Optimal Delay Analysis in Mobile adhoc Networks Using Topological Management of Nodes

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***Abstract*— Mobile ad-hoc network (MANET) is a multi-hop temporary autonomous system of mobile nodes with wireless transmitters and receivers without the aid of Pre-established network infrastructure. These networks provide dynamically changing network connectivity owing to mobility. The mobility model represents the moving behaviour of each mobile node in the MANET that should be realistic. It acts as a crucial part in the performance evaluation of MANET. The purpose of this paper is to study the impact of mobility on the performance of Ad-Hoc On-Demand Distance Vector Routing (AODV) protocol and propose a method to analyze the optimal delay in mobile ad-hoc networks and exploit the results in NS-2 simulator.**

***Index Terms*- Ad-hoc on Demand Distance Vector (AODV), MANET, Mobility Models, Network Simulator (NS-2).**

I. Introduction

A mobile ad hoc network (MANET) is an autonomous system of mobile hosts connected by wireless devices. There is no fixed infrastructure such as base stations. Each node in these types of network also acts as a router which forward data packets for other nodes. The need for Internet access through mobile devices, anywhere and anytime, has caused the development of model which is different in comparison to access based on a previously set fixed infrastructure over which wireless devices connect to the Internet nowadays. MANET is a collection of wireless mobile nodes that communicate with each other using multi-hop wireless links without any existing network infrastructure [1]. Each node in the network behaves as a router and forwards packets for other nodes. Routing as an act of moving information from source to destination through intermediate nodes is a fundamental issue for networks. Numerous widely used routing algorithms are proposed for wired networks. Routing is mainly classified into static and dynamic routing. Static routing refers to routing strategies set in the router, manually or statistically. Dynamic routing refers to routing strategies learned by an interior or exterior routing protocol [2]**.** Apart from that with the increase portable devices as well as progress in wireless transmission, Ad-hoc network gaining importance with the increasing number of widespread application[3],[4].A central challenge in the design of ad hoc networks is the development of dynamic routing protocols that can efficiently find routes between two communicating nodes. In order to find out the most adaptive and efficient routing protocol for the highly dynamic topology in ad- hoc networks, behaviour of routing protocols has to be analysed using varying node mobility speed, traffic and size of network. So, the goal is to carry out a systematic performance analysis of ad hoc routing protocol under mobility models.

The main aim of this paper is:

- •Understanding the ad -hoc routing protocol.
- •Understanding the Mobility models.
- •Analysing the delay performance differentials of routing protocol under mobility.

The organization of the paper is as follows. In the next Section 2, we survey related work. A description of considered routing protocol is given in Section 3. Section 4 describes types of the Random mobility models. In section 5 we discuss the problem formulation and explain our method. Section 6 presents the simulation based analysis and results. Finally, Section 7 concludes the paper and gives the future scope.

II. Related Work

In this section, we discuss related work. We distinguish between different approaches that used to study the effect of different mobility models on delay parameter when no. of nodes changes in a mobile ad-hoc network. In the [5] the authors show that the delay is influenced by different network parameters:1) channel access probability, 2) transmission power or transmission radius, 3)load on network and 4) density of nodes. Previous research in ad-hoc networks has invested on determining how the throughput and delay varies with the number of nodes. The authors in the [6] Gupta and Kumar introduced a random network model for studying throughput scaling in a fixed wireless network; The authors in the [7] has showed that by allowing the nodes to move, the throughput scaling of the network changes dramatically. From [7] and [6] the authors in the [8] showed that delay is characterized by three parameters: 1) the number of hops, 2) the transmission range, and 3) the node mobility and velocity. The authors propose schemes that exploit these three features to obtain different points on the delay curve in an optimal way. In [9] the experimental results illustrate that performance of the routing protocol AODV varies across different random mobility models: Random Waypoint, Random Direction and Random Walk. The performances of latest three mobility models have been evaluated in [10] with the routing protocol AODV. The results indicate that Random Waypoint Model is the best model which outperforms both Random Walk Model and Random Direction Model in both scenarios. The results shows that Random Waypoint produces least delay and highest throughput as compared to both of the Random Walk Model and Random Direction because the performance of these models drastically falls over a period of time.

III. AODV Routing Protocol

The Ad-hoc On Demand Distance Vector (AODV) [11] routing algorithm is a routing protocol designed for ad hoc routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains the routes as long as they are needed by the sources. In addition, AODV forms trees which connect multicast group members. The trees are made of group members and the nodes needed to connect the members. AODV routing protocol uses sequence numbers to ensure the freshness of routes. AODV is loop-free, self-starting, and it scales to large numbers of mobile nodes. The AODV protocol uses route request (RREQ) messages flooded through the network in order to discover the paths required by a source node. An intermediate node that receives a RREQ replies to it using a route reply message only if it has a route to the destination whose corresponding destination sequence number is greater or equal to the one contained in RREQ. The RREQ also contains the most recent sequence number for the destination of which the source node is known. A node which receives the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that exist in the RREQ. If this case occurs, it unicasts a RREP back to the source. In other case, it rebroadcasts the RREQ. The nodes keep track of the RREQ's source IP address and broadcast ID. If these nodes receive a RREQ which they have already processed, they discard the RREQ message and do not forward it. As the RREP message propagates back to the source node, it set up forward pointers to the destination. When the source node receives the message of RREP, it may start to forward data packets to the destination. If the source receives a RREP message later containing a greater sequence number or contains the same sequence number with a smaller hop count, it may modify its routing information for that destination and begin using the better route. As long as the route remains in active state, it will continue to be maintained. A route is considered in active state as long as there are data packets periodically travelling from the source to the destination along that route. When the source stops sending data packets, the links will time out and will be deleted from the routing tables.

IV Random Mobility Models

A. Random Waypoint Model

The Random Way Point Mobility Model [12] includes pauses between changes in direction and speed of the mobile nodes. A Mobile node begins by staying in one location for a certain period of time (i.e. pause). When this time expires, the mobile node then chooses a random destination in the simulation area and a speed that is uniformly distributed between [min-speed, max-speed]. Then the mobile node travels toward the newly chosen destination at the speed which is selected. Upon arrival, the mobile node pauses for a specified period of time starting the process again. In the simulation of ad-hoc networks, random waypoint model is a commonly used mobility model. The spatial distribution of network nodes moving according to this model is non uniform. A closed-form expression of this distribution and an in-depth investigation is still missing. This impairs the accuracy of the current simulation methodology of mobile ad hoc networks and makes it impossible to relate simulation-based performance outputs to corresponding analytical outputs. To remove these types of problems, it is presented a detailed analytical study of the spatial node distribution generated by random waypoint mobility model. The movement trace of a mobile node using the Random Waypoint model is shown in Fig 1.

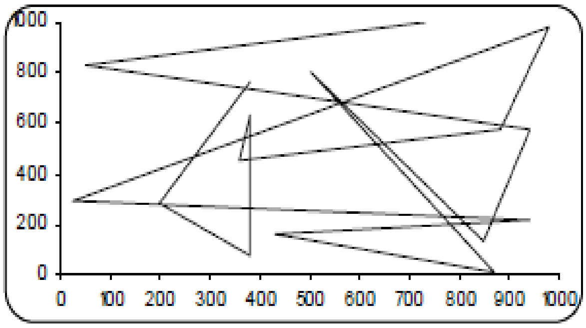

Fig 1. Node Movement in Random Way Point.

B. Random Walk Model

In this mobility model, a mobile node moves from its current location to a new location by randomly choosing a direction and speed. The new direction and speed are both chosen from pre-defined ranges as [0, 2*pi] and [minspeed, max-speed] respectively. The movement of a node in the Random Walk Mobility Model occurs in either a constant time interval 't' or a constant travelled distance 'd' ,and at the end, a new direction and speed are calculated. The movement trace of a mobile node using the Random Walk model is shown in Fig 2. Since many entities in nature move in extremely unpredictable ways, to mimic this erratic movement, the Random Walk Mobility Model was developed. A MN (mobile node) moves from its current location to a new location by randomly choosing a direction and speed. The new direction and speed are both chosen from pre-defined ranges as [0, 2*pi] and [minspeed, max-speed] respectively. The movement in the Random Walk Mobility Model occurs in either a constant time interval 't' or a constant distance travelled 'd', and at the end, a new direction and speed is find out. If a mobile node which moves according to this model reaches a boundary of simulation, it bounces off the simulation border with an angle determined by the incoming direction. Then the mobile node continues along this new path. Random Walk model is a memory-less mobility pattern. This feature can generate unrealistic movements such as sudden stops and sharp turns.

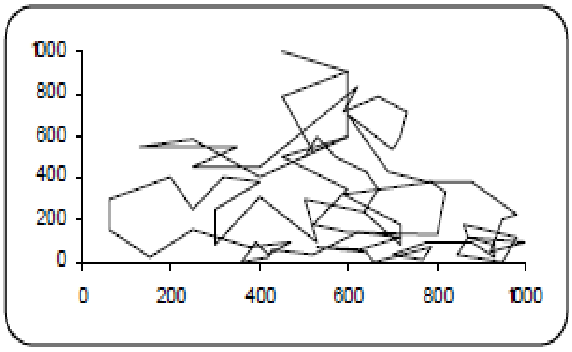

Fig 2. Node Movement in Random Walk

C. Random Direction Model

In the Random Direction Model, a mobile node chooses a random direction in which to travel similar to the Random Walk Model. The node then travels to the border of the simulation area in that chosen direction. When simulation boundary is reached, then the node pauses for a specified time, chooses another angular direction (between 0 and 180 degrees) and continues the process. This Mobility Model was created to overcome clustering of nodes in one part of the simulation area which is produced by the Random Waypoint Mobility Model. In Random Waypoint Mobility Model, the clustering of nodes occurs near the centre of the simulation area. In Random Waypoint Mobility Model, the probability of a mobile node choosing a new destination that is located in the centre of the area of the simulation or a destination that requires travel through the middle of the area of simulation is high. In this type of model, mobile nodes choose a random direction in which to travel similar to the Random Walk Mobility Model. Then a mobile node travels to the border of the simulation area in that chosen direction. When the boundary of the simulation is reached, then the mobile node pauses for a specified time, and chooses another angular direction [0, 180] and continues the process. The movement trace of a mobile node using the Random Direction model is shown in Fig 3.

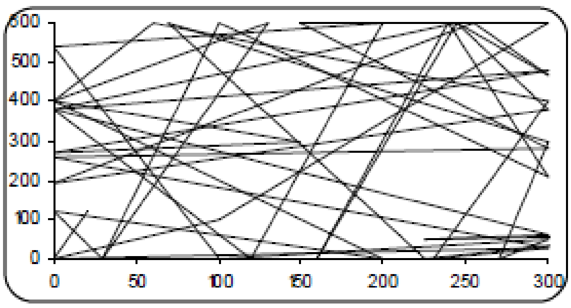

Fig 3. Node Movement in Random Direction

V. Problem Formulation

We know that the QoS (Quality of service) is to guarantee a certain level of performances to different applications. The mobile ad-hoc network is used in various applications with different QoS priority levels. For example, some applications are sensitive to the delay performance and other ones require a guaranteed level of throughput. In order to provide a certain level of performance a central challenge in the research areas of ad-hoc networks is with a density of nodes what appropriates routing and mobility protocols models to use at one scenario. To achieve this aim it is indispensable to know the optimal delay or throughput for a given number of nodes.

A. Proposed Technique

The purpose of this paper is to study the impact of mobility on the performances of routing. The mobility model is designed to describe the movement pattern of mobile user, and how their location, speed, acceleration, direction of movement, and pause distribution change over time. We propose a method that exploit the results and represent the analysis of optimal values curve of delay with the different no. of nodes. Because from the above related survey, we have seen that Random Waypoint Model provides the optimal delay as compared to both Random Walk and Random Direction therefore our proposed method is to plot the curve of the optimal delay for the Random Waypoint mobility model. This curve should represent the minimum acceptable values of delay assigned to each number of nodes. Delay optimization will be done by topological management of nodes. We will consider two types of factors to minimize the delay in mobile ad-hoc networks: Load on a forwarding node and Multigrouping of nodes. The ad-hoc reactive routing protocol Ad-Hoc On-Demand Distance Vector Routing (AODV) [13], [14] as a dynamic multi-hop on-demand routing protocol for mobile ad- hoc networks are considered. The algorithm for proposed technique for delay optimization is:

```
Search and decide source and destination
Maintain the routing table
To find the delay
{
Set the generator node
To find the path
{
 for transmission is not completed
{
 If cluster or multigrouping is formed
{
Check for node position
Set node reposition
{
Initial node position is N
Set node new position is N1
}
}
else
{
continue transmission
}
To find the load
{
If load found is heavy on node and load path is common
{
choose second optimal path to send the load
}
else
{
Continue transmission
```

```
}
}
}
}
}
exit.
```

Algorithm 1. Delay optimization

VI. Simulaton Based Analysis

A. Simulation Tool and Environment

In this paper, the simulation of AODV routing protocol is done by using network simulator (NS-2) software due to its simplicity and availability.NS-2 provides substantial support for simulation of routing protocols over a wired and wireless network [15]. NS-2 is written in C++ and OTCL. NS-2 includes a network animator called NAM animator which provides visual view of simulation. In order to achieve our aim we need to investigate how the AODV protocol behaves when load on nodes and multigrouping of nodes at same place increases. The following performance metrics are used for analysis of optimal delay:

1) Average end-to-end delay: The delay of a packet is the time it takes the packet to achieve the destination after it leaves the source. The average end-to-end delay Tavg is calculated as follows:

$$T_{Avg} = \frac{\sum_{i=1}^{N_r}(H_r^i - H_t^i)}{N_r}$$

Ht is emission instant of package i, Hr is reception instant of package i, Nr is the total number of packets received.

2) Throughput: The ratio of successfully transmitted data per second.

$$T = \frac{L-C}{L} R f(\gamma)$$

Where (L-C/L) b/s is the Payload Transmission Rate, (R) b/s Binary transmission rate, (L) Packet size, (C) Cyclic Redundancy Check, and f is the probability of receiving a packet correctly. This probability can be defined as a function of the signal-to-noise ratio.

3) Packet Delivery Ratio: It is defined as the ratio of the data packets successfully delivered to the destination.

PDR = Σ CBR Packets received / Σ CBR Packets sent

B. Simulation Parameters

The parameters used for the simulation analysis are provided in following Table1.

TABLE 1: SIMULATION PARAMETERS

Parameter	Value
Simulation time	600 sec
Number of nodes	10,20,30,40
Environment Size	1000 m X 1000 m
No of packets	50
Maximum Speeds	20 m/s
Packet Size	512 bytes
Radio Model	Two Ray Ground
Traffic Type	Constant Bit Rate
MAC Layer	MAC/802_11

C. Performance Analysis

1) Multigrouping of nodes-Fig. 4 shows that with AODV, when the clustering or Multigrouping of nodes increases at the same place (shown in orange colour) the delay increases because of very high drop ratio of packets. To remove this problem, we propose a technique as shown in Fig 5 when Multigrouping or clustering of multiple nodes at the same place exists, it eliminates the Multigrouping by repositioning of nodes in new positions to remove cluster and provides the zero or minimum no. of packets drop ratio. Fig 5 shows that data is being transfer from source to destination without dropping of data packets. So in proposed method, the delay is optimized as compared to problem.

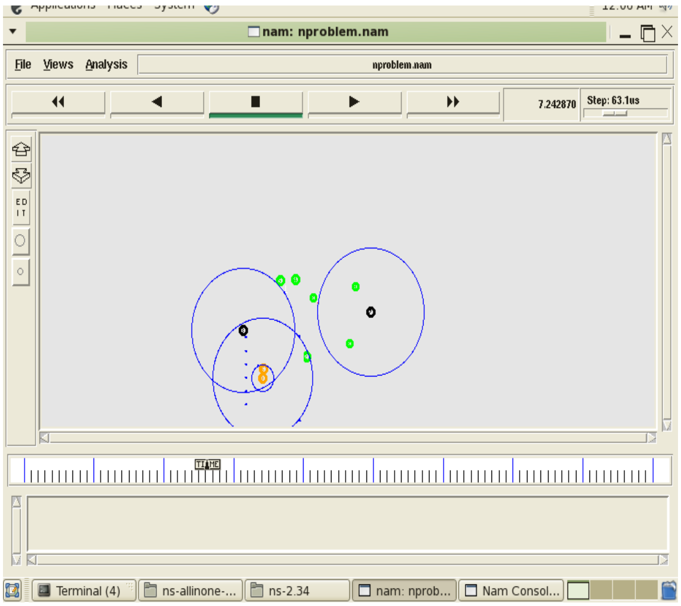

Fig 4. Problem of Multigrouping of nodes

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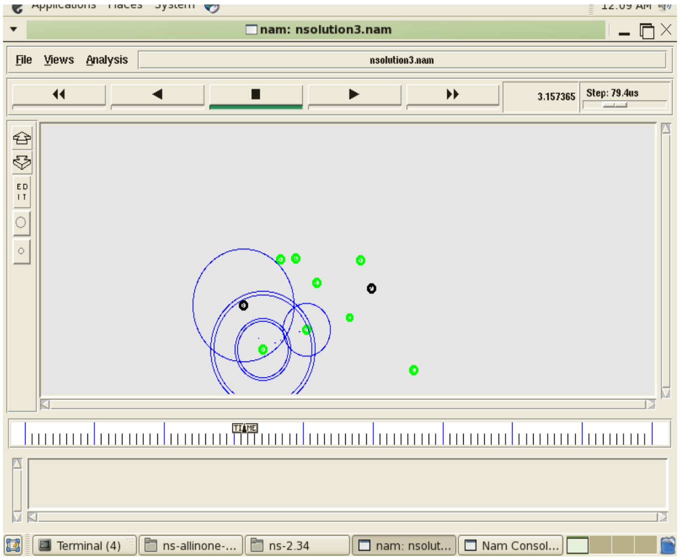

Fig 5. Solution of Multigrouping of nodes

2) Load on a forwarding node-Fig. 6 shows that with AODV, the delay increases when there is heavy load on node which is sent by multiple nodes simultaneously to that node. So in this case the energy of the node decreases (shown in red colour), therefore it provides high packets drop ratio. To remove this problem, we propose a technique in which when load on a forwarding node increases and energy of that node becomes low, it finds the second optimal path to send the load so that the load can be balance optimally within neighbour nodes and congestion on nodes can be removed. It provides the optimal load balancing within neighbour nodes, therefore decreases the packets lost or drop ratio as shown in Fig 7. The figure shows that data is being transfer without dropping the packets, so optimize the delay as compared to the problem.

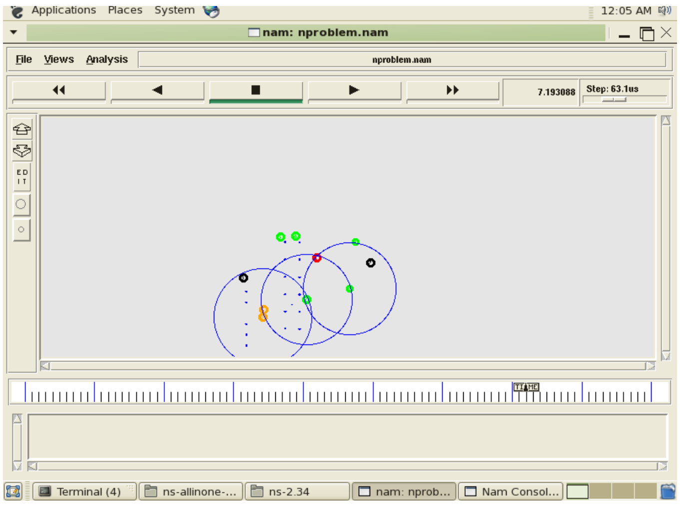

Fig 6. Problem of heavy load on forwarding node

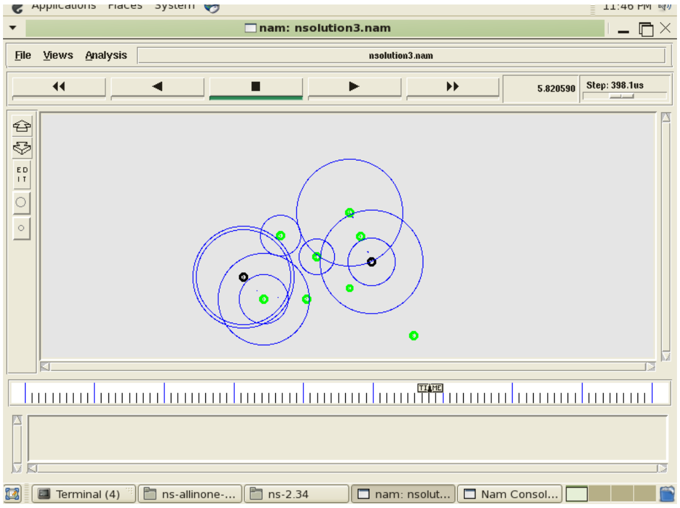

Fig 7. Solution of heavy load on forwarding node

D. Simulation Results

In this section we present our simulation results.The simulation result analysis is shown in the form of graphs with nodes 10 to 40. The three parameters are considered for the simulation analysis. Fig. 8 shows that the delay of our proposed solution is less as compared with mobility model Random Way Point (RWP).So our proposed technique provides the curve of optimal end-to-end delay.

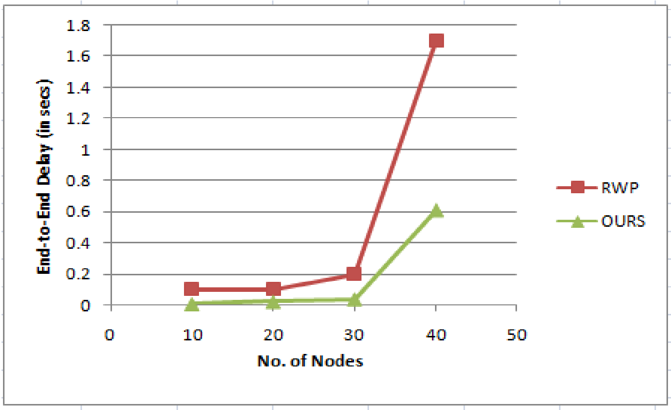

Fig 8. Optimal Delay vs. No. of Nodes

Fig. 9 shows Throughput with the varying no. of nodes. The figure shows that our proposed method shows higher throughput than Random Way Point mobility model.

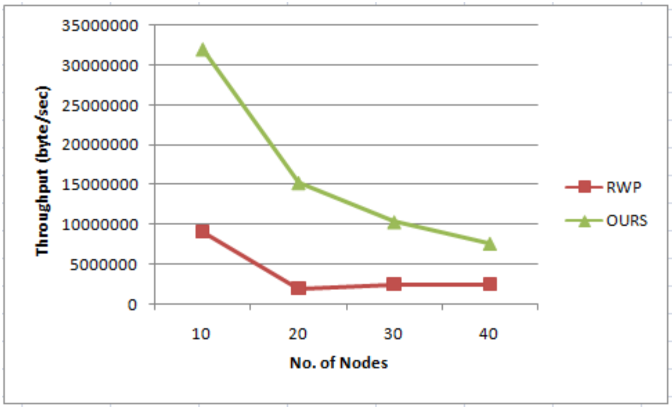

Fig 9. Throughput vs. No. of Nodes

Fig 10 shows Packet Delivery Ratio (PDR) for the varying number of nodes. As showing in this figure, our proposed method performed better in delivering packet data to the destination as compared to mobility model Random Way Point.

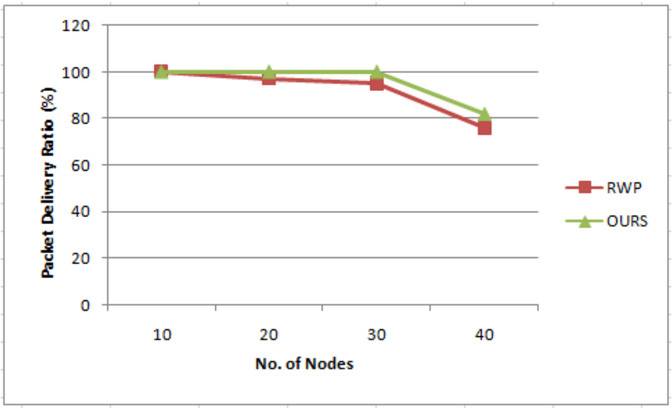

Fig 10. Packet Delivery Ratio vs. No. of Nodes

VII. CONCLUSION AND FUTURE SCOPE

The design of routing protocols are driven by specific goals and requirements based on respective assumptions about the network properties or application .In this paper, the optimal delay analysis of AODV routing protocol in MANET is done through network simulation tool NS-2 which gives the knowledge how to use routing schemes in dynamic network. The simulation analysis of Optimal Delay is done by using a method which provides to plot the curve of the optimal delay for the Random Waypoint mobility model. With this method, we hope to help the future studies in their choice of parameters in order to design the realistic scenarios which depict real world applications more accurately and more of QoS in mobile ad-hoc networks. In the future, further study should be devoted to the optimal delay-throughput and to the relationship between these two metrics that influence directly the performance of MANETs. The popular Mobility models should be improved, in order to develop a mobility model that accurately represent the environments where ad-hoc networks will be deployed, to meet the needs of QoS.

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