PERFORMANCE OF TRANSMISSION CONTROL PROTOCOL (TCP) CONGESTION CONTROL OVER WIRELESS LINKS USING MODIFIED SNOOP PROTOCOL

By

FURAT ASMAT MOOJID

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia In Partial Fulfillment of the Requirements for the degree of Master of Science

December 2003

To my Parents,
My friends,
My cousin Bahaa,
And especially my wife.

Abstract of thesis presented to Senate of Universiti Putra Malaysia in partial fulfilment of the requirement for the degree of Master of Science

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Chairman: Professor Borhanuddin Mohd. Ali, Ph.D.

Faculty: Engineering

Because of the burgeoning increase for data communication and multimedia services over wireless links, and rapid growth of wireless communications, many researches have been undertaken to find effective integrated protocols that satisfy this demands. Since wireless links normally show higher bit error rate and temporal disconnections compared with wired links, the losses are greater, this may also be caused by the mobility like handoff, and many wireless channel impairment errors and not just congestion. TCP deals with packet losses by applying congestion control mechanisms, which tends to degrade its performance.

Many protocols have been proposed including Snoop, to alleviate this problem. Our objectives here are to study and enhance the Snoop protocol using the modified ACK called Fake Acknowledgment under various network parameters.

In this thesis, a Fake ACK technique proposed based on the Snoop Acknowledgment procedure; this reduces the waiting time of the Fixed Host waiting for the right Acknowledgment to be received, and hence reducing the probability of initiating congestion control mechanism. The results show that the throughput of our technique is increased and the losses are decreased compared to traditional Snoop protocol, under different parameter values.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

Oleh

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Disebabkan peningkatan mendadak komunikasi data dan servis-servis multimedia melalui penghubung wayarles, dan perkembangan mendadak komunikasi wayarles, banyak kajian telah dijalankan untuk mencari protokol yang dapat memenuhi keperluan ini. Memandangkan penghubung wayarles kebiasaannya mempunyai kadar kesalahan bit yang lebih tinggi dan kemunskinan terputus hubungan yang lebih tinggi berbanding penghubung wayar, kehilangannya adalah lebih besar disebabkan masalah pergerakan seperti “handoff” dan banyak kesalahan pada saluran wayarles dan peringisan bukan sahaja kesesakan.

Pelbagai protokol telah dicadangkan antaranya Snoop, untuk mengatasi masalah ini. Matlamat kami adalah untuk mengkaji dan mengemaskini protokol Snoop menggunakan kaedah yang telah diubahsuai dipanggil “Fake Acknowledgment” dibawah parameter rangkaian dasar yang berbeza. Di dalam tesis ini, kaedah “Fake ACK” dicadang berdasarkan kepada prosedur “Snoop Acknowledgment”; ini

mengurangkan masa menunggu untuk hos tetap sementara “Acknowledgment” yang betul diterima, dan dari itu mengurangkan kemungkinan memulakan mekanisma kawalan kesesakan. Keputusan yang diperolehi menunjukkan bahawa prestasi pencapaian untuk kaedah kami ini akan meningkat dan kehilangan akan berkurangan berbanding protokol Snoop tradisional, dibawah nilai parameter yang berbeza.

ACKNOWLEDGEMNETS

I would like to express deep gratitude to my advisor and chairman of my supervisory committee Prof. Dr. Borhanuddin Mohd Ali, who has helped me with his guidance, advices, and corrections, especially his kind and patient.

I am no less grateful to the other committee members Dr. Mohamed Hadi Habaebi for support me all the times with his ideas and experience, which helped me to solve a number of problems those faced me.

And Puan Ratna, who is kind enough to read and comments on my work.

Also my thanks, to my colleagues at the wireless and broadband laboratories, for their kindness and help during my research time.

It is particular that I express my affectionate and deeply felt gratitude to my parents, my brothers, especially my wife who joined me step by step, my dear friend Khalid and my cousin Bahaa who encourage and support me to complete my work.

I certify that an examination committee met on 23rd December 2003 to conduct the final examination of Furat Asmat Moojid on his Master of Science thesis entitled "Performance of Transmission Control Protocol (TCP) Congestion Control Over Wireless Links using Snoop Protocol" in accordance with Universiti Pertanian Malaysia (Higher Degree) act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or currently submitted for any other degree at UPM or other institution.

FURAT ASMAT MOOJID

Date:

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LIST OF ABBREVIATIONS

ACK	**Acknowledgment**
ARQ	**Automatic repeat request**
ATM	**Asynchronous Transfer Mode**
BER	**Bit Error Rate**
BS	**Base Station**
BW	**Bandwidth**
CHD	**Channel Delay**
Cwnd	**Congestion Window**
Dup ACK	**Duplicate Acknowledgment**
E2E	**End-to End**
FEC	**Forward Error Correction**
FH	**Fixed Host**
FIFO	**First In First Out**
ELN	**Explicit Loss Notification**
FDDI	**Fiber Distributed Data Interface**
FIN	**Finish**
HDR LEN	**Header Length**
IP	**Internet Protocol**

LP	**Losses Probability**
MH	**Mobile Host**
MSS	**Maximum Segment Size**
MTU	**Maximum Transfer Unit**
NSv2	**Network Simulator version 2**
OTcl	**Objective Tcl**
PER	**Packet Error Rate**
Pkt	**Packet**
PS	**Packet Size**
PSH	**Push Flag**
RST	**Request**
RTT	**Round Trip Time**
SACK	**Selective Acknowledgment**
Ssthresh	**Slow Start Threshold**
SYN	**Synchronization**
TCP	**Transmission Control Protocol**
TD	**Transmission Delay**
URG	**Urgent Flag**

CHAPTER 1

BACKGROUND

1.1 Introduction

The transport layer is a heart of the whole protocol hierarchy. Its task is to provide reliable, cost-effective data transport from the source machine to the destination machine, independently of the physical network or networks currently in use.

Transmission Control Protocol was designed to provide a reliable end-to-end byte stream over an unreliable internetwork. An internetwork differs from a single network because different parts may have wildly different topologies, bandwidths, delays, packet sizes, and other parameters [18].

TCP was formally defined in RFC 793; the transmission control protocol (TCP) is a reliable connection oriented, end-to-end, error free protocol. A TCP connection is like telephone connection but with reliable data transmission between the computers.

The reliability guaranteed by sending cumulative Acknowledgment (ACK) after receiving in-sequence segment. Early TCP implementations only had a simple sliding window flow control mechanism without any congestion control. After observing a series of congestion collapses in 1980's, several innovative

congestion control mechanisms introduced into TCP in 1988. This TCP version called TCP Tahoe, includes the slow start, congestion avoidance, and fast retransmit algorithm. Two years later in 1990, the fast recovery algorithm was added to Tahoe to form a new TCP version called TCP Reno. And currently the dominating TCP version deployed in the Internet is TCP Reno version. These clarifications and some bug fixes are detailed in RFC 1122. Extensions are given in RFC 1323.

Since 1988, the Internet has grown tremendously; it has become clear that the TCP congestion avoidance mechanisms are not sufficient to provide good service in all circumstances [24]. Especially for instance, in wireless networks, the traditional assumption that packet loss is an indicator of network congestion may be invalid since high bet error rate and temporarily disconnection could be the main reason behind packet losses in wireless networks. Likewise, in asymmetric networks in which two directions of the connection could have vastly different bandwidth and different characteristics, TCP performance may suffer in the current heterogeneous networks.

Over the past decade, many schemes proposed to solve wireless networks low performance. Some of them attempt to make the TCP sender aware of existing wireless; others try to hide non-congestion related losses from TCP sender, because that some of packets losses can avoid invoking the congestion control algorithm when new congestion related losses occur [1]. A different solution, due to Balakrishnan, Snoop protocol does not break the semantics of TCP. It works by making several small modifications to the network layer code in the

base station. One of the changes is the addition of Snooping agent that observes and caches TCP segments going out to the mobile host and acknowledgments coming back from it. When the snooping agent sees a TCP segment going out to the mobile host but does not see an acknowledgment coming back before its (relatively short) timer goes off, it just retransmits when it sees duplicate acknowledgments from the mobile host go by [18].

Most current network application is Snoop protocol that desirable to achieve improving wireless part performance without changing existing TCP implementations [2]. The truth that is Snoop or any other solution could also suffer from not being able to completely shield the sender from wireless losses [3].

1.2 Objectives

The objectives of this thesis are as follow:

a) **To study the transmission control protocol, and its problems over wireless networks.**
b) **To investigate Fake ACK proposed scheme to improve TCP performance over wireless links especially link layer schemes.**
c) **To examine the effect of some parameters on the performance of TCP, by using Snoop Protocol, between fixed host and mobile host over Wireless Local Area Network.**

d) To propose a modified Snoop Protocol to evaluate the performance of the TCP congestion control, and

e) To improve the TCP congestion control by Proposed technique called Fake ACK Scheme to minimize the opportunity of referring to congestion control mechanism.

In our study we focus on the packets dropping as a standard for the performance. For pure wired network we studied the effect of three parameters on the dropping packets (performance). The original simulation runs within 10 seconds with fixed host, base station, mobile host.

The design parameters are Bandwidth, Transmission Delay, Loss Probability, and Channel Delay, while the performance parameters are the Throughput and Number of Packets Lost. The performance parameters observed by changing the design parameters one after another.

1.3 Thesis Organization

The thesis is organized as follow:

Chapter 1 is divided into five sections. The first three sections introduce the transmission control protocol (TCP), performance of TCP over wireless networks, and the motivations and objectives of this thesis.

Chapter 2 consists of five sections introducing the evaluation of the transmission control protocol and its versions with basic explanations and simple

mechanisms that used in TCP. Detailed explanation of how congestion control mechanisms work, and the TCP over wireless networks, with the related problems and the existing solutions proposed to enhance TCP over wireless and its performance.

Chapter 3 describes the methodology, including problem formulation and Snoop protocol as a link layer scheme, then the simulation and modeling including the topology and our proposed technique.

Chapter 4 presents the results and discussion of the comparisons and proposed technique in the thesis.

Finally, chapter 5 concludes the thesis and proposed future work to be done in this research area.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Wireless networks play a very important role in communications today. People want information on demand – any place, any time. Wireless networks help solve this problem. Reliable transport protocols however, such as TCP that have been traditionally used for wired networks do not perform as well on wireless networks. This is because TCP assumes that packet loss and unusual delays are mainly caused by congestion. TCP is thus tuned to adapt to such congestion losses by slowing down the amount of data it transmits. It drops its transmission window size and backs off its retransmission timer, thus reducing the load and congestion on the network. In wireless networks however, packet loss is often caused due to other factors besides congestion. Wireless channels often suffer from high bit error rates (BER) and intermittent connectivity due to handoffs [8].

2.2 TCP Protocol

Since 1981, TCP is the most popular transfer layer protocol, which provides transparent segmentation and reassembly of user data, and handles flow and

congestion control. For that reason, TCP is the base for Internet in this period [4].

Simply, TCP is transport layer connection oriented, reliable, full duplex, byte stream and end-to-end protocol [5]. Early TCP implementations only had a simple sliding window flow control mechanism without any congestion control. After observing a series of congestion collapses in 1980's, Jacobson introduced several innovative congestion control mechanisms into TCP in 1988 and they called this version of TCP Tahoe, includes slow start congestion avoidance and fast retransmit algorithms. After two years, in 1990, they added fast recovery algorithm to Tahoe to form a new TCP version called TCP Reno, and currently it is the most popular version used in the Internet. The current TCP versions seem to be not so efficient for the modern networking environment. TCP can be used over a large variety of networking and physical infrastructures that have very different characteristics: Ethernet, FDDI, and ATM over wires, optical fibers, radio waves, or infrared signals.

A TCP connection may, and usually does, work over all these different quality of service levels, and segments face different transmission environments [13].

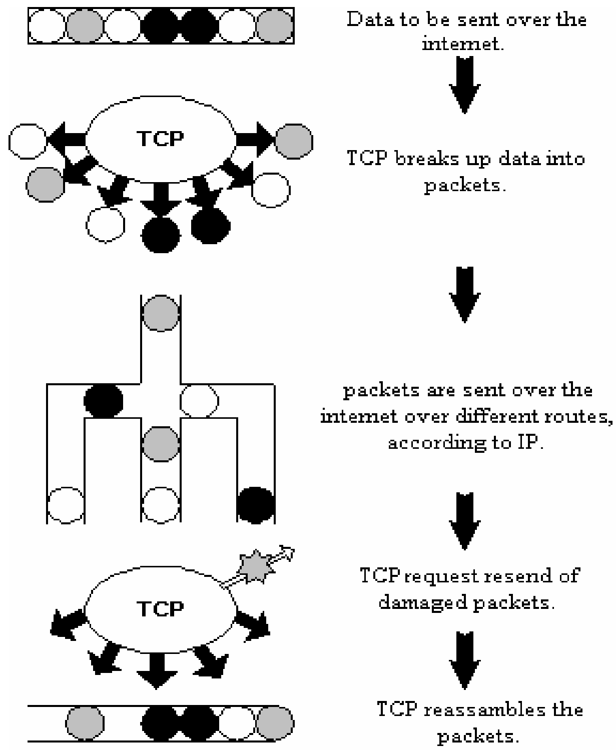

Fig.1 The TCP protocol

TCP assumes that all losses indicate congestion simply as increased delay, and it avoids this problem by retransmitting the lost packet, but sometimes when TCP retransmit the lost packets, this retransmission will aggravate the congestion instead of alleviating it, leading to increased traffic, until the network becomes useless (Congestion collapse). To avoid congestion collapse, when losses are detected, TCP retransmits the lost packet, and also reduces its transmission rate, allowing router queues to drain. Subsequently, it gradually increases its transmission rate so as to gently probe the network's capacity [15].

We must remember that the router or any switching point has a finite strong capacity (buffer) so on the worst case the total number of data-grams arriving at the congested switching point will grow until it reaches full capacity and starts to drop data-grams. [16]. From TCP definition, TCP is a connection-