Performance Analysis of TCP Variants under Routing Protocols of MANET using NS2

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ABSTRACT

The necessity and purpose for wireless communication system has increased dramatically over the recent years. In particular, the deployment of a wired network is not feasible under certain circumstances such as natural disasters, military war field, Ad-hoc network. The conventional TCP is the only better solution to address the issues in wireless networks and compatible with wired network as well. But still a little pinch of requirements are required for TCP to address the issues completely. TCP yields better performance in wired networks but lags in wireless environment due to frequent path breaks, topology being dynamic and using sliding window based data packet transmission between end to end. So, to provide reliable data communication support over MANET's, various TCP variants has been proposed to refine congestion control in MANETs. This research work eyes on evaluating the performance factors and QoS of different versions of TCP such as throughput, end-to-end packet delivery ratio and average delay. Possible scenarios under MANET are simulated and the parameters were set in NS2. Analysis portray the performance of TCP variants.

Index terms: TCP Vegas, TCP Reno, MANET, NS2

1. INTRODUCTION

Mobile Ad-hoc Networks (MANETs) are self -configuring networks consisting of mobile nodes that are communicating through wireless links. There is a cooperative engagement of a collection of mobile nodes without the required intervention of any centralized access point or existing infrastructure. The nodes move arbitrarily; therefore, the network may experience unpredictable topology changes. It means that a formed network can be deformed on the fly due to mobility of nodes. Hence, it is said that an Ad-hoc wireless network is self-organizing and adaptive. Due to infrastructure less nature of Ad-hoc networks, it has several applications in the area of commercial sector for emergency rescue operations and disaster relief efforts. MANETs also provides a solution in the field of military battlefield to detect movement of enemies as well as for information exchange among military headquarters and so on [1]. Also, MANET provides an enhancement to cellular based mobile network infrastructure. Nowadays, it is an inexpensive alternative for data exchange among cooperative mobile nodes [2].

2. OUTLINE

A. Routing Protocol in MANET

The routing is the process of transferring information (packets) across a network from a source to a destination. The routing infrastructure needs to be established in a distributed, self-organized way due to node mobility. The MANET routing protocols can be divided into three categories [3].

- Proactive protocols or table driven protocols
- Reactive protocols or on-demand protocols
- Hybrid Routing protocols

Ad-hoc on demand distance vector (AODV): It is an on-demand and distance-vector routing protocol, which means that a route is established by AODV from a destination only on demand [4]. AODV is capable of both unicast and multicast routing [5]. It allows the nodes to enter and leave the network at will. Routes will remain as long as the data packets are going from source and being getting delivered at the destination. When the source stops sending packets, the path will get timed out and terminated. It is loop-free, self-starting, and scales to large numbers of mobile nodes [6] [7]. AODV defines three types of control messages for route maintenance i.e., RREQ, RERR and RREP. The main advantage of AODV is that it is a beacon-full routing protocol so that its convergence is fast due to linked-node communication and disadvantage is that the periodic beaconing leads to unnecessary bandwidth consumption and overall computational overhead.

Dynamic Source Routing (DSR): DSR is again an on-demand protocol that comes under Reactive protocols category designed to restrict the bandwidth consumed by control packets in ad hoc wireless networks by eliminating the periodic table-update messages required in the table-driven approach [9]. Routes are discovered only when needed. The major difference is that it is beacon-less and hence does not require periodic hello packet (beacon) transmission, which are used by a node to inform its neighbours of its presence. The basic approach of this protocol during the route construction phase is to establish a route by flooding Route Request packets in the network. The destination node, on receiving a Route Request packet, responds by sending a Route Reply packet back to the source, which carries the route traversed by the Route Request packet received. In general, it can be defined that a protocol which uses the policy of routing the packets dynamically from the source is called as DSR protocol.

Destination-Sequenced Distance Vector (DSDV): DSDV is a table-driven routing [8] scheme for MANETs. The Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm is based on the idea of the classical Bellman-Ford Routing Algorithm with certain improvements. Every node maintains a routing table that lists all available destinations, the number of hops to reach the destination and the sequence number assigned by the destination node. The sequence number is used to distinguish stale and expire routing information from new ones and thereby eliminating the creation of loops.

B. TCP Protocol

Transmission Control Protocol (TCP)[10][11] is the predominant and most traditional protocol used in Internet. It carries majority of the Internet traffic in today's heterogeneous wireless and wired networks. TCP is reliable end to end protocol because TCP is trying to provide reliable data transmission between two entities. TCP is widely used as a connection oriented transport layer protocol that provides reliable data packet delivery over unreliable links. TCP primary purpose is to provide a connection-oriented reliable data transfer service between different applications to be able to provide these services on top of an unreliable communication system. TCP considers data transfer, reliability flow control, multiplexing, TCP segment, and congestion control and connection management. TCP does not depend on the underlying network layers and, hence, design of various TCP variants is based on the properties of wired networks. It is compatible with wired and wireless networks such as mobile telecommunications also. It also uses sequence numbers for every data packet and thereby ensures that the correct order of packets. It is used popularly in video streaming websites and other sensitive applications such as Internet banking, passport application.

TCP Vegas: Vegas is a TCP implementation which is a modification of RENO. It builds on the fact that proactive measure to encounter congestion is much more efficient than reactive ones. It tried to get around the problem of coarse grain timeouts by suggesting an algorithm which checks for timeouts at a very efficient schedule. Also it overcomes the problem of requiring enough duplicate acknowledgements to detect a packet loss, and it also suggests a modified slow start algorithm which prevents it from congesting the network.

TCP Westwood: TCP Westwood congestion control algorithm [12] use a bandwidth estimation, it executed at sender side of a TCP connection. The congestion window dynamics during slow start and congestion avoidance are unchanged. The general idea is to use the bandwidth estimate BWE to set the congestion window and the slow start threshold after a congestion episode. In TCP Westwood the sender continuously computes the connection BWE which is defined as the share bottleneck used by the connection. Thus, BWE is equal to the rate at which data is delivered to the TCP receiver. The estimate is based on the rate at which ACKs are received and on their payload. After a packet loss, the sender resets the congestion window and the slow start.

3. RELATED WORK

Extensive literature survey has been done to find the gaps TCP Variants over MANET Routing Protocols. Yuvaraju B N et al. [13] performed the simulation based analysis of variants of TCP on the three performance metrics such as Throughput, Average End-to-End delay and Packet Delivery ratio in low and high mobility by using ns2 simulator. After analysing the performance from simulated data and graphs obtained, we concluded that out of six TCP variants named TCP TAHOE, TCP RENO, TCP NEW RENO, TCP SACK, TCP FACK and TCP Vegas, performance of TCP Vegas is better for sending data and information due to its better packet delivery ratio and avg. End-to-End delay in both high and low mobility. B.S. Yew et al. [14] performed the simulation based analysis of TCP Vegas versus different TCP variants in homogenous and heterogeneous networks by using network simulator (ns-2). After simulation, it was observed that the overall performances of TCP variants in wired-cum-wireless network are poorer compared to their performances in wired network. It was also observed that TCP Vegas always exhibits significant lower delay as compared to other TCP variants in both wired and wired-cum-wireless network. MACURA et al. [15] described the evaluation and comparison of three control algorithms, which are Westwood+, New Reno and Vegas TCP by using ns2. Results show that Westwood+ TCP is friendly towards New Reno TCP and improves the fairness in bandwidth allocation whereas Vegas TCP is fair but is not able to grab its bandwidth share when coexisting with Reno or in the presence of reverse traffic because of its RTT-based congestion detection mechanism to reduce bottlenecks of TCP traffic. Final results show that Westwood+ significantly enhances utilization of wireless communication links that are affected by losses not due to congestion.

Rajneesh Kumar Gujral et al [16] has performed Analysis that at what speed and by taking how much zone radius ZRP will be able to perform efficiently and effectively for MANETs. Give a results that if the radius zone is small then the nodes act as reactive protocol so if the zone is less than the average delay is more. When the mobility rate is less then throughput, packet delivery ratio is maximum and if the mobility rate and zone size is increase the control overhead is also increased.

Simulation based analysis of TCP and UDP over ZRP has been analyzed in [17]. After analysis its results have concluded that, when zone size is very small it act as reactive routing protocol because the probability of destination node with in routing zone is less, so average delay is more. ZRP uses proactive routing within the zone as zone size gets increased then delay keeps on reducing destination nodes can come under the routing zone. As TCP is reliable protocol. When it has been analyzed on ZRP, its results shows maximum packet delivery ratio with lower mobility speed and lowest packet delivery ratio with highest mobility speed. Throughput is also inversely proportionate to mobility speed and zone size. Similarly, when we analyzed UDP due to its unreliable nature its performance is poor in all the scenarios. So after analysis and result discussion this paper concludes that UDP flows perform better in the case of dense networks with little or no mobility. TCP flows perform better for high mobility scenarios

Iffat Syad et al. [18] In this research, through simulations that were carried out by using Network Simulator-2 (NS-2) , the selected MANET Routing protocols i.e. DSR and DSDV were analysed in accordance with their finest performance of packets delivery rate, average end-to-end delay, and packet dropping, under TCP Vegas and TCP New Reno with mobility consideration. The simulation results indicate that DSDV has a better throughput performance but high average end-to-end delay and packet drop ratio as compared to DSR. Gayathri et al. [19] In the research work, MANET protocols like AODV, DSDV and DSR protocols performance analysis was investigated with TCP Reno, TCP new Reno and TCP Vegas using ns2. The analysis of TCP variants was based on the these performance metrics like Average End-to-End delay, Packet Delivery Fraction, Packet Loss, Routing Overhead and Convergence Time. These metrics were calculated by varying the node coverage area. The performance of TCP variants varies according to the routing protocols and network scenarios. Among all possibilities, the proposed TCP variant having better performance .TCP NEW RENO outperforms better as compared to other variants. DSR has performed well compared to all other protocols in terms of delivery ratio while AODV outperformed in terms of average delay. DSR generates lower overhead than AODV while DSDV generates almost constant overhead due to proactive nature. S. Mascolo et al. [20] evaluates and compares three control algorithms, which are Reno, Vegas and Westwood+ TCP, using the ns2 simulator, the dummy net emulator and live internet measurements. Results show that Westwood+ TCP is friendly towards Reno TCP and improves the fairness in bandwidth allocation whereas Vegas TCP is fair but it is not grab its bandwidth share when coexisting with Reno. Westwood+ improves utilization of lossy links w.r.t both Vegas and Reno and provides the highest bottleneck utilization in the presence of small capacity buffers. Md. Monzur Morshed et al. [21] In this paper, simulation results were carried out for different TCP packets under several QoS metrics such as drop, throughput, delay and jitter. Considering the performance on the variants of TCP, Vegas show the highest efficiency and performs best. So it concludes that in terms of drop rates, delivery rates and total receiving throughput, Vegas is clearly best among the four variants of TCP under the designed scenarios and environment that is simulated using NS2.

4. QoS BASED PERFORMANCE METRICS

The most popular performance metrics for a packet delivery protocol in MANET includes the QoS parameters such as Packet Delivery Ratio (PDR), average Throughput, average Delay, Routing Overhead and average Jitter which ensures the protocol is reliable and yields sublime results.

Packet Delivery Ratio (PDR): PDR also known as Packet Delivery Fraction which is nothing but the ratio of the data packets delivered to the destinations to those generated by the FTP/CBR sources. This metric posturizes both the completeness and perfection of the routing protocol in MANET. It can be determined from trace file of the NS2 simulation using AWK scripting which handles text base files of large volumes effortlessly. Trace file (.tr) contains all the mobility traces and agent traces.

$$PDR = \frac{\sum_{1}^{n} CBRrece}{\sum_{1}^{n} CBRsent} * 100$$

Average End to End Delay: Average End to End delay is the average time taken by a data packet to reach from source node to destination node. It is ratio of total delay to the number of packets received. It is the time taken by the packet to reach the destination as soon as it is routed from a source node under the guidance of a particular routing protocol.

$$Avg\_End\_to\_End\_Delay = \frac{\sum_{1}^{n} (CBRrecetime - CBRsenttime)}{\sum_{1}^{n} CBRrece} * 100$$

Throughput: Throughput is the ratio of total number of delivered or received data packets to the total duration of simulation time. the time average of number of bits that can be transmitted by each node to its destination is called as per-node throughput. The cumulative sum of per-node throughput over all the nodes in the network is called as the throughput of the network. Throughput is also determined for every scenario of the NS2 simulation.

$$Throughput = \frac{\sum_{1}^{n} CBRrece}{simulation\ time}$$

Normalized Protocol Overhead/ Routing Load: Routing Load is the ratio of total number of the routing packets to the total number of received data packets at destination.

$$Routing\_Load = \frac{\sum RTRPacket}{\sum CBRrece}$$

5. SIMULATION AND RESULTS

Table 1: Simulation Parameters set up

Parameters	*Values*
Number of nodes	25, 50, 100, 150, 200
Simulation time	15 sec.
Environment size	1000 x 1000
Traffic	CBR data traffic
Queue size	50
Routing Protocols	AODV, DSDV, DSR
Mobility model	Random Way-Point
Antenna type	Omni Directional
Simulator	NS-2.35
Operating System	Ubuntu 14.04 LTS

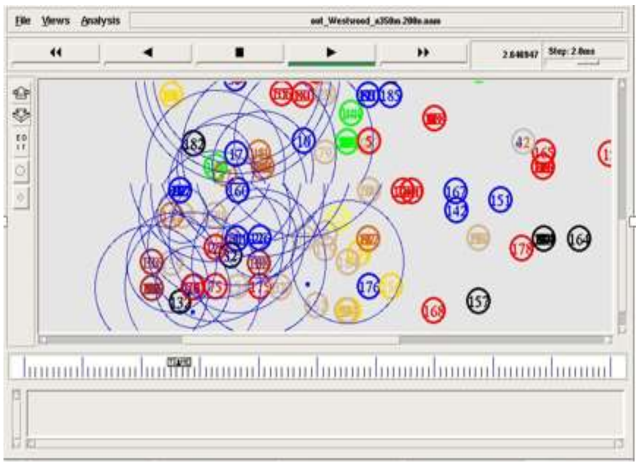

Figure 5.1 Scenario of 200 nodes of TCP westwood with AODV Routing Protocol

Average Delay: Figure 5.2 shows average delay versus number of nodes for MANET routing protocols under two TCP variants named Vegas and Westwood. It is observed that TCP Vegas having minimum average delay with AODV routing protocol followed by Westwood with AODV routing protocol whereas other TCP variant named TCP Westwood have worst performance with DSR routing protocol.

TCP Vegas have better performance because it works on the estimation Round Trip Time (RTT) which detects the congestion faster and at early stages without wasting time on waiting for packet lost to conclude that congestion occurs in the network, which concludes that faster delivery of data to the destination, lower will the delay and it also improves the efficiency of the network.

TCP variant Vegas gives best results with AODV routing protocol because AODV is a reactive and beacon-full routing protocol, in which convergence is fast due to the linked node communication.

The simulation is carried out using NS2. For retrieving the network information out of the trace file that is being generated from the simulation in NS2, Tracegraph 2.02 tool is also used. AWK scripting effortlessly helps in finding QoS parameters from the large sized trace file for each scenario that is simulated under wireless environment of MANET.

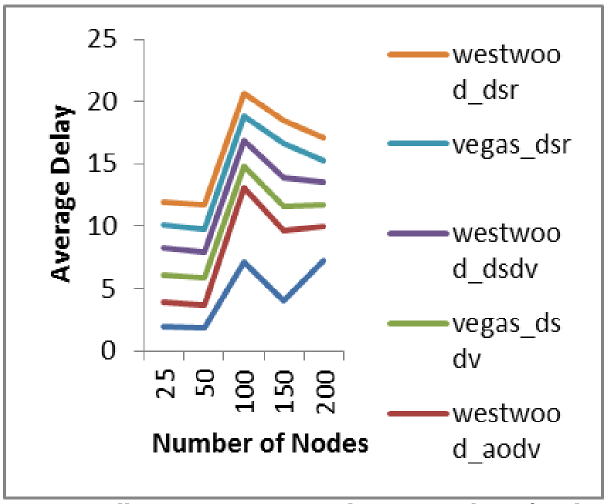

Figure 5.2: Illustrates Average Delay vs. number of node

Average Throughput: Figure 5.3 shows average throughput versus number of nodes for AODV, DSDV and DSR MANET routing protocols under two TCP variants named Vegas and Westwood. It is observed that TCP Westwood have maximum average throughput with DSR routing protocol whereas other TCP variant named TCP Vegas have worst performance with AODV routing protocol. When we increase the number of nodes in a network, more packets are dropped in the network due to the collision.

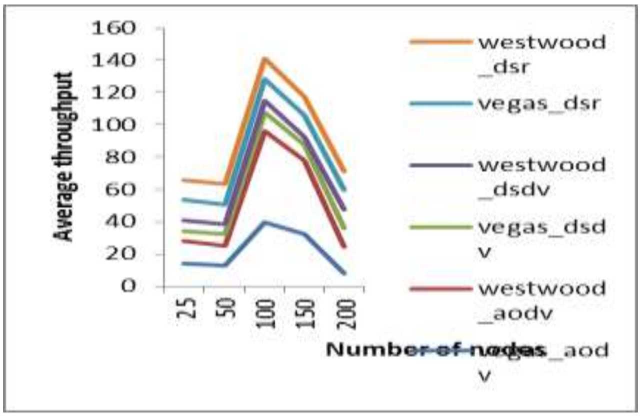

Figure 5.3: Illustrates Average throughput vs. number of node

Packet Delivery Ratio : Figure 5.4 shows Packet Delivery Ratio versus number of nodes for AODV, DSDV and DSR MANET routing protocols under two TCP variants named Vegas and Westwood. It is observed that TCP Westwood have maximum value of average throughput with DSR routing protocol whereas other TCP variant named TCP Vegas have worst performance with AODV routing protocol.

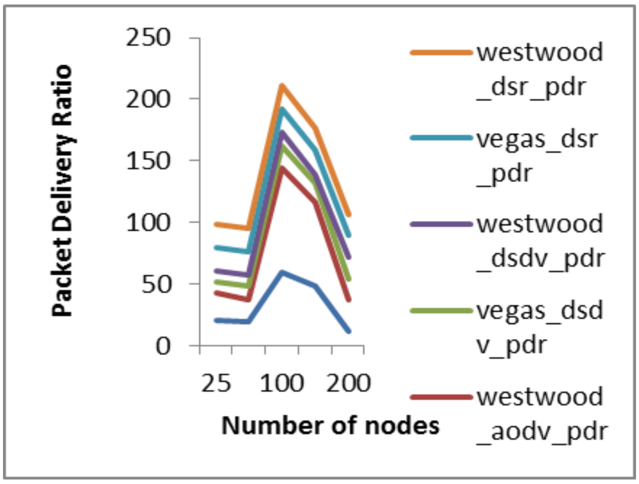

Figure 5.4: Illustrates packet delivery ratio vs. number of node

It is observed that TCP Westwood is better than other TCP variants for sending faster data to the destination and due to its faster recovery mechanism whereas TCP Vegas are giving linear delivery rate. Performance of DSR is better in PDF than AODV because in DSR route cache management is done via cache entry and only active routes are maintained in the route cache. As the number of nodes increases the neighbour density increases hence the value of PDR increases for all on demand routing protocols.

Routing Overhead: Figure 5.5 shows Routing overhead versus number of nodes for AODV, DSDV and DSR MANET routing protocols under two TCP variants named Vegas and Westwood. It is observed that TCP Vegas have minimum Routing overhead with AODV routing protocol whereas other TCP variant named TCP Westwood have worst performance with DSR routing protocol. AODV generates lower routing overhead than DSR while DSDV generates almost constant overhead due to proactive nature. AODV has lower routing overhead because it replies only once to the request arriving first and ignores the rest while DSR replies to all requests reaching a destination from a single request cycle. The major contribution to routing overhead in AODV is from RERRs, while RREPs constitute a large fraction of routing overhead in DSR.

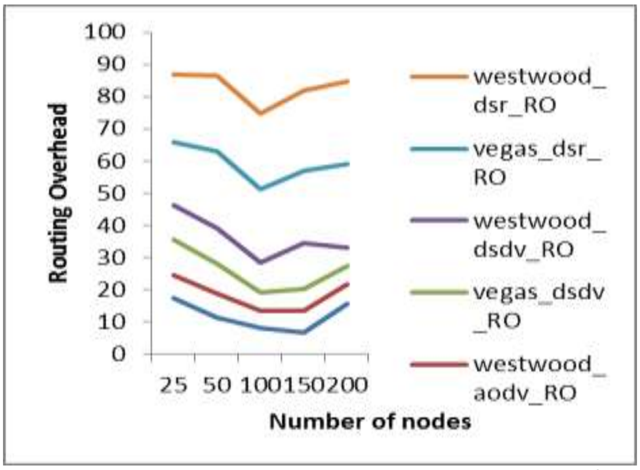

Figure 5.5: Illustrates routing overhead vs. number of node

Average Jitter: Figure 5.6 shows Average Jitter versus number of nodes for AODV, DSDV and DSR MANET routing protocols under two TCP variants named Vegas and Westwood. It is observed that TCP Vegas have minimum routing overhead with AODV routing protocol whereas other TCP variant named TCP Westwood have worst performance with AODV routing protocol. There is not much variation in the value of jitter as the number of nodes increases. TCP Vegas does not wait for loss to trigger congestion window decreases and calculate approximately the current throughput during each time,that is the main reason of Vegas having minimum Jitter.

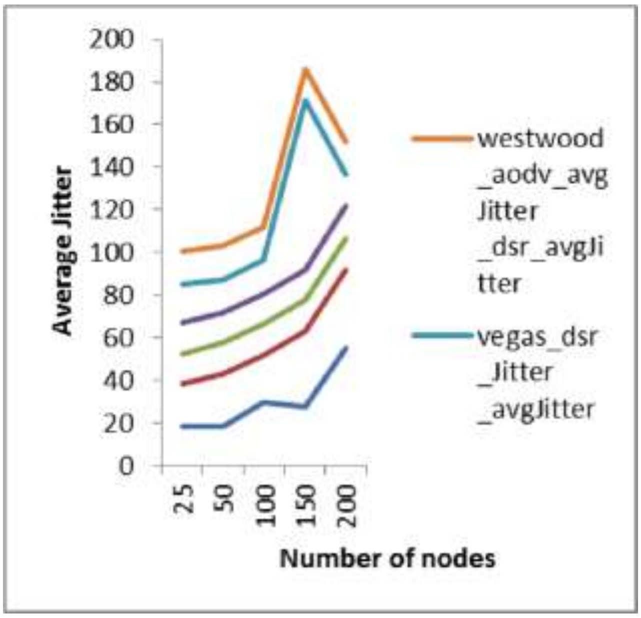

Figure 5.6: Illustrates Average Jitter vs. number of node

6. CONCLUSION AND FUTURE WORK

This study was conducted to simulate the performance of TCP variants over different MANET routing protocols i.e. AODV, DSDV and DSR based on average throughput, average delay, packet delivery ratio, routing overhead and average jitter. It has been found that packet delivery ratio and average throughput are better in case of TCP Westwood with DSR routing protocol with increased the number of nodes and mobility. It has been also found that average delay, routing overhead and average delay are better in case of TCP Vegas with AODV routing protocol as we increased the number of nodes and mobility.

The future work could be conducted with the analysis of MANET environment under Different quality of service (QoS) issues such as node energy consumption, issues of hidden and exposed terminals, and constraints in mobility and traffic criteria. Also more MANET protocols like Hierarchal state routing protocol (HSR), temporarily ordered routing protocol (TORA), Pre-emptive Ad-hoc on-demand distanceVector routing protocol (PAODV). Dynamic MANET OnDemand (DYMO) can be added for better analysis and comparison of protocols under different TCP variants. Other TCP variants can also be tested. In future more parameters will be taken into consideration such as different traffic scenarios, congestion window size, number of connections etc.

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