Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Consideration of technical issues to support WG Letter Ballot 13 comments against the consolidated IEEE 802.16 draft, P802.16-REVd/D1.**
Date Submitted	**2003-10-31**
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Re:	Comment resolution following WG Letter Ballot #13 on P802.16-REVd/D1 during WG Session#28.
Abstract	This document contains supplementary technical information to support comments proposing enhancements to the consolidated IEEE 802.16 draft, which will produce a more comprehensive multipoint system standard. No new modes that are not already described in the standards are required. Nothing is deleted from existing standards. These proposals have been defined in detail and analyzed against the existing draft.
Purpose	To provide supplementary technical information for consideration during resolution of the appropriate comments supplied in response to WG Letter Ballot 13.
Notice	
Release	
Patent Policy and Procedures	

Consideration of technical issues to support WG Letter Ballot 13 comments against the consolidated IEEE 802.16 draft, P802.16-REVd/D1.

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1 Introduction

In contributions to IEEE 802.16 Sessions 26 [7] and 27 [8], potential enhancements to the 802.16 standard were presented and discussed in WG session. Session 27 contribution IEEE C802.16-03/55r1 identified how a "directional mesh" multipoint system might be integrated tidily within the framework of the existing 802.16 standard with only minimal change. Additionally, many of the key requirements described and the consequential refinements proposed to the standard, could be seen to share some common ground with other enhancement proposals discussed at Session 26, associated with improved support for directional/steerable antennas [3] and an option for point-to-point support in the IEEE802.16 MAC [1].

Although at Session 27 detailed examination of the contributed proposals was postponed, their overall objective and direction was presented. It became evident that the new draft P80216-REVd_D1 that followed from the WG Recirculation Ballot 11 provided a more stable base for evaluation of the detailed proposals and consequently these have been refined and supplied as new comments into Letter Ballot 13 supported by the technical considerations and analysis in this contribution.

These proposals provide enhancements enabling a more comprehensive multipoint system standard and require only a small amount of change to the existing draft standard. They are defined in detail and can easily be added to the standard. As much as possible, use has been of existing resources in the 802.16 standard.
Specifically:

- No new modes that are not already described in the standards are required,
- Nothing is deleted from existing standards.

The following topic areas have been identified for consideration in detail in this paper:

- Frame structure suitable to support directed mesh (DM) operation.
- Support for efficient power control in both the uplink and downlink.
- Efficiency enhancement to the DFS option.
- A representative System Profile.

2 Frame structure

2.1 Aim

If 802.16 standard implementations are to benefit from the enhancements that a "Directed Mesh" (DM) configuration could bring then it is necessary to specify a suitable frame structure to support the use of a number of substantially directional antennas and a half-duplex radio architecture.

Efficient DM operation relies on supporting a number of simultaneous links from any node, each requiring the transmission of a FCH. Due to the standard's roots in PMP the transmission of the FCH is assumed to be broadcast in nature.

Rigid TDD operation is restrictive and potentially spectrally inefficient from the point of view of DM operation which benefits from the use of FDD-like operation enabling freedom in defining where a downlink or uplink transmission occurs during a frame, and which frequency is used. The following proposals address these concerns.

2.2 Proposal

2.2.1 Introduction

Examination of the draft 802.16 standard shows it is possible to integrate the required enhancements to support a DM configuration in two alternative ways, given the aims of link independence and frequency agility:

1. *802.16 AAS option*: The existing AAS option targets specific SS in the AAS portion of the frame and uses a private FCH [3]. This option also provides *alert slots* to enhance the chances of an SS being detected by the BS - a consequence of using directional antennas. This option is discussed in section 2.2.2 and is to be made available to SCa, OFDM and OFDMA PHYs over 2-11GHz

2. *FCH management*: Data bursts are transmitted on the supported links. The frame preamble and FCH are transmitted on all links, but on only one link per frame – transmissions are cycled on the supported links. Downlink TDMA traffic bursts are transmitted for all links during the data burst portion of the frame. This option is discussed in section 2.2.3 and is to be made available to the SC PHY over 10-66GHz.

Intra-frame frequency selection is discussed in section 2.2.4 and is proposed to be made available to all PHYs across all frequencies.

2.2.2 The AAS option

As the AAS option provides a solution to the "broadcast FCH" problem identified above, this section provides a form of words describing how aspects of the AAS option can be adopted to support DM operation. This section proposes additions to the standard that explain the use of AAS and how DM can be implemented as part of the AAS option. The proposals incur no impact to any MAC messages. Text is proposed for section 6.4.7.7 (pp162) and is illustrated in Figure 1. Section 2.2.2.1 provides a list of other textual modifications to support DM within the AAS option.

6.4.7.7.7 Introduction to the DM

The AAS option covers the frequency range 2-11GHz and provides a means of facilitating directed mesh (DM) for all PHY types. The use of substantially directional antennas within a DM solution inherently constrains broadcast opportunity for a node. The provision within the AAS option for private transmissions to a single SS to which the BS beam is pointed is strongly allied to the concept of private links addressed by a DM node. In this way, the FCH (traditionally broadcast for a PMP system) is transmitted to an SS within a data burst. The same mechanism supports unicasting of MAC management messages.

The use of the AAS option configured for DM is likely to see each and every frame configured for AAS, as each SS will effectively be an AAS SS. This preserves the possibility for interoperability. Within the RNG-REQ MAC message the *AAS broadcast capability* parameter will be set to 1 (*SS cannot receive broadcast messages*) thus assuming the FCH will not be read. Within the RNG-RSP MAC message the *AAS broadcast permission* will be set to 1 (*SS shall not issue contention-based bandwidth requests*). In this way there will be no need to transmit a broadcast frame preamble or FCH. All FCH will be transmitted privately to a specified SS in the data burst, together with MAC management messages. Synchronisation will be provided via the data burst preamble supported as part of the AAS option by all PHYs.

AAS-alert-slots shall be utilised to facilitate DM network entry for new nodes. New nodes entering the network shall behave as SS to fully utilise the network entry procedures. The use of AAS-alert-slots increases the probability of a BS receiving transmissions from a new SS.

Using the AAS option in unlicensed bands requires recognition of the DFS MAC requirements. Local regulatory requirements shall be met within AAS. This is likely to take the form of monitoring resources allocated in the areas where beams are formed and transmissions initiated.

Figure 1 *Additional text to be added to the AAS section (6.4.7.7) in support of DM.*

2.2.2.1 Other textual modifications in support of DM within the AAS option

There are a number of textual changes required in the current draft standard that will allow the use of DM within the AAS option. These are detailed in this section.

1) At present the preamble present flag within the OFDM DL-MAP IE is only 1 if DIUC==15. This may not always be the case for a TDMA burst system using AAS. It is proposed that this logic is removed from the OFDM DL-MAP IE table 207 (section 8.4.5.2, pp 447).

2) Concerning the OFDMA PHY: Section 8.5.5.2.2 describes the AAS IE format and contains the following text:

> *"Within a frame, the switch from non-AAS to AAS-enabled traffic is marked by using the extended DIUC = 15 with the AAS_DL_IE() to indicate that the subsequent allocations, until the start of the first UL-MAP allocation using TDD, and until the end of the frame using FDD, shall be for AAS traffic. When used, the CID in the DL-MAP_IE() shall be set to the broadcast CID."*

Given that CID is used for DL-FPC then it is inappropriate for the CID to be the broadcast CID. This paragraph should be modified as in Figure 2 below:

> *Within a frame, the switch from non-AAS to AAS-enabled traffic is marked by using the extended DIUC = 15 with the AAS_DL_IE() to indicate that the subsequent allocations, until the start of the first UL-MAP allocation using TDD, and until the end of the frame using FDD, shall be for AAS traffic. When used, the CID in the DL-MAP_IE() ~~shall~~ **may** be set to the broadcast CID.*

Figure 2 *Proposed modifications to paragraph from section 8.5.5.2.2.*

2.2.3 FCH management

This section describes a DM solution by configuring existing behaviours within the 802.16 standard. This configuration scheme is to be available to the SC PHY. This proposal is similar to that expressed in [1].

2.2.3.1 The concept

This solution transmits frames simultaneously on the number of links supported making decisions on which link receives the preamble and FCH. Traffic bursts are transmitted across all links during the frame. Issues with this approach are related to the retention of synchronisation. Synchronisation is to be enhanced via a TDMA preamble for data bursts. A diagrammatic representation of this concept is given in Figure 3. This representation shows a node behaving as a BS and SS. The BS controls 3 SS entities at other nodes, with an SS being supported via *link 4* in the diagram. During a frame the FCH is directed at a particular link with the remainder of the frame providing data bursts across the links supported.

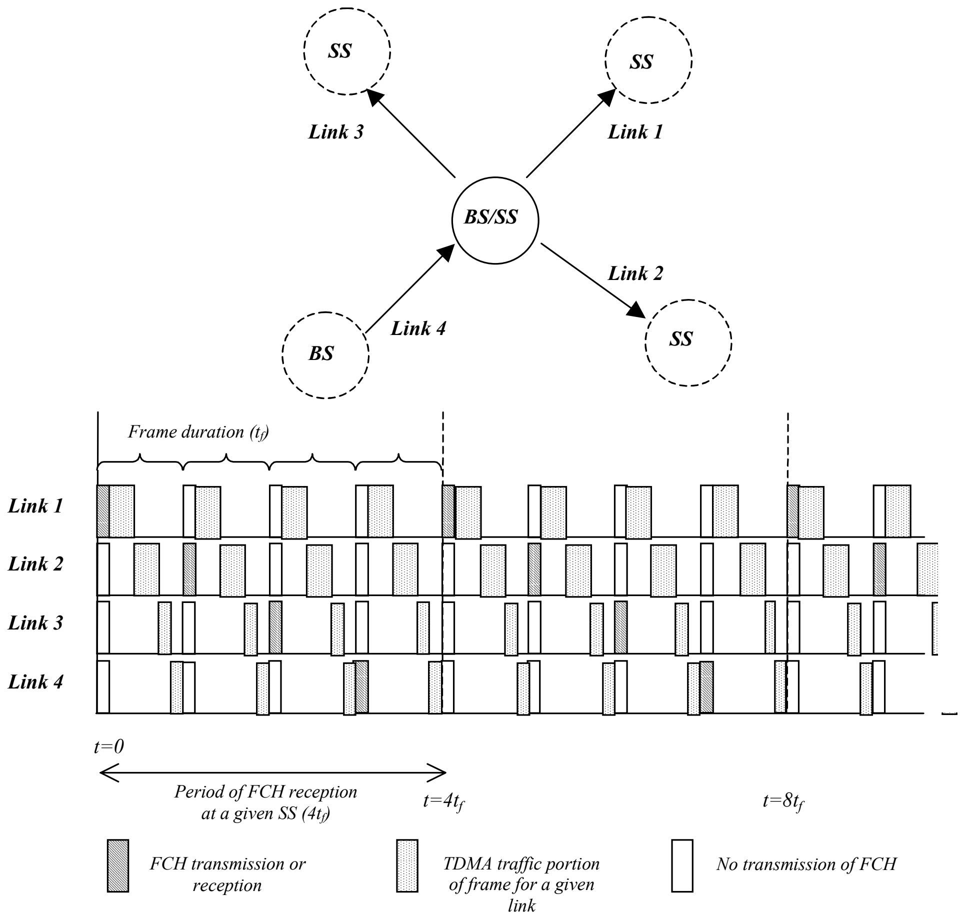

Figure 3 *Representation of the management of the FCH across supported links.*

2.2.3.2 FCH management for SC PHY

Currently, a PMP SS would expect to receive the FCH every frame, although there is a mechanism for retrying if it is not received. However DM SSs need to be configured to expect the FCH to be present only a percentage of the time. If the DL-MAP is used to describe sufficiently far into the future, then a SS can retain synchronization. It is likely that both the SS and the node acting as a BS will be required to accommodate more timing (and therefore frequency) uncertainty than in a PMP system that will receive the FCH every frame.

In summary the proposals addressing the PMP SC PHY to be configurable for DM use are:

- FCH is directed so the SS sees it 1 out of *n* times.
- The set of values for the PHY synchronisation field in the DL-MAP is expanded to indicate DM vs. PMP.
- The DL-MAP and UL-MAP are allowed to define when the FCH is to be again received.
- The nodes would need to be more tolerant of timing errors; hence support for TDMA in the downlink is configured.

Modifications to the SC PHY synchronization field are presented in Figure 4.

Table 126— SC PHY synchronization field

Syntax	Size	Notes
PHY Synchronization Field() {		
Network Configuration Type (NCT)	**4 bits**	**Flag to indicate network configuration type:** **0 = PMP** **1 = DM** **2 = PtP** **3…15** ***reserved***
Frame Duration Code()	**4 bits**	
Frame Number	24 bits	
If(NCT==DM) { **FCH expected**	**24bits**	**The number of frames before the Frame preamble and FCH will be transmitted again.**
}		
}		

Network Configuration Type defines the network type configured. If the network is DM then a **FCH expected** field is included. This is a 24-bit field that defines when the frame preamble and FCH will be next transmitted. As this transmission will be directed to a given SS it is effectively a private transmission to that SS. The **FCH expected** will indicate the transmission of a DL-MAP, UL-MAP, DCD or UCD. For network entry of DM it is possible to increase the frequency of occurrence of FCH transmission to assist new nodes to enter the network. The frequency can be reduced for the case of steady state network operation.

***Figure 4** Proposed modifications to SC PHY synchronisation field. Modifications are shown in **Bold**.*

Figure 5 provides modification to frame duration and frame duration codes for the SC PHY in table 120 (pp 313). The table currently shows 2 bits used with a modification to show 4 bits.

Table 120—Frame durations and frame duration codes

Frame duration code **(4 bit)**	Frame duration (T_F)	Units
0x01	0.5	ms
0x02	1	ms
0x03	2	ms
0x04 – 0x0F	***Reserved***	

***Figure 5** Proposed modifications to frame durations and frame duration codes for SC PHY. Modifications are shown in **Bold**.*

Changes required to the parameters and constants are given in Figure 6.

Table 275—Parameters and constants

System	Name	Time reference	Minimum value	Default value	Maximum value
BS	DL-MAP Interval	Nominal time between transmission of DL-MAP messages		**200ms (DM)**	200ms **(PMP)** **10s (DM)**
SS	Lost DL-MAP Interval	Time since last received DL-MAP message before downlink synchronization is considered lost		**600ms**	600ms **(PMP)** **11s (DM)**
SS	Lost UL-MAP Interval	Time since last received UL-MAP message before downlink synchronization is considered lost		**600ms**	600ms **(PMP)** **11s (DM)**

Figure 6 *Proposed modifications to Parameters and constants table. Additions are shown in* ***Bold****.*

To assist in the retention of synchronisation it is necessary to configure downlink TDMA to provide a data burst preamble. This is due to the possibility that the FCH may be not received from one frame to the next. The ability of the SC PHY to support TDMA burst in the downlink is already covered in the standard. This is configured within the DCD MAC message. In addition for support of the DL-FPC proposal to be recognised it is necessary to constrain SS CIDs to a single burst; thus ensuring power control is performed against the correct CID. The SC PHY supports FDD.

2.2.4 Intra-frame frequency selection

Intra-frame frequency selection provides flexibility in selecting frequency from data burst to data burst within the same frame. This is fundamental in realising one of the efficiency gains in DM networks. Adding fields in the TLV parts of the DCD and UCD MAC messages facilitate intra-frame frequency selection and is of low impact to the standard. Currently there is only support for frequency selection across the overall channel in the SCa, OFDM and OFDMA PHYs. SC is not supported because it is assumed that for TDD the uplink frequency is known from the downlink frequency and for FDD the duplex spacing is fixed. There is currently no scope for optional intra-frame frequency selection within the standard.

It is proposed to include *Frequency* selection parameters accompanying the DCD and UCD *TLV encoded information for the overall channel* and *TLV burst profile encoding* for all PHYs. Frequency selection in the

TLV encoded information for the overall channel may be used to configure the frame preamble and FCH section of the frame for the uplink, whilst *TLV burst profile encoding* is used for data bursts.

It is proposed that the DCD and UCD MAC messages have the following amendments shown in Figure 7 added to the TLV encodings. These TLVs are shown specifically in Figure 8 to Figure 10.

Table *14 and 16* —DCD and UCD MAC message format (section 6.4.2.3.1 and 6.4.2.3.3)

Syntax	**Size**	**Notes**
D(U)CD_Message_Format() {		
Management Message Type = 1,0	8 bits	
Downlink (Uplink) channel ID	8 bits	
Configuration Change Count	8 bits	
Additional UCD parameters…		
…		
…		
TLV Encoded information for the overall channel	Variable	TLV specific **Add *Frequency* for all PHY types to TLV encoding.**
Begin PHY Specific Section {		See applicable PHY section
for (*i* = 1; *i* <= *n*; *i*++) {		For each downlink burst profile 1 to *n*
Downlink(Uplink)_Burst_Profile		PHY specific **Add *Frequency* for all PHY types to TLV encoding.**
}		
}		
}		

***Figure** 7 Proposed scope of modifications to DCD and UCD MAC messages. NB this is a representation of DCD and UCD MAC messages. Additions are shown in **bold**.*

Table *279* — UCD channel encodings (section 11.1.1.1)

Name	Type (1 byte)	Length	Value	PHY scope
Frequency	3	4	Uplink Centre frequency	**All**

***Figure 8** Proposed Additions to TLV encoded information for the overall channel. Additions shown in bold.*

Table *280* — UCD burst profile encodings – Wireless MAN-SC (section 11.1.1.2)

Name	Type (1 byte)	Length	Value
Frequency	**18**	**4**	**Uplink frequency**

Table *281* — UCD burst profile encodings – Wireless MAN-SCa (section 11.1.1.2)

Name	Type (1 byte)	Length	Value
Frequency	**26**	**4**	**Uplink frequency**

Table *282* — UCD burst profile encodings – Wireless MAN-OFDM (section 11.1.1.2)

Name	Type (1 byte)	Length	Value
Frequency	**18**	**4**	**Uplink frequency**

Table *283* — UCD burst profile encodings – Wireless MAN-OFDMA (section 11.1.1.2)

Name	Type (1 byte)	Length	Value
Frequency	**17**	**4**	**Uplink frequency**

Figure 9 *Proposed modifications to the uplink burst profile encodings in UCD, PHY dependent. Additions shown in **bold**.*

Table *285* — DCD burst profile encodings – Wireless MAN-SC (section 11.1.2.2)

Name	Type (1 byte)	Length	Value
Frequency	**16**	**4**	**Downlink frequency**

Table *286* — DCD burst profile encodings – Wireless MAN-SCa (section 11.1.2.2)

Name	Type (1 byte)	Length	Value
Frequency	**30**	**4**	**Downlink frequency**

Table *287* — DCD burst profile encodings – Wireless MAN-OFDM (section 11.1.2.2)

Name	Type (1 byte)	Length	Value
Frequency	**15**	**4**	**Downlink frequency**

Table *288* — DCD burst profile encodings – Wireless MAN-OFDMA (section 11.1.2.2)

Name	Type (1 byte)	Length	Value
Frequency	**30**	**4**	**Downlink frequency**

***Figure 10** Proposed modifications to the downlink burst profile encodings in DCD, PHY dependent. Additions shown in **bold**.*

3 Optional fast power control

3.1 Aim

A Fast Power Control (FPC) option supported by the 802.16 standard has the potential to bring useful increases in system efficiency and system capacity, to reduce intra system interference and to assist regulatory compliance in some markets where spectrum is shared with other users.
Within PMP high downlink output powers are often decided a priori as part of the network planning procedure. The case of DM network operation may be considered as multiple PtP links, and in this respect a peer-to-peer behaviour is evident. The reciprocal relationship of links is distinct from the broadcast downlink and contended/scheduled uplink adopted for PMP systems. As for *uplink* power control, the notion of *downlink* power control is also required in DM (uplink and downlink are in italics because of the naming convention of a PMP system). In this case it is reasonable to want to adjust the downlink signal so as to be received optimally at the individual SS. Signal degradation due to rain, trees or other line of sight impairments can be combated by fast power control, at both ends of the link, as they are affected in a similar manner. For DM the ability to increase coverage is found in increasing the user density; with the control of user's transmit power critical in assisting with a corresponding capacity increase.

The FPC proposals are divided into the following specific areas:

- Proposal for an optional downlink FPC (DL-FPC) MAC message.
- Consequential DL-MAP message changes to support DL-FPC.
- Potential efficiency gains in the FPC MAC message.
- Optional FPC and DL-FPC for SC PHY.

3.2 Proposal

3.2.1 An optional downlink FPC (DL-FPC) MAC message

A DL-FPC MAC message is provided for optional downlink FPC. This message is generated by the SS in response to a decision made by a downlink power control algorithm implemented in the SS. This is illustrated in Figure 11. The power control algorithm is outside the scope of the standard but is likely to be based on the assessment and tracking of CINR. Each SS sends a DL-FPC MAC message using the basic CID. This controls the transmit power of the TDMA data burst for the paired CID at the BS. The SS is able to make independent power control decisions for all CIDs it supports in the downlink. In this way a specific SS may be power controlling a number of TDMA bursts with distinct CIDs. Power control of the FCH via the DL-FPC MAC message is a special case where a specific CID transmitted by the SS is recognised by the BS and used to change the power of the FCH transmission.

For DM operation, it is likely that a single SS may support several CIDs. Each CID is supporting a single data burst within the frame structure and will require individual power control. This is due to the fact that not all data bursts will be on the same frequency. Alternatively, multiple messages (with different CIDs) targeted for the same SS would be aggregated into a single burst that would be identified by basic CID in the DL-MAP. Power control could be asserted on these entities, not individual messages. Realisation of the DL-FPC MAC message is given in Figure 12. The BS handles the control of power in the downlink for each burst. From mapping of the CID received in the DL-FPC MAC message the BS can change the transmit power for a particular burst keyed by the CID.

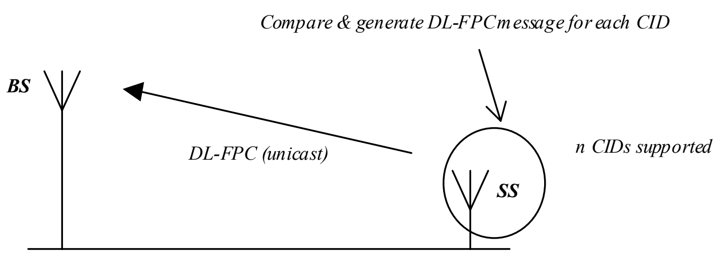

Figure 11 *Illustrative use of the DL-FPC MAC message.*

Table *84a* —DL-FPC MAC message format (add section 6.4.2.3.41)

Syntax	**Size**	**Notes**
DL-FPC_Message_Format() {		
Management Message Type = 46	**8 bits**	
Power adjust	**8 bits**	**(Signed 8 bit, 0.25 dB units)**
}		

Power Adjust

Signed integer, which expresses the change in power level (in multiples of 0.25 dB) that the SS shall apply to its current transmission power. *(Same as FPC MAC message). Additions are shown in **bold**.*

Figure 12 *Proposed DL-FPC MAC message in support of downlink FPC.*

3.2.2 Consequential changes to DL-MAP in the support of *DL-FPC*

The 802.16 definition of the term TDM means that data is encoded at different modulation rates as defined by the corresponding burst profile. The encoded downlink data is transmitted to all subscribers, most robust modulation burst profile first, to least robust last. Each of these encoded modulated data groups is called a burst. All messages that the MAC decides to send at a specific modulation rate are aggregated into a single burst, regardless of targeted SS. Because of the PHY level coding performed on the data (Viterbi, Reed-Solomon, etc) all data in a burst is logically linked with all the other data within the same burst. Subscribers receive and demodulate all DL bursts up to and including the least robust group the BS and SS have agreed the SS can support. Each SS examines the CID in the MAC header of each message in the burst and processes the ones that match its known set of active CID values. Under this scheme, a CID in the DL-MAP header serves no purpose since each burst transmitted may carry at least one message for each SS (in the worst case). The implication of this means the use of TDM is inappropriate for downlink power control.

TDMA within 802.16 means that data for each particular SS or group of SSs is segregated in distinct bursts (with or without leading preamble). In the TDMA case a CID in the DL-MAP means all the data in a burst is targeted to a specific set (one or more) of SSs and therefore each SS can decide based on that CID value whether or not to operate on the burst. For DL-FPC to be realizable, dedicating bursts supporting specific SS(s) is expected since this provides PHY layer data burst identification for power control purposes.

Currently all PHY apart from SC possess the ability to identify a data burst by the CID in each DL-MAP. The modified DL-MAP IE for the SC PHY is given in Figure 13.

Table 125—DL-MAP IE (page 319)

Syntax	Size	Notes
DL_MAP_IE() {		
DIUC	4	
StartPS	16	The starting point of the burst, in units of PS where the first PS in a given frame has StartPS=0
if(CID used enabled by burst profile) {		
CID	**16 bits**	**If enabled include the CID.**
}		
}		

Figure 13 *Proposed modification to the SC PHY DL-MAP IE format. Additions shown in **bold**.*

The configuration of the flag **CID used enabled by burst profile** is defined in the SC DCD encoding. The consequential addition of the TLV encoding is shown in Figure 14.

Table 285—DCD burst profile encoding – (page 569)

Name	Type (1 byte)	Length	Value
CID_in_DL_IE	**29**	**1**	**0 – CID does not appear in DL_MAP_IE (default)** **1 – CID does appear in DL_MAP_IE** **2…255 – Reserved.**

Figure 14 Proposed addition to the SC DCD burst profile encodings.Additions shown in ***bold****.*

3.2.3 Potential efficiency gains in the FPC MAC message

It is possible to use a more efficient means of encoding power control information in the downlink to provide uplink power control. Using a 4 bit code to represent the difference between the last power control measurement and the current one is more efficient than explicitly sending the 8 bit power level change. Given that potentially there are many SS to support, the use of a 4 bit code rather than an 8 bit representation of the value can provide a significant capacity saving due to a reduce MAC message size. The use of the 4 bit *Power Control Difference Code* is illustrated in Figure 15 and can be added after . This provides for a range of power control values from the configuration of a single value, termed the *Power Control Difference Base Value*. This change is proposed to all PHYs.

Table *83a* — FPC code resolution

Code	*Meaning*
0000	No change
0001	Increase power by *a* dB
0010	Decrease power by *a* dB
0011	Increase power by *2a* dB
0100	Decrease power by *2a* dB
0101	Increase power by *4a* dB
0110	Decrease power by *4a* dB
0111	Increase power by *8a* dB
1000	Decrease power by *8a* dB
1001	Increase power by *16a* dB
1010	Decrease power by *16a* dB
1011	Increase power by *32a* dB
1100	Decrease power by *32a* dB
1101	Increase power by *64a* dB
1110	Decrease power by *64a* dB
1111	*Reserved*

Figure 15 *FPC code resolution. For example a=0.25dB. This is a configurable entity in the UCD. a is the Power Control Difference Base Value*

The management and configuration of the *Power Control Difference Base Value* is performed using the UCD. The SS shall calculate and use the code mappings to interpret the FPC codes from the BS. The *Power Control Difference Base Value* TLV is encoded in the UCD as shown in Figure 16.

Table *279*— UCD channel encoding (page 563)

Name	Type (1 byte)	Length	Value	PHY scope
Power Control Difference Base Value	**20**	**1**	**0…255 (units of 0.125 dB) default 2 (0.25dB)**	**All**

Figure 16 *Power Control Difference Value represented as TLVs in the UCD. Additions shown in **bold**.*

An example is shown in Figure 17, with the modified FPC MAC message shown in Figure 18.

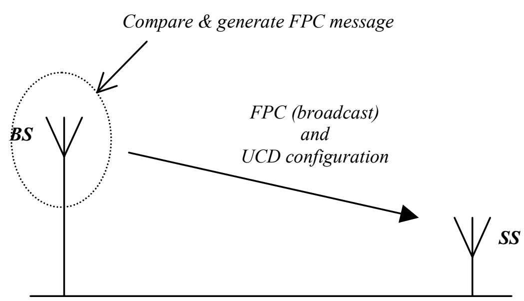

Figure 17 *Implementation of uplink power control.*

Table 84 — Fast Power Control (FPC) MAC message format

Syntax	Size	Notes
Fast_Power_Control message format () {		
Management message type = 38	8 bits	
Number of stations	8 bits	
for (*i*=0; *i*<Number of stations; *i*++) {		
Basic CID	16 bits	
~~Power adjust~~	~~8 bits~~	
Power Level Difference Code	**4 bits**	**The coded difference in power level from that currently used.**
}		
If !(byte_boundary) { Padding Nibble}	4 bits	*Padding to reach byte boundary*
}		

Power Level difference

4 bit code to represent the change in power level from the previous value.

Figure 18 *Amended FPC MAC message. Additions are shown in* ***bold****.*

To ensure consistency of approach the change to the FPC MAC message is also proposed for the Power Control IE. Therefore concerning the OFDM PHY, table 216 (section 8.4.5.3.3 pp453) and OFDMA PHY, table 240 (section 8.5.5.3.3 pp490) these require amending with the Power Level Difference Code. This also applies to the SCa PHY.

3.2.4 Optional FPC for SC PHY

There is no reason for the SC PHY not to support FPC and DL-FPC. The reason that it has not previously been specified for this PHY is that the propagation conditions thus far observed did not warrant it. With line of sight, high frequency, and relatively short links the worst-case rain fade rate is assumed to be in the order of 10 dB/sec. With the use of frame durations in the order of 1 ms then it is clear the existing power control mechanism would update at a sufficient rate. However, it is necessary for the SC PHY to support FPC and DL-FPC when considering foliage obstructions violating the line of sight where fading and therefore power control update rates increase significantly. In rural deployments fading due to tree obstruction is a strong possibility and needs to be catered for with the SC PHY.

In support of FPC for SC the CRABS report [5] describes results that demonstrate LMDS frequency bands experiencing significant fast fading both due to rain and foliage impairments. FPC will also allow the decoupling of accurate rain fade margin setting on links and improve resilience. The report presented in [6], although reporting measurements for the 5GHz band, indicates fades up to 180dB/sec based on obstruction from trees.

4 DFS

4.1 Aim

The aim of this section is to propose optional enhancements to the DFS procedures that will generally improve the efficiency of the interference detection capabilities through the possibility for unsolicited generation of non-primary user interference messages.

Within 802.16 the DFS procedures provide the following:

- Testing channels for primary users.
- Discontinuing operations after detecting primary users.
- Detecting primary users.
- Scheduling for channel testing.
- Requesting and reporting of measurements.
- Selecting and advertising a new channel.

The specification of DFS within the standard is intended to meet with anticipated regulatory requirements set forth in [4] and embodied in [2]. This section details enhancements to DFS for improved system efficiency.

4.2 Proposal

A REP-REQ message is issued by the BS to determine if interference is affecting the SS. This will be evident to the BS from the *Basic Report* field of the REP-RSP message issued by the SS in response to the REP-REQ MAC message. An unsolicited REP-RSP message shall be generated by the SS in the event of a primary user being detected in license-exempt bands. However, the polling of SS to determine if interference, other than primary user interference, has been detected is potentially bandwidth intensive. In addition the BS will only become aware of interference affecting an SS following the issuing of REP-REQ MAC message. The option for unsolicited generation of non-primary user interference, above a defined threshold, is proposed.

The OFDM PHY does not differentiate between CIDs in the DL-MAP Report IE (8.4.5.2.2, table209, pp448) unlike the SCa PHY. It is proposed to amend the DL-MAP Report IE to provide targeted measurement to individual SS. This will enhance implementation flexibility.

5 System Profiles

5.1 Aim

The aim of this section is to provide a set of representative DM system profiles to cover typical application scenarios. The system profiles are to cover:

- 10-66GHz WirelessMAN-SC PHY,
- 2-11GHz WirelessMAN-SCa,
- 2-11GHz WirelessMAN-OFDM,
- 2-11GHz WirelessMAN-OFDMA,

5.2 Proposal

In order to provide a profile for the following section are to be added to the appropriate area of the draft standard and to the relevant PHY.

5.2.1 10-66GHz WirelessMAN-SC PHY

12.1.3 Specific WirelessMAN-SC MAC and PHY profile features for DM

The following are options and parameters to provide DM using the WirelessMAN-SC MAC and PHY:

- FPC available.
- DL-FPC available.
- DL-MAP (Network Configuration Type (NCT) = 1).
- Frequency selection defined in the DCD and UCD for the channel encoding and burst profile encoding.
- DCD (PHY type = 1 (FDD)).
- DCD (Preamble presence = 1)
- DCD (CID_in_DL_IE = 1 (present in DL-MAP IE)).

Figure 19 *Addition of a DM system profile for the WirelessMAN-SC PHY.*

5.2.2 2-11GHz WirelessMAN-SCa PHY

12.2.5 Specific WirelessMAN-SCa MAC and PHY profile features for DM

The following are options and parameters to provide DM using the WirelessMAN-SCa MAC and PHY:

- FPC available.
- DL-FPC available.
- AAS option available.
- Frequency selection defined in the DCD and UCD for the channel encoding and burst profile encoding.
- FDD operation.
- DCD (Preamble presence = 1)
- DCD (CID_in_DL_IE = 1 (present in DL-MAP IE)).
- DFS – optional availability.

Figure 20 *Addition of a DM system profile for the WirelessMAN-SCa PHY.*

5.2.3 2-11GHz WirelessMAN-OFDM PHY

12.3.4 Specific WirelessMAN-OFDM MAC and PHY profile features for DM

The following are options and parameters to provide DM using the WirelessMAN-SCa MAC and PHY:

- FPC available.
- DL-FPC available.
- AAS option available.
- Frequency selection defined in the DCD and UCD for the channel encoding and burst profile encoding.
- FDD operation.
- DL-MAP (Preamble present = 1)
- DCD (CID_in_DL_IE = 1 (present in DL-MAP IE)).
- DFS – optional availability.

Figure 21 *Addition of a DM system profile for the WirelessMAN-OFDM PHY.*

5.2.4 2-11GHz WirelessMAN-OFDMA PHY

12.4.5 Specific WirelessMAN-OFDMA MAC and PHY profile features for DM

The following are options and parameters to provide DM using the WirelessMAN-SCa MAC and PHY:

- FPC available.
- DL-FPC available.
- AAS option available.
- Frequency selection defined in the DCD and UCD for the channel encoding and burst profile encoding.
- FDD operation.
- DCD (Preamble present = 1)
- DCD (CID_in_DL_IE = 1 (present in DL-MAP IE)).
- DFS – optional availability.

Figure 22 *Addition of a DM system profile for the WirelessMAN-OFDMA PHY.*

6 References

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7 Abbreviations and definition of terms

7.1 Abbreviations

AAS	Adaptive Antenna System
AAL	ATM Adaption Layer
ATM	Asynchronous Transfer Mode
BS	Base Station
CES	Circuit Emulation Service
CID	Connection ID
CP	Common Part
CS	Convergence Sublayer
DCD	Downlink Channel Descriptor
DCS	Dynamic Channel Selection
DIUC	Downlink Interval Usage Code
DFS	Dynamic Frequency Selection
DL	Downlink
DL-MAP	Downlink Map
DM	Directed Mesh
FCH	Frame Control Header
FDD	Frequency Division Duplex
FPC	Fast Power Control
GPS	Global Positioning System
IE	Information Element
IP	Internet Protocol
LMDS	Local Multipoint Distribution System
MAC	Media Access Control
OFDM	Orthogonal Frequency Division Multiplex
OFDMA	Orthogonal Frequency Division Multiple Access
PHY	Physical
PMP	Point to multi-point.
PtP	Point to point
RTG	Receive Transmit Gap

SBA	Switched Beam Antenna
SC	Single Carrier
SFID	Service Flow ID
SS	Subscriber Station
TDD	Time Division Duplex
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
TLV	Type Length Value
UCD	Uplink Channel Descriptor
UIUC	Uplink Interval Usage Code
UL	Uplink
UL-MAP	Uplink Map

7.2 Definition of terms

Directed mesh: The realisation of a physical mesh using substantially directional antennas.

Node: A term associated with a directed mesh network station. A node, due to the nature of mesh, may behave as a BS, SS, or both, and will generate and forward data to other nodes.

8 Acknowledgements

Thanks are extended to Brian Eidson, Itzik Kitrozser, Bob Nelson, and Ken Stanwood for background help in preparing this contribution. Some of the words in this document are theirs.

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