On Characterizing the Throughput Degradation for Network Coding with Two Sessions

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Abstract

The recent progress in network coding shows that for a single *multi-source multicast* session, namely when *all sinks* are interested in the same collection of information bits, the throughput of network coding is characterized by the classical min-cut max-flow theorem. However, when there are multiple sessions in the network, the attainable rate is generally less than the single session case and one does not know the precise characterization of the overall network throughput. In this work, a first step towards solving the aforementioned problem is provided by considering *two multicast sessions* for general directed acyclic networks. An explicit graph-theoretic characterization is provided for the feasibility of whether *two symbols* at different sources can be simultaneously multicast to *many sinks*, while some sinks are interested in only one source symbol. The existence of a routing scheme in such a scenario is equivalent to finding two edge-disjoint Steiner trees. It is proven in this work that the existence of a network coding scheme is equivalent to finding Steiner trees with controlled edge overlaps, and the characterization includes the well-studied butterfly graph as a special case. This Steiner-tree-based connection between network coding and traditional routing further enables new fully distributed, queue-length-based congestion control algorithms.