Chapter 7

Adaptive Scheduling for TCP-Fairness in Wireless Broadband Networks

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ABSTRACT

The exponential growth in multimedia traffic (Cisco Visual Networking Index, 2010), predominantly on UDP transport, poses a threat to the TCP’s best effort throughput. This problem is more acute in last mile broadband wireless access networks (Bakshi, Krishna, Vaidya, & Pradhan, 1997). Most scheduling algorithms discuss improving the combined TCP and UDP throughput or improving the TCP throughput without studying the effects of inelastic traffic such as UDP. This chapter furthers the necessity for TCP throughput protection and proposes a novel dynamically adapting Weighted Fair Queue (WFQ) based scheduling mechanism that provides a higher degree of TCP protection. This is accomplished by differentiating between TCP and UDP flows, buffer provisioning for each flow, and prioritizing TCP ACK packets. The simulation results show that the proposed mechanism yields a relative improvement of up to 29% of TCP goodput and 7.5% of aggregate MAC throughput over the mechanism without the proposed improvements.

INTRODUCTION

Internet is a huge ensemble of highly distributed networks where most of the communication is carried over Transmission Control Protocol (TCP), an elastic transport protocol. TCP provides reliability along with flow and congestion control between the endpoints. User Datagram Protocol (UDP) is another transport protocol which is inelastic in nature and enjoys a small share when compared with TCP in today’s Internet. UDP is mainly used for real time communications which is delay sensitive (Ex. A VoIP phone call).
Due to the advances made in multimedia and infotainment services over the Internet, use of UDP is seeing a meteoric rise (The Cooperative Association for Internet Data Analysis, 2010). If we assume that the total bandwidth available per base station (BS) is a constant value (e.g., say 100 Mbits) and the bursty UDP traffic increases, then the existing TCP traffic will get squeezed and the user experience for applications using TCP will get deteriorated. It is interesting to note that even few of the real time services, (Ex. Skype) use TCP for its transport (Baset & Schulzrinne, 2006). They will also incur a severe degradation in voice/video quality due to increasing UDP flows, which is bursty in nature. The negative impact of the increasing UDP traffic in Internet ranges from unfairness against competing best effort TCP traffic to the potential for congestion collapse which severely impacts the responsiveness of TCP based services (Floyd & Fall, 1999). UDP traffic also suffers with jitter by TCP’s continuously changing window size. However, in this chapter we specifically focus on the challenges in protecting TCP throughput in presence of UDP flows by means of isolation of TCP and UDP traffic.

In the past decade, the problem of TCP protection has been attracting attention of researchers around the world and a number of mechanisms/architectures have been suggested on the Internet core and edge routers to guarantee a minimum performance to the TCP services. A number of router mechanisms have been suggested with an essential goal of end-to-end congestion control that includes identification and restriction of bandwidth hungry flows that are unresponsive and competing with TCP. But unfortunately, this problem is not fully solved in access network which connects the end user with the Internet backbone. The problem is common on both wired and wireless, but more acute in wireless because:

1. Wireless medium is prone to have more losses when compared with wired medium.

2. Wireless medium has a limited shared bandwidth where wired medium has the luxury to increase bandwidth with increased hardware installations.

Most solutions proposed till date, mainly focus on transport, network layer algorithms to overcome this challenge. (Balakrishnan, Padmanabhan, Seshan, & Katz, 1997) analyzed and proposed few transport layer mechanisms for improving the TCP throughput in wireless links. (Todorovic & Lopez-Benitez, 2006) discussed various kinds of TCP in Wireless networks. (Capone, Fratta, & Martignon, 2004) analyze and propose bandwidth estimation algorithm for the congestion control algorithms in TCP specifically for wireless links where random losses are very high. These papers do not consider the effect of UDP on their model. (Cottrell, et al., 2005) test various variants of TCP in real time environment. (Xylomenos & Polyzos, 1999) measure TCP and UDP performance separately in a Wi-Fi LAN based environment. (Xylomenos & Polyzo, 2003) simulate the performance of TCP and UDP over GSM and WLAN with different variants of TCP. Even though these papers consider TCP and UDP traffic, it does not consider the combined effect of TCP and UDP. In (Bruno, Conti, & Gregori, 2008), the authors model concurrent TCP and UDP in WLAN but with a finite load of UDP. Most of the literature models and simulates wireless traffic based on Wi-Fi which uses Exponential Backoff Algorithm. But all the new generation technologies like WiMAX, LTE, etc uses more sophisticated schedulers and design to give more support for QoS. The design of the techniques needs to be modified to exploit the advantages of the latest Wireless technologies. A few research works have also observed that there can be potential performance gains if efficient protocol solutions are designed on the MAC layer of next generation wireless broadband networks (Discussed in Section 4). TCPACK prioritization is a technique where the ACK packets are given more priority than the data packets. But this tech-
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