Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS Journal of Applied Sciences
ISSN 1812-5654
DOI: 10.3923/jas.2023.170.177

Research Article
Comparative Performance Analysis on the Standard and Revised Routing Models of the Dynamic Source Routing Protocol

Lakshman Naik Lambani, Rahmatullah Khan and Ravi Bhushan Mishra

Department of Electronics Engineering, Indian Institute of Technology, Banaras Hindu University, Varanasi, Uttar Pradesh 221005, India

Abstract
Background and Objective: Mobile ad hoc networks require routing protocols to discover routes between nodes, which is challenging due to unpredictable network environments. Over the years, different versions of the conventional routing models have been proposed, but still proficient routing is quite essential. This paper examined DSR (dynamic source routing), a well-known routing protocol in mobile ad hoc networks for possible improvements. This study determined a comparative performance analysis of the standard and revised routing models of the DSR. **Materials and Methods:** These analyses were performed using NS-3.25 (Network Simulator, version 3.25) and with the help of various performances evaluating metrics such as the throughput, PDR (packet delivery ratio), EED (end to end delay), PL (packet loss) and NRL (normalized routing load). **Results:** Average numerical values of different performance evaluating metrics of either routing models of the DSR were obtained for different network node densities from the simulation results. Performances of the standard and revised dynamic source routing models were evaluated and compared through the graphs. **Conclusion:** This study concluded performance improvements in the revised DSR routing model as compared to its standard version for different node population scenarios.

Key words: Node mobility, routing model, route discovery, Mobile Ad hoc Networks (MANETs), DSR (dynamic source routing)

Citation: Lambani, L.N., R. Khan and R.B. Mishra, 2023. Comparative performance analysis on the standard and revised routing models of the dynamic source routing protocol. J. Appl. Sci., 23: 170-177.

Corresponding Author: Lakshman Naik Lambani, Department of Electronics Engineering, Indian Institute of Technology, Banaras Hindu University, Varanasi, India

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Mobile Ad hoc Networks (MANETs) are new-age wireless networks that operate without the need for centralized network equipment (i.e., network gateways, routers, network access points, etc.). This is because MANET nodes act as both routers and hosts. Mobile ad-hoc networks are self-forming and self-healing when needed, they are simple and economical to use. These ad hoc networks are very helpful in diverse applications such as military applications, emergency and rescue operations, collaborative and distributed computing, wireless sensor networks, wireless mesh networks and hybrid wireless networks[1]. These networks are very useful in establishing instant communication at battlefields, flood and earthquake hit areas[2]. To meet such critical applications, a better-performing routing protocol is very much needed for accomplishing efficient and error-free communication paths between the nodes. In the past few decades, different versions of the conventional routing models were proposed but still an efficient routing is quite essential.

Mobile ad hoc networks operate on multi-hop radio transmissions, a source node intensive to communicate with a destination node has to communicate across multiple hops to get the shortest and most efficient path to that destination[3,4]. A connected mobile ad hoc network with nine numbers of nodes 'N' has been demonstrated in Fig. 1. Scalability of mobile ad hoc networks depends upon packet forwarding capacity and the size of the network[5].

The process of finding a route from a source node to the destination node in a network is called routing[6], where, routing protocols ensure efficient and error-free routes. Some features such as resource allocation, node mobility and dynamic topographies mark the routing procedure a key challenge[3].

This paper presents simulation-based comparative analysis on DSR protocol. The unicast routing protocols communicate using a single channel whereas multicast protocols communicate using multiple channels[7]. The DSR operates as a unicast, reactive routing method that relies on a single channel[8,9].

DSR: Dynamic source routing is an on-demand type routing protocol which supports unicast communication and takes advantage of the source routing algorithm[10,11]. The DSR is also called a demand driven routing protocol developed for multi-hop relaying MANETs[12-14]. In DSR, bandwidth restrictions on control over heads are achieved by removing periodic table update messages, it does not require periodic transmissions of beacons or hello messages[1]. It employs source routing, as the complete path is included in the DSR heading and ropes unidirectional links. The DSR is used in Microsoft mesh networks[15].

Path discovery in DSR: If a source node 'S' initiates a communication with the destination node 'D', it generates RREQ (Route Request) message and floods it throughout the network because node 'S' does not have a valid route to 'D'. The RREQ messages hold information such as, source address, source ID (Identity), destination address and destination ID with an exclusive sequence number generated by the source node 'S'. Upon receiving the RREQ, intermediate nodes check the sequence number and either generate a RREP (Route Reply) message for the source node 'S' or forward the RREQ message to other nodes in the network. Intermediate nodes generate RREP only when they have valid routes to the destination. Before forwarding the RREQ, intermediate nodes add their address and ID in the RREQ and store it in their cache.

The process of route discovery in DSR was illustrated in Fig. 2, dotted lines represent connectivity between the nodes, forward arrows signify RREQ transmission and backward arrows denote transmission of the RREP message. When a source node 'S' floods the RREQ, immediate node 'P' receives the RREQ, but it has no valid path to 'D' and hence forwards it to nodes 'R', 'T' and 'Q' including its address to the source path. Node 'Q' does not have a valid path to node 'D', it forwards the RREQ to nodes 'U', 'V' and node 'D'. Node 'D' is the destination, so it generates the RREP message and passes it to the source node through nodes 'Q' and 'P'. The shortest route between node 'S' and 'D' is S-P-Q-D. During the path discovery process, every node which forwards the RREQ, stores the path information in the send buffer. The RREQ, RREP and RERR (Route Error) messages live a short period and are discarded by the nodes after their time-out period. During path breaks, the source node re-initiates the route discovery process[16]. During path discovery, every node acquires new path information, repetition of hop paths is avoided to elude control overheads. Path cashing in DSR involves cache structure, cache capacity and cache timeout[17].

Route maintenance in DSR: The DSR maintains routes in five different strategies namely, circulation of RERR messages, packet salvaging[18], auto-route shortening, RREQ hop limits and preventing RREP squalls.

The process of route maintenance in DSR was illustrated in Fig. 3. Here, the source node 'S' initiates a route discovery by generating a RREQ (S-D) to fetch the route up to the destination node 'D'. The shortest available route from 'S' to 'D' is S-B-F-D, but there is a route break between nodes 'F' and 'D'.

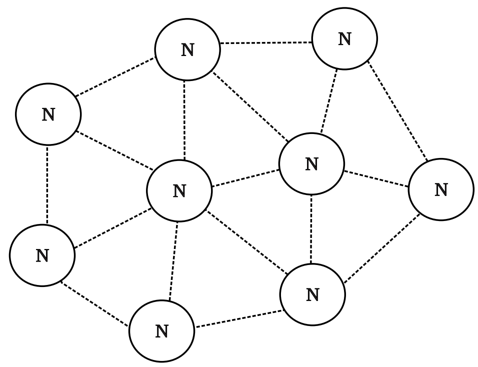

Fig. 1: Connectivity in a mobile ad hoc network

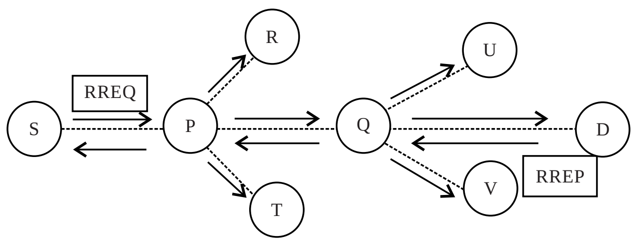

Fig. 2: Path discovery in DSR

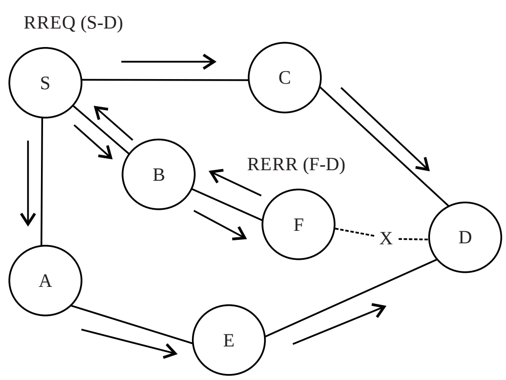

Fig. 3: Route maintenance in DSR

Node 'F' generates a RERR (F-D) message and spreads it all around the network. Upon receiving RERR (F-D) message, the source node 'S' looks into its cache for other available routes to the destination node 'D'. If there are no routes in the cache, the source node again generates a new RREQ to get a route up to the destination node 'D'. Other alternate routes to the destination node 'D' are S-C-D and S-A-E-D. Upon detecting a broken link, a node initiates route maintenance by generating a route error message and floods it. Then the node deletes the broken link route from its cache[3].

MANET routing protocols are helpful in establishing shortest routes and their maintenance. Over the years, much research were conducted on mobile ad hoc network routing protocols, many of these researches were based on performance comparison studies of some well-known conventional routing protocols considering network parameters, mobility models, transmission region, transmission range and type of offered load etc. In this study, a combination of network and DSR parameters was considered to achieve possible improvements in routing data packets considering different network sizes.

MATERIALS AND METHODS

Study area: This study was conducted recently at the Electronics Engineering Department of Indian Institute of Technology (Banaras Hindu University). Duration of this study was three months (from January, 2023 to March, 2023). These research works were performed with the help of network simulator -3 (NS-3, version 3.25) over the server grade CentOS (version 5.1) Linux operating system on an Acer server. Obtained packet data (results from the simulation based experiments) were used to calculate performance evaluating metrics. Various experiments were performed for different sets of node densities to test the revised DSR model.

Performance evaluating metrics: There are many performances evaluating metrics available to measure the performances of the routing protocols in MANETs. Some of them considered for this analysis are, the throughput, PDR (packet delivery ratio), EED (end-to-end delay), PL (packet loss) and the NRL (normalized routing load)[8,19].

Throughput: The number of data packets transmitted by the network between the source node and the destination node is known as the throughput. Higher values of throughput provide improved network performance. The unit of the throughput is Kbps (Kilobits per second):

$$\text{Throughput} = \frac{\text{Sum of recieved bytes} \times 8}{\text{Total simulation time} \times 1024} \quad (1)$$

Packet delivery ratio: The packet delivery ratio is the sum of data packets received to the sum of data packets sent. Higher values of this metric deliver better performance, deriving unit of PDR is percentage:

$$\text{PDR (\%)} = \frac{\text{Sum of data packets received}}{\text{Sum of data packets sent}} \times 100 \quad (2)$$

End-to-end delay: End-to-end delay can be defined as the average time interval between data packets generated at the source and their actual transfer at the destination. To get better protocol performances, delay values must be lesser. The unit of this metric is milli seconds (ms):

$$\text{EED} = \frac{\text{Total delay}}{\text{Sum of received packets}} \quad (3)$$

Packet loss: Packet loss can be termed as the difference between total sent data packets and total received data packets. For better and improved protocol performances, values of packet losses must be minimal. The unit of the PL is in numbers:

$$\text{PL} = \text{Total sent data packets-Total received data packets} \quad (4)$$

Normalized routing load: Normalized routing load is the fraction of sent routed data packets to the received data packets. The NRL can be derived in numbers, higher NRL values deliver enhanced protocol performances though higher NRL values indorse lesser efficiency concerning consumption of bandwidth[8,20]:

$$\text{NRL} = \frac{\text{Number of routed data packets sent}}{\text{Number of data packets received}} \quad (5)$$

Simulation tools: Simulation based analysis on the dynamic source routing protocol (DSR) were performed with the aid of NS-3. The NS-3 is discrete event-based open source software available for educational purposes including research. It holds the GNU GPLv2 license and is openly accessible for R and D (Research and Development) activities. Usage and debugging of this network simulator are easy as "it forms a compact simulation core". This network simulator provides all the support from simulation conjuration to the results for simulation based experiments. It has extensive research provisions on IP (Internet Protocol) and non IP based computer networks. Network simulator-3is popularly used for IP based wireless network simulations by researchers. It was developed from scratch using C^{++} along with optional Python bindings. As compared to NS-2 (Network Simulator-2), NS-3 has improved simulation reliability. In this simulator, APIs (Application Program Interfaces) of NS-2 have been replaced[10].

Network modeling: The 50 numbers of moving nodes were placed inside a rectangular network region of size, 300×1500 m. Mobile nodes ensure their mobility at a velocity of 20 mps within this region as per the random way point mobility model (RWPMM). Ten numbers of fixed source-sink connections were used for data transmission. The communication channel capacity was set to 2 Mbps with 7.5 dBm transmit power. The simulation run time was set to 200 seconds (transient period: 50 seconds). The network parameters used in the simulation were shown in Table 1.

Protocol modeling: The standard DSR routing protocol has many core parameters which are responsible in achieving better functioning of the protocol. Here, standard attributes of some core parameters have been altered to study protocol behavior and to test the protocol performances in terms of throughput, PDR, EED, PL and NRL. The DSR parameters considered for this study were shown in Table 2.

Statistical analysis: In this study, a typical ad hoc network model was simulated for different node sets using the standard and revised DSR protocol models separately. Obtained packet data of each protocol was used to determine the performance evaluating metrics. Different performance evaluating metrics were calculated in Table 3 and performances of the protocol models were compared.

Table 1: Network parameters used

Network parameter	Value
MANET routing protocol	DSR
Data transmission rate	2 Kbps
Rate of Wi-Fi	2 Mbps
Number of source/sink connections	10
Network expanse (rectangular)	300×1500 m
Node mobility speed	20 m $\sec^{-1}$
Node transmit power	7.5 dBm
Wi-Fi mode	Ad-hoc
Mobility model	Random way point mobility model
Data packet size	64 Bytes
Simulation time	200 sec
Node pause time	No pause time
Node concentration	30, 40, 50, 60, 70, 80, 90 and 100

Table 2: DSR parameters used in simulation

Protocol parameter	Assigned value
MaxSendBuffTime	25 sec
MaxMaintLen	40
MaxMaintTime	20 sec
RouteCacheTimeout	400 sec
MaxEntriesEachDst	25
SendBuffInterval	550 sec
NodeTraversalTime	30 msec
RreqRetries	12
MaintenanceRetries	3
NonPropRequestTimeout	25 msec
MaxSalvageCount	12
BlacklistTimeout	5 sec
GratReplyHoldoff	2 sec
RequestPeriod	550 msec
MaxRequestPeriod	15 sec
MinLifeTime	2 sec
RetransIncr	25 msec
MaxNetworkQueueSize	500

RESULTS AND DISCUSSION

In this study, a performance comparison of the standard and revised DSR routing protocols was presented, whereby attributes of core performance parameters of the standard DSR routing protocol were revised and modeled as the revised DSR. Experiments on dynamic source routing models were carried out to study their behavior and performances for different node population scenarios. Various experiments were conducted to test the revised DSR model considering 30, 40, 50, 60, 70, 80, 90 and 100 sets of network nodes (small and large node sets) and obtained results were compared with the results of the standard model. A screen shot of a running program script was shown in Fig. 4. As compared to the standard DSR routing model, the revised model gained improved network throughput and better data packet delivery between the source and destination nodes. The revised model has attained minimum delays in delivering data packets to the destination nodes with the least packet losses and routing overheads.

Compared to previous studies, where only the performance of different standard routing protocols were analyzed by varying different network parameters[6-8,10-13,18-21], offered traffic[22], media access control protocols and node velocities[23] using network simulator-2, the present study managed to obtain better performing revised DSR routing model taking protocol parameters into account with the help of network simulator-3. Similar studies on AODV and OLSR routing protocols were accomplished by researchers Lakshman *et al.*[24,25] considering protocol parameters.

Packet data obtained from the simulation experiments were utilized to calculate different performance-evaluating metrics discussed in the materials and method section. The same was shown in Table 3.

Table 3: Data sheet showing performances of the DSR models

	Throughput in kbps		PDR (%)		EED (msec)		Packet loss		NRL	
No. of nodes	STD.DSR	REV.DSR	STD.DSR	REV.DSR	STD.DSR	REV.DSR	STD.DSR	REV.DSR	STD.DSR	REV.DSR
30	12.37	12.98	61.87	64.88	15.41	13.53	2288.00	2107.00	0.619	0.649
40	12.75	12.84	63.75	64.20	14.22	13.94	2175.00	2148.00	0.638	0.642
50	11.41	12.55	57.07	62.73	18.81	14.85	2576.00	2236.00	0.571	0.627
60	12.93	12.98	64.65	64.88	13.67	13.53	2121.00	2107.00	0.647	0.649
70	11.92	12.94	59.58	64.68	16.96	13.65	2425.00	2119.00	0.596	0.647
80	10.94	12.51	54.68	62.57	20.72	14.96	2719.00	2246.00	0.547	0.626
90	12.86	12.93	64.32	64.63	13.87	13.68	2141.00	2122.00	0.643	0.646
100	13.04	13.30	65.20	66.48	13.34	12.60	2088.00	2011.00	0.652	0.665

PDR: Packet delivery ratio, EED: End-to-end delay, NRL: Normalized routing load, STD: Standard and REV: Revised

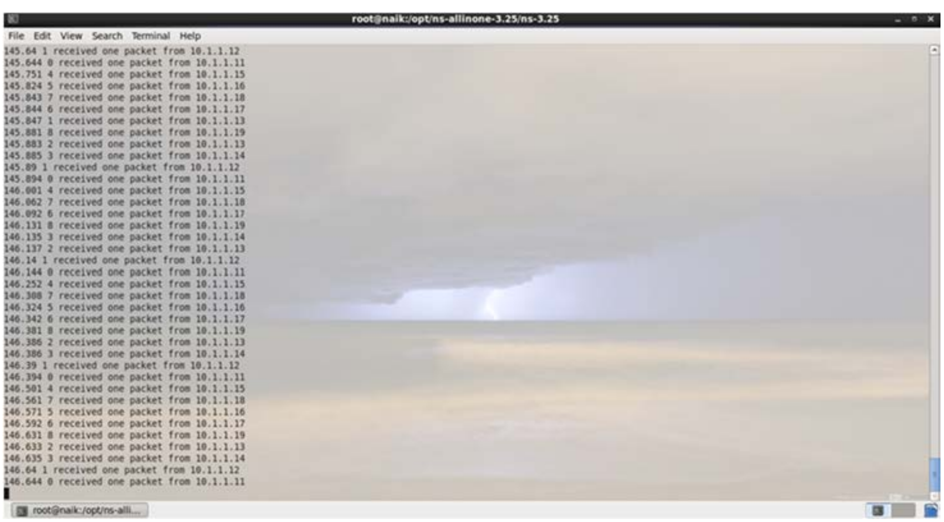

Fig. 4: DSR script under execution

NS-3 manet-routing-compare script

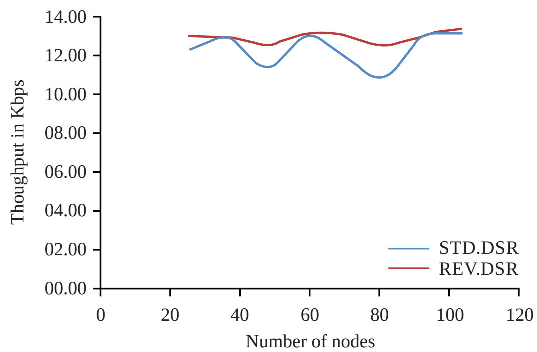

Fig. 5: Throughput

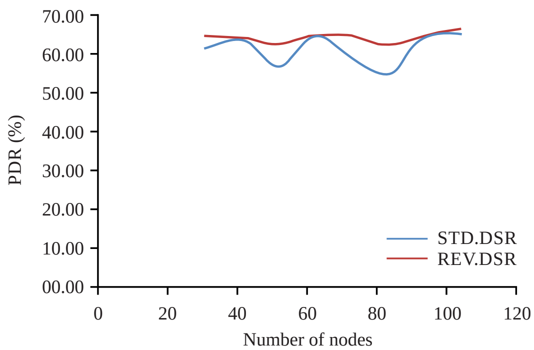

Fig. 6: Packet delivery ratio

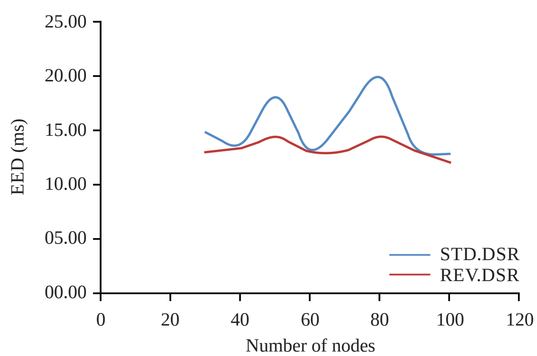

Fig. 7: End-to-end delay

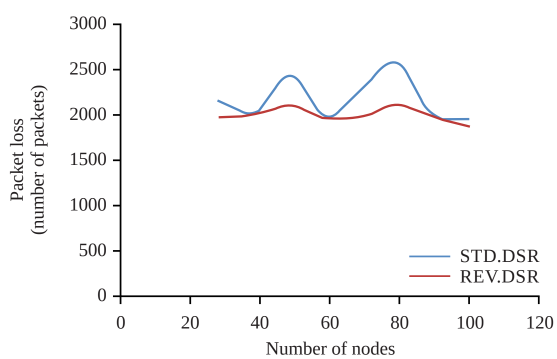

Fig. 8: Data packet loss

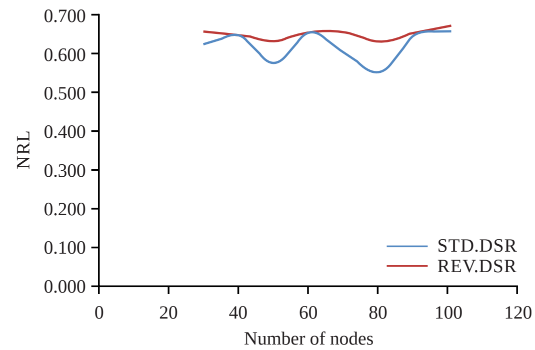

Fig. 9: Normalized routing load

Throughput: As compared to standard DSR, the revised DSR had better network throughput. The maximum bandwidth passed through the network was 13.30 Kbps for 100 sets of nodes. The throughput achieved for other node sets were presented in Table 3. Throughput graphs were shown in Fig. 5.

PDR: For different node densities, REV.DSR has shown constant and better packet delivery from the source node to the destination node. Packet delivery ratio of the STD.DSR was found to fluctuate. The PDR results were demonstrated in Fig. 6.

EED: Revised DSR has encountered lesser delays in delivering the data packets between the source and the destination nodes whereas, the standard DSR has met with large delays during data transmission sessions. Delay scenarios of both routing models were presented in Fig. 7.

PL: Data packet losses encountered in both the routing models were explored in Fig. 8. The revised model has shown better performances by achieving minimum packet losses as compared to the standard model.

NRL: Normalized routing load scenarios in either routing model were shown in Fig. 9. The REV.DSR has shown better results as compared to the STD.DSR by having minimal routing overheads. However, better-performing routing model may devour additional bandwidth.

Implications, applications, recommendations and limitations of the study: For different sets of the node populations (20, 40, 60, 80, 100 and 120), performance of the standard and revised DSR model was compared. As compared to the standard DSR model, the revised DSR gained improved throughput, better packet delivery, least end-to-end delays, minimum packet losses and least routing overheads. The revised dynamic source routing protocol will be helpful in establishing error-free and quick communication routes in critical applications such as military, emergency and rescue operations (during floods, earthquakes) etc. This study can be taken forward considering diverse network scenarios, other core protocol parameters and additional MANETs routing protocols. Results achieved in this study are limited to general network parameters and the attributes of some core parameters are taken into account.

CONCLUSION

According to simulation results and performance calculations, the revised DSR model has shown improved performance in terms of performance evaluating parameters as compared to its standard version. Attribute values considered for the revised DSR model may help improve the standard DSR routing protocol. Further research on standard and revised DSR routing models can be taken ahead for large number of network nodes with QoS (quality of service) concerns.

SIGNIFICANCE STATEMENT

Many researches were conducted on comparative analysis of MANET routing protocols considering network parameters. In this paper, network parameters as well as core attributes of the protocol were considered to study the behaviour of the revised DSR and compare its performance with the standard DSR. The routing protocols are considered as key protocols because they establish paths between network nodes effectively. The MANETs are very helpful at locations where network infrastructure does not exist. Some applications include, military operations, emergency rescue operations (during flood, earthquake, etc.). A better routing protocol is required to strengthen these networks in terms of effective connectivity. The purpose of this study is to enable scientists and engineers to consider better performing routing model while designing protocol suits.

ACKNOWLEDGMENT

The authors would like to thank Dr. Ramesh Singh Yadava, Computer Centre, Banaras Hindu University for providing his support in this study.

REFERENCES

1. Sahadevaiah, K. and O.B.V. Ramanaiah, 2010. An empirical examination of routing protocols in mobile ad hoc networks. Int. J. Commun. Network Syst. Sci., 3: 511-522.
2. Raghavendra, M. and P. Venkataram, 2017. ECA model based QoS AODV routing for MANETs. Int. J. Comput. Networks Commun., 9: 117-135.
3. Adam, S.M. and R. Hassan, 2013. Delay aware reactive routing protocols for QoS in MANETs: A review. J. Appl. Res. Technol., 11: 844-850.
4. Shanmugam, K., K. Subburathinam and A.V. Palanisamy, 2016. A dynamic probabilistic based broadcasting scheme for MANETs. Sci. World J., Vol. 2016. 10.1155/2016/1832026.
5. Huda Al Amri, M. Abolhasan and T. Wysocki, 2010. Scalability of MANET routing protocols for heterogeneous and homogenous networks. Comput. Electr. Eng., 36: 752-765.
6. Nand, P. and S.C. Sharma, 2011. Comparison of Routing Protocols for MANET and Performance Analysis of DSR Protocol. In: Advances in Computing, Communication and Control, Unnikrishnan, S., S. Surve and D. Bhoir (Eds.), Springer, Berlin, Heidelberg, ISBN: 978-3-642-18439-0, pp: 406-412.
7. Zafar, H., N. Alhamahmy, D. Harle and I. Andonovic, 2011. Survey of reactive and hybrid routing protocols for mobile ad hoc networks. Int. J. Commun. Networks Inf. Secur., 3: 193-216.
8. Lakshman, N.L., R.U. Khan and R.B. Mishra, 2016. Analysis of node density and pause time effects in MANET routing protocols using NS-3. Int. J. Comput. Network Inf. Secur., 8: 9-17.
9. Patel, A., S. Patel and A. Verma, 2012. A review of performance evaluation of AODV protocol in manet with and without black hole attack. Int. J. Emerging Technol. Adv. Eng., 2: 673-677.
10. Lakshman, N.L., R.U. Khan and R.B. Mishra, 2018. Comparative performance analysis on revised MANET routing protocols. Int. J. Appl. Eng. Res., 13: 2443-2451.
11. Hajlaoui, R., S. Touil and W. Achour, 2015. O-DSR: Optimized DSR routing protocol for mobile ad hoc network. Int. J. Wireless Mob. Networks, 7: 37-47.
12. Jin, J. and S. Ahn, 2016. A multipath routing protocol based on bloom filter for multihop wireless networks. Mobile Inf. Syst., Vol. 2016. 10.1155/2016/8151403.
13. Sandhu, D.S. and S. Sharma, 2013. Performance Evaluation of DSDV, DSR, OLSR, TORA Routing Protocols-A Review. In: Mobile Communication and Power Engineering, Das, V.V. and Y. Chaba (Eds.), Springer, Berlin, Heidelberg, ISBN: 978-3-642-35863-0, pp: 502-507.
14. Philip, P.C., R. Paulus, A.K. Jaiswal and A. Ashok, 2014. Comparative analysis of adhoc routing protocols in wi-fi & wi max networks using QualNet 6.1. Int. J. Curr. Eng. Technol., 4: 983-986.

15. Basurra, S.S., M. de Vos, J. Padget, Y. Ji, T. Lewis and S. Armour, 2015. Energy efficient zone based routing protocol for MANETs. Ad Hoc Networks, 25: 16-37.
16. Sirmollo, C.Z. and M.A. Bitew, 2021. Mobility-aware routing algorithm for mobile ad hoc networks. Wireless Commun. Mobile Comput., Vol. 2021. 10.1155/2021/6672297.
17. Bhagchandani, S.R. and D.S. Adane, 2013. Route cache optimizations of DSR protocol for VANET. Int. J. Comput. Sci. Technol., 4: 329-336.
18. Nand, P. and S.C. Sharma, 2011. Performance study of broadcast based mobile adhoc routing protocols AODV, DSR and DYMO. Int. J. Secur. Appl., 5: 53-64.
19. Jha, R.K. and P. Kharga, 2015. A comparative performance analysis of routing protocols in MANET using NS3 simulator. Int. J. Comput. Network Inf. Secur., 7: 62-68.
20. Khamayseh, Y., G. Obiedat and M.B. Yassin, 2011. Mobility and load aware routing protocol for ad hoc networks. J. King Saud Univ. Comput. Inf. Sci., 23: 105-113.
21. Acharekar, P., S. Mehta and S. Panbude, 2016. Comparative study for performance analysis of routing protocols in mobility and non-mobility scenarios. Emerging Trends Electr. Electron. Instrum. Eng. Int. J., Vol. 3. 10.5121/eeiej.2016.3301.
22. Aadri, A. and N. Idrissi, 2018. An advanced comparative study of MANETs routing protocols under varied number of nodes and mobility rate. J. Commun., 13: 284-292.
23. Patel, M.K. and D. Singh, 2016. Performance analysis of reactive and hybrid routing protocols in mobile ad hoc network. Int. J. Eng. Res. Technol., Vol. 4. 10.17577/IJERTCONV4IS15028.
24. Lakshman, N.L., R.U. Khan and R.B. Mishra, 2015. Analysis of performance enhancing parameters of AODV using NS-3. Afr. J. Comput. ICT, 8: 87-94.
25. Lakshman, N.L., R.U. Khan and R.B. Mishra, 2018. MANETs: QoS and investigations on optimized link state routing protocol. Int. J. Comput. Network. Inf. Secur., 10: 26-37.