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Performance Evaluation of TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) over Destination Sequence Distance Vector (DSDV) for Random Waypoint Mobility Model

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Abstract: A mobile Ad-hoc network (MANET) is a collection of wireless nodes aimed at information exchange and resource sharing. The Destination Sequence Distance Vector (DSDV) a well-known and widely used protocol for MANETs. This paper presents the comparative performance analysis of TCP and UDP (two transport layer protocols) over DSDV in a Mobile Ad hoc Network. Three performance metrics: throughput, end-to-end delay and packet loss parameters are used to evaluate the performance of TCP and UDP. A number of topology parameters are varied including node density, node speed and pause time. Simulations are performed using ns-2 which show that in general TCP traffic outperforms UDP traffic for DSDV. UDP flows perform better in the case of dense networks with little or no mobility. TCP flows perform better for high mobility scenarios.

Key words: DSDV · TCP · UDP MANET · Traffic pattern · Throughput · End-to-end delay · Packet loss

INTRODUCTION

The Mobile Ad-hoc Network (MANET) is a collection of wireless nodes communicating over the wireless medium without any infrastructure. Working in ad-hoc mode allows all wireless devices within range, to discover and to communicate in peer-to-peer fashion without involving any base station. These nodes form a random topology, where the routers are free to move arbitrarily and arrange themselves as required. In MANET, communication between two mobile nodes is made possible by providing a multi-hop path due to shorter range of radio signals. They offer transmission speeds of several Mbps, making possible the support of multimedia applications and real-time communications in MANETs. Since the area that must be covered may exceed the transmission range of the wireless devices, suitable routing protocols must be used to permit multi-hop communication, where as a hop is considered each wireless device. As the ad-hoc network has limited bandwidth, frequent topology changes and the energy limitations of the mobile hosts, the protocols used for wired networks are considered inappropriate for MANETs. Therefore, for this highly dynamic environment new routing protocols have been designed. These protocols are classified as either proactive or reactive. The proactive (or table-driven) protocols maintain their routes through periodic updates and each node locally maintains routing tables. On the other hand, in the reactive (or on-demand) protocols the routes are established when required. The proactive approach provides fast response to route requests, but consumes more bandwidth since the network connectivity information must be continuously updated to reflect topology changes [1].

Many Researchers have gone through TCP and UDP for different routing protocols using various mobility models. The Random Waypoint mobility model is particularly popular for TCP as its performance may be affected by the basic initialization of other mobility models such as Reference Point Group mobility models (RPGM), Freeway model, Manhattan Model (MM) [2].

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We have selected DSDV as a routing protocol. This protocol is widely used in wireless environment and has numerous implementations available. The main focus of our paper is the comparative analysis of TCP and UDP over DSDV protocol with respect to mobility, with varying pause time, node speed and node density. Our work participates to show that in which environment DSDV works better for different QoS metrics.

The rest of the paper is organized as follows. Section 2 describes the related work, section 3 describe introduction of DSDV protocol, section 4 presents simulation parameters, section 5 contains description of simulation models and evaluation and finally, section 6 contain the conclusion of the simulation results.

Related Work: The Destination Sequenced Distance Vector (DSDV) routing protocol is a routing protocol, developed in 1994 by C. Perkins. It uses a modified version of Bellman-Ford algorithm. For each node a sequence number is maintained which is generated from the destination, Bellman-Ford is usually used only when there are negative edge weights. The algorithm was developed by Richard Bellman and Lester Ford, Jr [3].

Authors discussed the performance and comparison of wireless routing protocols including DSDV [4]. They simulate fixed size network with varying pause time and velocity. They used simulation model with dynamic network size and pause time remained zero. The simulation measures all the QoS of the routing protocols, e.g. delay, jitter, throughput, loss ratio.

In [5], authors have discussed the performance evaluation of DSR, AODV and DSDV in grid environment to evaluate which routing protocol gives best performance in target mobile grid application. According to author, performance of DSR decreases with mobility with high rate as compare to DSDV and AODV.

The major issues of Ad hoc environment has discussed by authors in [6], it concern with energy consumption due to mobility. Mobile nodes are battery operated is a well known fact. OLSR and DSDV conserve less energy as compare to DSR and AODV.

The performance evaluation of, AODV, DSDV, DSR and TORA ad hoc routing protocols focusing on their suitability to support real time applications [1]. Simulations are done for a wide range of mobility and traffic scenarios.

MANET reactive and proactive routing protocols comparison evaluations has studied [7]. The protocols that use in MANET are DSDV, AODV, DSR, TORA, TORA, WRP ZRP and many more. The performance of these protocols are compared in term of packet delivery fraction, end-to-end delay normalized routing load routing overhead for 50 nodes and 100 nodes network model with different number of sources.

Most of the related work has done experiments on DSDV with TCP or UDP connection individually, but not on both comparatively. Our approach is novel on the basis of both TCP and UDP combine evaluation. All our effort is to identify in which environment TCP work well and UDP as well.

Destination Sequenced Distance Vector Routing Protocol: Destination Sequenced Distance Vector (DSDV) is a routing protocol for relatively small mobile ad hoc networks. This protocol is typically based on the Routing Information Protocol (RIP) used in wired routing systems. But in RIP, there is a possibility of packet looping during transmission. DSDV is an enhancement to RIP protocol which uses modified Bellman-Ford routing algorithm. DSDV use sequence numbers to avoid looping problem. This protocol maintains a routing table, which keeps track of the destinations of the whole network, next hop to the destination, number of intermediate nodes etc. Route dissemination in DSDV is either full dump or incremental dump. In full dump all the information is transmitted, while in incremental dump only the information after the last update is broadcasted. The full dump transmission is done, when excessive changes occurs in MANET, in that case incremental dump will be not be suitable as NPDU (network protocol data unit) overloaded highly. Route selection metric of DSDV is sequence number, most updated and recent sequence number route is selected, however in case, if two routes has equal sequence number then hop count will be measure for route selection.

Dumping fluctuation occurs in the serious limitation of DSDV, which is caused due to the irregular updates, different propagation speeds, different transmission intervals and asynchronous broadcast. To resolve this problem DSDV keeps a route settling time for each node. Every node will wait for a route with a better metric before advertising the update message. If a new route information occurs with better metric withen settling time, the old route information is discarded before advertising it [3].

The Simulation Enviroment: The Ns-2 is used as the simulator, developed by the University of California at Berkeley. It provides support for simulations of TCP, UDP, routing and multicast protocols over wired and wireless (local and satellite) networks [1]. It began to support simulations with respect to mobility after its extension by the Monarch Project of Carnegie Mellon University [8]. Support for different models of the ad-hoc routing protocols DSDV, AODV, DSR and TORA is also provided in this extension [9].

Random Way Point Mobility Model: The characteristics of mobility in ad-hoc environment are the node speed, pause time and the pattern of their movement. Random Waypoint mobility model is the simplest model in which node pauses for specific time within movement (in terms of direction and speed). It has following characteristics: a node randomly selects its waypoint (destination) with the uniform and randomly chosen velocity [0, Vmax], where *Vmax* is the maximum allowable speed for every nodes. After reaching to its destination it pauses for [0, Tmax], where *Tmax* is the maximum allowed pause time. When nodes reach the simulation terrain boundary, they bounce back and continue moving. Every node chooses its speed and direction independent of any other node. This process repeated till the simulation end [10].

The random waypoint model has been widely used in performance comparison studies of routing protocols. In this paper, we compare performance of TCP and UDP over DSDV using Random Waypoint Model.

Performance Metric: Different metrics are used to evaluate the performance of DSDV protocol. Our selected performance metrics are the most well known QoS measures. Also these metrics are frequently discussed in the performance evaluation by many researchers [11]. With the help of our selected metrics, we could clearly define the performance differences of both TCP and UDP over DSDV.

Throughput: The number of data packet passing through the network in unit time.

End-to-End Delay: The time from the data packets sent out by the sender to the packet received by the receiver.

Packet Loss: The ratio of the data packets dropped to those generated by the CBR sources.

Traffic Pattern: We use two different transport protocols for CBR traffic, TCP and UDP. The source and destination pairs remain constant for all the scenarios spread randomly over the 500x500 m^2 area. CBR packet size is 1000 Kbps.

Scenarios: Different scenarios are designed with varying node speed, density and pause time for the evaluation by keeping other parameters constant. The basic parameters which remain same for all scenarios are; total simulation time 500s and simulation area 500x500 m^2.

Varies node densities in some scenarios are 10, 15, 20, 25, 30, 35, 40 nodes having constant area, pause time (4.0 s) and node speed (20 m/s).

Different pause times used in simulation are 0, 50, 100, 150, 200, 250, 300, 350 400 seconds with constant speed and density. Speed is 20 m/s and nodes are 20.

To analyze the effects of mobility over TCP and UDP connections, we generate scenarios with varies speeds of 10, 20, 30, 40, 50m/s having constant pause time 4.0 se and number of nodes 20. All the scenarios are randomly generated 5 times.

Simulation Results: Ns-2.29 is used for the performance evaluation of TCP and UDP over DSDV. The tool “setdest” is used for random mobile scenario generation. We generate three different types of scenarios with varying node density, node speed and pause time. Each of the scenarios is further evaluated with three different performance metrics for both of TCP and UDP over DSDV. The metrics are throughput, end-to-end delay and packet loss. Overall, the performance is evaluated over a hundred different scenarios and finally we conclude according to simulation results that whether TCP or UDP works better in case of DSDV in wireless ad hoc networks. The simulation parameters are given in Table 1.

Impact of Node Density: The impact of node Density on the performance of TCP and UDP over DSDV in term of throughput, end-to-end delay and packet loss are discussed in the below sub sections of the paper. The simulation results show how node density affects the performance metrics in case of TCP and UDP over DSDV protocol in a MANET.

Throughput: According to our simulation results, the throughput of a network appears to be directly proportional to the node density as shown in Figure 1. The results also show that throughput of UDP is higher than that of TCP over DSDV for both dense and sparse networks. The x-axis shows the node density and y-axis shows the cumulative throughput of both TCP and UDP connections.

Table 1: Parameter Setting Before Simulation

Parameters	Values
Simulator	NS-2
Protocol	DSDV
Simulation Time	500 s
Simulation Area	500x500 m^2
Transmission Time	500 s
Traffic Type	UDP, TCP
Data Payload	1000 Kbps
No of Connections (TCP/UDP)	5 connections

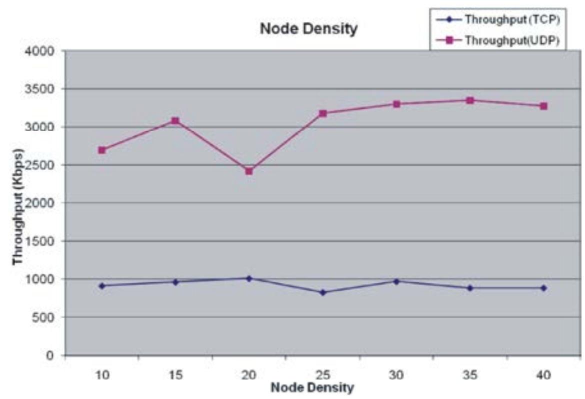

Fig. 1: TCP and UDP throughput comparison over DSDV

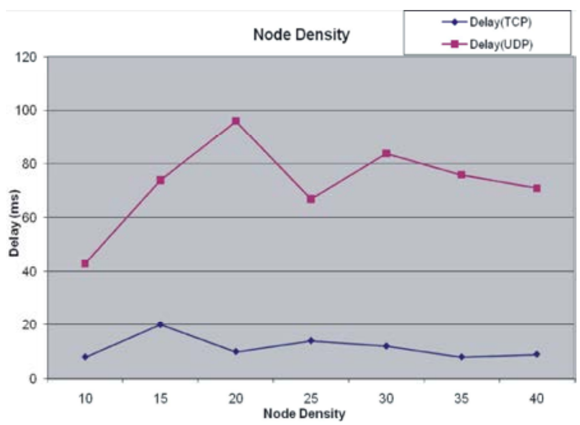

Fig. 2: TCP and UDP Delay comparison over DSDV

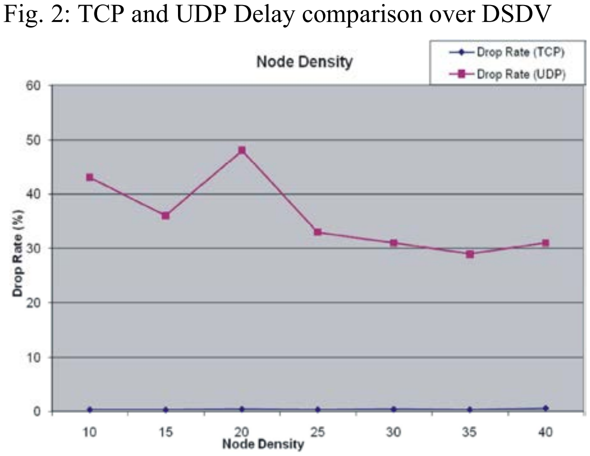

Fig. 3: TCP and UDP Packet loss comparison over DSDV

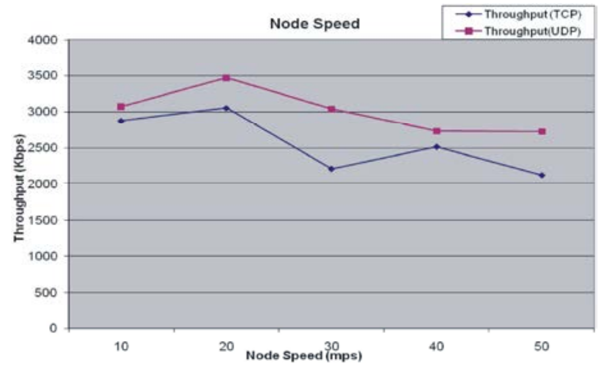

Fig. 4: TCP and UDP throughput comparison over DSDV Protocol in MANET with respect to speed

When the number of nodes increases, the transmit ion rate also improve for both TCP and UDP. In case of UDP the transmission rate is not controlled by the receiver in case of buffer full, while in TCP the receiver control the rate of packet transmission rate by window size. That is why the UDP throughput is higher than TCP.

End-to-End Delay: The end-to-end delay is the average delay of all 5 connections (UDP/TCP) packet sending and receiving time. Maximum Delay occurs in case of UDP connection as compare to TCP as shown in Figure 2. The result shows that node Density has a very less effect on TCP transmission delay, while in case of UDP transmission the delay is little more in case of less number of nodes than of more number of nodes. UDP transmission delay in case of 20 nodes is 74 s while in case of 40 nodes the delay is 71 s. By increasing the number of nodes the change in delay remain minor as compare to the initial start number of nodes.

UDP delay is highest because of no proper flow control mechanism, all the nodes transmit packets without knowing about receiver side buffer filling acknowledgement. In this way the packets are waiting in a Queue for long time.

Packet Loss: Figure 3 shows that in case of UDP transmission over DSDV protocol the packet loss ratio is much higher than TCP transmission.

The loss packets in case of TCP transmission is retransmitted again and again. While in case of UDP the packets are continuously transmitted without knowing whether it's received by the destination and also having no knowledge whether the receiver is ready or not for further packets receiving. The drop rate of TCP has less effect on number of nodes, while UDP drop rate decrease as the number of nodes increases.

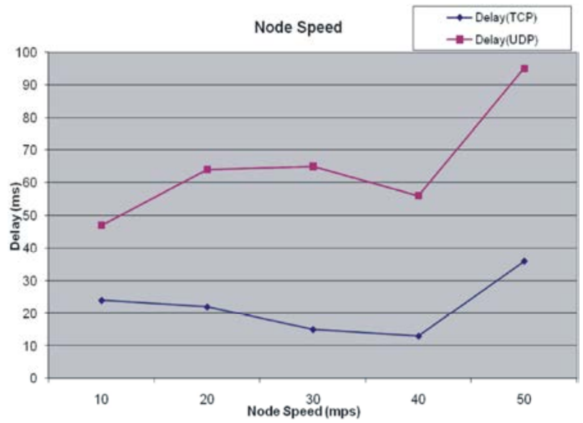

Fig. 5: TCP and UDP Delay comparison over DSDV Protocol in MANET with respect to speed

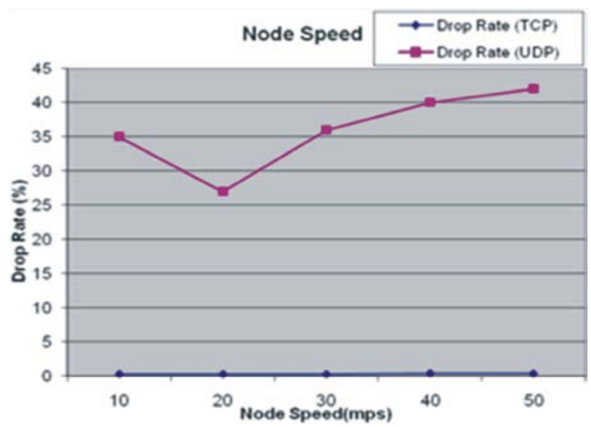

Fig. 6: TCP and UDP packet loss comparison over DSDV Protocol in MANET with respect to speed

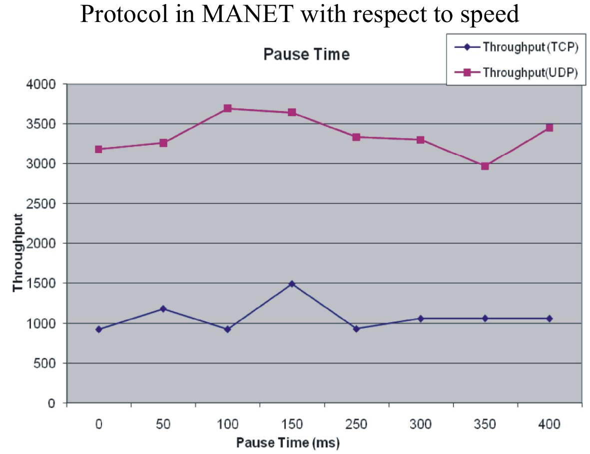

Fig. 7: TCP and UDP Throughput comparison over DSDV Protocol in MANAT with respect to pause time

Impact of Node Speed: The above mention QoS metrics are also evaluated with different node speed in both TCP and UDP connections over DSDV protocol.

Throughput: Highly throughput is experienced for the UDP than TCP. The throughput performance of UDP decreases quickly as the speed of node increases. The simulation results show that UDP is not reliable in more mobile environment as compare to TCP.

In highly mobility environment the nodes may have more chances to leave the transmission range which makes more chances of packet loss, as in UDP transmission packet loss can't retransmitted, hence its final throughput reduced than TCP transmission.

End-To-End Delay: Figure 5 Shows that in mobile environment, the End-to-End delay of UDP transmission over DSDV protocol is maximum than TCP transmission. UDP performance is degraded with highly node's speed. It has the same reason as describe in the above section.

Packet Loss: The packet loss ratio of UDP transmission over DSDV is very high than TCP transmission. This is shown in Figure 6.

As the UDP has no virtual connection concept to retransmit loss packets that are affect because of highly mobility, in which a node has more chances to leave the transmission range frequently. Also in transmission the sender has no information about receiver buffer. While in case of TCP transmission the sender sets its transmission rate according to receiver receiving rate.

Impact of Pause Time: In mobile scenario, the pause time is referring to the stopping time of a mobile node for communication. The above mention QOS also evaluated with different pause timing.

Throughtput: The throughput of UDP transmission over DSDV is higher than TCP transmission. This is also shown in Figure 7: In UDP transmission the sender has no constraint about the receiver receiving rate or losing packets because of less buffer size. The pause time has a very less effect on TCP as compare to UDP.

End-to-End Delay: The pause time has less effect on TCP traffic delay as compare to UDP transmission over DSDV protocol. This is shown in Figure 8. The Delay increases quickly in case of UDP traffic pattern as compare to TCP traffic model.

Packet Loss: The packet drop ratio of TCP transmission over DSDV protocol is less than UDP transmission. The pause time has no significant effect on TCP packet loss,

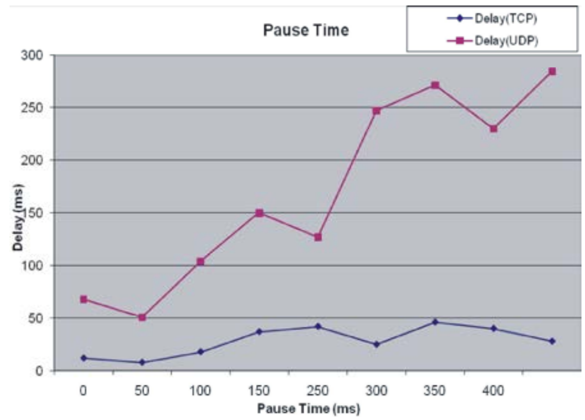

Fig. 8: TCP and UDP Delay comparison over DSDV Protocol in MANET with respect to pause time

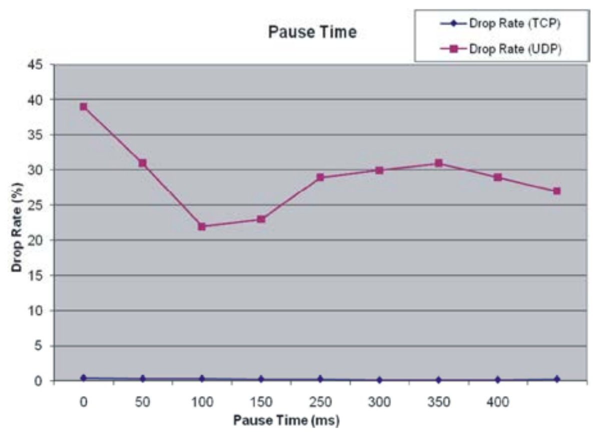

Fig. 9: TCP and UDP packet loss comparison over DSDV Protocol in MANET with respect to pause time

while in case of UDP the packet loss rate is high in case of low pause time as compare to higher values of pause time. This is shown in Figure 9.

CONCLUSION

The simulation results show that to get high throughput within a MANET system, we have to use UDP traffic over DSDV protocol but the mobility rate should not be high, because in highly mobile environments, the UDP performance degrades. We also conclude that TCP traffic over DSDV gives better results in terms of delay and packet loss in multiple scenarios. The pause time has insignificant effect on TCP traffic as compare to UDP. In short we conclude according to our simulations that UDP will work well in static or less mobile environment. However TCP will outperform in case of mobile environments. DSDV works well for TCP traffic as compared to UDP traffic type.

For high speed transmissions, we should use UDP traffic model for communication. UDP traffic is suitable in an environment where the users compromise on data loss but not on speed.

The pause time is also a good mechanism for controlling drop rate during communication. The UDP traffic loss rate can be reduce by setting high pause time. The DSDV should set a default high value of pause time e.g. 400s in a highly mobile environment.

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