

EXPERIMENTAL EVALUATION OF INTERFERENCE ALIGNMENT UNDER IMPERFECT CHANNEL STATE INFORMATION

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ABSTRACT

Interference Alignment (IA) has been revealed as one of the most attractive transmission techniques for the K -user interference channel. In this work, we employ a multiuser Multiple-Input Multiple-Output (MIMO) testbed to analyze, in realistic indoor scenarios, the impact of channel state information errors on the sum-rate performance of IA. We restrict our study to a 3-user interference network in which each user transmits a single data stream using two transmit and two receive antennas. For this MIMO interference network, only two different IA solutions exist. We also evaluate the performance gain obtained in practice by using the IA solution that maximizes the sum-rate.

1. INTRODUCTION

In wireless communications, an interference channel is obtained when various transmitter-receiver pairs operate simultaneously, sharing the same transmission medium. In this way, as shown in Fig. 1, data transmission from one transmitter to the corresponding receiver is interfered by the rest of the two transmitters in the network. Interference Alignment (IA) has been recently introduced as an attractive transmission technique for the K -user interference channel [1, 2], which is based on maximizing the interference-free space for the desired signal. In [2], it is shown that all the interference can be concentrated into half of the signal space at each receiver, whereas the remaining half is still available—free of interference—for the desired signal.

Unfortunately, most of the literature about IA is limited to theoretical analyses and computer simulations that rely only on synthetic, ideal, wireless channel models. Although the experimental evaluation of IA requires a complex set-up (e.g. three two-antenna transmitters and three two-antenna receivers for assessing the simplest 3-user interference network), it is important to evaluate the robustness and performance of IA under real-world circumstances (e.g. imperfect Channel State Information (CSI)). The insights obtained can be later used to improve current IA techniques.

To the best of our knowledge, the first experimental work on IA was presented in [3], where a technique that combines interference alignment and cancellation was implemented in a testbed made up of 20 Ettus Research LLC nodes with two antennas each. Several practical issues have been evaluated in this work, such as the impact of different modulations, frequency/time synchronization aspects, or the idea of applying the alignment at the sample level (i.e., before timing and frequency offset corrections). However, this technique requires an additional wired Ethernet connection to transfer already decoded packets between access points to cancel out some streams.

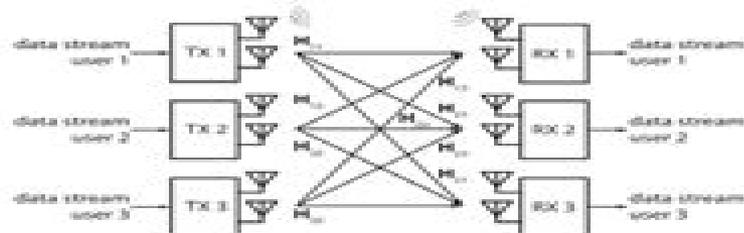


Figure 1: Scheme of the $(2 \times 2, 1)^3$ interference network.

Another experimental study on IA has been recently presented in [4], in which MIMO Orthogonal Frequency Division Multiplexing (MIMO-OFDM) 3-user interference channels are measured in indoor and in outdoor scenarios. Using the measured channels, IA techniques were evaluated in an off-line fashion. This work validates the feasibility of IA techniques and also evaluates the performance degradation under spatially correlated channels. However, notice that in [4] no aligned streams are actually transmitted over the wireless channel and, thus, many practical issues such as synchronization or hardware impairments are not taken into account.

In a recent work [5] we have studied the feasibility of IA in indoor channels, identifying also the main practical issues that affect the IA performance. As pointed out in previous theoretical works [6], we have found that imperfect CSI is a key limiting factor. In this work, we continue the analysis of the IA indoor measurements presented in [5], by evaluating the impact of imperfect CSI on the performance of IA in terms of sum-rate. We have restricted the study to the 3-user interference wireless channel, where each user sends one stream and it is equipped with two antennas at both sides of the link. For this scenario, which is typically denoted as $(2 \times 2, 1)^3$, closed-form IA solutions exist that can be found solving an eigenvalue problem.

2. INTERFERENCE ALIGNMENT FOR THE 2×2 MIMO 3-USER CHANNEL

Let us consider a 3-user interference channel comprised of three transmitter-receiver pairs (links) that interfere with each other as shown in Fig. 1. The discrete-time signal at receiver i is the superposition of the signals transmitted by the three users, weighted by their respective channel gains

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