Gaussian doubly dirty compound multiple-access channel with partial side information at the transmitters

Mostafa Monemizadeh, Elham Bahmani, Ghosheh Abed Hodtani, Seyed Alireza Seyedin

Department of Electrical Engineering, Ferdowsi University of Mashhad, Mashhad, Iran
E-mail: ghodtani@gmail.com

Abstract: In this study, the authors study a two-user Gaussian doubly dirty compound multiple-access channel with partial side information (GDD-CMAC-PSI) where two independent additive interference signals are considered, each one known non-causally and partially to one of the encoders but unknown to either of the receivers. This channel, first, can model two users communicating with two base stations suffering from interference, and second, includes many previously studied channels as its special cases. For such a communication scenario, first, a general capacity outer bound is derived. Depending on the values of cross link gains, they classify the channel into three classes: weak, strong and mixed GDD-CMAC-PSI. Next, assuming that the interference signals have infinite variances, they obtain capacity outer bounds for these classes. Then, an achievable sum-rate is derived for the GDD-CMAC-PSI using Costa’s strategy and thereby, they show that when both interference signals have infinite variances, this achievable sum-rate vanishes. Later, by utilising the lattice strategies and deriving achievable rate regions, independent of the interference powers, they show that in contrast with Costa’s strategy, lattice-strategies can achieve positive rates. Finally, depending on signal-to-noise ratio gaps at receivers, various achievable rates are obtained.

1 Introduction

The two-user compound multiple-access channel (CMAC) is a variant of the two-user interference channel (IC) where all messages sent by both transmitters are required to be decoded at both receivers [1–3]. In the CMAC, two basic and important multi-user channels, that is, multiple-access channel (MAC) and broadcast channel, can be seen concurrently. The CMAC was first studied by Maric et al. [1] where the capacity region of CMAC with common (CMACC) message and also the capacity region of CMAC with conferencing encoders were determined. The CMACC with conferencing decoders and the CMAC with both conferencing encoders and decoders have been studied in [2]. Recently, achievable rates for the CMACC with a specific type of correlated channel states [3] have been provided.

The study of communication channels with interference known at the transmitters as side information (SI) is of particular interest because we can apply such knowledge to mitigate the negative effect of the interference, thus achieving high and reliable data-rates. For instance, Costa [4] showed that the capacity of a single-user channel with additive white Gaussian noise (AWGN) when also afflicted by an additive white Gaussian interference is equal to the capacity of the interference-free AWGN channel provided that the additive interference is non-causally known at the transmitter. Also, Gueguen and Sayrac [5] obtained the capacity of the Costa channel with partial SI and showed that the part of interference which is known to the transmitter can be cancelled successfully but the unknown part of the interference acts as an additional noise and reduces the capacity.

One widely-used coding strategy for interference cancellation in Gaussian channels with interference non-causally known at the transmitters (dirty-paper channels) is the Costa’s strategy (Gaussian random binning) [4]. After successful use in the single-user dirty-paper channel [4, 5], Costa’s strategy has been used frequently for interference cancellation in state-dependent Gaussian multi-user channels, for example, see [6–9]. Recently, Zhang et al. [10] proposed a generalised Costa’s strategy, called active interference cancellation, that improves the performance of the Costa’s strategy by utilising some transmitting power to partially eliminate the interference at receivers.

Another well-known coding strategy for interference mitigation in the Gaussian dirty-paper channels is lattice strategy (linear structured binning) [11–18]. In recent decade, designing lattice codes with the same performance as random codes has been an interesting research area. For instance, Erez and Zamir [11] studied the problem of achieving the capacity of the power-constrained AWGN channel using lattice encoding and decoding. Erez et al. [12] presented a structured transmission scheme based on $n$-dimensional lattices for the Costa dirty-paper channel and showed that the capacity loss of such scheme goes to zero.