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Re:	Call for contribution on mobility enhancements – (802.16e-03/02) issued 2003-01-16
Abstract	The document includes enhancements to the OFDMA mode of the IEEE802.16a to enable it to work in a mobile environment.
Purpose	The 802.16e should adopt these enhancements as the base line additions to the OFDMA mode
Notice	
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Mobility Enhancements for the 2K OFDMA mode

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General

The following document concentrates on the enhancements we propose to the OFDAM mode of the IEEE802.16a in order to allow it to better operate in a mobile environment (or a mixed environment mobile + fixed). The deployment of such a system is supposed to be a multi-cell one; therefore some of the changes are focused on the ability to distinguish between cells and to move between them.

[Insert after section 8.5.1.1]

8.5.1.2 System aspects

There are several deployment scenarios, which are of most interest to us:

- Multi Cell Multi Frequency Network (MFN)
- Multi Cell Single Frequency Network (SFN)

The first option is the regular multi-cell with different frequencies allocated to each sector, such a deployment scenario is depicted in Figure 1 where each color represents a different frequency (in the right picture - frequency assignment).

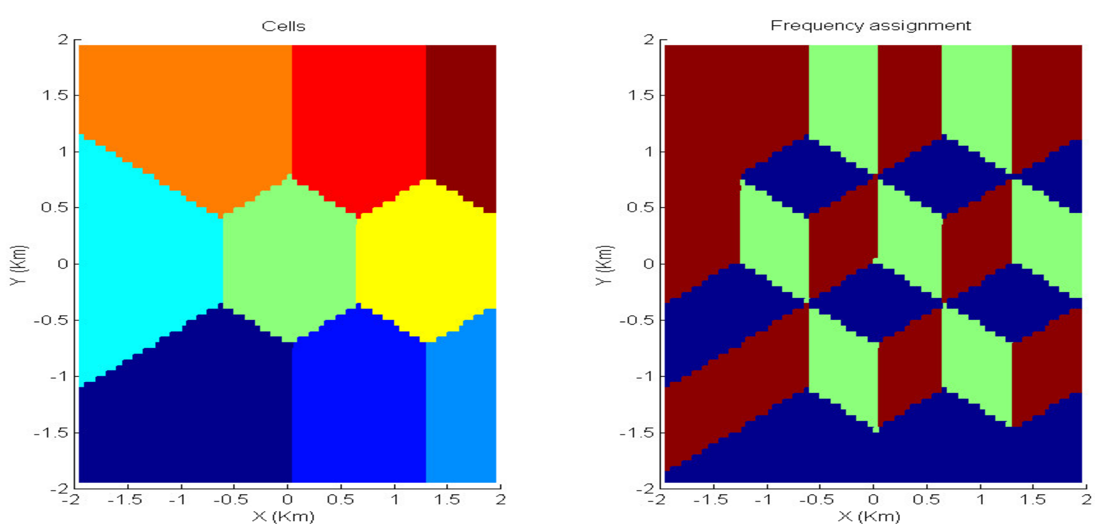

Figure 1: Multi-cell Deployment

Another possibility in OFDMA is to work with the second option – SFN, which means that each sector would use a logical entity of Sub-Channels (which will include several sub-channels), and then each color in the grid will represent such an entity. SFN allows the usage of a single channel to be divided into logical entities, rather

then splitting in into smaller physical units, this way the frequency diversity of each logical entity still has the same properties as the basic channel.
Many more advantages are possible due to the SFN architecture as:

- Bandwidth sharing between sectors
- Flexible deployment, without the need to change RF components.
- Capacity increase in a multi sector configuration (by using the same principles as CDMA)
- Easy extension of existing deployments
- Faster handoffs
- Soft handoff possibility without the need to switch RF channels
- Frequency diversity

The PHY layer supports this splitting seamlessly, but has to be aware that:

- Not all sub-channels might be used in the logical channel.
- The downlink frame prefix will be located at the left most corner of the usable sub-channels.

[End of text to be inserted]

PHY enhancements

This section includes the enhancements to the PHY layer.
[Insert after section 8.5.4.2]

8.5.4.3 Preamble only signal (for 802.16e)

A preamble only symbol shall be added to the DL transmission; this preamble shall be located before the first the frame preamble (defined in section 8.5.9.4.3.1) as shown in Figure. This preamble could be used in a multi-cell deployment for estimation, relative location calculation between base-stations and knowledge about the reception power and quality of the surrounding base-stations.

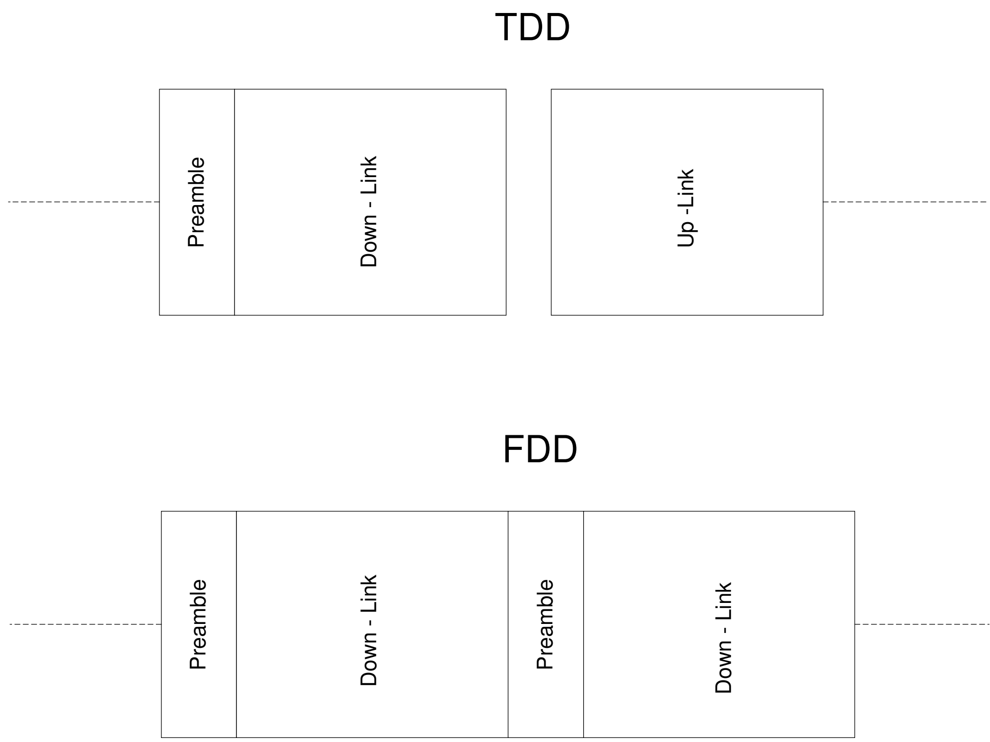

Figure xxx: Preamble Location within the frame transmission in TDD/FDD

The preamble will be transmitted on the carrier indices that obey the following formula:

$$\mathrm{mod}(UsedCarries, 6) = PN_{ID}$$

where:
PN_{ID} - an integer 0-5, setting the carriers location and PN sequence used
$UsedCarriers$ - the indices of the carrier to modulate

As can be noticed from the formula for PN_{ID} which differs in their modulo 6 calculation we have 6 different preambles, this will allow to work in a 6 sector deployment with each sector transmitting different preambles even for a single frequency deployment.
The modulation of the pilots shall be set accordingly to section 8.5.9.4.3, the initialization of the PRBS shall be set according to the following table:

PN_{ID}	PRBS Initialization
0	[11111111111]
1	[00011101010]
2	[11001010111]
3	[10111000101]
4	[01010100011]
5	[01110001100]

The modulation of the pilots in the frame preamble specified in section 8.5.9.4.3.1 shall be set according to the following table:

PN_{ID}	PRBS Initialization
0	[01010101010]
1	[00011101010]
2	[10011010011]
3	[01000101010]
4	[11100100011]
5	[00111001111]

[End of text to be inserted]

[Insert after section 8.5.6.1.2]

8.5.6.4 Mini Sub-Channels (for 802.16e)

The OFDMA Sub-Channel shall be further divided into smaller granularity mini Sub-Channels in order to gain more power concentration and better granularity.

8.5.6.4.1 DL Mini Sub-Channels

The regular Sub-Channel in the DL shall be further divided into 6 mini sub-channels. The regular sub-channel includes 48 data carriers, and a burst consists 3 time symbols, in order to keep backward compatibility and not change the frame structure the mini sub-channel will consists 8 carriers and a mini burst will consist 3 time symbol, this will give us a total of 24 data carriers per burst (1/6 the granularity of a regular burst).
The formula that defines what are the carrier indices allocated to a mini sub-channel out from the regular sub-channel:

$$mCarrier(j,k,i) = Carrier(6j+k,i)$$

where:
$mCarrier(j,k,i)$ - defines carrier j of mini sub-channel k within sub-channel i
$Carrier(x,y)$ - defines carrier x of sub-channel y, as defined in 8.5.6.1.2.
This structure enables each mini sub-channel to have the best frequency diversity, but still maintain a simple derivation from the regular sub-channel.
The usage of regular sub-channels and mini sub-channels is allowed in the system and therefore coexistence with 802.16a user is possible (a sub-channel that is divided into mini sub-channels will be used only in this structure).

8.5.6.4.2 UL Mini Sub-Channels

The regular Sub-Channel in the UL shall be further divided into 5 mini sub-channels. The 53 carriers of the regular sub-channel will be divided into 3 mini sub-channels each including 11 carriers and another 2 mini sub-channels each including 10 carriers.

The carriers which obey the following formula, are allocated to one mini sub-channel:

$$\mathrm{mod}(Carrier(j,i),5) = k$$

where:
$Carrier(j,i)$ - defines carrier j of sub-channel i, as defined in 8.5.6.1.2.
k - defines mini sub-channel k.
The structure of the mini sub-channel includes 8 data carriers and 2/3 pilot carriers.
Figure 2 depicts the mini sub-channel organization:

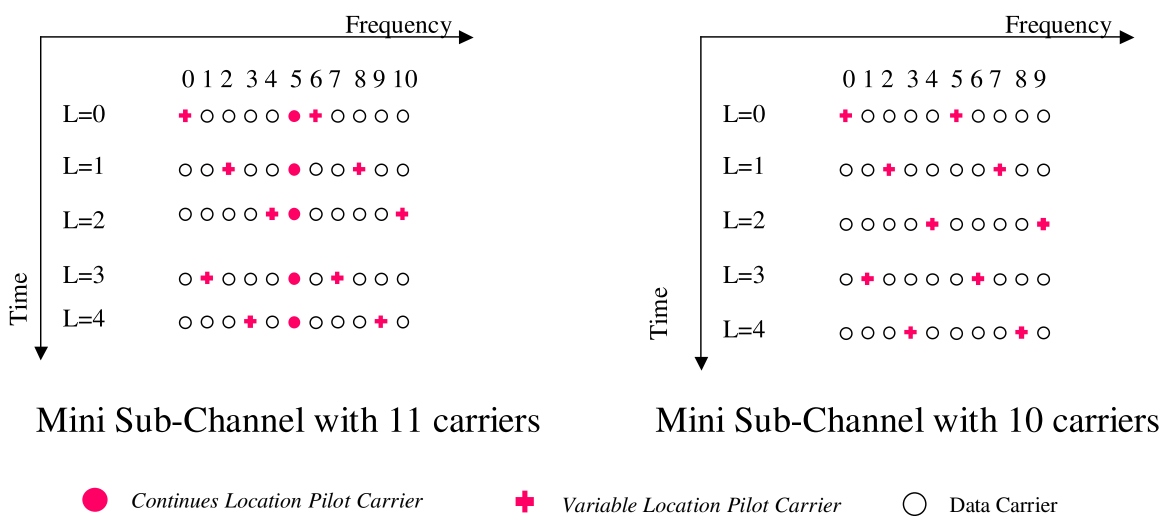

Figure 2: Mini Sub-Channel organization and structure

the structure proposed will enable a module 5 frame structure, with maximum frequency diversity.

8.5.6.4.3 Randomization

The randomization procedure will be performed as specified in section 8.5.9.1, with the same initialization procedure. The Sub-Channel offset, which sets the 6 LSB bits of the randomizer, shall be taken from the LSB bits of the mini Sub-Channel numbering.

8.5.6.4.4 FEC

The FEC option proposed shall include CTC and performed per mini burst, with the following parameters (and performed as described in section 8.5.9.2.3):

Modulation	Data Block Size (Bytes)	Coded Block Size (Bytes)	Code Rate	N	P0	P1	P2	P3
QPSK	3	6	½					
QPSK	4.5	6	¾					
16QAM	6	12	½					
16QAM	9	12	¾					
64QAM	9	18	2/3					
64QAM	13.5	18	¾					

8.5.6.4.5 Interleaving

The interleaving shall be performed per mini burst, as described in section 8.5.9.3.
The parameters for the interleaver are:

Modulation	Coded Bits Per Block (Ncbps)	Modulo used (d)
QPSK	48	16
16QAM	96	18
64QAM	144	16

8.5.6.4.6 Modulation

As described in section 8.5.9.4.

8.5.6.4.7 Pilots Modulation

The modulation of the pilots shall be set accordingly to section 8.5.9.4.3, the initialization of the PRBS shall be set according to the following table:

PN_{ID}	PRBS Initialization
0	[11111111111]
1	[00011101010]
2	[11001010111]
3	[10111000101]
4	[01010100011]
5	[01110001100]

The modulation of the pilots in the frame preamble specified in section 8.5.9.4.3.1 shall be set according to the following table:

PN_{ID}	PRBS Initialization
0	[01010101010]
1	[00011101010]
2	[10011010011]
3	[01000101010]
4	[11100100011]
5	[00111001111]

[End of text to be inserted]

MAC enhancements

This section includes the enhancements to the MAC layer.

Mini sub-channel Numbering

[Insert after section 8.5.5.3]

8.5.5.3.1 UL-MAP information IE (for 802.16e)

The mini sub-channel Numbering shall be done as follows:

Table xxx: OFDMA UL-MAP Information Element format

Syntax	Size	Notes
UL-Map_Information_Element() {		
CID	16 bits	
UIUC	4 bits	
if (UIUC == 4) {		
CDMA_Allocation_IE()	52 bits	
} Else if (UIUC == 15) {		
Extended UIUC dependent IE	Variable	Power_Control_IE() or AAS_UL_IE()
} else {		
OFDM Symbol offset	10 bits	
Subchannel offset	6 bits	
No. OFDM Symbols	8 bits	
No. Subchannels	5 bits	
Mini_Subchannel index	3 bits	000 – no mini subchannels used; 001 – mini subchannel 1 is allocated 010 – mini subchannel 2 is allocated 011 – mini subchannel 3 is allocated 100 – mini subchannel 4 is allocated 101 – mini subchannel 5 is allocated 110,111 – reserved
}		
}		

[End of text to be inserted]

[Insert after section 8.5.5.2]

8.5.5.2.1 DL-MAP information IE (for 802.16e)

The mini sub-channel Numbering shall be done as follows:

Table xxx: OFDMA DL-MAP Information Element format

Syntax	Size	Notes
DL-Map_Information_Element() {		
DIUC	4 bits	
if (DIUC == 15) {		
Extended DIUC dependent IE	Variable	AAS_DL_IE()
} else {		
OFDM Symbol offset	8 bits	
Subchannel offset	5 bits	
Boosting	3 bits	000: normal (not boosted); 001: +6dB; 010: -6dB; 011: +9dB; 100: +3dB; 101: -3dB; 110: -9dB; 111: -12dB;
No. OFDM Symbols	8 bits	
No. Subchannels	5 bits	
Mini_Subchannel index	3 bits	000 – no mini subchannels used; 001 – mini subchannel 1 is allocated 010 – mini subchannel 2 is allocated 011 – mini subchannel 3 is allocated 100 – mini subchannel 4 is allocated 101 – mini subchannel 5 is allocated 110,111 – reserved
}		
}		

[End of text to be inserted]

[Insert after section 8.5.4.6]

8.5.4.7 Logical channels (for 802.16e)

When the SFN scheme is deployed, each sector may be allocated with a different set of sub-channels as the usable resource.
The set of sub-channels, which is allocated to each BS, shall be referred as *Logical Channel*.
Each BS shall be allocated with a specific logical channel through the management layer.
The allocation of logical channels to the BSs may be dynamic and can be dependent of the current load distribution within the cell, i.e. if BS_1 does not have many registered SSs, while BS_2 approaching it's maximum capacity with current allocation, then the sub-channels can be moved from BS_1's logical channel to BS_2 logical channel.

[End of text to be inserted]

Extended OFDMA forward APC range

The Forward Automatic Power Control (FAPC) defined in the 802.16a should have more degrees of freedom, in order to facilitate finer control of variations in the mobile channel.
The following change is proposed for this purpose:
[In section **8.5.5.2 DL-MAP Information Element format**:]

- Change number of bits of **OFDM Symbol offset** field from 10 to 9.
- Change number of bits of **Boosting**[*] field from 2 to 3.
- Changed the possible values of the **Boosting** field as follows: 000: normal (not boosted); 001: +3dB; 010: +6dB; 011: +9dB; 100: -3dB; 101: -6dB; 110: -9dB; 111: -12dB;

[End of changes text]

Fast correction of uplink power, frequency and timing

Fast uplink tracking is an extension of the fast uplink power control support defined in the 802.16a. The extension is proposed in order to enable fast frequency and timing correction in the uplink, and offer better tracking of the variations introduced by the mobile channel.
The following section should be added into the standard.
[Insert after section 8.5.5.3.4]

8.5.5.3.5 UL-MAP Fast tracking indication

The UL-MAP Fast Indication in an UL-MAP entry used to provide fast power, time and frequency indications\corrections to SS that have transmitted in the previous frame.
The extended UIUC=15 shall be used for this IE with sub-code 0x03
The CID used in the Information Element should be a broadcast CID.

Table xxx—UL fast tracking Information Element

[*] This field should be moved from UL-MAP IE to DL-MAP IE due to an editorial error, and should be fixed in the errata process.

Syntax	Size	Notes
UL_Fast_tracking_IE() {		
extended UIUC	4 bits	Fast-Indication = 0x03
Number of Elements	8 bits	Number of Fast Indication bytes
for (*i* = 1; *i* <= *n*; *i*++) {		For each Fast Indication bytes 1 to n (n=Number of Element field)
Power correction	2	Power correction indication, 00: no change; 01: +2dB; 10: -1dB; 11: -2dB
Frequency correction	4	Frequency correction. Units are PHY-specific For OFDM/OFDMA: The correction is 0.1% of the carrier spacing multiplied by the 4-bit number interpreted as a signed integer (i.e. 1000: -8; … 0000: 0; … 0111: 7)
Time correction	2	Time offset correction. Units are PHY-specific For OFDM/OFDMA: The correction is floor(2 / F_s) multiplied by, 00: 0; 01: 1; 10: -1; 11: Not used
}		
}		

The UL Fast tracking IE is an optional field in the UL_MAP. When this IE is sent it provides an indication about corrections that should be applied by SS that have transmitted in the pervious UL frame. Each Indication byte shall correspond to one unicast allocation-IE that has indicated an allocation of an uplink transmission slot in the previous UL_MAP. The order of the indication bytes shall be the same as the order of the unicast allocation-IE in the UL-MAP.

[End of text to be inserted]