Broadband MIMO relay network with phase control

#Atsuki Mizuno, Daisuke Uchida and Hiroyuki Arai
Graduate school of Engineering, Yokohama National University
79-5 Tokiwadai Hodogaya Yokohama, 10gd176@gmail.com

Abstract

In this paper, we proposed a novel MIMO relaying system with phase control in the relay node. In this proposed scheme, we enhance the depleted eigenpath of MIMO E-SDM transmission. We indicate the effectiveness of proposed method through computer simulation.

1. Introduction

Next generation of MIMO technology is required to construct a wireless communication infrastructure, and one approach is constructing relay networks[1]. A merit of relay network is efficient communication at the cell edge or dead zone with the low cost than base station networks.

Characteristics of MIMO transmission depends on the propagation channel. When we consider the 2x2 MIMO E-SDM (Eigenbeam-Space Division Multiplexing) transmission [2][3], the second eigenpath is degraded. Therefore, we control the propagation phase to enhance the degraded eigenpath in the relay node.

In this paper, we propose a broadband 2×2 MIMO OFDM relaying system with phase control, and we also apply the LTE standard. Through computer simulation, we indicate the effectiveness of proposed method.

2. Basic theory of proposed method

Characteristics of MIMO transmission depends on the geometry of transceiver. One of the transmission methods called E-SDM is used to prevent the wave interference at the receiver. E-SDM transmission makes the orthogonal independent path. However when we consider the 2x2 MIMO transmission, the second eigenpath is degraded. Therefore, we redeems the degraded eigenpath by the propagation phase control.

We can divide a 2x2 MIMO channel into amplitude and phase, given by (1),

$$\mathbf{H} = \begin{bmatrix} r_{11}(\cos\theta_{11} + j\sin\theta_{11}) & r_{12}(\cos\theta_{12} + j\sin\theta_{12}) \\ r_{21}(\cos\theta_{21} + j\sin\theta_{21}) & r_{22}(\cos\theta_{22} + j\sin\theta_{22}) \end{bmatrix} \tag{1}$$

and we assume $\phi=\theta_{11}+\theta_{22}-\theta_{21}-\theta_{12}$, second eigenvalue reaches maximum when $\theta=\pm 180^\circ$ [2]. Characteristics of the eigenvalue by the phase change in the different channels are shown in Fig.1 (a) and (b). In the case of E-SDM transmission, communication quality depends on the second eigenpath. For this reason, we control the propagation phase to enhance the degraded eigenpath and we indicate the detail steps. First, we can ignore the direct path from the transmitter to receiver, because we assume the poor condition. Under this assumption, all of the transmitted signals through the relay node. Therefore, we can divide a total MIMO channel into $\mathbf{H}_1$, $\mathbf{H}_2$, $\mathbf{H}_3$ as shown in Fig.2. And we replace the relay node with virtual channel matrix $\mathbf{H}_2$. Other channel matrices of $\mathbf{H}_1$, $\mathbf{H}_3$ are expressed by eqs(2) and (3),

$$\mathbf{H}_1 = \sqrt{\frac{K}{K+1}}\mathbf{H}_D + \sqrt{\frac{1}{K+1}}\mathbf{H}_S \tag{2}$$

$$\mathbf{H}_3 = \sqrt{\frac{K}{K+1}}\mathbf{H}'_D + \sqrt{\frac{1}{K+1}}\mathbf{H}'_S \ . \tag{3}$$

$$K = \frac{P_D}{P_S}$$

Where the K represents Rician factor, and $\mathbf{H}_D$, $\mathbf{H}_S$ represent direct and scattering wave channel, respectively. Next, the relay node detects the pilot signals transmitted from the both side. Previously relay node defines the ideal total channel matrix $\mathbf{H}_t$, therefore we can demand the ideal relay matrix, as given by eqs. (4),(5) and (6), respectively.

$$\mathbf{H}_t = \mathbf{H}_3\mathbf{H}_2\mathbf{H}_1 \quad (4)$$

$$\mathbf{H}_t = \begin{bmatrix} Ae^{j\frac{2}{3}\pi} & Ae^{j\frac{1}{6}\pi} \\ Ae^{j\frac{1}{6}\pi} & Ae^{j\frac{2}{3}\pi} \end{bmatrix} \quad (5)$$

$$\mathbf{H}_2 = \mathbf{H}_3^{-1}\mathbf{H}_t\mathbf{H}_1^{-1} \quad (6)$$

Under this information, the phase of the total channel matrix is controlled ideally by the relay node.

3. BER performance in different channels

In this section, we simulated the 2x2 MIMO OFDM relaying model, and we also apply the proposed method for LTE standard. We enhanced the communication quality for broadband. In the simulation, we calculated the characteristics of propagation phase (ϕ) for LTE band as shown in Fig.4 (a) and (b). In Fig.4, we can confirm that ϕ is converged around 0^0 without reference to rician factor.

We simulated the BER performance as shown in Fig.5 and 6, respectively. In the case of without relay node, BER performance is degraded in Nakagami-Rice fading than Rayleigh fading channel, because the second eigenvalue is more degraded in Nakagami-Rice fading channel. In the case of relay network, the communication quality is enhanced similarly. And when SNR=15[dB], we can enhance the BER for about 10[dB] and 4[dB] in Nakagami-Rice and Rayleigh fading channel.

Therefore, proposed method of propagation phase control is more effectiveness in Nakagami-Rice fading channel than Rayleigh fading channel.

4. Conclusion

In this paper, we proposed 2x2 MIMO relaying system with propagation phase control in the relay node. Proposed scheme is based on the characteristic of E-SDM system, and we applied the LTE standard.

We redeemed the degraded eigenpath by the propagation phase control in the relay node. Through the computer simulation, we can indicate the effectiveness of proposed method.

5. References

[1] K. Sakaguchi and N. Kusashima, “Channel Capacity of Basestation Cooperation Multi-user MIMO based on Block Diagonalization,” pp. 7-12, Nov. 2009.

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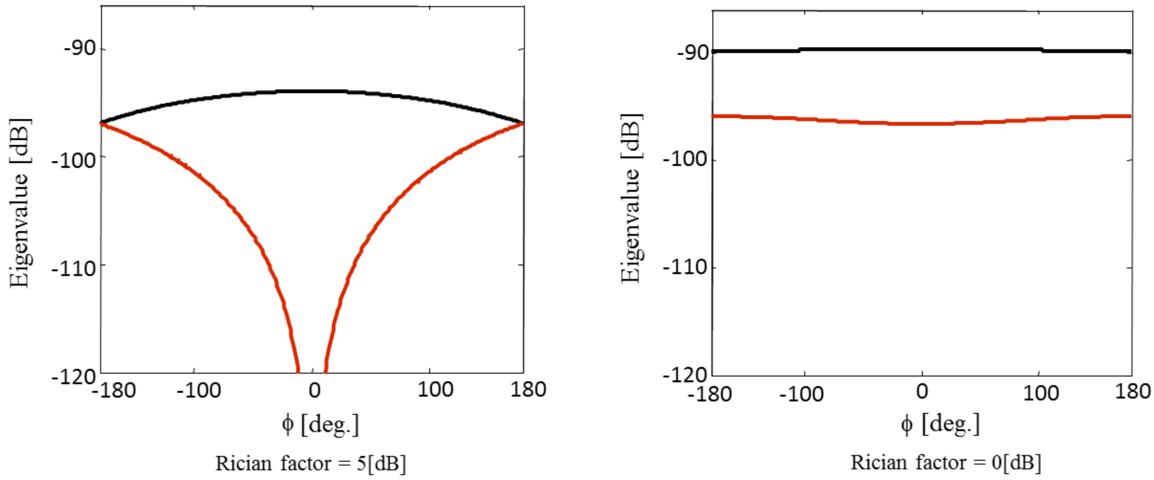
[3] R. Shimura and I. Sasase, “Transmit Phase Control to Increase the Minimum Eigenvalue of the Channel Correlation Matrix in the ETD System,” IEICE Trans. B Vol.J89-B No.3 pp.337-350 Mar. 2006.



(a) Nakagami-Rice fading channel (b) Rayleigh fading channel

Fig.1 Characteristics of Eigenvalue

1st eigenpath 2nd eigenpath

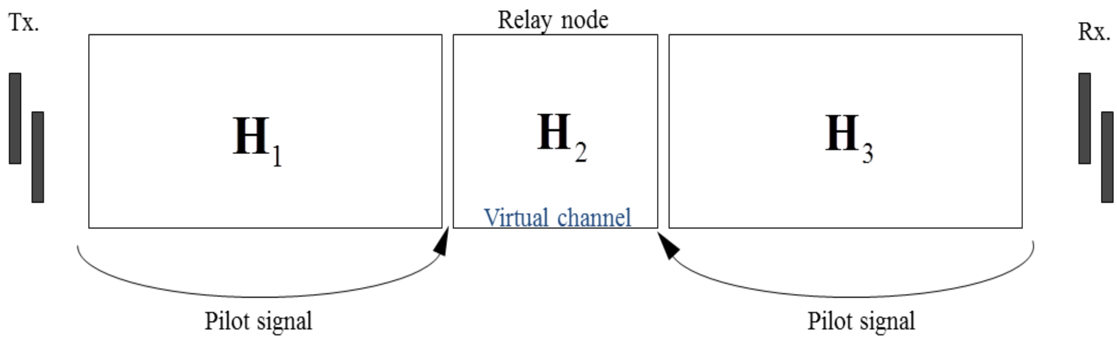


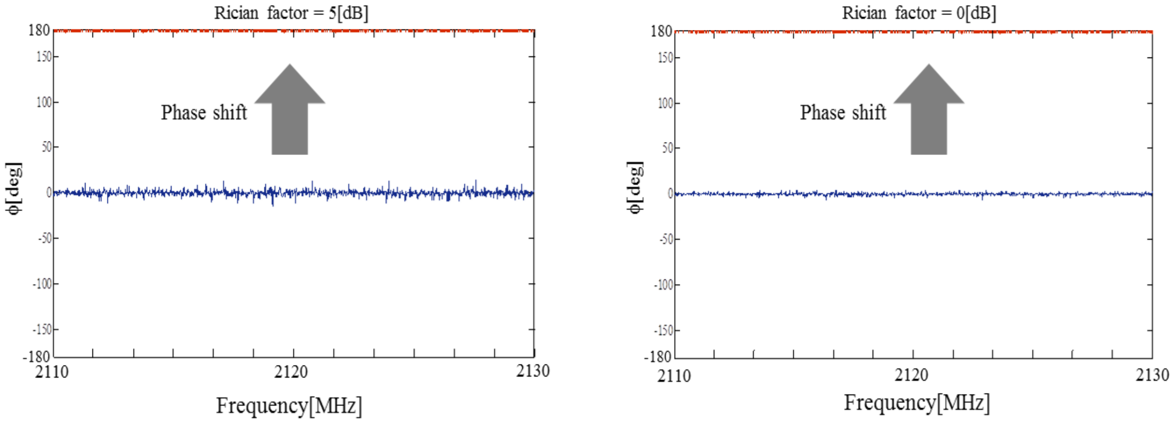
Fig.2 Channel model of 2x2MIMO transmission

parameters

situation : 2x2 MIMO transmission
transmission antenna : 2
receiving antenna : 2
relay node antenna : 4
Multiplexing method : OFDMA(Downlink)
Multiplexing scheme : FDD(Frequency Division Duplex)
Number of symbol : 1200

modulation method : 16QAM
transmission scheme : OFDM
Rician factor : 4 dB
propagation environment : Nakagami-Rice fading
subcarrier band : 15 kHz
Band width : 20 MHz
magnification of FFT : 2

Fig.3 Simulation parameters



(a) Nakagami-Rice fading channel (b) Rayleigh fading channel

Fig.4 Characteristics of $\phi(=\theta_{11}+\theta_{22}-\theta_{12}-\theta_{21})$ in the different channel

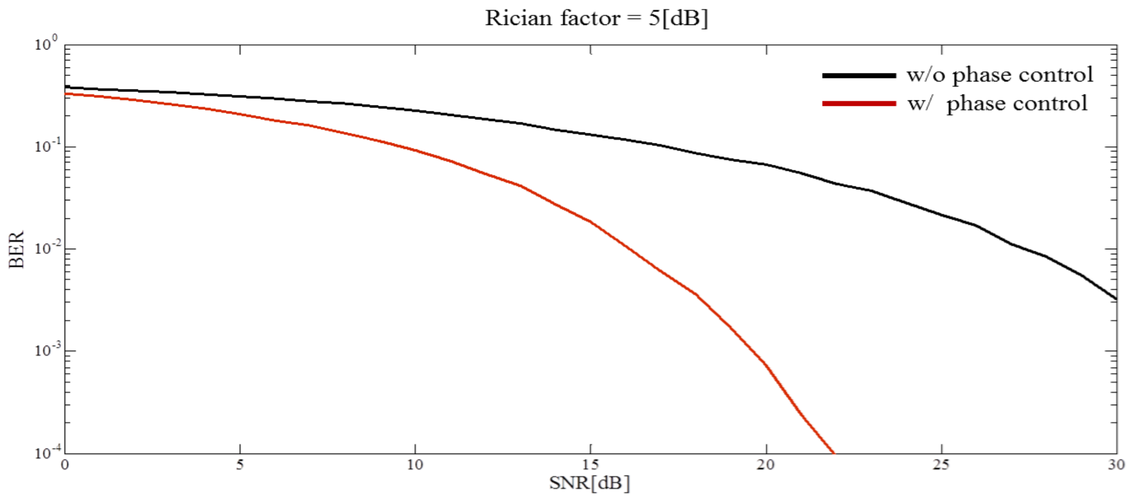


Fig.5 BER performance in Nakagami-Rice fading channel

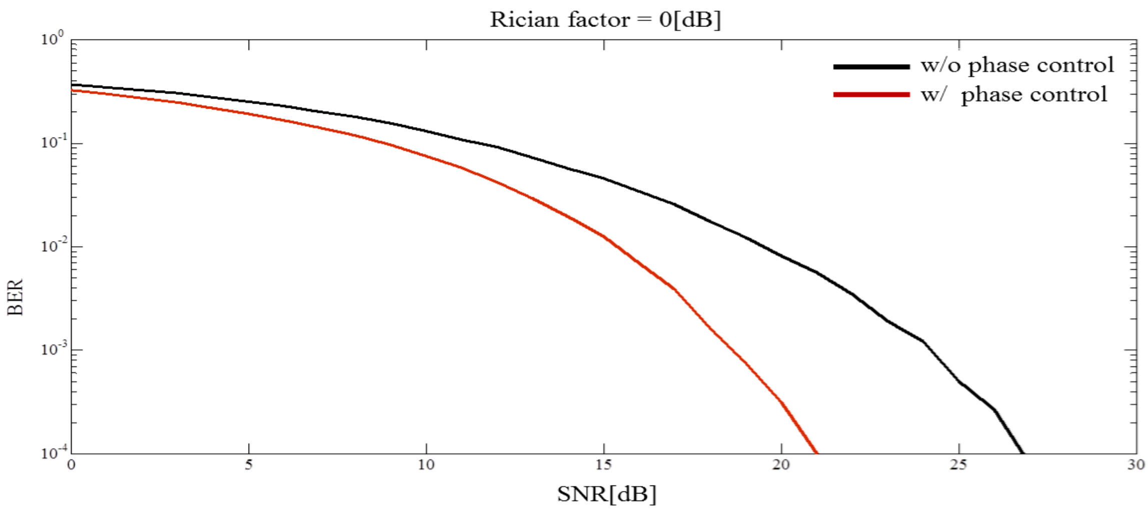


Fig.6 BER performance in Rayleigh fading channel