Chapter 3.16
The TFRC Protocol and Its Usage for Wireless Video Transmission

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ABSTRACT

The subject of this chapter is to present the TFRC (TCP-Friendly Rate Control) protocol in the area of efficient wireless video transmission and its possible usage in cross-layer power management mechanisms. The basic aspects of TFRC operation are presented, along with the suitability of TFRC usage for video transmission. The chapter examines related work and presents several mechanisms for efficient wireless video transmission using TFRC that have been proposed. These mechanisms utilize cross-layer approaches for adaptation of the power transmission level of the sender and TFRC feedback information regarding the wireless connection status from the receiver for improved transmission statistics, and therefore user experience, without unnecessary power consumption.

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INTRODUCTION

Networking complexity has led to the modularization of network architecture in layers. Traditional approaches focus on wired networks and try to separately optimize each network layer such as the physical, the medium access, the routing and the transport layer. This approach reduces the complexity and makes issues more manageable and architectures more flexible and upgradeable, but it may lead to suboptimal designs. Under this layered approach, communication occurs between two adjacent layers without taking into consideration the specific characteristics of multimedia applications. Although this layered approach has been the fundamental factor for the growth of the wired networks and the World Wide Web it seems to pose constrains when attempting to adapt protocol's behavior to multimedia applications characteristics and to wireless network conditions. Therefore, a careful cross-layer approach, where selected communication and interaction between layers is allowed, can have performance advantages without negating the successful layer separation that has guided network design so far. A theoretical discussion of the cross-layer problem framework can be found in (Schaar & Shankar, 2005).

Wireless transmission differs in an important way from wired communication, in that the notion of the link is not as fixed and can vary depending on the movement of the communicating nodes, the intermediate interferences and the transmission characteristics of the communicating nodes, most notably their transmission power. While increased power generally correlates with a stronger signal and therefore improved transmission characteristics, in many wireless scenarios reduced power consumption is desired. This trade-off has been explored by various researchers studying TCP (Transmission Control Protocol) modifications (Tsaoussidis & Badr, 2000, Zhang & Tsaoussidis, 2001, Jones et. al, 2001) trying to combine reduced power consumption with increased data throughput. Wireless standards such as IEEE 802.11 specify power saving mechanisms (IEEE 802.11 PSM), although studies have shown that PSM and other similar mechanisms carry a significant performance penalty in terms of throughput (Molta, 2005, Chen & Huang, 2004, Anastasi et. al, 2004, Simunic, 2005).

An important issue for the efficiency of wireless networks is to accurately determine the cause of packet losses. Packet losses in wired networks occur mainly due to congestion in the path between the sender and the receiver, while in wireless networks packet losses occur mainly due to corrupted packets as a result of the low Signal to Noise Ratio (SNR), the multi-path signal fading and the interference from neighboring transmissions. A second difference between wired and wireless networks is the "mobility factor". Mobility in wireless networks introduces a number of additional barriers in multimedia data transmission. Channel fading and handover time are the most important factors that cause packet losses as they introduce additional delays when the mobile user changes its location from one Access Point (AP) to another.

According to its specification, TFRC (Handley et al, 2003) is a congestion control mechanism for unicast flows operating in a best-effort Internet environment. It aims to be reasonably fair when competing for bandwidth with TCP flows, but at the same time achieving a much lower variation of throughput over time compared with TCP, making it thus more suitable for applications such as telephony or streaming media where a relatively smooth sending rate is important. However, TFRC is slower than TCP in responding to the available bandwidth. TFRC congestion control is appropriate for flows that would prefer to minimize abrupt changes in the sending rate, including streaming media applications with small or moderate receiver buffering before playback. TCP-like congestion control, halves the sending rate in response to each congestion event and thus cannot provide a relatively smooth sending rate.

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