Resource Allocation for Multi Access MIMO Systems

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ABSTRACT

In this paper, the authors discuss the emergence of new technologies related to the topic of the high-speed packet data access in wireless networks. The authors propose an algorithm for MIMO systems that optimizes the number of the transmit antennas according to the user’s QoS. Scheduling performance under two types of traffic modes is also discussed: one is voice or web-browsing and the other is for data transfer and streaming data.

Keywords: Adaptive Modulation and Coding (AMC), Channel State Information (CSI), DOF, MIMO, Optimization

INTRODUCTION

During the last few years, MIMO technology has attracted a lot of attention in the area of wireless communications since significant increases in throughput and range are possible at the same bandwidth and at same overall transmit power expenditure. Wireless MIMO communication exploits phenomena such as multipath propagation to increase data throughput and range, or reduce bit error rates rather than attempting to eliminate effects of multipath propagation as traditional SISO (Single-Input Single-Output) communication systems (Yang, 2005; Chuah, Tse, Kahn, & Valenzuelai, 2002). Multi-user multi-antenna transmission architecture with channel estimators cascaded at the receiver side is proposed so that each user can feedback channel state information (CSI) for the further process of antenna resource allocation (Jun Zhang & Letaief, 2005).

In MIMO, “multiple in” means a WLAN device simultaneously sends two or more radio signals into multiple transmitting antennas. “Multiple out” refers to two or more radio signals coming from multiple receiving antennas. These views of “in” and “out” may seem reversed; but MIMO terminology focuses on the system interface with antennas rather than the air interface. Whatever be the terminology, the MIMO’s basic advantage seems simple, i.e. multiple antennas receive more signal and transmit more signal (Yang, 2005). Maximal receive combining takes the signals from multiple antennas/receivers and combines them in a way that significantly boosts signal strength. This technique is fully compatible to 802.11a/b/g (Atheros Communications Inc., 2005). The capacity of the phased array system grows logarithmically with increasing antenna
array size, whereas the capacity of the MIMO system grows linearly (Caire & Shamai, 2003).

**MIMO TECHNIQUES**

There are four unique multi-antenna MIMO techniques available to the system designer namely: spatial multiplexing (SM-MIMO), space-time coding (STC-MIMO), diversity systems (DIV-MIMO), smart antenna (SA-MIMO):

Spatial multiplexing maximizes the link capacity, for spatial multiplexing the number of receive antennas must be greater than or equal to the number of transmit antennas. It makes the receivers very complex, and therefore it is typically combined with orthogonal frequency-division multiplexing (OFDM) (Yang, 2005; Zhang & Letaief, 2004). The IEEE 802.16e standard incorporates MIMO-OFDMA. The IEEE 802.11n standard which is expected to be finalized soon, recommends MIMO-OFDM. Compared to spatial multiplexing systems, space-time code STC-MIMO systems provide robustness of communications without providing significant throughput gains against spatial multiplexing systems (Gesbert, Shafi, Shiu & Naguib, 2003). Moreover, to support fully the cellular environments MIMO research consortia including IST-MASCOT, proposed to develop advanced MIMO communication techniques such as cross-layer MIMO, multi-user MIMO and ad-hoc MIMO.

Cross-layer MIMO enhances the performance of MIMO links by solving cross-layer problems occurred when the MIMO configuration is employed in the system (Jiang, Zhuang, & Shen, 2005). A Cross-layer technique has been enhancing the performance of SISO links as well. Examples of cross-layer techniques are Joint source-channel coding, Link adaptation, or adaptive modulation and coding (AMC), Hybrid ARQ (HARQ) and user scheduling. Multi-user MIMO can exploit multiple user interference powers as a spatial resource at the cost of advanced transmit processing while conventional or single-user MIMO uses only the multiple antenna dimension (Zhang & Letaief, 2004). Examples of advanced transmit processing for multi-user MIMO are interference aware precoding and SDMA-based user scheduling.

Ad-hoc MIMO is a useful technique for future cellular networks which considers wireless mesh networking or wireless ad-hoc networking. To optimize the capacity of ad-hoc channels, MIMO concept and techniques can be applied to multiple links between transmit and receive node clusters. Unlike multiple antennas at the single-user MIMO transceiver, multiple nodes are located in a distributed manner. So, to achieve the capacity of this network, techniques to manage distributed radio resources are essential like the node cooperation and dirty paper coding (DPC) (Caire & Shamai, 2003).

**CHANNEL MODELS AND DIVERSITY**

The Capacity of the channel has been calculated with some assumption. The H matrix represents the gain of complex channel and will be normalized in a way that makes it possible to compare the capacity for the MIMO system with a SISO system. A communication link with $N_T$ transmitting antennas and $N_R$ receiving antennas are considered.

During communication the packets is of shorter time span than the coherence time of the channel (Soysal & Ulukus, 2010). With these assumptions we can use this mathematical model.

$$r_t = Hs_t + v_t$$

Where $r_t = [r_1^t, r_2^t, ..., r_n^t]^T$ is the received signal at time instant $t$, $s_t = [s_1^t, s_2^t, ..., s_n^t]^T$ is the sent signal and $v_t$ is AWGN with unit variance and uncorrelated between the $n_R$ receiver antennas.

The $N_R \times N_T$ transition matrix is made up of elements $h_{ij}$ as follows:
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