COMPARISON BETWEEN TRANSMISSION CONTROL PROTOCOL SCHEMES ON WIRELESS ENVIRONMENT

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A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Computer Science)

Faculty of Computer Science and Information System
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NOVEMBER 2008

ABSTRACT

Transmission Control Protocol (TCP) is reliable transmission protocol. It resides on the transport layer in the TCP/IP stack serving the upper application layer. Wireless networks send and receive data over the air using Radio Frequencies. That makes them vulnerable to high collisions rates and high Bit Error Rate (BER). Transmissions over wireless links suffer from delays, frequent disconnections during handoffs and collisions along with standard TCP's congestion control mechanisms treat all errors as congestions and apply algorithms to degrade the throughput of TCP even more. In this study, wired and wireless TCP schemes are analyzed. This includes TCP-Tahoe, TCP-Reno, TCP-Vegas, TCP-Veno, TCP-SACK and TCP-Freeze. The TCP schemes are reviewed and several experiments are conducted. The results are then compared to check their performances regarding average throughput, average delay and their congestion window. Three different simulation environments that are considered that are Wired, Wireless and Heterogeneous using network simulator, NS-2.26 and NS-2.33. The results of the study show similarities and differences between the TCP schemes. From the simulations it is clear that in terms of packet delivery delays TCP-Vegas and TCP-Veno scored the best results in all the networks environments. They also achieved the best throughput in wired and heterogeneous networks while Freeze achieved the best throughput and congestion window in wireless (ad-hoc) environment. In wired networks TCP-SACK had the best congestion window; however, when implemented in with wireless mediums it did not perform well. Tahoe had the best congestion window in heterogeneous networks. The work for this study can be used as a reference for future researches in the area.TCP schemes such as Vegas and Veno implemented better algorithms to perform better over wireless links. TCP-Freeze which freezes all the timers and congestion window before handoffs helped improving TCP performance in mobile scenarios while proved ineffective in fixed wireless or wired scenarios.

ABSTRAK

Protokol Kawalan Transmisi (TCP) adalah protokol transmisi yang boleh dipercayai. Ia terletak pada lapisan pengangkutan di bahagian atas lapisan aplikasi perkhidmatan susunan TCP/IP. Rangkaian-rangkaian tanpa wayar menghantar dan menerima data melalui udara menggunakan Frekuenci Radio yang membuatkan mereka terdedah kepada kadar perlanggaran dan Kadar Ralat Bit (BER) yang tinggi. Transmisi melalui hubungan tanpa wayar mengakibatkan penundaan, kekerapan terputus sambungan semasa lepas tangan dan perlanggaran sepanjang bersama dengan piawaian mekanisma kawalan kesesakan TCP dan melaksanakan algoritma untuk menurunkan bebanan TCP dengan lebih banyak. Dalam kajian ini, skima-skima TCP berwayar dan tanpa way dianalisis. Ianya meliputi TCP-Tahoe, TCP-Reno, TCP-Vegas, TCP-Veno, TCP-SACK dan TCP-Freeze. Skima-skima TCP dikaji semula dan beberapa ujikaji dijalankan. Hasil dari kajian kemudian dibandingkan untuk melihat prestasinya dari segi purata bebanan, purata penundaan dan tetingkap kesesakan mereka. Tiga persekitaran simulasi yang berlainan yang dipertimbangkan iaitu berwayar, tanpa wayar dan heterogen menggunakan pensimulasi rangkaian, NS-2.26 dan NS-2.33. Hasil dari kajian ini menunjukkan kesamaan dan kelainan antara skima-skima TCP tersebut. Daripada simulasi-simulasi ini jelas bahawa terma-terma penundaan penghantaran paket TCP-Vegas dan TCP-Veno memperolehi hasil yang terbaik dalam semua persekitaran rangkaian. Kedua-duanya juga mencapai bebanan terbaik dalam berwayar dan rangkaian hetrogen manakala Freeze mencapai bebanan terbaik dan tetingkap kesesakan dalam persekitaran ad-hoc. Dalam rangkaian berwayar, TCP-SACK memperoleh tetingkap kesesakan terbaik, walaubagaimanapun, apabila dilaksanakan dalam medium tanpa wayar ia tidak menunjukkan prestasi yang baik. Tahoe mempunyai tingkap kesesakan terbaik dalam rangkaian-rangkaian heterogen. Kerja-kerja untuk kajian ini boleh digunakan sebagai rujukan untuk penyelidik-penyelidik yang akan datang di dalam bidang ini. Skema TCP seperti Vegas dan Veno laksanakan algoritma yang lebih baik untuk prestasi yang lebih baik pada hubungan-hubungan tanpa wayar. TCP-Freeze yang membekukan semua masa-masa dan tetingkap kesesakan sebelum lepas tangan membantu meningkatkan prestasi TCP di dalam senario-senario mudahalih sementara membuktikan ketidakcekapan dalam menetapkan senario tanpa wayar dan berwayar.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Computer networks have become a very important aspect in today's human world. Networking and internetworking are now very well known terminologies among specialists in every field of knowledge. For instance, hospitals use computer networks to link, store and share their patients' data between doctors and other branches.

Fixed networks are the most common types of networks that exist in the world of networks today. They build up from small Local Area Networks (LANs) which are connected to each other with routers and base links. Fixed (wired) networks use the fastest available data transfer mediums. They are used when a huge amount of data is needed to be transferred as fast as possible. Wired network can also provide a secure line when a point to point connection is used. However, wired network introduce some limitation when a network needs to be assembled and dissembled quickly and easily. They also limit the user mobility during communication (Bakshi, et al. ,1997).

A wireless network is a flexible data communication system implementation as an extension to or as an alternative to a wired network. Using Radio Frequency (RF) technology, wireless networks transmit and receive data over the air, minimizing the need for wired connection. Thus, wireless networks combine data connectivity with user mobility. Wireless network are easy to assemble and configure, they provide user mobility without losing communication sessions and they are easy to break down when needed. On the other hand, wireless networks can suffer from many problems including higher collision rate and higher Bit Error Rate (BER). The wireless networks also suffer from problems facing wireless signals like signal blockage and weather effects. Security wise, the wireless networks are considered the most vulnerable because of the shared transfer medium (Tian, Xu and Ansari, 2005).

A simple heterogeneous network is combined of a wired network and a cellular wireless network. The wired part consists of fixed hosts and routers. The router controls the flow of data throughout the network. It receives packets of data from a source host and route the data to their expected destination. The wired network extends to mobile hosts over wireless network links through base stations. The base station acts as a gateway between the two network environments. It routs packets to and from mobile hosts and the wired network. Figure 1.1 shows a simple heterogeneous network (Saarto, 2003).

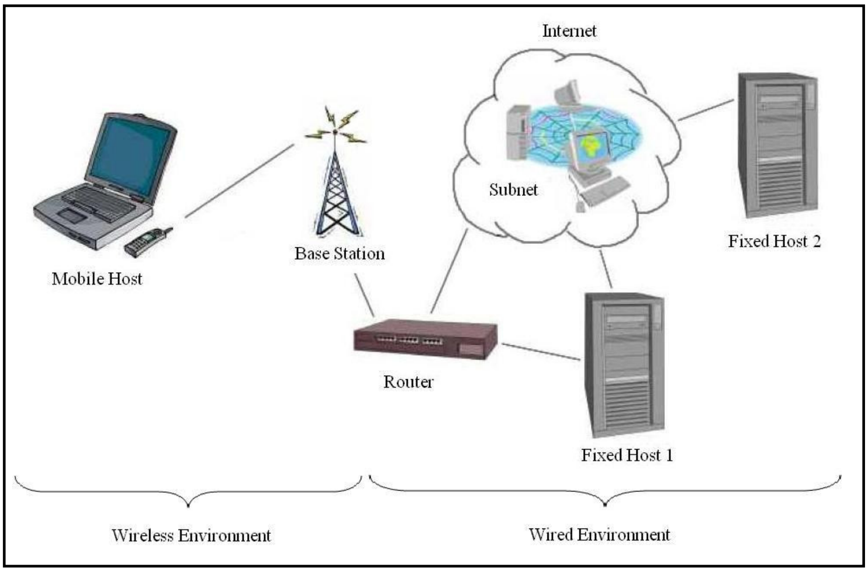

Figure 1.1: A Heterogeneous Network (Saarto, 2003).

1.2 Problem Background

The Transmission Control Protocol (TCP) was primarily designed for wired networks. In wired networks random BER is negligible, and congestion is the main cause of packet loss. Each TCP packet is associated with a sequence number. Only successfully received in-order packets are acknowledged to the sender by the receiver, by sending corresponding packets' Acknowledgments (ACKs) with sequence numbers of the next expected packets. On the other hand, packet loss or reception of out-of-order packets indicates failures. To eradicate such failures, TCP implements flow control and congestion control algorithms (Shamakumar, et al. ,2001).

Unlike the wired access networks, wireless links use the open air as the transmission medium and are subject to many uncontrollable quality-affecting factors such as weather conditions, urban obstacles, multipath interferences, large moving objects, and mobility of wireless end devices. As a result, wireless links exhibit much higher BERs than wired links. Also, limitations of radio coverage and user mobility require frequent handoffs, thus resulting in temporal disconnections and reconnections between the communicating end hosts during a communication session. A short disconnection event can actually stall the TCP transmission for a much longer period. Standard TCP cannot effectively handle high BER and frequent disconnections. Random packet losses are, therefore, inferred to network congestions rather than to the high BER effect that comes along with wireless networks. That would trigger the sender to execute congestions avoidance algorithms and unnecessarily reduces its sending rate. Short bursts of BERs may happen due to signal blockage or other signal quality affecting factors, such as noises and bad weather. That can lead to a high rate of random packet losses within a single Round Trip Time (RTT). The retransmission timer can experience an exponential back off if multiple packets were lost within one RTT. Two random packet losses within one RTT would cause the sender to stall transmission to up to one second. Figure 1.2 (Tian, Xu and Ansari, 2005), shows the difference between losing two packets within one RTT and losing two packets far apart. In the first scenario the graph shows that the sender had stalled the transmission for up to 50 RTTs or around 1 second. Standard TCP is unable to distinguish between congestive and random packet loss contributes to a drastic decrease of TCP's throughput (Tian, Xu and Ansari, 2005).

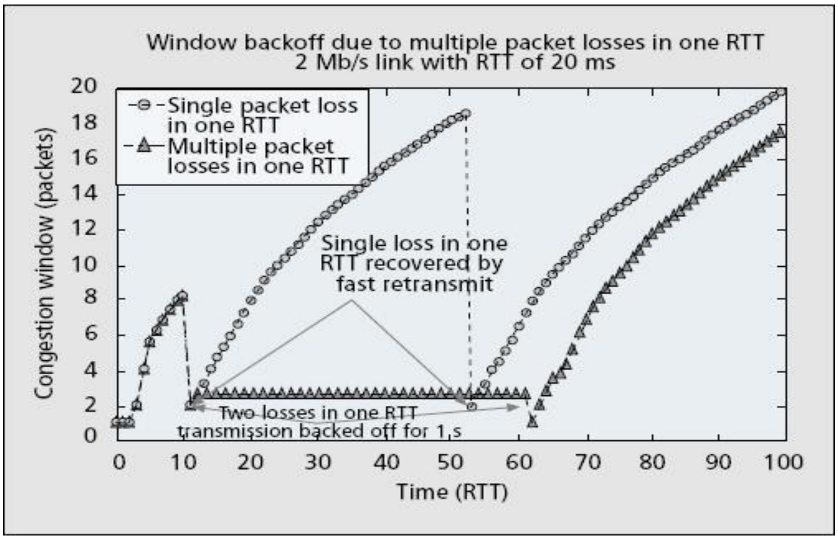

Figure 1.2: The Effect of Multiple Losses in One RTT in TCP Transmission (Tian, Xu and Ansari, 2005).

The TCP assumes a relatively reliable underlying network where most packet losses are due to congestion. In a wireless network, however, packet losses will occur more often due to unreliable wireless links than due to congestions. When using standard TCP over wireless links, each packet loss on the wireless link results in congestion control measures being invoked at the source. This causes severe performance degradation. This made implementing standard TCP over wireless links unreliable. Thus, more wireless TCP schemes such as Freeze-TCP (Goff, Moronski and Phatak, 2000), I-TCP (Bakre and Badrinath, 1994) and ATCP (Liu and Singh, 2001), were required to solve the problems facing the TCP on wireless environments (Tian, Xu and Ansari, 2005).

1.3 Problem Statement

The different wireless network environments introduced different problems that face the standard TCP. Over the years several schemes were implemented to increase the performance of TCP over wired and wireless mediums.

This project mainly examines the question:

"How does the Transmission Control Protocol distinguish between errors caused by router congestions and errors caused by wireless links?"

1.4 Project Objectives

With reference to the problem stated above, this study is attempting to achieve the following objectives:

(i) To review different available types and schemes of TCP protocol.
(ii) To analyze the negative effect of both wired and wireless network environments on the performance of TCP.
(iii) To compare the performance of various TCP schemes on wireless environments.

1.5 Project Scope

The scope of the project is to identify the limitations of several TCP schemes that are widely used over wireless links. The main points in this project are:

(i) The study will cover two wireless environments Ad-hoc and Cellular.
(ii) The study will focus on the performance of several TCP schemes in different wireless environments in terms of throughput, delays and TCP congestion window.
(iii) A simulation using Network Simulator 2 (NS2) will be carried out on six TCP schemes by sending packets FTP over TCP protocol.
(iv) An analysis study of the results will be carried out to understand effectiveness of each protocol when implemented on wireless environment.
(v) The project will focus mainly on TCP-Tahoe, TCP-Reno, TCP-Vegas, TCP-Veno, and TCP-SACK as TCP schemes on wired, wireless and heterogeneous environments. TCP-Freeze will be tested on both wireless and heterogeneous environments.

1.6 Importance of Study

Most of the applications, platforms and networks implement TCP as the main protocol to communicate. The first step toward the design of a better transport protocol for wireless networks has to be a better understanding of the way TCP works over wireless links. This would reveal the reasons for the inefficiency of TCP over wireless links. Studying different wireless TCP schemes can help understand the improvement of such schemes on the TCP performance over wireless networks. Thus, some of these schemes can be recommended to be used on other studies or applications.

1.7 Thesis Structure

This project is organized as follows:

Chapter 1 introduces a brief and general idea about computer networks and specifically wireless networks. This chapter also briefly discusses the Transport Control Protocol (TCP) and the limitation it faces within the wireless network environment. The project objectives and scope are mentioned in this chapter.

Chapter 2 discusses the literature reviews, where the background details and concepts of Transport Control Protocol (TCP) and its limitation on wireless networks are explained. The chapter also addresses TCP error control and recovery mechanisms. This chapter also discusses some existing TCP schemes that concern with improving the performance of TCP on wired and wireless environments. It also discusses the File Transfer Protocol (FTP) and the Network Simulator 2 (NS2). The network topologies are stated at the end of the chapter.

Chapter 3 discusses the research methodology used in this study. In this chapter the operational framework is presented to show the steps that need to be done to achieve the objectives of this project. The Network Model also will be described in this chapter. The Network Model is designed as simple as possible to avoid unnecessary drawbacks, whether they are caused by the complexity of the design or the infrastructure of the network model. The Simulation Model that shows the metrics of the simulation also will be described in this chapter.

Chapter 4 discusses the simulation setups and scenarios. The codes that configure the simulation setup and extract the results from the trace files are discussed in this chapter. A brief description about the code is discussed for demonstration purposes.

Chapter 5 includes the results of the simulation along with a discussion section about the results. The different schemes will be compared together to better understand how they perform against each other.

Chapter 6 will conclude the study and the final discussion and findings will be briefly discussed in this chapter. The limitations which this project has faced will also be stated in this chapter. Finally some recommendations and future work that could be suggested will conclude the project.

1.8 Summary

The ease of use, low cost and the vast variety of information made the Internet a necessity in the modern world. Users want to access information on the

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