Spatial Phase Coding in Uplink Coordinated Multiple-Point System for Improve Wireless Communication Performance

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Abstract: - This paper proposes a coordinated multi-point (CoMP) scheme for improving wireless communication performance. The signal from the transmitter is distorted by various reasons such as inter-cell interference (ICI), power reduction, incorrect channel estimation. In order to improve uplink communication performance, the proposed scheme applies the spatial phase coding (SPC). In this paper, two base stations and one user equipment are considered. The two base stations receive at same time from user equipment. By the SPC precoding, the receiver has high bit error rate (BER) performance and throughput. Therefore, proposed scheme reduces the problems of user equipment in the edge of cell coverage.

Key-Words: - CoMP, SPC, uplink, diversity

1 Introduction

In recent wireless communication system, demand for high data rate and high reliability is increased by users. To solve demand of user, various techniques are studied.

Long-term evolution (LTE) uses multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM)

The multiple-input multiple-output (MIMO) system is studied for improved wireless communication. The MIMO system can obtains high data rate and bit error rate (BER) performance according to number of antenna. In the MIMO system, the transmitter and receiver have multiple antennas. The wireless communication system is defined by number of antennas such as single-input single-out (SISO), multiple-input multiple-output (MIMO), multiple-input single-out (MISO) and single-input multiple-out (SIMO). The MIMO system is effective to multi-path fading but there are disadvantages of MIMO system such as device size, transmission power, cost in the mobile system.

The orthogonal frequency division multiplexing (OFDM) system assigns information to orthogonal sub-carriers and simply is implemented by fast Fourier transform (FFT). In OFDM system, sub-carriers experience narrowband frequency flat fading instead of wideband frequency selective fading. The OFDM system is robust to multipath fading environment and efficiently uses frequency resource. Therefore, OFDM system provides high data rate and robustness against frequency selective fading [1].

The interference from adjacent cell is main cause of performance degradation. coordinated multiple-point (CoMP) introduced in LTE-A - Rel. 11 for mitigate the inter cell interference (ICI) effect. The CoMP scheme reduces the ICI by cooperating with adjacent transmission points (TPs) and improve the throughput of user at the cell edge. Recent research of CoMP focus on downlink link but CoMP is useful scheme uplink system [2].

The Spatial phase coding (SPC) achieves a constructive superposition by simple feedback information. By the SPC the phase relation of the signals from TPs is assigned such that probability of constructive superposition of the signals at the receiver is increased [3].

This paper proposes a high performance uplink CoMP scheme for user equipment (UE) in cell boundary. In order to high reliability, proposed scheme uses SPC scheme with the backhauling network.

The organization of this paper is as follows: Section 2 introduces the system description of considered wireless communication. Section 3 presents the proposed scheme based on the CoMP system. The simulation performance is analyzed in Section 4. Finally, Section 5 concludes this paper.

2 System Model

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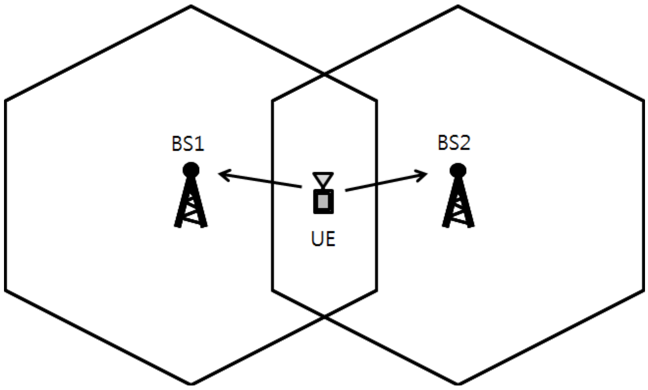

Fig. 1 System model of the CoMP uplink wireless communication

This paper considers the two TPs and one UE. Fig. 1 shows single user MIMO system model. The hexagon in Fig. 1 means cell coverage. The UE is located in between two TPs.

The uplink performance of UE is degenerated by power reduction or ICI likewise downlink system

In the CoMP system, many schemes are studied such as coordinated scheduling (CS), coordinated beamforming (CB) and joint processing (JT) scheme This paper focus on JP scheme. The JP scheme divided to joint transmission (JT) and dynamic point selection (DPS) scheme

JT uses multiple cells, such as radio resources (frequency and time) to transmit the same data at the same time. In the JT scheme, multiple TPs use same radio resources such as frequency and time to transmit the same data. Therefore, a receive performance is improved. The DPS scheme shares a transmited data such as the JT scheme.However, actual data transfer is decided depend on channel state. The receiver compares channel state of each subframe and selects signal that has minum path loss. And, the unselected signals are muting. Since the signal is transmitted to better channel, revceive performance improves. It can significantly improves throughput at the cell boundary.

The received signal $\mathbf{Y}$ in the receive antenna is as follows,

$$\mathbf{Y} = \mathbf{hx} + \mathbf{n} \tag{1}$$

where $\mathbf{H}$ is complex channel matrix and $\mathbf{X}$ is complex OFDM symbols. The $\mathbf{H}$ is complex additive white Gaussian noise (AWGN) that has zero mean and variance σ^2.

Therefore, path loss of signal from relay is small.

The function of path loss by distance is represented as follows,

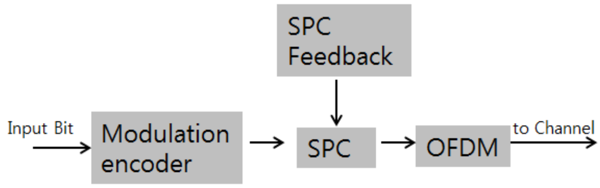

Fig. 2 The OFDM signal transmission procedure with SPC scheme

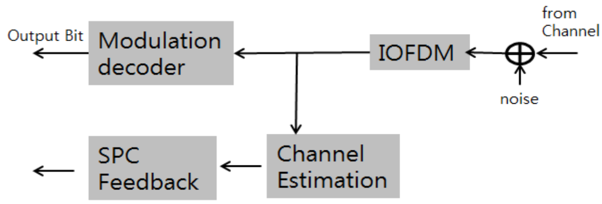

Fig. 3 The OFDM signal receive procedure with SPC scheme

$$L_P(d) \propto (\frac{d}{d_{ref}})^n \tag{2}$$

where $L_p(d)$ means a path loss by d . d is the distance between transmitter and receiver. The d_{ref} is a reference distance and n is defined to 2 in free space [4].

The system model assumes that the multiple TPs share the transmission data and the CSI of the UE through the ideal backhaul network. The ideal backhaul has infinite capacity and zero latency.

3 Proposed Scheme

The conventional communication scheme does not provide sufficient BER performance. To solve problems of the conventional communication scheme, the proposed scheme applies SPC scheme.

3.1 SPC

In fig 2 and 3, The OFDM signal transmission procedure with SPC scheme is expressed by block diagram. The SPC block uses the SPC feedback information from receiver. The feedback information includes the channel state information (CSI) of between TPs and UE. At the receiver antenna, transmitted signals are combined. The receiver sends estimated channel state and detects data bit.

The SPC scheme uses feedback information for phase flipping. The feedback information is decided by relation of the channels between a transmitter and a receiver.

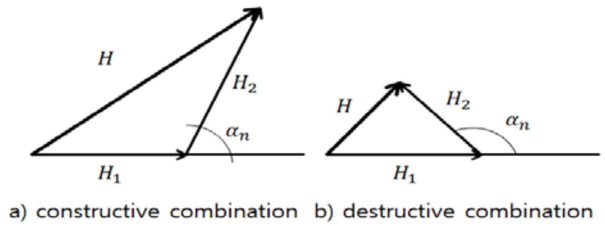

Fig. 4 a) constructive combination, b) destructive combination

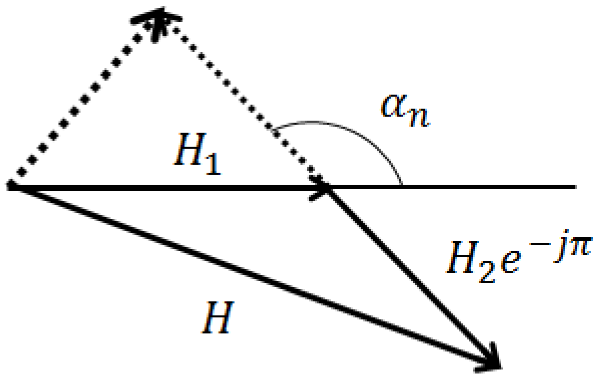

Fig. 5 Principle of phase flipping

Fig. 4 shows relation of H_1 and H_2 with a relative angle α.
In Fig. 4 a), channels have constructive superimposition and Fig. 4 b) shows destructive superimposition. The H is the superimposition of the channel H_1 and H_2 The precoding vector 1-bit SPC feedback information is expressed as follows,

$$F = \begin{cases} 1 & 0 < |\alpha_n| \le \dfrac{\pi}{2} \quad state1 \\ e^{-j\pi} & \dfrac{\pi}{2} < |\alpha_n| \le \pi \quad state2 \end{cases}, \qquad (3)$$

where F is the feedback information from the receiver. The precoding vector F has two possible states. The two states are determined by relative angle α_n The state 1 means constructive and state change is not necessary. But state 2 needs phase flipping since it is destructive superimposition. The assumption is that the phase relation between both channels is quasi constant.
The Fig. 5 shows a result of phase flipping. By the feedback information, H_2 is multiplied with $e^{-j\pi}$. Therefore, the destructive relation of the channels is changed to constructive.

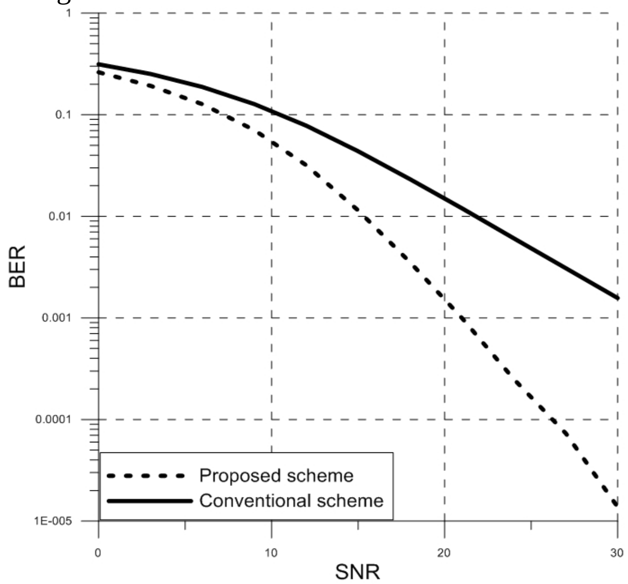

Fig. 6 BER performance of the Simulation

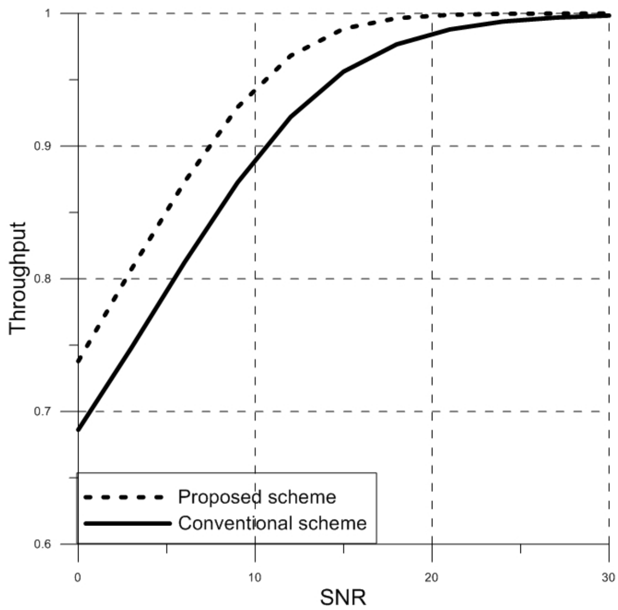

Fig. 7 Throughput of the Simulation

3.2 Proposed Scheme

In this section, the proposed scheme is described. If the UE moves to cell boundary btween two TPs, the CoMP system is requested. The TPs share the feedback information of CSI and UE transmits
The received signals on the proposed scheme is expressed as follows,

$$Y_1 = p_1 h_1 x + n$$
$$Y_2 = p_2 h_2 x + n, \qquad (4)$$

Where Y is received signal, p is feedback vector, x means transmission signal and n represents the noise. The Eq. 4 is arranged as,

$$Y = \hat{h}x + n, \quad (5)$$

$\hat{h}$ means phase flipped channel of The superposition signal.

4 Simulation Results

This section represents the performance of the proposed scheme compared with the conventional scheme.

The transmitted signals are modulated by a 16-quadrature amplitude modulation (QAM). The FFT size is 256 and the length of cyclic prefix is 64. The cyclic prefix is made up quarter of symbol. The transmitted signals experience Rayleigh fading and are influenced by AWGN. The path length of Rayleigh channel is defined as 7 and all channels are independent and time variant. The transmission power allocation is uniform and effect of the channel is assumed that the TP estimates the channel correctly. The simulation results are represented by BER and throughput performance. Throughput TH is calculated as

$$TH = (1 - p(r)) \times N_b \quad (7)$$

where N_b is the number of transmitted information bits and $p(e)$ is BER. The simulation results show that the conventional scheme can't provide the high BER performance compared with proposed scheme.

5 Conclusion

In this paper, the wireless cooperative communication CoMP scheme is proposed for UE at the edge of cell coverage. When the destination is located in the cell boundary, the transmitted signal is distorted by the interference and power reduction. The proposed scheme applies CoMP communication and the SPC pre-coding scheme for increase performance. The proposed scheme provides high BER performance and throughput performance Therefore, the proposed scheme is useful for the wireless communication system.

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