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Global optimum encoding packet selection mechanism based on opportunistic network coding for wireless network retransmission

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Abstract

Packet loss cannot be avoided in wireless network due to wireless transmission medium particularity, therefore improving retransmission efficiency is meaningful to wireless transmission. The current retransmission packet selection mechanisms based on opportunistic network coding (ONC) face low retransmission efficiency and high computational complexity problems. To these problems, an optimized encoding packet selection mechanism based on ONC in wireless network retransmission (OONCR) is proposed. This mechanism is based on mutual exclusion packets and decoding gain concepts, and makes full use of ONC advantages. The main contributions of this scheme are to control the algorithm complexity of the maximum encoding packets selection effectively, avoid the redundancy encoding packets due to the overlapping among encoding packets, and take the encoding packet local and global optimization problem into consideration. Retransmission efficiency is evaluated according to the computational complexity, the throughput, the retransmission redundancy ratio, and the number of average retransmission. Under the various conditions, the number of average retransmission of OONCR is mainly lower than that of other typical retransmission packet selection schemes. The average retransmission redundancy ratios of OONCR are lower about 5%~40% compared with other typical schemes. Simultaneously the computational complexity of OONCR is comparatively lower than that of other typical schemes.

Keywords wireless network, retransmission, network coding, throughput

1 Introduction

Wireless communication is easy to be affected by multipath effect, signal interference, noise etc. Wireless communication has more serious transmission error and packet loss compared with wired network [1–3]. Therefore the reliable transmission has become the principal factor to restrict and affect transmission performance in wireless environment. The reliable transmission technology of wireless network consists of orthogonal frequency division multiplexing (OFDM) [4], multiple input multiple output (MIMO) [5–7], cooperative diversity [8–10], forward error control (FEC) [11–14], automatic repeat request (ARQ) [15–18], hybrid ARQ (HARQ) [19–21] and network coding (NC) etc. NC allows the nodes in the network to encode the incoming packets, and forwards the encoding packets, different from the traditional storage-forward mode. Receivers can recover the requested packets according to corresponding coding packet received and the original packets available, thus realize the maximum transmission capacity deduced by the max-flow min-cut [22–23].

NC technology is not limited to single user packet information to recover the lost packets, instead has taken all the packet information into consideration to recover the lost packets comprehensively, which is apparently superior to point-to-point transmission performance [24]. Therefore

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NC technology can recover multiple requested packets simultaneously, which can reduce the number of the retransmission to improve retransmission efficiency. NC technology permits the node to encode the multiple data, which can reach the theory upper bound of multicast.

Network coding can be roughly classified as random linear NC (RLNC) and deterministic encoding. To RLNC, the encoding coefficients are chosen from finite field randomly by the source node [25–27]. To deterministic encoding the encoding coefficients are decided according to the predesigned algorithm by the source node [28–30]. ONC is an important class of deterministic encoding [31–33].

2 Related work

Some classic packet selection algorithms based on ONC have been proposed for wireless network retransmission, such as random-pick [34], most-least [35], NC wireless broadcasting retransmission (NCWBR) [36], Hamming-distance [37], weight-pick [38], weighted ONC retransmission (WONCR) [39] and parallel NC retransmission scheme (PNCR) [40]. In random pick, base station (BS) randomly selects two requested packet to generate encoding packet to the receivers, although this mechanism is simple, but the performance improvement is poor, it has tiny superiority to traditional retransmission schemes. In most-least, BS selects the packet with the most requests and the packet with the least requests to generate the encoding packet. In Hamming-distance, BS selects the two packets with largest Hamming-distance to generate the encoding packet. Most-least and Hamming-distance can have better performance than random-pick, but the number of packets combined or encoded is predetermined and fixed as two. According to the simulation results, the number of packet combined has apparent impact on the final performance [34–36]. The best performance cannot be reached in these two algorithms in most case. In NCWBR, according to the packet distribution matrix (PDM), in each round select the first of ‘1’ of each column in PDM as the packet encoded to generate new encoding. The performance of NCWBR still has tight relationship with packet distribution. When there is more than one packet unknown in the encoding packet to the receiver the requested packet cannot be decoded, and the encoding packet will be deleted. In this case, the performance is declined apparently [36]. Furthermore, some improvement of NCWBR proposed still cannot solve some special case expect to ‘breaking cross relation’, and how to deal redundancy or overlapping among these encoding packets to generate effective encoding packets is still waiting for resolve [41]. NC based retransmission (CoRET) employs Hamming-distance packet selection method and supports multicast wireless broadcast. The goal of CoRET is to find the average optimal number of required packets to encode to achieve the best performance in different channel quality, and the general rule has been proposed [37]. Weight-pick has proposed dynamic combination number and updating lost packet status, but the performance of weight-pick is apparently dependent on the packet distribution, in the extreme status the performance of weight-pick is not stable. Furthermore, the algorithm proposed in original paper is not so cleared and comprehensive [38]. Weighted packet scheduling algorithm based on ONC is proposed for relay-assisted multicast by Gou Liang. This scheme has taken the link state into consideration, and according to weighted PDM (WPDM) to select the packets encoded. This method tries to find the effective encoding packets with maximum number of original packets, but which is based on the searching result of the encoding packet of two original packets encoded with maximum transmission achievement currently. But the local optimum and global optimum of encoding packet problem are not considered in this scheme [39]. PNCR is proposed by using the parallel mechanism to resolve the number of retransmission problem. This method tries to find the effective encoding packets, during the polling procedure when the packet in set Ω can encode with packets in several stable sets, only the packet in the minimum sequence number stable set is chosen [40]. The following problems are existed some encoding opportunity may be missed when the number of packets encoded is more than 2, and the global optimum problem is not considered.

In the view of above analysis, OONCR proposed in this paper is an effective encoding mechanism. The selection packet mechanism of OONCR is met with the precondition of decoding, OONCR can generate effective encoding packet that can ensure decoding required packets at the receivers. Furthermore, the number of packets combined is dynamically decided according to the packet distribution to get the higher decoding achievement, and there are not additional expenditures on updating packet distribution information. Furthermore this scheme has taken the