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Comparative Study: Performance of SCTP with Competing Flows of the TCP over a Wired Network

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Abstract

The Stream Control Transmission Protocol has many features such as multi-streaming and multi-homing, and based on these features that enable to deal with multimedia applications. Therefore, it has become possible to use the SCTP as the transport layer protocol instead of other protocols such as TCP and UDP. Many studies on SCTP have been carried out under different environments in order to measure its performance under various conditions, but it has faced a lot of challenges, especially in the upper layer. The aim of this study is to measure and analysis the performance of throughput, jitter and delay of both SCTP and TCP. Where we prove this goal by compares the results of performance of both the SCTP and TCP over a Wired Network under similar conditions that have SCTP with UDP traffic to reach the desired results. It is expected that the results are obtained will be useful for researchers who want to improve SCTP in the future. It will be conducting all experiments of this research through a network simulation tool NS2.

Keywords: SCTP, TCP, Throughput, Jitter, Delay, NS2.

Introduction

Network protocols are a set of rules and conventions for communication between devices. Any layer of the network has a particular protocol that is used as a link between the two devices in order to keep the network. Computers and devices connect with each other over the Internet by using a protocol called TCP/IP. There are two protocols that handle data communications in an IP network: TCP and UDP. Both TCP and UDP protocol sends and receives the data between devices over the Internet and provides a range of different services. However, there are some differences between these protocols, where UDP protocol is unreliable, but faster in sending messages. On the other hand, TCP is not a fastest protocol for sending and receiving the data, but it is dependable.

This study focuses on performance of transport protocol SCTP (Stream Control Transmission Protocol) that facilitates the transfer of data between two points in the network. SCTP has many features such as carrying the data in multi-streaming, multi-homing, and keeps the message boundaries. Based on these features that enable to deal with multimedia applications, SCTP has become an important protocol. At the same time, SCTP has many advantages such as fragmentation of data to the maximum transmission unit size. In the case of multimedia, SCTP is better than UDP or TCP (Leu, and Ko, 2008), and use Unduplicated way to transfer the data without error, and optional bundling of the user messages into an SCTP (Rane, Kumbhar, and Sovani 2002). Furthermore, SCTP supports congestion control algorithms and error handling (McClellan 2003).

This study is simplifying the performance of SCTP and will show the functionality of SCTP. The proposed prototype of this study is designed by using network simulation NS2, which aims to improve the evaluation process performance of SCTP. The primary objective of this study is to measure and analysis the performance and effectiveness of throughput, jitter and delay of both SCTP and TCP. Where we prove this goal by compares the results of performance of both the SCTP and TCP over a Wired Network under similar conditions that have SCTP with UDP traffic to reach the desired results. It will be conducting all experiments of this research through a network simulation tool NS2.

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Problem statement

Many studies on SCTP have been carried out under different environments in order to measure its performance under various conditions, but it has faced a lot of challenges, especially in the upper layer. According to Boussen and Tabbane (2009) carried out experiments measuring the performance of data traffic, video streaming and other application layer protocol over SCTP in Wireless Local Area Network (WALN) with emphasis on the delay. In the same light, Scharf and Kiesel (2006), they studied the performance of SCTP in wireless networks. Further studies in the wireless environment, with particular emphasis on throughput, have been carried out (Ma et al...2005). Islam and Kara (2006) studied the throughput of the SCTP protocol in a multi-homing setup. It was found that a small number of SCTP streams, or SCTP in unordered mode, avoids head-of-line blocking as opposed to the transaction-based signaling applications over TCP (Kaytan, 2010). Irrespective of the large number of studies carried out on the performance of SCTP under various conditions, its performance in a best-effort network under similar conditions have not been explored enough at this time. Hence, the study goals to investigate the performance of SCTP in best-effort networks under similar conditions with particular emphasis on throughput, delay and delay jitter, and compares this results with TCP over a Wired Network.

Literature review

Stream Control Transmission Protocol (SCTP)

Stream Control Transmission Protocol (SCTP) is a reliable transporting protocol that facilitates the transfer of data between two pointers of contact (muller, 1999). SCTP is related to IP, which is located between SCTP user application and the connectionless packet network service. However, SCTP enables each endpoint of the group or association that provides the multiple IP addresses with another endpoint in combination with SCTP ports. Thus, the endpoints of the group or association communicate with each other using addresses. In addition, the addresses serve as a point of origination for the SCTP packets. The group or association spans across almost entire possible sources or destination combinations, which may be generated from each endpoint's lists.

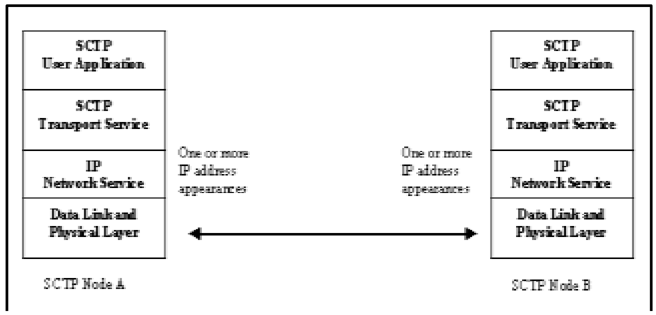

Figure 1: SCTP architectural view.

SCTP protocol has many features different from TCP and UDP as shown in the table below. As usual, the comparison between the protocols in the same layer measures the performance between them in order to become apparent for using. Actually, SCTP has become one of the necessary protocols because it has many advantages of being able to handle with multimedia applications that made him better than UDP or TCP (Leu, and Ko, 2008). Table 1 shows the different features of SCTP, TCP and UDP.

Table 1: Different features of SCTP, TCP and UDP (Amer., and Stewart.,2005)

Services/Features	SCTP	TCP	UDP
Connection-oriented	yes	yes	no
Full duplex	yes	yes	yes
Reliable data transfer	yes	yes	no
Partial-reliable data transfer	optional	no	no
Ordered data delivery	yes	yes	no
Unordered data delivery	yes	no	yes
Flow control	yes	yes	no
Congestion control	yes	yes	no
ECN capable	yes	yes	no
Selective ACKs	yes	optional	no
Preservation of message boundaries	yes	no	yes
Path MTU discovery	yes	yes	no
Application PDU fragmentation	yes	yes	no
Application PDU bundling	yes	yes	no
Multistreaming	yes	no	no
Multihoming	yes	no	no
Protection against SYN flooding attacks	yes	no	n/a
Allows half-closed connections	no	yes	n/a
Reachability check	yes	yes	no
Psuedo-header for checksum	no (uses vtags)	yes	yes
Time wait state	for vtags	for 4-tuple	n/a

The SCTP protocol has become famous for some special features it possesses; multi-streaming and multi-homing.

1- Multi-homing: Multi-homing supports two sets of IP addresses and ports that show that all the IP

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addresses will be involved in operations of sending and receiving data. The network that has two hosts is regarded as multi-homed (Stewart et al., 2008). On the other side, SCTP can send data by selecting just one address from the Alternate address and send; this function will provide the type of flexibility in face outages and network losses.

2- Multi-streaming: SCTP protocol functionality is the same as the TCP protocol, but SCTP is supporting multiple streams in its functionality when it makes SCTP better than TCP for transferring multimedia data. Each stream gives a particular number that is encoded in the SCTP protocol through the association. Therefore, SCTP allows sending and receiving of packets by exchanging these packets among multiple streaming's (Chaeng et al.,2009).

TCP protocol

Transmission Control Protocol (TCP) is reliable transporting protocol that used to send the data in the form of units of messages between devices. TCP is related to IP, while the (IP) physically cares about delivery of data, TCP takes care of tracking each unit of data together with calling packages that are divided into a message. Moreover, it can help sending and receiving through the network. It is slow in sending and receiving data, but it is a reliable protocol.

TCP is a transport protocol like UDP and SCTP with different functions and characteristics. TCP layers handle the data by passing the stack from an application layer to the physical network layer. Each layer will control information in the stack to ensure delivery data, which controlled by the information name header (Hunt, 1997). The data will be sent and received from each header to another and the delivery data in this process is called encapsulation. The data is exchanged between the transport layer and the network layer through the internet layer, which is the procedure for processing data, and then is received by the application layer.

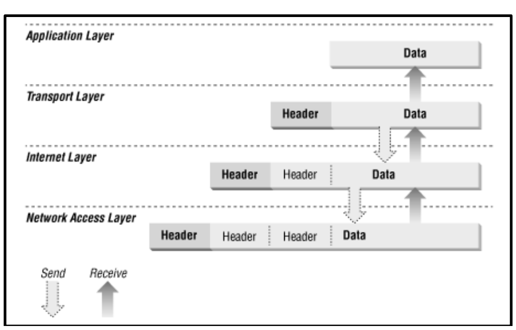

Figure 2: TCP Data encapsulation.

TCP has become a famous protocol that is used in the Internet and intranets. In addition, it has some features that work for transferring of data, which are stated below:

1- Connection Opening: TCP builds the initial fragment to open the connection between the sender and receiver and then the devices will exchange the IP addresses and port number to control the sequencing and data flow.
2- Reliable Communication: In a TCP connection the stream of the data sent from the sender will be reliably delivered (Del Rey, 1981).
3- Error Detection: In the receiving operation, the receiver will test the integrity of the data segment that are incoming, if the data is invalid the receiver will return it and send an error message to the sender, so in this case the network will be safe from corrupted data.
4- Connection Closing: In TCP sending and receiving operations, when the sender indicates that the connection will be terminated, the TCP sender will send segments to declare this to the receiver. There will not be more data sent, and the connection will be closed (TinkQuest, 1999).

The Experiment

In this study, we used network simulation tool (NS2) to compare the performance of TCP and SCTP over a Wired Network. It will describe the results as follows:

1. Network Simulator 2 (NS-2)

NS2 is a discrete event network simulator. It was constructed using C++ and OTCL at the University of California in 1989. NS is used in the simulation of routing protocols, offering simulation results for wireless and wired networks, and others. NS2 supports popular network protocols, It is popular in research given its open source model and online documentation.

2. Simulation Scenario (Simulation Topology)

Conducted two simulation scenarios to measure the performance of each of SCTP and TCP. Both of the simulation scenarios that we designed consist two routers that connected with ten source nodes and ten destination nodes. The experiments were repeated for both SCTP and TCP several times for the purpose of measuring throughput, delay and jitter.

The first experiment is to measure the performance of SCTP. Where the five source nodes will be generating FTP over SCTP traffic destined for the

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SCTP nodes on the other portion of the network, while the CBR over UDP generated by the rest of the nodes would be used to simulate the actual networking environment. The second experiment is to measure the performance of TCP.

The second experiment similar to the first experiment, exception replaces the TCP nodes in place of SCTP nodes. The source nodes are connected to the routers using 1 Mbps point-to-point link with a transmission delay of 10 ms, the destination nodes are connected to the other router using links with a bandwidth of 1 Mbps and 30 ms delay. Both routers are connected together using a 512 kbps point-to-point links that have a propagation delay of 100 ms. The simulator starts running from 10 sec and stops at 1000 sec.

3. Simulation Execution

In the completion of the simulation, NAM output and trace file were created. The NAM output shows the movement of the mobile host and the traffic flow that generated during the movement of the mobile host. The trace file will display the output file. The next step is to analyze the NS trace file and the performance metrics to get all the details about what happens when the simulations were running. In this study, were analyzed the trace file by using AWK language, and graphics by using Gnuplot program.

4. Performance Metrics

The performance metrics are factors that are used to evaluate the performance for something particular, or compare the performance between different system (Deru and Torcellini, 2005). These metrics will provide information about how the study will evaluate the performance of SCTP over the wired network. The data between a servers using SCTP or with TCP, will provide information to compare the result between two or more different systems. In this research, the performance metrics will be used for measuring and analysis the result between TCP and SCTP in terms of throughput, delay and jitter.

Data throughput is the highest quantity of data that can be transported from a sender to a receiver. Nevertheless, the description and measurement of throughput are complicated in defining a satisfactory level of quality (Bradner and McQuaid., 1999). Throughput is used for measuring hardware, software, as well as network.

Delay in the network is the time or period for data traveling through the network from the source to the destination or from an endpoint to another, which specifies how long the data will take to arrive (Amer and Stewart, 2005). The packet delay can be seen from inside the packet stream (Mohammed., 2010). More precisely, it can be described as the period for encryption and decryption in sending and receiving processed data between different endpoints.

Sometimes there were problems in the propagation delay of some seconds, and allowing packets to be sent by the first access, this situation it's called Jitter. Jitter means that there is synchronization in transmission or that defects occurred in the network itself (Almes et al., 1999). Jitter will eventually make the data change the direction of the traffic channel in the delayed access.

Results and discussion

This section presents the result of performance metrics throughput, delay and jitter for both of SCTP and TCP experiments, and compared the result of both experiments with each other in order to evaluate the performance of both SCTP and TCP protocols.

1. Throughput

Throughput used in this project as a metric to compare the performance of the SCTP and TCP. Table 2 presents the average throughput of TCP and SCTP traffic from sources nodes to destinations nodes.

Table 2. Average Throughput of SCTP and TCP traffic.

Nodes	Average Throughput of SCTP (kbps)	Average Throughput of TCP (kbps)
Node 2 – Node 12	67.35	97.59
Node 3 – Node 13	62.56	90.05
Node 4 – Node 14	65.89	88.09
Node 5 – Node 15	58.57	94.91
Node 6 – Node 16	64.98	84.07

Figure 3,4,5,6 and 7 show a comparison of average throughput by each pair nodes for both the TCP and SCTP, between node 2 and node 12, node 3 and node 13, node 4 and node 14, node 5 and node 15, node 6 and node 16 respectively. In this figures, throughput TCP shown in blue color and the SCTP in red color. Figure 8 shows the average throughput the SCTP and TCP streams in a combined figure.

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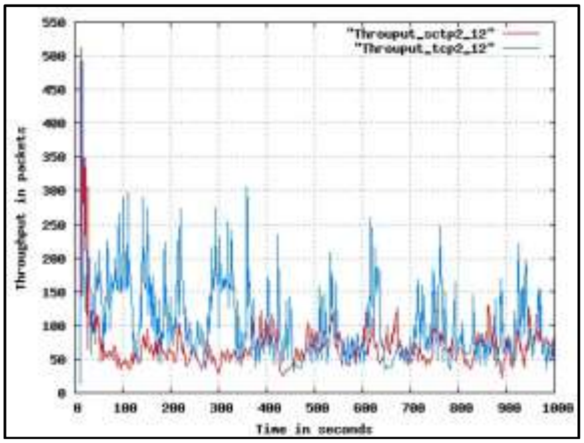

Figure 3: Comparison of Node 2-12 Throughput of TCP and SCTP.

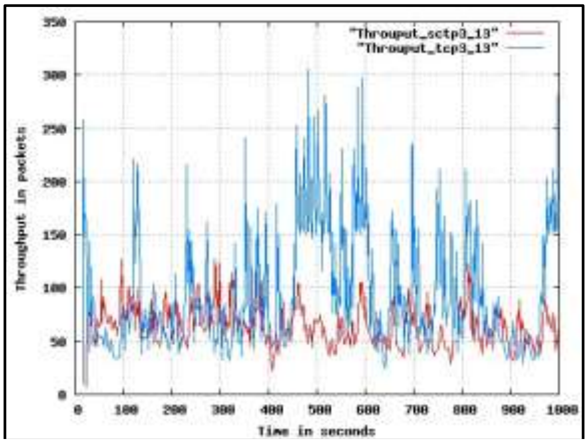

Figure 4: Comparison of Node 3-13 Throughput of TCP and SCTP.

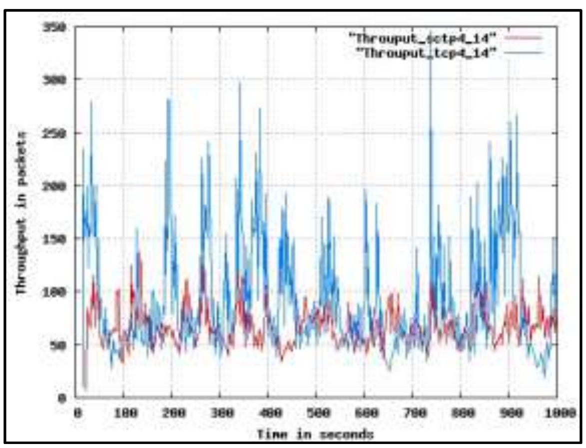

Figure 5: Comparison of Node 4-14 Throughput of TCP and SCTP.

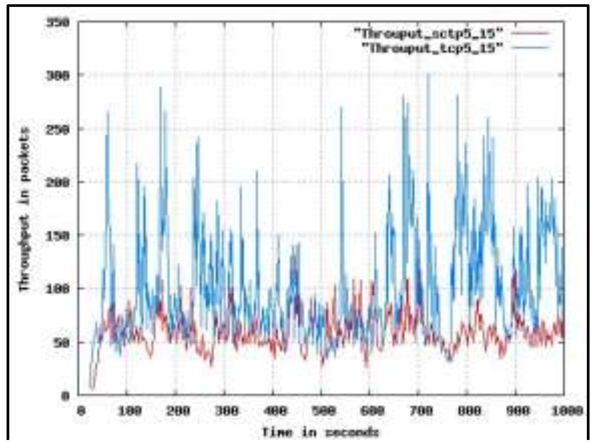

Figure 6: Comparison of Node 5-15 Throughput of TCP and SCTP.

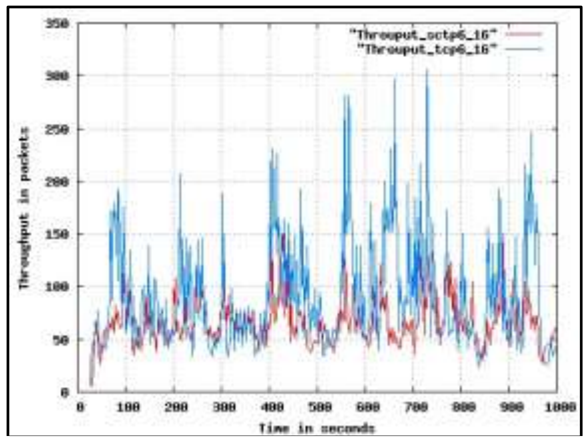

Figure 7: Comparison of Node 6-16 Throughput of TCP and SCTP.

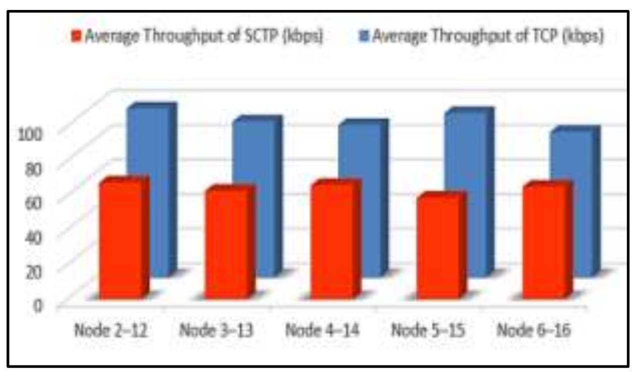

Figure 8: Average Throughput of SCTP and TCP.

As in Figure 8, show the performance throughput of TCP better than SCTP. Where, the TCP throughput more than the SCTP under similar conditions. The TCP throughput is smooth, however, the SCTP throughput was affected by the network environment, where it had a variation in throughput between increasing and decreasing.

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2. Jitter

Jitter used in this project as a metric to compare the performance of the SCTP and TCP. Table 3 presents the average jitter of TCP and SCTP between selected nodes.

Table 3. Average Jitter of SCTP and TCP.

Nodes	Average Jitter of SCTP	Average Jitter of TCP
Node 2 – Node 12	33.0629 ms	12.5925 ms
Node 3 – Node 13	35.6384 ms	13.6463 ms
Node 4 – Node 14	33.8442 ms	13.951 ms
Node 5 – Node 15	38.0793 ms	12.9476 ms
Node 6 – Node 16	34.3397 ms	14.6181 ms

Figure 9,10,11,12 and 13 show a comparison of average jitter by each pair nodes for both the TCP and SCTP, between selected nodes as in throughput. In this figures, jitter TCP shown in blue color and the SCTP in red color. Figure 14 shows the average jitter the SCTP and TCP streams in a combined figure.

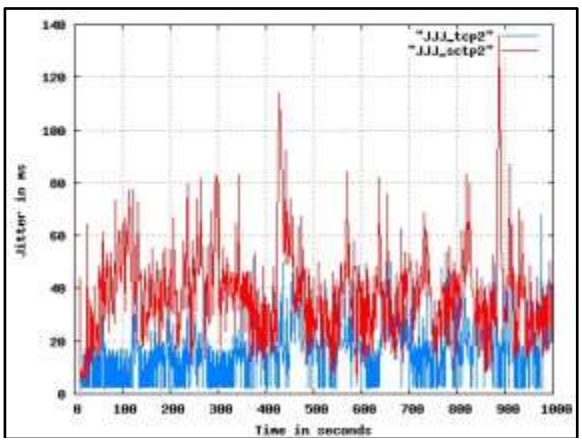

Figure 9: Comparison of Node 2-12 Jitter of TCP and SCTP.

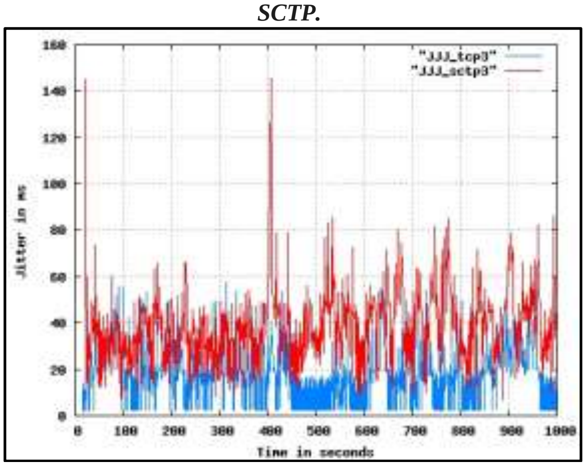

Figure 10: Comparison of Node 3-13 Jitter of TCP and SCTP.

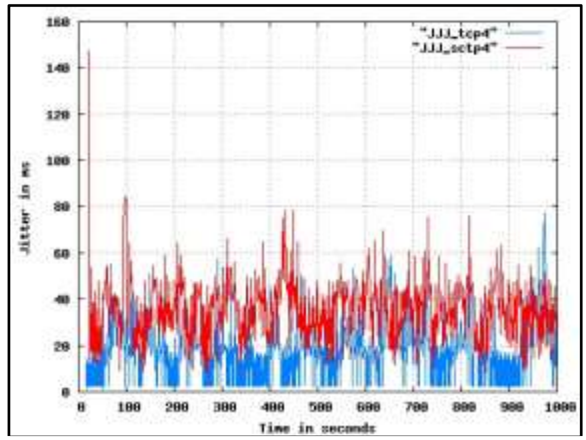

Figure 11: Comparison of Node 4-14 Jitter of TCP and SCTP.

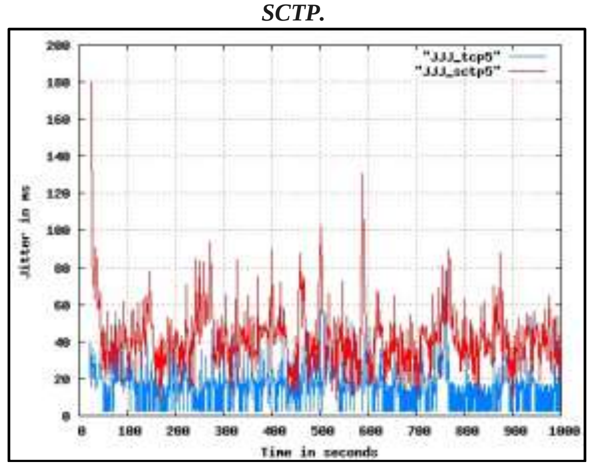

Figure 12: Comparison of Node 5-15 Jitter of TCP and SCTP.

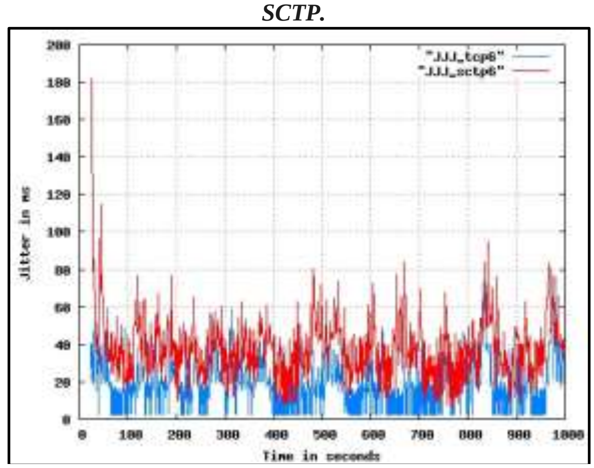

Figure 13: Comparison of Node 6-16 Jitter of TCP and SCTP.

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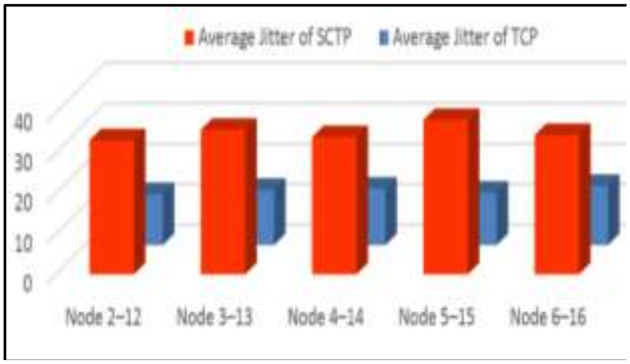

Figure 14: Average jitter the SCTP and TCP.

From the results as shown in figure 14, the jitter was confined to a maximum between 40 - 60 ms most of the time except for few instances where the SCTP stream shows a jitter more than 100 ms. Also, the jitter of the TCP stream has at certain instances reached zero. In figure 14, the average jitter for the SCTP more than TCP under similar conditions. This indicated that all SCTP nodes have delay jitter more than 3.3 sec compared with 1.4 sec for TCP.

3. Delay

Table 4 presents the average delay of TCP and SCTP between selected nodes.

Table 4. Average Delay of SCTP and TCP.

Nodes	Average Delay of SCTP	Average Delay of TCP
Node 2 – Node 12	1212.5 ms	839.674 ms
Node 3 – Node 13	1307.89 ms	909.96 ms
Node 4 – Node 14	1242.05 ms	930.282 ms
Node 5 – Node 15	1397.66 ms	863.958 ms
Node 6 – Node 16	1260.42 ms	975.418 ms

Figure 15,16,17,18 and 19 show a comparison of average delay by each pair nodes for both the TCP and SCTP, between node 2 and node 12, node 3 and node 13, node 4 and node 14, node 5 and node 15, node 6 and node 16 respectively. In this figures, delay TCP shown in blue color and the SCTP in red color. Figure 20 shows the average delay the SCTP and TCP streams in a combined figure.

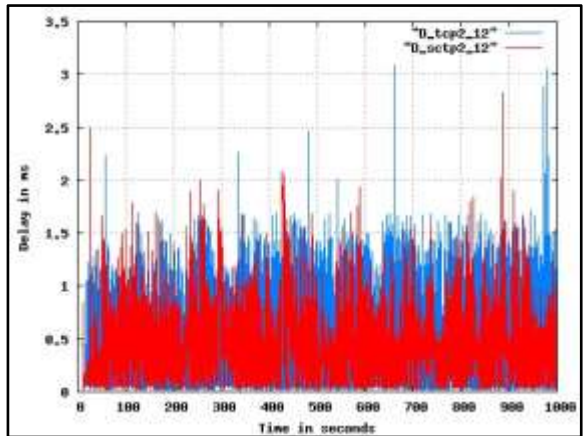

Figure 15: Comparison of Node 2-12 Delay of TCP and SCTP.

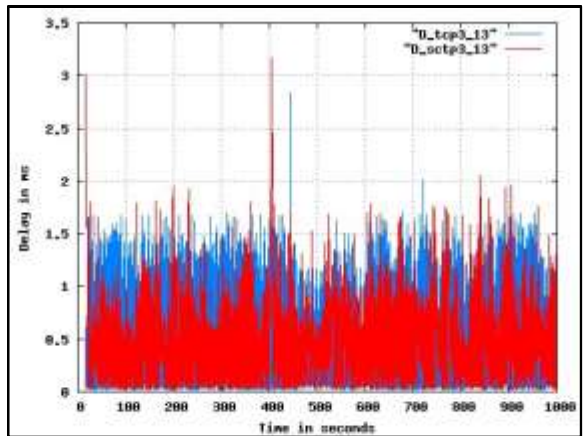

Figure 16: Comparison of Node 3-13 Delay of TCP and SCTP.

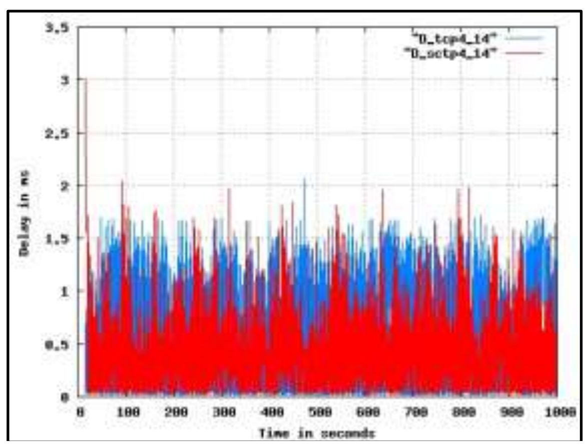

Figure 17: Comparison of Node 4-14 Delay of TCP and SCTP.

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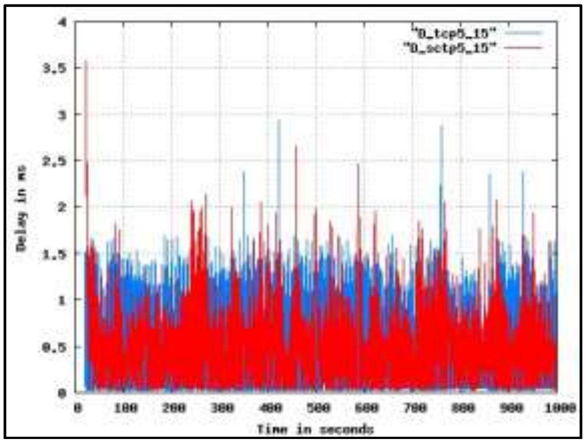

Figure 18: Comparison of Node 5-15 Delay of TCP and SCTP.

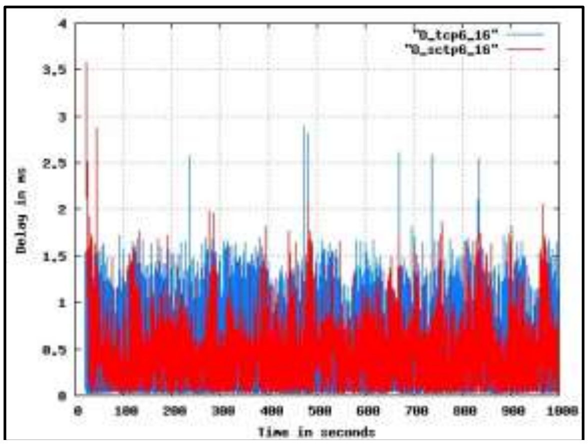

Figure 19: Comparison of Node 6-16 Delay of TCP and SCTP.

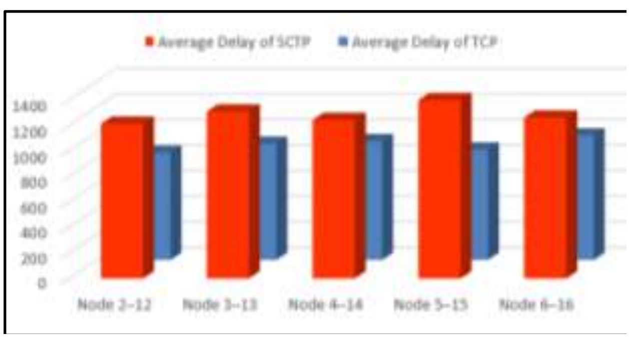

Figure 20: Average delay the SCTP and TCP.

From the results as shown in figure 20, it can be seen the SCTP undergoes a longer delay than the TCP under similar conditions. All the nodes of TCP have average delay times less than 900 ms, however average delay times more than 1.2 sec for SCTP.

Conclusion

The main purpose of this study is to measure the performance and effectiveness of throughput, jitter and delay of SCTP. It also compares the performance of SCTP with TCP in the same network environment. Thus, this study gave a profound analysis of SCTP and TCP over a wired network under similar conditions. Moreover, this study has pointed out the SCTP behavior in the wired network by using SCTP and UDP protocols, and compared their behavior with TCP behavior. In conclusion, this study showed some information about NS-2 as a useful simulator for the prominent network protocols and analysis the results.

References

[1] Almes, G., Kalidindi, S., and Zekauskas, M. (1999). A Round-trip Delay Metric for IPPM. RFC2681 , 4-14.

[2] Amer, P., & Stewart, R. (2005). Why is SCTP needed given TCP and UDP are widely available? Virginia, USA: https://www.isoc.org/briefings/017/ .

[3] Boussen, S., Tabbane, N., and Tabbane, S. (2009). Performance analysis of SCTP protocol in WiFi network. Fourth International Conference on Computer Sciences and Convergence Information Technology (pp. 178 -182). Tunisia: IEEE.

[4] Bradner, S., & McQuaid, J., (1999). Benchmarking Methodology for Network Interconnect Devices. RFC2544, 4.

[5] Chaeng, R., Lai, C., Huang, Y., and Chou, I. (2009). Multi-Stream Bandwidth Estimation for SCTP in High-Speed Networks. Communications and Networking Fourth International Conference (pp. 1-4). China: IEEE computer Society.

[6] Del Rey, M. (1981). Transmission Control Protocol-Darpa Internet Program-Protocol Specification. RFC793, 9-13.

[7] Deru, M., & Torcellini, P. (2005). Performance Metrics Research-Project – Final Report. Colorado: National Renewable Energy Laboratory.

[8] Hunt, C. (1997). TCP/IP protocol architecture. In TCP/IP network administration (pp. 9-23). Sebastopol CA, USA: O'Reilly Media.

[9] Islam, N., and Kara, A. (2006). Throughput Analysis of SCTP over a Multi-homed Association,. Computer and Information

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

Technology, CIT '06. The Sixth IEEE International Conference (pp. 1-6). Fukushima-ken, Japan: IEEE Computer Society.

[10] *Kaytan, M. (2010). TCP versus UDP Performance In Term Of Bandwidth Usage. Sintok-Malaysia: Universiti Utara Malaysia.*

[11] *Leu, F., & Ko, Z. (2008). A Novel Network Mobility Scheme Using SIP and SCTP for Multimedia Applications. International Conference on Multimedia and Ubiquitous Engineering (pp. 564-569). Taiwan: IEEE.*

[12] *Ma, L., Yu, F., and Leung, V ung. (2005). Modeling SCTP Throughput in Integrated WLAN/Cellular Networks. IEEE International Communications Conference (pp. 3445 – 3449). Vancouver, Canada: IEEE Computer Society.*

[13] *McClellan, S. (2003). Active path selection for SCTP. Patent application publication, 1-4.*

[14] *Mohammed, M. (2010). A Comparison of Performance between TFRC and UDP over a Mobile IP Network. Sintok, Malaysia: Universiti Utara Malaysia.*

[15] *Muller, N. (1999). SCTP Administrator's Guide. Boston, U.S: Hewlett-Packard Development Company, L.P.*

[16] *Rane, J., Kumbhar, N., and Sovani, K. (2002). Stream Control Transmission Protocol (SCTP) on Free BSD. India-Pune: Pune Institute of Computer Technology – Affiliated to University of Pune.*

[17] *Scharf, M., & Kiesel, S. (2006). Head-of-line Blocking in TCP and SCTP: Analysis and Measurements. IEEE Communications Society (pp. 1-5). Germany: IEEE GLOBECOM.*

[18] *Stewart, R., T''uxen, M., and Lei, P. (2008). SCTP: What is it, and how to use it? IEEE conference (pp. 1-10). IEEE Computer Society.*

[19] *TinkQuest, O., (1999). TCP Features.* http://library.thinkquest.org/28289/tcpfeatures.html