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Re:	This document responds to the Call for Comments on editor's draft IEEE P802.16-2003/D0, announced on 2003-08-07. It includes a set of proposed enhancements to the standard.
Abstract	This document contains a set of proposals for enhancements to the consolidated IEEE802.16 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 are defined in detail and could easily be added to the standard with only a small amount of change.
Purpose	For consideration as enhancements to IEEE802.16/802.16a/802.16c, as invited by the call for comments on the consolidated draft standard IEEE P802.16-2003/D0.
Notice	
Release	
Patent Policy and Procedures	

Proposals for Enhancements to IEEE 802.16 and 16a standards based on draft IEEE P802.16-2003/D0

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1 Introduction

At IEEE 802.16 Session 26, potential enhancements to the 802.16 standard were presented and discussed in WG session. One contribution IEEE C802.16-03/10r1, discussed the potential spectrum efficiency gains and benefits of a "directional mesh" multipoint system and how these systems 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 in Session 26, associated with improved support for directional/steerable antennas [5] and an option for point-to-point support in the IEEE802.16 MAC [3].

This document builds upon the Session 26 discussion and contains a set of detailed proposals for enhancements to the IEEE P802.16-2003/D0 draft.

These enhancements, which can be achieved with only a small amount of change to existing standards, are defined in detail and can easily be added to the standard. Specifically:

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

The proposals offer the possibility for significant performance improvements that may be used separately or in combination, under the following headings:

- Configuration for point-to-point style of operation (e.g. to provide a simple, general way to support directional mesh configurations or to allow lower-cost backhaul operating in-band using the same basic equipment design as a BS/SS),
- Improvements to allow antenna pointing messages to be used (e.g. to support directional mesh configurations or to add adaptive antennas at any frequency within the total range addressed),
- System efficiency improvements.

All proposals are optional, do not require any new modes that are not already in the standard(s) and would not affect operation of equipment built to previous versions of the standards (other than as the result of correcting any errors that may be found in existing standards.) Potential performance improvements include significant spectral efficiency gains, better coexistence by use of directed antennas, and increased system capacity within a single network. The aim is for all the proposed improvements to be supported over the full frequency range of 2-66 GHz, licensing environments and PHY layer options.

1.1 Point-to-point style of operation

The individual node interconnections in a mesh configuration, specifically where directional antennas are used to improve spectral efficiency, can be considered like point-to-point links[1]. Point-to-point operation is also a

[1] Although for any operational and efficiency considerations the entire multipoint network of links that form the mesh is important.

useful improvement for self–backhaul applications in P-MP networks (especially where regulations allowed this to be in the same band as the BS or SS equipment). In order to provide efficient point-to-point style of operation, the improvements summarized in table 1 should be made:

Table 1; improvements related to point-to-point style of operation

Improvement	Proposal title	Section
Allow a more flexible burst structure to be used within frames to improve spectral efficiency in a point-to-point configuration.	A flexible partitioned frame structure	2.1
To allow system configuration of links, so that a point-to-point operation can be supported more efficiently	Frame synchronization and management	2.2
Allow power control in both uplink and downlink so that a point-to-point configuration can minimize interference and improve frequency reuse.	Power control in both UL and DL	2.3

1.2 Antenna selection/pointing procedures

Table 2; improvements related to antenna pointing and selection procedures

Improvement	Proposal title	Section
Allow RF channel and antenna selection between burst profiles.	RF channel change and antenna selection between burst profiles	2.4

1.3 Efficiency improvements

Table 3; improvements related to system efficiency

Improvement	Proposal title	Section
To allow a power control method with less overhead, for use in point-to-point and mesh applications (improves spectral efficiency)	Efficient implementation of power control	2.5
To provide an efficient means of detecting radar transmissions in shared spectrum, so as to improve coexistence (may be mandated in some markets).	Radar avoidance	2.6
To extend the range of existing MAC messages that can be tunneled, to support point-to-point and mesh operation in all frequency bands	MAC message tunneling	2.7

2. Specific proposals

2.1 A flexible, partitioned frame structure

2.1.1 Aim

To provide an efficient optional burst structure of a TDD nature by using FDD-like half-duplex bursts, for use in point–to-point and mesh systems. Efficiency gains are provided by:

- Removal of contention on the air interface,
- Fine control over capacity allocation,
- Frequency reuse.

2.1.2 Proposal

To define a frame structure that can be configured for time-slotted usage. It is proposed that each timeslot has the ability to select an antenna and RF frequency.

2.1.3 Solution

Using an FDD-like solution enables freedom in defining where a DL or UL transmission occurs. Current TDD proposal within IEEE802.16 requires a UL sub-frame following a DL sub-frame in each frame. This is restrictive and spectrally inefficient. The standard provides half-duplex FDD operation to reduce equipment complexity where transmission and reception do not occur at the same time. The TDMA portion of the downlink sub-frame is used. This provides a preamble and enables SS to retain synchronization.

It is anticipated that the timeslot structure proposed within the frame will be used for long periods and will require infrequent reconfiguration. It is therefore not necessary to transmit a DL-MAP message (used to determine when bursts are to be sent with a given burst profile – related to the DUIC) at the beginning of every frame for a slowly varying frame structure such as this. Table 248 (IEEE P802.16-2003/D0: page 481) specifies a maximum repeat duration for DL-MAP transmission of 200ms. It is proposed that this should be removed, i.e. no maximum specified. In a similar fashion it will not be necessary to include a UL-MAP message in every frame for the same reason. In configuring the D(U)L-MAPs it is important to consider the time of flight for a burst and so this needs to be factored in when burst lengths are defined. The same is true for Rx-Tx and Tx-Rx transitions, termed RTG and TRG respectively.

The frame control section of the DL sub-frame structure contains only DL-MAP, UL-MAP and perhaps DCD and UCD. As no other payload is permitted (IEEE P802.16-2003/D0: section 8.2.5.1.2: page 302) then it is expected that the frame control section may not be used in every frame. This is of benefit as the transmission of a broadcast message at the start of each frame could cause undue interference. In PMP this problem is mitigated to a certain extent by the use of network planning – in a point–to–point or mesh configuration this is unlikely. A cyclic broadcast can be between frames to reduce the possibility of interference.

In considering the UL then a *contention slot for initial ranging* can be retained for new station entry while the *contention slot for BW requests* is not required as bandwidth allocation is determined a priori. Therefore no bandwidth requests will be issued. Figure 1 provides a proposed frame structure from configuration of the IEEE802.16 standard.

It is proposed to amend the standard to allow an FDD-like configuration to be used for point–to–point and mesh type operation. Table 1 (IEEE P802.16-2003/D0: section 1.2.4: page 2) needs to be amended accordingly to permit FDD-like operation in licence-exempt bands.

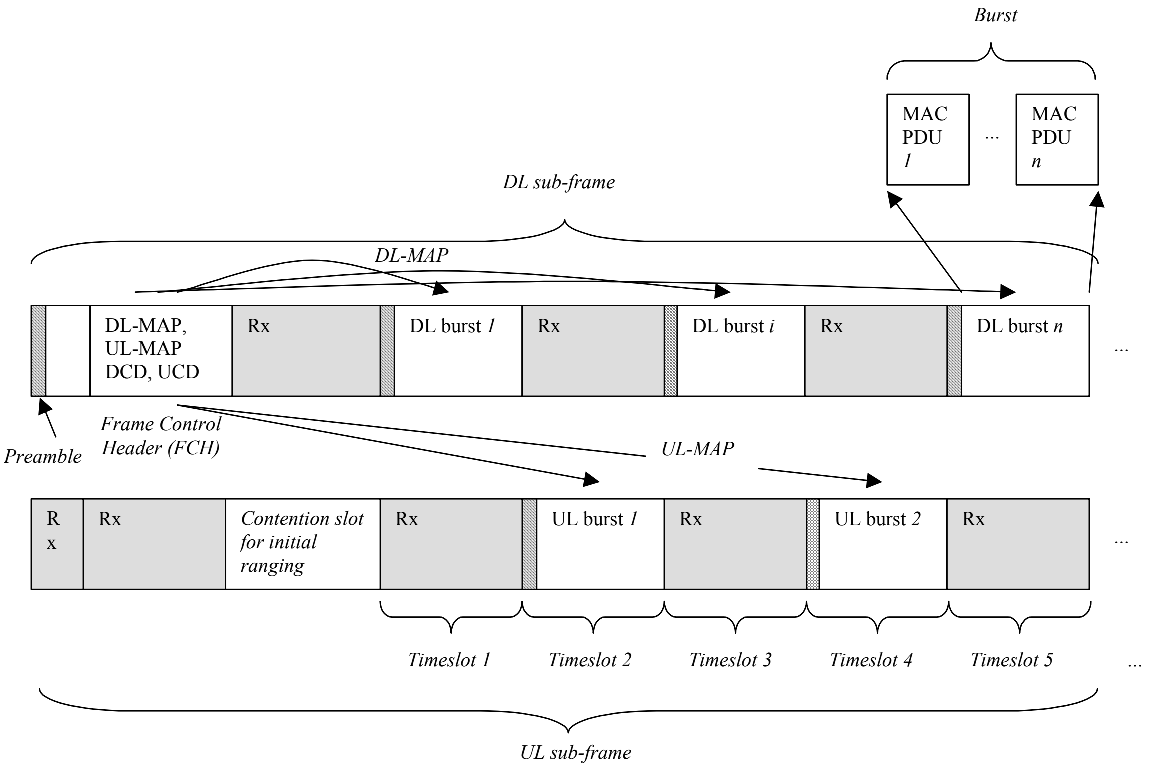

Figure 1 Detailed configuration proposal for an optional timeslot frame structure better suited to point-to-point style of operation in "directional mesh" in IEEE802.16. NB Time-of-flight compensation not shown, nor is the DL-BTG.

2.2 Frame synchronization and management

2.2.1 Aim

Each station within a point–to-point or mesh system is expected to be able to support one or a number of links to neighboring stations. Due to the configuration constraints within IEEE802.16, stations at either end of established links will behave as either a BS or SS. Currently new stations entering the system will behave as a SS and the station supporting the new station's entry will be a BS. Therefore it is expected that any particular station will support BS and SS terminating links and is likely to result in a 'master'/'slave' relationship; a relationship managed by the *station controller*.

For improved spectral efficiency within the system, each station should obtain synchronization to the other stations in the system. This may be achieved by using GPS. The behavior of which will aid interference reduction.

This proposal for frame synchronization and management will allow an efficient use of BS and SS entities in providing symmetric (peer-to-peer) operation.

2.2.2 Proposal

It is proposed to configure the frame structure using FDD-like operation. This will enable a station to support links as either a BS or SS.

2.2.3 Solution

2.2.3.1 General

The solution is presented with an example configuration. This is shown in Figure 3, with frame configuration given in Figure 4. The solution provides station configuration and synchronization using a fixed reference e.g. GPS. The *station hold-off* respects the constraints of H-FDD and permits a preamble to be transmitted on every link at the start of the frame but not at the same time. This is part of a so-called *slotted preamble* section of the frame. The *frame control header* or FCH follows. It is likely that there will be a gap following the *slotted preamble* section before the start of the FCH (as shown in Figure 4). To achieve this gap (which is not expected as the FCH is expected straight after the frame preamble) a similar method used for the UL, were the *start alloc time* is used, is proposed. The UL-MAP is defined in Table 17 (IEEE P802.16-2003/D0: page 64) and provides an indication of the start of the UL allocation in the form of the *start alloc time*. It is intended to include this mechanism in the DL-MAP in Table 15 (IEEE P802.16-2003/D0: page 62). This parameter will be a 32bit representation of the start of the FCH in mini-slots (similar to the UL version), and will be added to the DL-MAP. The modified DL-MAP MAC message is shown in Figure 2.

Syntax	Size	Notes
DL-MAP_Message_Format() {		
Management Message Type = 2	8 bits	
PHY Synchronization Field	Variable	See appropriate PHY specification.
DCD Count	8 bits	
Base Station ID	48 bits	
Number of DL-MAP Elements *n*	16 bits	
Allocation Start Time	**32bits**	**Addition of element.**
Begin PHY Specific Section {		See applicable PHY section.
for (*i* = 1; *i* <= *n*; *i*++) {		For each DL-MAP element 1 to *n*.
DL_MAP_Information_Element()	Variable	See corresponding PHY specification.
if !(byte boundary) {		
Padding Nibble	4 bits	Padding to reach byte boundary.
}		
}		
}		
}		

Figure 2 Proposed modifications to DL-MAP Table 15 (IEEE P802.16-2003/D0: page 62).

The FCH can be transmitted (if required), managed by the *station controller* in a cyclic fashion. If the station is supporting a link as a SS then the station will also have to receive in this portion of the frame. The *Alloc Start Time* defines the start of the uplink allocation and has a contended transmission slot (need to confirm the reliability given that there is a possibility of a clash, it is also possible to send a transmit opportunity as part of the UL-MAP for a polling-type implementation). Again as with the FCH part this section of the frame can be used for either for transmit or receive – depending on the station's configuration. The DL-MAP and UL-MAP define the remainder of the frame given that the burst profile is specified at this point. The RF channel and antenna (sometimes called *coloring*) used in the *frame control section* is taken from the DCD. If more than one frequency is used to support a number of timeslots on a link then a *primary color* can be defined, with the RF frequency and antenna stored as part of the **TLV Encoded information for the overall channel** parameter of the D(U)CD MAC message.

2.2.3.2 Installation

A brief discussion on the support for installation based on this proposal is included in this section. In enabling installation, it is possible to provide a station entry "welcoming set" of existing stations. These "welcomers" will transmit the DL-MAP MAC messages (used by the new station to obtain initial downlink synchronization) as part of the current IEEE802.16 standard. The DL-MAP will provide sufficient information for the new user to obtain full synchronization and to enter the system. The new station DL-MAP MAC message can be transmitted periodically by "welcomers" in the FCH on a specifically configured *color*.

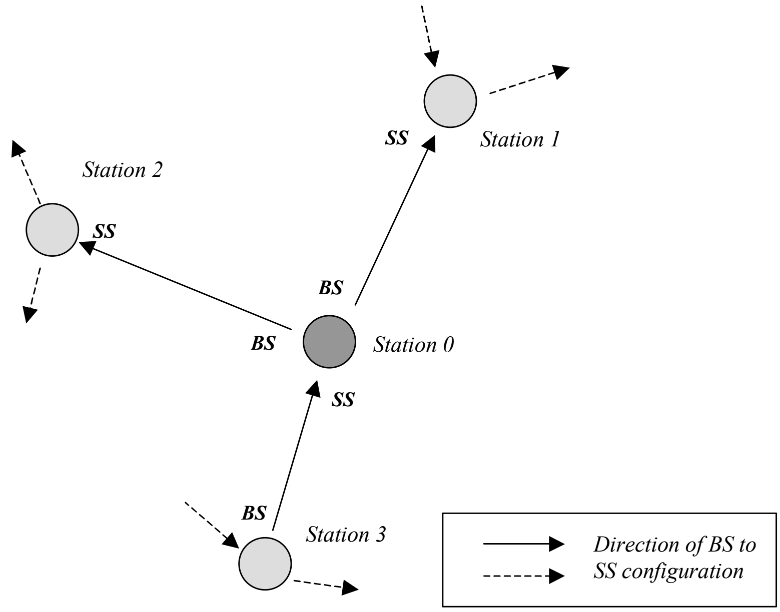

Figure 3 Example configuration for station 0. NB all links shown are duplex links, the arrowheads show BS to SS link termination orientation.

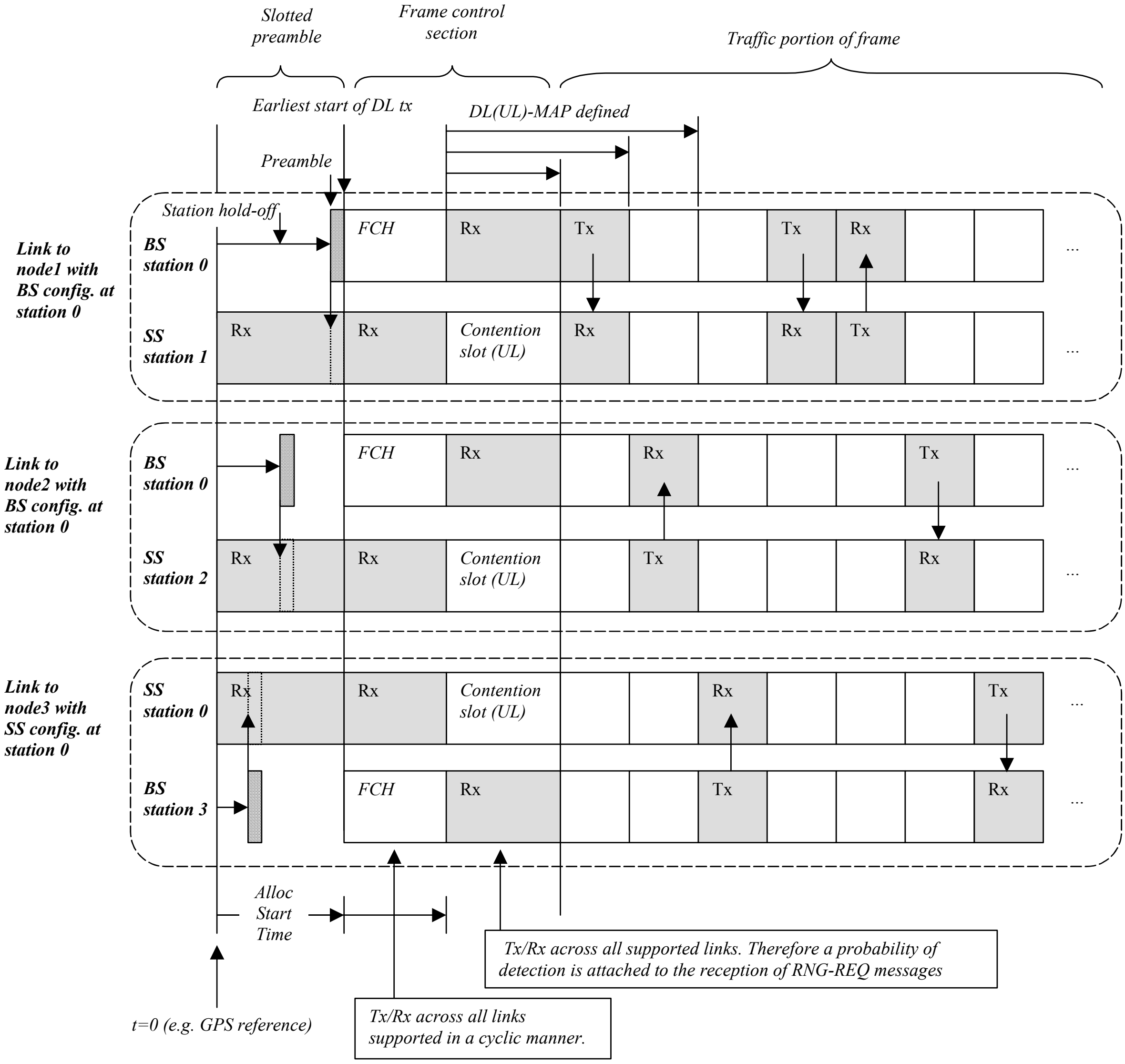

Figure 4 Configuration of links supported by station 0 and the multiple half links for H-FDD-like operation in IEEE802.16. NB Burst preambles are not shown, neither are TRGs. The diagram is not to scale.

2.3 Power control in both UL and DL

2.3.1 Aim

IEEE802.16 only supports power control on the UL. Point–to–point style of operation also inherent within "directional mesh" configurations requires the support of power control for both link directions. This is related to intra–system interference control and the prevention of interference to other systems.

2.3.2 Proposal

It is proposed that power control is introduced as an option in the downlink. This ensures that when configured for point-to-point or mesh operation IEEE802.16 will power control both ends of the link.

2.3.3 Solution

The REP-REQ and REP-RSP MAC message can be used for power control measurements; RNG-REQ and RNG-RSP MAC messages are used for the implementation of power control commands. This is shown diagrammatically in Figure 5, and represents the current state of the IEEE802.16 standard. The REP-REQ can seek both power control and interference avoidance measurements. REP_RSP provides a report following the solicited request. As part of the *Generic header* in the MAC PDU (payload of the PHY burst) the CID can be used to address SS. Including these messages in the PHY burst payload will provide power control measurements for all timeslots, across all frequencies.

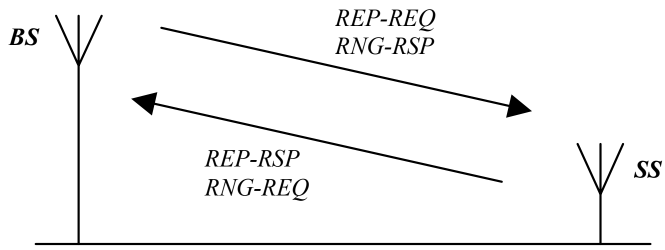

Figure 5 Configuration of MAC messages used in power control.

The IEEE802.16 standard should be extended to allow REP-REQ MAC messages to be sent by both the BS and SS, in addition both the BS and SS should be able to send REP-RSP MAC messages and be mandated to provide the necessary measurements. A similar proposal holds for the case that the RNG-REQ and RNG-RSP MAC message pair used for power control.
It is proposed that the ability to use power control should be extended to systems above 11 GHz – this is currently not required in section 6.4.2.3.33 (IEEE P802.16-2003/D0: page 93).

The signal quality on both the UL and DL can be monitored within the existing standard for point-to-point. The downlink is monitored using the MAC message pair DBPC-REQ/DBPC-RSP. This provides information on downlink performance, while uplink performance can be measured at the BS and controlled by the RNG-RSP MAC message: this is part of the BS originated periodic ranging procedure (section 6.4.10 IEEE P802.16-2003/D0).

2.4 RF channel change and antenna selection between burst profiles

2.4.1 Aim

A method is proposed whereby individual DL and UL bursts can be configured to specify the RF channel and antenna of operation. Antenna selection is used to ensure that the desired physical antenna is chosen at the station.

2.4.2 Proposal

IEEE802.16 specifies within the D(U)CD TLV encoded information for the overall channel (IEEE P802.16-2003/D0: table 14: page 61). Within this parameter a single RF channel is specified by the BS and is used by every SS. Thus one RF channel is used per BS in PMP. It is proposed to generalize the allocation of RF channel between bursts, thus providing flexibility and improved spectral efficiency realizable by point–to–point and mesh configurations.

2.4.3 Solution

It is proposed to include a *RF channel* and *Antenna Number* selection parameter accompanying the **Downlink(Uplink)_Burst_Profile** parameter. 12 burst profiles can be defined, with 5 available for TDMA downlink. It is therefore not practical for the *RF Channel* and *Antenna Number* to be included in this parameter. This adaptation provides improved flexibility required from burst to burst.

RF channel specification in D(U)CD **TLV encoded information for the overall channel** (IEEE P802.16-2003/D0: table 14: page 61) (*Channel Nr*) may be used to configure RF channel and physical antenna values for the frame preamble and FCH. It is therefore proposed to add Antenna Number to the D(U)CD **TLV encoded information for the overall channel**. This selection procedure can be triggered by the PtP/PMP flag proposed for the D(U)L-MAP.

It is proposed in Table 14 of the standard (IEEE P802.16-2003/D0: page 61) to be modified according to Figure 6. The proposal also holds for the UCD (Table 16 (IEEE P802.16-2003/D0: page 63)).

Syntax	Size	Notes
DCD_Message_Format() {		
Management Message Type = 1	8 bits	
Downlink channel ID	8 bits	
Configuration Change Count	8 bits	
TLV Encoded information for the overall channel	Variable	TLV specific **Add *Antenna Number* (2bytes) to table 252 (UL) and 257 (DL) (IEEE P802.16-2003/D0: pages 489 and 494 respectively) for all PHY types.**
Begin PHY Specific Section {		See applicable PHY section
for (*i* = 1; *i* <= *n*; *i*++) {		For each downlink burst profile 1 to *n*
Downlink_Burst_Profile		PHY specific **Add *RF Channel* (2bytes) and *Antenna Number* (2bytes) to tables 253-256 (UL) and 258-261 (DL) (IEEE P802.16-2003/D0: pages 491-494 and 495-498 respectively).**
}		
}		
}		

Figure 6 Proposed modifications to Table 14 (IEEE P802.16-2003/D0: page 61). The proposal also holds for the UCD (Table 16 (IEEE P802.16-2003/D0: page 63)).

2.5 Efficient implementation of power control

2.5.1 Aim

IEEE802.16 supports power control via the REP-REQ/REP-RSP and RNG-REQ/RNG-RSP MAC message pairs. The use of these messages is potentially wasteful with bandwidth due to their size and necessary high duty cycle across a number of timeslot/bursts, i.e. possible frequent power control updates.

It is evident that a PSH header (2bytes) is also required if a MAC SDU containing a REP-REQ or REP-RSP MAC message is included with payload data.
The examples below consider the *Generic header* required to form the MAC PDU. No PSH header is included as this analysis assumes no payload traffic is being carried in the burst/timeslot.

Message	Generic header	MAC message header	Payload	Total
REP-REQ (used for power control measurement request)	6	1	2	9
REP-RSP (whole report including the power control usable measurement)	6	1	11 (max.)	18 (max.)
REP-RSP (report containing the power control usable measurement only)	6	1	9	16
RNG-REQ (power control action request)	6	1	11	18
RNG-RSP (power control action)	6	1	28	35

Figure 7 Comparison of MAC message sizes used for power control. All dimensions are in bytes.

Each timeslot/burst would require (9+35) 44bytes to implement power control from BS to SS, and from SS to BS would require (16+18) 34bytes. This is an inefficient mechanism for power control. Ideally it is possible to represent power control command with a single bit to signal an increase or decrease in power by means of a zero or one respectively.

2.5.2 Proposal

It is proposed to add shorter MAC messages for reduced bandwidth requirements for power control operation. It is also proposed to remove the need for request MAC messages as BS or SS could be configured to send responses at regular, predefined, intervals.

2.5.3 Solution

REP-REQ need not be sent over the air interface but may be generated locally to stimulate a response (section 6.4.2.3.33: IEEE P802.16-2003/D0: page 93). It is possible, for the REP-RSP MAC message (section 11.1.7: IEEE P802.16-2003/D0: page 501), to remove the following parameters:

- Channel number,
- Start frame,
- Duration,
- Basic report,
- RSSI report.

This reduces the size of the REP-RSP MAC message to 9bytes from 16bytes, leaving only the *CINR report*. This is shown in Figure 8.

REP-REQ Report type	Name	Type	Length	Value
~~bit #0=1~~	~~Channel number~~	~~1.1~~	~~1~~	~~Physical channel number (see 8.6.1) to be reported on.~~
~~bit #0=1~~	~~Start frame~~	~~1.2~~	~~2~~	~~Frame number in which measurement for this channel started.~~
~~bit #0=1~~	~~Duration~~	~~1.3~~	~~3~~	~~Cumulative measurement duration on the channel in multiples of Ts. For any value~~

				~~exceeding 0xFFFFFF, report 0xFFFFFF.~~
~~bit #0=1~~	~~Basic report~~	~~1.4~~	~~1~~	~~Bit #0: WirelessHuman detected on the channel~~ ~~Bit #1: Unknown transmissions detected on the channel~~ ~~Bit #2: Primary User detected on the channel~~ ~~Bit #3: Unmeasured. Channel not measured~~
~~bit #1=1~~	CINR report	1.5	2	1 byte: mean (see also 8.3.2, 8.4.8, 8.5.11) for details) 1 byte: standard deviation
~~bit #2=1~~	~~RSSI report~~	~~1.6~~	~~2~~	~~1 byte: mean (see also 8.3.2, 8.4.8, 8.5.11) for details)~~ ~~1 byte: standard deviation~~

Figure 8 Proposal for amended REP-RSP TLV parameters for use in power control in section 11.1.7: IEEE P802.16-2003/D0: page 501.

Considering the RNG-REQ message; again this can be suppressed and generated locally (section 6.4.2.3.5: IEEE P802.16-2003/D0: page 65). The RNG-RSP MAC message can be reduced to 8bytes from 35bytes by removal of all but the *Power Level Adjust* element (section 11.1.4, tables 263 and 264: IEEE P802.16-2003/D0: pages 499 and 500). *This element is the transmit power offset adjustment (signed 8 bit, 0.25 dB units) and specifies the relative change in transmission power level that the SS is to make in order that transmissions arrive at the BS at the desired power.*
The proposal is summarized in Figure 9 with new names suggested for the reduced scope MAC messages. Power control messages are therefore specific to CIDs and therefore in point–to–point and mesh configuration specific to timeslot/burst.

Message	Generic header	MAC message header	Payload	Total
REP-RSP (measurement) **Suggested name change: REP_PC**	6	1	2	9
RNG-RSP (power control action) **Suggested name change: RNG_PC**	6	1	1	8

Figure 9 Proposal for amended MAC message for power control. All dimensions are in bytes.

2.6 Radar avoidance

2.6.1 Aim

To provide measurements of radar interference in support of markets where the detection of such radar is mandated; for example the 5GHz band in Europe.

2.6.2 Proposal

The measurement technique for radar detection is distinct from that provided by the REP-RSP MAC message that is used to measure long duration interference based on the impact on a burst preamble. It is also proposed that sufficient scope is made within the standard for radar detection and that detection can be achieved within defined timescale and with a certain degree of confidence. It is also proposed that any radar detection solution complies with ETSI EN301.893 [4].

2.6.3 Solution

To complement the interference avoidance discussed in section 6.4.14 (IEEE P802.16-2003/D0: page 242) it is expected that conformance to ETSI EN301.893 will provide a solution for both for RLAN and BFWA co-existence with radar. Figure 10 provides a mechanism for generating reports when radar is detected. Given that radar is detected this MAC message shall be sent in an unsolicited manner.

REP-REQ Report type	Name	Type	Length	Value
bit #0=1	Channel number	1.1	1	Physical channel number (see 8.6.1) to be reported on.
bit #0=1	Start frame	1.2	2	Frame number in which measurement for this channel started.
bit #0=1	Duration	1.3	3	Cumulative measurement duration on the channel in multiples of Ts. For any value exceeding 0xFFFFFF, report 0xFFFFFF.
bit #0=1	Basic report	1.4	1	Bit #0: WirelessHuman detected on the channel Bit #1: Unknown transmissions detected on the channel Bit #2: Primary User detected on the channel Bit #3: Unmeasured. Channel not measured
bit #1=1	CINR report	1.5	2	1 byte: mean (see also 8.3.2, 8.4.8, 8.5.11) for details) 1 byte: standard deviation
bit #2=1	RSSI report	1.6	2	1 byte: mean (see also 8.3.2, 8.4.8, 8.5.11) for details) 1 byte: standard deviation
<don't care>	**Radar report**	**1.7**	**1**	**bit 1 =1 Radar detected** **bit 1 = 0 Radar not detected**

Figure 10 Proposal for amended REP-RSP TLV parameters to handle radar detection in section 11.1.7: IEEE P802.16-2003/D0: page 501.

Procedures are required to address distinct areas of regulation. These are to be added to a new section 6.4.16: IEEE P802.16-2003/D0: page 246. The procedures are outside the scope of the standard but are defined in EN301.893 [4]. The procedures are:

- Monitoring of RF channels before and during use,
- Detection of radar at a minimum power level,
- The detection of radar should result in an RF channel change within a defined period,
- Provide uniform system loading across all RF channels.

Other procedures outside the scope of EN301.893 [4] may also be included for improved system performance and stability. These are:

- Negotiation of quiet times in the network for radar monitoring,
- Maintaining a list of usable RF channels,
- Detection with defined probabilities of success,

- Support for algorithms designed to reduce the probability of false detection,
- Possible use of schemes to detect radar during normal traffic reception.

In addition, it is proposed that the term DFS be attributed to radar detection only and not to general interference avoidance of related systems. The term DFS is used widely in section 6.4.14: IEEE P802.16-2003/D0: page 242 and shall be replaced.

2.7 MAC message tunneling

2.7.1Aim

Within IEEE802.16a the ability to tunnel MAC messages is not required outside the current mesh option. As “directional mesh” configurations embody the routing of user traffic through SS then MAC message tunneling is required. It is necessary to tunnel MAC messages to new stations in the system and at times of system reconfiguration.

2.7.2 Proposal

To include all relevant MAC messages used for point-to-point and mesh operation in the IEEE802.16 standard. Currently only 802.16a mesh related messages are included.

2.7.3 Solution

Extend table 105 (section 6.4.15: IEEE P802.16-2003/D0) to include all supported MAC messages. In addition, the ability to tunnel MAC messages should not be limited to the currently defined mesh mode of operation but also be available to support point-to-point style of operation.

3. Conclusions

This paper has proposed a set of enhancements to IEEE P802.16-2003/D0 that will support optional improvements related to a point-to-point style of operation supporting mesh and antenna management procedures. The proposals could be readily added to the planned revision of the 802.16 suite of standards.

4. Commentary proposals

Specific proposals for all the items in this contribution are included as a set of formal comments, submitted as invited in the call for comments

4.1 A flexible, partitioned frame structure

Comment:

Although the standard allows for a mesh configuration and can be configured for a basic form of point-to-point operation, the burst structure for these configurations is potentially spectrally inefficient. An effective optional improvement can be described which allows freedom in defining where a DL or UL transmission occurs.

Suggested remedy:

Include an optional burst structure with a TDD nature by using FDD-like half-duplex bursts, as described in IEEE C802.16d-2003/55 section 2.1. The following changes are proposed:
In table 248 (IEEE P802.16-2003/D0: page 481):

- Make maximum value for "DL-MAP interval" the default value, no maximum value,
- Make maximum value for "DCD interval" the default value, no maximum value,
- Make maximum value for "UCD interval" the default value, no maximum value,
- Make maximum value of "Lost DL-MAP interval" the default value, no maximum value,
- Make maximum value of "Lost UL-MAP interval" the default value, no maximum value,
- Make maximum value of T1 "Wait for DCD timeout" equal to 50seconds (previous value based on a 10second value of "DCD interval" multiplied by 5),
- Make maximum value of T12 "Wait for UCD descriptor" equal to 50seconds (previous value based on a 10second value of "UCD interval" multiplied by 5),
- For maintenance of point-to-point links and where infrequent UL-MAP and UCD MAC messages are expected Figure 61 (IEEE P802.16-2003/D0: page 163) should use a new parameter T22, instead of T12. For T22: *System* is "SS", and *Time reference* is "*Point-to-point maintenance*". There should be no maximum value for T22. The default value of T22 may be 15 minutes. The extended value of T22 ensures the SS does not time-out prematurely.

For the optional burst structure to be realizable it is necessary to allow FDD-like operation to be permitted in unlicensed spectrum when operating with point-to-point or mesh configuration. Table 1 (IEEE P802.16-2003/D0: page 2) should be modified accordingly.

4.2 Frame synchronization and management

Comment:

When operating in point-to-point or mesh configuration it is expected that a station will be expected to support one or a number of links to neighboring stations. The standard currently requiring BS or SS behavior to be adopted at each end of the link. It is proposed that an optional frame configuration that supports H-FDD-like operation is provided. This will allow a station to support single or multiple links as either a BS or SS or both.

Suggested remedy:

It is likely from such a configuration that there will be a gap between the frame preamble and the frame control header (FCH). It is proposed that the addition of a *start alloc time*, defined in the DL-MAP Table 15 (IEEE P802.16-2003/D0: page 62), provides an indication of the start of the FCH. This parameter will be 32bit representation of the start of the FCH in mini-slots (similar to the UL version). The modified DL-MAP is shown in IEEE C802.16d-03/55 figure 2.

4.3 Power control in both UL and DL

Comment:

The IEEE802.16 standard only supports power control in the UL direction. Efficient point-to-point style of operation inherent within mesh requires bi-directional power control. This will improve frequency reuse and coexistence (both intra-system and inter-system). In some bands such power control is mandated for regulatory compliance.

Suggested remedy:

In IEEE C802.16d-03/55 section 2.3 a proposal defines a simple method for configuring power control in both UL and DL. The following changes are proposed:

- Permit the SS to send REP-REQ MAC messages for power control measurement defined in section 6.4.2.3.33 (IEEE P802.16-2003/D0: page 93),
- Permit the BS to send REP-RSP MAC messages for power control measurement defined in section 6.4.2.3.33 (IEEE P802.16-2003/D0: page 93),
- Permit the BS to send RNG-REQ MAC messages for power control action defined in section 6.4.2.3.5 (IEEE P802.16-2003/D0: page 65),
- Permit the SS to send RNG-RSP MAC messages power control action defined in section 6.4.2.3.6 (IEEE P802.16-2003/D0: page 66),
- Permit BS to make measurements from the UL burst preamble and keep records of these measurements to produce REP-RSP MAC messages as in (IEEE P802.16-2003/D0: sections 8.3.2 (page 378), 8.4.8 (page 420), 8.5.11 (page 467)),
- Permit the SS to analyze REP-RSP MAC messages and generate RNG-RSP MAC messages accordingly as defined in section 6.4.2.3.6 (IEEE P802.16-2003/D0: page 66).
- Permit the Channel Measurement Report/Response MAC messages, section 6.4.2.3.33 (IEEE P802.16-2003/D0: page 93), to be used above 11 GHz.

4.4 RF channel change and antenna selection between burst profiles

Comment:

The standard does not include a general method for supporting configurable antenna systems (adaptive arrays, steered antenna systems or switched arrays). An optional method is proposed which allows for antenna direction/selection and RF frequency to be supported in each burst. This will allow the use of a range of "smart" antenna systems for PMP, point-to-point and mesh configurations, across the full 2-66 GHz frequency range addressed by the consolidated draft standard.

Suggested remedy:

A method is proposed in IEEE C802.16d-03/55 section 2.4 whereby individual DL and UL bursts can be configured to specify the RF channel and antenna/direction of operation. The following changes are proposed:

- Amend “UCD channel encoding” table 252 (IEEE P802.16-2003/D0: page 489) to include an *Antenna Number* type. The suggested code number is 4. Length is 2 bytes. This is for all PHY types.
- Amend “UCD burst profile encodings-WirelessMAN-SC” table 253 (IEEE P802.16-2003/D0: page 491) to include an *Antenna Number* type (length is 2 bytes) and *Channel Number* type (length is 2 bytes).

- Amend “UCD burst profile encodings-WirelessMAN-SCa” table 254 (IEEE P802.16-2003/D0: page 492) to include an *Antenna Number* type (length is 2 bytes) and *Channel Number* type (length is 2 bytes).
- Amend “UCD burst profile encodings-WirelessMAN-OFDM” table 255 (IEEE P802.16-2003/D0: page 493) to include an *Antenna Number* type (length is 2 bytes) and *Channel Number* type (length is 2 bytes).
- Amend “UCD burst profile encodings-WirelessMAN-OFDMA” table 256 (IEEE P802.16-2003/D0: page 494) to include an *Antenna Number* type (length is 2 bytes) and *Channel Number* type (length is 2 bytes).

- Amend “DCD channel encoding” table 257 (IEEE P802.16-2003/D0: page 494) to include an *Antenna Number* type. The suggested code number is 17. Length is 2 bytes. This is for all PHY types.
- Amend “DCD burst profile encodings-WirelessMAN-SC” table 258 (IEEE P802.16-2003/D0: page 495) to include an *Antenna Number* type (length is 2 bytes) and *Channel Number* type (length is 2 bytes).
- Amend “DCD burst profile encodings-WirelessMAN-SCa” table 259 (IEEE P802.16-2003/D0: page 496) to include an *Antenna Number* type (length is 2 bytes) and *Channel Number* type (length is 2 bytes).
- Amend “DCD burst profile encodings-WirelessMAN-OFDM” table 260 (IEEE P802.16-2003/D0: page 497) to include an *Antenna Number* type (length is 2 bytes) and *Channel Number* type (length is 2 bytes).
- Amend “DCD burst profile encodings-WirelessMAN-OFDMA” table 261 (IEEE P802.16-2003/D0: page 498) to include an *Antenna Number* type (length is 2 bytes) and *Channel Number* type (length is 2 bytes).

4.5 Efficient implementation of power control

Comment:

Power control message overhead is significant, particularly in point-to-point and mesh configurations, it is desirable to implement an optional method with lower overhead.

Suggested remedy:

In IEEE C802.16d-03/55 section 2.5 an optional method is proposed that allows significant reduction in overhead when implementing power control. The proposal is summarized in Figure 9 of the contribution. The following changes are proposed:

- Amend REP-RSP TLV parameters in section 11.1.7 (IEEE P802.16-2003/D0: page 501) as shown in IEEE C802.16d-03/55 figure 8 (to include only the *CINR report* parameter). This will provide a new optional MAC message called REP_PC.
- Amend RNG-RSP TLV parameters in section 11.1.4 (table 263) (IEEE P802.16-2003/D0: page 499) to include only the *Power Level Adjust* parameter. This will provide a new optional MAC message called RNG_PC.

4.6 Radar avoidance

Comment:

For some frequency bands and countries, the detection, identification and avoidance of interference from radars is required. An example is the 5 GHz frequency band for Europe. This kind of interference is distinct from that catered for by use of the REP-RSP MAC message – used for longer duration interference, rather than narrow pulsed interference (section 6.4.14: IEEE P802.16-2003/D0: page 242). To allow for radar detection and avoidance mandated in ETSI EN301.893 additions to the standard are required.

Suggested remedy:

Figure 10 of IEEE C802.16d-03/55 provides a mechanism for generating reports when radar is detection. Given that radar is detected this MAC message shall be sent in an unsolicited manner.

Procedures are required to address distinct areas of regulation. These are to be added to a new section 6.4.16: IEEE P802.16-2003/D0: page 246. The procedures are outside the scope of the standard but are defined in EN301.893 [4]. The procedures are:

- Monitoring of RF channels before and during use,
- Detection of radar at a minimum power level,
- The detection of radar should result in an RF channel change within a defined period,
- Provide uniform system loading across all RF channels.

Other procedures outside the scope of EN301.893 [4] may also be included for improved system performance and stability. These are:

- Negotiation of quiet times in the network for radar monitoring,
- Maintaining a list of usable RF channels,
- Detection with defined probabilities of success,
- Support for algorithms designed to reduce the probability of false detection,
- Possible use of schemes to detect radar during normal traffic reception.

In addition, it is proposed that the term DFS be attributed to radar detection only and not to general interference avoidance of related systems. The term DFS is used widely in section 6.4.14: IEEE P802.16-2003/D0: page 242 and shall be replaced.

4.7 MAC message tunneling

Comment:

MAC message tunneling is currently limited to 802.16a. In order to support point-to-point and mesh configurations in all available frequency band in the 2-66 GHz frequency range, it is proposed to extend MAC message tunneling to 802.16 (IEEE P802.16-2003/D0).

Suggested remedy:

It is proposed that the scope of table 105 (IEEE P802.16-2003/D0: page 245) be extended to the entire frequency range of operation and not limited to mesh mode of operation. The support for tunneling MAC messages should be extended to include all MAC messages within the standard (section 6.4.2.3: IEEE P802.16-2003/D0: page 59) and not limited to those in table 105 (IEEE P802.16-2003/D0: page 245).

5. Abbreviations

BFWA	Broadband Fixed Wireless Access
BS	Base Station
CS	Convergence Sublayer
CPS	Common Part Sublayer
DCD	Downlink Channel Descriptor
DCS	Dynamic Channel Selection
DFS	Dynamic Frequency Selection
DL	Down Link
DL-BTG	Down Link-Burst Transition Gap
FCH	Frame Control Header
GPS	Global Positioning System
H-FDD	Half-duplex Frequency Division Duplex
MAC	Media Access Control
OFDM	Orthogonal Frequency Division Multiplex
PMP	Point to Multi-Point
PS	Physical Slot
PSH	Packing Sub Header
PtP	Point to Point
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RLAN	Radio Local Area Network
RSSI	Received Signal Strength Indicator
RTG	Receive Transmit Gap
SAP	Service Access Point
SBA	Switched Beam Antenna
SNR	Signal to Noise Ratio
SS	Subscriber Station
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access
TRG	Transmit Receive Gap
UCD	Uplink Channel Descriptor
UL	Up Link

6. References

[1] IEEE Standard 802.16, *Air Interface for Fixed Broadband Wireless Access Systems*.

[2] Eklund C, et al., *IEEE Standard 802.16: A technical Overview of the WirelessMAN Air Interface for Broadband Wireless Access*, IEEE Communications Magazine, June 2002.

[3] Stanwood K., Marks R. B., *Proposal to add point-to-point option to IEEE802.16 MAC*, 21 July 2003, http://www.ieee802.org/16/docs/03/C80216-03_11.pdf.
[4] Draft ETSI EN 301 893 V0.r (2003-4): *Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive ETSI*.
[5] Herrera J., Polo V., Martinez J. M., Sanchis P., Corral J. L., Marti J., *Switched beam antennas in millimeter-wave band broadband wireless access networks,* 16 July 2003, http://www.ieee802.org/16/docs/03/C80216-03_09.pdf.

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