Coordinated Transmission for Wireless Interference Networks

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Abstract

Wireless interference networks refer to communication systems in which multiple source–destination pairs share the same transmission medium, and each source’s transmission interferes with the reception at non-intended destinations. Optimizing the transmission of each source–destination pair is interrelated with that of the other pairs, and characterizing the performance limits of these networks is a challenging task. Solving the problem of managing the interference and data communications for these networks would potentially make it possible to apply solutions to several existing and emerging communication systems. Wireless devices can carefully coordinate the use of scarce radio resources in order to deal effectively with interference and establish successful communications. In order to enable coordinated transmission, terminals must usually have a certain level of knowledge about the propagation environment; that is, channel state information (CSI). In practice, however, no CSI is a priori available at terminals (transmitters and receivers), and proper channel training mechanisms (such as pilot-based channel training and channel state feedback) should be employed to acquire CSI. This requires each terminal to share available radio resources between channel training and data transmissions. Allocating more resources for channel training leads to an accurate CSI estimation, and consequently, a precise coordination. However, it leaves fewer resources for data transmissions. This creates the need to investigate optimum resource allocation. This thesis investigates an information-theoretic approach towards the performance analysis of interference networks, and employs signal processing techniques to design transmission schemes for achieving these limits in the following scenarios. First, the smallest interference network with two single-input single-output (SISO) source–destination pairs is considered. A fixed-rate transmission is desired between each source–destination pair. Transmission schemes based on point-to-point codes are developed. The transmissions may not always attain successful communication, which means that outage events may be declared. The outage probability is quantified and the e-outage achievable rate region is characterized. Next, a multi-user SISO interference network is studied. A pilot-assisted ergodic interference alignment (PAEIA) scheme is proposed to conduct channel training, channel state feedback, and data communications. The performance limits are evaluated, and optimum radio resource allocation problems are investigated. The analysis is extended to multi-cell wireless interference networks. A low-complexity pilot-assisted opportunistic user scheduling (PAOUS) scheme is proposed. The proposed scheme includes channel training, one-bit feedback transmission, user scheduling and data transmissions. The achievable rate region is computed, and the optimum number of cells that should be active simultaneously is determined. A multi-user MIMO interference network is also studied. Here,
each source sends multiple data streams; specifically, the same number as the degrees of freedom of the network. Distributed transceiver design and power control algorithms are proposed that only require local CSI at terminals.

**Key Words**

Interference, Wireless Network, MIMO, Coordinated Transmission, Resource Allocation, Interference Alignment, Scheduling