AN ANALYSIS OF SCTP IN BEST-EFFORT NETWORK WITH COMPETING FLOWS

Elbara Khalid Ali Waleed

UNIVERSITI UTARA MALAYSIA

2011

AN ANALYSIS OF SCTP IN BEST-EFFORT NETWORK WITH COMPETING FLOWS

A project submitted to the Dean of Research and Postgraduate Studies Office in partial

Fulfillment of the requirement for the degree of

Master of Science (Information Technology)

Universiti Utara Malaysia

By

Elbara Khalid Ali Waleed

(804049)

KOLEJ SASTERA DAN SAINS
(College of Arts and Sciences)
Universiti Utara Malaysia

PERAKUAN KERJA KERTAS PROJEK
(Certificate of Project Paper)

Saya, yang bertandatangan, memperakukan bahawa
(I, the undersigned, certifies that)

ELBARA KHALID ALI WALEED
(804049)

calon untuk Ijazah
(candidate for the degree of) **MSc. (Information Technology)**

telah mengemukakan kertas projek yang bertajuk
(has presented his/her project of the following title)

AN ANALYSIS OF SCTP IN BEST-EFFORT NETWORK WITH COMPETING FLOWS

seperti yang tercatat di muka surat tajuk dan kulit kertas projek
(as it appears on the title page and front cover of project)

bahawa kertas projek tersebut boleh diterima dari segi bentuk serta kandungan dan meliputi bidang ilmu dengan memuaskan.
(that this project is in acceptable form and content, and that a satisfactory knowledge of the field is covered by the project).

Nama Penyelia
(Name of Supervisors) : **MR. KHUZAIRI MOHD ZAINI**

Tandatangan
(Signature) : _____ Tarikh (Date) : 20/3/2011

Nama Penyelia
(Name of Supervisors) : **MR. ADIB M. MONZER HABBAL**

Tandatangan
(Signature) : _____ Tarikh (Date) : 20/3/2011

Nama Penilai
(Name of Evaluator) : **MR. ROSHIDI DIN**

Tandatangan
(Signature) : _____ Tarikh (Date) : 21/3/2011

PERMISSION TO USE

In presenting this project of the requirements for a Master of Science in Information and Communication Technology (MSc. IT) from Universit Utara Malaysia, I agree that the University library may make it freely available for inspection. I further agree that permission for copying of this project paper in any manner, in whole or in part, for scholarly purposes may be granted by my supervisor(s) or in their absence, by the Dean of the Graduate School. It is understood that any copying or publication or use of this project or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to Universiti Utara Malaysia for any scholarly use which may be made of any material from my project paper.

Request for permission to copy or make other use of materials in this project, in whole or in part, should be addressed to:

Dean of Research and Postgraduate Studies

College of Arts and Sciences

Universiti Utara Malaysia

06010 UUM Sintok

Kedah Darul Aman

Malaysia

ABSTRACT

This study focuses on Stream Control Transmission Protocol (SCTP), which is defined by IETF in RFC 4960 as a new transport protocol. SCTP features such as multi-homing and multi-streaming, has attracted multimedia applications to use it as their transport protocol instead of UDP and TCP. However, the challenge faced by SCTP is in a best-effort network, where the network does not provide any Quality of Service for the upper layer. In this study, a comprehensive performance evaluation of SCTP in the best-effort network in the presence of other traffic flows will be carried out. The objectives of this research are to measure the performance of both TCP and SCTP over a Wired Network in terms of delay, jitter, and throughput in a network environment that has STCP with UDP traffic, and then compare SCTP and TCP performance results in terms of these performance metrics. All experiments conducted in this research were obtained through network simulation tools, i.e. NS 2. It is expected that the results obtained will become useful for future researchers in improving SCTP.

ACKNOWLEDGMENTS

Firstly, praise to Allah SWT for guiding and blessing me with perseverance and strength to complete this project. Secondly, I would like to thank my parents, especially my father, may Allah bless his soul, forgive him and admit him into paradise. Also, my appreciation goes to my mother, siblings and friends for their support throughout my program, may Allah reward all of you abundantly. In addition, my gratitude goes to my Supervisor, En. Khuzairi Mohd Zaini, and my Co-Supervisor, En. Adib M.Monzer Habbal, for guidance, support and constructive criticism towards the completion of this project, may Allah help you all. Lastly, I am indebted if I do not appreciate everybody that took part in the completion of this project, especially the University Utara Malaysian administration, staff and students, May Allah continue to bless all of you, ameen.

Elbara Khalid Ali Waleed

February 2011

TABLE OF CONTENTS

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

LAN	Local Area Network
WAN	Wide Area Network
HSTCP	High Speed Transmission Control Protocol
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol over Internet Protocol
FTP	File Transfer Protocol
HTTP	Hyper-Text Transfer Protocol
UDP	User Datagram Protocol
TFRC	TCP Friendly Rate Protocol
SCTP	Stream Control Transmission Protocol
MTU	Maximum Transmission Unit
OSI	Open Systems Interconnection
Ns-2	Network Simulator 2
WLAN	Wireless Local Area Network
VOIP	Voice Over IP
Ipdv	IP delay variation
RTEMS	Real-Time Executive for Multiprocessor System
RTO	Recovery Time Objective
MANET	Mobile Ad hoc Network
CWA	Congestion Window Action
CBR	Constant Bit Rate
PC	Personal Computer

CHAPTER ONE

INTRODUCTION

1.1 Introduction

A network is a link between two or more devices such as computers, telephones or anything else for communication to achieve the work that has to do with exchange of files in the case of the sharing of one printer between many computers. Actually, there are two basic types of networks; firstly, Local Area Network (LAN), where many devices link with each other in a limited environment such as a school, building, or even lab. Secondly, a Wide Area Network (WAN), which is also a device link between each other, but in a larger area or environment such as Kedah, Kuala Lumpur or even the world. In addition, there are many ways for arranging networks, which is called network topology. There two types of topology; logical and physical topology. The logical topology describes how the network information flows through the network while the physical topology is concerned with where the access points are placed for the computer layout. The topology classification is regarded as point-to-point, star, link, bus, ring, tree, and mesh. This study will focus on one of the stated classifications.

Indeed, the network has rules and conventions for communicating between devices, which are called network protocols. Any layer from the network standard layers (physical, data link, network, transport, session, presentation and application) has special protocols that are mentioned as the link between two devices and keep the network in good shape. For example, High-Speed Transmission Control Protocol (HSTCP) has

The contents of the thesis is for internal user only

References

Al-Kaisan, A., Ashrafuzzaman, M., and Ahsan, S. (2007). Reducing Congestion Collapse and Promoting Fairness in the Internet by Optimizing SCTP",. *10th International Conference on Computer and Information Technology, iccit* (pp. 1-5). Bangladesh : IEEE Computer Society.

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

Alnuem, M., Mellor, J., and Fretwell, R. (2009). New algorithm to control TCP behavior over lossy links. *International Conference on Advanced Computer Control, DOI 10.1109/ICACC* (pp. 1-5). UK: IEEE Computer Society.

Amer, P., & Stewart, R. (2005). *Why is SCTP needed given TCP and UDP are widely available?* Virginia,USA: http://www.isoc.org/briefings/017/,Copyright C Internet Society.

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.

Bradner, S., & McQuaid, J. (1999). Benchmarking Methodology for Network Interconnect Devices. *RFC 2544* , 4.

Byun, H., and Lim, J. (2005). Explicit window adaptation algorithm over TCP wireless networks . *IEEE Communications Conference* (pp. 1-6). IEEE Computer Society.

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.

Cheng, R., Deng, D., Chao, H., and Chen. (2010). An Adaptive Bandwidth Estimation Mechanism for SCTP over Wireless Networks. (pp. 1-6). Taiwan : IEEE Computer Society.

Cheng, R., Deng, D., Chao, H., and Chen, W. (2009). Performance analysis of SCTP protocol in WiFi network. *Fourth International Conference on Computer Sciences and Convergence Information Technology* (pp. 1-6). Taiwan : IEEE Computer Society.

Corsepius, R., Norum, E., Johns, C., Straumann, T., and Sherrill, J. (2010). RTEMS Operating System. *http://www.rtems.com* .

Dahlander, L., and Magnusson M. G. (2005). Relationships between open source software companies and communities. *Research Policy* , 481-493.

de Souza, E., & Agarwal, D. (2003). A HighSpeed TCP Study: Characteristics and Deployment Issues. *Lawrence Berkeley National Lab* (pp. 1-12). California,USA: Berkeley, CA.

Del Rey, M. (1981). Transmission Control Protocol-Darpa Internet Program-Protocol Specification. *RFC 793* , 9-13.

Demichelis, C., & Chimento, P. (2002). IP Packet Delay Variation Metric for IP Performance Metrics (IPPM). *RFC 3393* , 6-13.

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

Dorion, P. (2006). What is the difference between RPO and RTO (from a backup perspective)? *http://searchstorage.techtarget.com/generic/0,295582,sid5_gci1212112,00.html* .

Emma, D., Loreto, S., Pescap´e, A., and Ventre, G. (2006). Measuring SCTP Throughput and Jitter over Heterogeneous Networks. *20th International Conference on Advanced Information Networking and Applications,AINA* (pp. 1-5). IEEE Computer Society.

Fallon, S., Jacob, P., Qiao, Y., Murphy, L., Fallon, E., and Hanley, A. (2008). SCTP Switchover Performance Issues in WLAN Environments",. *IEEE CCNC proceeding* (pp. 1-5). Dublin, Ireland : IEEE Computer Society.

Floyd, S., Handley, M., Padhye, J., and Widmer, J. (September 2008). TCP Friendly Rate Control (TFRC): Protocol Specification. *RFC 5348* (pp. 7-10). London: University College London.

Fu, S., & Atiquzzaman, M. (2003). Improving End-to-End Throughput of Mobile IP using SCTP. (pp. 1-6). USA: IEEE Computer Society.

Funasaka, J., Neyagawa, T., and Ishida, K. (2010). Effect of SCTP Multistream Function Applied to Parallel Downloading. *IEEE Second International Conference on Communication Software and Networks(iccsn)* (pp. 1-5). Hiroshima: IEEE Computer Society.

Han, Y., Hwang, I., Kim, C., and Park, H. (2010). A New Attainable TCP Throughput Measurement Tool for Long Distance High Speed Networks. *IEEE Communications Letters, 10.1109/LCOMM* (pp. 1-5). IEEE Computer Society.

Hassan, M., Fahmy, S., Wu, J., Aziz, A.,. (2004). ", Chapter 4 page: – by Pearson Education, Inc, Pearson Prentice Hall, Upper Saddle River,, NJ07458. In M. a. Hassan, *High Performance TCP/IP Networking* (pp. 76-79). USA: Alan R. Apt.

Honda, M., Sakakibara, H., Nishida, Y., and Tokuda, H. (2007). SmSCTP: A Fast Transport Layer Handover Method Using Single Wireless Interface . (pp. 1-6). Japan: IEEE Computer Society.

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

Hurtig, P., & Brunstrom, A. (2008). Improved Loss Detection for Signaling Traffic in SCTP. *IEEE Communications Society subject matter experts for publication in the ICC* (pp. 1-6). IEEE Computer Society.

Islam, N., and Kara, A. (2006). Throughput Analysis of SCTP over a Multi-homed Association",. *Computer and Information Technology,CIT '06. The Sixth IEEE International Conference* (pp. 1-6). Fukushima-ken,Japan: IEEE Computer Society.

Joe, I., YAN, S. (2009). SCTP Throughput Improvement with Best Load Sharing based on Multihoming. *Fifth International Joint Conference on INC, IMS and IDC* (pp. 1-5). Seoul, Korea: IEEE Computer Society.

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

Kuhl, M., Kistner, J., Costantini, K., Sudit, M. (2007). Cyber attack modeling and simulation for network security analysis. *39th conference on Winter simulation by ACM* (pp. 1-9). IEEE Computer Society.

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.

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.

Mcclellan, S. (2003). Active path selection for SCTP. *Patent application publication* , 1-4.

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

Muller, N. (2009). *SCTP Administrator's Guide.* Boston,U.S: Hewlett-Packard Development Company, L.P.

Nagamalai, D., Lee, J. (2004). Performance of SCTP over high speed Wide area network. *Conference on Cybernetics and Intelligent Systems* (pp. 1-6). Singapore: IEEE Computer Society.

R, A. A. (2010). *Performance analysis of TFRC and UDP over Mobile-IP network with competing flows.* Sintok, Kedah Dar-ul-Aman: University Utara Malaysia.

Rahim, S., & Faisal-Hasan, S. (2009). Performance Evaluation of Fast TCP and TCP Westwood+ forMultimedia Streaming in Wireless Environment. *12 th International Conference on Computer and Information Technology (ICCIT 2009)* (pp. 1-6). Dhaka, Bangladesh: IEEE Computer Society.

Rahman, S., Atiquzzaman, M., Ivancic, W., Eddy, W., and Stewart, D. (2008). Implementation of SCTP in an open source REAL-TIME operating system. (pp. 1-7). IEEE Computer Society.

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

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.

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.

Takemoto, Y., Funasaka, J., Teshima, S., Ohta, T., and Kakuda, Y. (2008). SCTP Performance Improvement for Reliable End-to-end Communication in Ad Hoc Networks. *IEEE conference in Future Generation Communication and Networking, (FGCN)* (pp. 1-6). Hiroshima, Japan: IEEE Computer Society.

ThinkQuest, O. (1999). TCP Features. *http://library.thinkquest.org/28289/tcpfeatures.html#* .

Valera, A., Seah, W., and Rao, S. (2003). Cooperative Packet Caching and Shortest Multipath Routing in Mobile Ad hoc Networks. (pp. 1-10). Singapore: IEEE Computer Society.

Wang, L., Kawanishi, K., and Onozato, Y. (2009). Achieving Robust Fairness of SCTP Extension for MPEG-4 Streaming. (pp. 1-5). Japan: IEEE Computer Society.

Wolaver, D. H. (1991). *Phase - locked loop circuit design.* Prentice-Hall.

Xylomenos, G., Polyzos, G., Mahonen , P., Saaranen, M. (2001). TCP performance issues over wireless links. *IEEE Communications Magazine Conference* (pp. 1-7). IEEE Computer Society.

Yang, C., Chang, W., and Huang, I. (2007). CS-SCTP: A Collaborative Approach for Secure SCTP over Wireless Networks. (pp. 1-4). Taiwan: IEEE Computer Society.

Zhao, B., Vishwanath, A., and Sivaraman, V. (2007). Performance of high-speed TCP applications in networks with very small buffers . *First International Symposium on Advanced Networks and Telecommunication Systems* (pp. 1-2). Australia: IEEE Computer Society.