Multi-Path Video Streaming in Wireless Networks using Time-Slot based Scheduling

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ABSTRACT

This article proposes a scheme for scheduling real-time video packets through different paths in a quality of service (QoS) negotiation system, where active users have specific amounts of bandwidth negotiated with the network by each available interface. The considered QoS negotiation system implements a time-slot division strategy to allocate the negotiated bandwidth to users. We claim that an efficient scheduling strategy is essential to exploit the features of mobile computers equipped with multiple wireless interfaces, which can be used simultaneously for transmission of data belonging to a single application, while minimizing the reordering delay at the receiver side due to transmission of data via multiple-paths with varying characteristics. A new scheduling mechanism is developed by taking into consideration such QoS systems. The effectiveness of the scheme is verified and compared with the most popular scheduling schemes through extensive simulations. The results demonstrate that our algorithm outperforms the former scheduling algorithms effectively.

Keywords: Multipath scheduling, time-slot division network, real-time video streaming

INTRODUCTION

In next-generation wireless networks, users are expected to be able to receive the same services as they do over wired networks, including high bandwidth demanding services like real-time multimedia applications, which are highly sensitive to delay, jitter, and bandwidth restrictions. These characteristics become more significant in wireless mobile networks as the bottleneck for most wireless communications is the last hop, from the access point to the mobile terminals. Furthermore, such services should be provided over a variety of wireless technologies that exhibit different data rates.

Thus, the next-generation wireless networks are expected to provide constant high bandwidth for real-time multimedia applications to be successful. Two research topics, as follows, emerged recently to deal with such requirements:
• **Bandwidth aggregation:** Mobile terminals, equipped with multiple interfaces using different wireless technologies, are able to obtain simultaneous connections through these interfaces when the coverage areas of these technologies partially overlap. Such a capacity allows mobile terminals to increase the streaming bandwidth by distributing the load over multiple network paths.

• **Dynamic QoS negotiation:** A mobile terminal in a dynamic QoS negotiation system is able to negotiate with the network the desired service level for its traffic, which should be guaranteed by the network during the entire course of the session.

By combining the benefits of these two research areas, a user who wants to execute a real-time video application should negotiate the amount of bandwidth required by this application. If the bandwidth of a single interface is not enough to meet the required one, the user may consider two or more interfaces to ensure the quality of the video application. However, the transmission of packets of a single application via multiple paths, with varying characteristics in terms of capacity and propagation delay, makes those packets arrive to the final destination in an out-of-order manner, which results in packet reordering and an increased delay. Accordingly, the packet loss rates increase due to packets’ timer expiration.

In our previous work (Fernandez, Taleb, Ansari, Hashimoto, Kato, & Nemoto, 2007), we proposed a dynamic QoS negotiation system that allows users to negotiate dynamically the specific amount of bandwidth that their traffic need. Such a negotiation system implements a time-slotted approach for bandwidth allocation at the BSs to guarantee the negotiated service level to the MSs. To exploit the advantages of Internet service providers offering services via several wireless technologies, mobile computers equipped with multiple wireless interfaces that can be used simultaneously to increase their transmission rates, by aggregating the available bandwidth of these interfaces. We consider incorporating bandwidth aggregation in that QoS negotiation system. Therefore, a multipath scheduling algorithm suitable for the time-slot approach implemented in that system is required. Unfortunately, none of the former scheduling strategies works successfully in time-slot division networks. In this context, the contribution of this article consists in a new scheduling strategy for multipath delivery of data in a QoS system that uses a time-slot division approach for bandwidth allocation.

The article is organized as follows. We discuss the most relevant work pertained to multipath scheduling algorithms. We present a brief description of the considered QoS architecture. Then, we present the former multipaths scheduling algorithms and justify the need for a new scheme. We describe the proposed scheme and how it efficiently distributes the video packets on the available network paths to minimize the reordering delay. We show the performance evaluation of our scheduling mechanism. Finally, we present the conclusions.

**RELATED WORK**

Over the years, there has been a rapid deployment of wireless network technologies where coverage areas of different access points are overlapping and the advance of mobile computers devices are currently equipped with more than one wireless network interface. Mobile hosts can simultaneously use multiple communication channels to increase their throughputs. To achieve this goal, many research works have been conducted allowing mobile nodes to obtain multiple care-of-addresses (CoAs) (Fritsche & Heissenhuber, 2000; Perkins, 2002), and keeping senders always informed of these CoA registrations directly from the mobile hosts (Vadali, Jianhui, Yiqiong, & Guohong, 2001).

The issue of multipath video streaming has been studied in many previous works to address the out-of-order delivery to the final destination due to the heterogeneous characteristics of wireless links. For TCP applications, such a disorder in packet reception results in the transmission of duplicate acknowledgments (DupAcks), which is assumed as an indication of network conges-
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