Delay Optimization in Ad-Hoc Networks by Topological Management of Nodes

Neha
Dept of Computer Science Engg,
Sai Institute of Engg and Tech,
Amritsar,Punjab,India.
Email:neha_rkb_87@yahoo.co.in

Tanu Preet Singh
PhD Research Scholar, Dept. of CSE
Uttarakhand Technical University,
Dehradun, India-143001
tanupreet.singh@gmail.com

Dr R.K Singh
Prof. & OSD
Uttarakhand Technical University,
Dehradun, India-143001
rksinghkec12@rediffmail.com

***Abstract*-Mobile Ad-hoc networks are basically self organizing, self configuring and peer to peer multi-hop wireless networks in which the information packets are transmitted in a 'store and forward' manner from a source to an arbitrary destination via intermediate nodes. These networks provide dynamically changing network connectivity owing to mobility. The mobility model represents the moving behavior 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. We have studied the effects of various random mobility models on the performance of On- Demand Distance Vector Routing (AODV) and we develop a method to analyze the optimal delay in mobile ad-hoc networks which gives the better performances in terms of delay and throughput and exploit the results in NS-2 simulator.**

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

I. Introduction

Wireless networking is an emerging technology that allows user to access information and services electronically, by not depending upon their geographical position. The Wireless networks are classified as infrastructure networks and infrastructure less (ad-hoc) networks. 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 or centralized administration [1]. Each node in the network behaves as a router and forwards packets for other nodes. Routing as an act of moving information from a source to a 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 of portable of devices as well as progress in wireless transmission, Mobile 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, behavior of routing protocols has to be analyzed 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.
- Analyzing the delay performance differentials of routing protocol under mobility.

The paper is organized as follows. The survey of related work is described in Section 2. A description of considered routing protocol is given in Section 3. Different types of the Random mobility models are described in Section 4. 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) [5] routing algorithm is a routing protocol designed for mobile ad-hoc networks, It builds routes between nodes only as desired by source nodes, so it is an on demand algorithm. It maintains the routes as long as they are needed by the sources So, AODV minimizes the number of required broadcasts by creating routes only on-demand basis as opposed to maintaining a complete list of routes When a source mobile host desires to send a message and does not already have a valid route to the destination, it starts a path discovery process to locate the corresponding mobile host. It broadcasts a route request (RREQ) packet to its neighbours, which then forwards the request to their neighbours, until either the destination or an intermediate MH(mobile hop) with a "fresh enough" route to the destination is reached**.** AODV utilizes destination sequence numbers to ensure all routes are loop-free and contain the most recent information of the route. Each node maintains broadcast ID as well as its own sequence number, which is incremented for every RREQ the node initiates. Together with the node's IP address, this uniquely identifies an RREQ. Once the RREQ reaches the destination or an intermediate node with a fresh route, the intermediate or the destination node responds by unicasting a route reply (RREP) packet back to the neighbour from which it first received the RREQ message. When the RREP is routed back along the reverse path, the intermediate nodes on this path set up forward route entries in their route tables that point to the node from which the RREP came.

IV. Random Mobility Models

A. *Random Way Point 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.

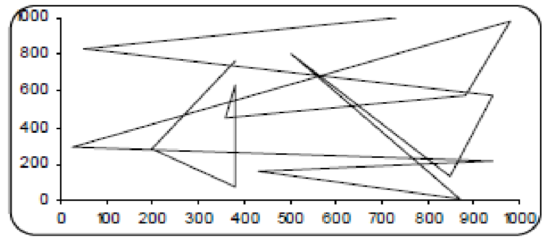

Figure 1. Node movement in Random Way Point

B. *Random Direction Model*

In the Random Direction Model, a mobile node chooses a random direction in which to travel. 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 2.

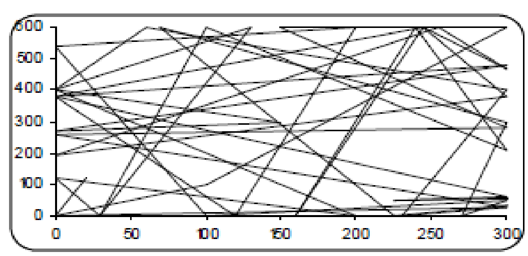

Figure 2. Node movement in Random Direction

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 optimal values curve of end-to-end delay in ad-hoc networks. Because from the above related survey, we have seen that Random Waypoint Model provides the optimal delay as compared to Random Direction model 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. In order to plot the curve of the optimal throughput for mobility model, the maximum values of throughput are considered for each number of nodes. Delay optimization will be done by topological management 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 of proposed technique for delay optimization is given as following Algorithm 1.

```
Search and decide source and destination;
Maintain the routing table;
To find the delay
{
Set the generator node;
Find the path
{
 for (transmission is not completed)
{
 If (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 is heavy and load path is common)
{
choose second optimal path;
}
else
{
Continue transmission;
}
}
}
}
}
exit.
```

Algorithm 1. Delay Optimization

VI. Simulation Based Analysis

A. *Simulation Tool and Environment*

In this paper, the simulation of AODV routing protocol is done by using network simulator version 2 (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. 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. For the simulation results, the following performance metrics are used:

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. Performance Analysis

The simulation analysis in NS-2 simulator is shown in the following figures. Fig 3 shows the problem of high dropping rate of data packets due to multigrouping i.e. multiple nodes increases at same place and when there is heavy load on forwarding node which is sent by multiple nodes simultaneously to that node which decreases the energy of the node. Fig 4 and Fig 5 remove this problem and show the optimal solution in which high dropping rate of data packets is controlled by proposed technique. These figures show that data is being transfer without dropping of data packets from source to destination. This proposed technique provides the optimal transmission end-to-end delay for ad-hoc networks. The parameters used for the simulation analysis are provided in following Table1.

TABLE 1. SIMULATION PARAMETERS

Parameter	Value
Channel type	Wireless channel
Simulation time	600 sec
Number of nodes	10,20,30,40
Environment size	1000 X 1000 m
No of packets	50
Packet size	512 bytes
Radio model	Two ray ground
Traffic type	Constant bit rate
MAC layer	MAC/802_11

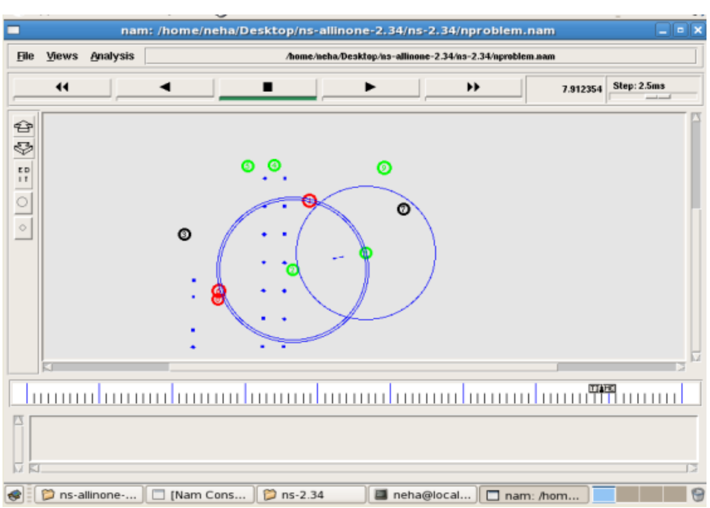

Figure 3. Problem of dropping of data packets during transmission

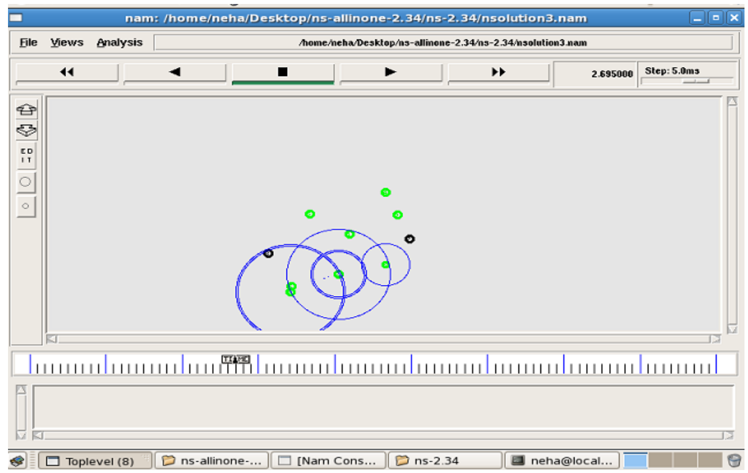

Figure 4. Solution of problem (multigrouping of nodes) for delay optimization

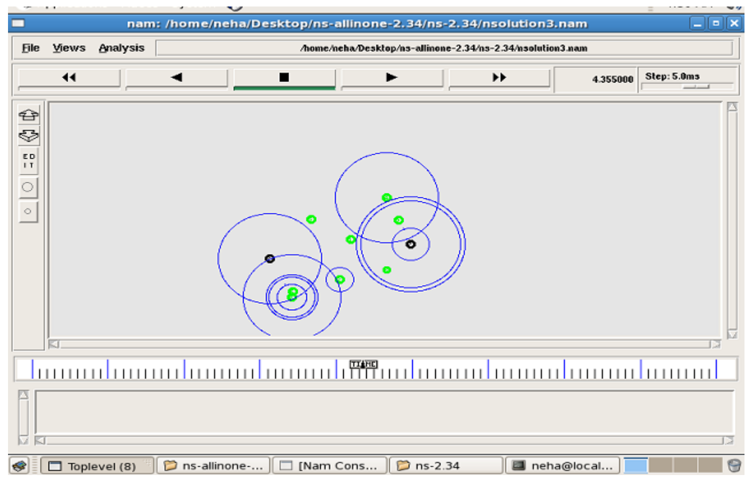

Figure 5. Solution of problem (heavy load on forwarding node) for delay optimization

C. Simulation Results

1) End-to-End Delay versus No. of Nodes:

Fig 6 shows that the delay of our proposed solution is less as compared with two mobility models Random Way Point (RWP) and Random Direction (RD). So our proposed technique provides the curve of optimal end-to-end delay.

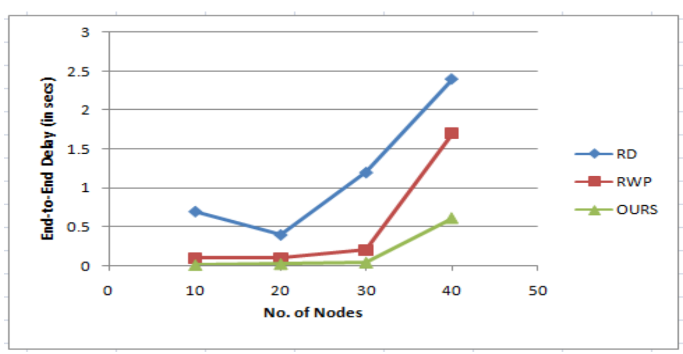

Figure 6. Optimal delay vs. No. of Nodes

2) **Throughput versus No. of Nodes:** Based on the result analysis of the Fig 7, our proposed method shows higher throughput than both Random Way Point and Random Direction mobility models. So our proposed method also produces the optimal throughput for all taken nodes density.

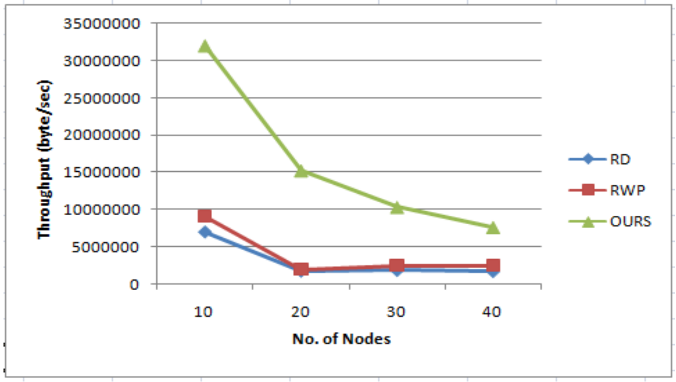

Figure 7. Throughput vs. No. of Nodes

3) **Packet Delivery Ratio versus No. of Nodes:** Fig 8 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 both mobility models Random Way Point and Random Direction.

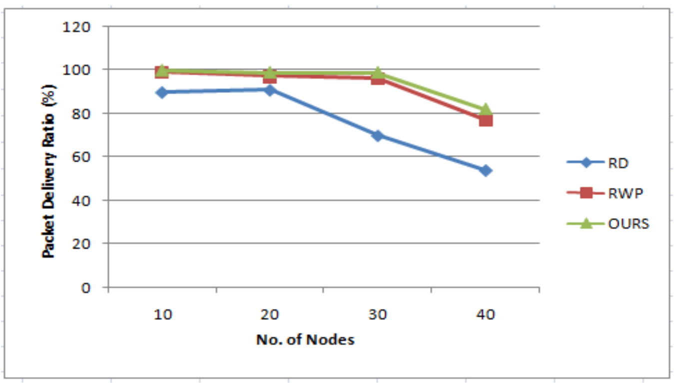

Figure 8. Packet Delivery Ratio vs. No. of Nodes

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 Way Point mobility model. It also produces the optimal throughput for all taken nodes density. 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.

References

[1] S. Shah,"Performance evaluation of ad hoc routing protocols using NS-2 simulation", In the Proceedings of the National Conference on Mobile and Pervasive Computing (CoMPC-2008), Chennai, India, August 2008.

[2] K. Gorantala, "Routing protocols in mobile ad hoc networks", Master Thesis, Department of Computing Science, Umeøa University, Sweden, June 2006.

[3] C. Siva Ram Murthy, B. S. Manoj, "Ad hoc wireless networks, architectures and protocols", Second Edition, Low price Edition, Pearson Education, 2007.

[4] Mehran Abolhasan, Tadeusz Wysocki, Eryk Dutkiewicz, " A review of routing protocols for mobile ad hoc networks", Technical report, Telecommunication and Information Research Institute, University of Wollongong, Wollong, NSW 2522. Motorola Australia Research Centre, 12 Lord St., Botany, NSW 2525, Australia, 2003.

[5] Srihari Narasimhan, Srisankar Kunniyur, "Effect of network parameter on delay in wireless ad-hoc network", University of Pennsylvania, August 29, 2004.

[6] P .Gupta, P. R. Kumar, "The capacity of wireless networks", IEEE Trans. on Information Theory, 46(2), pp. 388-404, March 2000.

[7] M. Grossglauser, D. Tse, " Mobility increases the capacity of ad hoc wireless networks", IEEE INFOCOM, Anchorage, Alaska, pp.1360-1369, 2001.

[8] S. R. Kulkarni, P. Viswanath, "A deterministic approach to throughput scaling in wireless networks", Preprint:http://www.ifp.uiuc.edu/pramodv/pubs/v021104.ps.

[9] S. Gowrishankar, T G Basavaraju, Subir Kumar Sarkar," Effect of random mobility models pattern in mobile ad hoc networks", India, June 2007.

[10] Mohd Izuan Mohd Saad, Zuriati Ahmad Zukarnain, " Performance analysis of random-based mobility models in MANET routing protocol", http://www.eurojournals.com/ejsr.htm 2009.

[11] C. E. Perkins, E. Belding-Royer, S. Das, " Ad hoc on-demand distance vector (AODV) routing", Experimental RFC 3561, Internet Engineering Task Force (IETF), July 2003.

[12] Samir R. Das, Robert Castaneda, Jiangtao Yan, Rimli Sengupta, "Comparative performance evaluation of routing protocols for mobile ad hoc networks", 7th International Conference on Computer Communication and networks(IC3N), pp 153-161, October 1998.

[13] C. E. Perkins, E. M. Royer, "Ad hoc on-demand distance vector routing" ,WMCSA, February 1999.

[14] C.E. Perkins, E.M. Royer, "Ad-hoc on demand distance vector routing protocols", in Proceeded 2nd IEEE work shop mobile computing system and applications, new ore leans, Loss Angelis, pp 90-100, February 2011.