Journal of Network and Computer Applications 34 (2011) 644–652

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

journal homepage: www.elsevier.com/locate/jnca

Joint admission and power control for quality-of-service in the wireless downlink ☆

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ARTICLE INFO

Article history:
Received 3 February 2010
Received in revised form
30 September 2010
Accepted 15 November 2010
Available online 19 November 2010

Keywords:
Wireless downlink networks
Power allocation
Admission control
Quality-of-service (QoS)
Approximation algorithms

ABSTRACT

This paper addresses the problem of joint admission and power control in the downlink of a single-cell code-division-multiple-access (CDMA) wireless network. The objective is to maximize the user-capacity (or base station revenue), while meeting the quality-of-service (QoS) requirements of each admitted user. This paper considers bounded maximum delay and bounded minimum data rate as the QoS measures. For applications with strict QoS requirements, we show that the *joint* problem can be solved to optimality by performing admission control and power allocation *separately*. To solve the admission control problem, we give an exact polynomial-time algorithm for user-capacity maximization, and an efficient approximation algorithm with guaranteed performance for base station revenue maximization. To solve the power control problem, we provide two simple power allocation heuristics. For applications with soft QoS requirements, we consider the problem of allocating transmit powers to *all* users such that the minimum fraction of QoS requirement satisfied for any user is maximized. Regardless of the number of users in the system, we show that the problem always reduces to *one-dimensional* search. This leads an efficient power control algorithm that provides, in $O(1)$ iterations, solutions arbitrarily close to the optimal one.

1. Introduction

Future generations of wireless networks will evolve from delivering best-effort traffic to supporting applications with heterogeneous quality-of-service (QoS) requirements, e.g., interactive multimedia and high-speed data access for downlink subscribers. The efficient allocation of radio resources is essential for supporting such applications (Liu et al., 2007). This paper considers a code-division-multiple-access (CDMA) wireless system in which the entire transmission bandwidth is shared between all users at all times. Therefore, time or frequency slots are not explicitly scheduled amongst the users. The *main* radio resource in such CDMA networks is transmit power. Power control plays, thus, an important role in the efficient management of CDMA networks (Lee et al., 2005). In particular, power control is an efficient means for interference management, and for providing QoS.

Data services such as streaming multimedia and Internet access play a significant role in third-generation wireless networks and beyond. One of the features of such services is that the traffic is highly asymmetric, i.e., the downlink will require more bandwidth than the uplink. Therefore, efficient resource allocation in the downlink becomes crucial (Lee et al., 2005; Lim and Kim, 2005). Motivated by this fact, this paper focuses on the following two admission and/or power control problems in the CDMA downlink.

- It is well-known that, in the case of strict QoS requirements and limited network resources (e.g., limited transmit power), it may not be possible to satisfy the QoS requirements of all users. For example, the celebrated power control algorithm in Foschini and Miljanic (1993) will not converge if a feasible power allocation (i.e., one that satisfies all QoS requirements) does not exist. Therefore, we address the following *joint admission and power control* problem. We are given a single-cell CDMA wireless network that contains one base station with limited power budget and a set of users with *strict* QoS requirements. The goal is to select the maximum (weighted) subset of users and allocate downlink transmit powers amongst them, such that each selected user meets its QoS requirements. Note that the objective of maximizing the (weighted) subset of users that can be successfully admitted captures both base station revenue maximization (in the case of unequal user weights) and user-capacity maximization (in case of equal user weights). Note that admission/scheduling is a medium access control (MAC) layer issue, while power control is a typical physical layer issue. Therefore, the studied problem is a cross-layer design problem.
- Now, assume that an optimal set of users has been admitted/scheduled. If the channel conditions/path gains change, then it

☆ Parts of this work were presented at *IEEE Vehicular Technology Conference* (*VTC*), Calgary, Canada, September 2008, and at *Third International Conference on Modeling, Simulation and Applied Optimization* (*ICMSAO*), Sharjah, UAE, January 2009.

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doi:10.1016/j.jnca.2010.11.001