COOPERATIVE MIMO COMMUNICATIONS

By

Hsin-Yi Shen

An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major Subject: Electrical Engineering

The original of the complete thesis is on file
in the Rensselaer Polytechnic Institute Library

Examining Committee:

Shivkumar Kalyanaraman, Thesis Adviser
Al-Hussein Abouzeid, Member
Biplab Sikdar , Member
Alejandra Mercado, Member
Babak Azimi-Sadjadi, Member
Bülent Yener, Member

Rensselaer Polytechnic Institute
Troy, New York

January 2009
(For Graduation May 2009)

ABSTRACT

In wireless network, spatial diversity can improve link quality and thus provide reliable energy-efficient transmission. Various system designs have been proposed to achieve spatial diversity. In this thesis we discuss a novel concept in wireless network: cooperative MIMO communications.

Cooperative MIMO communications provides spatial diversity in both transmitter and receiver. Unlike conventional MIMO communication, which requires multiple antennas equipped with transmitter and receiver, cooperative MIMO communications obtain transmitter diversity and receiver diversity through node cooperation. Sending and receiving group are formed to help transmission between source and destination.

Some previous research has considered the concept of cooperative communication and proposed their system designs. However, there are constraints in the system designs of previous research, such as number of senders and receivers. In this thesis we consider to loose these constraints and propose our system design to achieve not only a cooperative communication system, but a cooperative *MIMO* communication system.

We consider a more flexible system design of cooperative MIMO communication step by step. Before cooperative MIMO communication begins, the source and destination need to form sending and receiving groups. Thus we first address cluster recruiting issue and propose our cluster recruiting algorithm. After sending and receiving group are formed, the transmission can begin. But the synchronization between the multiple sending nodes is important for cooperative MIMO transmission. Therefore we consider the synchronization problem and propose an asynchronous receiver.

Although cooperative MIMO communication can provide reliable transmission with low power, node cooperation introduces system overhead and may sacrifice system capacity. Analysis of system overhead is desirable. Thus we consider system overhead and capacity for proposed system and provide our analysis in Chapter 5.

However, to achieve the system capacity, the transmitter and receiver diversity from sending and receiving groups need to be well utilized. A transmission scheme beyond the basic model is desired. Thus we propose an advanced design to provide reliable and energy-efficient transmission. Space-time block code (STBC) is implemented distributively in the sending group, and cooperative code combining is used in receiving group. With STBC and cooperative code combining, the inherent transmitter and receiver diversity is well utilized. Thus the proposed cooperative MIMO system can improve transmission reliability while transmission power is quite low.

After the advanced design, we loose the system constraint and further consider the imperfect condition in real situation that the multiple nodes in sending group have different carrier frequency offsets(CFO). We consider the advanced design described above, which uses space-time block code (STBC) in sending group and cooperative code combining in receiving group. The multiple nodes in sending group transmit space-time block coded data while each of the sending node has its own carrier frequency offset(CFO). Each node in the receiving group will receive the mixed STBC-coded data with multiple carrier frequency offset(CFO) distortion. To decode the distorted STBC-coded data, we propose the estimation method for multiple CFOs and the detection method to recover original sending data symbols. The details of CFO estimation and data detection are discussed.

In conclusion, we consider the system design of cooperative MIMO communication systems in this thesis. We design the cooperative MIMO communication system step by step. We start from cluster recruiting algorithm to full system design with space-time block coding (STBC) and code combining. With the full system design, we consider implementation issue in real imperfect world and provide advanced design strategy for cooperative transmission under multiple carrier frequency offsets (CFO). We consider important issues in cooperative MIMO communication systems and address them in following chapters. Conclusion and open issues are also proposed to make this thesis more complete.