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Orthogonal feedback scheme for network coding

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ABSTRACT

Network coding is a promising technology to improve the throughput and reliability of networks. One critical factor that contributes to a distinct advantage of network coding in a dynamic network circumstance is the existence of a perfect feedback scheme. The current feedback schemes for network coding require special conditions to operate. However, the conditions are extremely hard to meet in practice. In this paper, we propose a novel and effective feedback scheme, orthogonal coded feedback (OCF), in order to avoid the defects of the existing feedback schemes for network coding. Based on our knowledge, this is the first attempt to incorporate orthogonal coding over a finite field into network coding for addressing problems of feedback in network coding diagrams. We establish a simple mathematical model for the feedback scheme, and a thorough analysis has been conducted based on the proposed model. Moreover, we design a simple code generating algorithm for orthogonal coding that can be used in any finite field. Our extensive simulations indicate that the proposed OCF outperforms the current feedback schemes in various network topologies.

1. Introduction

Network coding is a promising technique to improve network throughput and reliability. This technique was discovered by Ahlswede et al. (2000). Since 2000 it has attracted significant research attention. The core of network coding is to encode received data at intermediate nodes between the source and the destination. With the assistance of encoding at intermediate nodes, we can forward, store and encode incoming messages, which is different from the traditional forwarding only operation of an intermediate node.

Feedback scheme for network coding is a critical element for real applications. Jafarisiavoshani et al. (2007a, b) took advantage of feedback to becomes aware of the subspace and discover bottleneck in p2p networks. With the help of perfect feedback, Sundararajan et al. (2008) proposed an extension of the ARQ scheme for network coding, known as *drop-when-seen* algorithm. Similar mechanisms are explored further for use in congestion control and rate adaptation (Ho and Viswanathan, 2009; Eryilmaz and Lun, 2006; Ho et al., 2006). In wireless networks, relay nodes in COPE (Katti et al., 2008) select an optimal packet combination according to reception of the receiver in feedback packets.

However, how to feedback was not discussed in the previous works. Fragouli et al. (2007) tackled this problem for the first time. They used a vector with length N to denote feedback, and set 1 at element i and set 0 for the other elements for the ith receiver. Each intermediate node, upon reception of multiple feedbacks, performs XOR operations on these vectors, and sends the outcome to upstream nodes. Using a number of simple examples, the authors illustrated that feedback can be employed for parameter adaptation to meet QoS requirements as well as for reliability purposes. Moreover, Sundararajan et al. (2009) studied a mechanism that incorporates network coding into TCP . The heart of this mechanism is that receivers acknowledge each degree of freedom in TCP connections. Such a scheme enables a TCP-like sliding-window approach for network coding. Based on the information in feedback, some researchers can get the necessary degrees of freedom, while others can obtain a min-cut set of links in network (Chih-Chun and Xiaojun, 2009) for fast resource allocation. Besides, in wireless mesh network based on Opportunistic Routing (OR), Koutsonikolas et al. (2010) proposed a CCACK scheme, which overcomes drawback null-space-based (NSB) (Joon-Sang et al., 2006) coded feedback and improves both throughput and fairness.

There are some limitations in feedback schemes mentioned above. The *XOR coded feedback* (XCF) scheme, proposed in Fragouli et al. (2007) is the only one that can be used in practice. However, it works just as well in some special network topologies as a result of several limitations. The feedback scheme proposed in Sundararajan et al. (2009) only considers feedback in one TCP connection, and ignores the reception of other TCP connections in the same session. It is able to decrease the times of retransmission in one TCP connection but not in the overall network coding

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