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Cooperation Strategies for the Broadcast and Multiple Access Channels

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Abstract—It has long been observed that cooperation between users in a communication network can improve its performance and simplify the coding schemes. In this talk I will describe recent results on cooperation for the broadcast and multiple access channels, and discuss few of the difficulties that arise when the number of users is large. New results and insights will be presented for specific scenarios.

I. INTRODUCTION

Due to their potential advantage, coding schemes that employ cooperation between users have attracted considerable attention in recent years. Among the most studied models are the multiple access channel (MAC) with cooperating encoders, and the broadcast channel (BC) with cooperating decoders. For the MAC there are two possible forms of cooperation - conference links and cribbing. In [9] Willems introduced and studied a two users MAC model where the encoders can communicate via conference links of limited capacity before transmission begins, and derived its capacity region. In a subsequent work [10], Willems and Van Der Meulen introduced the MAC with cribbing encoders, and derived its capacity region for all possible cribbing scenarios. In [1], Dabora and Servetto introduced the two users degraded BC with conferencing decoders, and derived its capacity region. The model of Dabora and Servetto can be viewed as a special case of the relay-broadcast channel (RBC) of Liang and Veeravalli [6], where the link from the relay to the destination is replaced by a noiseless bit pipe. The model of Dabora and Servetto was extended in [2], [3] to state-dependent channels. A new coding scheme was introduced by Dikstein et al., where binning replaces the block-Markov approach that was used by Dabora and Servetto in [1].

The coding schemes developed in [1], [2], [3], [6], [9] and [10], rely on the cooperation links, and cannot be used in their absence. In many modern ad-hoc communication systems, the cooperation resources are not allocated a priori, and their availability depends on many factors of which the system designer does not have control - e.g., weather conditions, presence of users that serve as relays, etc. A typical situation is that a user who wishes to transmit messages to a remote destination, is aware of the possibility that intermediate nodes in the network will act as relays, but their help is not guaranteed. Moreover, in most cases the transmitting user cannot be informed whether the cooperation resources are indeed available during transmission. It is therefore desired to devise coding schemes that take advantage of the cooperation resources when they are available, but can operate also when they are absent, although possibly at reduced rates. This set of problems can be viewed as a channel coding analog of some well known source coding problems, like multiple description [11], [12] and rate distortion when side information may be absent [4].

II. RECENT RESULTS

In [7] new models for the broadcast and multiple access channels with uncertain cooperation were presented. Specifically, for the broadcast channel, the model of [1] was extended to the case where the cooperation link is unstable and may be absent. The capacity region for this case was characterised. A model of a MAC with a cribbing link that may be absent was presented, and an achievable region derived based on a combination of super position coding and the block-Markov construction of [10]. Recently, an outer bound for the MAC model of [7] was derived, and the capacity region fully characterised for special cases of interest [5]. In [8], the BC with degraded message sets and conference link was presented, and its capacity region fully characterised. In this talk I will describe recent results on the MAC and BC with unstable cooperation, and discuss a few of the difficulties that arise when extending the basic cooperation models.

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