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Using of MIMO-OFDM Technology in Radio Access Systems

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Abstract: This article describes a wireless communication system for multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) systems. Considered scheme is more efficient, for example, in cases of multipath propagation between two antenna systems. Channel parameters estimated by pilot signal, the encoded signal adapts to variations of signal propagation conditions. Simulation results show the effectiveness of using of dedicated bandwidth, compared to other methods.

Key words: LTE · Channel coding · MIMO · OFDM · Symmetric channel

INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is one of the promising candidates for future wireless access scheme due to its high spectrum efficiency, robustness to frequency selective fading as well as the feasibility of low-cost transceiver implementation [1, 2]. In OFDM, the data stream is split into many sub-streams and transmitted in parallel. Each sub-channel is chosen to be narrow enough to eliminate frequency selectivity.

Recently, the multiple-input multiple-output (MIMO) multiplexing has been shown to tremendously increase the spectral efficiency of the wireless communication systems [3]. In MIMO multiplexing, transmit data sequence is transmitted from a different transmit antenna at the same time with the same carrier frequency. Therefore, the total transmission rate increases in proportion to the number of transmit antennas without requiring additional bandwidth.

Wideband wireless radio access technologies attracts with its successful opportunities. MIMO-OFDM system, based on fast Fourier transform and coding algorithm is effectively used. This paper considers the possibility of reducing the complexity of conventional MIMO-OFDM systems in the case of symmetric channels.

This work proposes transmission scheme for the systems which use MIMO-OFDM. This transmission approach significantly reduces the complexity of conventional MIMO-OFDM systems in the case of symmetric channels. The principle of the proposed scheme is based on channel coding, which allows using estimated channel parameters, extracted from the pilot signal transmitted from the receiver end. Thus, the transmitted signal is thoroughly adapted to channel disturbance and variations.

In recent years, Orthogonal Frequency Division Multiplexing OFDM technique has attracted a lot of attention in the standardization of broadband wireless systems. OFDM technique is a multicarrier modulation technique with a rather simple implementation performed using FFT/IFFT (Fast Fourier Transform/ inverse Fast Fourier transform) algorithms and robust against frequency-selective fading channels which is obtained by converting the channel into flat fading subchannels [4]. OFDM has been adopted for various of transmission systems such as Wireless Fidelity (WIFI), Worldwide Interoperability for Microwave Access (WIMAX), Digital Video Broadcasting (DVB), Long Term Evolution (LTE) [5].

Combining OFDM with Multiple Input Multiple Output MIMO technique increases spectral efficiency to attain throughput of 1 Gbit/sec and beyond and improves link reliability [6]. MIMO concept can be implemented in various ways, if we need to use the advantage of MIMO diversity to overcome the fading then we need to send the same signals through the different MIMO antennae and

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at the receiver end, the different antennae will receive the same signals traveled through diverse paths. If we want to use MIMO concept for increasing capacity then we need to send different set of data at the same time through the different MIMO antennae without the automatic-repeat request of the transmission.

Theoretically, MIMO technique to be efficient the antenna spacing needs to be at least half the wavelength of the transmitted signal, even though, in some recent research this theoretical bound has been conquered and recently some broadband mobile phones support more than one antenna [6,7]. Efficient implementation of MIMO-OFDM system is based on the FFT algorithm and MIMO encoding, such as Alamouti Space Time Block coding (STBC), the Vertical Bell-Labs layered Space Time Block code VBLASTSTBC and Golden Space-Time Trellis Code (Golden STTC).

In this paper, a new transmission scheme for MIMO-OFDM systems is proposed. The new transmission approach reduces significantly the complexity of the conventional MIMO-OFDM systems for the symmetric channel. The principal of the proposed scheme is based on channel coding which make use of the estimated channel parameters extracted from a pilot signal transmitted by the destination receiver. Thus, the transmitted signal is very much adapted to the channel impairments and variations.

The paper is organized as follows. In section II, the conventional MIMO-OFDM system is described. In section III, the new transmission model is presented. In section IV, the performances of the proposed transmission scheme are analyzed via simulations and a comparative study with the conventional MIMO-OFDM system using Alamouti encoder is also conducted. Finally, conclusions are drawn in section V. Although formatting instructions may often appear daunting, the simplest approach is to use this template and insert headings and text into it as appropriate.

Conventional MIMO-OFDM System: The general structure of MIMO-OFDM system is shown in Figure 1. The proposed system consists of 2 transmits and 2 receive antennas. The OFDM signal for each antenna is obtained by applying the IFFT and can be detected using FFT [8]. A pilot sequence is inserted and used for the channel estimation. Also, a cyclic prefix is inserted in front of the OFDM symbol at the last step of OFDM modulation block. The time length of the cyclic prefix should be greater than the maximum delay spread of the channel. The main function of the cyclic prefix is to

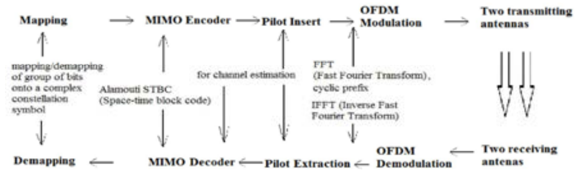

Fig. 1: MIMO-OFDM system model.

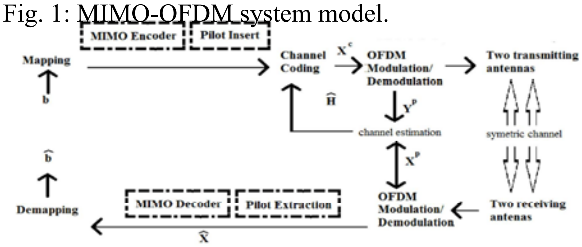

Fig. 2: Proposed MIMO-OFDM system model for symmetric channel.

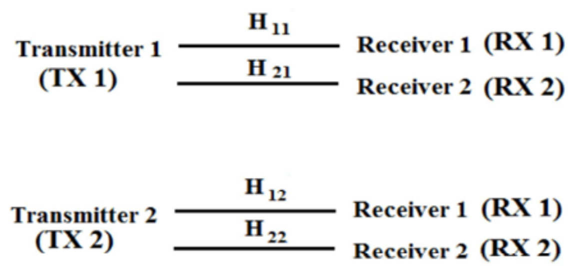

Fig. 3: MIMO channel model.

guard the OFDM symbol against Inter Symbol Interference (ISI), hence, this cyclic prefix is called the guard interval of the OFDM symbols. The MIMO coding can use several encoders such as STBC, VBLAST and Golden coding. In this paper, the conventional MIMO-OFDM system is implemented using Alamouti STBC with two transmits and two receive antennas.

New Transmission Model: The new transmission model is suitable for symmetric channels, such as the transmission between two base stations, microwave links, or radio beam transmission. The proposed MIMO-OFDM model is shown in the following Figure 2.

In this new MIMO-OFDM model, the channel parameters are estimated from a pilot data transmitted by the receiver end. These estimated parameters are used by a special channel coding block to adapt the transmitter signal to the diverse channel impairments and variations. To reduce the system complexity we have removed the pilot insert, the pilot extraction, the MIMO encoder and the MIMO decoder from the conventional MIMO-OFDM scheme. The channel coding is based on the channel variations, this channel in our case is between two transmit antennae and two receive antennae and it can be modeled as shown in the Figure 3. First, the receiver send a pilot signal to the transmitter, which can expressed as follows:

$$\begin{cases} Y_1^p = H_{11}.X_1^p + H_{21}.X_1^p + N_1^p \\ Y_2^p = H_{12}.X_1^p + H_{22}.X_2^p + N_2^p \end{cases} \quad (1)$$

Where:

X_1^p and X_2^p are the orthogonal transmitted pilot signals from the transmit antenna RX1 and RX2, respectively.

Y_1^p and Y_2^p are the received pilot signals on the receive antenna TX1 and TX2, respectively.

Y_1^2 and Y_2^2 are the received information at time slot 2 on receive antenna RX1 and RX2, respectively.

H_{ij} is the channel from j^{th} transmit antenna TXj to i^{th} receive antenna RXi, with i and j^{ϵ} {1,2}. N_1^p and N_2^p are the noise components on receive antenna TX1 and TX2, respectively. N_1^2 and N_2^2 are the noise at time slot 2 on the receive antenna TX1 and TX2 respectively.

Let us also define the pilot received signal Y^p:

$$X^p = \begin{bmatrix} X_1^p \\ X_2^p \end{bmatrix} \quad (1a)$$

the matrix channel H:

$$H = \begin{bmatrix} H_{11} & H_{12} \\ H_{11} & H_{12} \end{bmatrix} \quad (1b)$$

the pilot transmitted signal X^p:

$$X^p = \begin{bmatrix} N_1^p \\ N_2^p \end{bmatrix} \quad (1c)$$

and the noise vector N^p:

$$N^p = \begin{bmatrix} N_1^p \\ N_1^p \end{bmatrix} \quad (1d)$$

By using the above notations, equation (1) can be rewritten as

$$Y^p = H : X^p + N^p \quad (2)$$

In work [9] the channel parameters $\tilde{H}_{ij}$ are estimated as following

$$\begin{bmatrix} \widehat{H}_{11} & \widehat{H}_{12} \\ \widehat{H}_{11} & \widehat{H}_{11} \end{bmatrix} = \widehat{H}' = \begin{bmatrix} \widehat{H}_{11} + \dfrac{N_1^p}{X_1^p} & \widehat{H}_{21} + \dfrac{N_2^p}{X_2^p} \\ \widehat{H}_{12} + \dfrac{N_1^p}{X_1^p} & \widehat{H}_{22} + \dfrac{N_2^p}{X_2^p} \end{bmatrix} \quad (3)$$

$f\left(\left\|X_1^p\right\|^2 \text{ and } \left\|X_2^p\right\|^2 \square 1\right)$ then

$$\tilde{H}' = H' \quad (4)$$

Coded signal X^c given by

$$X^c = \tilde{H}^{-1}.X \approx H^{-1}, X \quad (5)$$

The received signal of the second time slot is given by the following equation

$$Y = H.X^c + N \quad (6)$$

The advantage of this channel coding is that there is no need to perform the channel estimation and MIMO encoding at the receiver, because going through the channel the received signal becomes

$$\begin{aligned} &Y = H.X^c + N = H.H^{-1}.X + N \\ &\Leftrightarrow Y = \tilde{X} \approx X + N \end{aligned} \quad (7)$$

So we can directly demodulate the received signal Y to find the estimation of the original transmitted symbol b (Figure 2).

RESULTS

The proposed MIMO-OFDM transceiver system is simulated using parameters shown in Table 3 [10-13]. These parameters are based on transmission between two base stations in LTE system.

In this part we are interested in comparing the proposed scheme with the conventional MIMO-OFDM system in the case of symmetric channel based on Alamouti STBC coding [14].

Figure 4 shows the variation of BER as a function of E_s/N_0. The proposed scheme has better performances than the standard MIMO-OFDM system. Besides the performance of this scheme, its complexity is low and there are no needs of complicate MIMO encoder or

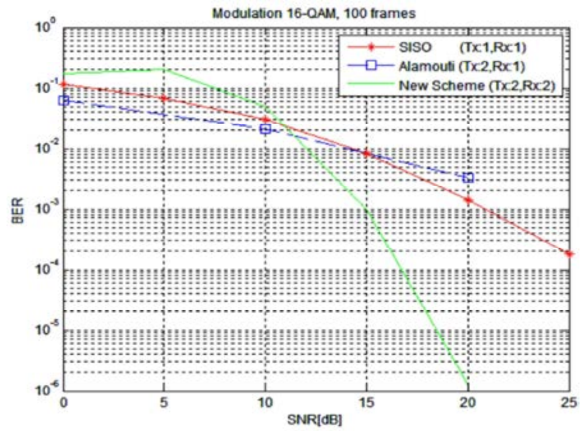

Fig. 4: Bit Error Rate as a function of Signal to Noise Ratio.

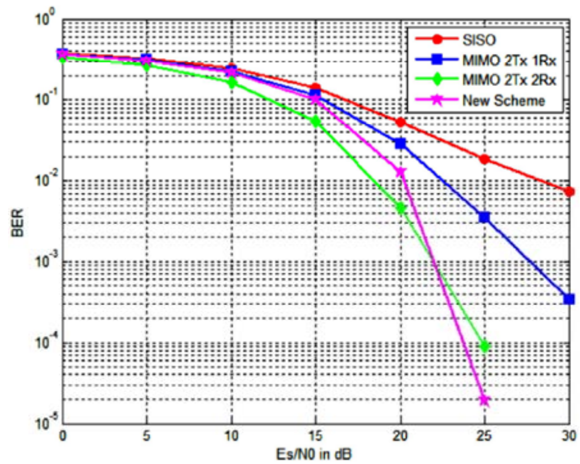

Fig. 5: Bit Error Rate as a function of Signal to Noise Ratio.

Table 1: Simulation Parameters

Parameters	Specifications
System	MIMO-OFDM
Constellation	16-QAM
T_s (µs)	72
f_c (GHz)	2.15
δf (KHz)	15
B (MHz)	5
Size of DFT/IDFT	512
MIMO encoder	Alamouti STBC (2Tx 2Rx)

channel estimation at the reception. In addition, to the simplification of the conventional MIMO-OFDM transceiver structure, bandwidth efficiency (also frame efficiency) can be highly increased.

Comparison Analysis: In the work [9] introduced a new signaling scheme with Multiple Inputs and Multiple Outputs MIMO system with Orthogonal Frequency Division Multiplexing OFDM with two base stations. Where to assess the quality of transmission was presented the graph showing the dependence of the signal to noise ratio (Figure 5).

Our resulting graph represented in Figure 4 in the case when there are two base stations, each base station includes one transmitter and one receiver.

From Figure 4 and 5, by comparing the characteristics of the main signal obtain improved performance in applying the modulator 16 QAM, i.e. characteristics is improved by about 20%.

Use of modulator 16 QAM, is convenient because it is cheaper and parameters satisfy the design and development of signal transmission systems with two base stations.

CONCLUSIONS

The proposed scheme is more efficient, for example, in cases of multipath propagation between two antenna systems. Encoded signal is adapted to signal variations on the use of the information of pilot signal. This approach can significantly reduce the complexity of conventional MIMO-OFDM systems, in the case of symmetric channels.

REFERENCES

1. Nee, R. and R. Prasad, 2000. OFDM for Wireless Multimedia Communications. New York and London: Artech House, pp: 260.
2. Park, S.R., Y.H. Jung and S.I. Lee, 2002. Low complexity symbol timing offset estimation schemes for OFDM systems. ETRI Journal, 24: 247-250.
3. Foschini, G.J. and M.J. Gans, 1998. On limits of wireless communications in a fading environment when using multiple antennas. Wireless Personal Commun, 6: 311-335.
4. Al-Naffouri, T.Y., K.M.Z. Islam, N. Al-Dhahir and S. Lu, 2010. A Model Reduction Approach for OFDM Channel Estimation Under High Mobility Conditions. IEEE Transaction on Signal Processing, 58(4): 2181 - 2193.
5. Chung, C., 2010. Spectral precoding for constant-envelope OFDM. IEEE Transaction on Communications, 58(6): 555 - 567.
6. Ketonen, J., M. Juntti and J.R. Cavallaro, 2010. Performance Complexity Comparison of Receivers for a LTE MIMO-OFDM System. IEEE Transaction on Signal Processing, 58(6): 3360-3372.

7. Lin, Z., P. Xiao, B. Vucetic and M. Sellathurai, 2010. Analysis of receiver algorithms for lte LTE SC-FDMA based uplink MIMO systems. IEEE Transaction on Wireless Communications, 9(1): 60-65.
8. Omri, A., R. Bouallegue, R. Hamila and M. Hasna, 2010. Channel estimation for LTE uplink system by perceptron neural network. International Journal of Wireless & Mobile Networks (IJWMN), 2(3): 155 - 165.
9. Omri, A. and R. Bouallegue, 2010. New transmission scheme for MIMO-OFDM system. International Journal of Next-Generation Networks (IJNGN), 3(1): 13 - 16.
10. Physical Channels and Modulation layer, 2009. 3rd Generation Partnership Project, Technical Specification Group Radio Access Network, TS 36.211, V8.8.0.
11. Base Station (BS) radio transmission and reception, 2009. 3 rd Generation Partnership Project, Technical Specification Group Radio Access Network, TS 36.104, V8.7.0.
12. Automatic Neighbour Relation (ANR) for UTRAN; Stage 2, 2012. 3rd Generation Partnership Project, Technical Specification Group Radio Access Network, TS 125 484, V10.1.0.
13. Layer 1 for interfaces supporting Multimedia Broadcast Multicast Service (MBMS) within E-UTRAN, 2012. 3rd Generation Partnership Project, Technical Specification Group Radio Access Network,TS 36.441, V11.0.0.
14. Wan, F., W.P. Zhu and M.N.S. Swamy, “A Signal-Perturbation-Free Transmit Scheme for MIMO-OFDM Channel Estimation,” IEEE Transactions on Circuits and Systems I, 57(8): 2208 - 2220, August, 2010.