2015 International Workshop on IT Convergence systems

Proceedings

Nov. 1-3, 2015

Yeungnam University

Gyeongsan, Korea

Organized by

Yeungnam Univiersity, Korea

Tohoku University, Japan

University of Electronics Science and Technology of China, China

Sponsered by

Yeungnam University Leaders in Industry-university Cooperation

BK21+ Creative Human Resource Development Team for ICT-based Smart Devices

Yeungnam University College of Engineering

Yeungnam University Telecommunication Research Center

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Session III *IT Convergence Systems*

Poster Session

Performance of Network Redundancy in SCTP: Effects of different Factors on Multi-homing

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Abstract

The main purpose of designing the Stream Control Protocol (SCTP) is to offer a robust transfer of traffic between the hosts over the network. For this reason SCTP multi-homing feature is designed, in which an SCTP sender can access destination host with multiple IP addresses in the same session. This paper introduces the effect of different network factors like concurrent cross traffic, congestion control algorithms and SACK timers on multi-homing feature of SCTP. Throughput and end-to-end packet delay are used as performance metrics to introduce the effect of these factors. The study concludes that concurrent cross traffic in the network behaves same on multi-homed interfaces. The congestion control algorithms effects on multi-homing; RED congestion control algorithm reduces delay and improves throughput of the SCTP multi-homing as compared to Drop Tail congestion control algorithm. In RFC 4960 recommended SACK timer is 200ms, but when 100ms SACK timer is used with concurrent multipath transfer in SCTP (CMT-SCTP) multi-homing, the high throughput and low delay is achieved as compared with 200ms and 300ms, which indicates that different SACK timers effects on multi–homing feature of SCTP. All the simulation works have been conducted in NS2 network simulator.

Keywords: transport layer protocols, SCTP, multi -homing, NS2

1. Introduction

Stream Control Transmission Protocol (SCTP) is a reliable transport layer protocol which operates on an unreliable packet service that is internet protocol (IP). The SCTP is defined in RFC 4960 [1]. For the past twenty years, Transport Control Protocol (TCP) [7] has provided reliable communication and the unreliable data delivery is provided by User Datagram Protocol (UDP) [6]. Many of the features of TCP and UDP can also be found in SCTP. It provides acknowledged error-free non-duplicated transfer of data. SCTP discovers path maximum transmission unit (MTU) for data transmission and bundles multiple user messages into a single SCTP packet. SCTP also provides a network-level fault tolerance through the support of multi-homing at either ends or both ends of the association [2]. Flow and congestion control in SCTP have been designed to assure that its traffic behaves similar to the TCP traffic, it allows SCTP for seamless introduction into existing IP networks [4]. The multi-homing feature is an essential property of SCTP for the applications that require high degree of fault tolerance rely on redundancy at multiple levels of transmission. TCP does not support multi-homing, anytime if an IP address become inaccessible due to an interface failure or any other reason, the TCP connection will timed out and will force upper layers to recover loss due to this failure. Such type of delay can be unacceptable for mission critical applications like IP Telephony. To overcome this problem, SCTP multi-homing is designed. SCTP supports multi-homing at transport layer to allow sessions or associations to remain alive even when one of the IP address becomes unreachable. It supports both IPv4 and IPv6 protocols and even it works with mixed environment of both; IPv4 and IPv6. An SCTP entity assumes each IP address of its peer as one separate transmission path [4]. The Figure 1 is showing a general architecture of SCTP multi-homing.

In this paper we show the performance of network redundancy (Multi-homing) in SCTP by introducing effect of different factors on multi-homing. This paper aims to determine the simulated results showing performance of network redundancy (Multi-homing) in SCTP by introducing the effect of concurrent cross traffic, congestion control algorithms and different SACK timers on multi-homing feature of SCTP.

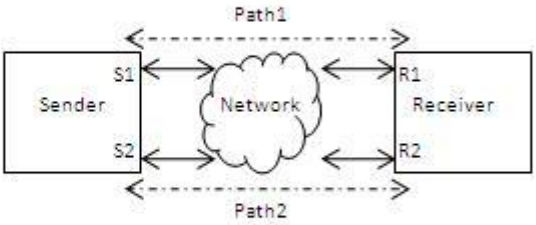

Figure 1 Multi-homing Architecture

The rest of the paper will be laid out as follows; in the Section-2, we present our experimental design including scope, requirements for experimental design and different network scenarios for experiments. In the section-3 results obtained from the experimental design are analyzed. Finally, in section-4 the paper presents conclusion and a necessary future work.

2. Experimental Design

This paper assumes an SCTP Concurrent Multipath Transfer (CMT-SCTP) [5] source and a CMT-SCTP receiver connected through dual-homed nodes. The network design contains the background traffic on both interface nodes according to the internet survey that is on internet TCP traffic is about 80% - 83% and UDP traffic is about 17% - 20% [4].

2.1. Scope and Experimental Scenario

The scope of the experiments includes five different configurations. In the first configuration the SCTP multi-homing is tested without any background traffic. Later, in next experiment TCP and UDP background traffic is introduced with default SACK timer (200ms) and Drop Tail congestion control algorithm. In the third simulation experiment RED congestion control algorithm is used instead of Drop Tail. According to RFC 4960 SCTP default SACK timer to send the gap acknowledgments is 200ms [1]. The fourth and fifth simulation uses SACK of 100ms and 300ms, respectively. The Figure 2 shows network topology used for the simulation. It is modeled using ns2.34 network simulator. The graphs are drawn in XGRAPH version 12.1.

To evaluate the performance of CMT-SCTP in multi-homing a more realistic topology is considered as shown in Figure 2. In this dual dumbbell topology, each router node R1, R2, R3, and R4 is connected to five edge nodes. The dual homed nodes A and B are the SCTP transport sender and receiver, respectively. The other edge nodes are single homed for the background traffic at the routers. The propagation delay between the edge nodes and routers is set to 5ms with 100mb of bandwidth. Each single homed edge node is attached with a traffic generator, introducing a cross traffic with 80% (four nodes on each edge) of TCP traffic and 20% (one node on each edge) [4]. R1 and R2 are bottleneck for the whole traffic and their buffer size is set to twice the link bandwidth-delay product which is a reasonable setting in practice [3]. The propagation delay between dual homed interfaces is set to 25ms. The two paths between the end points are fully separated. The path between R1 to R3 is set as primary path, and CMT-SCTP uses concurrent multipath transfer on both paths. After 0.5 seconds of simulation CMT-SCTP sender source starts initiating association with receiver CMT-SCTP. On 1.0 other cross traffics are injected in the network. The traffic of each test is ended after 30 seconds which is more than enough to check the effects on the performance of SCTP multi-homing [3]. Although the tests are also performed for 60 and 100 seconds of simulation, the results from 30 seconds are almost 99% same as from 60 and 100 seconds simulation.

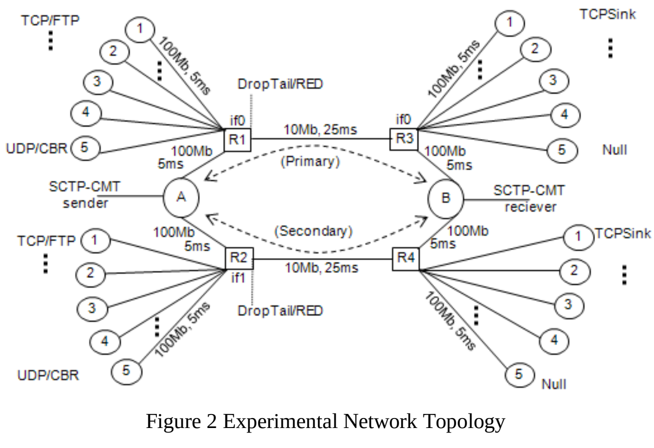

Figure 2 Experimental Network Topology

First simulation is started from one CMT-SCTP source without any background traffic (non-realistic environment). After testing the behavior of dual interfaces in a non-realistic environment, a more realistic configuration is used where TCP and UDP cross traffics are introduced. One simulation is performed with changing congestion control algorithm to RED in previous simulation configuration. Then finally two simulations are performed by changing the SACK timers to 100ms and 300ms. The average end-to-end delay and throughput is used as performance metrics. The average end-to-end delay defines all the possible delays for successful transmitted data of SCTP using multi-homing. There are many factors causing delay in the network, such as queuing delay, buffering during congestion, latency and retransmission delay. The throughput is the total number of successful transmitted bits to the destination. We measure throughput of both of the dual-homed interfaces of SCTP nodes. These metrics are checked and discussed with all the five simulations performed in this experimental setup.

3. Results and Analysis

The performance metrics described in Section-3.2 are tested for factors; concurrent traffic, congestion control algorithms and SACK timers during the simulations.

3.1. Results and analysis for Concurrent Traffic

The Figure 3 and figure 4 shows the throughput and delay results of simulation when no background traffic is present. The initial delay in figure 4 is the association establishment delay between the sender and receiver. It is further normalized after the association is established. Figure 5 shows throughput results of both dual-homed interfaces when background traffic is introduced on the routers R1 and R2. In the graphs, traffic-primary and traffic-secondary lines are showing background traffic on primary and secondary paths respectively. During the cross-traffic simulations we use Drop Tail congestion control algorithm on both interfaces with default 200ms SACK timer. Concurrent multipath transfer in SCTP sends concurrent traffic on both interfaces, the background traffic in the network affects SCTP multi-homing interfaces. Most of the bandwidth is used to deliver SCTP data packets as compared to background data traffic (TCP and UDP). The Figure 6 shows delay on primary and secondary paths after the concurrent traffic is introduced. The Table 1 shows that average throughput for both interfaces is 4.9847Mbps and average delay is 0.0451ms.

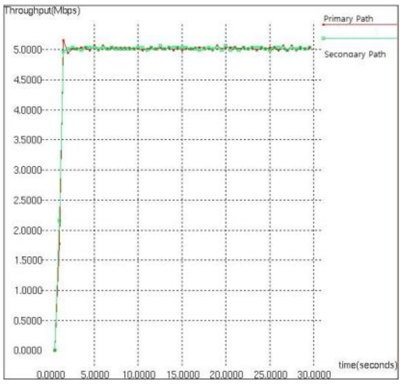

Figure 3 Throughput without background traffic

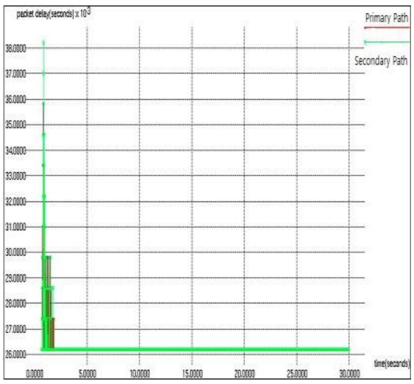

Figure 4 Delay without background traffic

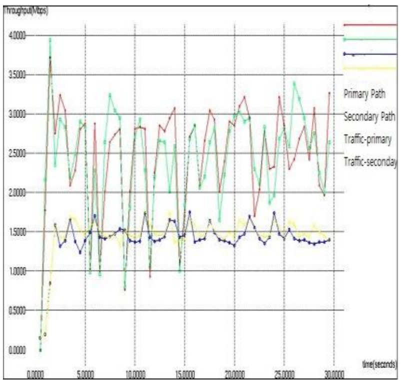

Figure 5 Throughput with background traffic

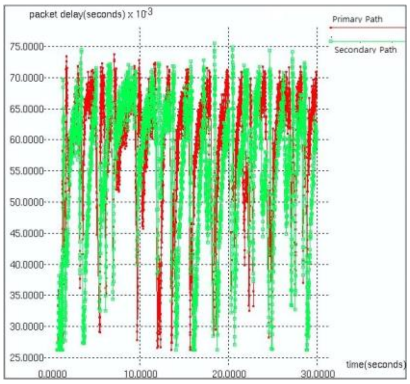

Figure 6 Delay with background traffic

3.2. Results and analysis for Congestion control Algorithms

The Figures 7 and Figure 8 are showing throughput and delay results of simulation on dual-homed interfaces with RED congestion control algorithm at the bottleneck. By comparing Figure 6 and 8, we see how different congestion control algorithms effects on multi-homing feature of SCTP. The Figure 6 shows the effect of Drop Tail algorithm on both interfaces, a global synchronization can be found in the graph. On the other hand when RED congestion control algorithm is used the Figure 8 shows the fair behavior of RED on both interfaces, which avoids global synchronization. The difference between the two paths for RED and Drop Tail is the same. The values in Table 1 describes that RED gives about 10% more efficient throughput and low delay as compared to Drop Tail algorithm. It shows that in case of RED algorithm average throughput of both interfaces is 5.2593Mbs and average delay is 0.0295ms. The RED drops more packets because RED is more fair than Drop Tail, in the sense that it possess a bias against traffic that uses larger portion of the bandwidth. The more a sender transmits, the more packets are dropped and that is what RED is doing with SCTP sender.

3.3. Results and analysis for different SACK timers

In CMT-SCTP it is suggested that the SACK information be treated as a concise description for the transmission sequence numbers (TSNs) from the receiver, hence from the SACK information a loss may not be immediately considered. The sender implies lost TSNs using information in SACKs and history information in the retransmission queue [5]. The Figures 5 and 6 show throughput and delay results of default SACK timer (200ms), we test two more simulations with 100ms and 300ms SACK timers to check its effect on multi-homing. The Figures 9 and 10 show throughput results for 100ms and 300ms SACK timers respectively. Comparing these figures with figure 5 we can see that in case of 100ms SACK timer the throughput behavior of both interfaces is almost consistent and similar and the average throughput is also higher than 200ms and 300ms SACK timers. The Figures 6, 11 and 12 show results of the delay for 100ms, 200ms and 300ms SACK timers with, respectively which are almost similar in all three cases. The increase of throughout in case of 100ms SACK timer is because CMT-SCTP consider received SACK as report for TSNs not only the lost packets.

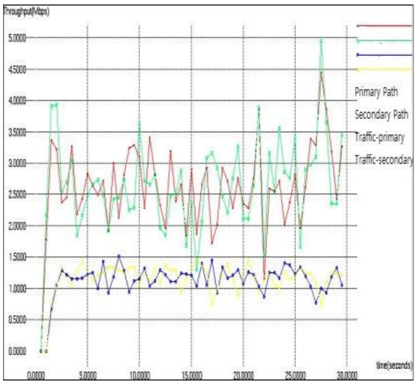

Figure 7 Throughput with background traffic and RED

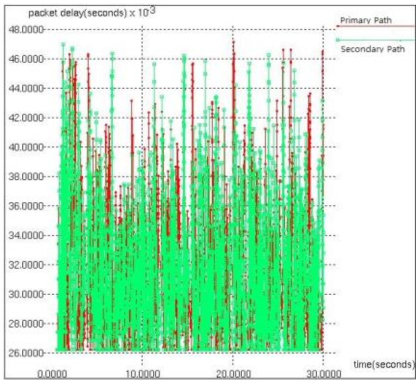

Figure 8 Delay with background traffic and RED

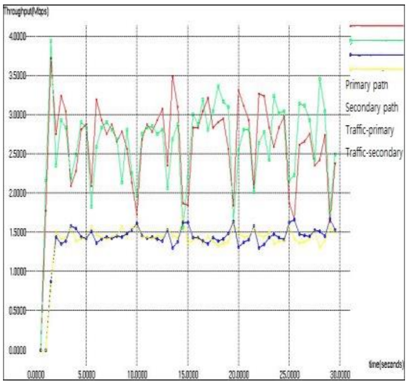

Figure 9 Throughput with background traffic and 100ms SACK

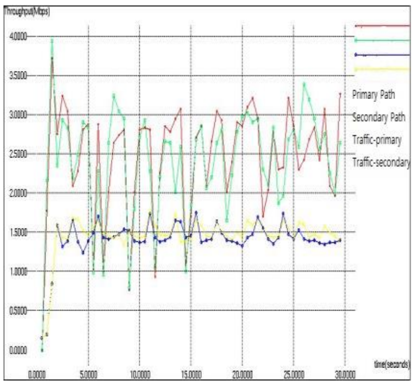

Figure 10 throughput with background traffic and 300ms SACK

4. Conclusion and Future Work

The main contribution of the paper is to show the impact of different factors like concurrent traffic in the network, congestion control algorithms and the different SACK timers on multi-homing feature of SCTP.

Concurrent Multipath Transfer using SCTP multi-homing (CMT-SCTP) is used in Network Simulator NS2 to introduce the effect of these factors. The results and analysis support our hypothesis and it can be concluded that when concurrent traffic is available in the network SCTP multi-homing provides efficient. The SCTP multi-homing proves its usefulness in term of efficiency while sending data over multiple paths. RED and Drop Tail congestion control algorithms have same impact on SCTP as TCP, but in case of multi-homed destinations the RED algorithm provides low delay and about 10% of high throughput as compared to Drop Tail algorithm. Furthermore, in RFC 4960 recommended SACK timer is 200ms, but when 100ms SACK timer is used with CMT-SCTP multi-homing, the high throughput and low delay is achieved as compared with 200ms and 300ms. It indicates that different SACK timers effects on multi-homing feature of SCTP. There is a significant weakness in our work which we have planned to address in near future. We have used only one CMT-SCTP source to establish SCTP multi-homed association; multiple CMT-SCTP associations can be tested for such network factors. The researchers working on SCTP have also introduced another concurrent multipath transfer using SCTP multi-homing called CMT with a potentially failed destination state (CMT-PF). In the future a work can be presented to evaluate CMT vs MT-PF on the basis of factors like concurrent traffic, congestion control algorithms and SACK timers. Moreover, the optimized value for the SACK timers or the Dynamic Sack timers can be investigated for more efficient results of SCTP multi-homing.

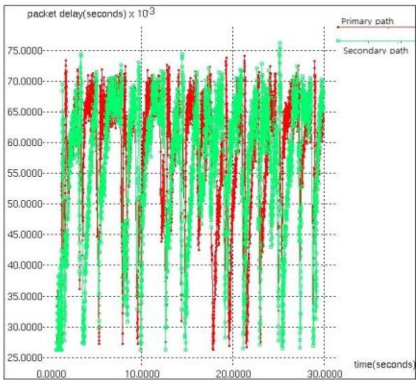

Figure 11 Delay with background traffic and 100ms SACK

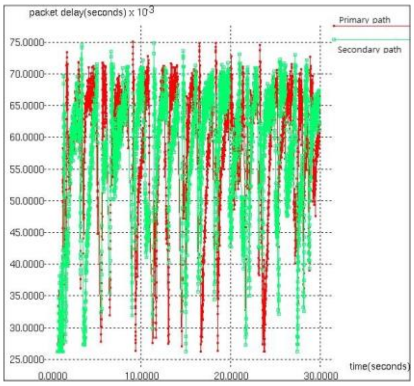

Figure 12 Delay with background traffic and 300ms SACK

	Throughput	Delay	Packet Sent	Packet Received	Packets Dropped
Drop Tail, SACK 200	4.9847	0.0451	18832	18750	82
RED	5.2593	0.0295	19736	19593	143
SACK 100ms	5.2504	0.0447	19800	19719	81
SACK 300ms	4.8578	0.0453	18371	18285	86

Table 1 Summary of the simulation results

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