Statistical Characterization of Network Coding Delay

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Abstract

The basic idea of network coding is that nodes are allowed not only to store -and forward packets, but also to process and mix the incoming information flows. This procedure is known in Information Theory as Network Coding. In random linear network coding, intermediate network nodes independently choose random linear mappings from inputs to outputs. The transfer matrix from sources to receivers should be an invertible matrix, such that the receivers are able to decode after they received a sufficient number of independent linear combinations.

Previous contributions on network coding focus mostly on throughput in asymptotic terms, leaving out the important aspect of network coding delay in non-asymptotic settings, i.e. with limited block length and limited number of combined packets. We also are motivated by real-time streaming applications, where the receivers must be able to decode packets and play out a stream before receiving large number of packets. Our first performance metric, the decoding delay, is defined as the number of time-slots between the first transmission of the encoding of the symbols and successful decoding at all the receivers. The second performance metric is in-order delivery delay of the symbols, which takes into consideration the order by which the symbols are delivered to the application layer after the decoding operation. Focusing on random linear network coding scenarios, we present a statistical characterization of decoding delay for non-asymptotic scenarios. The key idea of this characterization is to perform a brute-force search for all possible encodings, that is for a given number of packets, a given number of receivers and a given erasure pattern, we test all possible sets of linear combinations of symbols that can be sent in a given number of time-slots. The results show that the decoding delay distribution well fitted by a normal distribution, whose average value and variance depend on the considered scenario. The findings are useful for design purposes as it is now possible to optimize the network coding protocol with respect to average or worst case delay and also to define the required buffer size at the receivers.

Index Terms

network coding, statistical characterization, decoding delay distribution, in-order delivery delay