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Improved Hybrid MIMO Detector for Spatial Multiplexing Operation

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Abstract: ***Amount of data transfer has been increasing extremely high and it demands the use of promising multiple-input multiple-output (MIMO) system that can achieve remarkably high spectral efficiencies. However, due to the rapid growth of users and antennas the system complexity increases, which is the main problem with the several existed detection methods. Further, achieving the quality of performance (QoP) with low power and low energy using re-configurable architectures is the real challenge. To meet this scenario, this paper proposes novel hybrid MIMO detection (BHAI) method to compromise the complexity and the hardware design challenges. The main aim is to design hybrid detection scheme to improve the suitability for hardware implementation without compromising the bit error rate (BER) performance. The proposed method combines conventional linear detection methods (ZF/MMSE) with the Fuzzy K-best detection for quality enhancement. One of these combinations will be chosen using Cognitive Selective Permutation (CSP) theory, which is Adaptive to the SM input parameters, to achieve high QoP parameters. Simulations are done for different antenna configurations (2×2, 4×4) and simulation results confirm that BHAI method consumes less hardware and power without affecting BER performance.***

Index Terms: ***hybrid detection, K-Best, minimum mean square error, MIMO, QoP, SM and LTE, zero-force.***

I. INTRODUCTION

MIMO communication plays a vital role for the better implementation of IoT applications due to its higher spectral efficiencies. The advent of IoT along with the MIMO communication techniques leads to the complex environment for decoding the signals, though it provides a path for different applications such as wearable implantable devices, defense, e-textiles etc. Hence intelligent MIMO decoders are required for supporting the MIMO Communication System in terms of reduction of Complicity, high performance with the greater Speed.

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The BHAI detector has been proposed to meet above mentioned criteria. This detector is designed using intelligent algorithm and works on different SNR level of thresholds.

This is implemented on different architectures such as the Programmable Reconfigurable FPGA along with the Application Cores

Section-II deals with the related existed hybrid detectors, Section-III deals with the Working mechanism of proposed BHAI Detector. Section-IV deals with the architecture of proposed detector. Performance analysis and results were given in section-V. Finally, concluding remarks given in section -VI.

II. RELATED EXISTED WORKS

The author [2] presented a grid factorization based MIMO channel estimation technique for complexity cut back. They outlined a strategy and actualized a MIMO receiver, which utilizes Xilinx Virtex™-4 FPGA for quick parallel handling. More accentuation is driven on the capacity to expand the equipment in a simple way if the framework requires equipment refresh.

The author [3] suggested a dynamic scaling technique for the modified Gram-Schmidt QR decomposition increasing the numerical stability of the fixed point outline. FPGA has implemented with multiplier sharing architecture and multiplier saving techniques. The outlined 4x4 straight MMSE MIMO identifier is fit for agreeing to the proposed IEEE 802.11n standard. The outline conveys more than 420 Mbps supported throughput, with a little 2.77 µ s latency.

The authors [4] implemented FPGA using a scheme known as low complexity and low latency interference cancellation scheme. By clearing the inter-Bit interference and inter-antenna interference this scheme gives improvement in the performance in different channels of an LTE/LTE-A uplink MIMO receiver. This results in less data storage, reduced integrated circuit area, and minimum feedback latency.

III. PROPOSED MIMO DETECTOR (BHAI)

The BHAI MIMO detector consists of following two different phases as shown in figure 1.

- Signal-to-Noise Ratio Calculator and Selector
- Hybrid Adaptive Permutation (HAP) Engine

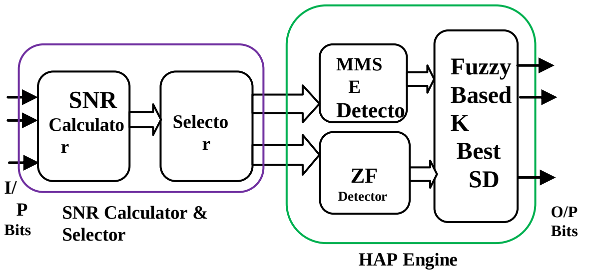

Fig.1: Block Diagram of Proposed BHAI Detector

Signal-to-Noise Ratio Calculator & Selector: This block consists of S/N Calculator & Selector sub-blocks. The Spatial Multiplexing inputs are considered for the proposed MIMO detector. SNR Calculator block calculates the S/N of incoming SM data bits and sends to the Selector sub-block. Selector sub-block compares the S/N levels with the threshold SNR level and selects the suitable detector as per following condition. If S NR level < SNR_THLD, ZF detector is selected, otherwise MMSE detector is selected. Accordingly, for each SNR preprocessed value, either one of the linear detector is selected to get the optimal solutions, which are suitable for the Fuzzy K-best Sphere decoding Stage in order to have the less dimension for the processing.

Hybrid Adaptive Permutation (HAP) Engine: This block consists of three sub-blocks: ZF Decoder, MMSE Decoder and Fuzzy K-Best Decoder. Accordingly, it consists of two hybrid engines: ZF with Fuzzy K-Best SD and MMSE with Fuzzy K-Best SD. These engines are selected based on the adaptive inputs of pre-processed SNR calculations as per the above condition. Depending on the selected hybrid engine, incoming bits are decoded either by ZF decoder or by MMSE decoder. In the next level, these bits are given to Fuzzy K-Best SD. Fuzzy rule set is applied, to intelligently select the initial radius of sphere and to dynamically upgrade the value of K, which gives high performance with very much reduced computational complexity.

Fuzzy Based K-Best Search: HAP engine incorporates the Fuzzy rule Sets and tree grows on as it reaches the optimal values.

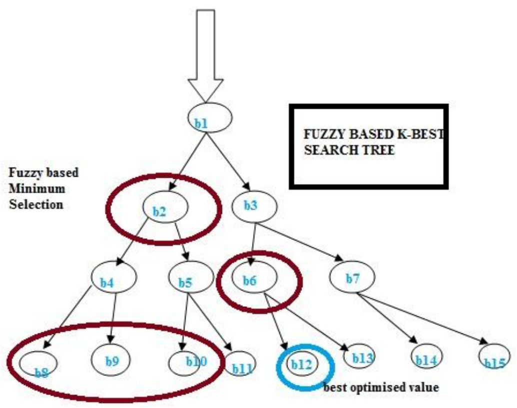

Fig.2: Fuzzy based K-Best Search Mechanism

IV. ARCHITECTURE OF PROPOSED DETECTOR

Implementation of ZF Detector IP CORE Unit:

ZF detector has been integrated as the IP Core with the usage of Pipelined Adders in terms of Multipliers. In this core Inverse Channel Matrix is implemented in the Input Channel Allocation buffers. Multipliers are replaced in terms of reusable adders with barrel shifters, which are area efficient.

Implementation of Fuzzy Rule:

The Fuzzy Rule Sets are implemented with the different thresholds, as the difference in PED values are large insense the partial solutions reaches the ML solution and K value remains to be small and vice versa condition is applied for this mechanism.

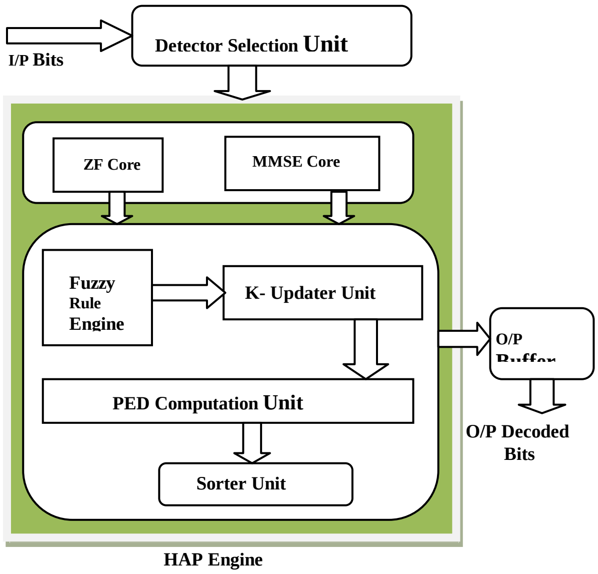

Fig.2: Architecture of Proposed BHAI Detector

K Best Decoding Process using Decoding Tree: Detection process begins at Root node, traverses breadth wise (left to right) in the forward direction from the level Nt to the level 1(bottom level),where leaf nodes were exist as shown fig.4.

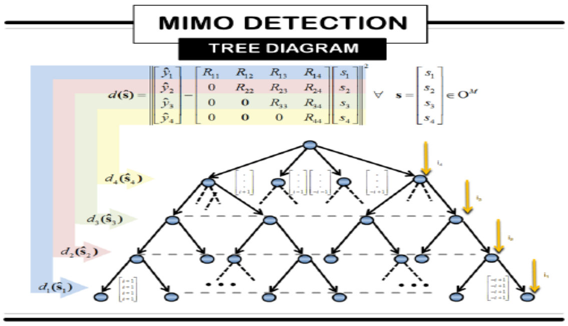

Fig.4: Decoding Tree

n this searching process, in any level, only after visiting all of its neighboring nodes, it traverses to the next level. At each level of the tree, this algorithm searches the PED's of all nodes (KM nodes in that level) in the forward direction (only) and prune all the nodes whose PED's are larger than sphere radius (r). Thereby sort out the remaining nodes in the ascending order based on their associated PED's and selects only the K-Best nodes (have lowest PED's) as surviving paths and only these nodes are expanded for the next level. The same procedure is continued until last level (Level 1) of tree is reached, which contain K Leaf nodes. Starting from last row of matrix R (corresponds to the level i= Nt), one symbol is detected.(i.e symbol transmission from antenna Nt is detected).

Based on this, next symbol is detected, in the immediate upper row of R (corresponds to the level i=Nt -1). (i.e symbol transmissions from both Nt and Nt -1).Thus starting from i=Nt , symbols are detected in the iterative manner. The objective of this algorithm is to non-exhaustively search the tree and find a leaf node with smallest PED, which corresponds to the estimated transmitted signal vector (i.e near ML solution).

Branch Metric or partial cost or partial distance metric cost: It is the distance (in Euclidean sense) between successive nodes and is calculated as

$$e_i(s^{(i)}) = \left| y_i - \sum_{j=i}^{N_t} r_{ij} s_j \right|^2 \qquad (1)$$

This equation (1) is common to all the children of a node under the consideration.

Cumulative Metric or PED: In order to perform the tree search, each node (in a level i) is associated with PED. It is the sum of all *branch metrics* accumulated when traversed from *root node* to a node in a level (i). This will be given as PED of nodes at level i is given as

$$T_i(s^{(i)}) = \sum_{i=1}^{N_t} \left| y_i - \sum_{j=i}^{N_t} r_{ij} s_j \right|^2 \qquad (2)$$

V. PERFORMANCE ANALYSIS

The performance of the proposed B-HAI detector has been evaluated based on the test bench designed with 2×2 MIMO with the different modulation techniques and with the AWGN channel. For comparative Analysis, the performance of the proposed B-HAI detector has been compared with the other hybrid detectors like MMSE+ZF, ZF + K-Best and MMSE + K-Best hard detectors.

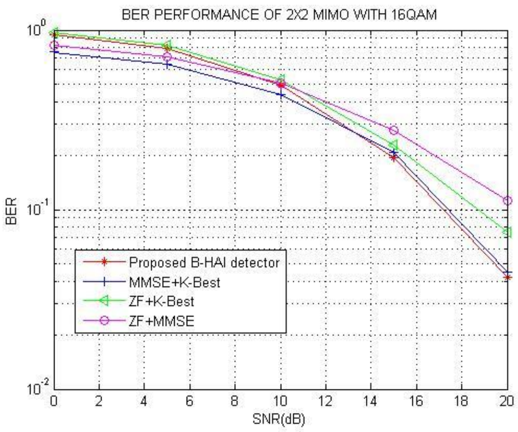

Fig.5: BER performance of B-HAI detector for 2×2 MIMO System with 16 QAM Modulation

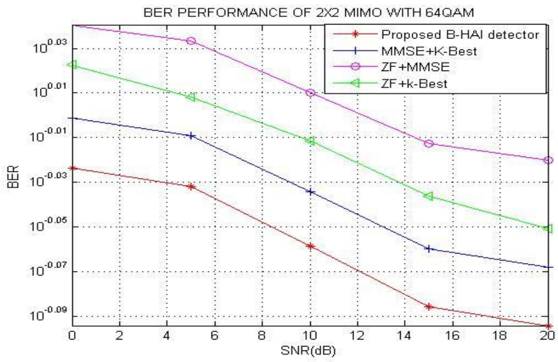

Fig.6: BER performance of B-HAI detector for 2×2 MIMO System with 64 QAM Modulation

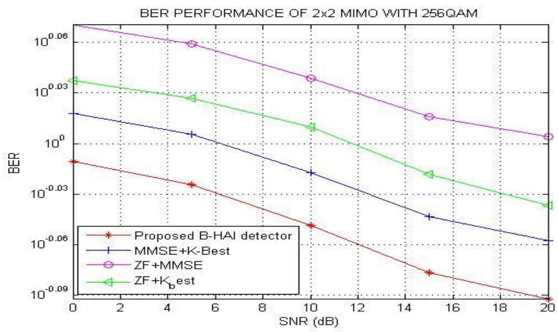

Fig.7: BER performance of B-HAI detector for 2×2 MIMO System with 256 QAM Modulation

VI. CONCLUSION

The proposed detectors outperform other combinations of the hybrid detectors in terms of Power, Throughput and BER performance. The designed detectors with the high throughput can be implemented in the Internet of things when it finds the applications of wearable implantable devices for monitoring the different body parameters of the users. These detectors with the Intelligence will lead to the Cognitive MIMO detectors which can be used as the pervasive and ubiquitous transceivers.

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