Comparative study on the performance of different TCP flavors

A thesis submitted to the Faculty of Information Technology in partial fulfillment of the requirement for the degree Master of Science (Information Technology) Universiti Utara Malaysia

By

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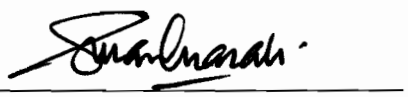
(Signature) : 

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ABSTRACT

Indeed the Transmission Control Protocol (TCP) is the main transport layer protocol for the end-to-end control that helps the creation of information communication. Most of today`s Internet applications depend on the Performance TCP simply because the most frequently used networks by today are the TCP/IP networks. TCP was originally created to handle the problem of network congestion collapse. In this research project, we had investigated the performance of four TCP variants namely Reno, Vegas, NewReno and SACK based on two performance measures: The Bandwidth (effective throughput) and fairness. The network topology is simple wired network and it will be configured into different scenarios to maximize the chances of achieving the desired goal. Simulation methodology is used in this study. The simulation tool or software that was used as an investigation environment is the popular NS-2 simulator. The objective was to investigate and find out the performance of TCP variants according to the bandwidth and fairness in a simple dumbbell wired network, in a hope to observe a better performance. However, the results are daunting, TCP Reno is the most aggressive (least fair one), and highest amount of throughput. In the case of TCP NewReno it follows Reno's steps by becoming the second most aggressive (second least fair), and second highest throughput. SACK (Sack1) is fair to Reno and NewReno, but when it is competing with Vegas, it shows that it is very unfair. Finally Vegas shows the highest degree of fairness (least aggressive) and as well Vegas produces the lowest amount throughput.

Keyword: TCP Reno, TCP Vegas, TCP Westwood, SACK, NS-2, Throughput, Fairness

ACKNOWLEDGEMENTS

First and for most, my solemn gratitude and sincere appreciation goes to the Almighty Creator, the giver of life, health, wisdom and knowledge, for blessing me with the gift of life. Secondly, my profound gratitude goes to my supervisor Dr. Osman B Ghazali for his helpful guidance, brotherly encouragement and most importantly giving me the inspiration during the course of this study.

I am always grateful to all members of my family, first being my Mother. I am thanking her for every prayer and supplication she made for me and as well for her love and most importantly being my mother. I , also would like to express my thanks to my brother *Ahmed Jama Omar*, for his financial support and as well taking care of me while I was student in overseas, both in Sudan and Malaysia. Let me say brother "what you have done for me, no one has done for me".

I would like to express here also my profound appreciation for all the staff and academicians in UUM for sharing their knowledge and experiences. Particular thanks to all the lecturers who taught while I was in UUM, first being *Assoc. Prof Fadzilah Siraj , Dr. Osman B Ghazali and Assoc. Professor Norshuhada Shiratuddin.*

As well, I am here by to express a big thank you to *Mr. Khuzairi bin Mohd Zaini* for being my evaluator and pinpointing the shortcomings of the report and then providing useful comments and suggestions.

I would like to conclude my acknowledgment, by once again thanking the Almighty God.

Abdulaziz Jama Omar,

14th May, 2009.

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LIST OF ABBREVIATIONS

TCP/IP	Transport Control Protocol/ Internet Protocol
TCP	Transport Control Protocol
MMS	Maximum Segment Size
DUPACK	Duplicate Acknowledgment
ACK	Acknowledgment
RTT	Round Trip Time
Cwdn	slow-start threshold
OSI	Open Systems Interconnection
DoD	Department of Defense
Rwnd	Receiver Advertised Window
NS-2	Network Simulator 2

LIST OF EQUATIONS

CHAPTER 1
INTRODUCTION

1.1 Introduction

With out doubt the Transmission Control Protocol (TCP) is the most frequently used transport protocol on the Internet [1]. Therefore understanding the performance of this protocol is an important issue in the areas of computer networking and telecommunications. TCP is a part of the TCP/IP internet protocol suite with two other protocols, namely UDP and SCTP. The TCP/IP protocol suite was developed before the OSI model was even available. As a consequence, it does not make use of the OSI as a reference mode. TCP/IP was created by using the Department of Defense (DoD) model as a base reference. Understanding how OSI model works and getting familiar with it is an essential matter, despite the fact that, because OSI is used to compare the TCP/IP suite with other protocol suites. Unlike the OSI model, the DoD reference model or commonly known as TCP/IP has four layers. Figure 1 shows the comparison between the two models. The four layers of the DoD model are [4]:

OSI Model	DoD or TCP/IP Model
Application layer	Application layer
Presentation layer	
Session layer	
Transport layer	Transport layer
Network layer	Internet layer
Data-Link layer	Network Interface layer
Physical layer	

Figure 1.1: Comparison of the TCP/IP Model and OSI Model [4]

The contents of the thesis is for internal user only

REFERENCES

[1] H. ELAARAG, "Improving TCP Performance over Mobile Networks", ACM Computing Surveys, Vol. 34, No. 3, p. 357–374, 2002.

[2] D.E. Commer, *Internetworking TCP/IP: Principles, Protocols, and Architecture*, Upper saddle, New Jersey: Prentice Hall, 2006.

[3] M. Ghaderi "TCP-Aware Resource Allocation in CDMA Networks" In Proc. ACM *MobiCom,* Los Angeles, USA. 2006

[4] G. Adrew, *TCP/IP JumpStart : Internet Protocol Basics*. Alameda, CA, USA: Sybex, Incorporated, 2002

[5] M. Hassan, *High Performance TCP/IP Networking: Concepts, Issues, and Solutions,* Upper saddle, New Jersey: Prentice Hall, 2004.

[6] TCP WESTWOOD Home available at: http://www.cs.ucla.edu/NRL/hpi/tcpw/

[7] L. A. Grieco and S. Mascolo "Performance Evaluation of Westwood+ TCP Congestion Control", 2004.

[8] W. Tomasi. *Introduction to Data Communications and Networkin*. Upper Saddle River, New Jersey, Ohio: Pearson Prentice Hall, 2005.

[9] A. H. Shabhli,S.Hassan and O.Ghazali , *Layered Multicast: Performance Study of Round Trip Time Estimation for TCP-equation Model*, Kedah, Malaysia: UUM, 2007.

[10] The Network Simulator - NS-2 available at: http://isi.edu/nsnam/ns/,[Accessed: 5th Janaury,2009].

[11] J.Chung and M.Claypool "NS by Example" available at: http://nile.wpi.edu/NS/, 2009.

[12] S. Low, L. Peterson, and L.Wang, "Understanding TCP Vegas: Theory and Practice " University of Melbourne, Australia , 2000.

[13]R. La, J. Walrand, and V. Anantharam "Issues in TCP Vegas" Department of Electrical Engineering and Computer Sciences, University of California at Berkeley, USA.

[14] J. Mo, R.J. La, V. Anantharam, and J. Walrand, "Analysis and Comparison of TCP Reno and Vegas" Department of Electrical Engineering and Computer Sciences, University of California at Berkeley, USA.

[15] M.Mathis, J.Mahdavi, S.Floyd and A.Romanow "TCP Selective Acknowledgment Options (SACK)" available at: http://www.opalsoft.net/qos/TCP-90.htm

[16] Yee`s Homepage of TCP/IP "TCP variants" available at http://www.hep.ucl.ac.uk/~ytl/tcpip/background/tahoe-reno.html [Accessed: 7th Janaury, 2009].

[17] F. Anjum "Comparative Study of Various TCP Versions over a Wireless Link with Correlated Losses" IEEE/ACM Transactions on Networking Vol.11, No, 3, 3003.

[18] K. Fall and S. Floyd. "Simulation-based comparisons of Tahoe, Reno, and SACK TCP". ACM Computer Communication Re-view, July 1996.

[19]K. Thompson, G. J. Miller, and R. Wilder. "Wide-area internet patterns and characteristics". IEEE Network, 11(6):10_23, November/December 1999

[20] J. Postel. "Transmission control protocol". IETF RFC 793 Standard, 1981.

[21] R. Braden. "A requirement for internet hosts -communication layers". IETF RFC 1122, 1989.

[22] M. Allman, V. Paxson, andW. Stevens. "TCP congestion control" .IETF RFC 2581, 1999.

[23] S. Floyd et.al "The NewReno Modification to TCP's Fast Recovery Algorithm", RFC 3782, 2004.

[24] O. Riva, *Analysis of Internet Transport Service Performance with Active Queue Management in a QoS-enabled network,* A PhD Thesis, University of Helsinki, 2003.

[25] J. Postel . "Transmission Control Protocol", RFC 793, September 1981.

[26] B. A. Forouzan. *TCP/IP Protocol Suite.* Boston, McGraw Hill, 2006.

[27]Huston G., *Internet Performance Survival Guide :QoS Strategies for Multiservice Networks,* New York, John Willey and Sons, 2000.

[28] J. Kurhonen. *Introduction to 3G Mobile Communications.* Artech House, Boston, USA, 2nd Edition, 2003.

[29] S. Floyd et al. "The NewReno Modification to TCP's Fast Recovery Algorithm", RFC3782, 2004.

[30] J. Manner and M. Kojo, "Mobility Related Terminology", RFC3753, 2004.

[31] S.Floyd et al. "Quick-Start for TCP and IP", RFC 4782, 2007.

[31]Webopedia, "FTP Definition" available at: http://www.webopedia.com/TERM/F/FTP.html [accessed 17th May 2009]

[32] Wiki "TFP Definition" http://en.wikipedia.org/wiki/File_Transfer_Protocol" [Accessed 17th May 2009]

[33] Network Simulator (NS-2) web site: http://www-mash.cs.berkeley.edu/ns

[34] Opnet Technologies Inc. web site: http://www.optnet.com

[35]M. Loetscher, *Simulative Performance Optimization for TCP over UMTS*, PhD thesis at the Institut für Technische Informatik und Kommunikationsnetze , Germnay, 2003.

[36] The Network Simulator (NS-2) January 6, 2009.

[37] O.Ghazali, *Scaleable and smooth TCP-friendly receiver-based layered multicast protocol.* PhD Thesis, College of Arts and Science, UUM, 2008

[39]B. Qureshi, M. Othman, and N. A. W. Hamid, "Progress in Various TCP Variants (February 2009)", Faculty of IT, UPM, Malaysia

[40] In Encyclopedia of Computer Science. "Definition of SIMULATION. " Hoboken, NJ: Wiley. Available at: http://www.credoreference.com/entry/encyccs/simulation [Accessed May 17, 2009]

[41] Ghazali, O. and S. Hassan. "TCP-friendly Layered Multicast Protocol for Multimedia Streaming" in the Proceedings of ICON 2005, Kuala Lumpur.

[43] Starting Point Geosciences, "Analytical Models" available at: http://serc.carleton.edu/introgeo/mathstatmodels/Analytical.html" [accessed 18th May 2009]

[44] The Blackwell Dictionary of Sociology, "Definition of Experiment" Publishers, 2000. Credo Reference. Available at: http://www.credoreference.com/entry/bksoc/experiment [accessed 18th May 2009]

[45] S.Hassan, *Simulation-based Performance Evaluation of TCP-friendly Protocols for Supporting Multimedia Applications in the Internet.* PhD thesis, School of Computing, University of Leeds, 2003.

[46] P. Wainwright, et al. *Professional Perl Programming*, Birmingham, UK: Wrox Press, 2001.

[47]Trace record Examples of Performance Analysis using NS: http://www.mathcs.emory.edu/~cheung/Courses/558/Syllabus/05-TCP-Sim/Obsolete/PerfAnal.html

[48]J.Olsen, *Stochastic modeling and simulation of the TCP protocol,* PhD thesis, Department of Mathematics Uppsala University.