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Source(s)	Tal Kaitz et al. Alvarion Ltd. 21 A Habarzel St. P.O. Box 13139, Tel-Aviv 61131, Israel Voice: +972-36457834 Fax: +972-36456222 mailto:tal.kaitz@alvarion.com
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DL subchannelization for OFDM mode

Tal Kaitz, Naftali Chayat Vladimir Yanover (Alvarion Ltd.)

1. Introduction

It is proposed to enhance the OFDM mode by introducing DL subchannelization (DL OFDMA) as an optional extension. DL subchannelization can improve the reuse factor and the link budget. DL subchannelization can also reduce the overheads associated with preambles, when operating in conjunction with AAS techniques. In addition, it is proposed to enhance system robustness by introducing low rate codes.

2. DL Subchannelization: Principles of operation.

The key features of the DL subchannelization proposal are as follows:

- The DL subchannelization is used in a dedicated region of the DL sub-channel. Thus backward compatibility is maintained.

- Maximum re-use of elements from 802.16REVd OFDM mode:
  - Same number of subchannels.
  - Same pilot and sub carrier locations.
  - Same basic FEC and interleaving schemes.
  - Same midamble based training format.

- Robust operation in high interference scenarios.
  - Dedicated control channel
  - Low rate codes.

- Simple implementation:
  - No concurrent reception of bursts.
  - A SS needs to decode a single burst at a time, control or data.

- Designed in support of AAS.

3. Detailed description

The DL subchannelization is transmitted in a dedicated section of the DL sub-channel. This section is pointed to by the regular DL map, where it is marked by a new DL-subchannelization extended IE. 802.16REVd SSs interpret this new IE as a 'dummy IE'. Thus backward compatibility is maintained.

The DL subchannelization region is marked by at least one pair of preamble and FCH burst, of one symbol duration each. The FCH contains a DLFP which points to the first burst of the control subchannel (CCH). The format of the DLFP is shown in Table 1. In an AAS systems, pairs of preamble and FCH may be repeated to create beam pattern diversity.

The CCH channel carries the DL and UL map information IE, termed CCH_MAP_Ies (See Table 2). Additional map IEs, of similar structure, are embedded in the DL burst. All map information elements are relevant to the next frame. A BST shall assume that the SS is not capable of receiving more than one burst in a single frame.

The map structure defined above forms a chain of maps. The control channel is typically used to initiate such a chain. Additionally, the BST may echo some of the embedded DL map information elements on the control subchannel. This may be used for recovery in case one of the embedded DL map IEs was lost.

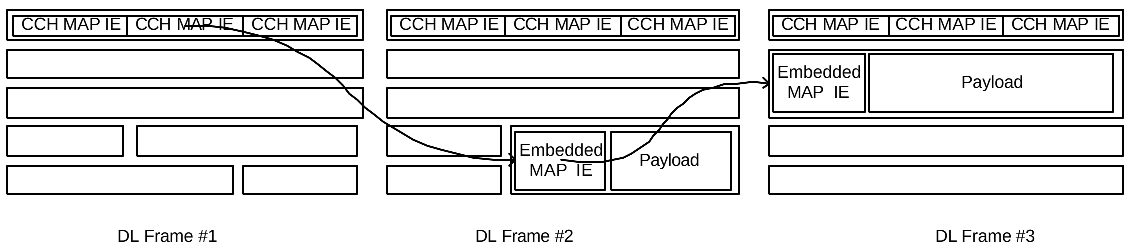


Figure 1 Map chaining

The control channel is composed of several bursts in descending order o robustness. Each burst contains the rate and length of the next burst. A SS decodes the chain of bursts until it decodes a MAP_IE designated to it or until it has reached a burst it cannot decode. This structure allows for a very robust control channel without compromising air efficiency. This is shown in Figure 2.

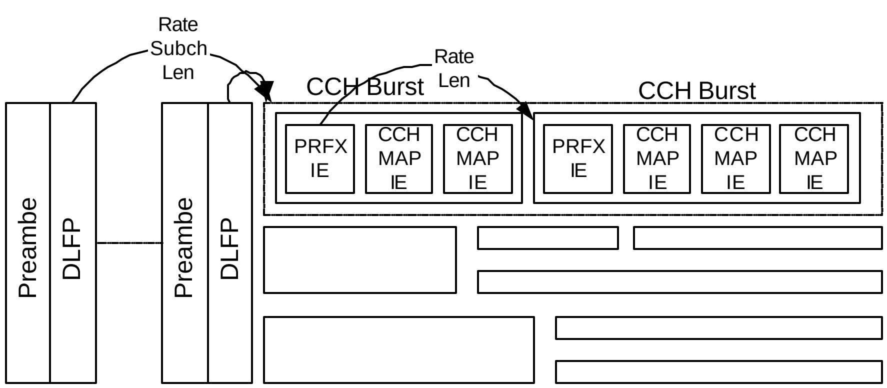


Figure 2 Format of DL Subchannelization section

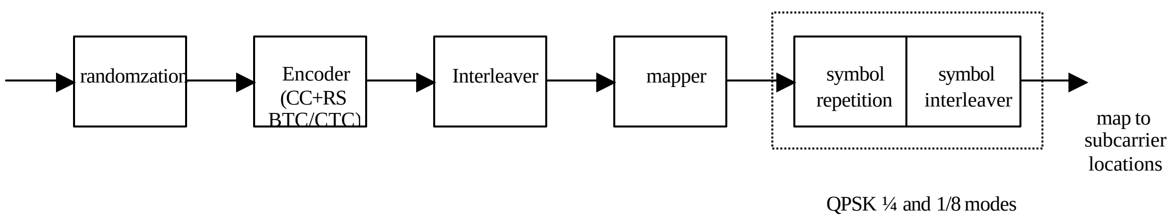
In AAS systems, bursts on the CCH may be transmitted using a directed a beam, or using beam pattern diversity. These bursts are typically transmitted at the end of the CCH. When a SS cannot determine the rate and length parameters of the CCH burst it shall assume the same parameters as set in the DLFP.

4. Low rate Error correction codes

It is proposed to introduce low rate error correction codes by concatenating a repetition code with a convolutional code. This is a similar approach to that used in the OFDMA section of 802.16REVd. The operation is as described below.

The encoding path includes the following elements: randomization, FEC, interleaving, modulation and symbol repetition and symbol interleaving. With the exception of symbol repetition and symbol interleaving, all elements are the same as in 802.16REVd.

The FEC scheme shall implement all the mandatory FEC modes of 802.16d. In these modes the symbol repetition and symbol interleaver are bypassed. Additionally, two new FEC modes are introduced: QPSK rate ¼ and QPSK rate 1/8 mode. In these modes, every mapped QPSK symbol is duplicated 2 or 4 times, respectively.



5. Specific text changes

<< Add in 8.3.5.3.1 after the paragraph about STC zone>>

The DL sub-frame may optionally contain a DL subchannelization zone as described in 8.3.5.3 PMP-DL subchannelization Zone.

<<Add section>>

8.3.5.3 PMP DL subchannelization.

The DL sub-frame may optionally contain a DL subchannelization zone. This zone is marked by a DL_SUBCH_IE in the DL Map.

The DL subchannelization zone is shown in Figure 3. The zone commences with a short preamble. The preamble is followed by an FCH burst, which is one symbol long, occupies the entire BW, and is transmitted using QPSK rate 1/8. The FCH is followed by sub-channelized traffic. The data and pilot subcarrier allocations of the subchannelized traffic are defined in table 211 ('OFDM symbol parameters). One of the subchannels is designated as the control subchannel (CCH).

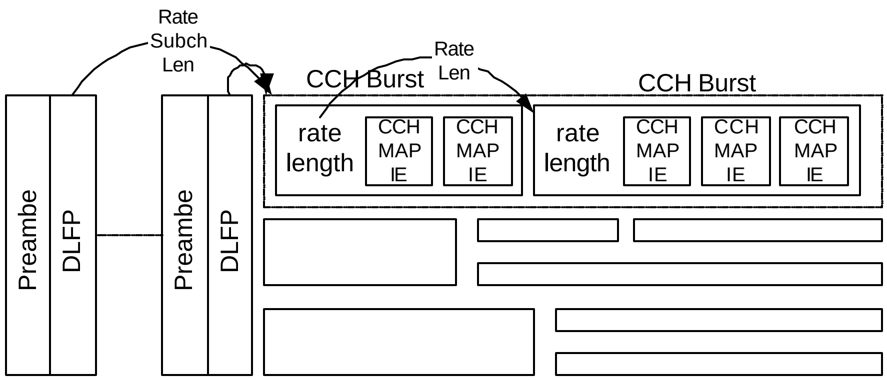


Figure 3 Format of DL Subchannelization section

The FCH contains the SBCH_DLFP, which points to the CCH, and contains the profile and length of the first burst in it. The FCH may be transmitted several times, thus achieving beam-pattern diversity. The SBCH_DLFP is shown in Table 1.

Field	Size	Comments
SBCH_DL_Frame_Prefix_Format() {		
Base_Station_ID **Frame_Number**	4 bits 4 bits	4 LSBs of BS ID. The burst specified by the DFLP shall not be decoded if these bits do not match those of the BS on which it is registered bits 4 LSBs of Frame Number field as specified in Table 214
Configuration_Change_Count	4 bits	4 LSBs of Change Count value as specified in 6.3.2.3.1
CCH Start	5bit	Points to the beginning of the CCH; expressed in terms of offset from the current preamble.
CCH subchannel index	5bits	The subchannel index, in which the CCH is transmitted. See table 192.
CCH_Rate ID **CCH duration**	4bits 4bits	The Rate ID, according to table XXX, of the first burst of the CCH. The duration of the first burst in the CCH.
CCH midamble repetition	2bits	The midamble repetition rate of the first burst of the CCH.
HCS	8bits	An 8-bit Header Check Sequence; calculated as specified in Table 5

}		
Total	40	

Table 1 Format of SBCH_DLFP

Each burst in the CCH carries exactly one CCH_IE, which contains the profile and duration of the next burst in the CCH, and a number of CCH_MAP_IE which point to data bursts. The number of CCH_MAP_IE is determined from the duration of the burst.

Field	Size	Comments
CCH_IE() {		
CCH_DIUC	4bits	The DIUC of the next burst of the CCH. DIUC ==14 signifies the end of the CCH.
CCH duration	4bits	The duration of the next burst in the CCH.
for (i=0 i<number of CCH_MAP_IEs; I++){ **CCH_MAP_IE**	64	Number of CCH MAP IE is determined according to the length of the burst.
}		
HCS	8bits	

Table 2 Format of CCH_MAP_IE

The structure of the CCH_MAP_IE, is shown in Table 3.

Field	Length, bits	Comments
Direction	1	0=This element defines a DL allocation 1=This element defines an UL allocation
Last MAP IE in the chain	1	If '1', points to burst that does not contain more MAP IEs. Otherwise points to burst that starts with similar IE pointing to the next burst etc.
UL MAP present	1	If '1', next in the burst is UL IE, otherwise regular MAC messages
Reserved	1	
IUC	4	IUC. Interpreted as UIUC if direction==1. Otherwise interpreted as DIUC
If (IUC!=1 && direction = =1)		
CID	16	

else {		
Frame index number	4	Identifies the frame in which the network entry request, which this message responds to, was transmitted. Indicates the number of DL frames elapsed since the network entry request was transmitted, to the current frame. If the request was transmitted in the previous frame, Frame index number=0.
Network entry code	4	
Reserved	8	
} Length	10	Length of the UL burst in symbols
Offset	11	Offset in symbols from the beginning of the next frame
Subchannel index	4+4	start subchannel + width
Preamble code	3	Information about the preamble rotation and midamble repetition.
HCS	8	HCS shall not be used when the CCH_MAP_IE is transmitted on the CCH.
Total	56/64	

Table 3 Format of CCH_MAP_IE

CCH_MAP_IE always points to a burst in the next frame. The pointed burst may contain an embedded map information element of similar structure, which points to a burst in the next frame. Thus a chain of maps is created. This is shown in Figure 4. Note that the CCH may be used to initiate such a chain of maps. The CCH_MAP_IE may echo the same information of the embedded information to help recover the chain in case of a channelerror.

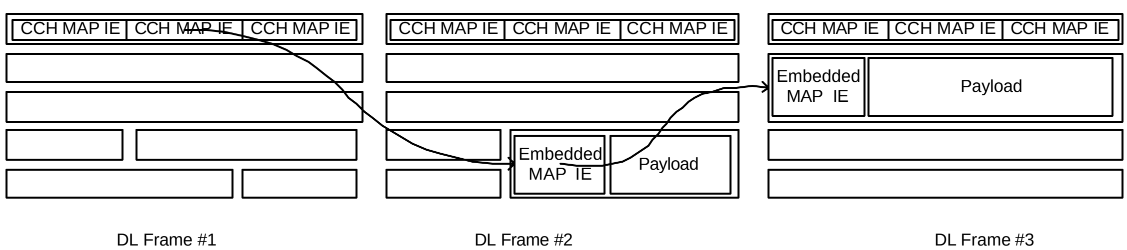


Figure 4 Map chaining

A BST shall assume that the SS is not capable of receiving more than one burst in a single frame. For AAS support, CCH bursts may be transmitted on directed beams or may be transmitted using beam pattern diversity.

<<Add section>>

8.3.6.2.6 DL SUBCH_IE format

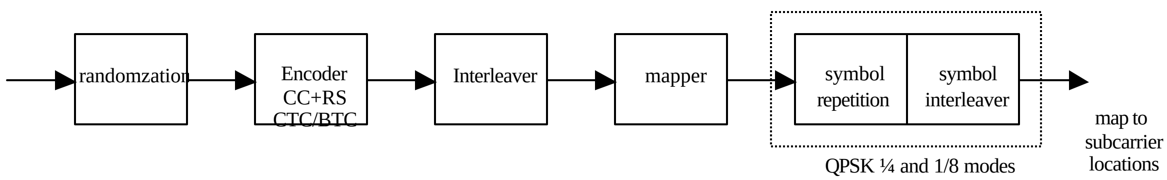
In the DL-MAP a DL subchannelization enabled BST (see 8.3.5.3) may transmit an extend IE with value of 0x05 to indicate that subsequent allocations use DL subchannelization. The DL_SUBCH_IE shall be the last element in the downlink map.

Syntax	Size	Comments
DL_SUBCH_IE{		
Extended DIUC	4bits	DL_SUBCH=0x05
Length	4bits	Length=0x00
}		

<<Change in DL-MAP Dummy IE format>>
0x05…0x0F to 0x06…0x0F

<<Change In 8.3.3>>

Channel coding is composed of three steps: randomizer, FEC, and interleaving and symbol mapper. They shall be applied in this order at transmission. When QPSK rate ¼ and QPSK rate 1/8 are employed, the channel coding is composed additionally of symbol repetition and symbol interleaver, applied after the interleaver. This is shown in figure XXX. The complementary operations shall be applied in reverse order at reception.



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8.3.3.5 Low rate codes using repetition codes.

For systems supporting of DL subchannelization, QPSK with coding rates ¼ and 1/8 are supported. These rates are achieved by concatenating the basic code (CC or CTC or BTC) with a repetition code. This is performed as follows:

Let N_{scps} denote the number of subcarrier per symbol. Let r denote the overall code rate (i.e. ¼ or 1/8).

The bit stream is randomized and passed through encoder (CC, BTC or CTC). Note the RS encoding is bypassed in this mode. The resulting coded bits are interleaved with a block size $N_{cbps} = \max(N_{scps}*2*r, 12)$. The resulting bits are mapped to QPSK symbols. Let $x_0, x_1\ x_2 \ldots$ denote the resulting symbols.

The symbol repetition block duplicates the symbols and multiplies them by a cover sequence. In QPSK 1/4 mode, the resulting symbols are

$x_0 ? w_0$, $x_0 ? w_1$, $x_1 ? w_2$, $x_1 ? w_3$, $x_2 ? w_4$, $x_2 ? w_5$, … , $x_k ? w_{2k}$, $x_k ? w_{2k+1}$,….

Where $\{w_k\}$ is the cover sequence. In QPSK 1/8 mode the output sequence is

$x_0 ? w_0$, $x_0 ? w_1$, $x_0 ? w_2$, $x_0 ? w_3$, $x_1 ? w_4$, $x_1 ? w_5$, $x_1 ? w_6$, $x_1 ? w_7$, … , $x_k ? w_{4k}$, …, $x_{k+3} ? w_{4k+3}$ …

The cover sequence is generated using the polynomial $x^{11}+x^9+1$. The sequence is initiated at the beginning of each burst. The sequence is initiated with the word

[BSID0 BSID1 BSID2 BSID3 1 0 1 0 1 0 1]

Where BSID0 BSID1 BSID2 BSID3 are the 4 LSB of the base station ID. The sequence is initiated at the beginning of every burst.

The resulting symbols are further interleaved to maximize the frequency diversity. Let $\{y_k\}$denote the duplicated symbols. In the QPSK rate ¼ mode, the resulting symbols are given by:

y_0, y_2, y_4,… $y_{Nscps-2}$, y_1, y_3, y_5,… y_{Nscs-1}.

In the QPSK rate 1/8 mode, the resulting symbols are given by

y_0, y_4, … $y_{Nscps-4}$, y_1, y_5, … $y_{Nscps-3}$, y_2, y_6, … $y_{Nscps-2}$, y_3, y_7, … y_{Nscs-1}.

The interleaved symbols are mapped to subcarrier locations frequency first.