Evaluation of Non-fading Propagation Models Over A Reactive Based Routing Protocol In Ad Hoc Networks

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ABSTRACT: *Ad hoc networks are characterized by multi-hop* wireless networks with frequently changing network topology *and lacks predefined infrastructure. The mobile nodes are wireless and following some predefined mobility pattern and using some propagation model and are efficiently connected to form an autonomous system. However, the network is dynamic in nature thus there is no restriction on the nodes and have complete freedom to join or leave the network. In this network, any change in network should be completely migrated across the network in quick time. In this research paper, the performance of two prominent non-fading propagation models – Two Ray Ground and Freespace propagation models are compared under on-demand routing protocols for mobile ad hoc networks—Ad Hoc On-Demand Distance Vector Routing (AODV). The performance of AODV is tested under Random Waypoint Model (RWP) and Random Direction (RD) Model using Network Simulator-2 (NS-2). We demonstrated that even though Two Ray Ground and Freespace propagation models share few similar behaviors, but the differences in the propagation mechanics can lead to significant performance differentials. The performance differentials are evaluated and analyzed using varying network size, topological area, transmission range, network load, mobility and pause time. Based on the observations, the conclusion and recommendations are given about how the performance of both propagation models and protocol can be improved.*

Keywords: Ad Hoc On-demand Distance Vector Routing (AODV), Random Waypoint (RWP), Two Ray Ground, Freespace

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1. Introduction

Recently mobile ad hoc networks (MANETs) have established great attention because of their self-pattern and maintenance capabilities. At the same time early research effort assumed a open and helpful environment and paying attention on different problems like multihop routing as well as wireless channel access, security has become a major objective to supply protected communication between nodes in a possible aggressive situation [1].

Mobile Ad-Hoc Network (MANET) is the combination of different wireless nodes and distributed during the network. In

MANET every single node uses the multi hops relations lacking infrastructure or centralized administration. Today a wide variety of routing protocols focused specifically at this situation have been developed and some functioning simulations are prepared. Depend on the prerequisite, different nodes in wireless network can modify its method energetically and randomly set up routes between supplier and destination. The key mission of wireless routing protocol is to look the challenges of the dynamically varying topology and set up capable way between two nodes with least routing overhead and bandwidth utilization [2].

The topology in network can modify quickly when nodes shift in a wireless situation. So, it is likely that packets have to be sent through different routes every time. Ad hoc routing protocols are used to determine paths between supplier and destination nodes. They fit in three groups, proactive, reactive and hybrid [3].Within proactive routing protocols nodes keep routing information to all the other node of the network that is stored in routing tables, which are sometimes modernized when topology alters [4].

2. Overview of Routing Protocols

Many MANET routing protocols were than developed to offer more and better routing. Protocols in MANETs are use for deciding on the best (multi-hop) routes to forward data across from supplier to destination [5].

In topology based method; the connected routing protocols can be generally classified into three groups periodic (also called proactive protocol or table driven), reactive (also called on-demand) and hybrid protocols. The periodic, try to keep the knowledge of all the current routes to all the other nodes by periodically swapping routing information, apart from whether the paths are being used for moving packets. Examples of these protocols contain Destination Sequenced Distance Vector (DSDV), Fisheye Stateless Routing (FSR), Cluster Gateway Switching Routing (CGSR) as well as Wireless Routing Protocol (WRP). Reactive protocols, in distinction to the above, make paths only when important for carrying traffic. Example of these protocols includes Ad Hoc On-Demand Distance Vector Routing Protocol (AODV), Dynamic Source Routing (DSR), Temporally-Ordered Routing Algorithm (TORA) as well as Associativity-Based Routing (ABR). The hybrid approach merges the properties of both periodic and reactive routing protocols. Example of these protocols can be ZRP [6].

3. Types Of Propagation Models

The propagation models are usually described as: fading models and non-fading models.

3.1 Fading Models

Fading propagation models account for the truth that a radio wave has to wrap a little area when the gap to the sender is decreasing. Examples can be Rician and Shadowing and Rayleigh. In Small scale models the signal power is computed which depends upon on slight movements. However, in case of radio waves multipath propagation, a slight movement of the receiver can cause a huge change in the received signal strength at the receiver end.

3.2 Non-fading Models

Non-fading propagation models are propagation models which account for the radio wave covering increasing area when the distance between sender and receiver is increasing. The non-fading models includes free-space and two ray ground [7][8]. Also there is another factor that should be taken in account is computation of signal power which mainly depends on node's traveling. The signal attenuation is also the issue due to diverse objects (or large scale fading) and changes in visibility due to multipath fading (or small scale fading). Large scale fading is takes in account when there is a large gap between transmitter and receiver, on the other hand, in case of small scale fading, the receiver receives signal through multiple paths and also experiences fluctuation in signal strength usually over small distance [7].

3.3 Freespace Propagation Model

The Free space propagation model is such type of path loss model in which there is no signal interruption or route loss model in which there is an uninterrupted route signal between the sender and the receiver, and also there is no environmental fading factors such as atmospheric attenuation or problem of multipath component [9]. In the sender power called as Pt and the received power is called as *Pr* is given by:

$$Pr = Pt\, Gt\, Gr\, (\lambda / 4\Pi d)2$$

In the above equation Gr and Gt are sender and receiver antenna gains, where as d denotes the distance between the sender and receiver, and the wavelength is calculated by $\lambda = c/f$. i.e the signal [6]. According to the single direct route between the communicating colleagues rarely exists at longer distances [10] [11].

3.4 Two Ray Ground Propagation Model

The Two Ray Ground Model assumes that the radio signal comes or reaches the receiver through more than one route i.e. by two routes, one route is light of sight path and the other the route is through reflected or refraction wave. According to the two ray ground model, the received signal power is measured mathematically by

$$Pr = \frac{Pt \,.\, Gt \,.\, Gr \,.\, (ht\, hr)^2}{d2}$$

In the above equation Pt denotes the broadcasted power, *Gr* and *Gt* shows antenna gain at the sender and the receiver respectively, d shows the gap between the sender and the receiver, and ht and hr are the heights of the sender and the receiver, respectively [11].

4. Introduction to Mobility Models

The following entity based mobility models are described under:

4.1 Random Waypoint Model (RWP)

The Random Waypoint Mobility Model introduces pause times and causes mobile nodes (MNs) to change direction and/or speed. An MN starts by choosing random destination and moves towards it, when reaches it stays for a certain period of time called as pause time. On expiration of this time, the MN chooses another randomly choosen destination in the simulation area and also selects a speed which is uniformly distributed between [minspeed, maxspeed]. The MN then starts travelling towards the newly chosen destination upon that selected speed. Again on arrival, the MN stays or pauses for a certain predetermined time period before it starting the process again.

In RWP, there is a strong and depend relationship between node speed and pause time in using Random Waypoint Mobility Model. For example, a scenario in which the MNs maintains a moderate or slow speed and experiences long pause times that produces a more consistent or stable network and a scenario with fast MNs speed and shorter pause times [12].

4.2 Random Direction Model (RD)

The Random Direction Mobility Model (Royer et al, 2001)[13] actually created to overcome node's density or concentration than average number of neighbors produced by the Random Waypoint Mobility Model. A density means high concentration of nodes in single part of the simulation area. However, in the case of the Random Waypoint Mobility Model, such type of clustering usually occurs near or close to the center of the simulation area. In the Random Waypoint Mobility Model, choosing of new destination by MNs is usually high near to the center of the simulation area or high probability or percentage of MNs choosing a new destination that is mostly located near to the center of the simulation area. Thus, the MNs behaves to appear converge, disperse, and converge again during the simulation time. In order to ease such type of behavior experience by Random Waypoint Model a model in which distribution of MNs in semi-constant arrangement fashion throughout the simulation area, so the Random Direction Mobility Model was introduced [13]. In this model, MNs randomly choose a random direction within the simulation area and travels towards it in similar fashion to the Random Walk Mobility Model. During the simulation time a MN travels towards the border of the simulation area in that direction. Once the MN reaches the simulation boundary, the MN pauses for a specified time and chooses another angular direction (between 0 and 180 degrees) and again continues the process [12].

5. Related Work

Propagation model is a group of mathematical expressions, algorithms and diagrams used to show the radio characteristics of a known environment [14]. Propagation model are three types empirical representation, deterministic model, semi deterministic model, Empirical models are depend on measurement data, easily, use statistical properties, and not very correct always. Semi-deterministic models depend upon empirical models and deterministic aspects. The Deterministic models are site-specific, and need huge number of geometry data about the cite, very vital computational exertion, exact. Path loss can be defined as the ratio of the power of the broadcasted signal to the energy of the same signal received by the receiver, on a certain path. It is a function of the propagation gap. The assessment of route loss is very necessary for planning and organizing wireless transmission networks. The loss of the path or route is based on a number of issues like the radio frequency used and the nature of the terrain [6].

Rhattoy and Zatni (2012) [15] illustrated and displayed the simulation findings of the effect of many radio propagation models on the implementation and performance of ad hoc networks. To completely understand how these different radio models effect the networks performance, the performances of different routing protocols AODV, DSR and DSDV for each propagation model has been compared and in addition the comparison of energy performance based routing protocols and propagation models were illustrated. The consequences focused on the notion of nodes' pace and the number of connections by utilizing the Network Simulator (NS-2).Fading models like Rayleigh, Ricean, Shadowing and Nakagami has been used in the current research work. The simulation results have revealed that several propagation models have a considerable influence on the functi oning of the ad hoc mobile network. The latter decreases fastly when the fading models, specially Ricean, Rayleigh, Shadowing and Nakagami are taken into consideration. The basic reasons of their deterioration are the result of the big change in the received intensity signal. According to the results to the routing protocols' performance, we find out that there is no favorable protocol among the others all scenarios and the assessing condition.

Tamilarasan and Sivaram (2012)[2] described the comparative study as well as performance analysis of three mobile ad hoc routing protocols AODV, DSR, and TORA with the help of Two Ray Ground Propagation Model underneath the different parameters i.e. packet delivery ratio, end-to-end delay, path optimality, media access delay, routing overhead performance metrics. AODV has the good performance in every round of metrics. DSR is good for networks with reasonable mobility rate. It has small overhead that makes it appropriate for small bandwidth and small power networks. TORA is best for operation in larger mobile networks. This networks having crowded population of nodes. The main benefit is its brilliant support for different routes and multicasting.

Debnath et al (2011)[16] examined the non-fading and fading propagation models in ad hoc network. The propagation models that are used in the research work are free-space; two ray ground as well as shadowing models. The research explained that the shadowing effects need to be considered in order to emulate a real world condition. It is shown with the help of simulation that the shadowing effects have graved influence on the functioning of an ad hoc network. It also contributed to the detail investigation of the shadowing effects on the routing protocol as well as the Medium Access Control (MAC) layer scheme. The results of the simulation showed that the effects of shadowing can be reduced by using proposed solutions concerning to the presented results.

Jain and Shrivastava (2011)[17] presented the study on the activities of different routing protocols with route loss propagation models, different performance metrics are used for this comparison such as average jitter, packet delivery fraction, throughput as well as average end to end delay. The studies would be useful in choosing the right protocol for any in action operating environment. Comparative analysis was carried out for the simulated consequences by varying the Pause time underneath AODV and DSR protocols with the help of Random Waypoint Mobility Model. This study results into the conclusion that the overall performance of DSR is good in both of the propagation models, and AODV perform better in average end-to-end delay in Two Ray Ground model.

6. Simulation Environment

In performing simulations, the effect of varying mobility models on the working of AODV ad hoc routing protocol [18] is analyzed and tested under NS-2 simulator [19]. The simulations are performed for the network of 10 nodes with MAC 802.11 wireless channel, and Two Ray Ground and Free Space propagation models used under Omnidirectional antenna by varying mobility speed, pause time and radio transmission range.

The nodes are initially placed randomly in a rectangular region. All nodes move according to the Random Waypoint Model and Random Direction Mobility Models respectively. The node's maximum speed is uniformly distributed from 1 to 14 m/s. The pause time is kept to 20 seconds respectively, for the entire 600 seconds of simulation time for all the scenarios. The transmission range is varied from 50 meters to 250 meters in different scenarios. The terrain areas used were 500m x 500m and 1200m x 1200m respectively. The traffic patterns used was Constant Bit Rate (CBR) using 5 connections. Each CBR source sends 512-byte packet at the sending rate of 4 packets/seconds.

6.1 Performance Metrics

1) In this study the following metrics are used to evaluate the performance of the routing protocol.

a) Packet Delivery Ratio (PDR): The packet delivery ratio is measured as the ratio between the data packets received to data packets send. The Packet Delivery Ratio is measured in percentage.

b) Network Access Delay: The Network Access Delay is the total time experiences during buffering of packets during route discovery phase and latency, time to wait for packets at the queuing interviewing, also MAC packets retransmission delays, and propagation delay during transfer times. The Network Access Delay is measured in seconds.

c) Average Throughput: The throughput is calculated as the total number of data packets received divided by the simulation time. It is measured in Mega bits per second.

d) Protocol Overhead: It is the total number of routing packets transmitted or forwarded during the simulation time. It is measured in number of packets and bytes.

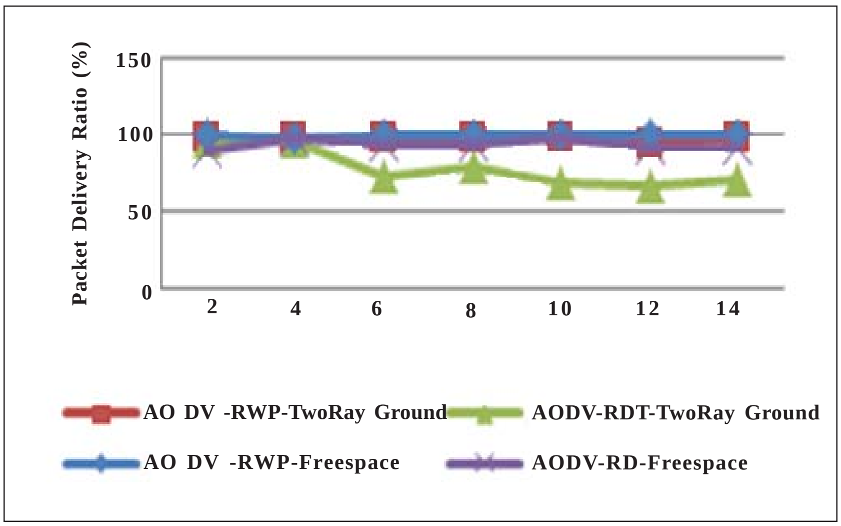

Figure 1. Packet Delivery Ratio vs. Mobility Speed for 10 nodes, Area: 500x500 meters, pause time: 20 seconds, Mobility pattern: RWP and RD, Propogation Models: Two Ray Ground and Free space, Transmission Range: 250 meters

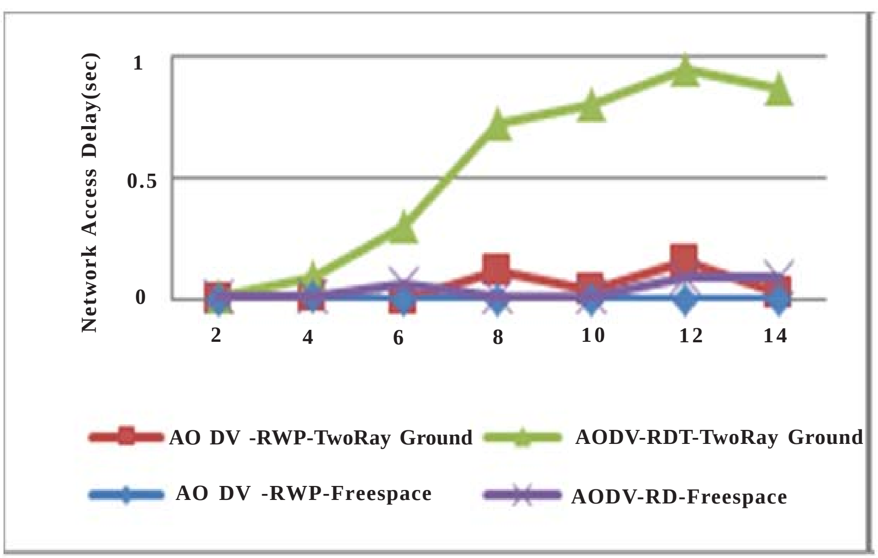

Figure 2. Network Access Delay vs. Mobility Speed for 10 nodes Area: 500x500m, Pause time: 20 seconds, Mobility pattern: RWP and RD, Propogation Models: Two Ray Ground and Free space, Transmission Range: 250 meters

6.2 Results And Observations

1) Scenario 1 with varying max speed for small terrain area (*nodes* = 10): In this scenario, the network size is kept to 10 nodes moving according to RWP and RD mobility patterns in the entire simulation area of 500x500 meters. The CBR traffic sources are kept to 5 connections at sending rate of 4 packets per second for 10 communication nodes. The mobility speed of nodes is varied from 2 to 8 m/sec and nodes pause for period of 20 seconds during the entire simulation time of 600 seconds. The graphs for packet delivery ratio, network access delay, average throughput and protocol overhead over Two Ray Ground and Free Space propagation models are shown below.

The Figure 1 shows when the number of nodes are set to 10 and area is 500x500, also the radio propagation range is set to 250 meters, then graph illustrated that AODV performs well by varying mobility speed from 2 to 14 m/sec, especially in case of Line of Sight propagation models. The result also shows that, by changing mobility pattern, the effect of varying mobility speed has more impact on packet delivery ratio of AODV protocol at CBR traffic load of 5. However, packet delivery ratio of AODV declines when using RD over Two Ray Ground model, due to fact that in RD nodes chooses angular direction after reaching the boundary of the simulation area during the simulation time, that drastically effect the deviation of convergence of radio signal between transmitter and receiver.

The Figure 2 shows the effect of varying mobility speed over Network Access Delay of AODV using RD and RWP mobility models over Two Ray Ground and Free space propagation models. The results showed that the Network Access Delay of AODV across mobility speed for small number of nodes within the relatively large area of RD over Two Ray Ground propagation model is phemomonily increasing as node's mobility increases beyond 4 m/sec. However, using RWP over Two Ray Ground propagation model also showed irregular increase in Network Access Delay with the increase in mobility speed. Moreover, Two Ray Ground propagation model suffered a lot in case of Network Access Delay, due to non direct line of sight propagation of signals and due to other interferences than line of sight propagation.

The Figure 3 depicts the Protocol overhead of RWP and RD over both propagation models. The graph illustrates that the protocol overhead of both mobility models increases across both Two Ray Ground and Free space propagation models with espect to mobility speed, which is mainly due to increase in packet drop ratio and network access delay that give rise the protocol overhead of both the mobility model but especially of Two Ray Ground propagation model across RD mobility model. However, protocol overhead of Free space propagation model across RWP model is low and consistent throughout the mobility

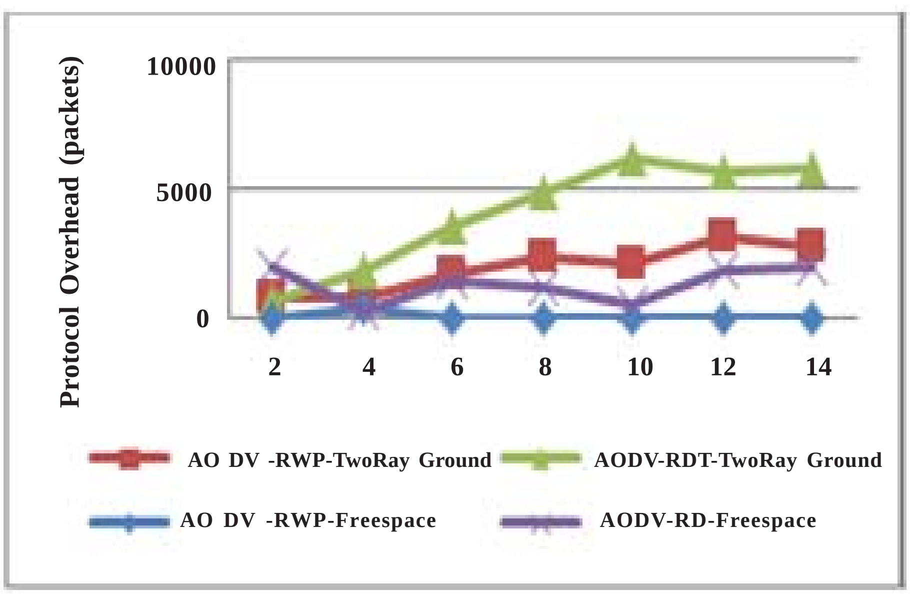

Figure 3. Protocol Overhead of AODV vs. Mobility Speed for 10 nodes Area: 500x500m, Pause time: 20 seconds, Mobility pattern: RWP and RD, Propogation Models: Two Ray Ground and Free space, Transmission Range: 250 meters

speed due to clear line of sight propagation.

2) Scenario 2 with varying max speed for large terrain area (for *nodes* = 10): In this network nodes are kept to 10 but terrain size is extended from 500x500 meters to 1200x1200 meters. Also transmission range is decreased slightly to 200 meters than the first scenario.

The below graph in Figure 4 displays the performance of AODV protocol in terms of packet delivery ratio is greatly affected by varying network area to 1200x1200 meters for small network size (i.e. 10 nodes) at radio range of 200 meters for both mobility and

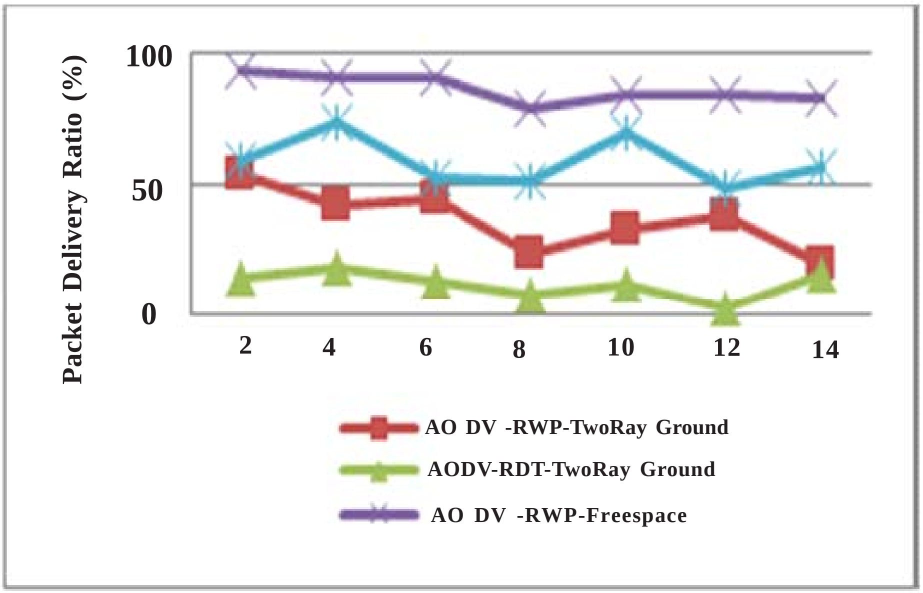

Figure 4. Packet Delivery Ratio of AODV vs. Max Speed for 10 nodes, Area: 1200x1200m, Pause time:20 seconds, Mobility pattern: RWP and RD, Propogation Models: Two Ray Ground and Free space, Transmission Range:200 meters

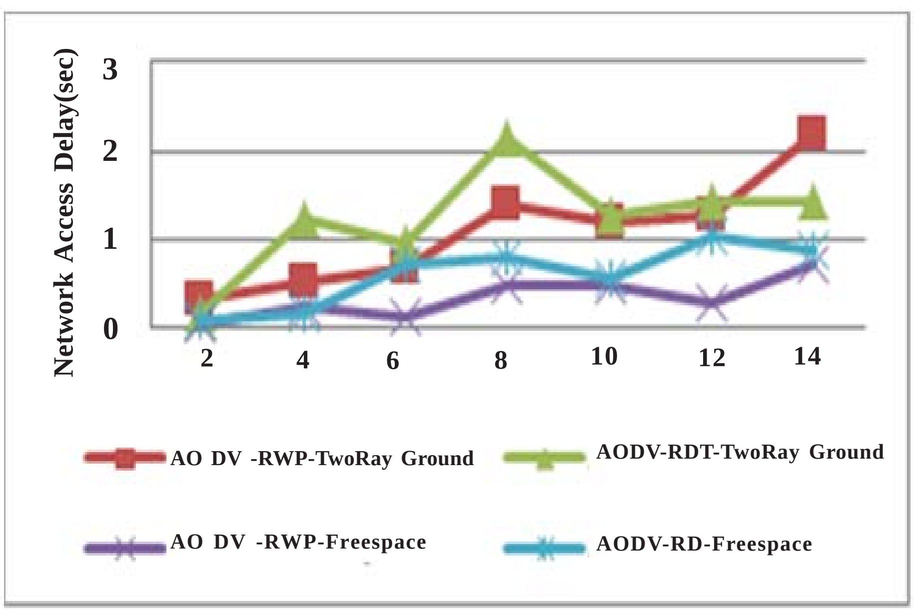

Figure 5. Network Access Delay of AODV vs. Mobility Speed for 10 nodes, Area: 1200x1200m, Pause time:20 seconds, Mobility pattern: RWP and RD, Propogation Models: Two Ray Ground and Free space, Transmission Range:200 meters

propagation models. However, AODV performance is also affected by changing mobility models. In other words, RWP over Free space model shows good packet delivery at transmission range of 200 meters. Also, AODV give packet delivery ratio of 98% at mobility speed of 2m/sec, while RD over Free space shows higher packet delivery ratio of 78% at mobility speeds of 4 and 10 m/sec respectively. Whereas RWP and RD over Two Ray Ground shows decrease in packet delivery ratio by increasing mobility speed beyond 2 m/sec due to multipath propagations.

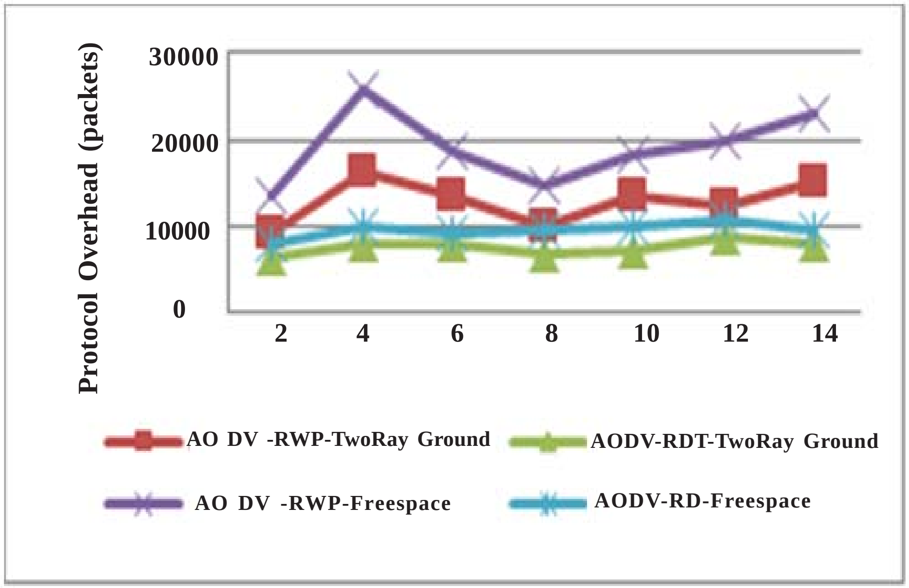

Figure 6. Protocol Overhead of AODV vs. Mobility Speed for 10 nodes, Area: 1200x1200m, Pause time:20 seconds, Mobility attern: RWP and RD, Propogation Models: Two Ray Ground and Free space, Transmission Range:200 meters

The Figure 5 shows the effect of increasing network size to 1200x1200 meters and setting the transmission range to 200 meters for 10 nodes at pause time of 20 seconds. The result shows that the Network Access Delay of AODV protocol varies as mobility speed increases beyond 4 m/sec due to reception of packets by the receivers from far away nodes during the simulation time especially using Two Ray Ground and RD model. However, both mobility models shows low Network Access Delay using Free space propagation model using RWP model in large area space, due to adapting to single line of sight propagation and high density of nodes near the center of simulation area.

The Figure 6 shows the Protocol Overhead of AODV protocol by using two different propagation channels. The result shows that by using the mobility model over Free space propagation model, the protocol overhead of AODV begins to increase as mobility speed increases beyond 4 m/sec. However, AODV behave well using Two Ray Ground propagation model due to multipath signal propagation.

7. Conclusion and Future Work

The main conclusion of this research thesis is that, the performance of ad hoc routing protocol vary across different mobility, propagation models and using different number of nodes, mobility speeds, pause times, number of traffic sources, simulation area in terms of Packet Delivery Ratio, Network Access Delay, Average Throughput and Protocol Overhead etc. As discussed and analyzed in results and discussion section, the performance of ad hoc protocol is greatly affected by the mobility model. However, the performance of ad hoc protocol is changes with the change in propagation model used in particular scenario across different traffic and mobility parameters. The performance of AODV is tested and analyzed in terms of above said performance metrics across Random Waypoint and Random Direction Mobility Models over Two Ray Ground and Free Space Propagation Models using different scenarios. The graph illustrated that with the increase in mobility speed, AODV performed excellently under direct line of sight (LOS) and non direct line of sight (NLOS) propagation models using Random Waypoint and Random Direction Models. Also when the terrain size and number of nodes are small and also pause time and traffic load set to low, then performance of AODV using Random Waypoint Model over both propagation models were better in terms of

Packet Delivery Ratio, Network Access Delay and Protocol Overhead with respect to mobility speed at default transmission range than Random Direction Model over Two Ray Ground model.

However, when the terrain area was sparsed and number of nodes were spread apart and at higher traffic load, then the performance of AODV deteriorated in terms of Network Access Delay and Protocol Overhead with increased in pause time at low mobility speed using Two Ray Ground Model than Free Space. But when terrain area and number of nodes were large in number at higher traffic load then Packet Delivery Ratio increases and Network Access Delay and Protocol Overhead decreases with increase in pause time at lower speed and larger transmission range using both Mobility Models over Two Ray Ground Propagation Model. But when the network becomes sparse or traffic load becomes high then the performance produced by AODV decreases sharply ofrequently sometimes.

It is seen that the performance of AODV is highly affected by varying transmission range for both mobility models over two propagation models at lower pause time and higher mobility speed in large network size.

In future, we will plan to extend research work by studying other routing protocols such as DSR, DSDV and FSR etc. and comparing these protocols in the light of other propogation models and mobility patterns by using different scenarios. Further, a study of the proactive and reactive routing protocols under varying network size, network loads, mobility and traffic patterns that will help designers to choose the right propogation model under a robust routing protocol for a particular scenario during deployment stage.

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