Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**OFDMA PHY Layer Support for SHO Based Macro-Diversity Transmission**
Date Submitted	**2004-07-08**
Source:	Wen Tong, Peiying Zhu, Ming Jia, ,Jianglei Ma, Hang Zhang and Mo-Han Fong Nortel Networks — wentong@nortelnetworks.com MyungKwang Byun, SeungJoo Maeng, Jaeho Jeon, Jeongheon Kim, Jungwon Kim, JaeWeon Cho, PanYuh Joo, ChangHoi Koo Samsung Electronics — panyuh@samsung.com Wenzhong Zhang, Mary Chion ZTE — mchion@ztesandiego.com Itzik Kitroser, Yigal Leiba, Yossi Segal, Zion Hadad Runcom Technologies — itzikk@runcom.co.il Min-Sung Kim KT — cyberk@kt.co.kr Donnie Dongkie Lee SK Telecom — galahad@netsgo.com
Re:	IEEE 802.16e D3 Draft
Abstract	Summary of the OFDMA PHY layer capabilities to support macro-diversity based on SHO. This contribution is the harmonized one between C80216e-04_165.doc and C80216e-04_170r1.doc. New corrections is highlighted in blue color.
Purpose	To incorporate the changes here proposed into the 802.16e D4 draft.
Notice	
Release	
Patent Policy and Procedures	

OFDMA PHY Layer Support for SHO Based Macro-Diversity Transmissions

1 Background

Soft hand-off based macro-diversity transmission enables the concurrent transmissions to a target MSS from multiple BSs. This allows the MSS to exploit the macro-diversity gain to enhance both high speed user bit rate coverage and seamless hand-off of real-time service. Current OFDMA PHY possesses the key hooks to enable such capabilities, in what follows, we summarize the enhancements to realize the PHY layer support for SHO based macro-diversity transmission in both DL and UL. The MAC layer operation of soft hand-off is dealt with several other contributions.

2 SHO Based Macro-Diversity Transmission Scenarios

2.1 DL SHO based macro-diversity with RF combining

The DL macro diversity RF combining has the following advantages:

1. It turns interference into signal, hence significantly improves CIR and increases data throughput.
2. It is transparent to the MSS reception operation.
3. It enables simple MSS backward compatibility.

To allow RF combining, the data from multiple BSs must be sent on the same data sub-carriers. BSs shall use the same data randomizer.

For FUSC permutation, the logical sub-channel to physical sub-channel mapping and physical sub-channel forming are based on IDcell. The data randomizer is based on OFDM symbol offset and sub-channel offset. To satisfy the RF combining condition and maintain the PHY backward compatibility, a common IDcell and data region should be used for all active BSs.

For PUSC, the logical to physical channel mapping is based on IDcell for each segment. The actual sub-carrier in a physical channel is permuted based on IDcell. To perform RF combining, we need to use the same IDcell.

For adjacent sub-carrier permutation, logical to physical channel is not dependent on the IDcell, the actual sub-carrier in a physical channel is permuted based on IDcell. To perform RF combining, we need to use the same IDcell.

To perform RF combing for all permutation, a common solution is to define a SHO zone which uses a common IDcell. This can be achieved by reusing the existing TD_Zone_IE. In addition, since the active set updates is a slow process, the collaborative BSs in the active set can jointly optimize the SHO zone data region, such that the potential unused recourses in the SHO zone can be minimized.

2.1.1 PUSC with same permutation and the same CID in each cell

The first solution is to use DL_TD_Zone_IE for the BSs in the active set with a common IDcell=0, the BSs in an active set transmit the packet with same CID in the same data region. MSS uses the same procedure to decode data as in non-SHO mode; signals from multiple BSs are energy combined if the relative delays among the active BSs are smaller than prefix.

The second solution for PUSC is that each BS PUSC allocation is the based on the default arrangement, therefore each sector PUSC is mapped based on different permutations, however, the collaborative transmission BSs in the active set each transmits additional PUSC segment with the permutation identical to the anchor segment. In addition, the active set will resolve the potential CID collision among the collaborative BSs in the active set.

In both the solutions, the data region to be allocated can be defined in two ways. The first one is to use DL_MAP_IE for the anchor BS. In this method, MS should keep monitoring DL_MAP of the anchor BS in SHO mode. The second one is to use DL_MAP_IE for the anchor BS and DL_PUSC_Burst_Allocation_in_Other_Segment_IE (the proposed IE; see the end of this document) for the others BSs in active set. The second method allows MS to select the best quality MAP message. Since every BS in active set directs MS to the same data burst allocation, the MS in SHO mode may choose any MAP message having higher quality. E.g., MS selects MAP message in the segment of which preamble has higher received signal level or CINR.

2.1.2 FUSC/AMC with same permutation and the same CID in each cell

A SHO Zone is created by using DL_TD_Zone_IE with a common IDcell=0, the BSs in an active set shall transmit the same data in the data region defined in DL_MAP_IE and MSS uses the same procedure to decode data as in non-SHO mode. The signals from multiple BSs are energy combined if the relative delays within active BSs are smaller than prefix. BSs shall coordinate their schedulers such that different MSSs use different data regions. BSs shall coordinate their schedulers to avoid interference to channel estimation. Alternatively, we can use PUSC permutation with the field "use all SC indication to 1"in TD_ZONE_IE format with a common IDcell=0.

2.2 DL SHO based macro-diversity with soft combining

The same DL transmission format i.e. the same CID are mapped onto different PHY sub-channels based on different permutations and transmitted over different BSs in the active set. The MSS separately demodulates the different BSs transmission and combines the received packet at LLR level. Therefore the soft coming of macro-diversity gain is achieved. However it requires complexity increase in MSS because MSS has to implement the soft-combing receiver.

2.2.1 PUSC/FUSC/AMC with different permutation and the same CID in each cell

BSs in the active set concurrently transmit the same data with the same CID and use the same data randomizer, but use the subchannel with different permutation.
There are two possible ways to use the same CID among active BSs.
One is to consider a centralized controller which coordinates the active BSs to use the common CID without collision. In this case, one method to inform MSS of the allocation information from each BS is to use the DL_MAP_IE together with Data_location_in_another_BS_IE from anchor BS. MSS only receive the DL-MAP from anchor BS. Another method is that each BS sends its own DL-MAP with allocation of the data region for MSS. In this case, MSS should be able to open all the DL-MAP from BSs in the active set.
The other is to use preamble ID along with CID in DL/UL MAP_IE to inform that CID in this IE is for BS with corresponding preamble ID. HO_Anchor_Active_DL_MAP_IE is used in active non-anchor BS to indicate that the allocated burst is for anchor BS and CID of this burst is that of the anchor BS instead of active non-anchor BS. HO_Anchor_Active_UL_MAP_IE is used in UL for the same purpose.
On the other hand, HO_Active_Anchor_DL_MAP_IE is used in anchor BS to indicate that the allocated burst is for active non-anchor BS and CID of this burst is that of the active non-anchor BS instead of anchor BS. For the uplink, HO_Active_Anchor_UL_MAP_IE is used.
To allocate the burst for active BS by using MAP_IE in active BS, HO_CID_Translation_MAP_IE is used along with normal MAP IE. This IE is used to translate the CID of anchor BS to the temporal CID which will be used in the active non-anchor BS. This MAP_IE is applied on both DL and UL.

In all cases, MSS demodulates signals from each BS, and combines soft bits from each BS, then decodes the packet based on the combined soft bits. For this, MSS is required to process the data from all ~~serving~~active BSs separately and apply the maximal ratio combining at LLR level. In addition, the active set will resolve the potential CID collision among the collaborative BSs in the active set.
For PUSC, as long as the PUSC segments in active set are disjoint, PUSC of each sector in active set may be mapped based on either same permutation or different permutation.

2.3 DL SHO based Interference avoidance

2.3.1 PUSC/FUSC/AMC with same permutation and the same CID in each cell

A SHO Zone is created with a common IDcell=0 with DL_TD_Zone_IE, MSS receives the DL_MAP_IE (or MIMO_DL_basic_IE) form the anchor BS, only one BS in the active is allowed to transmit in each burst data region, and the other collaborative BSs in the active set can simply turn off their transmissions in the data region in the SHO zone to achieve interference avoidance. MSS uses the same procedure to decode data as in non-SHO mode.

2.4 DL Macro-diversity SHO with selection combining

2.4.1 PUSC/FUSC/AMC with different permutation and the different CID in each cell

BSs in active set transmit the same data but with different CID. MSS demodulates data from each BS and selects one successfully decoded data.

2.5 DL Macro-diversity MIMO

2.5.1 PUSC/FUSC with same permutation and the same CID in each cell

Define a SHO Zone where a common IDcell is used. BSs in an active set shall transmit the same data in the data region defined in DL_MAP. A pre-determined antenna selection formula can be used. For FUSC, anchor BS shall coordinate schedulers to avoid channel estimation interference.

A SHO Zone is created with a common IDcell=0 with DL_TD_Zone_IE, MSS receives the MIMO_DL_basic_IE together with Data _location_in_another BS_IE from anchor BS. Total N antennas of 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 MSS capability and channel condition. The antennas selection can be varied from sub-channel to sub-channel to maximize spatial diversity. The allocated antennas in the BSs in the active set concurrently transmit the same data with the same CID, the BSs in the active set use the same data randomizer, the MSS demodulates the MIMO signals, and combines soft bits from each antenna, then decodes the packet based on the combined soft bits.

Note that all the cases discussed in section 2.1 to 2.4 are directly applicable to MIMO case, with the need to expand an additional MIMO_in_another_BS_IE.

2.6 UL SHO based macro-diversity

2.6.1 PUSC

The MSS transmits data to ~~serving~~anchor BS but other BSs in active set can also receive the data on the ~~serving~~anchor BS segment, which makes the selection diversity possible.

In the case of PUSC permutation (8.4.6.2.2), PUSC of each sector in active set should be mapped based on the same permutation with a common IDcell. On the other hand, in the case of optional PUSC permutation (8.4.2.5.2), PUSC of each sector in active set may be mapped based on either same permutation or different permutation, as long as the PUSC segments in active set are disjoint.

The data region to be allocated can be defined in two ways. The first one is to use UL_MAP_IE for the anchor BS. In this method, MS should keep monitoring UL_MAP of the anchor BS in active set. The second one is to use UL_MAP_IE for the anchor BS and UL_PUSC_Burst_Allocation_in_Other_Segment_IE (the proposed IE; see the end of this document) for the others BSs in active set. The second method allows MSS to select the best quality MAP message. Since every BS in active set directs MS to the same data burst allocation, the MSS in active set may choose any MAP message having higher quality. E.g., MS selects MAP message in the segment of which preamble has higher received signal level or CINR.

3 Summary

The SHO based macro-diversity transmission scenarios can be summarized in Table 1.

Table 1 Comparisons of SHO Based Macro-Diversity Transmission

Configurations		RF Combining		Soft Combining		Joint MIMO		Interference Avoidance		Frame Selection	
		PUSC	FUSC	PUSC	FUSC	PUSC	FUSC	PUSC	FUSC	PUSC	FUSC
Common Permutation Required		Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No
Common CID Required		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
DL Feasibility		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
UL Feasibility		No	No	No	No	No	No	No	No	Yes	Yes
MSS Backward Compatible	RX (DL)	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No
	TX (UL)	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes
Coverage benefit		Energy combining with interference level reduction		LLR combing with same level interference		LLR combining with interference level reduction		Interference level reduction only		Selective diversity with same level interference	
		OFDMA DL_TD_Zone_IE OFDMA_ DL_MAP_IE DL PUSC Burst Allocation in Other Segment IE MIMO_DL_basic_IE OFDMA DL_TD_Zone_IE Dummy_MAP_IE in non-anchor BS		OFDMA_ DL_MAP_IE OFDMA_Data _location_in_another BS_IE MIMO_DL_basic_IE MIMO_Data _location_in_another BS_IE HO_Anchor_Active _DL/UL_MAP_IE HO_Active_Anchor _DL/UL_MAP_IE SHO CID Translation MAP IE Dummy_MAP_IE in non-anchor BS		MIMO_DL_basic _IE MIMO_Data _location_in_another BS_IE		OFDMA DL_TD_Zone_IE OFDMA_ DL_MAP_IE DL PUSC Burst Allocation in Other Segment IE MIMO_DL_basic_IE ………………. OFDMA DL_TD_Zone_IE		OFDMA_ DL_MAP_IE OFDMA_Data _location_in_another BS_IE UL PUSC Burst Allocation in Other Segment IE MIMO_DL_basic_IE MIMO_Data _location_in_another BS_IE	

Note that Dummy MAP IE for RF combining can be defined by MAP_IE with Padding CID (0xfffe).
The burst is not counted as a valid burst.

4 Proposed Changes in Document

4.1 PUSC

[Add following section on line 46 page 76]

[Insert the following text before section 8.4.5.4]

8.4.5.3.12 DL PUSC Burst Allocation in Other Segment IE

In the DL-MAP, a BS may transmit DIUC=15 with the DL PUSC Burst Allocation in Other Segment IE () to indicate that data is transmitted to the SS in other segment through other BS.

Table xxx DL PUSC Burst Allocation in Other Segment IE

Syntax	Size	Notes
DL PUSC Burst Allocation in Other Segment IE () {		
Extended DIUC	4bits	DL PUSC Burst Allocation in Other Segment IE () == 0x0B
Length	4bits	Length=0x0A
CID	16bits	
DIUC	4bits	
Segment	2bits	Segment number for other BS' sector
IDcell	5bits	Cell ID for other BS' sector
Used Subchannels	6bits	Used subchannels at other BS` sector Bit #0: 0-11 Bit #1: 12-19 Bit #2: 20-31 Bit #3: 32-39 Bit #4: 40-51 Bit #5: 52-59
OFDMA symbol offset	8bits	
Subchannel offset	6bits	
No. OFDMA symbols	7bits	
No. Subchannels	6bits	
Boosting	3bits	000: normal (not boosted); 001: +6dB; 010: - 6dB; 011: +9dB; 100: +3dB; 101: -3dB; 110: -9dB; 111: -12dB;
Repetition coding indication	2bits	00 - No repetition coding 01 - Repetition coding of 2 used 10 - Repetition coding of 4 used 11 - Repetition coding of 6 used
reserved	7bits	shall be set to zero
}		

8.4.5.3.13 HO Anchor Active DL MAP IE

This MAP IE is in the DL-MAP of active non-anchor BS and indicates the burst from Anchor BS.

Table xxx HO Anchor Active DL MAP IE

Syntax	Size	Notes
HO Anchor Active DL MAP IE () {		
Extended DIUC	4 bits	HO Anchor Active MAP IE = 0x0C
Length	4 bits	Length

for (each bursts) {	16 bits	
Anchor Preamble	8 bits	Preamble of anchor BS
Anchor CID	16 bits	Basic CID in anchor BS
DIUC	4 bits	
OFDMA symbol offset	8bits	
Subchannel offset	6bits	
No. OFDMA symbols	7bits	
No. Subchannels	6bits	
Boosting	3bits	000: normal (not boosted); 001: +6dB; 010: - 6dB; 011: +9dB; 100: +3dB; 101: -3dB; 110: -9dB; 111: -12dB;
Repetition coding indication	2bits	00 - No repetition coding 01 - Repetition coding of 2 used 10 - Repetition coding of 4 used 11 - Repetition coding of 6 used
}		
}		

8.4.5.3.14 HO Active_Anchor DL MAP IE

This MAP IE is in the DL-MAP of the anchor BS and indicates the burst from active non-anchor BS.

Table xxx HO Active_Anchor_DL MAP IE

Syntax	Size	Notes
HO Active_Anchor DL MAP IE () {		
Extended DIUC	4 bits	HO Active_Anchor MAP IE = 0x0D
Length	4 bits	Length
for (each bursts) {	16 bits	
Active Preamble	8 bits	Preamble of active BS
Anchor CID	16 bits	Basic CID in anchor BS
DIUC	4 bits	
OFDMA symbol offset	8bits	
Subchannel offset	6bits	
No. OFDMA symbols	7bits	
No. Subchannels	6bits	
Boosting	3bits	000: normal (not boosted); 001: +6dB; 010: - 6dB; 011: +9dB; 100: +3dB; 101: -3dB; 110: -9dB; 111: -12dB;
Repetition coding indication	2bits	00 - No repetition coding 01 - Repetition coding of 2 used 10 - Repetition coding of 4 used

		11 - Repetition coding of 6 used
}		
}		

8.4.5.3.15 HO CID Translation MAP IE

The HO burst from active non-anchor BS is indicated by the MAP IE in DL-MAP of that BS with temporary assigned CID.
Because the CID is different from the anchor CID, the CID Translation MAP IE should provide translation of the Active CID into the Anchor CID. This translation IE is transmitted by Active non-anchor BS and applied on both DL and UL IEs. The translation is valid only in the frame.

Table xxx SHO CID Translation MAP IE

Syntax	Size	Notes
HO CID Translation MAP IE () {		
Extended DIUC	4 bits	CID Translation MAP IE = 0x0E
Length	4 bits	Length
for (each bursts) {	16 bits	
Anchor Preamble	8 bits	Preamble of anchor BS
Anchor CID	16 bits	Basic CID in anchor BS
Active CID	16 bits	Temporal CID
}		
}		

[Add following section at the end of page 78]

[Insert the following text before section 8.4.5.5]

8.4.5.4.17 UL PUSC Burst Allocation in Other Segment IE

In the UL-MAP, a BS may transmit UIUC=15 with the UL PUSC Burst Allocation in Other Segment IE () to define uplink bandwidth allocation in other segment.

Table xxx. UL PUSC Burst Allocation in Other Segment IE

Syntax	Size	Notes
UL PUSC Burst Allocation in Other Segment IE () {		
Extended UIUC	4bits	UL PUSC Burst Allocation in Other Segment IE () == 0x08
Length	4bits	Length=0x08

CID	16bits	
UIUC	4bits	
Segment	2bits	Segment number for other BS' sector
UL_IDcell	7bits	Cell ID for other BS' sector
OFDMA symbol offset	8bits	
Subchannel offset	6bits	
Duration	10bits	
Repetition coding indication	2bits	00 - No repetition coding 01 - Repetition coding of 2 used 10 - Repetition coding of 4 used 11 - Repetition coding of 6 used
reserved	1bits	shall be set to zero
}		

8.4.5.3.18 HO Anchor Active UL MAP IE

This MAP IE is in the UL-MAP of active non-anchor BS and indicates the burst from Anchor BS.

Table xxx HO Anchor Active UL MAP IE

Syntax	Size	Notes
HO Anchor Active UL MAP IE () {		
Extended UIUC	4 bits	HO Anchor Active MAP IE = 0x09
Length	4 bits	
for (each bursts) {	16 bits	
Anchor Preamble	16 bits	Preamble of anchor BS
Anchor CID	16 bits	Basic CID in anchor BS
Start subchannel offset	12 bits	
UIUC	4 bits	
Duration	10 bits	
Repetition coding indication	2bits	00 - No repetition coding 01 - Repetition coding of 2 used 10 - Repetition coding of 4 used 11 - Repetition coding of 6 used
}		
}		

8.4.5.3.19 HO Active_Anchor UL MAP IE

This MAP IE is in the UL-MAP of the anchor BS and indicates the burst from active non-anchor BS.

Table xxx HO Active_Anchor_UL MAP IE

Syntax	Size	Notes
HO Active_Anchor UL MAP IE () {		
Extended UIUC	4 bits	HO Active_Anchor MAP IE = 0x09
Length	4 bits	
for (each bursts) {	16 bits	
Active Preamble	16 bits	Preamble of active BS
Anchor CID	16 bits	Basic CID in anchor BS
Start subchannel offset	12 bits	
UIUC	4 bits	
Duration	10 bits	
Repetition coding indication	2bits	00 - No repetition coding 01 - Repetition coding of 2 used 10 - Repetition coding of 4 used 11 - Repetition coding of 6 used
}		
}		

4.2 MIMO

[Insert the following text before section 8.4.5.4]

8.4.5.3.13 MIMO_in_another_BS_IE

In the DL-MAP, a BS may transmit DIUC=15 with the MIMO_in_another_BS_IE () to indicate that data is transmitted to the MSS through other BS at the same frame. This IE shall be right after the IE defining the same data or data region received in the anchor BS.

Table XX. MIMO_in_another_BS_IE format

Syntax	Size	Notes
MIMO_in_another_BS_IE () {		
Extended DIUC	4 bits	0x09
Length	4 bits	Length in bytes
Segment	2 bits	Segment number
Used subchannels	6 bits	Used subchannels at other BS Bit #0: 0-11 Bit #1:12-19 Bit #2: 20-31 Bit #3: 32-39 Bit #4: 40-51 Bit #5:52-59
IDCell	5 bits	Cell ID of other BS
Num_Region	4 bits	
for (i = 0; i< Num_Region; i++) {		
OFDMA Symbol offset	10 bits	
Subchannel offset	5 bits	
Boosting	3 bits	
No. OFDMA Symbols	9 bits	
No. subchannels	5 bits	

Matrix_indicator	2 bits	STC matrix (see 8.4.8.1.4.)
		Transmit_diversity = transmit diversity mode indicated in the latest TD_Zone_IE().
		If (Transmit_Diversity == 0b01)
		{
		00 = Matrix A
		01 = Matrix B
		10-11 = Reserved
		}
		elseif (Transmit_Diversity == 0b10)
		{
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Reserved
		}

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