International Telecommunication Union

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TELECOMMUNICATION
STANDARDIZATION SECTOR
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Y.1541

Amendment 3
(05/2008)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Internet protocol aspects – Quality of service and network performance

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Network performance objectives for IP-based services

Amendment 3: Revised Appendix VIII – Effects of IP network performance on digital television transmission QoS

Recommendation ITU-T Y.1541 (2006) – Amendment 3

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Network performance objectives for IP-based services

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Revised Appendix VIII – Effects of IP network performance on digital television transmission QoS

Summary

Amendment 3 to Recommendation ITU-T Y.1541 replaces former Appendix VIII, which provides additional information about the analysis leading to the selection of the objective values in Table 3.

Source

Amendment 3 to Recommendation ITU-T Y.1541 (2006) was agreed on 30 May 2008 by ITU-T Study Group 12 (2005-2008).

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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1) Appendix VIII

Modify Appendix VIII as follows:

VIII.1 Introduction

This appendix details a part of the analysis behind the specification of provisional network QoS classes 6 and 7 in Table 3. The objective values were selected in order to support digital television transmission. The IP packet loss ratio (IPLR) objective in classes 0 through 4 was insufficient to support this application, as stated in the previous version of this appendix.

VIII.2 Hypothetical reference endpoint (HRE) for high-bandwidth video signals

It is important to first establish a reference endpoint for video transport. The proposed endpoint is based on work done previously by the ATIS T1A1 sub-committee, as well as analysis of typical video transport endpoint models spanning both compressed and uncompressed video by the Video Services Forum (VSV). There may ultimately be a need to establish more than one HRE to allow point-to-point and point-to-multipoint transmission, but this analysis is restricted to the simpler case of the point-to-point HRE.

Sender		**Receiver**
Video (uncompressed SDI, multi- or single-compressed-MPEG-2 stream DVB-ASI, etc.), Multiple Audio Streams, Ancillary Data		Video (uncompressed SDI, multi- or single-compressed-MPEG-2 stream DVB-ASI, etc.), Multiple Audio Streams, Ancillary Data
Embedder		De-Embedder
Packetizer/Interleaver/FEC		FEC-1/De-inteleaver/De-packetizer
RTP		RTP, Sufficient De-Jitter Buffer
UDP		UDP
IP		IP
	(Physical Layer)	

Figure VIII.1 – Hypothetical reference endpoint for digital television

The digital television transport uses an IP network where uncompressed video packets or MPEG-compressed video packets are encapsulated into either UDP/IP or RTP/UDP/IP. We assume that RTP/UDP/IP is the protocol used and that the following protocol overhead applies:

IP packet length = (7 × 188-Byte MPEG packets) + RTP/UDP/IP packet overhead

The following clauses describe three profiles of video services and give a rationale for the deployment of error correction mechanisms in IP networks to guarantee the appropriate level of quality and reliability.

VIII.3 Service profiles and end-to-end packet performance requirements

The technical requirements for this appendix will be limited to three service profiles: contribution services profile, primary distribution service profile and access distribution service profile. These three profiles encompass the vast majority of the video industry's applications and needs. We also present the performance requirements for these profiles in terms of packet loss at three different viewer quality levels, or hit rates.

VIII.3.1 Contribution video services profile

Contribution services typically have the highest performance and can vary from uncompressed to mildly compressed video and audio signals. Contribution connections allow exchange of content by a network or its affiliates for further use, e.g., for bringing signals back from fixed, temporary, or remote locations to the studio for editing or immediate rebroadcast. In those scenarios, for long-haul applications, terrestrial fibre, microwave or satellite infrastructure endpoint connections can be utilized.

Contribution can also mean the outbound delivery of signals from the main network studio to network affiliates for rebroadcasting and typically employs satellite or long-haul terrestrial network services. Today, these outbound connections are provided by way of fixed or on-demand private leased lines (fibre), or in certain, less-extensive applications, ATM services offering DS-3, OC-3, or OC-12 bandwidth.

In addition to those real-time applications, sometimes IP services are used for non-real-time file exchange between video and audio servers and for monitoring and control of remote systems. As the same user may use their IP service for contribution video and file transfer, the contribution service profile also easily accommodates file transfer and remote control.

VIII.3.2 Primary distribution video service profile

Distribution means delivery of video and audio content either directly to the consumer or to cable head-ends for transmission through a cable television plant. In these applications, typically a lower signal quality (lower data rates) is needed, as little additional signal processing will be applied. Traditionally for these applications, terrestrial or satellite services are used. There are two types of distribution signals, primary and access. Primary distribution connections are feeds from the local affiliate to the cable head-end or to the television transmission tower, and ordinarily, these connections are comparable to, or slightly lower in quality than, contribution connections. Primary distribution may be provided by satellite, short-haul terrestrial microwave, or fibre optic connection. Access distribution involves the delivery of the content from the cable head-end to the final consumer over the cable television plant or through the air in the form of a broadcast emission from the television transmitter tower antenna. The VSF recommends that 40 Mbit/s represent the bit rate of this type of service.

VIII.3.3 Access distribution service profile

Access distribution service profile is defined as TV services currently being delivered by cable and satellite networks. Since the quality achieved by these networks is somewhat subjective, this contribution will characterize quality as an upper bound on video data errors (due to network) in a specific window of time.

VIII.3.4 Performance requirements for the service profiles

Quality of service for this application will be given in terms of actual number of errors (performance hits) in a specific time period. Table VIII.1 was constructed based on recommendations from active members of the Video Services Forum and represents expected error rates that service providers (e.g., DirecTV), as well as users (e.g., Fox Sports Network), would demand.

Table VIII.1 – Digital television loss/error ratio recommendations

Profile (Typical bit rate)	One performance hit per 10 days	One performance hit per day	10 performance hits per day
Contribution (270 Mbit/s)	4×10^{-11}	4×10^{-10}	4×10^{-9}
Primary Distribution (40 Mbit/s)	3×10^{-10}	3×10^{-9}	3×10^{-8}
Access Distribution (3 Mbit/s)	4×10^{-9}	4×10^{-8}	4×10^{-7}

This table assumes all lost packets cause a performance hit (possibly visible or audible impairment), and seven MPEG TS packets are encapsulated in a single IP packet. The required packet loss ratio is given at the intersection of a hit rate and profile. For example, access distribution allowing a quality level of 1 performance hit per day requires a packet loss ratio of 4×10^{-8}.

VIII.4 Forward error correction (FEC)/Interleaving to improve UNI-UNI performance

Even an IP network conforming to QoS Classes 6 or 7 is not capable of providing the packet loss rates required for the profiles above, and edge equipment is needed to correct for packet errors, packet losses and reordered packets. We assume the service uses FEC/Interleaving as defined by the Pro-MPEG Forum COP-3 recommendation (Code of Practice) and as reflected in Table VIII.2. Note that this 2-dimensional FEC/Interleaving specification is slightly more powerful than the base layer of digital video broadcast application-layer-FEC (DVB AL-FEC) of Annex E [b-ETSI TS 102 034]. The DVB AL-FEC base layer is consistent with the 1-dimensional Pro-MPEG FEC.

Table VIII.2 – FEC/Interleaving to achieve desired end-to-end hit rates

	Minimal Correction	Moderate Correction	High Correction
Minimum Network Performance			
Loss Distance (Packets)	100	50	50
Loss Period (Packets)	5	5	10
Applied FEC			
FEC L, D	5, 20	5, 10	10, 5
FEC Overhead (%)	5	10	20
Resulting Video Performance Quality	High	High	High

Note that the specification of network performance above utilizes two new terms. Loss distance (LD) and loss period (LP), defined in [b-IETF RFC 3357], are packet loss pattern parameters. LP defines the maximum number of consecutive packets that can be lost, while LD defines the minimum number of good packets that must arrive between lost packets for the algorithm to properly correct for losses. The LD and LP values describe the minimum network performance correctable by the corresponding FEC in the same column. The FEC is defined by Length (L) and Depth (D) algorithm parameters that define the robustness of the method.

Correction of network impairments is not free, as it consumes additional bandwidth. The overhead values in the table represent three levels of robustness, where 5% represents minimal correction, 10% represents moderate correction and 20% represents the highest amount of correction. Note that the more robust the algorithm we choose, the higher the overhead. It is the VSF's position that these three values encompass the majority of the needs in the industry.

As an example, a 2 Mbit/s video service requiring minimal correction would be configured with (L, D) settings of (5, 20). This would generate an extra 100 kbit/s (5% of 2 Mbit/s) of network traffic for the FEC packets, resulting in a total data rate of 2.1 Mbit/s. Similarly, a 270 Mbit/s service requiring high correction would be configured with (L, D) values of (10, 5) which would generate an additional 54 Mbit/s of network traffic, resulting in an aggregate rate of 324 Mbit/s.

VIII.5 Laboratory assessment of forward error correction (FEC)/Interleaving effectiveness

Laboratory test results with the Pro-MPEG Forum COP-3 recommendation 2-dimensional FEC/Interleave (5, 50) indicate that:

– UNI-UNI loss ratio of 10^{-4} improves to 1.5×10^{-8} (covers most of the access profile);

– UNI-UNI loss ratio of 10^{-5} improves to 2×10^{-10} (covers most profiles).

It was concluded that an IP network with UNI-UNI IPLR and IPER conforming to Table 3, Class 6 or 7 will support the digital television application described above, providing that the appropriate FEC/Interleaving is applied.

VIII.6 Additional performance parameters

The Video Services Forum concluded that the values for IPTD and IPDV specified in Table 3, Classes 6 and 7 are sufficient for digital television transport.

VIII.7 Further analysis with advanced FEC schemes

The IPTV Focus Group (see http://www.itu.int/ITU-T/IPTV/index.phtml) prepared an analysis of application layer error recovery mechanisms. Their numerical results utilize the enhancement layer of the DVB-IP AL-FEC mechanism. This is a decoder enhanced according to [b-ETSI TS 102 034], Annex E, subclause E.5.1.2, which describes the Digital Fountain Raptor code (and is apparently more powerful than the Pro-MPEG Forum COP-3 recommendation 2-dimensional FEC/Interleave code).

The IPTV FG analysis used the following assumptions and inputs:

1) Mean time between visible artefacts (MTBA) or 4 hours (slightly more demanding than the 10 hits per day level used in the VSF study).

2) Two video stream rates: 2.1 Mbit/s for Standard Definition and 9.4 Mbit/s for High Definition.

3) Seven MPEG-2 TS packets per RTP payload.

4) A set of FEC protection periods, ranging from 100 ms to 1000 ms.

5) A fixed average packet loss ratio of 10^{-3}.

6) Two network loss models, one with independent random packet loss, and another with fixed length bursts of loss corresponding to 8 ms of time (less than 2 packets for SD and 8 packets for HD). The fixed length burst loss model is intended to simulate a DSL access line subjected to electrical impulse noise, and each impulse causes an outage equal in length to the DSL interleaving depth, which is taken to be 8 ms.

The IPTV Focus Group results are shown in Table VIII.3 below, over a range of protection periods.

Table VIII.3 – Required overhead for DVB-IP AL-FEC for different bit rates, different channel models at IPLR of 10e-3, and different protection periods

Protection period	Random, 2.1 Mbit/s	Random, 9.4 Mbit/s	Burst, 2.1 Mbit/s	Burst, 9.4 Mbit/s
100 ms	16%	5%	20%	12%
200 ms	8%	3.5%	10%	6%
400 ms	5%	3%	7%	4%
600 ms	4%	2%	4%	2.5%
800 ms	3.5%	2%	4%	2.5%
1000 ms	3%	2%	4%	2%

The FEC overhead is reasonable and within the same range used with the Pro-MPEG Forum COP-3 recommendation 2-dimensional FEC/Interleave in Table VIII.2.

When the network characteristics are similar to the two cases examined (8 ms loss bursts or random independent loss), the analysis using [b-ETSI TS 102 034], Annex E, subclause E.5.1.2 FEC shows that the Y.1541 Class 0 or 1 objectives are sufficient.

Note that the degree to which these two network models represent the actual conditions experienced in digital video transmission over packet networks is not known at this time and requires further study.

VIII.8 Analysis of retransmission schemes

This clause currently identifies an area for further study. There may be existing analyses that can be summarized in this clause, following review.

VIII.9 Recovery from errors and losses due to protection switching schemes

This clause currently identifies another area for further study.

Most protection switching schemes, such as SONET rings and MPLS-Fast Re-Route (MPLS-FRR) require at least 50 ms to replace a failed primary path with a backup path. In practice, restoration times on the order of 100-200 ms are possible. None of the example correction schemes considered above can compensate for such long outages. However, if a design goal is correcting outages of this long duration, it may be possible to devise a scheme that can correct the burst losses with additional penalties of longer delay and more overhead.

2) Bibliography

Add the following reference to the Bibliography:

[b-ETSI TS 102 034] ETSI TS 102 034 V1.3.1 (2007), *Digital Video Broadcasting (DVB); Transport of MPEG-2 TS Based DVB Services over IP based networks*.

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