and provides minimum average jitter in comparison to DSR and AODV protocol. Also from the results, it can be further concluded that with increase in node density, OLSR provides minimum average MAC delay. The average MAC delay of OLSR has a very small variation in comparison to DSR and AODV protocol. From all the above results, it can be conclude that the OLSR RP performs efficiently in comparison to AODV and DSR protocol.

6 Conclusion

The present research involves the performance evaluation of designed MANET scenario for AODV, DSR, and OLSR RP with variation in node density and pause time. The simulation results reveal that the OLSR RP outperforms AODV and DSR in throughput and average jitter evaluation. When it comes to average MAC delay, the OLSR does not get effected much and performs better even with the increase in node density. The OLSR RP works optimally with a 13,150 throughput, 0.17 s average Jitter, and 0.0036 s MAC delay for 120 nodes at a pause time of 30 s. This signifies that pause delay can be kept small or large based on the desired network application and amount of data to be transferred for analysis. This simulation work will facilitate the hardware designers in selecting the components for various sub-modules of the nodes to be used in deploying field network.

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