Cooperative Network Coding

Next Generation Technology for Today's Warfighter

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Abstract

Cooperative Network Coding **(CNC) is a novel technology that synergistically integrates *Network Coding* with *Cooperative Communications* to produce superior network reliability and provide inherent security features, while improving the throughput for a large class of networks including wireless sensor networks, satellite networks, and selected military networks.**

We investigated the effect of data-link feedback and retransmissions on the performance of wireless sensor networks using Cooperative Network Coding. Our preliminary investigation found that data-link feedback provides higher throughput for systems using Cooperative Network Coding when the number of nodes per cluster is relatively small and/or the connectivity of the network is low and/or the probability of transmission loss of a link is high. That is, Cooperative Network Coding with data-link feedback provides higher throughput when the network node density and connectivity is low (i.e., for sparse networks).

Motivation

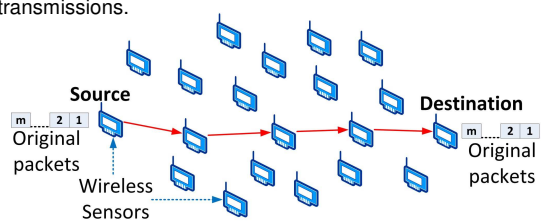
Classic Multihop / *Ad-hoc* Packet Networks

•In classic *ad-hoc* wireless packet networks, such as sensor networks, a path (a sequence of nodes between the source and the destination) is chosen and then packets are forwarded along the path.

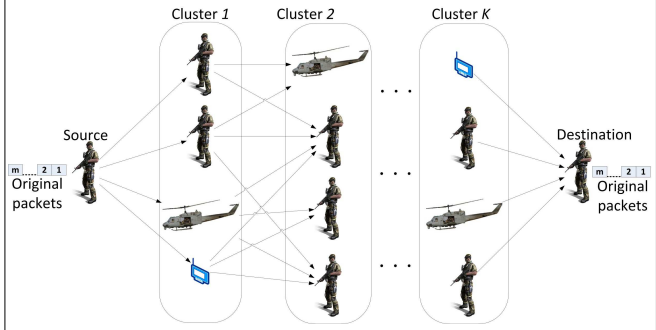
•If any packet is lost during the transmission, that specific packet can be retransmitted from the source node.

•The probability of successful reception of a multihop network is lower than the probability of successful reception of a single hop network.

•To combat the link-level packet loss and to avoid significant end-to-end throughput degradation, networks often use link-level retransmissions.



Cooperative Network Coding Model[a]



Operation

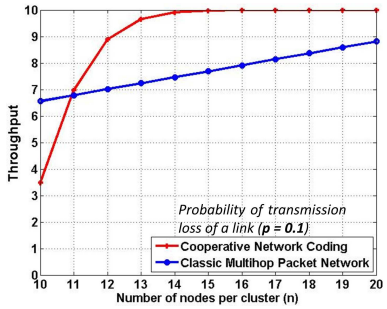
1.The source transmits combination packets towards the nodes in cluster 1. A cluster is (dynamically) formed by a group of nodes geographically located close to each other.

2.Nodes in cluster 1 create a combination packet from the received packets and transmit it towards the next cluster.

3.Nodes, in cluster 2 through *K*, receive the combination packets and act as MISO (Multiple Input, Single Output) nodes by receiving multiple combination packets and transmitting only one packet.

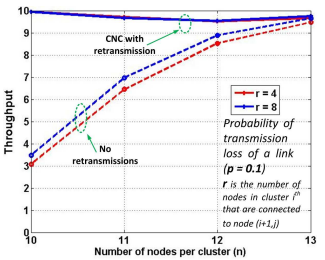
4.The destination receives combination packets from cluster *K* and decodes the original message.

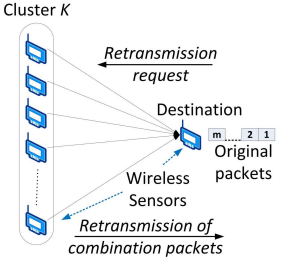
5.The sink must receive a minimum number of packets necessary to recover the original information.



Cooperative Network Coding with Data-Link Feedback[b]

Cooperative Networking with data-link feedback is implemented between nodes in the last cluster and the destination node.





Summary / Benefits

CNC has the potential to significantly improve the communication capabilities, such as (combat) situation awareness.

CNC is a feedforward technology, so that when packets are in error, it is quite likely that the other network paths have provided the necessary information for the destination node to recover the transmitted packets.

CNC has higher throughput compared to classic multihop nets.

CNC with data-link feedback can help to increase the network's performance without increasing the cluster size.

Research Directions

1. Evaluation of Cooperative Network Coding in practical scenarios.
2. Effects of mobility on dynamic behavior of the cooperative cluster nodes, capacity, and security.
3. Effect of non uniform link capacity on MANETs and sensor nets.
4. Investigate end-to-end delay due to network coding operations and cooperative communications.
5. Joint and Cross-layer Optimization of Cooperative Communication and Network Coding.

References

a. Z.J. Haas and T-C. Chen, "Cluster-based Cooperative Communication with Network Coding in Wireless Networks," IEEE MILCOM 2010, San Jose, CA, October 31 - November 3, 2010.

b. G. Arrobo, R. Gitlin and Z. J. Haas, "Effect of Link-Level Feedback and Retransmissions on the Performance of Cooperative Networking", submitted to WCNC 2011.