Behavior analysis of Self-Similarity characteristics of network traffic with UDP and TCP

Sanjay Kumar Patra
Dept. of CSEA,IGIT,SARANG

S.N.Mishra
Dept. of CSEA,IGIT,SARANG

Abstract - Network traffic is high variability across wide range of time scales and this variability network traffic exhibits self-similarity. In stochastic self-similarity processes network traffic remains unchanged or invariant when viewed at different time scale, a behavior which is in contrast with Poisson processes. This paper mainly focuses on the behavior of TCP and UDP in network traffic. When we send packets back to back either in protocol like TCP or UDP, the burstiness in traffic is observed. This burstiness occurs due to message segment, slow start, ACK, self clocking and ON-OFF sources of TCP. Traffic in internet is also caused by TCP and UDP. Self- similarity of network traffic is also representing in LRD. In this paper we experiment on the behavioral changes of the network by TCP and UDP when load is same or high in networks causing self-similarity. We simulate by taking different scenarios: in each scenario we put two CPEs and two routers. The simulation is carried out using NetSim6.2.

Keywords - TCP, ACK (acknowledgement).Congestion control, CPE (Customer Premise Equipment like LAN, Access point), Router, and AIMD.

I. INTRODUCTION

Statistical studies have been done now a day to analysis traffic behavior in network. It is concluded that network traffic shown fractal behavior i.e. self-similarity and long range dependency (LRD). Due to variability in space and time it is observed the burstiness in network. LRD behavior of IP traffic can be mentioned as TCP traffic due to largest Hurst exponent and largest variance among the transport protocol.UDP traffic is also LRD but having small variance and Hurst exponent with TCP.[9,11]
TCP and UDP both induce the presence of self-similarity when load is low and loss is rare traffic looks Poisson but when load is high and network is overloaded TCP congestion control can smooth out the burstiness of the aggregate stream is bottleneck to Poisson. Time scale below which TCP gives rise to sustained correlation and long-lived TCP flow exhibits necessarily a correlation structure [5,6].TCP and UDP use the sockets to connect the application level for communication.TCP dominates 95% for the major part of the traffic it consists of FTP,E-mail and some application.TCP at transport level covers nearby 90% of the bandwidth of the transferred data of total volume.
Heavy-tail effect causes due to variable size of file when transfer in the network, Guanghui He et.al suggested that TCP traffic prediction which exploits the result in the context of AIMD (additive increases and multiplicative decreases) steady state dynamics and gives an optimal operation at which a TCP connection should operate [7]. If throughput ‘f’ attained by the TCP connection, ‘B’ is the background traffic then the number of connection that traverse the bottleneck link be denoted as ‘N’, Bandwidth of the link ‘C’, than the optimal operational point or point of line or capacity line is

$$f + B = C \text{ and } f/B = 1/(N-1)$$

So it is the concept of AIMD because when additive line B and N increases "f" decreases. Even in zero background traffic if we increase the number of connection then also we found f will affect the network [7].Markovian process model could not be applied for network traffic because traffic burst can be smooth over long time scale but contradict in traffic measurement. Also high capacity link produce non-Gaussian traffic but in WAN we can applied Markovian chain in case of VBR [3]. When back-to-back packet send in TCP and UDP sources it causes significant correlation in even short time scale. This is happened due to message segment, slow start, self-clocking could shape the packet of TCP connection in two levels ON-OFF pattern [10].Burstiness might cancel out because of the huge number of different multiplexed flows They apply their theory to smoothly truncated Levy flights and the linear fractal model in examining the variability of Internet traffic from self-similar to Poisson as per their examination burstiness of the packet lengths decreases significantly compared to earlier traces.[2] The transport level protocols(TCP and UDP) operate above the IP level and therefore IP traffic aggregates these flows.TCP works in transport level which covers by 90% of the bandwidth of the transferred data of total volume . Other protocol control only 1-2% of total traffic. HTTP and FTP traffic dominate at the application level.[11].TCP itself as a deterministic process creates chaos, which generates self-similarity. heavy tailed ON/OFF and chaotic TCP together contribute to the phenomena, called fractal nature of Internet traffic.[8] The Internet traffic is self-similar or long-range dependent in nature. This implies the existence of concentrated periods of high activities (peaks) and low activities (valleys), i.e., burstiness, at a wide range of time scales. In the context of packet sampling, this implies that either the sampling rate must be high enough or the sampling strategy has to be judiciously devised, in order to capture all the peaks and valleys in the traffic.[3]
When there is smaller number of sources and therefore large data rate per source it is more likely that there will be enough lost packets. TCP congestion control creates self similarity with Hurst parameter showing both short range and LRD depending upon system parameters. The distribution of the QoS metrics includes queue length, packet delay and loss [1].TCP and UDP creates self-similarity at application level as well as transport level. Traffic generated by HTTP,FTP,SMTP etc at application level are aggregated by TCP traffic[11].Most of the time UDP traffic is smoother than TCP at constant or exponential distribution of data over WAN network. At different

distribution of data we observe TCP and UDP shows LRD and multi-fractal structure at transport level. It is also observe that UDP shows less fractal properties than TCP. The LRD as measured by the Hurst Parameter estimate was not influenced by the traffic load or number of active TCP connection.[4]

In this paper we define various characteristics of fractality that shows in network by TCP and UDP. Also examine Markov chain model to verify that it can apply for network traffic in UDP protocol. We simulate by creating a single scenario where we take two routers and two CPEs and perform many experiment by changing different parameter using NetSim6.2.Results are shown in the paper. In Section-I we discuss on UDP and in section-II discus on TCP. In section III we perform a comparative observation between TCP and UDP then at last the conclusion. All the three characteristics define in this paper by changing the file size buffer size, window size and other parameter in same network configuration then we analyses how it affect to network utilization , packet data loss and delay occurs in network.

II. SECTION I

Network traffic Congestion can occur when data arrives from a fast network to slower network. It can also occur when multiple input streams arrive at a router whose capacity is less than the sum of the input. Let f(i) input data and capacity of router z(i) so when Σ f(i) < Σ z(i) then TCP is mainly used to avoid traffic congestion in network.

In our first experiment we demonstrate behavior of UDP protocol we create a scenario of WAN where we take two routers and two CPEs. Then we set properties of routers and CPE's then simulate again and again to analysis the behavior. First we set the properties of CPE in four layers such as Application, Transport, and network and data link. We fixed the properties of Transport, Network and data link layer.

We set properties of Transport layer as protocol UDP and segment size or Maximum segment size (MSS) as 1472 bytes. Where MSS is MSS=MTU-(network and transport layer protocol header). In network layer we set protocol as IPv4 and set IP address and subnet mask. In Data link layer Protocol P2P and MTU (maximum transmission unit) to 1500 bytes. After 1500 bytes it breaks into another segment unit.

In application layer set Transmission type as Point to Point and destination as name of next CPE. Then to check traffic here we generate two type of traffic such as (a) data (b) voice. Let first we discus about (a) data .When we chose Data as traffic type we simulate five times to check the behavior of UDP by changing some parameter like Application data size, Inter arrival time and fixed the value of generation rate to 0.5888mbps.

The five instances in which we conduct simulate are

(a) Application data size distribution type as constant, mean application data size 1472 bytes and Inter arrival distribution type constant, Mean inter arrival time 20,000 micro second.

(b) Application data size distribution type as exponential, mean application data size 1472 bytes and Inter arrival distribution type constant, Mean inter arrival time 20,000 micro second.

(c) Application data size distribution type as constant, mean application data size 1472 bytes and Inter arrival distribution type exponential, Mean inter arrival time 20,000 micro second.

(d) Application data size distribution type as exponential, mean application data size 1472 bytes and Inter arrival distribution type exponential, Mean inter arrival time 20,000 micro second.

(e) Application data size distribution type as constant, Mean application data size 1472 bytes and Inter arrival distribution type uniform, Mean inter arrival time 20,000 micro second.

Distribution type is constant means output of the distribution is constant it can be modified by user and exponential means distribution is probability distribution during inter arrival of packets changes at a constant average rate the distribution is poisson type distribution. In case of uniform the packet size generate between as it is fixed between minimum and maximum. In case of uniform inter arrival distribution generation rate fixed to 1.215.

After simulation we analyze Utilization, loss, Delay, Queue delay, Propagation delay and Transmission time. Utilization is the ratio of current network traffic to the maximum traffic the network can handle. It is an important indicator of the bandwidth usage in the network.

Utilization (%) = Effective Utilization (%) + Overhead (%) + Loss (%).

Effective Utilization is Fraction of network capacity devoted to carrying payload of the successful packets/frames/cells. Overhead is Fraction of network capacity devoted to carrying Overhead of the successful packets/frames/cells. Loss is the Fraction of network capacity devoted to carrying error packets/frames/cells. This includes both payload and overhead of these packets. Delay metrics provides the time taken per link per packet or time taken per hop per packet. Here delay means Queue delay, propagation delay and Transmission time.

Changing parameter and performing simulation (a), (b), (c), (d) and (e) we get following result as mention in table 1.

Table-1: UDP simulation for (a), (b), (c), (d) and (e)

Experiment Name	Utilization (%)	Effective Utilization(%)	Overhead (%)	Loss(%)	Unutilized (%)	Delay(ms)	Queuing Delay(ms)	Propagation Delay(ms)	Transmission Time(ms)
Exp1_udp_8_co	64.582	62.69	1.281	0.611	35.418	1597.184	1472.397	0.005	124.782
udp_co_exp	64.582	62.69	1.281	0.611	35.418	1610.229	1485.443	0.005	124.782
EXP2_UDP_8_EX	63.836	61.272	2.083	0.48	36.164	1511.119	1434.758	0.005	76.356
udp_exp_const_8	64.519	62.313	2.203	0.002	35.481	1575.97	1502.664	0.005	73.301
udp_exp_uni	63.836	61.272	2.083	0.48	36.164	1588.205	1511.844	0.005	76.356

In the Table-1 it is clear that when we change the parameter of distribution of data and inter arrival time the traffic type information became self similar. This can be clearly mark by above five simulation In case of (a) , (b) and (c),(d) utilization, transmission time and loss became same where delay and queuing delay varies. Utilization and delay is depending up on traffic between CPE and router. In the Figure-1, Figure-2, Figure-3 and Figure-4 we show the variation between data and channel traffic .In Figure-1 we find that the bandwidth usage in the network decreases when distribution of data become exponential or poisson and distribution loss of packet /frames became less that we get in Figure-2.But delay and queue delay frequently changes for any distribution of data which we find in Figure-3 and Figure-4.

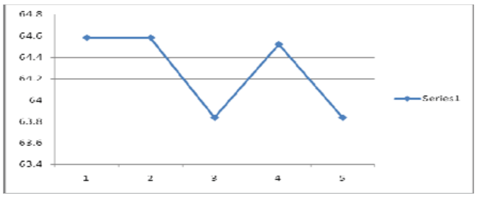


Figure-1: Utilisation by UDP

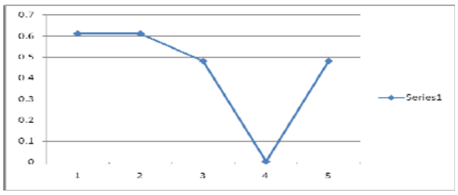


Figure-2:Loss in UDP

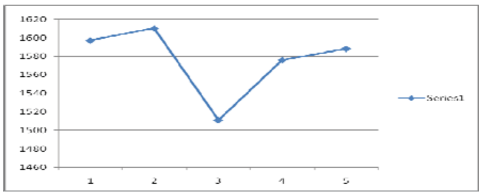


Figure-3:Delay in UDP

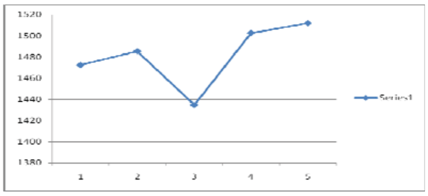


Figure-4:Queue delay in UDP

Next section we perform simulation traffic type distribution of UDP between Data and Voice.When we choose traffic type is voice and service type are CBR(constant bit rate),VBR(variable bit rate) then simulate the same scanario and then we compare the result with traffic type data we get the following result which are mentioned in Table-2.In case of service type VBR again we simulate taking two model such as Detemistic suppression model and Markove chain suppression model . The following result we get after simulation here in case of traffic type Data utilisation of bandwidth is high it is ovious but when voice tranfer over channel at CBR and VBR(Markov chain model) it is nearly same but loss is more than CBR in comapre to VBR-MC.Same way delay and queue delay varies in different instances but one thing is that when service type is VBR and two model separetly we implement then in case of deterministic model loss is negligible and in case of VBR-MC we get some losses of packets. Though we find utilization of bandwidth and channel is less in case of VBR deterministic and also delay is less as compare to VBR-MC.

Table-2 UDP simulation for CBR and VBR

Experiment Name	Utilization (%)	Effective Utilization(%)	Overhead (%)	Loss(%)	Unutilized (%)	Delay(ms)	Queuing Delay(ms)	Propagation Delay(ms)	Transmission Time(ms)
Exp1_udp_8_co	64.582	62.69	1.281	0.611	35.418	1597.184	1472.397	0.005	124.782
udpcbr	63.918	53.801	10.117	0.0	36.082	278.423	262.537	0.005	15.881
udpvbr_8_det	36.458	30.688	5.771	0.0	63.542	16.794	0.915	0.005	15.874
exp_udp_vbr_mc_8	63.868	53.728	10.103	0.038	36.132	229.987	214.095	0.005	15.887

In the following Figrure 5,6,7,8 we shows the utilization,loss,delay and queue delay in comparasion to CBR,VBR-MC will perform better but between VBR-D and VBR-MC model VBR-MC will perform more to avoid traffic in network.channel.In all cases of voice transmission transmission time varies very little which can causes fractal in network.

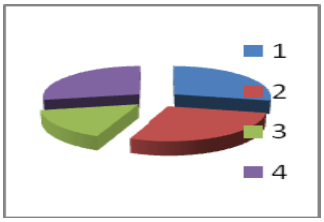


Figure-5: Utilization of UDP in channel

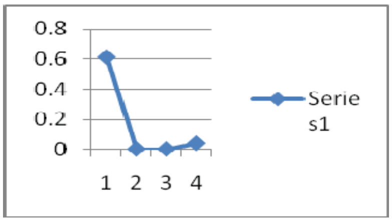


Figure-6:Loss in UDP for CBR and VBR

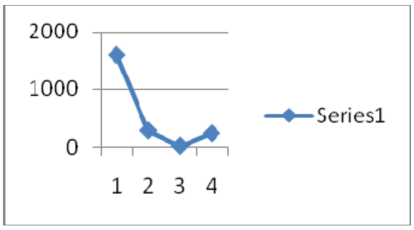


Figure-7: Delay in UDP for CBR and VBR

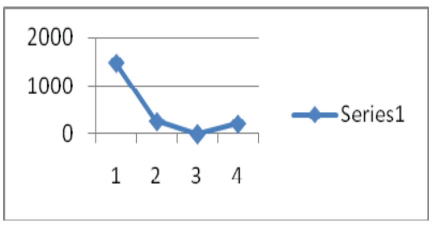


Figure-8: Queue delay in UDP for CBR and VBR

III. SECTION II

In this section we will discuss on TCP .Here also we take same scenario two CPEs and two routers and analysis the result. First we set the properties of CPE in four layers such as Application, Transport, Network and Data link. We fixed the properties of Transport, Network, and data link layer; acknowledge type un-delay and congestion type in first simulation Old Tahoe and next Tahoe.

We set properties of Transport layer as protocol TCP and segment size or Maximum segment size (MSS) as 1472 bytes. In network layer we choose protocol as IPv4 and set IP address and subnet mask. In Data link layer Protocol P2P and MTU (maximum transmission unit) to 1500 bytes. After 1500 bytes it breaks into another segment unit. Here we take Data as traffic type we simulate two times to check the behavior of TCP by changing some parameter like Application data size, Inter arrival time. Application data size distribution is constant, inter arrival time back log due to packet are transmit after getting the acknowledgement.

After simulation we show the result in Table-3 where we see that in TCP transmission between congestion type Old Tahoe and Tahoe implementing Jacobson's algorithm Tahoe is better than old Tahoe due to fast transmission and fast recovery.

Table-3:TCP simulation Old Tahoe and Tahoe.

Experiment Name	Utilization (%)	Effective Utilization(%)	Overhead (%)	Loss(%)	Unutilized (%)	Delay(ms)	Queuing Delay(ms)	Propagation Delay(ms)	Transmission Time(ms)
TCP_const_8	51.69	48.545	2.456	0.69	48.31	329.474	203.621	0.005	125.849
TCP_tahoe_8	53.337	50.075	2.494	0.768	46.663	319.631	194.053	0.005	125.574

Here we find in case of Tahoe loss is more and utilized is less but overall it performs better than Old Tahoe.

IV. SECTION III

In this section we will compare the result between UDP and TCP and shows that result in Table-4 and Figure-9, 10 and 11.

Table-4: simulation result between UDP and TCP.

Experiment Name	Utilization (%)	Effective Utilization(%)	Overhead (%)	Loss(%)	Unutilized (%)	Delay(ms)	Queuing Delay(ms)	Propagation Delay(ms)	Transmission Time(ms)
TCP_const_8	51.69	48.545	2.456	0.69	48.31	329.474	203.621	0.005	125.849
TCP_tahoe_8	53.337	50.075	2.494	0.768	46.663	319.631	194.053	0.005	125.574
Exp1_udp_8_co	64.582	62.69	1.281	0.611	35.418	1597.184	1472.397	0.005	124.782
EXP2_UDP_8_EX	63.836	61.272	2.083	0.48	36.164	1511.119	1434.758	0.005	76.356
udpcbr	63.918	53.801	10.117	0.0	36.082	278.423	262.537	0.005	15.881
udpvbr_8_det	36.458	30.688	5.771	0.0	63.542	16.794	0.915	0.005	15.874

From the above table when we compare output data between UDP and TCP we find in UDP-D it is not smother than TCP. Loss, Utilization, Delay we have shown it in Figure-9, 10, 11 which shows loss is less in UDP but delay, queue delay is more in many cases than TCP.TCP and UDP use the destination port number to de multiplex incoming data from IP and their port number are independent but due to check sum of UDP is optional and in case of TCP it is mandatory that is why UDP is smother and performing better than TCP. Also UDP header is simple and Like TCP it does not care about transmission of data it is smother but not reliable than TCP. From Table-2 last experiment result that is UDP-MC and Table-3 TCP simulation we can conclude that Markov process can apply for network traffic over voice transmission in UDP protocol.

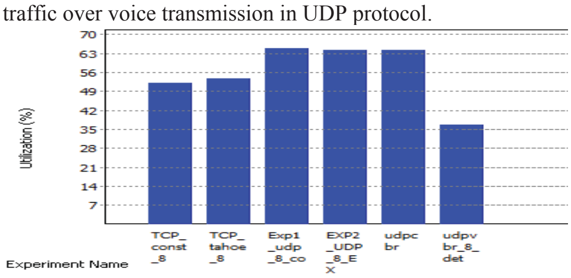
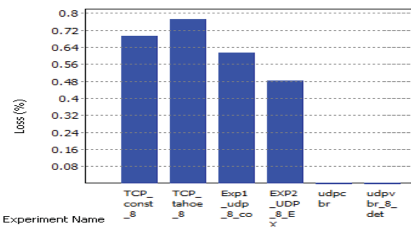


Figure-9: utilisation compare between TCP, UDP



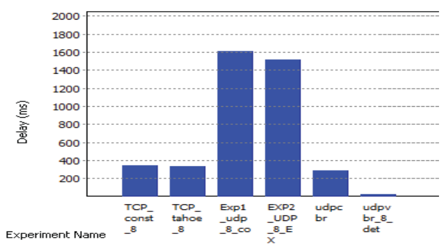


Figure-10:Loss compare between TCP,UDP Figure-11: Delay between UDP and TCP

V. CONCLUSION

In the present work, we have investigated the behavioral response of TCP and UDP in network traffic through a simulation using two CPEs and two routers in each scenario. It is observed that, UDP and TCP show self-similarity in network. From the experimentation with UDP and TCP, we conclude that UDP is not smoother than TCP in all cases. TCP is reliable than UDP. When load is low, traffic is Poisson but for a higher load self-similarity in the network is found. In a constant traffic, it does not affect on the buffer size of router. With an increase in day to day intermediate devices and associated increase in traffic, it is required to avoid congestion and delay in network. In view of this, the future perspectives of the present work points towards a more involved investigation to develop statistical models to check the flow control of UDP and TCP in any network and simultaneously manipulate self-similarity in RTT with different time instances.

REFERENCES

[1] Xiaolong jin,Geyong Min et. al., "Quality-of-service analysis of Queuing system with LRD network Traffic and variable service capacity", IEEE transaction on wireless comm.,vol II.No.2,February 2012,pp.562-570.

[2] G.Tredik and T.Gyires,"Levy Flights and Fractal Modeling of Internet Traffic",IEEE/ACM tractions on networking,Vol.17,No.1,Febryary 2009.

[3] G. He and J. C. Hou, "On sampling self-similar Internet traffic," Comput. Netw, vol. 50, no. 16, pp. 2919–2936, Nov. 2006

[4] Cheolwoo Park et. al. "LRD in changing internet traffic mix",Elsevier,computer networks 48,2005,pp.401-422

[5] Daniel R Figueiredo et. al.,"On TCP and self-similar traffic",Elsevier,performance evaluation 61,2005,pp.129-141.

[6] Nawaporn Wisitpongphan,Jon M.Peha,"Effect of TCP on self-similarity of Network Traffic"Proceedings of 12th IEEE,ICCCN,1-4,2003.

[7] Guanghui He,Y.Gao,J.C.Hou,K.Park,"A case for Exploiting self-similarity of Network Traffic in TCP congestion Control",proceeding of the 17th IEEE computer society,2002.

[8] Andras Veres,Miklos Boda "The chaotic nature of TCP congestion control",Ericsson research,2000.

[9] Dr Thomas B Fowler," A short tutorial on fractals and internet Traffic", the Telecommunication review, 1999.

[10] Gyorogy TERDIK and Tibor GYIRES,"Fractal Modeling Of Internet Traffic"

[11] Self-similarity in telecommunication by O.I.Sheluhin et.al,john wiley & Sons,Ltd.