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Abstract	To allow for concurrent transmission of bursts, this contribution proposes four new extended IE formats (2x OFDM DL-MAP IE, SCa DL-MAP IE and SCa UL-MAP IE). The approach of using extended IEs for concurrent transmission of bursts will neither affect the control structure during normal operation nor will it introduce additional overhead.
Purpose	For inclusion in the 802.16-REVd_D3 document
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Extended IE format for concurrent transmission of bursts

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References

[SmartAntennas] T. Rappaport, J. Liberti, “Smart Antennas for Wireless Communications: IS-95 and Third Generation CDMA Applications”, Prentice Hall, 1999

[802.16a-2003] IEEE802.16a-2003

[802.16-REVd/D3-2004] IEEE802.16-REVd/D3-2004

Executive summary

To allow for concurrent transmission of bursts, this contribution proposes four new extended IE formats (2x OFDM DL-MAP IE, SCa DL-MAP IE and SCa UL-MAP IE). The approach of using extended IEs for concurrent transmission of bursts will neither affect the control structure during normal operation nor will it introduce additional overhead.

Introduction

If an antenna array is applied at the 802.16 base station, beamforming algorithms allow the transmission of power in certain directions to increase the receiver signal-to-noise ratio. It is also possible to steer nulls into certain directions to decrease co-channel interference. A beam is steered by applying a weight, i.e. a complex number to each antenna element. Thus, a beam is represented by a weight vector $\mathbf{w_i}$ which contains one weight per antenna element (see figure 1). If multiple beams are applied, one weight vector per beam has to be calculated ($\mathbf{w_0}$, $\mathbf{w_1}$, $\mathbf{w_{K-1}}$).

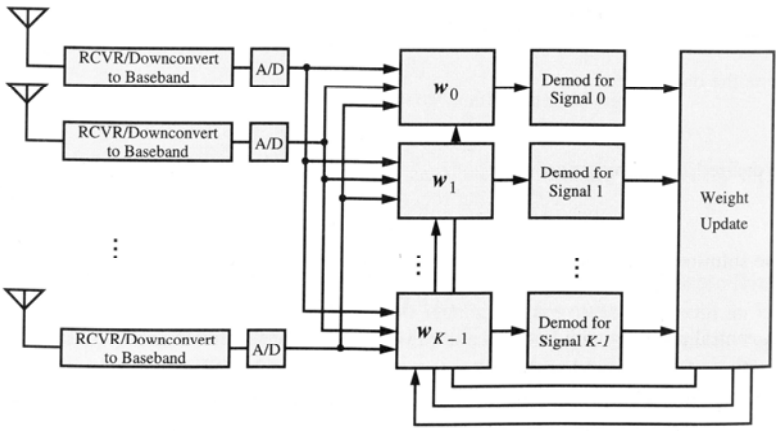

figure 1: Beamformer for multiple signals [SmartAntennas]

By applying multiple beams, a signal can be directed to a certain SS, e.g. user 1, and a null can be placed in the direction of another SS, e.g. user 2, assuming the SSs can be separated well enough by the applied algorithm. At the same time, on the same frequency a different signal can be sent by the BS which is directed to user 2 and has a null steered to user 1. The amplitude factors of an optimized beamforming algorithm in a two-user scenario are shown in figure 2. Similarly several SSs can be served simultaneously without significant interactions. This principle can be applied in downlink as well as in uplink.

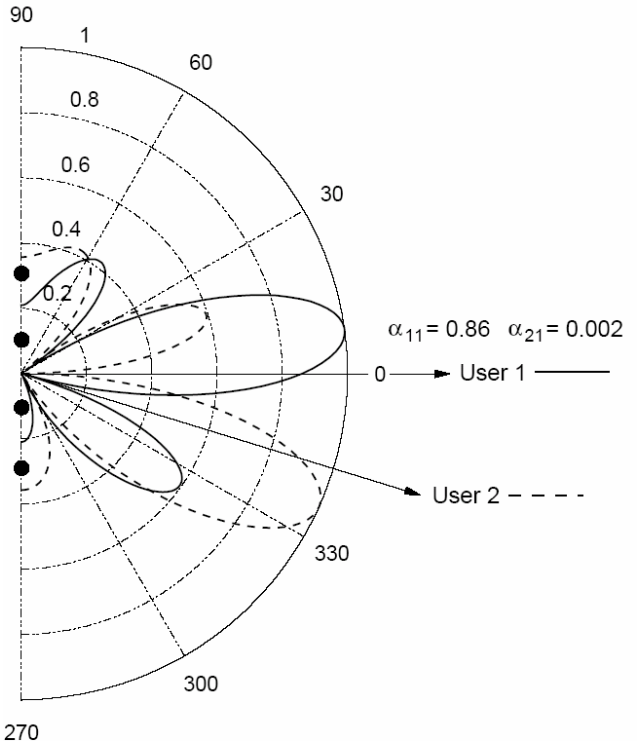

figure 2: Amplitude factors in a two user scenario and two optimized beam patterns

The resulting structure of the IEEE 802.16 MAC frame with concurrent DL/UL bursts has to be specified by the DL-MAP and UL-MAP respectively. Besides the time dimension a new spatial dimension occurs, this is outlined in figure 3.

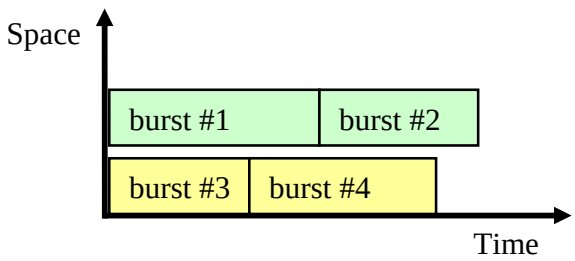

figure 3: Concurrent bursts

OFDM

Within the OFDM PHY of [802.16-REVd/D3-2004] the DL-MAP information element (IE) contains the CID and the start time (refer to table 203 on page 429). The DL-subframe implicitly contains a successive sequence of bursts. It is sufficient to specify the start time in the DL-MAP IE, due to the fact that the start time of the following burst is implicitly the end of the current downlink burst. But within the DL-MAP IE the duration is still missing and that disables the transmission of concurrent bursts in DL direction. Thus, this contribution proposes a new extended OFDM DL-MAP IE to include the burst duration.

In downlink, a preamble shall be included in front of each concurrent burst. Like in uplink, the preambles of concurrent bursts could be cyclically shifted. An equivalent DL-MAP IE is proposed.

OFDMA

The OFDMA MAP IEs contain all necessary information to specify concurrent bursts. No changes are proposed for this PHY mode.

SCa

The current SCa PHY is based on a successive sequence of bursts. It is sufficient to specify the Offset, i.e. start time, in the DL- and UL-MAP information element (IE), due to the fact that the Offset of the following burst is implicitly the end of the current burst. Having a new degree of freedom, the successive structure may be substituted by a parallel one. Both, the UL- and the DL-MAP IEs need to determine the start and the end of each burst to be able to signal concurrent bursts to the SSs. For the downlink, a preamble shall be included in front of each concurrent burst and the CID of the assigned SS has to be specified. Thus, a SCa DL- and UL-MAP extended IE is proposed.

The approach of using extended IEs for concurrent bursts will neither affect the control structure during normal operation nor will it introduce additional overhead.

Proposed Contribution

Insert at the end of the first paragraph of 6.4.7.6.1 (line 30 on page 160):

An additional benefit is the signal-to-noise ratio (SNR) gain realized by coherently combining multiple signals, and the ability to direct this gain to particular users. Another possible benefit is the reduction in interference achieved by steering nulls in the direction of co-channel interferers. Combining the benefits of increasing the SNR of certain subscribers and steering nulls to others, enables bursts to be concurrently transmitted to spatially separated SSs. For the uplink direction the same principle can be applied in a reciprocal fashion. A concurrent transmission of bursts does not necessarily increase the system's range but may enhance system capacity.

Insert at the end of 6.4.7.6.2 (line 55 on page 160):

The control of the AAS part of the frame may be done by unicasting private management messages to individual SSs. These messages shall be the same as the broadcast management messages, except that the basic CID assigned to the SS is used instead of the Broadcast CID.
If AAS enabled SSs can decode the broadcast DL-MAP and DCD messages, the BS may specify concurrent bursts by means of the extended concurrent transmission IE format as described in 8.2.1.5.5.2.6, 8.2.1.5.5.3.4 and 8.3.5.2.6.

Insert new section 8.2.1.5.5.2.6, fix up the table numbers as required (line 1 on page 391):

8.2.1.5.5.2.6 Concurrent transmission IE format

In the DL-MAP, a BS may transmit DIUC=15 with a DL_Concurrent_IE() to specify one of a set of parallel downlink bursts for transmission. The extended format explicitly specifies the duration and the CID of the corresponding downlink burst. A preamble may precede the downlink burst specified by this IE. When present the preamble shall have the same characteristics as the burst set preamble of the current DL subframe.

Table 178 – SCa Concurrent transmission IE format

Syntax	Size	Notes
DL_Concurrent_IE() {		
Subcode	4 bits	CONC = 0x04
Length	4 bits	Length = 7
Preamble present	1 bit	0 – No preamble preceding burst 1 – Preamble precedes burst
Reserved	3 bits	
DIUC	4 bits	
Offset	16 bits	
CID	16 bits	
Duration	16 bits	Duration of burst in PS
}		

DIUC:

A 4-bit DIUC shall be used to define the burst type associated with that burst. Burst Descriptor shall be included into DCD message for each DIUC used in the DL-MAP. The DIUC shall be one of the Data Grant (1-12) values defined in Table 172.

Offset:

Offset (in units of PSs) to the start of the data burst from the start of the frame.

CID:

Identifies the target of the concurrent burst. The value may be a unicast or multicast address. When specifically addressed, the CID shall be the Basic CID of the SS.

Duration:

Specifies the length of the associated burst in PS.

Insert new section 8.2.1.5.5.3.4, fix up the table numbers as required (line 17 on page 394):

8.2.1.5.5.3.4 Concurrent transmission IE format

In the UL-MAP, a BS may transmit UIUC=15 with the UL_Concurrent_IE() to specify one of a set of parallel uplink allocations for transmission. This format explicitly specifies the duration of the corresponding uplink burst.

Table 183 – SCa Concurrent transmission IE format

Syntax	Size	Notes
UL_Concurrent_IE() {		
Subcode	4 bits	CONC = 0x03
Length	4 bits	Length = 4 if Burst set type is not Subchannel 5 if Burst set type is Subchannel
UIUC	4 bits	
Offset	12 bits	
Duration	12 bits	Duration of burst in minislots
Reserved	4 bits	
If (Burst set type is Subchannel) {		
Starting subchannel	4 bits	
Subchannel count	4 bits	
}		
}		

UIUC:

UIUC shall be used to define the type of uplink access and the burst type associated with that access. A Burst Descriptor shall be included into an UCD message for each UIUC used in the UL-MAP. The UIUC shall be one of the values defined in Table 179 except Gap, End of map or Extended UIUC.

Offset:

Indicates the start time, in units of minislots, of the burst relative to the Allocation Start Time given in the UL-MAP message.

Duration:

Specifies the length of the associated burst in minislots.

Starting subchannel:

For bursts associated with the subchannel burst frame type, this parameter specifies starting subchannel assigned to the transmission. Specifies the length of the associated burst in minislots.

Subchannel count:

For bursts associated with the subchannel burst set type, this parameter specifies the number of adjacent subchannels assigned to the transmission.

Insert new section 8.3.5.2.6, fix up the table numbers as required (page 432):

8.3.5.2.6 DL-MAP concurrent transmission IE format

In the DL-MAP, a BS may transmit DIUC=15 with a DL_Concurrent_IE() to specify one of a set of parallel downlink bursts for transmission. This format explicitly specifies the duration of the corresponding downlink burst. A preamble may precede the downlink burst specified by this IE.

Table 209 – OFDM DL_MAP Concurrent transmission IE format

Syntax	Size	Notes
DL_Concurrent_IE() {		
Extended DIUC	4 bits	CONC = 0x03
Length	4 bits	Length = 2
DIUC	4 bits	
Duration	12 bits	Duration of burst in OFDM symbols
}		

DIUC

A 4-bit DIUC shall be used to define the burst type associated with that time interval. Burst Descriptor shall be included into DCD message for each DIUC used in the DL-MAP. The DIUC shall be one of the Burst Profile values (1-12) defined in Table 204.

Duration

Indicates the duration of the burst, in units of OFDM symbols. The duration is inclusive of the preamble contained in the allocation, if present.

Change entry of table 203 (on page 429):

Preamble present	1 bit	0 = not present, 1 = present if **(**DIUC == 15 **AND NOT Extended DIUC = 3)**, shall be 0

Insert new section 8.3.5.2.7, fix up the table numbers as required (page 432):

8.3.5.2.7 DL-MAP Physical Modifier IE

The Physical Modifier Information Element indicates that the subsequent bursts utilize a preamble, if present, which is cyclically delayed in time by M samples. Equation (76) defines the waveform transmitted during these training symbols. The PHYMOD_IE can appear anywhere in the DL map, and it shall remain in effect until another PHYMOD_IE is encountered, or until the end of the DL map.

Only stations which are allocated in bursts specified by a DL-MAP concurrent transmission IE format (8.3.5.2.6) shall receive the timely shifted preamble.

Syntax	Size	Notes
PHYMOD_IE() {		
Extended DIUC	4 bits	PHYMOD = 0x04
Length	4 bits	Length = 1
Preamble Time Shift	8 bits	Preamble time shift
}		

Preamble Time Shift

The parameter indicating how many samples of cyclic shift are introduced into the training symbols of the following bursts (M in Equation (76)).

Change section number 8.3.5.2.6 to 8.3.5.2.8 (on page 432)

Change entry of table 209 (on page 432):

Extended DIUC	4 bits	~~**0x03**~~ **0x05** … 0x0F