Cooperation in Interference Networks

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Extended Abstract

In this tutorial paper, we focus on the rate improvements in wireless peer-to-peer networks when users cooperate. We consider pairs of uncoordinated sources and destinations that compete for the same bandwidth. When simultaneous transmissions occur, users experience interference. Orthogonalization techniques, such as TDMA, although leading to simple network architecture, are suboptimal in terms of achievable rates. Although cooperation in fully connected interference networks does not increase the capacity at very large SNR (signal to noise ratio) [5,7], for moderate and small SNR improvements can be substantial [1,2,3,4].

Cooperation strategies in interference networks have been presented in [1,2,3,4,5], and references therein. The fundamental idea is that transmitters listen to the channel, decode some of the message streams sent by the other sources, and then cooperatively send all the decoded streams. In other words, each source in a cooperative peer-to-peer network acts as a relay for the other sources. In general, the exact capacity characterization of a general relay network is an open problem. Recently there have been interesting progresses based on the analysis of ``scaling'' behavior of the network [6,7].

We shall revise available results of two basics forms of cooperation: a) *superposition coding* [1], whose goal is to create a virtual MIMO (multiple input multiple output) antenna system among the sources, and b) *dirty paper coding* [2,3], whose goal is to pre-cancel the interference as it will be experienced at the intended receiver.

We will then discuss those two strategies in light of the two network architectures that have been shown to be asymptotically optimal in fully connected networks: i) *hierarchical communications* [6], optimal when the number of users grows to infinity, and ii) *interference alignment* [7], optimal when the SNR grows to infinity at each source.

We will also discuss what kind of results can be expected when the hypothesis under which optimality have been proved are relaxed. Numerical examples will be shown to demonstrate the benefits of cooperation. We will conclude with a brief discussion on the ``cost'' of physical layer cooperation on the network protocols and architectures.

References

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