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Proposal for IEEE 802.16m Super-frame Header Design

Sassan Ahmadi and Shantidev Mohanty

1. Introduction and Background

The downlink control channel delivers important control information that is required for the proper operation of an IEEE 802.16m system. Information carried in downlink control channel can be classified into different categories as described in contribution IEEE C802.16m-08/297.doc. The classification of system parameters and system configuration information in this contribution is summarized below.

1. Essential system parameters and system configuration information (ESCI): This includes a minimal set of time critical system configuration information and parameters needed for the MS to complete access in a power efficient manner. Examples of such information are CP size, system bandwidth, etc. This group of information also includes the superframe configuration information related to the configuration of sub-frames within the superframe.
2. Extended system parameters and system configuration information (EXSCI): This category includes additional system parameters and system configuration information not critical for access, but needed and used by all MSs after system acquisition. It may be noted that unlike ESCI, EXSCI is not present in all super-frame headers, e.g., the transmission frequency of EXSCI could be 1 second.

In this contribution an attempt has been made to provide a recommendation on design principles for the transmission of system parameters and system configuration information, i.e., ESCI and EXSCI in the frame structure adopted in IEEE 802.16m group that is shown in Figure 1. In this frame structure, a super-frame comprises an integer number of radio frames and each frame consists of an integer number of sub-frames where each sub-frame is further composed of an integer number of OFDMA symbols as shown in Figure 1. The first frame in a super-frame contains super-frame header (SFH) that includes system configuration information. Including in the system configuration information is RS or BS type, cell type, duplex mode, etc.

This contribution proposes structure and transmission format of FCP, ESCI, and EXSCI accordance with IEEE 802.16m frame structure. ESCI and EXSCI are transmitted in the super-frame header (SFH).

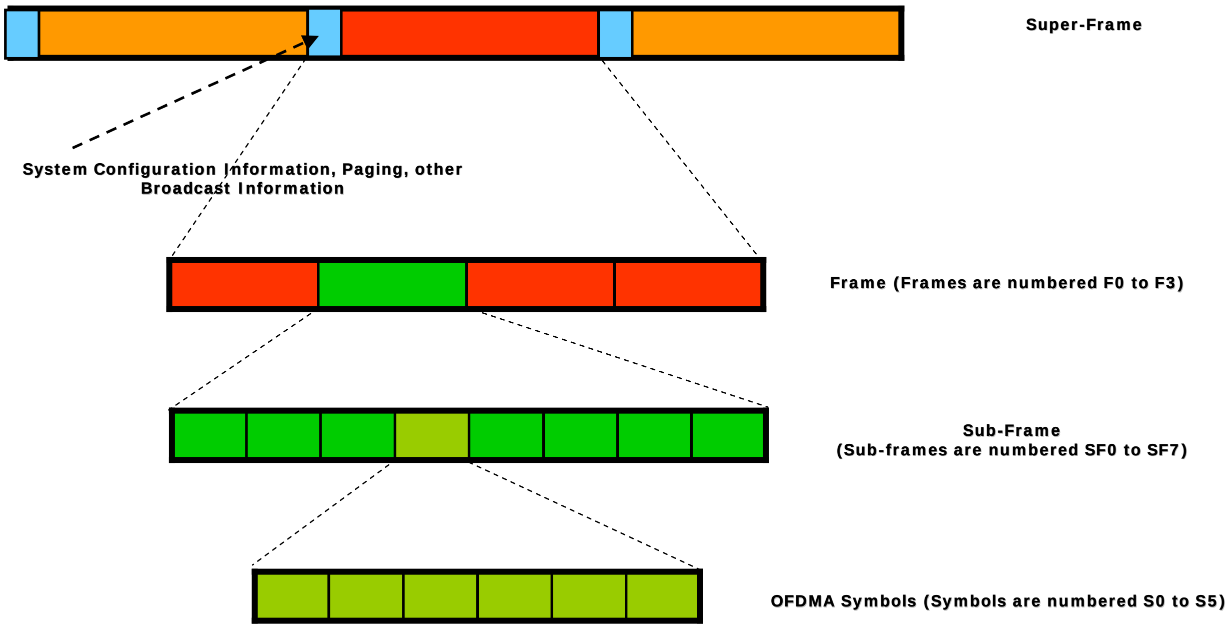

Figure 1: The super-frame/frame/sub-frame structure in IEEE 802.16m.

It is imperative to identify the issues with the structure and performance of control channel structure of the reference system [2] before providing any new solution. Therefore, in the following section the key attributes of a number of control channel structures specified in mobile WiMAX reference system are critically reviewed.

1.1 Analysis of broadcast control information transmission mechanism in IEEE 802.16e-2005 STD

In IEEE 802.16e-2005 STD control information is transmitted using the following mechanisms.

- Frame Control Header (FCH): FCH specifies the type of sub-channelization used in the OFDMA frame. In addition it specifies the MCS and length of the DL MAP. It is located at a fixed location immediately after the preamble and has fixed size, e.g., 48 bits for all FFT sizes except 128. These 48 bits are generated by duplicating the 24 bit information bits of FCH. It uses the fixed MCS (QPSK ½) and repetition coding (4). Thus, the size of FCH is always four DL PUSC slots and first four slots that immediately follow the preamble are used for FCH. As the location, MCS, and size of FCH are fixed it is easy to locate and process the FCH that provides MCS and length of DL MAP. Therefore, FCH enables the usage of flexible MCS and length for DL MAP. Further more, FCH specifies the sub-channels used in the first PUSC zone. In summary, FCH contains essential information to process the remaining part of the frame.
- DL/UL MAP: The DL/UL MAP message has a fixed header part that contains some system configuration information such as sector ID, operator ID,

DCD/UCD count, number of DL OFDMA symbols (DL/UL ratio), frame number, and frame duration code.

- DCD/UCD messages: Downlink Channel Descriptor (DCD) and Uplink Channel Descriptor (UCD) messages contain downlink and uplink channel configuration information, respectively. These messages contain majority of the system configuration information, e.g., system bandwidth, DL/UL frequencies, duplex mode (TDD/FDD), BS ID, TTG, RTG, MAC version, cell type, etc. Additional details about the DCD/UCD messages are provided below.

The DCD and UCD messages are transmitted by a BS at regular time intervals. The user terminals use the information contained in DCD and UCD messages to learn about the downlink (DL) and uplink (UL) channel parameters, respectively. The information contents of these two messages are used for different purposes. While some information fields are present in the DCD/UCD messages in all types of system configurations, some other fields are present only when certain system configurations are used. The information fields of the DCD message that are used for all types of system configurations are hereafter referred to as mandatory DCD information fields. On the other hand, the information fields of the DCD message that are used only for some system configuration are hereafter referred to as configuration-dependent DCD information fields. For example, BS equivalent isotropic radiated power (EIRP), transmit/receive transition gap (TTG), receive/transmit transition gap (RTG), base station identifier (BSID), etc. are mandatory DCD information fields, whereas DL adaptive modulation and coding (AMC) allocated physical bands bitmap is configuration-dependent DCD information fields as it is present only when AMC permutation is used. Similarly, tile usage of subchannels type 1 (TUSC1) permutation active subchannels bitmap is also configuration-dependent DCD information field as it is present only when TUSC1 permutation is used.

In a similar note, the information fields of the UCD message that are used for all types of system configurations are hereafter referred to as mandatory UCD information fields. On the other hand, the information fields of the UCD message that are used only for some system configuration are hereafter referred to as configuration-dependent UCD information fields. For example, frequency, periodic ranging codes etc are mandatory UCD information fields, where as Band AMC Allocation Threshold is configuration-dependent DCD information fields as it is present only when Band AMC permutations is used.

While the user terminals use mandatory DCD information fields and mandatory UCD information fields, hereafter collectively referred to as *mandatory system configuration information (MSCI)* for different types of control operations such as DL/UL synchronization, network discovery and selection, initial-network entry, handoff, network re-entry from idle mode, etc. The configuration-dependent DCD/UCD information fields, hereafter collectively referred to as *configuration-dependent system configuration information* (CSCI) are mostly used for traffic exchange by users in connected mode. In other words, the MSCI could be used by a user terminal that just powered up to learn the system information that is required to enter to the network. Similarly, when a user terminal moves from its serving BS to a target BS it requires the MSCI of the target BS to perform handoff and during inter-technology handoff when a user terminal moves from a non-WiMAX network, e.g., Wi-Fi or 3GPP it requires MSCI of WiMAX network to perform vertical handoff from non-WiMAX network to WiMAX network. It may be noted that MSCI is similar to the basic and extended system parameters and system configuration information described earlier.

Currently, a mobile WiMAX BS broadcasts the DCD and UCD messages containing both MSCI and CSCI. Furthermore, the mobile station (MS) or the subscriber station would be able to acquire DCD/UCD only after successful decoding of the DL common control channel also known as medium access protocol (DL-MAP). The location of the DCD/UCD in the DL sub-frame is determined through decoding of the broadcast information element (BIE) included in the DL-MAP at certain intervals.

Figure 2 illustrates a downlink IEEE 802.16e-2005 STD frame containing DCD and/or UCD messages. The downlink frame shown in Figure 2 corresponds to an IEEE 802.16e-2005 STD based wireless system employing time division duplex (TDD) mode of operation. The frame starts with a preamble that is used for synchronization followed by FCH. FCH is followed by downlink MAP (DL-MAP) and uplink MAP (UL-MAP) messages that contain sub-channel allocation and other control information for downlink (DL) and uplink (UL) sub-frames, respectively. The remaining part of the DL frame contains control and data traffic for different users.

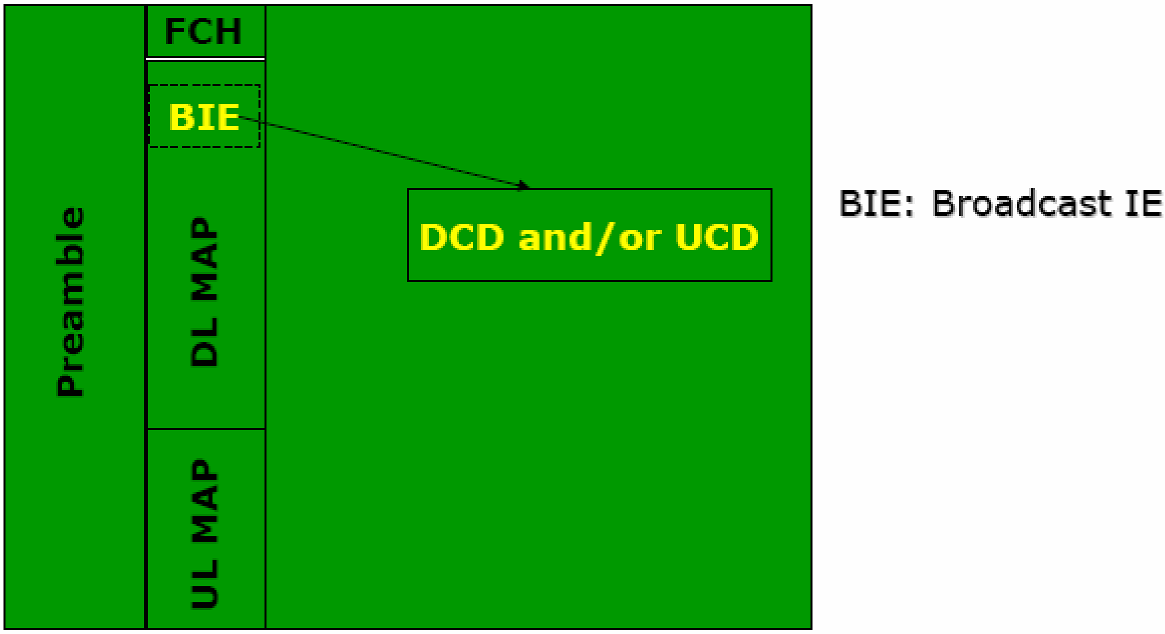

Figure 2: Methods used in IEEE 802.16e-2005 STD to transmit DCD/UCD messages.

When the BS needs to send DCD and/or UCD message(s), it includes a broadcast information element (BIE) in the DL MAP. The BIE indicates the location of the DCD and/or UCD message(s) in the DL frame. The user terminals learn about the presence of BIE by processing the DL-MAP message. Using the BIE the user terminals learn the location of the broadcast message in the DL sub-frame and process the corresponding DL sub-frame region to receive the DCD/or UCD message(s).

Analysis of the existing DCD/UCD message transmission and reception in IEEE 802.16e-2005 STD based systems:

Next, we present the analysis of the DCD/UCD message transmission procedures used in the reference system.

1. Disadvantages
    a. When a user terminal wants to learn system configuration information, it processes the DL-MAP of all the received frames to search for the presence of BIE and then it processes the part of the frame pointed by the BIE to detect if DCD/UCD messages are present. This may require significant processing by the user terminals thus consuming more power.

    b. Some of the network operations that use information contained in the DCD/UCD messages, especially MSCI present in the DCD/UCD have to meet latency support requirements of mobile WiMAX systems. For example, different network operations that use part of MSCI and their delay requirements per IEEE 802.16m standard are shown in Table 1. Thus, MSCI fields required for a procedure should be transmitted by the BS with appropriate periodicity that meets the delay requirement for this procedure. For example, to meet the intra-frequency handoff interruption delay of 30 ms, the average time to acquire MSCI required for this should be limited to 20 ms assuming that other steps involved in this operation could take up to 10 ms. If we want to limit the delay associated with acquiring MSCI to a maximum value of 20 ms, then the required MSCI should be transmitted every four mobile WiMAX frames further considering that the frame duration is 5 ms. Similarly, other MSCI that are used by other delay-constraint network operations needs to be transmitted once in every m*th* frame, where m is an integer. When some or all of MSCI is required to be transmitted once in every m*th* frame the existing approach of using BIE to specify the presence as well as location of DCD/UCD message may not be necessary and incurs unnecessary MAP overhead associated with BIE. This is because if some or all of MSCI is transmitted once in every mth frame, the user terminals can learn that the frame numbers 0, m, 2m, 3m, 4m etc. contain the information at a predetermined location. Thus, use of BIE to learn the presence of MSCI becomes redundant.

c. The existing approach of using BIE to indicate the presence as well as location of DCD/UCD message is not efficient when a user terminal connected to one BS, referred to as serving BS, wants to learn the MSCI of another BS. For example, a user terminal interested in handoff needs to learn the MSCI of the neighboring BSs and to receive and process all the frames of the neighboring BSs as it does not know in which frame the DCD/UCD messages are present. As the user terminal can communicate with only one BS at a particular time, it needs to take time off from its serving BS when it receives the frames of neighboring BSs. This time off interrupts SS’s ongoing communication with the serving BS and results in more power consumption. This problem is aggravated as the number of neighboring BSs, whose MSCI the said user terminal wants to learn, increases.

d. To accommodate for the flexible design of DCD/UCD messages its contents are encoded using TLV format incurring larger overhead for these messages.

2. Advantages

a. The flexibility of DCD/UCD message structure makes it possible for the BS to transmit different system configuration information with required periodicity. In addition, new information fields can be easily added to these messages.

Table 1: MSCI of DCD and UCD messages used by operations with latency requirements per IEEE 802.16m

Network operation	Delay requirement	MSCI DCD fields that are required during the operation	MSCI UCD fields that are required during the operation
Idle_state_to_active_state_transition (this includes ranging as well as MAC, security, IP connection establishment etc)	100 ms	MSCI parameters used for DL/UL synchronization, ranging and MAC establishment	MSCI parameters used for ranging
Intra-frequency handoff interruption	30 ms	MSCI parameters used for DL/UL synchronization and ranging	MSCI parameters used for UL synchronization and ranging
Inter-frequency handoff interruption	100 ms		

1.2 Summary of Issues with the Reference System DL Control Channel Structure

There are several issues with the existing control channel structures that motivate a new design for the IEEE 802.16m control channel structure.

1. The size of the DL/UL control channel has a direct impact on the L1/L2 overhead. As discussed in Section 1.1 although DCD/UCD message structure that carries majority of the system configuration information in the reference system is flexible, they have large L2 overhead. This overhead associated with system configuration information transmission mechanism must be reduced in order to meet the requirements on spectral efficiency, sector throughput, and user throughput.
2. As the essential system configuration information are not located at a known location a user terminal has to process all the frames to learn this information. This is inefficient.

Also, there are a few desirable characteristics of SFH design as follows:

1. Meet the latency requirements of network procedures: The transmission mechanism of system configuration information must meet the latency requirement of operations that use this information.
2. Lower L2 overhead while providing enough room for future extensions: The structure of system configuration information should provide mechanism that has enough room to add new fields in future while limiting the amount of reserved bits to minimize L2 overhead in the absence of these extensions. Thus, the size of system configuration information should be adaptive to the amount of information present.
3. Known location in IEEE 802.16m frame structure: Essential system parametrs and system configuration information (ESCI) and Extended system parameters

and system configuration information (EXSCI), is transmitted using mechanism that is in accordance with the IEEE 802.16m frame structure and has a known location in order for the user terminals to easily locate this.

4. Use of diversity techniques for SFH: SFH should use diversity to improve coverage especially better cell edge performance.

2. Super-frame Header Design Considerations

Discussion of the IEEE 802.16m FCP and SFH control channel structures would require a careful consideration of the desired features listed in Section 1.2. The following sub-section proposes methods to achieve each one of these features.

2.1 Meet the latency requirements of network procedures

As discussed earlier essential system parameters and system configuration information is used by different network procedures such as initial network entry, network re-entry from idle mode, handoff. In order to meet the latency requirements of these procedures a user terminal has to acquire the essential system parameters and system configuration information in timely manner. As discussed in Section 1, system parameters and system configuration information is divided into two classes: essential system parameters and system configuration information (ESCI); extended system parameters and system configuration information (EXSCI). While ESCI is essential for network entry/re-entry, EXSCI is not critical for these operations. Thus, ESCI needs to be transmitted more frequently to meet the latency requirements of network entry/re-entry. On the other hand, EXSCI can be transmitted less frequently as shown in Figure 3 where ESCI is transmitted once in every super-frame whereas the EXSCI is transmitted once in every 50th super-frame.

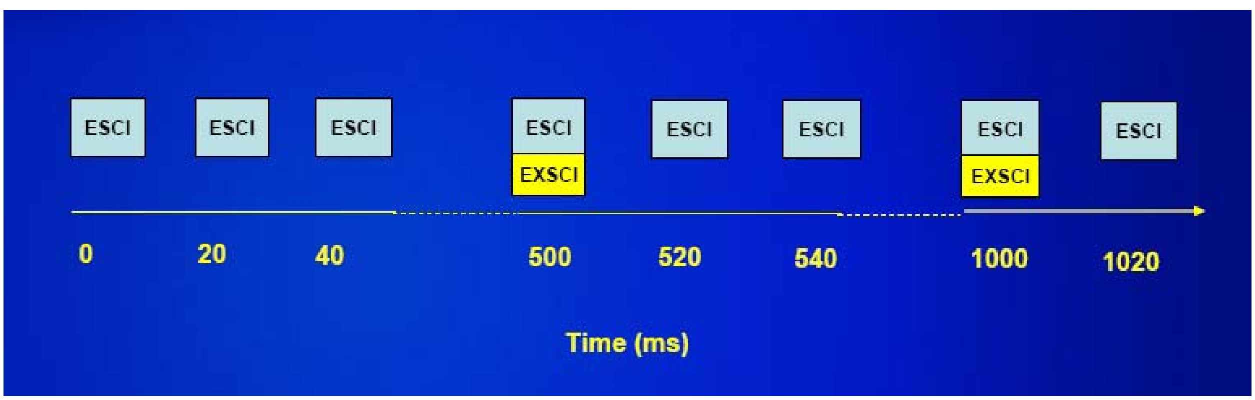

Figure 3: Transmission frequency of ESCI and EXSCI.

Different information fields of SFH are shown in Table 2 when only ESCI is present. It can be observed from Table 2 that the size of ESCI is different in TDD and FDD mode as TTG, RTG, and No of DL sub-frames fields are present only in FDD mode. In addition, the size of ESCI is going to be different in future if new fields are added to ESCI. The length and identification of the extended fields are specified using the length of the extended fields information as shown in Table 2. In summary, the size of ESCI depends on the duplex mode and for a particular duplex mode it may vary on a long term (order of 1-2 years) when future protocols are introduced.

Table 2: Information fields of SFH when only ESCI is present.

Information fields	Size (in bits)	Notes
Sector ID	8	
Super-frame number	12/24 (TBD)	
PHY protocol revision	3	
MAC protocol revision	3	
Number of Tx antennas	3	
System bandwidth (5, 10, 20, others)	3	
CP length (1/32, 1/16, 1/8, 1/4)	2	(FFS)
Cell type (femto, pico, micro, macro)	2	
UL load indicator	1	
Relay station or BS station indicator	1	
DCD count, UCD count	16 (8, 8)	
Band class (frequency) table index	4/8 (TBD)	
Information required for ranging	TBD	
Duplex mode (TDD, FDD, HFDD)	2	
If (Duplex mode == TDD){		
TTG	16	
RTG	8	
No of DL sub-frames (DL/UL ratio)	3	
}		
Size, MCS, and repetition coding for common control and signaling channel	12 (8, 2, 2)	
EXSCI indicator	1 (=0)	Indicates if EXSCI is present in this SFH
If (EXSCI indicator ==1) {		
MCS of EXSCI	6/8	(FFS)
}		
Length of extended fields (in bytes)	6/8 (TBD)	Specifies the length of fields that are added in the subsequent PHY/MAC protocol revision.
CRC indicator	1	Indicates if CRC is used to protect the contents of SFH
If (Length of extended fields !=0){		
Extended field 1	X1	
Extended field 2	X2	

.		
Extended field n	Xn	
}		
Padding	1-7	To ensure that SFH is byte aligned
If (CRC indicator == 1) {		
CRC	16/32 (TBD)	
}		

Different information fields of SFH are shown in when both ESCI and EXSCI are present. It can be observed from Table 2 that the size of ESCI is different in TDD and FDD mode as TTG, RTG, and No of DL sub-frames fields are present only in FDD mode. In addition, the size of ESCI is going to be different in future if new fields are added to ESCI. The length and identification of the extended fields are specified using the length of the extended fields information as shown in Table 2. In summary, the size of ESCI depends on the duplex mode and for a particular duplex mode it may vary on a long term (order of 1-2 years) when future protocols are introduced.

Table 3: Information fields of SFH when both ESCI and EXSCI are present.

Information fields	Size (in bits)	Notes
Sector ID	8	
Super-frame number	12/24 (TBD)	
PHY protocol revision	3	
MAC protocol revision	3	
Number of Tx antennas	3	
System bandwidth (5, 10, 20, others)	3	
CP length (1/32, 1/16, 1/8, 1/4)	2	(FFS)
Cell type (femto, pico, micro, macro)	2	
UL load indicator	1	
Relay station or BS station indicator	1	
DCD count, UCD count	16 (8, 8)	
Band class (frequency) table index	4/8 (TBD)	
Information required for ranging	TBD	
Duplex mode (TDD, FDD, HFDD)	2	
If (Duplex mode == TDD){		
TTG	16	
RTG	8	
No of DL sub-frames (DL/UL ratio)	3	

}		
Size, MCS, and repetition coding for common control and signaling channel	12 (8, 2, 2)	
EXSCI indicator	1 (=1)	Indicates if EXSCI is present in this SFH
If (EXSCI indicator ==1) {		
MCS of EXSCI	6/8	(FFS)
}		
Length of extended fields (in bytes)	6/8 (TBD)	Specifies the length of fields that are added in the subsequent PHY/MAC protocol revision.
CRC indicator	1	Indicates if CRC is used to protect the contents of SFH
If (Length of extended fields !=0){		
Extended field 1	X1	
Extended field 2	X2	
.		
Extended field n	Xn	
}		
If (EXSCI indicator == 1) {		
BS ID	24	
Multi-RAT support indicator	1	
If (Multi-RAT support indicator ==1) {		
Multi-RAT systems bitmap	TBD	
}		
NSP	TBD	
Paging group ID	16	
Other fields	TBD	
.		
}		
Padding	1-7	To ensure that SFH is byte aligned
If (CRC indicator == 1) {		
CRC	16/32 (TBD)	
}		

Using Table 1 and Table 2 it can be noted that the size of SFH depends on the following factors: duplex mode, presence of extended fields, and presence of EXSCI. Out of these three factors duplex mode is unlikely to change once a system is deployed; presence of extended fields varies over a very long period of time, e.g., one to two years. On the other hand, presence of EXSCI varies over a short period of time, e.g., 1 second. The periodicity of EXSCI is carefully decided to achieve balance between L2 overhead and EXSCI acquisition delay.

As the SFH size varies both in long as well as short period of time, this proposal recommends to keep the size of SFH flexible. The size of SFH is indicated in the frame control prefix (FCP) as described in Section 2.4.

2.2 **Lower L2 overhead while providing enough room for future extensions:**

While it is desirable to minimize the size of SFH, it is also essential to have enough room to add new fields in future, e.g., in the revisions of the IEEE 802.16m STD. One of the ways to provide room for future extensions is to have reserved bits. The use of reserved bits has the following tradeoffs. The size of reserve bits should be long enough to provide enough room for future extensions. However, keeping too many reserved bits increases L2 resource wastage of the current system deployments. On the other hand, if smaller number of bits is reserved to limit the L2 resource wastage future extension possibilities are restricted.

Thus, it is desired to have a mechanism that achieves a good balance between the L2 resource wastage vs. future extension possibilities. This contribution proposes the use of “Length of extended fields” field in ESCI to achieve this goal. The size of Length of extended fields is one byte. Thus, the size of ESCI could be increased up to 256 bytes in future. This method limits the L2 resource wastage of the current system to one byte. Thus, the use of Length of extended fields provides mechanism to extend the size of ESCI as required in the future revisions of the IEEE 802.16m STD without L2 resource wastage in the absence of such extensions. The usage of Length of extended fields is shown in Table 2 and Table 3.

2.3 **Known location and transmission format of SFH in IEEE 802.16m frame structure:**

A user terminal needs to know the location of the SFH in order to acquire ESCI and possibly EXSCI. The location information of SFH has two aspects: starting location of the SFH and the size of SFH in terms of amount of physical resources, e.g., number of slots. This contribution proposes to transmit SFH in such a way that the starting point of SFH is fixed relative to the IEEE 802.16m preamble. The size of SFH has short term as well as long variation as discussed in Section 2.1. MCS of the SFH is fixed. Thus, size is the only variables with respect to location of SFH. This contribution proposes to use FCP to indicate the size of SFH. It may be noted that as SFH is present only in the beginning of a super-frame, only the FCP of the first frame in a super-frame needs to specify the size of SFH. In all frames of the super-frame the FCP specifies the size and transmission format of the common control and signaling channel (CCSCH). Thus, FCP has different functions in the first frame and remaining three frames in a super-frame as shown in Figure 4. FCP occurs in every frame and is located immediately after IEEE 802.16m frame preamble. The size of FCP is fixed to 16 bits and its structure is shown in Figure 4. FCP is always transmitted using fixed transmission format, e.g., QPSK ½, repetition 6. As location, size, and transmission format of FCP is always fixed a user terminal can decode this without any other information.

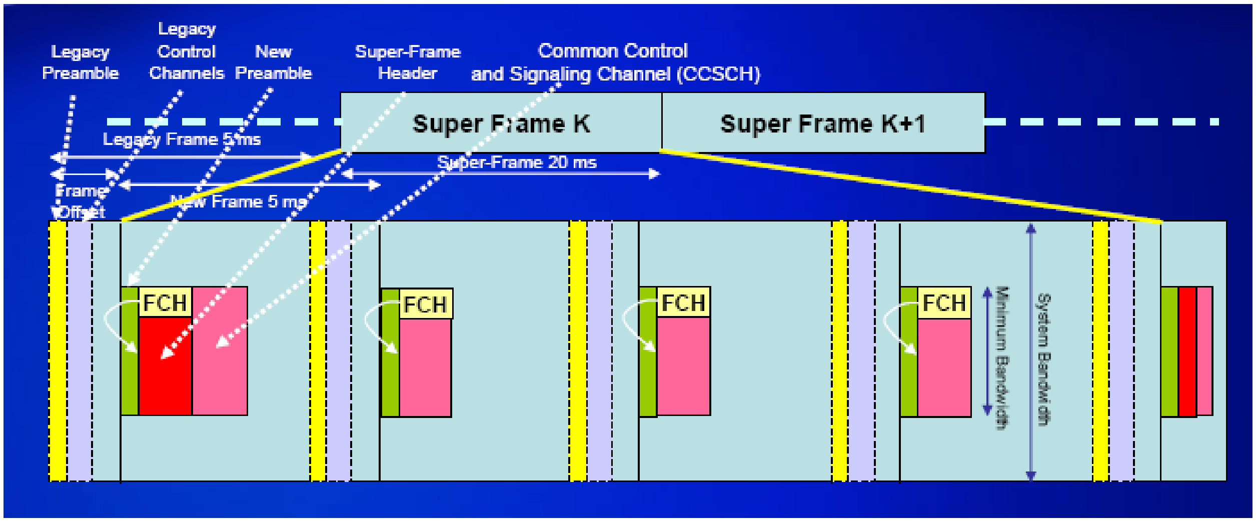

Figure 4: Function of FCP in different frames inside a super-frame.

Fields	Size (in bits)	Notes
FCP indicator	2	00: super-frame header 01-11: CCSCH
If (FCP indicator == 00) {		
Length of SFH	9	Number of slots
Reserved}	5	
Else {		
MCS of CCSCH	2	
Repetition coding of CCSCH	2	
Length of CCSCH	8	Number of slots
Reserved}	2	

The functionalities of FCP are summarized below.

FCP carries information about the control channel that follows it. FCP indicator identifies the control channel that follows the FCP. In the first frame of a super-frame, i.e., when FCP indicator =0, SFH follows the FCP. In this case, FCP specifies the size of SFH; and ESCI contains size, MCS, and repetition coding information of CCSCH. In the first frame of a super-frame SFH is located immediately after FCP and CCSCH is located immediately after SFH. As SFH always follows FCP, its location is relatively fixed. On the other hand, in the second, third, and fourth frames of a super-frame, i.e., FCP indicator = 01-11, FCP specifies MCS, repetition coding, and size of CCSCH. In these frame, CCSCH follows the FCP.

The proposed dual functionalities of FCP have the following advantages:

- The same physical resource is used to convey information about SFH and CCSCH. Thus, it minimizes L1/L2 overhead.
- It provides mechanism to change the size and repetition coding of SFH to enable flexible SFH design.

Its functionalities are similar to the FCH in the reference system.

2.4 **Use of diversity techniques for SFH**

TX diversity or other multi-antenna techniques that improves control channel reliability at the cell-edge should be used for SFH.

3. Proposed Downlink Control Channel Structure

In the previous sections, some important requirements and considerations in the design of the FCP and SFH were discussed. The proposed FCP and SFH control channel structures are similar for TDD and FDD duplex schemes resulting in maximal baseband processing commonalities in both duplex schemes (which further include H-FDD) that is highly desirable from implementation perspective. The location of FCP and SFH in the proposed frame structure for IEEE 802.16m is shown in Figure 4. The functionalities, structure and contents of FCP are described in Section 2.4. The structure of SFH is described in Section 2.1. Details about location, size, and transmission format of SFH are described in various subsections of Section 2.

4. Proposed Text for SDD

Insert the following text into Downlink Control Structure sub-clause (i.e. Chapter 11 in [3]):

------------------------------- Text Start ---

11. x.3.1 Superframe header (SFH)

A user terminal needs to know the location of the SFH in order to acquire essential system parameters and system configuration information (ESCI) as well as extended system parameters and system configuration information (EXSCI). The location information of SFH has two aspects: starting location of the SFH and the size of SFH in terms of amount of physical resources, e.g., number of slots. The starting point of SFH is fixed relative to the new preamble. The size of SFH has short-term as well as long–term variation depending on the content.

The transmission format of the SFH is always the same. Thus, size of SFH is the only variable with respect to location and transmission format of SFH.

11. x.3.1.1 Frame Control Prefix (FCP)

An FCP is used to indicate the size of SFH. It may be noted that as SFH is present only in the beginning of a super-frame, only the FCP of the first frame in a super-frame needs to specify the size for SFH. In other frames of the super-frame, the FCP specifies the size and transmission format of the common control and signaling channel

(CCSCH). Thus, FCP has different functions in the first frame and remaining three frames in a super-frame as shown in Figure x.1.

FCP occurs in every frame and is located immediately after the new preamble. The size of FCP is fixed to 16 bits and its structure is shown in Figure x.1. FCP is always transmitted using fixed transmission format, e.g., QPSK ½, repetition 6. As location, size, and transmission format of FCP is always fixed a user terminal can decode this without any other information.

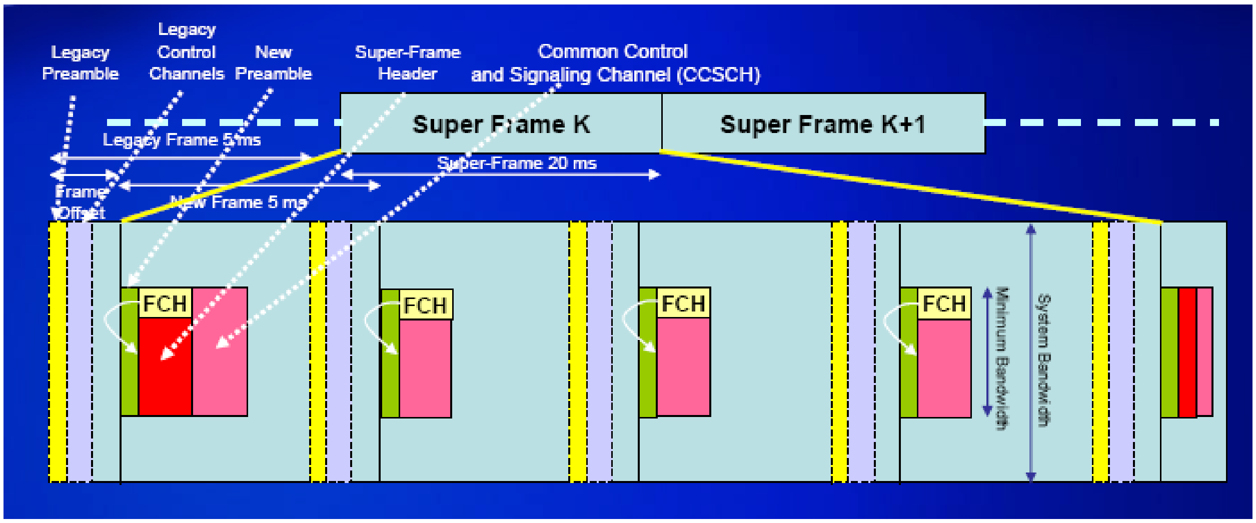

Figure x.1: Function of FCP in different frames inside a super-frame.

Fields	Size (in bits)	Notes
FCP indicator	2	00: super-frame header 01-11: CCSCH
If (FCP indicator == 00) {		
Repetition coding of SFH	2	
Length of SFH	9	Number of slots
Reserved}	4	
Else {		
MCS of CCSCH	2	
Repetition coding of CCSCH	2	
Length of CCSCH	8	Number of slots
Reserved}	2	

The functionalities of FCP are summarized below.

FCP carries information about the control channel that follows it. FCP indicator identifies the control channel that follows the FCP. In the first frame of a super-frame, i.e., when FCP indicator =0, SFH follows the FCP. In this case, FCP specifies the size of SFH; and

ESCI of SFH contains size, MCS, and repetition coding information of CCSCH. In the first frame of a super-frame SFH is located immediately after FCP and CCSCH is located immediately after SFH. As SFH always follows FCP, its location is relatively fixed. On the other hand, in the second, third, and fourth frames of a super-frame, i.e., FCP indicator = 01-11, FCP specifies MCS, repetition coding, and size of CCSCH. In these frame, CCSCH follows the FCP.

The dual functionalities of FCP have the following advantages:

- The same physical resource is used to convey information about SFH and CCSCH. Thus, it minimizes L1/L2 overhead.
- It provides mechanism to change the size of SFH to enable flexible SFH design.

11. x.3.1.2 System Parameters and Configuration Information

System parameters and configuration information is divided into two categories: essential system parameters and system configuration information (ESSI); and extended system parameters and system configuration information (EXSCI). ESCI is used by different network procedures such as initial network entry, network re-entry from idle mode, handoff. While ESCI is essential for network entry/re-entry, EXSCI is not critical for these operations. Thus, ESCI needs to be transmitted more frequently to meet the latency requirements of network entry/re-entry. On the other hand, EXSCI can be transmitted less frequently as shown in Figure x.2 where ESCI is transmitted once in every super-frame whereas the EXSCI is transmitted once in every 50th super-frame (i.e., every 1 sec).

Figure x.2: Transmission frequency of SSCI and LSCI.

ESCI is always present in the SFH. The size of ESCI is different in TDD and FDD mode as TTG, RTG, and No of DL sub-frames fields are present only in FDD mode. In addition, the size of SSCI is going to be different in future if new fields are added to ESCI. Thus, size of ESCI can be different for different duplex mode and the size of ESCI for the same duplex mode could vary in long term (order of 1-2 years when new revisions of IEEE 802.16m is introduced). ECH_m indicates the size of SFH containing ESCI. EXSCI is present only in some of the SFH and its presence is indicated by EXSCI indicator field. If EXSCI indicator field is set, then ESCI specifies the length and MCS of LSCI.

------------------------------- Text End ---

5. References

[1] IEEE Std. 802.16e-2005, IEEE Standard for Local and metropolitan area networks, Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, and P802.16Rev2/D3 (February 2008).

[2] WiMAX Forum™ Mobile System Profile, Release 1.0 Approved Specification (Revision 1.4.0: 2007-05-02), http://www.wimaxforum.org/technology/documents.

[3] IEEE 802.16m-08/003r1, “The Draft IEEE 802.16m System Description Document”