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IJSRNSC

Volume-6, Issue-4, August 2018
Research Paper

Int. J. Sc. Res. in
Network Security
and Communication

ISSN: 2321-3256

Evaluating the Performance of TCP over Routing Protocols in MANETs Using NS2

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Received: 07/Jul/2018, Revised: 15/Jul/2018, Accepted: 18/Aug/2018, Published: 31/Aug/2018

***Abstract* -** While MANETs exhibit unique advantages, but at the same time special characteristics of MANETs such as bandwidth constrained variable capacity links, infrastructure-less, multi-hoprouting, network scalability, dynamic network topology impose many challenges to TCP protocol which aims at providing coordination to the shared access medium among a number of mobile nodes. This paper presents an overview of the TCP protocols over routing protocol. The main target of our paper is to measure the performance of TCP protocols over different routing protocol in MANET. Further performance of TCP protocols is analyzed and compared for varying network size to find out which protocol is more suitable. We have done the simulation of our work with the help of Network simulator (NS-2). Node density, mean node-to-node delay, throughput and packet delivery ratio are employed for performance evaluation and these are computed only in case of varying network size.

Index Terms – TCP, Routing Protocols, Network Simulator

I. INTRODUCTION

Recently, mobile communications and wireless has experienced an extraordinary development. Currently, mobile wireless networks have two variations: (1) Networks with fixed and wired gateways in other term infrastructure-based network connections, these are connected using base stations. All the communication goes through these base stations. Wireless local area network is one of the applications of this type. (2) Infrastructure-less mobile network is also recognized as ad-hoc network, which has no fixed router in ad-hoc network, all can do movement and they can also connect randomly. Nodes of this kinds of networks works like routers which find out and preserve routes to different nodes in the communication network that result in a multi-hop routing. MANET is a most capable and quickly growing network which is depended on a self-organized and quickly arranged network. It is more susceptible than wired network because of dynamic topology, threats from compromised nodes inside the network, scalability, mobile nodes, partial physical security, and not have of centralized management. Due to these complexities MANET offers many challenges to TCP protocol which aims at providing connection among a number of mobile nodes. The various versions of popular TCP protocol such TCP Tahoe, Reno New Reno.The main focus of this thesis is the technological aspects of TCP protocol offered by other versions and more specifically, the impact of variation in two different aspects of mobility i.e. speed and pause time over these networks using routing protocol in MANET. The rest of the report is organized as follows: In Section II we discuss description and related works. In Section III we discussed overview of survey papers. In Section IV we Review of routing protocols. Section V we discusses introduction to TCP variants. Section VI we discuss Tools, Techniques & Results. . Section VII we conclude the paper and gives research directions

II. DESCRIPTION OF THE RELATED WORK

At present, research based on MANET is very hot and dynamic and the attempts of the research group with the present and future MANET enabling tools will definitely cover the way for commercially feasible MANETs and their novel and exhilarating applications. In the search of a suitable protocol suite for MANET many researchers have analyzed the capacity of TCP versions over routing protocol in MANET.

In 2011 **Noor Mast et al. [1]**, conducted a survey in the field of Wireless Ad-hoc Networks focusing on the techniques recommended for performance enhancement of TCP in wireless Ad- hoc Networks. They mentioned the problems that TCP face in MANET, like channel contention and frequent link failure, which is heavy problem and offer the base for other problems to occur. They compared all approaches those fall under the same category.

In 2010 **Mohit and K. C. Shet et al. [5]**, computed the performance of TCP variations in static and Mobile Ad-hoc Networks as well as routing protocols. They had employed routing protocols like AODV, DSDV, OLSR, and DSR. They also employed TCP variations like TCP-Reno, TCP Tahoe, TCP-New Reno, TCP-Vegas, and TCP-SACK. Simulation results indicate that all TCP variation performed high for DSR protocol but DSDV with all the TCP variations accomplished the less throughput.

In 2013 **H Paul and Priyanka Sarkar [3]**, presented a review on high Speed TCP Variations in Wireless Mobile Networks, authors evaluated and implemented the Congestion control techniques in TCP SACK and addition of TCP Reno's congestion control approaches. The TCP SACK employs TCP Reno's congestion control approaches to decrease or increment the size of congestion window. They also presented on the whole throughput of the connected network by keep away from superfluous delays during retransmission of lost packets, while congestion is noticed by the failure of a data packet, and TCP SACK go into the Fast Recovery stage like in TCP Reno.

In 2012 **Henock Mulugeta et al. [4]** compared the capacity of TCP variantions over routing protocols. They estimates that the AODV accomplished the maximum throughput for all the TCP variations and TCP Newreno gives much higher throughput. They also conclude that if there is an enhancement in the nodes quantity, the throughput of all the TCP variants are worst over DSR, AODV, and DSDV routing protocols. The average throughput of TORA is least for all TCP variations.

III. OVERVIEW OF MANETS

MANET [9, 7] is an independent gathering of nodes or devices like sensors, laptops, smart phones, those correspond with one other above bandwidth controlled wireless links and work jointly in a distributed way to offer the essential network serviceability in the nonexistence of a fixed infrastructure. MANET can with dynamism be set up anyplace and anytime. Devices that laze inside one other's variety can converse directly with each other and are liable for enthusiastically determining one another. To facilitate communication among nodes those have not openly within each other's send target, in-between nodes in the network work as routers that pass on data to the destination. These mobile devices are frequently have constrained of energy- i.e., battery-powered- equipment's with a large variations in their capacities. Moreover, nodes are autonomous in the sense that they are liberated to adhere or went away the connections and they might progress arbitrarily, which results in repeated and random topology alter. In these dynamic, energy-constrained, circulated multi-hop backgrounds, nodes necessitate to systematize themselves energetically in order to deliver the essential network functionality in the dearth of fixed infrastructure or essential administration. Although the mobile ad hoc networks, design constraints provide many advantages. This kind of network is extremely matched for use in circumstances, where a inflexible infrastructure is not obtainable, non trusted, much costly or unpredictable. Due to their self-organizing, self-creating, and self-administering capacities, MANET might be quickly organized with less user involvement. Excessive planning is not required of base station installation or wiring. Also, adhoc networks don't require to work in a individual fashion, however can be fond of to the Internet, therefore merging diverse devices and allowing their services obtainable to another end users. Moreover, energy arguments, range, and capacity encourage their wide use with existing cellular infrastructures as they can enlarge reporting and connectivity. The adhoc network may be used in urgent situation search-and-rescue operations, battlefield operations and data acquirement in hostile terrain, E-commerce (electronic payments anytime and anywhere), in education for ad hoc communications during lectures or meetings etc.

IV. ROUTING PROTOCOL

Routing protocols [6] be employed to discover the route used for sending of packets. As mobile adhoc networks are represented by a multihop network topology that can amend regularly because of mobility and where mobile nodes themselves be active as routers to route packets to the destination, effective routing strategies are required to maintain communication bridge between nodes, without reason of too much transmit overhead, control on the power guarded devices, and computational load. A routing protocol must have to address the challenges associated with MANET like mobility, error-prone and shared channel, QoS, loop-free routing, bandwidth constraint, location-dependent contention, quick route reconfiguration, minimal way attainment delay, distributed routing method, least control overhead, network scalability. A huge number of solutions have previously been projected. A variety of routing protocols are classified in the following categories:

A) **Proactive Routing Protocol**

They effort to keep steady, date-to-date routing information to each nodes of the whole connections every times. For this purpose, proactive protocols [6, 2] exchange routing control information occasionally as well as on topological modifications by broadcasting or propagating and all nodes have to preserve one or more tables to save routing information. This can cause substantial control traffic overhead and ultimately wasting the bandwidth and limited device power of mobile nodes. Several times, it is non-essential to keep an up-to-date way to all different nodes and these updated information might be already out of date when received the nodes. The advantage however is that route to any destination is always available. a number of of the existing proactive adhoc routing protocols are: FSR (Fisheye State Routing), WRP (Wireless Routing Protocol), HSR (Hierarchical State Routing), DSDV (Destination Sequenced Distance-Vector), CGSR (Cluster head Gateway Switch Routing), and GSR (Global State Routing).

B) **Reactive Routing Protocol**

Reactive protocols [6, 7] attempt to remove the traditional routing tables and thus decrease the requirement for updating these tables to path modifications in the topology. Whenever a source needs a path to a target, it has to set up the route by route detection process, keep it by some way of route maintenance method until and unless either the way is not desired longer or it turn into unreachable, and lastly split it by route deletion approach. Some re-active routing protocols are: TORA (Temporally-Ordered Routing Algorithm), AODV (ad hoc On-Demand Distance Vector Routing), DSR (Dynamic Source Routing), LAR (Location Aided Routing), CBR (Cluster Based Routing), ABR (Associativity Based Routing).

V. INTRODUCTION TO TCP VARIANTS

The TCP protocol is a reliable connection oriented window based transportation layer protocol to achieve its reliability through acknowledgements and sequence numbers. TCP utilizes the ACK like a travel clock during data transition for the network and regulate the transmission speed as per to the accessibility of capacity of networks.

Slow start and overcrowding avoidance algorithms are the important phases of the

TCP congestion technique. TCP performs the following operations such as given below:

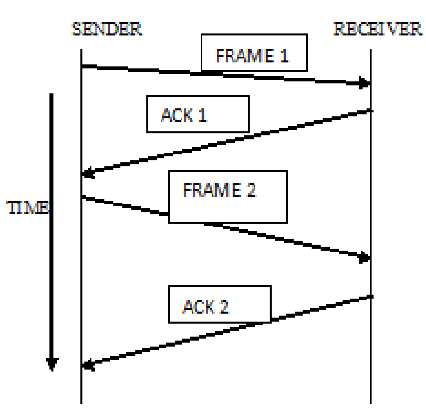

Figure 4.1: TCP Normal operation

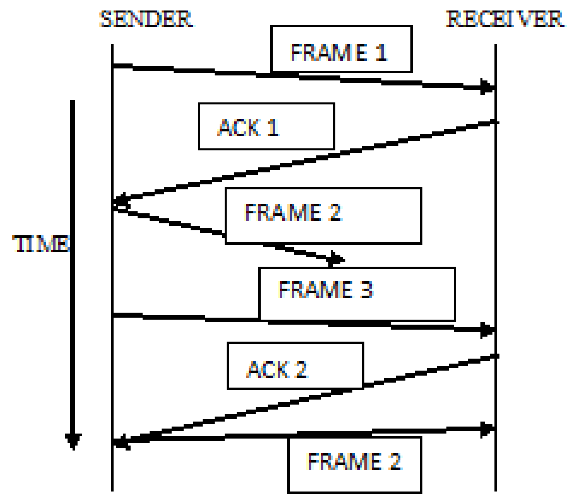

Figure 4.2: TCP Lost Data Operation

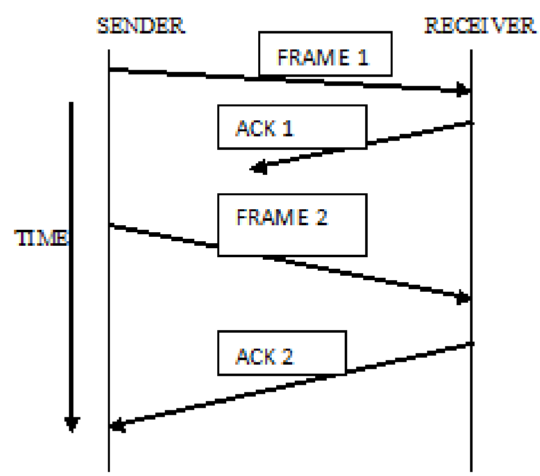

Figure 4.3: TCP Lost Ack operation

A) TCPRENO:

Before timeout event occurs, TCP Reno detects and retransmits more than one lost packet. It does not forever wait for three duplicate acknowledgements. As a result it can retransmit quicker. TCP Reno does not reduce the congestion window too much in advance. TCP Reno suggests fast recovery to avoid slow start phase.

Reno requires that the receiver immediately give an acknowledgement for each time, when a data segment is received. Whenever it receives three duplicate acknowledgements, it is a strong indication of segment has been misplaced and it immediately resends the data segment with no waiting for timeout. One more modification is that if a packet lost, it does not decrease the congestion window size to 1. Problems in TCP Reno**:** TCP Reno only retransmits one packet per RTO. It receives for TCP sender a high time to recuperate from congestion. Whenever it detects multiple packets fail packet from one window even then RENO does not perform too well.

Problems in TCPreno:

It only retransmits one packet per RTO, so it takes for TCP sender a high time to get back from congestion. When multiple packets lost from one window after that RENO doesn't perform well and degrades the lots of capacity of the connections.

B) TCPNEWRENO:

TCP Newreno is capable to detect several packet failures from single window size of data. Like Reno, it also enters into fast re-transform mode whenever it gets multiple duplicate packets. It does not exit fast recovery until and unless whole data packets received. It also conquers the problems done by Reno during diminishing the congestion window multiple times. It exits from fast recovery phase where whole data segments in the window are acknowledged. Problems in Newreno: Newreno experiences from the truth that it keeps one RTT to find every packet lost. It also needs one RTT to get back every packet fail.

Problems:

New-Reno undergoes from the verity that it's taking one RTT to find all packet lost. It also needs one RTT to recovers every packet loss. Occasionally packets are now kept by duplicate ACK and TCP Newreno by mistake goes into quick recovery and bisects its congestion window.

C) TCP SACK

TCP-Sack changes the fast recovery and retransmission methods, this is applied in TCP-Reno. The difficulty that has been seen in TCP-Reno and New Neno was, they merely resend one packet per RTO. However in TCP-Sack, multiple nodes can be resend per RTO when several packets loss from one window of data. If replicate acknowledgments gets from TCP receiver, TCP-Sack can appeal for quick retransmit and fast recovery methods like as TCP-New Reno do. The main difficulty with SACK is that, its current selective acknowledgements which are not offered by the destination node. More memory space are also required.

D) TCP VEGAS

The target of TCP Vegas is to contain a convinced several bytes or packets in the queues of the connections. The supported features by TCP Vegas are that it has modified slow-start, New retransmission, Congestion avoidance. The problems associated with it are that Vegas may not alleviate if buffers are short

VI. TOOLS, TECHNIQUES & RESULTS

Nework Simulator-2 (ns-2) [8] is used to simulate the desired network environment as ns-2 provides the full support to simulate TCP over routing protocols with mobility. Ns-2 has been build up to offer an extensible network simulation platform and open for networking area. In short, ns-2 offers techniques of how packet data networks perform and offers a simulation engine for end users to do different kinds of experiments. All the core models of NS-2 are written in C++ and front-ends is also in C++ code must be done for numerous scripting languages like TCL, Python and Perl with the help of particular binding originators. The software engineering and advances in C++ compiler technology are heavily utilized by the core of ns-2. The main framework of NS-2 has a hierarchical object scheme with integrated tracing, attributes, and callbacks. It is a discrete event simulation approach and memory-efficient packet handling system, which is build upon these foundations. it drive development in each simulation algorithm.

A) SIMULATION ENVIRONMENT:

The main traget of this NS-2 based implementation is to compare the performance of TCP protocols over routing protocol in MANETs environments in three different scenarios. In the first and second scenario network with 3 nodes is created and FTP traffic is generated at a rate of 100kb/s form source nodes (mobile devices with Node-IDs range from 1 to 3) to destination nodes (mobile devices with Node-IDs ranging from 4 to 6) respectively. In every scenario movement of nodes is modeled using Random Waypoint Mobility Model within a implementation range of 500m X 500m and simulation is run for the duration of 100s. In the first scenario, multiple runs at different speeds of 10, 20, & 30 m/s while keeping pause time constant at 1s are conducted. In the second scenario, multiple runs at different pause times of 1, 2, & 3 s while keeping speed constant at 20m/s are conducted. In the third scenario, multiple runs with different number of nodes as 10, & 20 are conducted where FTP traffic is generated at a rate of 100kb/s form source nodes (devices with Node-IDs ranging from 1 to 10) to destination nodes (devices with Node-IDs ranging from (Number of nodes) to ((Number of nodes)-10)) respectively. In this scenario, nodes shift at the velocity of 20m/s and after reaching the destination take a pause of 1s before starting the movement again.

Table 6.1: Simulation parameters during first scenario of varying Speed and Constant Pause Time of 1s

Parameters	Values
TCP Protocols	Tahoe,reno,newreno, sack & vegas
Routing protocol	DSDV & AODV
Mobility Model	Random Waypoint
MAC Protocol	IEEE802.11
No. of mobile nodes	3,10, & 20
No. of connections	2,5, & 10
Simulation time	100s
Packet size	512 Bytes
Simulation area	500m X 500m
Traffic source	FTP
Data rate	100 Kb/s
Speed	10,20,& 30 m/s
Pause time	1,2, &3 s

B) SIMULATION RESULTS AND ANALYSIS:

Performance of TCP over routing protocol in MANETs in above mentioned scenarios using the following performance metrics:

i. **Packet delivery ratio:** the ratio of total number of packet get to the total number of packet transmits is called PDR.

ii. **Average end to end delay:** It is the total delay experienced by the packet from the time of production of packet at the source node to the time of its getting at the destination.

iii. **Throughput:** Total quantity of data received actually at the destination divided by the time it acquires for recipient to obtain the final packet is called throughput.

iv. **Average Node Density-** The node density describes the performance of given network that is varying number nodes. When number of nodes increase / decrease, its performance may affect by the varying number of nodes

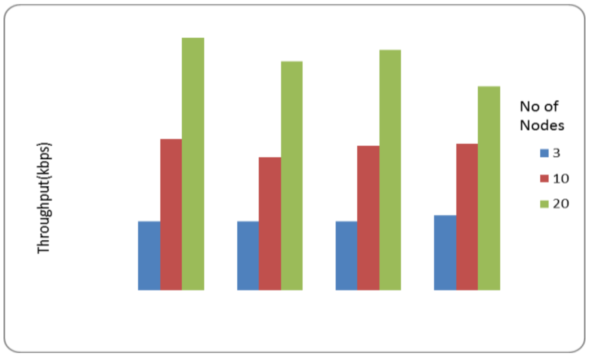

Figure 6.1: Throughput of AODV with TCP Variants

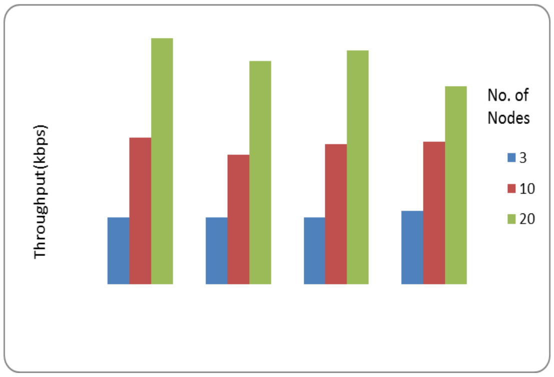

Figure 6.2: Throughput of DSDV with TCP Variants

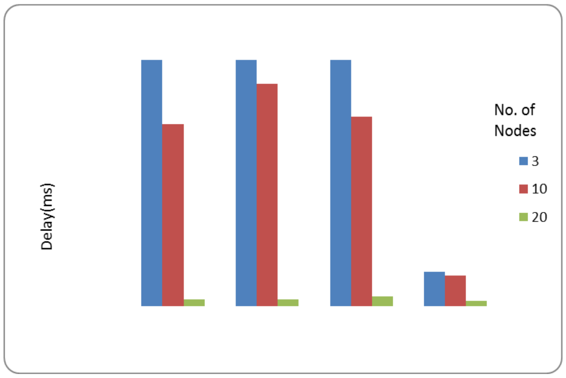

Figure 6.3:Delay of AODV with TCP Variants

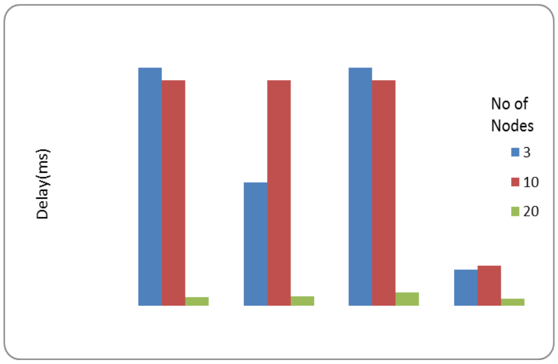

Figure 6.4:Delay of DSDV with TCP Variants

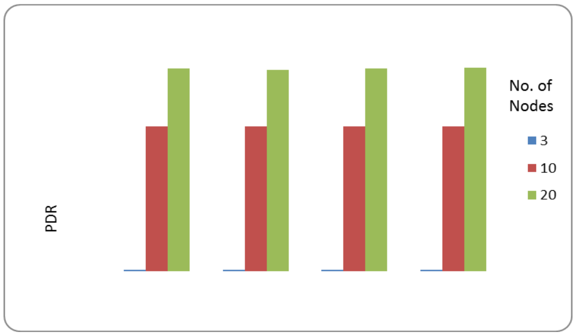

Figure 6.5:PDR of AODV with TCP Variants

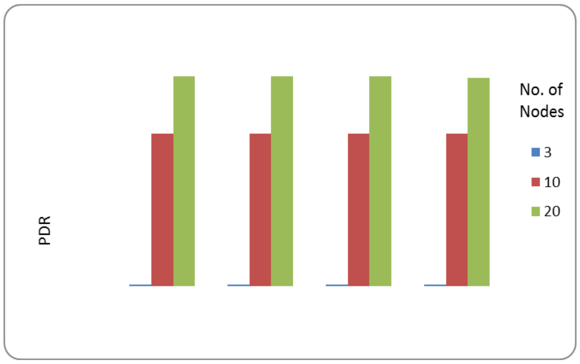

Figure 6.6:PDR of DSDV with TCP Variants

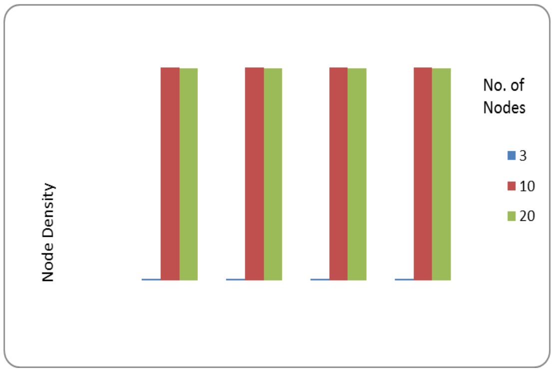

Figure 6.7: Node Density of AODV with TCP Variants

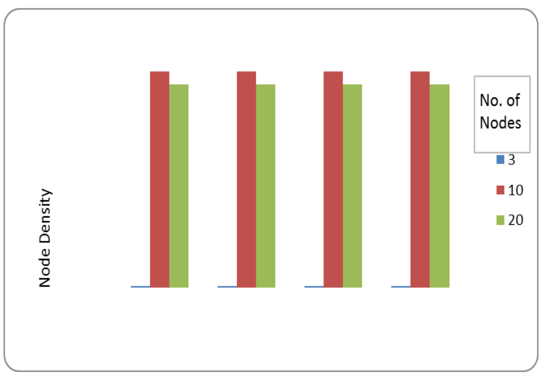

Figure 6.8: Node Density of DSDV with TCP Variants

Fig. 6.1 – Fig. 6.8 presents the results summarized in tables 6.2 - 6. in graphical formats.

Fig. 6.1 & Fig. 6.2 mean throughput of TCP versions with DSDV and AODV routing protocols in MANETs environments. The TCP Newreno got maximum throughput with AODV routing protocol than other TCP versions. The TCP Sack achieved highest throughput with DSDV routing protocol than other TCP versions Fig.6.2 & Fig.6.4 demonstrates the average delay of TCP with DSDV and AODV routing protocols in MANETs environments. The TCP Vegas achieved least node to node delay with both AODV and DSDV routing protocol than other TCP versions. Fig.6.5 to Fig. 6.8 shows PDR and Node Density using AODV & DSDV routing protocol for 3 to 20 nodes simulation scenarios. Through simulation results TCP versions play equal PDR & Node density with AODV and DSDV routing protocols.

VII. CONCLUSION AND FUTURE SCOPE

In case of MANET where mobile users are free to move, leave or join the connections resulting in an unpredictable dynamic topology, the performance of various TCP versions with different routing protocols were compared and evaluated. Through simulation results the TCP Reno and TCP Newreno have achieved highest throughput than other version for DSDV and AODV routing protocols. TCP Vegas performed best because it achieved least end to end delay for AODV and DSDV for 3, 10, & 20. Fig.6.1 to Fig.8 shows the TCP versions achieved same PDR and Node density using AODV & DSDV routing protocol.

So finally it can be concluded that TCP New Reno is more efficient than other protocol with AODV and TCPreno is more efficient with DSDV routing protocol.

In future impact of varying speed, pause time and network size on the energy consumption of the TCP versions can also be analyzed and compared.

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