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A Generalized TCP Fairness Control Method for Multiple-Host Concurrent Communications in Elastic WLAN System Using Raspberry Pi Access Point

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ABSTRACT

The IEEE802.11n wireless local-area network (WLAN) has been widely adopted due to the flexible coverage and lower installation cost. However, the TCP throughput unfairness was detected when multiple hosts concurrently communicate with a single access-point (AP). Previously, the authors proposed the TCP fairness control method for only two hosts in the elastic WLAN system using Raspberry Pi AP, which dynamically adapts the topology according to the traffic demand. The delay is introduced in the packet transmission to the faster host from the AP, which is optimized by the PI feedback control such that the measured throughput becomes equal between the hosts. In this paper, the authors proposed a generalization of this method for any number of hosts by newly introducing the target throughput as the equal goal among the hosts. It is dynamically updated using the measured throughputs. The effectiveness of the proposal is verified through experiments using the elastic WLAN system testbed with one AP and up to four hosts.

KEYWORDS

PI Control, Raspberry Pi, TCP Throughput Fairness, Testbed, Transmission Delay, WLAN

INTRODUCTION

Nowadays, the IEEE802.11n *wireless local-area network (WLAN)* has been extensively applied around the world due to its characteristics of the easy installation, the flexible coverage, and the low cost (Crow et al., 1997). WLAN offers the Internet access through the wireless medium. Thus, it consists of several benefits such as mobility, flexibility, and portability. Hence the popularity of WLAN is increasing in offices, schools, hotels, and various public spaces (Dash et al., 2017).

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In WLAN, hosts are mostly non-uniformly located (Mittal et al., 2008), and the number of users or the traffics tend to fluctuate unpredictably depending on the time and day of the week (Balazinska & Castro, 2003) (Kotz & Essien, 2005). Furthermore, the conditions of network devices and communication links may be influenced by different factors, such as weather changes, bandwidth controlled by their authorities, power shortages, or device failures (Nadeem et al., 2009).

The authors therefore have studied the *elastic WLAN system* that dynamically adapts the network configuration depending on traffic demands and network conditions, to reduce the energy consumption and improve the performance (Mamun et al., 2016) (Mamun et al., 2017). In addition, the authors have implemented the testbed using *Raspberry Pi* as the software access point (AP) using *hostapd*. *Raspberry Pi* is a card-size, single-board computer that has the built-in wireless network interface (NIC) supporting IEEE802.11n (Raspberry Pi, 2019).

In WLAN, the *fairness* of the throughput performance among the hosts is the fundamental request to be satisfied by the network users for the fair network service among them regardless of host locations in the network field (Pilosof et al., 2003). This fair network service is essential for the network service provider. Thus, the fairness issues in WLAN have been extensively explored (Shi et al., 2014)-(Kemerlis et al., 2006). Among them, the *TCP throughput fairness* is the most important one, because the TCP (Transmission Control Protocol) is the protocol adopted at most of the common network services for users such as Web systems and electronic mails.

However, our preliminary experiments using the *elastic WLAN system* testbed have revealed that the *TCP throughput unfairness* will appear among hosts that are concurrently communicating with the same AP, when they are located at different distances from the AP. This unfairness can be caused by the differences in the *modulation and coding scheme (MCS)* and *the TCP congestion window size*.

Within our survey, most of existing methods to solve this unfairness problem require the modifications of the standard protocol for data communications in the *back-off time algorithm* of the *CSMA/CA protocol* or in the *TCP congestion window control*. Because they are usually implemented at the *operation system* (OS) or *kernel* in a computer, it is necessary to modify the source codes for OS (Pilosof et al., 2003) (Blefari et al., 2007) (Hua et al., 2012) (Freemon, 2014). Then, it causes another serious problem such that every time the OS is updated, this updated OS must be modified to incorporate these methods (Li et al., 2004).

To overcome the drawback of existing methods, the authors proposed the *TCP fairness control method* for concurrently communicating *two hosts* in the *elastic WLAN system* using *Raspberry Pi* AP in the previous work. In this method, the *transmission delay* is introduced at the packet transmission from the AP to the faster host, so that the slower host can take more transmission opportunities, using standard *Linux commands*. This delay is dynamically controlled to achieve the acceptable throughput fairness by using the *PI feedback control* as the application (Sudibyo et al., 2019). Thus, our proposal does not require the modifications of OS (Sudibyo et al., 2018). Unfortunately, this method can be applied only to two hosts, although any number of hosts may communicate with an AP concurrently.

In this paper, the authors propose a generalization of the *TCP fairness control method* to deal with any number of concurrently communicating hosts. The *target throughput* is newly introduced as the equal target among the hosts, which is dynamically updated from the measured throughputs of the hosts, since the throughput is varied in each network field and topology.

For evaluations, the authors carry out the proposed method in the *elastic WLAN system testbed* using *Raspberry Pi AP* and confirm the effectiveness through comprehensive experiments up to four hosts.

The remainder of this paper is organized as follows: Section 2 discusses related works of literature while section 3 reviews previous works. Section 4 presents the generalized TCP fairness control method. Sections 5 and 6 evaluates the proposal through testbed experiments. Finally, Section 7 concludes this paper with future works.