Effect of Traffic Type on the Performance of Table Driven and On Demand Routing Protocols of MANET

Patil V.P.
Smt. Indira Gandhi College of Engineering, New Mumbai, India.

Abstract:
An ad hoc network is a collection of mobile nodes that dynamically form a temporary network. Routing in a MANET is challenging because of the dynamic topology and the lack of an existing fixed infrastructure. In such a scenario a mobile host can act as both a host and a router forwarding packets for other mobile nodes in the network. Routing protocols used in mobile ad hoc networks (MANET) must adapt to frequent or continual changes of topology, while simultaneously limiting the impact of tracking these changes on wireless resources. In his paper investigation has been done on the effect of change in number of nodes on MANET routing protocols. Here, it has been analyzed and compared the performance of MANET routing protocols AODV and DSDV based on both CBR and TCP based traffic patterns. The NS-2 simulator is used for performing various simulations. Simulation results show that Reactive protocols better in terms of packet delivery ratio and average end-to-end delay.

Keywords: AODV, CBR, DSDV, MANET, NS2, Proactive Routing, Reactive Routing, TCP.

I. Introduction

A MANET[1,2] consists of a number of mobile devices that come together to form a network as needed, without any support from any existing Internet infrastructure or any other kind of fixed stations. Formally, a MANET can be defined as an autonomous system of nodes or MSs also serving as routers connected by wireless links, the union of which forms a communication network modeled in the form of an arbitrary communication graph. In such environment, Neighbor nodes communicate directly with each other's while communication between non-neighbor nodes performed via the intermediate nodes which act as routers. As the network topology changes frequently because of node mobility and power limitations, efficient routing protocols are necessary to organize and maintain communication between the nodes.

MANETs have several salient characteristics: i) Dynamic topologies ii) Bandwidth constrained, variable capacity links, iii) Energy-constrained operation and limited physical security etc. Therefore the routing protocols used in ordinary wired networks are not well suited for this kind of dynamic environment. In this paper an effort has been done to evaluate the routing performance of AODV and DSDV using Network Simulator NS2 and results have been analyzed.

The rest of the paper is organized as follows: Section II presents the mobile ad hoc routing protocols. Section III provides an overview and general comparison of the routing protocols used in the study. The related work is described in section IV. The simulation environment and performance metrics are described in Section V and then the results are presented in Section VI. Section VII concludes the paper.

II. Routing Protocols

Routing protocols for Mobile ad hoc networks can be broadly classified into two main categories:
1) Proactive or table-driven routing protocols
2) Reactive or on-demand routing protocols.
3) Hybrid routing protocols

2.1. On-Demand Routing Protocols (Reactive)

Reactive routing protocols [3], [4] try to utilize network bandwidth by creating routes only when desired by the source node. Once a route has been established, it is maintained by some route maintenance mechanism as long as it is needed by the source node. When a source node needs to send data packets to some destination, it checks its route table to determine whether it has a valid route. If no route exists, it performs a route discovery procedure to find a path to the destination. Hence, route discovery becomes on-demand. These routing approaches are well known as Reactive routing. Examples of reactive (also called on-demand) ad hoc network routing protocols include ad hoc on-demand distance vector (AODV), temporally ordered routing algorithm (TORA), dynamic source routing (DSR)[5].

2.2. Table Driven Routing Protocols (Proactive)

In proactive or table-driven routing protocols, each node continuously maintains up-to-date routes to every other node in the network. Routing information is periodically transmitted throughout the network in order to maintain routing table consistency. Thus, if a route has already existed before traffic arrives, transmission occurs without delay. Otherwise, traffic packets should wait in queue until the node receives routing information corresponding to its destination. However, for highly dynamic network topology, the proactive schemes require a significant amount of resources to keep routing information up-to-date and reliable. Certain proactive routing protocols are Destination-Sequenced Distance Vector (DSDV) [9], Wireless Routing Protocol (WRP) [10, 11], Global State Routing (GSR) [11] and Cluster head Gateway Switch Routing (CGSR) [11].

2.3 Hybrid Protocols

Hybrid protocols are the combinations of reactive and proactive protocols and takes advantages of these two protocols and as a result, routes are found quickly in the routing zone. Example Protocol**:** ZRP (Zone Routing Protocol), GPSR (Greedy perimeter stateless routing).

Iii. Overview of Aodv, Dsdv Routing Protocols and Traffic Pattern Types

Every routing protocol has its own merits and demerits, none of them can be claimed as absolutely better than others. In this paper the two reactive routing protocols – AODV, DSDV has been selected for evaluation.

3.1. Ad hoc On-demand Distance Vector Routing (AODV)

Ad-hoc On-demand distance vector (AODV) [12, 13] is another variant of classical distance vector routing algorithm, a confluence of both DSDV [9] and DSR [14]. It shares DSR's on-demand characteristics hence discovers routes whenever it is needed via a similar route discovery process. However, AODV adopts traditional routing tables; one entry per destination which is in contrast to DSR that maintains multiple route cache entries for each destination. The initial design of AODV is undertaken after the experience with DSDV routing algorithm. Like DSDV, AODV provides loop free routes while repairing link breakages but unlike DSDV, it doesn't require global periodic routing advertisements. AODV also has other significant features. Whenever a route is available from source to destination, it does not add any overhead to the packets. However, route discovery process is only initiated when routes are not used and/or they expired and consequently discarded. This strategy reduces the effects of stale routes as well as the need for route maintenance for unused routes. Another distinguishing feature of AODV is the ability to provide unicast, multicast and broadcast communication. AODV uses a broadcast route discovery algorithm and then the unicast route reply massage.

3.2 Destination-Sequenced Distance Vector (DSDV)

Destination-Sequenced Distance Vector (DSDV) [6] is a hop-by-hop distance vector protocol based on the classical Bellman-Ford mechanism. In DSDV, each node maintains a routing table which contains an entry for destination node in the network. The routing table contains entries such as the next hop address, metric or the number of hop counts, and the sequence number. Sequence numbers are assigned by destination node for identification of the routes. DSDV tags each route with a sequence number and considers a route X more favorable than Y if X has a greater sequence number, or if the two routes have equal sequence numbers but X has a lower metric. This was done so that the routing tables have the latest updated path. The sequence number for a route is updated every time a new route discovery is initiated. When a broken link is encountered, the sequence number is set to infinity and it is broadcasted to all the nodes so that the routing tables of the node containing the broken link can be updated to infinity and the link is discarded. The sequence number of every route is assigned by the destination and it is incremented for every route discovery operation. Thus in case of mobile ad-hoc networks, the sequence numbers enable DSDV to maintain up to date routing information at the nodes ensuring the consistency of routing data across all routing tables. Both periodic and triggered route updates are initiated by DSDV to maintain consistency of routing information. In case of periodic updates, fresh route discovery operations are initiated after the elapse of fixed interval of time. Triggered route updates are initiated whenever a node encounters a broken link which can be a result of sudden network topology change or communication link failure.

3.3 Traffic type:

There are two types of traffic patterns used in this paper a) TCP and b) UDP (CBR)

A) Transmission Control Protocol (TCP)

It is often referred to as TCP/IP due to the importance of this protocol in the Internet Protocol Suite. TCP operates at a higher level, concerned only with the two end systems, (e.g. between web browser and a web server). TCP provides reliable, sequential delivery of a stream of data from one program on one computer to another program on another computer. Common uses of **TCP** are e-mailing support, file transfer, Web applications. Among its features, TCP controls message size, the rate at which messages are exchanged, and network traffic congestion. As for **IP**, it handles lower-level transmissions from computer to computer as a message transferred across the Internet.

B) User Datagram Protocol (UDP)

It is part of the base protocols of the Internet Protocol Suite. Programs on networked computers can send short messages sometimes called datagrams. UDP does not guarantee any reliability (it happens that datagram may be out of order, duplicated, or goes missing without any notice). The fact that no checking whether all packets are actually delivered is made, UDP proves to be faster and more efficient, for applications that do not need guaranteed delivery. UDP find its uses in situations like Time-sensitive applications where the problems due to delayed packets are avoided and It is also useful for servers that answer small queries from huge numbers of clients. UDP supports packet broadcast (conveys to all on local network) and multicasting (conveys to all subscribers).

IV. Related Work

Several researchers have done the qualitative and quantitative analysis of Ad-hoc Routing Protocols by means of different performance metrics. They have used different simulators for this purpose. Broch et al. [19], conducted experiments with DSDV, TORA, DSR and AODV. They used a constant network size of 50 nodes, 10 to 30 traffic sources, seven different pause times and various movement patterns. Packet delivery fraction (PDF), number of routing packets and distribution of path lengths were used as performance metrics. They extended *ns-2* discrete event simulator [20], developed by the University of California at Berkeley and the VINT project [21], to correctly model the MAC and physical-layer behavior of the IEEE 802.11 wireless LAN standard. Ehsan and Uzmi [22], presented the performance comparison of DSDV, AODV, DSR and TORA based on simulations performed using network simulator-2. Three metrics: normalized routing overhead, packet delivery fraction and average end to end delay, were used to measure performance. Karthikeyan et al. [23] studied the Reactive protocols, DSR and AODV as well as a Proactive Protocol, DSDV and their characteristics with respect to different mobility were analyzed based on packet delivery fraction, routing load, end to-end delay, number of packets dropped, throughput and jitter using Network Simulator (ns-2). However, in all the cases, only CBR sources were used for generating traffic.

Performance comparison of AODV and DSR routing protocols in a constrained situation is done in [24]. The authors claim that the AODV outperforms DSR in normal situation but in the constrained situation DSR out performs AODV, where the degradation is as severe as 30% in AODV whereas DSR degrades marginally as 10%.Ahmed and Alam [25] compare three routing protocols (DSR, AODV, and TORA) through simulations conducted with a discrete-event simulator (OPNET Modeler 10.5 version).Simulation results indicate that under specific simulation parameters TORA presents a higher performance than AODV and DSR.

Perkins ET all [26] show the performance of two on demand routing protocols namely DSR and AODV. Though both AODV and DSR use on demand route discovery, they have different routing mechanics. The authors observe that for application oriented metrics such as delay, throughput DSR outperforms AODV when the numbers of nodes are smaller. AODV outperforms DSR when the number of nodes is very large. The authors do show that DSR consistently generate less routing load than AODV. In Kumar et al. [27], a comparison of the performance of two prominent on-demand reactive routing protocols for MANET (DSR and AODV) is presented, along with the traditional proactive DSDV protocol. In Rahman and Zukarnain [28] the performance comparison between three routing protocols, namely AODV, DSDV and an improvement of DSDV, is presented. The authors use three network metrics, namely packet delivery ration, end-to-end delay, and routing overhead.

V. Proposed Methodology and Performance Metrics

5.1 Problem formulation:

The research in this MANET area has continued with prominent studies on routing protocols such as Ad hoc On-demand Distance Vector (AODV), Destination-Sequenced Distance-Vector Routing protocol, (DSDV) and Dynamic Source Routing Protocol (DSR). Several studies have been done on the performance evaluation of routing protocols based on CBR traffic pattern using different evaluation methods. Different methods and simulation environments give different results and consequently, there is need to broaden the spectrum to account for effects not taken into consideration in a particular environment. It is observed that most of the research work is based on CBR traffic pattern whereas most of the traffic approximately 95% on the Internet carries TCP. It is desirable to study and investigate the Performance of different MANET routing protocols under both CBR and TCP traffic patterns. In this paper, we will evaluate the performance of Reactive protocols (AODV) and Proactive protocols (DSDV) of mobile ad-hoc network routing protocols for both CBR and TCP traffic patterns. The performance of these routing protocols is evaluated with respect to various parameters such as average end-to-end delay, throughput and packet delivery ratio.

5.2 Performance metrics:

Design and performance analysis of routing protocols used for mobile ad hoc network (MANET) is currently an active area of research. To judge the merit of a routing protocol, one needs metrics both- qualitative and quantitative- with which to measure its suitability and performance. Specifically, this paper evaluates the performance comparison of AODV and DSDV routing protocols. The following performance metrics are used to compare the performance of these routing protocols in the simulation:

a) Packet Delivery Ratio

Packet delivery ratio is calculated by dividing the number of packets received by the destination through the number of packets originated by the application layer of the source. It specifies the

packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the more complete and correct is the routing protocol.

b) Average End-To-End Delay

Average End-to-End delay (seconds) is the average time it takes a data packet to reach the destination. This metric is calculated by subtracting time at which first packet was transmitted by source from time at which first data packet arrived to destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times. This metric is significant in understanding the delay introduced by path discovery.

c) Throughput

The throughput of the protocols can be defined as percentage of the packets received by the destination among the packets sent by the source. It is the amount of data per time unit that is delivered from one node to another via a communication link. The throughput is measured in bits per second (bit/s or bps).

VI. Simulation, Results and Performance Analysis

6.1 Simulations

In this paper, two different scenarios have been taken. In the first scenario, traffic pattern is taken as CBR and no. of nodes have been varied and performance comparison has been made between AODV and DSDV protocols. In the second scenario, traffic pattern is taken as TCP and no. of nodes have been varied and a performance comparison has been made between AODV and DSDV protocols. Identical mobility pattern are used across protocols to gather fair results.

6.1.1 Test Scenario 1

In the first scenario, the simulation based on TCP traffic pattern is selected. Parameters of this scenario are summarized in table 1. Here, TCP sources are used which use flow control and retransmission feature.

6.1.2 Test case Scenario 2

In the second scenario, the simulation based on CBR traffic pattern has been chosen. Parameters of this scenario are summarized in table 2. CBR sources are used that started at different times to get a general view of how routing protocol behaves.

6.2 Results and performance comparison

Performance of AODV and DSDV protocols is evaluated under both CBR and TCP traffic pattern. Extensive Simulation is done by using NS-2.

Table 1: Simulation Parameters for Test Case of TCP

PARAMETERS	VALUES
No. Of Nodes	25, 50,75, 100
Simulation Time	50 Seconds
Environment Size	1000x1000
Simulation Speed	20 m/sec
Pause Time	5 Seconds
Packet Size	512 bytes
Packet Rate	4 pkts/sec
Traffic Type	TCP
Simulator type	NS2 -2.34

Table 2: Simulation Parameters for Test Case of UDP (CBR)

PARAMETERS	**VALUES**
No. Of Nodes	25, 50,75, 100
Simulation Time	50 Seconds
Environment Size	1000x1000
Simulation Speed	20 m/sec
Pause Time	5 Seconds
Packet Size	512 bytes
Packet Rate	4 pkts/sec
Traffic Type	UDP (CBR)
Simulator type	NS2 -2.34

6.2.1 Throughput

As it can be seen in case of CBR traffic pattern that throughput of AODV protocol is better than as compared to DSDV protocols. In case of CBR traffic, throughput remains almost constant for these two protocols irrespective of number of nodes. In case of TCP traffic, throughput changes rapidly with respect to change in the number of nodes. This is shown in fig 1 and 2.

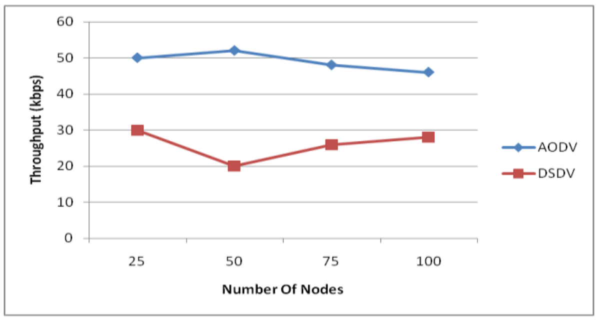

Figure 1: Throughput for CBR Traffic Pattern

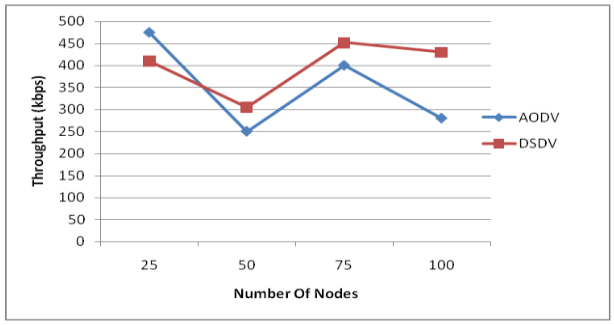

Figure 2: Throughput for TCP Traffic Pattern

6.2.2 Average end-to-end Delay

It is seen that Average end-to-end Delay of proactive routing protocols (DSDV) is less as compared to reactive routing protocol (AODV) in any kind of traffic pattern i.e. either CBR (Figure 3) or TCP (Figure 4). Average end-to-end Delay is also remains almost constant in DSDV whereas it varies in the case of AODV protocol with respect to change in number of nodes.

6.2.3 Packet Delivery Ratio

It is observed that in case of CBR traffic Reactive protocols deliver almost all the originated data packets converging to 100% delivery whereas Proactive protocols (DSDV) Packet Delivery Ratio is approx 50% (Figure 5). Reactive protocols perform better than the proactive protocols in case of CBR traffic pattern. In the case of TCP traffic pattern (Figure 6), Packet delivery ratio of AODV protocols remains almost constant whereas it changes rapidly for DSDV protocol irrespective of the network load.

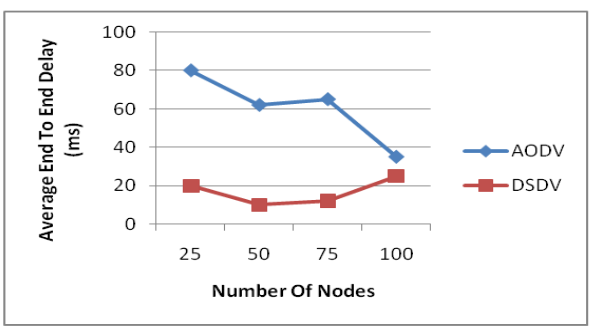

Figure 3: Average End to End Delay for CBR Traffic.

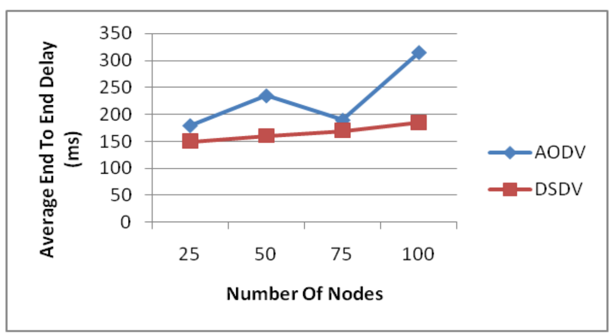

Figure 4: Average End to End Delay TCP Traffic

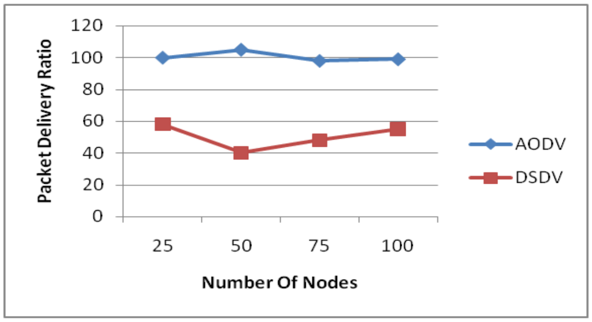

Figure 5: Packet Delivery Ratio for CBR Traffic Pattern.

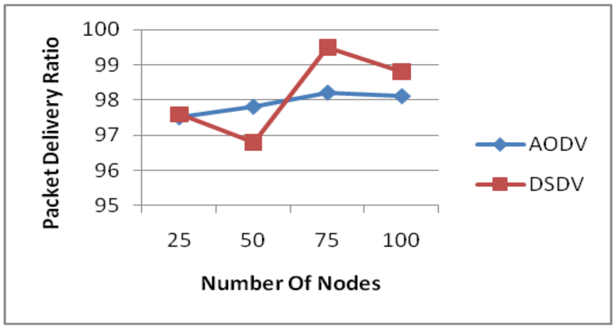

Figure 6: Packet Delivery Ratio for TCP Traffic Pattern

VII. Conclusion

This study was conducted to evaluate the performance of two MANET protocols i.e. AODV, and DSDV based on CMU's generated TCP & CBR traffic. These routing protocols were compared in terms of Packet delivery ratio, Average end-to-end delay, and throughput when subjected to change in no. of nodes & traffic type. In this paper, evaluation of the routing protocols, unlike previous works of similar nature, brings out the effect of routing protocols on the TCP performance. Through experiments, first the essential differences between TCP and UDP traffic and therefore need to consider TCP traffic for routing protocol performance evaluation. Based on these experiments three performance metrics i.e. Packet delivery ratio, Average end-to-end delay, and throughput were measured for quantifying the performance of the protocols. Simulation results show that Reactive protocols better in terms of packet delivery ratio and average end-to-end delay. Performance can also be analyzed for other parameters like Jitter, Routing Overhead. By evaluating the performance of these protocols new protocols can be implemented or changes can be suggested in the earlier protocols to improve the performance.

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AUTHOR

Er. PATIL V.P. is currently working as a faculty member in Electronics and Telecommunication Engineering department in Smt. Indira Gandhi college of Engineering, New Mumbai. He is graduate in B.E. and post graduate in M.TECH (ELECTRONICS DESIGN AND TECHNOLOGY) .He is having 25 years of experience in teaching in engineering colleges. His area of research is in computer communication networking and microwave engineering.