Project	IEEE 802.16 Broadband Wireless Access Working Group		
Title	Quality of Service (QoS) classes for BWA		
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Re:	This contribution is in response to call for contributions dated July 16, 1999 from the editor of IEEE 802.16 system requirements (SR) document. It is proposed that the material presented herein, be integrated in section 6.0 of the SR draft document.		
Abstract	This document proposes QoS classes for BWA based on the classes that have been defined for IMT-2000 by ITU-R TG 8/1 in its draft Recommendation M.1079 (June 1999 edition). This definition of classes have also been accepted by Fixed Wireless Access (FWA) defined by ITU JRG 8A/9B. The alignment of the QoS definitions across various radio domains will allow for seamless interworking between various radio accesss systems.		
Purpose	For review by the group and incorporation in systems requirements document		
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Release	The contributor acknowledges and accepts that this contribution may be made publicly available by 802.16.		

1 Introduction.

The core networks such as IP will interlink the diverse access networks (including fixed wireless access) for providing ubiquitous multimedia services. As the wireless networks (cellular, PCS 3G BWA and satellites) are growing rapidly, there is a need to extend QoS (Quality of Service) for services that are available in wired domain in wireless case with minimal degradation, to meet end-to-end QoS. The QoS classes, attributes and performance requirements for BWA are presented in this contribution that aligns with those defined in ITU-R for IMT-2000 and FWA systems.

2 Scope

This contribution summarizes the objectives and requirements relating to performance and requirements for services in BWA to be used for IP network access. References to and extracts of material from existing ITU Recommendations dealing with performance and availability parameters are made where appropriate. In particular, revised M.1079 that defines the following QoS classes for various services in IMT-2000 are used in BWA context here.

3. BWA QoS Classes

When defining the BWA QoS classes the restrictions and limitations of the air interface have to be taken into account. It is not reasonable to define complex mechanisms as have been in fixed networks due to different error characteristics of the air interface. The QoS mechanisms provided in the radio network have to be robust and capable of providing reasonable QoS resolution. Table 1 illustrates proposed QoS classes for BWA.

In the proposal there are four different QoS classes (or traffic classes):

- Conversational class,
- Streaming class,
- Interactive class and
- Background class.

The main distinguishing factor between these classes is how delay sensitive the traffic is: Conversational class is meant for traffic which is very delay sensitive while Background class is the most delay insensitive traffic class.

Conversational and Streaming classes are mainly intended to be used to carry real-time traffic flows. The main divider between them is how delay sensitive the traffic is. Conversational real-time services, like video telephony, are the most delay sensitive applications and those data streams should be carried in Conversational class.

Interactive class and Background are mainly meant to be used by traditional Internet applications like WWW, Email, Telnet, FTP and News. Due to looser delay requirements , compared to conversational and streaming classes, both provide better error rate by means of channel coding and retransmission. The main difference between Interactive and Background class is that Interactive class is mainly used by interactive applications, e.g. interactive Email or interactive Web browsing, while Background class is meant for background traffic, e.g. background download of Emails or background file downloading. Responsiveness of the interactive applications is ensured by separating interactive and background applications. Traffic in the Interactive class has higher priority in scheduling than Background class traffic, so background applications use transmission resources only when interactive applications do not need them. This

is very important in wireless environment where the bandwidth is premium compared to fixed networks.

3.1 Conversational class

The most well known use of this scheme is telephony speech. But with Internet and multimedia a number of new applications will require this scheme, for example voice over IP and video conferencing tools. Real time conversation is always performed between peers (or groups) of live (human) end-users. This is the only scheme where the required characteristics are strictly given by human perception.

Real time (RT) conversation scheme is characterized by that the transfer time must be low because of the conversational nature of the scheme and at the same time that the time relation (variation) between information entities of the stream must be preserved in the same way as for real time streams. The maximum transfer delay is given by the human perception of video and audio conversation. Therefore the limit for acceptable transfer delay is very strict, as failure to provide low enough transfer delay will result in unacceptable lack of quality. The transfer delay requirement is therefore both significantly lower and more stringent than the round trip delay of the interactive traffic case.

Real time conversation - fundamental characteristics for QoS:

- preserve time relation (variation) between information entities of the stream
- conversational pattern (stringent and low delay)

3.2 Streaming class

When the user is looking at (listening to) real time video (audio) the scheme of real time streams applies. The real time data flow is always aiming at a live (human) destination. It is a one way transport.

This scheme is one of the newcomers in data communication, raising a number of new requirements in both telecommunication and data communication systems. It is characterised by that the time relations (variation) between information entities (i.e. samples, packets) within a flow must be preserved, although it does not have any requirements on low transfer delay.

The delay variation of the end-to-end flow must be limited, to preserve the time relation (variation) between information entities of the stream. But as the stream normally is time aligned at the receiving end (in the user equipment), the highest acceptable delay variation over the transmission media is given by the capability of the time alignment function of the application. Acceptable delay variation is thus much greater than the delay variation given by the limits of human perception.

Real time streams - fundamental characteristics for QoS:

- preserve time relation (variation) between information entities of the stream

3.3 Interactive class

When the end-user, that is either a machine or a human, is on line requesting data from remote equipment (e.g. a server), this scheme applies. Examples of human interaction with the remote equipment are: web browsing, data base retrieval, server access. Examples of machines interaction with remote equipment are: polling for measurement records and automatic data base enquiries (tele-machines).

Interactive traffic is the other classical data communication scheme that on an overall level is characterised by the request response pattern of the end-user. At the message destination there is an entity expecting the message (response) within a certain time. Round trip delay time is therefore one of the key attributes. Another characteristic is that the content of the packets must be transparently transferred (with low bit error rate).
Interactive traffic - fundamental characteristics for QoS:

- request response pattern
- preserve payload content

3.4 Background class

When the end-user, that typically is a computer, sends and receives data-files in the background, this scheme applies. Examples are background delivery of E-mails, SMS, download of databases and reception of measurement records.
Background traffic is one of the classical data communication schemes that on an overall level is characterised by that the destination is not expecting the data within a certain time. The scheme is thus more or less delivery time insensitive. Another characteristic is that the content of the packets must be transparently transferred (with low bit error rate).
Background traffic - fundamental characteristics for QoS:

- the destination is not expecting the data within a certain time
- preserve payload content

Table 1: BWA QoS classes

Traffic class	**Conversational class** conversational RT	**Streaming class** streaming RT	**Interactive class** Interactive best effort NRT	**Background** Background best effort NRT
Fundamental characteristics	• Preserve time relation (variation) between information entities of the stream • Conversational pattern (stringent and low delay)	• Preserve time relation (variation) between information entities of the stream	• Request response pattern • Preserve payload content	• Destination is not expecting the data within a certain time • Preserve payload content
Example of the application	- voice	- streaming video	- Web browsing	- background download of emails

4. QoS Parameters

4.1 General

The parameters related to throughput/bitrate should be separated for uplink/downlink in order to support asymmetric bearers. Table 2 illustrates the relationship between the service attributes and classes.

In Table 2, the BWA bearer attributes and their relevancy for each bearer class are summarised. Observe that traffic class is an attribute itself.

Table 2. BWA bearer attributes defined for each bearer class.

Traffic class	Conversational class	Streaming class	Interactive class	Background class
Maximum bitrate	X	X	X	X
Delivery order	X	X	X	X
SDU size information	X			
Reliability	X	X	X	X
Transfer delay	X	X		
Guaranteed bit rate	X	X		
Traffic handling priority			X	
Allocation/Retention priority	X	X	X	X

4. Range of QoS requirements

It shall be possible for one application to specify its QoS requirements to the network by requesting a bearer service with any of the specified traffic type, traffic characteristics, maximum transfer delay, delay variation & bit error ratios.
The following table indicates the range of values that shall be supported by FWA. These requirements are valid for both connection and connectionless traffic. It shall be possible for the network to satisfy these requirements without wasting resources on the radio and network interfaces due to granularity limitations in QoS.

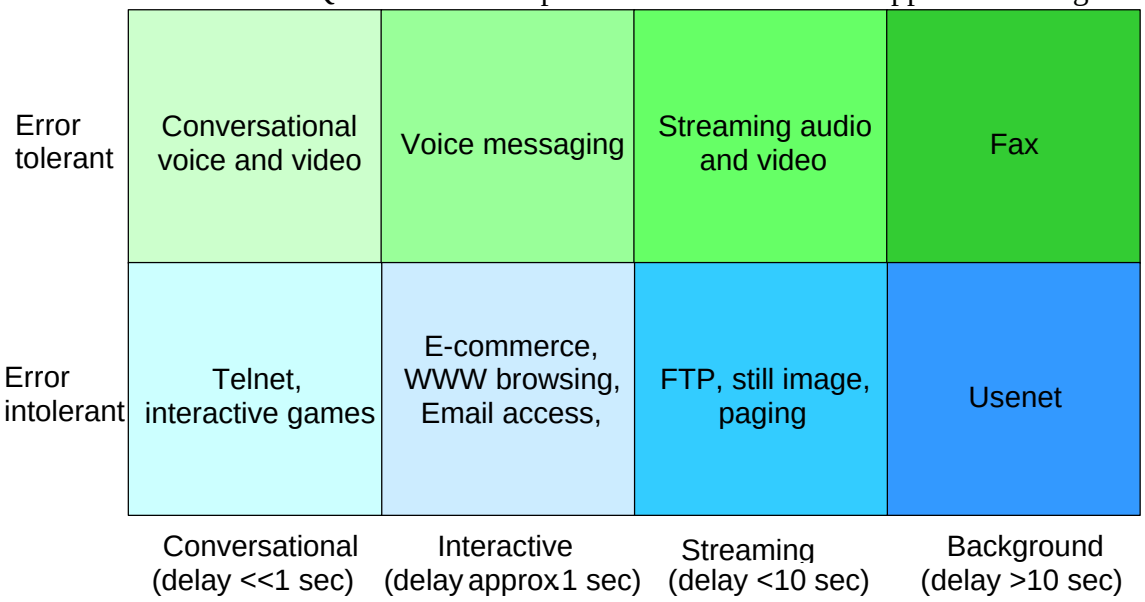
Table 4 BER and Delay requirements for BWA operating environments

	Real Time (Constant Delay)	**Non Real Time (Variable Delay)**
Operating environment	**BER/Max Transfer Delay**	**BER/Max Transfer Delay**
BWA	Max Transfer Delay 20 - 300 ms BER 10-3 - 10-7 (Note 1)	Max Transfer Delay 150 ms or more (Note 2) BER = 10-5 to 10-8
NOTE 1; There is likely to be a compromise between BER and delay. NOTE 2; The Max Transfer Delay should be here regarded as the target value for 95% of the data.		

4.1 Supported End User QoS

Figure 3 Groups of applications behavior in terms of QoS requirements

This section outlines the QoS that shall be provided to the end user / applications. Figure 3 below



summarises the major groups of application in terms of QoS requirements. Applications and new applications may be applicable to one more groups.

The following tables further elaborate BWA end user / application QoS requirements.

Table 5: End-user Performance Expectations - Conversational / Real-time Services

Medium	**Application**	**Degree of symmetry**	**Data rate**	**Key performance parameters and target values**		
				One-way Delay	Delay Variation	Information loss
Audio	Conversational voice	Two-way	4-13 kb/s	<150 msec preferred <400 msec limit	< 1 msec	< 3% FER
Video	Videophone	Two-way	32-384 kb/s	< 150 msec preferred <400 msec limit Lip-synch : < 100 msec		< 1% FER
Data	Telemetry - two-way control	Two-way	<28.8 kb/s	< 250 msec	N.A	Zero
Data	Interactive games	Two-way	< 1 KB	< 250 msec	N.A	Zero
Data	Telnet	Two-way (asymmetric)	< 1 KB	< 250 msec	N.A	Zero

Table 6: End-user Performance Expectations - Interactive Services

Medium	**Application**	**Degree of symmetry**	**Data rate**	**Key performance parameters and target values**		
				One-way Delay	Delay Variation	Information loss
Audio	Voice messaging	Primarily one-way	4-13 kb/s	< 1 sec for playback < 2 sec for record	< 1 msec	< 3% FER
Data	Web-browsing - HTML	Primarily one-way		< 4 sec /page	N.A	Zero
Data	Transaction services – high priority e.g. e-commerce, ATM	Two-way		< 4 sec	N.A	Zero
Data	E-mail (server access)	Primarily One-way		< 4 sec	N.A	Zero

Table 7: End-user Performance Expectations - Streaming Services

Medium	**Application**	**Degree of symmetry**	**Data rate**	**Key performance parameters and target values**		
				One-way Delay	Delay Variation	Information loss
Audio	High quality streaming audio	Primarily one-way	32-128 kb/s	< 10 sec	< 1 msec	< 1% FER
Video	One-way	One-way	32-384 kb/s	< 10 sec		< 1% FER

Data	Bulk data transfer/retrieval	Primarily one-way		< 10 sec	N.A	Zero
Data	Still image	One-way		< 10 sec	N.A	Zero
Data	Telemetry - monitoring	One-way	<28.8 kb/s	< 10 sec	N.A	Zero

5 References

ITU-R Recommendations

Recommendation Revised M.1079 (June 1999)

6 Recommendations

This contribution recommends the performance/availability requirements and objectives presented in this contribution be used as input for incorporation in BWA Systems Requirements document.