Impact of Propagation Environment on the Performance of Direction Oriented Forwarding through Minimum Number of Edge Nodes (DOF-MEN) Routing Protocol In Ad Hoc Networks

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ABSTRACT- One sort of wireless ad-hoc network is called MANET (Mobile Ad-hoc Network), which is an autonomous network made up of wireless nodes and routers connected by wireless connections. Transmission of data in effective way is important. The DOF-MEN (Direction Oriented Forwarding through Minimum Number of Edge Nodes) protocol is the protocol which lessens the amount of messages for route discovery. It attempts to choose just single node as the next following hop. The node's address is added by the sender. Therefore, only the chosen node will receive and subsequently transmit the data. This protocol increases the throughput, Packet Delivery Ratio, and cuts down on the Routing Overhead. Several aspects affect the routing protocol's execution accuracy in mobile ad hoc networks (MANET). The propagation model is a crucial thing to be considered among many. MANET experiences an enormous loss in performance due to blockage between transmission devices and fluctuation in the receiver's signal intensity. Therefore, it's crucial to determine how Radio Propagation Model and study of performance of routing protocol in MANET. Here we do simulation and analysis using NS2 (Network Simulator 2). The outcome demonstrates that the MANET routing protocol's performance is more influenced by the propagation model.

Keywords: Mobile Ad-hoc Network, Direction Oriented Forwarding, Minimum Number of Edge Nodes, Radio Propagation Model.

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1. INTRODUCTION

No centralized administration or fixed network infrastructure, like base stations or access points, is required for ad hoc networks. The ad-hoc topology depends on the place of the nodes, the communication range of their receiver and transmitter, the level of communication power level and co-channel interference level, wireless connectivity, node's mobility. This topology may be modified with time based on the mentioned parameters [1].

As a signal moves through the wireless channel, it experiences a variety of propagation effects, resulting from the presence of structures, mountains, and other similar barriers, including reflection, diffraction, and scattering [2].

2. OVERVIEW OF PROPAGATION MODEL

The propagation model's properties could sporadically and randomly vary depending on the location. It is possible to define each wireless channel as a function of received signal intensity, time, space, frequency, and distance. The propagation effects of reflection, diffraction, and scattering that occur as a signal travel via a wireless channel could be caused by an obstruction.

A single line of sight or a blocked path between the receiver and transmitter may exist during transmission. In a mobile communication system, the propagation mechanisms of reflection, diffraction, and scattering have a significant impact. [3]. When a propagating wave hits an object that is smaller in dimension than itself, reflection happens. Waves may partially refract during reflection. Diffraction occurs when a barrier blocks a radio path and the wave propagates across it. When a smaller wavelength propagation medium shifts the wave's direction, scattering happens. The two primary features of a wireless channel are path loss and fading. Two categories exist for the propagation models: fading and non-fading models. Wireless communication design includes fading as a crucial component. The signal variation over a transmission medium is called fading. The broadcast signal and channel parameters determine fading in a mobile radio channel. The fading propagation model's signal strength measurement was dependent on the user's or node's movement. The signal may fade in many ways depending on parameters such as bandwidth and route loss [4].

The non-fading communication paradigm, on the other hand, spreads its radio signal across a larger area as the distance increases. A component of the non-fading model is the free space and two ray ground models. To fully comprehend the concept of a channel in a wireless network, one must have a thorough understanding of the dispersion of signal intensity obtained. The protocol improves the efficiency by reducing the energy consumption and routing overhead of the network. Flooding is completely avoided. The Location Aided Routing (LAR) protocol uses the location information to reduce the search region. The Zone Routing Protocol (ZRP) utilizes the nodes of one particular zone. The proposed DOFMEN protocol utilizes both zone and location information. In the proposed protocol instead of involving all the nodes of one particular zone, only one node is involved in forwarding data. It improves the network performance. The route discovery messages consume more resources. Reducing the number of route discovery messages will reduce the resource utilization [5].

A. Free Space Model

This model calculates the signal power based on the guess that there is only one clear of sight between sending device and receiving device. This model basically represents that each transmitter has a circular communication range around it. The receiver collects all the data packs within this communication range. It does not receive the data packs outside this communication range. The following *equation 1* is used to determine the distance-based receiving signal strength at d [5].

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} \quad (1)$$

Where -

P_t is the signal's strength as it is sent.

G_t and G_r are the antenna gain for transmission and reception, respectively.

L (L =1) is the parameter for system loss.

λ is the wave length.

B. Two Ray Ground Model

The two-ray ground model believes that the receiver receives two signals. One is the direct signal and another one is the signal which is reflected from the ground. It means the receiving device gets signal through various paths (one is direct pathway and the earth reflecting pathway is yet another). Whereas Free space model posits that there is single direct pathway. To determine the receiver power at a distance d, apply the equation shown below [6].

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

Where - h_t and h_r are the height of the sending and receiving antenna, correspondingly.

G_t and $G_r$standthe sender and receiver's respective antenna gains. L(L >=0) = system loss factor .

For short distance the interaction of the generative and negative of straight and ground reflected pathway signals causes oscillation. So, for tiny distances, the two-ray ground model doesn't really produce good results. Nevertheless, at short distances, the free space model works well.

C. Shadowing Model

Earlier mentioned 2 models think that signal power of receiving device's data diminishes based on the separation between the transmitter and recipient and the optimal circle-shaped communication coverage. Path loss also uses some Gaussian random variables to add some environmental influence. Two components make up the shadowing model. Path loss determines the first, while distance from the receiving device determines the second. The following equation3 values the mean collected power at given distance by using path loss model Pr(d). It makes reference to points that are near together (d0) and uses the exponent for the path loss.[7], [8]

$$\frac{P_r(d_0)}{P_r(d)} = \left(\frac{d}{d_0}\right)^{\beta} \quad (3)$$

When the β is greater, the obstruction becomes high and then the received power is decreasing faster. The shadowing model's second component displays the change in received power at a specific range. The random variable is log normal. This model is characterized by the following *equation*

$$\left[\frac{P_r(d)}{P_r(d_0)}\right] = -10\beta \log\left(\frac{d}{d_0}\right) + XdB \quad (4)$$

Where the random variable X dB is a Gaussian with an average of zero and a standard deviation of σdB. By altering the path loss exponent's value, it can adopt to different environments [8-9].

3. DOF-MEN PROTOCOL FOR MANET

The DOF-MEN protocol for MANET is discussed in this section. The quantity of route discovery messages is reduced using this protocol. It attempts to decide just one node as the following hop. The node's address is added by the sender. Therefore, only the chosen node will accept and subsequently transmit the data [10]. It pinpoints the position of the goal. It only chooses one edge node for forwarding if the destination is beyond the source node's zone. Not every edge node receives the message. All MNs in the network are covered by a wireless Base Station (BS) used by DOF-MEN. *Figure 1* illustrates how BS splits the network into 6 zones.

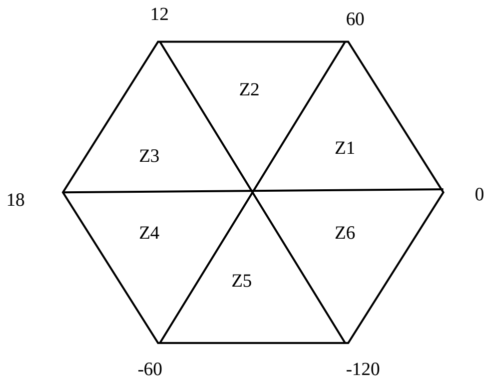

Figure.1 The network region is divided into 6 zones

It allocates one angle value for each zone as proof of identity (θ_n). Each node knows its location ID. The location Identification (ID) consists of an angle value, and a radial distance value from the 'BS'. The 'ID' is with respect to 'BS'.

A. Position ID

The BS keeps a positioning table with all the nodes' positions in it. The *table 1* shows the zone where the node is present in the network. The BS transmits a BEACON signal and then gets a reply. The radius and angle of the node make up the ID.

Table 1: The Location Table in the CN

S. No	Node number	Time stamp	Edge or Neighbor	distance	energy
1	n_1	T_1	E	Dis_1	E_1
2	n_2	T_2	N	Dis_2	E_2
3	n_3	T_3	N	Dis_3	E_3
4	n_4	T_4	E	Dis_4	E_4

B. Coverage Area

Every node has a unique transmission area. *Figure 2* shows the communication range of one node. Coverage area refers to this range. [10].

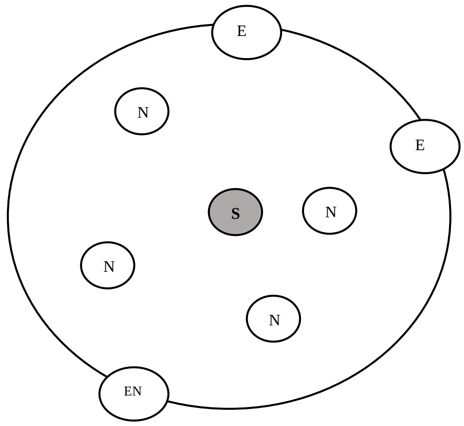

Figure. 2. The edge nodes(E)and neighbour nodes(E) of node Source(S)

Neighbors are nodes that are all located inside the coverage region. All of the node's neighbours can communicate with it directly. Edge nodes are the nodes that are along the border. The node uses these edge nodes to relay information when connecting with other nodes. The received signal intensity will determine if the node is an edge node or a neighbour.

Neighbor Table (NT) and Edge Neighbor Table are maintained by the node (ENT). By using BEACON signals, it keeps the routing tables up to date. The name and position are kept in the table. The following *table 2* defines the neighbor table of each node. The node maintains the list of neighbors and their parameters in the table. Each node uses BS to determine its location. In relation to the base station, the position is given.

Table 2: The Neighbour table

S. No	Node number	Time stamp	Edge or Neighbor	distance	energy
1	n_1	T_1	E	Dis_1	E_1
2	n_2	T_2	N	Dis_2	E_2
3	n_3	T_3	N	Dis_3	E_3
4	n_4	T_4	E	Dis_4	E_4

C. Data Transmission

When Sending information to a recipient host D, the source host S first checks its tables. It can transfer the data straight to destination node D if the entry is present. The destination address field now includes the node's name. In the event that it is unavailable, it will transmit a packet of requests to the BS to obtain the node's location.

The BS transmits the destination node's location ID (angle, radius). Because the BEACON signals are gathered by the BS on a regular basis and calculates the ID. All nodes have knowledge of its location, base station, network size, and region size. The source node first selects the Next Hop and initiates the transmission process after receiving the ID of the destination.

 # DOF-MEN Algorithm:

1. // Get the Source ID (θ_s , r_s),
2. // Get the Destination ID (θ_d , r_d)
3. // Source node compares the IDs of source and destination
4. If $\theta_s = \theta_d$//(both nodes are present in same zone)
5. // evaluates the radius value.
6. If $r_s$is greater than r_d then (Source is away from the Destination)
7. S selects the Edge Node with ID (θ_s , r_s - 2)
8. Else
9. S selects the Edge Node with ID (θ_s , r_s + 2)
10. End
11. S forwards data via the selected Edge Neighbor

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node
12. Else If $\theta_s \neq \theta_d$ then (source and Destination are not in same region)
13. If $\theta_s + \theta_d$=0 or 180 then
14. Select the neighbor in the same zone.
15. S chooses the EN with ID (θ_s , r_s - 2)
16. (The EN is available in between S and Basestation.)
17. Else Calculate D1=$|\theta_d - \theta_1|$ and D2=$|\theta_d - \theta_2|$then
18. Select the node in min D direction as next source
19. End
20. End

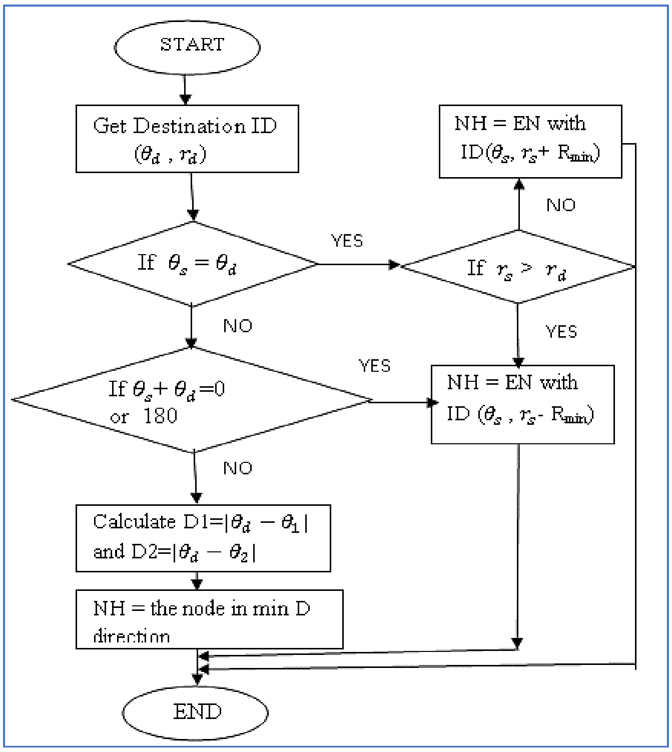

Figure 3. Flowchart for the phase of NH selection

The source node obtains the location 'ID' of the destination node (θ_d,r_d). Then the 'S' compares the location 'ID'. If both 'S', and 'D' are present in the same zone, 'S' selects the edge node with location id (angle, r_s - Rmin) or (angle, r_s + Rmin). If both 'S' and 'D' are not present in the same zone, the 'S' will identify the direction in which the 'D' is present. Then 'S' will choose the edge node which is present in the identified direction. The selected next hop node also does the same. The entire path is identified in the same way between 'S' and 'D'. The data are transmitted. It totally avoids flooding. It chooses only one subsequent forwarding node, and straightly directs data to that node, *figure 3*. If source and destination nodes are not in same region, it will select the edge node in corresponding direction. The following *figure 3* describes the situation.

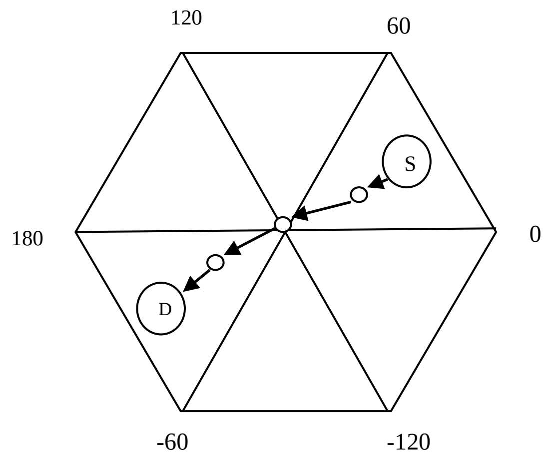

Figure. 3. Edge nodes are used by S and D to communicate.

The chosen Edge Node becomes the new source. This procedure is repeated until reaching the destination. Flooding is completely avoided. There are three intermediary nodes utilised in the example above. Nodes that are still present won't reply. The separation between the sender and receiver determines how many overhead packets there are overall.

4. SIMULATIONS AND RESULTS

The Network Simulator 2 (NS2) carried out the simulation. A discrete - time simulator called the NS2 network simulator is used to model both wireless and wired networks. The network's topological structure, the nodes' mobility modes, and the configuration of each node's function can all be defined using NS instructions. Here, NS2 is employed to evaluate how well the aforementioned methods performed.

Here, the experiment is done with different node counts to examine how the propagation model made an impact on the routing protocol. The AWK command is applied to assess the experimental outcomes found in the output trace files that were generated. The parameters for the simulation are shown in *table 1* below.

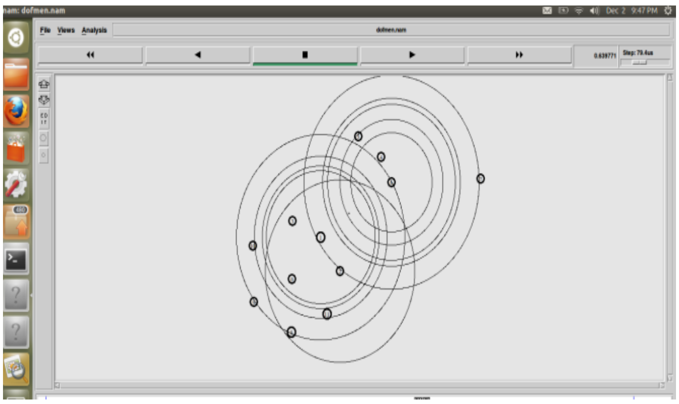

Figure 4. The Screenshot of ns2 simulation

Table 3: Simulation Performance Date

Parameters	
Chanel	Wireless Channel
Propagation	Two Ray Ground
Phy type	Wireless phy
Mac type	802_11
Queue type	Drop tail
Antenna type	Omni directional antenna
Traffic	CBR
Data rate	5Mb
Max packet in queue	50
Packet size	1000
Topology Range	500x500
Transmission Range	250m

The simulation parameters are meticulously chosen to ensure a thorough evaluation of the DOF-MEN algorithm across diverse network scenarios. The number of nodes directly impacts network density and topology, crucial factors affecting routing efficiency and scalability. By varying this parameter, we can assess the algorithm's performance across both small-scale and large-scale networks, gauging its scalability and robustness. Additionally, the chosen data rate influences network throughput and congestion, reflecting real-world traffic scenarios and enabling evaluation of the algorithm's handling of varying traffic loads. Introducing node mobility mirrors real-world dynamics, allowing assessment of the algorithm's adaptability to dynamic network conditions and its ability to maintain efficient routing paths amidst frequent topological changes [11-15].

A. Routing Overhead

For analysis, it is computed what percentage of messages are sent by routing agents. *Table 3* shows the Routing overhead values of DOF-MEN protocol over three radio propagation models. The total amount of routing packets which are used for route establishment is divided by the complete set of data and control packets that were delivered gives the metric routing overhead ratio. The network’s healthiness depends on the battery power ingestion, and the bandwidth utilization of the nodes. These two parameters are greatly affected by the parameter routing overhead. The control packets are used for data transmission, and network management. Both the transmitted and forwarded packets are included. The following *equation 5* represents the formula of calculation of the routing overhead.

Routing overhead = (Count of control packets routed /(Count of control packets routed + Data packets sent in number)) (5)

Table 3. Routing overhead values of DOF-men protocol over three radio propagation models

S.NO	Number of nodes	Routing Overhead comparison		
		Free Space	Two-ray	Shadowing
1	5	0.1854	0.1874	0.2121
2	10	0.186	0.1899	0.2168
3	15	0.1863	0.1905	0.2205
4	20	0.1902	0.2102	0.2291

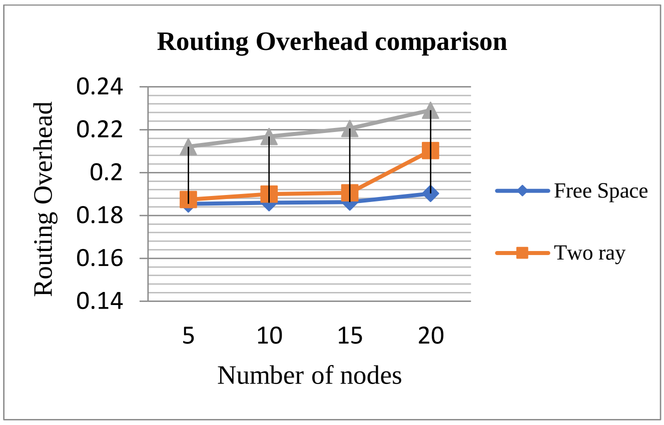

Figure 5. Routing Overhead comparison graph

Figure 5 shows that the Routing Overhead is high with shadowing model than other two models. The figure shows that the protocol DOFMEN has given reduced routing overhead over the free space propagation model. The free space propagation model is the simplest propagation model which reflects the line-of-sight pathway between transmitter, and receiver. The signal strength's decline is dependent on the distance amid transmitter, and receiver. So, the possibility of data loss is less in the free space model. Like that the two-ray model also considers mainly the distance amid transmitter, and receiver. Hence with two-ray model also the data loss is less. But the third model shadowing model considers the effect of fading, hence the received signal strength has been reduced. Some packet may be dropped due to lower received signal strength. It raises the amount of retransmissions. The retransmission raises the number of routing packets, control and management packets. Hence it increases the routing overhead. At the end of simulation, the free space model has the routing overhead of 0.1937 which is lower than two ray model by 7.84%, and then shadowing model by 15.45%.

B. Throughput

The total quantity of information that a sender sends to a recipient R is divided by the amount of time it takes R to obtain the most recent packet, is known as the throughput. Network throughput is a measurement of how well a communication message is delivered through a route of communication. The quantity of packets received successfully per unit time. The *equation 6* represents the formula to calculate throughput.

Throughput= (Number of bytes received*8) / (Simulation time * 1024) kbps (6)

Table 4. Throughput values of DOF-men protocol over three radio propagation models

S.no	Number of nodes	Throughput comparison		
		Free Space	Two ray	Shadowing
1	5	520.12	490	169
2	10	481.23	398.3	115
3	15	470	377	108
4	20	425	300	80.98

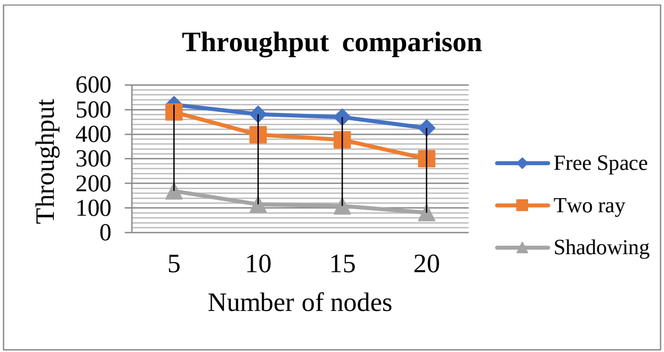

Figure 6. Throughput comparison

Figure 6 shows that the throughput is high with Free Space model than other two models. The figure displays that the protocol DOFMEN has given better throughput over the free space propagation model. The throughput in two-hop transmission is generally smaller quantity than the throughput of direct transmission. In Free space propagation model, the data transmission is taking place between two nodes through a line-of-sight path between them. But for Two ray model, and shadowing model more than one path is there. Hence the throughput value is reduced for two ray model, and shadowing model.

5. CONCLUSION

Here we analyzed the impact of Radio propagation model on the performance of the DOF-MEN protocol. Here we present comparative study of DOF-MEN protocol with radio propagation models (Free Space, Two-ray ground, Shadowing). The performance analysis was carried out for the simulated results by varying the number of nodes. Different performance parameters are used for this analysis such as Routing Overhead, Packet Delivery Ratio and Throughput. The DOF-MEN performance decreases from free space model to Shadowing model.

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