Transient QoS Measure for Call Admission Control in WCDMA System with MIMO*

Cheol Yong Jeon and Yeong Min Jang

School of Electrical Engineering,
Kookmin University,
861-1, Jeongneung-dong, Songbuk-gu, Seoul 136-702, Korea
{feon77,yjang}@kookmin.ac.kr

Abstract. This paper presents an efficient capacity evaluation algorithm of the WCDMA with multiple-input multiple-output (MIMO) system for quality of service (QoS) support. To define the capacity of the system, we derive the E_b/N_o gain taking into account MIMO concept and the outage probability as the QoS measure using central limit approximation, Chernoff bound and the refined large deviation approach. Based on the QoS measures, we propose an efficient transient call admission control (CAC) algorithm. Numerical results show that there is a substantial increment in system capacity by adopting MIMO system and the theory of the refined large deviation approach is a good approach for transient QoS support.

1 Introduction

Third-generation mobile wireless systems are often referred to as universal mobile terrestrial telecommunication systems (UMTS's). The UMTS system intends to integrate all forms of mobile communications, including terrestrial, satellite, and indoor communications. Consequently, UMTS must support a number of different air interfaces [1]. One of the main air interfaces for this system is referred to as wideband code division multiple access (WCDMA), which is the topic of this paper. WCDMA is based on CDMA scheme by which multiple users are assigned radio resource using spread spectrum techniques. Although all users are transmitting in the common bandwidth, individual users are separated from each other via the use of orthogonal codes. If total energy from all users, however, is over the given threshold (signal-to-noise ratio (SNR) or energy per bit per bandwidth), the system can not admit any more users [2, 3].

Here we focus on MIMO system to increase the system capacity. Wireless channel using multiple antennas at each ends is commonly referred to as a MIMO channel. Technology built around MIMO channels resolves the fundamental issue of having to deal with two practical realities of wireless communications: a user terminal of limited battery power, and a channel of limited bandwidth. Given fixed values of transmit power and channel bandwidth, this new technology offers

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a sophisticated approach to exchange increased system complexity for increasing the capacity (i.e., the spectral efficiency of the channel, measured in bits per hertz) up to a value significantly higher than that attainable by any known method based on a single-input single-output (SISO) channel. More specifically the MIMO channel capacity is roughly proportional to the number of transmitter or receiver antennas, whichever is smaller. That is to say, we have a spectacular increase in spectral efficiency, with the channel capacity being roughly doubled by doubling the number of antennas at both ends of the link [1, 4, 5].

Up to now, the capacity analysis was investigated individually MIMO and CDMA. The MIMO spectral efficiency increases linearly with antenna number and the capacity of CDMA system decreases by transmitted user's power [2]. In this paper, we focus on the MIMO technology and on the calculating simultaneous user numbers in the WCDMA systems with MIMO. Then this paper presents how much more increase users in this system by numerical result. We apply the fluid flow queuing model for CAC in WCDMA system with MIMO. Traffic control is necessary to avoid possible congestion at each network node and achieve the QoS requirement by each connection. Due to real time constraints and the dynamic behavior in the system, preventive (e.g. predictive) control is more suitable then reactive control [6]. CAC is form of the preventive traffic control. The CAC is responsible for deciding whether or not a new call can be accepted while maintaining QoS in the network. We choose the transient outage probability as measure of QoS and desire a scheme which optimizes both the transient and steady state performance [7, 8]. So, we provide a complete transient solution of the system starting from a given initial condition. This paper present a general theory to deal with the transient analysis of multiple types of traffic. In order to cope with the computational complexity, a general theory of approximations and bounding approaches should be explored. In this paper, we propose new approximations and bounds for the transient fluid model [9] to deal with requirement of real time computation.

This paper is organized as follows: Section II discusses the spectral efficiency of WCDMA system with MIMO. We discuss CAC algorithm and derive the outage probability and cell loss ratio for CAC in section III. Section IV presents numerical result and finally come to conclusion in section V.

2 Spectral Efficiency of the WCDMA System with MIMO

2.1 MIMO in Gaussian Channel

When we use n_T transmit antennas and n_R receive antennas, m =min(n_T, n_R) and n=max(n_T, n_R), the MIMO capacity increases linearly with m. The average SNR per n_R receiver antenna [10, 11] is given by

$$SNR = g\frac{E[|Hx|^2]}{E[|n|^2]} \qquad (1)$$