Bounds on the Throughput Gain of Network Coding in Unicast and Multicast Wireless Networks

Junning Liu, Dennis Goeckel, Don Towsley

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Abstract

Gupta and Kumar established that the per node throughput of ad hoc networks with multi-pair unicast traffic scales with an increasing number of nodes $n$ as $\Theta(n) = T(1/vn \log n)$, thus indicating that performance does not scale well. However, Gupta and Kumar did not consider network coding and wireless broadcasting, which recent works suggest have the potential to significantly improve throughput. Here, we establish bounds on the improvement provided by such techniques. For random networks of any dimension under either the protocol or physical model that were introduced by Gupta and Kumar, we show that network coding and broadcasting lead to at most a constant factor improvement in per node throughput. For the protocol model, we provide bounds on this factor. We also establish bounds on the throughput benefit of network coding and broadcasting for multiple source multicast in random networks. Finally, for an arbitrary network deployment, we show that the coding benefit ratio is at most $O(\log n)$ for both the protocol and physical communication models. These results give guidance on the application space of network coding, and, more generally, indicate the difficulty in improving the scaling behavior of wireless networks without modification of the physical layer.