The effect of the encoded symbols with large degree in distributed fountain code

Zhi Jing, Inseon Kim, and Hong-Yeop Song

연세대학교

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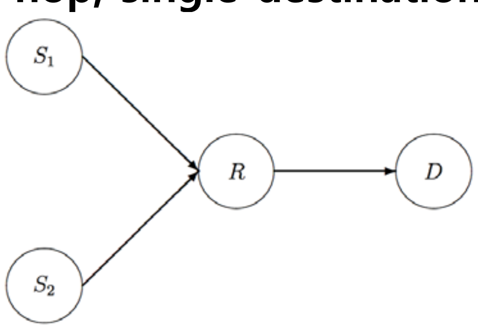
1. Introduction

- Fountain code were proposed to decreases the number of retransmission, and LT code was the first practical fountain code for one source and one destination.
- SLRC was proposed for the channel with more sources and more destinations. The performance is good at high overhead, but poor at low and middle overhead.
- In this paper, we focus on the encoded symbols with large degree to improve the performance at low and middle overhead in SLRC.

2. Soliton-like rateless coding (SLRC)[3]

- **Two-user, two-hop, single-destination system model**



- **SLRC protocol**

  1) LT coding at each source
  2) At relay, combining the encoded symbols by following:

  if $u \leq \lambda$ and any encoded symbol whose $degree < 3$

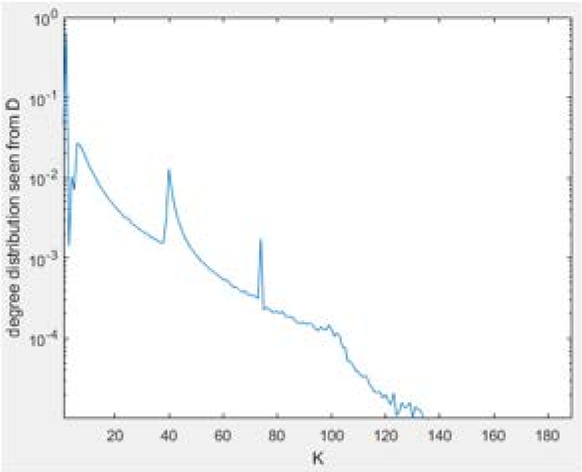
  forward that encoded symbol;

  else

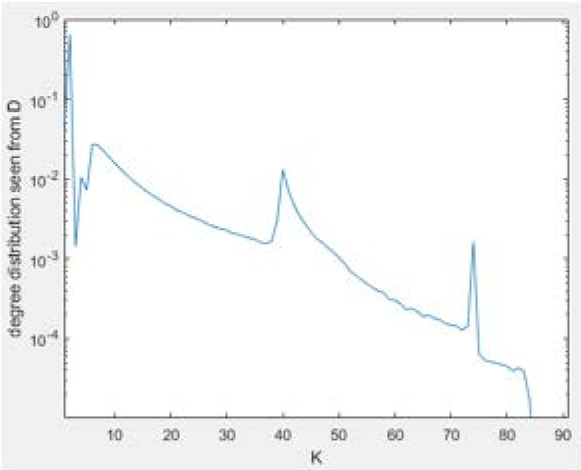
  forward the XOR the encoded symbol to the destination.

4. Simulation Result

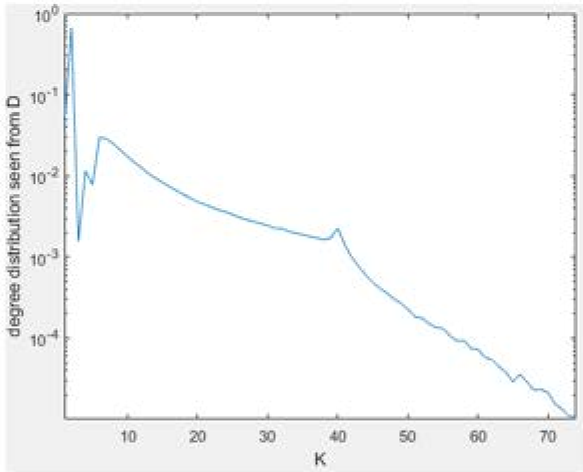
- $K = 100$, $\lambda = 0.95$.
- The degree distribution at overhead 20%:



(a) original SLRC



(b) Modified SLRC with $\alpha = 0.99$



(c) Modified SLRC with $\alpha = 0.95$

The degree distribution of modified SLRC is Soliton-like.

where u is uniform random variable on [0, 1] and λ is a constant;

- **Soliton-like distribution**

  1) $p_K(1) > 0$ for finite values of K that is the number of information symbol,

  2) $\lim_{K\to\infty} p_K(1) = 0$,

  3) $p_K(1) \ll p_K(2)$,

  4) $\lim_{K\to\infty} p_K(2) \geq 0.5$,

  5) $argmax_k\, p_K(k) = 2$,

  6) There exists an ordered set A of integers: $\forall x, y \in A$ and $|A| \geq 3$, $p_K(x) \geq p_K(y)$ if $x \leq y$.

3. Modification of SLRC

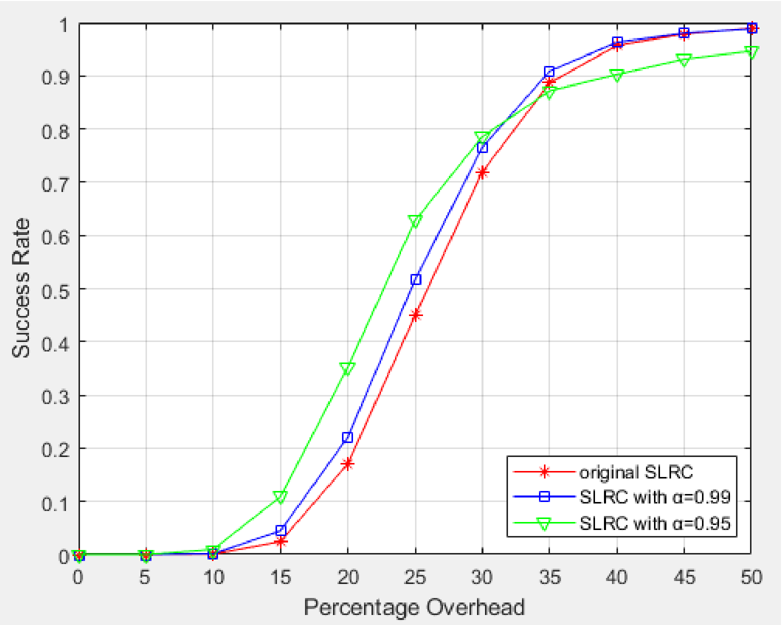
- The encoded symbol with large degree improves the probability of decoding failure at low and middle overhead.
- Want to reduce the maximal degree N at each source.
- Modified degree distribution $\mu(x)$ at sources:

$$\mu(x) = \begin{cases} p(x), & x = 1, 2, \dots, N-1 \\ \alpha - \sum_{x=1}^{N-1} p(x), & x = N \\ 0, & x = N+1, \dots, K \end{cases}$$

where

$$\sum_{x=1}^{N-1} p(x) < \alpha \leq \sum_{x=1}^{N} p(x)$$

- Success rate:



Success rate is improved at low and middle overhead; and decreased at high overhead.

Specially, approximately 18% increases at the overhead of 20% and 25%.

5. Conclusion

- The encoded symbol with large degree provides negative effect to decoding processing at low and middle overhead, and positive effect at high overhead.
- The future work is how to control the encoded symbols with large degree to increase success rate at different overhead.

Reference

[1] M. Luby, "LT Codes", *Proc. of 43rd Annual IEEE Symp. Foundations Comput. Science*, pp. 271-280, 2002.

[2] S. Puducheri, J. Kliewer, T. E. Fuja, "The design and performance of distributed LT codes", *IEEE Trans. Inf. Theory*, vol. 53, no. 10, pp. 3740-3754, Oct. 2007.

[3] A. Liau, S. Yousefi, K. Min, "Binary Soliton-like rateless coding for the Y-network", *IEEE Trans. Commun.*, vol. 59, pp. 3217-3222, Dec. 2011.