Radio Propagation Models: A Performance Analysis based Impact of Sparse and Dense Deployment of Nodes under Different Propagation Models in Mobile Ad-hoc Networks (MANETs)

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Research Article

Keywords: MANET, OLSR, MPR, Propagation Models, Sparse, Dense, NS-2

Posted Date: September 14th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-905314/v1

Radio Propagation Models: A Performance Analysis based Impact of Sparse and Dense Deployment of Nodes under Different Propagation Models in Mobile Ad-hoc Networks (MANETs)

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Abstract: Mobile Ad-hoc Network (MANET) is the most emerging and fast expanding technology since the last two decades. 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 exchange of information from source to a destination is known as the process of routing. Spectacular amount of attention has been paid by researchers to reliable routing in ad-hoc networks. Efficiency and accuracy of a protocol depends on many parameters in these networks. In addition to other parameters node velocity and propagation models are among them. Calculating signal strength at receiver is the responsibility of a propagation model while mobility of nodes is responsible for topology of the network. A huge amount of loss in performance is occurred due to variation of signal strength at receiver and obstacles between transmissions. Simulation tools are developed to analyze the weakness and strength of protocols along with different parameters that may impact the performance. The choice of a propagation models have an abundant effect on performance on routing protocols in MANET. In this research, it has been 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 Throughput, average packet drop and average latency. The results predicted that propagation models and mobility has a strong impact on the performance of OLSR in considered scenarios.

Keywords: - MANET, OLSR, MPR, Propagation Models, Sparse, Dense, NS-2.

I. INTRODUCTION

1.1 Mobile Ad-hoc Network (MANET)

This chapter gives a brief knowledge about MANET which is also known as Wireless Ad Hoc Network (WANET). The nodes of MANET may easily transport from one place to another that's why this is called MANET. The nodes are mobile in general that involve no external entity i.e. no infrastructure for the arrangement of nodes. Every node in this network operates as a host and router. This usually operates on the physical layer adjacent with the physical layer via which it makes route from one node to another. MANETs consist of a peer-to-peer, self-forming, self-healing network that doesn't need any external entity i.e. centralized entity. From the year 2000–2015, MANET typically communicates at radio wave frequencies with range (30 MHz–5 GHz) (Draves *et al.,* 2004).

MANET is an uninterruptedly self-configuring, with no central entity network of mobile nodes connected wirelessly as shown in Figure 1.1. In this network, every node has the ability to move from one place to another freely with having no restrictions and these nodes are independent on each other but sometimes they do dependent. Because of nodes mobility the topology of this network evolves rapidly and has highly dynamic topology. When these nodes are moving freely it also effects on the signal strength in which data loss like packet loss, delay and less throughput occurs.

Such kinds of ad hoc networks are operated independent from anyone else or might be associated with the bigger Internet. They may contain one or various and distinctive links with the adjacent nodes. This feature results in changing topology of the network with high mobility of the nodes (Draves *et al.,* 2004).

MANET is auto configuring network which does not require the static infrastructure and communicate without a central control. It is a cost effective and replaces expensive networks. These ad hoc networks works with the nearby nodes directly or through some other nodes like multi hop routing mechanism. The nodes in this network may also utilize for the relaying selection and usage according to the needs in a specific region. The nodes directly communicate with the other nodes whenever they come closer so that they gain the range of communication between them. This network has been performing since the last decades for many uses and applications which have reliability and efficiency through which it has drawn the attention of researchers. Due to mobility nature of nodes, sometimes these nodes undergoes through obstacles during transmission which causes less throughput, high packet drop and high latency. From this perspective the current research has focused to calculate the strength of the signal from source to destination by taking into account the embedded propagation models (Draves *et al.,* 2004).

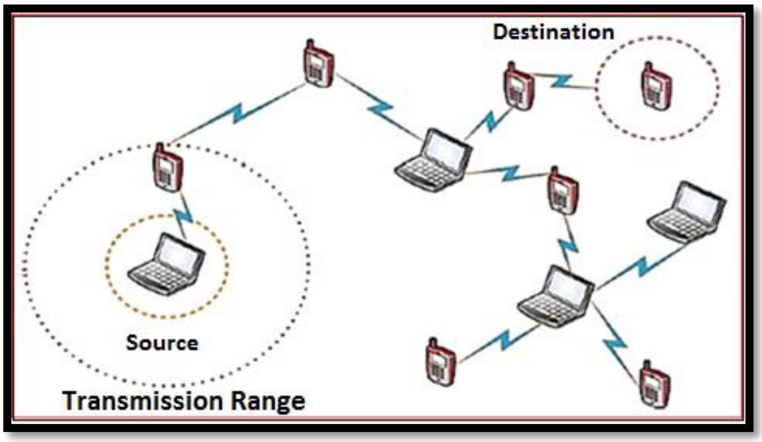

Figure 1.1: A Scenario of MANET (Prakash *et al.,* 2017)

As mentioned above, this network deals with the radio wave propagation models which are implanted in each device that works on the physical layer because of the antenna. The propagation models are connected with the antenna in which from both sender and receiver the signal propagation has to calculate by these propagation models. When some obstacle comes in the way of communication then the propagation model has to calculate that if there is no clear LoS. There are three kinds of propagation models proposed in this research that are shadowing, two ray ground and free space. Each model performs different functionalities depend on the communication path. Speaking of which, when there is no clear LOS then two ray model are properly utilized because this model creates two ray signal with the ground through reflection it communicates with the receiver even if there exist some obstacle that blocking the communication path. When the nodes come very closer to each other the free space propagation model can be used because this model deals with clear LOS in low range. It does not create two ray signals, it only communicate directly with having a free and clear LOS path to transfer the data (Draves *et al.,* 2004).

Furthermore, when the two ray model is using in low distance then it creates an issue due to the oscillation of the signals by reflecting, refracting, diffracting and scattering. So, each propagation model in MANET has a great and tremendous impact on each node depending on the communication path, mobility of node, communication range and the signal power. Network Simulator-2 (NS-2) has been witnessed as an important simulation tool for calculating these radio wave propagation models from transmitter antenna to receiver antenna. It also depends on the sender and receiver antenna, as they are equipped with dipole, Omni-directional or directional antenna. These radio wave propagation models also directly depend on the scenario of the network that how many nodes have been deployed and how many distance they have from one another. The sparse and dense scenarios has been selected and taken into account for this study in which each propagation model operates and performs their tasks according (Xiang and Yang, 2018).

There are four factors that directly affect the radio wave propagation signal i.e. the signal suffers from these transmission impairment with noise, attenuation and fading as shown in Figure1.2.

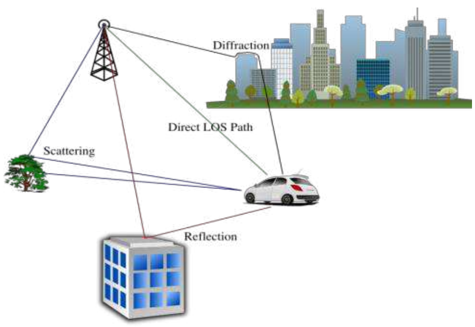

Figure 1.2: Scenario of Direct LoS, Reflection, Diffraction and Scattering (Eltahir, 2007)

The first one is reflection in which the signal has to reflect equally as it was transmitted i.e. both the angle on incident and angel of reflection should be equal if not then the signal will not deliver as it was propagated. The second one is scattering in which the single propagation suffers from an external object that completely divide the strength of the signal into small signals and in a results the signal can't reach to the destination due to scattering. This problem occurs when there some obstacle comes between the communication path via which transmission loss (dBm) and path loss (dB) occurs. The third one is diffraction in which the propagated signal's wavelength is smaller than the object in which the signal has to make incident and in a result the signal may reach to the destination but the strength of the signal weakens due to diffraction the signal divided. Some signals go to other direction and some go to the destination side. The fourth one is direct LoS communication between transmitter and receiver in which they are clearly visible to each other (Eltahir, 2007).

For the solution of the above mentioned issues that directly effects on the propagated signal's strength causes to block the signal. The three proposed radio wave propagation models have been analyzed and discussed in different scenarios accordingly. These models also show the impact in sparse and dense network scenarios.

Wireless networks are playing out a huge character in the ground of correspondence. Remote systems are utilized for the equipped correspondence at war zone, producing utilizations, and Emergency activity, for example, safeguard and group control. The change among wired and remote systems is the correspondence way. The physical medium required under wired systems. Remote systems grew very standard in different utilizes in the resulting issues, for example, simple establishment, steadfastness and dependability, cost, data transmission, complete vital vitality, security and effectiveness of the system. All networks are having static infrastructures. Most common fixed centralized entity based networks are network of cellular, Wi-Fi, Wi-MAX, cordless telephone, RADAR and satellite communication etc. (Khandakar, 2012).

Upcoming variation in the hardware components (generation) wireless ad-hoc networks are performing an outstanding character in the rapid placement of autonomous movable users, effective and active communication for alternative operation of tragedy assistance efforts, and martial networks. Ad-hoc networks have no such combine topologies that pave a huge area of interest. These topologies can evolve randomly and dynamically. Some fixed and static routing schemes that are usually utilized for internet wireless network. These cannot be utilized to ad-hoc networks directly due to some specific and general considerations that are not in every case to every dynamically evolving network and that may also be not factual for movable users (Draves *et al.,* 2004).

Mobile Ad-Hoc networks have no base station and use multi-hop communication with each other. MANET has highly dynamic network topology dissemination that creates it a hot topic of investigation since 90's. The profitable achievement of cellular communication has controlled to a powerful consideration among wireless networks in thoughtful and forecasting radio propagation features in many urban and sub-urban regions also without buildings. Henceforth, it is actual important to have the ability of causal best possible node location, gaining proper rates of data and approximating their area of paving (coverage), deprived of leading a series of propagation amounts that are costly and consuming time. Therefore, it is essential to improve successful model of propagation for providing the stricture recommendations for many systems. In Mobile Ad-Hoc networks, routing, rate variation, topology manage and interference managing perform a remarkable part for communication. Research on planning a link metric which signifies time unreliable wireless connect excellence for wireless mesh routing has been fairly dynamic (De Couto *et al*., 2003). While, the struggle to improve and design the effectiveness of used routing algorithm have a little impact (Draves *et al*., 2004).

1.2 Features of MANETs

Being an infrastructure less network, MANET possesses a number of features which enables its users to use it more frequently (De Couto *et al*., 2003).

1.2.1 Remote Areas Access

Remote area access gives great aspect establishing an infrastructure less network in areas where residents is less dense. It enables to save a vast amount of rate of setting an infrastructure, as MANET can be used depending ahead the model of communication (De Couto *et al*., 2003).

1.2.2 Infrastructure Can Be Made Instantly

As MANET does not depends on any physical links, at any position of time and of any category of requirement. MANET can be set up and used, because common network requires pre-planning but MANET does not (De Couto *et al*., 2003).

1.2.3 Large-Small Network

Another huge attribute of Mobile Ad-Hoc Networks is the capability of changing the size of network as per requirement i.e. number of nodes can be attached and any number of nodes can be disconnected (De Couto *et al*., 2003).

1.2.4 Symmetric Environment

As all the nodes are related in functionality and can act either as node or a router resulting in a symmetric environment (De Couto *et al*., 2003).

1.2.5 Disaster Relief Ability

Any communication is level to natural disasters and can be totally destroy it. So in order to keep the resources on infrastructure, MANET can be used in those areas which are extremely level to natural disasters leading to a huge amount of success in cost saving (De Couto *et al*., 2003).

1.2.6 Dynamic Topology

The movable nodes of the MANET can travel from one location to another with different rush. The set of connection topology can be different randomly. In this network node can transmits packets nevertheless of this active location. Nodes are reliable and efficient to manage and design any particular function and operate properly despite shifting their own location (De Couto *et al*., 2003).

1.2.7 Distributed Operation

To manage the network is spread between all the nodes of the network and there is not any middle node which is dependable for all communication. Every node is similarly accountable for creation the declaration possible. Nodes themselves can decide their particular (De Couto *et al*., 2003).

1.2.8 Multi Hop Routing

It is clear from the name that the communication of one node with another by using multi routes between that node and the target node or source to destination. In this network multi hop routing takes place by using multiple nodes (De Couto *et al*., 2003).

1.2.9 Autonomous Terminal

From the given name it reveals that in this network every node acts as host and router depend on the desired communication from one node to another. By taking information from one node and passing it another node, like the use of relay nodes (De Couto *et al*., 2003).

1.2.10 Light Weight Terminals

Most of the nodes or devices in this network have low weight which can be transported easily from one place to another due to light weight nature of these devices. Such as, smartphones, laptops which have limited and light weight memory chips and have the ability that are managed by equipped CPUs (De Couto *et al*., 2003).

1.3 Applications of MANET

Subsequent are the major and key applications of MANET:

1.3.1 Military Battlefield

Due to MANET's technology it doesn't require any infrastructure and may be recognized simply in any environmental area. Thus, these networks are very helpful in battle-field of military combat to build the communication probable among the armed forces, (Head Quarters) HQs and military automobiles (Corson and Macker, 1999).

1.3.2 Collaborative Work

MANETs are considered necessary by some commercial organizations to design and develop the cooperative and collaborative computing (Corson and Macker, 1999).

1.3.3 Local Level

MANET can compose the connection among devices by some occasion of the period. Thus these networks are valuable to create the communication probable nearby i.e. in a meeting or a laboratory etc. (Corson and Macker, 1999).

1.3.4 Personal Area Network (PAN)

A private region network needs tiny collection and incomplete digit of stations attached to every other. Bluetooth equipment can be helpful in creation link among devices then these arrangements to lead the schemes of MANETs (Corson and Macker, 1999).

1.3.5 Rescue and Disaster Management

MANET may be simply generating to make communication probable in event of saving actions in case of a tragedy like fire, flood or quake in which other traditional infrastructure networks becomes dense (Corson and Macker, 1999).

1.4 Types of MANETs

MANET is broadly divides into different kinds. The main three types are iMANETs, VANETs and FANETs. These are shown in the Figure 1.3 and explained accordingly in the given subsections that shows the overall types of MANET or WANET (Wireless Ad-hoc NETwork) (Corson and Macker, 1999).

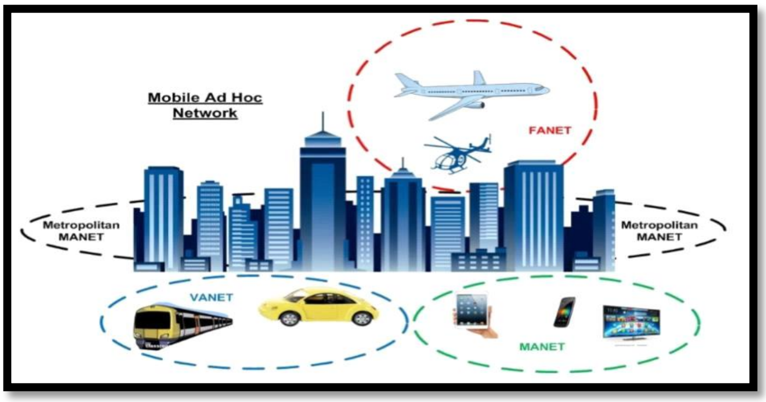

Figure 1.3: Types of MANETs a scenario (Singh *et al.*, 2014)

1.4.1 Vehicular ad hoc networks (VANETs)

It is a type of MANET in which the communication takes place by using moving vehicles that communicates with each other and by using the RSU (Roadside Unit).

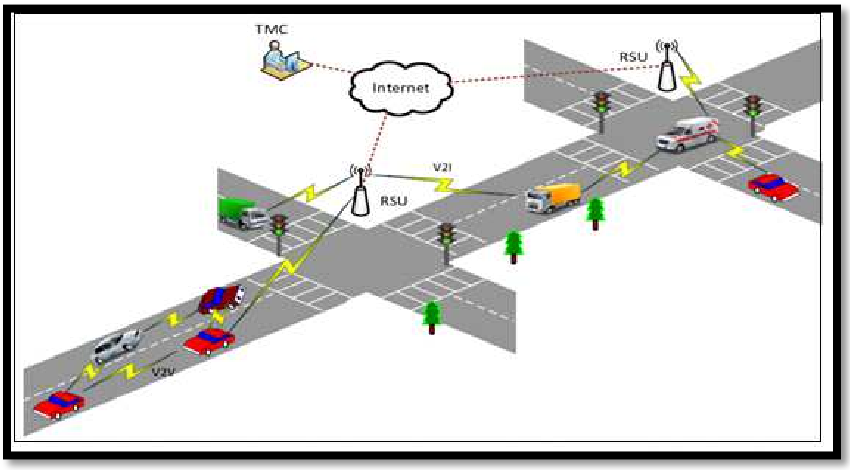

Figure 1.4: Scenario of VANETs (Singh *et al.*, 2014)

An intelligent vehicular ad hoc network (InVANETs) is a latest kind in this network in which each vehicle is equipped with smart technologies and sensors (Corson and Macker, 1999).

1.4.2 Flying ad hoc networks (FANETs)

FANET is a special type of MANET in which the communication takes place by using ground nodes and aerial nodes such as quad-copter, drones etc. (Xiang and Yang, 2018).

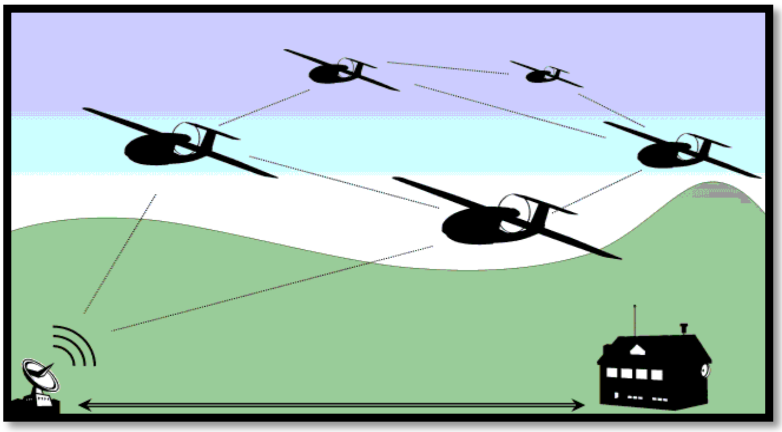

Figure 1.5: A Scenario of FANETs (Xiang and Yang, 2018)

1.5 Challenges and Issues in MANETs

The key issue and challenge in this network is the high mobility of nodes which leads to changes topology rapidly and causes link breakage also the topology of this network is extremely dynamic which changes very fast. Furthermore, the devices in this network have limited battery power and limited bandwidth of wireless channel which causes a major issue in this network. The following are the key factors that make MANET challenging task (Tamilarasi, 2001).

Several researches and surveys have showed the technical issues and challenges facing MANET.

MANET possesses lot of advantages having no central entity and cost effective. Despite these advantages, it also has a lot of issues and challenges that must be taken into considerations (Tamilarasi, 2001).

1.5.1 Security

Security is an important aspect in wireless communication which is a major problem and issue to these networks. Due to wireless connectivity and ad hoc nature of MANET the security is one of the major issue and challenge for designing of this network. This wireless nature of medium is easily to be hacked, eavesdropped and the nature of ad hoc and wireless nodes mobility creates an issue which is vulnerable to many attacks of security. Security creates a big issue in this network when designing it (Hong, 2002).

1.5.2 Quality of Service

Due to rapid and dynamic change in the topology of MANET also deals with the QoS which shows the efficiency and stability of the network. QoS is an obligatory aspect which must be solved properly and be providing better services of communication to the network through which the network can be considered well enough for better communication (Hong, 2002).

1.5.3 Routing Overhead

Overhead occurs due to some flooding mechanism in the network by unnecessary requests from one node to another. In MANET it is a challenging task to reduce the overhead and deploy flow control mechanism via which routing overhead can be reduced (Hong, 2002).

1.5.4 Inter-networking

The term inter-networking indicates the movable wireless nodes connectivity with the fixed motionless devices like Access Point (AP) and with the devices that are IP enabled or IP based. These qualities existing in a single device is a research challenge and issue which needs to be solved effectively to operate in interoperable manner with heterogeneous behavior (Hong, 2002).

1.5.5 Power Consumption

Due to limited batter equipped in devices that are operating in MANET suffers from consumption of power which is a research challenge. To design such kind of network in which the residual energy of the nodes remains high. The function of mobile like the platform and other equipped integrated circuits should be optimized to consume less energy. For this scenario some routing schemes should be taken into account that are power aware (Hong, 2002).

1.6 MANET Design Considerations

MANETs faces numerous challenges; due to node mobility, resource constraints, unreliable links, wireless radio medium, lack of infrastructure, absence of centralized entity and design of conventional routing protocols. Therefore for designing MANET there are some issues that should be taken into account consideration first (Naseeruddin and Patil, 2016).

1.6.1 Node mobility

When designing MANET the mobility of the nodes must be considered effective that causes no harm of link breakage. Therefore, they suffer from frequent route changes and high packet loss. Furthermore, repeatedly movable nodes might affect network dividers which in turn, degrade Quality-of-Service (QoS) levels; therefore, it becomes vital to improve QoS levels in this highly dynamic environment (Basagni *et al*., 2004).

1.6.2 Resource constraints

The devices used in communication in MANET have limited battery power, CPU capability, storage capacity and bandwidth. That's why from this perspective it is a challenging to when designing a suitable and reliable MANET by proving effective QoS, balancing the load of nodes like reduce overhead and excluding threatening nodes from the network (Conti *et al*., 2014).

1.6.3 Unreliable Links

Due to wireless connectivity and link in MANET these links are highly error affiliated and may be disconnect soon. Moreover, they may cause interference, frequent path breaks, increase in collisions, high bit error rate and high packet loss; monitoring such issues to preserve dependability of wireless links is imperious (Goyal *et al*., 2011).

1.6.4 Wireless Radio Medium

This is a significant and important aspect in MANET while designing it. The main focus on the antenna design and the medium through the nodes can communicate with the help of radio waves. It is mandatory to keep in account a reliable radio medium for these network such kind of medium that can be keeping aside from the perpetrators. The channels should be selected efficient which possess high bandwidth with high level of throughput and minimum level of latency (Xiang and Yang, 2018).

1.6.5 Lack of Infrastructure and Centralized Entity

Because of no central entity and no infrastructure in MANET the nodes suffers from the lack of infrastructure because every node operates as host and router in which the path can be made via multiple nodes. The key management and security control become a research challenge in this network due to no central point (Naseeruddin and Patil, 2016).

1.6.6 Design of Routing Protocol

Due to rapid evolving of topology and fast moving of nodes, the link stability is a major task in this network. So, these networks need reliable and robust routing schemes which guarantee the efficiency and accuracy of the network. As the nodes move freely from place to place and they change their positions which ultimately affects the overall performance of the network. The efficient and secure routing scheme design have a great impact on the network layer through which the layer can be stay aside from hacking and other harm in the network. Many routing schemes have been designed and some are in infancy which leads these networks to the next generation wireless networks. These schemes have the ability of operability and heterogeneity to the network in which the nodes communicate with the different platforms and with the IP-based devices. In short, routing scheme designing for MANET is the most important factor because these are the specific rule which governs telecommunication. Without routing schemes the communication can't take place or performed. So, protocol needs to be efficient and robust (Naseeruddin and Patil, 2016).

1.7 Importance of MANET

With the passage of time it has been witnessed and being witnessing that MANET plays a significant role in the field of communication. It is the most important factor in ad hoc networks that can be easily adapted and can be easily designed and implemented. It is cost effective which can be created with low budget. From the applications of this network it can be estimated that how much importance have gained by this network in the perspective of personal type of communication.

It has two aspects, one is central entity based also known as infrastructure based and the other one without central entity also known as infrastructure-less network. With the fast growing technologies the variation of hardware components also takes place in MANET. As discussed and mentioned above the features, benefits, types and applications of MANET is clearly shows the significance and importance of this network (Ghosekar *et al*., 2010).

With the economic and business perspectives, MANET is opening new ways to provide full facility to the organizations like schools, college, universities, the telecommunication companies and even the financial aspects. MANET also provides positive aspects to the manufacturing companies in which they are designing new devices that are equipped with the latest enhancement to improve the ad hoc networks (Wu *et al*., 2007).

1.8 Optimized Link State Routing (OLSR) Protocol

The term OLSR routing scheme is a proactive i.e. table driven protocol that is designed and planned for MANETs. The major and key features of OLSR is the improvements of clean interconnection state schemes which decreases the area and size of the control packets along with the amount of control packet transmission when needed. OLSR decreases routing overhead to achieve the transportation and mobility of the traffic overhead by utilizing Multipoint Relays (MPR), which is the important strategy after OLSR. The MPR are nodes one-hop nearby that has been selected to transmit packets forward. In despite of pure flooding in the network, the packets are transmitted by MPR nodes. This criterion decreases the routing overhead in the network, so having the capabilities of additional pure apart or besides pure flooding within the network overhead. The OLSR reduces the overhead problem and solved it properly by the use of MPRs. This delimits the network overhead, thus being more capable than pure enhanced link state routing scheme (Katoch and Gupta, 2016).

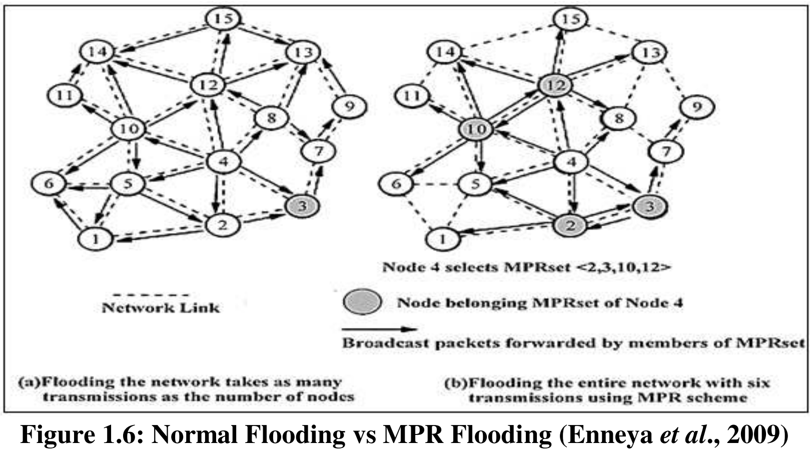

Figure 1.6: Normal Flooding vs MPR Flooding (Enneya *et al*., 2009)

OLSR is well appropriate to huge and dense mobile networks. Due to the use of MPRs, the greater and extra dense a network, the extra OLSR is accomplished. MPRs supports by giving the shortest path to the receiver. The only situation is that all MPRs broadcast the information of the connection for their MPRs choosers (selectors) (i.e. the nodes that have been selected them as MPRs). The topology of the network information is preserved by sometimes exchange information of the link state. If additional reactivity to topological evolving is obligatory, the scheduling for switching the information of the link state may be decreased. OLSR utilizes three types of control messages: Topology Information (TC), HELLO and Multiple Interface Declaration (MID). A Hello message is transmitted occasionally to every node within the nearby ranges. These Hello messages keeps the information about the nearby nodes and that nodes that are selected as MPRs (i.e. the selector set of MPR), also a record of the nearby nodes with the bi-directional relation that have not yet been completed (Katoch and Gupta, 2016).

Each node sometimes floods the network with a TC message by utilizing the multi-point relaying approach. This type of message consists of the MPR chooser set nodes. The type of MID message is utilized for declaring that the desired node is exploiting OLSR more than single interface. The MID message is flooded through the entire network with the help of MPRs. Multi-point Relays is described as; A node denoted by N selects randomly sub-section of its one hop symmetric nearby nodes to transmit the data transfer. This sub-class is referred as a set of MPR, paves every nodes that have the range of away two hops. The set of MPR is calculated from the node's information about single and multi-hop routing. This info can be obtained and extracted from the HELLO messages. The MPR selectors set are preserved at every node. An MPR selector set is the kind of nearby nodes that have selected the nodes as MPR (Katoch and Gupta, 2016).

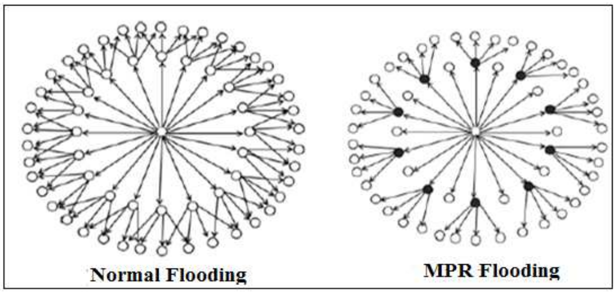

Figure 1.7: Normal Flooding vs MPR Flooding (Qin and Kunz 2003)

Upon getting a small packet, a node checked its Selector set of MPR to observe if the transmitter has select the n node as MPR otherwise the packet is executed unnecessary. The selections of Multi-point Relay Nodes are completed through selecting MPR set so that at least of one-hop symmetric nearby regions are capable to get every nearby region symmetric two-hops. For the calculation of the MPR set, the node gives command to calculate the set of MPR, the node ought to have the connection state information about every one-hop and two-hops nearby regions. In order to calculate the MPR set, the node demand to compute the MPR set, the node essential have link state information about all one-hop and two-hop neighbors. This information is assembled from HELLO messages again. The nodes have only the motivation diverse than WILL_NEVER can be assumed as MPR. The detection of nearby nodes is responsible as the link in an ad-hoc network may be either uni-directional of bi-directional, a scheme for the determination of the link state is desirable (Katoch and Gupta, 2016).

In OLSR, a HELLO message provides the above reason. The HELLO messages are transmit from time to time for the sensing of neighbor. When a HELLO message is received by a node that has the address, it records of the link to the sender node as a symmetric. As an instance that how this scheme performs, assume that there are two nodes A and B that have not yet a known link with every other. First of all, A transmits a void HELLO message. When B gets this message and doesn't discover its own ware about. It records within the routing table so that the connection to A is asymmetric. Then B transmits a HELLO message announcing A as an asymmetric neighbor. By getting this message and locating its own ware about, a records and store the connection to B as symmetric. Then A transmits a HELLO message announcing as a symmetric neighbor B and B stores A as a symmetric neighbor by the feedback of this message. TC gives the idea about the topology of the network that is derived from the packets of topology control (TC). These packets have nodes of the selector set of MPR, and they are transmitted by every node in the entire network by time dependent and also when some changes and modifications are detected in the selector set of MPR.

The packets are flooded in the settings of the link utilize the multi-point by relaying approach. All nodes that are in the network can gets such kinds of TC packets by which they exclude the information for making the table of the topology. The calculation of route is created by the algorithm for shortest path is utilized for the calculation of the route that are originated when some alteration is spotted in some of these: the nearby set, the link set, the two-hops nearby set, the numerous boundary relationship information base and the topology set. For the calculation of the routing able, the information is taken from the nearby and the topology set in which the entries of the route are added originating from one-hop nearby accessing the calculation of the hop of all the event from side to side (Clausen and Jacquet, 2003).

1.9 Propagation Models

The features of wireless links source essential borders on the efficiency of WANETs. The feature of a wireless link is a compound grouping of impact because of the path failure, and multi-path loss. Radio transmission may differ meaningfully on the basis of the location, occurrence of action, speed of node, causes of interference, and other active issues. Path failure measures the loss that takes place in power of signal because of the space and the combination of the things among the two nodes. Fading of Shadow describes the variations about normal path failure. The models of propagation are generally considered as fading and non-fading.

The model of propagation of the non-fading, justifies for the detail that a radio signal has to pave an increasing region by the time of the distance that is increasing to the sender. Instances are two-ray ground and free-space models of propagation. While on the other side, propagation model of the fading calculates the power of signal that is dependable on the actions of the node of frames of small time. An amount of the statistical paradigm are utilized to designate fading in the settings of wireless and the major often utilized dissemination for huge measure fading is shadowing. In this work of research, the three models of propagation have been utilized that are Two ray ground, Shadowing propagation and Free space propagation (Sarkar *et al.*, 2003).

1.9.1 Shadowing Propagation Model

This model of propagation utilizes the mathematical parameters for examining and analyzing of the obtained energy assuming power to have a chance up and down. It is the outcome that the obtained power of the signal altered because of the items obstructing the path of the propagation between the destinations (receiver) i.e. because of the effects of the fading as shown in Figure 1.8. These variations are fortified power of local mean which is: the short-term average for exclude and eliminate the variations because of the multi-path fading. This type of version has two parts, the first part the mean gets authority at the distance d that is a path-loss (dB) model utilizing a near-in distance which acts and stated by Pr(d) and Pr(do) correspondingly, while the second part of the model reflects and range of the gained power at fairly distance (Sarkar *et al.*, 2003).

Mathematically,

$$\frac{P_r(d)}{P_r(d_o)} \Big|_{dB} = -10\beta log\left(\frac{d}{do}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.1)$$

Where, β is the path failure example that is mathematically determined by field size.

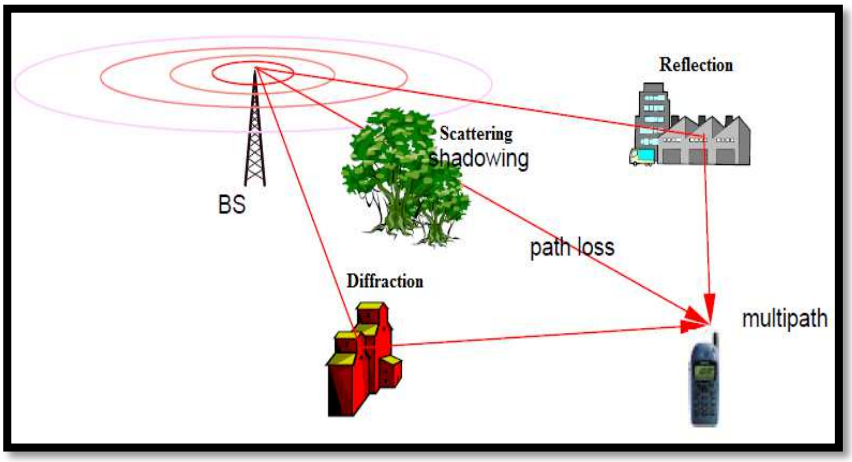

Figure 1.8: Scenario of Shadowing Propagation Model (Khan *et al.,* 2017)

1.9.2 Two Ray ground Propagation Model

A single line-of-sight (LoS) path between two movable nodes is rarely the simply mean of broadcasting. Thus, the model of propagation of two-ray ground assumes equally the shortest path a reflection of ground path which provides more correct calculation at an extended range (distance) than the model of free space as shown in Figure 1.9. (Sarkar *et al.*, 2003).

The acknowledged authority at distance (d) is projected by:

$$P_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{d^4 L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.2)$$

Where Pt 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.

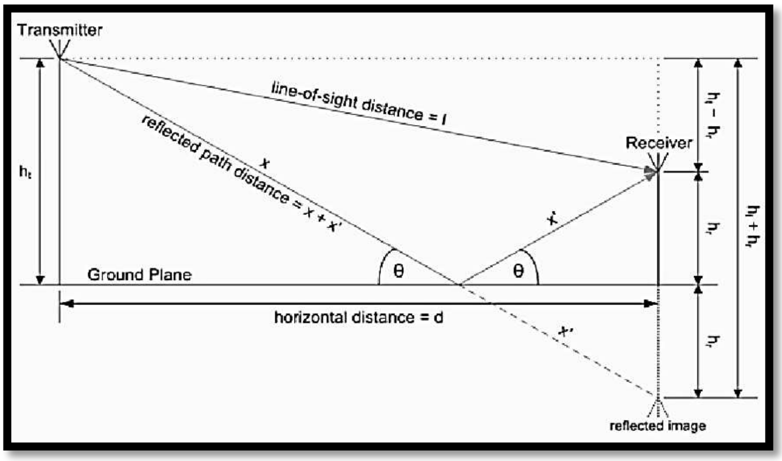

Figure 1.9: Scenario of Two Ray Ground Propagation Model (Eltahir et al., 2007)

1.9.3 Free Space Propagation Model

This is a high level model of radio wave propagation in which communication takes place when there is free clear LoS as shown in Figure 1.10. 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 away from the sender that has to confront a best region.

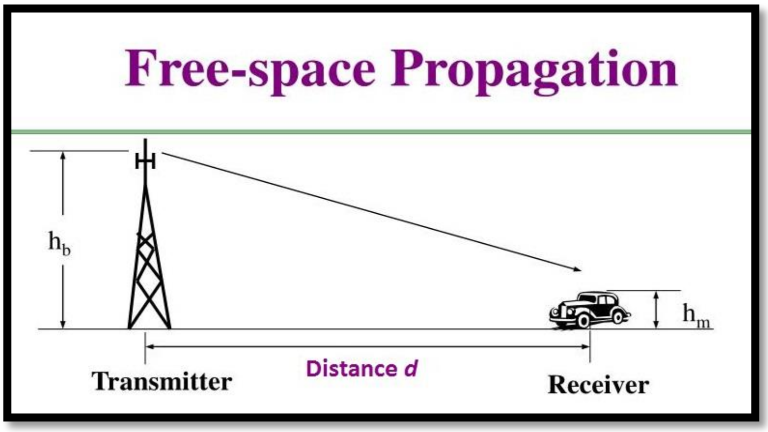

Figure 1.10: Scenario of Free-Space Propagation Model (Khan *et al.,* 2017)

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 1.3 for the calculation of the gained power of the signal in the model of Fee Space at the distance (d) from the transmitter (Schmitz and Wenig, 2006).
This level can be calculated by using the Equation 1.3.

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1.3)$$

Where, P_t is the power of the transmitted signal. G_t and G_r are the gains of the antenna of the receiver and the transmitter separately, where λ is the wavelength and L ($L \geq 1$) is the system loss. It is usual to choose $G_t = G_r = 1$ and $L = 1$ in the simulations of NS-2.

1.10 Problem Statement

In recent decades several member of the research community has analyzed, estimated and examined the performance of routing protocols under unique circumstances to check the efficiency and stability of routing by changing the number of simulation parameters. The role of propagation model is of much importance as they keep the nodes connected. A huge amount of loss occurred due to the variation of signal strength at receiver and obstacles between transmissions which causes high latency, less throughput and high packet loss ratio. So, it is of great importance to observe that how the performance of routing is affected under different propagation models. Secondly, to analyze, examine and result the impact of different propagation models in sparse and dense scenarios. The focus of this work will be to evaluate and assess the performance using different models of propagation i.e. Two Ray ground, shadowing and free space model using Optimized Link State Routing (OLSR) scheme in urban sparse and dense topologies.

1.11 Objectives

1. To investigate the performance of Shadowing, Two Ray and Free Space radio models of propagation for sparse and dense environments.
2. To analyze and report the results in terms of performance evaluation parameters i.e. Average Throughput, Average Latency and Average Packet Drop during simulation for each scenario.

1.12 Research Solution

Following are the research solution for this study to achieve the objectives:

- Assessment of literature review relevant to this study in broader view.
- Diagnosing routing anomalies.
- Preparation of environment for simulation.
- Install and configure the simulator i.e. ns-allinone-2.35-RC5.
- Prepare mobility and TCP traffic for the proposed scenarios through "setdest" and "cbrgen" tools.

1.13 Thesis Organization

The rest of the organization of the thesis is:

Chapter II describes the related work for the concerned study.

Chapter III suggests and shows research methodology for the proposed research model.

Chapter IV consists of tables and graphs that shown the simulations and analysis of each and every scenario accordingly.

Chapter V consists of summary, contribution, conclusion, recommendation and future work and also concludes the thesis of the research.

1.14 Summary

This chapter gave the idea of MANET along with its applications, issues, challenges, design considerations and briefly overview of routing protocols. Apart from these it briefly discussed with mathematical expressions of propagation models for the proposed research model. Finally, the problem statement and objectives of the research were also discussed.

II. LITERATURE REVIEW

This literature review describes the past works that have been done on the desired field of study for further analysis and interpretation. In short, it is the summary of the related work for the presented and some evaluated research work related to the current one. The action of revising includes assessing entity source as well as synthesizing these bases in order to achieve a wide observation to the relative field of study. This chapter is general and rising approaches, famous outlines and leanings, areas of MANET in the perspectives of propagation models.

Prasad and Jansen (1995) read the articulations for Signal to Noise in addition to Multi Access Interference Ratio (SINR) without and with get assorted variety considering Nakagami-m blurring channel. The investigation is likewise reached out to Rake collector with Maximal Ratio Combining (MRC) strategy with various accepting reception apparatus. The outcomes are displayed as far as BER and improvement of collector affectability because of assorted variety. At last, ideal estimations of framework parameters like number of symmetrical recurrence division multiplexing (OFDM) sub-transporter, ideal code length and request of get decent variety for a given BER are resolved. It is seen that there is critical improvement due to get assorted variety, higher request code length just as OFDM sub-transporter in a Multi-carrier direct sequence code division multiple access (MC-DS-CDMA) system. In Proposed work they had worked on the relationship between MRC diversity and Nakagami-m fading is examined and analyzed. The error performances of several modulation schemes with diversity over Rayleigh fading and without diversity over Nakagami-m fading is analyzed and compared. The analysis is further extended to diversity over Nakagami-m fading channel. An attempt has been made to find the physical interpretation of Nakagami -m with MRC diversity over Rayleigh fading channel. A novel equivalence is obtained between diversity orders over Rayleigh fading and Nakagami parameter-m.

Qin and Kunz, (2003) examined the effect of a shadowing model on the presentation of these two directing conventions. At that point they set another sign power limit during the course revelation process so just those connections with sufficient sign power will be picked; we additionally diminish some control messages for DSR. The recreation result show huge increments in parcel conveyance proportion and diminishes in bundle inertness for the two conventions.

They have used only one model that is shadowing but they focus on threshold values and power of the signal at the transmitter and the receiver side. In contrast of the proposed mechanism this paper is not related to our suggested one because we have focused to find the impact of sparse and dense environment but they focused to reduce the control messages under the proposed parameters.

Stepanov *et al.* (2005) examined and analyzed execution of MANET conventions and applications in ns-2. They normally offered just straightforward radio propagation models that disregard obstructions of a proliferation domain. In this paper, they incorporated a progressively exact radio spread model into a reenactment device. The model depended on beam following and thinks about geographic information of the recreation zone. They demonstrated that the use of an increasingly exact engendering model changes reproduced association topologies significantly. Thus, they got distinctive execution assessment results. As far as they could possibly know, no other investigation of MANETs has been performed so far with such a definite radio spread model. Thus, this paper has additionally given new bits of knowledge on the reasonable execution of MANETs in outside situations.

They have presented simple propagation model that neglect obstacles of propagation environment but in our study our motive was to check and evaluate the performance of three suggested propagation models. They provided an accurate radio propagation model for simulation tool. In Stepanov *et al.* (2005) they proposed a realistic performance for outdoor environments. In summary, no similarities were found in contrast of the above paper with our proposed one.

Schmitz and Wenig (2006) expressed that the radio wave proliferation model strongly affects the consequences of the reenactment run. This work shows the confinements of current recreation situations and portrays a high exactness engendering model dependent on the utilization of a beam tracer. By utilizing a parallelized preprocessing step we made this spread model doable for use in organize test systems. In light of two models, the impacts on trademark execution properties in Mobile Ad Hoc Networks are appeared. We found that the physical layer reenactment greatly affects directing convention proficiency.

Dhoutaut *et al,* (2006) analyzed that through certifiable experimentations we initially describe the conduct of the channel with respect to misfortunes, we de-duce a lot of properties required for lightweight models as yet delivering applicable outcomes. At that point we execute them in a model we called shadowing-design which we at long last use in a VANET unmistakable situation where it extensively alters the aftereffects of an information proliferation application.

Eltahir (2007) introduced the choices accessible and give the parameters utilized in the formation of situations for indoor and open air conditions in a urban domain. They indicated the impacts of radio spread models for wave engendering into ns-2. They showed that the use of increasingly exact radio engendering model changes reenacted topologies significantly between usually utilized propagation models. Subsequently, they acquired distinctive execution assessment results. They analyzed radio propagation models execution assortment of measurements, Packets sent, throughput, dropped bundles, Packet Delivery Ratio, and parcel steering overhead. For development situations case, they guessed greatest speed and respite time. Analysts must know about noteworthy contrast between the genuine association topologies and the topologies got with basic models offered by MANET reenactment instruments. For getting quantitative execution assessment brings about the objective region, increasingly precise radio spread models should be utilized.

There is a big difference between the above paper and our proposed mechanism. They have taken indoor and outdoor environments while we have taken sparse and dense with the defined numbers of nodes. Also they have taken two different parameters with the contrast of our proposed mechanism. By taken different parameters and different scenarios their exit no relevant work.

Itoua (2008) analyzed the efficiency of some well-known ad-hoc schemes under diverse propagation models in MANETs. Under the different mobility models the concerned study was conducted, these models were two ray ground, shadowing and free space model. Also the impact of these models on the existing routing schemes DSDV, DSR and AODV routing schemes. The requirement of a successful mobility model is that it shows the moving performance of every mobile node. The experimental analysis of the simulation had shown the open choice of the existing propagation model that acts and has a specific major role in the selecting of the routing schemes, since it may cause the effect harmfully on the performance of the concurrent scenario.

They have taken different protocol for the sake of propagation models both reactive and proactive protocols for the concerned scenario the main difference is that we have taken only OLSR protocol that's belong to the proactive category with the help of FTP and TCP agents.

Stepanov and Rothermel, (2008) incorporated an increasingly reasonable physical layer model into a recreation instrument. It comprises of a radio proliferation model and a model of remote transmission blunders. They have been assessed against certifiable estimations. They demonstrated that such increasingly reasonable models change reproduction results impressively. As far as they could possibly know, no other investigation of MANETs has been performed so far with such an itemized physical layer model. Thus, this paper additionally gives new experiences on the presentation of MANETs in genuine open air situations.

After reading the paper we concluded that there are no similarities in comparison with our proposed research work. We have taken the OLSR protocol for the spares and dense environments.

Otto *et al,* (2009) explored the effect of practical radio spread settings on the assessment of VANET-based frameworks. Utilizing a lot of instrumented autos, they gathered IEEE 802.11b sign spread estimations between vehicles in an assortment of urban and rural conditions. They found that sign engendering between vehicles fluctuates in various settings, particularly between viewable pathway ("down the square") and non-observable pathway ("around the bend") correspondence in a similar setting. Utilizing a probabilistic shadowing model, we assess the effect of various parameter settings on the exhibition of a pestilence information dispersal convention and examine the ramifications of our discoveries. We likewise propose a variety of a fundamental sign proliferation model that fuses extra authenticity without giving up versatility by exploiting ecological data, including hub areas and road data.

Shabbir *et al.* (2011) assessed between various proposed radio spread models that would be utilized for LTE, similar to Stanford University Interim (SUI) model, Okumura model, Hata COST 231 model, COST Walfisch-Ikegami and Ericsson 9999 model. The examination is made utilizing various landscapes for example urban, rural and provincial territory. SUI model shows the most minimal way lost in every one of the territories while COST 231 Hata model represents most elevated way misfortune in urban region and COST Walfisch-Ikegami model has most elevated way misfortune for rural and rustic conditions.

Tripathy and Mohapatra, (2013) examined and analyzed the effect of proliferation model on altered variant of OLSR Ad-Hoc steering convention under various situations. The exhibition on OLSR and its altered form because of various physical spread model assumes a significant job in Ad-Hoc arrange. The two beam ground model and shadowing model is utilized in various conditions from low thick like urban region and profoundly thick like city region. The simulations extended these directing conventions over various engendering model are utilized to break down the presentation like parcel conveyance portion, delay, throughput, steering overhead, vitality.

They have been proposed the propagation model using OLSR protocol. They have taken two ray ground and shadowing model for different environments. With our proposed work is different from the above because we have taken three models and also different parameters.

Rhattoy and Zatni, (2013) focused on Ricean, Rayleigh, Shadowing and Nakagami models by noticing the development of the routing layer‘s presentations on the basis of the features of the physical layer. For this reason, the author's matched the efficiency and performance of some routing schemes (DSR, AODV and DSDV) for every propagation model as mentioned and then showed the simulation outcomes of the effect of diverse radio propagation models on the efficiency of ad-hoc networks. Rendering to the simulation results, it may be confirmed that the selection of the propagation models had a huge effect on the routing scheme actions and efficiency. The presentation reduces quickly when the disappearing models, mainly Ricean, Rayleigh, Shadowing and Nakagami are taken into account. According to the results to the routing protocols' performance, the author's established out that there exist no better scheme between the others all situations and the measuring principles. Similarly, no subject how numerous links there are, it was noticed that DSDV and AODV have an improve delay in terms than DSR.

They have focused the performance of routing protocols like DSR, AODV and DSDV for the propagation models. They have been taken the Ricean, Rayleigh, Shadowing and Nakagami models. Our research work is different from the above because we have taken the OLSR protocol and also different models.

Kifle *et al,* (2013) examined and analyzed the effect of receiving wire tilting on engendering shadowing is altogether explored for urban situation. Results have presented that changing radio wire tilt significantly affects the shadowing map. Not at all like to the 3GPP supposition, has the removed shadowing map showed presence of its reliance with radio wire tilt setting. Besides, it has been seen that shadowing maps of various division receiving wires on an equivalent destinations are far less connected than the 100% relationship supposition in the present settled 3-GPP models. Hence, the tilt reliance of shadowing may require a reexamining of as of now accessible propagation models and suspicions.

Mehta *et al.* (2013) examined and analyzed the exhibition of three significant radio propagation models that are two beam ground, free space and shadowing with the presentation assessment measurements that are PDR and E2ED. The MANET convention considered here is AODV and they have likewise thought to be a malignant assault known as dark gap assault. They have played out our recreations considering both the cases for example with dark opening and without dark gap assault. They presented that the utilization of progressively exact radio spread model changes reenacted topologies significantly between ordinarily utilized propagation models. Therefore, they acquired distinctive execution assessment results. They have thought about two beam ground, free space and shadowing spread model's presentation based on PDR and E2E delay. The outcomes may fluctuate in the sensible reproduction condition where the obstructions, for example, structures will prompt the sign blurring which will likewise influence the exhibition of the two beam ground, free space and shadowing propagation models.

The main difference is that they have worked on security by using AODV (reactive protocol), while our research work is to check propagation models impact of sparse and dense environments.

Amjad *et al.* (2015) featured the significance of the physical layer and its effect on arrange execution in Mobile Ad Hoc Networks (MANETs). This was shown by reproducing different MANET situations utilizing Network Simulator-2 (NS-2) with improved capacity by including engendering misfortune models (e.g., adjusted Two-Ray Ground model, ITU Line of Sight and Nonline of Sight (ITU-LoS and NLoS) model into road gullies and consolidated way misfortune and shadowing model (C-Shadowing)). The recreation results were then contrasted and the first Two-Ray Ground (TRG) model effectively accessible into NS-2. The situation basically recreated was that of a versatile domain utilizing Random Way Point (RWP) portability model with a variable number of obstructions in the reproduction field, (for example, structures, and so on., causing variable lessening) so as to examine the degree of correspondence misfortunes in different engendering misfortune models. Execution of the Ad Hoc On-request Distance Vector (AODV) steering convention was additionally examined and analyzed in an impromptu domain with 20 hubs.

They have been used the physical layer and also checked the performance of networks. They have been taken AODV routing protocol and also taken 20 nodes. Our research scenarios have no similarity with the above work we have been taken OLSR routing protocol and also the different numbers of nodes 25 nodes and 50 nodes.

Venkataramana *et al.* (2015) examined the presentation of two beam ground and shadowing propagation models based on AODV and DSR steering conventions in MANETs. Propagation models indicated solid effect on the exhibition of steering conventions during recreations. They have researched the effect of well-known propagation models Two-beam and Shadowing on the presentation of AODV and DSR directing conventions utilizing NS-2. Trial results found that both AODV and DSR demonstrated better throughput in two-beam ground model.

They have been taken the reactive protocols AODV and DSR for the evaluation and impact of propagation models that are two ray ground and shadowing. Our research work is different from the above work we have been taken OLSR routing protocol.

Mohapatra and Tripathy, (2016) proposed the various metric executions in upgraded connect state directing is done and it was examined and analyzed over various propagation models like two beam ground and shadowing. Since correspondence range and recurrence assumes a significant job in correspondence parts of specially appointed system, so alongside hub thickness these parameters are additionally considered with multi metric based OLSR convention. The exhibition parameter considered for investigation incorporates parcel conveyance part, throughput, delay and directing overhead examination.

Naseeruddin and Patil, (2016) presented the efficiency of the different routing schemes like DSR, DSDV, AOMDV and AODV schemes in the perspective of three types of different models of mobility based on models of propagations that were shadowing, nakagami and two ray ground. The experimental results of the simulation indicated that schemes have preserved their essential features through diverse settings but with significant modification and changes when the energy of diverse models of propagation encountered. Considering unstable mobility scenario-1, AODV scheme in mobility model Nakagami is talented based on throughput and PDR, though DSDV in mobility model Nakagami effectively performed other schemes on the basis of power and delay parameters. Taking into account, unstable travel load setting DSR scheme in mobility model Nakagami is the most effective based on consumption of energy and PDR. Generally, it can be done that schemes have preserved their inhabitant and characteristic features throughout divergent settings but the key changes and modifications on the basis of the impact of diverse environments of propagation.

They presented both protocol proactive and reactive and they use DSR, DSDV, AOMDV and AODV. They have used propagation models one of them is Nakagami that is not relevant to the proposed mechanism also they have used different scenarios none of them are spares and dense found. After thoroughly evaluating, this paper possess no similarity with the OLSR oriented proposed model

Bhoyroo and Bassoo, (2016) examined and analyzed the exhibition of the Nakagami radio proliferation model, which is a sensible model to mimic genuine situations. Besides, this paper inspects how VANETs successfully diminish traffic clog. Topologies and situations identified with the Mauritian street geography have been created and reproduced on NS-2. The outcomes acquired plainly shows that VANETs can effectively reduce the issue of traffic blockage and that the presentation of the Nakagami model contrasts with the degree of blurring. This complexity in the presentation of the Nakagami model is additionally featured when a distinction of around 12% is seen between the throughputs for the various degrees of blurring.

Kumari and Jangra, (2016) examined and analyzed the result of two non-fading models of propagation named free space and two ray ground model, by the key features and outcomes of the ad-hoc routing schemes like AODV, DSR and Location-Aware Routing scheme in terms of delay, average throughput, and routing overhead. The authors observed that the act and efficiency of LAR1 routing protocol is top, and performance of DSR protocol is worst as radio verity increase. In comparison of two ray ground and free space model, Two ray ground models is best in case of AODV and DSR, but in case of LAR1 free space model gives best effect. Further this study would be extended to investigate the performance of LAR1 routing protocol in fading propagation model.

They have been taken the AODV, DSR and TORI routing protocol for checked the performance of two ray ground and free space. Our research work had different from that because we have been taken OLSR routing protocol and checked with the different propagation models.

Khan *et al.* (2017) proposed three radio propagation models that include shadowing model, free space model and two ray ground model are evaluated and analyzed as a core contribution. These models are implemented in MANETs environments in the light of changing traffic and mobility parameters. The effects of the different radio propagation models are analyzed over the destination-sequenced distance-vector (DSDV) routing protocol. In DSDV, the sequence numbers are used to maintain routes and new routes overcome the old routes when sequence numbers of the old routes become obsolete. To better understand the behavior of radio propagation models, simulations are conducted using Network Simulator-2. The metrics used in simulations include ratio of packet delivery, throughput, average delay, and packet drop ratio in a relation with the pause time and mobility parameters. The obtained results indicate that the two ray ground model is more suited for the DSDV protocol than the random waypoint model in terms of packet success ratio, data packets sent, throughput, and average network delay. Further, the model has a lower value for packets dropped than the Free Space and Shadowing models at higher pause times.

They have been proposed the propagation models for changing the traffic light used the DSDV protocol. They have been checked that which model give the best and accurate performance. Our research scenario is different from these work because we have been taken OLSR protocol and have been different parameters.

Mishra *et al*. (2017) talked about the presentation and correlation of various steering conventions, for example, AODV, DSDV, AOMDV and DSR over responsive stream (TCP) and inert stream (UDP). To break down the presentation of directing conventions in MANET dependent based on various reenactment parameters like throughput, bundle drop, start to finish delay, lingering vitality and parcel conveyance proportion (PDR). The correlation has been accomplished for expanding number of hubs having a fixed territory zone. All Simulations are finished utilizing system test system (NS-2). In future this work will be examined and analyzed and looked at the exhibition of steering convention under various radio proliferation model, for example, Free Space Model, Shadowing Model, Small-Scale Fading model and Nakagami model.

Poonia, (2017) examined the study of Two Ray Ground and Nakagami radio engendering models for vehicular impromptu arranges in Indian Scenarios just as to locate the best effective model, which is increasingly appropriate in different situations. Yield of this examination will be helpful for applying proficient models on the practical high way situation, particularly traffic brought about by the four wheelers. This model will likewise be productive for maintaining a strategic distance from overwhelming street clog and thruway street mishaps brought about by a high and uneven speed of traffic just as the different street conditions, similar to way gaps and street hindrances, and so forth.

Sood et al, (2018) used beam following and explanatory condition models of 2.4 GHz engendering along passage and outdoors areas of London Underground to assess the exhibition of an communication based train control (CBTC) framework. For examination, they considered existing way misfortune models for burrow situations and research whether they can give adequate exactness to be utilized for arrange convention structure. They have indicated that material science based models lead to solid expectations at the system level, comparable in constancy to utilizing estimated information and dissimilar to utilizing disentangled station models of the way misfortune type.

Rahul et al. (2019) displayed the exhibition investigation of various observational radio engendering models utilized in remote cell systems. It specific, the parameters, for example, way misfortune and cell inclusion zone are read for various cell systems from second-generation (2G) to fifth-generation (5G). Exact forecast of way misfortune and inclusion territory is exceptionally alluring for arranging of any remote correspondence frameworks. Thinking about the urban territory, the correlation is made between Hata model, Stanford University Interim (SUI) model, and altered SUI models. As an inspiration for new millimeter wave (mm-wave) cell frameworks, i.e., for 5G correspondence, the examination is performed at 28 GHz. Considering 75 dBm as the ideal least got power, it is seen that 2G correspondence (at 900 MHz utilizing Hata model) encounters the most reduced way misfortune and in this way results into biggest inclusion zone. The way misfortune is seen to be most extreme for the future mm-wave frameworks (at 28 GHz utilizing altered SUI model) that straightforwardly suggest the littlest inclusion territory.

Zhihua *et al.* (2019) presented invention relates to a method for predicting indoor three-dimensional space signal field strength by an outdoor to indoor propagation model, which comprises the steps of: establishing a 3-D space scene model from a transmitting base station to a target building: predicting space field strength of an outer envelope of the target building according to an extended COST-231-Walfisch-kegami propagation model; generating, on the outer envelope of the target building, a series of outdoor to indoor virtual rays in accordance with a certain resolution; simulating a propagation procedure of the virtual rays using a ray tracing propagation model algorithm, to predict three dimensional space signal field strength in the target building. In the present invention, an extended COST231–Walfisch Ikegami propagation model is adopted for the transmitting base station and the outdoor region of the target building, while a ray tracing propagation model algorithm is adopted for the indoor region of the target building, which effectively combines an outdoor empirical propagation model and an indoor deterministic propagation model, so that a good equilibrium is achieved between calculation efficiency and calculation accuracy and the algorithm has a strong engineering applicability.

Katagiri *et al,* (2019) proposed an estimation based range database utilizing model classifier. In the radio proliferation, way misfortune is the crucial factor to perceive the inclusion region. In any case, it is hard to precisely assess the radio condition through just way misfortune estimation in view of the shadowing deviation. In this way, we build the K spread models including shadowing and bring together the engendering model at the point where the shadowing attributes are comparable. The database right off the bat aggregates the got sign quality marker (RSSI) identified with the areas of recipients and we develop the model classifier. At that point, the database doles out the engendering model in each work with the goal that root mean squared blunder (RMSE) among datasets and the models is limited. They utilized estimation datasets of a 3GPP cell band in the genuine condition to develop the model classifier. Our outcomes show that the proposed strategy can precisely gauge the radio engendering while the enrolled information size is essentially diminished. Moreover, we talk about a strategy for control dependent on the proposed technique for improving the correspondence productivity.

Shutimarrungson and Wuttidittachotti, (2019) presented the improvement of propagation models for remote sensor systems for avalanche the board frameworks. Estimations of way misfortune in potential regions of avalanche event in Thailand were set up. The impact of the vegetation and mountain territory in the specific region was in this way considered with respect to the deliberate way misfortune. The estimation was done with short-extend transmission/gathering at 2400MHz comparing to IEEE 802.15.4 remote sensor systems. The estimation arrangement was partitioned into two principle cases, to be specific, the transmitting and accepting receiving wires introduced on the ground and 1-m high over the ground. The estimation results are appeared in this paper and used to create propagation models reasonable for activity of short-extend remote sensor systems of avalanche the board frameworks. The spread model produced for the primary case was accomplished by fitting the arrived at the midpoint of test information by the log-ordinary model in addition to the standard deviation. For the subsequent case, the model was gotten from the beam following hypothesis. The mountain-side reflection way was included into the model which contained the reflection coefficient characterized for the dirt property. Moreover, the subsequent propagation models were utilized so as to reasonably assess the presentation of remote sensor systems through simulations which were led by utilizing Castalia. In the simulations, the sensor hubs were set as deterministic and irregular disseminations inside square reenacted systems. The examination between the outcomes acquired from the deterministic and arbitrary conveyances are talked about.

2.1 Summary

Based on the literature review, it was concluded that majority of the researchers were worked on different types of propagation models in the perspectives of diverse mobility settings under the simulation base studies. From this chapter, it was also witnessed that propagation models were used for indoor and outdoor mobility environments for the sake of network improvements. Speaking of which, unlike OLSR that has been proposed in this research with the procedure of methodology has witnessed that none of the related work have been done like the way it has been proposed. Apart from OLSR, many authors have used AODV, DSR, DSDV etc. already existing MANET protocols with the help of different kinds of propagation models like Nakagami for the sake of network improvement to generate alternative results from the simulation scenarios.

III. RESEARCH METHODOLOGY

Research methodologies suggest the techniques for the collection of data and plan the proposal that how the work will be carried out using specified methods, tools and techniques as shown in Figure 3.1. How the objectives of the research work will be fulfilled by collecting data in a manner to obtain the required results. The methodology adopted for conducting research work in wireless and networks domain consists of three approaches i.e. theoretical analysis of data, experiments and simulations. Descriptive theoretical analysis approach will be followed if the focus of the research study is to present the research problems in a relevant framework. For manipulation of actual processes the method of experiments will be followed by using specific guidelines. When you have to check the actual system performance in a series of ways using different parameters and are cost effective and hardworking in reality the process of simulation will be followed. Simulations are the replications of realism for exploring the model, it offers to arrange and format the algorithm properties (Larsen, 2012).

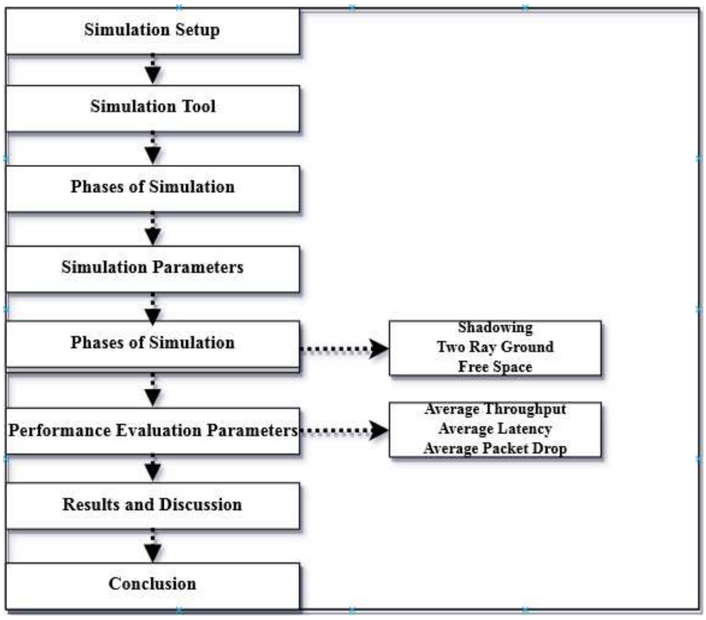

Figure 3.1: Flow of Proposed Research Model

This research works belongs to the latter category which is simulations. Network models and protocols are normally evaluated using different parameters by means of simulation to check the efficiency and stability of the protocols from different angles and directions. The impacts of different variables are studied by means of simulation using multiple scenarios for each protocol. For the purpose of simulation a popular network simulation tool known as NS-2 will be used throughout this research work. NS-2 is the most popular efficient accurate simulation tool available for almost all operating environments like Microsoft Windows, Linux and FreeBSD. This tool is composed of two languages Tool Command Language (TCL) and C++. The purpose of using two languages is the implementation of the protocols on the backend is the responsibility of C++ while OTCL deals with (Siakoulis *et al.,* 2014).

The proposed simulation model and its parameters are depicted in Figure 3.1. The flow of simulation start from writing 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 3.1.Each script will be executed multiple times and 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 to Microsoft excel for visual comparison based on the varied simulation parameters (Siakoulis *et al.,* 2014).

3.1 Simulation Setup

The tool used for the purpose of simulation in this research study is the popular tool used for carrying out this type of research studies is Network Simulator 2 (NS-2). NS-2 is the widely used tool which has been incorporated into many wireless test beds 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 (Fall and Varadhan, 2005).

3.1.1 Simulation Tool

NS-2 was originally originated in 1989 at Berkely labs in University of California. The development of this simulator was made possible by a group of people in a project namely Virtual Inter Network Testbed (VINT). The NS-2 has released in many versions among them the more efficient and stable version till now is NS-2 (Fall and Varadhan, 2005). It is well-known and very popular in the research community of wired and wireless networks domains. The reason behind the widespread use is the open source environment it provides and is also well tested by the research community. The code used for the development of NS-2 is Object Oriented programming language C++. The simulator is able to use TCL language scripts at the front end for quick configuration and execution of simulation scripts. The OTcl framework is integrated in NS-2 for running the scripts written in TCL Language (Issariyakul and Hossain, 2011).

3.1.2 Tool Command Language (TCL)

The developer of Tool Command Language (TCL) was John Ousterhourt. OTcl language is used by NS-2 for creation and configuration of scripts for simulation scenarios. Experimenting with quick prototyping and written application is an easy task using this language. The support of object oriented approach is known as OTcl and use interpreter. The code of C++ programming language is speedy to run however making changes to the code is sluggish while on the other hand the counterpart OTcl is well suited for making quick changes. Several changes can be made in no time to different topologies and simulation scenarios. The down side of OTcl as compared to C++ is that it is slow in running. The architecture of NS-2 is depicted in Figure 3.2.

The instructions are given to the NS-2 simulator via TCL scripts by user as commands input which are executed by the simulator. As the scripts execution phase is completed two files are generated as output in the form of (.tr) and (.NAM). The former is used for analysis of results while the latter one is used for visual animation of the topology (Sajeer *et al.,* 2011).

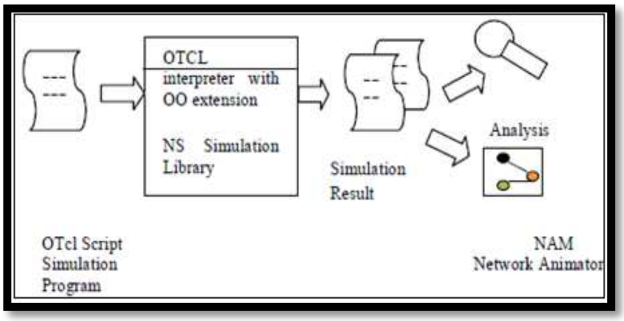

Figure 3.2: NS-2 Architecture (Issariyakul *et al.,* 2011)

3.2 Phases of Simulation

The simulation work of this research work can be broadly categorized in to 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 3.3.

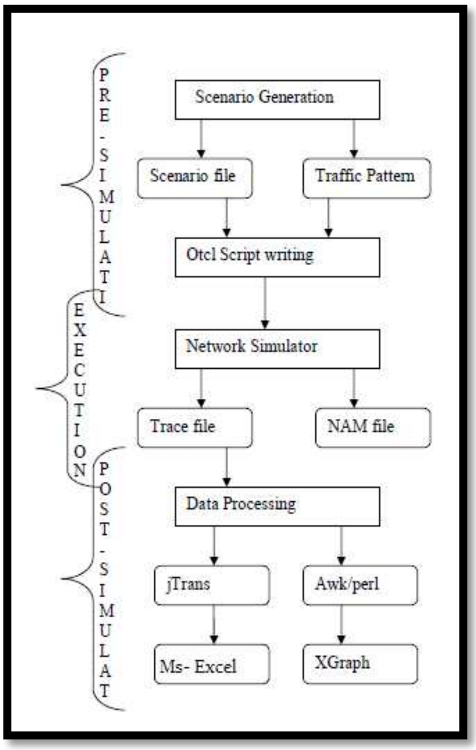

Figure 3.3: Phases of Simulations

3.2.1 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 on the basis of simulation parameters from each other like number of 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.

3.2.2 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 specified amount of time such as number of packets sent, dropped and received etc. While the animation file contains the physical and visual layout of the network topology.

3.2.3 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). A number of techniques can be applied for getting the desired information. Perl and awk scripts are the two common techniques used for analysis of the results obtained from simulation while some people export the trace files to excel for the purpose of analysis.

3.3 Simulation Parameters

Extensive simulations will be carried out in order to investigate the efficiency and performance of OLSR scheme under diverse models of propagation. A number of simulation scenarios will be tested by varying simulation parameters like various terrain size ie. Sparse and Dense network size. Secondly, sparse and dense network will be simulated for each propagation model listed in the Table 3.1. 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 Way point (RWP) as the mobility model with a pause time of 2 seconds. The simulation will last for 100 seconds against each considered scenarios. The simulation will demonstrate that how the performance of OLSR scheme will be affected by the size of the network in diverse scenarios. Further the outcomes of this study will reveal that which propagation model provides better results for sparse and dense network scenarios under OLSR as a routing agent.

Table 3.1: General Simulation Parameters.

Parameter	Value
Simulation Tool	NS-2
Channel type	Wireless 802.11
Routing Protocol	OLSR
Proposed Network Scenarios	Sparse and Dense
Number of Nodes for Sparse and Dense	25 and 50
Propagation Models	Shadowing Two Ray Ground Free Space
Performance Parameters	Average Throughput (kbps) Average Latency (milliseconds) Average Packet Drop (packets)
Simulation time	100 seconds
Network Volume	500m X 500m
Agent	Transmission Control Protocol (TCP)
Mobility of nodes	1 to 10 m/s
Pause Time	2 Seconds

3.4 Propagation Models

The features of wireless links source essential borders on the efficiency of WANETs. The feature of a wireless link is a compound grouping of impact because of the path failure, and multi-path loss. Radio transmission may differ meaningfully on the basis of the location, occurrence of action, speed of node, causes of interference, and other active issues. Path failure measures the loss that takes place in power of signal because of the space and the combination of the things among the two nodes. Fading of Shadow describes the variations about normal path failure. The models of propagation are generally considered as fading and non-fading.

3.4.1 Shadowing

This model of propagation utilizes the mathematical parameters for examining and analyzing of the obtained energy assuming power to have a chance up and down. It is the outcome that the obtained power of the signal altered because of the items obstructing the path of the propagation between the destinations (receiver) i.e. because of the effects of the fading.

3.4.2 Two Ray Ground

A single line-of-sight (LoS) path between two movable nodes is rarely the simply mean of broadcasting. Thus, the model of propagation of two-ray ground assumes equally the shortest path a reflection of ground path which provides more correct calculation at an extended range (distance) than the model of free space (Sarkar *et al.*, 2003).

3.4.3 Free Space

This is a model of huge level. 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 away from the sender that has to confront a best region. Consequently, the power of received signal minimizes with the distance of the square level.

3.5 Performance Evaluation Parameters

The performance of protocols and algorithms after the simulation can be tested and evaluated on the basis of some criteria i.e. evaluation metrics or parameters in the domain of networks. The performance metrics chosen for this research study is Average throughput, Average Latency and Average Packet drop.

3.5.1 Average Throughput (kbps)

Throughput refers to the amount items or material passing through a system. In jargon of networks throughput is the amount of data transferred successfully from source to destination in a network in a specified amount of time. Throughput is measured normally in bits/sec. Higher throughput denotes the effectiveness and efficiency of the network (Salamat and Sunita, 2016).

This metric can be calculated using the Equation 3.1.

$$\text{Average Throughput} = \sum_{i=1}^{n} \frac{\text{Received packets i} \times \text{packet size}}{\text{Total simulation time}} \ldots\ldots\ldots\ldots(3.1)$$

3.5.2 Average Latency (milliseconds)

Network Latency refers to indicate any type of delay that happens during the communication over the network. Specifically, the time taken by a packet from the departure of source node in a network till the arrival at the destination (Salamat and Sunita, 2016).

This metric can be calculated using the Equation 3.2.

$$\text{Average Latency} = \sum_{i=1}^{n} \frac{(\text{Received time i} - \text{Sent time i})}{\text{Total data}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.2)$$

3.5.3 Average Packet Drop (packets)

Average Packet drop refers to the amount of average number of packets that has been dropped or lost during transmission of data travelling in a network from one place to another. Drops are typically caused by the transmission errors, collision in wireless network and congestion in the network (Salamat and Sunita, 2016).

This metric can be calculated using the Equation 3.3.

$$\text{Average Packet Drop} = \sum_{i=1}^{n} \frac{(\text{Packet\_Dropped}_i \times \text{Packet\_Size})}{\text{Total\_Time}} \ldots\ldots\ldots\ldots(3.3)$$

3.6 Results and Discussion

After implementation and mathematical modeling, each scenario of the proposed mechanism have been analyzed and discussed from the simulation results. These scenarios have showed the accurate and efficient performance of the desired study on the basis of performance evaluation parameters i.e. Average Throughput, Average Latency and Average Packet drop.

3.7 Conclusion

Based on the proposed evaluation parameters i.e. average throughput, average latency and average packet drop, it has concluded the accuracy and performance of the sparse and dense network topologies. These have been tested based on various propagation models that are shadowing, two ray ground and free space.

3.8 Summary

The methodology the proposed research work has been introduced along with simulation setup and the performance evaluation parameters. Also general simulation parameter's table has given in this chapter that shows the requirements for the concerned study. A stepwise methodological framework has been introduced in Figure 3.1 that shows the sequence of the proposed research methodology accordingly that how the proposed work have been carried out.

IV. RESULTS AND DISCUSSION

This chapter gives the thorough discussion and analysis of the concerned simulations w.r.t different parameters and simulation scenarios accordingly. In short, this chapter explains the results and analysis with tabular and graphical illustrations for each and every scenario taken for the simulations.

The environment of MANET provides a variety of matrices for the purpose of analysis and evaluation of routing protocols. This study analyzed the performance of OLSR to check the effects of well-known propagation models i.e. Two Ray Ground, Free Space model and Shadowing where the nodes are mobile and managed through Random Way Point mobility model. The simulation has been carried out using (Network Simulator-2) NS-2 with CMU wireless ad hoc network. The nodes are randomly scattered forming an ad hoc network of sparse and dense topologies consisting of 25 and 50 nodes respectively. The nodes move randomly according to Random Way Point mobility model in a space of 500m X 500m.

The performance evaluation has been done on the basis of simulation results and analysis by using the standard metrics i.e. Average throughput, average packet drop and average Latency. The OLSR protocol has been tested by considering the well-known propagation models. The simulation has been carried out by changing the parameters connection pattern and node movement scenarios files for sparse and dense environment. The result analysis has been differentiated and evaluated on the basis of each propagation model for sparse and dense networks.

4.1 Results Analysis and Discussion of Average Throughput (kbps)

Throughput refers to the amount items or material passing through a system. In jargon of networks throughput is the amount of data transferred successfully from source to destination in a network in a specified amount of time. Throughput is measured normally in kilobits/sec. Higher throughput denotes the effectiveness and efficiency of the network. Figure 4.1 and 4.2 predicts the throughput of Two Ray Ground, Free Space and Shadowing radio wave propagation models for sparse and dense environment using OLSR as routing protocol. It can be seen from the results depicted that, throughput of propagation models doesn't change so much for sparse scenarios. Two-ray model accept that the sign arrives at the recipient through two ways, one a viewable pathway way, and the other the way through which the reflected wave is gotten. The throughput of meager situation for Two Ray is less for because of the way that the two-ray model doesn't give a decent outcome for a short separation because of the wavering brought about by the helpful and ruinous mix of the two-ray. The throughput of free spaces diminishes in thick system and all the more explicitly in profoundly thick condition. This because of the idea of Free

Space model that free space engendering model expect the perfect proliferation condition that there is just one make observable pathway way between the sender and receiver.

Table 4.1: Average Throughput (kbps) of Sparse Environment.

Propagation Model	Sparse Environment
Two Ray Ground	554.8
Free Space	558.5
Shadowing	535.7

The values of Table 4.1 are portrayed in Figure 4.1 as a graphical representation. Every propagation model has given different values in average throughput (kbps). Two ray ground has given 554.8 (kbps) values, while Free Space has given 558.5 (kbps) and Shadowing has given 535.7 (kbps) values in Sparse Environment. It was suppose that two ray ground will give better result in the perspective of average throughput (kbps) but since the nodes are mobile and they can come closer to each other. So, the nodes are closer to each other than two ray ground model gives poor result because its signals creates oscillations that causes low throughput and free space has given better result because the node come closer to each other. To be duly noted that free space gives better result in scenario when there is clear LoS from source node to destination node.

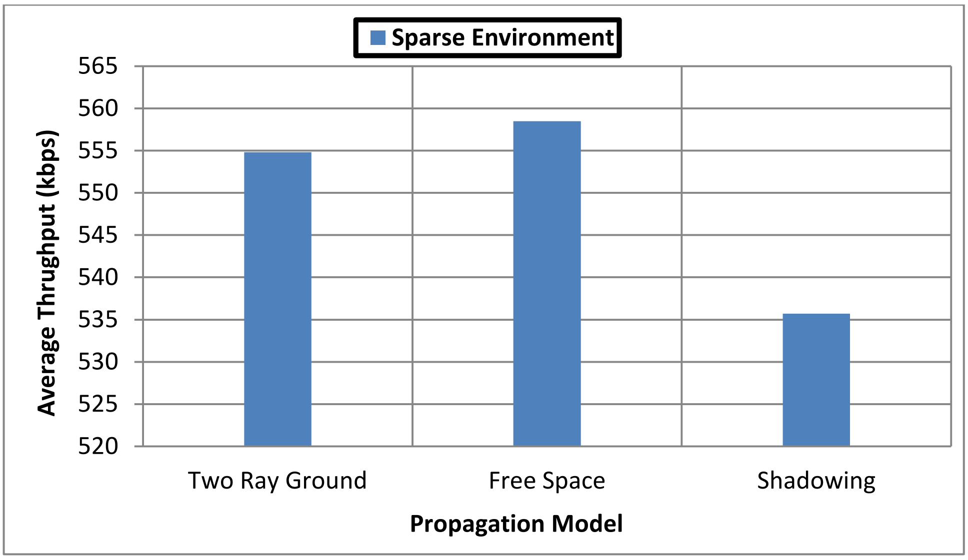

Figure 4.1: Average Throughput (kbps) of Sparse Environment

It must however be mentioned that the increase in throughput for Two ray is interesting from a relative view, because this study doesn't work for optimization. This study tried to determine and evaluate the protocol for propagation models under mobility factor for sparse and dense networks. It was concluded from the simulation results that for FTP type traffic using OLSR as routing agent the deterministic models i.e. Two ray and Free Space have less impact on the throughput as compared to probabilistic model i.e. Shadowing. The overall results in all scenarios shows that the performance of Free space model perform better among the considered models and it is the model of choice in present circumstances.

Table 4.2: Average Throughput (kbps) of Dense Environment.

Propagation Model	Dense Environment
Two Ray Ground	440.2
Free Space	517.4
Shadowing	496.6

The values of Table 4.2 are portrayed in Figure 4.2 as a graphical representation. Every propagation model has given different values in average throughput (kbps). Two ray ground has given 440.2 (kbps) values, while Free Space has given 517.4 (kbps) and Shadowing has given 496.6 (kbps) values in Dense Environment.

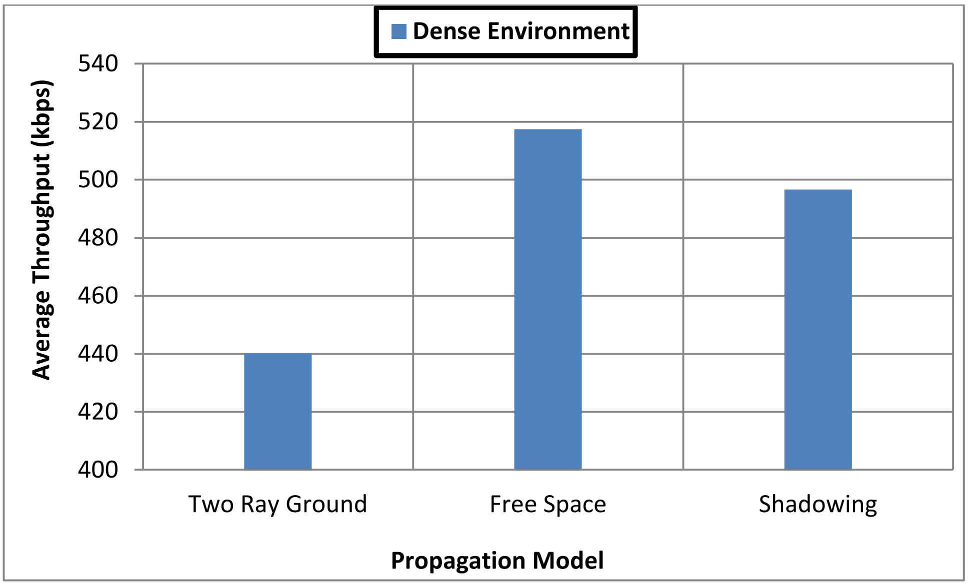

Figure 4.2: Average Throughput (kbps) of Dense Environment

4.2 Results Analysis and Discussion of Average Latency (ms)

Average Network Latency refers to indicate any type of delay that happens during the communication over the network. Specifically, the time taken by a packet from the departure of source node in a network till the arrival at the destination. This includes all the possible delays caused by node's processing time, queuing delays, retransmission delay at the MAC layer and propagation time. By analyzing the simulation results it is observed that the average latency of two ray ground is relatively high initially in sparse scenario with low mobility. This increase in delay leads to lower throughput as shown in Figure 4.3 and 4.4. The average latency of shadowing and free space go neck to neck initially in sparse networks with both mobility speed and a negligible difference has been observed in dense networks. While the delay for two ray ground changes from scenario to scenario. It can be observed from Figure 4.3 and 4.4 that average latency increases, for all the propagation models under consideration as the network goes from sparse to dense.

A slight increase has been noticed in dense network for low mobility. This happens because of the increased probability of collisions and packet drops due to network congestion, when traffic load and network density increases. Generally as the scenario is dense, the nodes in the network the route changes quickly and more frequently in high mobility which further leads to more link breakages which eventually impact the delay of the network. It can be concluded from the graphs of average latency that the overall performance of two ray ground is acceptable as compared to shadowing and free space, while free space achieved slightly better results than shadowing. In terms of average latency the impact of two ray ground is acceptable and the results are satisfactory in the concerned considerations. Shadowing model too has the worst delay characteristics because of the loss of packets information with respective nodes.

Table 4.3: Average Latency (ms) of Sparse Environment.

Propagation Model	Sparse Environment
Two Ray Ground	0.323
Free Space	0.527
Shadowing	0.482

The values of Table 4.3 are portrayed in Figure 4.3 as a graphical representation. Every propagation model has given different values in average latency (millisecond). Two ray ground has given 0.323 (millisecond) values, while Free Space has given 0.527 (millisecond) and Shadowing has given 0.482 (millisecond) values in Sparse Environment.

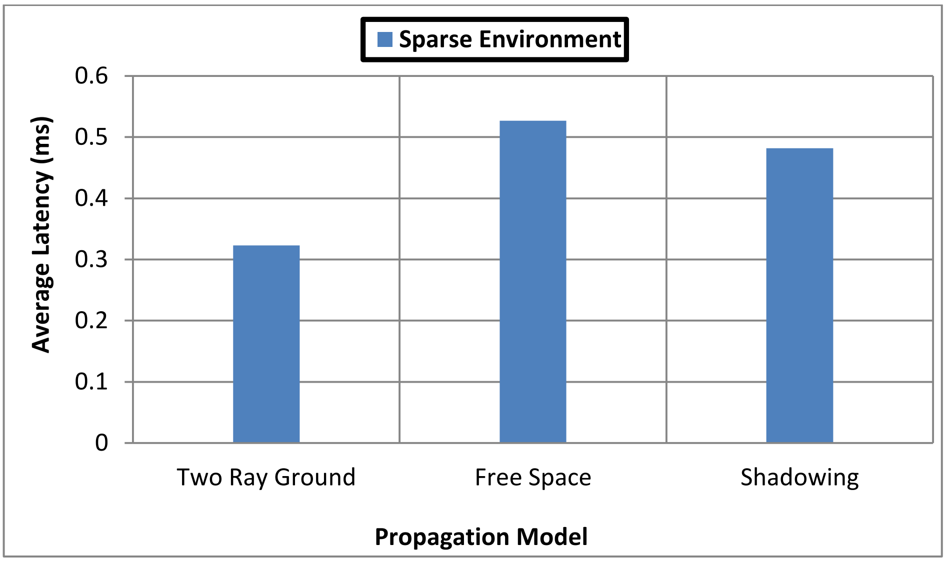

Figure 4.3: Average Latency (ms) of Sparse Environment

The Table 4.3 and 4.4 and Figure 4.3 and 4.4 show average latency of sparse environment for the proposed scenarios. Since the nodes are movable, so due to mobility of nodes two ray ground model have given better result in contrast to the other two propagation models.

Table 4.4: Average Latency (ms) of Dense Environment.

Propagation Model	Dense Environment
Two Ray Ground	0.572
Free Space	0.778
Shadowing	0.825

The values of Table 4.4 are portrayed in Figure 4.4 as a graphical representation. Every propagation model has given different values in average latency (millisecond). Two ray ground has given 0.572 (millisecond) values, while Free Space has given 0.778 (millisecond) and Shadowing has given 0.825 (millisecond) values in Dense Environment.

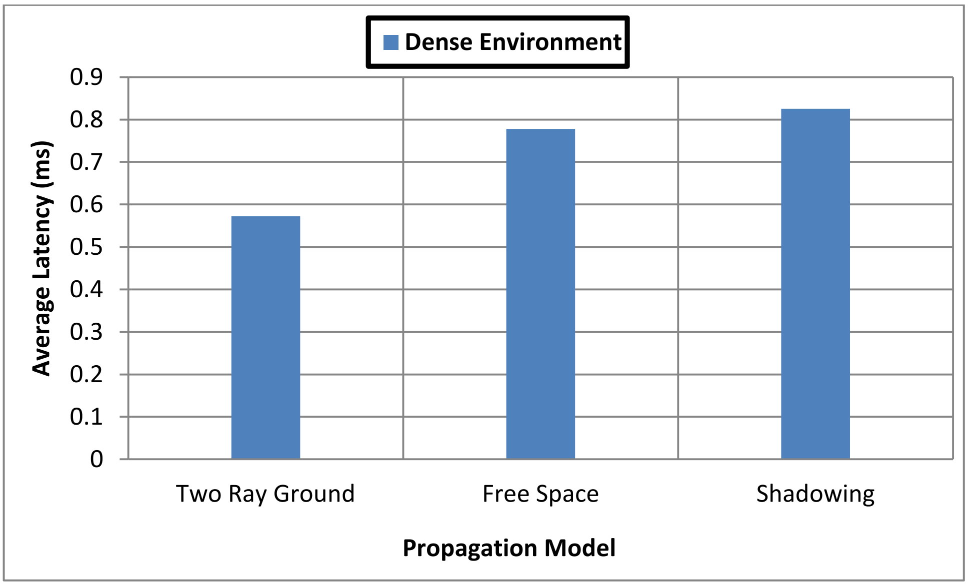

Figure 4.4: Average Latency (ms) of Dense Environment

4.3 Results Analysis and Discussion of Average Packet Drop (packets)

Packet drop is the number of packets that is initiated from sender node but no successfully traversed at the receiver node (Gruber *et al.,* 2004). The outcomes of the simulation results shows that the number of packets discarded or dropped in dense network is high as compared to sparse. According to the Figure 4.3, in dense scenarios the probability of collision is high due to channel contention and interference which further results in packet drop. It can be observed from the graph that performance of two ray is better by dropping less packets. While the average number of packets dropped by free space is quite higher from two ray as well as shadowing.

Table 4.5: Average Packet Drop (packets) of Sparse Environment.

Propagation Model	Sparse Environment
Two Ray Ground	206
Free Space	386
Shadowing	333

The values of Table 4.5 are portrayed in Figure 4.5 as a graphical representation. Every propagation model has given different values in average packet drop (packets). Two ray ground has dropped 206 (packets) values, while Free Space has dropped 386 (packets) and Shadowing has dropped 333 (packets) in the proposed Sparse Environment.

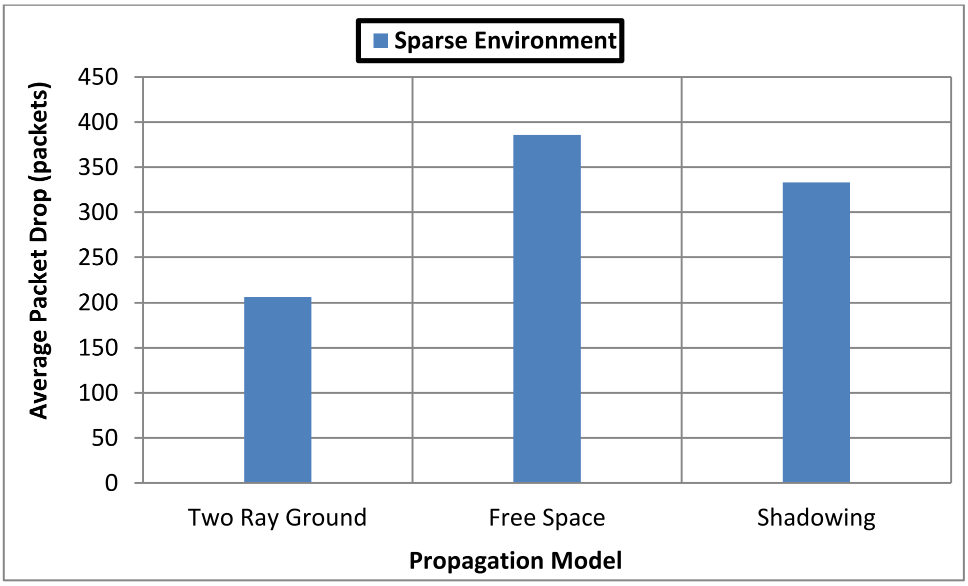

Figure 4.5: Average Packet Drop (packets) of Sparse Environment

It is revealed clearly from Figure 4.5 that Two Ray Ground model has given much better result in less packet drop scenario in contrast to the other two propagation models. This study tried to determine and evaluate the protocol for propagation models under mobility factor for sparse and dense networks. It was concluded from the simulation results that for FTP type traffic using OLSR as routing agent the deterministic models i.e. Two ray and Shadowing have less impact on the average packet drop as compared to probabilistic model i.e. Free Space model. The overall results in all scenarios shows that the performance of Two Ray Ground model perform better among the considered models and it is the model of choice in present circumstances.

Table 4.6: Average Packet Drop (packets) of Dense Environment.

Propagation Model	Dense Environment
Two Ray Ground	581
Free Space	608
Shadowing	447

The values of Table 4.6 are portrayed in Figure 4.6 as a graphical representation. Every propagation model has given different values in average packet drop (packets). Two ray ground has dropped 581 (packets) values, while Free Space has dropped 608 (packets) and Shadowing has dropped 447 (packets) in Dense Environment.

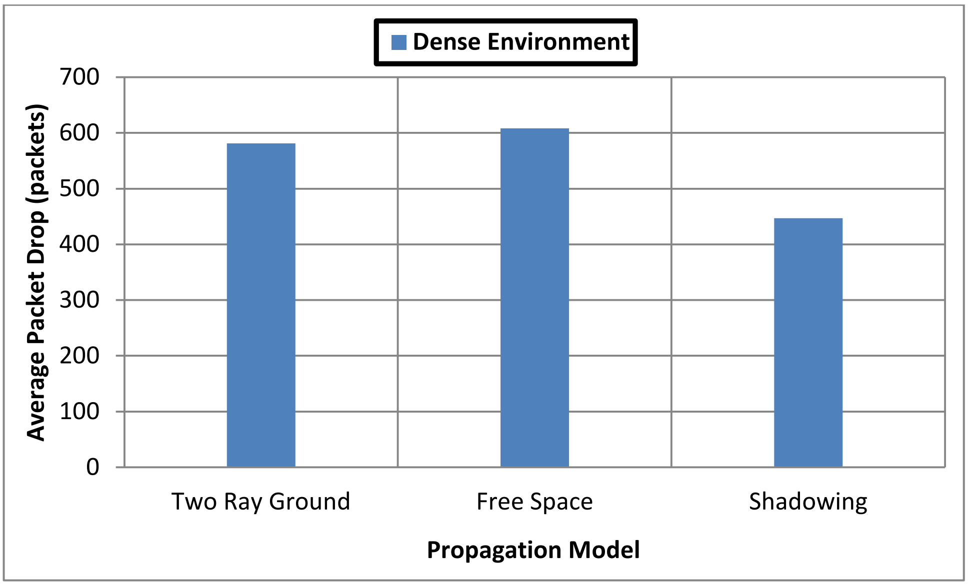

Figure 4.6: Average Packet Drop (packets) of Dense Environment

Shadowing impact accept that the sign level can change generally for a given separation between two hubs. This expands the likelihood that the sign level may go beneath a specific required level called a limit level. For this situation, a getting versatile hub may not effectively get a parcel. After that they got sign level goes underneath a limit level. Subsequently, there will be bundle misfortunes in the system if a system is enormous enough to have normal connection separation more prominent than around 200. The Free Space terrible showing is because of the low force of the sign brought about by the impediments. This outcomes in the bundle misfortune on feeble connections, shows wrongly the connections disengagement and prompts the interference. In contrast the performance of free space is comparatively high when latency and throughput is considered as metric.

4.4 Summarized 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 sparse and dense scenarios. It has been concluded that every propagation model has performed well according to the best adaptable environment as shown in Table 4.7. This table depicts the average values of both sparse and dense environments.

The summarized results show the merge values in average of both sparse and dense environments.

Table 4.7: Summarized Average Results in Tabular Form.

Propagation Model	Average Throughput (kbps)	Average Latency (ms)	Average Packet Drop (packets)
Two Ray Ground	497.5	0.4475	393.5
Free Space	537.95	0.6525	497
Shadowing	516.15	0.6535	390

The values of Table 4.7 are illustrated in the following Figures. For sparse and dense environments the overall average values have been calculated and portrayed in the given Figures 4.7, 4.8 and 4.9. Figure 4.7 denotes the average throughput in kbps of sparse and dense environments under the proposed three propagation models i.e. two ray ground, free space and shadowing.

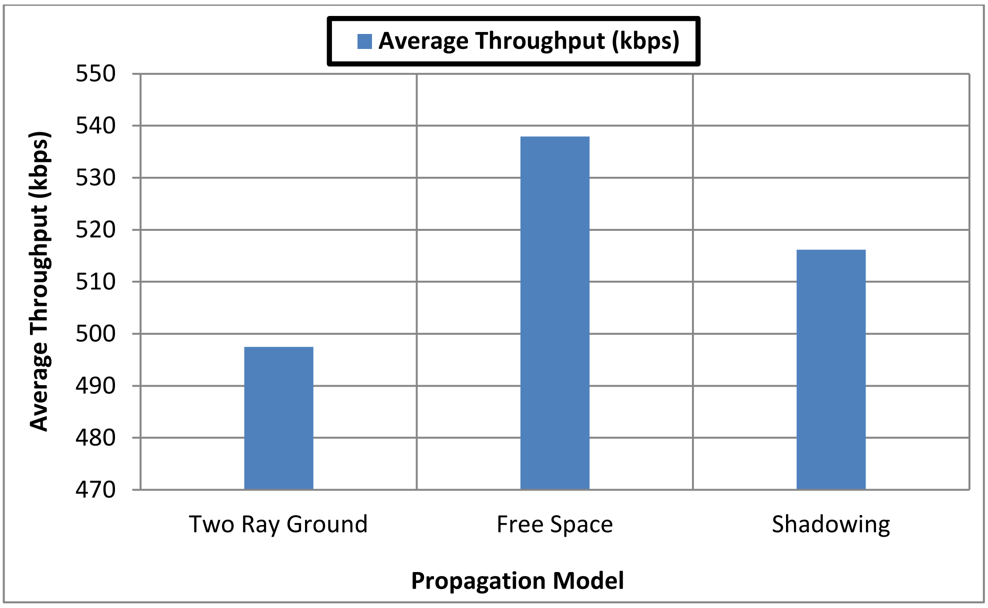

Figure 4.7: Average Throughput (kbps) of Sparse and Dense

From Figure 4.7 it can be clearly witnessed that the average throughput in kbps of two ray ground model has given poor results. Because the nodes can traverse from one place to another due to nodes mobility that's why they often come to close range and Two Ray propagation model does not gives better result when the nodes are close to each other. But the main motive was to assess and analyze the impact of these propagation models under sparse and dense settings of nodes. From Figure 4.7 it has also verified that Two Ray model can be used in settings where nodes have long ranges from each other's from meters up to kilometers range but still it has given 67% results out of 100%.

Figure 4.8 illustrates the average latency in milliseconds of sparse and dense environments under the proposed three propagation models i.e. two ray ground, free space and shadowing.

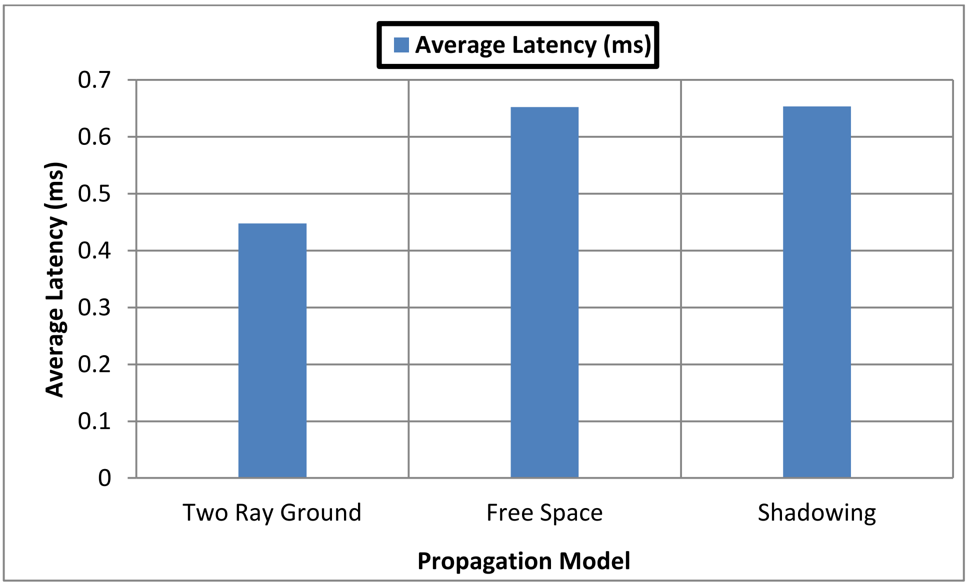

Figure 4.8: Average Latency (ms) of Sparse and Dense

Figure 4.9 denotes the average packet drop in packets of sparse and dense environments under the proposed three propagation models i.e. two ray ground, free space and shadowing.

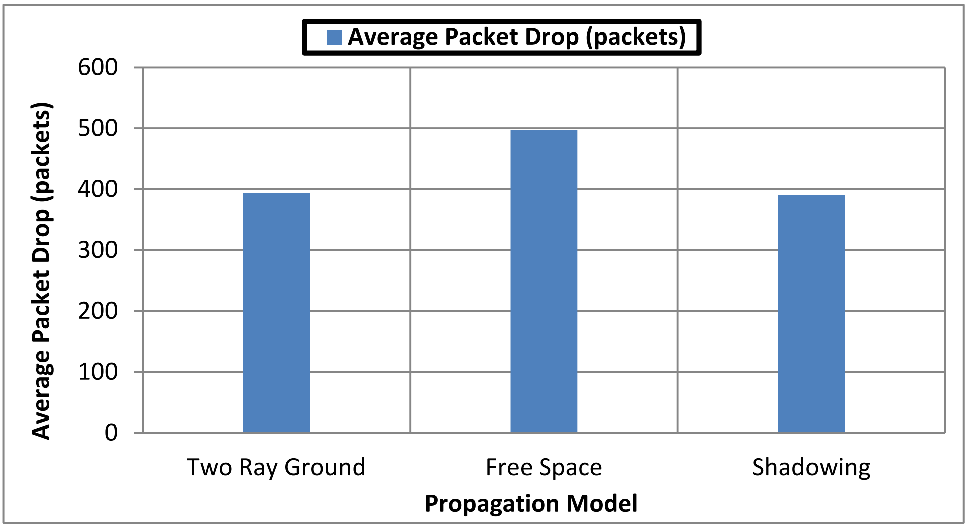

Figure 4.9: Average Packet Drop (packets) of Sparse and Dense

4.5 Summary

The average calculated values of sparse and dense for Two Ray Ground, Free Space and Shadowing propagation models have been depicted in Table 4.7. Every propagation model has given different values. The main motive and task of this research was to check and evaluate the performance of each and every propagation model in different proposed scenarios by taking 25 nodes for sparse and 50 nodes for dense environment. It has witnessed that the sparse and dense scenarios in MANET has great impact on the performance of the proposed propagation models. Since the nodes move freely from one place to another that's why every propagation model has given better and poor results because some models gives better results when there is close range between nodes and some gives better when nodes are at long distance from each other's.

V. SUMMARY, CONCLUSION AND RECOMMENDATION

This chapter provides summary, conclusion, contribution and recommendation along with future work of the proposed mechanism and it also concludes the research.

5.1 Summary

In chapter 1^{st}, the detail outlines of Mobile Ad hoc Network (MANET) have been examined alongside its key issues, difficulties and applications. Toward the finish of section first, the issue explanation and targets of the investigation was additionally given. In 2^{nd} chapter, the detail overviews of the related work have been given from the viewpoints of various authors identified with the concerned investigation of the premium. In 3^{rd} chapter, the proposed parameters of the examination technique alongside the simulation tool have been talked about in detail. In 4^{th} chapter, the outcomes have been gotten from NS-2 simulator and examined every single situation in like manner.

The performance of the sparse and dense network topologies were evaluated by using NS-2 simulations. The impact on the sparse and dense node deployment were tested based on the concerned parameters average throughput, average latency and average packet drop under different propagation models which are shadowing, two ray ground and free space. The results have been concluded from the simulations and have shown the effects of these parameters.

5.2 Conclusion

This research has been efficiently carried out by taking sparse and dense network scenarios for the proposed model. From NS-2 simulations, it has clearly been witnessed that radio propagation models has a strong impact on node mobility as well as increasing and decreasing number on nodes. The proposed three radio wave propagation models were taken into considerations that are Shadowing, Two Ray Ground and Free Space. Each propagation model has performed well in their desired scenario in which they possessed the ability to outperform. In average throughput, free space model has performed well in contrast to the other two models. Due to the mobility nature and clear path for communication free space has performed well in sparse scenario for average throughput. Similarly, in dense scenario free space has also performed well in comparison with two ray ground and shadowing models.

In average latency for both sparse and dense scenarios the efficient results have been performed by two ray ground model due to the covering of long distance i.e. in two ray ground the signal propagates much faster and longer that the other propagation models. In average packet drop, two ray has performed better for sparse scenario due to long distance between nodes in which this model performs well by covering long distance and creating direct communication and via ground reflection. For dense scenario two ray has given poor performance due to the low range between nodes because of the signal oscillation and collision by direct signal and reflecting signal.

The average calculated values of sparse and dense for Two Ray Ground, Free Space and Shadowing propagation models have been depicted in chapter IV. Each propagation model has given dissimilar values. The key purpose and task of this research was to check and assess the performance of all propagation models in diverse proposed scenarios by selecting 25 nodes for sparse and 50 nodes for dense environment. It has been observed that the sparse and dense scenarios in MANET have great effect on the performance of the proposed propagation models along with OLSR protocol. Since the nodes move freely from one place to another that's why every propagation model has given better and poor results because some models gives better results when there is close range between nodes and some gives better when nodes are at long distance from each other's. Two-Ray model has performed well in average calculated results which indicate that this model is best for each scenario.

5.3 Contribution

The term contribution expresses involvement and role in the desired field of study in the perspective of pros and cons. Well, from this research it has been already clearly revealed that the major task was to examine and evaluate the performance of different propagation models as mentioned for the concerned study. It has been clearly observed the contribution in the desired study that has shown a great impact on the performance of Sparse and Dense nodes deployment under the proposed propagation models. The main contribution in the proposed work is the selection of 25 nodes for sparse and 50 nodes for dense and then the simulation analysis of these nodes under different propagation models to check which one has a huge impact on the performance of these models. In addition, it was the major contribution by taking different scenarios that were not yet selected by other authors for the concerned study.

5.4 Recommendation and Future Work

In this research the apprehensive study was carried out to analyze and examine the performance and effectiveness of diverse propagation models. For the purpose of sparse and dense network topologies on the basis of the performance assessment parameters average throughput, average latency and average packet drop by utilizing proactive (table-driven) OLSR protocols.

In future, these topologies can be tried under various propagation models alongside various portability models in MANETs. Additionally, jitter, way misfortune, organize strength period, complete vitality utilization and so on can be utilized as execution assessment parameters to create the best and elective outcomes in examination with the best in class arrangements. The reproduction devices NS-3, MATLAB, Opnet, Omnet++ and so on can likewise be utilized for the concerned examination by taking diverse radio wave propagation models such as Okomora/hata model, Nakagami model, Crosswave, Ricean, Raylei etc.

By increasing demand of MANET in market and commercial uses, it covers many tasks but also possess some issues and challenges which is a future concern. Like the node scalability and geographic scalability also effect on this network that needs proper adjustment and schemes along with latest radio wave propagation models like CrossWave radio wave propagation model. This model has the ability to avoid collision and minimize flooding which ultimately reduces overhead problem. For better results and better network latest propagation model needs to be implemented by taking different scenarios like indoor and outdoor or rural and urban scenarios and the results can be carried out via simulations.

In this network each node operates as a router and host, through which at some point these nodes creates flooding mechanism which increases overhead because the nodes communicates directly without external entity or centralized control system. From this viewpoint, each node should be equipped with propagation model in which the network performs well. In addition, Quality of Service (QoS) in MANET is very complex problem that could be a major concern for future researchers which needs to be enhanced.

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

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