Project	IEEE P802.16 Broadband Wireless Access Working Group	
Title	Contribution to the Systems Document in the Issue of 802.16, Quality of Service	
Date Submitted	18 June, 1999	
Source	William Myers Bosch Telecom, Inc Richardson, TX	Voice: 972-852-7110 Fax: 972-852-6757 E-mail: wmyers@boschtelecominc
Re:	System Requirements. Call for Contributions 802.16sc-99/12 (99/05/20), Item 3, QoS-based categories.	
Abstract	Broadband fixed wireless access systems are planned for multi-service applications that may have different quality of service categories. Categories and parameters are proposed. The ITU 27,500 km hypothetical reference path and parameters from existing standards are used to allocate parameters to the access section of the reference path. Some parameters are derived where no standard has provided an access section allocation.	
Purpose	The quality of service table and appropriate text are for inclusion in the system requirements document	
Notice	This document has been prepared to assist the IEEE P802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.	
Release	The contributor acknowledges and accepts that this contribution may be made publicly available by 802.16.	

Contribution to the Systems Document in the Issue of 802.16, Quality of Service

William Myers
Bosch Telecom, Inc.

Abstract

Broadband fixed wireless access systems are planned for multi-service applications that may have different quality of service categories. Categories and parameters are proposed. The ITU 27,500 km hypothetical reference path and parameters from existing standards are used to allocate parameters to the access section of the reference path. Some parameters are derived where no standard has provided an access section allocation

Quality of Service Parameters

For a cell- or packet-based transmission protocol, quality of service requirements are allocated on end to end path requirements. Because applications will include telephone, data, video conferencing, video, and other forms of audio transmission, several classes, or categories, of service are identified. The most stringent class is for 64 kbps telephone circuits, commonly referred as constant bit rate in ATM.

From the end to end ITU 27,500 km hypothetical reference path defined by ITU-T G.826, the end point (or user terminal) interconnects with other feeder and switched network sections of the reference network national portion (see Appendix A). The national portion connects with other national portions to form an international network. The access section at the end point described in ITU-R F.1189 is relevant to the final broadband wireless path considered in IEEE 802.16.

Three quality of service (QoS) general categories are proposed. These are defined in ITU-T I.356 and are the basis for Table 1. Recommendation ITU-T G.826 defines error ratio requirements for 64 kbps telephone circuits, the stringent class, and ITU-T G.114 defines the delay requirement. Error ratios, such as errored seconds, are specified in G.826 in place of error rate terms because they can be measured in-service with a packet or cell based architecture.

The stringent service class is intended for telephone traffic (64 kbps voice) with limited delay requirements. The tolerant class is defined for service that is not delay-sensitive but is error sensitive. The unspecified or unbounded class is provided for other services.

Although I.356 is oriented toward ATM, a similar series of recommendations, including ITU-T I.380, is in work for IP systems.

Table 1 End to End Parameter Upper Limit Allocation

	Source	QoS Classes		
		Stringent Class	Tolerant Class	Unspecified Class (U)
Errored second ratio	G.826	0.04	0.04 Note 1	U
Severely errored second ratio	G.826	0.002	0.002 Note 1	U
Background block error rate	G.826	2×10^{-4}	U	U
Delay	G.114	400 ms	U	U
Delay variation	I.356	3 ms	U	U
Cell loss ratio	I.356	3×10^{-7}	10^{-5}	U

Note 1. The tolerant case is defined by I.356 in terms of CER using the same default values as for the stringent case, however errored ratios are recommended.

Appendix A describes how the allocation is made for the broadband wireless access section of the hypothetical reference path for the stringent case. A proposed allocation is made for the PHY and MAC layers of the access section in Table 2, using available standards. Delay is derived from ATM application layer expectations and a typical network configuration.

Table 2 Proposed QoS Allocation for PHY and MAC

	QoS Classes		
	Stringent Class	Tolerant Class	Unspecified Class (U)
Errored second ratio	3.4×10^{-3}	3.4×10^{-3}	U
Severely errored second ratio	1.7×10^{-4}	1.7×10^{-4}	U
Background block error rate	1.7×10^{-5}	U	U
Delay	19.5 ms Note 1	U	U
Delay variation	<1.5 ms Note 2	U	U
Cell/packet loss ratio	6.9×10^{-8}	3.5×10^{-6}	U

Note 1 Delay is for the entire access section based on ATM

Note 2 Delay variation is for the national section.

Allocation of errored ratios was done according to I.356.

Delay (transmission time) is allocated for the access section using G.114 and is not allocated down to the lower layers (1 and 2). This may require additional study.

The delay variation is allocated using I.356 and is applicable to the national portion of a high speed ATM network in I.356. The allocation to the access section and to the lower layers may require further study.

Default parameters from I.356 were used for cell loss ratio. An allocation, described in I.356, for the national portion of 34% was made for the stringent class and 23% for the tolerant class. Allocation to the access section and to layers may require further study.

Conclusions

Three quality of service categories are proposed for the System Document of 802.16. Critical parameters are proposed for each service category by allocation from the ITU hypothetical reference path to the access section of the path using available ITU standards. The values lead to considerations of fixed versus variable packet sizes and have implications for LLC requirements.

Several areas of the allocation need additional study. ITU-R (WP 9A) has presented several questions regarding the need for performance objectives of fixed wireless access radio systems.

References:

ITU-R F.1189-1 Error performance objectives for constant bit rate digital paths at or above the primary rate carried by digital radio-relay systems which may be a part or all of the national portion of a 27,500 km hypothetical reference path.

ITU-T G.114 Transmission systems and media - General characteristics of international telephone connections and international telephone circuits.

ITU-T G.826 Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate.

ITU-T I.356 Series 1: Integrated services digital network. Overall network aspects and functions - Performance objectives

ITU-T I.380 Internet protocol data communication service - IP packet transfer and availability performance parameters.

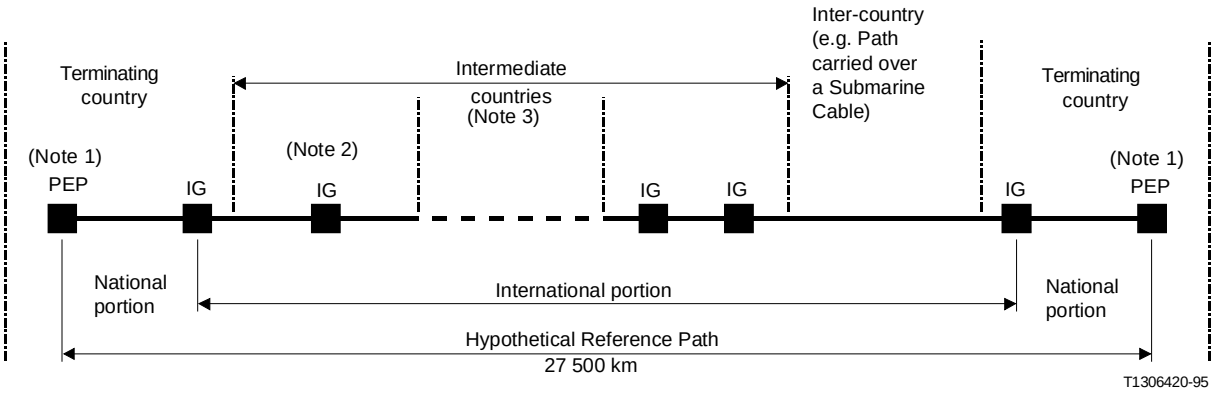
RFC 2205 ITEF. Resource ReSerVation Protocol (RSVP) --Version 1 Functional Specification

Appendix A

Rationale for Local Access Stringent Class Parameters

Considering that Broadband Wireless Access (BWA) circuits may interconnect to a larger network including international connections, the Hypothetical Reference Path, Figure A-1, described in ITU-T G.826 is the basis for allocation of parameters.

Figure A-1 ITU Hypothetical Reference Path (G.826)



NOTES

1 If a path is considered to terminate at the IG, only the international portion allocation applies.
2 One or two international Gateways (entry or exit) may be defined per intermediate country.
3 Four intermediate countries are assumed.

Network interfaces in Figure A-1 are:

PEP	Path End Point	ICPCE	Inter-Country Path Core Element
ISC	International Switching Center	IPCE	International Path Core Element
FS	Frontier Station	IB	International Border

For telephone applications, the end-to-end objectives error performances are described in ITU-T G.826 and delay performance in G.114. Error performance is in terms of errored second ratio (ESR), severely errored second ratio (SESR) and background block error ratio (BBER). These are further defined in G.826.

For user data rates of 1.5 to 15 Mbps, the end-to-end performance values are listed below. This is the basis for allocation.

Table A-1 End-to-End Performance Limits for Telephone Applications

Parameter	Limit, 1.5 - 5 Mbps	Limit, 5 - 15 Mbps
Transmission time limit	400 ms	400 ms
ESR	0.04	0.05
SESR	0.002	0.002
BBER	2×10^{-4}	2×10^{-4}

Broadband wireless access is the final access link to the user for 802.16. The ACCESS part of the national network portion is shown in Figure A-2.

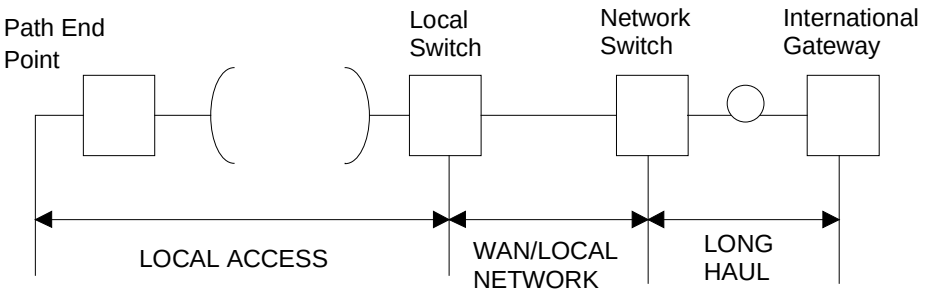


Figure A-2 Generic National Portion Configuration

(adapted from F.1189)

From ITU-T G.826, each national portion is allocated a fixed block allowance of 17.5% of the end-to-end objective. For digital radio links, ITU-R F.1189 allocates error performance objectives to the Access section. For the 1.5 - 5 Mbps case, the allocation is shown in Table A-3. These values can be extended to higher data rates using the factors in ITU-R F.1189.

Table A-3 Error Performance for Access Network Section (F.1189)

Parameter	Limit
ESR	0.04 x C
SESR	0.002 x C
BBER	$2 \times C \times 10^{-4}$

Note: C = 0.75 to 0.85 (7.5 to 8.5%)

The sum of the allocation percentages A% + B% + C% should not exceed the 17.5% total for the national portion, where A and B are the allocations for the other two sections.

Considering that the wireless access section would consist of low cost user terminals, then the weighting of the BWA is toward the higher 8.5% value.

One way transmission time for a national section is allocated 50 ms in G.114. For an example national link, 6 digital switches and 3 multiplexers are included. Switches are assumed to be telephone switches or ATM switches.

Table 4 Example Access Section Delay Worksheet

Processing System	Contribution	Transmission Time
Total Allocated National Section	Allocated	50 ms
Propagation time	2,500 x 5us/km	13 ms
PCM coder/decoder	1	1
Digital transient exchange	6 x 0.5ms	3
Transmultiplexer	3 x 1.5ms	4.5
Local digital exchange	2 x 1.5	3
ATM application layer (ATM cell)	AAL1, 6ms	6
Remainder for access section for 802.16		19.5 ms

For an IP network, switch delays are expected to be larger than what is included above. Also queuing time must be considered even for a Real Time Protocol (RTP) (RFC 2205) transport. For example, if a 4 kilobyte data packet is in process of transmission from a router at the time an RTP packet is received, a queuing delay of 20 ms could occur for a DS1 router. Also, a 64 kb voice packet of 160 bytes would require 20 ms to construct. Delay for an IP network is for further study.

Delay variation is allocated 3 ms end to end in ITU-T I.356. An allocation of 1.5 ms is made for the Access section based on 34 to 45 Mbps. For the access section, something less than 1.5 ms would apply. For lower data rates this may be difficult to achieve and requires further study.