Notice of the Final Oral Examination
for the Degree of Master of Applied Science

of

LE LIANG

BEng (Southeast University, 2012)

“Practical Precoding Design for Modern Multiuser MIMO Communications”

Department of Electrical and Computer Engineering

Thursday, November 19, 2015
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Engineering Office Wing
Room 430

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(Supervisor)
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Dr. Roberta Hamme, School of Earth and Ocean Sciences, UVic

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Abstract

The use of multiple antennas to improve the reliability and capacity of wireless communication has been around for a while, leading to the concept of multiple-input multiple-output (MIMO) communications. To enable full MIMO potentials, the precoding design has been recognized as a crucial component. This thesis aims to design multiuser MIMO precoders of practical interest to achieve high reliability and capacity performance under various real-world constraints like inaccuracy of channel information acquired at the transmitter, hardware complexity, etc. Three prominent cases are considered which constitute the mainstream evolving directions of the current cellular communication standards and future 5G cellular communications. First, in a relay-assisted multiuser MIMO system, heavily quantized channel information obtained through limited feedback contributes to noticeable rate loss compared to when perfect channel information is available. This thesis derives an upper bound to characterize the system throughput loss caused by channel quantization error, and then develops a feedback quality control strategy to maintain the rate loss within a bounded range. Second, in a massive multiuser MIMO channel, due to the large array size, it is difficult to support each antenna with a dedicated radio frequency chain, thus making high-dimensional baseband precoding infeasible. To address this challenge, a low-complexity hybrid precoding scheme is designed to divide the precoding into two cascaded stages, namely, the low-dimensional baseband precoding and the high-dimensional phase-only processing at the radio frequency domain. Its performance is characterized in a closed form and demonstrated through computer simulations. Third, in a mmWave multiuser MIMO scenario, smaller wavelengths make it possible to incorporate excessive amounts of antenna elements into a compact form. However, we are faced with even worse hardware challenges as mixed signal processing at mmWave frequencies is more complex and power consuming. The channel sparsity is taken advantage of in this thesis to enable a simplified precoding scheme to steer the beam for each user towards its dominant propagation paths at the radio frequency domain only. The proposed scheme comes at significantly reduced complexity and is shown to be capable of achieving highly desirable performance based on asymptotic rate analysis.