CodeCast: Network Coding Based Multicast in MANETs

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I. INTRODUCTION

A large scale, interactive and high quality multimedia distribution system is one of the popular Internet applications. As the bandwidth of the last-mile link grows and the technology of streaming evolves, assorted commercial peer-to-peer applications [1] have shown that current Internet has enough available bandwidth to support TV-quality streaming of 450-600 Kbps. However, none of the above peer-to-peer applications is designed for a more volatile network, such as lossy networks with wireless transmission, mobile networks with mobility churn, delay tolerant networks with intermittent Internet access.

Vehicular Ad-hoc Networks (VANETs) possesses all three characteristics. Park et al. [2] proposed CodeCast, a network coding based multicast protocol for mobile wireless ad hoc networks. This work aims at demonstrating the performance of CodeCast in a real environment. We implemented the network coding based protocol on top of the Click modular router [3]. The experiment results show that with up to 30% of artificial packet drop, the implemented CodeCast element can recover 91%~99% of lost packets. The significant improvement in the packet delivery ratio improved the quality of the video at leaf nodes by 1~4 dB PSNR (Peak Signal to Noise Ratio).

II. BACKGROUND: CODECAST

CodeCast is a multicast protocol for ad hoc network using network coding. The notion of network coding, which refers to performing coding operations on the contents of packets through a network, is generally attributed to Ahlswede et al. [4], who showed the utility of the network coding for multicast. The concept behind network coding is that instead of transmitting packets separately and independently, a sender transmits a linear combination of k packets, where k is the number of packets (or blocks) in a single generation in CodeCast. After receiving k packets with all linearly independent coefficients, the receiver can then decode and recover the contents of the original packet. Network coding is beneficial when packets are transmitted through multiple paths; more specifically, nodes receive packets from multiple intermediate nodes. Since all packets are coded to contain a linear combination of k packets, the receivers can then decode and recover the original content from any of k linearly independent packets.

III. SYSTEM IMPLEMENTATION

The network coding functionality is implemented in the Click modular router as an extended element. Server side and client side share the same element, and they are only distinguished from the script. The element first checks the source address of received packets. If the packets are from the local host, CodeCast element encodes them to generate coded packets. If the packets are from external IP addresses (i.e., received from intermediate nodes), the element will store them and tries to decode. If CodeCast element has received an enough number of packets to decode, it starts decoding and forwards the original data to local host. The element will broadcast a re-encoded packet whenever it receives a helpful packet that increases its rank for a given generation.

IV. DEMO SCENARIO AND RESULTS

We illustrate the topology used in the demo (a simple 2-hop and 4-node scenario). Node n_1 is the streaming server, n_2 and n_3 are intermediate nodes, and n_4 is the leaf node (these nodes display video in real-time) Although a real wireless network already has a certain amount of packet losses due to the channel fading and interference, we explicitly configure the packet drop rate from 0% to 30% to emulate a highly lossy wireless network. In our demo, all nodes are located in the same contention domain, but the leaf node is configured to drop the packet received from the server at the CodeCast element. The two intermediate nodes are allowed to receive from each other. We measured Packet Delivery Ratio (PDR) and Peak Signal to Noise Ratio (PSNR) with different number of blocks per generation. No coding corresponds to the case of single block per generation. Fig. 2 clearly shows that network coding significantly improves the performance. PDR and PSNR increase as the number of blocks per generation increases, and the packet drop probability decreases.
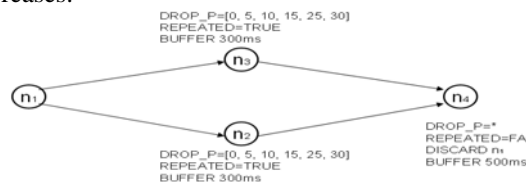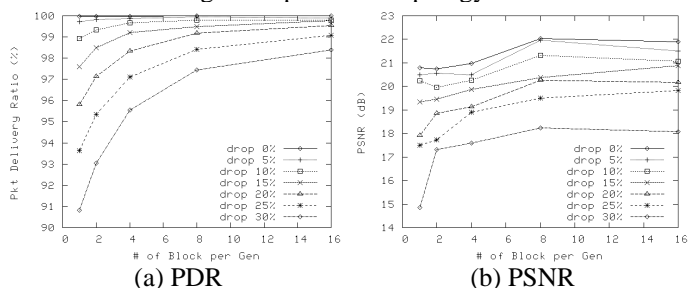

Fig. 1. Experiment Topology

(a) PDR (b) PSNR

Fig. 2. PDR and PSNR

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