

Simulative Investigations of AODV Routing Protocol with Different Propagation Models with CBR Traffic

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ABSTRACT

Mobile ad-hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure or centralized administration. Mobile ad-hoc network have the attributes such as wireless connection, continuously changing topology, distributed operation and ease of deployment. In our study, we examine and display the simulative investigations of Ad-hoc On-demand Distance Vector (AODV) routing protocol with different propagation models. The performance analysis and simulation are carried out to evaluate network performance based on various metrics packets received, packets lost and throughput. This study would be helpful in choosing the appropriate radio propagation model for any active operating environment.

Keywords: Mobile Ad-hoc Network (MANET), Ad-Hoc on Demand Distance Vector (AODV), Network Simulator (NS-2), Propagation models.

1. INTRODUCTION

Ad-hoc mobile network is a collection of mobile nodes that are dynamically and arbitrarily located in such a manner that the interconnections between nodes are capable of changing on a continual basis. In order to facilitate communication within the network, a routing protocol is used to discover routes between nodes. Routing protocols in traditional wired networks were developed keeping in view that they will select the path from source to the destination and maintain the flow of packets through the best routes available. These protocols were based on link-state or distance vector algorithms those find an optimal path. In the wired networks the nodes didn't move frequently or are dependent on the topology of the network but this is not the case with the ad hoc networks as the nodes are free to move. The topology of the networks change frequently and determination of path is too expensive because each host is in direct communication only with the nodes those are within its transmission range. Moreover the bandwidth available with such networks are very less as compared to the wired networks, hence the periodic updates might consume a large amount of bandwidth and cannot promptly reflect the frequent topology changes in ad hoc networks. The primary goal of such an ad hoc network routing protocol is correct and efficient route establishment between a pair of nodes so that messages may be delivered in a timely manner. Route construction should be done with a minimum of overhead and bandwidth consumption [1]. In this paper, we present investigations on the behavior of AODV networks routing protocol with various propagation model.

The rest of the paper is organized as follows: Section 2 gives an overview of reactive routing protocol AODV, Section 3 describes the performance evaluation criteria, Section 4 describes propagation models and Section 5 discusses the result analysis. Finally Section 6 discusses about conclusion derived from the results.

2. AD HOC ON DEMAND DISTANT VECTOR ROUTING

Routing protocols for ad-hoc can be classified into two broad categories depending on how they react to topology changes (Figure 1) [2, 3]:

- Proactive or table-driven protocols
- Reactive or on-demand protocols

The Ad Hoc On-Demand Distance Vector (AODV) routing protocol described in [4] is an improvement on DSDV because it typically minimizes the number of required broadcasts by creating routes on a demand basis, as opposed to maintaining a complete list of routes as in the DSDV algorithm.

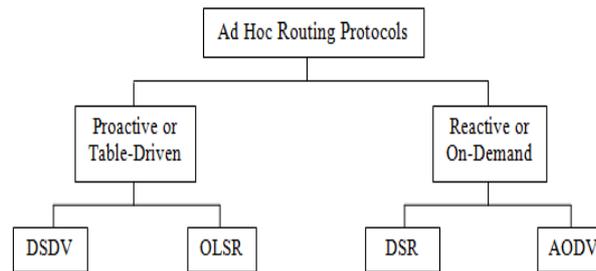


Figure 1 Classification of Ad Hoc Routing Protocols

AODV protocol allows mobile nodes to quickly obtain routes for new destinations, and it does not require nodes to maintain routes to destinations that are not in active communication. Also, AODV routing permits mobile nodes to respond link breakages and changes in network topology in a timely manner. The main objectives of the protocol is quickly and dynamically adapt to changes of conditions on the network links, for example, due to mobility of nodes the AODV protocol works as a pure on-demand route acquisition system [5]. Control messages [4, 6, 7] used in AODV are:

- Route Request Message (RREQ)
- Route Reply Message (RREP)
- Route Error Message (RERR)
- Route Reply Acknowledgment (RREP-ACK)
- Message
- HELLO Messages

When a source node desires to send a message to some destination node, and doesn't have a valid route to the destination, it initiates a path discovery process to locate the other node. It broadcasts a route request (RREQ) control packet to its neighbors, which then forward the request to their neighbors, and so on, either the destination or an intermediate node with a "fresh enough" route to the destination is located [5].

3. PERFORMANCE EVALUATION CRITERIA

The performance evaluation criteria for the characterization of wireless ad hoc network play a vital role for effective design of high performance network. Besides this it provides comparison of results, which are useful for the verification of performance metrics. There are many metrics that are commonly used to characterize the performance of networks and constituent parts of networks. The performance evaluation criteria we have considered in this dissertation are Packet Received, Packet Lost and Throughput.

3.1 Packet Received and Lost

Packet loss is a measure of the number of packets dropped by the routers due to various reasons. Packet loss is determined as the probability of a packet being lost in transit from a source A to a destination B. A One-way Packet Loss Metric for IPPM is defined in RFC 2680 [8]. RFC 3357 [9] contains One-way Loss Pattern Sample Metrics. Most of the multimedia applications are classified as bandwidth and delay sensitive but are generally loss-tolerant, i.e., they require strict bandwidth and delay guarantees but can tolerate certain amount of data/packet losses. Data/packet loss in these applications results in slightly reduced quality of output (e.g., jerks in video or voice output), but can be neglected to some extent. Bulk data transfers may require reliable transmission i.e. small packet loss between A and B. In this situation, if any packets are lost, they must be retransmitted, reducing performance. In addition, congestion-sensitive protocols such as standard TCP assume that packet loss is due to congestion, and respond by reducing their transmission rate accordingly. Congestion and errors are the two main reasons for packet loss.

3.2 Throughput (Kbytes/second)

It is defined as total number of packets received by the destination. It is a measure of effectiveness of a routing protocol. Finally what matters is the number of packets delivered successfully.

4. PROPAGATION MODELS

In a propagation model, we use a set of mathematical models which are supposed to provide an increasing precision. Propagation radio models are three types: path loss, shadowing and fading. The first type can be expressed as the power loss during the signal propagation in the free space. The second type is characterized by fixed obstacles on the path of

the radio signal propagation. The third category is the fading which is composed of multiple propagation distances, the fast movements of transmitters and receivers units and finally the reflectors.

4.1 Free Space Propagation Model

The free space propagation model is the simplest path loss model. The received power is only dependent on the transmitted power, the antenna's gains and on the distance between the sender and the receiver. It accounts mainly for the fact that a radio wave which moves away from the sender has to cover a larger area. So the received power decreases with the square of the distance [14]. The free space propagation model assumes the ideal propagation condition that there is only one clear line-of-sight path between the transmitter and receiver. H. T. Friis presented the following equation to calculate the received signal power in free space at distance d from the transmitter.

$$P_R = P_T G_T G_R (\lambda/4\pi d)^2$$

Where P_T is the transmitted signal power G_T and G_R are the antenna gains of the transmitter and the receiver respectively. λ is the wavelength.

4.2 Two Ray Ground Propagation Model

One more popular path loss model is the two-ray model or the two-path model. The free space model described above assumes that there is only one single path from the transmitter to the receiver. But in reality the signal reaches the receiver through multiple paths (because of reflection, refraction and scattering). The two-path model tries to capture this phenomenon [14]. The model assumes that the signal reaches the receiver through two paths, one a line-of-sight path, and the other the path through which the reflected wave is received. According to the two-path model, the received power is given by:

$$P_R = P_T G_T G_R (ht.hr /d^2)^2$$

Where P_T is the transmitted power, G_T and G_R are the transmitter and receiver antenna gains, respectively, in the direction from the transmitter and receiver, d is the distance between the transmitter and receiver, and ht and hr are the heights of the transmitter and receiver, respectively.

4.3 Shadowing Propagation Model

Fading refers to the fluctuations in signal strength when received at the receiver. Fading can be classified into two types: fast fading and slow fading. Fast fading refers to the rapid fluctuations in the amplitude, phase, or multipath delays of the received signal, due to the interference between multiple versions of the same transmitted signal arriving at the receiver at slightly different times.

Slow fading occurs when objects that partially the transmissions lie between the transmitter and receiver. Slow fading may occur when the receiver is inside a building and the radio wave must pass through the walls of a building, or when the receiver is temporarily shielded from the transmitter by a building. Slow fading is also referred to as shadow fading (shadowing) since the objects that cause the fade, which may be large buildings or other structures, block the direct transmission path from the transmitter to the receiver.

5. RESULT ANALYSIS

Simulation environment consists of 20 wireless nodes forming an ad hoc network, moving about over a 800 m X 800 m flat space for 120 seconds of simulated time, the output is taken with the help of the nam animator with .nam file as the input file. NAM animation tool is used for viewing network simulation traces and real world packet trace data. Figure 2 shows ad hoc network with Two Ray ground propagation, Figure 3 shows ad hoc network with Free Space propagation and Figure 4 shows ad hoc network with Shadowing propagation. Simulation parameters are shown in the table below:

Table 1 Simulation Parameters

Parameter	Value
Simulation Time	120 seconds
Environment Size	800 meter x 800 meter
Packet Size	512 bytes
Traffic Type	CBR (Constant Bit Rate)
Mobility model	Random Way Point
Propagation Model	1) Two Ray Ground 2) Free Space 3) Shadowing
No of nodes	20
CBR Sources	1

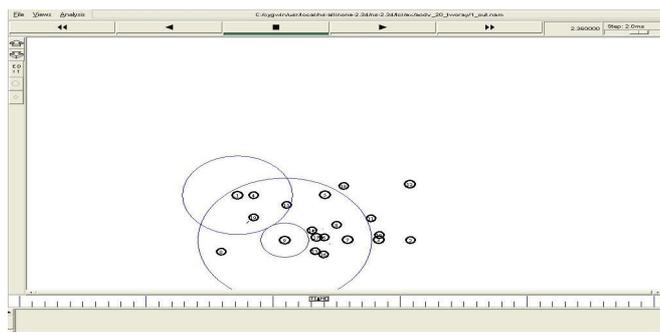


Figure 2 Simulation environment consisting 20 wireless nodes forming an ad hoc network with two ray ground propagation model

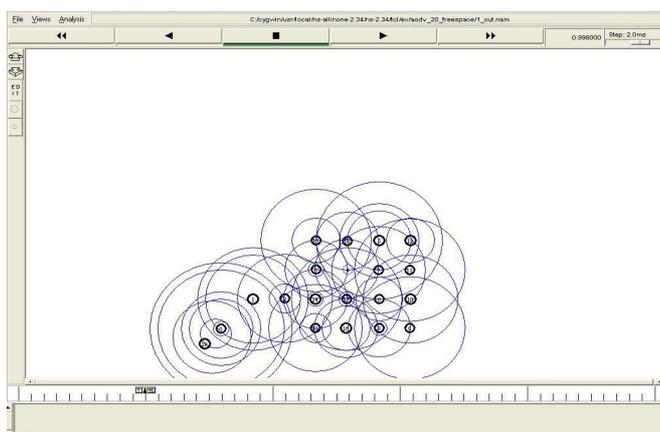


Figure 3 Simulation environment consisting 20 wireless nodes forming an ad hoc network with free space propagation model

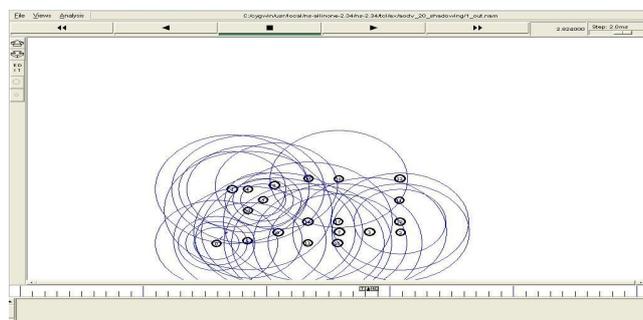


Figure 4 Simulation environment consisting 20 wireless nodes forming an ad hoc network with shadowing propagation model

In figures 5, 6, 7 we have observed the behaviour of AODV with various propagation models, Two Ray Ground propagation model, Free Space propagation model and Shadowing propagation model Figure 5 shows the comparison of no. of packets received in AODV with two ray ground, free space and shadowing propagation models. These three propagation models are shown by different coloured lines in the graph, the pink line represents two ray ground, blue line represents free space and yellow line represents shadowing propagation model. It has been observed that for free space and two ray ground propagation model there is no packet flow till time $t=1.0209$. At the same time, for shadowing propagation model there is no packet flow till $t=2.81974$. It is cleared by analyzing the graph that no. of packets received are highest for free space propagation model throughout the simulation time. When we consider two ray ground and shadowing propagation model, it is observed that from $t=1.0209$ to $t=3.39715$ no. of packets received are more for two ray ground as compared to shadowing propagation model. After $t=3.39715$ the no. of packets received increased rapidly for shadowing propagation model. Hence, no. of packets received are more for shadowing propagation model as compared to two ray ground propagation model. We can arrange these propagation models in a following order from highest packets received rate to lowest packet received rate:

Free Space Propagation > Shadowing Propagation > Two Ray Ground Propagation

When we consider packet lost for these three propagation models which is shown in figure 6. We have observed that there is no packet flow from $t=0$ to $t=2.13938$ for two ray ground. For shadowing propagation model no packet flows for time interval $(0, 2.78541)$. For free space propagation model there is no packet loss throughout the simulation time. After $t=2.13938$ packet loss slowly increases for two ray ground propagation model and after $t=2.49073$ it became constant. For shadowing propagation model no. of packets lost increases very rapidly from $t=2.78541$ to $t=3.90179$, after this time interval it becomes constant. By observing the behavior of AODV for various propagation models, we can state that if we consider no. of packets lost then the free space is best among these three propagation models, two ray ground is performing average and shadowing propagation model is worst.

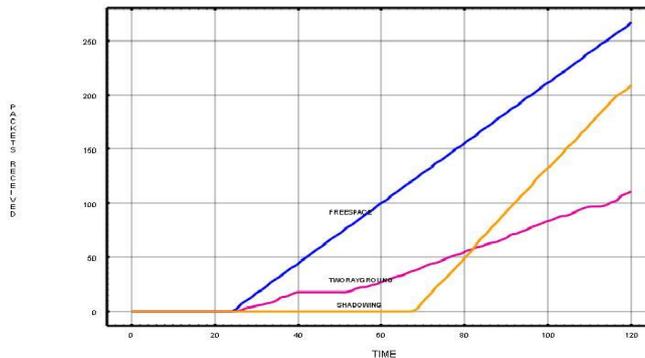


Figure 5 Packets received comparison in AODV with different propagation models.

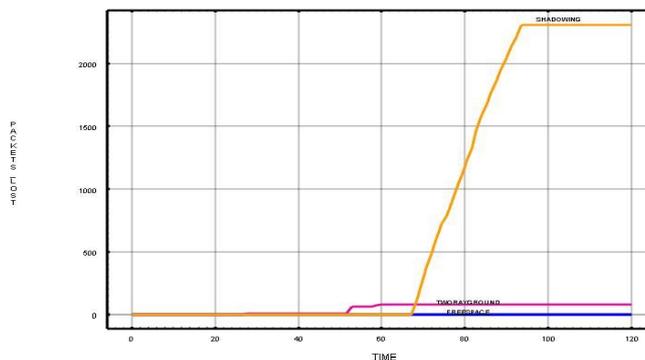


Figure 6 Packets lost comparison in AODV with different propagation models.

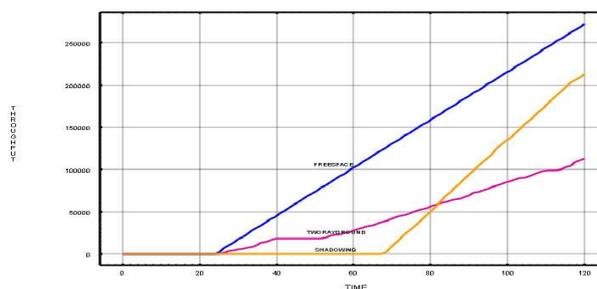


Figure7 Throughput comparison in AODV with different propagation models

Figure 7 shows the comparison of throughput, it is observed that up to $t=1.0033$ throughput remains zero for these three propagation models. After this time throughput increases with simulation time for two ray ground as well as free space propagation model, but we can state that throughput is more for free space as compared to two ray ground. When we consider shadowing propagation model throughput remains zero till $t=2.79674$ and then starts improving. When we consider throughput analysis of these three propagation models together we can state that free space is much better than two ray ground as well as shadowing propagation models.

6. CONCLUSIONS

The paper is an explorative study of the reactive routing protocol AODV with various propagation models. From figures 5 to 7, we can conclude that no. of packet received and throughput is highest in case of Free Space propagation and lowest in case of Shadowing Propagation. On the other hand no. of packets lost is lowest in Free Space propagation

and highest in Shadowing propagation. The above investigated behavior is because the free space propagation model assumes the ideal propagation condition that there is only one clear line -of-sight path between the transmitter and receiver. From this study, we conclude that free space propagation model performs better in most of the situations as compared to other propagation model. Further we can also extend our study for additional performance metrics for the same network.

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