Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Accommodation of the TG1 MAC at TG4**
Date Submitted	**2001-01-13**
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Re:	This document points to some issues that should be resolved for further progress in the direction to TG4 MAC given TG1 MAC as a baseline. It 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	The following issues considered: – Lower channel quality: ARQ, Power/rate control – Features Related to Specific Traffic Demand Statistics – Changes implied by the difference in PHY – QoS parameters – Dynamic Frequency Selection
Purpose	The document is submitted as a part of development of 802.16.4 MAC given TG1 MAC as a baseline
Notice	
Release	
Patent Policy and Procedures	

Accommodation of the TG1 MAC at TG4

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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] A Behavioral Model of Web Traffic, Hyoung-Kee Choi, John O. Limb. Georgia Institute of Technology, 1999
[4] The nature of the beast. Recent traffic measurements from an Internet Backbone. By Greig Miller and Kevin Thompson, 1997.
[5] IEEE 802.16c-00/10. Some Issues of Accommodation of TG1 MAC at TG3. By Vladimir Yanover
[6] IEEE 802.16p-00/10. Some Issues of Accommodation of TG1 MAC at TG3. By Vladimir Yanover
[7] IEEE 802.16.3p-00/56.Using the TG1 MAC for the TG3 Purposes. V.Yanover, S.Varma, H.Ye
[8] IEEE 802.16.3-01/XX. Reservation Tools for the 802.16.4 MAC. Naftali Chayat, Vladimir Yanover
[9] IEEE 802.16.3-01/XX. Data Integrity in 802.16.4 MAC Naftali Chayat, Vladimir Yanover, Inbar Anson

2. Goal of the Document

This document points to some issues that should be resolved for further progress in the direction to TG4 MAC given [1] as a baseline. It should be considered together with [8], [9].

3. Main Problems

There are two groups of problems that appears in the accommodation of the TG1 MAC [1] to the needs of the TG4. The problems of the first group are exactly the same as for TG3 MAC:

- TG1 MAC Should be cleaned from the TG1 PHY specific definitions, parameters etc. (this is partially done)
- TG4 Systems will function in a more hostile channel environment as compared to TG1:
    - Co-channel interference
    - Multipath
- TG4 Systems will see a different mix of traffic types as compared to TG1
    - TCP traffic will dominate, as opposed to TDM
    - Support large number of relatively low bit rate bursty sources

See [6-7] about more detailed description of the problems and possible solutions.

The second group form the problems specific to the usage of non-licensed frequency bands. These problems are

- 802.11a/HIPERLAN-like PHY features are to be supported
- A definition of the QoS should be done
- The definition of the QoS parameters set, UL services and reservation tools should be changed accordingly
- Recovery features should be employed to ensure QoS support while operating in the band suffering from the random bursty interference
- Such (PHY) features as Dynamic Frequency Selection and Adaptive Power Control should be supported by MAC

4. Problems and Solutions Common for TG3 and TG4

The following solutions proposed in [6]-[7] for the TG3 specific problems should be applied also to the TG4 MAC. See the documents [8], [9] submitted to 802.16 for the details.

4.1. Lower Channel Quality

The following are the reasons why we have to be ready for lower channel quality and less stable channel conditions than in the TG1 applications

- Cheap CPEs with less budget to installation and less possibilities for an operator to place better antennas at proper places
- Lower Radio frequencies together with possible in-door deployment imply multipath interference
- Inter-cell interference in mass cellular deployment
- Interference because of sharing the medium with e.g. hidden 802.11-UNII band terminals and simply non-IEEE devices

Above reasons may essentially increase BER so that the FER (Frame Error Rate) might go as high as to several percents. This triggers the higher layers retransmissions, which impact negatively on the TCP applications (very sensitive to the delay variations and packet loss). So additional functions needed to fight against these problems, such as

- **MAC Level ARQ** including (see comment at [1], 2.5)
  - Checksum definition for a fragment
  - ARQ Feedback concept (ACK, NACK, ACK timeout, interaction with Convergence Layer entities, etc.) and the coding of the correspondent messages
- **Dynamic Rate Control (per packet)**, clearly associated in implementations with ARQ (packet failure requires retransmission at lower rate etc.)
- **Transmit Power Control**, designed to deal with long no-transmit periods and fast recovery. Possible solution could be, for example, a RNG-RSP -like packet [1] sent by a BS as a response to an uplink packet ad BS s discretion.

4.2. Features Related to Specific Traffic Demand Statistics

The following paragraph describes the traffic demand characteristics expected in the Wireless Data Access types of applications. For the residential and SOHO deployment the Internet access obviously becomes the most important if not a dominant application.

Possible solutions for the specific problems are briefly sketched.

4.2.1. Expected Traffic Demand Features

4.2.1.1. Numerous Streams with Low Duty Cycle

4.2.1.1.1. Problem

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. See [3] for more details.

Thus the total uplink demand is a composition of a large number of small elementary demands, with low duty cycle, that appear randomly and independently at numerous CPEs.

This implies a specific problem of the fast recognition of UL demand.

4.2.1.1.2. Possible Solution

The best solution is based on the Parallel Polling mechanism when each CPE is choosing to transmits in some of small contention slots chosen according to some binary code so that the BS can reduce further polling to a small subset of the associated CPEs [8].
One more solution is to employ some sort of slotted fragmented data contention instead of slotted Bandwidth Request.

One more possible solutions is to employ contention-based data frame transfers with exponential Backoff (as in 802.11 DCF with usage RTS-CTS type transactions).

4.2.1.2. Statistics of Packet Sizes

See e.g. [4] for the statistics of packets sizes in the Internet: 60% of the packets are < 200 bytes and 80% of packets < 600 bytes. This statistics is expected to be valid also for the demand of residential and similar CPEs. This calls for lowering the overheads in MAC messages and in allocation granularity.

So the problem is to provide a mechanism for allocation to a large number of small independent data units in both DL and UL directions. For that a concatenation mechanism might be employed [7].

5. TG4 Specific Problems and Solutions

5.1. 802.11a/HIPERLAN-like PHY Support

The following definitions in [1] should be changed to the terms of 802.11a PHY instead TG1 PHY.

1. Change the messages related to frame structure (like DL-MAP) Definition of the Uplink Channel Descriptor attributes including the Physical Layer Burst Profile Parameters (UCD message)
2. The same should be done for Downlink Channel Descriptor
3. Redefine correspondently the PHY Control portion of the downlink subframe
4. Redefine PHY Synchronization issue and the relevant messages
5. The measurement functions, such as delay, frequency offset and power measurement functions should be described applying to 802.11a terms

5.2. A new definition of the QoS

The QoS concept should be clarified concerning TG1 changes to the direction desired for TG4. The difference between TG1 (TG3) and TG4 is that an unlicensed frequency band is used so virtually nothing is known about the interference and therefore cell capacity.

To bind this problem to reality, we have to remind real life experience of the companies that goes for the deployment of wireless data access equipment in unlicensed band(s). They never have the situation when nothing is known . They try the given unlicensed band in the specific location If the level of interference is acceptable, they install equipment and provide the service. This may last for years. Finally, the company may switch to licensed frequencies or simply leave the business. So the first lesson is that

- There is always enough capacity

Now, there still may be interference in some busy hours of the day. The solution may be

- To provide the committed QoS when there is no or little interference
- To survive increasing of the interference
- To provide fair degradation of QoS to all SSs/connections

This definition is proposed for the QoS for the unlicensed band(s).

This definition can be followed by the schedule using the information on degradation (measured: retransmissions overhead etc.)

5.3. New QoS parameters' Sets and UL Services

The new point in 802.16.3 comparatively to 802.16.1 is that the situation when the active set of QoS parameters cannot be actually kept because of the unpredictable interference. So we need to define certain signaling to support MAC behavior in this situation:

- The messages DSA-XXX ([1], 6.2.1.2) have to accommodate TBD means to assign priorities in keeping the QoS parameters within the given boundaries. Example: if the boundaries are given for the CS PDU s loss rate and delay, there may be priority to handle e.g. delay, possible increasing in the loss rate.
- Certain features should be defined on alarming higher layer applications when the parameters come out of the defined range. This requires additions in 6.1.1. Primitives .

5.4. MAC Frame Structure

MAC Frame structure should be reconsidered to remove the requirement of the constant length frame.

The 802.11a PHY includes possibility to have SIGNAL field in the beginning of the PHY PDU so that there is no need to define the PHY parameters through MAP messages. So the format MAP messages ([1], 6.2.1.2) should be changed to involve the possibility to define the time slot for the SS without specifying the PHY parameters for the transmission.

Reconsider the MAC Control portion of the downlink subframe. Time unit(s) should be redefined including the time units used in MAP messages and Tx/Rx, Rx/Tx gaps and possibly duration of inter-burst gaps or mid-ambles should be defined in the same units. (See [1], definition of DCD and UCD messages)

5.5. Constants and Content of Messages Related to Performance, Delays, QoS

These topics should reconsidered to apply the parameters relevant to 802.16.3 PHY instead of 802.16.1 PHY.

5.5.1. Frame Length

See Frame Length options in PHY Synchronization topic, [1]: 0.5, 1, 2 milliseconds.
The TG4 type of applications obviously requires flexible frame size that may change from frame to frame, dependently on bit rates and granularity of the capacity allocation.

Suppose we transmit from a CPE to BS using the rate 4 Mbps. Then for 1 ms we may transmit 4000 bits. If the DL/UL ratio is 3:1 and only 50% is actually used by the given CPE (overheads etc.), then we may transmit only 1000 bits per frame that is 12 times less than the Ethernet packet of maximum length and 3 to 5 times less than the typical packet.

Tradeoff about the frame length is between the overheads (frame map, fragmentation etc.) involved and the data delivery delays, especially the latency in the recognition of uplink demand.
We need to employ here a possibility to change the frame s size and to change it quickly.

5.5.2. Time Related Parameters

See e.g. Downlink Burst Type Change Request (DBTC-REQ) Message
(Map relevance, ACK timeout etc.)

6. TG4 Specific Features to Be Added

This paragraph contains the examples of the functions to be added to the MAC because of TG3 specific application or other requirements

6.1. Dynamic Rate (Power) Control

Because of the potentially more fast (comparatively to the frame length) changes in the propagation conditions (interference, multipath etc.), we need an additional mechanism to support more dynamic, ideally per packet, changes in the bit rate (power) for communication to a CPE. This may be implemented by the allocation of channel time to the SS without specifying the PHY parameters.

6.2. Dynamic Frequency Selection

To support the Dynamic Frequency Selection feature, the following changes may be applied:

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