Chapter 1

Introduction

Trellis-coded modulation (TCM) [1] was proposed by Ungerboeck in 1982 for bandwidth-efficient communication over the additive white Gaussian noise (AWGN) channels. Since that, people believe that modulation and coding should be combined for improved performance. When transmitting over fading channels, a symbol interleaver is applied to improve the performance. However, TCM is also subjected to the limited diversity order [2] due to the minimum number of the distinct symbols along any error event. Later, It has been shown that the diversity order will be increased by using a bit interleaver over fading channels [3]-[5]. In [6], the author shows that iterative decoding can increase the minimum intersignal Euclidean distance of BICM. This is also important to AWGN channels. With the soft decoding and the "Turbo principle", BICM with iterative decoding (BICM-ID) performs very well over both fading and AWGN channels.

Extrinsic information transfer (EXIT) charts [7] have been analytical tools to study the convergence behavior of an iterative processing scheme for both serial and parallel concatenated systems. Traditionally, the convergence behavior of an iterative scheme just be observed by bit error rate (BER) analysis. If we want to know how the performance is improved by iterative processing, we can just run the simulations and observe the BER performance. Now, Brink said that the convergence behavior of an iterative scheme can be analysis by mutual information between extrinsic information and corresponding bits. Another advantage of EXIT chart analysis is that it needs not to run the simulation of the overall system. After we choose the constituent codes, such as the inner detectors and the outer decoders, we just need to analyze the individual code. Then we can predict the convergence behavior of the system. Compared with the BER simulations, EXIT charts are more efficient. In this thesis, we will use EXIT chart to design the BICM-ID system.

In BICM-ID systems, the choice of the mapping (labeling) is very important to achieve a high coding gain over the iterations. When the constellation size is increased, exhaustive search for the optimal labeling is impractical due to the high complexity. Several mapping are introduced in [5], but there is still no general design algorithm. In this thesis, we propose some methods to design the suitable labeling in BICM-ID systems for a given outer code. Simulations show that the performance will be improved very much after we choose a more suitable labeling.

For different requirements of the systems, we can adjust the coding scheme and labeling to achieve. By pruning away some of the possible state transitions in the decoding trellis, a determinate state convolutional code is formed [8]. It inserts some determinate bits (zeros or ones) into information bits before encoding. Due to these determinate bits we can pruning away some paths when decoding. This will result in the improvements on the performance. Besides, if we want to have higher code rate, rate-compatible punctured convolutional (RCPC) codes [9], [10] and and UEP turbo codes [11] can be employed. Designing “Trellis pruning” convolutional codes and punctured convolutional codes with EXIT chart is proposed in this thesis.

The rest of this thesis is organized as follows: Chapter 2 describes the system model. The calculations of the bit metrics in the BICM-ID system is depicted in chapter 3. In chapter 4, we introduce the EXIT chart. Labeling design is introduced in chapter 5. In chapter 6, the path-pruned convolutional codes and punctured convolutional codes in the BICM-ID system will be described. Finally, we give some conclusions and future works in chapter 7.