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Title	Scheduling Services for 802.16	
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Source(s)	Vladimir Yanover Alvarion Ltd. 11/5 Shtern Str. Herzlya, Israel	Voice: +972-36457834 Fax: +972-36456222 mailto:vladimir.yanover@alvarion.com
Re:	802.16REVd/D4 Sponsor Ballot	
Abstract	The document contains suggestions for definition of data delivery services for 802.16 from the prospect of 1) types of QoS contracts 2) set of parameters for each contract 3) system behavior	
Purpose	The document is contributed to support certain comment on 802.16REVd/D4 Sponsor Ballot	
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Scheduling Services for 802.16

Vladimir Yanover (Alvarion Ltd.)

1. References

- [1] IEEE P802.16-REVd/D4-2004, IEEE Standard for Local and metropolitan area networks Part 16: Air Interface for Fixed Broadband Wireless Access Systems
- [2] IEEE P802.16e/D2, Part 16: Air Interface for Fixed and Mobile
- [3] Broadband Wireless Access Systems — Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, 2 April 2004

2. The Document's Goal

The document's goal is to extend the definition of data delivery services from 802.16e [2] to fixed systems also. The definitions addresses 1) types of QoS support 2) set of QoS parameters for each type of service 3) system behavior. As such, they extend existing Uplink Polling services. Certain changes are suggested for better alignment of the definitions and Uplink Polling services.

3. Incentive for adding definition of data delivery services

First, there is no *direct* specification of services for data delivery in QoS terms for fixed systems, except UGS service in 6.3.5 "Uplink scheduling service". Note that, being located under this title, UGS service is for UL only. Other definitions in that section refer to request / grant process but not data delivery. For example, definition of Real-Time Polling Service (rtPS) in 6.3.5.2.2: " The service **offers real-time, periodic, unicast request opportunities**, which meet the flow's real-time needs and allow the SS to specify the size of the desired grant".

Second, scheduling services are for UL only.

Interoperability does not require uniform scheduling at base stations from different vendors, but nevertheless common platform for scheduling would be useful. It will significantly simplify development of performance test specifications and 802.16 MIB. It is especially important for mobile and nomadic applications, which obviously require network-wide definition of services.

Such definitions may be done using more or less same set of QoS parameters as Uplink scheduling services, but few parameters are missing

It is suggested to add Time Base parameter, which represents time interval for rate measurement. This parameter is necessary for consistent definition of Minimum Reserved Traffic Rate and Maximum Sustained Traffic Rate: rate measurement is performed at time interval of length equal to time base.

Suggested change for each service type narrows down set of applicable QoS parameters.

4. Specific changes in the Standard

This chapter contains specific changes suggested in IEEE 802.16REVd/D4.

[Change in section 6.3.5]

6.3.5 ~~Uplink~~—Scheduling services

Scheduling services represent the data handling mechanisms supported by the MAC scheduler for data transport on a connection. Each connection is associated with a single data service. Each data service is associated with a set of QoS parameters which quantify aspects of its behavior. These parameters are managed using the DSA and DSC message dialogs.

Four services (11.13.12) are supported: Unsolicited Grant Service (UGS), Real-time Polling Service (rtPS), Non-real-time Polling Service (nrtPS), and Best Effort (BE). The following text provides a brief description of each of the supported scheduling services, including the mandatory QoS parameters that shall be included in the service flow definition when the scheduling service is enabled for a service flow. A detailed description of each QoS parameter is provided in 11.13.

The UGS is designed to support real-time data streams consisting of fixed-size data packet transmitted at periodic intervals, such as T1/E1 and Voice over IP without silence suppression. ~~The mandatory~~ QoS service flow parameters for this scheduling service are [Time Base \(11.13.18\)](#), [Minimum Reserved Traffic Rate \(11.13.9\)](#), [Maximum Sustained Traffic Rate \(11.13.7\)](#), [Maximum Latency \(11.13.15\)](#), [SDU Size \(11.13.17\)](#), [Tolerated Jitter \(11.13.14\)](#), and [for UL service flows Request/Transmission Policy \(11.13.13\)](#). [The Minimum Reserved Traffic Rate parameter shall have the same value as the Maximum Sustained Traffic Rate parameter](#)

The rtPS is designed to support data streams consisting of variable-sized data packets that are transmitted at fixed intervals, such as moving pictures experts group (MPEG) video. ~~The mandatory~~ QoS service flow parameters for this scheduling service are [Time Base \(11.13.18\)](#), [Minimum Reserved Traffic Rate \(11.13.9\)](#), [Maximum Sustained Traffic Rate \(11.13.7\)](#), [Maximum Latency \(11.13.15\)](#), [Tolerated Jitter \(11.13.14\)](#), and [for UL service flows Request/Transmission Policy \(11.13.13\)](#).

The nrtPS is designed to support delay-tolerant data streams consisting of variable-sized data packets for which a minimum data rate is required, such as FTP. ~~The mandatory~~ QoS service flow parameters for this scheduling service are [Time Base \(11.13.18\)](#), [Minimum Reserved Traffic Rate \(11.13.9\)](#), [Maximum Sustained Traffic Rate \(11.13.7\)](#), [Traffic Priority \(11.13.6\)](#), and [for UL service flows Request/Transmission Policy \(11.13.13\)](#).

The BE service is designed to support data streams for which no minimum service level is required and therefore may be handled on an a space-available basis. ~~The mandatory~~ QoS service flow parameters for this scheduling service are [Time Base \(11.13.18\)](#), [Maximum Sustained Traffic Rate \(11.13.7\)](#), [Traffic Priority \(11.13.6\)](#), and [Request/Transmission Policy \(11.13.13\)](#).

6.3.5.1 Outbound transmission scheduling

Outbound transmission scheduling selects the data for transmission in a particular frame/bandwidth allocation and is performed by the BS for downlink, and SS for uplink. In

addition to whatever other factors the scheduler may deem pertinent, the following items are taken into account for each active service flow:

- The scheduling service specified for the service flow.
- The values assigned to the service flow's QoS parameters.
- The availability of data for transmission.
- The capacity of the granted bandwidth.

6.3.5.2 Uplink request/grant ~~scheduling~~ policy

Uplink request/grant ~~scheduling~~ policy is ~~enforced~~ ~~performed~~ by the BS with the intent of providing each subordinate SS with bandwidth for uplink transmissions or opportunities to request bandwidth. By specifying a scheduling service and its associated QoS parameters, the BS scheduler can anticipate the throughput and latency needs of the uplink traffic and provide polls and/or grants at the appropriate times.

Table 92 summarizes the ~~uplink request/grant policy and bandwidth usage rules~~ ~~scheduling services and the poll/grant options available~~ for each ~~scheduling service~~. The following subclauses define service flow scheduling services ~~for uplink operations~~.

Table 92—Scheduling services ~~for uplink service flows and bandwidth usage rules~~

Scheduling type	PiggyBack Request	Bandwidth stealing	Polling
UGS	Not allowed	Not allowed	PM bit is used to request a unicast poll for bandwidth needs of non-UGS connections
rtPS	Allowed	Allowed	Scheduling Only allows unicast polling allowed
nrtPS	Allowed	Allowed	Scheduling may restrict a service flow to unicast polling via the transmission / request policy; otherwise all forms of polling are allowed
BE	Allowed	Allowed	All forms of polling allowed

6.3.5.2.1 UGS

The UGS is designed to support real-time service flows that generate fixed size data packets on a periodic basis, such as T1/E1 and Voice over IP without silence suppression. The service offers ~~opportunities for transfer of fixed amount of data size grants~~ on a real-time periodic basis, which eliminate the overhead and latency of SS requests and assure that ~~transmission opportunities grants~~ are available to meet the flow's real-time needs. ~~The size of these grants shall be sufficient to hold the fixed length data associated with the service flow (with associated generic MAC header and Grant management subheader) but may be larger at the discretion of the BS scheduler.~~

For UL service flows the BS shall provide ~~grants Data Grant Burst IEs~~ to the SS at periodic intervals based upon the Maximum Sustained Traffic Rate of the service flow. ~~The size of these grants shall be sufficient to hold the fixed length data associated with the service flow (with associated generic MAC header and Grant management subheader) but may be larger at the discretion of the BS scheduler.~~ In order for this service to work correctly, the Request/Transmission Policy (see 11.13.13) setting shall be such that the SS is prohibited from using any contention request opportunities for this connection. ~~The key service IEs are~~

~~the Maximum Sustained Traffic, Maximum Latency, the Tolerated Jitter, and the Request/Transmission Policy. If present, The Minimum Reserved Traffic Rate parameter shall have the same value as the Maximum Sustained Traffic Rate parameter.~~ The Grant Management subheader (6.3.2.2.2) is used to pass status information from the SS to the BS regarding the state of the UGS service flow. The most significant bit of the Grant Management field is the Slip Indicator (SI) bit. The SS shall set this flag once it detects that this service flow has exceeded its transmit queue depth. Once the SS detects that the service flow's transmit queue is back within limits, it shall clear the SI flag. The flag allows the BS to provide for long term compensation for conditions, such as lost maps or clock rate mismatches, by issuing additional grants. The poll-me (PM) bit (6.3.6.3.3) may be used to request to be polled for a different, non-UGS connection.

The BS ~~is not mandated to shall not~~ allocate more bandwidth than the Maximum Sustained Traffic Rate parameter of the Active QoS Parameter Set, excluding the case when the SI bit of the Grant Management field is set. ~~In this case, the BS may grant up to 1% additional bandwidth for clock rate mismatch compensation.~~

6.3.5.2.2 rtPS

The rtPS is designed to support real-time service flows that generate variable size data packets on a periodic basis, such as moving pictures experts group (MPEG) video. The service offers real-time, periodic, unicast request opportunities, which meet the flow's real-time needs and allow the SS to specify the size of the desired grant. This service requires more request overhead than UGS, but supports variable grant sizes for optimum data transport efficiency.

For rtPS service flows the BS shall provide periodic transmission opportunities, according to amount of data available for transmission and QoS parameters specified (Maximum Sustained Traffic Rate, the Minimum Reserved Traffic Rate, the Maximum Latency).

For uplink service flows the BS shall provide periodic unicast request opportunities in timely manner to learn UL demand. In order for this service to work correctly, the Request/Transmission Policy setting (see 11.13.13) shall be such that the SS is prohibited from using any contention request opportunities for that connection. The BS may issue unicast request opportunities as prescribed by this service even if prior requests are currently unfulfilled. This results in the SS using only unicast request opportunities in order to obtain uplink transmission opportunities (the SS could still use unsolicited ~~Data Grant grants Burst Types~~ for uplink transmission as well). All other bits of the Request/Transmission Policy are irrelevant to the fundamental operation of this scheduling service and should be set according to network policy. ~~The key service IEs are the Maximum Sustained Traffic Rate, the Minimum Reserved Traffic Rate, the Maximum Latency and the Request/Transmission Policy.~~

6.3.5.2.3 nrtPS

The nrtPS offers transmission opportunities on a regular basis.

For uplink service flows the BS shall perform ~~The nrtPS offers~~ unicast polls on a regular basis, which assures that the service flow receives request opportunities even during network congestion. The BS ~~typically~~ polls SSs with UL nrtPS service flows ~~CIDs~~ on certain

~~an~~ interval and / or provides sufficient number of contention request opportunities. ~~on the order of one second or less. The BS shall provide timely unicast request opportunities.~~ In order for this service to work correctly, the Request/Transmission Policy setting (see 11.13.13) shall be set such that the SS is allowed to use contention request opportunities. This results in the SS using contention request opportunities as well as unicast request opportunities and unsolicited grants. ~~Data Grant Burst Types.~~ All other bits of the Request / Transmission Policy are irrelevant to the fundamental operation of this scheduling service and should be set according to network policy.

6.3.5.2.4 BE service

The intent of the BE service is to provide efficient service for best effort traffic.

For uplink service flows ~~In order for this service to work correctly,~~ the Request / Transmission Policy setting shall be set such that the SS is allowed to use contention request opportunities. This results in the SS using contention request opportunities as well as unicast request opportunities and unsolicited grants. ~~Data Grant Burst Types.~~ All other bits of the Request/Transmission Policy are irrelevant to the fundamental operation of this scheduling service and should be set according to network policy.

[Change in section 11.3.7]

11.13.7 Maximum sustained traffic rate

This parameter defines the peak information rate of the service. The rate is expressed in bits per second and pertains to the SDUs at the input to the system. The value of this parameter is calculated from the byte following the MAC header HCS to the end of the MAC PDU payload. If this parameter is omitted, then it defaults to a value of 0 bits per second (i.e., no bandwidth is reserved for the flow).

“Maximum Sustained Traffic Rate = R (bits/sec) with Time Base T(sec)” means the following. Let S denote additional demand accumulated at the MAC SAP of the transmitter during an arbitrary time interval of the length T. Then the amount of data forwarded to PHY (in bits) during this interval should be not more than $\min \{S, R * T\}$.

~~Explicitly, this parameter does not include MAC overhead, such as MAC headers or CRCs. This parameter does not limit the instantaneous rate of the service since this is governed by the physical attributes of the ingress port. However, at the SS in the uplink direction, the service shall be policed to conform to this parameter, on the average, over time. At the BS in the downlink direction, it may be assumed that the service was already policed at the ingress to the network and the BS is not required to do additional policing.~~ If this parameter is omitted or set to zero, then there is no explicitly mandated maximum rate. This field specifies only a bound, not a guarantee that the rate is available. The algorithm for policing to this parameter is left to vendor differentiation and is outside the scope of the standard.

[Change in section 11.13.9]

11.13.9 Minimum reserved traffic rate

This parameter specifies the minimum rate, reserved for this service flow. The rate is expressed in bits per second and specifies the minimum amount of data to be transported on

behalf of the service flow ~~when~~ averaged over time interval equal to Time Base. ~~The specified rate shall only be honored when sufficient data is available for scheduling.~~

~~When insufficient data exists, the requirement imposed by this parameter shall be satisfied by assuring the the available data is transmitted as soon as possible.~~

~~The BS shall be able to satisfy bandwidth requests for a service flow up to its Minimum Reserved Traffic Rate. If less bandwidth than its Minimum Reserved Traffic Rate is requested for a service flow, the BS may reallocate the excess reserved bandwidth for other purposes. The aggregate Minimum Reserved Traffic Rate of all service flows may exceed the amount of available bandwidth.~~

“Minimum Reserved Traffic Rate = R (bits/sec) with Time Base T(sec)” means the following. Let S denote additional demand accumulated at the MAC SAP of the transmitter during an arbitrary time interval of the length T. Then the amount of data forwarded to PHY (in bits) during this interval should be not less than $\min \{S, R * T\}$.

The amount of data is calculated from the byte following the MAC header HCS to the end of the MAC PDU payload. If this parameter is omitted, then it defaults to a value of 0 bits per second (i.e., no bandwidth is reserved for the flow by default).

The value of this parameter is calculated from the byte following the MAC header HCS to the end of the MAC PDU payload. If this parameter is omitted, then it defaults to a value of 0 bits per second (i.e., no bandwidth is reserved for the flow).

[Insert new section 11.3.22]

11.13.22 Time Base

Type	Length	Value	Scope
[24/25].29	2	Time base value, in ms	DSA-REQ/RSP, DSC-REQ/RSP

Length of time interval used for calculation of Minimum reserved traffic rate and Maximum sustained traffic rate

[Add to the Table 337]

Type	Parameter
29	Time base