
Congestion Control in Mobile Adhoc Network Using TCP Variants

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ABSTRACT

Research conducted just of recent reveals that Transport Control Protocol (TCP) does not perform well in a mobile environment as it does in other networks and this is as a result of several factors that affect the TCP performance in Mobile Adhoc Networks (MANETs). In this paper, a detailed analysis of factors that affect TCP performance in MANETs was carried out in order to determine the performance of various routing protocols. The throughput transferred across the network was measured from statistical window of the NS analyzer and simulation results that TCP Vegas performed better than other variants because it was able to maintain its bandwidth up to some reasonable points worthy of note. Similarly, from the congestion window shown in Figures 5, 6 and 7, TCP Vegas shows less delay from physical view due to detecting packet loss before congestion occurs in the network. Based on the results obtained, it is evident that TCP Vegas performed better than other routing protocol for sending information due to better packet delivery across the network.

Key words: Transport Control Protocol, MANETs, TCP Variants and Congestion control

INTRODUCTION

Ad-hoc network is a group or sets of wireless mobile computers in which nodes conjoin by forwarding packets for each other to allow them to communicate beyond direct wireless transmission range. MANETs is a group of mobile nodes that are connected over unrelated wireless links. They can be symmetric and asymmetric in nature. Symmetric and asymmetric links is one out of the numerous challenges experienced in a mobile adhoc network and research has shown that wireless sensors networks is one of the promising application area for adhoc networks that has receive great attention over the years (cordeiro and Agrawal, 2016). It has numerous application such as military exercises, internet of things, disaster relief, and mining site operation (Jaat and Tiwari, 2016). Wireless ad-hoc network can configure its self that is they are self-configuring and they are dynamic in nature where nodes are free to move. Furthermore, these mobile node are independent from each other and communicate via radio wave. Most of the mobile nodes that are in radio range can communicate directly to each other, whereas other node that are

not in the radio range needs the assistance of intermediate nodes to routes their packets. (Matten and Anwar 2016). However in this case, the nodes are restricted to sending and receiving information but rather they do not route anything across the network. It is interesting to know that mobile network can operate in a standalone fashion or could probably be connected to a large network such as the internet.

The developing of third-generation (3G) cellular networks has significantly improved data transmission speed, which enables various organizations to use applications that require a variety of higher-speed mobile data services. Meanwhile, new standards for short-range radio such as Bluetooth, 802.11, Hiperlan, and infrared transmission are also in use because they helps in creating a wide range of new applications for enterprise and home networking by permitting data communication and wireless broadband multimedia in both homes and offices (Liu and Lee 2016). Many types of wireless devices are available today as results of emerging technologies such as mobile terminals, PDAs, pocket size PCs, hand-held PCs,

laptops, cellular phone, wireless sensors, and satellite receivers, to mention but few.

Congestion in network is one of the problems that are posing great challenges. Congestion always occurs when the incoming number of packets is greater than the capacity of the network and if not taken care off can lead poor communication (Talau et al. 2015). The problem that prompted this research ever since is the increasing problem of congestion control in mobile ad-hoc networks. Transport control protocol TCP do not work properly with the specific effects occurring in MANETs as a result of congestion and this is because TCP has originally been designed for the Internet. The need to study the congestion control of different TCP variants using available throughput, packet delay on the network becomes paramount and hence the motivation of this research work.

The aim of this paper is to study and compare the Transport Control Protocol (TCP) variants in controlling congestion in MANETs in order to ascertain its performance over the networks. This can be achieved by Generating random graph model in a dynamic topology and coding using Oriented Tool Command Language (OTCL) script and finally using Network Simulator trace analyzer to obtain results. The remainder of this paper is structured into different sections; section one covers the introduction, section two deals with the Routing protocols in MANETs. Section three comprises of Congestion Control Algorithms of TCP Variants, section four deals with the design and software implementation. Section five covers results discussions and conclusion.

Routing Protocols in MANETs

MANETs are collection of symmetric and asymmetric wireless nodes where there is no networking infrastructure in the form of base stations (Maheshwari, et al., 2014). TCP has poor performance in MANET due to congestion and the nature of topology (static or dynamic) (Giordano, 2002). In general, classification of routing protocols in Mobile Ad hoc Network can be done in many ways but they are mostly done base on routing strategy and network structure (Janakiraman, et al., 2014).

Adhoc routing protocol can be classified into three categories namely, table driven or

proactive, source on demand driven or reactive and hybrid. In this paper, much emphasis is laid to source on demand driven (reactive) protocols and they include; Ad hoc On Demand Distance Vector (AODV), Temporally ordered Routing Algorithm (TORA), Associativity Based Routing (ABR), Signal Stability-Based Adaptive Routing (SSAR) and finally Location-Aided Routing Protocol (LAR) (Duvvuri and Krishna, 2016).

a. **Ad hoc On Demand Distance Vector**

(AODV): This is a distance vector type of routing protocol that uses different messages to discover and maintain various links such as Route Requests (RREQs), Route Replies (RREPs), and Route Errors (RERRs). They require nodes to retain active routes within the network. It has great advantage of minimizing the number of required broadcast and it create routes on demand basis unlike maintaining complete lists of routes for every destination like DSDV (Muchintala, 2016). It also has disadvantages in the sense that intermediate nodes can lead to inconsistent routes if the source sequence number is very old.

b. **Dynamic Source Routing:** It was primarily designed for mobile ad hoc networks with hundreds of nodes having high mobility rate. DSR works without any periodic updates. This reduces overheads for large routing updates at the network. (Papadimitratos and Haas, 2002). Dynamic Source Routing protocol (DSR) uses source routing and the source completes its hop sequence to the destination. In this case, each node retains a route cache for saving all the known routes and the initiation of route discovery process can only be carry out if the desired route is missing in the route cache. The disadvantage of DSR is that the route maintenance mechanism does not locally repair a broken down link within the network.

c. **Destination Sequence Distance Vector:**

This is an example of Proactive Routing Protocol and is a distance routing protocol

(Prashar and Kapur 2016). This routing protocol is based on classical Bellman-Ford routing algorithm. In DSDV, each node has a record of all destinations and numbers of hops to those destinations are incrementally updated to reduce network traffic generated by route updates (Duvvuri and Krishna, 2016). It has the advantage of creating ad hoc networks with small number of nodes and it guarantees free node path. However, it is not suitable for highly dynamic networks.

Congestion Control Algorithms of TCP Variants

Congestion control has significantly increases over the years as a result of intensive research and this researches were centered on TCP variants aimed at studying congestion control in MANET in order to outline the increasing causes of congestion in MANETs (Maheshwari, et al., 2014). With the growing demand of data and the use of internet, internet protocol is responsible for approximately 90% of internet traffic in today's wireless and wired networks. Today, TCP is widely utilize as a good connection oriented transport layer protocol that offers reliable data packet delivery over inaccessible links (Jaat and Tiwari, 2016).

TCP variants possess some special features, and these features includes TCP Tahoe, TCP Reno, TCP New Reno, TCP Vegas (Duvvuri and Krishna, 2016). TCP Tahoe is one of the simplest variants and it doesn't have fast recovery. TCP Tahoe was the first version of TCP and it is based on the principle of packets conservation. (Duvvuri and Krishna, 2016). It has slow start and coarse retransmission time.

TCP RENO retains the basic principle of Tahoe, such as slow starts and the coarse grain retransmit timer. TCP Reno implements an algorithm called Fast recovery (Chaudhary and Kumar 2017). Reno performs very well over TCP when the packet losses are small. But it always face difficulty with multiple packet losses in one window (Khan, et al., 2015).

New RENO is a slight modification over TCP-RENO. It can detect multiple packet losses and is performs better that RENO in the event of multiple

packet losses (Shinko et al. 2017). However, no fast-recovery is present as in the case of RENO

TCP Vegas is a modification of New Reno and it was designed to encounter congestion rather than packet loss (Bisoy, and Pattnaik 2017). TCP Vegas is a modification of New Reno and it was designed to encounter congestion rather than packet loss (Nor and Maulana 2017). TCP Vegas is a congestion avoidance algorithm that shows more emphasis on packet delay, rather than packet loss, as a signal in order to determine the rate at which to send packets in the network.

DISCUSSION

Network Simulator 2 is used for the simulation and it is a very powerful simulation tool that works at packet level and provides significant support to simulate bunch of protocols like TCP, UDP, FTP, HTTP, and DSR for both wired and wireless networks. In this research, the analysis of the data obtained from the simulations is not straightforward. However, there is need for a standalone application that is able to easily translate the NS-2 trace files into graphics and this has led to the development of a new data analysis tool called NS2 Visual Trace Analyzer.

The programming was done using TCL scripts and an NS simulator object was created from the script with a new setup of topography. Interested reader can contact the author of this work for more detail on the scripts and its implementation on NS2 simulation tool. Simulation was carried out with different node densities and packets of 1500 bytes were used in distributing packet across the networks. The applications used are file transfer protocol (FTP) and Constant Bit Rate (CBR) with radio propagation, a two Ray Ground and the Omni antenna with a simulation time of 20 seconds for each configuration run time.

Similarly, each simulation run was tested for different techniques namely: TCP Tahoe, TCP Reno, TCP New reno and TCP Vegas and there throughput transferred was measured using trace analyzer for the different number of nodes for AODV, DSR and DSDV protocol in MANETs. TCP throughput for Tahoe was found to be in bits per second as seen in Table 1 and throughput transferred from source to destination was recorded

from the simulation. Figure 1 shows graph of throughput transferred against number of nodes showing performances of routing protocols such as AODV, DSR and DSDV are compared. AODV shows a better performance in throughput due to significant increase from 120bps to 280bps as the corresponding node density and mobility are increase. DSR shows much better throughput at beginning of simulation with 160bps and has the node density is increase the throughput decrease to about 40bps which shows a fall in amount of packet transferred in the network. DSDV shows less performance in terms of routing protocol when compared to AODV and DSR and its throughput started at 80bps and it maintains that value until the highest number of node when it shows a decrease in in 40bps. AODV performs well because its throughput was increasing as seen in Figure 1 but DSDV much stable throughput when compared to the other routing protocols. The throughput performance for Reno and it is measured in kb/s is far higher than that of TCP Tahoe as shown in Table 2. The graphical interpretation of Table two is shown in Figure 2. This shows the performance of Reno and has depicted DSDV shows much better performance as seen in the Table 2, it has the highest throughput 84kb/s at the start and it was able to maintain its bandwidth to 93kb/s much better when compared to DSR and AODV. TCP New Reno generated a trace file and its throughput from NS analyzer is shown in Table 3.

From the result obtained in Figure 3, AODV started with a throughput of 32kb/s and increases up to 90kb/s and maintains that throughput to 93kb/s but as the density approaches it reaches maximum and also it shows a slight decrease to 75kb/s due to congestion.

DSR for New Reno shows similar result with Reno as a result of increase and decrease in throughput from 12kb/s back to 12kb/s as obtained from NS analyzer. DSDV performs very well and quite similar with that of Reno and its throughput when compared to other routing protocol shows better bandwidth at a start with 84kb/s and with a much increase to 93kb/s due to less congestion. TCP Vegas was also tabulated as depicted in Table 4 and its throughput was also in kb/s. From the graph the throughput for AODV started at 35kb/s and it

shows a significant increase when the nodes are increased from 30 to 40, and during that period it was able to maintain its throughput till when we get to the highest number of node and drops to 75kb/s. DSR also shows a rise in throughput at beginning of setup with 14kb/s, as the density increases it also shows an improvement in throughput of about 26kb/s which shows less congestion in the routing protocol.

DSDV for Vegas also performs quite well in that its throughput at start of the simulation was 91kb/s and maintained that throughput of 40 node density due to congestion in the network it shows a slight drop to 32kb/s.

Packet delay Variation for some Variants (Jitter)

The packet delay variation for some of the routing protocol were obtained from the network simulator analyzer for Reno, New Reno and Vegas as shown in Figures 5, 6 and 7 respectively for the highest maximum number of node in the network and the variants which has less congestion. For the purpose of this research, the queue size for network was set to be 50 and the packet identification (ID) is a unique number given to a node in the NS analyzer and it always increases to a maximum value.

CONCLUSION

In this paper, the network was simulated using NS2 and their performances was compared base on varying node density and throughput of TCP Reno, TCP Tahoe, TCP New Reno and TCP Vegas under the same network mobility and topology. Throughput transferred across the network was measured from statistical window of the NS analyzer and it was observed from the results that TCP Vegas performed better than other variants in the sense that it was able to maintain its bandwidth for DSDV, DSR and AODV up to some reasonable points when compared with TCP Reno, New Reno, and Tahoe using the same yardstick. From the congestion window seen in Figures 5, 6 and 7, TCP Vegas as shown in Figure 7 shows less delay from physical view due to detecting packet loss before congestion occur in the network From these comparison TCP Vegas performed better than other routing protocol for sending information due to better packet delivery across the network.

Further work can consider More TCP variants such as TCP FACK and TCP SACK with new mechanisms in order to compare their performance metrics within the MANETs

Table 1: TCP Tahoe for Various Node Densities and Different Routing Protocols

Routing protocols	Number of Nodes			
	20	30	40	50
	Throughput(bps)			
AODV	120	240	240	280
DSR	160	160	80	40
DSDV	80	80	80	40

Table 2: TCP Reno for Various Node Densities and Different Routing Protocols Routing protocols

	Number of Nodes			
	20	30	40	50
	Throughput(Kbps)			
AODV	12	93	93	75
DSR	12	9	27	12
DSDV	84	93	95	93

Table 3: TCP New reno for Various Node Densities and Different Routing Protocols

Routing protocols	Number of Nodes			
	20	30	40	50
	Throughput(Kbps)			
AODV	32	90	93	75
DSR	12	9	27	12
DSDV	84	93	95	93

Table 4: Result Obtained for TCP Vegas for Various Node Densities and Different Routing Protocols.

Routing protocols	Number of Nodes			
	20	30	40	50
	Throughput(Kbps)			
AODV	35	91	92	75
DSR	14	18	21	26
DSDV	91	92	92	32

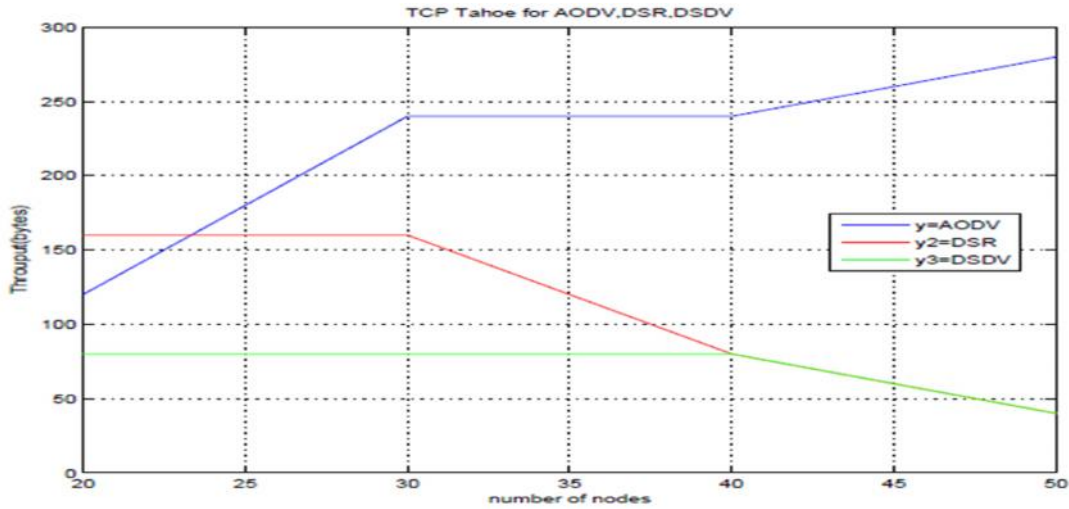


Figure 1: A graph of throughput transferred against number of nodes.

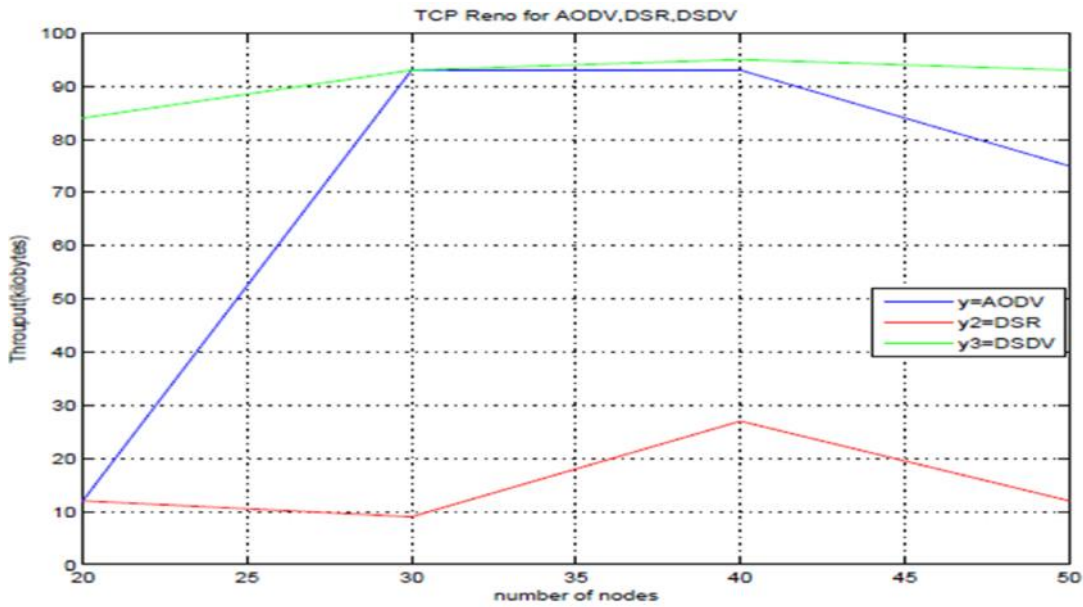


Figure 2: Throughput TCP Reno with Different Routing Protocols.

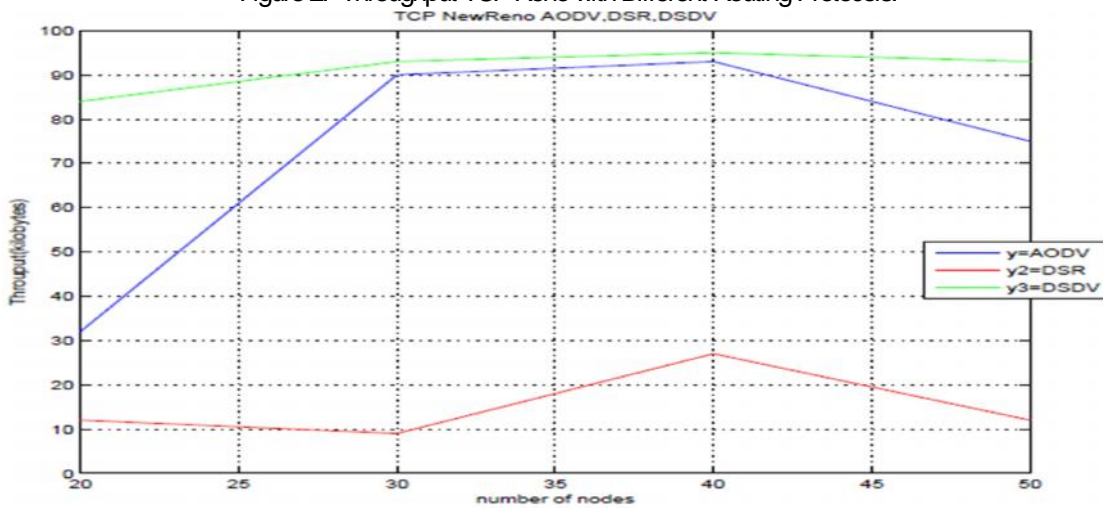


Figure 3: Throughput TCP New Reno with Different Routing Protocols.

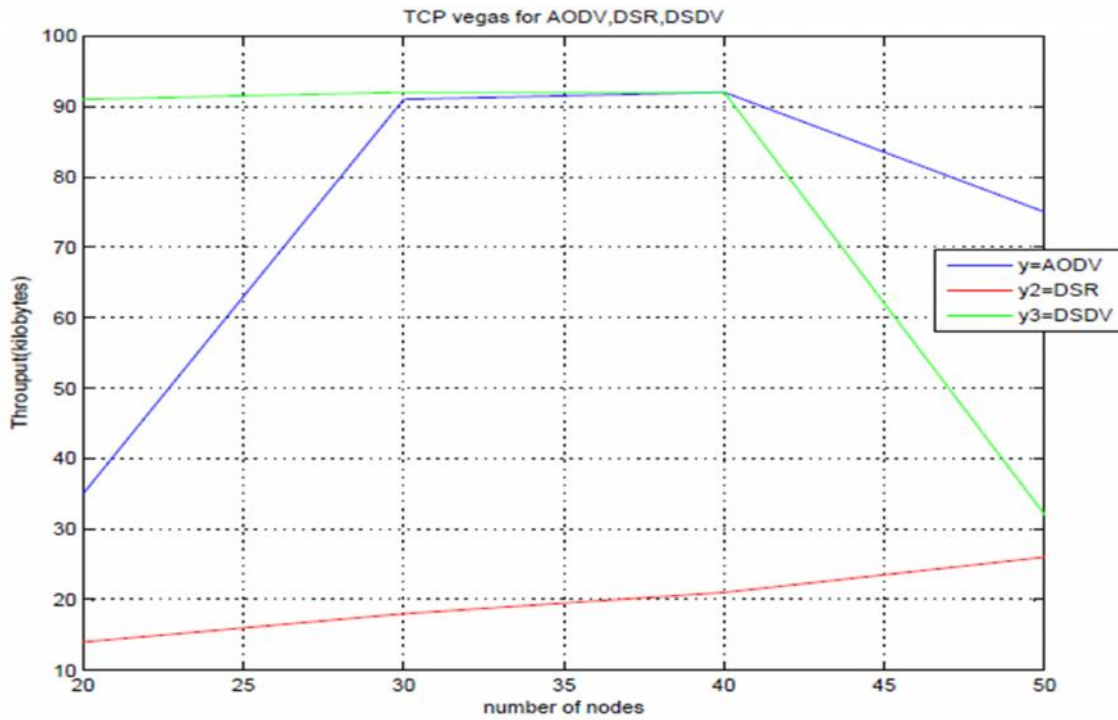


Figure 4: Throughput TCP Vegas with Different Routing Protocols

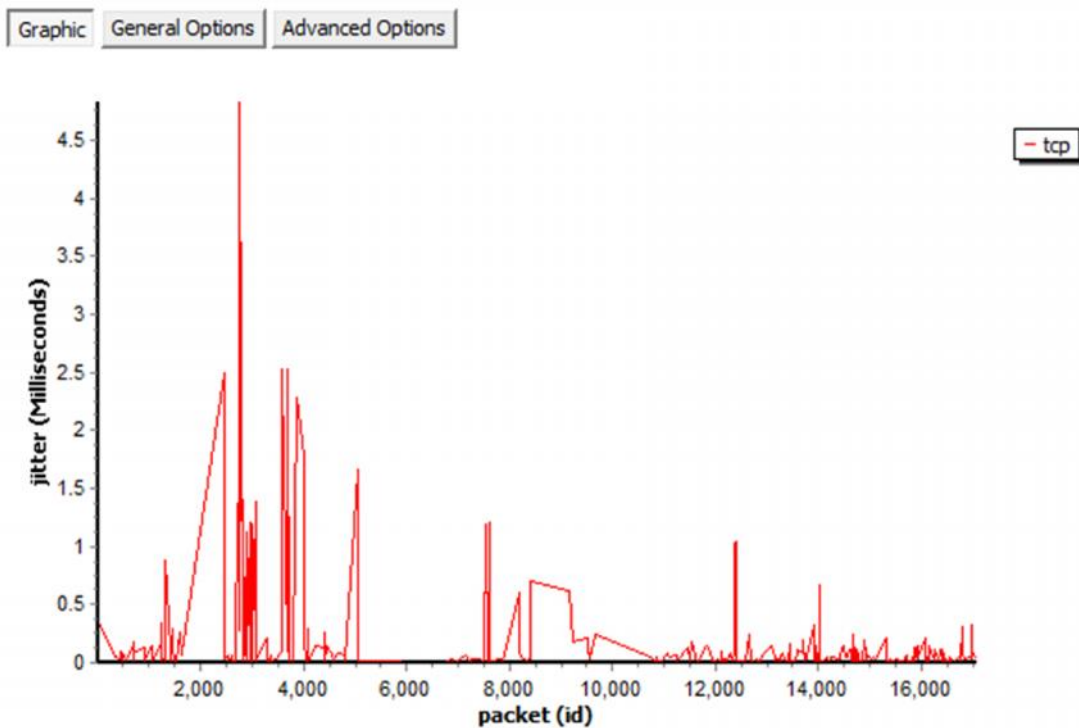


Figure 5: Packet Delay Variation Jitter Reno (AODV)

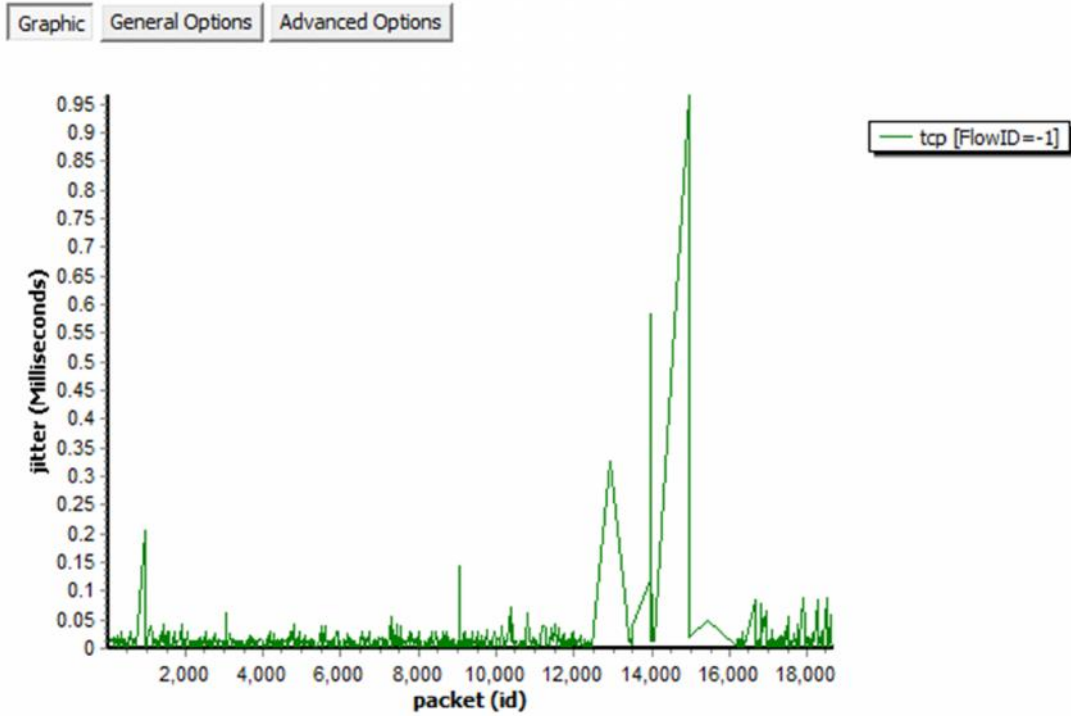


Figure 6: Packet Delay Variation Jitter Reno (DSDV)

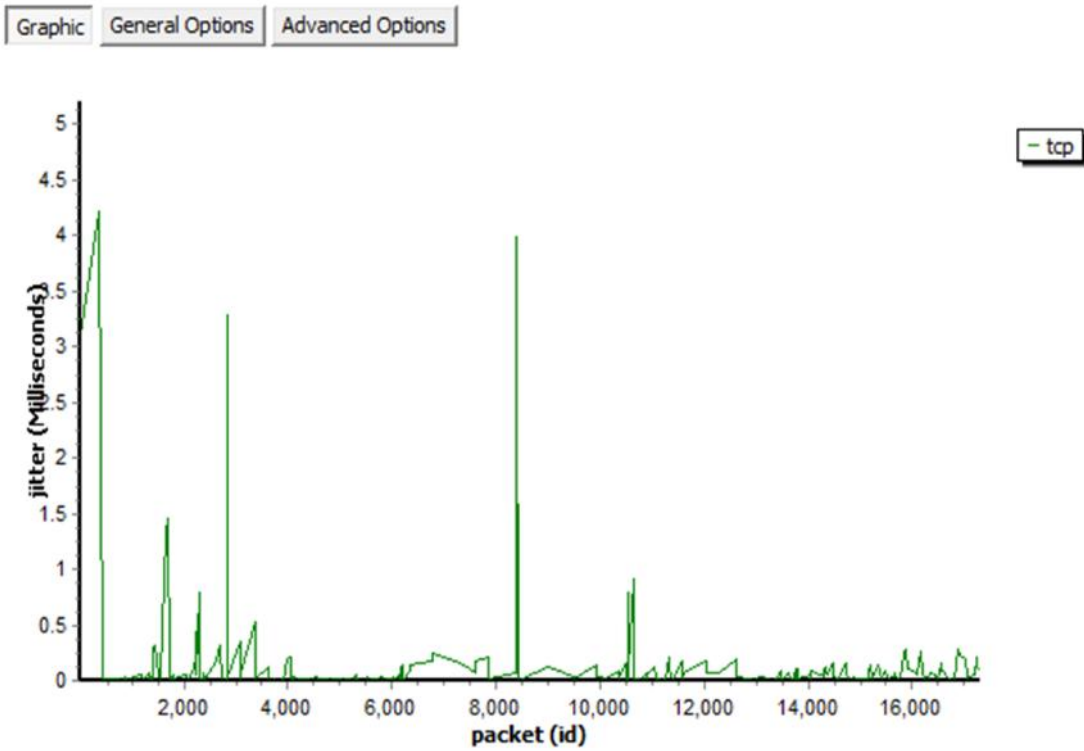


Figure 7: Packet Delay Variation Jitter Vegas (AODV)

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