



# Effect of Different Propagation Models in Routing Protocols

Munsifa Firdaus Khan, Indrani Das

**Abstract:** Mobile Ad hoc Networks (MANET) are wireless networks where communication of nodes takes place via radio waves. Due to dynamic topology and mobility of nodes frequent path failure takes place which in return affects the Quality of Service (QoS) in MANET. This paper mainly focuses on the experimental analysis on different propagation models namely Two-ray ground reflection, Free Space and Shadowing models on AODV and DSDV. We have done rigorous experiments to verify the effects of various propagation models and try to find its environment suitability. The QoS parameters we have used for the observation of the performance are throughput, delay and Packet-Delivery-Ratio (PDR). Simulation is done using NS-2. Free Space model gives better performance in both the protocols in contrast to other models. This paper will be helpful for researchers, students who are newly involved in research for better understanding and utilization of propagation models in corresponding environment.

**Keywords:** MANET, AODV, DSDV, Propagation model.

## I. INTRODUCTION

Mobile Ad hoc Networks (MANET) are self expandable and self constructive wireless networks that provides communication among nodes without any predetermined framework. Since it is a wireless network, communication takes place through radio waves. The unique characteristics of MANET like dynamic topology of nodes, mobility of nodes, inadequate resources, lack of central coordination etc. makes routing complicated which creates difficulty to provide QoS support in MANET. As a result of the exceptional characteristics of MANET, it has become a dynamic research area. MANET has a huge application domain due to its ease of deployment. It is used in emergency operations like search and rescue, military fields and commercial fields.

Quality-of-Service (QoS) is the performance level of services offered by a network to the user. The purpose of providing better QoS support in MANET is to attain good network performance so that the data transmission is done successfully. Parameters like jitter, maximum delay, maximum packet loss rate, minimum bandwidth, cost etc. must be available for QoS support [1].

In this paper, we have done the experiment in NS-2 to examine QoS provided by routing protocols- AODV and DSDV.

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\* Correspondence Author

**Munsifa Firdaus Khan\***, Department of Computer Science, Assam University, Silchar, Assam, India. E-mail: munsifa737@gmail.com

**Indrani Das**, Department of Computer Science, Assam University, Silchar, Assam, India. E-mail: indranidas2000@gmail.com

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We have evaluated the impact of various propagation models namely Free Space, Two-ray ground reflection and Shadowing on the performance of MANET. We have used QoS metrics like throughput, delay and PDR for performance analysis.

This paper has been arranged as- Section II represents the related work, Section III exploits the different propagation models. In Section IV, we discuss the routing protocols. Section V gives the simulation experiments and Section VI presents the results and discussion. Finally, Section VII concludes the paper.

## II. RELATED WORK

Gruber et al. [3] introduce the well known Walfisch-Ikegami propagation model to allow ad hoc simulations in urban areas. It is observed that the model allows sufficient accuracy while not significantly delaying the computation. The authors introduce an improved version of random way point mobility model in order to use a realistic simulation set up. The simulation has been carried out in two different urban situations. For limited networks and low mobility, the performance of DSR is better than AODV with respect to packet loss and path optimality whereas, AODV outperforms DSR with increased number of nodes and high mobility. When the simulation is executed on flat environment, the performance of AODV and DSR degrades. It provides limited lifetime of the path therefore frequent route rectification is needed for continuous exchange of data.

Schmitz and Wenig [4] introduce a propagation model which has high and depends on the exercise of a ray-tracer. Throughput and delay of multiple constant bit rate (CBR) are used for evaluation of the radio wave propagation model. The authors considered two different scenarios like indoor and outdoor for simulation. Here, AODV performs different with this model in contrast to its performance with Two Ray Ground model. It is also examined that for indoor scenarios hop-count and delays increases.

Joshi [5] presents a review based on the existing and recent developments in the field of radio transmission and propagation. The author discusses various existing radio propagation models and techniques.

Mehta et al. [6] examines various radio propagation models to check their performances on AODV using and without using Black Hole attack. Parameters used are Packet delivery fraction (PDF) and End to end delay. Using black hole attack in AODV affects the network performance. The PDF is poor while using black hole attack in AODV.

Mollet and Kisangiri [7] elaborates various propagation model.

The present paper gives emphasis to statistical models and explains models limitations and applications. The authors examine the models by performing field measurements at different locations. The values for path loss are evaluated and distinguished with actual model for different terrains. It is observed from the result that a substantial discrepancy with the empirical models for all the terrains.

Noh and Choi [8] examined wave propagation models at two indoor locations and one outdoor location using a time rate of 1% and 50%. At 1% time rate the quality of the signal is poor and time rate both the indoors and outdoors are similar at 50%. On the ground of these results, authors have proposed two propagation models that perform better than the COST231 model in both the locations.

### III. PROPAGATION MODELS

In Network Simulators (ns) the radio propagation models have been implemented to calculate the received signal power of each packet. Every node in a wireless network has a receiving threshold that is present at the physical layer. After receiving a packet, the signal power is checked with the threshold value. If the signal power of the packet is less than the receiving threshold then it is noted as an error and the MAC layer drops the packet. NS-2 has three distinct propagation models namely, free space model, two-ray ground reflection model and the shadowing model.

#### A. Free Space Model:

This is a simple path loss model having large scale. It is used to measure received signal power when there is a direct route between the transmitter and receiver. The numerical equation to measure the received signal power in free space at distance  $dist$  is given by:

$$P_r(\text{dist}) = \frac{(P_t G_t G_r \lambda^2)}{(4\pi)^2 (\text{dist})^2 L}$$

where  $P_r(\text{dist})$  is the signal power received,  $P_t$  is the signal power transmitted,  $G_t$  is the gain of the transmitter antenna and  $G_r$  is the gain of the receiver antenna.  $L$  is the system loss,  $dist$  is the distance between the transmitter and receiver and  $\lambda$  is the wavelength. Generally, in simulations the values for  $G_t$ ,  $G_r$  and  $L$  is set to one.

The Path loss in Free Space model, PL defines during propagation from transmitter to receiver how much signal power is lost. It is given by:

$$PL(\text{dist}) = PL(\text{dist}_0) + 10\gamma \log(\text{dist}/\text{dist}_0) + X_\sigma$$

where  $\gamma$  serve as the relationship between the distance and the received power. For wireless channel, the value for  $\gamma$  is greater.  $X_\sigma$  denotes a zero-mean Gaussian random variable of standard deviation  $\sigma$ . [5], [8].

#### B. Two-Ray Ground Reflection Model

This model is also a popular path loss, broad range model where the receiver receives signals via two paths one is straightforward path and the other path through which the reflected wave is received [14]. The received signal power at a distance  $dist$  is enumerated by the following arithmetical statement:

$$P_r(\text{dist}) = \frac{(P_t G_t G_r h_t^2 h_r^2)}{(\text{dist}^4 L)}$$

Where  $h_t$  denotes the heights of transmitter antenna and  $h_r$  denotes the heights of receiver antenna. With increasing distance the power losses in two ray ground model in compared to free space model. However, for minimum distance, the two-ray ground reflection model does not give an excellent outcome due to the fluctuation of the rays. When distance is minimum, free space model is preferred. One of the limitations of this model is that in ns-2 both the transmitter and receiver have to be on the similar height [5], [8]. This model is convenient when multipath effect is changed by a reflection of signal. The reason behind the formation of multipath effect is reflection, diffraction and scattering. Due to the generation of numerous copies of a signal the power gain decreases.

#### C. Shadowing Model

This model comprises of two sections. The primary one is well-known as path loss model, which calculates the received signal power at distance  $dist$ , indicated by  $P_r(\text{dist})$  is computed as below:

$$\left[ \frac{P_r(\text{dist})}{P_r(\text{dist}_0)} \right]_{\text{db}} = -10\beta \log\left(\frac{\text{dist}}{\text{dist}_0}\right)$$

Where  $\beta$  is termed as the path loss exponent. The last part of the shadowing model calculates the received signal power at a determined distance by the following formula:

$$\left[ \frac{\text{dist}}{\text{dist}_0} \right]_{\text{db}} = 10\beta \log\left(\frac{\text{dist}}{\text{dist}_0}\right) + X_{\text{dB}}$$

Where  $X_{\text{dB}}$  is known as a Gaussian random variable having mean value zero. Standard deviation ( $\sigma$ ) also known as shadowing deviation has also value zero for  $X_{\text{dB}}$ . Table-I and Table-II presents some values for path loss exponent ( $\beta$ ) and shadowing deviation ( $\sigma$ ) with respect to the corresponding environment [5], [8].

**Table-I: Values for  $\beta$ [8]**

Environment		Path loss exponent ( $\beta$ )
Outdoor	Free Space	2
	Shadowed urban area	2.7-5
Indoor	Line of sight	1.6-1.8
	Obstructed	4-6

**Table-II: Values for  $\sigma$ [8]**

Environment	Shadowing Deviation ( $\sigma$ )
Factory, Line of sight	6-Mar
Factory, Obstructed	6.8
Outdoor	12-Apr
Office, hard partition	7
Office, Soft partition	9.6

#### IV. ROUTING PROTOCOLS

We have studied here two routing protocols. One is proactive namely DSDV and other is reactive namely AODV routing protocol.

##### A. Destination Sequenced Distance Vector (DSDV) Routing Protocol:

Destination Sequence Distance Vector (DSDV) is a proactive i.e., table driven routing protocol where each node maintain up to date route information about every nodes in a network [11]. This protocol mainly resolves the routing loop problem. One of the advantages of this protocol is that minimum delay is required as all the paths are accessible to all destinations. For huge or changing network, this protocol is not suitable [2].

##### B. Ad Hoc on Demand Distance Vector (AODV) Routing Protocol

Ad Hoc On Demand Distance Vector(AODV) is a reactive i.e. on demand routing protocol where it begins path discovery at any time when a source node requires a path to a particular destination [2] [12]. The routes discovered by AODV are always free from loops due to the use of a sequence number [12]. A routing table is maintained by every node in AODV which keeps the data about the destination. AODV allows route maintenance. Whenever a link fails due to mobility of nodes its corresponding neighbor nodes responds to the failure in paths. One of its advantages is the flexibility for extremely dynamic environment [13].

#### V. SIMULATION EXPERIMENTS

##### A. Simulation Environment:

We have done experiments using NS-2. The Simulation parameters have been given in the Table-III. For performance analysis, in NS-2, we have considered three group of nodes: 25 as a small group of nodes, 75 as a medium group of nodes and 100 as a huge group of nodes. The QoS parameters that we have used for performance analysis are: throughput, delay and Packet Delivery Ratio (PDR).

**Table-III: Simulation Environment**

Parameters	Values
Simulation area	500x400
Number of nodes	25,75 and 100
Simulation Start time	10 seconds
Simulation end time	150 seconds
Mobility Model	Random Way Point
Channel	Wireless
Interface queue	Queue/droptail/priqueue
Antenna	Omnidirectional
Routing Protocol	AODV and DSDV
MAC	802.11
Propagation Models	Two-ray ground reflection, Free Space and Shadowing

*Throughput:* It is said as the amount of data packets transmitted through a path. The unit of throughput is measured in terms of Kbps [2].

*Delay:* It is termed as a time taken by a network for transmission of data packets from a particular source node to a destination node. It can be measured in terms of seconds, microseconds, milliseconds and so on. Here it is measured in terms of seconds [2].

*Packet Delivery Ratio (PDR):* It is expressed as the ratio between the numbers of packets received by a destination node to the number of packets generated by a source node [2].

##### B. Simulation Results

To estimate the effect of the different propagation models on MANET, thorough experiment have been done using QoS parameters throughput, delay and PDR. In this paper, two routing protocols namely AODV and DSDV have been considered for performance analysis. We have done two comparisons using the parameters mentioned above in the Table-III, one is comparison of both the routing protocols and another is using these routing protocols we have compared different propagation models.

*Throughput:* The parameters and corresponding values for throughput of AODV and DSDV have been given in the Table-IV and Table-V. It is observed from Fig.1 that for AODV Free Space gives the highest throughput whereas Two ray ground reflection gives the least throughput. It is also observed that for Free Space, the throughput for varying nodes does not differ much whereas for two ray ground, throughput decreases with increasing number of nodes. In case of shadowing, with increasing number of nodes throughput also increases. In AODV, the highest throughput value is 0.0203 kbps using Free Space propagation model for 25 no. of nodes whereas for 100 no. of nodes using two ray ground reflection model the throughput value is 0.0101 kbps which is least. On the other hand, for DSDV, Free Space and two ray ground propagation model have almost similar throughput values whereas shadowing model gives the least throughput for DSDV. It is observed that the highest throughput value is 0.0197 kbps for 25 no. of nodes using Free Space model and the least throughput value is 0.0177 kbps for 100 no. of nodes using two ray ground reflection models. Free Space propagation model outperforms well in compared to other propagation models in both AODV and DSDV routing protocols.

**Table-IV: Throughput for AODV**

No. of nodes	Propagation models		
	Free Space	Two ray ground reflection	Shadowing
25	0.0203	0.0151	0.0172
75	0.0202	0.0136	0.0191
100	0.0200	0.0101	0.0196

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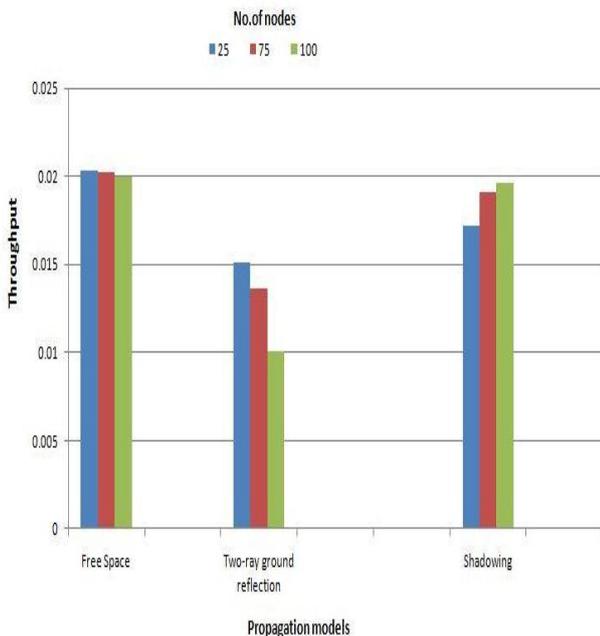
Table-V: Throughput for DSDV

No. of nodes	Propagation models		
	<i>Free Space</i>	<i>Two ray ground reflection</i>	<i>Shadowing</i>
25	0.0197	0.0196	0.0178
75	0.0191	0.0185	0.0181
100	0.0186	0.0177	0.0176

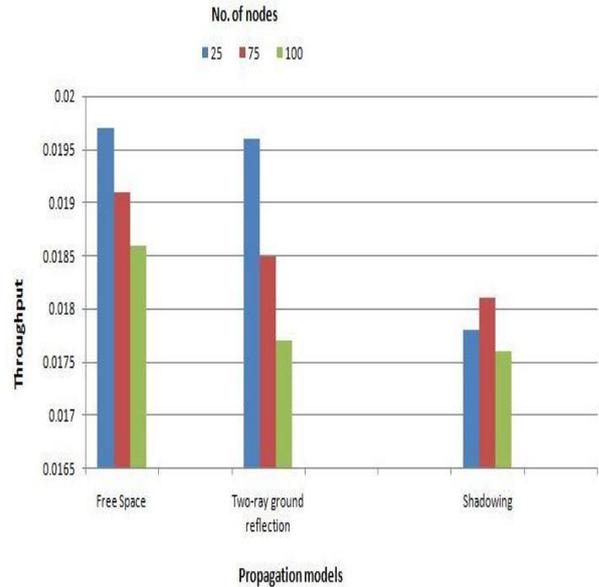
▪ **PDR:** The parameters and corresponding values for PDR of AODV and DSDV have been given in the Table -VI and Table-VII. It is observed from Fig. 3 that the PDR values are same i.e. 0.9991 for all the three set of nodes in Free Space propagation model. In case of 75 nodes, two ray ground gives the least PDR value of 0.9948 whereas shadowing gives the highest PDR value of 0.9974 among all the set of nodes. It is observed that Free Space model outperforms well in AODV in compared to other propagation models whereas two ray ground gives the least PDR values among all the models. On the other hand, for DSDV with increasing number of nodes PDR values decreases in Free Space model whereas it is increasing for shadowing model. It is seen that for 75 no. of nodes, two ray ground gives the least PDR value of 0.9960. It is concluded that Free Space model gives better PDR values for both AODV and DSDV. It is also seen that in both AODV and DSDV the PDR values for two ray ground is almost similar.

Table -VI: PDR for AODV

No. of nodes	Propagation models		
	<i>Free Space</i>	<i>Two ray ground reflection</i>	<i>Shadowing</i>
25	0.9991	0.9976	0.9972
75	0.9991	0.9948	0.9974
100	0.9991	0.9965	0.997



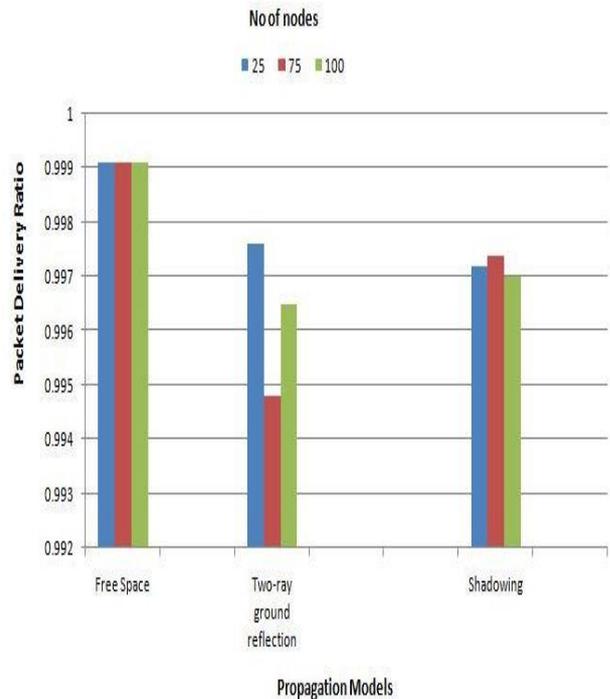
**Fig.1. Throughput for AODV.**



**Fig. 2. Throughput for DSDV.**

Table-VII: PDR for DSDV

No. of nodes	Propagation models		
	<i>Free Space</i>	<i>Two ray ground reflection</i>	<i>Shadowing</i>
25	0.9982	0.9973	0.9958
75	0.9972	0.9960	0.9965
100	0.9971	0.9962	0.9970



**Fig.3. PDR for AODV.**

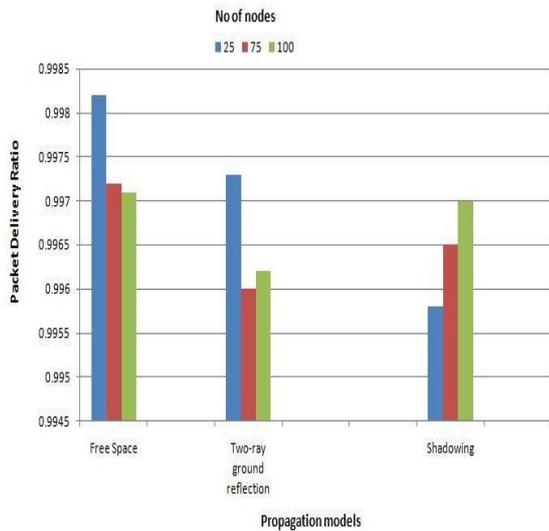


Fig.4. PDR for DSDV.

Delay: The parameters and corresponding values for delay of AODV and DSDV have been given in the table 8 and table9. It is seen that in Fig. 5 for AODV, Free Space model gives the least delay among all the models and for different set of nodes the delay values does not differ much in Free space model. It is also observed that for 100 no. of nodes, two ray ground gives the highest delay of 238.0624 seconds. In AODV, Two ray ground model shows the highest delay values for all set of nodes in compared to other propagation models. The shadowing model gives maximum delay of 138.4186 seconds for 25 no. of nodes amongother set of nodes in AODV whereas for 75 and 100 no. of nodes delay is almost similar i.e. 124.6766 seconds and 124.3980seconds respectively. It is concluded that in AODV, free spacemodel gives the minimum delay values whereas two ray ground gives maximum delay values. On the other hand, for DSDV two ray ground gives better delay values in compared to other models as shown in Fig. 6. For 100 no. of nodes using two ray ground the delay value is minimum of 144.3090 seconds whereas it gives maximum value of 241.9005 seconds for 75 no. of nodes in DSDV which is lower than other delay values using other two models. It is observed that in DSDV, the delay values increases with increasing no. of nodes in Free Space model. Using shadowing model in DSDV, the delay values are almost similar for 25 and 100 no. of nodes i.e. 249.1194 seconds and 249.9887 seconds respectively. It is seen from the observations that two ray ground provides minimum delay values in DSDV whereas in AODV it gives the maximum delay values when compared with other propagation models. It is also observed that in AODV free space gives minimum delay values whereas it gives maximum delay values in DSDV.

Table-VIII: Delay for AODV

No. of nodes	Propagation models		
	Free Space	Two ray ground reflection	Shadowing
25	119.9517	155.1515	138.4186
75	120.4028	163.1576	124.6766
100	120.4136	238.0624	124.3980

Table-IX: Delay for DSDV

No. of nodes	Propagation models		
	Free Space	Two ray ground reflection	Shadowing
25	242.5116	184.2649	249.1194
75	252.0645	241.9005	241.9144
100	258.8052	144.3090	249.9887

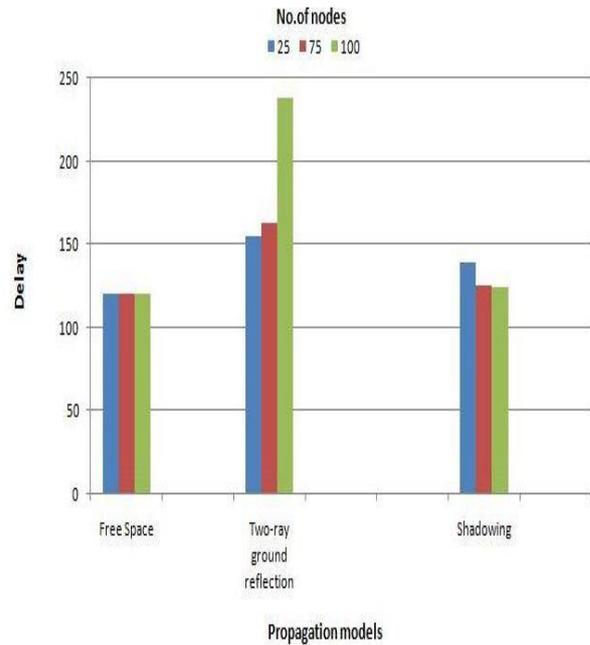


Fig.5. Delay for AODV.

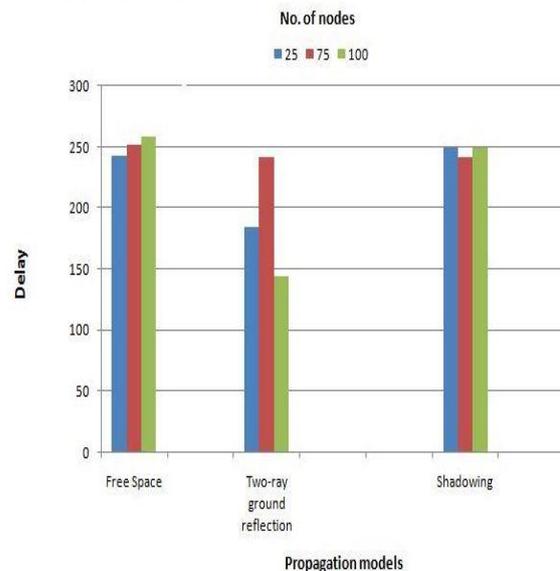


Fig.6: Delay for DSDV.

## VI. RESULTS AND DISCUSSION

We have considered three propagation models namely Free Space, Two ray ground reflection and Shadowing models for better understanding of the characteristics of propagation models and to check the environment suitability. We have also considered one proactive and one reactive routing protocols namely DSDV and AODV respectively for analysis of the performance of various propagation models. We have done rigorous experiments on NS-2 using QoS metrics throughput, delay and PDR. We have considered three set of nodes, 25, 75 and 100 as small, medium and large density of nodes respectively. It is observed from the simulation results that in AODV, Free Space model gives maximum throughput, maximum PDR and minimum delay in compared to other propagation models. The major reason behind the better performance of Free Space is that the way this model works. It does not consider absorbing obstacles and reflecting surfaces. Generally, the effect of the surface of the earth is not considered [14]. It is also observed that in AODV, varying nodes does not affect in case of Free Space models. The results are almost similar for three different set of nodes in AODV. Furthermore, in AODV, two ray ground model gives the least quality of performance i.e minimum throughput, minimum PDR and maximum delay values. The reason behind the poor performance of Two ray ground reflection is the distance between the antennas. When the distance is minimum, the power of the model increases else it decreases and thus degrades the performance [14]. Shadowing model in AODV gives better throughput whereas for DSDV it gives the least throughput. Due to the objects barriers between a transmitter and receiver the received signal power varies which influence the performance in protocols. It is observed that with varying protocol the influence of the model varies. On the other hand, for DSDV, the Free Space model has maximum throughput, maximum PDR and maximum delay values in compared to other models. It is observed that Two ray ground reflection model gives minimum delay values in DSDV in compared to other models. It is seen from the simulation results that the performance of propagation models are varying with different routing protocols.

## VII. CONCLUSION AND FUTURE WORK

This paper discuss different propagation models namely two ray ground reflection, free space and shadowing. These models show different results on different scenarios in NS-2. Moreover, we have consider two routing protocols for performance observation of the propagation models using three set of nodes viz. 25, 75 and 100. We have evaluated the above routing protocols using QoS parameters throughput, delay and PDR. It is concluded from the experimental results that Free Space gives better performance in both the routing protocols with different group of nodes in compared to other models. However, QoS is better in free space using AODV routing protocol. It is observed that delay value is higher in DSDV using Free Space. It is important to decrease delay values and increase throughput and PDR in order to achieve QoS. Throughput and PDR are found satisfactory using Free Space propagation model in both the routing protocols. One

of the future directions of this paper is to improve the above propagation models so that better QoS can be achieved.

## REFERENCES

1. Khan MF, Das I (2017) A study on quality-of-service routing protocols in mobile ad hoc networks. In: 2017 international conference on computing and communication technologies for smart nation (IC3TSN). IEEE, 2017, pp. 95–98.
2. Khan MF, Das I (2019) An Investigation on Existing Protocols in MANET. © Springer Nature Singapore Pte Ltd. H. S. Saini et al. (eds.), Innovations in Computer Science and Engineering, Lecture Notes in Networks and Systems 74, 2019, pp. 215–224.
3. Gruber, Ingo, Oliver Knauf, and Hui Li. "Performance of ad hoc routing protocols in urban environments." *Proceedings of European Wireless*. 2004.
4. Schmitz, Arne, and Martin Wenig. "The effect of the radio wave propagation model in mobile ad hoc networks." *Proceedings of the 9th ACM international symposium on Modeling analysis and simulation of wireless and mobile systems*. ACM, 2006.
5. Joshi, Sumit. "Outdoor propagation models a literature review." *International Journal on Computer Science and Engineering* 4.2, 2012, pp. 281–291.
6. Mehta, Abhinav, Rohit Jain, and Vinay Somani. "Comparison of different Radio Propagation Models with and without Black Hole Attack on AODV routing protocol in MANET." *International Journal of Computer Applications* 61.1, 2013.
7. Mollel, Michael S., and Michael Kisangiri. "An overview of various propagation model for mobile communication." *Proceedings of the 2nd Pan African International Conference on Science, Computing and Telecommunications (PACT 2014)*. IEEE, 2014.
8. Noh, Sun-Kuk, and Dong You Choi. "Propagation Model in Indoor and Outdoor for the LTE Communications." *International Journal of Antennas and Propagation* 2019, 2019.
9. Gagandeep Singh and Rohit Dubey. "A Review Of Aodv Routing Protocol For MANET." *International Journal of Business Management And Scientific Research*. Vol. 17. May 2016.
10. Royer, Elizabeth M., and Charles E. Perkins. "An implementation study of the AODV routing protocol." *2000 IEEE Wireless Communications and Networking Conference. Conference Record (Cat. No. 00TH8540)*. Vol. 3. IEEE, 2000.
11. Landge P, Nigavekar A (2016) Modified aodv protocol for energy efficient routing in manet. *Int J Eng Sci Res Technol* 5(3), pp.523–529.
12. C. Siva Ram Murthy and B. S. Manoj, "Ad hoc Wireless Networks: Architectures and Protocols", *Prentice Hall PTR*, May, 2004.

## AUTHORS PROFILE



**Munsifa Firdaus Khan**, M.Sc (Gold Medalist) in Computer Science from Assam University (A Central University), Silchar, Assam, India in 2014. Currently, I am pursuing Ph.D in the Department of Computer Science, Assam University, Silchar, Assam, India under the supervision of Dr. Indrani Das, Assistant Professor, Computer Science, Assam University, Silchar, Assam, India. I have been awarded Maulana Azad National Fellowship (MANF) 2017-18 for continuing my research work. My publications are available in the following link below: <https://scholar.google.com/citations?user=h2vxnUIAAAAJ&hl=en>



**Dr. Indrani Das** her B.E., M.Tech and Ph.D in Computer Science and Engineering. She is working as an Assistant Professor in the Department of Computer Science in Assam University (A Central University), Silchar, Assam, India. She received her Ph.D from School of Computer and Systems Sciences,

Jawaharlal Nehru University, New Delhi, India in 2015. Her current research interest includes Mobile Ad hoc Networks and Vehicular Ad hoc Networks, IoT.