Simulation based Analysis of AODV Routing Protocol in Ad Hoc Network under different Mobility and Propagation Loss Models using NS-3

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ABSTRACT
Mobile ad hoc network is an infrastructure-less network, that consist of mobile nodes, with the ability to communicate with each other without any centralized unit. The main features of MANETs are, wireless medium, dynamic topology, distributed cooperation, vulnerable to many security attacks and data loss because of the mobility of nodes.

Many routing protocols have been developed for MANET, but ad hoc on Demand Distance Vector (AODV) routing protocol is preferred as the best routing protocol for MANET, because it minimizes the routing overhead more than the other protocols and hence improves the performance of the network. In this article, we have analyzed and evaluated the performance of Nakagami propagation loss model and Friis propagation loss model under different mobility scenario at different speeds to measure the performance parameter such as Packet Delivery Ratio (PDR), Throughput and Packet loss, the routing protocol used in are research is AODV. [1][2].

Keywords
AODV, MANET, NS3, Friis Propagation Loss Model, Nakagami Propagation Loss Model, RWP, Constant Position Mobility Model.

1. INTRODUCTION
Mobile Adhoc Network consist of mobile nodes which communicate to each other through wireless links. The mobile nodes that are in radio range to each other can directly communicate, whereas the other node needs some intermediate nodes to route their packets to a particular designation [15]. These types of networks and can communicatewithout the helpof any fixed infrastructure such as access points or base stations. For this purpose MANET is very useful because of its important characteristics such asunique operation, Multi hop routing, dynamic topology, Shared Physical medium. MANET can face many problems, such as security attacks and data loss because of mobility of nodes, which causes the network topology to change very frequently and as a result the data loss may be very high.

In this article we have compared two prominent propagation loss models with AODV routing protocol in two different mobility schemes with various node speed i.e. in static environment and dynamic environment by using constant position mobility and random way point (RWP) mobility model.

2. MOTIVATION
During the review of our research in MANET for past few years we came across few important areas such as routing, propagation loss models, mobility models, and performance of routing protocols at different nodes speed etc. Among which routing and mobility models has been widely used by the researchers. In our paper we have focused on the two different propagation loss models, which are Nakagami and Friis propagation loss models. We compared the propagation loss models for different parameters.

3. ROUTING PROTOCOLS IN MANET
Routing is basically the process of transmitting data or packets from source node to the Destination node. In Ad-Hoc network the topology changes very frequently in this manner making packet routing is very challenging. Routing protocol controls the stream of information in systems and furthermore chooses the efficient way to achieve the goal. [18] Routing protocols can be categorized on various bases such as on the topology of network for routing that is proactive and reactive routing protocols, on the basis of communication strategy used for transmitting the information from source to destination that is unicast, broadcast and multicast routing. [8]

3.1 AODV Routing Protocol
AODV [19] is an on demand routing protocol which is basically designed for use in MANET, it is intended for networks that contains large number of nodes. The source, destination and next hop nodes are addressed by using IP addressing, and each nodes in the network maintains a routing table that consists the information about neighboring nodes. AODV has both on demand and table driven routing protocol features, AODV supports multicasting as well as unicasting within a uniform framework. Each route has a lifetime after which the route expires if it is not used. [9]

4. NAKAGAMI PROPAGATION LOSS MODEL
This radio propagation loss model is based on mathematical general modeling of a radio channel with fading. In comparison to the existing propagation loss models such as shadowing and two ray ground, Nakagami propagation loss model has more justified parameters which allow a closer representation to a realistic ideology of the wireless communication channel. [20][3]

5. FRIIS PROPAGATION LOSS MODEL
Friis propagation loss model was basically described by Harald T. Friis. This was initially used for the modeling the Line-of-sight (LOS) path loss incurred in a particular channel. The mathematical formula is established and based on the inverse square of the distance which states that the received power (*Pr*) decays by a factor of square of the distance (*d*) from the transmitter.

$$\mathbf{P_r \propto \frac{1}{d^2}}$$

Receiver power is obtained by the following equation.

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

Where Pr(d) is equals to Received signal power in Watts expressed as a function of separation –d meters between the transmitter and receiver.

Pt is equals to Power at which the signal was transmitted in Watts.

Gt and Gr are equals to the Gains of transmitter & receiver antennas when compared to an isotropic radiating antenna with unit gain of λ.

Where λ is equal to the wavelength of carrier in meters. Lis equals to all the other Losses that are not associated with propagation loss. This includesthe other losses like loss at the antenna, transmission line attenuation, loss at various filters etc. The factor is usually greater than or equal to 1.

λ is calculated by $\frac{c}{f}$, where C = 299792458 m/s considered as the speed of light in vacuum, and **f**is the frequency in Hz. [4]

6. MOBILITY MODELS

Mobility models are used describe the movement pattern of mobile nodes in an ad hoc network.As the location, velocity and acceleration change over time with the change in movement of the nodes. Since mobility patterns play a vital role in determining the protocol performance, it is important for mobility models to simulate the movement pattern of targeted network in a reasonable way. Otherwise, the observations made and the conclusions drawn from the simulation result may be not justified. Thus, when evaluation of protocols is done, it is necessary to choose a proper and justified mobility model. [10]

6.1 Random Way Point Mobility Model

Random Waypoint Mobility (RWP) [13] Model includes pause times between changes in direction and/or speed. Mobile Nodes (MN) starts to move in one location for some period of time (i.e., a pause time), once this time expires, the MN picks another destination randomly in the simulation area and a speed that is uniformly distributed between (min. speed / max. speed). The MN then travels toward the newly chosen destination at the selected speed. Upon arrival, the MN stops for a specific time period before starting the process again. [15]

6.2 Constant Position Mobility Model

NS-3 [11] has considered constant position mobility model [12] for static network where the movement of nodes are not allowed. This is mobility model is particularly designed by the ns-3 developers for no movement networks, i.e. mobility is not allowed.

7. PARAMETERS FOR SIMULATION SETUP

Table 1

Parameters	Values
No. of Nodes	25
Simulation Time	100,200,300,400,500 seconds
Routing Protocol	AODV
Mobility Models	Constant Position & Random Way Point
Distance Between Two Nodes	500 Meters
Propagation Loss Models	Nakagami & Friis
Data Rate	1 Mbps
Simulation Tools	1. NS 3.26 2. GNU Plot (for graphs)
Nodes Placement	Fixed & Dynamic
Mobility speed(max) for Random Way Point	5m/s,10m/s,20m/s
Mobility speed (min) for Random Way Point	1m/s,5m/s,10m/s

8. PERFORMANCE MATRICES

According to the simulation parameters, the considered protocols AODV have been compared on the basis of their performance in Packet Loss, Throughput and packet delivery ratio.

8.1 Throughput

Throughput is defined as the successful delivery of numbers of bits that can be transmitted from a source node to the destination node.

8.2 Packet Delivery Ratio

Packet delivery ratio is defined as the ratio of successful packets received by the destination node to the data packet generated by the source node. It can also be defined by formula:

$$\mathbf{PDR = \frac{SuccessfuldataPacketReceives}{TotalDataPacketSend}}$$

8.3 Packet Loss

Packet loss refers to the amount of data (number of packets) that fails to arrive at its intended destination. Network administrators consider this metric when looking at the efficacy and performance of data systems.

9. SIMULATION SETUP

Our simulation starts with 25 nodes placed in constant position mobility and random waypoint mobility at a distance of 500 meters between the nodes in the simulation area. Once our simulation runs we have checked the performance of the propagation loss model for both constant mobility and random way point mobility. For the comparison we have analyzed Nakagami & Friis propagation loss model with AODV as the main routing protocol. We have used NS-3.26 simulator to simulate the results.

10. RESULTS

On comparing Nakagami and Friis Propagation Loss Models for Random Way Point Mobility at various speeds the simulation results are as follows:

10.1 Packet Loss

In the graphs below we have considered random way point mobility model with different speeds, 1m/s (min) and 5m/s (max) in fig 1, 5m/s (min) and 10m/s (max) in fig 2, and 10m/s (min) and 20m/s (max) in fig 3. We have compared the Performance of Nakagami and Friis propagation loss model for AODV to measure packet loss for all the three considered speeds. The graph is between simulation time and packet loss. From the graphs it is clear that the packet loss is more in Friis as compared to Nakagami.

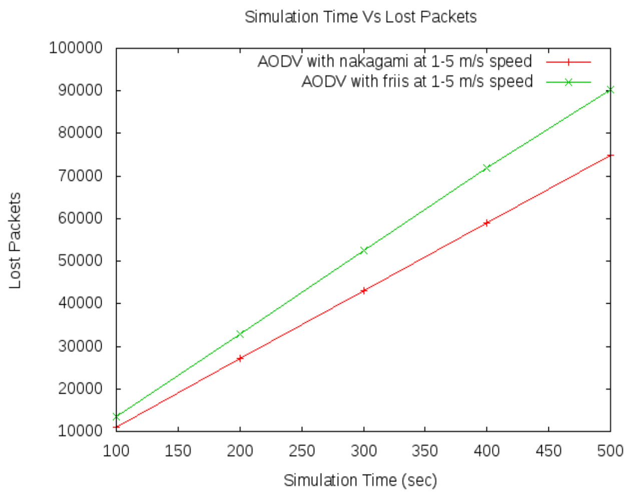

Fig: 1 Packet loss Vs Simulation time (speed 1-5 m/sec)

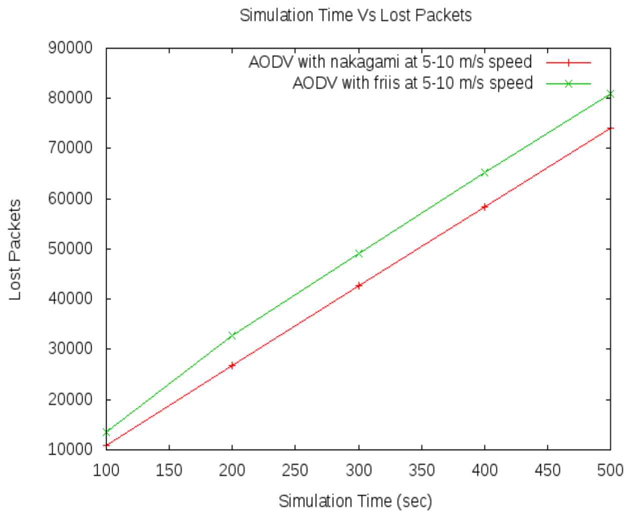

Fig: 2 Packet loss Vs Simulation time (speed is 5-10 m/sec)

10.2 Packet Delivery Ratio

In the graphs below we have considered random way point mobility model with different speeds, 1m/s (min) and 5m/s (max) in fig 4, 5m/s (min) and 10m/s (max) in fig 5, and 10m/s (min) and 20m/s (max) in fig 6.

We have compared the Performance of Nakagami and Friis propagation loss model for AODV to measure Packet delivery ratio for all the three considered speeds.The graph is between simulation time and packet delivery ratio. From the graphs it is clear that the PDR is less in Friis than in Nakagami.

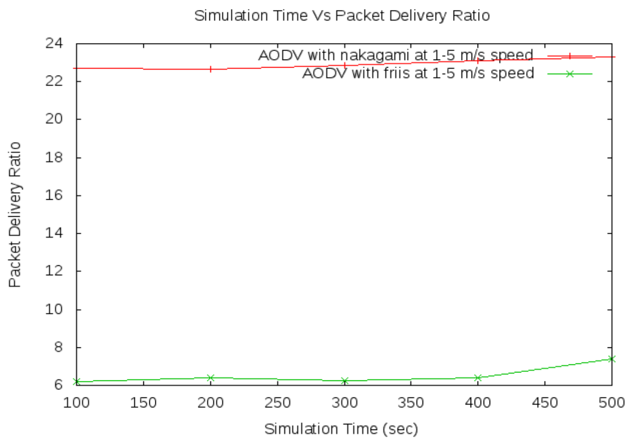

Fig: 4 PDR Vs Simulation Time (speed is 1-5 m/sec)

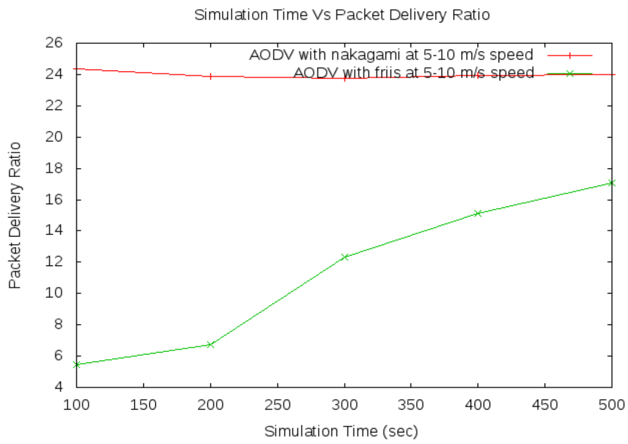

Fig: 5 PDR Vs Simulation time (speed is 5-10 m/sec)

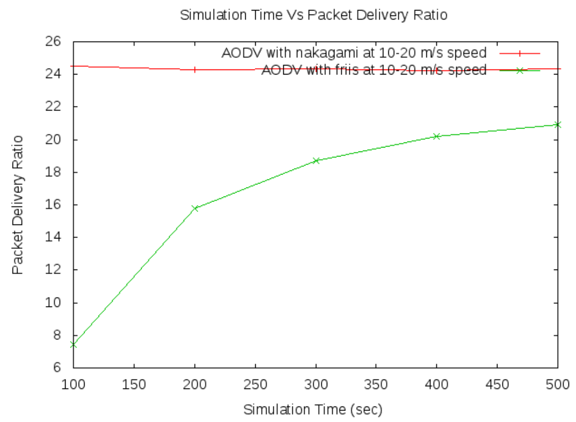

Fig: 6 PDR Vs Simulation time (speed 10-20 m/sec)

10.3 Throughput

In the graphs below we have considered random way point mobility model with different speeds, 1m/s (min) and 5m/s (max) in fig 7, 5m/s (min) and 10m/s (max) in fig 8, and 10m/s (min) and 20m/s (max) in fig 9. We have compared the Performance of Nakagami and Friis propagation loss model for AODV to measure Throughput for all the three considered speeds.The graph is between simulation time and Throughput. From the graphs it is clear that the Throughput is less in Friis and more in Nakagami.

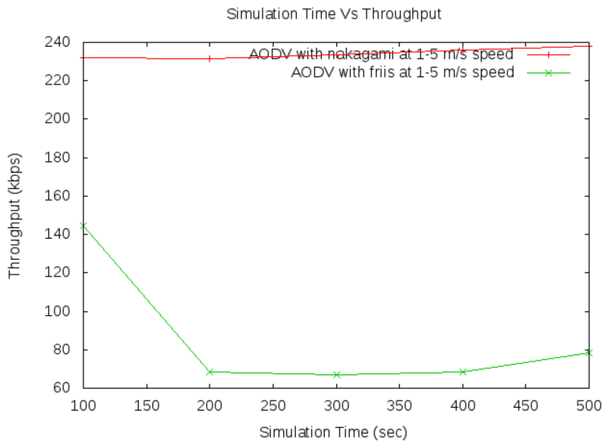

Fig: 7 Throughput Vs simulation time (speed 1-5 m/sec)

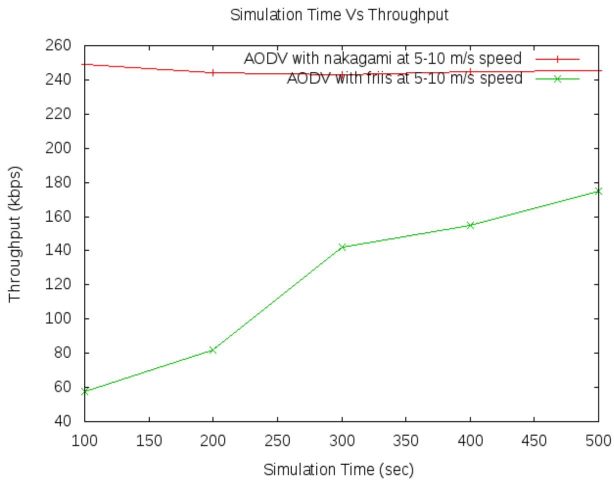

Fig: 8 Throughput Vs Simulation time (speed 5-10 m/sec)

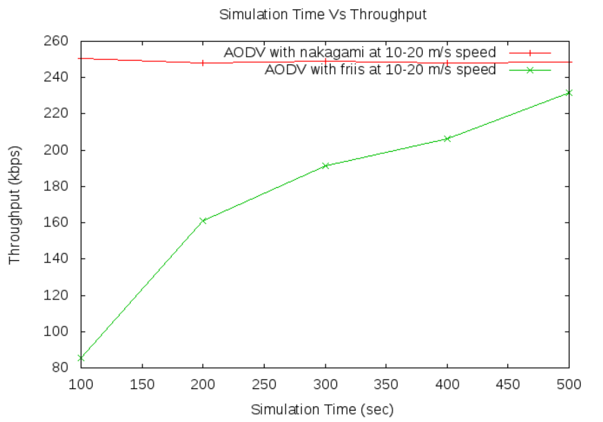

Fig: 9 Throughput Vs Simulation time (speed 10-20 m/sec)

11. FOR CONSTANT POSITION MOBILITY

In the graphs below we have considered constant position mobility model. We have compared the Performance of Nakagami and Friis propagation loss model for AODV to measure Packet loss, PDR, and Throughput respectively in fig 10,fig 11 and fig 12 .In fig 10 The graph is between simulation time and Packet Loss, in fig 11 the graph is between PDR and simulation time, in fig 12 the graph is between Throughput and simulation time.

From the fig 10 it is clear that packet loss is more in Friis than in Nakagami while nakagami has considerably less lost packets.From the fig 11 it is clear that the PDR is more in Nakagami and less in Friis. In fig 12 the Throughput is also greater in Nakagami than in Friis.

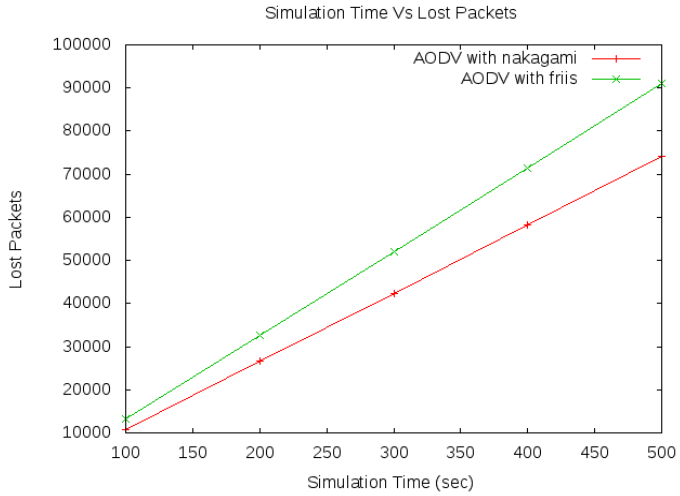

Fig:10 Packet Loss Vs Simulation time

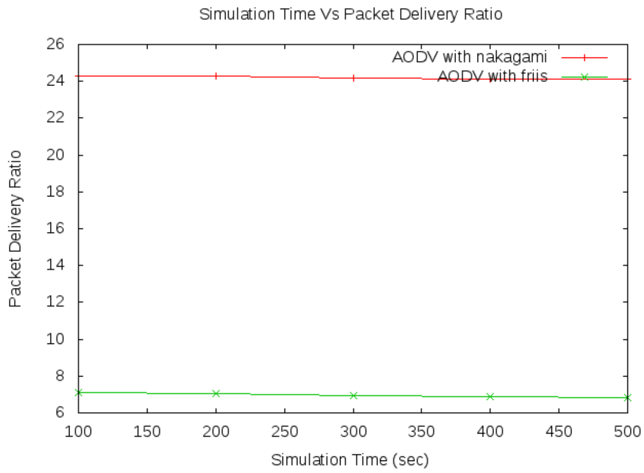

Fig: 11 PDR Vs Simulation time

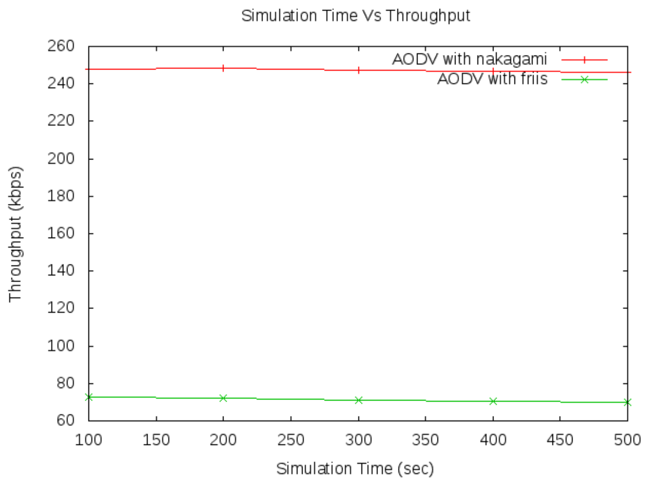

Fig: 12 Throughput Vs Simulation time

12. CONCLUSION

During our Simulation we compared the performance of AODV routing protocol with two Prominent Propagation Loss Models that are Friis and Nakagami on various performance matrices. From the results of the simulation we observed that the Nakagami propagation loss model performance was better than the Friis propagation loss model in both the mobility model and various node speed for the AODV routing protocol.

This article analyzes the performance of Propagation Loss models under different mobility scenario using ns-3. Comparison of Nakagami Propagation Loss model and Friis Propagation Loss model is done for better performance for the performance Parameters that are Packet Loss, Packet Delivery Ratio, and Throughput.

So after analyzing all the values we can conclude that the Nakagami propagation loss model outperforms the Friis propagation loss model in all the mobility scenarios, various node speeds.

MANET is widely growing field of research nowadays, therefore extensive research is also going on by many researchers in this filed. Form our research we would like to propose that still good and important research can be focused on the propagation loss and delay models, to make the routing protocols more efficient in the field of MANET.

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