Virtual MIMO Techniques for Distributed Broadband Wireless systems (DBWS)

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1. Introduction

The provision of broadband services to everyone is considered one of the key components for enabling the so-called information society. Traditionally, the delivery of broadband connections to the end user has been targeted through the deployment of optical fiber leading to the concepts of fiber to the curb and fiber to the home. However during the last decade the impact of wireless telephony and wireless LAN's has been such that the liberation of a physical connection created in the end user a new sense of freedom and autonomy in his/her relation to communications.

It is obvious that everyone would like to have this freedom with any service, and this has spurred considerable research to extend true broadband access to wireless communications. However the provision of the high bit rates (~1Gbit/s) that could be envisioned of interest for the end user and might be easily provided with fixed optical connections still represents enormous challenges to the wireless community. It is more or less consensual that to achieve targets outlined for systems beyond IMT-2000 of providing around 1Gbit/s for pedestrian and 100Mbit/s for high mobility, will require the use of multiple antennas at the transceivers to exploit the scattering properties of the wireless medium. Unfortunately due to the physical limitations in the size of the transceivers, the number of antenna elements cannot be large and the spacing between them is limited, which implies that the degree of channel independence achieved is insufficient in most scenarios to reach the high capacities envisioned. One solution to achieve the fundamental results predicted by the theory is to have the mobiles communicating simultaneously with several antennas with perfect cooperation between them. Conceptually, this allows the antennas to be treated as physically distributed antennas of one composite base station. The key to achieve perfect cooperation is to have the radio signals transparently transmitted / received to / from a central unit where all the signal processing is performed. Considering the high capacities envisioned optical fiber due to its low attenuation and enormous bandwidth is the obvious technology choice to build these transparent interconnections.

The objective of this thesis is to investigate virtual MIMO techniques in distributed antenna systems. An important aspect of the conducted studies will be low-overhead/limited transmitter Channel State Information (CSI) MU-MIMO strategies in a single frequency reuse context with BS cooperation for OFDMA. Efficient user grouping algorithms will be studied as well as PHY layer metrics to be used by the MAC layer (to perform scheduling).

This research is integrated in an international cooperation project (Futon) where IT MOTION will be technical manager, and involving 16 partners from 12 countries.

2. Performed Activities

Following guidelines show the activities have been done within the project objective:

- Study downlink of MIMO OFDM systems

when multiple users exist

- Implement different transmitter and receiver oriented methods such as zero forcing and block diagonalization to develop the performance of the system by mitigating the interference level such as:

Distributed antenna systems (DAS): which are claimed to be more efficient in terms if transmit power and reduced level of fading and antenna correlation. DAS concept was evolved into the system under study named as distributed MIMO OFDM system.

- Precoding methods have been extended in the context of new system
- A study was taken on the effect of different path loss gains in proposed distributed system.
- Studies showed that block diagonalization can be used efficiently in such systems
- To further improve the system performance the ways of efficient allocating of transmit power to users was studied,
- A new closed power allocation method was proposed. This method is based on minimization of the sum of the inverse signal-to-noise ratio (SNR^{-1}) on each user terminal.
- For that we considered a distributed cellular system where several base stations are transparently linked to a central unit and thus a joint processing can be done. We further assumed that the user terminals are equipped with an antenna array and the distributed BSs equipped with single or array antenna. The aim of this joint distributed precoding and power allocation scheme is to remove the intercell interference and improve the user fairness at the cell-edges. Simulation results showed that the proposed scheme cause significant improvement in the system performance and is effective when the users are located within the cell edge zone. Also the proposed power allocation algorithm was extended to multi subcarrier case, where the transmit power has constraint and allocated per user per subcarrier.

A study have been done on another possibility of allocating power which allocate power based on minimizing the Average user BER expression of the system where no closed from solution exists but the it is optimal. It was interesting to compare the results using above iterative minimization which have been used proposed before in the literature. The comparison showed that our proposed closed form method is a little bit degraded from the optimal solution but off course with less amount of complexity because of closed form computations.

3. Publications

The work up to now had some contribution to FUTON project. Besides one accepted and three submitted papers:

3.1. Publications in Conferences:

-R. Holakouei, A. Silva and A. Gameiro." Precoded Multiuser Distributed MIMO OFDM Systems". The Sixth International Symposium on Wireless Communication Systems 2009 (ISWCS'09), Siena-Tuscany, University of Siena, Italy

3.2. Submitted Papers:

- R. Holakouei, A. Silva and A. Gameiro. "Transmit Power Allocation for Block Diagonalized Distributed MIMO OFDM Systems", VTC2010, Taiwan

- R. Holakouei, A. Silva and A. Gameiro. "Transmission Schemes for Distributed MIMO OFDM Systems", AINA2009, Australia

- R. Holakouei, A. Silva and A. Gameiro "Precoding Techniques for Distributed MIMO OFDM Systems", WCNC 2010, Australia

4. Work Plan Evolution

Transmitter oriented techniques such as precoding and transmitter power loading are still the most wanted ones because they force the receiver side (usual mobile terminal) be very simple. Using distributed topologies and MIMO concept will greatly improve the system performance and increase the system capacity which is exactly the main need of communication networks nowadays. The plan will concentrate more on precoding techniques and power loading methods with low complexity and high efficiency and we will follow the following guidelines in future. For next step it would be interesting to propose more efficient method of minimizing BER which explicitly consider the concept of DAS in our system, so that we can benefit from this concept as much as possible to improve the system performance.