Network Coding Scheme based on Selection of Number Input Packets in X-topology Network

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Introduction

Network coding is a scheme that a node is allowed to generate output packet in function of its input packets. There are two popular network coding methods: XOR and Random Linear Network Coding (RLNC).

Inter-session coding is mixing the packets from the different sessions. This approach can reduce the number of transmissions by taking advantage of information redundancy. Although XOR is simple and low complexity, but it is not suitable for erasure networks, then RLNC is preferred. RLNC is the general case of XOR. The output packet of RLNC is

$$p_{out} = \sum_{i=1}^{n} c_i p_i \tag{1}$$

where n is number of input packets, p_i is an input packet, c_i is a coefficient (for XOR, c_i is equal to 0 or 1).

Intra-session coding is mixing the packets from the same flow. Since RLNC could be counted as an end-to-end erasure codes, thus it is often used in intra-session coding to improve the reliability in the erasure wireless networks. However, RLNC introduces the computational complexity of encoding/decoding and coding vector overhead when the number of input packets is large.

This paper is to study the application of network coding in lossy wireless networks. We proposed a coding scheme applying intra-session RLNC and inter-session RLNC to reduce the number of transmissions and to lower the complexity and overhead introduced by RLNC in intra-session.

System Model

Considering a X-topology network as in Fig-1 below,

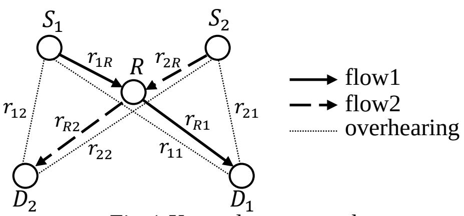

Fig-1 X-topology network

where $r_{1R}, r_{2R}, r_{R1}, r_{R2}$ are successful transmitting ratio of the links, and $r_{11}, r_{22}, r_{12}, r_{21}$ are successful overhearing ratio of the links. These ratios could be estimated by information attached with the acknowledgment (ACK) of the previous successful transmissions.

The source S_1 aims to send N_1 packets to D_1 and S_2 aims to send N_2 packets to D_2. Both flows intersect at R, which is assigned to forward packets of both flows.

Intra-session RLNC is applied at S_1 and S_2 and inter-session RLNC is applied at R. When the receiver (R or D_1 or D_2) could decode the coded packets received, an ACK is sent to the sender. Here, we suppose that all ACKs could be received successfully.

Proposed Coding Scheme

To reduce the total number of transmission, we need to define the number of packets n_1 ($n_1 \le N_1$) and n_2 ($n_2 \le N_2$) to pick from N_1 and N_2 respectively and to send from S_1 and S_2 respectively for each generation.

We roughly applied the concept of *transmission efficiency* from [1]. The number of transmissions on the broadcast link R to D_1 and D_2 is lowest when n_1 and n_2 verify the ratio:

$$\frac{n_1}{n_2} = \frac{\tau_{21R} + \tau_{R12} - 1 - \tau_{R12}\tau_{22R}}{1 + \tau_{R12}\tau_{12R} - \tau_{11R} - \tau_{R12}} \tag{2}$$

where $\tau_{11R} = \frac{r_{11}}{r_{1R}}$, $\tau_{12R} = \frac{r_{12}}{r_{1R}}$, $\tau_{21R} = \frac{r_{21}}{r_{2R}}$, $\tau_{22R} = \frac{r_{22}}{r_{2R}}$ and $\tau_{R12} = \frac{r_{R1}}{r_{R2}}$.

The values of n_1 and n_2 are chosen not to be too large. Our desired range is between 10 and 20. In the case that the values is too large, we divided n (n_1 or n_2) packets into various batches. The size of each batch, $\tilde{n}$ is:

$$\tilde{n} = \lceil nr^p \rceil + q \tag{3}$$

where p and q are integers chosen such that $\tilde{n}$ is inside the desired range and n is a multiple of $\tilde{n}$, and r is the successful transmitting ratio (r_{1R} or r_{2R}). The output packets are generated for each batch and sent to R. When the coded packets from a batch are decodable by the receiver, an ACK will be sent to the sender. After that, the sender will send the next batch until all batches are successfully transmitted.

Conclusion

We proposed a coding scheme, selecting the appropriate number of input packets, in order to reduce the total number of transmissions and the computational complexity of encoding/decoding and the coding vector overhead in intra-session RLNC. We hope that it could provide better performance in energy consumption and end-to-end delay, comparing to the scheme without network coding or the scheme simply applying RLNC.

Reference

[1] L. Hai et al, "R2NC: robust inter-session network coding in lossy wireless networks,"*in Communications, IET*, vol.9, no.2, pp.184-195, 22-01-2015