A Study of Two Equalization Techniques for Sparse Multipath Channels

by

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Abstract

Sparse multipath channels are wireless links commonly found in communication systems such as terrestrial broadcasting, underwater acoustic and cellular land mobile. Their impulse responses are characterized by a few significant multipath terms that are widely separated in time. With high speed transmission, the length of a sampled sparse channel can reach hundreds of symbol intervals, although the majority of taps in the sampled channel are near zero-valued. Classical equalizers thus become too complex for tackling these channels, as their complexity is either a linear or an exponential function of the sampled channel length. In this thesis, two low-complexity techniques are suggested for solving this problem.

First, nonuniformly spaced tapped-delay-line (TDL) equalizers (NU-Es) are examined. Analytical expressions that explicitly indicate the tap values and tap positions of infinite-length, symbol-spaced (T-spaced) TDL equalizers for sparse multipath channels are derived, and simple design rules for allocating taps to finite-length, T- and T/2-spaced, minimum mean square error (MMSE) NU-Es are formulated based on the derived results. This design-rule-based method demonstrates a better trade-off between accuracy and efficiency than existing tap allocation schemes. The resultant NU-Es also achieve a lower overall computational complexity than conventional, uniformly spaced TDL equalizers (U-Es) of the same span for both directly adaptive and channel-estimate-based implementations. The approach can be extended to design NU-Es in receive diversity systems.

The second solution is a turbo equalizer that utilizes a parallel-trellis framework for both its maximum a posteriori (MAP) equalizer and decoder. The framework allows a sparse multipath channel to be equalized with a bank of low-state trellises. With prefiltering, a broad range of sparse multipath channels can be tackled, including nonminimum-phase ones. Analogously, the framework is suitable for a class of convolutional and turbo codes with sparse generator polynomials. Use of these codes results in a low-latency, memory-efficient turbo equalizer, as the encoding structure of the codes partially integrates the interleaving operation, thus simplifies the interleaver design. Two generalizations of the parallel-trellis turbo equalizers to multiple-input-multiple-output (MIMO) systems have also been considered.