Chapter 17

Wireless Transport Layer Congestion Control Evaluation

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ABSTRACT

The performance of transport layer protocols can be affected differently due to wireless congestion, as opposed to network congestion. Using an active network evaluation strategy in a real world test-bed experiment, the Transport Control Protocol (TCP), Datagram Congestion Control Protocol (DCCP), and Stream Control Transport Protocol (SCTP) were evaluated to determine their effectiveness in terms of throughput, fairness, and smoothness. Though TCP’s fairness was shown to suffer in wireless congestion, the results showed that it still outperforms the alternative protocols in both wireless congestion, and network congestion. In terms of smoothness, the TCP-like congestion control algorithm of DCCP did outperform TCP in wireless congestion, but at the expense of throughput and ensuing fairness. SCTP’s congestion control algorithm was also found to provide better smoothness in wireless congestion. In fact, it provided smoother throughput performance than in the network congestion.

1. INTRODUCTION

With the rise of wireless networking, performance expectations have steadily increased as technology has consistently improved. Similarly, internet applications that depend on streaming timeliness centric data in the midst of congestion, e.g., streaming movies, internet radio, online gaming, etc., have taken the forefront in pushing the limits of wireless and other networking technologies. Congestion based limitations can result from the finite bandwidth and erratic loss due to the characteristics of the physical medium. The protocol layer that deals with these limitations and transporting data in the midst of these challenges is the transport layer.

The most popular protocol in this layer, TCP, has been thoroughly investigated in this context. As a result, several new protocols have been
developed and standardized to implement new strategies and features for dealing with the changing demands of these internet applications. The protocols considered in this article include DCCP and SCTP which approach this task in different ways, but which both attempt to provide the necessary functionality to facilitate further growth in performance.

DCCP and SCTP

The Datagram Congestion Control Protocol (DCCP) was designed for applications that need connection based congestion control without reliability (Kohler et al., 2006). The most significant feature of DCCP is its modular configurability of the congestion control algorithm. Depending on the network environment and the requirements of the application, it can handle congestion differently depending on which standardized congestion control algorithm it uses. These algorithms are denoted by their Congestion Control Identifiers (CCID). The CCID’s standardized so far include CCID2, which is designed to behave TCP-like with several of the same mechanisms as TCP, and CCID3, which is designed to be TCP-friendly but to control congestion based on an equation so that traffic is affected less rapidly but more smoothly (Kohler et al., 2006). The Stream Control Transport Protocol (SCTP) has similar congestion control mechanisms as TCP including the SACK extension, slow start, congestion avoidance, and fast retransmit (Ye et al., 2002). Though the congestion control mechanisms of these protocols are all related to TCP and focus on interaction with TCP traffic, they each vary in specific ways that can affect how they interact with wireless congestion. It is these variations that will provide different behaviors and performance in different congestion environments.

2. MOTIVATIONS AND RELATED WORKS

Several authors have investigated the individual performance of the transport layer protocols in question. Holland and Vaidya (1999) focused on fairness, a congestion control metric considered in this article. The fairness of TCP in particular was proven to be lacking in wireless networks. Takeuchi et al. (2005), however, points out DCCP’s own limitations in fairness when sharing a bottleneck with TCP. Simulation has also been performed using DCCP focusing on throughput smoothness, another metric adopted by this article, where DCCP was shown to be strong in this arena by Navaratnam et al. (2006). Rhee and Xu (2007) analyzes the TFRC congestion control algorithm to determine its limitations. They then verify their findings using ns2 simulations. Active wireless experimentation has been performed with TCP (Bruno et al., 2007) and DCCP (De Sales et al., 2008) where these transport protocols are evaluated in wireless networks similarly to the methodology adopted in this article. SCTP has also been experimented with using heterogeneous network environments using a network evaluation tool designed for this purpose by Emma et al. (2006).

At the time of this writing, the literature was lacking consistent experimental evaluation that included all the aforementioned protocols. This is what inspired the authors to utilize the evaluation techniques used in the related articles and go one step further to perform an active evaluation of the currently available transport layer protocols in a single consistent experimental test-bed environment. This goal was pursued in the master’s thesis by Shore (2010) and the results were a baseline comparison of the characteristics of these protocols and their behavior in response to wireless and network congestion. The goal for this article
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