Asymptotic Throughput and Throughput-Delay Scaling in Wireless Networks: The Impact of Error Propagation

Abstract:

This paper analyzes the impact of error propagation on the achievable throughput and throughput-delay tradeoff in wireless networks. It addresses the particular class of multihop routing schemes for parallel unicast that achieve a throughput scaling of $\Theta(n^{-\frac{1}{2}})$ per node in a network of n nodes. It is shown that in the finite-block-length case, necessitated by finite decoding memory at the nodes, the guaranteed per-node throughput in the network cannot scale better than $o(n^{-r})$ per node for any $r > 0$. This bound on the guaranteed per-node throughput is tighter than the $O(\frac{1}{n})$ bound shown previously. Instead of focusing on the probability of error for each link, which is intractable, an approach of bounding mutual information is employed to show tight results on the achievable throughput and throughput-delay tradeoffs. It is shown that for multihop transmission protocols, error propagation leads to significant changes in the tradeoff between the throughput $T(n)$ and the delay $D(n)$, compared to previous results. The best known scaling behavior is only $D(n) = \Theta(n (\log{n}) T(n))$ under maximum throughput scaling, where the block length required scales as $\Omega(\log{n})$. When decoding memory at nodes is constrained to be $O(\log \log n)$, the achievable tradeoff worsens to $D(n) = \Theta(n (\log{n})^2 T(n))$.