Adaptive Transmission Scheme with Precoding for Improved Performance in the Wireless Communication

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Abstract: - In the wireless communication system, the mobile station (MS) has a performance degradation by path loss and inter-cell interference (ICI) according to the MS's movement. Especially, the MS suffers from ICI by the unwanted signal of neighboring cell. This letter proposes adaptive transmission scheme according to the MS's movement in order to prevent the degradation of performance by path loss and ICI. The proposed scheme uses a cooperative communication and pre-coding scheme in order to improve the performance of the wireless communication system. When the MS is located in cell edge, the proposed scheme can reduce ICI by using coordinated multi-point (CoMP) and pre-coding. The proposed scheme can reduce a power of the unwanted signal by using the destructive pre-coding. Also, the destructive pre-coding does not cause the performance degradation of the MSs in the neighboring cell. The simulation results show that the proposed scheme can improve more a performance than the conventional scheme in the wireless communication system.

Key-Words: - cell edge, CoMP, cooperative transmission, SPC

1 Introduction

Recently, A high spectral efficiency, high reliability and high data rate are essential in the wireless communication systems. The requirement of high spectral efficiency can be satisfied by using multi-carrier modulation realized by a orthgonal frequency division multiplexing (OFDM) [1].

The requirements of reliability and data rate can be satisfied by using a multiple input multiple output (MIMO) system [2]. Because the MS has restrictions on the size and cost of device, installation of additional antenna for application of the MIMO system is difficult at the MS. But a cooperative communication can solve these problems. The cooperative communicaion does not have restric-tions on the size and cost of device. In cooperative communication, the MS is used as relay. Coorperative communication makes a virual MIMO system by using the other MS. Therefore, cooperative communication obtains diversity gain without additional installation of antenna. Additionaly, cooperative communication can obtain the improved diversity gain by using pre-coding scheme [3].

When a MS is located in cell edge, the ICI is caused by the unwanted signal of neighboring cell. So, the method that improve the performance of the MS in the cell edge has been studied. Coordinated multi-point (CoMP) is a cooperative communication between the base station. The CoMP is a method that aims to reduce ICI in the cell edge. The MS can communicate with more than one cell located in differnt points. The CoMP can improve the performance of the wireless communication system in the cell edge [4].

Spatial phase coding (SPC) is used in order to obtain the improved diversity gain. The SPC is one of the pre-coding scheme. The SPC modifies the phase between channel coefficients of mutiple relay. The chennel state information (CSI) is neccesary for the modification of phase. At the MS's receiver, the signals can be constructively superimposed by using the SPC.

This letter is composed as follws. Section 2 shows the system model in order to explain the proposed shceme. Section 3 explains the SPC. Section 4 explains the propsed scheme for the adaptive transmmision scheme with the cooperative communication and the SPC in order to imrprove the performance of the wireless communication. Section 5 shows the simulation resulsts of the proposed scheme. Section 6 is conclusion.

2 System Model

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In this section, the system model of the proposed scheme is explained. The system model is cooperative communication based on OFDM. The system model is composed of two adjacent cell. Fig.1 shows system model of the proposed scheme. The BS_1 and BS_2 refer to base station. The $H_{i,j}$ refers to channel coefficient in the left cell and $H'_{i,j}$ refers to channel coeficient in the right cell. The case is determined according to the distance from the base station. The constructive SPC applies to the dotted lines and the destructive SPC applies to the dash line. The CSI for SPC can be obtain through channel estimation. The channel estimation is assumed to be perfect. All the MS can be used as relay and the relay uses decode and forward (DF) cooperative communication method. The signals suffer from path loss. The case 1 is that the MS is close to the base station. The case 2 is that the MS moves away from the base station. The case 3 is that the MS is located in the cell edge. If the MS is located in case 3, the receiver of MS suffers from ICI caused by the unwanted signal.

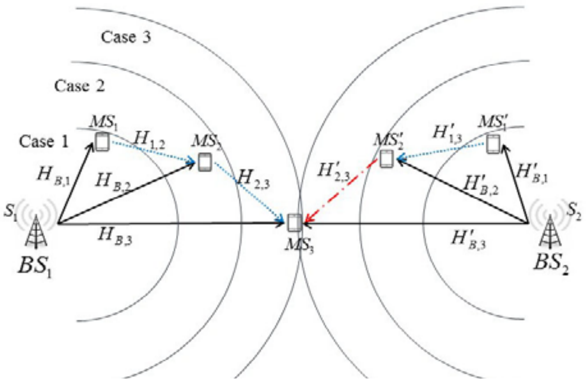

Fig.1 The system model of the proposed scheme

3 Spatial Phase Coding

The pre-coding scheme can obtain the improved diversity gain. The SPC belongs to pre-coding scheme. The pre-coding vector is determined depending on the relation of the channel coefficients. The SPC requires the CSI in order to obtain the relation of the channel coefficients. Thus, the channel estimation is necessary in the SPC scheme. The α refers to the phase among the different channel coefficients. The modification of phase by the pre-coding vector is determined depending on the α. Fig.2 shows the two type of the α. The H refers to the superimposed channel. Fig.2a) shows the constructive α and Fig.2b) shows the destructive α. If the α is constructive, the wireless system can obtain the improved diversity gain [5].

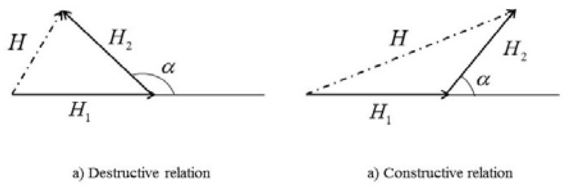

Fig.2 Two type of phase relation

The pre-coding vector of the 1-bit feedback SPC is as follows,

$$C = \begin{Bmatrix} 1 & 0 < |\alpha| \le \dfrac{\pi}{2} & state1 \\ e^{-j\pi} & \dfrac{\pi}{2} < |\alpha| \le \pi & state2 \end{Bmatrix}. \quad (1)$$

The C refers to the pre-coding vector. The 1-bit feedback SPC has two state according to the α. If the α is $\pi/2 < \alpha \le \pi$, the α is modified by the pre-coding vector C. Fig.3 shows the modific-ation of phase.

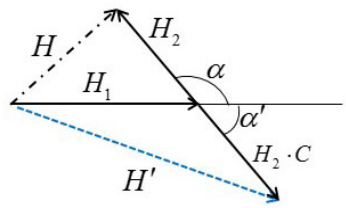
Fig.3 The modification of the phase relation

The α' refers to the modified phase relation and the H' refers to the modified H. Fig.3 shows that the C can superpose constructively two channels.

4 Proposed Scheme

In this section, the proposed scheme is explained in detail. This letter proposes new scheme in order to improve the reliability in the wireless commun-ication system. The proposed scheme uses different transmission method depending on the distance from the base station in order to prevent the path loss and ICI. When the MS moves, the receiver of MS undergoes the path loss and ICI depending on the location of MS and distance from base station. In the proposed scheme, the transmittion methods are classifed into three cases depending on location of the MS. This section explains the proposed scheme accoding to each case and movement of the MS.

4.1 The MS is close to the base station

In Fig.1, the case 1 is a situation that the MS is close to the base station. In the case 1, the signal undergoes attenuation less than the other caeses. In the case 1, the base station uses single input single output (SISO) OFDM. At the receiver, the received signal is as follows,

$$Y_{MS1} = \sum_{k=1}^{N_{SC}} S_1^k H_{BS,1}^k + N^k . \qquad (2)$$

The N^k refers to Gaussian noise of the k-th subcarrier. The N_{SC} is the number of subcarriers and H^k is the k-th subchannel. S_1^k refers to the signal on the k-th subcarrier in the left cell.

4.2 Distance between the MS and base station is far

In Fig.1, the case 2 is situation that distance between the MS and base station is far. In the case 2, the signals undergo path loss. The proposed scheme uses the cooperative communication and SPC in order to obtain the diversitiy gain. In the case 2, one relay is used in the cooperative communication. The receiver of MS can constructively superpose the received signals through the different paths by using the SPC. At the receiver, the received signal is as folllows,

$$Y_{MS2} = \sum_{k=1}^{N_{SC}} \hat{S}_1^k H_{1,2}^k + S_1^k H_{B,2}^k C^k + N^k . \qquad (3)$$

$\hat{S}_1^k$ refers to the relay signal on the k-th subcarrier by using the DF cooperative communication. C^k refers to the k-th pre-coding vector. The MS can obtain the CSI for the pre-coding vector through channel estimation. In this case, the proposed scheme can improve the performance of MS by using the cooperative communication and SPC.

4.3 The MS is located in the cell edge

In Fig.1, the case 3 shows that the MS is located in the cell edge. In the case 3, because the signal undergo path loss and ICI, the performance of MS is degraded. The ICI is caused by the unwanted signal of neighboring cell. The proposed scheme can prevent path loss by using cooperative communication and constructive SPC. In the neighboring cell, the proposed scheme uses cooperative communication and the destructive SPC in order to reduce the unwanted signal. The destructive SPC superposes destructively the received signals. Power of the superimposed signal by destructive SPC is reduced. Therefore, the proposed scheme can reduce the ICI. At the receiver, the received signal is as folllows,

$$Y_{MS3} = \sum_{k=1}^{N_{SC}} (\underbrace{\hat{S}_1^k H_{2,3}^k + S_1^k H_{B,3}^k C^k}_{a} + N^k) + \sum_{k=1}^{N_{SC}} (\underbrace{\hat{S}_2^k H_{2,3}^k{}' + S_2^k H_{B,3}^k{}' C^{k\prime}}_{b} + N^{k\prime}) . \qquad (4)$$

S_2^k refers to the signal on the k-th subcarrier in the neighboring cell. In the case 3, S_2^k acts as the interference signal. $H^{k\prime}$ is the k-th subchannel and $C^{k\prime}$ is the k-th destructive pre-coding vector in the neighbo-ring cell. The power of a is increased and the power of b is decreased in order to improve the performance of the wireless system in the cell edge.

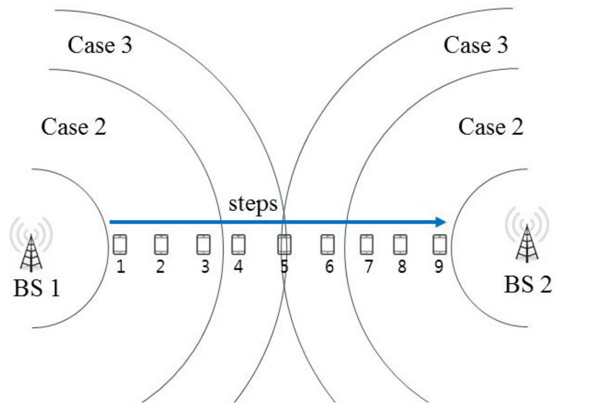

Fig.4 Moving scenario for the propsed scheme

4.4 Moving scenario

In the wireless communication, the MS undergose different path loss according to the movement of the MS. The path loss equation is as follows,

$$L_p(d) \propto \left(\frac{d}{d_{ref}} \right)^n . \qquad (5)$$

$L_p(d)$ refers to the value of path loss of distance d and the d_{ref} refers to the reference distance. The d_{ref} is commonly 1km and n is 2 in free space. The proposed scheme can apply to moving scenario. Fig.4 shows steps in the moving scenario. The MS moves into step 9 from step 1. The path loss is applied to each step through Eq.(5). If the MS is located in the step 1, 2, 3 and 4, the MS is serviced by BS 1. If the MS is located in the step 5, the MS is serviced by either BS 1 or BS 2. If the MS is located in the step 6, 7 ,8 and 9, the MS is serviced by BS 2. Because the proposed scheme uses different transmission scheme according to each step and case, the proposed scheme can obtain improved performance in the moving scenario.

5 Simulation Results

In this section, the simulation results and the parameters are explained. The simulation is based on OFDM system. Table 1 is the simulation parameter.

Table 1 Parameters for the simulation

The number of subcarreirs	256
The cyclic prefix	64
Channel path	7-path Rayleigh channel
Channel coding	Convolution coding
Constraint length	7
Code rate	1/2
Moduation type	QPSK
Pre-coding scheme	SPC

Fig.5 shows bit error rate (BER) performance of the proposed and conventional scheme with 9 steps of the moving scenario. The MS moves into step 9 from step 1. The step 1, 2, 3, 7, 8 and 9 are scenario in case 2 and step 4, 5 and 6 are scenario in case 3. In Fig.5, the slope of case 2 shows that the conventional scheme has a dramatic BER performance degradation caused by path loss. On the other hand, the proposed scheme has a better BER performance than the conventional scheme, furthermore the proposed scheme can prevent performance degradation caused by a path loss.

6 Conclusion

The proposed scheme can improve the performance of the system in the wireless communication system. Because the proposed scheme has the improved performance through adaptive transmission scheme according to the movement of MS, the proposed scheme is more useful than conventional scheme in the moving scenario. The simulation results show that the proposed scheme has a better BER performance than the conventional scheme in the moving scenario.

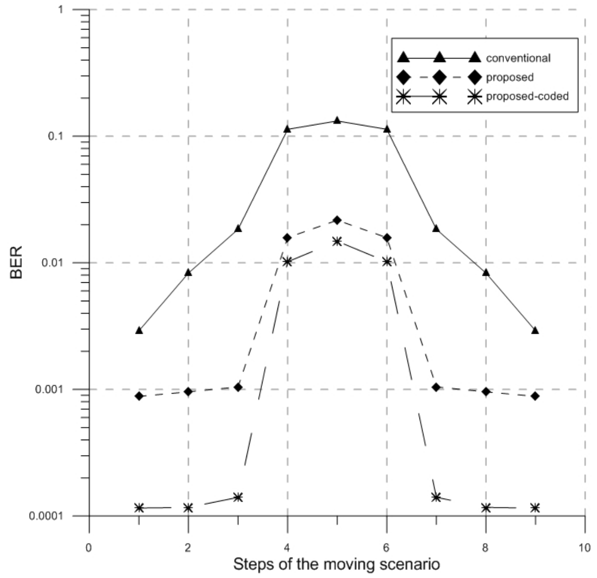

Fig.5 BER performance of the propsed and conventional scheme in the moving scenario

Acknowledgment

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