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TCP Traffic Based Performance Investigations of MANET Routing Protocols Using NS2.35

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Abstract An Ad-hoc network is a dynamically changing network of mobile devices that communicate without the support of a fixed structure. TCP is a connection oriented transport protocol that provides reliable, in-order delivery of data to the TCP receiver. Hence, its use over Mobile Ad-Hoc networks is a certainty. This paper does the comprehensive investigations on routing protocols Dynamic Source Routing (DSR), Ad-hoc On demand distance vector (AODV) and Destination-Sequenced Distance-Vector (DSDV) using ns2 simulator considering TCP as transport protocol and FTP as traffic generator. Simulation results indicate that the performance of proactive routing protocol DSDV is far better than reactive routing protocols. DSR which uses source routing is the best among reactive routing protocols. It is observed that TCP is not appropriate transport protocol for highly mobile multihop wireless networks because TCP protocol is unable to manage efficiently the effects of mobility.

Keywords: Ad-hoc Networks, AODV, DSDV, DSR, NS-2, TCP.

1. Introduction

With the ever increasing demand for connectivity the need for mobile wireless communication is inevitable. Most of the portable communication devices like portable laptops and hand held devices have the support of a fixed base station or access point that corresponds to the last-hop-wireless model. This trend can be observed in wide-area wireless cellular systems. However, such a support is not available in settings where access to a wired infrastructure is not possible. Situations like natural disasters, conferences and military settings are noteworthy in this regard. This has led to the development of Mobile Ad-hoc Networks [1].

An Ad hoc network is a dynamically changing network of mobile devices that communicate without the support of a fixed structure. There is a direct communication among neighboring devices but communication between non-neighboring devices requires a routing algorithm. Many different protocols have been proposed to solve the multi-hop routing problem in ad-hoc networks [2]. Such protocols are, traditionally, divided into two classes [1, 3]:

- Proactive routing protocols.
- Reactive routing protocols.

Proactive or Table-Driven routing protocols attempt to continuously determine the network connectivity so that route is already available when a packet needs to be forwarded. Example include Destination sequenced Distance Vector (DSDV) protocol [4]. The DSDV protocol requires each mobile station to advertise, to each of its current neighbors, its own routing table.

Reactive or On-Demand protocols employ a Just-In-Time (JIT) approach; this type of routing creates routes only when desired by the source node on demand. Examples include Dynamic Source Routing (DSR) protocol [5] and Ad hoc On Demand Distance Vector (AODV) protocol [6, 7]. It computes the routes when necessary explicitly lists this route in the packets header, identifying each forwarding hop by the address of the next node to which to transmit the packet on its way to the destination host.

TCP is a connection-oriented transport layer protocol that provides reliable, in-order delivery of data to the TCP receiver. It is the most widely used transport protocol for data services like file transfer, email and WWW browser. TCP was mainly developed to be deployed within wired networks.

The papers [8-12] did the comparison of routing protocols for ad-hoc networks considering only few characteristics that should be possessed by routing protocols and all consider UDP as transport protocol.

This paper is organized as follows. In Section 2 deals with simulation model. Section 3 presents the simulation results and conclusion is given in section 4.

2. Simulation Model

Our protocol evaluations are based on the simulation using NS-2 (NS 2.35). NS-2 is a discrete event simulator that simulates a variety of IP networks.

2.1 Simulation Environment

Simulation environment consists of 50 wireless nodes forming an ad-hoc network, moving about over a 670 X 670 meter flat space for 200 seconds of simulated time (Figure 1). Each run of the simulator accepts as input a scenario file that describes the exact motion of each node and the exact sequence of packets originated by each node, together with the exact time at which each change in motion or packet origination is to occur. In order to enable direct, fair comparisons between the protocols, protocols are simulated under identical loads and environmental conditions. We pre-generated number of different scenario files with varying movement patterns and traffic loads.

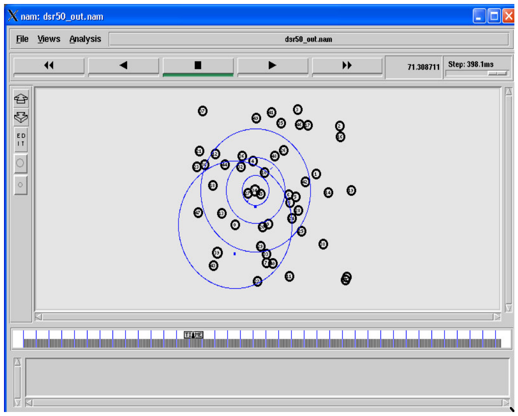

Figure 1: Simulation Environment consisting 50 wireless nodes forming an ad-hoc network

Nodes in the simulation move according to a model that we call the random waypoint model. The movement scenario files we used for each simulation are characterized by a pause time. Each node begins the simulation by remaining stationary for pause time seconds. It then selects a random destination in the 670 X 670 meter space and moves to that destination at a speed distributed uniformly between 0 and maximum speed. Upon reaching the destination, the node pauses again for pause time seconds, selects another destination, and proceeds there as previously described, repeating this behaviour for the duration of the simulation.

We run our simulations with movement patterns generated for 5 different pause times: 0, 50, 100, 150, 200 seconds. A pause time of 0 seconds corresponds to continuous motion, and a pause time of 200 seconds (the length of the simulation) corresponds to no motion. Table 1 provides the simulation parameters.

TABLE 1: TYPICAL SIMULATION PARAMETERS

Parameter	Value
Max Speed	20 meters/second
Simulation Time	200 seconds
Environment Size	670 meter x 670 meter
Packet Size	512 bytes
Traffic Type	TCP
Packet Rate	4 packets/second
Mobility model	Random Way Point

2.2 Performance Metrics

The key performance metrics chosen for comparing the protocols are throughput, packet delivery fraction, routing overheads, Average end-to-end delay and packets lost. Throughput is a measure of effectiveness of a protocol. Packet delivery fraction is a measure of efficiency of the protocol. To achieve a given level of data routing performance, two different protocols can use differing amounts of overhead, depending on their internal efficiency. Delay is an important metric which is very significant with multimedia and real-time traffic.

3. Results and Discussions

Simulations have been conducted with varying different network parameters in order to measure the performance of the protocols.

3.1 Varying Mobility

The simulation results bring out some important characteristic differences between the routing protocols.

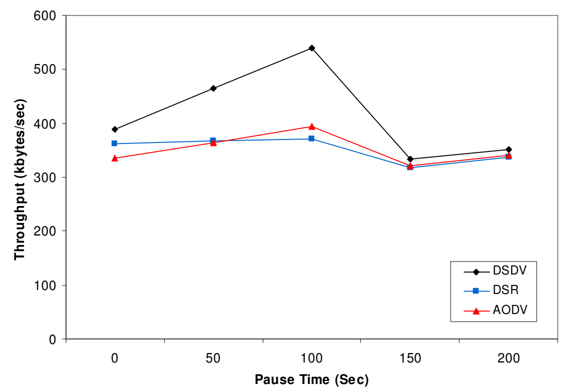

Figure 2: Throughput as a function of node mobility rate (pause time)

From the Figure 2, it can be inferred that DSDV throughput is far better than other protocols. Though proactive protocols are intrinsically not suitable for any mobile network because they involve periodic exchange of information resulting in consumption of energy of battery operated nodes; they are capable of maintaining a connection which is required for TCP traffic. Since DSR pre-computes the routes before sending the packets its packet delivery ratio is better than other protocols as shown in Figure 3. All the protocols deliver a greater percentage of the originated data packets when there is little node mobility (i.e., at large pause time), when there is no node motion. DSR perform particularly well, delivering over 98% of the data packets regardless of mobility rate.

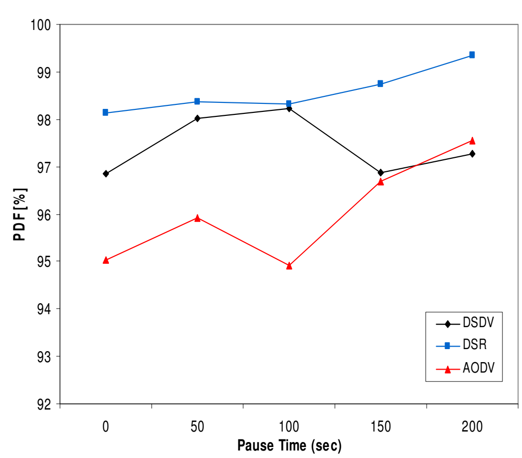

Figure 3: Packet Delivery Fraction as a function of node mobility rate (pause time)

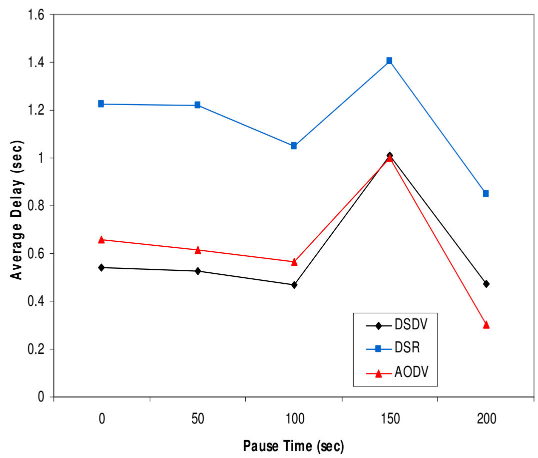

Figure 4: Average end-to-end delay as a function of node mobility rate (pause time)

The average packet delay increases with mobility for all protocols, as shown in Figure 4. However, DSR has a much higher delay of the order of 1.0 second than DSDV regardless of mobility rate due to the way routes are detected in DSR. DSDV exhibits a low delay less than 0.6 seconds because only packets belonging to valid routes at the sending instant get through.

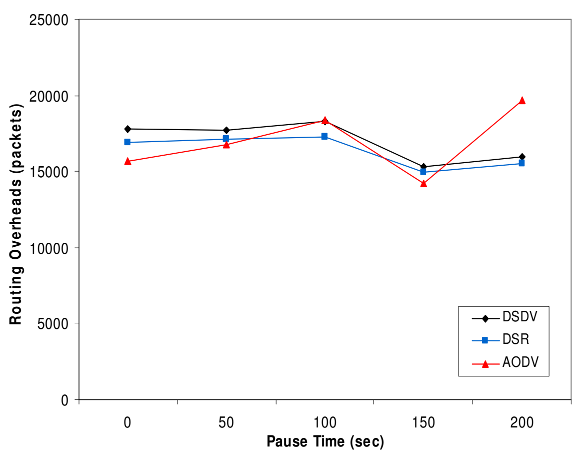

Figure 5: Routing overheads as a function of node mobility rate (pause time)

Routing overhead of all the protocols DSDV, AODV and DSR are significantly constant, as indicated in the Figure 5. DSDV is better than the other two protocols in dropping packets as indicated in Figure 6. DSDV, DSR and AODV show drop of 84, 432, 475 packets at lowest mobility i.e. at pause time of 200 seconds.

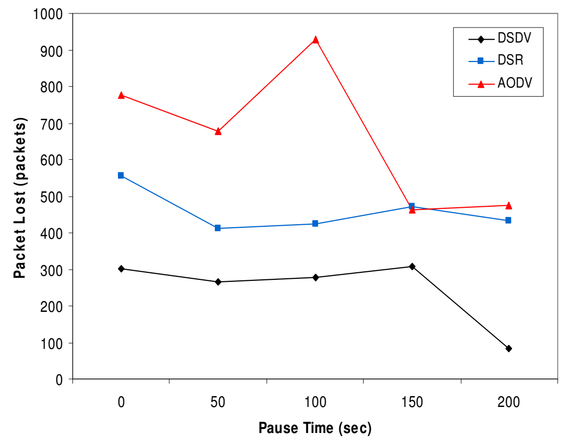

Figure 6: Packet Loss as a function of node mobility rate (pause time)

It is observed that TCP protocol is unable to manage efficiently the effects of mobility because TCP was mainly developed to be deployed within wired networks. Station movements in ad hoc networks may cause route failures and route changes and hence, packet losses and delayed ACKs. Unlike wired networks, where packet loss is mainly caused by network congestion, in MANETs there are many other reasons to lose a data packet. However, TCP considers that all packet losses are due to network congestion and activates the congestion control mechanism. Packet losses in MANETs can be either related to wireless communication environment (i.e. the effect of fading, interference, multipath routing, etc.) or to the dynamic nature of such networks (i.e. link failures, network partitioning). This latter could be due to the node mobility or to the node battery depletion. This could lead to frequent route re-computation within the network. This also leads to unnecessary retransmissions and throughput degradation. Thus, the impact of mobility on all the protocols is surprisingly not much significant.

3.2 Varying Scalability

Simulation are conducted by taking three different size networks of 25, 50 and 100 wireless nodes, generated for a pause time of 0 second.

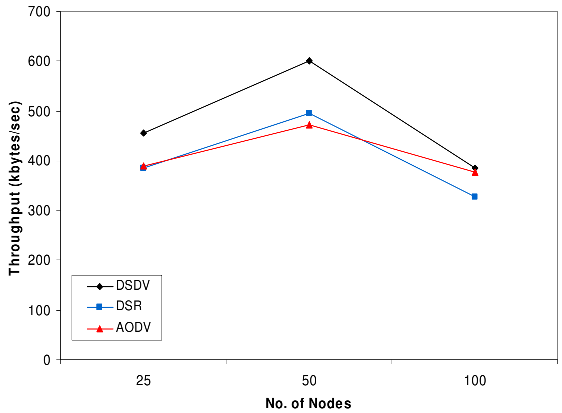

Figure 7: Throughput as a function of node density

Figure 7 shows that the throughput of DSDV (delivering 599 kbytes/second for the network of 50 nodes) is better than the other source routing protocols. It is observed that all the protocols gives best results for the network of 50 nodes. Throughput decreases for all protocols for other two networks of 25 and 100 nodes. AODV shows minimum throughput of the order of 471 kbyes/second for the network of 50 nodes.

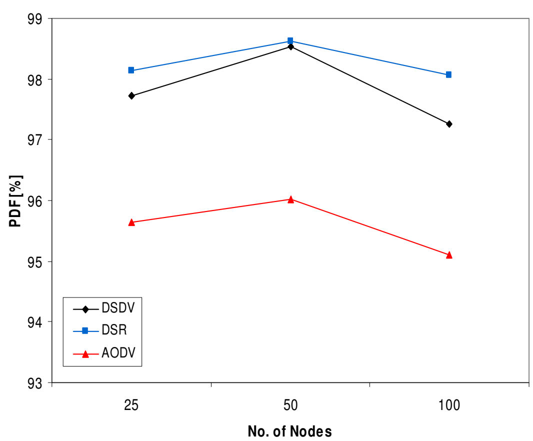

Figure 8: Packet Delivery Fraction as a function of node density

Since DSR is on-demand protocol, its packet delivery ratio is better than other protocols delivering more than 98% of the packets, as shown in Figure 8. Whereas AODV's performance is relatively poor when throughput and packet delivery ratio are considered as metrics because AODV is able to deliver 95-96% of the packets.

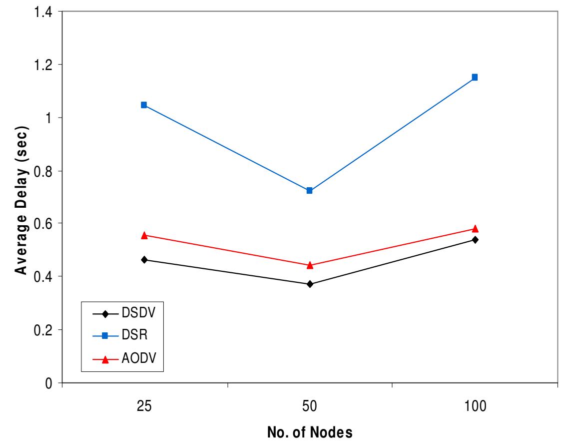

Figure 9: Average end-to-end delay as a function of node density

Since DSDV is a proactive routing protocol, it uses already established route and thus resulting in low average delay. Figure 9 shows minimum delay for DSDV varying between 0.3 to 0.5 seconds for the three networks. Whereas DSR due to its source routing introduces greater delay of the order of 1.0 second. It is observed that all the protocols introduce least delay in network of 50 nodes, thus giving best performance in the network containing 50 nodes.

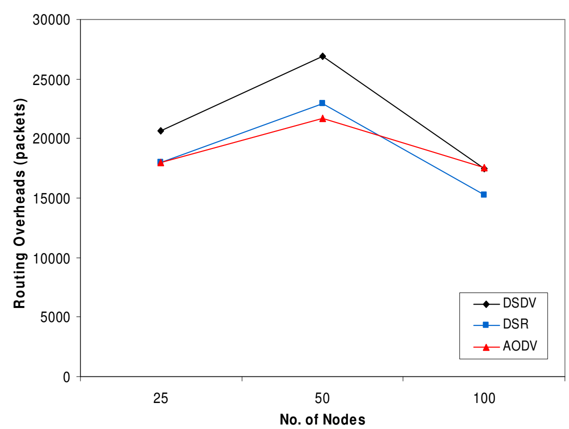

Figure 10: Routing overhead as a function of node density

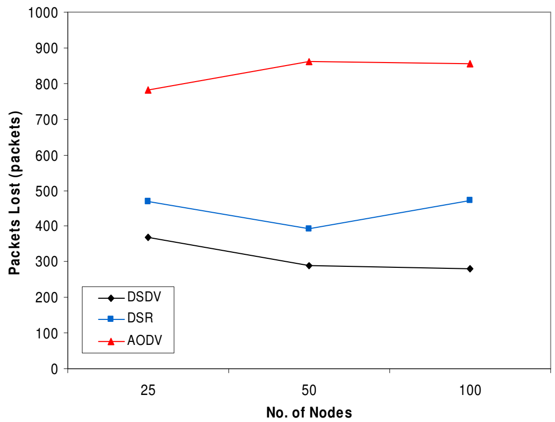

Figure 11: Packet lost as a function of node density

Routing overhead of DSDV is significantly greater than DSR and AODV, transmitting maximum 26920 packets for the network of 50 nodes, as indicated in the Figure 10. DSDV is better than other two protocols in dropping packets as indicated in Figure 11. DSDV shows least packet lost dropping 280 packets whereas source routing protocol AODV shows maximum packet drop dropping 854 packets for the network of 100 nodes.

3.3 Varying maximum speed

Mobility of the nodes basically shows how fast the nodes are moving. Simulations are conducted with movement patterns generated for 5 different maximum speeds: 1, 2, 5, 10, 20, and 50 metres/second. We have considered a wide range of speeds for our mobile nodes from 1 meter/second (3.6 kilometer/hour) that corresponds to walking at a slow pace, to 50 meters/second (180 kilometers/hour), the speed of a very fast car.

The variation of performance of all the protocols with speed is similar to the variation in performance with mobility as shown in Figures. DSDV performs better than all the remaining protocols. Figure 12 shows that the throughput of DSDV near about 400 kbytes/second, which is better than the other source routing protocols DSR and AODV which shows throughput between 300 kbyes/second to 393 kbytes/second.

Since DSR is on-demand protocol, its packet delivery ratio is better than other protocols, delivering more than 98% packets as the speed increases, as shown in Figure 13. AODV's performance is relatively poor delivering 95-96% packets and packet delivery ratio decreases with the increase in speed.

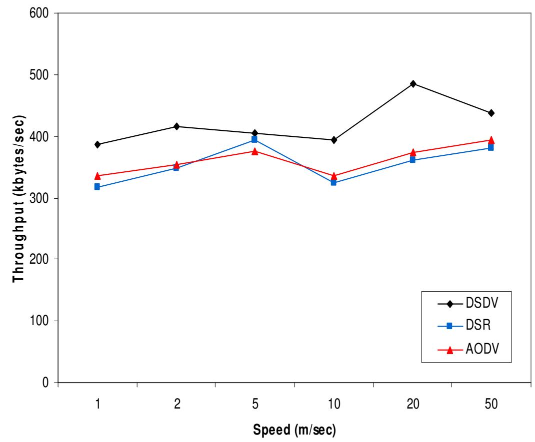

Figure12: Throughput as a function of maximum speed

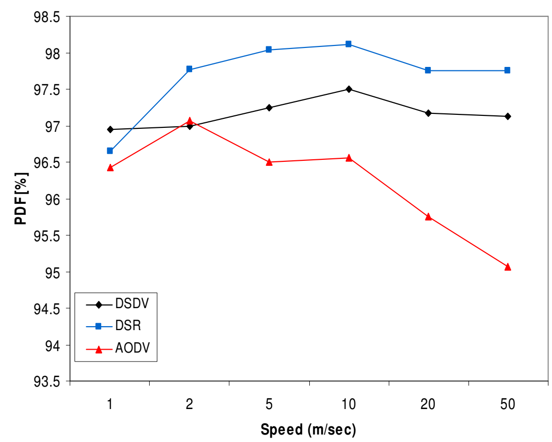

Figure13: Packet Delivery Fraction as a function of maximum speed

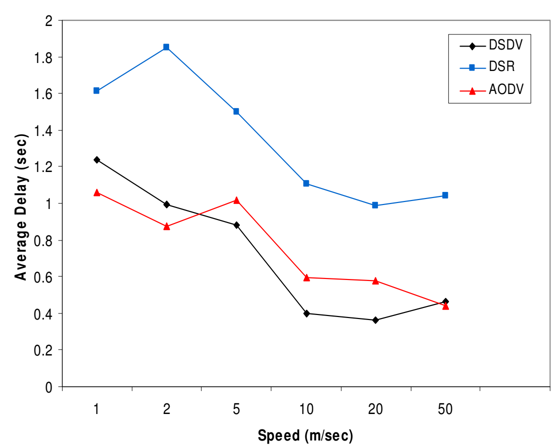

Figure 14: Average end-to-end delay as a function of maximum speed

Since DSDV is a proactive routing protocol, it uses already established route and thus resulting in low average delay of 0.3 seconds at speed of 20 meters/second, as shown in Figure 14. Whereas DSR due to its source routing introduces greater delay of 0.9 seconds at speed of 20 meters/second.

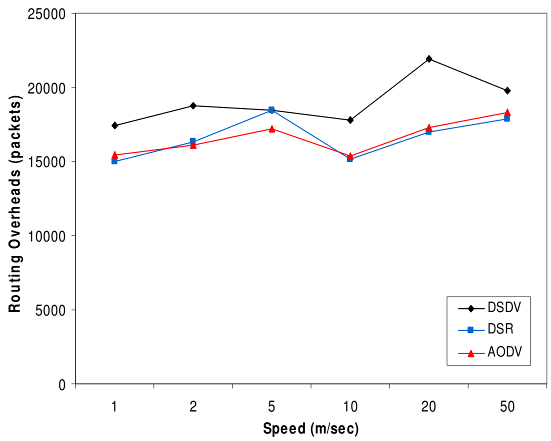

Figure15: Routing overhead as a function of maximum speed

Routing overhead of DSDV is significantly greater than DSR and AODV, transmitting more than 17432 packets whereas DSR and AODV are able to transmit between 15035-14847 packets, as indicated in the Figure 15.

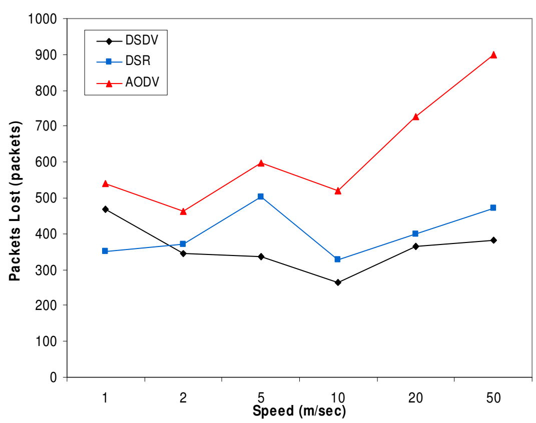

Figure16: Packet Loss as a function of maximum speed

DSDV shows the best performance as it shows the drop of 264 packets in comparison to DSR and AODV which shows drop of 327 and 521 packets, as indicated in Figure 16. Overall performance of DSDV is better than the other source routing protocols DSR and AODV.

4. Conclusions

We compared performance of routing protocols DSR, AODV and DSDV for mobile ad hoc networks considering TCP as the transport protocol and FTP as the traffic generator. Our simulations have shown that performance of a routing protocol varies widely across different performance differentials varying node mobility, network size and maximum speed. TCP was mainly developed to be deployed within wired networks. It is observed that TCP is not appropriate transport protocol for highly mobile multihop wireless networks because TCP protocol is unable to manage efficiently the effects of mobility. Node movements in ad hoc network may cause route failures, route changes and, hence, packet losses and delayed ACKs. The TCP misinterprets these events as congestion signals and activates the congestion control mechanism. This leads to unnecessary retransmissions and throughput degradation. Hence, TCP sources should not be used to study performance in MANET.

Simulation results indicate proactive routing protocol DSDV performance is best considering its ability to maintain connection by periodic exchange of information, which is required for TCP, based traffic. DSR which uses source routing is the best among reactive routing protocols. Results are only valid when we consider TCP traffic. It is observed that TCP is not appropriate transport protocol for highly mobile multihop networks and thus UDP should be preferred. For UDP based traffic, performance of reactive routing protocols is better than proactive routing protocols.

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