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Assessing the efficacy of various Propagation Models on the DYMO routing protocol in Mobile Ad hoc Networks

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Abstract:

Mobile Ad hoc Networks (MANETs) fall under wireless infrastructure-free networks with nodes communicating with each other. Due to node mobility, the routes are frequently changed, and it is necessary to find new routes, which is a challenging task. The packets are received and transmitted by the node with the help of routing protocols. The number of routing protocols was defined for MANETs to improve the QoS for ad hoc networks. Among them is the Dynamic MANET On-demand (DYMO) protocol. The AODV protocol was extended in version 2., which works better for large networks with high mobility. Numerous factors affect a protocol's accuracy and efficiency. Among them, propagation models play a significant role in these networks. The propagation model is responsible for determining the signal strength at the receiver. Significant degradation in performance is caused by variability in signal intensity at the receiver and the presence of barriers that obstruct transmissions. The selection of propagation models significantly impacts the efficiency of routing protocols in MANET. Using the EXata 5.4 simulator, we investigate the impact of different propagation models – Free space, two-ray ground, Rayleigh, fast_Rayleigh, and Ricean- on the performance of the DYMO routing protocol. Simulation results of different propagation models are analyzed using performance metrics such as Unicast Received Throughput, Average Unicast End-to-End Delay, Average Unicast Jitter, Energy consumed in Transmit mode, and Energy consumed in Receive mode. The findings indicated that propagation models significantly influence the performance of DYMO in the scenarios under consideration. The Two-Ray ground model outperforms other propagation models.

Keywords: MANETs, DYMO protocol, Propagation Models, QoS metrics, Exata 5.4

1. Introduction

A MANET is a multi-hop wireless network that can set itself up and has a structure that changes dynamically. It is a collection of mobile nodes that can join and leave the network due to the mobility of the nodes [1]. So, the number of average connected paths is affected by the nodes' mobility, which also affects the routing protocol's performance [2].

Routing is choosing the best path from the available paths for data packets to travel through the network to reach the destination. In a MANET, a node can operate as a transceiver, router, and forward data packets. There are three different types of routing protocols in MANETs. These protocols are Proactive, Reactive, and Hybrid routing. Reactive routing is also known as On-demand and dynamic routing. AODV, DYMO, and DSR are the reactive routing protocols [3]. So, the routing in MANETs is another challenging issue with node mobility.

Propagation models significantly impact the performance evaluation of MANETs by influencing signal strength, coverage, link quality, interference, noise, multipath fading, and the behaviour of routing protocols. The choice of a propagation model affects the accuracy of simulating wireless communication, impacting network connectivity, Throughput, and packet delivery. This work selects different models, such as Free Space, Two Ray Ground, Rayleigh, Fast Rayleigh, and Ricean, which offer varying levels of realism in representing signal propagation characteristics in diverse environments. The accuracy of the propagation model contributes to assessing the scalability, reliability, and overall performance of MANET protocols and algorithms under different network conditions, including mobility and dynamic channel variations.

The following are the work's significant contributions:

1. To assess MANET performance, authors examined at the DYMO reactive routing protocol and propagation models.
2. The performance evaluation measures Unicast Received Throughput, Average Unicast End-to-End Delay, Average Unicast Jitter, Energy consumption in Transmit mode, and Energy consumption in Receive mode for various propagation models.
3. Simulations are carried out on EXata version 5.4, and performance based on the mentioned metrics is analyzed.

The remaining sections of the paper are structured as follows: Section 2 provides a literature review of related work; Section 3 delineates the materials employed in the study; Section 4 outlines the research methodology; Section 5 outlines the process of experimentation and simulation; Section 6 analyses performance and results; and Section 7 concludes the work and discusses future directions.

2. Literature review of related work

The performance analysis of routing protocols in MANETs has been the subject of numerous studies in the past. Authors in [1-3] have compared various routing protocols, node mobilities, Node deployments and terrain sizes with different simulation scenarios.

Hota, L. et al. compare existing routing protocols and propagation models for reliable packet dissemination in vehicular ad hoc networks. Two-way ground and FRIIS transmission models do better in simulations than compared models. The OLSR routing protocol also does better than AODV and DSDV [5].

Zakaria, Y. et al. analyze and compare various propagation models for radio signal prediction in urban, suburban, and rural environments. The Egli model shows rural areas' highest path loss values [6].

Mollel et al. address propagation models used in network planning and optimization, focusing on empirical models. Field measurements in Dar es Salaam revealed inconsistencies with empirical models for all-terrain areas, highlighting the importance of accurate signal predictions [7].

Rani et al. survey various outdoor and indoor propagation models in wireless communication, analyzing path loss caused by obstacles and varying results in urban, suburban, and rural areas [8].

Naseem et al. provide an overview of propagation models in wireless communication systems, addressing issues like fading, path loss, shadowing, Doppler spread, and cochannel interference [9].

The study conducted by Hussain et al. investigates the influence of mobility and propagation models on the performance of OLSR routing in dense and sparse MANET scenarios. The study found that propagation models and mobility significantly influence OLSR performance in these scenarios [10].

3. Materials

3.1 DYMO Routing Protocol

One of the on-demand routing protocols is DYMO. RREQ, RREP, and RERR are all implemented by DYMO. The source node utilises RREQ to find plausible paths to the destination node. The source node utilises RREQ to find potential routes to the destination. RREP establishes a route between destination, source, and intermediate nodes. RERR indicated a bad path from any intermediate node to the destination. DYMO focuses on route finding and maintenance. During route discovery, the source node notifies its intermediate neighbor node of an RREQ if it does not have a route entry to the destination node. If the neighboring node has an entry destination, RREP is sent. An RREQ message is sent otherwise. Intermediary nodes add their addresses to RREQ messages during transmission. Each intermediary node that sends RREQ specifies the accumulating or retrograde path. RERR was used for route maintenance. Link failures create RERR messages. Only connection failure nodes receive the RERR message when a node multicast is produced. Route discovery needs to be redone if any nodes have a packet to the same destination following the deletion of a route record [1][2].

3.2 Propagation Models

3.2.1 Two Ray

The Two-Ray Ground Reflected model of radio propagation predicts route losses when a transmitting and receiving antenna are in line of sight (LOS). Usually, there is a height difference between the two antennae. One ground-reflected wave makes up the majority of the two components of the received signal: the LOS and multipath components. The propagation model works well in outdoor settings where there is a chance of ground reflection of signals [4].

3.2.2 Free space propagation model

The free space propagation model predicts the strength of the received signal when there is a clear, direct line of sight between the transmitter and the receiver. This model is commonly experienced via microwave line-of-sight radio links and satellite communication systems. The propagation model works well in open, outdoor settings with little interference when there are no obstructions or reflections [4].

3.2.3 Rayleigh Fading

The Rayleigh distribution is often employed in mobile radio channels to characterise the statistically time-varying characteristics of the envelope of a single multipath component or the received envelope of a flat fading signal. The envelope of a sum of two quadrature Gaussian noise signals is known to follow a Rayleigh distribution. Many tiny, random scatterers are assumed to exist in the environment by the model. Constructive and destructive interference cause the resulting signal to fade. It works well in crowded indoor and urban areas [4].

3.2.4 Ricean Fading

The direct path is typically the strongest component that fades deeper than the multipath components when it is line-of-sight. The Rician distribution approximates this type of signal. Both situations with a strong line-of-sight signal and scattered signals are appropriate for this concept. It is frequently utilised in situations when there is a clear line of sight, like outside [4].

3.2.5 Fast **Rayleigh** Fading

Movement of the transmitter or receiver and surface reflections are the main causes of Fast Rayleigh Fading. High Doppler spread with a Doppler bandwidth equal to or larger than the signal bandwidth is seen in the fast fading when the channel fluctuations are as fast as or faster than the signal changes. This paradigm works well in situations where wireless channels change quickly, including high-mobility settings [4].

4. Research Methodology

Three methods make up the research methodology in the field of wireless networks: theoretical data analysis, experimentation, and simulations. If the research aims to explain the problems in a meaningful context, a descriptive theoretical analysis approach will be used, which may not be suitable with many hypotheses and assumptions. The method of experiments will be used to set up genuine processes; certain guidelines and procedures will be followed, but it is costly and difficult to set up. The simulation process will be employed when it is cost-effective to check the actual system performance in various ways using different parameters. Simulations are realism replicas that allow you to explore the model by arranging and configuring the algorithm properties. As a result, the simulation is carried out to conduct the experiment.

5. Experimentation and Simulation Process

Simulation Process:

This simulation study compares the performance of the different propagation models, such as Free Space, Two Ray Ground, Rayleigh, Fast_Rayleigh, and Ricean, on the DYMO routing protocol with mobile nodes arranged in a Random waypoint mobility model. The simulations were run on EXata version 5.4, considering the mobility speed, simulation time, and constant pause time. Table 1 shows the simulation parameters used in the evaluation.

Table 1. Parameter setting for the Simulation process

Parameter	Value
Routing Protocol	DYMO
Propagation Model	Free Space, Two Ray Ground, Rayleigh,

	Fast_Rayleigh, Ricean
Packet size	512Kb
Network size	40
Mobility Speed	10 mts/sec
Pause Time	0 sec.
Rate of data	11 Mbps
Node Deployment	Random
Traffic agent	UDP
Application Traffic	CBR
Antenna Type	Omni directional
Simulation Time	300 sec.
Terrain size	1000 x 1000 sq.mts
Mobility Model	Random waypoint

6. Performance Evaluation Results and Analysis:

The following metrics are considered to evaluate the performance of the routing protocol.

6.1 Unicast Received Throughput (bits/second)

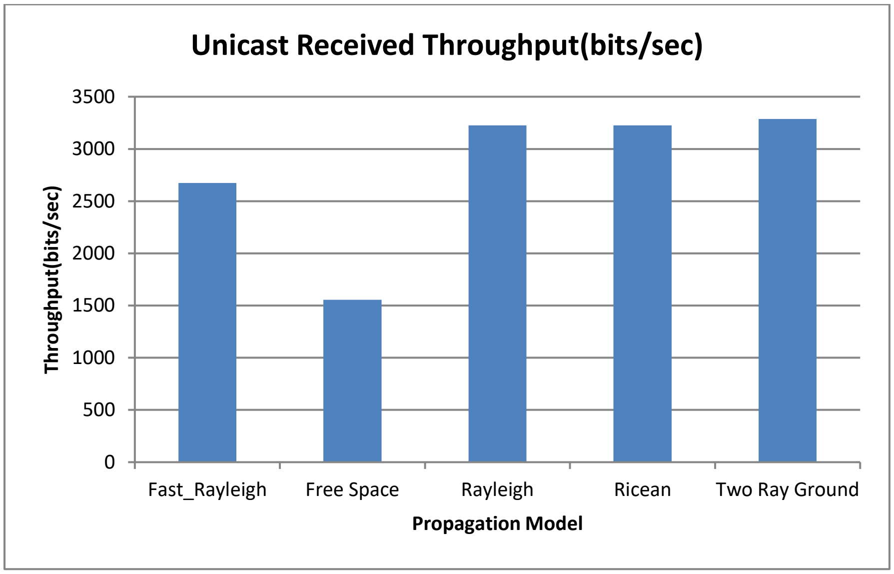

Fig 1. Unicast Received Throughput of different propagation models

Figure 1 depicts the Unicast Received Throughput of several propagation models on DYMO protocol. We discovered that throughput is greater in Rayleigh, Ricean, and Two Ray ground propagation models because these models are appropriate for urban, transparent line-of-sight conditions.

6.2 Average Unicast End-to-End Delay (seconds)

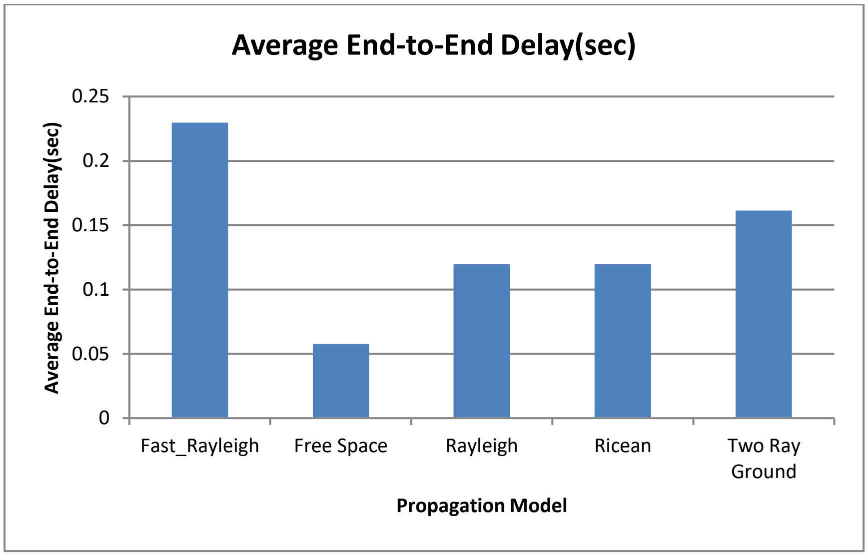

Fig 2. Average Unicast End-to-End Delay of Different Propagation Models

Fig. 2 shows the Average Unicast End-to-End Delay of different propagation models on the DYMO protocol. The simulation results showed that the average Unicast End-to-End Delay is higher in Fast_Rayleigh and minimum in the Free Space propagation model.

6.3 Average Unicast Jitter (seconds)

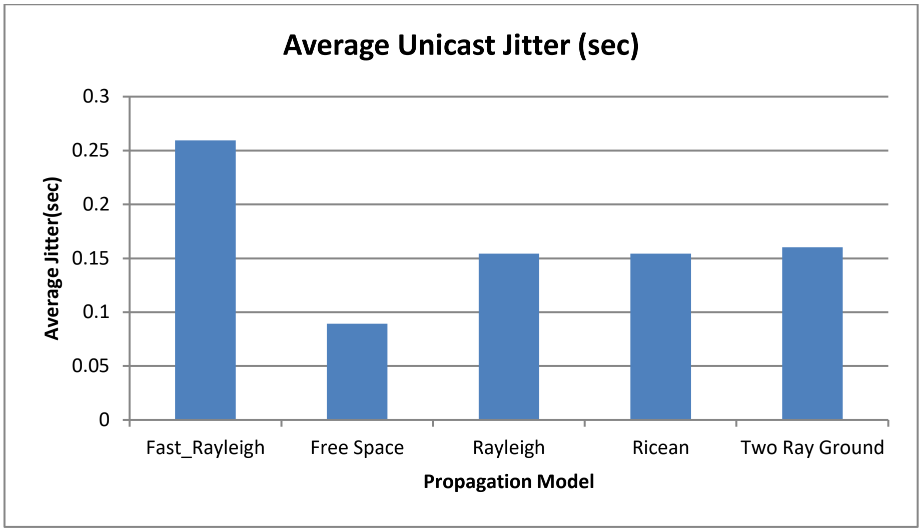

Fig 3. Average Unicast Jitter of different propagation models

Fig. 3 shows the Average Unicast Jitter of different propagation models on the DYMO protocol. The simulation results depict that the average Unicast Jitter is higher in Fast_Rayleigh and minimum in the Free Space propagation model.

6.4 Energy consumed in Transmit mode

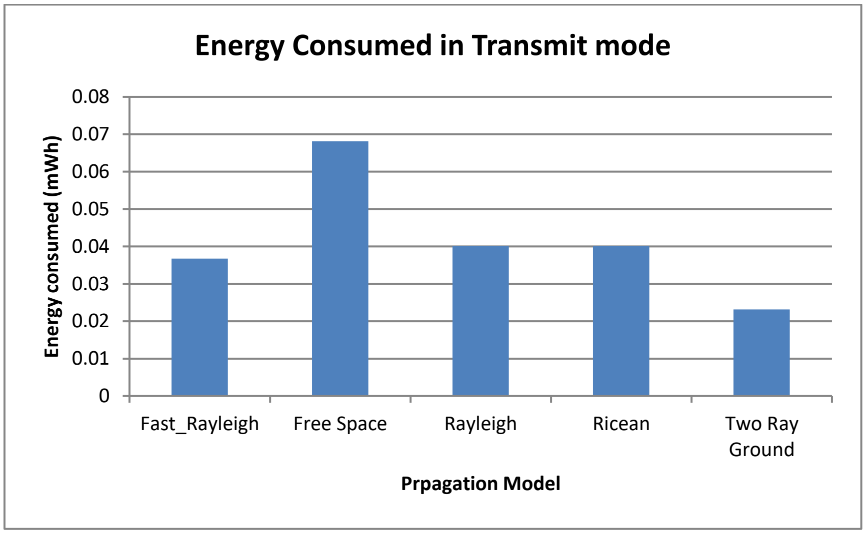

Fig 4. Energy consumed in the transmit mode of different propagation models

Fig. 4 shows the Energy consumed in the transmit mode of different propagation models on the DYMO protocol. From the simulation results, we observed that Energy consumed is higher in the Free space model and minimum in the Two-Ray ground propagation model.

6.5 Energy consumed in Receive mode

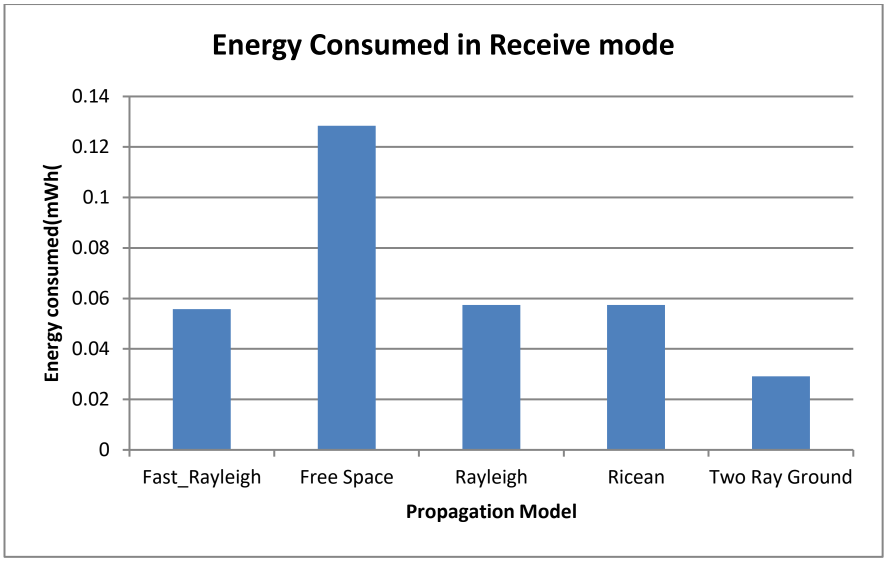

Fig 5. Energy consumed in the Receive mode of different propagation models

Fig. 5 shows the Energy consumed in the receive mode of other propagation models on the DYMO protocol. From the simulation results, we observed that Energy consumed is higher in the Free space model and minimum in the Two-Ray ground propagation model.

7. Conclusions

The propagation models are important to understand the behaviour of wireless signals in different environments. Selecting the best propagation model suitable to the environment and routing protocol enhances the network performance. So, in this research, an effort has been made to analyze the performance of different propagation models such as Free Space, Two Ray Ground, Rayleigh, Fast_Rayleigh, and Ricean on the DYMO protocol and to select the best propagation model for the network configuration. The simulation results reveal that the Two-Ray ground model performs better and is suitable for the network environment to continue further research. Future research can be carried out on different routing protocols with various mobility models, pause times, simulation times, and network environments.

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