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| Description | |

# Study of Retransmission Protocol with Compute-and-Forward in Multi-Source Multi-Relay Network

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## Introduction

A PNC approach, compute-and-forward (CF) based on nested lattice codes (NLC) [1], linearly combines the block signals (codewords) of multiple sources that transmit their data simultaneously to the common receiver. For the application of CF in multi-source multi-relay network (MSMRN), the destination needs to correctly receive sufficient linearly independent combined codewords forwarded from the relays to recover the original packets of all sources [1]. If not sufficient, the retransmissions from sources are needed. The work in [2] manages the retransmissions by using the status of packet reception at the destinations. Our work aims to study the retransmission protocol in MSMRN where CF is employed by proposing a retransmission scheme where in addition to transmitting new packet with expecting that the unrecovered previous packets will be decoded in future round, the fairness between sources is also considered.

## System Model

This paper considers a simple MSMRN, two-source two-relay single destination. Each node is equipped with single antenna. We assume no loss in the the transmissions from the relays to the destination. Only the transmission from the sources to the relays are considered. Time synchronization and slotted time are assumed. Blocked and Rayleigh fading are assumed for each link. Only real channel coefficients are considered.

For each round, both sources encode their $M$ packets into NLC codewords and simultaneously transmit to the relays codeword by codeword. For the packets sent simultaneously, relay $l \in \{1,2\}$ computes the superimposed codewords of all sources to generate a linear combination of codewords, called combined codewords, with a combination coefficient vector $\mathbf{a}_l = [a_{1l}, a_{2l}]^T \in \mathbb{F}_q^2$ where $\mathbb{F}_q$ is a finite field with size $q$ and $\mathbf{a}_l$ is not zero vector. Only combined codewords that has computation rate region [1] higher than NLC coding rate $R = \log_2 q$ are forwarded to the destination, otherwise they are discarded. The destination can recover the original packets of both sources if it receives two forwarded linearly independent combined codewords, i.e., the matrix $[\mathbf{a}_1, \mathbf{a}_2] \in \mathbb{F}_q^{2\times 2}$ is full rank.

At the end of each round, feedback is sent by the destination to all sources via relays and orthogonal channel to inform the reception statuses of transmitted packets, recovered or not recovered, and which packets to be retransmitted. Recovered packets are kept to help recovering the other unrecovered packets. Feedback might be loss according the channel state. If a source does not receive the feedback, it re-sent the same packets. $\tau_f$ is denoted as the ratio of transmission time of a feedback to a slot time. In this paper, channel efficiency is defined as the ratio of the total number of recovered packets to the total transmission time in time slots.

## Proposed Scheme

A combined codeword which has $\mathbf{a}_l = [a_{1l}, a_{2l}]^T$ in form of unit vector, i.e., one of $a_{1l}$ and $a_{2l}$ is zero, is considered recoverable. For example, if $a_{1l}$ is non-zero, the correspondent packet of source 1 is recovered. If $a_{1l}$ and $a_{2l}$ are non-zero and both sources packets have not been recovered yet, one of source packet is expected to be recoverable in the future round after successful retransmission of the other source packets, i.e., when the event that matrix $[\mathbf{a}_1, \mathbf{a}_2]$ is full rank happens.

$r_1$ and $r_2$ are denoted as the instantaneous numbers of packets of source 1 and 2, respectively, that are recovered and expected to be recoverable. If $r_1 > r_2$, the number of packets that are expected to be recoverable is counted into source 2 if the case above happens, and it is counted into source 1 if $r_1 \leq r_2$. The destination informs the sources which packets are recovered and expected to be recoverable (all considered as successfully recovered) instead of only recovered packets. Each source retransmit the packets that are not successfully recovered and new packets.

## Conclusion

The proposed scheme is expected to improve the channel efficiency and the fairness between sources.

## References

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