Interference Alignment on the Deterministic Channel and Application to Fully Connected AWGN Interference Networks

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Abstract—An interference alignment example is constructed for the deterministic channel model of the K user interference channel. The deterministic channel example is then translated into the Gaussian setting, creating the first known example of a fully connected Gaussian K user interference network with single antenna nodes, real, non-zero and constant channel coefficients, and no propagation delays where the degrees of freedom outerbound is achieved. An analogy is drawn between the propagation delay based interference alignment examples and the deterministic channel model which also allows similar constructions for the 2 user X channel as well.

I. INTRODUCTION

Understanding the capacity of wireless networks is the “Holy Grail” of network information theory. Since exact capacity characterizations are unlikely to be found for most multiuser communication scenarios, there is an increased interest in approximate and/or asymptotic capacity characterizations as a means to understanding the performance limits of wireless networks. Promising approaches in this direction include degrees of freedom characterizations [1], [2], [3], [4] and deterministic channel models [5], [6], [7]. Degrees of freedom characterizations seek the asymptotic scaling of network capacity with signal-to-noise-ratio (SNR). Deterministic channel models have lead to capacity characterizations within a constant number of bits for several interesting cases. While a precise connection between deterministic channel models and degrees of freedom characterizations has not been made in general, it is clear that the two approaches have a lot in common. Both the degrees of freedom perspective as well as the deterministic channel perspective focus on the high SNR regime and in both approaches, the noise is de-emphasized in order to gain a better understanding of the broadcast and interference aspects of wireless networks. In this paper, we explore further the relationship between these two perspectives.

One of the main results to come out of the degrees of freedom perspective is the concept of interference alignment. Interference alignment refers to the idea that signals can be designed to cast overlapping shadows at the receivers where they constitute interference while they remain distinguishable at the receivers where they are desired. This idea has lead to some surprising results for wireless networks. For example, it has been shown that a K user interference network has K/2 degrees of freedom. In other words, as the total transmit power of the network is increased (or equivalently, as the AWGN power at each receiver is decreased), every user in an interference network will be able to simultaneously achieve half of the capacity (bits/sec/Hz) that he could achieve in the absence of the interference from other users. Similarly, for M x N node X networks, i.e. networks of M transmitters and N receivers where an independent message needs to be communicated between each transmitter-receiver pair the number of degrees of freedom equals \(\frac{MN}{M+N-1}\). Interference alignment is the key to this result as well.

The degrees of freedom of wireless interference networks have been characterized under a variety of communication scenarios. However, several important questions remains open. One such unsolved question is to prove or disprove the Host-Madsen-Nosratinia conjecture [8] that states that fully connected wireless interference networks with single antenna nodes and constant channel coefficients have only 1 degree of freedom. The term “fully-connected” refers to the condition that all channel coefficients are non-zero. In other words, all receivers see interference from all transmitters. For a fully connected K user interference network the total degrees of freedom cannot be more than K/2. The achievability of K/2 degrees of freedom has been established for fully connected wireless interference networks under each of the following scenarios.

1) If the channels coefficients are chosen from a continuous distribution but allowed to vary over time or frequency slots, then the K user fully connected interference network has K/2 degrees of freedom with probability 1. The key is to treat multiple transmitted scalar symbols as a supersymbol, or a signal vector. The variations of the channel coefficients create a distinct linear transformation of the signal vectors between each transmitter receiver pair. Thus, the same set of transmitted signal vectors, after they pass through these distinct channels, are able to align at one receiver where they constitute interference and be distinct at another receiver where they are desired.