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Congestion prevention in broadband wireless access systems: An economic approach

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ABSTRACT

While the demand for mobile broadband wireless services continues to increase, radio resources remain scarce. Even with the substantial increase in the supported bandwidth in the next generation broadband wireless access systems (BWASs), it is expected that these systems will severely suffer from congestion, due to the rapid increase in demand of bandwidth-intensive multimedia services. Without efficient bandwidth management and congestion control schemes, network operators may not be able to meet the increasing demand of users for multimedia services, and hence they may suffer an immense revenue loss. In this paper, we propose an admission-level bandwidth management scheme consisting of call admission control (CAC) and dynamic pricing. The main aim of our proposed scheme is to provide monetary incentives to users to use the wireless resources efficiently and rationally, hence, allowing efficient bandwidth management at the admission level. By dynamically determining the prices of units of bandwidth, the proposed scheme can guarantee that the number of connection requests to the system are less than or equal to certain optimal values computed dynamically, hence, ensuring a congestion-free system. The proposed scheme is general and can accommodate different objective functions for the admission control as well as different pricing functions. Comprehensive simulation results with accurate and inaccurate demand modeling are provided to show the effectiveness and strengths of our proposed approach.

1. Introduction

Despite the support for high bandwidth in an emerging broadband wireless access systems (BWASs) such as 3.5G high speed downlink packet access (HSDPA) (3GPPTS 25.308, 2003) and WiMAX (IEEE 802.16-2004, 2004) and (IEEE 802.16e, 2005), it is expected that these systems will severely suffer from congestion. This is due to the wide support for bandwidth-intensive multimedia services mainly such as video on demand. Therefore, means to efficiently overcome the problem of congestion in BWASs must be developed. Network operators typically employ call admission control (CAC), which is an admission level provisioning strategy that aims mainly at protecting the quality of service (QoS) of ongoing user connections from being severely degraded as a result of new admitted ones. CAC has been extensively studied in the literature (Rong et al., 2007; Nasser and Hassanein, 2008; Rong et al., 2007; Zorba and Perez-Neira, 2007; Rodrigues and Olsson, 2005; Choi and Shin, 2000; Ma et al., 2000; Leong et al., 2006; Kazmi et al., 2000; Kim, 2000; Li et al., 2004; Sun and Krzyman, 1998; Hjelm, 2000; Epstein and Schwartz, 2000; Nasser and Hassanein, 2006).

Existing CAC schemes have been shown to be very efficient in improving the packet-level QoS (e.g., packet delay, average throughput, etc.) of ongoing connections during congested periods. However, they are not as efficient in improving the admission-level QoS (e.g., connection blocking probabilities). This is because these schemes by themselves cannot avoid congestion, because they do not provide incentives to users to share wireless system resources rationally and efficiently. Therefore, the connection blocking and dropping probabilities can reach high levels during congested periods. To overcome this problem, there has been some research work recently on an integrating CAC with admission-level dynamic pricing in order to control connection request arrivals to the system through monetary incentives, hence, maintaining the admission-level QoS at the desired thresholds (Nasser and Hassanein, 2006; Hou et al., 2002; Yaipairoj and Harmantzis, 2004; Hew and White, 2005). In an admission-level dynamic pricing, the price for a unit of time or bandwidth is determined when the user initiates a connection request before she is admitted to the system. The price

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