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Research Article

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Distance-Based Performance Evaluation of Two-Ray Ground and Free Space Propagation Models in Mobile Ad-hoc NETwork (MANET)

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Abstract: Mobile Ad-hoc NETwork (MANET) is a decentralized type of wireless network. The network is ad hoc because it does not rely on a pre-existing infrastructure, such as routers in wired networks or access points in managed wireless networks. One of the major issue and challenging area in MANET is the process of routing due to dynamic topologies and high mobility of mobile nodes. The efficiency and accuracy of a protocol depend on many parameters in these networks. In addition to other parameters node velocity and propagation models are among them. Calculating signal strength at the receiver is the responsibility of a propagation model while the mobility of nodes is responsible for the topology of the network. A huge amount of loss in performance is occurred due to the variation of signal strength at the receiver while increasing and decreasing the distance of nodes. In this paper, a novel approach is identified and portrayed of the said propagation models based on distance from each other. It has been analyzed to check distance based performance evaluation of Two Ray Ground and Free Space Radio Wave Propagation Models on the performance of Ad-hoc On-demand Distance Vector (AODV) Routing Protocol in MANET. The simulation has been carried out in (Network Simulator-2) NS-2 by using performance metrics that are Average Throughput (kpbs), Average Latency (milliseconds) and Average Packet Drop (packets). The results predicted that propagation models and mobility have a strong influence on the performance of AODV in considered distance based scenario.

Keywords: MANET, AODV, Two Ray Ground Propagation Model, Free Space Propagation Model, Distance Based Performance.

1. Introduction

The unfolding wide-scale growth of the mobile-phone market is in the development of empowering practical real-world positioning environments for MANET and its based applications and services. The quality of these applications and services will innately rest on the behavior of the underlying MANET network; hence, these behaviors need to be well understood.

Figure 1: Scenario of MANET (Joshi, 2011)

MANET is an ad-hoc network that needs no physical entity like central entity. It is self-configuring and self-organized network. MANET becomes very common to use, it is very simple and ease of deployment, when there are much limitations to install wired network either for restrictively of wired infrastructure or for duration of the installation or for other details. It can be the key in these situations. For example, MANET can be used and compatible for precarious circumstances which include law-enforcement, military, along with disaster recovery and emergency rescue (Bakshi and Mishra, 2003).

A MANET is characterized by a set of mobile nodes connecting using wireless networks. The easy use of MANET is flexible and low cost network lead to the communication era for their extensive usage. While the sending and receiving of data in this network is carried out via the location information of the node from source to destination for finding suitable routes. This procedure can be done via an efficient and robust routing scheme like AODV that uses the concept of flooding for finding the route initiation. Apart from this, some issues may exist in this network like mobility of node, having limited power of computation etc. are to be solved properly because MANET possess some breakage in routes that makes an broad issue to this (Hoebeke *et al.,* (2004).

MANET consists of movable nodes that communicate with one another directly without any physical infrastructure. In recent decades, these networks are evolving with the latest technological enhancements. Though, with these advantages, MANET also suffers when the node goes away from each other by possessing long distance of communication. Due to mobility nature of MANET, the data loss and less throughput occurs because these nodes are equipped with propagation models which have limited range of signal propagation. Going away from each other's and increasing distance between nodes ultimately effects on propagation models which weaken the strength of the signal. Every propagation model performs within specific region or range of communication. From this viewpoint recent research has focused on distance based performance evaluation of two ray ground and free space radio wave propagation models. By placing different ranges in meters from one node to another and to check the performance of each radio wave propagation model in different scenarios with equal range in meters.

The core objectives of the research are;

- To investigate distance based performance evaluation of Two Ray Ground and Free Space propagation models in MANETs.
- To simulate and analyze distance based performance evaluation results in terms of Average Throughput, Average Latency and Average Packet Drop.

The current research has focused on the performance evaluation of two radio waves propagation models on distance based. To the best of our knowledge the main novelty and contribution in this research is that no work under the same title or methodology has been carried out for propagation models that are evaluated under distance based. The current research has positive feature and that has a direct link with the radio wave propagation models and that positive and novel part is the distance. Many studies have been conducted but those have focused on varying number of nodes, varying different scenarios like sparse, dense, indoor, outdoor, urban etc. but performance evaluation and analysis on distance based has not performed in the related work that is present in the literature review chapter. Whenever propagation takes place in communication it deals with the range or distance in which it suffers due to limited range of communication and signal propagation. The proposed work will be tested under performance evaluation parameters that are average throughput, average latency and average packet drop. By varying the distance from source to destination the two radio wave propagation models have been selected that are Two Ray Ground and Free Space. There may be some authors, who have conducted distance based evaluation but as far as we know in our related work there is no similarity with our proposed work. This is the first attempt as we have studied so far to analyze and evaluate the radio wave propagation models based on distance.
The rest of the paper is organized as; section 2 explains and consists of related literature in which the related work has been shown from different articles. Section 3 explains the main procedure and methodology of this paper along with simulation setup. Section 4 is consisting of the experimental results along with evaluation of the results. And finally, section 5 consists of conclusion which concludes this research.

2. Literature Review

Sun et al. (2018) provided a comprehensive synopsis of the channel models that will likely be used in the design of 5G radio systems. They started with a discussion on the framework of channel models, which consists of classical models of path loss versus distance, large-scale, and small-scale fading models, and multiple-input multiple-output channel models. Then, key differences between mmWave and microwave channel models are presented, and two popular mmWave channel models are discussed: the 3rd Generation Partnership Project model, which is adopted by the International Telecommunication Union, and the NYUSIM model, which was developed from several years of field measurements in New York City. Examples on how to apply the channel models are then given for several diverse applications demonstrating the wide impact of the models and their parameter values, where the performance comparisons of the channel models are done with promising hybrid beam forming approaches, including leveraging coordinated multipoint transmission. These results showed that the answers to channel performance metrics, such as spectrum efficiency, coverage, hardware/signal processing requirements, etc., are extremely sensitive to the choice of channel models.

Grimm (2019) derived on-body antenna parameters and physically motivated EM propagation models that can be used to develop scalable path gain models as well as optimized design strategies. Considering planar dissipative surfaces, an intuitive propagation model was discussed, which followed the classical Somerfield problem. An appropriate solution for quasi-static ranges is adapted and consulted to discuss basic principles of electromagnetic propagation of on-body line-of-sight scenarios for selected frequencies between 400 MHz and 60 GHz. Based on these results, an antenna de-embedding was introduced in the course of their thesis, which was capable of modeling the average radiated antenna far field. Furthermore, a decomposition of the total on-body far field into a TM field component and a TE one was discussed to define two equivalent electric dipole sources. This approach enabled the definition of the on-body directivity as well as the effective antenna area to discuss the radiation properties of the corresponding antenna geometry in terms of on-body communications. While this approach was primarily limited to line-of-sight propagations, a cylindrical dielectric phantom was introduced to cover non-line-of-sight links as well. In this case, the introduced de-embedding method is used to model the quasi-static range while the bended propagation path was treated by an adapted cylindrical model, which emphasizes the TM/TE-related far field decomposition of the planar model. Finally, the theory that was derived was verified by numerical full human body examples as well as by measurement setups in an anechoic chamber.

El Chall et al. (2019) investigated LoRaWAN radio channel in the 868 MHz band. Extensive measurement campaigns were carried out in both indoor and outdoor environments at urban and rural locations in Lebanon (Saint Joseph University of Beirut campus, Beirut city, and Bekaa valley). Based on empirical results, PL models were developed for LoRaWAN communications and compared with widely used empirical models. Moreover, the performance and the coverage of LoRaWAN deployment were evaluated based on real measurements. The results showed that the proposed PL models were accurate and simple to be applied in Lebanon and other similar locations. Coverage ranges up to 8 km and 45 km were obtained in urban and rural areas, respectively. This revealed the reliability of this promising technology for long-range IoT communications.

Gulfam et al. (2019) presented a thorough analysis on the azimuthal multipath shape factors and second-order fading statistics (SOFS) of outdoor and indoor mmWave radio propagation channels. The well-established analytical relationship of plain angular statistics of a radio propagation channel with the channel's fading statistics is used to study the channel's fading characteristics. The plain angle-of-arrival measurement results available in the open literature for four different outdoor radio propagation scenarios at 38 GHz, as well as nine different indoor radio propagation scenarios at 28 GHz and 38 GHz bands, are extracted by using different graphical data interpretation techniques. The considered quantifiers for energy dispersion in angular domain and SOFS are true standard-deviation, angular spread, angular constriction, and direction of maximum fading; and spatial coherence distance, spatial auto-covariance, average fade duration, and level-crossing-rate; respectively. This study focuses on the angular spread analysis only in the azimuth plane. The conducted analysis on angular spread and SOFS is of high significance in designing modulation schemes, equalization schemes, antenna-beams, channel estimation, error-correction techniques, and interleaving algorithms; for mmWave outdoor and indoor radio propagation environments.

Yaro and Sha'ameri (2018) considered signal attenuation to be the major contributor to the TDOA estimation error and its effect based on path loss propagation model on the PE accuracy of the MLAT system was determined. The two path loss propagation models considered were: Okumura-Hata and the free space path loss (FSPL) model. The transmitter and receiver parameters used for the analysis are based on actual system used in the civil aviation surveillance. Monte Carlo simulation result based on square ground receiving station (G RS) configuration and at some randomly selected aircraft positions showed that the MLAT system with the Okumura-Hata model has the highest PE error. The horizontal coordinate and altitude errors obtained considering the Okumura-Hata are 2.5 km and 0.6 km respectively higher than that obtained with the FSPL model.

Harinda et al. (2019) used NS-3 to simulate radio propagation for Long range wide area network (LoRaWAN) at 868 MHz in an urban environment using the Okumura-Hata model, the COST-231 Hata, and the COST 231 Walfish-Ikegami (COST-WI). LoRaWAN use radio frequency 868 MHz for communication in Europe. The predicted received signal strength values were compared with the real-world measurements taken in the city of Glasgow to analyze the validity and accuracy of the empirical models when used for planning and coverage prediction in LoRaWAN networks. The comparison between models and measurements showed that Okumura-Hata under-estimated the received signal strength in Glasgow city scenario while COST-WI over-estimated the same power. Similarly, the Okumura-Hata model showed higher accurate predictions whereas COST-WI accuracy was the least. The magnitude of mean absolute error indicates how big or small models prediction error can be expected. This study can be used to give an insight into the effectiveness and accuracy of empirical propagation models for evaluation of Internet of Things (IoT) connectivity with LoRaWAN networks in a non-line of sight (NLOS) urban environment.

Hussain et al. (2020) analyzed to check the impact of different propagation models on the performance of Optimized Link State Routing (OLSR) in Sparse and Dense scenarios in MANET. The simulation has been carried out in NS-2 by using performance metrics as average packet drop, average latency and average Throughput. The results predicted that propagation models and mobility have a strong impact on the performance of OLSR in considered scenarios.

3. Proposed Methodology

These research works belong to the latter category which is simulations. Network models and protocols are normally evaluated using different parameters using simulation to check the efficiency and stability of the protocols from different angles and directions. The impacts of different variables are studied using simulation using multiple scenarios for each protocol.

The proposed simulation model and its parameters are depicted in Figure 4. The flow of simulation starts from writing a TCL script composed of simulation parameters of the proposed scenarios. The parameters will be varied in each TCL scripts according to the parameters in Table 2. Each script will be executed multiple times and the average value will be calculated against each evaluation parameter. The result of all simulation scenarios will be recorded for further analysis against the chosen performance metrics. The results will be also incorporated into Microsoft excel for visual comparison based on the varied simulation parameters.

3.1 Simulation Scenario

The tool used for simulation in this research study is the popular tool used for carrying out this type of research studies, NS-2 is the widely used tool which has been incorporated into many wireless testbeds and industry standards for carrying out discrete event simulations. The techniques used for analyzing the results will be PERL and AWK scripts using the .tr files generated by running the TCL scripts. Further, the results will be depicted in the form of graphs in Microsoft Excel for visual appearances. The simulation work of this research work can be broadly categorized into three major phases, i.e. Pre simulation phase, Execution Phase, and Post Simulation phase. General and diagrammatic views of these phases are shown in Figure 7.

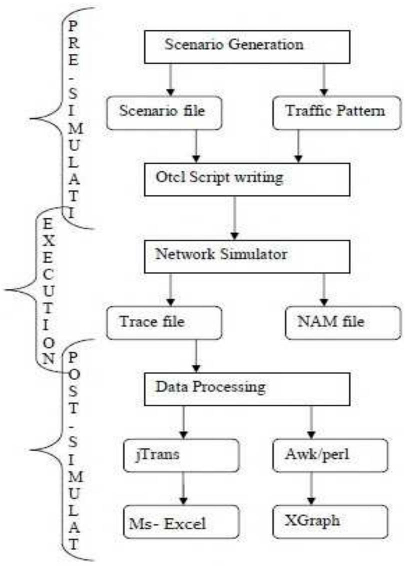

Figure 7: Phases of Simulations

3.1.1 Pre-Simulation Phase

The pre simulation phase is the initial phase in which all the parameters are set before the actual work starts. This phase defines that how many simulation scenarios will be created and will be differentiated based on simulation parameters from each other like several hosts in the scenario, topology of the network, mobility models, selection of protocols on different layers, simulation time, terrain size of the network, selection of performance evaluation parameters and much more beyond this. A TCL script will be written composed of the aforementioned parameters and protocols.

3.1.2 Execution Phase

The execution phase will accomplish the task of running the simulation script which will be prepared in the previous phase written in OTcl language. After executing the scripts of each simulation scenario two files will be obtained in the form of output i.e. trace and animation file. The trace file is composed of all the events that occurred during the simulation for a specified amount of time such as several packets sent, dropped and received, etc. While the animation file contains the physical and visual layout of the network topology.

3.1.3 Post Simulation Phase

The last phase of the simulation process is the post-simulation phase whose purpose is to critically analyze the obtained results and get the required information from the generated files (trace files). Several techniques can be applied to getting the desired information. Perl and awk scripts are the two common techniques used for the analysis of the results obtained from simulation while some people export the trace files to excel for analysis.

Extensive simulations will be carried out to investigate the efficiency and performance of the AODV scheme under diverse models of propagation. Several simulation scenarios will be tested by varying simulation parameters like various terrains. Secondly, the distance based evaluation will be simulated for each propagation model listed in Table 1. The simulation will be carried out for taking transport agent as TCP and application layer traffic as FTP. The nodes will be deployed randomly in a simulation area of 500m×500m area using Random Waypoint as the mobility models with a pause time of 2 seconds. The simulation will last for 100 seconds against each considered scenarios. The simulation will demonstrate how the performance of the AODV scheme will be affected by the size of the network in diverse scenarios. Further, the outcomes of this study will reveal which propagation model provides better results for distance based scenarios under AODV as a routing protocol.

Table 1: General Simulation Parameters.

Simulation Parameter	Value
Simulation Tool	Network Simulator-2
Channel type	Wireless 802.11
Routing Protocol	AODV
Performance Evaluation Parameters	Average Throughput (kbps) Average Latency (milliseconds) Average Packet Drop (packets)
Propagation Models	Two Ray Ground Free Space
Simulation time	100 seconds
Simulation Area	500m X 500m
Number of Nodes	100
Maximum Distance	40 meters
Minimum Distance	10 meters
Agent	Transmission Control Protocol (TCP)
Packet Size	1000 Bytes
Mobility Model	Random Way Point
Node Mobility	1-10 m/sec
Pause Time	2 seconds

3 Propagation Models

3.1 Two-Ray Ground Propagation Model

This kind of model also has the ability of large-scale quantity. It is called two ray because it creates two ray with the ground by using the propagation of a signal in two way as shown in Figure 2. As for direct LOS and by using the ground as a medium for reflection of signal this model takes place in both scenarios. It is said that the energy of the received signal is the total of sum of the direct LOS path and also the path having the reflection of the signal with the ground from sender and receiver. Some limitations in this model arise during the simulation that is for communication the transmitter and receiver should be placed at the same height from each other. It is also revealed that this model given efficient results and performance at a long distance in contrast with the free space which given best results in short distance (Khan et al., 2017).

The power P of received by distance d is shown by:

$$P_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{d^4 L} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

In this case P_t is the power of transmitted signal, G_t and G_r are the gains of the antenna transmit and receive, h_t and h_r are heights of received and transmitted antenna respectively and L is the arrangement failure (Khan *et al.*, 2017).

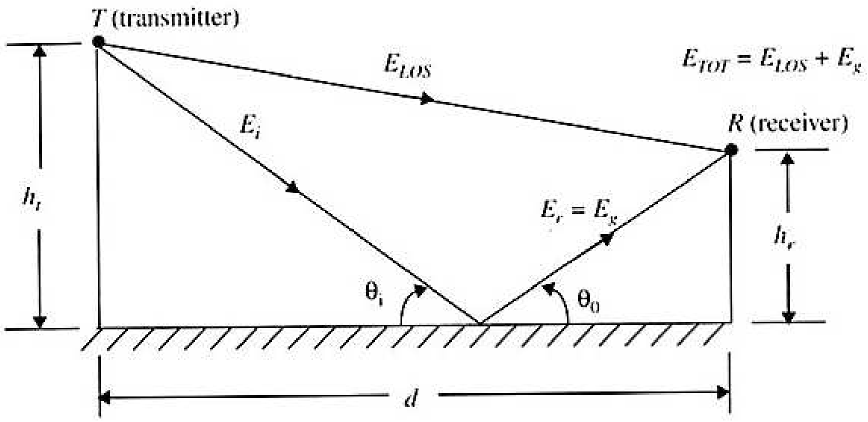

Figure 2: Scenario of Two Ray Ground Propagation Model (Eltahir et al., 2007)

3.2 Free Space Propagation Model

This is a model in which it contains only free space and no obstacles in the middle of the source and destination because it only focuses on the clear LOS as shown in Figure 3. The gained power is just reliant on the power of transmitted, the antenna's gains and on the distance between the destination and the source. It takes into considerations the majority for the detail that the signal of radio waves transfers far from the sender that has to confront a best region. Consequently, the power of received signal minimizes with the distance of the square level. The model of propagation of free space undertakes the best propagation form that there is only one perfect LoS path between the receiver and the transmitter. H.T Friis suggested the equation 1.2 for the calculation of the signal gained power in the model of Fee Space at the distance (*d*) from the sender/transmitter (Schmitz and Wenig, 2006).

This model can be calculated by using the equation 2.

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

Where, P_t is the transmitted signal's power. G_t and G_r are the antenna's gains of the receiver and the transmitter separately, where λ is the wavelength and L $(L \geq 1)$ is the loss of the system. It is usual to choose $G_t = G_r = 1$ and $L = 1$.

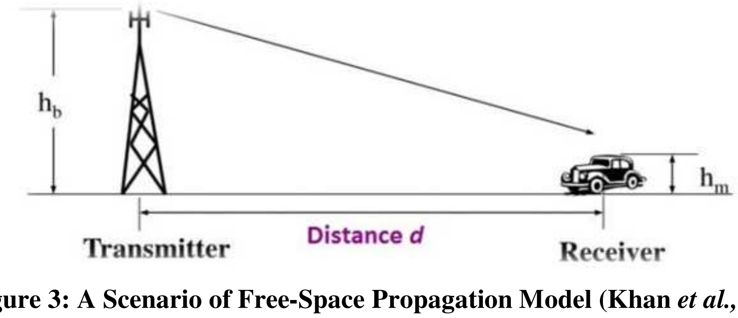

Figure 3: A Scenario of Free-Space Propagation Model (Khan *et al.,* 2017)

4. Results & Analysis

This section provides the experimental results along with proper justification for the proposed method. Each scenario is discussed with tabular and graphical illustration. From viewpoint of the proposed approach in which two propagation models are mentioned for analysis and evaluation based on the performance evaluation parameters that are Average Throughput, Average Latency and Average Packet Drop. These evaluation metrics are explained subsequently.

4.1 Average Throughput (kbps)

Throughput refers to the number of items or material passing through a system. In the jargon of networks throughput is the amount of data transferred successfully from source to destination in a network in a specified amount of times. Throughput is measured normally in bits/sec. Higher throughput denotes the effectiveness and efficiency of the network (Jubair et al., 2018). This metric can be calculated using Equation 3.

$$\text{Average Throughput}= \sum_{i=1}^{n} \frac{\text{Received packets i } \times \text{packet size}}{total\ simulation\ time} \quad (3)$$

From the given equation the average throughput can be calculated. In this regard the mentioned values are the average throughput of two ray ground and free space propagation models. As shown in the given table and graphical illustration that two ray ground and free space has shown better performance in respect to average throughput. The distance based performance has been recorded in which four sequences are used for distance that are completely in meters in which starting point is 0 and the last point or maximum value is 40 meters. At 0 or initial point both have values in 0 which and when the simulation has started then at distance 10m the value of two ray ground is 90 whereas the value of free space is 89 at that point. Proceeding to the next level i.e., increase in the distance from 10 t0 20m the value of two ray ground is 91 and free space is 80. Similarly, the distance 40m the value of two ray ground is 83 and free space is 78. These recorded values are the throughput in kbps in which the two ray ground has shown better performance as compared to free space. The main reason is that the signal propagates and can pave long distance in two ray ground model which doesn't need clear LOS. But free space purely focus on the clear LOS that's why the signal can't travel in large distance in this scenario that's why it has shown poor performance in contrast with the two ray ground.

Table 2: Average Throughput (kbps) of two ray ground and free space.

Propagation Model	Distance in Meters 0	Distance in Meters 10	Distance in Meters 20	Distance in Meters 30	Distance in Meters 40
Two Ray Ground	0	90	91	85	83
Free Space	0	89	80	75	78

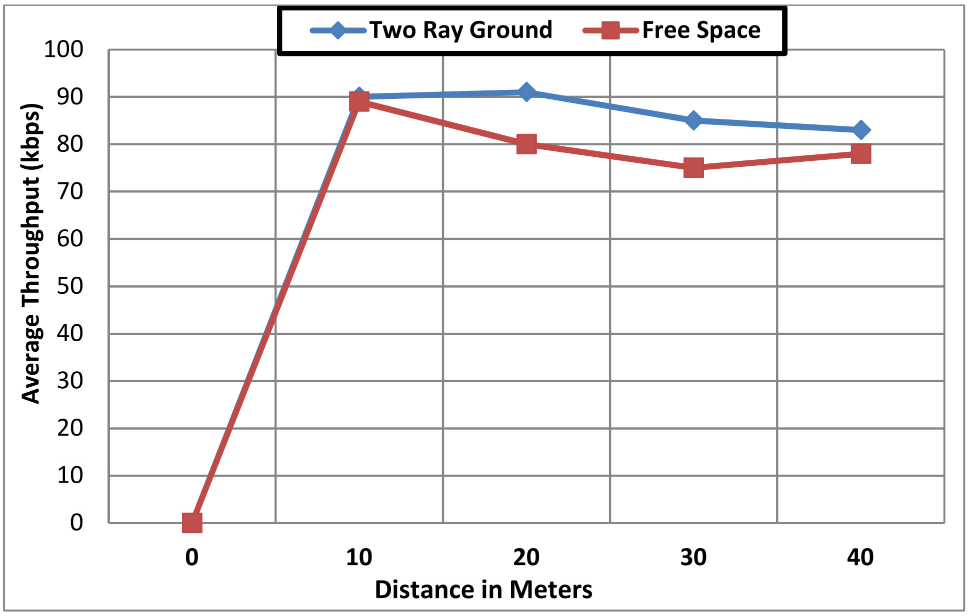

Figure 4: Average Throughput (kbps) of two ray ground and free space

4.2 Average Latency (milliseconds)

Network Latency refers to indicate any type of delay that happens during the communication over the network. Specifically, the time is taken by a packet until the departure from a source node in a network until the arrival at the destination (Jubair et al., 2018). This metric can be calculated using Equation 4.

$$\text{Average Latency}=\sum_{i=1}^{n} \frac{received\ time\ i - sent\ time\ i}{Total\ data} \quad (4)$$

From the given equation 4 the average latency can be calculated. In this regard the mentioned values are the average latency of two ray ground and free space propagation models. As shown in the given table and graphical illustration that two ray ground and free space has shown better performance in respect to average latency. The distance based performance has been recorded in which four sequences are used for distance that are completely in meters in which starting point is 0 and the last point or maximum value is 40 meters. At 0 or initial point both have values in 0 but when the simulation has started then at distance 10m the value of two ray ground is 0.8 whereas the value of free space is 1 at that point. Proceeding to the next level i.e., increasing in the distance from 10 to 20m the value of two ray ground is 0.4 and free space is 0.9. Similarly, at distance 40m the value of two ray ground is 0.5 and free space is 0.2. These recorded values are the latency in milliseconds in which the two ray ground has shown better performance as compared to free space. The main reason is that the signal propagates and can pave long distance in two ray ground model which doesn't need clear LOS. But free space purely focus on the clear LOS that's why the signal can't travel in large distance in this scenario that's why it has shown poor performance in contrast with the two ray ground.

Table 3: Average Latency

Propagation Model	Distance in Meters 0	Distance in Meters 10	Distance in Meters 20	Distance in Meters 30	Distance in Meters 40
Two Ray Ground	0	0.8	0.4	0.1	0.5
Free Space	0	1	0.9	0.5	0.2

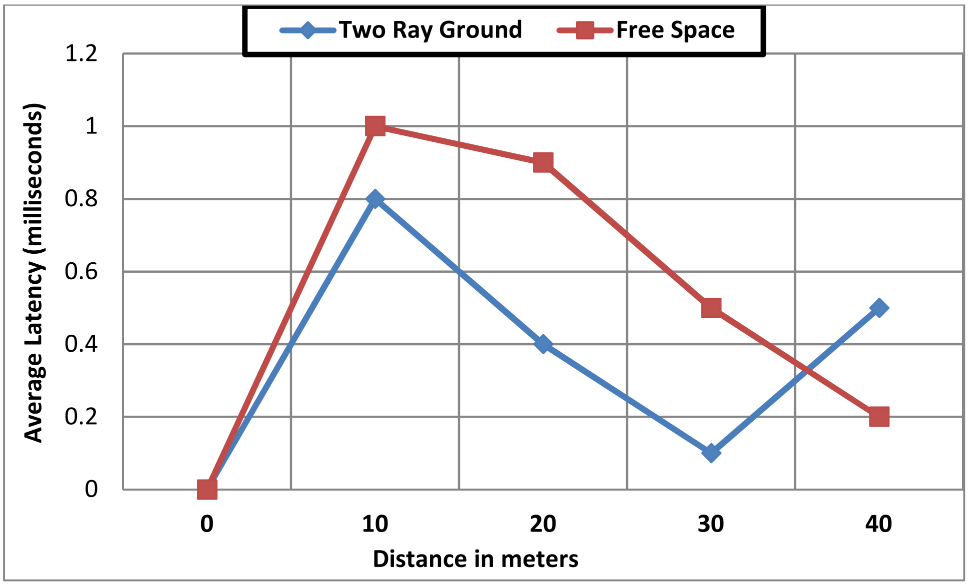

Figure 5:

4.3 Average Packet Drop (packets)

Average Packet drop refers to the amount of an average number of packets that have been dropped or lost during transmission of data traveling in a network from one place to another. Drops are typically caused by transmission errors, a collision in wireless network and congestion in the network (Jubair et al., 2018). This metric can be calculated using Equation 5.

$$\text{Packet Drop} = \sum_{i=1}^{n} \frac{\text{Packet\_Dropped} \times \text{Packet\_Size}}{Total\ Time} \quad (5)$$

From the given equation 5 the average packet drop values can be calculated. In this regard the mentioned values are the average packet drop of two ray ground and free space propagation models. As shown in the given table and graphical illustration that two ray ground and free space has shown better performance in respect to average packet drop. The distance based performance has been recorded in which four sequences are used for distance that are completely in meters in which starting point is 0 and the last point or maximum value is 40 meters. At 0 or initial point both have values in 0 but when the simulation has started then at distance 10m the value of two ray ground is 207 whereas the value of free space is 387 at that point. Proceeding to the next level i.e., increasing in the distance from 10m to 20m the value of two ray ground is 352 and free space is 607. Similarly, at distance 40m the value of two ray ground is 350 and free space is 200. These recorded values are the packet drop in packets in which the maximum size of the packet is 1000 bytes in which the two ray ground has shown better performance as compared to free space but especially after the overall average value is better. The main reason is that the signal propagates and can pave long distance in two ray ground model which doesn't need clear LOS. But free space purely focus on the clear LOS that's why the signal can't travel in large distance in this scenario that's why it has shown poor performance in contrast with the two ray ground. At the last point during simulation the free space has given best performance in which it has dropped fewer amounts of packets but by combining the results and taking into consideration the average level then the two ray ground model has achieved better result.

Table 4:

Propagation Model	Distance in Meters 0	Distance in Meters 10	Distance in Meters 20	Distance in Meters 30	Distance in Meters 40
Two Ray Ground	0	207	352	205	350
Free Space	0	387	607	287	200

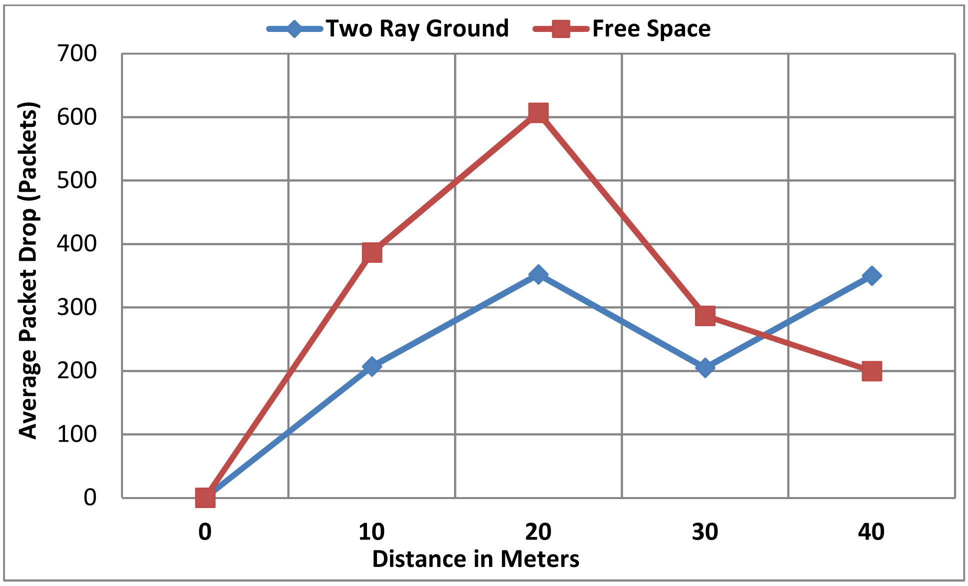

Figure 5:

4.4 Compiled Average Results

By combining all propagation models' results and evaluating the average values of average throughput (kbps), average latency (ms) and average packet drop (packets) for two ray ground and free space are shown in the given table.

Table 3: Compiled Average Results.

Propagation Model	Average Throughput (kbps)	Average Latency (ms)	Average Packet Drop (packets)
Two Ray Ground	87.25	0.45	278.5
Free Space	80.5	0.65	370.25

The values of Table 3 are illustrated in the following Figures separately in which the mentioned evaluation metrics are shown differently. By taking the average evaluation of the simulation results the two ray ground has shown outstanding performance as compared to free space model. Free space model has also shown best result in different points. From this evaluation, it has concluded that two ray ground model can achieve better performance as compared to free space model. The main reason is that two ray ground's signal can travel in both LOS and N-LOS in which it uses the two way ground reflection mechanism to calculate the signal strength.

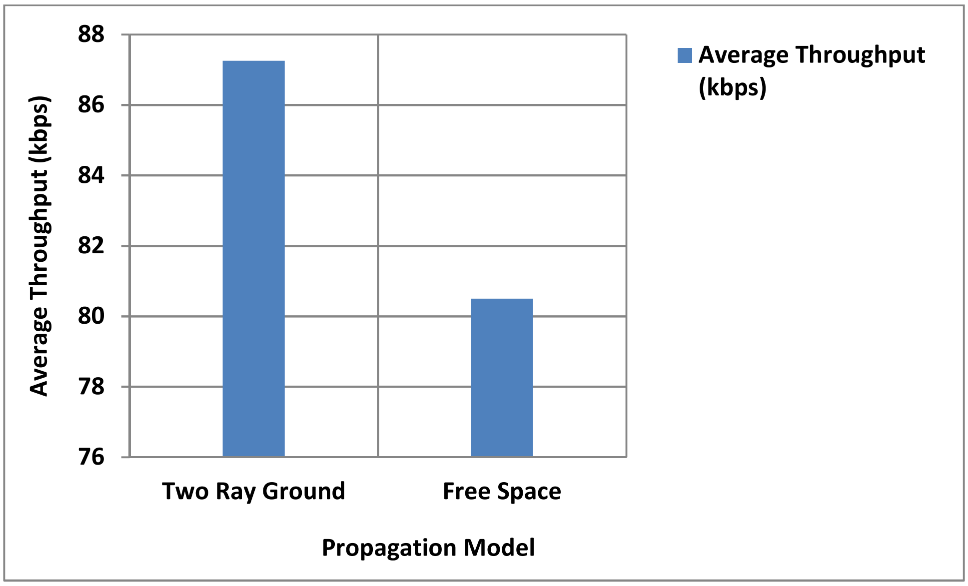

Figure 6: Average Throughput

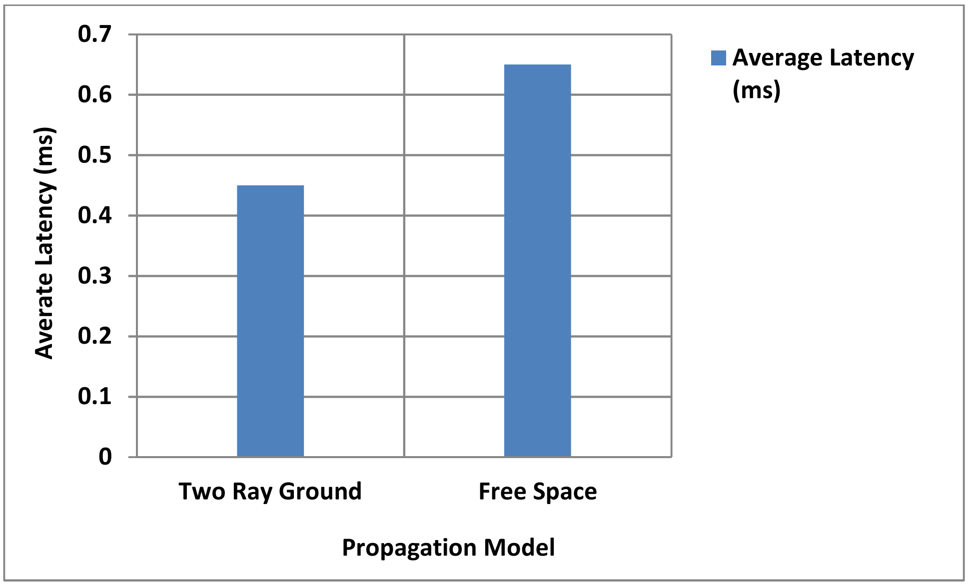

Figure 7: Average Latency

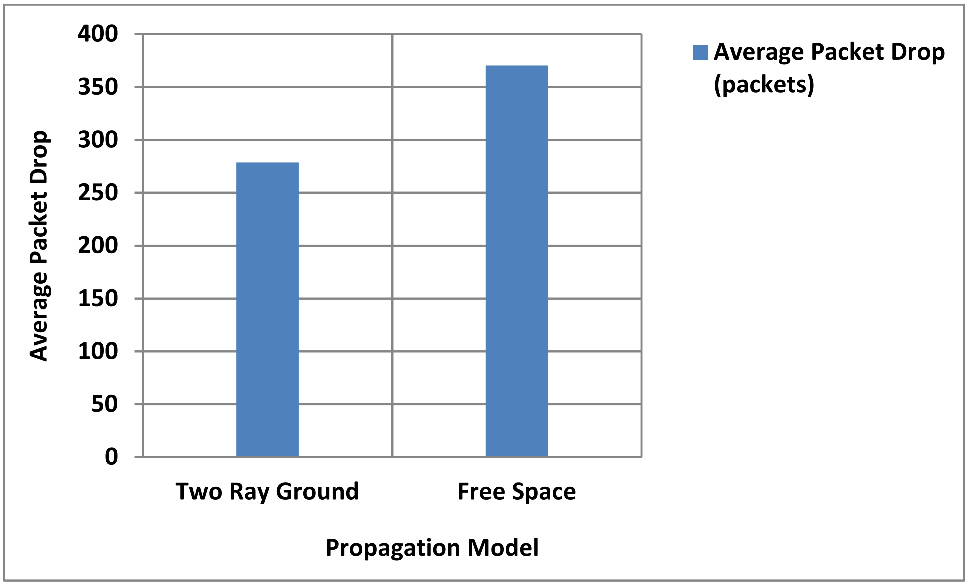

Figure 8: Average Packet Drop

5. Conclusion

MANET is a decentralized type of wireless network. The network is ad hoc because it does not rely on a pre-existing infrastructure, such as routers in wired networks or access points in managed wireless networks. Calculating signal strength at the receiver is the responsibility of a propagation model while the mobility of nodes is responsible for the topology of the network. A huge amount of loss in performance is occurred due to the variation of signal strength at the receiver while increasing and decreasing the distance of nodes. In this paper, a novel approach is identified and portrayed of the said propagation models based on distance from each other. The simulation findings have revealed that the different propagation models have a considerable impact on the performance of the ad hoc mobile network especially based on the distance as mentioned from 10m to 40m. This research study presented the performance evaluation of AODV protocol under varied propagation models with distance based environment. The analysis has been made to identify and find out how much impact each propagation model has on the performance of the AODV protocol in chosen based on distance in meters. Different performance results have been obtained against the selected propagation models. The AODV protocol has been evaluated using performance metrics i.e. Average throughput, average latency, and average packet drop. The results indicated that the effect of fading increases with the speed of mobile nodes. The analysis of simulation results is performed based on the three previously defined metrics. Simulations from the NS-2 are performed by changing the node's distance concerning the different scenarios: from the minimum range of 10m to the maximum range of 40m. It has been analyzed to check distance based performance evaluation of Two Ray Ground and Free Space Radio Wave Propagation Models on the performance of Ad-hoc On-demand Distance Vector (AODV) Routing Protocol in MANET. The simulation has been carried out in NS-2 by using performance metrics that are Average Throughput (kpbs), Average Latency (milliseconds) and Average Packet Drop (packets). The results predicted that propagation models and mobility have a strong influence on the performance of AODV in considered distance based scenario.

Authors' Contribution: All the authors contributed in this paper accordingly. The order of authors in this manuscript is maintained depending on the level of contributions they made in this paper.

Conflict of Interest: The authors declared no conflict of interest.

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