Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**MIMO SHO based Macro diversity transmission for coverage improvement**
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Re:	IEEE 802.16e D3 Draft
Abstract	Enhancement of handoff capability and procedures ~~Crossed-out indicates deleted text~~ and indicates newly added text from the original contribution
Purpose	To incorporate the changes here proposed into the 802.16e D4 draft.

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MIMO SHO based Macro diversity transmission for coverage improvement

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1 Background

~~In this contribution, two physical layer enhancements for the handoff operation are proposed for a frequency reuse-one OFDMA multi-cell system. These enhancements are based on the MIMO/MISO capabilities for both BS and MSS to exploit the macro-diversity. The first is joint BS soft-handoff based on the space time coding structure to enhance the user data rate in the very poor geometry users. The second is to allow the minimum data rate connection during the very low geometry handoff process. It should be noted that the proposed handoff solutions are also applicable to the MBS service.~~

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.

The following sections describe few examples of MIMO Macro diversity schemes. The actual scheme can be left for the implementation choice.

2 The examples of Macro diversity transmission

MIMO-OFDMA Macro diversity transmission scheme is configured with multiple BS transmissions in division in frequency domain, and the space-time coding (STTD/SM) associated with each BS antenna. The packet delivering to SHO MSS is duplicated to all the active BSs. Two examples of Macro diversity transmissions are : (assuming 3 active BSs)

1. *Joint* multiple BS transmission division in frequency domain.
   - Data packet is divided into three sub-packets, and each BS transmits one sub-packet, each BS organizes the space-time coding for two antennas and mapped onto OFDM time-frequency AMC sub-channel while 2/3 of the band is empty without signal transmission. Each transmitted AMC sub-channel is power boosted by $10\log_{10}(3)$dB to realize the full power transmission. The MSS receives the entire frequency band and performs space-time decoding to retrieve the packet data.
   - The same data packet is space-time encoded by each BS, each BS's transmission is mapped into different AMC sub-channel in frequency domain. The 2/3 of the band is empty without signal transmission. Each transmitted AMC sub-band is power boosted by $10\log_{10}(3)$ dB. The MSS receives the entire frequency band and performs diversity combining for each sub-bands and space-time decoding to retrieve the packet data.
2. *Joint* multiple BS antenna space-time coding transmission division in frequency domain.
   - Data packet is divided into three sub-packets. BS-1 antenna α and BS-2 antenna β performs the space-time encoding for the 1st sub-packet; BS-2 antenna α and BS-3 antenna α performs the space-time encoding for the 2nd sub-packet; BS-3 antenna β and BS-1 antenna β performs the space-time encoding for the 3rd sub-packet. Each antenna pair transmits one sub-packet, i.e. mapped onto one OFDM time-frequency sub-band accordingly, see Figure 1, the 2/3 of the band is empty without signal transmission. Each transmitted sub-band is power boosted by $10\log_{10}(3)$ dB. The SS receives the entire frequency band and performs space-time decoding to retrieve the packet data.
   - Data packet is encoded by 3 versions of space-time coding combinations (i) BS-1 antenna α and BS-2 antenna β (ii) BS-2-antenna α and BS-3 antenna α (iii) BS-3 antenna β and BS-1 antenna β antenna. Each combination transmits the same data packet. Each antenna pair is mapped onto one OFDM time-frequency sub-band accordingly and the 2/3 of the band is empty without signal transmission. Each transmitted sub-band is power boosted by $10\log_{10}(3)$ dB. The MSS receives the entire frequency band and performs diversity combining for each sub-bands and space-time decoding to retrieve the packet data.

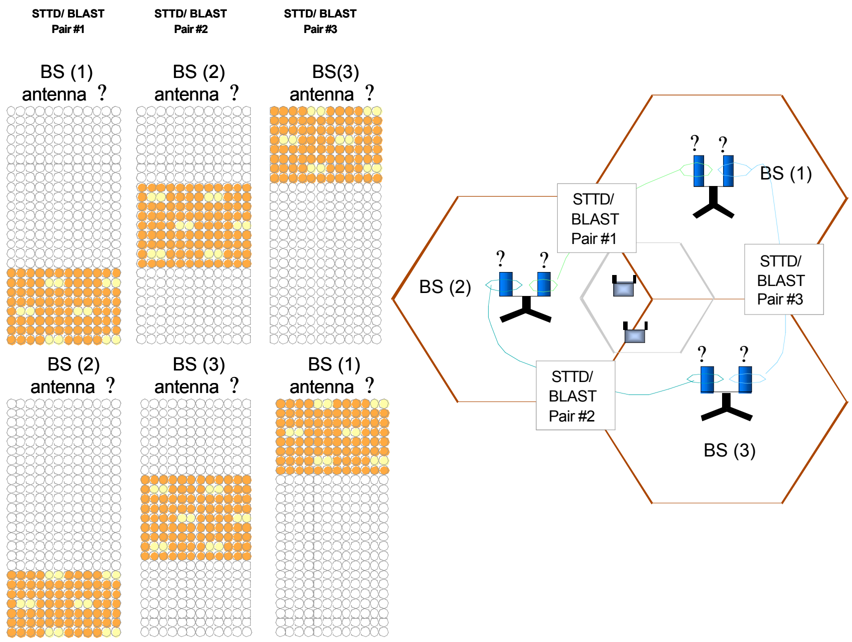


Figure 1 Example of MIMO Macro diversity transmission

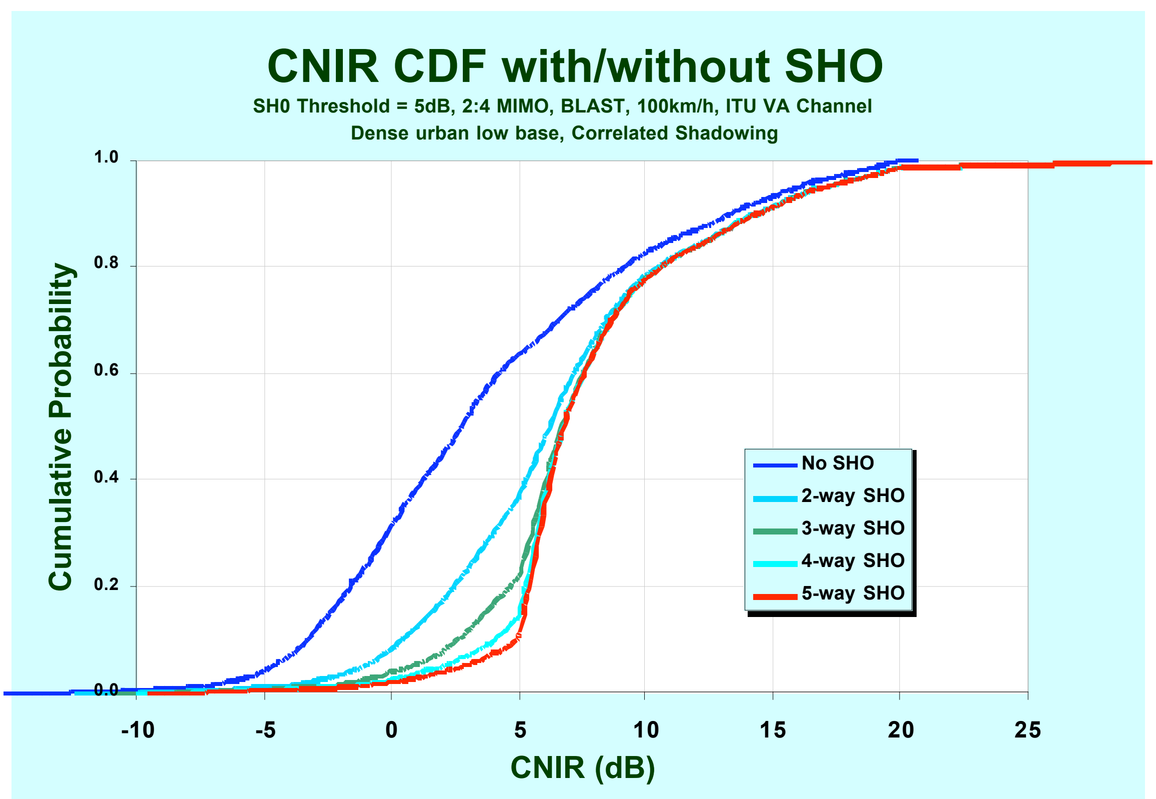
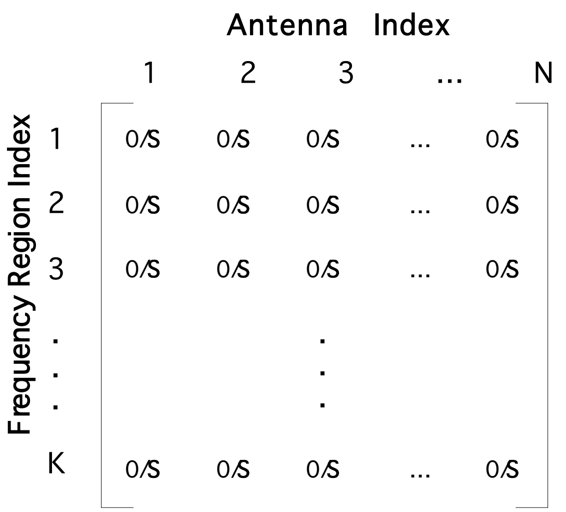


Figure 2 Impact of SHO-based Macro diversity transmission

The above schemes can be generalized to BSs with different configurations. All antennas from active BSs can be used as an anetenna pool. For each data region or subchannel, select certain number of antennas from the antenna pool to form MIMO transmission. To maximize the Macro diversity gain, it is preferred to select antennas for each transmission from different active BSs and vary antenna selection from sub-channel to subchannel. The procedure to establish the active BSs can reuse the SHO procedure.

A general expression for Macro-MIMO operation is shown in Figure 3. Where N is the total number of antennas in the antenna pool 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'. Two antennas per BS is assumed for the following example.

Figure 3



* 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 3 for Macro-MIMO with RF combing. In this example, after RF combining from three BSs, the received data is further STC decoded.

Figure 3

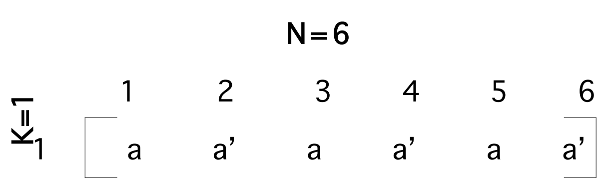


Figure 4 is an example for Macro-MIMO with diversity combining and STC decoding.

Figure 4

N=4

K=2	1	2	3	4
1	a	a’	0	0
2	0	0	a	a’

Figure 5 is an example for Macro-MIMO with data rate enhancement combined with STC.

Figure 5

N=4

K=2	1	2	3	4
1	a	a’	0	0
2	0	0	b	b’

Finally, Figure 6 shows an example for three schemes combined.

Figure 6

N=6

K=5	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

Specific text changes

[Add the following text into section 8.4.8.2.4]

---------Start text proposal-------

8.4.8.2.4 MIMO Soft-hand-off based Macro-diversity Transmission

The soft hand-off (SHO) zone is defined by the OFDMA downlink TD_ZONE_IE by setting the IDcell=0. For the SHO-BSs joint transmission, for the STC capable MSS, the total *N* antennas of SHO-BSs constitute an antenna pool. A pre-determined antenna selection formula can be used. The MIMO transmit format are specified in Section 8.4.8.1.4 for two-transmit-antenna case and Section 8.4.8.2.3 for four-transmit-antenna case. The MIMO pilot transmission is two-antenna transmission for PUSC and FUSC will follow the arrangement of the Figure 245 and section 8.4.8.1.2.1.2 respectively (Figure 207 for the optional FUSC and AMC permutations). The MIMO pilot transmission is four-antenna transmission for PUSC and FUSC will follow the arrangement of the Figure 251 and Section 8.4.8.2.2 respectively (Figure 208 for the optional FUSC and AMC permutations). The un-selected antennas are set to the null transmission.

MSS shall demodulate signal in the same procedure as in non-SHO mode if it does not receive MIMO_in_another_BS_IE() or Macro_MIMO DL Basic IE(). The same data are transmitted from multiple BSs in the same data regions. MSS performs RF or diversity combining.

MSS shall performs soft data combining when it receives MIMO_in_another_BS_IE(). In this case, the same data are transmitted in the same or different data region.

MSS will demodulate signal in the same procedure as in non-SHO mode, then it will perform soft combining for those data regions with the same packet index when it receives Macro_MIMO DL Basic IE().This scheme benefits from combination of RF, diversity combining and soft data combining.

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

8.4.5.3.xx Macro-MIMO DL Basic IE format

Table aaa specifies DL-MAP IE for Macro-MIMO in SHO Mode.

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

---------End text proposal-------