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Efficient Rate-Constrained Nash Equilibrium in Collision Channels with State Information

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Abstract

We consider a wireless collision channel, shared by a finite number of users who transmit to a common base station. Users are self-optimizing, and each wishes to minimize its average transmission rate (or power investment), subject to minimum-throughput demand. The channel quality between each user and the base station is time-varying, and partially observed by the user in the form of channel state information (CSI) signals. We assume that each user can transmit at a fixed power level and that its transmission decision at each time slot is stationary in the sense that it can depend only on the current CSI. We are interested in properties of the Nash equilibrium of the resulting game between users.

We define the feasible region of user's throughput demands, and show that when the demands are within this region, there exist exactly two Nash equilibrium points, with one strictly better than the other (in terms of average power) for all users. We further address the performance benefits of improved CSI, and show that if even a single user obtains better CSI, the average power of *all* users is reduced. We then provide some lower bounds on the channel capacity that can be obtained, both in the symmetric and non-symmetric case. Finally, we show that a simple greedy mechanism converges to the best equilibrium point without requiring any coordination between the users.