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SERIES P: TELEPHONE TRANSMISSION QUALITY, TELEPHONE INSTALLATIONS, LOCAL LINE NETWORKS

Models and tools for quality assessment of streamed media

Parametric bitstream-based quality assessment of progressive download and adaptive audiovisual streaming services over reliable transport – Audio quality estimation module

Recommendation ITU-T P.1203.2

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Recommendation ITU-T P.1203.2

Parametric bitstream-based quality assessment of progressive download and adaptive audiovisual streaming services over reliable transport – Audio quality estimation module

Summary

Recommendation ITU-T P.1203.2 specifies the short-term audio quality estimation module for Recommendation ITU-T P.1203. The ITU-T P.1203 series of ITU-T Recommendations specifies modules for a set of model algorithms for monitoring the integral media session quality for transport control protocol (TCP) type video streaming. The models comprise modules for short-term video-quality and audio-quality estimation (the latter specified in this Recommendation). The per-one-second outputs of these short-term modules are integrated into estimates of audio-visual quality and together with information about initial loading delay and media playout stalling events, these are further integrated into the final model output, the estimate of integral quality. The respective ITU-T work item has formerly been referred to as parametric non-intrusive assessment of TCP-based multimedia streaming quality or P.NATS. The Recommendation ITU-T P.1203.2 part of Recommendation ITU-T P.1203 provides details for the module for bitstream-based, short-term audio quality estimation.

Only one audio module is recommended for all four modes 0 to 3 of the Recommendation ITU-T P.1203 model series, corresponding to mode 0. The model is identical to the audio coding quality estimation component of the user datagram protocol (UDP) streaming related prediction model described in Recommendation ITU-T P.1201.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T P.1203.2	2016-11-29	5	11.1002/1000/13160

Keywords

Adaptive streaming, audio, audiovisual, IPTV, mean opinion score (MOS), mobile video, mobile TV, monitoring, multimedia, progressive download, QoE, TV, video

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Recommendation ITU-T P.1203.2

Parametric bitstream-based quality assessment of progressive download and adaptive audiovisual streaming services over reliable transport – Audio quality estimation module

1 Scope

This Recommendation describes the short term audio quality estimation module which is an integral part of the ITU-T P.1203 series. [ITU-T P.1203] describes a set of objective parametric quality assessment modules. Combined, these modules can be used to predict the impact of audio and video media encodings as well as Internet protocol (IP) network impairments on the quality experienced by an end-user of multi-media streaming applications.

The addressed streaming techniques comprise progressive download as well as adaptive streaming, for both mobile and fixed network streaming applications over transport control protocol (TCP) or other TCP like protocols which are not affected by transmission errors.

The model described is restricted to information provided to it by an appropriate packet- or bitstream-analysis module. The overall ITU-T P.1203 model is applicable for the effects due to audio- and video-coding as well as initial buffering and re-buffering (which are both perceivable as stalling of the media) as the typical degradations associated with progressive download. As final output, the ITU-T P.1203 series models target integral audio-visual media quality scores.

This Recommendation describes only one audio quality module. With regard to the required input data, this audio module corresponds to mode 0 of [ITU-T P.1203].

The same, purely header-based/bitrate-based audio quality module is also specified in [ITU-T P.1201.2]. Using a large number of subjective experiments, it was validated that this model also leads to accurate predictions within the scope of [ITU-T P.1203].

The audio module predicts mean opinion scores (MOS) on a 5-point absolute category rating (ACR) scale (see [ITU-T P.910]) as a per-one-second MOS score.

During the development of [ITU-T P.1201], explicit short-term audio quality tests were carried out in order to validate the stand-alone use of the audio module for the estimation of audio-only quality. It could be shown within the scope of [ITU-T P.1201] that this is possible.

It must be noted however, that since the subjective tests conducted for [ITU-T P.1201] included packet loss degradations, some range-equalization and other bias considerations may need to be considered (see for example [b-Zielinski_2008]) if the module is to be used stand-alone within the scope of [ITU-T P.1203].

This model cannot provide a comprehensive evaluation of audio transmission quality as perceived by an *individual* end user because its scores reflect the impairments due to audio coding only. Furthermore, the scores predicted by a parametric model necessarily reflect an average perceptual impairment. Note also that the model was developed and validated for one specific encoder and decoder implementation. If a different encoder and decoder pair is used in a monitoring situation the scores may not reflect that.

Effects such as audio level or noise (and corresponding similar audio factors) or other impairments related to the audio signals are not reflected in the scores computed by this model. Moreover, the scores predicted by a parametric model (i.e., without access to payload information, such as the audio signals) necessarily reflect a somewhat simplified representation of the perceptual impairment of the considered stream.

However, presuming that it is applied in an appropriate manner, according to this Recommendation, the model still enables estimation of some coding quality related information and thus valid and in most cases accurate predictions.

Tables 1.1 and 1.2 indicate the areas and parameter ranges for which the Pa module specified in this Recommendation has been validated and for which applications it can be used, with some caution.

Table 1.1 – Application areas, test factors and coding technologies where ITU-T P.1203.2 for adaptive streaming and progressive download has been verified and is known to produce reliable results

Applications for which the model is intended	
In-service monitoring of audiovisual, TCP-based video and audio. Both so called over the top (OTT) services (for example YouTube) and operator managed video services (over TCP), using the protocols HTTP/TCP/IP and RTMP/TCP/IP. Note that this model is agnostic to the type of container format (e.g. Flash (FLV), MP4, WebM or 3GP.	
Performance and quality assessment of live networks (including codecs) considering the effect due to encoding bitrate.	
Audio test factors for which the model has been validated	
Input audio length	20 s The audio model produces a per-second score considering a 20 second sliding window.
Bitstream container	Coded audio bitstream contained in transport stream (TS) segments
Encoder/Decoder implementation	The model has been trained using the following audio encoder: – AAC-LC: libfdk_aac, low complexity (LC) mode (ffmpeg). – A common framework was developed based on the above codec, all the test data was generated using the common framework.
Audio sample rate	48 000 samples/s
Audio bitrate	16, 32, 64 and 98 kBit/s/channel Audio bitrate was always varied in a correlated fashion with the video bitrate, i.e., high video bitrate corresponds to high audio bitrate and vice versa. Bearing to this condition it has been observed that audio quality has very little effect on the overall audio-visual quality.
TS segment length	1-9 seconds NOTE – The segment length determines how often the audio quality can be adapted.
Audio channels	2 (stereo), same signal encoded for each channel.

Table 1.2 – Application areas, test factors and coding technologies for which ITU-T P.1203.2 is assumed to give valid results

Test factors where the model can be used but the results may not be reliable (conditions not included in subjective tests underlying the model development)
All factors as indicated in Table 1.1, with additions as described below: Codecs: HE-AACv2, AC3, MPEG-LII Bitrates: 4.75-576 kbit/s NOTE – ITU-T P.1203 was tested on AAC-LC only. The audio module alone has been tested with the codecs mentioned above with dedicated audio-quality tests during [ITU-T P.1201] development.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T P.800.1] Recommendation ITU-T P.800.1 (2016), *Mean opinion score (MOS) terminology*.

[ITU-T P.910] Recommendation ITU-T P.910 (2008), *Subjective video quality assessment methods for multimedia applications*.

[ITU-T P.911] Recommendation ITU-T P.911 (1998), *Subjective audiovisual quality assessment methods for multimedia applications*.

[ITU-T P.1201] Recommendation ITU-T P.1201 (2012), *Parametric non-intrusive assessment of audiovisual media streaming quality*.

[ITU-T P.1201.1] Recommendation ITU-T P.1201.1 (2012), *Parametric non-intrusive assessment of audiovisual media streaming quality – Lower resolution application area*.

[ITU-T P.1201.2] Recommendation ITU-T P.1201.2 (2012), *Parametric non-intrusive assessment of audiovisual media streaming quality – Higher resolution application area*.

[ITU-T P.1202] Recommendation ITU-T P.1202 (2012), *Parametric non-intrusive bitstream assessment of video media streaming quality*.

[ITU-T P.1202.1] Recommendation ITU-T P.1202.1 (2012), *Parametric non-intrusive bitstream assessment of video media streaming quality – Lower resolution application area*.

[ITU-T P.1203] Recommendation ITU-T P.1203 (2016), *Parametric bitstream-based quality assessment of progressive download and adaptive audiovisual streaming services over reliable transport.*

[ITU-T P.1203.1] Recommendation ITU-T P.1203.1 (2016), *Parametric bitstream-based quality assessment of progressive download and adaptive audiovisual streaming services over reliable transport –Video quality estimation module.*

[ITU-T P.1203.3] Recommendation ITU-T P.1203.3 (2016), *Parametric bitstream-based quality assessment of progressive download and adaptive audiovisual streaming services over reliable transport –Quality integration module.*

[ITU-T P.1401] Recommendation ITU-T P.1401 (2012), *Methods, metrics and procedures for statistical evaluation, qualification and comparison of objective quality prediction models*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 mean opinion score (MOS): [ITU-T P.800.1].

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 model, model algorithm: An algorithm with the purpose of estimating the subjective (perceived) quality of a media sequence.

3.2.2 sequence: A short decoded audio, video or audiovisual portion of a stream, typically shorter than 30 seconds.

3.2.3 bitstream: The part of an IP-based transmission where the actual audiovisual, video, or audio content is available in encoded and packetized form.

3.2.4 compression artefacts: Artefacts introduced due to lossy compression of the encoding process.

3.2.5 media adaptation: Refers to events where the player switches video playback between a known set of media quality levels while adapting to network conditions.

3.2.6 initial buffering: Refers to the time in seconds between the initiation of video playback by the user and the actual start of the playback.

3.2.7 rebuffering or stalling artefacts: Artefacts coming from rebuffering events at the client side, which could be a result of video data arriving late. Usually, stalling events are indicated to the viewer, e.g., in the form of a spinning wheel.

3.2.8 Pa: Audio quality estimation module ([ITU-T P.1203.2] this Recommendation).

3.2.9 Pv: Video quality estimation module (see [ITU-T P.1203.1]).

3.2.10 Pq: Quality integration module (see [ITU-T P.1203.3]).

3.2.11 integral quality: The quality as it is perceived by a subject in a subjective test, which corresponds to the scope of this Recommendation. Artefacts presented in the subjective tests typically include a combination of audio compression, video compression, rebuffering and stalling effects.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAC	Advanced Audio Coding
AAC-LC	Advanced Audio Coding – Low Complexity
AC3	Audio Coding 3
ACR	Absolute Category Rating
ARQ	Automatic Repeat Request
API	Application Programming Interface
DASH	Dynamic Adaptive Streaming over HTTP
FEC	Forward Error Correction
GOP	Group Of Pictures
HD	High Definition (television)
HE-AAC	High-Efficiency Advanced Audio Coding
HTTP	Hypertext Transfer Protocol
IP	Internet Protocol

LC	Low Complexity
MOS	Mean Opinion Score
MPEG	Moving Pictures Expert Group
NTSC	National Television Systems Committee
OTT	Over The Top
PAL	Phase Alternating Line
PCC	Pearson Correlation Coefficient
RMSE	Root Mean Square Error
TCP	Transport Control Protocol
TS	Transport Stream
UDP	User Datagram Protocol

5 Conventions

None.

6 Pa module in ITU-T P.1203 context

The overall model structure is shown in Figure 6-1, highlighting the position of the *Pa* module. More details on the general structure can be found in the introductory [ITU-T P.1203].

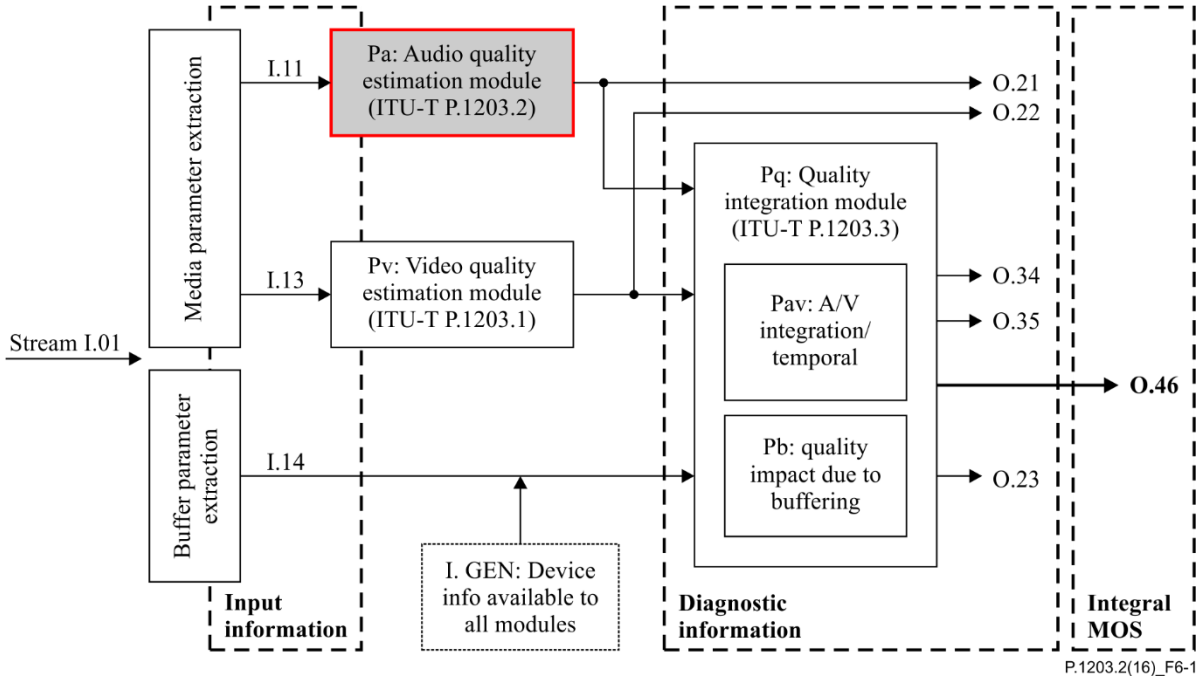

Figure 6-1 – *Pa* module in context of building blocks of the ITU-T P.1203 model

6.1 *Pa* module modes

The modes of operation for ITU-T P.1203.2 are defined in the Table 6-1. Detailed information on exactly which inputs are available for each mode is provided in Table 7-1. A single model is specified for all modes and is described in clause 8.

Table 6-1 –ITU-T P.1203.2 modes

Mode	Encryption	Input	Complexity	Comments
0	Encrypted media payload and media frame headers	Meta-data	Low	Module defined in this Recommendation
1	Encrypted media payload	Meta-data and frame header information	Low (see comments)	Same as mode 0
2	No encryption	Meta-data and up-to 2% of the media stream	Medium (see comments)	Same as mode 0
3	No encryption	Meta-data and any information from the video stream	Unlimited (see comments)	Same as mode 0

7 Model input

The model receives media information and prior knowledge about the media stream. The audio quality module receives the following input signals, regardless of the mode of operation:

I.11: Audio coding information.

Note that fault correction techniques, such as automatic repeat request (ARQ) and forward error correction (FEC) used for user datagram protocol (UDP) based streaming are not applicable for this case, where the streaming is TCP based. In TCP-based transport all retransmissions and packet loss information is typically handled transparently by the transport layer and while it can be available to the models described in this Recommendation it is not needed. Any packet loss or packet retransmissions are conveyed to the models described in this Recommendation as latency.

7.1 I.11 input specification

Since the audio quality module for mode 0 will be used as a component for the ITU-T P.1203 series models, I.11 consists of two parameters:

– Audio codec

– Bitrate in kbit/s

Details can be found in Table 7-1.

Table 7-1 – Description of I.11

ID	Description	Values	Frequency	Modes available
I.GEN				
0	The resolution of the image displayed to the user	Number of pixels (WxH) in displayed video	Per media session	All
1	The device type on which the media is played	PC or mobile	Per media session	All
I.11				
7	Target audio bit-rate	Bit-rate in kBit/s.	Per media segment	All

Table 7-1 – Description of I.11

ID	Description	Values	Frequency	Modes available
8	Segment duration	Duration in seconds	Per media segment	All
9	Audio frame number	Integer, starting with 1	Per media segment	1,2,3
10	Audio frame size	Size of the frame in bytes	Per audio frame	1,2,3
11	Audio frame duration	Duration in seconds	Per audio frame	1,2,3
12	Audio codec	One of: AAC-LC, AAC-HEv1, AAC-HEv2, AC3	Per media segment	All
13	Audio sampling frequency	Hz	Per media segment	All
14	Number of audio channels	2	Per media segment	All
15	Audio bit-stream	Encoded audio bytes for the frame	Per audio frame	2,3

8 Model algorithm and output

The [ITU-T P.1203.2] model for audio has one output, O.21. It provides output values on the 5-point ACR scale ("MOS") per output sampling interval.

One single audio quality module is recommended to be used in the ITU-T P.1203 series models. This audio quality module algorithm is the same as the one specified in [ITU-T P.1201.2]. It is summarized here for completeness:

$$O.21 = MOSfromR(QA) \qquad \text{(Eq. 13d in [ITU-T P.1201.2])}$$

with:

$$QA = 100 - QcodA \qquad \text{(Eq. 13c in [ITU-T P.1201.2], with coding degradations only, i.e., with QtraA = 0)}$$

where:

$$QcodA = a1A \times \exp(a2A \times Bitrate) + a3A \qquad \text{(Eq. 13a in [ITU-T P.1201.2])}$$

`Bitrate` is the audio bitrate in kbit/s.

The function MOSfromR is given in clause 6.4 of [ITU-T P.1201.2] and is provided below:

```
function MOS = MOSfromR(Q)

set MOS_MAX = 4.9;
set MOS_MIN = 1.05;

if (Q > 0 & Q < 100),
       MOS = (MOS_MIN+(MOS_MAX-MOS_MIN)/100×Q+Q×(Q-60)×(100-Q)×7.0E-6);
elseif (Q >= 100),
      MOS = MOS_MAX;
else
      MOS = MOS_MIN;
end
```

Coefficients a1A, a2A and a3A depend on the audio codec. These audio model coefficients are provided in Table 8-1:

Table 8-1 – Audio model coefficients for different audio codecs (coding degradations only), adapted from Table 1 of [ITU-T P.1201.2]

Audio codec	a1A	a2A	a3A
MPEG1 L2	100.0	–0.02	15.48
AC3	100.0	–0.03	15.70
AAC-LC	100.0	–0.05	14.60
HE-AAC v2	100.0	–0.11	20.06

Bibliography

[b-Zielinski_2008] Slawomir Zielinski, Soren Bech and Francis Rumsey (2008), *On some biases encountered in modern audio quality listening tests – A review, Journal Audio Engineering Society (JAES)*, 56(6), 427-451. http://www.aes.org/e-lib/browse.cfm?elib=14393

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