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Performance Evaluation of Routing Protocols for Mobile Ad Hoc Networks

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ABSTRACT

Mobile Ad Hoc Networks (MANETs) are the networks formed by a number of autonomous wireless nodes. These are the infrastructure-less networks and are highly dynamic such that network topology and conditions constantly vary. As a result of variability in network conditions, routing in MANETs is a challenging task. Recent research in this area is directed towards testing existing routing protocols for these networks as well as proposing new protocols. In this work, we evaluate two important routing protocols for MANETs namely the Ad-hoc On-demand Distance Vector (AODV) protocol and Destination sequence Distance Vector (DSDV) protocol. Through ns2 simulations, we compare the performance of these protocols in terms of delay, load and throughput. Our results show that AODV outperforms DSDV when used in ad hoc networks.
KEYWORDS: Mobile ad hoc network, network simulator, AODV, DSDV, performance evaluation.

1. INTRODUCTION

An ad-hoc network or MANET is formed by a group of nodes that are allowed to move freely in any direction without the need for some fixed infrastructure or external authority. The nodes have complete autonomy to form their own connections. When the nodes enter the network they lack any prior knowledge about other nodes. These self configuring nodes learn about the surrounding nodes by themselves and comprehend approaches to connect with neighbouring nodes. Due to mobility of nodes, the network configuration has the capacity to change rapidly and unpredictably. The nodes are multipurpose and function as end systems and as routers simultaneously. When acting as routers, they manage routes amongst the different nodes [1] [2].

The focus of this work is to explore important routing protocols proposed for MANETs and evaluate their performance in terms of delay, routing load and throughput. Routing is the process of finding best routes among nodes and moving packets across a network from one host to another through best routes. Routing in MANETs is highly complex due to mobility of nodes and hence many protocols have been proposed. In this work we select the two important routing protocols, AODV and DSDV that are mostly used in wireless networks and compare their performance when used in MANETs. Ad hoc on-demand distance vector Routing is a reactive protocol which means a route is created only when the source node needs to transmit packets. Each node is responsible for maintaining a routing table which keeps tabs on next hop IP addresses and destination sequence numbers. Route discovery cycle is used for route finding and Sequence number used for loop prevention and to fulfill route freshness criteria. AODV also provides unicast and multicast communication. Destination-Sequenced Distance Vector is a proactive protocol. It is a table driven Distributed Bellman-Ford algorithm. Each node maintains a hop count for each destination. The routing tables are periodically sent by nodes to their neighbors though sending full dumps are less frequent then smaller incremental updates. The Nodes re-calculate shortest path upon the receipt of a routing table update. The use of Sequence number is done to avoid loops in the path to a particular destination. Our results show that AODV gives better performance in these networks and are most suitable for dynamic network conditions especially when network grows with time and more nodes join the network, AODV gives superior performance.

The remaining paper is organized as follows: Section 1 gives the introduction, in section 2 we discuss the important related work. In section 3 we discuss the simulation parameters and strategy. Section 4 presents the results and finally section 5 concludes the paper.

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1. Related Work

There is a lot of work done in the field of MANETs routing and in this section we discuss some of the significant work done. In most of the work different permutations of the routing protocols were selected for evaluation. Most of the work has focused upon DSR, TORA, and ZRP routing protocols. We selected AODV and DSDV because these are time-tested, stable and suitable for wireless networks. Although some work exists in testing these protocols for Ad-hoc networks but the simulation parameters and focus is different from our work [1] – [8].

In [1] the authors observe that AODV has the ability to maintain connections by periodic exchange of information, as a result it performs better and predictably. DSR performs well at high mobility and DSDV performs better but the routing overhead is more. In [2] the authors focused on MANETs with high node density, large number of short connections and low speed, they find that the best performance is given by AODV in terms of throughput while DSR and TORA are not suitable when the number of connections is large.

We have focused upon delay, routing load and throughput which is explored to some extent in [5]. In [5] the authors compared the routing protocols under conditions like communication discontinuity, difference in simulation times and high node densities. Another important part of the evaluation is the usage of mobility models. The Random waypoint mobility model introduces the concept of pausing nodes at specific times to see the output. In our work we have chosen different criteria for evaluation, instead of making the nodes stationary at pause times we have chosen to allow random motion and we observe results in relation to the expanding network size. In [8] Ghaffari et al. have analyzed different routing protocols of MANETs with performance metrics of throughput, end-to-end delay and network load by simulating multimedia (video conferencing) traffic. Their simulation results show that proactive protocol OLSR outperforms reactive protocol AODV and hybrid protocol TORA due to readily available routing paths.

2. NS2 Simulations

2.1. Network Simulator (NS2)

We use Network Simulator NS2 [9] – [10] for performance evaluation of routing protocols which is installed on Ubuntu that runs on Oracle VM virtual box. The NS2 is an open source simulator which allows us to setup network topology and configuration and specify parameters in order to observe the behavior of protocols. A rectangular field of 500m *500m is used as maximum size of the network. Traffic files are imported in TCL script at the time of execution. We use the default packet size of 512 bytes and all data packets waiting for route are kept in send buffer. Interface queue maximum size is 10 packets. IFQ holds all the routing packets until MAC layer transmits them. The simulation duration is 100s for (CBR) constant bit rate traffic type. We used Random Movement for our simulations and also randomly initialized the nodes initial position. Simulation parameters that remain constant during simulations are given in Table 1.

Table 1. Simulation Parameters

Parameters	Values
Adhoc Routing Protocols	AODV, DSDV
Radio-propagation model	Propagation/TwoRayGround
Network interface type	Phy/WirelessPhy
MAC type	Mac/802_11
Interface queue type	Queue/DropTail/PriQueue
Link layer type	CSMA/CA
Simulation Time	100sec
Routing Protocols Number of nodes	20, 60, 100
Environment Size	500*500
Queue Length	10
Packet	512 bytes
Traffic type	CBR

2.2. Simulation Sequence

To make the comparison between the two different routing protocols we execute and simulate our proposed scenarios. The flow diagram is shown in Figure 1. After the creation of traffic scenarios as discussed earlier the output file generated is fed into the wireless TCL script. After the TCL file is executed a trace file is produced that captures events occurring in the network. The data in the trace file is very valuable to someone trying to read performance measures but the presentation is in a block

form. To extract pertinent data for the evaluation awk script is used. This simulation is performed to evaluate the performance based on the three metrics 'Average end-to-end delay', 'Normalized routing load' and 'Throughput' hence three awk files are produced. The results of these metrics are placed into .csv files from where graphs are plotted [11].

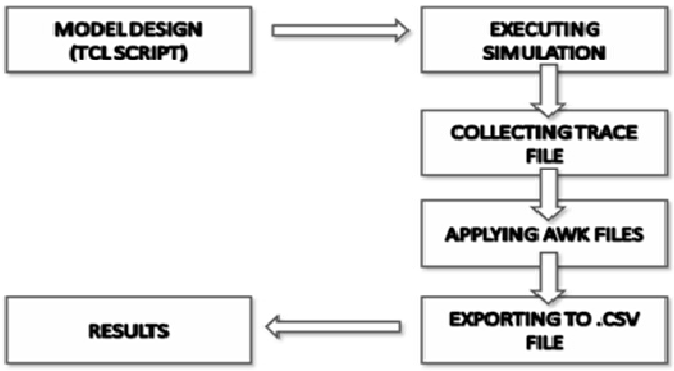

Figure 1. Simulation Sequence

3. Results and Analysis

This section presents the simulation results in graphical form and observations drawn from these results.

3.1. Average end to end delay

The average end-to-end delay is defined as the time taken for a data packet to be transmitted across a MANET from source to destination (receive time – sent time) / total number of data packets received [12]. Keeping all parameters constant, we extended network size by increasing the number of nodes from 20 till 60 in increments. It is observed that the average end-to-end delay remains constantly low in AODV as compared to DSDV with the most delay being seen for large network size. Although performance of DSDV improves with increasing network size but AODV still performs better. The trend however shows that with even larger network size DSDV can compare well with AODV.

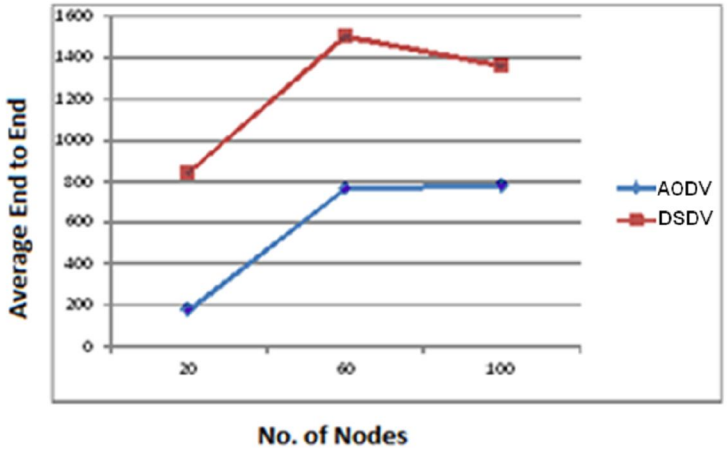

Figure 2. Average End to End delay vs. No of Nodes

3.2. Normalized routing load

Normalized routing load is defined as the total number of routing packets transmitted per data packet and is estimated by dividing the total number of routing packets sent by the total number of data packets received [12]. The Normalized Routing Load is observed to be much lesser in AODV as compared to DSDV. This means that in DSDV half of the packets that are sent are actually received.

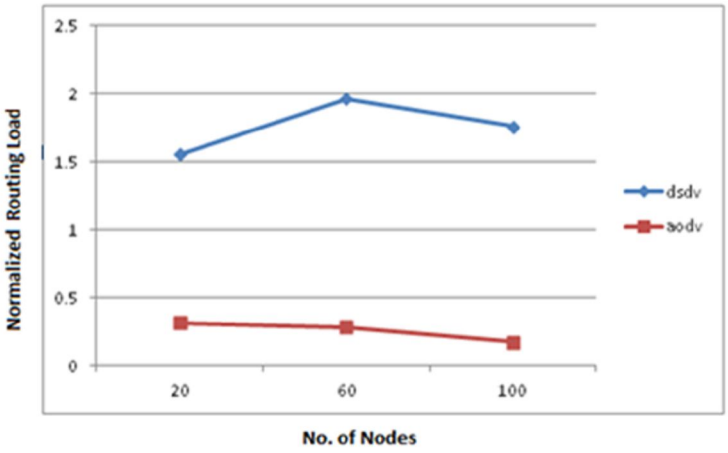

Figure 3. Normalized Routing Load vs. No of Nodes

3.3. Throughput

It is defined as the total number of useful packets received at all the destination nodes in a certain time, measured in kilo bits per second (kb/s). Even though the results are very close to each other AODV manages to have a higher throughput than DSDV. Also the trend shows better AODV performance as network size grows large.

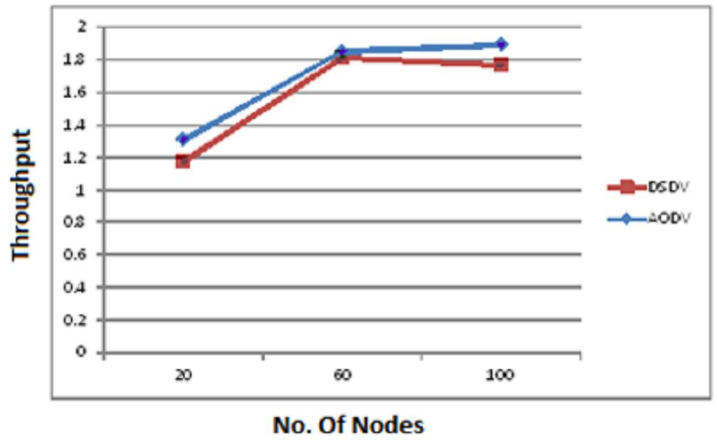

Figure 4. Throughput vs. No of Nodes

4. Conclusion

This paper presents the performance evaluation of two most important routing protocols namely AODV and DSDV in mobile ad hoc networks. The focus of this evaluation is average delay, routing load and throughput. Through NS2 simulations we observe that the performance of these protocols is related to the network size with AODV giving better throughput in large sized networks while DSDV gives better results in terms of delay. In future we plan to propose modification in these protocols in order to adapt them to the requirements of ad hoc networks.

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