STUDY OF THE FUNDAMENTAL LIMITS OF INFORMATSION TRANSMISSION AND PROCESSING,INCLUDING CONCEPTS SUCH AS ENTROPY,MUTUAL INFORMATION AND CHANNEL CAPACITY

Kurbonov Sarkorjon Sanjar Ugli
Working place: Investment and foreign trade department of Navoi city
Position: Leading Manager

Abstract: *In these series of multi-part papers, a systematic study of fundamental limits of communications in interference networks is established. Here, interference network is referred to as a general single-hop communication scenario with arbitrary number of transmitters and receivers, and also arbitrary distribution of messages among transmitters and receivers. It is shown that the information flow in such networks follows similar derivations from many aspects. This systematic study is launched by considering the basic building blocks in Part I. The Multiple Access Channel (MAC), the Broadcast Channel (BC), the Classical Interference Channel (CIC) and the Cognitive Radio Channel (CRC) are proposed as the main building blocks for all interference networks. First, a brief review of existing results regarding these basic structures is presented. New observations are also presented in this regard. Specifically, it is shown that the well-known strong interference conditions for the two-user CIC do not change if the inputs are dependent. Next, new capacity outer bounds are established for the basic structures with two receivers. These outer bounds are all derived based on a unified framework. By using the derived outer bounds, some new capacity results are proved for the CIC and the CRC; a mixed interference regime is identified for the two-user CIC where the sum-rate capacity is established.*

INTRODUCTION

In his landmark paper [1], Shannon derived the fundamental limits of communications for a point-to-point channel. This fundamental limit called channel capacity represents the maximum rate of information which can be reliably transmitted over a communication system. Channel capacity theorem, as the fundamental theorem of information theory, states that in a transmitter/receiver communication setup if the information rate is equal to or less than the channel capacity, there exist encoding and decoding schemes for the transmitter and the receiver which enable transmission with arbitrarily small error probability in the presence of noise. On the other hand, if the information rate is greater than the channel capacity, regardless of the coding scheme used in the system, the error

probability is close to one.

Despite the single user channel for which the capacity is known, the problem still remains unsolved for many multiuser communication networks. Up to now, capacity bounds have been widely studied for different multiuser settings. Nevertheless, we are still far from a unified theory for the subject. Most of existing research concentrates on the study of certain networks individually, and there are few works which deal with the information theoretic issues for the networks systematically from a unified point of view. The multiuser networks can be categorized based on their essential features such as interference, relay or interactive user cooperation.

Each of these key features may appear in different topologies, but its effect on the behavior of information flow does not change in essence from one model to another. In other words, different network topologies which are common in the essential features exhibit similarities from many aspects. Now if we recognize these similarities, then it is possible to adapt them to create a unified mathematical language for re-describing the behavior of the networks in a systematic approach. Thus, we can have powerful tools which are applicable not only for studying some given specific scenarios but also for arbitrary large topologies. In these multi-part

papers, we will try to build such a systematic study for the interference networks. In communication systems, the interference arises, in principle, when the signal of a transmitter during transmission interferes with the other signals in the network before being received by the desired user. The interference signals are not noise and indeed they convey information for the other users. Therefore, from the viewpoint of a particular user, a transmitting signal may be interference or contain information. Such description of the interference is suitable more for the Gaussian networks in which a linear combination of the network input signals and Gaussian noise is received at each receiver. More precisely, one can state that in an arbitrary communication network, a received signal at a certain user has been interfered if it contains information regarding both desired and undesired messages for that user. Hence, the interference is essentially unavoidable in almost all multiuser communication scenarios. However, in these multi-part papers, the term "interference network" is referred to the general single-hop communications scenario with arbitrary number of transmitters and receivers with arbitrary distribution of messages among transmitters and receivers but without any interactive (relay) node [2]. In fact, the essential feature, which uniformly appears in these networks, is the interference element. Moreover, as we will discuss in the following, the classical interference channel is one of the main building blocks of these networks. Hence, we generally refer to them as the interference networks. We intend to show that the information flow in such networks follows similar directions in many aspects.

CONCLUSION

We tried to build a systematic study of fundamental limits of communications for the interference networks with arbitrary configurations. We launched this study by investigating capacity limits for the basic building blocks in this part. We proposed the MAC, the BC, the CIC and the CRC as the main building blocks for all interference networks. First, we briefly reviewed the existing results regarding these channels. We then established new capacity outer bounds for the basic structures with two receivers.

These outer bounds are all derived based on a unified framework. Using the derived outer bounds, we identified a "mixed interference regime" for the two-user CIC and obtained the sum-rate capacity for this regime. This result contains the previously known one regarding the Gaussian mixed interference channel as a special case. Also, we presented a noisy interference regime for the one-sided CIC in which treating interference as noise is sum-rate optimal. For the CRC, we derived a full characterization of the capacity region for a class of "more-capable" channels. Finally, we studied capacity bounds for the two-user BC, the two-user CIC and the CRC with one-sided receiver side information where one receiver has access to the non-intended message. Our results lead to new insights regarding the nature of information flow in the basic interference networks.

REFERENCES:

[1] C. E. Shannon, "A mathematical theory of communication," Bell Syst Tech. J, vol. 27, no. 3, pp. 379–423, 1948.

[2] E. C. van der Meulen, "Three-terminal communication channels," Adv. Appl. Probab., vol. 3, pp. 120–154, 1971.

[3] T. M. Cover and J. A. Thomas, Elements of Information Theory. 2nd ed, New York: Wiley, 2006.

[4] T. M. Cover, "Broadcast channels," IEEE Trans. Inf. Theory, vol. IT-18, no. 1, pp. 2–14, Jan. 1972.

[5] P. P. Bergmans, "Random coding theorem for broadcast channels with degraded components," IEEE Trans. Inf. Theory, vol. 19, no. 2, pp. 197–207, 1973.

[6] R. G. Gallager, "Capacity and coding for degraded broadcast channels," Probl. Inf. Transm., vol. 10, no. 3, pp. 3–14, 1974.

[7] R. Khosravi-Farsani and F. Marvasti, "Interference networks with general message sets: A random coding scheme" [Online] available at:

http://arxiv.org/abs/1107.1839.

[8] "Interference networks with general message sets: A random coding scheme", 2011, 49th Annual Allerton Conference on Communication, Control,

and Computing., Monticello, IL, Sep. 2011.

[9] S. I. Gel'fand and M. S. Pinsker, "Coding for channel with random parameters," Probl. Contr. Inf. Theory, vol. 9, no. 1, pp. 19–31, 1980.

[10]M. Costa, "Writing on dirty paper," IEEE Transactions on Information Theory, vol. 29, no. 3, pp. 439-441, May 1983.

[11]H. Weingarten, Y. Steinberg, and S. Shamai (Shitz), "The capacity region of the Gaussian multiple-input multiple-output broadcast channel," IEEE Trans. Inf.

Theory, vol. 52, no. 9, pp. 3936–3964, Sep. 2006.

[12]A. B. Carleial, "Interference channels," IEEE Trans. Inf. Theory, vol. IT-24, no. 1, pp. 60–70, Jan. 1978.