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Title	**Reservation Tools for the 802.16.4 MAC**
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Re:	This document is submitted in response to IEEE 802.16.4-00/01 **Call for Contributions for Modifications of 802.16 MAC and 802.11a - HIPERLAN/2 PHY for the WirelessHUMAN Standard**
Abstract	This document figures the changes needed in the TG1 MAC reservation tools to adjust them to the TG4 PHY and to serve the specific needs of TG4 applications
Purpose	The document is submitted as a part of development of 802.16.4 MAC given TG1 MAC as a baseline
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Reservation Tools for the 802.16.4 MAC

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1. References

[1] IEEE 802.16.1/D1 - 2000, December 2000. Draft Standard for Air Interface for Fixed Broadband Wireless Access Systems
[2] IEEE 802.16.3-00/02r4. Functional Requirements for the 802.16.3 Interoperability Standard
[3] IEEE 802.16.3p-00/56.Using the TG1 MAC for the TG3 Purposes. V.Yanover, S.Varma, H.Ye
[4] Subir Varma. Comments on the use of the TG1 MAC for TG3 Purposes. IEEE 802.16.1c-00/11

2. Foreword

This documents addresses the issues pointed by [2], [3] as required for the accommodation of the 802.16.1 MAC [1] to the needs of the 802.16.4 applications where the total demand per Base Station (sector) is an integration of numerous (tens or even hundreds) streams passing to/from CPEs.

Each stream might expose both continuous and discontinuous (bursty) demand. In the latter case the demand might be triggered by an arrival of a single upper layer PDU such as an IP datagram encapsulated into an Ethernet packet. Demand duty cycle might be very low, especially for residential subscribers. For example, such a subscriber might require data transfer once in a minute, during few seconds only.

In such conditions, it becomes critically important to provide powerful reservation tools for encountering the demand for uplink data transmission.

Each topic of this document contains a special paragraph that points to the specific way of integration of the proposed function into [1]. Some of the issues (like Parallel Polling) need certain support from PHY (that is already in for the case 802.16.4). So their evaluation should be postponed up to the moment when the basics of 802.16.4 PHY become more clear. These ideas are present here because they may to influence on the PHY definition assuming the great advantages this may provide for the performance of 802.16.4 systems.

3. Reservation Tools

3.1. Parallel Polling

3.1.1. Proces Description

This function should have a support in PHY (in OFDM it is based on the usage of different subcarriers). It may be used for both GPC and GPT modes.

Parallel Polling for OFDM is using N time slots, each one of the length of one OFDM symbol. Each SU having UL demand has its own set of time-subcarrier slots within the total 64 x N available. It is supposed that AU assigns a set of slots to each SU. Special multicast

CIDs should be assigned to certain groups of SSs that e.g. have been evaluated as having the same probability of changing the activity.

Transmission in the slots assigned to the SU means that it has a data to Tx. More slots may be assigned to the same SU to enlarge the number of bits to be transferred (may require to apply a sort of FEC). This code then is considered as a binary number N that means request for possibility to Tx N symbols in UL direction

If implemented, this type of polling would have a great advantage comparatively to the regular unicast or multicast polling.

Suppose that we have 100 SSs to be polled to encounter appearance of the uplink demand. Unicast polling with 802.11a-like PHY and the 3.5 MHz wide Radio channel may require as many as 300 OFDM symbols (~ 50 ms). Multicast polling, assuming only 10 SSs actually having a demand, may require 90 symbols ~ 1.5 ms. Parallel Polling may take 20 symbols ~ 360 usec. Assuming the frame length is 5 ms and we use for the above process 10% of the frame time, we get the transaction delays correspondently 500 ms, 15 ms and 3.6 ms. Note also that the Parallel Polling is the complete polling of all the SSs while the performance of the Multicast Polling has a statistical nature.

3.1.2. Update Needed in 802.16 MAC Document

This update should be postponed up to the moment when the basics of the 802.16.4 PHY become clear. These ideas are present here because they may to influence on the PHY definition assuming the great advantages this may provide for the performance of 802.16.4 systems

The following changes needed in [1] to employ Parallel Polling.

3.1.2.1. New Parameter

A new parameter should be added under the 11.1 MAC Management Message Encodings . This is a parameter carrying the information of the following format:

{Slot Number (1 byte) , Subcarrier Mask (8 bytes)}
This parameter assigns the correspondent slots/subcarriers for the usage by the given SS. The Slot Number is an offset (0 based) from the beginning of the region allocated by the UL-MAP Information Element with the multicast CID associated with the given SS.

3.1.2.2. New Types of Management Messages

These types are

1. Parallel Polling Group Assignment Request (PPA-REQ) Message. This message contains the CID, Transaction ID and the set of TLVs that assigns the slot(s) to be used by the given SS, in the format {Slot #, Subcarrier Mask}
2. Parallel Polling Group Assignment Response (PPA-RSQ) Message confirms the reception of the PPA-REQ messages and agreement between SS and BS on usage of certain time slots for the Parallel Polling.

Both messages will be described under 6.2.1.2 MAC Management Messages [1].

3.1.2.3. New UIUC

Location: Table 4 in 6.2.1.2.4, line 5 page 55 [1].

A new UIUC will be needed to define time allocation of a time slot for the parallel polling. The Connection ID used in the UL-MAP message for this process should be a multicast address.

3.1.2.4. PHY Definitions in

The PHY section should define the waveforms to be used for the Parallel Polling (e.g. combinations of OFDM subcarriers). The correspondent transmissions will be of one symbol long.

3.1.2.5. Capabilities

The correspondent TLVs should be added to Registration Request message (SS capabilities) and Registration Response message (REG-RSP). The encoding is TBD.

3.2. Flexible Frame Size as a Tool for Better Channel Utilization

3.2.1. Motivation

The 802.16.4 residential and similar applications may expose considerable changes in the number of serviced SSs e.g. associated with busy hours. So it becomes important to provide more flexibility in the tradeoff between the channel utilization and the response time (which is one of the main delay components).

The frame size defines the minimum latency in the DL and UL transmissions. In the original 802.16.1 MAC this is a constant. It is proposed for the 802.16.4 applications to employ the variable frame size that may change from frame to frame. This allows for changing the periodicity and moments of DL/UL switching so adjusting the frame structure to the rate of changes in the demand.

3.2.2. Changes Required in DL-MAP Message Definition

The 802.16.4 system has to broadcast the length of the current/next frame in the DL- or UL-MAP message, for that a new TLV is needed. This TLV should be added under the 6.2.1.2.3 Downlink MAP (DL-MAP) Message , in the 802.16.4 version of PHY Synchronization Field (Figure 16) line 18, page 50 [1]. The length will be expressed in the correspondent (TBD) PHY specific units. One of the options should be UNDEFINED that means no restrictions applied so that the actual frame time is defined each frame as an interval between the consequent DL-MAP messages.

The following text at line 7, p.20 [1]

3.14 Frame: A frame is a fixed duration of time, which contains both transmit and receive intervals. is proposed to change to the following

3.14 Frame: A frame is a fixed duration of time, which starts from the beginning of the burst containing DL-MAP message and lasts up to the beginning of the next burst containing DL-MAP message

3.2.3. New UIUC

Location: Table 4 in 6.2.1.2.4, line 5 page 55 [1]. A new UIUC will be needed to figure LIMITED type of time allocation for the specific SS. If this UIUC is used in the UL-MAP Information Element, it means that the offset value provides the maximum time to be used by the given SS. The actual time (as well as the transmission rate in the case of PHY header is applied) is at the discretion of the SS. After the completion of SS transaction, the BS may re-allocate to the rest of the specified time interv l

It is proposed to add to the Table 4 (Uplink Map Information Elements line 6, page 55 [1]) the following new raws:

IE Name	Uplink Interval Usage Code (UIUC)	Connection ID	Offset
Restricted grant	12	any	This UIUC is used to grant the connection / SS the limited amount of time (that potentially may not be completely used by the SS). The PHY parameters are not specified[1]
Offset of the start of the next frame	13	zero	[In proper TG3 PHY units]

3.3. Improved Piggybacked Requests

It is suggested to changed GM field in the Figure 5, page 37 [1] to at least 15 bits. This is needed to provide at least the same functionality as for the standalone reservation request (Figure 7).

3.4. SS Decision on the Transmission Rate

This function would improve flexibility in the channel usage and make possible more dynamic changes in the transmission policy following the changes in the channel state. It may be used for both scheduled and contention based transmissions allowing e.g. respond by a data message to the poll from BS instead of sending BW reservation request first.

This function should have a support in PHY. In 802.11a-like OFDM it may be based on usage of the SIGNAL field attached to the transmitted data where all the PHY properties are figured.

In this case it is proposed to add the following new UIUC

IE Name	Uplink Interval Usage Code (UIUC)	Connection ID	Offset
Non-specified set of PHY parameters	14	any	This UIUC is used to grant the connection / SS certain amount of time to be used by the SS at its discretion