Efficient Signal Detection for MIMO-OFDM System

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Abstract. Recently, the multiple-input multiple-output (MIMO) schemes have been proposed as efficient solution for future wireless system. MIMO schemes can achieve a significant increase in the bandwidth efficiency as well as an improvement of the transmission reliability. In this paper, switching for the detection schemes based on channel condition is proposed in MIMO system. The QRD-M detection scheme has better performance and high complexity than the QRPIC detection scheme. Two detection schemes are efficient switched based on channel condition. Therefore the proposed detection scheme has little performance degradation, but it has low complexity.

Keywords: MIMO-OFDM, QR-decomposition, Switching detection

1 Introduction

The multiple input multiple output-orthogonal frequency division multiplexing (MIMO-OFDM) system can obtain high channel capacity and spectrum efficiency in wireless communication system. For high rate and high quality wireless communication services, MIMO-OFDM system is a promising solution. Therefore, a lot of signal detection schemes have been developed for MIMO-OFDM system[1].

In terms of the performance of MIMO-OFDM detection scheme, the maximum likelihood detection (MLD) scheme is theoretically optimal. MLD scheme has best BER performance, but it is not practical for its complexity. The complexity of MLD scheme is increased exponentially with the number of transmit antennas and the modulation order[2].

To reduce the complexity of ML detection scheme, a QR-decomposition based M algorithm (QRD-M) was proposed. The QRD-M detection scheme limits survived path in ML detection scheme[3]. Furthermore, the QRD-M detection scheme use QR-decomposition reducing calculation complexity. Therefore the complexity of the QRD-M detection scheme is lower than ML detection scheme with similarly performance.

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One of the other detection schemes of MIMO-OFDM system, QRPIC (Parallel Interference Cancellation using QR-decomposition) detection scheme was proposed. The QRPIC detection scheme also uses QR-decomposition reducing calculation complexity. The first stage of QRPIC detection scheme detects the first signal using QR-decomposition to improve accuracy. In the next stage detection, the sorted PIC detection scheme is run[4].

In this paper, a switching detection scheme based on channel condition is proposed. The proposed detection scheme has a threshold for switching detection scheme. Therefore, the proposed detection scheme has lower complexity than QRD-M detection scheme with similarly BER performance.

2 System Model

In this paper, we consider the MIMO system with M transmit and N receive antennas($M \leq N$). If $k$ is the number of subcarriers, the OFDM symbol of $i$-th transmit antenna is denoted as $x_i = [x_i(0), x_i(1), \cdots, x_i(k-1)]$. The OFDM symbols are simultaneously transmitted over $M$ transmit antennas. The received signal model on the $k$-th subcarrier can be written as

\[
\mathbf{r}(k) = \sum_{i=1}^{N} \sum_{j=1}^{M} H_{i,j}(k) \cdot x_j(k) + \mathbf{n}(k) = \mathbf{H}(k) \cdot \mathbf{x}(k) + \mathbf{n}(k)
\]

where $i$ and $j$ are receive and transmit antenna index respectively, $\mathbf{x}(k) = [x_1(k), x_2(k), \cdots, x_M(k)]^T$ denotes the $M \times 1$ transmit symbol vector, $\mathbf{r}(k)$ is the $N \times 1$ receive symbol vector and $\mathbf{n}(k)$ denotes the $N \times 1$ complex Gaussian additive noise vector. $\mathbf{H}(k)$ is an $N \times M$ MIMO channel matrix. Each element of $\mathbf{H}(k)$ is independent and identically distributed complex Gaussian random variables of equal variance.

3 Proposed Detection Scheme

The proposed detection scheme is the switching detection scheme based on threshold for channel condition. The threshold of the proposed detection scheme is calculated 1-norm condition number of channel matrix. The threshold $C_{TH}(H)$ is described as follows:

\[
C_{TH}(H) = \frac{1}{k} \sum_{i=1}^{k} C_i(H)
\]

where $C_i(H)$ is the 1-norm number of the $i$-th channel matrix. After setting the threshold, the receiver selects the high performance detection scheme for badly conditioned channels. The receiver selects the low complexity detection scheme for good conditioned channels.
4 Simulation Result and Conclusion

In this section, BER performance of the proposed detection scheme compared with conventional detection scheme is shown. In this simulation, high performance detection scheme is QRD-M detection scheme and low complexity detection scheme is QRPIC detection scheme. The channel model is Rayleigh fading channel and length of channel path is 5. The number of subcarrier is 128.

![BER performance of proposed and conventional detection schemes](image)

Fig. 1 shows the BER performance of the proposed detection scheme compared with conventional detection schemes with $M = N = 4$ and 16-QAM modulation. Complexity of the proposed detection scheme is less than the QRD-M detection scheme. Moreover the proposed detection scheme has similar BER performance with the QRD-M detection scheme. The complexity is calculated by multiplying operation. The number of multiplying operation of proposed detection scheme is about 69.5% of the QRD-M detection scheme.

As a result, the proposed detection scheme has low complexity than the QRD-M detection scheme with similar BER performance.

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References