



OFDMA PHY SAP Interface Specification for 802.16 Broadband Wireless Access Base Stations

Revision: 2.31
Date: June 15, 2007

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Revision History

Date	Description	Rev.
12/17/2004	Initial draft for OFDMA PHY SAP	2.00
11/16/2005	Updates from 16eD12 (Table 3-6 FEC Code Type Coding) Improved support for HARQ. Changed packet length definition in Chapter 7. Added corrected figures in Chapter 3	2.23
12/10/2005	Editorial changes. Added support for HARQ flush operation at PHY.	2.24
12/15/2005	Expected length (taken from RXVECTOR) is reported by PHY even for unreadable (invalid) bursts - section 5.10. Added HARQ ACK Subchannel structure	2.25
01/11/2006	Modified Section 4.3 – the Type field now mandatory in all message segments; small editorial changes in Sections 3 and 5.	2.26
04/27/2006	Editorial changes – text clarifications 4.3, 5.1, 5.4, 5.7;RSSI per subcarrier dynamic range extended 5.12, 5.10. Added clarifications to distinguish between AAS	2.27

	and general beamforming. Moved placement of AAS handle within DL- and UL- burst definition structures for greater flexibility (modified tables 3-15, 3-17, 3-18 3-25, 3-34 and 3-35). Added support for sounding (modified tables 3-31 and 3-35, added table 3-39) and fast feedback channel (modified table 3-37 and section 5-10). Frame number used by PHY reported to MAC via TXSTART.ind; UL PUSC zone can have subchannel rotation disabled. Clarified segmentation rules for TXSTART.req, TXSDU.req, RXSTART.req and RXSDU.ind. Defined new method for coding zone/burst/sub-burst numbers in TXSDU.req and TXSDU.conf. Updated figures 4-2 and 4-3.	
05/22/2006	Sub-bursts descriptors include modulation/coding (tables 3-18 and 3-40). Modified initial LW offset in Table 3-42.	2.28
09/06/2006	Added Initial Frame Number clarification in Section 5.3. Extended PHY_TXEND.ind primitive in Section 5.6. Added HARQ data burst Indication type in Section 5.9. Proposed new MAC addressing convention for PHY SAP Ethernet encapsulation in Section 7. Removed unused SNR field from PHY_RXSDU.ind (Section 5.10) and RXCDMA.ind (Section 5.12) status data	2.29
02/07/2007	Added new Burst Type, 'Control Command' to Downlink (3.4.3) and Uplink (3.5.3) descriptors. Changed range and coding of the RSSI. Extended MIMO-related definitions	2.30
03/30/2007	Extended PAPR/Safety Zone Channel Specific Part of Uplink Burst Parameter Structure (Table 3-32). Number of slots fields extended from 8 to 10 bit – affected Tables 3-14; 3-19, 20, 21 and 22; 3-35; 3-43. UL sub-bursts allocation scheme is time-first now. Setting 'dedicated pilots' elevated to Generic Part of Downlink Zone Parameter Structure – affected Tables 3-8, 9, 10, 11 and 12. Table 3-7 and 3-23 – added PHY SAP version stamp	2.31

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1 Purpose of this Specification

The purpose of this specification is to define PHY SAP for 802.16 Base Stations MAC – OFDMA PHY communication. In particular, it aims at:

- Clear separation of MAC- and PHY-level processing.
- Definition of low-latency data-plane level MAC-PHY communication for in-band control and data transmission, supporting a number of concurrently serviced PHY entities.
- Enabling parallel design, implementation, and testing of the 802.16 MAC and the 802.16 PHY.
- Giving support for simulation of an 802.16 PHY to perform stand-alone 802.16 MAC verification testing.
- Providing support of MAC-level interoperability testing (BS-SS) without PHY.
- Making possible seamless integration of an 802.16 MAC implementation with an 802.16 PHY implementation.
- Providing definition of the assumptions and constraints for the MAC and PHY interface.

1.1 Abbreviations

AAS	Advanced Antenna System
ACID	HARQ channel ID
AI_SN	HARQ Sequence Number
ACK	Acknowledgement
ADC	Analog-to-Digital Converter
AGC	Automatic Gain Control
AMC	Adaptive Modulation-Coding
ARQ	Automatic Repeat reQuest
ASIC	Application-Specific Integrated Circuit
BF	Beamforming
BS	Base Station
BTC	Block Turbo Code
BW	bandwidth
CC	Convolutional Code
CDMA	Code Division Multiple Access
CID	Connection IDentifier
CINR	Carrier-to-Interference-and-Noise Ratio
CP	Cyclic Prefix
CRC	Cyclic Redundancy Check
CTC	Convolutional Turbo Coding
DAC	Digital-to-Analog Converter
DCD	Downlink Channel Descriptor
DIUC	Downlink Interval Usage Code
DL	downlink
DLFP	DownLink Frame Prefix
DSP	Digital Signal Processor

EOP	End Of Packet
FCH	Frame Control Header
FDD	Frequency Division Duplex
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FHDC	Frequency Hopping Diversity Coding
FPGA	Field-Programmable Gate Array
FUSC	Full Usage of SubChannels
HARQ	Hybrid ARQ
HCS	Header Check Sequence
IANA	Internet Assigned Numbers Authority
IE	Information Element
I/F	inteface
IFFT	Inverse Fast Fourier Transform
ISSID	Internal SS IDentifier
IR	Incremental Redundancy
LDPC	Low Density Parity Check
LNA	Low-Noise Amplifier
lsb	Least Significant Bit(s)
LW	Long Word (32bits)
MAC	Medium Access Control layer
MBS	Multicast / Broadcast Services
MIMO	Multiple Input Multiple Output
MRC	Maximum Ratio Combining
msb	Most Significant Bit(s)
MSF	Media Switch Fabric
NACK (or NAK)	Negative ACK
OFDMA	Orthogonal Frequency Division Multiple Access
PAPR	Peak-to-Average Power Ratio
PCI	Peripheral Component Interconnect
PDU	Protocol Data Unit
PUSC	Partial Usage of SubChannels
PHY	physical layer
PRBS	Pseudo-Random Binary Sequence
PS	Physical Slot
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase-Shift Keying
RF	Radio-Frequency transceiver
RSSI	Receive Signal Strength Indicator
RTG	Receive/transmit Transition Gap

Rx	receiver
SAP	Service Access Point
SDMA	Spatial Division Multiple Access
SDU	Service Data Unit
SISO	Single Input Single Output
SM	Spatial Multiplexing
SNR	Signal-to-Noise Ratio
SOP	Start Of Packet
SPI	System Packet Interface
SS	Subscriber Station
STC	Space Time Coding
STTD	Space Time Transmit Diversity
TDD	Time Division Duplex
TTG	Transmit/receive Transition Gap
TUSC	Tile Usage of SubChannels
Tx	transmitter
UCD	Uplink Channel Descriptor
UEP	Unequal Error Protection
UIUC	Uplink Interval Usage Code
UL	uplink
XID	cross-Identifier
ZT	Zero-Tailing

2 PHY SAP Introduction

2.1 Overview

2.1.1 Base Station Reference Model

Figure 2-1 shows a reference model of a Base Station (BS). The Reference Point C represents the interface between the MAC and the PHY. This document defines a protocol and data structures for communication across this reference point for an 802.16 MAC and an 802.16 OFDMA PHY.

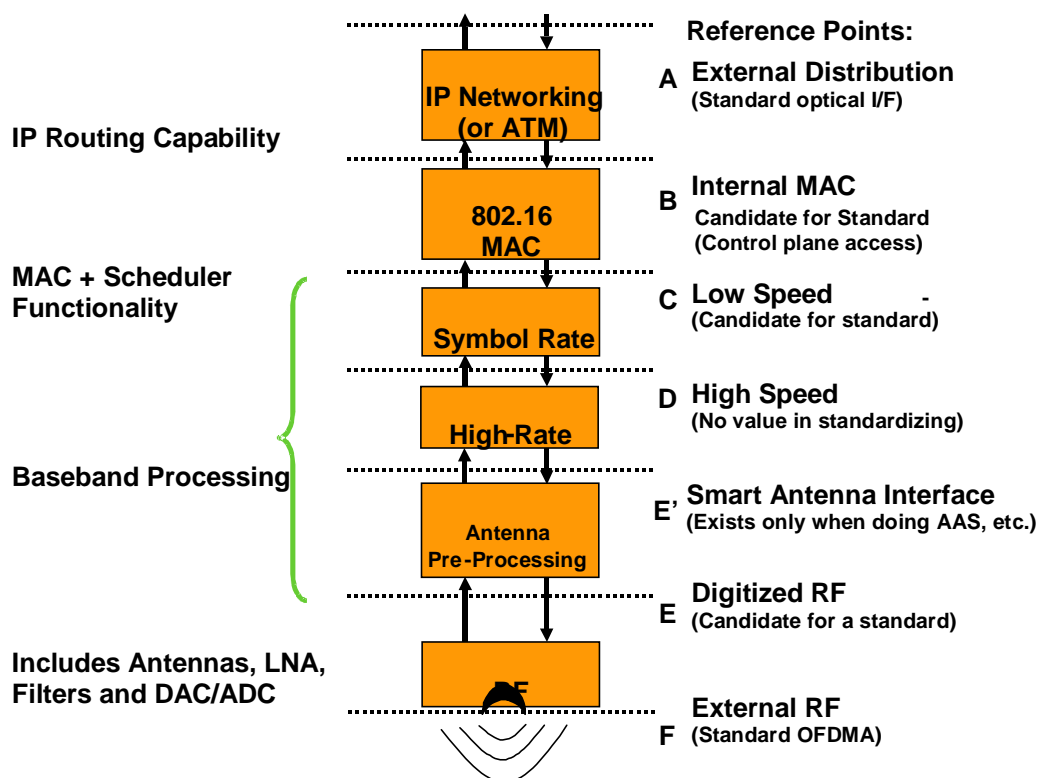


Figure 2-1: BS Reference Model

Figure 2-2 illustrates at a high level the hardware in a multi-sector and single sector BS.

- The multi-sector BS contains a PHY processor (can be implemented as one or more ASICs, FPGAs or DSPs) for each sector. There is one or more RF entities for each sector, depending on the number of antennas deployed in each sector, one MAC processor on which the MAC instances corresponding to each of the sectors are deployed and there is a common physical link that connects the PHY processors and the MAC processor.
- In the single-sector BS, there is a single PHY processor, one or more RF processors and one MAC processor. The MAC and PHY are connected via a point-to-point link.

Other configurations are possible, but from the perspective of the MAC-PHY interface, these two configurations represent the major cases that need to be handled by a MAC-PHY protocol.

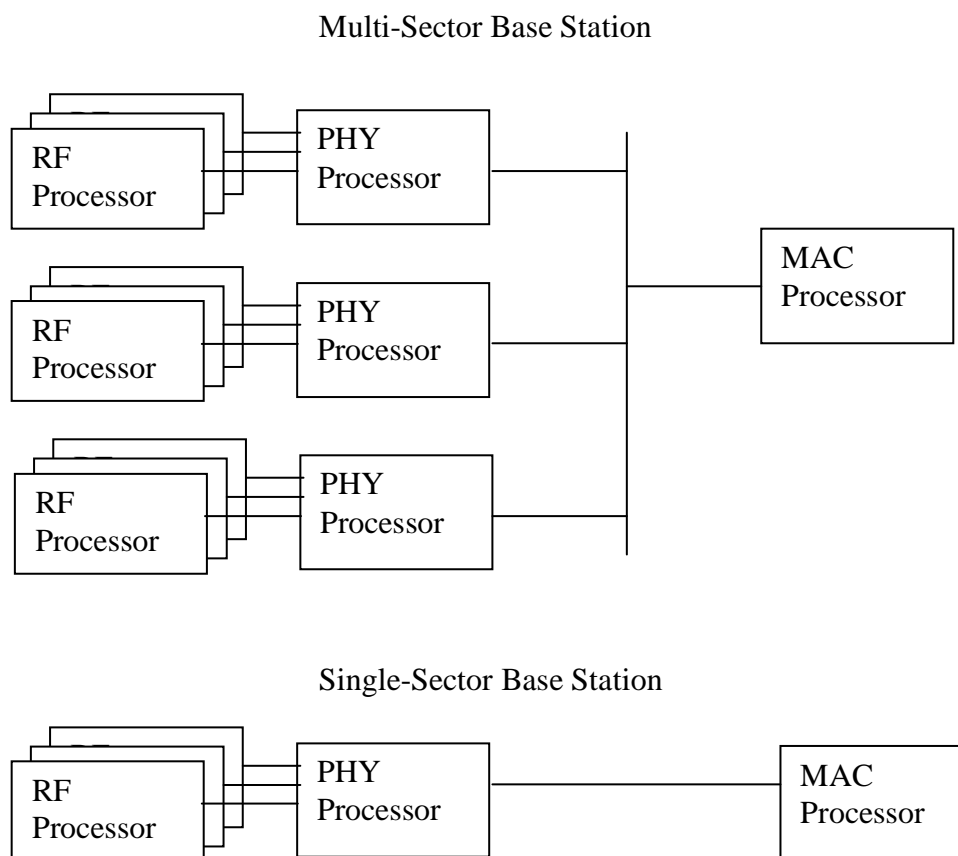


Figure 2-2: Example BS implementations

2.1.2 MAC-PHY Protocol Overview

The MAC-PHY protocol defined in this document is designed to handle both of the cases illustrated in Figure 2-2. There is a separate instance of the protocol for each instance of the PHY and logical MAC instance. The MAC-PHY protocol is composed of separate protocols for transmit - within the downlink (DL) subframe and for receive - within the uplink (UL) subframe, so a full-duplex operation is supported. The protocol primitives are PHY-type-agnostic. Supporting missing features and new PHY types requires mainly modification of the TXVECTOR/RXVECTOR structures.

The downlink protocol consists of the following major interactions:

- The MAC sends the PHY a description of the current DL subframe (TXVECTOR). This description provides all of the information that the PHY needs to encode/modulate the data bursts to be sent as part of the subframe.
- The MAC sends the PHY the burst data for the current DL subframe.
- The PHY (optionally) confirms buffering of the burst data and finally provides to the MAC the status of the overall transmit operation in the DL subframe.
- The MAC sends the PHY a description of the next DL subframe, etc.

The uplink protocol consists of the following major interactions:

- The MAC sends the PHY a description of the current UL subframe (RXVECTOR). This description provides all of the information that the PHY needs to demodulate/decode the data bursts that are to be received as part of the subframe.
- The PHY sends the MAC the burst data for the current UL subframe.
- Certain types of data burst may require longer processing by the PHY and the PHY can send them to the MAC separately from the data bursts for the current UL subframe.
- The MAC sends the PHY a description of the next UL subframe, etc.

The MAC-PHY protocol is defined using a layered approach. The document defines a set of messages that achieve the communications described above independently of the structure of the frame descriptors and types of data bursts.

The messages can be mapped to various underlying transports such as Ethernet or SPI-3 bus.

2.2 Assumptions

The following assumptions have been made:

1. There is a clean separation between the PHY and the MAC. All MAC operations (such as ARQ and the scheduling of airlink resources) are implemented outside the PHY. The PHY does not need to have any information about the internal operation of the MAC. In addition, the PHY does not need to inspect the contents of any MAC PDUs to obtain control information.
2. The PHY does not need to understand the UCD/DCD or the burst profiles. The MAC specifies the modulation, FEC type, and repetition coding directly, so that the PHY does not need to deal with UIUC and DIUC numbers to determine the modulation/code rate.
3. The PHY does not need to understand the structure of the DL and UL maps. The MAC provides information to the PHY about the contents of each frame (zones, bursts, etc.) in a software-friendly format.
4. The bandwidth of the physical link over which the MAC-PHY protocol operates is provisioned to handle the MAC-PHY protocol traffic for the supported channel bandwidth and number of SDMA users.
5. The PHY SAP is defined to allow a single MAC to control/support multiple PHY entities over a shared physical link.
6. The physical link over the MAC-PHY protocol operates offers reliable delivery of MAC-PHY protocol messages – every message sent over the bus will be delivered to the other side without error and messages will not be misordered. To ensure detection of PHY or MAC problems, missing or errored primitives are detected by PHY and MAC Rx/Tx state machines and cause corrective actions, including PHY and/or MAC reset.
7. Both PHY and MAC sides implement hardware flow control.
8. It is assumed that MAC processing is much faster than this of the PHY; therefore, PHY cannot overflow MAC (which is not true in the opposite direction). Some of the defined ‘confirmation’ primitives (related to TXSDU requests) can be omitted if buffering at PHY is fast enough to accept all related requests within single frame. If not, the ‘confirmation’ primitives serve for protocol-level flow control between MAC and PHY.
9. Both the MAC and the PHY devices are able to buffer a number of PHY_XXX messages prepared to be sent to the other side. In the event that the MAC/PHY must drop protocol messages due to lack of space in the buffer, PHY_TXSDU.request / RXSDU.indication messages are dropped before any other PHY_XXX messages.
10. The PHY will not be changed on the fly without restarting the MAC (no hot swap). Because of this, there is no need to specify the PHY type in the MAC-PHY protocol messages.
11. The PHY SAP is focused on BS side; it may be used both on BS and SS side, but the SS side requires some modifications to the present specification. The current description defines the BS primitives only.

3 Base Station Frame Descriptors

This section focuses on the BS version of Downlink and Uplink Frame Descriptors.

The downlink descriptor is also referred to as the TXVECTOR and the uplink descriptor is also referred to as the RXVECTOR. The Frame Descriptors are used by the MAC to communicate the structure of individual frames to the PHY. The Downlink Frame Descriptor describes the structure of and burst allocations in a DL subframe, while the Uplink Frame Descriptor describes the structure of and burst allocations in the UL subframe.

The information in the frame descriptors is a subset of the information that the BS MAC encodes into the DL and UL maps that are broadcast to the SSs. The structure of the frame descriptors does not mirror precisely that of the maps. The information in the frame descriptors is limited to the information that the PHY requires to process the data within given subframe. Each type of allocation is described in a single way in the descriptors, even though there may be multiple ways to describe the allocation in the maps.

The frame descriptors defined in this document are intended to cover all of the different types of allocations allowed by the OFDMA PHY in the 802.16e standard. They have been structured to try to anticipate future extensions.

3.1 Frame Structure

This section describes the structure of an 802.16 OFDMA PHY frame and the different types of allocations that can be created by the MAC.

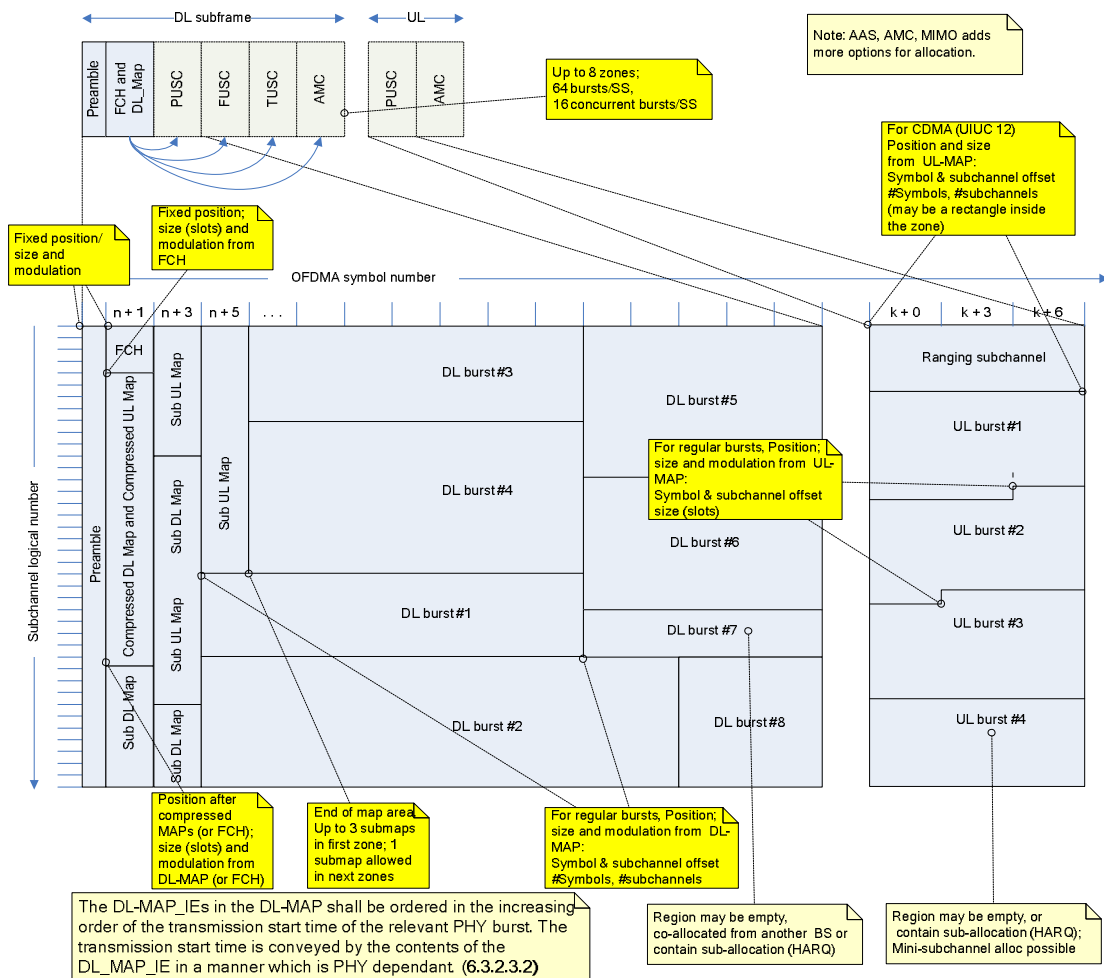


Figure 3-1: Typical OFDMA TDD frame format

Figure 3-1 shows a typical OFDMA TDD frame. The frame is divided into a DL subframe and UL subframe.

3.1.1 Downlink Subframe Structure

The first symbol within the DL subframe contains a preamble. The structure and processing of the preamble by the base station is specified in the standard. It does not change on a frame-by-frame basis, so the preamble is assumed to exist in the first symbol of the frame and is not explicitly described in the downlink frame descriptor.

3.1.1.1 Downlink Zones

The DL subframe is divided into one or more zones. A zone is a region of the subframe starting at one symbol and ending at another. Associated with each zone is the subchannelization scheme used within the zone. There are three types of downlink zones. In normal zones, data is transmitted using a single antenna. In STC zones, data is transmitted using STC (Alamouti), general beamforming or MIMO coding using two or more antennas. In AAS zones, data is transmitted using specific beamforming techniques. It should be noted that the standard uses the same information element (IE) to describe normal and STC zones in the DL map, but in the frame descriptor they are differentiated.

The standard also defines an optional common sync symbol, which can be transmitted as the last symbol of the downlink, in every fourth frame. Although the common sync symbol is technically not a zone, the slot structure of the frame may require that additional symbols preceding the common sync symbol are left unused. It is convenient to describe the common sync symbol as a type of zone in the frame descriptors.

A special AAS calibration zone may also be needed – to be allocated on demand. PHY can signal a need of a proper AAS calibration action and MAC should allocate a proper number of ending symbols within DL subframe, at some future time.

3.1.1.2 Downlink Bursts

Within each zone, the transmission resources are allocated in bursts. Bursts are not allowed to cross zones. The following subsections describe the different types of bursts that exist in the downlink.

3.1.1.2.1 FCH

The FCH always occupies a rectangular region, constituting the first burst in the first zone. The FCH contains information about the code rate and modulation level of the DL map and its length. It is always encoded using a specified code rate and modulation level. There are two different formats of FCH, for 128FFT and for the remaining FFT sizes. For FFT sizes other than 128, the first 4 slots contain 48 bits modulated by QPSK with coding rate $\frac{1}{2}$ and repetition coding of 4. For FFT-128, the first slot is dedicated to FCH and repetition is not applied.

3.1.1.2.2 Downlink Maps

Following the FCH (in the same symbol and the next logical subchannel) is the DL map. The standard defines multiple types of DL and DL/UL maps. The basic DL map always begins after the FCH, but other types of maps, such as the Sub-DL-UL-Map can begin at other places in the downlink subframe. There can be up to three Sub-DL-UL-Maps per frame. Sub-DL-UL-Map message is used only with compressed DL and appended UL Map structure.

The allocation of slots for all of the different types of maps is performed in the same way. Figure 3-2 illustrates map allocations in the first zone of the DL subframe. The different map allocations are numbers from 1 to 4. Each map allocation begins in a slot at a given subchannel and symbol offset. The size of the allocation is defined by the number of slots occupied by the map. The slots are always allocated along the frequency axis first. When the last subchannel is reached, the allocation wraps up to the lowest number subchannel in the next slot time. In the figure, map allocations 2 and 4 are examples of how the allocation wraps to the next slot time.

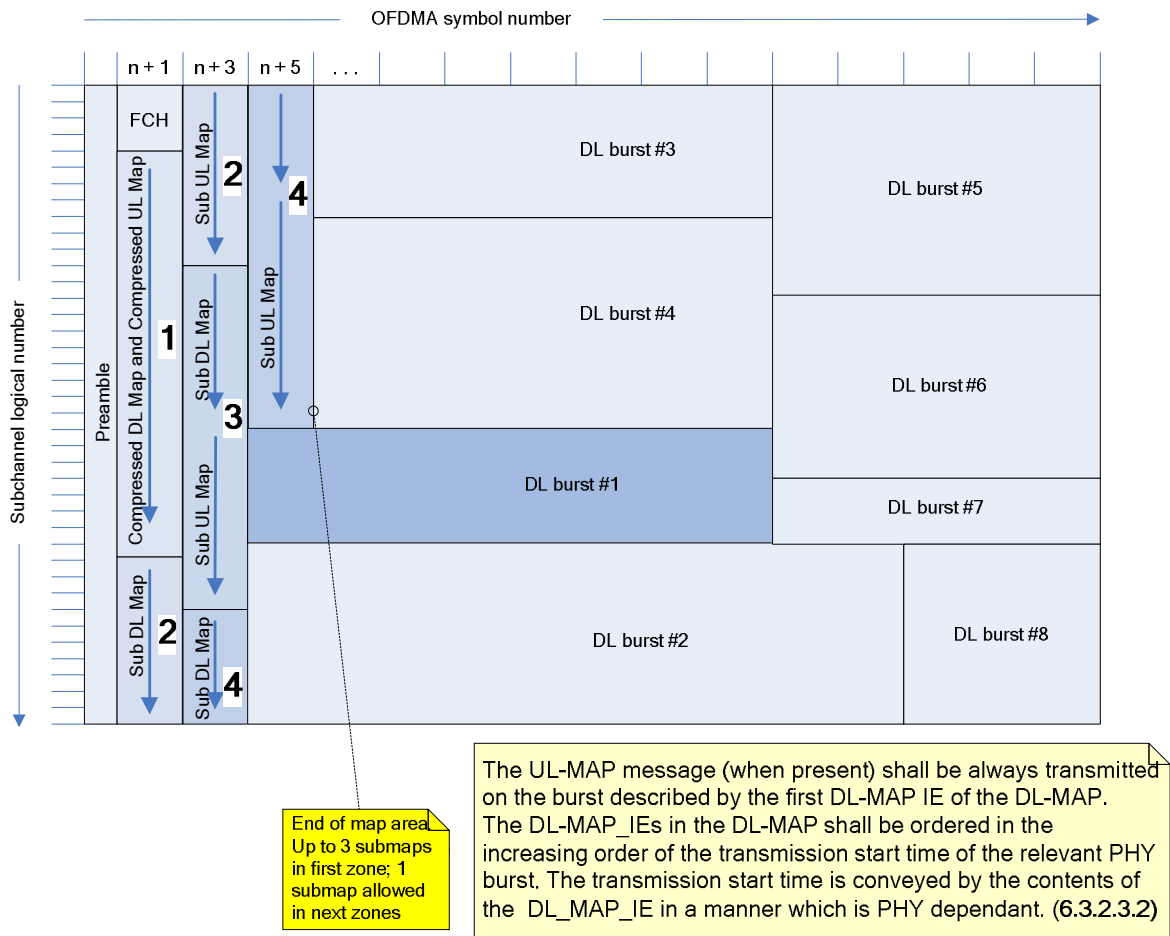


Figure 3-2: DL map allocations

3.1.1.2.3 Normal Data Bursts

Normal data bursts are allocated rectangular regions within the subframe. Such regions are described by a starting subchannel and symbol offset and a number of subchannels and symbols. There are a number of examples of normal data bursts in Figure 3-1. They are labeled DL burst #1 through DL burst #8.

3.1.1.2.4 Uplink Map

The standard defines the UL Map as a normal data burst (when compressed DL and appended UL Map structure is not used), so the allocation for the UL map is a normal data burst. The UL-Map is placed always in the first DL burst.

3.1.1.2.5 PAPR Allocation

A PAPR allocation can be created anywhere within the subframe to allow the PHY to minimize the peak to average power ratio within each symbol of the frame, by transmitting specially chosen data that minimize this ratio. The BS MAC must tell the BS PHY the location of such an allocation, even though the allocation is not described in the DL Map, as none of the Ss needs to receive/process the data in this allocation. For the purposes of the frame descriptor, PAPR allocations are defined to be rectangular allocations.

3.1.1.2.6 Sub-Allocation Data Bursts

The standard defines a second type of allocation for data bursts, meant to support the situation where the data for each subscriber must be sent in a separate burst (this type of allocation was defined

specifically for HARQ-enabled data, but the standard does not require that this type of allocation be used exclusively for HARQ bursts).

Figure 3-3 illustrates this type of allocation. In this type of allocation, there is an “outer allocation” (labeled “downlink allocation” in the figure) which is defined as a rectangular region in the subframe, much like a normal data burst. Sub-allocations are defined within this “outer allocation”. Sub allocations are specified by the starting symbol and subchannel offset and the number of slots. Slots are allocated in a frequency first fashion in a way similar to maps. The first three sub-allocations within the outer allocation are shown in the figure (the suballocations are labeled “HARQ sub-bursts” in the figure). For the middle sub-allocation the starting symbol and subchannel is identified together with the order in which slots are allocated.

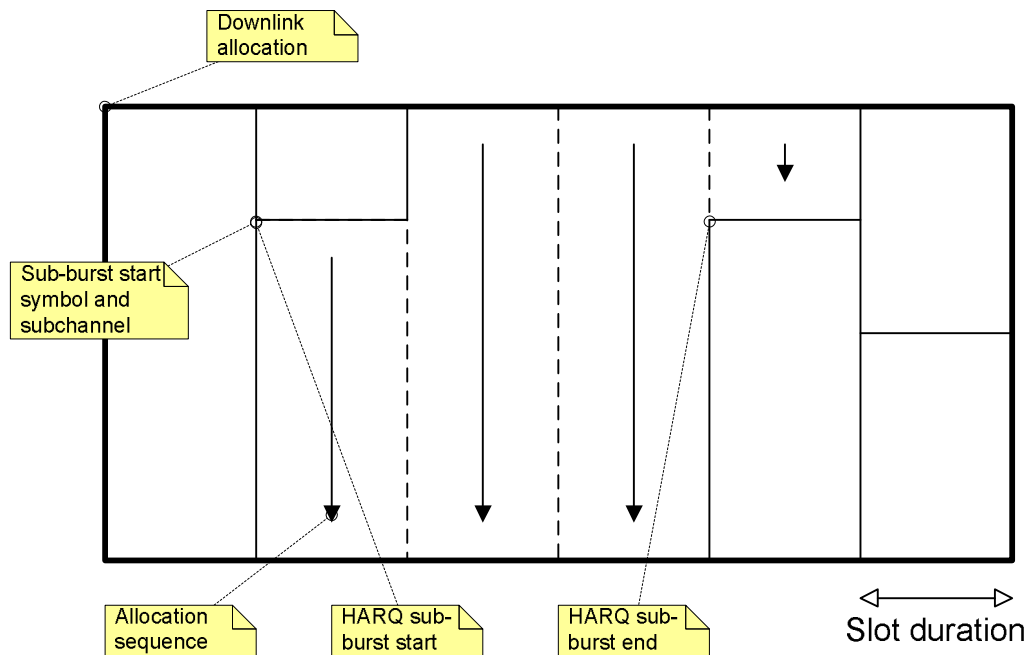


Figure 3-3: Downlink sub-allocation data burst

3.1.2 Uplink Subframe Structure

3.1.2.1 Uplink Zones

The uplink subframe is divided into one or more zones. A zone is a region of the subframe starting at one symbol and ending at another. Associated with each zone is the subchannelization scheme used within the zone.

The standard defines two types of zones in the uplink subframe. Bursts transmitted within non-AAS zones can be received using a single antenna or using multiple antennas (MRC, general beamforming or MIMO). Within AAS zones, bursts are received at the base station using specific beamforming techniques.

3.1.2.2 Uplink Bursts

Within each zone, the transmission resources are allocated in bursts. Bursts are not allowed to cross zones. The following subsections describe the different types of bursts that exist in the uplink.

3.1.2.2.1 HARQ ACK Channel

HARQ ACK Channels are defined as rectangular regions in the subframe. They have a specific structure, where a slot carries the ACKs for two different HARQ channels from different subscriber stations. The individual ACKs are defined as HARQ ACK Subchannels (sub-bursts of HARQ ACK Channel – see Section 3.1.2.2.10).

3.1.2.2.2 Fast Feedback Channel

Fast feedback channels are defined as rectangular regions in the subframe. They also have a specific structure, in which slots are shared by multiple channels. The slots within a fast feedback allocation can carry different types of data. Normal fast feedback channels carry 4 bits of information, enhanced fast feedback channels carry 6 bits of information in one slot, or 3 bits in 1/2 slot. Primary/secondary channels carry 6 bits and 4 bits respectively. Slots are allocated dynamically to subscribers by BS periodically for limited or unlimited time.

3.1.2.2.3 Ranging Regions

There are several types of contention based regions used for ranging and bandwidth request purposes. These are initial ranging, handover ranging, periodic ranging, and bandwidth request. There are two types of contention based region allocations. The first type is used for initial ranging and handover ranging. They are referred to as Initial Ranging/Handover Ranging Allocations. The second type of allocation is for periodic ranging and bandwidth request. They are referred to as Periodic Ranging/Bandwidth Request Allocations. It should be noted that in the standard, both types of allocations are allocated using the same information element (IE), but it is convenient for the sake of the frame descriptors to make a distinction between these two types of allocations.

Both Initial Ranging/Handover Ranging Allocations and Periodic Ranging/Bandwidth Request Allocations are defined as rectangular allocations. Each allocation consists of one or more ranging slots. Figure 3-4 illustrates a ranging opportunity that contains multiple ranging slots. The dimensions of a slot depend on the type of allocation (initial/handover or period/bandwidth request) and on the specified number of symbols over which ranging is performed. For initial ranging/handover ranging the choices are 2 or 4 symbols, while for periodic ranging/bandwidth request the choices are 1 or 3 symbols. The unused area at the end of the region allocation can exist if the number of symbols in the allocation is not a multiple of the number of symbols in the region. In the figure below, the number of symbols required to transmit the appropriate ranging/BW request code (1, 2, 3 or 4 symbols), is denoted as N_1 . N_2 denotes the number of subchannels required to transmit a ranging code (6 in the case of PUSC and TUSC1 and 8 in the case of Optional PUSC, TUSC2, and AMC).

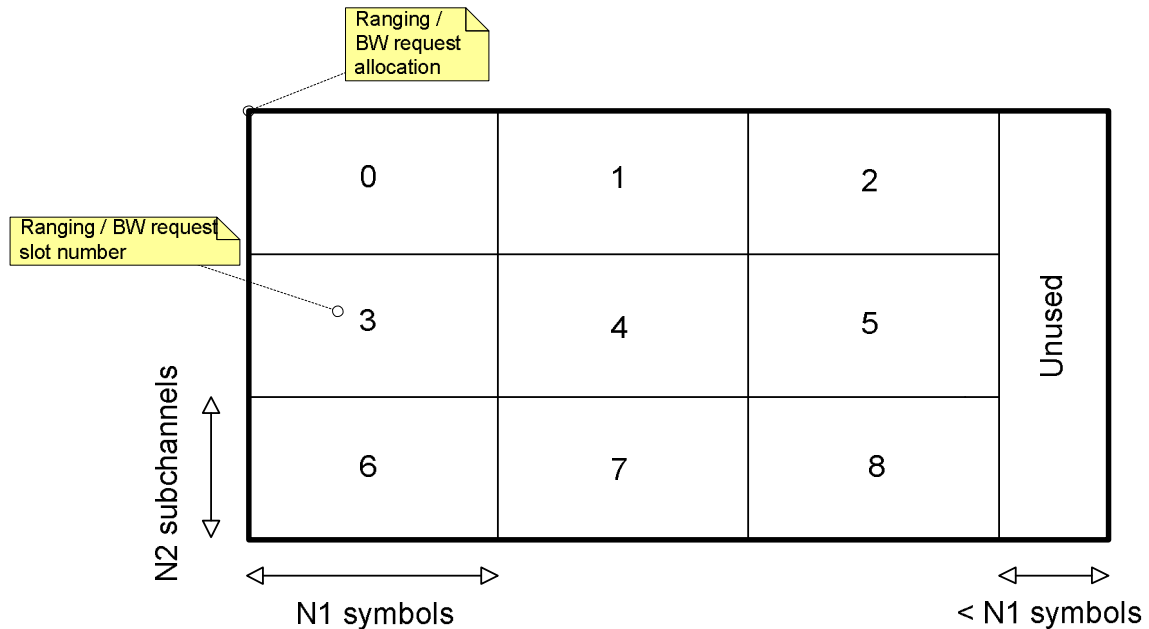


Figure 3-4: Ranging allocation

3.1.2.2.4 PAPR/Safety Zone

PAPR/Safety Zone allocations are rectangular allocations. PAPR allocations are used to allow the subscriber stations to insert tones to minimize the PAPR of the symbols that they transmit. Safety

channels are used by adjacent base stations to designate specific frequencies/time slots for limiting the interference in 1x frequency reuse scenario.

3.1.2.2.5 Sounding Zone

Sounding Zone allocations are also rectangular. In the UL Map, they are allocated using the same IE as the PAPR/Safety Channels, but it is convenient to describe them as separate allocations in the frame descriptor. In a Sounding Zone there can be one or more sounding signals arriving from different subscribers at the same time.

3.1.2.2.6 Noise Floor Allocation

In order to measure the noise (and interference) floor, the base station MAC may want to create an empty allocation in the UL Map and instruct the PHY to measure the noise received in this “empty” allocation. For this purpose, the Noise Floor Allocation is defined. This allocation is rectangular. Since calculation of the noise floor is a local base stations issue, this allocation does not correspond to any specific IE in the UL Map structure.

3.1.2.2.7 Normal Data Burst

Normal data bursts in the uplink are defined by a starting subchannel and symbol offset and by a duration expressed in number of slots. The allocations are created by allocating slots along the time axis until the end of the zone and then wrapping to the first symbol/slot in the next subchannel and processing along the time axis. Figure 3-5 illustrates several normal data burst allocations within a zone (labeled “UL burst #1” through “UL burst #4”). The order in which slots are allocated is shown by the arrows that overlay UL burst #2.

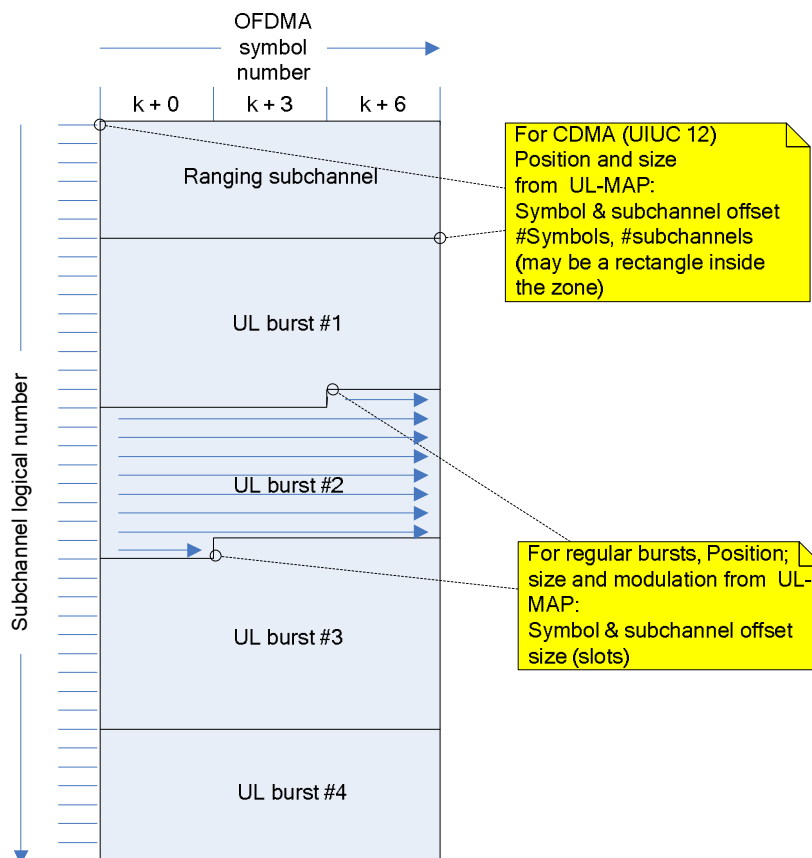


Figure 3-5: Normal data burst allocations in the uplink

3.1.2.2.8 Sub-Allocation Data Burst

The standard defines a second type of allocation for data bursts, meant to support the situation where the data for each subscriber must be sent in a separate burst. (This type of allocation was defined specifically for HARQ-enabled data, but the standard does not require that this type of allocation be used exclusively for HARQ bursts).

In this type of allocation, there is an “outer allocation” that is defined in the same way as a normal data burst allocation. Sub-allocations are defined within this “outer allocation”. Sub allocations are specified by the starting symbol and subchannel offset and the number of slots. Slots are allocated in a time first fashion. Figure 3-6 illustrates this type of allocation. In the figure, one of the sub-allocation allocations within “UL burst #2” is shown. The arrows indicate the order in which slots are assigned to the sub-allocation from within the outer allocation.

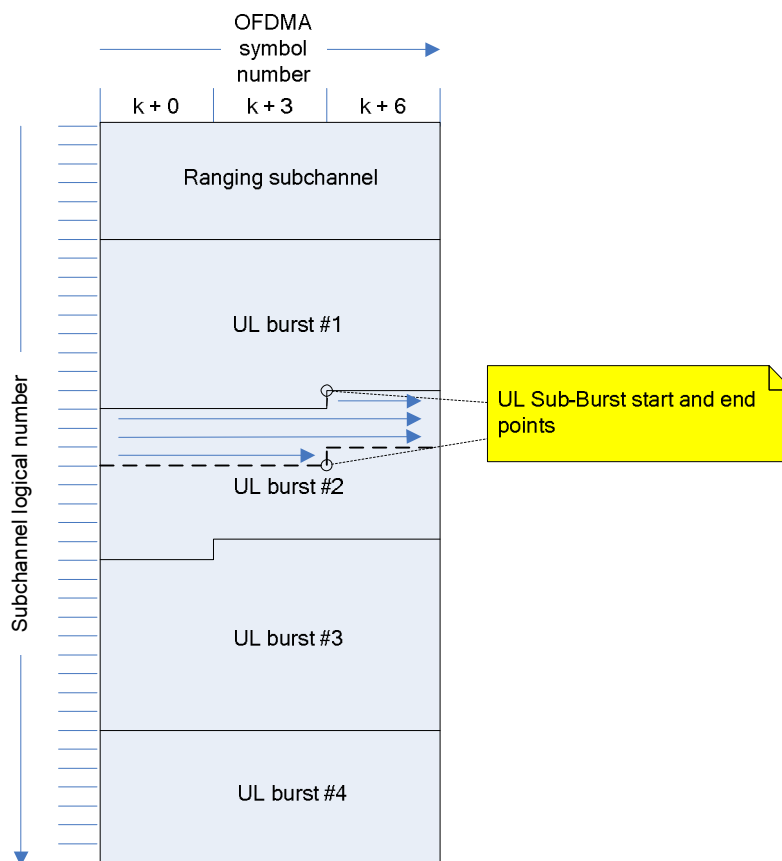


Figure 3-6: Sub-alloc type allocations in the uplink

3.1.2.2.9 Mini-Subchannel Burst

Mini-subchannel allocations allow a number of users to share an allocation by splitting up the tiles that make up each slot and allocating them to the users that share the allocation. This allows a given user to transmit on a smaller number of tones than is otherwise possible.

The dimensions of Mini-subchannel allocations are specified in the same way as normal data allocations in the uplink. A parameter called CType identifies the type of mini-subchannel. There are four types. Two types are shared by two users. The difference is how the tiles within a slot are shared between the users. The other two types are shared by 3 and 6 users. Each user is identified by a user id.

The following figures illustrate the four different types of mini-subchannels. In each of the figures, the allocation is shown using the red outline. The manner in which the slots are split between the users that share the allocation (the mini-subchannels) is indicated using different colors.

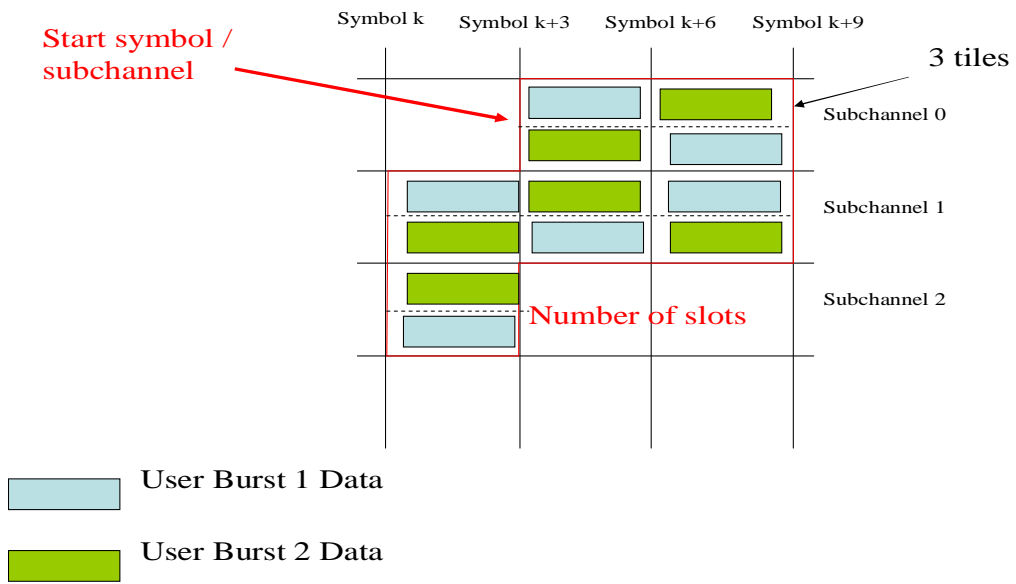


Figure 3-7: Mini-subchannels (Ctype = 0)

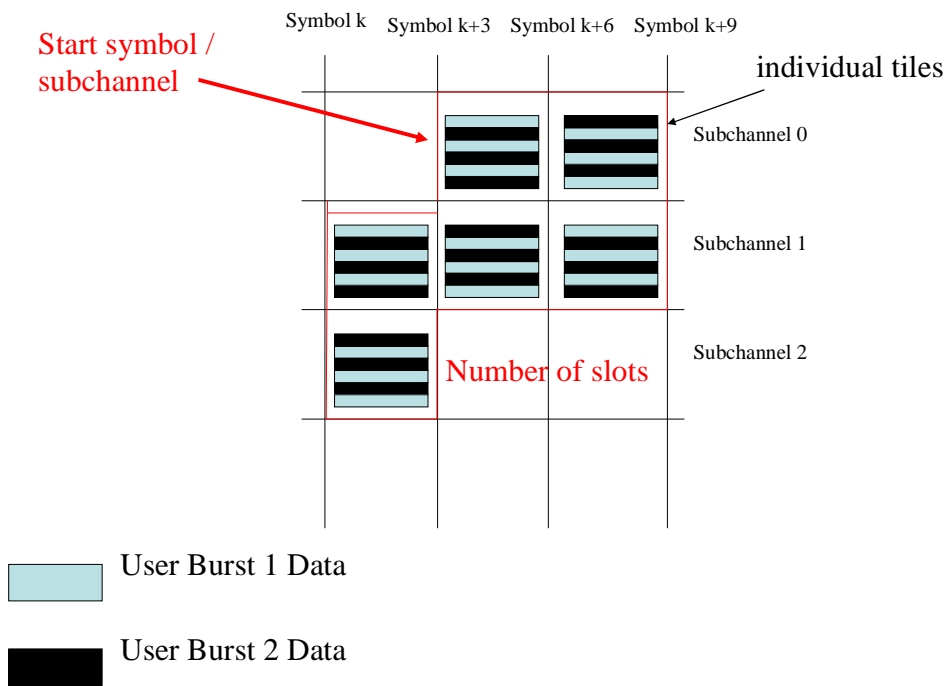


Figure 3-8: Mini-subchannels (Ctype = 1)

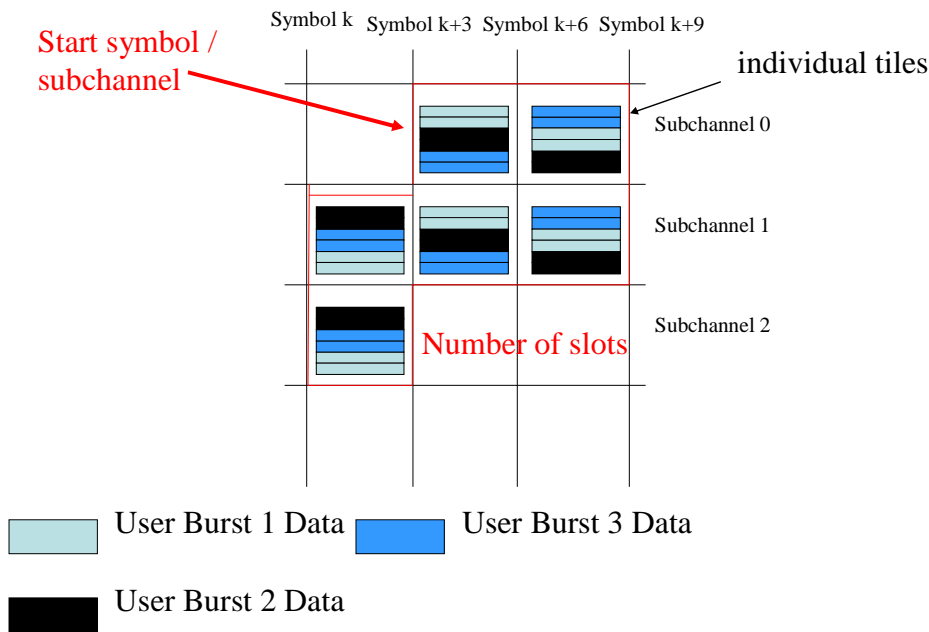


Figure 3-9: Mini-subchannels (Ctype = 2)

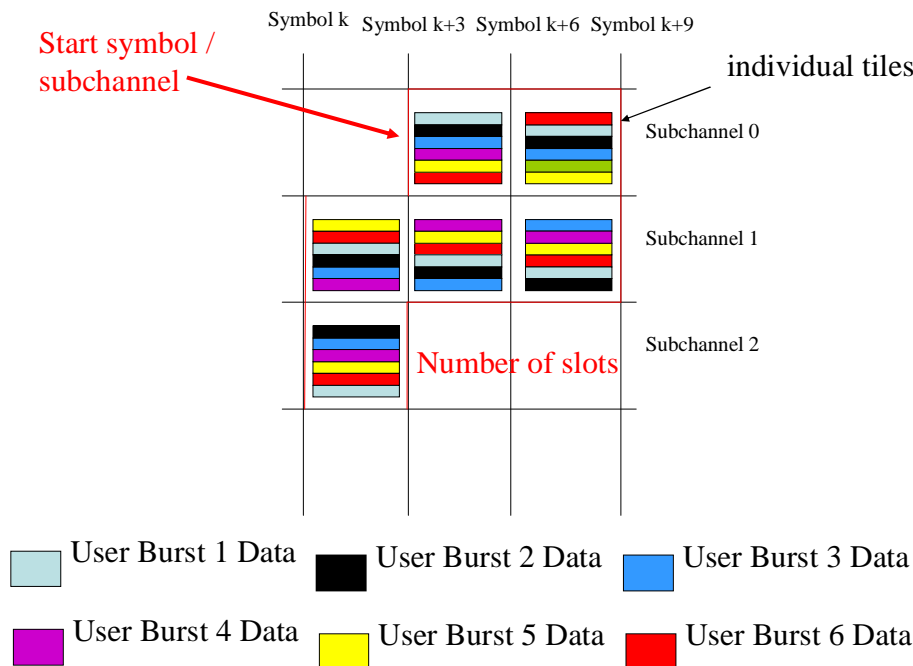


Figure 3-10: Mini-subchannels (Ctype = 3)

3.1.2.2.10 HARQ ACK Subchannel

HARQ ACK Subchannel looks much like Mini-subchannel Ctype = 1 (see Figure 3-8). The subchannel occupies half of the slot, so a slot can be shared between two subscribers. The even half subchannel consist of Tile(0), Tile(2) and Tile(4). The odd half subchannel consist of Tile(1), Tile(3) and Tile(5).

HARQ ACK subchannel 2n is the first half of slot n; HARQ ACK subchannel (2n+1) is the second half of slot n.

3.2 Frame Descriptors Hierarchy

The downlink subframe and uplink subframe of each frame is described by a frame descriptor (TX/RXVECTOR). The frame descriptors for the downlink and uplink are similar in structure, but the specific parameters are different. In this section, the top-level structure of a frame descriptor is described, for both the downlink and uplink. The following figure shows the descriptor hierarchy.

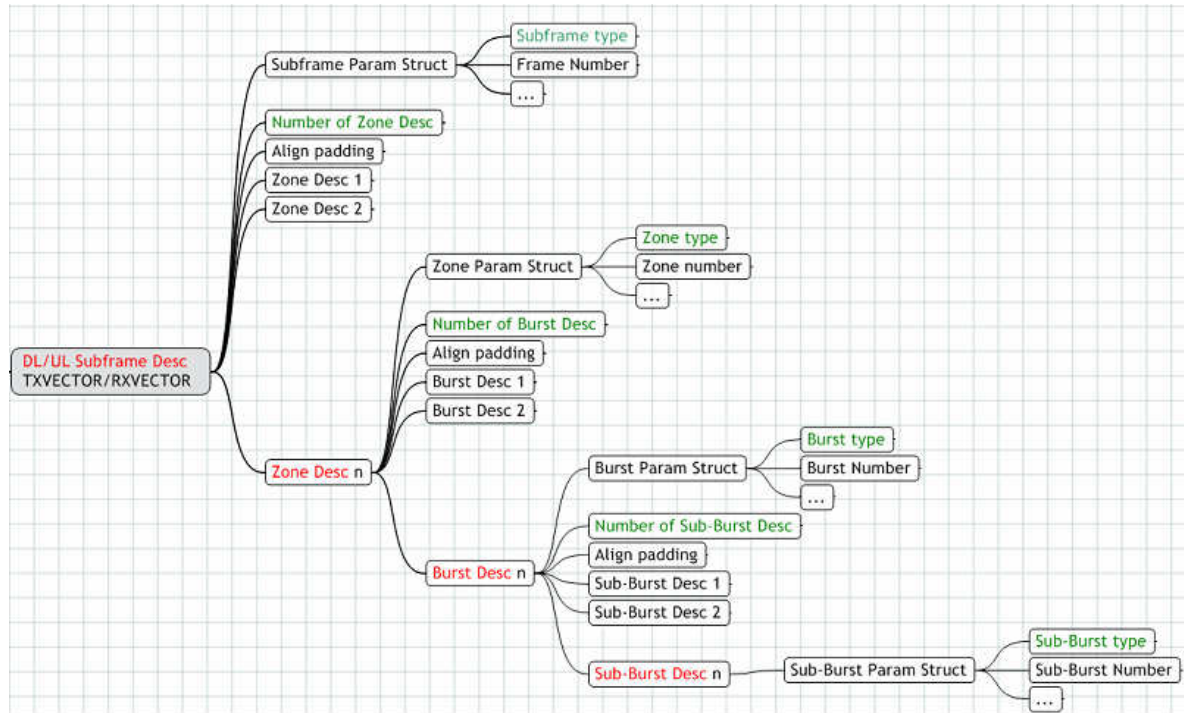


Figure 3-11: Frame descriptor hierarchy

The description of the subframe is divided into zones. The frame descriptor consists of a series of zone descriptions. Each zone description contains a zone descriptor that describes the zone and a list of burst descriptors. Each burst descriptor describes one burst within the associated zone. Table 3-1 shows the format of a frame descriptor. Table 3-2 shows the structure of a zone description. Each Burst can be further subdivided into Sub-Bursts as shown in Table 3-3. At each level (subframe, zone, burst, sub-burst) each descriptor is identified by a type value, unique within a subframe (UL and DL subframe type values may overlap).

Note: Unlike the convention used in the definition of the DL- and UL-Map (which was devised to save precious air bandwidth), the frame descriptors utilize explicit parameters, even when the same parameter is repeated for multiple bursts. For example, DL/UL Map would use default <parameter 1> valid for subsequent map IEs, until the value is changed explicitly to some another value <parameter 2>, which in turn would remain in force until explicitly revoked or changed. In the descriptors, each descriptor must be given together with either <parameter 1> or <parameter 2>, as appropriate.

Table 3-1: Subframe descriptor format

LW	Bits	Size	Description
		64 bits	Subframe Parameter Structure (see Table 3-7 for DL and Table 3-23 for UL)
		8 bits (3 bits used)	Number of Zone Descriptors
		24 bits	Padding to align on 32 bit boundary

LW	Bits	Size	Description
		variable	Zone Descriptor for zone 1 (see Table 3-2)
		variable	Zone Descriptor for zone 2
		variable	Zone Descriptor for zone n

Table 3-2: Zone descriptor format

LW	Bits	Size	Description
		variable	Zone Parameter Structure (see sections 3.4.2 for DL and 3.5.2 for UL zone parameter definitions)
		8 bits	Number of Burst Descriptors in this zone
		24 bits	Reserved (padding to align on 32 bit boundary)
		variable	Burst Descriptor for Burst 1 (See Table 3-3)
		variable	Burst Descriptor for Burst 2
		variable	Burst Descriptor for Burst n

Table 3-3: Burst descriptor format

LW	Bits	Size	Description
		variable	Burst Parameter Structure (see sections 3.4.3 for DL and 3.5.3 for UL zone parameter definitions)
		8 bits	Number of Sub-Burst Descriptors in this burst
		24 bits	Reserved (padding to align on 32 bit boundary)
		variable	Sub-Burst Descriptor for Sub-Burst 1 (See Table 3-4)
		variable	Sub-Burst Descriptor for Sub-Burst 2
		variable	Sub-Burst Descriptor for Sub-Burst n

Table 3-4: Sub-burst description format

LW	Bits	Size	Description
		variable	Sub-Burst Descriptor Structure (see sections 3.4.3 for DL and 3.5.3 for UL zone descriptor definitions)

3.2.1 Parameter Structure Formats

The zone, burst and sub-burst parameter structures are defined in a manner that allows for the addition of structures for new types of zones, bursts and sub-bursts in the future. A zone/burst parameter structure template is shown in Table 3-5. The structure begins with a structure type, which indicates which type of zone or burst is being described. First three bits of the type (**yyy**) are used to specify nesting level of a given descriptor. The next 5 bits are used to define specific type within the nesting level. The zone/burst sequential number is used for verification / internal mapping purposes. Following are the parameters that are common to all zones or bursts. Finally, are the specific parameters that describe the specific zone/burst that is being described. There is a separate structure for the specific parameters for each Structure Type. In order to allow for variable size descriptors and for modification/expansion of the descriptors in the future, the type specific parameters are preceded by a parameter giving the number of lower-level descriptors. Padding is added, so that all structures are aligned on a 32-bit boundary.

Table 3-5: Parameter structure template

LW	Bits	Size	Description
		8 bits	Structure Type yyy00000 : First Structure Type yyy00001 : Second Structure Type
		8 bits	sequential number of this structure within the parent structure
		variable	Structure Parameters

The zone, burst, and sub-burst descriptors are different for the downlink and uplink. Type values assignments are unique within downlink and uplink subframes (but not globally). Downlink descriptors are defined in section 3.4 and uplink descriptors are defined in section 3.5.

3.3 Common Parameter Definitions

3.3.1 FEC Code Type Field Coding

The following Forward Error Correction (FEC) code types are used in the DL and UL burst and sub-burst descriptors.

Table 3-6: FEC code type coding¹

Value	Description
0	QPSK (CC) 1/2
1	QPSK (CC) 3/4
2	16-QAM (CC) 1/2
3	16-QAM (CC) 3/4
4	64-QAM (CC) 1/2
5	64-QAM (CC) 2/3
6	64-QAM (CC) 3/4
7	QPSK (BTC) 1/2
8	QPSK (BTC) 3/4
9	16-QAM (BTC) 3/5
10	16-QAM (BTC) 4/5
11	64-QAM (BTC) 5/8
12	64-QAM (BTC) 4/5
13	QPSK (CTC) 1/2
14	Reserved
15	QPSK (CTC) 3/4
16	16-QAM (CTC) 1/2
17	16-QAM (CTC) 3/4
18	64-QAM (CTC) 1/2
19	64-QAM (CTC) 2/3
20	64-QAM (CTC) 3/4

¹ State: as of IEEE 802.16-2005 specification

Value	Description
21	64-QAM (CTC) 5/6
22	QPSK (ZT CC) 1/2
23	QPSK (ZT CC) 3/4
24	16-QAM (ZT CC) 1/2
25	16-QAM (ZT CC) 3/4
26	64-QAM (ZT CC) 1/2
27	64-QAM (ZT CC) 2/3
28	64-QAM (ZT CC) 3/4
29	QPSK (LDPC) 1/2
30	QPSK (LDPC) 2/3 A code
31	QPSK (LDPC) 3/4 A code
32	16-QAM (LDPC) 1/2
33	16-QAM (LDPC) 2/3 A code
34	16-QAM (LDPC) 3/4 A code
35	64-QAM (LDPC) 1/2
36	64-QAM (LDPC) 2/3 A code
37	64-QAM (LDPC) 3/4 A code
38	QPSK (LDPC) 2/3 B code
39	QPSK (LDPC) 3/4 B code
40	16-QAM (LDPC) 2/3 B code
41	16-QAM (LDPC) 3/4 B code
42	64-QAM (LDPC) 2/3 B code
43	64-QAM (LDPC) 3/4 B code
44	QPSK (CC with optional interleaver) 1/2
45	QPSK (CC with optional interleaver) 3/4
46	16-QAM (CC with optional interleaver) 1/2
47	16-QAM (CC with optional interleaver) 3/4
48	64-QAM (CC with optional interleaver) 2/3

Value	Description
49	64-QAM (CC with optional interleaver) 3/4
50	QPSK (LDPC) 5/6
51	16-QAM(LDPC) 5/6
52	64-QAM(LDPC) 5/6
53..255	reserved

3.4 Downlink Descriptors (TXVECTOR)

3.4.1 Downlink Subframe Parameter Structure

This is the top-level descriptor for downlink subframe.

Table 3-7: Downlink subframe parameter structure format

LW	Bits	Size	Description
0	31:24	8 bits	Subframe Type (000xxxxx) 00000001 – Downlink Subframe (00000011-00011111 – reserved : 101xxxxx-111xxxxx – reserved)
0	23:16	8 bits	Frame Number
0	15:8	8 bits	<i>reserved</i>
0	7:0	8 bits	231(decimal) – PHY SAP version number
1	31:0	32 bits (18 bits)	Downlink reserved (=0)

Note: <LW> in the following tables are given relative to Zone Descriptor start within the Subframe Descriptor.

3.4.2 Zone Parameters Structures

In the downlink, there are the following types of Zone Parameter Structures:

- Normal – This type of structure is used to define a zone in which neither STC/MIMO, general beamforming nor AAS is performed. Data is transmitted using one antenna, with no special coding in this type of zone.
- STC – This type of structure is used to define a zone in which STC/MIMO encoding is used to transmit the data, using multiple antennas. Note that this zone can also be used with general beamforming. In the DL MAP, this type of zone is indicated using a STC_Zone IE with the STC type of “No STC” and permutation with dedicated pilots.
- AAS – This type of structure is used to define a zone where a specific beamforming is used to transmit the data using between 2 and 12 antennas.
- Common Sync Symbol – This type of structure is used to define a region of the subframe between 1 and 3 symbols wide in which the last symbol is used to transmit the common sync symbol. The common sync symbol is technically not a zone in the subframe, but it is convenient to define it as such in the frame descriptor. The common sync symbol zone may be more than one symbol wide because the slot structure of the different subchannelization schemes requires that symbols be allocated to zones in groups of 1, 2, or 3.
- AAS Calibration Zone – PHY can signal a need of a proper AAS calibration action and MAC should allocate a proper number of ending symbols (across all subchannels) within DL subframe in a form of AAS Calibration Zone, not later than suggested by the PHY.

The common part of the zone parameter structure has the parameters specified in the Table 3-8. Each zone parameter structure in the DL frame descriptor contains this generic part and one of the specific parts. The specific parts of the structure are defined in the tables that follow.

Table 3-8: Generic Part of Downlink Zone Parameter Structure

LW	Bits	Size	Description
0	31:24	8 bits	Zone Type (001xxxxx) 00100000 : Normal Zone Parameters 00100001: STC Zone Parameters 00100010: AAS Zone Parameters 00100011: Common Sync Symbol Parameters 00100100: AAS Calibration Zone (00100101-00111111: reserved)
0	23:16	8 bits	Zone Number (unique within DL subframe, starting from 0)
0	15:8	8 bits	Start Symbol Offset (from beginning of DL subframe)
0	7:0	8 bits	End Symbol Offset (from beginning of DL subframe)
1	31:24	8 bits (4 bits used)	Permutation Type 0000: PUSC 0001: FUSC 0010: Optional FUSC 0011: AMC – 1 x 6 0100: AMC – 2 x 3 0101: AMC – 3 x 2 0110: TUSC1 0111: TUSC2 1000-1111: reserved
1	23:16	8 bits (1 bit used)	Use all subchannels indicator 0: use only subchannels specified in PHY configuration register ² (implementation specific) 1: use all subchannels
1	15:8	8 bits (5 bits used)	DL_PermBase
1	7:0	8 bits (2 bits used)	PRBS_ID – used with PUSC zones, in which ‘use all subchannels’ indicator is set
2	31:24	8 bits (1 bit used)	Dedicated pilots 0: pilots are broadcast 1: pilots are dedicated

² How segments are defined and how the subchannel allocation is performed at the initialization time is beyond the scope of this specification

LW	Bits	Size	Description
2	23:0	24 bits	Reserved (padding to align on 32 bit boundary)
		variable	Zone Specific Data (per Zone Parameter Structure Type)

Table 3-9: Normal and AAS Calibration Zone-Specific Part of Downlink Zone Parameter Structure

LW	Bits	Size	Description
3			(empty)

Table 3-10: STC Zone -Specific Part of Downlink Zone Parameter Structure

LW	Bits	Size	Description
3	31:24	8 bits (3 bits used)	STC type 000: STC using 2 antennas 001: STC using 3 antennas 010: STC using 4 antennas 011: FHDC using 2 antennas 100-111: reserved
3	23:16	8 bits (2 bits used)	Matrix Indicator 00: Matrix A 01: Matrix B 10: Matrix C 11: reserved
3	15:8	8 bits (1 bit used)	Midamble presence 0: not present 1: present
3	7:0	8 bits (1 bit used)	Midamble boosting 0: no boosting 1: boosting

Table 3-11: AAS Zone -Specific Part of Downlink Zone Parameter Structure

LW	Bits	Size	Description
3	31:24	8 bits (2 bits used)	Preamble configuration 00: 0 symbols (preambles not supported)

LW	Bits	Size	Description
			01: 1 symbol 10: 2 symbols 11: 3 symbols
3	23:16	8 bits (1bit used)	SDMA supported indication 0: SDMA not supported 1: SDMA supported
3	15:0	16 bits	Reserved (padding to align on 32 bit boundary)
		variable	Algorithm Specific Information (per Zone Type)

Algorithm-specific information is used to allow the MAC to provide the AAS processing part of the PHY with additional information that is specific to the weight calculation/selection algorithm used by the system, (e.g., a position index within a fixed grid, obtained at receive as part of status information).

Table 3-12: Common Sync Symbol-Specific Part of Downlink Zone Parameter Structure

LW	Bits	Size	Description
3			(empty) No Zone type specific data

3.4.3 Burst Parameter Structures

There are the following types of downlink data burst parameter structures.

- Map Data Burst Parameter Structure
- Normal Data Burst Parameter Structure
- PAPR Allocation Parameter Structure

Table 3-13 shows the common downlink burst parameter structure. Table 3-14 – Table 3-16 describe the burst type specific structures.

Table 3-13: Generic Part of Downlink Burst Parameter Structure

LW	Bits	Size	Description
0	31:24	8 bits	Burst Type (010xxxxx): 01000000 : Map Data Burst 01000001: Normal Data Burst 01000010: Control Command ³ 01000011 PAPR Allocation (01000100-01011111: reserved)

³ If present, this pseudo-burst description shall be present as the first in the first zone description only. Only the Burst Type field is relevant, the remaining fields shall be set to zero.

LW	Bits	Size	Description
0	23:16	8 bits	Burst Type extension: 00000000: no extended data: 00000001: AAS v1 00000010: MIMO v1 (00000011-01111111:Reserved by Intel 10000000-11111111:User-defined)
0	15:8	8 bits	Burst Number (used to correlate burst data, counted within a zone, starting from 0)
0	7:0	8 bits	Modulation/FEC Code Type See Table 3-6 for an enumeration of the types.
1	31:0	32 bits	Burst Data Length in bytes (if no sub-bursts)
2	31:24	8 bits	OFDMA Symbol offset (from start of DL subframe)
2	23:16	8 bits (6 bits used)	Subchannel offset
2	15:8	8 bits (3 bits used)	Boosting 000: normal 001: +6dB 010: -6dB 011: +9dB 100: +3dB 101: -3dB 110: -9 dB 111: -12 dB
2	7:0	8 bits (2 bits used)	Repetition coding indication 00: No repetition coding 01: Repetition coding of 2 10: Repetition coding of 4 11: Repetition coding of 6
		variable	Burst Type Specific Descriptor (per Burst Descriptor Type)

Table 3-14: Map Data Burst-Specific Part of Downlink Burst Parameter Structure

LW	Bits	Size	Description
3	31:16	16 bits (10 bits used)	Number of slots (duration) after repetition code is applied.

LW	Bits	Size	Description
3	15:0	16 bits	Reserved (padding to align on 32 bit boundary)

Table 3-15: Normal Data Burst-Specific Part of Downlink Burst Parameter Structure

LW	Bits	Size	Description
3	31:24	8 bits	Number of Symbols
3	23:16	8 bits (6 bits used)	Number of Subchannels
3	15:0	16 bits	AAS Handle (to enable AAS info update at PHY; null if not used or not known). Ignored if sub-bursts are present
		variable	Optional Burst Parameters (see section 3.4.3.1)

Table 3-16: PAPR Allocation-Specific Part of Downlink Burst Parameter Structure

LW	Bits	Size	Description
3	31:24	8 bits	Number of Symbols
3	23:16	8 bits (6 bits used)	Number of Subchannels
3	15:0	16 bits	Reserved (padding to align on 32 bit boundary)

3.4.3.1 Optional Burst Parameters

Optional Burst Parameters are used to specify additional parameters that apply to the different types of bursts, but are optional depending on whether the burst is a MIMO or AAS burst. The presence or absence of these additional parameters is indicated by the value of the Burst Type extension parameter (see Table 3-13). The data structures for the optional burst parameters are having the same layout as the zone and burst descriptors. There are separate definitions for the common parameters in a common structure and there are type-specific parameters in type specific structures. For the moment, the optional burst parameters are defined for AAS and MIMO.

Table 3-17: AAS-Specific Part of Downlink Optional Burst Parameters

LW	Bits	Size	Description
4	31:24	8 bits (1 bit used)	Preamble Modifier Type 0: frequency shifted preamble 1: time shifted preamble
4	23:16	8 bits (4 bits)	Preamble Shift index (frequency shift when PM type = 0 and time shift when PM type = 1)

LW	Bits	Size	Description
		used	
4	15:0	16 bits	Reserved (padding to align on 32 bit boundary)
		variable	Algorithm specific Information (per Burst Type extension)

The SDMA is supported by allowing multiple overlapping AAS allocations. PHY, when detecting such allocations will process them as SDMA.

The purpose of algorithm specific information is to allow for a way for specific PHY/MAC to pass information that is specific to the AAS algorithm that is being employed. Some examples of algorithm specific information might be the beam on which to transmit the data (in a beam steering system), or information to correlate this burst to an uplink burst received in an earlier frame, whose weights should be used as the basis of the weights for this burst.

Table 3-18: MIMO-Specific Part of Downlink Optional Burst Parameters

LW	Bits	Size	Description
4	31:24	8 bits (2 bits used)	Matrix indicator 00: Matrix A 01: Matrix B 10: Matrix C 11: reserved
4	23:16	8 bits (2 bits used)	Layer index
4	15:0	16 bits	Reserved (padding to align on 32 bit boundary)
		variable	Algorithm specific Information (per Burst Type extension)

3.4.4 Sub-Burst Parameter Structures

There are the following types of downlink data burst descriptors.

- Sub-Allocation Data Burst Descriptor

Table 3-19 shows the common downlink sub-burst descriptor parameters

Table 3-19: Common Part of Downlink Sub-Burst Parameter Structure

LW	Bits	Size	Description
0	31:24	8 bits	Sub-Burst Type (011xxxx) 01100000: No HARQ 01100001: HARQ Chase Combining 01100010: HARQ IR-CTC 01100011: HARQ IR-CC

LW	Bits	Size	Description
			01100100: MIMO Chase Combining 01100101: MIMO IR-CTC 01100110: MIMO IR-CC 01100111: MIMO-STC (01101000-01111111: reserved)
0	23:16	8 bits	Sub-Burst number (unique for the sub-bursts of a burst, starting from 0)
0	15:8	8 bits (6 bits used)	Symbol Offset (from start of DL subframe)
0	7:0	8 bits (6 bits used)	Subchannel Offset
1	31:16	16 bits (10 bits used)	Number of slots in this sub-burst
1	15:0	16 bits	Reserved
2	31:24	8 bits	Reserved
2	23:16	8 bits	Modulation/FEC Code Type See Table 3-6 for an enumeration of the types.
2	15:0	16 bits (signed)	ISSID (MAC-internal SS id – used by PHY in case of HARQ)
3	31:16	16 bits	AAS Handle (to enable AAS info update at PHY; null if not used or not known)
3	15:8	8 bits (3 bits used)	Boosting 000: normal 001: +6dB 010: -6dB 011: +9dB 100: +3dB 101: -3dB 110: -9 dB 111: -12 dB
3	7:0	8 bits (2 bits used)	Repetition coding indication 00: No repetition coding 01: Repetition coding of 2 10: Repetition coding of 4

LW	Bits	Size	Description
			11: Repetition coding of 6
4	31:0	32 bits	Sub-Burst Data Length in bytes (including 2 bytes for CRC-16 if HARQ)
		variable	Optional parameters (structure depends on Sub-Burst type; see 3.4.4.1 for definition)

3.4.4.1 Optional Sub-Burst Parameters

Table 3-20: No HARQ-Specific Part of Downlink Optional Sub-Burst Parameters

LW	Bits	Size	Description
5			<i>No specific parameters</i>

Table 3-21: HARQ Chase Combining-Specific Part of Downlink Optional Sub-Burst Parameters⁴

LW	Bits	Size	Description
5	31:24	8 bits (4 bits used)	HARQ channel id (ACID)
5	23:16	8 bits (1 bit used)	HARQ sequence number (AI_SN) – this value enables to differentiate new transmissions from retransmissions
5	15:8	8 bits (2 bits used)	00 – no flush action 10 – flush request to PHY for the ISSID/ACID 11 – flush request to PHY for the given ISSID (ACID and AI_SN fields above are irrelevant in this case)
5	7:0	8 bits	Reserved (padding to align on 32-bit boundary)

Table 3-22: MIMO Chase Combining-Specific Part of Downlink Optional Sub-Burst Parameters⁵

LW	Bits	Size	Description
5	31:24	8 bits (4 bits used)	HARQ channel id (ACID)
5	23:16	8 bits (1 bit)	HARQ sequence number (AI_SN) – this value enables to differentiate new transmissions from retransmissions

⁴ This sub-burst type can be present in Normal Data Burst or in Control Command Type

⁵ This sub-burst type can be present in Normal Data Burst or in Control Command Type

LW	Bits	Size	Description
		used)	
5	15:8	8 bits (2 bits used)	00 – no flush action 10 – flush request to PHY for the ISSID/ACID 11 – flush request to PHY for the given ISSID (ACID and AI_SN fields above are irrelevant in this case)
5	7:0	8 bits (2 bits used)	Layer index

3.4.5 Downlink Frame Descriptor Usage Notes

3.4.5.1 FCH Handling

The FCH is described by a Normal Data Burst. The MAC is assumed to perform duplication of the 24 bits long FCH to make it 48 bits - so that the data that the MAC passes to the PHY looks like a normal data burst. Note that - as an exception - for 128FFT the FCH is shorter, it contains just 12 bits.

3.4.5.2 Sub-Allocation Bursts

The Sub-allocation bursts are described using two levels of descriptors. The burst parameter structure describes the “outer” allocation, while the sub-burst descriptors are used to describe each of the sub-allocations within an outer allocation (being a normal burst).

3.4.5.3 AAS Bursts

AAS bursts are described using the normal or sub-allocation burst descriptors along with AAS Optional Burst Parameters.

3.4.5.4 HARQ Bursts

HARQ bursts are described using the Sub-allocation burst descriptor, with the optional HARQ parameters included. It is assumed that MAC has full control over HARQ action at PHY.

3.4.5.5 MBS Bursts

Multicast and Broadcast Service bursts are described using normal data burst descriptors.

3.5 Uplink Descriptors (RXVECTOR)

3.5.1 Uplink Subframe Parameter Structure

This is the top-level descriptor portion for uplink subframe.

Table 3-23: Uplink Subframe Parameter Structure Format

LW	Bits	Size	Description
0	31:24	8 bits	Subframe Type (000xxxxx) 00000010 – Uplink Subframe (00000011-00011111 – reserved : 101xxxxx-111xxxxx – reserved)

LW	Bits	Size	Description
0	23:16	8 bits	Frame Number
0	15:8	8 bits	<i>reserved</i>
0	7:0	8 bits	231(decimal) – PHY SAP version number
1	31:0	32 bits (18 bits)	Allocation start time in PS (counted from start of the DL subframe described by most recent TXVECTOR)

Note: <LW> in the below tables are given relative to Zone Descriptor start within the Subframe Descriptor.

3.5.2 Zone Parameter Structures

In the uplink, there are the following types of Zone Parameter Structures:

- Normal – This type of structure is used to define a zone in which AAS is not used (note this type can be used also with general beamforming).
- AAS – This type of structure is used to define a zone where specific beamforming is used to receive data.

Table 3-24: Generic Part of Uplink Zone Parameter Structure

LW	Bits	Size	Description
0	31:24	8 bits	Zone Type (001xxxxx) 00100000 : Normal Zone Parameters 00100001: <i>reserved</i> 00100010: AAS Zone 00100011: <i>reserved</i> (00100011-00111111 <i>reserved</i>)
0	23:16	8 bits	Zone Number (unique within UL subframe, starting from 0)
0	15:8	8 bits	Start Symbol Offset (from start of UL subframe)
0	7:0	8 bits	End Symbol Offset (from start of UL subframe)
1	31:24	8 bits (3 bits used)	Permutation Type 000: PUSC 001: Optional PUSC 010: AMC – 1 x 6 011: AMC – 2 x 3 100: AMC – 3 x 2 101-111: <i>reserved</i>
1	23:20	4 bits (1 bit used)	Use all subchannels indicator 0: use only subchannels specified in PHY configuration register (implementation specific)

LW	Bits	Size	Description
			1: use all subchannels
1	19:16	4 bits (1 bit used)	Disable PUSC subchannel rotation 0: rotation enabled 1: rotation disabled
1	15:8	8 bits (7 bits used)	UL_PermBase
1	7:0	8 bits (1 bit used)	Rx AGC range extension 0 – default range 1 – range to cover SS very close to BS
		variable	Zone Type Specific Data (per Zone Descriptor Type)

Table 3-25: Normal Zone -Specific Part of Uplink Zone Parameter Structure

LW	Bits	Size	Description
2			No specific parameters

Table 3-26: AAS Zone -Specific Part of Uplink Zone Parameter Structure

LW	Bits	Size	Description
2	31:24	8 bits (2 bits used)	Preamble configuration 00: 0 symbols (preambles not supported) 01: 1 symbol 10: 2 symbols 11: 3 symbols
2	23:16	8 bits (1 bit used)	Preamble type 0: frequency shifted preamble 1: time shifted preamble
2	15:8	8 bits (1bit used)	SDMA supported indication 0: SDMA not supported 1: SDMA supported
2	7:0	8 bits	Reserved (padding to align on 32 bit boundary)
		variable	Algorithm Specific Information (per Zone Type)

3.5.3 Burst Parameter Structures

In the uplink, there are the following types of Data Burst Parameter Structures:

- HARQ ACK Channel Allocation Parameter Structure
- Fast Feedback Channel Allocation Parameter Structure
- Initial Ranging/Handover Ranging Allocation Parameter Structure
- Periodic Ranging/Bandwidth Request Allocation Parameter Structure
- PAPR/Safety Zone Allocation Parameter Structure
- Sounding Zone Allocation Parameter Structure
- Noise Floor Calculation Allocation Parameter Structure
- Normal Data burst Allocation Parameter Structure

Table 3-27 shows the common downlink burst parameters. Table 3-28 –describe the burst type specific structures.

Table 3-27: Generic Part of Uplink Burst Parameter Structure

LW	Bits	Size	Description
0	31:24	8 bits	Burst Type (010xxxxx): 01000000: HARQ ACK Channel allocation 01000001: Fast Feedback Channel allocation 01000010: Initial Ranging/Handover Ranging region 01000011: Periodic Ranging/Bandwidth Request region 01000100: PAPR/Safety Zone allocation 01000101: Sounding Zone allocation 01000110: Noise Floor Calculation allocation 01000111: Normal Data burst 01001000: Control Command ⁶ 01001001: <i>reserved</i> 01001010 – 01001111: reserved
0	23:16	8 bits	Burst Type extension: 00000000: no extended data: 00000001: AAS v1 00000010: MIMO v1 (00000011-01111111:Reserved by Intel 10000000-11111111:User-defined)
0	15:8	8 bits	Burst Number (used to correlate burst data, unique within a zone, starting from 0)
0	7:0	8 bits	Modulation/FEC Code Type See Table 3-6 for an enumeration of the types.

⁶ If present, this pseudo-burst description shall be present as the first in the first zone description only. Only the Burst Type field is relevant, the remaining fields shall be set to zero.

LW	Bits	Size	Description
1	31:0	32 bits	Burst Data Length in bytes (if no sub-bursts)
2	31:24	8 bits	OFDMA Symbol offset (from start of UL subframe)
2	23:16	8 bits (6 bits used)	Subchannel offset
2	15:8	8 bits	Reserved
2	7:0	8 bits (2 bits used)	Repetition coding indication 00: No repetition coding 01: Repetition coding of 2 10: Repetition coding of 4 11: Repetition coding of 6
3	31:16	16 bits (signed)	ISSID (MAC-internal SS id – used by MAC to match incoming .indication with specific SS) – normal data burst with no sub-bursts. Ignored when sub-bursts are present.
3	15:0	16 bits	AAS Handle (to enable AAS info update at PHY; null if not used or not known). Ignored when sub-bursts are present
		variable	Burst Type Specific Descriptor (per Burst Descriptor Type)

Table 3-28: HARQ ACK Channel Specific Part of Uplink Burst Parameter Structure

LW	Bits	Size	Description
4	31:24	8 bits	Number of Symbols
4	23:16	8 bits (6 bits used)	Number of Subchannels
4	15:0	16 bits	Reserved (padding to align on 32 bit boundary)

Table 3-29: Fast Feedback Channel Specific Part of Uplink Burst Parameter Structure

LW	Bits	Size	Description
4	31:24	8 bits	Number of Symbols
4	23:16	8 bits (6 bits used)	Number of Subchannels
4	15:0	16 bits	Reserved (padding to align on 32 bit boundary)

Table 3-30: Initial Ranging/Handover Ranging Allocation Specific Part of Uplink Burst Parameter Structure

LW	Bits	Size	Description
4	31:24	8 bits	Number of Symbols
4	23:16	8 bits (6 bits used)	Number of Subchannels
4	15:8	8 bits (1 bit used)	Ranging method 0: ranging over 2 symbols 1: ranging over 4 symbols
4	7:0	8 bits	Reserved
5	31:16	16 bits	Zone XID (Used by MAC for matching future CDMA code with current allocation region; used with RXCDMA.indication only)
5	15:0	16 bits	Reserved (padding to align on 32 bit boundary)

Table 3-31: Periodic Ranging/Bandwidth Request Allocation Specific Part of Uplink Burst Parameter Structure

LW	Bits	Size	Description
4	31:24	8 bits	Number of Symbols
4	23:16	8 bits (6 bits used)	Number of Subchannels
4	15:8	8 bits (1 bit used)	Ranging method 0: ranging over 1 symbol 1: ranging over 3 symbols
4	7:0	8 bits	Reserved (padding to align on 32 bit boundary)
5	31:16	16 bits	Zone XID (Used by MAC for matching future CDMA code with current allocation region; used with RXCDMA.indication only)
5	15:0	16 bits	Reserved (padding to align on 32 bit boundary)

Table 3-32: PAPR/Safety Zone Channel Specific Part of Uplink Burst Parameter Structure

LW	Bits	Size	Description
4	31:24	8 bits	Number of Symbols
4	23:16	8 bits (6 bits)	Number of Subchannels

LW	Bits	Size	Description
		used)	
4	15:8	8 bits (1 bit used)	0 – UL PAPR reduction 1 – UL Safety zone
4	7:0	8 bits	Reserved (padding to align on 32 bit boundary)

Table 3-33: Sounding Zone Allocation Specific Part of Uplink Burst Parameter Structure

LW	Bits	Size	Description
4	31:24	8 bits	Number of Symbols
4	23:16	8 bits (6 bits used)	Number of Subchannels
4	15:8	8 bits (1 bit used)	Sounding type (0 = Type A, 1 = Type B)
4	7:0	8 bits (1 bit used)	Separability type (0 = all subcarriers, 1 = decimated subcarriers in a band; used if Sounding type = 0)
5	31:24	8 bits (3 bits used)	Max Cyclic Shift Indx (used if Separability = 0) 000: P=4; 001: P=8; 010: P=16, 011: P=32 100: P=9; 101: P=18; <i>110-111: reserved</i>
5	31:24	8 bits (3 bits used)	Decimation value (used if Separability = 1) Sound every <i>D</i> th subcarrier within the sounding allocation. Decimation value <i>D</i> is 2 to the power of (1 plus this value), hence 2,4,8,... up to maximum of 128, and 111 means decimation of 5.
5	23:16	8 bits (1 bit used)	Decimation offset randomization (0 = no randomization, 1 = randomization)
5	15:0	16 bits	Reserved (padding to align on 32 bit boundary)

Table 3-34: Noise Floor Calculation Allocation Specific Part of Uplink Burst Parameter Structure

LW	Bits	Size	Description
4	31:24	8 bits	Number of Symbols
4	23:16	8 bits (6 bits used)	Number of Subchannels

LW	Bits	Size	Description
		used)	
4	15:0	16 bits	Reserved (padding to align on 32 bit boundary)

Table 3-35: Normal Data Burst Specific Part of Uplink Burst Parameter Structure

LW	Bits	Size	Description
4	31:16	16 bits (10 bits used)	Number of slots (duration)
4	15:0	16 bits	Reserved (padding to align on 32 bit boundary)
		variable	Optional Burst Parameters (see section 3.5.3.1)

3.5.3.1 Optional Burst Parameters

Optional Burst Parameters are used to specify additional parameters that apply to the different types of bursts, but are optional depending on whether the burst is a MIMO or AAS burst. The presence or absence of these additional parameters is indicated by the value of the Burst Type Extension parameter (see Table 3-27). The data structures for the optional burst parameters are having the same layout as the zone and burst descriptors. The common parameters are specified in a common structure and the type-specific parameters are specified in type specific structures. The current version of this document defines optional burst parameters for AAS and MIMO.

Table 3-36: AAS-specific part of Uplink Optional Burst Parameters

LW	Bits	Size	Description
5	31:24	8 bits (1 bit used)	Preamble Modifier Type 0: frequency shifted preamble 1: time shifted preamble
5	23:8	16 bits	Reserved
5	7:0	8 bits (4 bits used)	Preamble Shift index (frequency shift when PM type = 0 and time shift when PM type = 1)
		variable	Algorithm specific Information (per Burst Type extension)

The purpose of algorithm specific information is to allow for a way for specific PHY/MAC to pass information that is specific to the beamforming algorithm that is being employed. Some examples of algorithm specific information might be the beam on which to transmit the data (in a beam steering system), or information to correlate this burst to an uplink burst received in an earlier frame, whose weights should be used as the basis of the weights for this burst.

Table 3-37: MIMO-specific part of Uplink Optional Burst Parameters

LW	Bits	Size	Description
5	31:24	8 bits (2 bits used)	Matrix indicator (dual antenna SS) 00: Matrix A (STTD) 01: Matrix B (SM) 10: Reserved 11: Reserved
5	23:16	8 bits (4 bits used)	Pilot patterns 0001: pattern A 0010: pattern B 0100: pattern C 1000: pattern D
5	15:12	4 bits (1 bit used)	Collaborative MIMO control 0: non-collaborative 1: collaborative
5	11:8	4 bits (1 bit used)	0: Single TX antenna SS 1: Dual TX antenna SS
5	7:0	8 bits (2 bits used)	Layer index
		variable	Algorithm specific Information (per Burst Type extension)

3.5.4 Sub-Burst Parameter Structures

In the uplink, there are the following types of Data Burst Descriptors:

- Sub-Alloc Data Burst Allocation Descriptor
- Mini-Subchannel Burst Allocation Descriptor
- Fast Feedback Allocation Descriptor
- Sounding Signal Allocation Descriptor

Table 3-38 shows the common uplink sub-burst descriptor parameters.

Table 3-38: Common Part of Uplink Sub-Burst Parameter Structure

LW	Bits	Size	Description
0	31:24	8 bits	Sub-Burst Type (011xxxx) 01100000: No HARQ 01100001: HARQ Chase Combining 01100010: HARQ IR-CTC 01100011: HARQ IR-CC 01100100: MIMO Chase Combining 01100101: MIMO IR-CTC 01100110: MIMO IR-CC

LW	Bits	Size	Description
			01100111: MIMO-STC 01101000: Mini-subchannel 01101001: Fast Feedback channel 01101010: HARQ ACK subchannel 01101011: Sounding signal (01101100-01111111: reserved)
0	23:16	8 bits	Sub-Burst number (unique within the burst, starting from 0)
0	15:0	16 bits (signed)	ISSID (MAC-internal SS id – used by MAC to match incoming .indication with specific SS)
1	31:16	16 bits	AAS Handle (to enable AAS info update at PHY; null if not used or not known). For sounding signal, AAS Handle helps PHY associate given signal with subsequent correlated UL burst.
1	15:0	16 bits	Reserved (padding to align on 32 bit boundary)
		variable	Optional information (per Sub-Burst Type extension)

3.5.4.1 Optional Sub-Burst Parameters

Table 3-39: Mini-Subchannel Allocation-Specific Part of Uplink Sub-Burst Parameter Structure

LW	Bits	Size	Description
2	31:24	8 bits (2 bits used)	CType 00: 2 mini-subchannels adjacent tiles 01: 2 mini subchannels interleaved tiles 10: 3 mini subchannels 11: 6 mini subchannels
2	23:16	8 bits (3 bits used)	Mini-subchannel Index of this allocation
2	15:0	16 bits	Reserved (padding to align on 32 bit boundary)

Table 3-40: Fast Feedback Allocation-Specific Part of Uplink Sub-Burst Parameter Structure

LW	Bits	Size	Description
2	31:24	8 bits	Feedback type coding (to be returned to MAC together with feedback) 00000001: 3 bit-MIMO Fast-feedback 00000010: Enhanced FAST_FEEDBACK 00000100: reserved 00001000; reserved

LW	Bits	Size	Description
			00010000: UEP fast-feedback 00100000: A measurement report shall be performed on the last DL burst ⁷ 01000000: Primary/Secondary FAST_FEEDBACK 10000000: DIUC-CQI Fast-feedback
2	23:23	1 bit	Reserved = 0
2	22:20	3 bits	Feedback sub-type 0 – CQI (CINR) measurement 1 – Control feedback
2	19:8	12 bits (up to 9 bits used)	CQICH_ID (to be returned to MAC together with feedback)
2	7:6	2 bits	Reserved
2	5:0	6 bits	Slot offset

Table 3-41: HARQ ACK Subchannel Allocation-Specific Part of Uplink Sub-Burst Parameter Structure

LW	Bits	Size	Description
2	31:28	4 bits	ACID (to be returned to MAC together with ACK)
2	27:0	28 bits	Reserved (padding to align on 32 bit boundary)

Table 3-42: Sounding Signal -Specific Part of Uplink Sub-Burst Parameter Structure⁸

LW	Bits	Size	Description
2	31:24	8 bits (3 bits used)	Sounding symbol index within Sounding zone
2	23:16	8 bits (2 bits used)	Power assignment method 00 = equal power; 01 = Reserved; 10 = Interference dependent. Per subcarrier power limit; 11 = Interference dependent. Total power limit.
2	15:8	8 bits (1 bit used)	Power boost (0 = no boost, 1 = boost)

⁷ See IEEE 802.16-2005 specification, section 8.4.5.4.10.1

⁸ Defined currently for Sounding type A only

LW	Bits	Size	Description
2	7:0	8 bits (1 bit used)	Allocation mode (0 – Normal, 1- Band AMC)
3	31:24	8 bits (7 bits used)	Start frequency band (if Allocation mode = 0)
3	23:16	8 bits (7 bits used)	Number of frequency bands (if Allocation mode = 0)
3	31:16	16 bits (12 bits used)	Band bit map (if Allocation mode = 1)
3	15:8	8 bits (5 bits used)	Cyclic time shift index (if Separability type = 0)
3	15:8	8 bits (6 bits used)	Decimation offset (if Separability type = 1)
3	7:0	8 bits	Reserved (padding to align on 32 bit boundary)

The below table describes the remaining Sub-Burst types.

Table 3-43: Sub-Allocation -Specific Part of Uplink Sub-Burst Parameter Structure

LW	Bits	Size	Description
2	31:24	8 bits	Symbol Offset (from start of UL subframe)
2	23:16	8 bits (6 bits used)	Subchannel Offset
2	15:0	16 bits (10 bits used)	Number of slots in this sub-allocation
3	31:0	32 bits	Sub-Burst Data Length in bytes
4	31:24	8 bits (2 bits used)	Repetition coding indication 00: No repetition coding 01: Repetition coding of 2 10: Repetition coding of 4 11: Repetition coding of 6
4	23:16	8 bits	Modulation/FEC Code Type See Table 3-6 for an enumeration of the types.

LW	Bits	Size	Description
4	15:0	16 bits	Reserved (padding to align on 32 bit boundary)
		variable	Optional parameters (structure depends on Sub-BurstType parameter, see below)

Table 3-44: No HARQ-Specific Part of Uplink Optional Sub-Burst Parameters

LW	Bits	Size	Description
5			<i>No specific parameters</i>

Table 3-45: HARQ Chase Combining-Specific Part of Uplink Optional Sub-Burst Parameters⁹

LW	Bits	Size	Description
5	31:24	8 bits (4 bits used)	HARQ channel id (ACID)
5	23:16	8 bits (1 bit used)	HARQ sequence number (AI_SN) – this value enables to differentiate new receives from re-submitted receives
5	15:8	8 bits (2 bits used)	00 – no flush action 10 – flush request to PHY for the ISSID/ACID 11 – flush request to PHY for the given ISSID (ACID and AI_SN fields above are irrelevant in this case)
5	7:0	8 bits	Reserved (padding to align on 32 bit boundary)

Table 3-46: MIMO Chase Combining-Specific Part of Uplink Optional Sub-Burst Parameters¹⁰

LW	Bits	Size	Description
5	31:24	8 bits (4 bits used)	HARQ channel id (ACID)
5	23:16	8 bits (1 bit used)	HARQ sequence number (AI_SN) – this value enables to differentiate new receives from re-submitted receives
5	15:8	8 bits (2 bits used)	00 – no flush action 10 – flush request to PHY for the ISSID/ACID 11 – flush request to PHY for the given ISSID (ACID and AI_SN fields above are irrelevant in this case)

⁹ This sub-burst type can be present in Normal Data Burst or in Control Command Type

¹⁰ This sub-burst type can be present in Normal Data Burst or in Control Command Type

LW	Bits	Size	Description
5	7:0	8 bits (1 bit used)	Matrix (dual antenna SS) 0: Matrix A 1: Matrix B

3.5.5 Uplink Frame Descriptor Usage Notes

3.5.5.1 Sub-Allocation Bursts

The Sub-allocation burst descriptor is used to describe each of the sub-allocations within an outer allocation (being a normal burst). The MAC creates a sub-allocation burst descriptor for each of the sub-allocations.

3.5.5.2 Mini Subchannel Bursts

The mini-subchannel burst descriptor is used to describe the mini-subchannel allocation for each of the users of the mini-subchannel. The MAC creates a mini-subchannel burst descriptor for each of the users. Each of these describe the same allocation (being a normal burst) and differ only in the mini-subchannel index parameter.

3.5.5.3 AAS Bursts

AAS bursts are described using the normal or sub-allocation burst descriptors along with AAS Optional Burst Parameters.

3.5.5.4 HARQ Bursts

HARQ bursts are described using the Sub-allocation burst descriptor, with the optional HARQ parameters included. It is assumed that MAC has full control over HARQ action at PHY.

3.5.5.5 CDMA Allocation (UIUC=14)

CDMA Allocations are described using normal data bursts allocation descriptors. They are allocated in the same zone as the former UIUC=12 allocation took place.

3.5.5.6 Fast_Ranging_IE Allocations

Contention-based Ranging allocations described with UIUC=12 are described using Initial/Handover Ranging or Periodic Ranging/Bandwidth Request Burst Allocation Descriptors.

Non-contention-based Ranging allocations described by the Fast_Ranging_IE with UIUC=15 and Extended UIUC=9 are described using Normal Data Burst Allocation Descriptors.

4 Protocol Description

The MAC and the PHY communicate by exchanging PHY SAP primitives. These primitives allow the MAC to pass control information and data to be transmitted to the PHY and allow the PHY to pass status information and received data to the MAC. The control information that is passed with these primitives consists mainly of the frame descriptor structures presented earlier in this document.

The protocol is message-based, in which the maximum size of a message is specified as part of the configuration of the interface. Primitives can be fragmented to fit into the maximum message size. The message header facilitates segmentation / reassembly process. It is assumed that within the same PHY entity the primitive fragments will arrive not intermixed with other primitives fragments.

Messages can be encapsulated into packets for transport across the physical link. Encapsulations for SPI-3 and Ethernet are defined later in this document.

4.1 PHY SAP Primitives

The following set of primitives is defined for PHY SAP:

Table 4-1: PHY SAP Primitives

Description	Reference chapter
PHY_TXSTART.request	5.1
PHY_TXSTART.confirmation	5.2
PHY_TXSTART.indication	5.3
PHY_TXSDU.request	5.4
PHY_TXSDU.confirmation	5.5
PHY_TXEND.indication	5.6
PHY_RXSTART.request	5.7
PHY_RXSTART.confirmation	5.8
PHY_RXSTART.indication	5.9
PHY_RXSDU.indication	5.10
PHY_RXEND.indication	5.11
PHY_RXCDMA.indication	5.12

The primitives are described later in this document (see chapters 4.3 and 5).

4.2 MAC – PHY Communication

The major data plane communication that occurs between the MAC and the PHY is described in the following subsections. Not all of communication with PHY occurs over the PHY SAP (using the PHY SAP primitives) – the communication with control plane is implementation specific. It is mentioned here for the sake of completeness.

4.2.1 PHY Initialization

Note: this section is informative only.

It is assumed that PHY initialization and configuration is *not* performed using PHY SAP, but using some other method which is PHY specific. The PHY initialization process typically involves communication between PHY sub-system and the Control Plane sub-system through the PCI bus (or other means) connection. The managing interface provides the information about the underlining PHY operation and default PHY parameter values which are pertinent to the MAC and PHY interaction.

After the PHY sub-system is powered up, the Control Plane downloads the PHY firmware into the PHY sub-system and also populates specific PHY parameters and PHY profiles for that particular PHY sub-system. The parameters and profiles can include the following:

- PHY entity ID – identify this particular PHY with respect to multiple sectors (including segments), multiple antennas and multiple carriers (the value is assigned by Control Plane).
- PHY profile – this profile information specifies the characteristic and the performance of this particular PHY sub-system including the following:
 - Channel bandwidth
 - Frame duration selection
 - Number of used sub-carriers
 - Sampling factor
 - Channel coding selection
 - Pilot modulation
 - Interleaving mechanism
 - Preamble selection
 - Modulation selection
 - Frame structure
- Duplex method, TDD/FDD.
- Ratio of CP to useful time, $G = 1/4, 1/8, 1/16$ or $1/32$
- AAS, MIMO, HARQ, etc. options.

4.2.2 General PDU and SDU handling between MAC and PHY Layers

The MAC – PHY communication is done using the PHY SAP interface.

As defined in the IEEE 802.16 spec, data transferred via the MAC and PHY protocol layers undergo a number of transformations. Figure 4-1 shows only the most important ones (note that PHY SDU mapping to FEC blocks is simplified). We describe here transmit processing only. Receive processing is the reverse of transmit processing

The MAC Layer prepares data from MAC management messages or data SDUs for transmission. The MAC performs either fragmentation, or packing (or neither) while forming MAC PDUs. The formed MAC PDUs are concatenated into bursts and presented to the PHY Layer as PHY SDUs for transmission in the next frame, along with control information describing how they are to be handled (contained in TXVECTOR). In the BS case, this control information is equivalent to the DL-Map message, and contains data such as:

- FEC code type – identifying a burst profile,
- Preamble present flag,
- Start time of a burst.

Note that the mapping between the MAC PDUs and PHY SDUs is not 1:1. In Figure 4-1, we show an example in which MAC PDU 1, MAC PDU 2 and MAC PDU 3 are concatenated to become PHY SDU 1.

The PHY layer computes the SDU byte length by summing up the PHY_TXSDU.request message segment lengths, so it is able to correctly construct the PHY PDUs – i.e., subsequent FEC block(s).

At the BS, the preparation of PHY PDUs includes adding preambles (where required), combining PHY SDUs into OFDMA symbols and providing padding at FEC blocks for each processed burst (to fill whole OFDMA slots). It is the receiving SS MAC responsibility to discard the padding. FEC blocks are constructed according to modulation and coding connected with a given burst profile. The PHY SDU has a (1:1) mapping to the DL burst. Bursts have (many:many) mapping to OFDMA symbols.

The BS MAC Layer DL scheduler is responsible of grouping MAC PDUs into bursts. The PHY will therefore perform a simple sequential processing of the transmitted MAC PDU groups according to the TXVECTOR contents (equivalent to the current DL Map).

At the SS, the preparation of PHY PDUs includes the adding of preambles (where required), and providing padding at FEC blocks for each processed PHY SDU (to fill whole OFDMA slots). It is the responsibility of the receiving BS MAC to discard the padding. FEC blocks are constructed according to modulation and coding connected with a given burst profile as defined in received UL-MAP for the current frame. The PHY SDU has a 1:1 mapping to the UL burst.

The SS MAC Layer UL scheduler is responsible for grouping MAC PDUs into sets forming bursts at the PHY Layer. The PHY will therefore perform a simple sequential processing of the transmitted MAC PDU groups, according to TXVECTOR contents (equivalent to received UL Map).

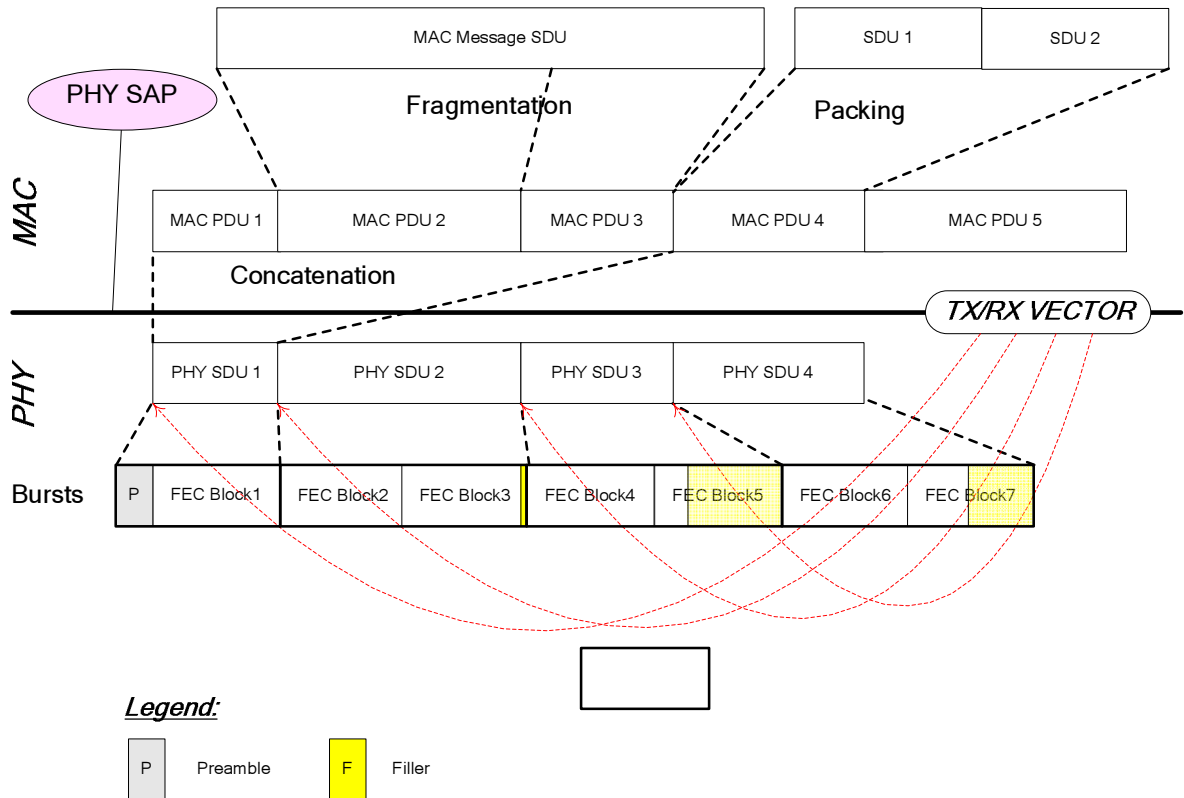


Figure 4-1: MAC PDU transmission

4.2.3 Downlink and Uplink Burst Profiles Setup

The set up of Downlink and Uplink Burst profiles is accomplished by the MAC layers of the BS. The base station PHY layer does not have direct involvement for these tasks and is not aware of the burst profiles.

4.2.4 Downlink Subframe Setup

At the BS, the MAC sends a PHY_TXSTART.request primitive to the BS PHY. This primitive conveys the structure of the downlink subframe (in the form of TXVECTOR), including all information required by the PHY that is encoded into the DL Map. After receiving the PHY_TXSTART.request primitive, the BS PHY responds with the PHY_TXSTART.confirmation to acknowledge the reception of the PHY_TXSTART.request.

The scenario is shown in Figure 4-2 along with the corresponding SS receiver setup. Note that the exchange of PHY_TXSTART.request and .confirmation primitives occurs before the start of frame transmission. If the RX_START.request primitive is segmented, the .confirmation is expected after the reception of the last .request segment.

4.2.5 PHY SDU Transmission from BS MAC to PHY

After receiving the PHY_TXSTART.confirmation primitive, as illustrated in Figure 4-2, the BS MAC sends the BS PHY a PHY_TXSDU.request primitive for each data burst contained in the current DL subframe. Each PHY_TXSDU.request primitive corresponds to one of the bursts described in the subframe description (TXVECTOR) sent as part of the PHY_TXSTART.request primitive. The PHY_TXSDU.request primitive carries the burst data and control information to allow the PHY to correlate this burst with the corresponding description in the PHY_TXSTART.request. It should be noted that the FCH, DL Map, and UL Map are all considered data bursts and are sent to the PHY in a PHY_TXSDU.request primitive.

The protocol can operate in one of two modes. In the first mode, the PHY, after buffering the last segment of received PHY_TXSDU.request, responds with the primitive PHY_TXSDU.confirmation to indicate that the data have been buffered for transmission. This .confirmation message is used to implement message-level flow control between the MAC and PHY. When running in this mode, the MAC does not send the next PHY_TXSDU.request until it has received the PHY_TXSDU.confirmation for the last request. In the second mode, PHY_TXSDU.confirmation messages are not used. In this mode the MAC is free to send PHY_TXSDU.request messages at whatever rate it wishes.

The PHY_TXSTART.indication is sent at the beginning of each downlink subframe. The PHY_TXSTART.indication is used to provide coarse synchronization between the PHY and the MAC. It allows the MAC to track the start of each DL frame.

After transmitting the last symbol of the DL subframe, the PHY sends a PHY_TXEND.indication primitive to the MAC to indicate the end of transmission for this particular frame. This scenario is shown in Figure 4-2. Note that an abbreviated form of the primitives names is used.

Note: Possible .request message segmentation not shown. The .confirmation (if used) is expected after the last .request segment.

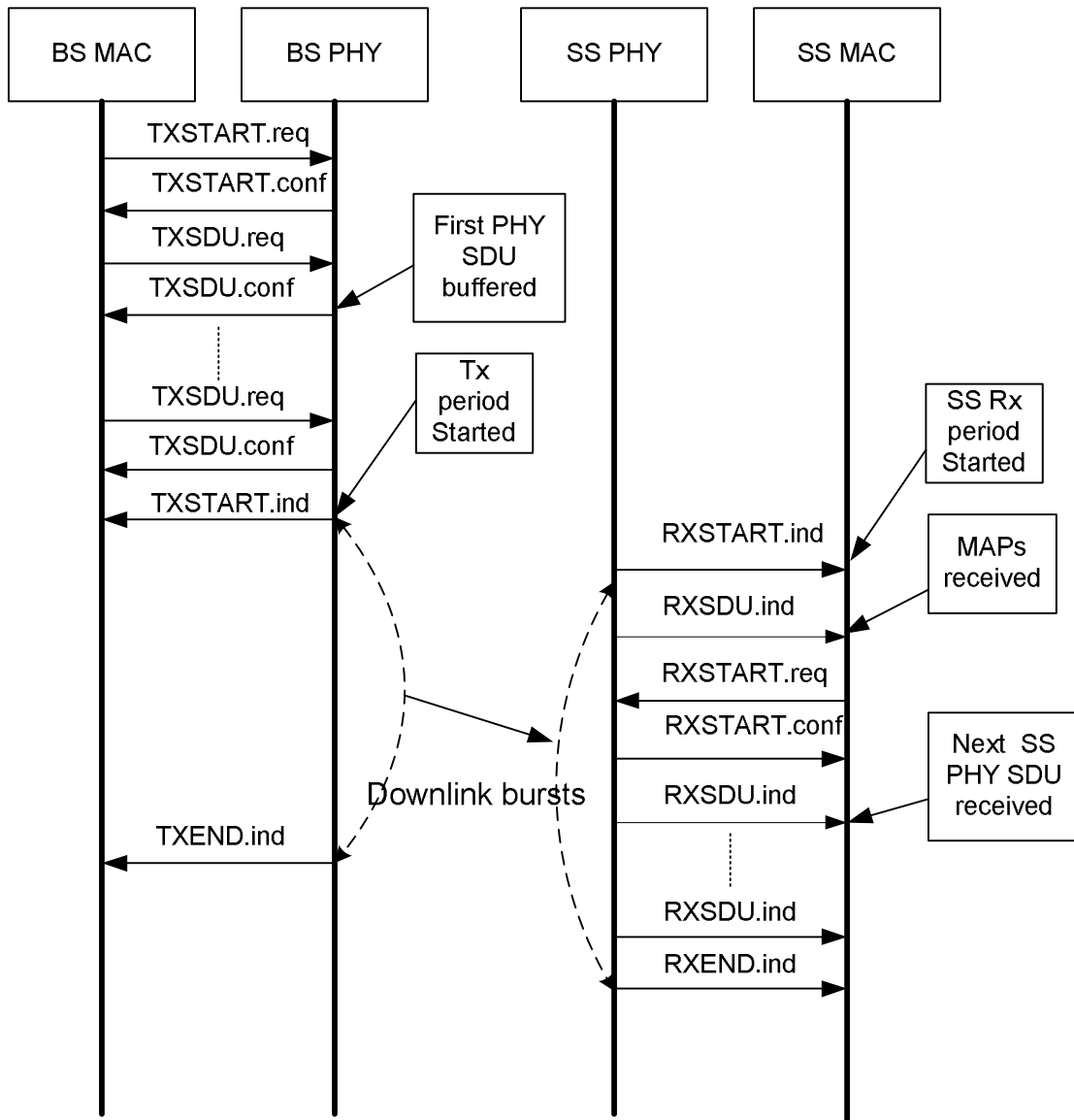


Figure 4-2: Example of using PHY_TXSDU for BS transmitting

4.2.6 Uplink Subframe Setup

At the start of each frame before the PHY is to begin receiving data, the BS MAC sends a PHY_RXSTART.request primitive to the PHY. This primitive contains a description of the structure and expected contents of the UL subframe (in the form of the RXVECTOR). The RXVECTOR includes all information contained in the UL Map required by the PHY in order to receive and decode the bursts contained in the subframe. The MAC is responsible for sending the PHY_RXSTART.request message early enough to allow the PHY to decode its contents in time to begin receiving the first symbol of the UL subframe. After receiving the PHY_RXSTART.request primitive, the PHY responds with the PHY_RXSTART.confirmation primitive. The scenario is shown in Figure 4-3 along with SS transmission setup. Note that an abbreviated form of the primitives names is used. Note also that the exchange of PHY_RXSTART.request and .confirmation primitives can occur before the BS PHY receiver is ready to begin receiving the frame.

Note: Possible .request message segmentation not shown. The .confirmation is expected after the last .request segment.

4.2.7 PHY PDU Reception from BS PHY to MAC

Having received the PHY_RXSTART.request primitive, the BS PHY knows the structure and precise start time of bursts within the UL subframe. The PHY receives symbols from the UL subframe and demodulates/decodes the bursts contained within the subframe. For each uplink burst, PHY sends the PHY_RXSDU.indication primitive along with payload data and status information that allows the MAC to identify this burst within the subframe and access receiver information such as timing, frequency offset, etc. In the event that a burst cannot be decoded due to errors, the PHY sends a PHY_RXSDU.indication primitive with no burst data, indicating that there was an error receiving this particular burst.

Protocol-level flow control is not defined for the transmission of PHY_SDU.indication primitives. It is assumed that the MAC can receive all of the primitives for a UL subframe at line rate, and the PHY is free to send the primitives as they become available. The scenario is shown in Figure 4-3.

Note: Possible .indication message segmentation not shown.

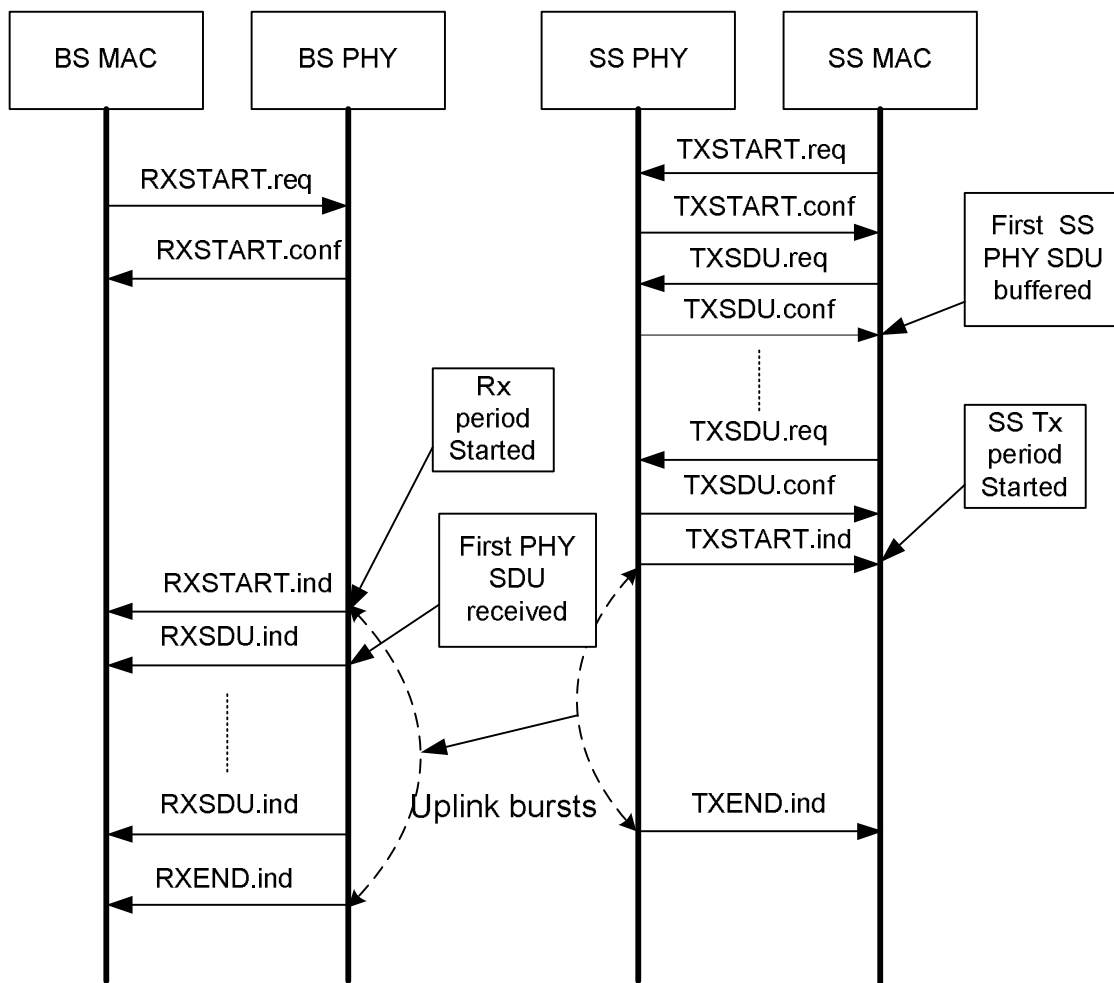


Figure 4-3: Example of using PHY_RXSDU for BS receiving

When the BS PHY begins to receive UL subframe data, it sends the PHY_RXSTART.indication primitive to the MAC to indicate the timing of this event. After sending the last PHY_RXSDU.indication primitive associated with the current UL subframe, the PHY sends the PHY_RXEND.indication primitive to indicate the end of the subframe. These scenarios are also shown in Figure 4-3.

4.2.8 CDMA Codes Reception

An SS transmits CDMA codes for ranging and bandwidth allocation purposes, in contention slots allocated by BS. Processing of CDMA codes at the BS PHY is time-consuming, and may last longer

than one subframe. The RX_CDMA.indication primitive is sent to the BS MAC outside the context of the PHY_RXSTART.request primitive and the corresponding PHY_RXEND.indication primitive. Because transmission slots for CDMA are not granted per particular SS, but rather are allocated for an 'anonymous' subscriber, the communication SS – BS using the CDMA code is performed in a different way as compared to a regular data bursts exchange. To correctly react to a particular CDMA code, BS must maintain history of previous allocations (containing frame number, zone type, etc.). The arriving CDMA code is placed by BS PHY into RXCDMA.indication together with information enabling the BS MAC to associate the CDMA code with the previous allocation, and correctly react (in some cases by generating a response to the sender of a particular CDMA code). This requires that PHY keeps information about allocated CDMA regions (as defined in RXVECTOR) until all CDMA codes from a given frame are processed. The MAC must maintain information on previous CDMA allocations for some time (implementation specific), to correctly interpret the incoming RXCDMA.indication. To facilitate this processing, MAC assigns ZoneXID for UIUC 12 allocation area, and PHY reports with RXCDMA.indication this ZoneXID.

4.3 Generic Message Header, Format, and Coding

All PHY SAP primitives are translated into messages by prefixing the segmentation header, as defined in Table 4-2. Each segment contains appropriate message type field, uniquely identifying given PHY SAP primitive.

Table 4-2: 802.16 PHY SAP Message Header

LW	Bits	Size	Description
0	31:26	6 bits	PHY entity ID (sector, antenna, carrier, etc.)
0	25:24	2 bits	Message Segmentation bits 00: Middle segment of the message segment sequence 01: Last segment of the message segment sequence 10: First segment of the message segment sequence 11: The entire message is contained in this segment
0	23:16	8 bits	Message type
0 -	<i>Message body fragment</i>

The PHY entity ID is supplied by the Control Plane during the initialization to both MAC and PHY layers. This identifier allows the MAC to communicate with multiple PHY instances.

The message type values are known to both PHY and MAC. The segmentation bits are used to correctly reassemble fragmented messages. It is recommended that payload is split into fragments at 32 bits boundary.

In the case of the Intel® IXP2XXX product line of network processors, the messages are always transferred over IXP2XXX Media Switch Fabric (MSF) as single SOP/EOP segments. This is true both in the case of 'native' transfer (i.e., when PHY is connected directly to IXP2XXX via SPI) and in the case when messages are sent encapsulated via Ethernet. Each such segment holds either entire message or a portion of the message. The Message Segmentation bits in the message header convey the information which logical message segment is being transferred in the MSF segment (entire message, first, middle, or last).

The IXP2XXX network processor offers just a few (configurable) MSF segment sizes which can be either 64, 128 or 256 bytes. The used MSF segment length is arbitrary; a commonly used value is 128 bytes. When a message spans more than a single segment, it is allowed to transfer within each segment a portion of the message shorter than the MSF segment length (i.e., it is not required that first and middle segments fill the MSF segment completely). Some PHY implementations may require the intermediate segments to be multiples of 16-bit or 32-bit words, however. Note that SPI interface

provides to a receiver the length of just received data segment – this is the basic method of learning the message segment length. The Ethernet encapsulation carries the segment length information in the Payload Length field of the encapsulation header.

4.3.1 Message Type Field Coding

Each primitive is assigned a unique message type, specified in Table 4-3.

Table 4-3: Type Field Coding

Value	Description
0	<i>Reserved</i>
1	PHY_TXSTART.request
2	PHY_TXSTART.confirmation
3	PHY_TXSTART.indication
4	PHY_TXSDU.request
5	PHY_TXSDU.confirmation (optional)
6	PHY_TXEND.indication
7	PHY_RXSTART.request
8	PHY_RXSTART.confirmation
9	PHY_RXSTART.indication
10	PHY_RXSDU.indication
11	PHY_RXEND.indication
12-14	<i>Reserved (OFDM)</i>
15	PHY_RXCDMA.indication
16-17	<i>Reserved (OFDMA SS)</i>
18-255	<i>Reserved</i>

The confirmations marked as 'optional' must be configured in the same way on both sides (PHY and MAC) as either enabled or disabled and cannot be changed at run-time.

4.3.2 Error Code Field Coding

In this document, the following error code (ERRORCODE) are defined, to provide the cause of errors that occur in communications between the MAC and the PHY. The error code is generic and can be applied to applicable PHY SAP primitives. The ERRORCODE is an 8-bit value.

Table 4-4: Error Code (ERRORCODE) Field Coding

Value	Description
0	Success
1	Primitive is not supported (for requests); Restart flag (for TXSTART.indication)
2	FEC code type is not supported
3	Overflow
4	Underrun
5	Transport Media Error
6	TX data size do not match TXVECTOR
7	Invalid RX/TX VECTOR format
8-255	Reserved

5 PHY SAP Primitives

In this section we specify the format of each of the primitives exchanged across the PHY SAP interface. The message segmentation header is shown with each primitive for convenience.

5.1 PHY_TXSTART.request

Table 5-1: PHY_TXSTART.request

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 1
0	15:0	16 bits	Length of TXVECTOR
			TXVECTOR

This primitive is issued by the MAC to request the BS PHY to start the transmission of PHY PDUs in the nearest DL subframe, and carries all the control information needed for the local PHY, such as start and end times of transmission and PHY parameters for multiple bursts, types of preambles, etc. As a result of the reception of this primitive, the PHY sends a confirmation primitive, and at the proper moment, starts transmission of the PHY PDUs or performs requested actions as defined by the control information contained in TXVECTOR. The TXVECTOR corresponds to the DL-Map currently being sent to remote SS. The TXVECTOR contains only those DL-Map parameters which are necessary for PHY to perform correct transmit actions.

The BS version of the TXVECTOR is formatted as shown in Section 3.4.

As a convention, the first BS expected burst, containing FCH (DLFP) is numbered as 0 (zero); the next bursts, holding PHY SDUs are numbered starting from 1. For each subsequent zone the numbering of bursts is restarted from 1. The Length field contains entire TXVECTOR length and is replicated in all segments of the PHY_TXSTART.request message.

PHY randomization is done using the OFDMA Symbol Offset and Subchannel Offset fields.

5.2 PHY_TXSTART.confirmation

Table 5-2: PHY_TXSTART.confirmation

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 2
0	15:8	8 bits	Status Success = 0 Fail = ERRORCODE
0	7:4	4 bits	reserved
0	3:0	4 bits	Next Frame Number (lsb) – from TXVECTOR

This primitive issued by the PHY confirms reception of PHY_TXSTART.request primitive and provides the command execution status to the MAC. If the PHY was not able to process the PHY_TXSTART.request primitive it returns an error code (ERRORCODE) to indicate the issue. Note that the PHY_TXSTART.confirmation is sent after the last segment of received PHY_TXSTART.request. This confirmation is mandatory. The Frame Number field is typically used by TX state machine to trace events regarding the given frame.

5.3 PHY_TXSTART.indication

Table 5-3: PHY_TXSTART.indication

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 3
0	15:8	8 bits	Status Success = 0 (normal operation) or 1 (during initialization) Fail = ERRORCODE
0	7:4	4 bits	Extended frame number if == 1; if == 0 only LW 0 is present
0	3:0	4 bits	Current Frame Number (lsb) – from TXVECTOR
1	31:24	8 bits	Reserved
1	23:0	24 bits	Initial Frame Number (from PHY)

This primitive is issued by the PHY to indicate to the MAC that the DL subframe has just started. This primitive is sent once per frame. It is used to enforce and maintain synchronization between the PHY and MAC on a frame by frame basis.

This primitive is also used to achieve initial synchronization between the PHY and the MAC. After the PHY is initialized (or restarted) it periodically transmits this primitive at frame start time of each frame. The PHY sets the status field to a value of 1 to indicate that this is an initial synchronization event. Until PHY enters normal operation mode, it should continue sending just TXSTART.ind with status = 1 (and Current Frame Number = 0). The PHY enters normal operation mode after receiving first PHY_TXSTART.request from the MAC. From this time on, subsequent PHY_TXSTART.indications are normally sent with a status field value of 0 and Current Frame Number field taken from TXVECTOR. The Current Frame Number field is typically used by MAC TX state machine to trace events regarding the given frame.

When using extended frame number format, PHY can provide Initial Frame Number, which can be used by MAC to initialize its Frame Number counter.

This primitive may signal an Underrun error, in the case that the expected PHY_TXSTART.request, or related PHY_TXSDU.request primitives do not arrive on time.

5.4 PHY_TXSDU.request

Table 5-4: PHY_TXSDU.request

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header

LW	Bits	Size	Description
0	23:16	8 bits	Message type = 4
0	15:13	3 bits	DL zone number (counted from 0)
0	12:10	3 bits	Sub-burst/burst split point (from msb to lsb) 000: all 10 bits for burst number 001: 1 bit sub-burst and 9 bits burst number 010: 2 bit sub-burst and 8 bits burst number 011: 3 bit sub-burst and 7 bits burst number 100: 4 bit sub-burst and 6 bits burst number 101: 5 bit sub-burst and 5 bits burst number 110: 6 bit sub-burst and 4 bits burst number 111: 7 bit sub-burst and 3 bits burst number
0	9:0	10 bits	DL sub-burst/burst number in this zone (starting from 0)
1 -	PHY SDU

This primitive issued by MAC transfers a PHY SDU to the PHY and requests the transmission of this SDU within the nearest DL frame. It is generated after the corresponding PHY_TXSTART.request primitive. The PHY should accumulate the total length of each burst (summarizing PHY SDU segment lengths from PHY messages) and compare it with the length taken from the TXVECTOR. If it detects unexpected difference it should indicate an error in the PHY_TXEND.indication primitive. The first burst (number 0) in the first zone contains the FCH (DLFP). Subsequent bursts carry regular PHY SDUs. The zone/burst/sub-burst numbering field is present in all segments of PHY_TXSDU.request message.

5.5 PHY_TXSDU.confirmation

Table 5-5: PHY_TXSDU.confirmation

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 5
0	15:13	3 bits	DL zone number (counted from 0)
0	12:10	3 bits	Sub-burst/burst split point (from msb to lsb) 000: all 10 bits for burst number 001: 1 bit sub-burst and 9 bits burst number 010: 2 bit sub-burst and 8 bits burst number 011: 3 bit sub-burst and 7 bits burst number 100: 4 bit sub-burst and 6 bits burst number 101: 5 bit sub-burst and 5 bits burst number 110: 6 bit sub-burst and 4 bits burst number 111: 7 bit sub-burst and 3 bits burst number
0	9:0	10 bits	DL sub-burst/burst number in this zone (starting from 0)
1	31:16	16 bits	Reserved empty field (=0) for long word alignment
1	15:8	8 bits	status

LW	Bits	Size	Description
			Success = 0 Fail = ERRORCODE
1	7:4	4 bits	reserved
1	3:0	4 bits	Next Frame Number (lsb) – from TXVECTOR

The PHY_TXSDU.request primitives are serviced in one of two modes. The mode in which the PHY and MAC operate is selected at initialization time and it not changed during run time. In the case that a single MAC controls more than one PHY entity, all PHY entities are required to operate in the same mode.

In the first mode, the PHY_TXSDU.confirmation primitive is issued by the PHY after receiving the last segment of a PHY_TXSDU.request primitive. It confirms that the PHY is ready to receive the next PHY_TXSDU.request primitive. The status parameter may represent “success” or “failure.” The “failure” may appear, for example, in the case when the PHY runs out of a buffer space (this is typically considered as a ‘hard error’). The error code is included in the primitive to indicate the problem. The Frame Number field is typically used by TX state machine to trace events regarding the given frame.

In the second mode, the MAC sends PHY_TXSDU.request primitives at whatever rate is convenient (without any flow control from the PHY). In this mode, the PHY_TXSDU.confirmation primitive is not used.

5.6 PHY_TXEND.indication

Table 5-6: PHY_TXEND.indication

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 6
0	15:8	8 bits	Status Success = 0 Fail = ERRORCODE
0	7:4	4 bits	PHY request (LW 1) 0000 – LW 1 not present 0001 – AAS calibration request present in LW 1
0	3:0	4 bits	Current Frame Number (lsb)
1	31:24	8 bits	Requested AAS Calibration Zone size (in symbols, at end of DL subframe)
1	23:20	4 bits	Requested AAS Calibration Zone allocation deadline (in seconds)
1	19:16	4 bits	Number of consecutive frames with AAS Calibration Zone allocation
1	15:0	16 bits	reserved

This primitive is issued by the PHY to indicate the transmission of the last symbol in the DL subframe (at PHY DSP level) triggered by the PHY_TXSTART.request primitive. The error code is set to indicate possible transmission problems within DL subframe. The Frame Number field is typically used by TX state machine to trace events regarding the given frame. This primitive can also be used by PHY to request scheduling of a calibration action from MAC (the calibration can be made over several consecutive frames).

5.7 PHY_RXSTART.request

Table 5-7: PHY_RXSTART.request

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 7
0	15:0	16 bits	Length of RXVECTOR
			RXVECTOR

This primitive is issued by the MAC to request the BS PHY to start the reception of the nearest UL subframe, as defined by AllocationStartTime contained in the RXVECTOR (see Table 3-23). The RXVECTOR carries all of the control information required by the PHY to receive and decode the UL data bursts. After receiving this primitive, the PHY sends a confirmation primitive and at the proper moment begins to receive and decode UL symbols. The RXVECTOR corresponds to the the UL-Map sent to the remote SSs in the previous frame. It contains only those UL-Map parameters which are necessary for the PHY to perform correct receive actions. In particular, PHY is given absolute FEC code types corresponding to current UCD mapping. Note that for the first frame the RXVECTOR is empty.

The BS version of the RXVECTOR is formatted as specified in Section 3.5.

The RXVECTOR elements correspond to the uplink bursts provided by PHY for reception. As a convention, the expected bursts holding PHY SDUs are numbered starting from 1. For each subsequent zone the numbering is restarted from 1. The Length field contains entire RXVECTOR length and is replicated in all segments of the PHY_RXSTART.request message.

PHY randomization is done using the OFDMA Symbol Offset and Subchannel Offset fields.

5.8 PHY_RXSTART.confirmation

Table 5-8: PHY_RXSTART.confirmation

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 8
0	15:8	8 bits	Success = 0 Fail = ERRORCODE
0	7:4	4 bits	reserved
0	3:0	4 bits	Frame Number (lsb) – from RXVECTOR (BS: Next frame in air)

This primitive is generated by the PHY after it has received and processed a complete PHY_RXSTART.request primitive. It provides a confirmation of the reception of the request the command execution status to the MAC. If the execution is not successful, the PHY returns an error code (ERRORCODE) to indicate the issue. This confirmation is mandatory. The Frame Number field is typically used by RX state machine to trace events regarding the given frame.

5.9 PHY_RXSTART.indication

Table 5-9: PHY_RXSTART.indication

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 9
0	15:8	8 bits	Status Success = 0 Fail = ERRORCODE
0	7:4	4 bits	reserved
0	3:0	4 bits	Current Frame Number (lsb)

This primitive is issued by the PHY to indicate to the MAC the actual start of the UL subframe. The PHY generates this primitive in normal operation mode (after receiving first PHY_RXSTART.request from the MAC). The Frame Number field is used by RX state machine to trace events regarding the given frame.

5.10 PHY_RXSDU.indication

Table 5-10: PHY_RXSDU.indication

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 10
0	15:0	16 bits (signed)	SSID (MAC-internal SS id – used by MAC to match incoming .indication with specific SS ¹¹),
1	31:31	1 bits	Integrity 0 (valid data), 1 (invalid data) – meaningful for HARQ data bursts only
1	30:0	31 bits	Number of bytes received (including possible padding) or planned to be received (when ‘invalid data’)

¹¹ If PHY does not support this feature, alternatively this field can contain UL zone/burst/sub-burst number in this zone – coding utilize convention as described in section 5.4

LW	Bits	Size	Description
2	31:24	8 bits	RSSI per subcarrier level (-150dBm to -22.5dBm), unsigned, 0.5 dBm step size [0..255]
2	23:16	8 bits	CINR (-10 dB to 53 dB), signed, 0.5 dB step size [-20..+106]
2	15:8	8 bits	Reserved
2	7:0	8 bits	Power Offset (-31.75 dB to +31.75 dB), signed, 0.25 dB step size [-127..+127]
3	31:28	4 bits	Current Frame Number (lsb) copied from RXVECTOR
3	27:24	4 bits	ACID for HARQ data bursts; 0 otherwise
3	23:20	4 bits	Indication Type (0 = Data burst, 1= HARQ ACK channel, 2 = Fast Feedback Channel, 3 = HARQ data burst, 4 = MIMO data burst, 5 = MIMO HARQ data burst, other values reserved) ¹²
3	19:17	3 bits	Zone Permutation Type 000: PUSC 001: Optional PUSC 010: AMC – 1 x 6 011: AMC – 2 x 3 100: AMC – 3 x 2 101-111: reserved
3	16:16	1 bits	Update AAS handle in MAC (if = 1)
3	15:0	16 bits	AAS Handle (NULL if not known/assigned; used for TX)
4	31:0	32 bits	Time deviation in units of 1/Fs: signed
5	31:0	32 bits	Frequency deviation in Hz: signed
6 -	Indication Type-dependent data (PHY SDU if Indication Type = 0)

The primitive is generated by the PHY to send the contents of a received PHY SDU from the PHY to the MAC. The PHY generates this primitive in normal operation mode (after receiving first PHY_RXSTART.request from the MAC). The 'UL burst number in this frame' (if present) contains the UL burst number as assigned for regular data bursts for a given zone in RXVECTOR.

The primitive includes a set of PHY indicators that figure the result of the whole PHY activity triggered by this particular UL burst, including the received signal quality. This status information is used by the BS-implemented link adaptation and power control algorithms.

The ISSID field is present in all segments of the PHY_RXSDU.indication, while the remaining status fields are present in the first (or only) message segment.

¹² This field can be used to speed-up Rx processing at MAC, if supported by PHY. MAC can still retrieve the type information from the current RXVECTOR, but such approach takes more processing cycles on Rx.

The PHY_RXSDU.indication primitive is sent to the MAC for every UL burst even when the burst could not be decoded. This ensures proper protocol handshaking between the MAC and PHY. The Frame Number field is typically used by RX state machine to trace events regarding the given frame.

The received PHY SDU data is sent in one of the following formats, depending on the type of burst.

- Data burst – Received data is passed as an array of bytes in network byte order.
- HARQ ACK Channel – data is passed as an array of structures where each structure contains an ACK/NACK indication from one channel in the allocation. The order of the ACK/NACK indications in the array matches the order of the HARQ ack channels as specified in the standard.
- Fast Feedback Channel - – data is passed as an array of structures where each structure contains the feedback received in one channel in the allocation. The order of the feedback items in the array matches the order of the fast feedback allocations as specified in the standard.

The different types of burst formats carry the following specific parameters (in addition to the common ones):

- Special Channel
 - Burst data (decoded according to the standard) MAC must parse out the individual channels.
- Data burst
 - Number of bytes received
 - RSSI
 - CINR
 - Frequency Offset
 - Time of Arrival Offset
 - Power Offset
 - Burst Data

Table 5-11 shows the HARQ ACK channel data format.

Table 5-11: HARQ ACK channel data format

LW	Bits	Size	Description
6	31:16	16 bits (signed)	ISSID
6	15:12	4 bits	ACID
6	11:10	2 bits	Reserved
6	9:9	1 bit	ACK Valid: 0 (valid data), 1 (invalid data)
6	8:8	1 bit	1 = ACK; 0 = NAK
6	7:0	8 bits	Reserved
7			<i>(next items from the HARQ ACK channel, if any)</i>

Table 5-12 shows the Fast Feedback channel data format.

Table 5-12: Fast Feedback channel data format

LW	Bits	Size	Description
6	31:16	16 bits (signed)	SSID
6	15:0	16 bits (up to 9 bits used)	CQICH_ID
7	31:24	8 bits	Feedback type coding 00000001: 3 bit-MIMO Fast-feedback 00000010: Enhanced FAST_FEEDBACK 00000100: <i>reserved</i> 00001000; <i>reserved</i> 00010000: UEP fast-feedback 00100000: A measurement report performed on the last DL burst ¹³ 01000000: Primary/Secondary FAST_FEEDBACK 10000000: DIUC-CQI Fast-feedback
7	23:23	1 bit	Feedback Valid: 0 (valid data), 1 (invalid data)
7	22:20	3 bits	Feedback sub-type 0 – CQI (CINR) measurement 1 – Control feedback
7	19:8	12 bits	Reserved
7	7:0	8 bits	Feedback value (number of bits used depends on feedback type)
8			(next items from the Fast Feedback channel, if any)

5.11 PHY_RXEND.indication

Table 5-13: PHY_RXEND.indication

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 11
0	15:8	8 bits	Status Success = 0 Fail = ERRORCODE
0	7:4	4 bits	PHY AAS report present

¹³ See IEEE 802.16-2005 specification, section 8.4.5.4.10.1

LW	Bits	Size	Description
			0000 – not present (only LW 0 is significant) 0001 – AAS info aged out report present
0	3:0	4 bits	Current Frame Number (lsb)
1	31:24	8 bits	Number of affected SS
1	23:16	8 bits	Reserved
1	15:0	16 bits (signed)	ISSID of the SS for which the AAS info has been aged out
			...(next ISSIDs if any)

This primitive is issued by the PHY to indicate that no more RXSDU.indications sent from PHY to MAC can be expected for this particular UL subframe (as defined by the proceeding PHY_RXSTART.request). The status for this primitive applies to the entire UL subframe, not to any individual UL burst. The error code and the statistics for each UL burst are sent to MAC in the PHY_RXSDU.indication primitive. The primitive may contain a list of ISSIDs of the SS for which their AAS info has aged out. The Frame Number field is typically used by RX state machine to trace events regarding the given frame.

5.12 PHY_RXCDMA.indication

Table 5-14: PHY_RXCDMA.indication

LW	Bits	Size	Description
0	31:24	8 bits	Message Segmentation Header
0	23:16	8 bits	Message type = 15
0	15:0	16 bits	ZoneXID
1	31:24	8 bits	CDMA code
1	23:16	8 bits	CDMA symbol
1	15:8	8 bits	Reserved
1	7:0	8 bits	CDMA subchannel
2	31:24	8 bits	RSSI per subcarrier level (-150dBm to -22.5dBm), unsigned, 0.5 dBm step size [0..255]
2	23:16	8 bits	CINR (-10 dB to 53 dB), signed, 0.5 dB step size [-20..+106]
2	15:8	8 bits	Reserved
2	7:0	8 bits	Power Offset (-31.75 dB to +31.75 dB), signed, 0.25 dB step size [-127..+127]
3	31:28	4 bits	Current Frame Number (lsb) copied from RXVECTOR

LW	Bits	Size	Description
3	27:16	12 bits	Reserved
3	15:0	16 bits	AAS Handle (NULL if not known/assigned; used for TX)
4	31:0	32 bits	Time deviation in units of 1/Fs: signed
5	31:0	32 bits	Frequency deviation in Hz: signed

The primitive is issued by the BS PHY to indicate to the MAC that a CDMA code has been received in a specific ranging slot. The PHY generates this primitive in normal operation mode (after receiving first PHY_RXSTART.request from the MAC). This primitive includes a set of PHY indicators that are used for the CDMA type ranging or bandwidth reservation process. The Frame Number field is typically used by RX state machine to trace events regarding the given frame.

ZoneXID helps MAC placing the next UIUC=14 allocation in the same zone where the originating UIUC=12 allocation was performed.

In the UL there are the following types of CDMA Burst Formats:

- Initial Ranging/Handover Ranging/Periodic Ranging
- Bandwidth Request

6 PHY SAP Messages over SPI

The PHY SAP natively uses the IXP2XXX MSF SPI interface as transport. In this case no additional special encapsulation is needed and the max message size equals to the MSF selected segment size.

7 PHY SAP Messages over Ethernet

As mentioned in the previous chapter, the PHY SAP natively uses the MSF SPI interface as transport. There are, however, certain cases when passing the PHY SAP messages over Ethernet would be beneficial. For example, an external PHY simulator may be utilized to perform verification testing of the 802.16 MAC layer. It can also be used as the basic medium for MAC-PHY communication.

The Ethernet II format has been selected for PHY SAP message encapsulation. The Ethertype field is set to 0x08FF, indicating PHY SAP v 2.xx encapsulation (i.e., the OFDMA version). To avoid problems with frames shorter than 60 bytes (Ethernet II limitation), an additional 2 byte field was introduced. It carries information about the packet length. This encapsulation is depicted in Figure 7-1. Note that the encapsulated PHY SAP message segment must not exceed the selected MSF segment length. Therefore, the max. allowed message segment length is different with and without the Ethernet encapsulation:

- Without encapsulation, the max PHY SAP segment length equals to MSF segment length
- With encapsulation, the max PHY SAP segment length equals to MSF segment length – 16

Note the MSF segment holds entire Eth packet without 4-byte FCS (which is generated by Eth MAC hardware).

A description of the Ethernet encapsulation header contents (total 16 bytes) is as follows:

- Ethernet Dst MAC address [6 bytes] – address of 802.16 MAC or PHY
- Ethernet Src MAC address [6 bytes] – address of 802.16 PHY or MAC
- Ethernet Type [2 bytes], fixed value 0x08FF (the number currently unused at IANA)
- Packet Length [2 bytes]: includes 16-byte encapsulation header and PHY SAP message segment length.

Payload, holding PHY SAP message segment can contain from 1 to (MSF segment length –16) bytes.

In order to ease the task of distinguishing RX primitives from TX primitives (at simulated or real PHY), different MAC addresses are proposed for each primitives group. The default Ethernet MAC Address values are given below.

- **RX primitives:** 802.16 MAC Eth Address = xx:xx:xx:xx:yy:03
and 802.16 PHY Eth Address = xx:xx:xx:xx:yy:01
- **TX primitives:** 802.16 MAC Eth Address = xx:xx:xx:xx:yy:02
and 802.16 PHY Eth Address = xx:xx:xx:xx:yy:00

The 'xx:xx:xx:xx' address part is user selectable. The 'yy' is set equal to PHY entity ID. The final byte of the address identifies MAC or PHY side and RX or TX primitives.

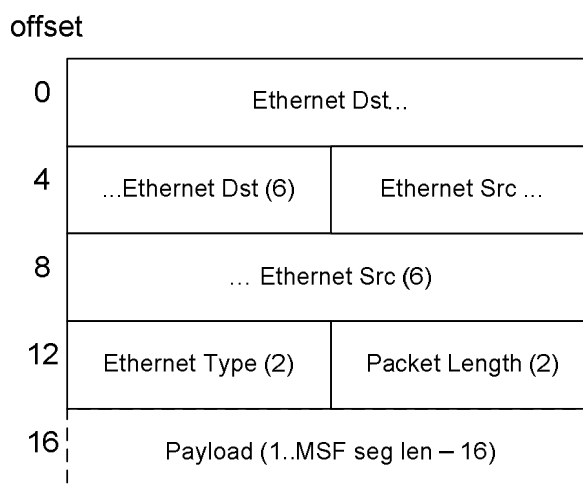


Figure 7-1: PHY SAP Ethernet encapsulation

