Interference Alignment with Imperfect Channel Knowledge and Secrecy Constraints

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Abstract

In this thesis, the degrees of freedom (DOF) of wireless networks are studied with imperfect channel state information at transmitters (CSIT) and/or secrecy constraints. Different interference alignment schemes are proposed to establish the DOF lower bound for a variety of wireless networks.

For the imperfections of CSIT, we mainly have two practical concerns. The first concern is the long delay of the high-resolution feedback from receivers to transmitters such that the obtained CSIT is totally outdated. The second concern is the inaccurate estimation on the instantaneous CSIT. Specifically, the first scenario is solely investigated in a delayed CSIT model, and a combination of these two types of imperfections is studied in a mixed CSIT model. The DOF of wireless networks are studied based on these two CSIT models. Regarding secrecy constraints, we also consider two scenarios, to be specific, the weak secrecy where the confidentiality is measured by the normalized information leakage with respect to the codeword length, and the strong secrecy where the total information leakage of the whole codeword is used as the secrecy measure.

In the first part of the thesis, the impact of imperfect CSIT is investigated for the multi-hop broadcast networks. The Maddah-Ali \\& Tse (MAT) alignment is extended to the considered multi-hop network to make use of the delayed CSIT, and it is also shown that the MAT scheme can be integrated with linear beamforming to achieve the optimal sum DOF of a two-user multi-hop broadcast network with mixed CSIT.

In the second part of the thesis, the secrecy constraints are subjected to the studied networks. With weak secrecy constraints, we propose artificial noise alignment approaches for seeking the optimal secure degrees of freedom (SOF) of wireless $X$ networks, the multiple-input single-output (MISO) broadcast channel and the two-hop interference channel. It is worth noting that the proposed alignment schemes are also based on divergent CSIT conditions, i.e., delayed, mixed or even no CSIT. With strong secrecy constraints, the secure coding based on channel resolvability and the signaling method by interference alignment are combined to provide the optimal SDOF of the $K$ $-$user interference channel with confidential messages. It is worth noting that a general framework of the secure interference alignment encoder is provided in the thesis, which consists of two functional sections: the stochastic encoding section to provide secure codes and the alignment section to provide signaling solutions. This framework can be applied to all the network models studied in the latter part of the thesis.