Advanced techniques of Interference Alignment: Application to Wireless Networks

Mots clés :
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- Domaine scientifique principal: Divers

Résumé du projet de recherche (Langue 1)

(Interference alignment) is a breakthrough paradigm for networks that consists of several mutually interfering source-destination pairs that share the same resources. Interference networks were long believed to be fundamentally interference limited, that is, the optimal communication strategy at high SNR is resource division among users. Because of this, today's commercially available networks are build so as to avoid interference. Interference alignment is an interference management technique that achieves a linear scaling of the network throughput with the number of source-destination pairs, a scaling that would be impossible with interference avoidance. Two alignment approaches are known in the literature: linear interference alignment for time-varying channels [1] and non-linear interference alignment for static single-antenna channels [2]. In the former case the alignment problem can be formulated as that of solving an overdetermined system of equations with respect to a subset of the unknowns and can be cast into the familiar language of vector spaces. The latter, requires deep results in number theory that roughly state that the space of real-valued numbers has infinite dimensions over the field of rational numbers. At present no unifying framework exists that encompasses both approaches. The novel framework will be used to design actual codes. First lattice-based codes are designed for channels with integer-valued coefficients and later extended to real-valued (resp. complex-valued) channel coefficients. (Intellectual Merit:) The central impact of the proposed work stems from its unified theoretical treatment of interference alignment. No such unified framework or methodology exists at present. Although it has been often observed that classical linear algebra tools are insufficient for network problems, the theory of modules has not emerged so far as a tool to explain, analyze and design codes for interference networks. This research, by exploring a novel foundations of interference alignment, will provide the community with an extremely rich toolset to design and analyze codes, which is expected to impact and benefit other network problem such as network coding and compute-and-forward. (Broader impacts:) From a technical perspective the new paradigm proposed in this research will enlarge the scope of information processing in interference networks from linear algebra to algebra, and provide an important step forward into the consolidation of a comprehensive theory of network science for distributed, decentralized, interfering networks. The results of this research will be presented at major national and international professional venues, in the information theory and communication networks communities and are expected to be of immediate use to the industrial sector. ([References]) [1] Syed A. Jafar, "Interference Alignment: A New Look at Signal Dimensions in a Communication Network," (Foundations and Trends in Communications and Information Theory), Vol. 7, No. 1, USA, 2011. [2] Abolfazl Seyed Motahari, Shahab Oveis Gharan, Mohammad-Ali Maddah-Ali, and Amir Keyvan Khandani, "Real interference alignment: Exploiting the potential of single antenna systems," (IEEE Trans. Inform. Theory), 2009.

Résumé du projet de recherche (Langue 2)

(Performance Analysis:) Development of a novel framework for interference network performance analysis. The main goals are: to unify recently emerged techniques under the umbrella of module theory, to identify module theory tools to analyze the performance of discrete deterministic linear network, and to extend the insights gained from discrete deterministic linear networks to wireless networks. (Code Design:) Application of the novel framework to code design. The main goals are: to design codes that achieve the Degrees of Freedom upper bound in Wireless networks, to analysis the performance (and possibly modify) the obtained class of codes to operate satisfactorily at moderate or medium SNR, and to design encoding and decoding algorithms with low-complexity for practical implementation of the proposed codes.

Informations complémentaires (Langue 1)

We will collaborate, through this subject, with Dr Cong Ling from Imperial College, London and Dr Daniela Tuninetti from University of Illinois in Chicago.