## Chapter 1

## Introduction

Convolutional codes were first introduced by Elias in 1955. He showed that redundancy can be introduced into a data stream through the use of a linear shift register. The resulting codes were very good to reduce the probability of erroneous transmission of information over noisy communication channels. The decoding can be done by exhaustive checking of all message sequences or by checking likely sequences. Among all of the decoding algorithms, Viterbi decoding algorithm and sequential decoding algorithm are two of the most importance.

Viterbi decoding is the most popular decoding algorithm for convolutional codes. It is in principle a maximum-likelihood (ML) decoding algorithm; that is, the decoder output selected is always the code word that gives the largest value of the log-likelihood function. However, because the Viterbi decoder uses an exhaustive search on a trellis, the complexity of a Viterbi decoder grows exponentially in proportion to the constraint length of the convolutional code. Consequently, it will become infeasible for codes with long constrain length.

In contrast to the drawback of the Viterbi algorithm, the sequential decoding algorithm is one with computational complexity being independent of the code constraint length. It's computational complexity is adaptable to the noise level. However, the sequential decoding algorithm is not an ML decoder, and therefore, is only suboptimal in performance.

Recently, Han and Chen proposed a new sequential decoding algorithm using a new metric based on a variation of the Wagner rule. As a consequence, a new maximum-likelihood sequential decoding algorithm (MLSDA) was established. If the

convolutional codewords are transmitted with equal prior probability, MLSDA can therefore achieve optimal reduction on transmission error probability. According to the MLSDA, we present a new VLSI architecture for the sequential decoder, which is named maximum-likelihood sequential decoder (MLSD).

In the design of a sequential decoder using stacks, the stack memory management is the most important issue. Paths stored in the stack memory must be sorted to find the best one until them can be further extended. This operation is very time consuming, and so the decoding speed of the stack algorithm is limited. Recently, Lavoie proposed a new type of systolic priority queue (Parallel Entry Systolic Priority Queue) (See Fig. 1.1) to replace the traditional stack memory management technique. The systolic priority queue doesn't arrange the metrics of nodes in order, but it can always deliver the node of best metric in a constant time. Furthermore, the systolic priority queue can operate much faster than the traditional technique. In this thesis, we refer to the priority queue to implement MLSDA and maintain the high decoding speed quality.

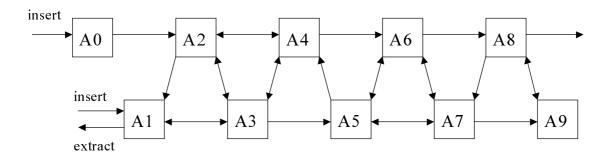


Fig. 1.1 PESPQ structure

All 1/2 convolutional codes may be treated as an equivalent 2/4 codes during the decoding phase if we combine two input bits as one unit. Consequently, we might have some advantage in VLSI implementation such as decoding speed; however, the

gate counts of decoder will be increased. In order to reduce the number of gates while we implement MLSDA for 1/2 (3/6) codes, we provides an advanced decoder architecture by modified the multiple-inputs systolic priority queue proposed by Kao.

This thesis is organized as follows. MLSDA is presented in chapter 2 and the original architectures proposed before for PESPQ and MISPQ algorithms are briefly described. The modified PESPQ and MISPQ algorithms to implement MLSDA are presented in chapter. 2. In this chapter, the structured architecture of the decoder is also introduced, with emphasis on the functionality of its modules. Simulation results on the average speed of decoding rate in different signal-to-noise ratio are provided to verify the superiority of the proposed designs. Conclusions are given in chapter 4.

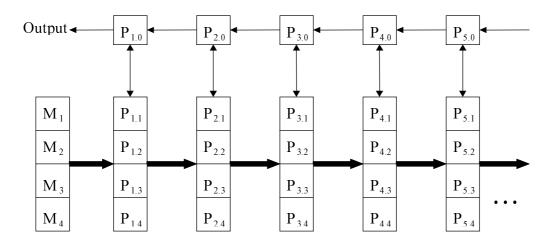


Fig. 1.2 Structure of MISPQ