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Comparative study of various Traffic Generator Tools

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Abstract— **In our paper we have compared the performance of network evaluation tools (PackETH, Ostinato, and D-ITG) over 10Gbps link. The performance of these tools was evaluated in terms of bandwidth utilization over the link. In laboratory setup, two computers with Linux operating systems were connected via 10Gbps crossover cable. TCP and UDP traffic for the payload sizes varying from 64Bytes to 8950bytes was generated by tools and the corresponding throughput was measured. The performance of D-ITG in multithreaded mode is compared with Iperf. For TCP connection Ostinato measured highest bandwidth of 9Gbps while for UDP traffic packETH achieved a throughput of 9.9Gbps. Since D-ITG was not able to achieve such a high throughput we tried to run it in multithread mode for a constant payload size (<1500 Bytes) and its performance is then compared to Iperf.**

Keywords— Throughpu; Traffic generators; 10Gbps link; TCP; UDP.

I. INTRODUCTION

Traffic generators are used to inject the packets in the network in a controlled way. This synthetic traffic can further be used for design, development and testing of networks. The robust traffic generator tools are generally required by the network researchers to evaluate the network performance through realistic experiments. In past few years the networks have become extremely diverse in terms of protocols, applications, devices and access technologies. Thus, the need for flexible traffic generator tools arises which can work efficiently under different network conditions. To evaluate the performance of different emerging traffic generation tools a comparison is required which could help researchers to evaluate a network in a better way. In this paper we have compared the performance of packETH [1], Ostinato [2] and D-ITG [3] tools over a 10Gbps Ethernet link. With single thread D-ITG was not able to utilize the bandwidth of 10Gbps. So after comparing the performance of these tools D-ITG in multi-thread mode is compared with Iperf. For this comparison a fixed payload size of 1460 Bytes is used.

The previous work related to this study was done by authors in [4]. They carried out a laboratory experiments to compare the performance of four traffic generator tools: Iperf [5], Netperf [6], D-ITG [3] and IP-Traffic [7]. The performance of all these tools was measured in terms of bandwidth on a windows platform for a TCP protocol. The authors in [4] varied the packet size from 128-1408 and illustrated that for 100Mbps link Iperf showed the highest throughput and IP-traffic the lowest.

Another work related to this field was done over a gigabit link by authors of [8]. They compared traffic generators: UDP Generator [9], Iperf [5], MGEN [10], Mtools [11], Rude & Crude[12] with the performance of D-ITG. The bandwidth utilization of a Gigabit Ethernet link connected between Linux PC's for UDP traffic was measured.

Our work provides the performance analysis of the tools (D-ITG, packETH, Ostinato) over a 10Gbps link. The performance evaluation of these tools was done on the basis of bandwidth utilization. The tools used in our experiment are open source and freely available. The traffic, with various payload sizes, was generated by the tools and the throughput was measured accordingly over the 10Gbps link.

The rest of the paper is organized as follows: traffic generator tools are discussed in Section II. In Section III, experimental setup is discussed. Section IV compares the features of the analyzed tools. In section V results are discussed followed by Conclusion in Section VI and future work in Section VII and then appendices and references.

II. TRAFFIC GENERATOR TOOLS

Various features of the three traffic generation tools are discussed in this section.

A. PackETH

PackETH [1] is GUI and CLI based stateless packet generator tool for Ethernet. It was developed and maintained for Linux, but some ports for Windows and MAC have also been done. It can craft and send any possible packet or sequence of packets on the Ethernet link and supports the protocol: Ethernet II, Ethernet 802.3, 802.1q, QinQ, user defined Ethernet frame. It also supports ARP, IPv4, IPv6 network layer protocol and UDP, TCP, ICMP, ICMPv6, IGMP transport layer protocol. It can be used to send jumbo frames (if network driver supports it) which is very important feature for our experiment. Parameters like IP and MAC address, UDP payload can be varied while sending packets.

B. Iperf

Iperf is used for the evaluation of parameters like bandwidth, delay, and window size and packet loss for both

TCP and UDP traffic. It has both command line as well as GUI based interface. Its graphical interface is written in JAVA and is called Jperf. It can be installed on Linux/Unix and windows system. Iperf client connects to Iperf server and the bandwidth utilization from client to server is measured

C. D-ITG

D-ITG (Distributed Internet Traffic Generator)[14] is a platform that can generate both IPV4 and IPV6 traffic having patterns defined by the Inter Departure Time (IDT) between packets and the Packet Size (PS) probability distributions: Constant ,Uniform ,Pareto ,Cauchy ,Normal ,Poisson and Gamma. It can also be used to measure the One Way Delay (OWD), Round Trip Time (RTT), packet loss, jitter, and throughput [13]. These features are not available in Ostinato and packet. D-ITG runs on Linux (Ubuntu, Debian, fedora, centos) , windows, OSX and FreeBSD. ITGSend generates the traffic and directs it towards the ITGRecv. Both ITGRecv and ITGSend can generate a log file for every sent and received packet. Multi flow mode is also supported by D-ITG.

D. Ostinato

Ostinato is a user level traffic generator tool [13] with a friendly GUI. It can run on windows, Linux, BSD and Mac OS X. The common standard protocols supported by ostinato are Ethernet/802.3/LLC SNAP; ARP, IPv4, IPv6, IP-in-IP, IP Tunneling (6over4, 4over6, 4over4, 6over6); TCP, UDP, ICMPv4, ICMPv6, IGMP, MLD and many text based protocols like HTTP, SIP, RTSP, NNTP etc. It also supports client server architecture. It can create and configure sequential and interleaved streams of different protocols at different rates. Flexibility to add any unimplemented protocol is also provided through a user defined script.

III. EXPERIMENTAL SETUP

A. Laboratory setup

The laboratory set up comprises of two computers (servers) with Linux (Centos 6.2, Kernel Version 2.6.32 – 220) operating system connected using cross over cable using TCP/IP protocol (IPv4) as illustrated in Figure 1. The severs have Intel(R) Xeon(R) CPU with 2.93GHz CPU and 64GB of memory using Network Card Mellanox Technologies MT25418 [ConnectX VPI PCIe 2.0 2.5GT/s - IB DDR / 10GigE. The jumbo payload (>1500Bytes) were sent over 10Gbps Ethernet link to achieve the maximum throughput.. While comparing the performance of D-ITG in multi-thread mode with Iperf the MTU for the link was set to 1500 Bytes. The transmission speed is measured at the interface through which we are sending the packets.

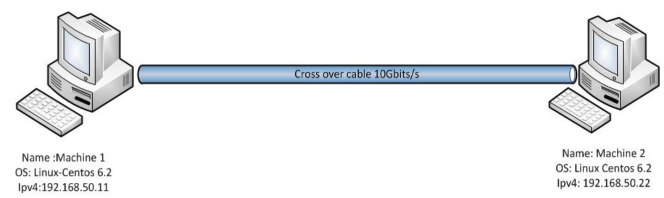

Figure 1: Laboratory setup

B. Parameter settings

The tables below describe the parameters settings that were done while running the traffic generator tools.

1) *PackETH-*. For the sake of simplicity we have only varied the packet size and kept the number of packets as infinite and bandwidth as maximum for each test. The tool was used to send both the UDP and TCP packets. The settings are mentioned in Table 1.

TABLE I: packETH Parameters

Bandwidth	Maximum
Number of packet send	Infinite
Protocol	TCP and UDP
Payload size	64-8950 Bytes
Experiment time	10seconds

2) *Iperf-* The default payload size used in Iperf is 1460 Bytes and default protocol is TCP. The protocol is chaneged according to our experiments through a simple command line options.

TABLE II: Iperf Parameters

Payload size	1460 bytes
Protocol	TCP/UDP
Number of threads	1-12
Experiment time	10seconds

3) *D-ITG-* The default parameters used in D-ITG were changed according to the settings of other tools. The settings are mentioned in Table 3.The payload size is varied through a simple command line option. Default delay parameter is one-way –delay which is not changed for our test.

TABLE III: D-ITG Parameters

Packets per second	500000
Protocol	TCP and UDP
Payload size(single thread mode)	64-8950 Bytes
Payload size(multi-thread mode)	1460 Bytes
Number of Threads	1-12
Experiment time	10seconds

4) *Ostinato-* The separate stream for TCP and UDP traffic is created by setting source and destination MAC and IP address. The rest of the settings are done according to parameters mentioned in Table 4. The stream control options are set as burst.

TABLE IV: Ostinato Parameters

Packets per burst	10
Burst per second	50000
Protocol	TCP and UDP
Payload size	64-8950 Bytes
Experiment time	10seconds

IV. COMPARATIVE STUDY OF TOOLS

In this section we have compared the three tools according to their features. All the three traffic generators that we have considered can work with various protocols and can use IPv4 and Ipv6.They are able to evaluate the TCP and UDP traffic. There are some transport layer protocols like DCCP (Datagram Congestion Control Protocol) and SCTP (Stream Control Transmission Protocol) which can be tested by D-ITG but not by packETH and Ostinato. PackETH supports RTP (Real time transport protocol) which enables it to send a payload with the sine wave of any frequency for G.711. In addition to the various in-built protocols Ostinato also provides a framework to add any unimplemented protocol. All the three traffic generator tools can run efficiently on both Linux and Windows operating systems.

There are various features that are unique to D-ITG. D-TIG can measure QoS metrics like: packet loss, jitter, round trip time and one way delay. All the three traffic generators can be used to measure the throughput. D-ITG also provides the option of generating TCP and UDP traffic with different probability distribution functions. Probability distributions supported by it are: Uniform, Normal, Cauchy, Exponential, Pareto, Poisson and Gamma for various packet sizes and packet inter-arrival times. D-ITG can generate multi-flow traffic that can be sent towards one or more receivers.

The significant feature of packETH is that its performance has been tested for a 40Gbps link [1]. Although it was not able to achieve the full line rate for shorter packets but with payload size of 9000 bytes for UDP protocol maximum line rate achieved by packETH was 37.5Gbps. The comparison of tools in tabular form is presented in Table 5.

Iperf is a bandwidth measurement tool which is used to measure the quality of a network link for TCP and UDP traffic. It is a user-level application [13] for testing various network parameters like bandwidth, packet loss and jitter. The accuracy of this tool may vary in different conditions. D-ITG can also measure these metrics. Iperf can generate only TCP and UDP traffic.

V. RESULTS

The default settings mentioned in section 3 were used while testing the performance of each traffic generator. UDP and TCP traffic was generated for various payload sizes. The payload sizes are varied in multiples of 64. Starting with 64 Bytes the payload size was doubled for every test up to 1024 Bytes then varied in multiples of 128 Bytes up to 3072 Bytes and finally it is incremented by 1024 Bytes till 8192 Bytes. For every payload size 10 runs were made.

When D-ITG in multi-threaded mode is compared with Iperf the number of threads is varied from 1 to 12 and the payload size is kept constant as 1460 Bytes. As the default payload size supported by Iperf is 1460Bytes.

A. For UDP

The comparison of results in Fig 2 indicates that for each payload size packETH was able to utilize the maximum bandwidth. The maximum change in throughput for packETH was 1385 Mbps when packet size has been changed from 1408 Bytes to 1664 Bytes while there is a change of 273 Mbps for Ostinato and 370Mbps for D-ITG. For the payload size of 1408 Bytes (<1500 Bytes) the highest throughput achieved is 3.83Gbps by packETH and lowest is 2.25Gbps by D-ITG. As payload size is increased (>1500 Bytes) a significant change in throughput is seen for packETH

For larger payloads the percentage of overhead to payload sizes is less which increases the bandwidth utilization and hence the throughput. PackETH is able to achieve a speed of 9.3Gbps at a payload size of 5120 Bytes after which there is a little change in the throughput. For ostinato the throughput of 9.79Gbps is achieved at packet size of 8192 Bytes. And the maximum throughput that D-ITG was able to achieve with payload size of 8950Bytes is 7.9Gbps (using single thread).

Hence, for UDP traffic the maximum bandwidth utilization of 9.xGbps is shown by PackETH at a payload size of 5120Bytes.

B. For TCP

The results in Fig 3 indicate that for each payload size the highest throughput is given by Ostinato. For a payload size of 1408 Bytes (<1500 Bytes) the maximum throughput of 2.85Gbps is produced by Ostinato and lowest throughput of 1.75Gbps by packETH. The reason behind the decrease in throughput for TCP traffic when compared to UDP traffic is that a TCP connection requires a 3-way handshake. Hence each packet requires a SYN and ACK packet. Small payload sizes will flood the link with ACK which will reduce the bandwidth utilization.

For jumbo payloads the throughput has increased for all three traffic generators. The maximum throughput of 9Gbps is achieved by Ostinato for a payload size of 8950 Bytes. At this maximum payload size (8950 Bytes), packETH gives a throughput of 7.8Gbps and D-ITG gives 6.2Gbps (using single thread).

At a payload size of 4096 bytes DITG shows a noticeable change in its throughput (increase of 870Mbps) with respect to packETH. After this data point, there is very little variation in the throughput of D-ITG whereas packETH shows linear increase in its throughput.

For the TCP traffic Ostinato performs well and is able to achieve a speed of 9Gbps.

For TCP and UDP traffic Ostinato and PackETH respectively have shown better performance over a 10Gbps link as compared to D-ITG running in single-thread mode.

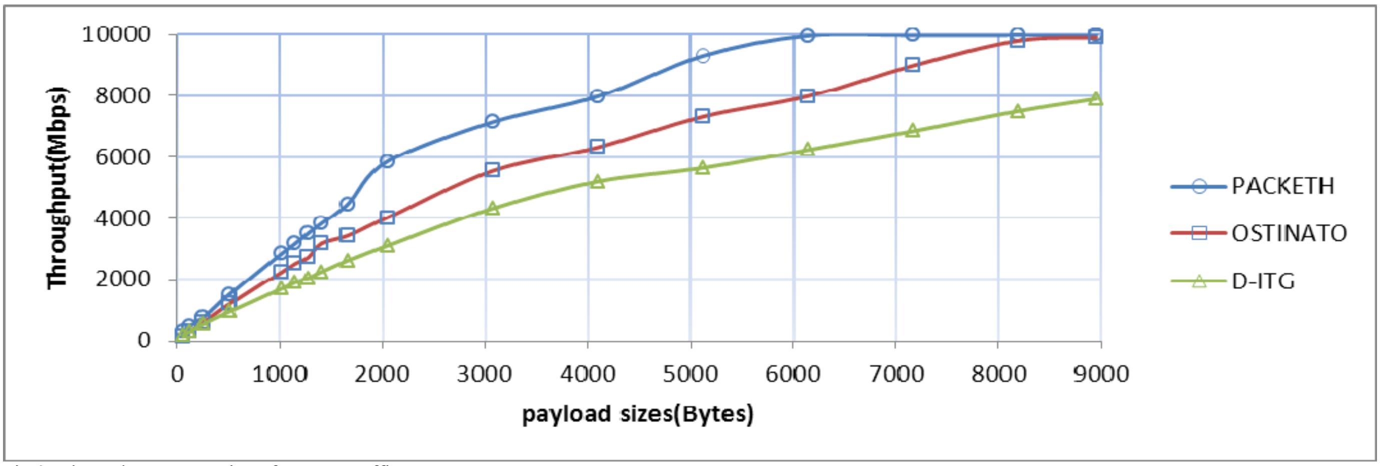

Fig 2: Throughput comparison for UDP traffic

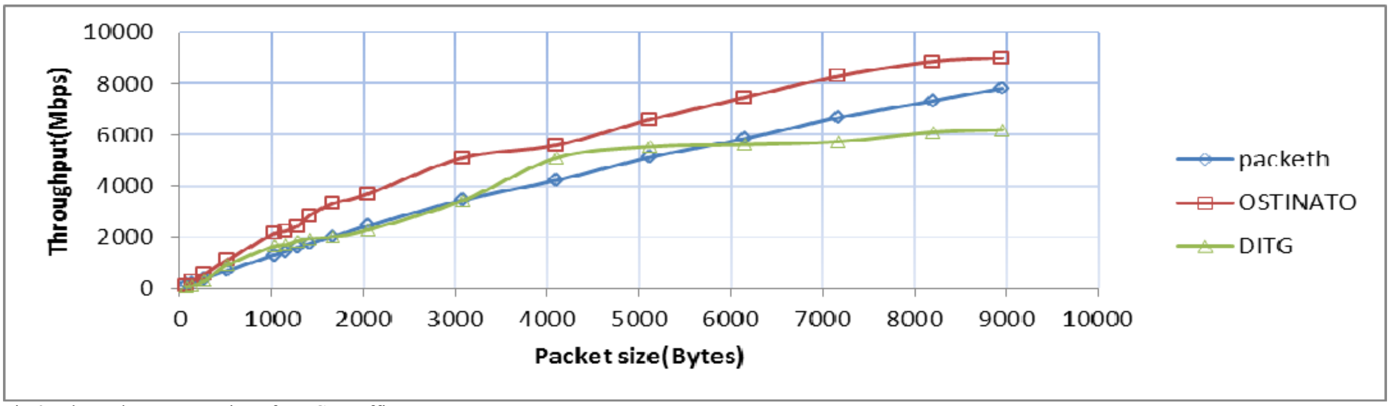

Fig 3: Throughput comparison for TCP traffic

C. *Comparison of D-ITG and Iperf in multithreaded mode*

In case of TCP traffic the results in Fig.4 shows that throughput for D-ITG increases linearly as number of threads are increased while there is a very little change in the throughput of Iperf when number of threads are increased above 4. With 10 threads D-ITG was able to achieve a speed of 9.8Gbps without using jumbo frames. Iperf achieved a maximum throughput of 9.5Gbps with 7 threads. When D-ITG was ran in single-thread mode it achieved a throughput of 6.2Gbps only (using jumbo frames) while in multi-thread mode it achieved 9.8Gbps (payload size <1500 Bytes). Iperf showed a sudden increase in its throughput (5.4Gbps to 8.9Gbps) when thread is increased from 1 to 2.

In case of UDP traffic, the maximum throughput achieved by D-ITG was 8.4Gbps with 12 threads while the bandwidth utilization measured by Iperf was only 12.6Mbps for 12 threads which is very less when compared to D-ITG. D-ITG can achieve a throughput of 8.XGbps with 7 threads and a payload size of 1460Bytes.

For both TCP and UDP traffic D-ITG was able to achieve a high throughput as compared to Iperf.

Iperf is basically used to measure the maximum bandwidth utilization for TCP traffic as shown in Fig 4 while for UDP traffic it creates streams of specified bandwidth and measure various UDP characteristics. Hence we are not able to achieve the desired throughput for UDP traffic as illustrated in fig 5.

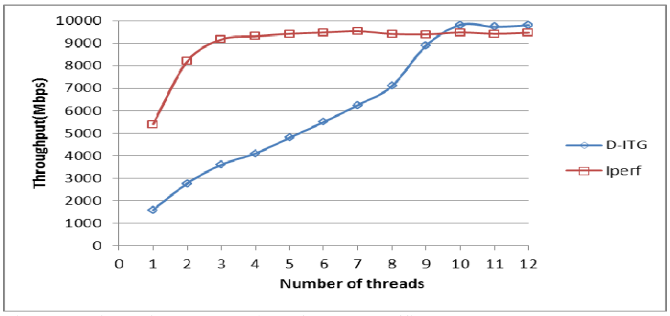

Figure 4: Throughput comparison for TCP traffic

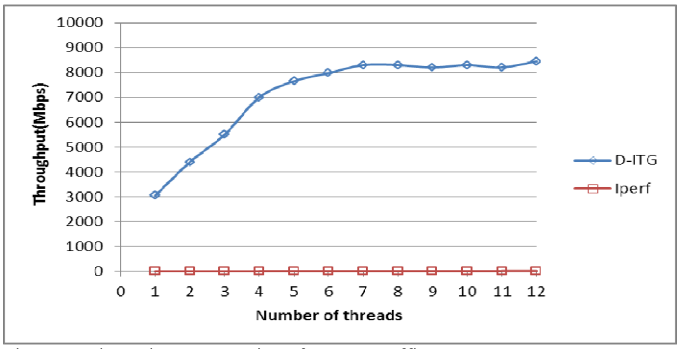

Figure 5: Throughput comparison for UDP traffic

VI. CONCLUSION

In this paper we have evaluated the performance of three traffic generators (DITG, packETH, Ostinato) on Linux operating system for both TCP and UDP traffic. For UDP traffic the throughput of 9.XGbps is achieved by packETH and Ostinato. But packETH achieved this throughput at a payload size of 5120 Bytes and Ostinato achieved it for 8195 Bytes. For TCP traffic only Ostinato was able to achieve a throughput of 9Gbps. After our evaluation, the performance of packETH was found to be better for UDP traffic and Ostinato for TCP traffic. D-ITG, running in a single thread mode, was able to achieve a throughput of only 6.2Gbps in case of TCP and 7.8Gbps in case of UDP. D-ITG running in a multithread mode has achieved a throughput of 9.8Gbps in case of TCP and 8.5Gbps in case of UDP for a constant payload size of 1460 Bytes. While Iperf measured the maximum bandwidth utilization of 9.5Gbps for TCP traffic only

VII. FUTURE WORK

An extension of this work can be the evaluation of other traffic generator tools for TCP and UDP traffic with IPv6 protocol. Next step of this work can also be the performance monitoring of these and various other traffic generators over a 40Gbps link.

ACKNOWLEGDMENT

We express our sincere thanks to all the authors whose papers related to this area are published in various conferences and journals. Their work has helped a lot in our research.

APPENDICES

A. TOOLS COMPARISON

TABLE V: Tools comparison

Traffic generators	Operating system	Network protocols	Transport Protocol	Interface	Probability distribution	Multi-thread support
PackETH	Linux, Windows	IPv4,IPv6	UDP,TCP and many more	GUI, Command line	NO	NO
Ostinato	Linux, Windows, Free BSD	IPv4,IPv6	TCP, UDP, ICMPv4, ICMPv6, IGMP, MLD	GUI	NO	NO
D-ITG	Linux, Windows	IPv4, IPv6	UDP, TCP, DCCP, SCTP, ICMP	Command line	YES, for IDT(inter departure time) and PS (packet size)	YES

B. RESULTS SUMMARY

1. TCP traffic

TABLE VI: Throughput comparison for TCP traffic

Packet size (in Bytes)	Throughput(in Mbps)		
	PackETH	**Ostinato**	**D-ITG**
64	150	135	62
128	231	290	105
256	395	565	285
512	695	1110	920
1024	1310	2150	1650
1152	1450	2250	1700
1280	1610	2450	1850
1408	1745	2850	1950
1664	2031	3320	2020
2048	2460	3700	2300
3072	3452	5100	3430
4096	4230	5600	5100
5120	5130	6600	5540
6144	5850	7450	6520
7168	6670	8300	5740
8192	7320	8850	6100
8950	7810	9000	6200

2. UDP Traffic

TABLE VII: Throughput comparison for UDP traffic

Packet size (in Bytes)	Throughput(in Mbps)		
	PackETH	**Ostinato**	**D-ITG**
64	316	145	200
128	492	305	300
256	760	602	550
512	1510	1195	950
1024	2850	2245	1700
1152	3170	2515	1900
1280	3510	2725	2050
1408	3830	3175	2250
1664	4465	3430	2620
2048	5850	4020	3100
3072	7140	5540	4320
4096	7980	6320	5200
5120	9300	7320	5640
6144	9954	7990	6240
7168	9970	8990	6850
8192	9975	9790	7500
8950	9980	9890	7900

3. D-ITG and Iperf in multi-thread mode

TABLE VIII: Throughput for TCP traffic

Number of threads	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Throughput (in Mbps) D-ITG	1583	2770	3600	4100	4800	5500	6250	7100	8900	9820	9740	9808
Throughput (in Mbps) Iperf	5400	8190	9170	9310	9420	9480	9540	9410	9390	9480	9420	9470

TABLE IX: Throughput for UDP traffic

Number of threads	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Throughput (in Mbps) D-ITG	3050	4400	5500	7000	7650	7980	8300	8300	8200	8300	8205	8450
Throughput (in Mbps) Iperf	1.05	2.1	3.15	4.19	5.24	6.29	7.34	8.39	9.44	10.5	11.5	12.6

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