Study of Balanced Cooperative Coding Scheme for Linear Data Exchange Problem

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1. Introduction

In this paper, we consider a group of nearby wireless end devices such as mobile phones exchanging their packets with minimum total number of transmissions to fulfill the requirements of all members in the group. This problem can be solved by the linear solution in which each client transmits the linear combinations of the received packets. As the end devices rely on the limited energy resources, fairness among them will be a desirable property to avoid the battery of a certain device dies very quickly. We introduce a cooperative algorithm that will maintain the fairness among nodes by distributing the number of transmissions they make. In this algorithm, nodes intelligently change their turn to transmit a linear combination of the received packets to share the burden among the nodes within the group.

2. Problem Description and Related Work

A group of nearby wireless devices downloads packets from a same base station. We assume that some devices only receive a fraction of the packets because of the wireless link imperfection such as low bandwidth and noisy channel. Instead of requesting the lost packets to the base station from each device, they can share the packets they received to each other within the group by using the short-range link such as Bluetooth or Wi-Fi. Many research works showed that cooperation between nearby devices can give much benefits such as energy saving, bandwidth saving and low delay because the expensive cellular links are free for another users. We also assume that client devices are within transmission range of each other and they can communicate with one hop transmission over a short-range link.

By the linear network coding approach, the benefits of cooperation can even increase because many devices can gain from one coded packet transmission simultaneously. In this approach, a client device creates linear combination of its received packets and chooses one combination that will benefit the other peers. By its principle, the client with the maximum number of packets possesses, most of the time, the best combination that will increase the others. Reference [1] showed the lower and upper bound of the number of transmissions needed to satisfy other clients and they did not consider the fairness among the clients. It means that the client who possesses maximum number of packets will always make the transmission. If there are more than one candidate client, their scheme chose the next transmitter randomly.

This is the problem we want to solve in our algorithm to share the fairness among as many clients as possible. In [2], the authors used the unparking method by sending the access request message to turn the role of master and slave for transmission for the Piconet based distributed cooperative approach, which is similar to our problem.

3. Proposed Balanced Coding Scheme

In our approach, we do not need the control messages to change a client device from one role to another from time to time. Instead, we keep a table in every client which will save the information of which client has received which packets and the number of transmissions each client makes. After each round of coded packet transmission, every node updates its table and they can easily decide who should take turn for transmission in next round. This is possible because all nodes are within the one-hop transmission range and every node can hear the transmission from a peer. Moreover, each node should also take into account the number of transmissions each client has made so far for the transmitter selection in order to maintain the fairness among the clients.

4. Simulation and Discussion

We created a computer simulation in MATLAB to study the performance of our proposed scheme. We only used the finite elements from GF(2) to index each packet received or lost in each client for less complexity. We compare our scheme with the normal one that does not consider the balancing capability. The results of simulation show that our proposed scheme can significantly balance the burden of clients participating in cooperation. We used initial packet receiving probability 0.6, 10 packets and the number of clients participating in the group is 5.

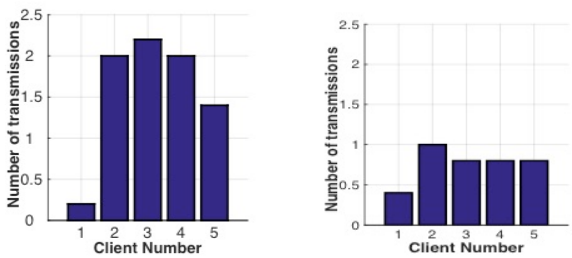

Figure 1. Number of transmissions before and after balance

References

[1] Rouayheb, S. Y. E., A. Sprintson, and P. Sadeghi, 2010, On Coding for Cooperative Data Exchange: CoRR, v. abs/1002.1465.

[2] Zhang, Q., F. H. P. Fitzek, and M. Katz, 2007, Cooperative Power Saving Strategies for IP-Services Supported over DVB-H Networks, IEEE Wireless Communications and Networking Conference, 2007.WCNC 2007., IEEE.

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