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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Multimedia Quality of Service and performance – Generic and user-related aspects

Opinion model for video-telephony applications

Recommendation ITU-T G.1070

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Recommendation ITU-T G.1070

Opinion model for video-telephony applications

Summary

Recommendation ITU-T G.1070 proposes an algorithm that estimates videophone quality for quality of experience (QoE)/quality of service (QoS) planners. This model can be used by QoE/QoS planners to help ensure that users will be satisfied with end-to-end service quality. The model provides estimates of multimedia quality that take interactivity into account and it allows planners to avoid under-engineering.

The application of this Recommendation is limited to QoE/QoS planning. Other applications such as quality benchmarking and monitoring are outside the scope of this Recommendation.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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1.1	ITU-T G.1070 (2007) Amd. 1	2009-11-12	12	11.1002/1000/9187
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Keywords

MOS, multimedia, opinion model, QoE, QoS, quality planning, subjective quality, video telephony.

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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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In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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1 Scope

This Recommendation describes a computational model for point-to-point interactive videophone applications over IP networks that is useful as a quality of experience (QoE)/ quality of service (QoS) planning tool for assessing the combined effects of variations in several video and speech parameters that affect the QoE. This model can be used by QoE/QoS planners to help ensure that users will be satisfied with end-to-end service quality. Actually, they want to avoid under-engineering. Network, application and terminal quality parameters of high importance to QoE/QoS planners are incorporated into this model.

The model provided in this Recommendation needs to be a flexible tool capable of providing feedback on individual qualities as well as overall quality.

This Recommendation is very different from [ITU-T J.148] in terms of input parameters. In this Recommendation, multimedia quality is calculated by using network, application and terminal equipment parameters, whereas in [ITU-T J.148], the calculation is done by using speech and video signals.

This Recommendation assumes videophone applications using dedicated videophone terminals, desktop PCs, laptop PCs, personal digital assistants (PDAs) and mobile phones. The speech bandwidth is limited to the telephone band (300-3400 Hz).

The application of this Recommendation is limited to QoE/QoS planning. Other applications such as quality benchmarking and monitoring are outside the scope of this Recommendation.

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 G.107] Recommendation ITU-T G.107 (2015), *The E-model: a computational model for use in transmission planning*.

[ITU-T G.107.1] Recommendation ITU-T G.107.1 (2015), *Wideband E-model*.

[ITU-T G.113] Recommendation ITU-T G.113 (2007), *Transmission impairments due to speech processing*.

[ITU-T G.122] Recommendation ITU-T G.122 (1993), *Influence of national systems on stability and talker echo in international connections*.

[ITU-T G.711] Recommendation ITU-T G.711 (1988), *Pulse code modulation (PCM) of voice frequencies*.

[ITU-T J.144] Recommendation ITU-T J.144 (2004), *Objective perceptual video quality measurement techniques for digital cable television in the presence of a full reference*.

[ITU-T J.148]	Recommendation ITU-T J.148 (2003), *Requirements for an objective perceptual multimedia quality model*.
[ITU-T P.79]	Recommendation ITU-T P.79 (2007), *Calculation of loudness ratings*.
[ITU-T P.561]	Recommendation ITU-T P.561 (2002), *In-service non-intrusive measurement device – Voice service measurements*.
[ITU-T P.562]	Recommendation ITU-T P.562 (2004), *Analysis and interpretation of INMD voice-service measurements*.
[ITU-T P.563]	Recommendation ITU-T P.563 (2004), *Single-ended method for objective speech quality assessment in narrow-band telephony applications*.
[ITU-T P.564]	Recommendation ITU-T P.564 (2007), *Conformance testing for voice over IP transmission quality assessment models*.
[ITU-T P.800]	Recommendation ITU-T P.800 (1996), *Methods for subjective determination of transmission quality*.
[ITU-T P.833]	Recommendation ITU-T P.833 (2001), *Methodology for derivation of equipment impairment factors from subjective listening-only tests*.
[ITU-T P.834]	Recommendation ITU-T P.834 (2002), *Methodology for the derivation of equipment impairment factors from instrumental models*.
[ITU-T P.862]	Recommendation ITU-T P.862 (2001), *Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs*.
[ITU-T P.862.1]	Recommendation ITU-T P.862.1 (2003), *Mapping function for transforming P.862 raw result scores to MOS-LQO*.
[ITU-T P.862.2]	Recommendation ITU-T P.862.2 (2007), *Wideband extension to Recommendation P.862 for the assessment of wideband telephone networks and speech codecs*.
[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.920]	Recommendation ITU-T P.920 (2000), *Interactive test methods for audiovisual communications*.
[ITU-R BS.1387-1]	Recommendation ITU-R BS.1387-1 (2001), *Method for objective measurements of perceived audio quality*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms shown in Table 1:

Table 1 – List of definitions

Name	Description	Unit
AD	Absolute audio-visual delay	–
b_n	Video bit rate (n = 1, 2, …, N)	kbit/s
Bpl_S	Speech packet-loss robustness	–
Br_V	Video bit rate	kbit/s
D_{bnfm}	Degree of video quality robustness against packet loss (n = 1, 2, …, N, m = 1, 2, …, M)	–
D_{FrV}	Degree of video quality robustness due to frame rate reduction	–
D_n	Degree of video quality robustness due to frame rate reduction (n = 1, 2, …, N)	–
D_{PplV}	Degree of video quality robustness against packet loss	–
f_m	Frame rate (m = 1, 2, …, M)	fps
Fr_V	Video frame rate	fps
I_{coding}	Objective measurement of basic video quality accounting for coding distortion	–
Idd	Degradation caused by pure delay in [ITU-T G.107]	–
Idd,WB	Degradation caused by pure delay in [ITU-T G.107.1]	–
$Idte$	Degradation caused by talker echo in a narrowband context	–
$Idte,WB$	Degradation caused by talker echo in a wideband context	–
$Ie\text{-}eff$	Degradation caused by speech coding and packet loss in a narrowband context	–
$Ie\text{-}eff,WB$	Degradation caused by speech coding and packet loss in a wideband context	–
Ie_S	Speech coding distortion in a narrowband context	–
Ie_S,WB	Speech coding distortion in a wideband context	–
I_n	Objective measurement of maximum video quality at each bit rate (n = 1, 2, …, N)	–
I_{Ofr}	Objective measurement of maximum video quality at each bit rate	–
MM_q	Objective measurement of multimedia quality accounting for the influence of speech and video quality and speech and video delay	–
MM_{SV}	Audio-visual quality	–
MM_T	Audio-visual delay impairment factor	–
MS	Audio-visual media synchronization	–
Ofr	Optimal frame rate that maximizes video quality at each bit rate	–
O_n	Optimal frame rate (n = 1, 2, …, N)	–
Ppl_S	Speech packet-loss rate	%
Ppl_V	Video packet-loss rate	%
Q	Speech quality index	–
R	Transmission rating factor	–
S_q	Objective measurement of speech quality	–

Table 1 – List of definitions

Name	Description	Unit
$S_q(V_q)$	Objective measurement of speech quality accounting for influence of video quality	–
TELR	Talker echo loudness rating in a narrowband context	dB
TELR,WB	Talker echo loudness rating in a wideband context	dB
T_S	Speech delay	ms
T_V	Video delay	ms
V_q	Objective measurement of video quality	–
$V_q(S_q)$	Objective measurement of video quality accounting for influence of speech quality	–
V_{qs}	Subjective video quality	
$V_{qs}(b_n, f_m)$	Subjective video quality under conditions of b_n and f_m	–

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACR Absolute Category Rating

AEC Acoustic Echo Canceller

BP Baseline Profile

CIF Common Intermediate Format (352 × 288 pixels)

CT Codec Type

ERL Echo Return Loss

HP High Profile

KFI Key Frame Interval

LSA Least Square Approximation

MOS Mean Opinion Score

PDA Personal Digital Assistant

QCIF Quarter CIF (176 × 144 pixels)

QQVGA Quarter Quarter VGA (160 × 120 pixels)

QVGA Quarter Video Graphics Array (320 × 240 pixels)

RLR Receiving Loudness Rating

SLR Sending Loudness Rating

VDS Video Display Size

VF Video Format

VGA Video Graphics Array (640 × 480 pixels)

5 Conventions

In this Recommendation, "subjective quality" refers to the mean opinion score (MOS) obtained in absolute category rating (ACR) tests as defined in [ITU-T P.800], [ITU-T P.910], [ITU-T P.911] and [ITU-T P.920], depending on the media under evaluation and evaluation context such as one-way listening/viewing and two-way interactive communication.

6 Application

The application of this Recommendation is limited to QoE/QoS planning. Other applications such as quality benchmarking and monitoring are outside the scope of this Recommendation. Table 2 gives an overview of various Recommendations related to objective quality assessment methods and their intended applications, the media types they apply to, and the subjective quality aspects that are taken into account.

Table 2 – Relationship of ITU-T G.1070 to other ITU Recommendations for objective quality assessment

<table>
<tr><th rowspan="2">Media</th><th rowspan="2">Estimated subjective quality</th><th colspan="3">Application</th></tr>
<tr><th>Benchmarking/ Intrusive monitoring</th><th>Non-intrusive monitoring</th><th>Network planning</th></tr>
<tr><td rowspan="3">Speech</td><td>One way (listening quality)</td><td>[ITU-T P.862]/ [ITU-T P.862.1] (telephone band) [ITU-T P.862.2] (wideband)</td><td>[ITU-T P.563], [ITU-T P.564] (telephone band)</td><td rowspan="3">[ITU-T G.107] (telephone band) [ITU-T G.107.1] (wideband)</td></tr>
<tr><td rowspan="2">Two way (conversational quality)</td><td colspan="2">FFS (telephone-band)</td></tr>
<tr><td></td><td>[ITU-T P.561], [ITU-T P.562] (telephone band)</td></tr>
<tr><td>Audio</td><td>One way (listening quality)</td><td>[ITU-R BS.1387-1]</td><td></td><td></td></tr>
<tr><td>Video</td><td>One way (viewing quality)</td><td>[ITU-T J.144] (cable TV) FFS (multimedia)</td><td>FFS (cable TV) FFS (multimedia)</td><td></td></tr>
<tr><td rowspan="2">Speech/Audio and Video</td><td>One way</td><td colspan="2" rowspan="2">[ITU-T J.148] (multimedia)</td><td>FFS (video streaming)</td></tr>
<tr><td>Two way</td><td>[ITU-T G.1070] (videophone)</td></tr>
<tr><td>Data</td><td>One way</td><td>FFS (web browsing)</td><td></td><td>[ITU-T G.1030] Annex A (web browsing)</td></tr>
<tr><td colspan="5">NOTE – FFS stands for "for further study"</td></tr>
</table>

7 Framework

The framework of the opinion model treated in this Recommendation is illustrated in Figure 1. Its input parameters are video and speech quality parameters that are considered important in QoE/QoS planning. The model consists of three functions: video quality estimation, speech quality estimation and multimedia quality integration functions. The degradation caused by pure delay is considered only in the multimedia quality integration function.

This Recommendation provides basic formulae for the above functions. The outputs from the model are multimedia quality (MM_q), video quality influenced by speech quality ($V_q(S_q)$), and speech quality influenced by video quality ($S_q(V_q)$).

The model assumes some specific evaluation conditions for terminals, environments, and evaluation contexts, and quality estimation under other evaluation conditions is currently under study. In this sense, these are the limitations of the current Recommendation.

It should be noted that the effects of a codec on subjective quality are dependent on its implementation. In particular, the quality of a video codec cannot be estimated based simply on the information about the coding technology (e.g., MPEG-4) used in the system under test, although specifying the implementation of a speech codec based on the standard (e.g., [ITU-T G.711]) employed in the system under test is relatively easy. For example, there are a number of different implementations for MPEG-4 codecs due to variations in coding-parameter settings and decoder characteristics. Therefore, the coefficients of video and speech quality estimation functions in this Recommendation were determined by referring to tables prepared in advance for each video and speech codec. A coefficient database for video is illustrated in Figure 2. Such tables can be constructed by using the methodology provided in Annex A for video and by using [ITU-T P.833] or [ITU-T P.834] for speech.

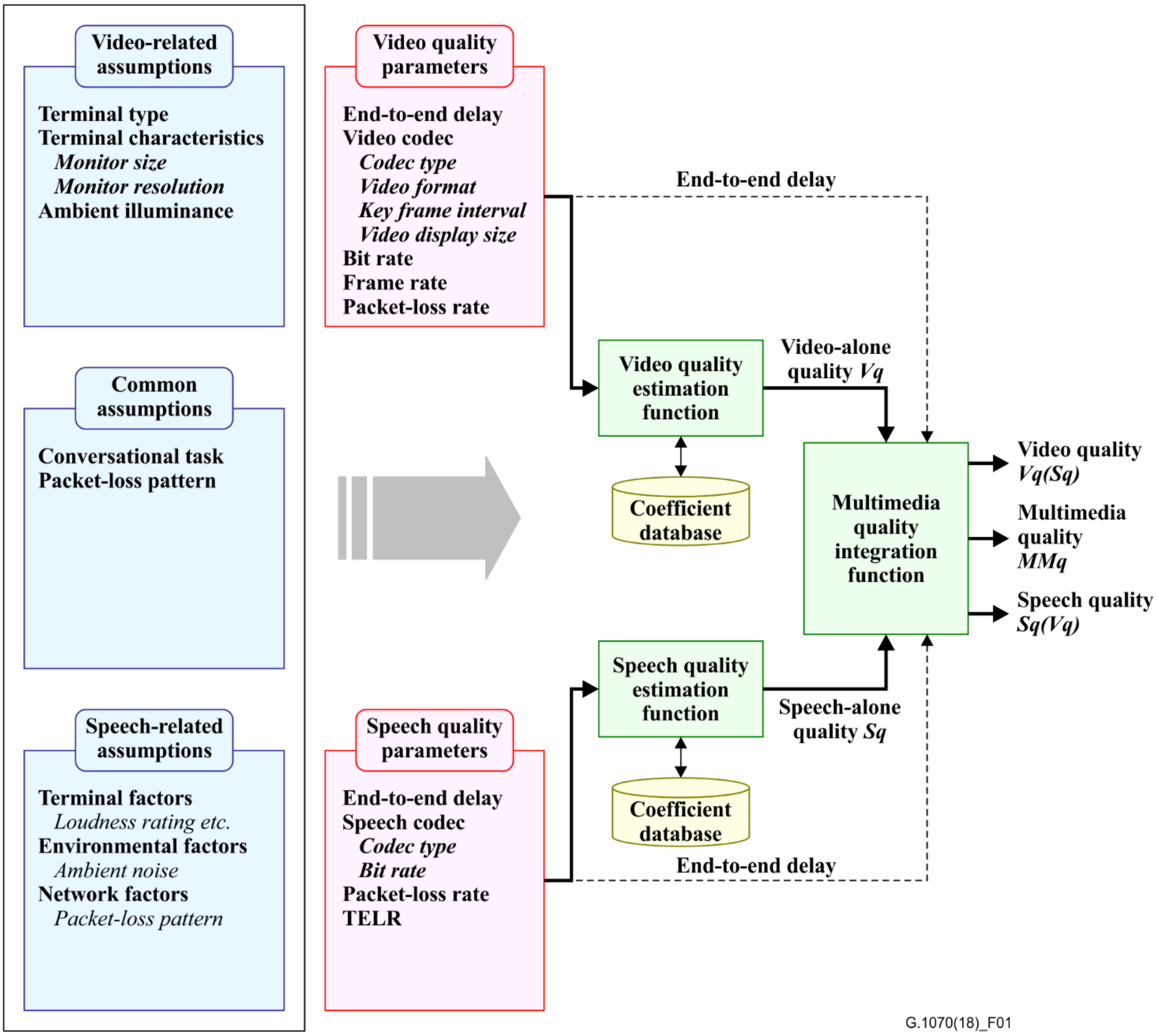

Figure 1 – Framework of a multimedia communication quality assessment model

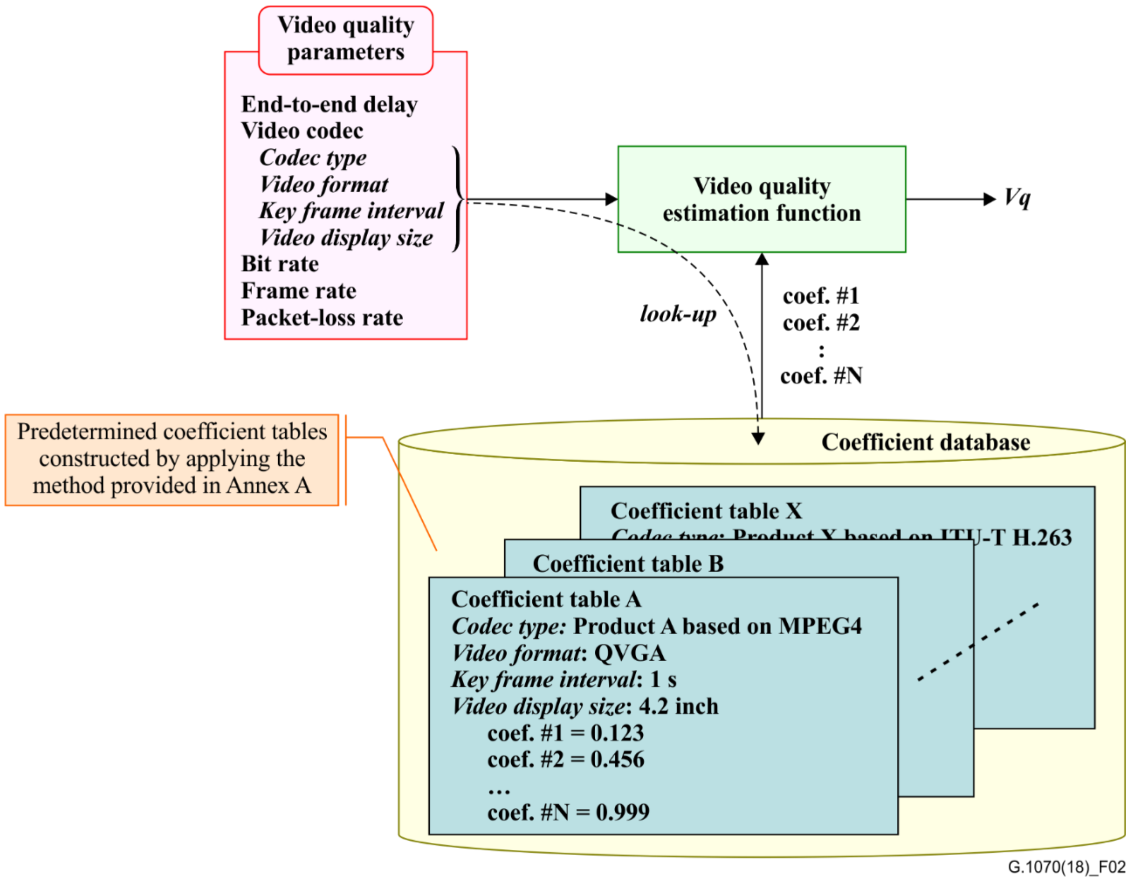

Figure 2 – Determination of coefficients that depend on codec implementation

8 Model assumptions

This clause describes conditions that the model assumes for terminals, environments, and evaluation contexts.

8.1 Speech-related assumptions

8.1.1 Terminal factors

The model assumes the use of a handset as the interface for the voice path. We recognize that in many cases the interface will be a hands-free or headset unit; further work is needed to include these in the ITU-T G.107 and ITU-T G.107.1 models, before they can be included as options for the multimedia model. This means that one needs to be very careful when evaluating a mobile terminal, which usually has a hands-free function.

If a noise canceller and/or an automatic gain controller is applied, it is assumed that the device works without causing any additional degradation of speech signals.

8.1.2 Environmental factors

The assumed ambient noise is Hoth noise at 35 dB(A). Although other ambient noise conditions can be assumed to exist, especially in mobile applications, dealing with such conditions is for further study.

8.2 Video-related assumptions

8.2.1 Terminal factors

The model estimates video quality which has been evaluated by using a monitor whose specifications are listed in Table 3. Although this Recommendation treats video-telephony services using dedicated videophone terminals, desktop PCs, laptop PCs, PDAs and mobile phones, the effects of terminal characteristics with specifications other than those shown in Table 3 are still under study.

NOTE – Specifications of monitors used in most PDAs and mobile phones are lower than those in Table 3. Thus, the model's predictions are often more sensitive than the users' opinions. Table 3 suggests nominal values, which are assumed by the model in this Recommendation, for use in QoE/QoS planning.

Table 3 – Assumptions about monitor characteristics

Monitor specifications	Value
Diagonal length (Note)	2-10 inches
Dot pitch	<0.30
Colour temperature	6500 K
Bit depth	8 bits/colour
Refresh rate	≥60 Hz
Brightness	100-300 cd/m^2
NOTE – "Diagonal length" refers to the image size on the monitor screen.	

8.2.2 Environmental factors

The nominal ambient illumination is taken to be 500 lux. The model assumes video content to be a so-called "bust shot" with a grey background; this does not however, take into consideration moving backgrounds in mobile applications, nor does it consider a camera shaking due to hand movement.

8.3 Task-related assumptions

Conversational tasks in subjective quality evaluation affect the resultant conversational quality. In particular, the effects of delay have great impact on the interactivity in a conversation. Therefore, it is desirable that the model takes into account the kind of task assumed in the service. However, the only task currently considered in the model is "free conversation". This means that the video image of a conversation partner is displayed on the screen. Modelling of conversational tasks other than free conversation is for further study.

9 Model inputs

This clause describes the input parameters used in the model.

9.1 Speech quality parameters

The parameters described in this clause are similar to those in [ITU-T G.107] and in [ITU-T G.107.1]. Speech quality parameters not listed in this clause are assumed to take their default values as defined in [ITU-T G.107] and [ITU-T G.107.1].

9.1.1 Speech delay (T_S [ms])

This refers to an end-to-end, one-way delay in speech. Considering the delay in terminals, such as the processing delay and jitter-buffer delay is extremely important. An input value of T_S must be less than 1000 ms.

9.1.2 Speech coding distortion (Ie_S, Ie_S,WB)

Distortion due to speech coding needs to be quantified as Ie_S and Ie_S,WB. The Ie_S and Ie_S,WB values for ITU-T standard codecs are provided in Appendices I and IV of [ITU-T G.113], respectively. The Ie_S and Ie_S,WB values for other codecs should be derived by applying the methods defined in [ITU-T P.833] or [ITU-T P.834].

9.1.3 Speech packet-loss robustness (Bpl_S)

Packet-loss robustness of a speech codec should be quantified as Bpl_S. The Bpl_S values for ITU-T standard codecs are provided in Appendices I and IV of [ITU-T G.113].

9.1.4 Speech packet-loss rate (Ppl_S [%])

This refers to the end-to-end IP packet-loss rate in speech. Considering the packet loss in a terminal-jitter buffer and the packet loss in networks is extremely important. The value should be less than 20 [%].

9.1.5 Talker echo loudness rating (*TELR, TELR, WB*)

This is the sum of sending loudness rating (SLR), receiving loudness rating (RLR), and echo return loss (ERL) in the talker-echo path. SLR and RLR are defined in [ITU-T P.79], and ERL is defined in [ITU-T G.122].

9.2 Video quality parameters

9.2.1 Video delay (T_V [ms])

This refers to an end-to-end one-way delay in video. Considering the delay in terminals, such as the processing delay and jitter-buffer delay is extremely important. An input value of T_V must be less than 1000 ms.

9.2.2 Video codec specifications

The model's coefficients (see Figure 2) for coding and packet-loss distortion are determined by looking up the coefficient database that is provided in Annex B. For conditions other than those in Annex B, one needs to derive coefficients by applying the method described in Annex A.

9.2.2.1 Codec type and implementation

This information is used to identify the specific implementation of a video codec under evaluation so that the model utilizes the coefficients appropriate to that implementation. The method to derive coefficients is provided in Annex A.

9.2.2.2 Spatial resolution

This parameter refers not to the actual/effective spatial resolution reflecting the performance of a camera and/or a display but to the theoretical spatial resolution employed in a codec. It is better to measure the effective spatial resolution, if possible, and reflect it in the quality estimation. [ITU-T P.800] provides a methodology for measuring the effective spatial resolution. However, how to reflect such results in the quality estimation model is still under study.

The model handles video whose size is between quarter quarter VGA (QQVGA) and video graphics array (VGA).

9.2.2.3 Key frame interval

This is the time interval in which video is coded solely from intra-frame information. This affects the effectiveness of video coding (i.e., quality versus video bit rate) and the robustness against packet-loss degradation.

9.2.3 Video packet-loss rate (Ppl_V [%])

This refers to the end-to-end IP packet-loss rate in video. Considering the packet loss in a terminal-jitter buffer and the packet loss in networks is extremely important. The value should be less than 10 [%].

9.2.4 Video frame rate (Fr_V [fps])

This refers to the frame rate used in an encoder and does not reflect frame repetition used by a decoder, for example, in the case of packet loss. This Recommendation assumes that the range of the frame rate is from 1 to 30 fps.

9.2.5 Video bit rate (Br_V [kbit/s])

This refers to the video bit rate at an encoder.

10 Model outputs

The model outputs are multimedia quality (MM_q), speech quality accounting for the influence of video quality ($S_q(V_q)$), and video quality accounting for the influence of speech quality ($V_q(S_q)$).

NOTE – The determination of $V_q(S_q)$ and $S_q(V_q)$ is for further study.

11 Model description

11.1 Speech quality estimation function for narrowband speech

First, the speech quality parameters defined in clause 9.1 are mapped to a quality index Q as follows:

$$Q = 93.193 - Idte - Ie\text{-}eff \tag{11-1}$$

NOTE 1 – The quality index Q is equivalent to the transmission rating factor R defined in [ITU-T G.107], but the definition in this Recommendation is simplified due to the smaller number of input parameters.

NOTE 2 – Quality evaluation characteristics in multimedia applications might be different from those expected in telephony applications. Therefore, the model described in this clause is a provisional method. The applicability of [ITU-T G.107] in such applications is still under study.

NOTE 3 – The delay quality is considered separately in the multimedia quality integration function (see Figure 1), so Equation 11-1 excludes *Idd*, which represents the degradation caused by pure delay in [ITU-T G.107].

Idte represents the degradation caused by talker echo and is defined as:

$$Idte = \left[\frac{94.769 - Re}{2} + \sqrt{\frac{(94.769 - Re)^2}{4} + 100} - 1\right]\left(1 - e^{-T_S}\right) \tag{11-2}$$

where:

$$\mathrm{Re} = 80 + 2.5(TERV - 14) \tag{11-3}$$

and:

$$TERV = TELR - 40\log\frac{1 + \frac{T_S}{10}}{1 + \frac{T_S}{150}} + 6e^{-0.3T_S^{\,2}} \tag{11-4}$$

Ie-eff represents the degradation caused by speech coding and packet loss and is defined as:

$$Ie\text{-}eff = Ie_S + (95 - Ie_S)\cdot\frac{Ppl_S}{Ppl_S + Bpl_S} \tag{11-5}$$

Speech quality S_q is defined as a function of the quality index Q.

For $Q < 0$: $S_q = 1$

For $0 < Q < 100$: $$S_q = 1 + 0.035Q + Q(Q-60)(100-Q)7\times10^{-6} \quad (11\text{-}6)$$

For $Q > 100$: $$S_q = 4.5$$

11.2 Speech quality estimation function for wideband speech

The speech quality parameters defined in clause 9.1 are mapped to a quality index Q as follows:

$$Q = 129 - Idte,WB - Ie\text{-}eff\,,WB \quad (11\text{-}7)$$

NOTE 1 – The quality index Q is equivalent to the transmission rating factor R defined in [ITU-T G.107.1], but the definition in this Recommendation is simplified due to the smaller number of input parameters.

NOTE 2 – Quality evaluation characteristics in multimedia applications might be different from those expected in telephony applications. Therefore, the model described in this clause is a provisional method. The applicability of [ITU-T G.107.1] in such applications is still under study.

NOTE 3 – The delay quality is considered separately in the multimedia quality integration function (see Figure 1), so Equation 11-7 excludes *Idd,WB,* which represents the degradation caused by pure delay in [ITU-T G.107.1].

Idte,WB represents the degradation caused by talker echo and is defined as:

$$Idte,WB = \left[\frac{129 - Re,WB}{2} + \sqrt{\frac{(129 - Re,WB)^2}{4} + 100} - 1\right]\left(1 - e^{-T_S}\right) \quad (11\text{-}8)$$

where:

$$\mathrm{Re},WB = 80 + 3(TERV,WB - 14) \quad (11\text{-}9)$$

and:

$$TERV,WB = TELR + K - 40\log\frac{1+\frac{T_S}{10}}{1+\frac{T_S}{150}} + 6e^{-0.3T_S{}^2} \quad (11\text{-}10)$$

For $T_S < 100$ ms:

$$K = 0.08\cdot T_S + 10 \quad (11\text{-}11)$$

For $T_S \geq 100$ ms:

$$K = 18 \quad (11\text{-}12)$$

Ie-eff,WB represents the degradation caused by speech coding and packet loss and is defined as:

$$Ie\text{-}eff\,,WB = Ie_S,WB + (95 - Ie_S,WB)\cdot\frac{Ppl_S}{Ppl_S + Bpl_S} \quad (11\text{-}13)$$

$$Qx = \frac{Q}{1.29} \quad (11\text{-}14)$$

Speech quality S_q is defined as a function of the quality index Qx.

For $Qx < 0$: $$S_q = 1$$

For $0 < Qx < 100$: $$S_q = 1 + 0.035Qx + Qx(Qx-60)(100-Qx)7\times10^{-6} \quad (11\text{-}15)$$

For $Qx > 100$: $$S_q = 4.5$$

11.3 Video quality estimation function

11.3.1 Calculation of video quality, V_q

Video quality V_q is calculated using the video quality parameters defined in clause 9.2. V_q is expressed as:

$$V_q = 1 + I_{coding} \exp\left(-\frac{Ppl_V}{D_{PplV}} \right) \tag{11-16}$$

where I_{coding} represents the basic video quality affected by the coding distortion under a combination of video bit rate (Br_V [kbit/s]) and video frame rate (Fr_V [fps]), and the packet loss robustness factor D_{PplV} expresses the degree of video quality robustness due to packet loss where Ppl_V [%] represents the packet-loss rate.

11.3.2 Basic video quality affected by coding distortion, I_{coding}

The basic video quality affected by coding distortion I_{coding} is expressed as:

$$I_{coding} = I_{Ofr} \exp\left\{ -\frac{\left(\ln(Fr_V) - \ln(O_{fr}) \right)^2}{2 D_{FrV}{}^2} \right\} \tag{11-17}$$

The O_{fr} is an optimal frame rate that maximizes the video quality at each video bit rate (Br_V) and is expressed as:

$$O_{fr} = v_1 + v_2\, Br_V, \quad 1 \le O_{fr} \le 30, \; v_1 \text{ and } v_2\text{: const} \tag{11-18}$$

where $Fr_V = O_{fr}$, $I_{coding} = I_{Ofr}$, I_{Ofr} represents the maximum video quality at each video bit rate (Br_V) and is expressed as:

$$I_{Ofr} = v_3 - \frac{v_3}{1 + \left(\frac{Br_V}{v_4} \right)^{v_5}}, \quad 0 \le I_{Ofr} \le 4, \; v_3, v_4, \text{ and } v_5\text{: const} \tag{11-19}$$

D_{FrV} represents the degree of video quality robustness due to frame rate (Fr_V) and is expressed as:

$$D_{FrV} = v_6 + v_7\, Br_V, \quad 0 < D_{FrV}, \; v_6 \text{ and } v_7\text{: const} \tag{11-20}$$

Coefficients v_1, v_2, ..., and v_7 are dependent on the codec type (CT), video format (VF), key frame interval (KFI) and video display size (VDS); see Annex B.

11.3.3 Packet loss robustness factor, D_{PplV}

The packet loss robustness factor D_{PplV} represents the degree of video quality robustness against packet loss and is expressed as:

$$D_{PplV} = v_{10} + v_{11} \exp\left(-\frac{Fr_V}{v_8} \right) + v_{12} \exp\left(-\frac{Br_V}{v_9} \right), \quad 0 < D_{PplV} \tag{11-21}$$

where Ppl_V represents the packet-loss rate.

Coefficients v_8, v_9, ..., and v_{12} are dependent on the codec type, video format, key frame interval, and video display size (see Annex B).

11.4 Multimedia quality integration function

11.4.1 Calculation of the multimedia quality, MM_q

The multimedia quality MM_q is calculated using speech quality S_q, video quality V_q, speech delay T_S, and video delay T_V. MM_q is expressed as:

$$MM_q = m_1\ MM_{SV} + m_2\ MM_T + m_3\ MM_{SV}\ MM_T + m_4 \quad (11\text{-}22)$$

where MM_{SV} represents audio-visual quality, MM_T represents the audio-visual delay impairment factor, and coefficients m_1, m_2, ..., and m_4 are dependent on the video display size and conversational task. MM_q is bounded between 1 and 5.

11.4.2 Audio-visual quality, MM_{SV}

The audio-visual quality MM_{SV} is expressed as:

$$MM_{SV} = m_5\ S_q + m_6\ V_q + m_7\ S_q\ V_q + m_8 \quad (11\text{-}23)$$

Coefficients m_5, m_6, ..., and m_8 are dependent on the video display size and conversational task. MM_{SV} is bounded between 1 and 5.

11.4.3 Audio-visual delay impairment factor, MM_T

The MM_T represents the degree of the audio-visual quality degradation due to audio-visual delay and synchronization and is expressed as:

$$MM_T = \max\{AD + MS, 1\} \quad (11\text{-}24)$$

$$AD = m_9\ (T_S + T_V) + m_{10} \quad (11\text{-}25)$$

$$MS = \min\{m_{11}\ (T_S - T_V) + m_{12}, 0\} \quad if\ T_S \geq T_V \quad (11\text{-}26)$$

and:

$$MS = \min\{m_{13}\ (T_V - T_S) + m_{14}, 0\} \quad if\ T_S < T_V \quad (11\text{-}27)$$

where *AD* represents the absolute audio-visual delay and *MS* represents the audio-visual media synchronization.

Coefficients m_9, m_{10}, ..., and m_{14} are dependent on the video display size and conversational task.

NOTE 1 – Provisional values of m_i were developed for two different video displays, namely a 4.2-video display size with a QVGA video format and a 2.1-inch video display with a QQVGA video format. The conversational task was free conversation. These values are provided in Annex C.

NOTE 2 – Currently, the derivation of $V_q(S_q)$ and $S_q(V_q)$, which are video quality affected by speech quality and vice versa, is under study.

12 Accuracy of model

The Pearson product-moment correlation between the empirical subjective quality and the quality estimate generated by the model was used for evaluating the accuracy of the speech quality estimation function, the video quality estimation function, and the multimedia quality integration function. The correlation *r* should be calculated over all the test data sets as follows:

$$r = \frac{\sum_{v=1}^{V}\left(y_v - \bar{y}\right)\left(x_v - \bar{x}\right)}{\sqrt{\sum_{v=1}^{V}\left(y_v - \bar{y}\right)^2 \sum_{v=1}^{V}\left(x_v - \bar{x}\right)^2}}$$

where V is the number of test data sets, and the mean values of the data sets are calculated as follows:

$$\bar{x} = \frac{1}{V}\sum_{v=1}^{V} x_v$$

and:

$$\bar{y} = \frac{1}{V}\sum_{v=1}^{V} y_v$$

where:

x_v: represents the estimated quality of test data; and

y_v: represents the subjective quality of test data.

The accuracy of the speech quality estimation function, which is presented in [ITU-T G.107], is described in [b-Möller].

The accuracy of the video quality estimation function was verified in the following manner:

1) The validity of the forms (Equations 11-16 to 11-21) was verified by using the subjective quality database employing [ITU-T H.264] and MPEG-4 codecs (DB#1 to DB#4 in Table 4). Here, the coefficients v_1, v_2, ..., and v_{12} were optimized for each database. The cross-correlation is about 0.975 on average [b-Yamagishi 1], [b-Yamagishi 2].

2) The validity of the optimized coefficients v_1, v_2, ..., and v_{12} was verified by applying them to unknown data. This was done by optimizing the coefficients by DB#5 and DB#7, and applying them to DB#6 and DB#8 (see Table 5). The cross-correlation is about 0.955 on average [b-Yamagishi 3].

Table 4 – Verification of the form of video quality estimation function for various terminals

	r	**CT**	**VF**	**KFI [s]**	**VDS [inches]**
DB#1	0.967 [b-Yamagishi 1]	ITU-T H.264	QVGA	1	4.2
DB#2	0.987 [b-Yamagishi 1], [b-Yamagishi 2]	MPEG-4	QVGA	1	4.2
DB#3	0.973 [b-Yamagishi 2]	MPEG-4	QVGA	1	8.5
DB#4	0.972 [b-Yamagishi 2]	MPEG-4	VGA	1	8.5

Table 5 – Accuracy of the video quality estimation function

	r	**CT**	**VF**	**KFI [s]**	**VDS [inches]**
DB#5	0.951 [b-Yamagishi 3]	MPEG-4	QVGA	1	4.2
DB#6	0.961 [b-Yamagishi 3]	MPEG-4	QVGA	1	4.2
DB#7	0.958 [b-Yamagishi 3]	MPEG-4	QQVGA	1	2.1
DB#8	0.949 [b-Yamagishi 3]	MPEG-4	QQVGA	1	2.1

The accuracy of the multimedia quality integration function was verified as follows.

The speech and video quality (S_q and V_q) were estimated by the speech and video quality estimation functions described in clauses 11.1, 11.2 and 11.3, respectively. Next, these values and speech and video delay values (T_S and T_V) were fed into the multimedia quality integration function given in clause 11.4. By comparing the estimated multimedia quality with the multimedia quality obtained by a conversational subjective test, the validity of the multimedia quality integration function was evaluated.

An [ITU-T G.711] codec without a packet-loss concealment algorithm was used as a speech codec. The speech packet-loss rate varied from 0 to 10%. No echo was introduced in the evaluation system. The video codec was MPEG-4, and the video bit rate was 2 Mbit/s and 1 Mbit/s for QVGA and QQVGA, respectively. The video packet-loss rate varied from 0 to 5%. The video frame rate was between 2 to 30 fps. One-way delay varied from 167 to 1000 ms and was controlled for speech and video separately to evaluate the effects of lip synchronization. The number of experimental conditions was 88.

The subjective testing method was 5-grade conversational ACR defined in [ITU-T P.910]. There were 32 subjects. The viewing distances were 50 and 80 cm for QQVGA and QVGA, respectively. The number of judgments by each subject was 140. All the conditions (88) were assessed by each subject. Some were assessed twice or more.

The estimation accuracy of the [ITU-T G.1070] model, including speech and video quality estimation functions, is demonstrated in Table 6.

NOTE – These databases were used for optimizing the coefficients of the multimedia quality integration function under each VDS condition. The coefficients are provided in Annex C.

Table 6 – Accuracy of the multimedia communication quality assessment model

	r	**Speech codec**	**Video codec**	**VF**	**KFI [s]**	**VDS [inches]**
DB#9	0.83	ITU-T G.711	MPEG-4 at 2 Mbit/s	QVGA	1	4.2
DB#10	0.91	ITU-T G.711	MPEG-4 at 1 Mbit/s	QQVGA	1	2.1

Annex A

Methodology for deriving the coefficients in the video quality estimation function with respect to coding and packet-loss degradation

(This annex forms an integral part of this Recommendation.)

A.1 Methodology for deriving coefficients v_1, v_2, ..., and v_7

Using the subjective video quality MOS, which is called V_{qs} hereafter, for various video bit rate (Br_V) and video frame-rate (Fr_V) conditions, coefficients v_1, v_2, ..., and v_7 are calculated in the following four steps.

Step A.1.1: Calculation of values I_{Ofr}, O_{fr}, and D_{fr}

1) By employing M different frame rates for each video bit-rate condition b_n, Table A.1 is obtained.

Table A.1 – Relationships among Br_V, Fr_V, and V_q

Br_V	Fr_V	V_q
b_n	f_1	$V_{qs}(b_n,f_1)$
b_n	f_2	$V_{qs}(b_n,f_2)$
...	...	...
b_n	f_m	$V_{qs}(b_n,f_m)$
...	...	...
b_n	f_M	$V_{qs}(b_n,f_M)$

NOTE 1 – M represents the number of frame rate conditions. $f_1 > f_2 > ..... > f_M$.

NOTE 2 – $V_{qs}(b_n, f_m)$ represents the MOS under the condition with a video bit rate of b_n and a frame rate of f_m.

2) By applying the data set in Table A.1 to Equation 11-16, O_{fr}, I_{Ofr} and D_{fr} are approximated for each video bit rate b_n based on the least square approximation (LSA). The result is given in Table A.2.

Table A.2 – Relationship between Br_V, I_{Ofr}, O_{fr}, and D_{fr}

Br_V	O_{fr}	I_{Ofr}	D_{fr}
b_1	O_1	I_1	D_1
b_2	O_2	I_2	D_2
...	...	...	...
b_n	O_n	I_n	D_n
...	...	...	...
b_N	O_N	I_N	D_N

NOTE 3 – N represents the number of video bit-rate conditions. $b_1 > b_2 > ..... > b_N$.

Step A.1.2: Calculation of coefficients v_1 and v_2

By applying b_n and O_n for n = 1, 2, ..., N in Table A.2 to Equation 11-18, coefficients v_1 and v_2 are approximated based on the LSA.

Step A.1.3: Calculation of coefficients v_3, v_4, and v_5

By applying b_n and I_n for n = 1, 2, ..., N in Table A.2 to Equation 11-19, coefficients v_3, v_4 and v_5 are approximated based on the LSA.

Step A.1.4: Calculation of coefficients v_6 and v_7

By applying b_n and D_n for n = 1, 2, ..., N to Equation 11-20, coefficients v_6 and v_7 are approximated based on the LSA.

A.2 Methodology for deriving coefficients v_8, v_9, …, and v_{12}

Using the subjective video quality (V_{qs}) related to video bit rate (Br_V), video frame rate (Fr_V) and video packet-loss rate (Ppl_V), coefficients v_8, v_9, …, and v_{12} are calculated in the following four steps.

NOTE 1 – The subjective quality characteristics of packet-loss degradation often depend on the duration of video sequences used in a subjective test, so one should use video sequences that have a reasonable length (e.g., 1 min).

Step A.2.1: Calculation of values D_{PplV}

By applying I_{coding}, which is calculated by using the coefficients derived in clause A.1, and subjective video quality (V_{qs}) to Equation 11-16, the packet loss robustness factor D_{PplV} is approximated based on the LSA for each combination of Br_V and Fr_V, as shown in Table A.3.

Table A.3 – Relationships among video bit rate, video frame rate, and D_{PplV}

D_{PplV}		Fr_V					
		f_1	f_2		f_m		f_M
Br_V	b_1	D_{b1f1}	D_{b1f2}	...	...	...	D_{b1fM}
	b_2	D_{b2f1}	D_{b2f2}	...	...	...	D_{b2fM}
	...	...	...	...	...	...	...
	b_n	D_{bnf1}	D_{bnf2}	...	D_{bnfm}	...	D_{bnfM}
	...	...	...	...	...	...	...
	b_N	D_{bNf1}	D_{bNf2}	...	...	...	D_{bNfM}

NOTE 1 – N represents the number of video bit-rate conditions.

NOTE 2 – M represents the number of video frame-rate conditions.

NOTE 3 – D_{bnfm} indicates a temporary value of the packet-loss robustness factor D_{PplV} for a video bit rate of b_n and a frame rate of f_m.

Step A.2.2: Calculation of coefficient v_8

By applying f_m and $D_{PplV} = D_{b1fm}$ for m = 1, 2, ..., M to Equation A-1, coefficients a, b and v_8 are approximated based on the LSA.

$$D_{PplV} = a + b \exp\left(-\frac{Fr_V}{v_8}\right) \tag{A-1}$$

Step A.2.3: Calculation of coefficient v_9

By applying b_n and $D_{PplV} = D_{bnf1}$, for n = 1, 2, ..., N to Equation A-2, coefficients c, d and v_9 are approximated based on the LSA.

$$D_{PplV} = c + d \exp\left(-\frac{Br_V}{v_9}\right) \tag{A-2}$$

NOTE 2 – Coefficients a, b, c and d are temporary and never used in the following calculation.

Step A.2.4: Calculation of coefficients v_{10}, v_{11} and v_{12}

By applying v_8, v_9, $D_{PplV} = D_{bnfm}$, $Br_V = b_n$, and $Fr_V = f_m$ for n = 1, 2, ..., N and m = 1, 2, ..., M to Equation 11-21, coefficients v_{10}, v_{11} and v_{12} are approximated based on LSA.

Annex B

Coefficients in the video quality estimation function with respect to coding and packet-loss degradation

(This annex forms an integral part of this Recommendation.)

B.1 Coefficients for small and medium screen

This clause provides the coefficient tables to be used for video quality estimation. Table B.1 summarizes the conditions under which each coefficient table was constructed.

NOTE 1 – The coefficient tables given in this annex cannot be applied to arbitrary MPEG-4 or MPEG-2 codecs. This is dependent on the implementation and setting of the codec, as noted in clause 7. Therefore, if one needs coefficient values for a codec which are not included in this table, the procedure described in Annex A should be used to create appropriate tables.

Table B.1 – Conditions for deriving coefficient tables

Factors	# 1	# 2	# 3	# 4	# 5
Codec type	MPEG-4	MPEG-4	MPEG-2	MPEG-4	[ITU-T H.264]
Video format	QVGA	QQVGA	VGA	VGA	VGA
Key frame interval (s)	1	1	1	1	1
Video display size (inch)	4.2	2.1	9.2	9.2	9.2

The resultant coefficient values are provided in Table B.2.

NOTE 2 – These coefficient values were determined based on subjective tests with video sequences of 10 s. Therefore, the quality estimation based on these coefficients may result in an optimistic evaluation in comparison with that of the video quality of longer video sequences in evaluating the effects of packet loss.

Table B.2 – Coefficient table for the video quality estimation function

Coefficients	# 1	# 2	# 3	# 4	# 5
v_1	1.431	7.160	4.78	1.182	5.517
v_2	2.228×10^{-2}	2.215×10^{-2}	1.22×10^{-2}	1.11×10^{-2}	1.29×10^{-2}
v_3	3.759	3.461	2.614	4.286	3.459
v_4	184.1	111.9	51.68	607.86	178.53
v_5	1.161	2.091	1.063	1.184	1.02
v_6	1.446	1.382	0.898	2.738	1.15
v_7	3.881×10^{-4}	5.881×10^{-4}	6.923×10^{-4}	-9.98×10^{-4}	3.55×10^{-4}
v_8	2.116	0.8401	0.7846	0.896	0.114
v_9	467.4	113.9	85.15	187.24	513.77
v_{10}	2.736	6.047	1.32	5.212	0.736
v_{11}	15.28	46.87	539.48	254.11	–6.451
v_{12}	4.170	10.87	356.6	268.24	13.684

NOTE 3 – The values for the condition number # 3 have been obtained for a packet loss rate smaller than or equal to 2% and for coding bit rates higher than 128 kbit/s. The coefficients of Table B.2 should be used only within the specified ranges.

NOTE 4 – The values for the conditions numbered # 4 and # 5 have been obtained for bit rates higher than 300 and 400 kbit/s, respectively and below 1.5 and 2 Mbit/s, respectively. Packet loss rates were smaller than 5% and the frame rate was set between 5 and 25 fps. The coefficients of Table B.2 should be used within the specified ranges.

B.2 Coefficients for small screen (with screen size of 6 inches)

Table B.3 summarizes the conditions under which each coefficient table was constructed.

NOTE 5 – The coefficient tables given in this annex can be applied to the most popular ITU-T H.264 baseline profile (BP) and high profile (HP) settings, including format, bit rate, frame rate and packet loss rate.

Table B.3 – Conditions for deriving coefficient tables

Factors	#1	#2	#3	#4	#5	#6	#7	#8
Codec	H.264 BP	H.264 BP	H.264 BP	H.264 BP	H.264 HP	H.264 HP	H.264 HP	H.264 HP
Format	VGA	4CIF	720p	1080p	VGA	4CIF	720p	1080p
Bit rate	128, 192, 512, 768, 1024	128, 256, 512, 1024, 1280	256, 384, 512, 2048, 3200	512, 768, 1024, 4096, 6400	128, 192, 512, 768, 1024	128, 256, 512, 1024, 1280	256, 384, 512, 2048, 3200	512, 768, 1024, 4096, 6400
Frame rate	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30
Packet loss rate	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3

The resultant coefficient values are provided in Table B.4.

Table B.4 – Coefficient table for the video quality estimation function

Coefficients	#1	#2	#3	#4	#5	#6	#7	#8
v_1	6.743	3.854	2.040	1.711	5.610	6.964	6.311	2.773
v_2	0.9998×10^{-2}	1.2010×10^{-2}	1.0991×10^{-2}	0.8978×10^{-2}	1.0113×10^{-2}	0.7019×10^{-2}	0.8123×10^{-2}	0.8987×10^{-2}
v_3	3.051	3.240	3.593	4.283	3.379	3.582	3.681	3.952
v_4	168.1	206.3	296.2	513.2	182.3	214.1	262.04	460.3
v_5	1.766	1.681	1.322	0.850	1.310	1.200	1.280	1.281
v_6	1.130	1.624	1.683	1.392	2.230	1.755	1.973	2.119
v_7	18.340×10^{-4}	6.443×10^{-4}	4.297×10^{-4}	2.517×10^{-4}	7.512×10^{-4}	6.348×10^{-4}	3.332×10^{-4}	3.234×10^{-4}
v_8	1.232	1.580	1.324	1.254	1.511	1.134	1.244	1.282
v_9	53.25	208.34	102.00	307.35	136.21	170.99	343.33	262.44
v_{10}	3.353	4.672	3.363	1.847	4.053	4.250	2.762	1.981
v_{11}	6.025	7.874	18.534	17.460	20.162	7.982	6.251	22.839
v_{12}	80.752	15.114	96.237	3.999	22.332	12.001	6.013	7.999

B.3 Coefficients for large screen (with screen size of 65 inches)

Table B.5 summarizes the conditions under which each coefficient table was constructed.

NOTE 6 – The coefficient tables given in this annex can be applied to most popular ITU-T H.264 BP and HP settings, including format, bit rate, frame rate and packet loss rate.

Table B.5 – Conditions for deriving coefficient tables

Factors	#1	#2	#3	#4	#5	#6	#7	#8
Codec	H.264 BP	H.264 BP	H.264 BP	H.264 BP	H.264 HP	H.264 HP	H.264 HP	H.264 HP
Format	VGA	4CIF	720p	1080p	VGA	4CIF	720p	1080p
Bit rate	128, 192, 512, 768, 1024	128, 256, 512, 1024, 1280	256, 384, 512, 2048, 3200	512, 768, 1024, 4096, 6400	128, 192, 512, 768, 1024	128, 256, 512, 1024, 1280	256, 384, 512, 2048, 3200	512, 768, 1024, 4096, 6400
Frame rate	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30	8, 15, 30
Packet loss rate	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3	0, 0.5, 1, 3

The resultant coefficient values are provided in Table B.6.

Table B.6 – Coefficient table for the video quality estimation function

Coefficients	#1	#2	#3	#4	#5	#6	#7	#8
v_1	5.643	3.813	1.849	1.238	4.623	5.277	5.891	2.209
v_2	1.042×10^{-2}	1.120×10^{-2}	1.060×10^{-2}	0.921×10^{-2}	0.7214×10^{-2}	0.8876×10^{-2}	0.9086×10^{-2}	0.6834×10^{-2}
v_3	2.862	3.058	3.281	3.724	3.243	3.384	3.535	3.622
v_4	178.2	250.2	306.4	364.2	193.5	238.2	222.8	312.1
v_5	1.972	1.859	1.607	1.043	1.271	1.216	1.209	1.167
v_6	1.263	1.369	1.858	1.378	1.977	1.686	1.875	1.577
v_7	11.026×10^{-4}	9.324×10^{-4}	4.324×10^{-4}	3.461×10^{-4}	13.245×10^{-4}	9.122×10^{-4}	2.031×10^{-4}	3.786×10^{-4}
v_8	1.125	1.368	1.121	1.344	1.477	1.221	1.409	1.322
v_9	49.34	112.0	168.5	252.4	141.3	228.5	283.6	362.4
v_{10}	3.047	3.564	2.449	1.365	3.464	4.434	2.764	1.486
v_{11}	5.824	6.875	15.286	16.318	14.315	8.562	5.871	7.964
v_{12}	92.465	25.977	9.888	2.015	18.225	9.998	6.110	2.122

Annex C

Coefficients in the multimedia quality integration function

(This annex forms an integral part of this Recommendation.)

This annex provides the coefficient values for the multimedia quality integration function. As stated in clause 11.3, the coefficients are dependent on the video display size and conversational task. The coefficient tables in this annex assume two different video display sizes, which are 4.2, and 2.1 [inch]. They were derived by using "free conversation" as a conversational task.

Table C.1 – Coefficients of the multimedia quality integration function

Coefficients	4.2 inch	2.1 inch
m_1	-4.457×10^{-1}	-6.966×10^{-1}
m_2	-6.638×10^{-1}	-8.127×10^{-1}
m_3	4.042×10^{-1}	4.562×10^{-1}
m_4	2.321	3.003
m_5	-3.255×10^{-1}	-1.638×10^{-1}
m_6	3.309×10^{-1}	3.626×10^{-1}
m_7	1.494×10^{-1}	1.291×10^{-1}
m_8	5.457×10^{-1}	5.456×10^{-1}
m_9	-3.235×10^{-4}	-1.251×10^{-4}
m_{10}	3.915	3.763
m_{11}	-1.377×10^{-3}	-1.065×10^{-3}
m_{12}	0.000	1.465×10^{-2}
m_{13}	-1.095×10^{-3}	-1.002×10^{-3}
m_{14}	0.000	0.000

Bibliography

[b-ITU-T G.1030] Recommendation ITU-T G.1030 (2005), *Estimating end-to-end performance in IP networks for data applications.*

[b-Bijl] Bijl, P., and Valeton, J.M. (1999), *Guidelines for accurate TOD measurement, Proc. SPIE 3701, Infrared Imaging Systems: Design, Analysis, Modeling, and Testing X, 14.*

[b-Möller] Möller, S. (2000), *Assessment and Prediction of Speech Quality in Telecommunications, Kluwer Academic Publishers. Boston, MA.*

[b-Yamagishi 1] Yamagishi, K., and Hayashi, T. (2006), *Verification of Video Quality Opinion Model for Videophone Services, 2nd ISCA/DEGA Tutorial and Research Workshop on Perceptual Quality of Systems, pp.143-148.*

[b-Yamagishi 2] Yamagishi, K., and Hayashi, T. (2006), QRP 08-1: *Opinion Model for Estimating Video Quality of Videophone Services, GLOBECOM 2006, IEEE.*

[b-Yamagishi 3] Yamagishi, K., and Hayashi, T. (2008), *Video-Quality Planning Model for Videophone Services, ITE, Vol. 62, No. 7.*

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