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Definition of compressed private maps for SOFDMA

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1 Problem Statement

The 802.16e standard refers to private maps, for example in section 6.3.7.6.1, without defining what private maps are, how they may be used, or whether support for private maps is mandatory. In particular, there is no specification of where private maps may occur in the DL subframe, or whether their PHY burst allocation refers to the frame containing the private map, or a subsequent frame. Because private maps fix several efficiency problems inherent in the basic DL/UL-MAP messages when used for AAS and other applications, it is necessary to clearly define the format and use of private maps.

In an AAS system, using a single broadcast map message robust enough for cell-edge users to address users throughout the cell is highly inefficient. AAS systems typically have a link budget gap between the broadcast transmissions and beam-formed unicast transmissions. A very robust coding rate is necessary for the broadcast transmissions to bridge this link budget gap. Using the most robust coding rate for all MAP IEs causes the map overhead to consume an unacceptable amount of the available bandwidth. For example, the analysis in [1] shows that the map overhead would be 40% or more under realistic traffic assumptions.

The map overhead is significantly reduced by using multiple map messages with different modulation / coding rates, and placing each MAP IE into the map message whose modulation / coding rate roughly matches the targeted SS's downlink link budget. However, for mobile subscribers, the downlink link budget will be continually changing. In addition, in AAS systems, a SS link budget can be interference limited as opposed to noise limited. For AAS systems, it is desired that maps utilize the same AAS processing as data.

A solution is to remove the majority of the MAP IEs from the broadcast maps, and instead send them as unicast transmissions. Use of individually targeted private maps allows the broadcast map size fluctuations to be reduced.. Furthermore, the individually targeted private maps benefit from selecting of the modulation / coding rate that best fits the subscriber's downlink link budget. This allows the targeted private maps to be transmitted at a higher rate, which reduces the map overhead. Finally, in AAS systems, unicast maps can be beamformed adding allowing for an additional improvement in efficiency.

Even so, it is inefficient to simply define a private map as a special case of a DL-MAP or UL-MAP message that contains only a single IE directed to a unicast CID, since the MAC message header cannot be amortized over multiple IEs. Table 1 illustrates the inefficiency of using a regular map message with a single IE.

Table 1 - Map Message Efficiency

	Regular DL-MAP + UL-MAP[1]	**Compressed DL-MAP + UL-MAP[2,3]**
Map messages size sum	512 bits	312 bits
DL+UL-MAP IE size	72 bits	72 bits
Map efficiency (IE size / message size)	14%	23%

This inefficiency becomes even more significant at the lower end of the scalability of the SOFDMA PHY. Table 2 shows the percent of a frame's bandwidth consumed by uncompressed private map messages as a function of FFT size based on the following assumptions:

- The frame has a 5 ms duration, and the cyclic prefix fraction is 1/8.
- 24 users are supported per frame per 10 MHz.
- The available bandwidth excludes:
  - frame preamble symbol
  - FCH
  - broadcast DL/UL-MAP messages that each contain 8 MAP IEs per 10 MHz and are encoded at QPSK-1/2 with 2x repetition coding
- The frame bandwidth is divided evenly between DL PUSC and UL PUSC.
- For simplicity, ranging allocations and AAS-DLFP are not considered in the frame bandwidth.
- INC_CID = 0 in the DL-MAP.
- As in the above table, the DL/UL-MAP messages (broadcast and uncompressed private) each contain an AAS IE.
- The private map messages are transmitted with 16-QAM-1/2 with 1x repetition coding.

The bandwidth consumption of the compressed private map messages proposed below is also shown.

Table 2 - Map Message Bandwidth Consumption

[1] The DL-MAP contains an AAS DL IE, a DL-MAP IE to locate the UL-MAP, and a DL-MAP IE to provide the targeted allocation. The UL-MAP contains an AAS UL IE. The MAC header and CRC are included in the message size. The OFDMA PHY version of the PHY Synchronization Field is used.

[2] The compressed DL-MAP includes an AAS DL IE and a DL-MAP IE to provide the targeted allocation. The compressed UL-MAP contains an AAS UL IE. The CRC is included in the message size. The OFDMA PHY version of the PHY Synchronization Field is used.

[3] The compressed maps column is included for the sake of reference only, since the standard currently specifies that compressed maps occur only immediately following the DL Frame Prefix. Thus, compressed maps cannot be used as private maps.

	Users per frame	Uncompressed private DL/UL-MAP bandwidth consumption	Compressed private DL/UL-MAP bandwidth consumption
2K FFT / 20 MHz	48	27%	5.5%
1K FFT / 10 MHz	24	28%	5.6%
512 FFT / 5 MHz	12	29%	5.8%
128 FFT / 1.25 MHz	3	51%	10%

Note: Compressed private map uses single IE mode.

2 Proposed Solution

It is proposed to define an unambiguous OFDMA-PHY compressed private map format, to specify where the private map may occur in the frame, to specify which frame contains the PHY burst allocation referenced in the private map, and to clarify that support for private maps is optional.

Two modes of the compressed private maps exist, one that supports multiple IEs and is almost identical to the broadcast compressed map, and an optimized compressed map for handling a single DL and/or UL IE.

3 Proposed Text Changes

[Add new section 8.4.5.8]

8.4.5.8 Compressed Private Maps

Compressed private maps may be located in positions in the frame other than immediately following the DL Frame Prefix. Compressed private maps have the most significant two bits of the first byte set to 1. This distinguishes the compressed private map message from a standard MAC header in the same manner as non-private compressed maps. The compressed private map message is distinguished from the non-private compressed map message by context. Non-private compressed maps, by definition, must occur immediately after the DL Frame Prefix. Compressed private maps may occur anywhere in the DL subframe other than immediately after the DL Frame Prefix.

8.4.5.8.1 Compressed Private DL-MAP

The compressed private DL-MAP format is presented in Table XXX. The multiple IE compressed private DL-MAP message presents the same information as the compressed DL-MAP format. The single IE compressed private DL-MAP message eliminates the fields that are not relevant since the message is targeted to a single CID. For the single IE compressed private DL-MAP message, the DL_PermBase of the zone containing the assigned DL allocation is assumed to have the same value as the zone in which the compressed private DL-MAP message is located.

Table XXX—Compressed private DL-MAP message format

Syntax	Size	Notes
Compressed_Private_DL-MAP() {		
Compressed map indicator	2 bits	Set to binary 11 for compressed format
Reserved	1 bit	Shall be set to zero
UL-MAP appended	1 bit	
Compressed Map Type	1 bit	Set to 1
Compressed private map type	1 bit	0 = multiple IE, 1 = single IE
if (Compressed private map type == 0) {		
Map message length	11	
PHY Synchronization Field	32 bits	
DCD Count	8 bits	
Operator ID	8 bits	
Sector ID	8 bits	
DL IE count	8 bits	
for (*i* = 1; *i* <= DL IE count; *i*++) {		
DL-MAP_IE()	*variable*	
}		
if !(byte boundary) {		
Padding Nibble	4 bits	Padding to reach byte boundary.
}		
CRC-32	32 bits	If a private UL-MAP is appended, the CRC field is located after the private UL-MAP. The CRC is computed across all bytes of the private map(s) starting with the byte containing the compressed private map indicator through the last byte of the map(s) as specified by the Map message length field. The CRC calculation is the same as that used for standard MAC messages.
} else {		
DCD Count Included	1 bit	1 = DCD Count included
CID Included	1 bit	1 = CID Included The CID shall be included in the first compressed private MAP if it was pointed to by a DL-MAP IE with INC_CID == 0 or by a DL-MAP IE with a multicast CID.
PHY modification Included	1 bit	1 = included.
If (CID Included) {		
CID	16 bits	
}		
If (PHY modification Included) {		
Preamble Select	1 bit	0 = Frequency shifted preamble 1 = Time shifted preamble
Preamble Shift Index	4 bits	Updated preamble shift index to be used starting with the frame specified by the Frame Offset.
Reserved	3 bits	Set to zero
}		
if (DCD Count Included) {		
DCD Count	8 bits	
}		
DIUC	4 bits	Only burst profile DIUCs allowed
Frame Offset	3 bits	
If (current zone permutation is FUSC or optional FUSC) {		
Zone symbol offset	8 bits	

}		
OFDMA Symbol Offset	8 bits	
Subchannel Offset	7 bits	
No.OFDMA symbols	7 bits	
No. Subchannels	7 bits	
Repetition Coding Indication	2 bits	0b00 – No repetition coding 0b01 – Repetition coding of 2 used 0b10 – Repetition coding of 4 used 0b11 – Repetition coding of 6 used
Padding bits	1 bit	If a compressed private UL-MAP is appended, no intervening padding bits are used.
CRC-16	16 bits	If a compressed private UL-MAP is appended, the CRC field is located after the private UL-MAP. A CRC16-CCITT value, as defined in ITU-T Recommendation X.25, is computed across all bytes of the compressed private DL-MAP and if present, the associated compressed private UL-MAP.
}		

Common Fields

Compressed map indicator

A value of binary 11 in this field indicates the map message conforms to the compressed map format. If the message immediately follows the DL Frame Prefix, then this field indicates a non-private compressed map message (see 8.4.5.6). If the message is anywhere else in the frame, then this field indicates the private compressed map defined here.

Compressed Map Type

Value of 1 = compressed private map, value of 0 is undefined.

UL-MAP appended

A value of 1 indicates a compressed private UL-MAP (see 8.4.5.6.2) is appended to the current compressed private DL-MAP data structure.

Compressed Private Map Type

Indicate either a multi-IE or single-IE compressed private map.

Multi-IE Fields

Map message length

This value specifies the length of the compressed private map message(s) beginning with the byte containing the Compressed private map indicator and ending with the last byte of the compressed private DL-MAP message if the UL-MAP appended bit is not set or the last byte of the compressed private UL-MAP message if the UL-MAP appended bit is set. The length includes the computed 32-bit CRC value.

PHY Synchronization

This field holds frame number and frame duration information. See 8.4.5.1 and Table 271

DCD Count

Matches the value of the configuration change count of the DCD, which describes the downlink burst profiles that apply to this map.

Operator ID

This field holds the least significant 8 bits of the most significant 24 bits of the 48-bit Base Station ID.

Sector ID

This field holds the least significant 8 bits of the 48-bit Base Station ID.

DL IE count

This field holds the number of IE entries in the following list of DL-MAP IEs.

Single-IE Fields

DCD Count Included
Specifies if a DCD count is included. Only required if the DCD count is changed.
CID Included
The CID shall be included in the first compressed private MAP if it was pointed to by a DL-MAP IE with INC_CID == 0 or by a DL-MAP IE with a multicast CID.
Phy Modification Included
Indicates if a preamble modifier is included
Connection Identifier (CID)
Represents the assignment of the IE to a unicast address.
Preamble Select
Specifies the preamble type
Preamble Shift Index
The preamble shift index in time or frequency, as specified by the Preamble Select field.
DCD Count
Matches the value of the configuration change count of the DCD, which describes the downlink burst profiles that apply to this map.
DIUC
DIUC used for the burst.
Frame Offset
The frame in which the burst is located. A value of zero indicates an allocation in the subsequent frame.
Zone symbol offset
The offset of the OFDMA symbol in which the zone containing the burst starts, measured in OFDMA symbols from beginning of the downlink frame referred to by the Frame Offset.
OFDMA Symbol offset
The offset of the OFDMA symbol in which the burst starts, measured in OFDMA symbols from beginning of the downlink frame referred to by the Frame Offset.
Subchannel offset
The lowest index OFDMA subchannel used for carrying the burst, starting from subchannel 0.
No. OFDMA Symbols
The number of OFDMA symbols that are used (fully or partially) to carry the downlink PHY Burst.
No. of subchannels
The number of subchannels with subsequent indexes, used to carry the burst.
Repetition coding Indication
Indicates the repetition code used inside the allocated burst.

8.4.5.8.2 Compressed Private UL-MAP

The compressed private UL-MAP format is presented in Table YYY. The message may only appear after a compressed private DL-MAP message to which it shall be appended. The compressed private UL-MAP uses multiple/single IE format to match the format of the associated compressed private DL-MAP.

Table YYY—Compressed private UL-MAP message format

Syntax	Size	Notes
Compressed_Private_UL-MAP() {		
if (Compressed private map type == 0) {		
UCD Count	8 bits	
Allocation Start Time	32 bits	
while (map data remains){		
UL-MAP_IE()	*variable*	
}		
if !(byte boundary) {		
Padding Nibble	4 bits	Padding to reach byte boundary.
}		
} else {		
UCD Count Included	1 bit	1 = UCD Count included.

PHY modification Included	1 bit	1 = Preamble shift index included. Preamble modification is only relevant in AAS UL zones . Private maps in non-AAS zones shall not include the preamble shift index.
Power Control Included	1 bit	1 = Power control value included
if (PHY modification Included) {		
Preamble Select	1 bit	0 = Frequency shifted preamble 1 = Time shifted preamble
Preamble Shift Index	4 bits	Updated preamble index to be used starting the with the frame specified by the Frame Offset
Reserved	3 bits	Set to zero
}		
if (Power Control Included) {		
Power Control	8 bits	Signed integer in 0.25 dB units
}		
if (UCD Count Included) {		
UCD Count	8 bits	
}		
UIUC	4 bits	Only burst profile UIUCs allowed
Frame Offset	3 bits	
If (AAS zone) {		'AAS zone' = 1 if the DL zone in which this message is located is an AAS zone.
OFDMA Symbol Offset	8 bits	
Subchannel Offset	7 bits	
No. OFDMA symbols	7 bits	
No. Subchannels	7 bits	
} else {		
Slot Offset	11 bits	
Zone Start	8 bits	
Zone Duration	7 bits	
Duration	10 bits	
Padding Bits	1 bit	
}		
Repetition Coding Indication	2 bits	0b00 – No repetition coding 0b01 – Repetition coding of 2 used 0b10 – Repetition coding of 4 used 0b11 – Repetition coding of 6 used
}		
}		

Multi-IE Fields

UCD Count

Matches the value of the Configuration Change Count of the UCD which describes the uplink burst profiles which apply to this map.

Allocation Start Time

Effective start time of the uplink allocation defined by the UL-MAP.

Single-IE Fields

UCD Count Included

Indicates if UCD Count is included

Phy Modification Included

Indicates if a preamble modifier is included

Power Control Included

Indicates if a SS power control byte is included

Preamble Select
Specifies the preamble type
Preamble Shift Index
The preamble shift index in time or frequency, as specified by the Preamble Select.
Power Control
The change in transmit power level that the SS should apply starting on the frame specified by the Frame Offset.
UCD Count
Matches the value of the configuration change count of the UCD, which describes the uplink burst profiles that apply to this map.
UIUC
UIUC used for the burst.
Frame Offset
The frame in which the burst is located. A value of zero indicates an allocation in the subsequent frame.
OFDMA Symbol offset
The offset to the starting location of the uplink burst is referenced to the DL preamble of the subsequent frame, and consists of an integer symbol offset specified here, as well as the addition of the TTG known from DCD messages. If TTG is not present in the DCD (for FDD) it is assumed to be zero.
Subchannel offset
The lowest index OFDMA subchannel used for carrying the burst, starting from subchannel 0.
No. OFDMA Symbols
The number of OFDMA symbols that are used (fully or partially) to carry the uplink burst.
No. subchannels
The number of subchannels with subsequent indexes, used to carry the burst.
Slot Offset
The location of the first slot of the uplink burst, relative to the starting location of the zone.
Zone Start
The starting location of the zone containing the uplink burst is the sum of the Zone start, measured in OFDMA symbols from the beginning of the frame specified by the Frame Offset, and the TTG.
Zone Duration
The duration of the zone containing the uplink burst, measured in OFDMA symbols.
Duration
Indicates the duration, in units of OFDMA slots, of the allocation.
Repetition coding Indication
Indicates the repetition code used inside the allocated burst.

[Modify section 11.8.3.7.6]

11.8.3.7.6 OFDMA compressed private map support

This field indicates the compressed private map parameters supported by a WirelessMAN-OFDMA SS.

Type	Length	Value	Scope
155	1	bit #0: H-ARQ MAP Capability bit #1: private map support bit #2: DL frame offset 0: support compressed private maps with Frame Offset >= 1 1: support compressed private maps with Frame Offset >= 2 bit #3: UL frame offset 0: support compressed private maps with Frame Offset >= 1 1: support compressed private maps with Frame Offset >= 2 Bits #4-7: private map chain concurrency 0 indicates no limit 1-15 indicate maximum concurrent private map chains	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)

4 References

1. 802.16e submission, “Multiple Broadcast Maps”, Ran Yaniv, Tal Kaitz, Vladimir Yanover, Naftali Chayat, *Alvarion Ltd*.