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PERFORMANCE ANALYSIS OF ROUTING PROTOCOLS FOR CBR TRAFFIC IN MOBILE AD-HOC NETWORKS

Md. Ashek Raihan Mahmud[1] --- **Md. Mahbubur Rahman**[2] --- **Md. Sipon Miah**[3]†
[1,2,3]*Department of Information and Communication Engineering, Islamic University, Kushtia, Bangladesh*

ABSTRACT

This paper presents the comparative performance analysis of Ad-Hoc routing protocols: Destination-sequenced distance vector (DSDV), Dynamic source routing (DSR) and Ad hoc on-demand distance vector (AODV) based on constant bit rate (CBR) traffic patterns. Simulation results show that firstly, the UDP throughput for DSR routing protocol is largest among the others. Secondly, the routing overload of DSDV and AODV is higher than DSR. Finally, DSDV shows the lowest end-to-end delay for UDP transmission than AODV and DSR.

Keywords: MANET, DSDV, DSR, AODV, CBR, End-to-end delay, Routing overhead, Throughput.

Contribution/ Originality

The paper's primary contribution is finding that among the three protocols analyzed which routing protocol performs better in given circumstances.

1. INTRODUCTION

Internet Technology and Mobile Communication are a part and parcel of modern society. Due to recent technological advances in network infrastructures, laptop computers and wireless communication device, mobile computing has enjoyed a great improvement and enhancement. The mobile and computing devices are not only getting smaller, cheaper, more convenient and more powerful, they also run more applications and network services. Although infrastructure-based networks provide a great way for mobile devices to get network services, there are situations in which user-required infrastructure is not cost-effective, not available, cannot be installed, or cannot be installed in time in a given geographic area. Providing the needed connectivity and network services combined with significant advances in technology, requires new alternative ways to deliver connectivity is gaining increased attention in recent years. These are focused around having mobile devices within the transmission range connect to each other through automatic configuration, setting up an ad hoc mobile network that is both flexible and powerful. In this way, not only can mobile nodes communicate with each other, but also receive

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† Corresponding author

internet services through an internet gateway node, effectively extending both network and internet services to non infrastructure areas. Mobile ad-hoc network is an autonomous system of mobile nodes connected by wireless links where each node operates as an end system and a router for all other nodes in the network. The nodes are free to move and organize themselves in an arbitrary fashion.

Because nodes in Mobile Ad-hoc Networks (MANETs) are forwarding packets for each other, some sort of routing protocols are necessary to make the routing decisions. The highly dynamic nature of ad hoc mobile networks results in frequent changes and unpredictability in network topologies, adding difficulty and complexity to routing among the mobile nodes within the network. These added challenges, coupled with the critical importance of routing protocols in establishing communication among mobile nodes, make the routing area, perhaps the most active research area within the MANET [1-5] domain. Especially over the last few years, numerous routing protocols and algorithms have been proposed and their performance under various network environments and traffic conditions are closely studied and compared. Although a number of studies under TCP have been conducted and protocol modifications have been suggested. Improving and analyzing UDP performance in MANETs is still an active area of research. In this research we worked with UDP/CBR traffic for measuring the performances of three routing protocols [6-9] used in mobile ad hoc networking.

In many literatures several performance evaluation of MANET routing protocols comparing TCP with UDP traffic have been presented [10-17] and solutions have been suggested to find compatibility when sharing common wireless media. Gupta, et al. [10] identified the factors affecting the TCP throughput in the presence of interacting UDP flows for both AODV and DSR. They found that the throughput of TCP degrades severely in the presence of UDP flows. They also proposed the use of per flow fairness through a mechanism called backpressure to increases the TCP throughput. Johansson, et al. [11] simulated AODV, DSR and OLSR protocols in different transmission control protocol scenarios for static, less dynamic and highly dynamic mobility conditions. AODV performs better generating low routing traffic overhead. In the case of TCP connection scenarios, DSR shows good performance in download response time and has low routing overhead. For UDP connection scenarios, OLSR maintained the demand for end-to-end delay, but generated larger traffic overhead. Milenko Petrovic and Aboelaze [12] observed the performance of TCP and UDP over IEEE 802.11 ad hoc network using string and mesh topology. Their work indicates that IEEE 802.11 as an ad hoc network is not very suitable for bulk transfer using TCP, it is much better for real-time audio. A larger network results in a much degraded performance for both TCP and UDP.

A comparative performance analysis of TCP and UDP over DSDV protocol in a Mobile Ad Hoc Network was made in Zahid Farman, et al. [13]; Sharma and Gupta [14]. Simulations showed that, TCP/FTP traffic outperforms UDP/CBR traffic for DSDV. They concluded that, throughput of UDP/CBR traffic over DSDV protocol is high in low mobility condition. But in highly mobile environments, the UDP performance degrades. Gundalwar and Chavan [15] evaluated the performances of AODV, AOMDV, DSR and DSDV routing protocols using NS-2

Simulator. They used energy level, Network throughput, End-to-end delay, packet loss ratio, and packet routing overhead as performance metrics. Observation shows that, AODV outperforms in energy conservation for both TCP and UDP traffic. AOMDV and AODV outperform in network throughput for TCP and UDP traffic respectively. DSDV shows low end-to-end delay, negligible loss of packets and routing overhead in UDP traffic.

Christian, et al. [16] have studied the effects on low rate multi-hop UDP flow and a competing TCP flow. The result shows that, TCP's congestion control does not seem efficient enough to have marginal impact on other traffic in the network. Singh, et al. [17] analyzed the performance of UDP over AODV & DSR in mobile ad hoc networks. The performance metrics includes throughput and end-to-end packet delay. It is observed from the results of simulation that, throughput of UDP traffic increases when the node number increases. The UDP throughput is largest over the DSR routing protocol. DSDV shows the lowest end-to-end packet delay for UDP transmission. In this paper, we tried to compare the performances of DSDV, AODV and DSR routing protocols for UDP packet transmission. We used throughput, end–to-end delay and routing overhead as performance metrics. We made a number of simulations for different scenarios to compare the protocol performances.

Rest of the paper is organized as section 1- illustrates the necessity and motivation of the research, section 2- briefly describes the routing protocols used in this research, section 3- gives the overview of the simulation environment, section 4- analyzes the results obtained and finally section 5- depicts the epilogue.

2. ROUTING PROTOCOLS USED

2.1. Destination-Sequenced Distance-Vector

Destination sequenced distance vector (DSDV) [7] routing is a table-driven routing protocol based on the classical distributed Bellman-Ford routing algorithm .The Improvement made here is the avoidance of routing loops in a mobile network of routers .Each node is the mobile network maintains a routing table in which all of the possible destinations within the non-partitioned network and the number of routing hops(in this case, number of radio hops) to each destination are recorded .Hence ,routing information is always made readily available ,regardless of whether the source node requires a route or not.A sequence numbering system is used to allow mobile hosts to distinguish stale routes form new ones. Routing table updates are sent periodically throughout the network to maintain table consistency. This can, therefore, generate a lot of control traffic in the network, rendering an inefficient utilization of network recourse. To alleviate this problem, DSDV uses two types of route update packets. The first is known as full dump. This type of packet carries all available routing information and can require multiple network protocol data units (NPDUs).During periods of occasional movement, these packets are transmitted infrequently. Smaller incremental packets are used to relay only information that has changed since the last full damp.

New route broadcasts will contain the address of the destination node, the number of hops to reach the destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to broadcast. The route labelled with the most recent sequence number (in increasing order) is always used. In the event that two updates have the same sequence number, the route with the smaller hop count is used.

2.2. Ad Hoc On-Demand Distance Vector (AODV)

AODV routing protocol [8] is an on demand routing protocol. Here routes are established when they are required. In the routing table of AODV, the station only has the information of the next hop and destination pair. Each node maintains a temporary routing table with an entry for each active route that contains: Destination IP address, destination sequence number, hop count (number of hop to the destination), next hop, list of precursors, and lifetime of the route. When a source node needs to send data packets to some destination, it checks its route table to determine whether it has a route. If no route exists, it performs a route discovery procedure to find a path to the destination. Hence, route discovery becomes on-demand. The benefit of this approach is that signalling overhead is likely to be reduced compared to proactive approaches, particularly in networks with low to moderate traffic loads. When the number of data sessions in the network becomes high, then the overhead generated by the route discoveries approaches, and may even surpass, that of the proactive approaches. The drawback to reactive approaches is the introduction of route acquisition latency. That is, when a route is needed by a source node, there is some finite latency while the route is discovered. In contrast, with a proactive approach, routes are typically available the moment they are needed. Hence, there is no delay to begin the data session.

2.3. Dynamic Source Routing Protocol (DSR)

The Dynamic Source Routing protocol [9] is similar to AODV in that it is a reactive routing protocol with a route discovery cycle for route finding. However, it has a few important differences. One of the primary characteristics of DSR protocol is that, it uses source routing. It means that the source station knows the whole route to the destination. A complete list of intermediate stations to the destination kept in the header of each data packet. Instead of maintaining a route table for tracking, routing information, DSR utilizes a route cache. The cache allows multiple route entries to be maintained per destination, thereby enabling multipath routing. When one route to a destination breaks, the source can utilize alternate routes from the route cache, if they are available, to prevent another route discovery. Similarly, hen a link break in a route occurs, the node upstream of the break can perform route salvaging, whereby it utilizes a different route from its route cache, if one is available, to repair the route. However, even when route salvaging is performed, a RERR message must still be sent to the source to inform it of the break. Other characteristics that distinguish DSR from other reactive routing protocols include the fact that DSR's route cache entries need not have lifetimes. Once a route is laced in the route cache, it can remain there until it breaks.

3. SIMULATION ENVIRONMENT

In this section, mobility pattern, movement scenarios and traffic model are described in Table 1.

Table-1. Mobility pattern, movement scenarios and traffic model

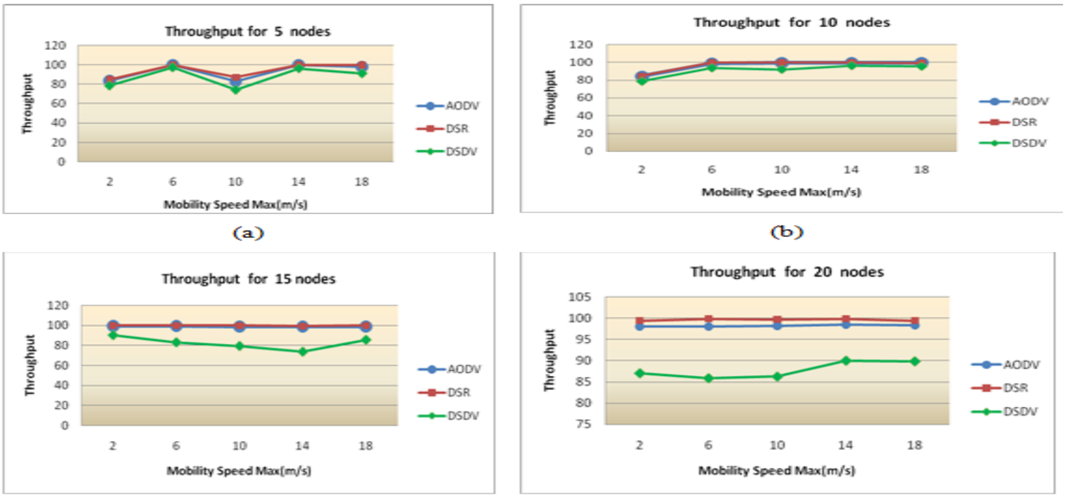
Routing protocols	**DSDV, DSR and AODV**
Network Simulator	NS2
Topology Area	500*500 square meter flat grid
Number of Nodes	5, 10, 15, 20
Speed of Nodes	2, 6, 10, 14 and 18 m/s
Simulation Time	200s
Data Packet Size	512 Bytes (fixed)
Packet Transmission Rate	4 Packets per second
Mobility Pattern	Random
Traffic Source	Constant Bit Rate (CBR)

4. SIMULATION RESULTS ANALYSIS

4.1. Throughput

A network's end-to-end throughput is a measure of the network's successful transmission rate, and is usually defined as the number of data packets successfully delivered to their final destination per unit of time. Throughput/Packet Delivery Ratio (PDR) measures the protocol performance in the network and this performance may depend on factors such as packet size, network load, as well as the effects of frequent topological changes.

In the figure 1, the packet delivery fractions are plotted at different speeds to see how the throughput varies for different network scenarios.



(c) (d)

Figure-1. Throughput of AODV, DSDV and DSR under UDP for 5, 10, 15 and 20 nodes with the speed of 2 m/s, 6 m/s, 10 m/s, 14 m/s and 18 m/s respectively

From figure 1(a), 1(b), 1(c) and 1(d) it is seen that UDP performance under DSR is best for all network scenarios. Because of both being on demand protocols the performance of DSR and AODV are almost same. When they need to send data then only at that time they have to connection establishment. So there is less routing overload. But the UDP performance under DSDV is low since a stale routing table entry causes data packets to be forwarded over a broken link. DSDV maintains only one route per destination, so each packet that the MAC layer is unable to deliver is dropped due to the lack of alternate routes.

Here is an important thing to be noticed from figure 1 that for every protocols, except some inconsistency in the case of DSDV, throughput increases when the number of nodes increases as the topology becomes dense the connectivity is rich.

4.2. Average End-to-End Delay Performance

An end-to-end delay is the time it takes for a packet to travel through the network from source to destination. Calculation of the average end-to-end delay 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. The average end-to-end delay is the summation of all end-to-end delays divided by total data packets arrived at destination node.

In the figure 2, the end-to-end delay is plotted at different speeds to see how the throughput varies for different network scenarios.

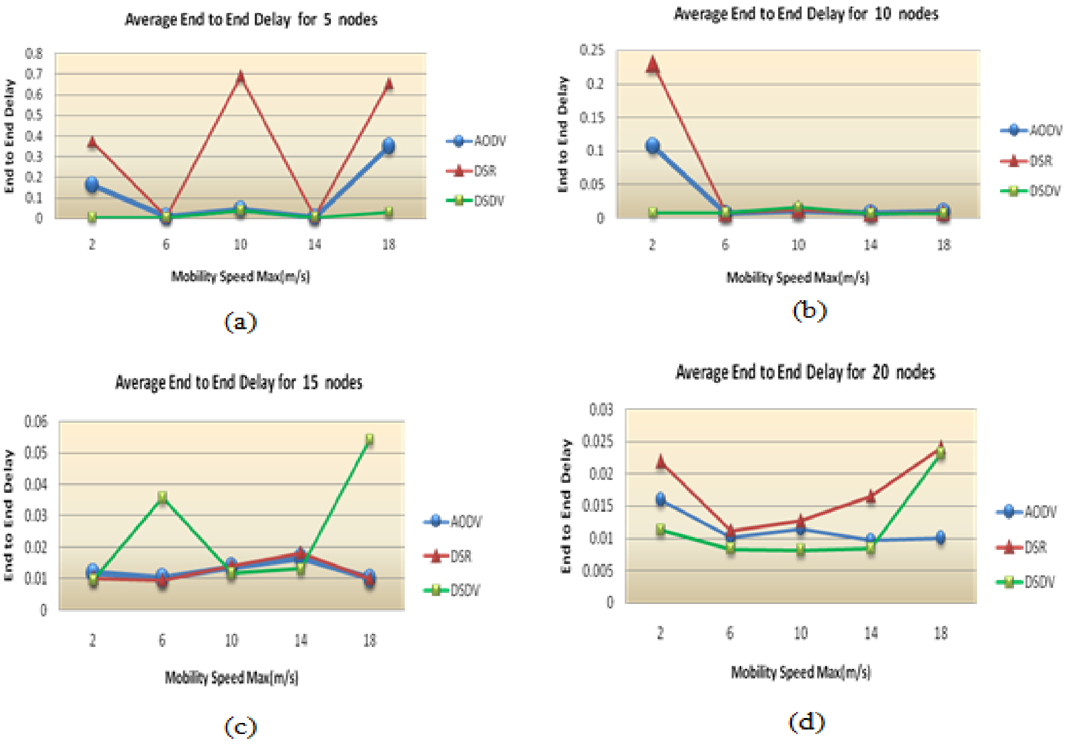


Figure-2. Average end- to-end delay of AODV, DSDV and DSR under UDP for 5, 10, 15 and 20 nodes with the speed of 2 m/s, 6 m/s, 10 m/s, 14 m/s and 18 m/s respectively

In figures 2(a), 2(b), 2(c) and 2(d), except a few inconsistencies, DSDV shows the lowest end-to-end packet delay for UDP transmission. This is because when a node needs to establish a route, it requires route discovery process under AODV and DSR protocols rather than finding the route in its routing table as DSDV. It is also observed that, AODV has less end-to-end delay than DSR.

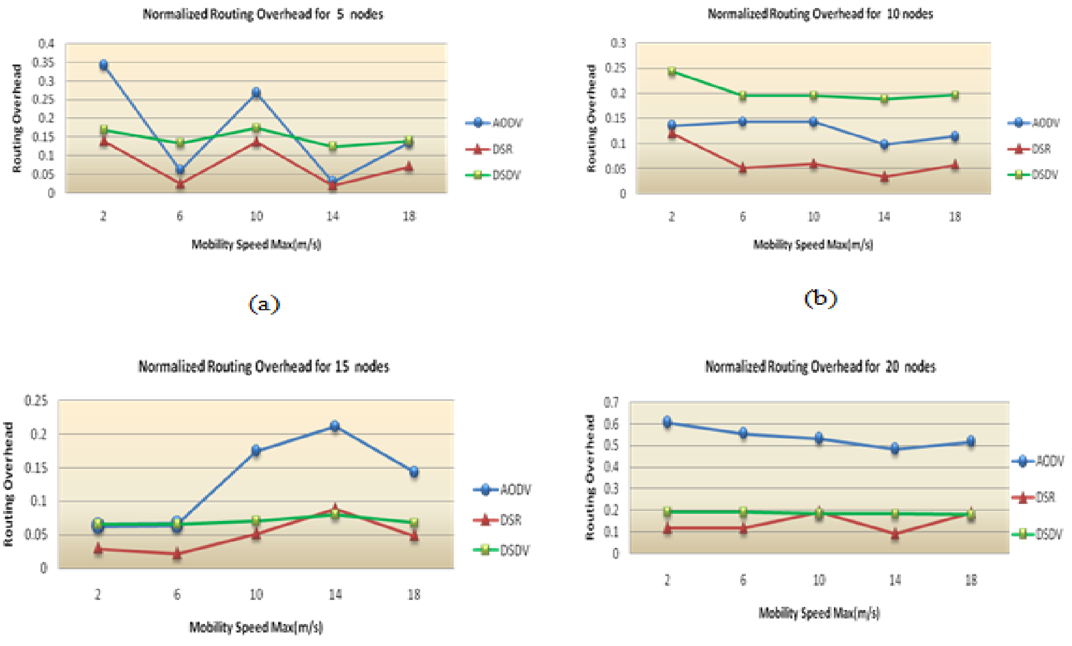
This is directly proportional to the number of route breaks due to the frequency of route discoveries in AODV but in DSR the large number of replies received in response is associated with high MAC overhead and cause increased interference to data traffic.

It can be concluded from figure 2 that, for DSR the delay is much more than AODV and DSDV with an increased number of sources and high mobility. Because of high mobility there are more link failures therefore there are more route discoveries. DSR and AODV takes more time during the route discovery process as first it finds the route hop by hop and then it gets back to the source by back tracking that route. Where as in the case of DSDV delay decreases with the increase of mobility and number of sources.

4.3. Normalized Routing Overload Performance

Normalized Routing Load is the ratio between the total number of routing packets and the total number of successfully delivered packets. For packets sent over multiple hops, each transmission of the packet (each hop) counts as one.

The routing Overload graphs shown in this section are based on total number of routing packets sent by the network layer during the course of the simulation.



(a) (b)

(c) (d)

Figure-3. Normalized routing overload of AODV, DSDV and DSR under UDP with 5, 10, 15 and 20 nodes at the speed of 2 m/s, 6 m/s, 10 m/s, 14 m/s and 18 m/s respectively

The protocols impose different amounts of routing overload, as shown in the graph. From figure 3(a) and 3(b) for 5 and 10 nodes network scenarios the routing overhead of DSDV is high. From figure 3(c) and 3(d) for 16 and 20 nodes network scenarios the routing overhead of AODV is high. This is because AODV is on-demand routing protocols, so as the number of sources increases, it has to sent more routing packets due to there are more destinations to which the network must maintain working routes i.e. for available nodes it has to send more routing packets to establish various routes.

From figure 3 it can be observed that DSR has the least routing overload among the three at all times and the routing overload increases slightly as the number of nodes increases. The routing overload of DSR is almost zero at minimum speed. This is because once a rout discovery process is completed; there is no need to perform the discovery process again. The routing overload for DSDV is large due to it has to periodic broadcast to contain all information about all network nodes.

The table 2 shows a numerical comparison of the three protocols, where it is ranked "1" for the best up to "3" for the worst.

Table-2. Numerical comparison of the three routing protocols

Metrics	AODV	DSR	DSDV
Delay	2	3	1
Routing Overload	3	1	2
Throughput	2	1	3

5. CONCLUSIONS

It is observed from the simulation results for four network scenarios that UDP throughput for DSR routing protocol is largest among the others. The routing overload of DSDV and AODV is higher than DSR because for its periodic broadcasting to collect information in routing tables. DSDV shows the lowest end-to-end delay for UDP transmission than AODV and DSR.

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