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Conjoint Turbo Decoding with Low-Complexity Link Adaptation in Overloaded MIMO-OFDM System

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***Abstract*—A low-complexity link adaptation algorithm for maximizing the energy efficiency (EE) of MIMO-OFDM systems is presented in the paper. The third generation partnership project (3GPP) long term evolution (LTE) employs turbo codes as its forward error correction (FEC) standard to achieve an excellent error-correcting capability.In ideal MIMO system gratifying performance is obtained with the help of conventional turbo decoding scheme, but deterioration in performance occurs in overloaded case. Thus a joint turbo decoding scheme is also introduced in the paper. Higher throughput is achieved by implementing multiple –input multiple-output (MIMO) system in LTE. The proposed scheme estimates the Bit Error Ratio (BER), throughput and energy efficiency.**

Keywords: Link adaptation, overloaded MIMO-OFDM, Turbo Codes, Joint Decoding, energy efficiency, PER

I. INTRODUCTION

A typical multiple-input multiple-output (MIMO) system requires the number of receive antennas to be greater than or equal to the number of transmit antennas. After all the trend of increasing number of antenna elements in both transmitters and receivers, some mobile terminals might not be able to meet this ideal condition owing to limitations in their form factor. Thus, an overloaded MIMO system with the number of transmit antennas larger than that of receive antennas, is likely to become a general application in the near future.

Orthogonal frequency division multiplexing (OFDM) is an extensively used modulation and multiplexing scheme. It is wireless system with a large bandwidth and low complexity. Thus, the important accept of OFDM is the broadband technology. The basis for OFDM is the Multicarrier Modulation (MCM) system, a system with multiple sub bands and subcarriers are used through which a less or no Intersymbol Interference (ISI) is obtained MIMO system is one ofthe key solutions to realizing high-speed and reliable data transmission in wireless communications. Utilizing multiple transmit and receive antennas, MIMO systems can yield a significant improvement in capacity [1]. Hence MIMO systems have been adopted by the third-generation partnership project (3GPP) for use in the long-term evolution (LTE) standard.

In the proposed system a link adaptation method is introduced. In this method an estimation of channel parameters such as Bit Error Ratio (BER), throughput and energy efficiency respectively. Using this method a low complex system is obtained with less number of iteration.

In section II the related works is illustrated. Proposed system is described in section III. It is then followed by simulation result in IV. Finally, conclusions are presented in section V.

II. RELATED WORKS

An optimum performance in the error rate is provided by the joint maximum a posteriori (joint-MAP) detection-decoding in a turbo-MIMO system. But it has a very high computational complexity. Therefore, a more feasible decoding scheme for the turbo-MIMO system is required.The easiest approach to conduct turbo-MIMO decoding is by using separate processes for detection as well as decoding. In this approach, soft information from the MIMO detection block is sent to the decoding blocks. In each decoding block, turbo decoding is conducted independently to each transmitted stream [2]-[3]. In this paper, we are labeling this scheme as conventional turbo decoding.

The implementation of conventional turbo decoding on an overloaded MIMO system leads to the problem of significant performance degradation

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that occurs in the detection process [4]. This degradation in the performance significantly reduces the quality ofthe decoder outputs. Unfortunately,by increasing the number of iterations in turbo decoding this degradation cannotbe avoided.

To improve the decoding performance, information exchanges between detection blocks and the decoding blocks can be implemented. Hard information is used as the decoding feedback in [6]. Iterative detection and decoding (IDD) schemes, which employ soft information exchanges between those blocks, can be implemented [8]–[15] to increase the decoding quality even further. In these schemes, however, repetitive detection processes are required to generate updated soft information. Hence a low complexity detection algorithm should be used in these schemes. In [11]-[13], MAP-based detection algorithms with complexity reduction are employed. These algorithms, however, can only be implemented in thetypical MIMO system where the number of receive antennas is not less than that of transmit antennas.

In this paper, another scheme to improve the decoding performance of overloaded MIMO systems was proposed. Similar to the conventional turbo decoding scheme, the existing joint decoding scheme conducts the detection process only once, and removes the potential of the detection stage to become a bottleneck in the whole detection decoding process. But instead of conducting separate turbo decoding for each signal stream, this scheme conducts cooperative decoding between all signal streams. We call our proposed scheme joint turbo decoding.

III. PROPOSED SYSTEM

A. *Overloaded MIMO-OFDM with turbo codes*

Fig. 1 represents the block diagram of transmitting section of MIMO-OFDM system using N_T transmit antenna. A transmission through multiple antennas has a significant advantage over a single-antenna transmission with higher order modulation in terms of better spatial diversity. As a result, a transmission through multiple antennas gives more randomness, which is an important factor for obtaining good channel coding performance. In the case of overloaded system i.e. $N_T > N_R$, a systematic parallel concatenated convolutional codes with two 8-state encoders and one internal interleaver is the specification of the turbo code used here in the LTE system.

Before transmitting the output of the turbo encoding is given to the rate matching (RM) section.To support higher data rates the LTE provided a RM function. In the RM the bits are combined according to the 2^n format and then the bits are converted to decimal.

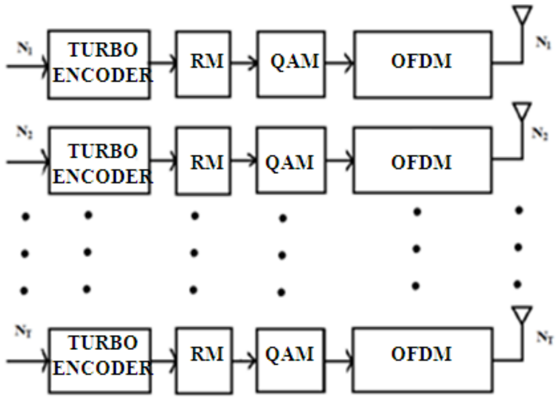

Fig.1. Block diagram of MIMO-OFDM system with turbo encoding

Later the RM outputs are modulated using the QAM/ PSK modulation. The next section is the OFDM modulation. It works on the principle of converting a serial symbol stream to a parallel symbol stream with each symbol from the parallel set modulating a separate carrier. The decimal data from the RM is converted to complex form in the OFDM section and is then transmitted through multiple antennas.

B. *Link Adaptation*

Link adaptation is introduced in the proposed system in order to avoid the drawback of the existing system that is increased number of iteration. In the case of existing system the iteration of turbo code has to be conducted till the BER threshold is reached. Hence to avoid the complexity and reduced iteration the proposed system is introduced.

In the proposed system a fading less path is found in order to provide an efficient transmission of data. Along with this the channel is estimated to evaluate the BER, throughput and maximized energy efficiency. Using this method a better BER, throughput and energy efficiency is achieved

C. *Joint turbo decoding*

Fig. 2 represents the block diagram of receiving section of MIMO-OFDM system with joint turbo decoding using N_R receive antenna. One of the powerful error correction code is turbo code and it's encoding scheme can be considered as concatenated convolutional codes.

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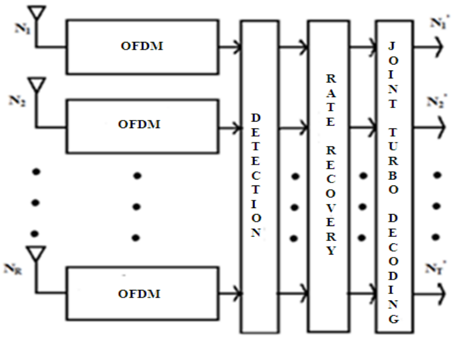

Fig.2. Block diagram of joint turbo decoding

Decoding of the Turbo code is obtained through the utilization of two soft-in soft-out (SISO) decoders. In the decoding section, one SISO decoder delivers the Log-Likelihood Ratio (LLR) information to another decoder, which uses this LLR to generate better reliable decoded information. Subsequently the second decoder sends its result back to the first one to refine the information therein. Such iterations of information exchange can be conducted several times for improved the signal quality.

Here in the receiver section, the transmitted data is initially passed through an OFDM demodulator. The output of OFDM contains the data with removed guard intervals. After the detection process the data is passed through the rate recovery through which it reaches the turbo decoder. Finally, the desired output data is recovered at the receiver section with less interference and loss of data.

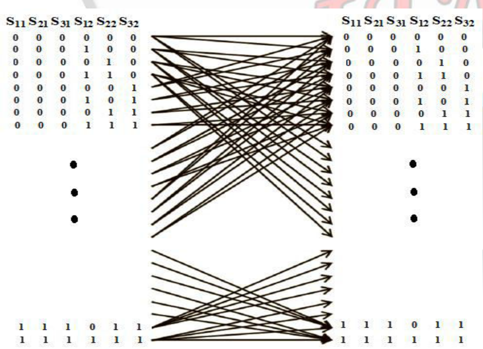

Fig.3. Super trellis diagram

However, instead of conducting separate turbo decoding for each signal stream, the proposed system conducts conjoint decoding between all signal streams. In addition to conjoint decoding, to combine thetrellis diagrams from all the streams, a super-trellis diagram are employed which is shown in Fig. 3.

TABLE I. Simulation conditions

Coding Scheme	Turbo codes, Rates: 1/3, 1/2		
Interleaver	4800, 2432, 1600, 1216		
Modulation	QPSK, 16QAM, 64QAM, 256QAM		
Multiplexing	OFDM		
Subcarrier Spacing	15 kHz		
Channel Bandwidth	2.5 MHz		
DFT Size/ Occupied Subcarries	256 / 151		
Sampling Frequency	3.84 MHz		
Cyclic Prefix	5.21 _s (first symbol) 4.69_s (six following symbols)		
Link adaption			
Transmit Antennas	2	3	4
Conventional Scheme	64	171	8 192
Proposed Scheme	8	8	8
Received antennas	2		
Channel Model	6-tap typical urban 18-tap Rayleigh fading		

IV. SIMULATION RESULT

Simulations have been conducted to verify the performance of the overloaded MIMO-OFDM and the proposed link adaptation technique in overloaded MIMO- OFDM system. Fig.4 indicates the transmitted signal and the received signal.

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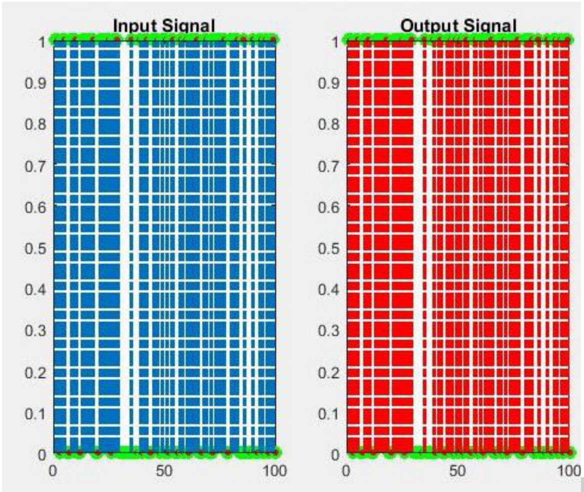

Fig.4. Input and output signal of conjoint turbo system

It is clear that the data loss is very less even after the reception. Thus the packet error rate is reduced using the proposed scheme. Also the system has improved throughput and maximized energy efficient.

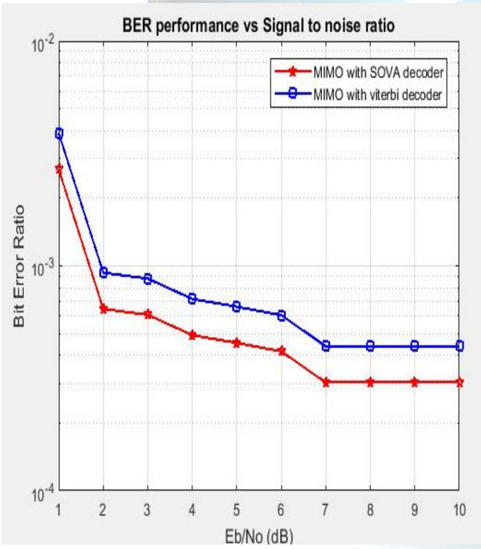

Fig.5.BER performance

Fig.5 shows the BER performance of the proposed scheme. The MIMO system with Soft Output Viterbi Algorithm (SOVA) which is usually used in the turbo coding shows better BER performance than the conventional system. However, the output signal obtained is almost similar to the transmitted signal as shown in Fig. 4, hence the system has a better throughput.

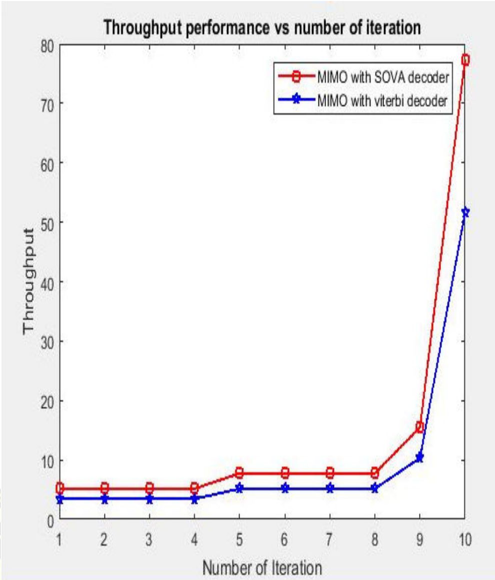

Fig.6.Throughput improvement

The throughput performance of the proposed system is depicted in Fig. 6. Thus, the link adaptation method improves the system throughput and maximizes energy efficiency.

V. CONCLUSION

In this paper, a joint decoding scheme for turbo codes, so called joint turbo decoding, has been proposed. In joint turbo decoding, calculations of soft information are conducted for each combination of bits from all streams instead of separately between each stream. In addition, the trellis diagrams of the encoders from all streams are combined using a super-trellis diagram. Link adaptation is introduced in the proposed system in order to avoid the drawback of the existing system. Using this method a better BER performance, throughput and energy efficiency is achieved.

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