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Macro-MIMO Enhancements for Cellular OFDMA Systems

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1 Introduction

This document describes macro-MIMO enhancements for cellular OFDMA system that improve soft handoff performance and/or overall cell throughput. Once a SHO Zone is defined where a common IDcell is used, BSs in an active set shall transmit data in the data region defined in DL_MAP. A pre-determined antenna selection formula can be used. A total of N antennas from SHO-BSs constitute an antenna pool. The anchor BS selects certain amount of antennas from the antenna pool, and decides MIMO transmission mode based on SS capability and channel condition. The antennas selection can be varied from sub-channel to sub-channel to maximize spatial diversity. For a particular subchannel, the allocated antennas in the BSs in the active set concurrently transmit the data for the same packet with the same CID and use the same data randomizer. The SS receives the RF-combined MIMO signal from the same data region and demodulates it, , and then decodes the packet based on the combined soft bits between the different data region. When the source data in different subchannels are different, this macro-MIMO scheme intends to achiever higher cell throughput.

To sum up, the following three levels of macro-MIMO operations can be combined to improve overall handoff performance and cell throughput:

1. Macro-MIMO with RF combining :
   The packet delivering to SHO SS is duplicated and all or some antennas in the antenna pool formed with SHO BSs transmit the data for the same packet in the same data region such as a subchannel. RF combined signal is received at SS and MIMO decoding follows.

2. Macro-MIMO with diversity combining :
   The packet delivering to SHO SS is duplicated and some antennas in the antenna pool formed with SHO BSs transmit the data for the same packet in the same data region for RF combining. In addition, the data for the same packet is transmitted through another set of antennas in another data region with the same size, and these two can be soft-combined in order to achieve diversity combining.

3. Macro-MIMO with data rate enhancement :
   The packet delivering to SHO SS is duplicated and some antennas in the antenna pool formed with SHO BSs transmit the data for the same packet in the same data region for RF combining. In addition, the data for the different packet is transmitted through another set of antennas in another data region, and these two can be separately decoded in order to achieve data rate increase. Note that for this scheme, two data regions shall be different.

For a certain SS, these three schemes may be implemented simultaneously. Note also that this macro-MIMO enhancement operation is transparent to SS, which mean each SHO SS does not have to know which BSs are transmitting in order to decode the transmitted data.

1.1 The example of Macro-MIMO operation

Two antennas per BS is assumed for the following example.

A general expression for Macro-MIMO operation is shown in Figure 1. Where N is the number of antenna used for Macro-MIMO and K is the number of allocated frequency region for the SS. The '0' in the matrix indicates 'no data transmission' and '**S**' is 'data transmission'.

Figure 1

$$\begin{array}{cc}
 & \text{Antenna Index} \\
\text{Frequency Region Index} & \begin{array}{c|ccccc|}
 & 1 & 2 & 3 & \ldots & N \\
1 & 0/S & 0/S & 0/S & \ldots & 0/S \\
2 & 0/S & 0/S & 0/S & \ldots & 0/S \\
3 & 0/S & 0/S & 0/S & \ldots & 0/S \\
\vdots & & & \vdots & & \\
K & 0/S & 0/S & 0/S & \ldots & 0/S
\end{array}
\end{array}$$

* S = [a or a' or b or b' ... k or k']

* N = (# of BS)*(# of Antenna per a BS)

A simple example is given in Figure 2 for Macro-MIMO with RF combing. In this example, after RF combining from three BSs, the received data is further STC decoded.

Figure 2

$$\begin{array}{cc}
 & N=6 \\
K=1 & \begin{array}{c|cccccc|}
 & 1 & 2 & 3 & 4 & 5 & 6 \\
1 & a & a' & a & a' & a & a'
\end{array}
\end{array}$$

Figure 3 is an example for Macro-MIMO with diversity combining and STC decoding.

Figure 3

$$\begin{array}{cc}
 & N=4 \\
K=2 & \begin{array}{c|cccc|}
 & 1 & 2 & 3 & 4 \\
1 & a & a' & 0 & 0 \\
2 & 0 & 0 & a & a'
\end{array}
\end{array}$$

Figure 4 is an example for Macro-MIMO with data rate enhancement combined with STC.

Figure 4

$$\begin{array}{cc} & N=4 \\ K=2 & \begin{array}{c|cccc|} & 1 & 2 & 3 & 4 \\ 1 & a & a' & 0 & 0 \\ 2 & 0 & 0 & b & b' \end{array} \end{array}$$

Finally, Figure 5 shows an example for three schemes combined.

Figure 5

$$\begin{array}{cc} & N=6 \\ K=5 & \begin{array}{c|cccccc|} & 1 & 2 & 3 & 4 & 5 & 6 \\ 1 & a & a' & 0 & 0 & a & a' \\ 2 & a & 0 & 0 & 0 & 0 & a' \\ 3 & a & a' & 0 & 0 & a & a' \\ 4 & b & b' & b & b' & 0 & 0 \\ 5 & b & b' & 0 & 0 & 0 & 0 \end{array} \end{array}$$

2 Specific Text Changes

[Add a new section in 8.4.5.3.xx on page 531]

8.4.5.3.xx Macro-MIMO DL Basic IE format

To enhance soft handoff (SHO) and/or improve cell throughput in cellular OFDMA system, MIMO may be applied in the macroscopic level, once a certain SS enters a SHO Zone where a common IDcell is used among BSs in the active set. DL data transmission from BSs in the active set is transparent to the SHO SS. Table aaa specifies DL-MAP IE for this functionality.

Table aaa – Macro_MIMO_DL_Basic_IE()

Syntax	Size (bits)	Notes
Macro_MIMO_DL_Basic_IE() {		
Extended DIUC	4	0x09
Length	4	Length in bytes
Num_Region	4	
For (i=0;i<Num_Region;i++) {		
OFDMA Symbol offset	8	

Subchannel offset	6	
Boosting	3	
No. OFDMA symbols	7	
No. Subchannels	6	
Packet index	4	Packet index for each region

Matrix indicator	2	STC matrix (see 8.4.8.1.4)
		STC = STC mode
		indicated in the latest STC_Zone_IE().
		
		if (STC ==01) {
		00 = Matrix A
		01 = Matrix B
		10-11 = Reserved }
		elseif (STC == 10) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Reserved
		}

Num_layer	2	
for (j=0;j<Num_layer;j++) {		
If (INC_CID == 1) {		
CID }	16	
Layer_index	2	
DIUC	4	0-11 burst profiles
}		
}		
}		

Packet Index
Indicates the packet index for the particular region. The regions with the same packet index shall be diversity combined at SS.

References:

[1] IEEE P802.16e/D3 Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands