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Fundamental Limits of Cooperation

Angel Lozano, Robert W. Heath Jr., Jeffrey G. Andrews

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Cooperation is viewed as a key ingredient for interference management in wireless systems. This paper shows that cooperation has fundamental limitations. The main result is that even full cooperation between transmitters cannot in general change an interference-limited network to a noise-limited network. The key idea is that there exists a spectral efficiency upper bound that is independent of the transmit power. First, a spectral efficiency upper bound is established for systems that rely on pilot-assisted channel estimation; in this framework, cooperation is shown to be possible only within clusters of limited size, which are subject to out-of-cluster interference whose power scales with that of the in-cluster signals. Second, an upper bound is also shown to exist when cooperation is through noncoherent communication; thus, the spectral efficiency limitation is not a by-product of the reliance on pilot-assisted channel estimation. Consequently, existing literature that routinely assumes the high-power spectral efficiency scales with the log of the transmit power provides only a partial characterization. The complete characterization proposed in this paper subdivides the high-power regime into a degrees-of-freedom regime, where the scaling with the log of the transmit power holds approximately, and a saturation regime, where the spectral efficiency hits a ceiling that is independent of the power. Using a cellular system as an example, it is demonstrated that the spectral efficiency saturates at power levels of operational relevance.

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