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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**

Quality of experience requirements for IPTV services

Recommendation ITU-T G.1080

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Recommendation ITU-T G.1080

Quality of experience requirements for IPTV services

Summary

Recommendation ITU-T G.1080 defines user requirements for quality of experience (QoE) for Internet protocol television (IPTV) services. The QoE requirements are defined from an end user perspective and are agnostic to network deployment architectures and transport protocols. The QoE requirements are specified as end-to-end and information is provided on how they influence network transport and application layer behaviour. QoE requirements for video, audio, text, graphics, control functions and meta-data are provided. Compression coding schemes addressed in this Recommendation are examples, and detailed numeric values as performance targets, e.g., bit rate, packet loss rate, are also examples. The readers may appropriately choose or replace these parameter values in order to be consistent with the requirements of each IPTV service context to which they are intended to be applied.

Source

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IPTV, QoE, QoS.

FOREWORD

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Recommendation ITU-T G.1080

Quality of experience requirements for IPTV services

1 Scope

This Recommendation defines user requirements for quality of experience (QoE) for IPTV services. The QoE requirements are defined from an end-user perspective and are agnostic to network deployment architectures and transport protocols. The QoE requirements are specified for the end-to-end service and information is provided on how they influence network transport and application layer behaviour. Compression coding schemes addressed in this Recommendation are examples, and detailed numeric values given as performance targets, e.g., bit rate, packet loss rate, are also examples. The readers may appropriately choose or replace these parameter values in order to be consistent with the requirements of each IPTV service context to which they are intended to be applied.

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 E.800] Recommendation ITU-T E.800 (1994), *Terms and definitions related to quality of service and network performance including dependability*.
- [ITU-T F.700] Recommendation ITU-T F.700 (2000), *Framework Recommendation for multimedia services*.
- [ITU-T H.262] Recommendation ITU-T H.262 (2000) | ISO/IEC 13818-2:2000, *Information technology – Generic coding of moving pictures and associated audio information: Video*.
- [ITU-T H.264] Recommendation ITU-T H.264 (2005), *Advanced video coding for generic audiovisual services*.
- [ITU-T P.10/Amd.1] Recommendation ITU-T P.10/G.100 (2006), Amd.1 (2007), *New Appendix I – Definition of Quality of Experience (QoE)*.
- [ITU-T P.800] Recommendation ITU-T P.800 (1996), *Methods for subjective determination of transmission quality*.
- [ITU-T T.140] Recommendation ITU-T T.140 (1998), *Protocol for multimedia application text conversation*.
- [ITU-T Y.1541] Recommendation ITU-T Y.1541 (2006), *Network performance objectives for IP-based services*.
- [ITU-R BT.500-11] Recommendation ITU-R BT.500-11 (2002), *Methodology for the subjective assessment of the quality of television pictures*.
- [ITU-R BT.601-6] Recommendation ITU-R BT.601-6 (2007), *Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios*.



3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 Quality of experience (QoE) [ITU-T P.10/Amd.1]: The overall acceptability of an application or service, as perceived subjectively by the end-user.

NOTE 1 – Quality of Experience includes the complete end-to-end system effects (client, terminal, network, services infrastructure, etc.).

NOTE 2 – Overall acceptability may be influenced by user expectations and context.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 channel zapping: The act of quickly changing from one channel to another.

3.2.2 clean audio: Audio track of an IPTV service with background sounds removed.

3.2.3 group of pictures: The group of pictures (GOP) is a group of successive pictures within a MPEG-coded film and/or video stream. Each MPEG-coded film and/or video stream consists of successive GOPs. From the MPEG pictures contained in it, the visible frames are generated.

3.2.4 triple play services: Services that include IPTV, VoIP, and Internet access.

3.2.5 VoD trick modes: Download and streaming video on demand (VoD) systems provide the user with a large subset of VCR functionality including pause, fast forward, fast rewind, slow forward, slow rewind, jump to previous/future frame, etc. These functions are usually referred to as "trick modes".

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

A/V	Audio Video
AAC	Advanced Audio Coding
AC-3	Dolby digital audio (Advanced Codec 3)
ARQ	Automatic Repeat reQuest
AVC	Advanced Video Codec
AVS	Audio and Video coding Standard (Chinese)
BER	Bit Error Rate
BML	Broadcast Markup Language
CBR	Constant Bit Rate
CPU	Central Processing Unit
DCT	Discrete Cosine Transform
DSCQS	Double Stimulus Continuous Quality Scale
DSL	Digital Subscriber Line
DVB	Digital Video Broadcast

DVD	Digital Video Disk
ECG	Electronic Content Guide
EPG	Electronic Program Guide
FEC	Forward Error Correction
FFW	Fast ForWard
fps	frames per second
GOP	Group of Pictures
GWR	GateWay Router
HDTV	High Definition TeleVision
HG	Home Gateway
HTML	HyperText Markup Language
IGMP	Internet Group Management Protocol
IGP	Interactive Gateway Protocol
IP	Internet Protocol
IPG	Interactive Program Guide
IPTV	Internet Protocol TeleVision
MOS	Mean Opinion Score
MP	Measured Point
MP3	MPEG-1 audio layer 3
MPEG	Moving Pictures Expert Group
MPLS	MultiProtocol Label Switching
NICAM	Near Instantaneous Companded Audio Multiplex
PAL	Phase Alternating Line
PC	Personal Computer
PDV	Packet Delay Variation
PHB	Per-Hop Behaviour
PLR	Packet Loss Ratio
PTD	Packet Transfer Delay
QoE	Quality of Experience
QoS	Quality of Service
RFC	Request For Comments
SDH	Synchronous Digital Hierarchy
SDTV	Standard Definition TeleVision
SECAM	SEquentiel Couleur A Mémoire (sequential color with memory)
SMPTE	Society of Motion Picture and Television Engineers
SONET	Synchronous Optical NETwork
STB	Set-Top Box



TS	Transport Stream
VBR	Variable Bit Rate
VCR	Video Cassette Recorder
VoD	Video on Demand
VoIP	Voice over IP

5 Introduction to QoE

QoE is defined in [ITU-T P.10/Amd.1] as the overall acceptability of an application or service, as perceived subjectively by the end-user. It includes the complete end-to-end system effects (client, terminal, network, services infrastructure, etc.) and may be influenced by user expectations and context. Hence in principle, QoE is measured subjectively by the end-user and may differ from one user to the other. However, it is often estimated using objective measurements.

Differences in perceptual acuity and preference mean that QoE judgments obtained from different people may vary. Therefore, measurements of QoE are generally made using group data. Where the necessary studies have been done to calibrate the relationship with QoE, it may also be estimated using objective measurements.

A number of system performance characteristics contribute to QoE of the media stream. For example, the codec and the encoding bit rate used, media resolution in the source and at the display, corruption or loss of information, and delay. Interactions among video content, the codec and bit rate used, and the specific bits corrupted and/or packets lost contribute to a high variability in the perceived quality of the video output.

There are additional factors that can influence the viewer's response. Some of these affect the perception of quality, such as the context of the judgment (a particular image will be rated one way in the context of standard definition TV (SDTV), another in the context of high definition TV (HDTV), and still differently in the context of a video clip on Internet), cultural background, motivation, attention related factors, emotional state, and so on. (Direct evaluations of QoE are designed to exclude these factors, since they are not generally under the control of a network operator and so do not contribute to equipment requirements.)

Other factors influence the viewer's judgment of acceptability. These include things like previous experience with the specific communication mode or related modes (for instance, experience with DVD quality will influence how acceptable one finds IPTV or VoD), how much one is paying for the service, and what special benefits the service provides (mobility, time independence, exceptionally large program library), and so on.

Acceptability is not equivalent to QoE. A low resolution video image will have a lower QoE than a high resolution image, but it may be completely acceptable for certain applications and services, depending on the end device, the physical size of the display, and the purpose for which it is being used.

Figure 5-1 shows factors contributing to QoE. These factors are organized as those related to quality of service and those that can be classified as human components.

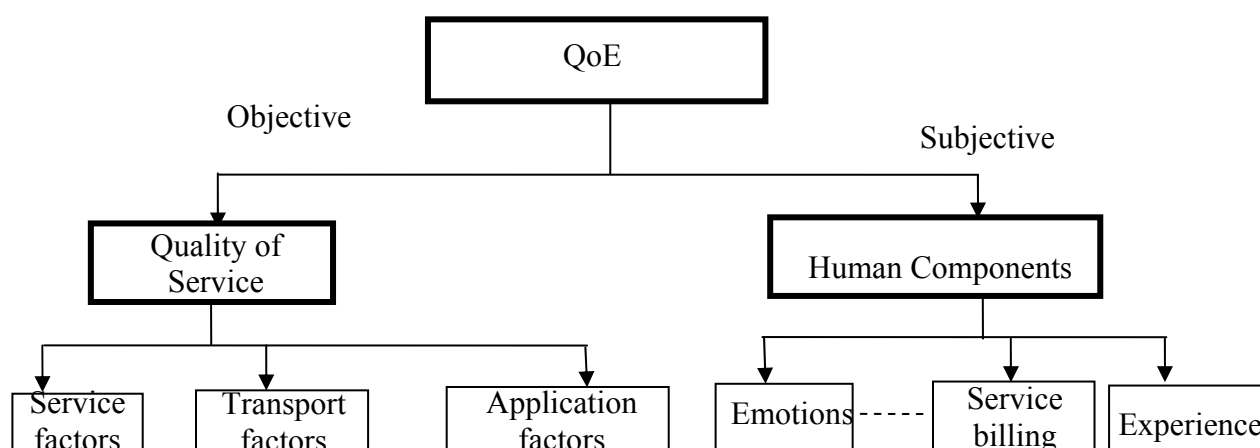


Figure 5-1 – QoE dimension

QoE for video is often measured via carefully controlled subjective tests [ITU-R BT.500-11], [ITU-T P.800], where video samples are played to viewers, who are asked to rate them on a scale typically consisting of five points. The ratings assigned to each case are averaged together to yield a mean rating or mean opinion score (MOS).

Quality of service (QoS, see [ITU-T E.800]) involves the totality of characteristics of a telecommunication service that bear on its ability to satisfy stated and implied needs of the user of the service. In general, network performance is a major component of QoS, and so network mechanisms for QoS are an important consideration. QoS mechanisms include any mechanism that contributes to the improvement of the overall performance of the system and hence to improving end-user experience. QoS mechanisms can be implemented at different levels. For example, at the network level it includes traffic management mechanisms such as buffering and scheduling employed to differentiate between traffic belonging to different applications. QoS mechanisms at levels other than the transport include loss concealment, application forward error correction (FEC), etc.

Related to QoS are the QoS performance parameters. Similarly to the QoS mechanisms, QoS parameters can be defined for different layers. At the network layer, those parameters usually include packet loss rate, delay and delay variation.

Note that in Figure 5-1, service billing relates to the "value for money" perceived by the user for the particular service.

Typically, there will be multiple service level performance (QoS) metrics that impact overall QoE. There are a number of service level performance characteristics (that is, objective parameters of service performance such as encoding bit rate, packet loss, delay, availability, etc.) that affect QoE. In general, these are correlated with QoE as measured by the MOS. The relation between QoE and service performance (QoS) metrics is typically estimated empirically. Once identified, the QoE/QoS relationship can be used in two ways:

- a) Given a QoS measurement, one could in principle predict the expected QoE for a user, with appropriate assumptions.
- b) Given a target QoE for a user, one could in principle deduce the net required service layer performance, with appropriate assumptions.

To ensure that the appropriate service quality is delivered, QoE targets should be established for each service and be included early on in system design and engineering processes where they are translated into objective service level performance metrics. Quality of experience will be an important factor in the marketplace success of triple-play services and is expected to be a key differentiator with respect to competing service offerings. Subscribers to network services do not care how service quality is achieved. What matters to them is how well a service meets their expectations for effectiveness, operability, availability, and ease of use.

6 QoE for video and audio

QoE requirements for video and audio may be based on QoE scales such as the mean opinion score (MOS) and double stimulus continuous quality scale (DSCQS) [ITU-R BT.500-11]. However, conducting subjective tests is difficult because they are time-consuming and expensive. Moreover, reliable objective quality assessment methods have not been established for transmitted video and audio. Therefore, this clause provides provisional QoE requirements on the basis of the objective parameters that are correlated to the subjective QoE.

This Recommendation addresses QoE targets and shows how to express QoE requirements in the context of numerical parameters such as bit rate or packet loss rate. The process of determining QoE performance targets must consider a number of issues, for example: the purpose of the IPTV service, QoE level of the current broadcasting systems (which sets user expectation), compression coding scheme to be used for the service, content characteristics, content provider requirements, customer satisfactions. While the requirement values shown in the tables in this clause are NOT generically applicable to any specific or all IPTV services, they are to be understood as provisional values which are subject to change. Readers of this Recommendation are invited to replace the numerical values shown in the tables in this clause with appropriate ones that conform to the requirements required by a specific IPTV service context.

6.1 Requirements for media compression and synchronization

One of the main components of QoE for video and audio is digitization and compression of video and audio source materials and the various settings and parameters selected. Since video compression schemes such as those defined by the moving pictures expert group (MPEG) are not lossless and an identical copy of the original source material cannot be recovered, there are potentially negative impacts on video picture quality and therefore on viewer QoE. The main factors influencing video QoE at the application layer due to compression are:

- Quality of source material.
 - The quality of the delivered media depends on the quality of the source material.
- The baseline quality (no network impairments) of the codec.

NOTE 1 – A partial list of video codecs is provided in Appendix II.

- Resolution.
 - Some systems reduce the horizontal resolution to achieve the target bit rates, for example in standard definition television (SDTV) the resolution may be reduced to 'half' or 'three quarters', which produces a less sharp picture than 'full' resolution.
- Bit rate.
 - During periods of high complexity (entropy), compression may leave visible artefacts if the bit rate is not sufficient.

- Application layer video encoding – constant bit rate (CBR) vs. variable bit rate (VBR) at the encoder output.
 - Video encoding is naturally variable bit rate, but to simplify network engineering for Telco delivery systems, the video encoders are set to provide a constant bit rate (as averaged over some specified time period in the order of seconds).
 - VBR streams such as those used in DVD encoding have constant quality since the bit rate is allowed to vary to accommodate varying complexity of the source material.
 - CBR streams have variable quality since there may be times when the bit rate is insufficient to accommodate the video complexity, but CBR streams allow straightforward traffic engineering and system design.
- Group of pictures (GOP) structure.
 - Shorter GOPs improve quality in terms of performance of random accessibility and error recovery, but reduce the maximum compression ratio.
 - Longer GOPs improve maximum compression ratio, but increase channel change time and the amount of damage a lost packet will cause.
 - Dynamic GOPs can be used to better handle scene changes and other effects but are not always implemented on set-top boxes (STBs). In addition, dynamic GOPs can cause variability in zapping latency and may complicate mechanisms intended to increase zapping speed.
- Motion vector search range.
 - Wider searches provide improved quality but at increased complexity and encoder delay.
 - Large search ranges are required for high motion content such as sports.
- Rate Control.
 - Mode decisions greatly affect the bit rate.
 - Proprietary schemes are commonly used to gain competitive advantage.
- Pre-processing (such as noise reduction).
 - Usually proprietary and non-standard, but can improve bit rate/quality trade-off.
- Tandem encoding and rate shaping (e.g., digital turnaround).

Video compression artefact examples

Figure 6-1 illustrates several kinds of compression artefacts that are largely due to insufficient bits allocated, resulting in a too coarse quantization of DCT coefficients or motion vectors and/or poor motion estimation. Additional details of compression artefacts may be found in [b-NTIA264].

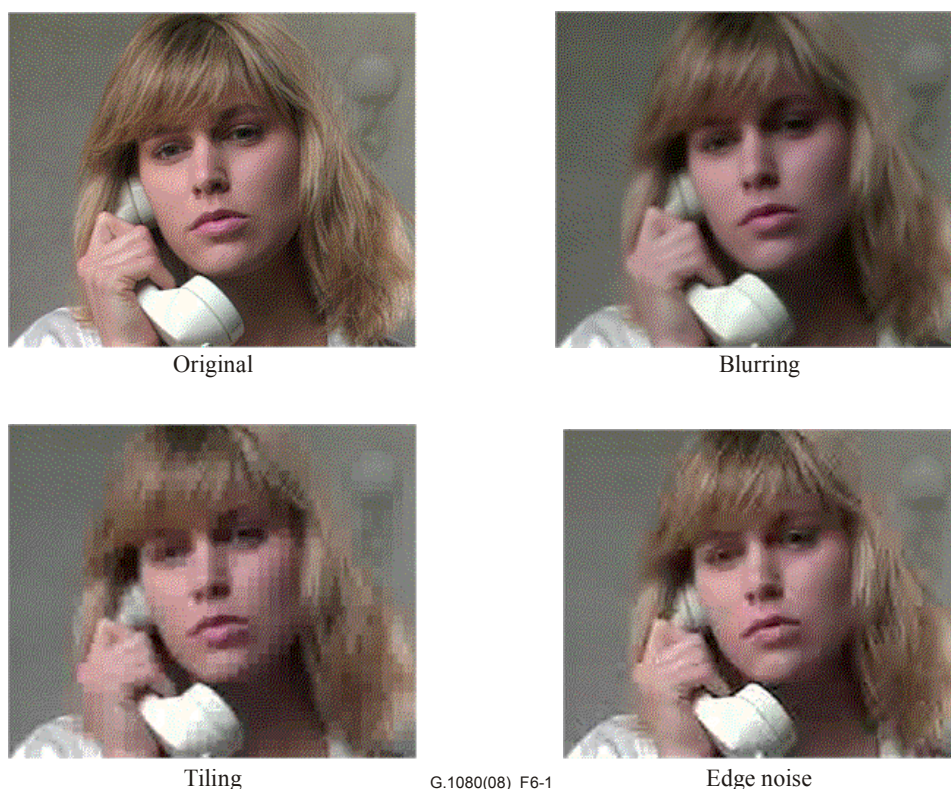


Figure 6-1 – Compression artefacts¹

Similarly, there are similar parameter implications on the audio side.

NOTE 2 – A partial list of audio codecs is provided in Appendix II.

In addition to the separate audio and video application layer impairments, the synchronization between audio and video components must be maintained to ensure satisfactory QoE. There has been a great deal of research on A/V synchronization requirements in video conferencing and analogue broadcast systems, and specifications have been developed in such bodies as ITU-R ([ITU-R BT.1359-1]).

Because audio that appears before video is very unnatural (sound takes longer to propagate than light, so sound lagging visual is normal), some bodies specifying television specific A/V synchronization have recommended tighter tolerances than those typically used for video conferencing applications.

Recommended provisional minimum engineering objectives for application layer and data plane parameters are presented in the following clauses for various video services.

NOTE 3 – Appendix III provides supplementary information related to the following clauses.

6.1.1 Standard definition TV (SDTV): General minimum objectives

Table 6-1 provides provisional video application layer performance objectives at the MPEG elementary stream level, prior to IP encapsulation for broadcast SDTV (480i / 576i). The objectives for audio elementary stream bit rates are additionally specified below.

¹ Source ITS Video Quality Research (2003)