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| Title | **Proposed Text of DL PHY Control Structure Section (11.7 DL PHY control structure) for the IEEE 802.16m Amendment** | |
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| Re: | "802.16m amendment text":<br>IEEE 802.16m-08/053r1, "Call for Contributions on Project 802.16m Draft Amendment Content".<br>Target topic: "11.7 DL PHY control structure, especially mapping". | |
| Abstract | This contribution proposes detailed text on DL PHY control structure | |
| Purpose | To be discussed and adopted by TGm for the 802.16m amendment. | |
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# Proposed Text of DL PHY Control Structure Section (11.7 DL PHY control structure) for the IEEE 802.16m Amendment

*Mark Cudak, Bishwarup Mondal, Fan Wang, Amitava Ghosh, Fred Vook, Bill Hillery, Eugene Visotsky, Anup Talukdar*

**Motorola**

## 1) Introduction

The contribution proposes the text of DL PHY Control structure section to be included in the 802.16m amendment. The proposed text is developed so that it can be readily combined with IEEE P802.16 Rev2/D8 [1], it is compliant to the 802.16m SRD [2] and the 802.16m SDD [3], and it follows the style and format guidelines in [4].

## 2) Proposed Text

The text proposed in this contribution is based on subclauses 11.7 in the IEEE 802.16m SDD [3]. Supporting simulations are contained in [5].

There are some outstanding issues reflected in the SDD text that must be resolved in the amendment:

- Bootstrapping: The synchronization and access process must be enabled by the control channel design. The amendment text must identify how the AMS learns the required information during the synchronization process and subsequent decoding of the various control channels. There is an implied order of SCH, PBCH, SBCH (perhaps optional) RACH and USCCH. A diagram of a proposed bootstrapping process is captured in Figure 1.
- USCCH: The USCCH description encompasses the functionality for dynamic allocation, persistence allocation and fast feedback information. It is reasonable to break this into three distinct physical control structures. This contribution defines the three supporting physical channels:
    - Unicast Dynamic Allocation Control Channel (UDACCH)
    - Unicast Persistent Allocation Control Channel (UPACCH)
    - Unicast Fast Feedback Control Channel (UFFCCH)
- PHY Management Messages – The USCCH structures as discussed by many in TGm and as proposed in this document significantly reduces the payload size of the allocation messages. Many of the functions conveyed in the 16e DL/UL MAP no longer fit in a USCCH allocation (e.g. CQICH allocation, etc). This contribution proposes a new PHY Management Message similar in concept to the MAC management messages defined 16e but which are specific to the 16m PHY.
- Channel Raster: Per Table 647—OFDMA parameters, the DC subcarrier is logically mapped to the center subcarrier making the only practical mapping of the SCH to the center 5 MHz. Given a fixed frequency allocation (e.g. 20 MHz), the location of the pre-amble will be dependent on how many 16m carriers are allocated. For example, in a 20 MHz, an operator may allocate four 5MHz carriers, two 10 MHz carriers or one 20 MHz carrier. The AMS will have to test multiple hypothesis on the carrier configuration in order to find the 16m synchronization channel. The impact of legacy 16e channel rasters may complicate this issue further.

The following is the high level outline of the DL Control Structure:

15.3.X. Downlink Control Structure
**15.3.X.1 Physical Downlink Control Channels**
15.3.X.1.1 Synchronization Channel
15.3.X.1.2 Broadcast Control Channel
15.3.X.1.2.1 Primary Broadcast Control Channel
15.3.X.1.2.2 Secondary Broadcast Control Channel
15.3.X.1.3 Unicast Service Control Channel
15.3.X.1.3.1 Unicast Dynamic Allocation Control Channel
15.3.X.1.3.1 Unicast Persistent Allocation Control Channel
15.3.X.1.3.2 Unicast Fast Feedback Channel
**15.3.X.2 Downlink Control Physical Resource Mapping**
15.3.X.2.1 Synchronization Channel
15.3.X.2.2 Broadcast Control Channel
15.3.X.2.2.1 Primary Broadcast Control Channel
15.3.X.2.2.2 Secondary Broadcast Control Channel
15.3.X.2.3 Unicast Service Control Channel
15.3.X.2.3.1 Unicast Dynamic Allocation Control Channel
15.3.X.2.3.2 Unicast Persistent Allocation Control Channel
15.3.X.2.3.2 Unicast Fast Feedback Control Channel
**15.3.X.3 Downlink Control Information Elements**
15.3.X.3.1 Broadcast Control Channel
15.3.X.3.2 Unicast Service Control Channel
15.3.X.3.3 PHY Management Messages

## 3) References

[1] IEEE P802.16 Rev2/D8, “Draft IEEE Standard for Local and Metropolitan Area Networks: Air Interface for Broadband Wireless Access,” Oct. 2008.

[2] IEEE 802.16m-07/002r7, “802.16m System Requirements”

[3] IEEE 802.16m-08/003r6, “The Draft IEEE 802.16m System Description Document”

[4] IEEE 802.16m-08/043, “Style guide for writing the IEEE 802.16m amendment”

[5] IEEE 802.16m-08/941, “Pre-coding for DL Unicast Service CCH”

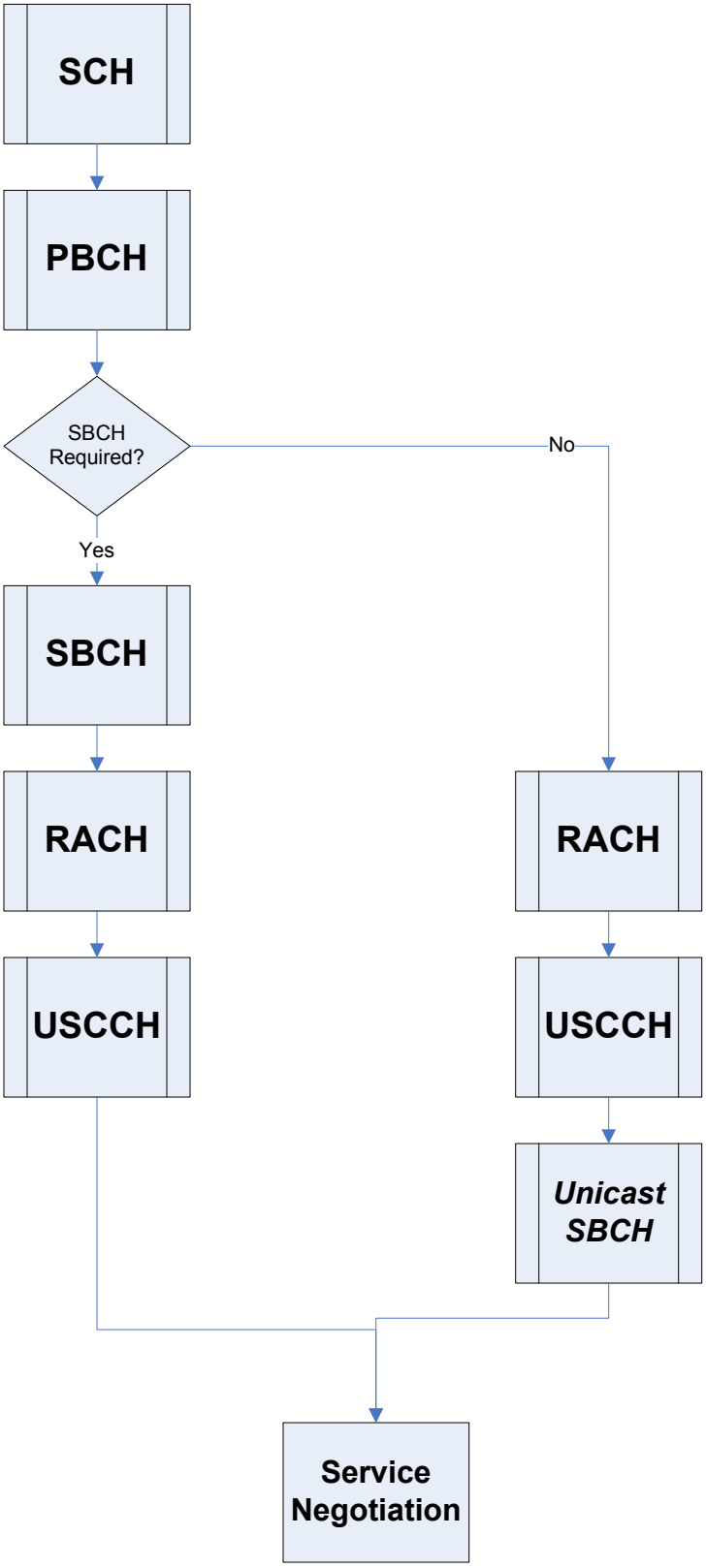


Figure 1Control cahnnelchannel decoding order (bootstrapping)

# 15.3 Physical Layer

## 15.3.x. Downlink Control Structure

DL control channels convey information essential for system operation. In order to reduce the overhead and network entry latency, and improve robustness of the DL control channel, information is transmitted hierarchically over different time scales from the superframe level to the subframe level.

In mixed mode operation (legacy/802.16m), an 802.16m MS can access the system without decoding legacy FCH and legacy MAP messages.

### 15.3.x.1 Physical Downlink Control Channels

The downlink supports several unique physical control channels

#### *15.3.x.1.1 Synchronization Channel (SCH)*

The synchronization channel (SCH) is a DL physical channel which provides a reference signal for time, frequency, and frame synchronization, RSSI estimation, channel estimation, and ABS identification.

#### *15.3.x.1.2 Broadcast Control Channel (BCH)*

The Broadcast Channel (BCH) carries essential system parameters and system configuration information. The BCH is divided into two parts: Primary Broadcast Channel (PBCH) and Secondary Broadcast Channel (SBCH).

**15.3.x.1.2.1 Primary Broadcast Control Channel (PBCH)**

The Primary Broadcast Channel (PBCH) carries essential system parameters and system configuration information. The PBCH is transmitted every superframe. The SBCH may also be transmitted. When present, SBCH may be transmitted over one or more superframes.

**15.3.x.1.2.2 Secondary Broadcast Control Channel (SBCH)**

The Secondary Broadcast Channel (SBCH) carries additional system parameters and system configuration information. When present, SBCH may be transmitted over one or more superframes.

#### *15.3.x.1.3 Unicast Service Control Channel (USCCH)*

Unicast service control information intended for one user or more users. The USCCH includes scheduling assignment, power control information, HARQ ACK/NACK information.

**15.3.x.1.3.1 Unicast Dynamic Allocation Control Channel (UDACCH)**

Uplink and downlink resources are allocated dynamically to AMSs using the Unicast Dynamic Allocation Control Channel. At least one instance of UDACCH exists per frame.

#### 15.3.x.1.3.2 Unicast Persistent Allocation Control Channel (UPACCH)

Uplink and downlink resources may be allocated to AMSs on a persistent basis using the persistent Unicast Persistent Allocation Control Channel (UPACCH). The UPACCH is allocated on an as needed basis and may not always be present.

#### 15.3.x.1.3.3 Unicast Fast Feedback Control Channel (UFFCCH)

Fast feedback to AMSs transmitting on the uplink are communicated using the Unicast Fast Feedback Control Channel (UFFCCH). The UFFCCH may carry HARQ ACK/NACK information for uplink data transmission and power control information. The UFFCCH is allocated on an as needed basis and may not always be present.

## 15.3.x.2 Downlink Control Physical Resource Mapping

The mapping and encoding of resources onto the downlink physical structure.

### *15.3.x.2.1 Synchronization Channel (SCH)*

In mixed deployments, the presence of the preamble in the first symbol of the IEEE 802.16e frame is implicit.

The location of the SCH symbol(s) is fixed within the superframe and is transmitted at the beginning of the second downlink subframe. The SCH occupies only the subcarriers in the PRUs within the center 5 MHz bandwidth. Table 1 defines which PRUs contain the SCH. The format of the SCH is FFS.

The AMS will determine lower 9 [or 8] MSBs of the Cell ID from the SCH.

Table 1 PRUs allocated to the SCH

| Nominal channel bandwidth, *BW* (MHz) | 5 | 7 | 8.75 | 10 | 20 |
|---|---|---|---|---|---|
| Number of physical resource units | 24 | 48 | 48 | 48 | 96 |
| PRUs allocated to the SCH | 0 to 23 | TBD | TBD | 12 to 35 | 36 to 59 |

### *15.3.x.2.2 Broadcast Control Channel (BCH)*

The SFH includes PBCH and the SBCH, and is located in the first subframe within a superframe. The PBCH and SBCH occupy no more BW than 5 MHz.

#### 15.3.x.2.2.1 Primary Broadcast Control Channel (PBCH)

The PBCH and SBCH are transmitted using predetermined modulation and coding schemes.

The instantaneous modulation and coding rate for PBCH is QPSK and approximately R=1/8 coded. The PBCH may be combined over multiple frames to achieve a lower effective code rate via repetition coding.

The PBCH is transmitted as single stream with one reference pilot stream. Single stream TX diversity is used to combine the multiple transmit antennas. The MS is not required to know the antenna configuration prior to decoding the PBCH.

The PBCH will be allocated to 2 PRUs in a 5 MHz bandwidth. The allocation of PRUs per nominal bandwidth is defined in Table 2 below:

Table 2 PRUs allocated to the PBCH

| Nominal channel bandwidth, *BW* (MHz) | 5 | 7 | 8.75 | 10 | 20 |
|---|---|---|---|---|---|
| Number of physical resource units | 24 | 48 | 48 | 48 | 96 |
| PRUs allocated to the PBCH | 0, 23 | TBD | TBD | 12, 35 | 36, 59 |

Of the 24 PRUs available in 5 MHz, the PBCH will be allocated positions 0 and 23 as show in Figure 2 below. The PRUs will utilize the one antenna pilot format defined in Section X.X Downlink Physical Structure. The BCH info will be encoded at R=3/20, scrambled by the Cell ID[1], interleaved, QPSK modulated and mapped to the allocated PRUs. The channel encoding and cell specific scrambling is FFS.

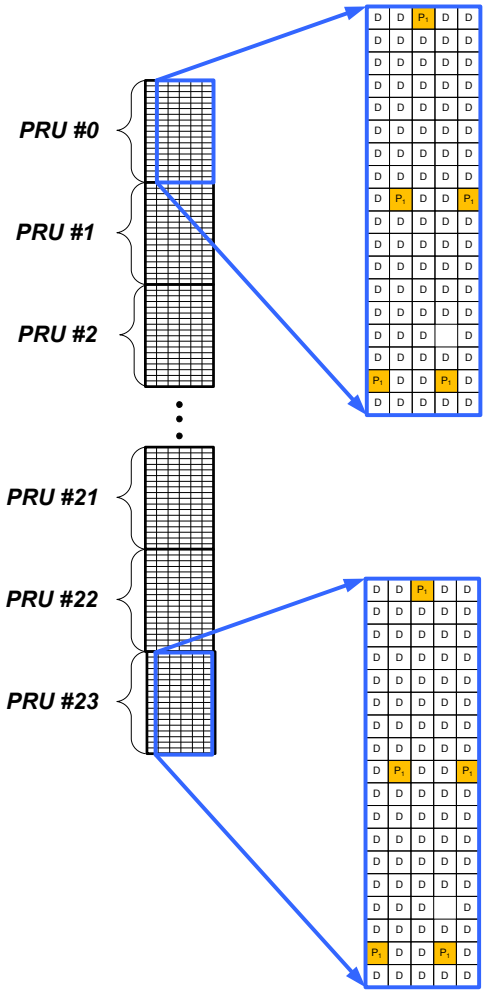


Figure 2

**15.3.x.2.2.2 Secondary Broadcast Control Channel (SBCH)**

[1] The BCH scrambling function is FFS.

TBD

### *15.3.x.2.3 Unicast Service Control Channel (USCCH)*

The unicast service control channel is composed of the UDACCH, UPACCH and UFFCCH.

#### 15.3.x.2.3.1 Unicast Dynamic Allocation Control Channel (UDACCH)

15.3.x.2.3.1.1 UDAACH Transmission Format

For user-specific control information intended for a single user, multiple information elements are coded separately. The modulation of user-specific control information is QPSK. The user-specific control information is encoded with an R=1/2 code.

The user-specific control information is 32 bits long and is protected with a 16 bit CRC. The CRC is masked with the Basic CID while the control information carries the allocation information. The user-specific control information is mapped to one or more Logical Map[2] Resource Units (LMRU).

Repetition coding of a PDACCH allcoation may be used to achieve effective code rates of R=1/4, R=1/8 and R=1/16. The LMRUs over which a single user-specific codeword is mapped is a called a Logical Map Allocation (LMA). The applicable coding rate is blindly detected through the aid of a tree like structure. The tree-like structure reduces the search space for the AMS. Figure 3 illustrates a tree-like structure in a 4 PRU segment having only 14 possible LMA encodings providing 8 R=1/2, 4 R=1/4, 2 R=1/8 and 1 R=1/16 LMA encodings.

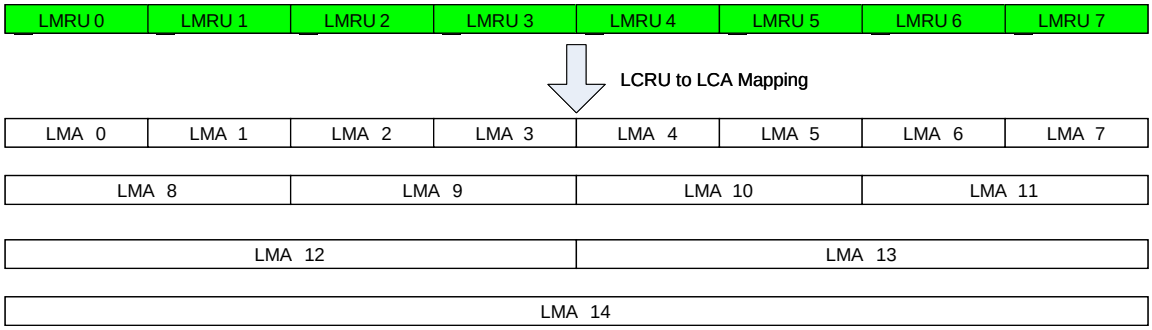


Figure 3 Tree-Like Structure for Blind Decoding

15.3.x.2.3.1.2 UDAACH Resource Mapping

The UDACCH is located in the primary frequency partition identified in the PBCH by the Primary Frequency Parition (PFP) information element.

The UDACCH has the following properties:

- The UDACCH is allocated in the PRUs having the most significant index following frequency partition as defined in Equation (178) of Section 15.3.5.2.3.

[2] The term “map” is used as opposed to “control” in contribution IEEE C802.16m-008/940 as CRU is now used to describe contiguous resource units.

- The UDACCH is independent of the CRU/DRU allocation such that the CRU/DRU allocation need not be known prior to decoding.
- One instance of the UDACCH is mapped into a predetermined number of PRUs based on the sub-frame type. (e.g. type 1, type 2 or type 1 short).
- One instance of the UDACCH carries multiple separately coded UDACCH Allocation IEs (LMRA).
- Multiple instances of the UDACCH may be dynamically allocated depending on cell loading and traffic patterns. The maximum number of instances per sub-frame is FFS
- The existence of a UDACCH instance is blindly decoded.

Table 3 defines the number of PRUs allocated and capacity in UDACCH allocation IEs for a UDACCH instances for a particular subframe type.

Table 3 Dimensions of a UDACCH instance

| Sub-frame Type | UDACCH Size (PRUs) | UDACCH Capacity (LMRUs) |
|---|---|---|
| Type 1 short | 6 | 10 or 9 |
| Type 1 | 4 | 8 |
| Type 2 | TBD | TBD |

The UDACCH instance is mapped into the predefined starting locations
Specifically, the UDACCH instances are allocated in PRUs beginning at:

$$UDACCH[i] = (L_{SB5\ FP_i} + L_{MB5\ FP_i} - 1) - UDACCH_{Size} * i, \quad \text{(XXX)}$$

where

*i* is the UDACCH instance starting with 1

$UDACCH_{Size}$ is defined by Table 3

Two methods of resource mapping are defined for both non-precoded and precoded transmission of the UDAACHH.

*15.3.x.2.3.1.2.1 Tone-Pair Based LMRU Instance*

A tone-pair based permutation is used to distribute the UDAACH across the 4 or 6 PRUs allocated to the UDACCH instance. The tone-pair UDACCH format is intended for non-precoded allocations where the pilots are common to all AMS receiving assignments on the UDAACH. A tone-air UDAACH instance is shown in Figure 4 below.

For a type 1 sub-frame, a tone-pair UDACCH instance is comprised of 4 PRUs. The subcarriers are permuted similar to DRUs using the subcarrier permutation formula defined in Section XXX. Although, the permutation

is identical the subcarrier permutation used by DRUs, the LMRUs differ in as the subcarriers of a UDACCH instance are not co-mingled with the data allocation. This independence allows the DRUs to blinding decoded without knowledge of the CRU/DRU partition employed.

Figure 4 assumes a 2 Tx BS using SFBC for LMRU transmission with a two antenna pilot pattern.

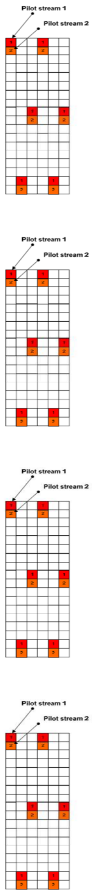


Figure 4 Resource allocation for an tone-pair UDACCH instant

For a Type 1 short subframe, a UDACCH Tone-Pair Formatted Instance is comprised of 6 PRUs. As before, the subcarriers are permuted similar to DRUs using the subcarrier permutation formula defined in Section XXX. After subcarrier permutation, the resource is subdivided into 10 LMRUs. As before, the pilot patterns supported are identical to those defined in Section XXX.

*15.3.x.2.3.1.2.2 Tile-based LMRU*

A tile based permutation is used to distribute the UDAACH across the 4 or 6 PRUs allocated to the UDACCH instance. The tile based UDACCH format is intended for precoded allocations where the pilots are dedicated to a given AMS receiving assignments on the UDAACH.

The tile-based LMRU uses a distributed tile permutation as shown in Figure 5**Error! Reference source not found.** below. Each LMRU is composed of a number of Physical Map Mini Tiles (PMMT). Each PMMT is equally divisible into a PRU and contains dedicated pilots that are pre-coded with the control information.

For a type 1 subframe, a tile-based UDACCH Instance is comprised of 4 PRUs. These PRUs are subdivided into 6 PMTs each 3 subcarriers by 6 symbols. Each PMMT contains 2 pre-coded pilots as shown in Figure

5**Error! Reference source not found.**. 3 PMMTs from different PRUs are grouped to form the LMRU. 8 LMRUs are interleaved over the 4 PRUs allocated to the tile-based UDACCH instance.

For a type 1 short sub-frame, a tile-based UDACCH Instance is comprised of 6 PRUs. As before, these PRUs are subdivided into 6 PMMTs each 3 subcarriers by 5 symbols. As before, each PMMT contains 2 pre-coded pilots. For an type 1 short subframe, 4 PMMTs from different PRUs are grouped to form the LMRU. 9 LMRUs are interleaved over the 4 PRUs allocated to the tile-based UDACCH instance.

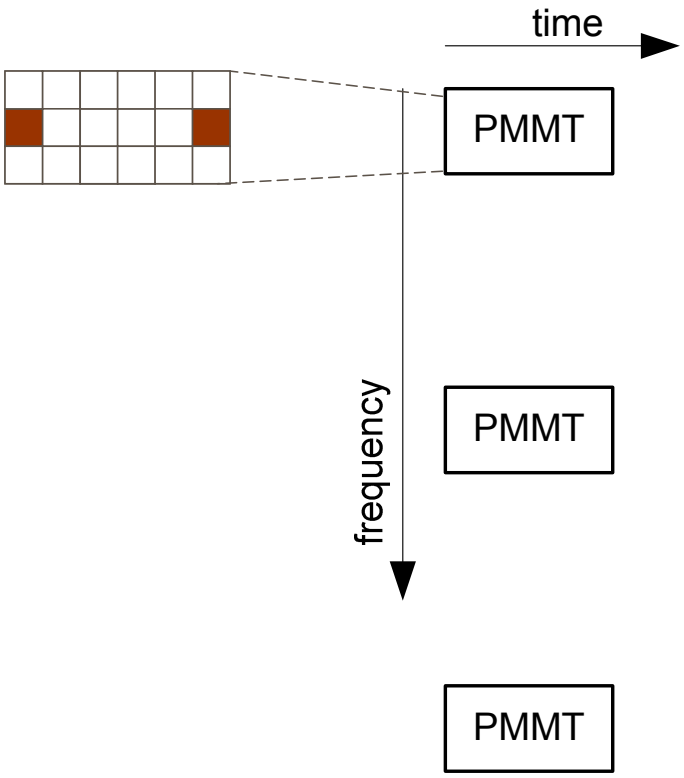


Figure 5 Resource allocation for an tile-based UDACCH instance in a type 1 short sub-frame

#### 15.3.x.2.3.2 Unicast Persistent Allocation Control Channel (UPACCH)

The format for Unicast Persistent Allocation Control Channel mapping if FFS.

#### 15.3.x.2.3.3 Unicast Fast Feedback Control Channel (UFFCCH)

The Unicast Fast Feedback Control Channel mapping is FFS.

### 15.3.x.3 Downlink Control Information Elements

The content of the information elements transmitted in the downlink control channels is captured in this section.

<Editor's Note: IEEE 802.16 has traditionally captured this information in the PHY however it may be more appropriate to move this section to the MAC>

### *15.3.x.3.1 Broadcast Control Channel*

The content of the PBCH and SBCH are captured in this section. The PBCH communicates information necessary for initial access. The contents of the PBCH are captured in Table 4 and are FFS. The contents of the SBCH are captured in

Table 4 PBCH Information Elements

| Information Element | Description | Size (Bits) |
|---|---|---|
| TDDR | Time Division Duplex Ratio | 3 |
| BW | Bandwidth | 4 |
| DSAC | Downlink Subband Allocation Count | 5 |
| DPFC | Downlink Frequency Partition Count | 12 |
| USAC | Uplink Subband Allocation Count | 5 |
| UPFC | Uplink Frequency Partition Count | 12 |
| PFP | Primary Frequency Partition – The frequency partition where critical control channels resided such as the Unicast Service Common Control Channel (USCCH). | 2 |
| UF | USCCH Format – Identifies the format of the USCCH as using tone-pair-based or tile-based | 1 |
| SR | SR – Identifies whether the SBCH must be decoded prior to initial access. (Otherwise, SBCH information is acquired through other means e.g. unicast transmission, pre-HO serving BS, etc) | 1 |
| MIMO Midamble | Identifies whether a MIMO midamble is configured.<br>00 – No MIMO Midamble<br>01 – 2 TX antenna MIMO Midamble<br>10 – 4 Tx antenna MIMO Midamble<br>11 – 8 Tx antenna MIMO Midamble | 2 |
| | Total: | 47 |

Table 5 SBCH Information Elements

| Information Element | Description | Size (Bits) |
|---|---|---|
| Service Provider ID | Service provider ID | 24 bits |

| | | |
|---|---|---|
| | | |

### *15.3.x.3.2 Unicast Service Control Channel*

The USCCH allocates dynamic resources on UDACCH and persistent allocations on the UPACCH. The contents of the UDACCH are presented in Table XX. The contents of the UPDAACH are presented in Table XX.

Table 6 UDACCH Information Elements

| Information Element | Description | Size (Bits) |
|---|---|---|
| AL | Allocation Link – Identifies whether the allocation is sent on the uplink or the downlink | 1 |
| ACID | Hybrid ARQ Channel ID | 4 |
| AI_SN | Hybrid ARQ Channel Sequence Number | 1 |
| SPID | Subpacket Identified – Identifies the incremental reducnc | 2 |
| RA | Resource Allocation – Determines the start, length and number of subframes spanned the allocation. For a complete resource allocation:<br>5 MHz => 9 bits<br>10 MHz => 11 bits<br>20 MHz => 13 bits | 13 |
| PS | Payload Size – Specifies the payload size of the information packet (units are TBD) | 3 |
| MM | MIMO Mode – determines the transmission format | FFS |
| PermMode | The permutation mode defined the CRU/DRU partitioning of the current subframe | FFS |
| MCRC | Masked Cyclic Redundancy Code – A CRC that is masked by the user Connection ID (CID) | 16 |
| | Total: | 47 |

Table 7 UPACCH Information Elements

| Information Element | Description | Size (Bits) |
|---|---|---|
| TBD | | |
| | | |

### *15.3.x.3.3 PHY Management Messages*

PHY management message are sent in resources allocated by a PDAACH allocation. The PHY management messages are used to configure the PHY resources such as allocating fast feedback channels or assigning multicast group IDs. The precise message and message formats are for FFS.