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Comparative Analysis of TCP variants with AODV in Mobile Ad Hoc Network

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Abstract— TCP was designed for wired networks and the sender assumes that packet loss is an indicator of network congestion, but this assumption may not apply to Mobile Ad hoc Networks (MANETs). In Mobile Ad Hoc networks, performance of the standard TCP is significantly degraded due to characteristics of MANET such as route failures due to node mobility and link errors. In this paper, we investigate the effects of node's Mobility and No of Nodes on the performance of TCP variants such as Reno and Vegas. Reno views the packet loss as signal of network congestion, while Vegas uses the difference in the expected and actual throughput rates as network congestion indicator. Simulation results from the implementation of different have been obtained. Routing protocol such as Ad hoc On-Demand Distance Vector (AODV) has been investigated to obtain the performance of TCP variants in this paper.

Keywords- TCP, MANET, TCP Reno, TCP Vegas, AODV, PDR, Throughput, End to End Delay

1. INTRODUCTION

A Mobile Ad Hoc Network (MANET)[1] is an autonomous collection of nodes which are mobile and are wireless. They communicate with each other in an autonomous infrastructure. It does not follow a centralized administration. Due to the mobile nature of host, the network topology changes unpredictably. The main feature of MANET is its decentralized and non-administered nature which makes it self-organizing. MANETs have a great scope in the field of the scientific and industrial community. Such networks are forecasted to have dynamic, sometimes rapidly changing, random, multi hop topologies, which are likely composed of relatively bandwidth constrained wireless links.

MANETS are more vulnerable than wired networks when attacks are taken in consideration. Some conditions that make MANET vulnerable are:

- Open medium
- Dynamically changing network topology
- Cooperative algorithms
- Lack of centralized monitoring
- Lack of clear line of defence

MANETs are widely used in military exercises, mine works, disaster relief operation etc. To make MANETs more efficient for these applications, it has to be more secure and reliable.

The performance of the various TCP variants were examined based on the performance metrics of Packet Delivery Ratio, Throughput and End to End Delay taking AODV as routing protocol and by using NS-2.35 simulator [15].

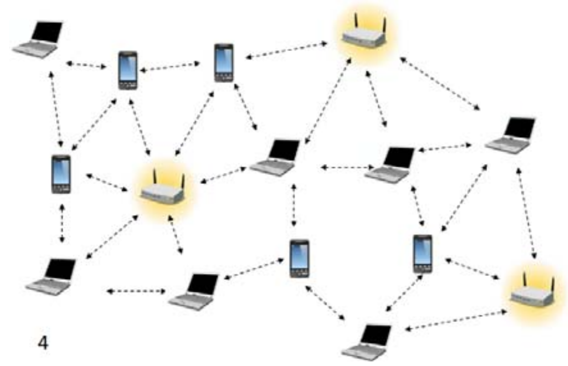


Fig1.Infrastructure of Mobile Ad hoc Network [1]

2. BRIEF INTRODUCTION TO TCP AND ITS VARIANTS

2.1. *Transmission Control Protocol [14],[12]*

Transmission Control Protocol, TCP is the Internet's most widely used transport control protocol. Its strength is in its adaptive nature of control algorithm and congestion avoidance, The TCP was first proposed by V. Jacobson. It was further refined in Reno version of TCP. The two major control mechanisms of TCP are its congestion control and congestion avoidance mechanism.

2.1.1 *Slow Start*: TCP estimates the bandwidth available before sending the data or else it would affect the throughput of TCP connection (throughput will decrease drastically). The reason behind this is that if the buffer gets full, the intermediate routers would drop the packets form the buffer. The Slow Start mechanism has a new parameter which is responsible to control the rate at which packets are sent, congestion window denoted by cwnd.

2.1.2 *Congestion Avoidance*: An algorithm used by TCP to avoid losing packets is known as Congestion Avoidance Algorithm. Congestion avoidance takes place when the value of cwnd becomes greater than ssthresh. In this phase, the cwnd is increased by one1 full-sized segment every RTT. Congestion avoidance continues to run until congestion is detected. There are two ways to detect congestion one is receipt of duplicate acknowledgment and due to time timeout.

2.2. *TCP Variants[5],[9],[11]*

Two TCP variants are used in this paper namely:

2.2.1 *TCP Reno:*

When it is in slow start phase size of congestion window is increased by one MSS (Maximum Segment Size) when it receives an acknowledgment (ACK) packet. The ACK packet indicates a successful reception of a data packet by the receiver. It induces packet losses to estimate the available bandwidth in the network. TCP Reno adopts the congestion avoidance phase, in which for each arrival of an ACK, TCP increases the congestion window by a fraction of MSS.

2.2.2 *TCP Vegas* :

TCP Vegas Calculate the difference between the expected throughput and actual throughput rates to estimate the available bandwidth in the network. The idea behind this is that when the network is not congested, the actual throughput rate will be close to the expected throughput rate, otherwise, the actual rate will be smaller than the expected rate [6]. TCP Vegas uses this difference in throughput rates, estimates the congestion level in the network and updates the congestion window size accordingly.

3. ROUTING PROTOCOL [6],[9]

A routing protocol is needed whenever a packet needs to be transmitted to a destination via number of nodes and numerous routing protocols have been proposed for such kind of ad hoc networks. These protocols find a route for packet delivery and deliver the packet to the correct destination. MANET routing protocol are of three types i.e. proactive, reactive and hybrid routing protocol. AODV has been taken the prime routing protocol which is a reactive routing protocol in this paper.

3.1. *Ad Hoc on Demand Distance Vector [6], [7],[12]*

Ad Hoc on Demand Distance Vector routing protocol [14] is a reactive routing protocol which establish a route when a node requires sending data packets. It has the ability of unicast & multicast routing. It uses a destination sequence number (DestSeqNum) which makes it different from other on demand routing protocols. It maintains routing tables, one entry per destination and an entry is discarded if it is not used recently. It establishes route by using RREQ and RREP cycle. If any link failure occurs, it sends report and another RREQ is made.

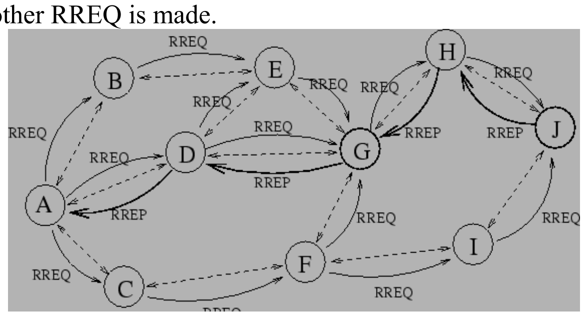


Fig 2 : AODV RREQ packet Format[4]

Three message types:

3.1.1 Route Request (RREQ)

When a route to a new destination is needed, the node uses a broadcast RREQ to find a route to the destination. A route can be determined when the RREQ reaches either the destination itself, or an intermediate node with a "fresh enough" route to the destination.

3.1.2 Route Reply (RREP)

The route is made available by unicasting a RREP back to the source of the RREQ. Since each node receiving the request caches a route back to the source of the request, the RREP can be unicast back from the destination to the source

3.1.3 Route Error (RERR)

Nodes monitor the link status of next hops in active routes When a link break in an active route is detected, a RERR message is used to notify other nodes that the loss of that link has occurred The RERR message indicates which destinations are now unreachable due to the loss of the link

4. PERFORMANCE METRICS AND SIMULATION RESULTS

4.1. *Performance Metrics [12]*

To compare some of the protocols then, we need to consider some of the metrics for comparing the performance of these protocols. Some of the Performance metrics [7]-[9] that we have used to calculate the performance of the routing protocols are as follows:

4.1.1. Packet Delivery Ratio

The PDR is defined as the ratio of the total data packets delivered to the destinations to those data packets generated by the sources.

$$\text{Packet Delivery Ratio} = \frac{\text{Packets Delivered}}{\text{Data packets Generated}}$$

4.1.2. Throughput

Throughput is defined as the total size of useful packets that received at all the destination nodes in a unit time. Throughput of node A to B is:

$$\text{Throughput} = \frac{\text{No of Bits from node A to Node B}}{\text{Observation Duration}}$$

4.1.3. Average End-To-End Delay

Average End-to-End delay (seconds) is the average time taken by a data packet to reach the destination.

$$\text{End to End Delay} = \frac{\sum \text{(Arrive time - Send Time)}}{\sum \text{(No. of connection}}$$

4.2. *Simulation Model*

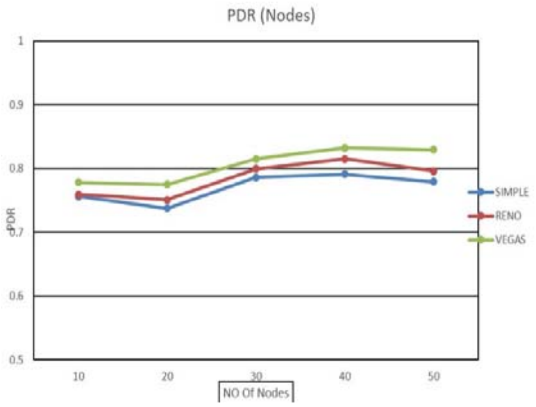
Network Simulator (Version 2.35), also known as NS2, is an event driven simulation tool that has been proved useful in studying the dynamic nature of communication networks. NS2 helps in simulating wired as well as protocol and wireless network (e.g., routing algorithms, TCP, UDP). We carried out the simulation and evaluated the performance of AODV with different TCP variants based on the performance metrics i.e. packet delivery ratio, throughput and end-to-end delay with the following parameters:

Parameter	Value
Radio Model	TwoRay Ground
Routing Protocol	AODV
Agent	TCP/FTP
Packet Size	512
Area	800m x 800m
Application	FTP
MAC	Mac/802_11
Simulation Time	50 s
No. Of Nodes	10,20,30,40,50
Max Speed	10,20,30,40,50

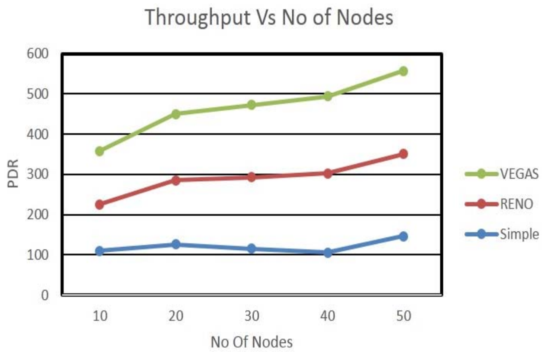
Table 4.1

4.3. Simulation Result

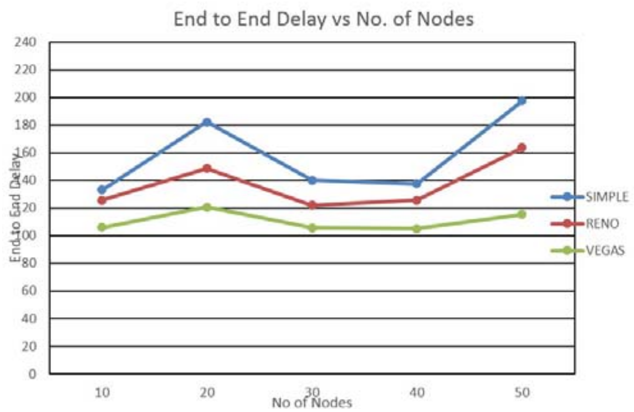
4.3.1. Comparison of TCP variants by varying No Of Nodes



[A] PDR



[B] Throughput



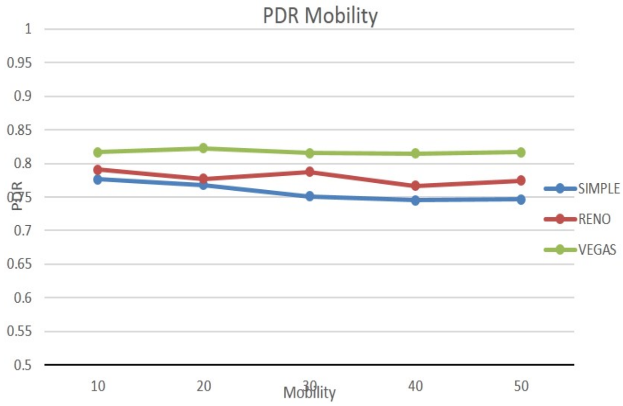
[C] End to End Delay

Fig 3 (A,B,C)Comparison of PDR, Throughput and End to End Delay by varying No of Nodes

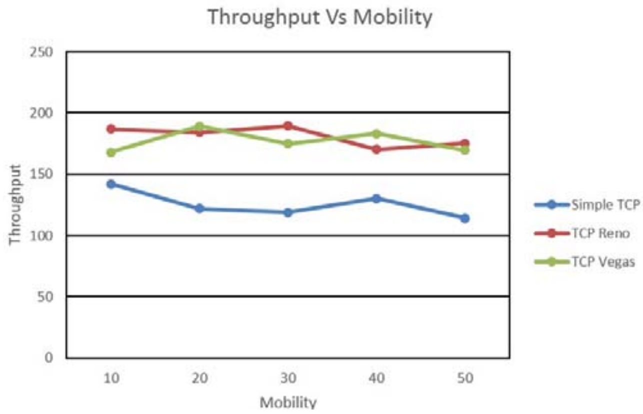
Fig A shows the ratio of the data packets of each protocol which was able to deliver at time. We observe that TCP Vegas performs slightly better than TCP Reno. As No of nodes are increased, PDR for TCP Vegas increases by 20 %. Simple TCP does not perform well when error model is applied as it is almost 50% less than TCP Vegas. Considering the throughput, TCP Vegas has clearly the best throughput among three. It performs around 40-45 percent better than TCP Reno.

Reno gives average values and performs almost 50 percent better than simple TCP. The End to End Delay is best for TCP Vegas and performs 45% better than Simple TCP. At higher values of nodes, TCP Reno faces huge delay but TCP Vegas give average values

4.3.2 Comparison of TCP variants by varying mobility



[D] PDR



[E] Throughput

[F] End to End Delay

Fig 4 (D,E,F)Comparison of PDR, Throughput and End to End Delay by varying Mobility

Fig D shows the ratio of the data packets of each protocol which was able to deliver at time. We observe that TCP Vegas performs far better than TCP Reno. As No of nodes increases, PDR for TCP Vegas remains constant. Simple TCP does not perform well when error model is applied as it is almost 50% less than TCP Vegas. Considering the throughput, TCP Vegas and TCP Reno performs almost equal, but for higher value of mobility, TCP Vegas proves to perform better with AODV. End to End Delay is best for TCP Vegas and performs 45% better than Simple TCP. At higher values of nodes, TCP Reno and Simple TCP faces huge delay but TCP Vegas give low delays making itself prominent.

5. SUMMARY

This paper compares the three popular TCP variants TCP Vegas, TCP Reno and Simple TCP taking AODV as routing protocol on basis of performance metrics. Simulation results shows that amongst all the variants, TCP Vegas has a stable and most efficient End to End Delay when clubbed with AODV. TCP Vegas proves to give better performance when Mobility is varied. TCP Reno gives average value for both scenarios. Throughput is high for TCP Vegas when nodes are varied but both TCP Vegas and Reno gives better performance when mobility is varied. Talking about the PDR, we observed that TCP Vegas performs far better than TCP Reno and Simple TCP. Hence it is clear from the graphs that TCP Vegas performs best with AODV as routing protocol.

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