QUEUEING ANALYSIS OF OPPORTUNISTIC SCHEDULER EXPLOITING MULTIUSER DIVERSITY

Yoora KIM [1] and Gang Uk HWANG [1]

1) *Department of Mathematical Sciences and Telecommunication Engineering Program, Korea Advanced Institute of Science and Technology, Daejeon 305-701, KOREA*

Corresponding Author : Yoora KIM, jd_salinger@kaist.ac.kr

ABSTRACT

In this paper, we consider a wireless communication network with multiple users where an opportunistic scheduler exploiting multiuser diversity is employed. We focus on the joint effect of the queue state at the data link layer and the channel state at the physical layer on the performance of the opportunistic scheduler. Accordingly, we model the arrival process, the service process and the queue state recursion. We then develop a two dimensional Markov chain containing the queue state as well as the channel state. From the stationary and limiting distributions of the Markov chain, we derive QoS measures such as throughput, average queue length, blocking probability and average queueing delay.

INTRODUCTION

In wireless communication networks, the demand for high data rates has been continuously increasing, but available radio spectrum is extremely limited. In order to enhance the spectral efficiency over wireless channels, multiuser diversity has been studied for a wireless network with multiple users [1–4]. Multiuser diversity was introduced by Knopp and Humblet [1], which is the effect that different users experience peaks in their channel quality at different times [5]. It is known that multiuser diversity is the optimal channel assignment scheme to maximize the total information-theoretic capacity of a multiuser system [1–3,6].

Tse [6] and Li and Goldsmith [7] suggested a scheduling algorithm over spatiotemporally varying wireless channels in which different MSs experience different channel conditions at the same time: at each scheduling instant, the channel should be allocated to the MS with the most favorable channel conditions. Such a rule is often called Greedy scheduling or MaxSNR scheduling. Rather than combating the channel variations, the Greedy scheduler exploits the inherent randomness in channel characteristics to boost the total information-theoretic capacity of a multiuser system. In this sense, the Greedy scheduler is also called opportunistic scheduler.

In this paper, we consider a down link in a cellular wireless network where a centralized controller or a base station (BS) communicates with K mobile stations (MSs), denoted by MS-k $(k = 1, \ldots, K)$. At the data link layer of the BS, K number of logical queues of finite size L are implemented for MSs. Packets to be scheduled to the same MS are buffered in the same logical queue in the order of arrival. Then, the opportunistic scheduler at the BS forwards packets in each queue to corresponding MS with the first-in-first-out (FIFO) discipline.

At the physical layer, data are transmitted frame-by-frame through wireless channel, where the frame duration is constant with length T_f (sec). In our model, we divide time axis into

equal intervals T_f referred as slots and construct a discrete-time system. We adopt a block fading channel model where the fading channel remains invariant per frame, but is allowed to vary from frame to frame. To describe the received signal-to-noise ratio (SNR) γ per frame statistically, we use the general Nakagami-m model because the Nakagami-m model represents a broad class of fading channels. We also use a discrete-time finite-state Markov chain (FSMC) channel model as in to describe the fading process of an arbitrary MS-k,

We then focus on the joint effect of the queue state at the data link layer and the channel state at the physical layer on the performance of the Greedy scheduling. Accordingly, we model the arrival process, the service process and the queue state recursion. We then develop a two dimensional Markov chain containing the queue state as well as the channel state. From the stationary and limiting distributions of the Markov chain, we derive QoS measures such as throughput, average queue length, blocking probability and average queueing delay.

REFERENCES

1. R. Knopp and P. A. Humblet, "Information capacity and power control in single-cell multiuser communications", *Proc. of IEEE ICC*, Vol. 1, pp. 18-22, Seattle, June 1995.
2. Q. Ma and C. Tepedelenlioğlu, "Practical multiuser diversity with outdated channel feedback", *IEEE Trans. Veh. Technol.*, Vol. 54, No. 4, 2005, pp. 1334-1345.
3. P. Viswanath, D. N. C. Tse, and R. Laroia, "Opportunistic beamforming using dumb antennas", *IEEE Trans. Inf. Theory*, Vol. 48, No. 6, 2002, pp. 1277-1294.
4. Zhouhua, Yangdacheng, Qiweishi, and MaMin, "On performance of mutiuser diversity in SISO and MIMO wireless communication", *Proc. of IEEE PIMRC*, Vo. 3, pp. 7-10, Beijing, China, Sept. 2003.
5. X. Qin and R. A. Berry, "Distributed approaches for exploiting multiuser diversity in wireless networks", *IEEE Trans. Inf. Theory*, Vol. 52, No. 2, 2006, pp. 392-413.
6. D. N. Tse, "Optimal power allocation over parallel Gaussian broadcast channels", *Proc. IEEE Int. Symp. on Inf. Theory*, pp. 27, Ulm, Germany, June 1997.
7. L. Li and A. J. Goldsmith, "Capacity and optimal resource allocation for fading broadcast channels–Part I: Ergodic capacity", *IEEE Trans. Inf. Theory*, Vol. 47, No. 3, 2001, pp. 1083-1102.