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Cooperative Receiving Scheme for Downlink of Cellular Systems

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Abstract ***— In wireless mobile cellular systems, it has been popular for mobiles to support some short-range wireless communication protocols (SRWCPs)−Bluetooth, Zigbee, NFC (near field communication), etc. In this paper, we introduce a simple SRWCP-aided downlink cooperative receiving scheme. In the proposed scheme, a cluster is composed by some active mobiles which can be connected via SRWCPs, and then the base station transmits inter-mobile interleaved data to the active mobiles simultaneously. Each mobile merges its own received data with the handed-over data from partner mobiles in the cluster through SRWCPs. Since each mobile can use the data received from several independent wireless channels—channels between the base station and mobiles in the cluster, we can expect some diversity gain.***

Keywords — Cooperative Receiving, Inter-mobile Interleaving, Short Range Wireless Communication Protocol

I. INTRODUCTION

In wireless mobile cellular systems, it is very important to improve the immunity to wireless fading channels in order to guarantee a high quality of service (QoS) for mobiles. For this, recently, cooperative receiving schemes using a mobile cluster have been studied [1]-[4]. According to the signal direction (downlink or uplink) and the cluster structure, the conventional patents can be classified as in Table I. Thus, in this paper, we are going to propose a new downlink cooperative receiving scheme using the cluster composed of some active mobiles which is not covered by existing schemes yet.

It has been popular for mobiles in cellular systems to support some short-range wireless communication protocols (SRWCPs)−Bluetooth, Zigbee, NFC (near field communication), etc. Thus, mobiles can easily communicate with adjacent mobiles under an SRWCP [5],[6].

Motivated by this, we introduce a simple SRWCP-aided downlink cooperative receiving scheme: 1) the serving base station sets up a cluster of some adjacent active mobiles which can be connected via SRWCPs; 2) the base station transmits inter-mobile interleaved data to the active mobiles simultaneously; 3) each mobile in the cluster classifies the received data, and hands over the data for the partner mobiles to them under the SRWCPs; 4) each mobile merges its own received data with the handed-over data from partner mobiles in the same cluster. Since each mobile can use the data received from several independent wireless channels—channels between the base station and mobiles in the same cluster, we can expect some diversity gain like the case of the frequency-interleaved transmit diversity (FITD) [7],[8].

TABLE I
CLASSIFICATION OF CONVENTIONAL PATENTS

	Cluster structure	
	composed of one active mobile and some idle mobiles	composed of some active mobiles
Uplink cluster → base station	[1], [4]	[2], [3]
Downlink base station → cluster	[4]	

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II. PROPOSED COOPERATIVE RECEIVING SCHEME

We propose a simple SRWCP-aided downlink cooperative receiving scheme. For a convenience of the description, we consider the case where two active mobiles in a CDMA based cellular system are connected via a SRWCP—that is, the mobile cluster is composed of two active mobiles.

A. TRANSMITTER SIDE: BASE STATION

In a conventional CDMA-based cellular system, downlink signal for each mobile is independently generated through a symbol-level processing (such as channel coding, interleaving, rate matching, and digital modulation) and a chip-level processing (such as spreading and scrambling). In the proposed system, contrary to a conventional system, the serving base station sets up a mobile cluster of some adjacent active mobiles which can be connected via SRWCPs, and performs inter-mobile interleaving on the symbol-level processing outputs for the mobiles in the cluster. Fig. 1 shows a simplified downlink structure of CDMA-based cellular systems including an inter-mobile interleaving for the mobile cluster which is composed of MU1 and MU2.

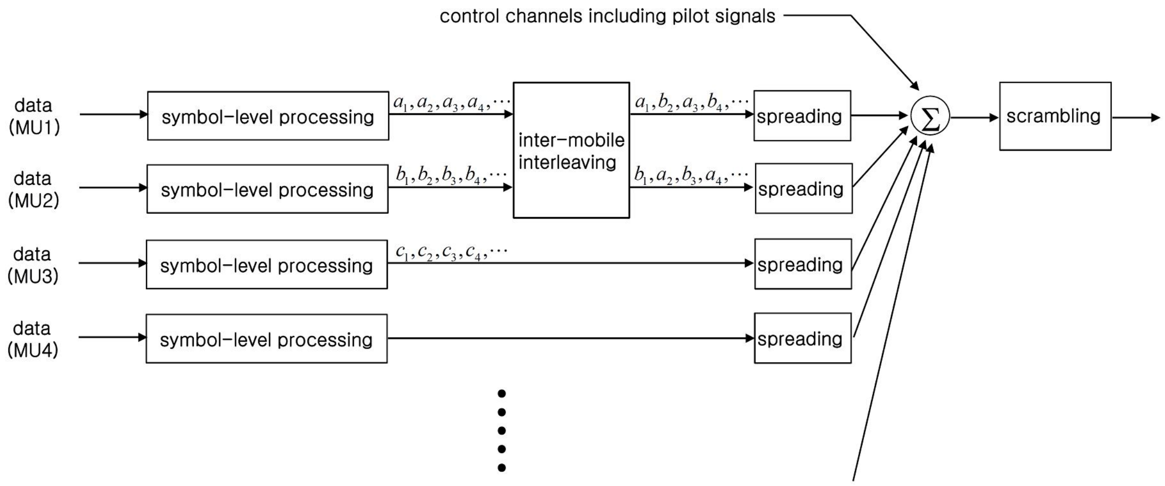

Fig. 1 Simplified downlink structure of a CDMA-based cellular system including an inter-mobile interleaving.

The inter-mobile interleaving is a simple process to exchange the symbol-level processing outputs in order for the data to be alternatively transmitted through downlink channels for mobiles in the same cluster. Let's define the symbol-level processing outputs for MU1 and MU2 as $\{a_1, a_2, a_3, a_4, \cdots\}$ and $\{b_1, b_2, b_3, b_4, \cdots\}$, respectively. Then, in the case of the mobile cluster composed of MU1 and MU2, the data with even-numbered index, a_{2k} and b_{2k} are exchanged each other as shown in Fig.1. It can be easily extended to the case that a mobile cluster is composed of more than two active mobiles. For example, assume that a mobile cluster is composed of three mobiles, MU1, MU2 and MU3: if we define the symbol-level processing output for MU3 as $\{c_1, c_2, c_3, c_4, \cdots\}$, the outputs of inter-mobile interleaving for MU1, MU2 and MU3 can be obtained in the form of $\{a_1, b_2, c_3, a_4, b_5, c_6, a_7 \cdots\}$, $\{b_1, c_2, a_3, b_4, c_5, a_6, b_7 \cdots\}$ and $\{c_1, a_2, b_3, c_4, a_5, b_6, c_7 \cdots\}$, respectively.

Each inter-mobile interleaved symbol stream is spread by mobile-specific spreading code and summed with other downlink channels, such as control channels and data channels for other active mobiles. Finally, the summed downlink signal is transmitted after being scrambled by cell-specific scrambling code.

B. RECEIVER SIDE: MOBILE CLUSTER

The mobiles in the cluster, MU1 and MU2 receive the downlink signal from the base station through wireless channels, $h_1(t)$ and $h_2(t)$, respectively, which can be generally assumed to be independent. Fig.2 shows a receiver structure for the mobile cluster composed of MU1 and MU2.

After descrambling, despreading and Rake combining, MU1 and MU2 can obtain soft outputs for the inter-mobile interleaved symbol stream, that is $\{\hat{a}_1, \hat{b}_2, \hat{a}_3, \hat{b}_4, \hat{a}_5, \hat{b}_6, \cdots\}$ and $\{\hat{b}_1, \hat{a}_2, \hat{b}_3, \hat{a}_4, \hat{b}_5, \hat{a}_6, \cdots\}$, respectively. The cooperative mobiles, MU1 and MU2 exchange soft output values by using a short range wireless communication protocol: MU1 hands over $\{\hat{b}_{2k},\ k=1,2,3,\cdots\}$ which was received through wireless channel $h_1(t)$ to MU2; MU2 hands over $\{\hat{a}_{2k},\ k=1,2,3,\cdots\}$ which was received through wireless channel $h_2(t)$ to MU1.

Then, MU1 merges its own received data, $\{\hat{a}_{2k-1},\ k=1,2,3,\cdots\}$ with the handed-over data from MU2, $\{\hat{a}_{2k},\ k=1,2,3,\cdots\}$, and MU2 also performs the equivalent operation—we call this operation the inter-mobile deinterleaving (see Fig.2). The outputs of the inter-mobile deinterleaving are passed to the symbol-level decoding process.

In detail, the output stream of the inter-mobile deinterleaving for MU1, $\{\hat{a}_1, \hat{a}_2, \hat{a}_3, \hat{a}_4, \hat{a}_5, \hat{a}_6, \cdots\}$ is composed of $\{\hat{a}_{2k-1},\ k=1,2,3,\cdots\}$ which was received through $h_1(t)$ and $\{\hat{a}_{2k},\ k=1,2,3,\cdots\}$ which was received through $h_2(t)$. For MU2, similarly, $\{\hat{b}_1, \hat{b}_2, \hat{b}_3, \hat{b}_4, \hat{b}_5, \hat{b}_6, \cdots\}$ is composed of $\{\hat{b}_{2k-1},\ k=1,2,3,\cdots\}$ which was received through $h_2(t)$ and $\{\hat{b}_{2k},\ k=1,2,3,\cdots\}$ which was received through $h_1(t)$.

It is worthwhile to note that the cooperative mobiles in the cluster, MU1 and MU2 can use both its own wireless channel from the base station and the partner's wireless channel from the base station, that is, both of $h_1(t)$ and $h_2(t)$. Furthermore, the proposed inter-mobile interleaving/deinterleaving is conceptually equivalent to the frequency-interleaved transmit diversity (FITD) where data are alternatively transmitted through two transmit antennas [7],[8]. Thus, we can expect some diversity gain like the case of FITD.

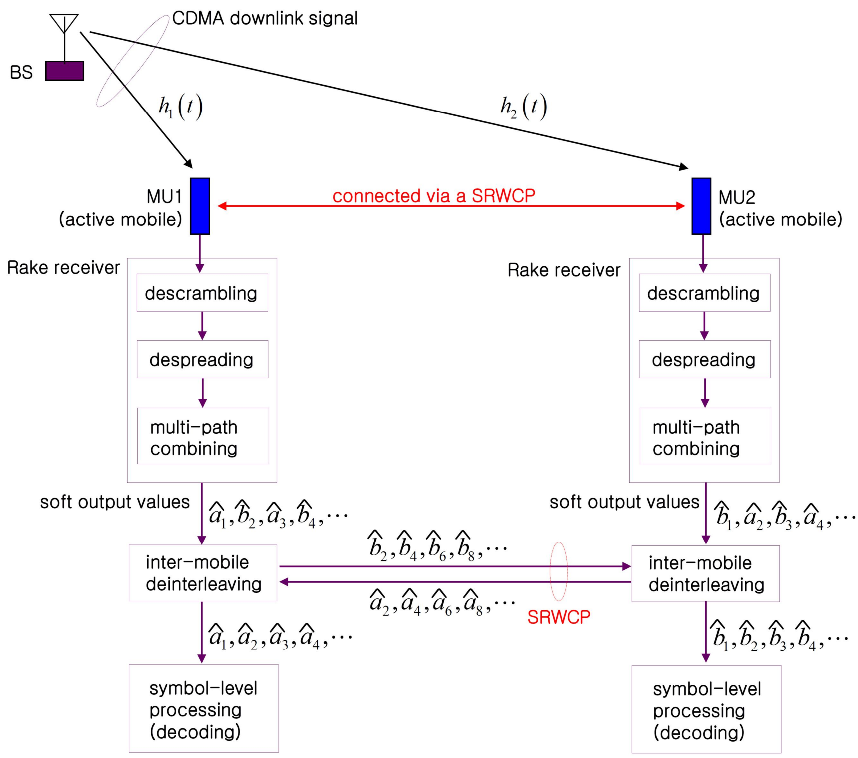

Fig. 2 Receiver structure for the mobile cluster composed of MU1 and MU2.

III. CONCLUSION

Motivated by the fact that the recent mobile units in cellular systems generally support some SRWCPs, we proposed a simple SRWCP-aided downlink cooperative receiving scheme. In the proposed scheme, a mobile cluster is composed of some adjacent active mobiles which can be connected via SRWCPs, and the inter-mobile interleaving is performed in order for the data to be alternatively transmitted through downlink channels for mobiles in the cluster. It was shown that the proposed inter-mobile interleaving/deinterleaving is conceptually equivalent to the FITD where data are alternatively transmitted through two transmit antennas. Consequently, we can expect some diversity gain like the case of the FITD.

ACKNOWLEDGMENT

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