

**On the Rate Regions of Single-Channel and Multi-Channel Full-Duplex Links**

**Abstract:**

We study the achievable *rate regions of full-duplex links* in the *single- and multi-channel cases* (in the latter case, the channels are assumed to be orthogonal, e.g., OFDM). We present analytical results that characterize the uplink and downlink rate region and efficient algorithms for computing rate pairs at the region’s boundary. We also provide near-optimal and heuristic algorithms that “convexify” the rate region when it is not convex. The convexified region corresponds to a combination of a few full-duplex rates (i.e., to time sharing between different operation modes). The algorithms can be used for theoretical characterization of the rate region as well as for resource (time, power, and channel) allocation with the objective of maximizing the sum of the rates when one of them (uplink or downlink) must be guaranteed (e.g., due to QoS considerations). We numerically illustrate the rate regions and the rate gains (compared with time division duplex) for various channel and cancellation scenarios. The analytical results provide insights into the properties of the full-duplex rate region and are essential for future development of scheduling, channel allocation, and power control algorithms.

**Existing System:**

While a few recent papers considered non-negligible SI and the resulting rate gains, *there is still no explicit characterization of the FD rate region for a given profile of residual SI over frequency*1 *and parameters of the wireless signal*. Most recent research has focused on maximizing the total throughput without considering Quality of Service (QoS) requirements. Namely, there has been very limited work on asymmetric traffic requirements on the uplink (UL) and downlink (DL). While in Time Division Duplex (TDD) systems asymmetric traffic can be supported via time-sharing between the UL and DL, in FD the dependence of the bi-directional rates on the transmission power levels and Signal-to-Noise Ratio (SNR) levels is much more complex. Any (combination) of the following policies can be used: (i) FD with reduced transmission power at

one of the stations. (ii) FD with fewer channels allocated to one of the stations, and (iii) time-sharing between a few types of FD transmissions.

**Proposed System:**

We then consider the *multi-channel* case in which channels are orthogonal, as in Orthogonal Frequency Division Multiplexing (OFDM). We assume that the *shape of the power allocation is fixed* but the total transmission power can be varied. Namely, the ratios between power levels at different channels are given. For each channel, the residual SI is some fraction of the transmitted power. We characterize the FD rate region and analytically show that any point on the region can be computed with a lowcomplexity binary search. We also focus on determining the TDFD rate region, which due to the lack of structure cannot in general be obtained via binary search. However, we argue that in practice the TDFD rate region can be determined in real time.