Robust Multimedia Communications over Packet Networks

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Abstract

Multimedia communications over packet networks, and in particular the voice over IP (VoIP) application, have become an integral part of society. However, the unreliable and heterogeneous nature of packet networks has led to a best-effort delivery of services. Delay, limitation of bandwidth, and packet-loss rate all affect the quality of service (QoS). In this thesis, we address two important network impairments in the design of robust multimedia communication systems: packet delay-variation and packet-loss.

Paper A considers the mitigation of the effect of packet delay-variation for audio communications by introducing a buffer at the receiver side. A new adaptive playout scheduling approach is proposed to control the buffering length, or, equivalently, the packet playout deadlines, in response to varying network conditions. A Wiener process is used to model the fluctuation of the buffering length without any playout adjustment. The playout scheduling problem is then reformulated as a stochastic impulse control problem by taking the playout adjustment as the control signal. The proposed approach is shown to be the optimal solution to the new control problem. It is demonstrated experimentally that the proposed approach provides improved perceived conversational quality.

Papers B, C and D address the packet-loss issue. Paper B focuses on the design of a low-complexity packet-loss concealment (PLC) method that is compatible with existing speech codecs for VoIP application. The new method is rigorously motivated based on the autoregressive (AR) speech model and the minimum mean squared error (MMSE) criterion. The effect of model estimation error on the prediction of the missing speech segment is also considered and an upper bound for the prediction error is derived. Both the theoretical and experimental results provide insight in the performance of the heuristically designed PLC methods. On the other hand, Paper C and D consider an active packet-loss-resilient coding scheme, namely multiple description coding (MDC). In general, MDC can be used for the transmission of any media data. Paper C derives a simple and accurate approximation of the rate-distortion lower bound of a particular multiple description scenario and then demonstrates that the performance loss of some practical MD systems can be evaluated easily with the new approximation. Paper D studies the performance limit of a vector Gaussian multiple description scenario. An outer bound to the rate-distortion region is derived, and the outer bound is tight when the problem specializes to the scalar Gaussian case.