Asian Journal of Applied Science and Technology (AJAST)
Volume 1, Issue 3, Pages 268-270, April 2017

Tree Search Based Fano Algorithm for Configurable Joint Detection and Decoding for MIMO Systems

A.Kalaivani[1] and R.Gomathi[2]

[1]*UG Scholar, IFET College of Engineering, Villupuram, Tamilnadu, India.*
[2]*Senior Assistant Professor, IFET College of Engineering, Villupuram, Tamilnadu, India.*

Article Received: 14 April 2017 *Article Accepted: 25 April 2017* *Article Published: 30 April 2017*

ABSTRACT

Multiple-Input Multiple-Output (MIMO) communication has been recognized as the technology of choice for contemporary wireless systems, due to its capability to significantly improve communication quality and efficiency. The Joint Detection-Decoding (JDD) scheme with convolutional codes has been proposed of designing efficient MIMO receiver structure. Specifically, the JDD architecture combines two significant blocks, i.e., MIMO detector and convolutional decoder, into one unit and can improve the BER performance. This paper aims to investigate the design trade-offs of the JDD/CJDD scheme resulted by tree search based Fano algorithm and to elucidate the optimal utilization scenario for different performance considerations. Specifically, the CJDD schemes will be implemented based on three tree search algorithms, breadth-first search, depth-first search, and Fano algorithm. Furthermore, performance metrics of timing efficiency, are complexity, and processing variability will be explored for these three algorithms respectively.

Keywords: Fano algorithm, Multiple-Input Multiple-Output and Tree search algorithms.

1. INTRODUCTION

JDD algorithm is examined the validity of every path in the tree based on the trellis structure of the encoder .the JDD algorithm has a significant drawback that it performs only when the number of output bits per trellis stage can be completely mapped to one node of the tree, such as 16-QAM with rate-1/2 or 64-QAM with rate-1/3 codes.

Joint Detection and Decoding Scheme (JDD)

In this separate structure, of the MIMO detector finds the shortest path and delivers the detected result to the decoder; the BER performance of this scheme is not optimal. The joint scheme requires only single tree search engine that performs MIMO detection and channel decoding procedures currently. MIMO detection and decoding of convolutional code concurrently for the system of 16-QAM modulation with rate-1/2 codes.

Configurable Joint Detection and Decoding Scheme (CJDD)

The essential concept of the CJDD approach lies in the Valid Symbol Finder (VSF) operation, which checks the state of channel encoder, generates valid output (coded) bits, and combines these valid output bits into valid symbols according to the modulation scheme and the code rate of encoder.

The CJDD-KB Algorithm

The K-Best (KB) algorithm lies within the class of breadth first approaches and sets up a threshold K where according to the path metrics, K best nodes as the survivors and discards others. At first, the starting point enters each states from survivor series into VSF algorithm. After the VSF algorithm returns output bits, next valid states, and all the path metrics, the returning metrics will be sorted with ascending order and only K best paths are survived. The advantages of CJDD-KB algorithm:

- Predictable,
- The memory usage and computing time can be estimated in advance

It does not guarantee finding the real shortest path in the tree structure and thus results in degraded BER performance. To be specific, the value of parameter K plays the critical role on the determination of performance and complexity.

- A small K results in severely degraded BER, although the utilization of hardware resources can also be reduced.
- A larger K improves the BER performance at the cost of degraded throughput as well as increased hardware complexity and power dissipation

The CJDD-DFS Algorithm

The typical DFS algorithm uses a threshold to determine which paths are promising or should be discarded.

At the beginning, the variable MIN is set as a threshold to store the smallest current path metric and the default value is infinite, in order to ensure that the first path metric can be successfully updated to the variable MIN.

The CJDD-DFS algorithm will send its encoder state into VSF to determined valid paths. After the path metrics are returned, the smallest path metric is identified and compared with the variable MIN. If the path metric is smaller than MIN, the algorithm will update the threshold and check whether the node from next L_v level(s) is the leaf node. On the other hand, when the path metric is larger than MIN, the index goes back L_v level(s) and discards this path permanently.

If the algorithm has checked all the tree structure and the index is back to the root, the algorithm will return information bits from the path with the shortest path metric MIN and end the algorithm.

Advantages

- The shortest path in the tree structure and thus results in the optimal BER performance.
- The CJDD-DFS algorithm greatly reduces the storage requirement, comparing to the CJDD-KB method.

Disadvantages

- It is difficult to predict the computation time
- Path is available at the end of tree search

2. PROPOSED SYSTEM

The CJDD-Fano Algorithm

The CJDD-DFS algorithm has a prominent drawback that it needs to traverse all the way down to the bottom of the tree and reverse back to the top level, where such lengthy traversing distance results in excessive delays and latencies. Its main feature is to perform threshold checking in different paths back and forth repeatedly. When all the path metrics in the tree structure are greater than the threshold, the algorithm will automatically increase the value of threshold until there is a path can pass it.

The main difference between the CJDD-Fano and CJDDDFS algorithms lies in the threshold adjustment strategy. The threshold of CJDD-DFS algorithm is updated ascending, while the threshold of CJDD-Fano algorithm can be increased or decreased in different situations.

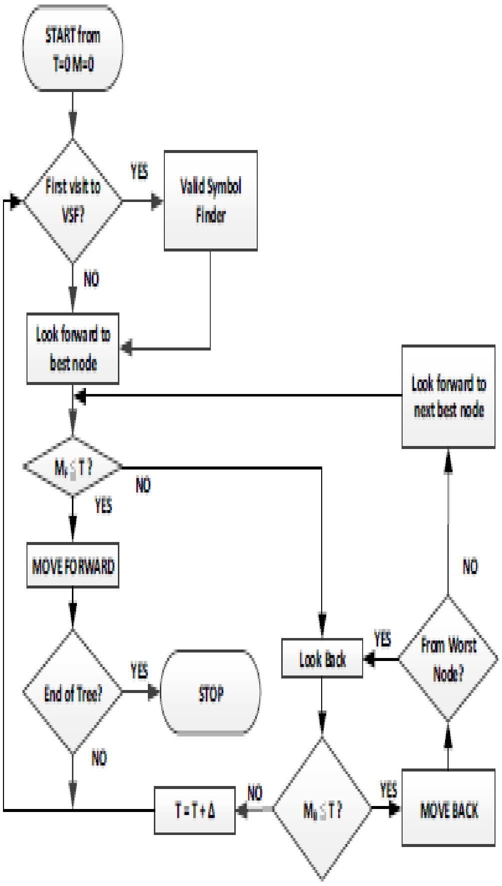

Fig 1. Fano algorithm of CJDD approach

3. CONCLUSION

This paper presented three CJDD algorithms based on different tree search structures. Specifically, we explicitly elucidate the advantages and disadvantages of each algorithm from the aspects of BER performance, computational complexity, area complexity, and run-time variations.

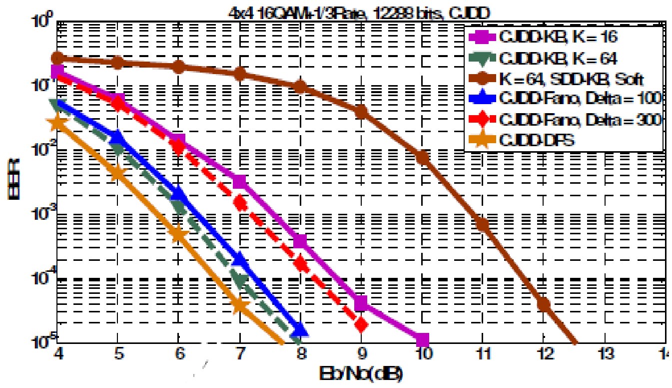

Fig.2. Comparison of BER performance

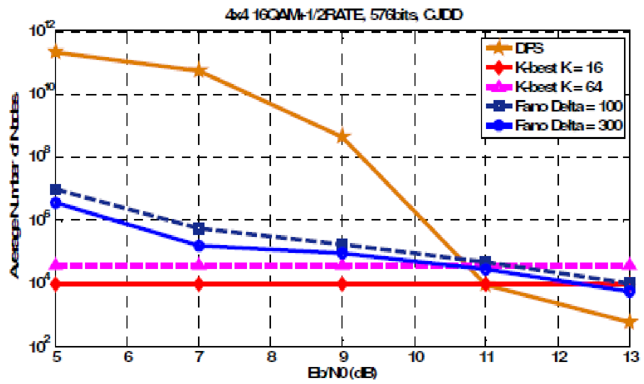

Fig.3. Comparison of search nodes

REFERENCES

[1] Chien-Hao Huang, Chia-Po Yu, and Chung-A Shen, *IEEE International Conference on Computing, Networking and Communications (ICNC)-2016.*

[2] F. Rusek, D. Persson, B. K. Lau, E. G. Larsson, T. L. Marzetta, E. O, and F.Tufvesson, "Scaling up MIMO: Opportunities and Challenges with Very Large Arrays," *IEEE Signal Proces. Magazine*, vol. 30, no. 1, pp. 40-46, Jan. 2013.

[3] E. G. Larsson, F. Tufvesson, O. Edfors, and T. L. Marzetta, "Massive MIMO for next generation wireless systems," *IEEE Communications Magazine*, vol. 52, no. 2, pp. 186-195, Feb. 2014.

[4] C. P. Sukumar, C.-A. Shen, and A. M. Eltanin, "Joint Detection and Decoding for MIMO Systems Using Convolutional Codes: Algorithm and VLSI Architecture," *IEEE Trans. Circuits Syst.-I*, vol.59, no.9, pp. 1919-1931, Sep 2012.

[5] A. Burg, M. Borgmann, M. Wenk, M. Zellweger, W. Fichtner, and H.Bolcskei, "VLSI implementation of MIMO

Volume 1, Issue 3, Pages 268-270, April 2017

detection using the sphere decoding," *IEEE Jour. Solid-State Circuits*, vol. 40, no. 7, pp. 1566-1577, July 2005.

[6] M. Shabany and P. G. Gulak, "A 675 Mb/s, 4×4 64-QAM K-best MIMO detector in 0.13 μm CMOS," *IEEE Trans. VLSI Systems*, vol. 20, no. 1, pp.135-147, Jan. 2012.

[7] M.-T. Shiue, S.-S. Long, C.-K. Jao, and S.-K. Lin, "Design and Implementation of Power-Efficient K-Best MIMO Detector for Configurable Antennas," *IEEE Trans. VLSI Systems*, vol. 22, no. 11, pp.2418-2422, Nov. 2014.

[8] S. Lin and D. J. Costello Jr., Error Control Coding. Englewood Cliffs, New Jersey: Prentice-Hall, 2nd Ed., 2004.

[9] F. Sun and T. Zhang, "Low-power state-parallel relaxed adaptive Viterbi decoder," *IEEE Trans. Circuits Syst. I*, vol. 54, no. 5, pp. 1060–1068, May 2007.

[10] F. J. Martin-Vega, F. Blanquez-Casado, F. J. Lopez-Martinez, G. Gomez, and J. T. Entrambasaguas, "Further Improvements in SOVA for High-Throughput Parallel Turbo Decoding," *IEEE Comm. Letters*, vol. 19, no. 1, pp. 6-9, Jan. 2015.

[11] C.-A. Shen, C.-P. Yu, and C.-H. Huang, "Algorithm and Architecture of Configurable Joint Detection and Decoding for MIMO Wireless Communications with Convolutional Codes," *IEEE Trans. on VLSI Systems*, [on-line access] May 2015.

[12] J. B. Anderson and S. Mohan, "Sequential coding algorithms: A survey and cost analysis", *IEEE Trans. Commun.*, vol. COM-32, no. 2, pp.169 -176, 1984.

[13] V. Y. Pham, Z. Lai, and T. T. Tjhoung, "Fano Detection Algorithm for MIMO Systems," *in Proc. IEEE Int. Conf. on Inform, Comm. & Sig. Proc.*, Dec. 2007.

[14] C.-A. Shen, A. M. Eltawil, K. N. Salama, and S. Mondal, "A Best-First Soft/Hard Decision Tree Searching MIMO Decoder for a 4×4 64-QAM System," *IEEE Trans. VLSI Systems*, vol. 20, no. 8, pp.1537-1541, Aug.2012.