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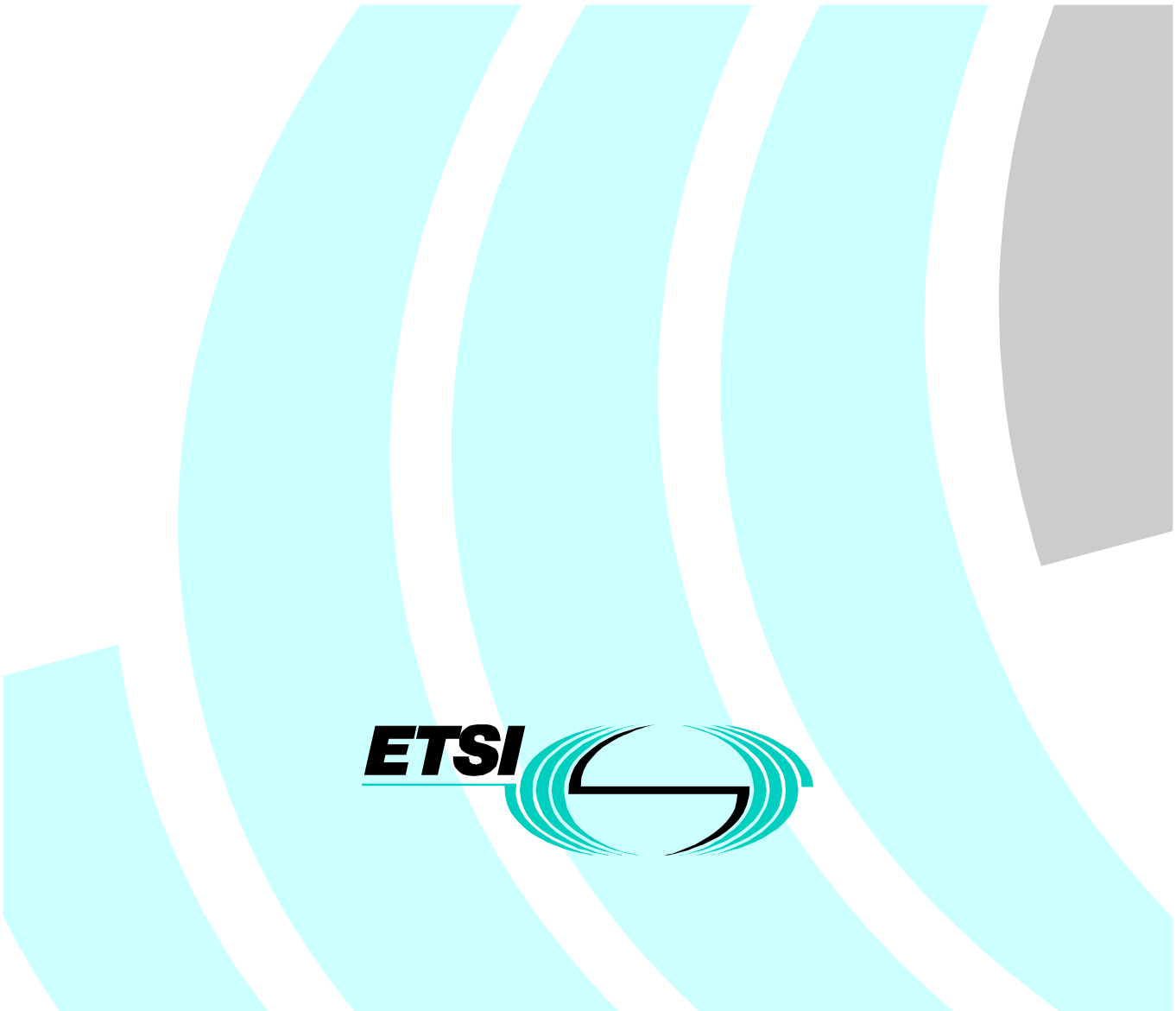
Technical Specification

Telecommunications and Internet Protocol Harmonization Over Networks (TIPHON); End to End Quality of Service in TIPHON Systems; Part 2: Definition of Quality of Service (QoS) Classes



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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Project Telecommunications and Internet Protocol Harmonization Over Networks (TIPHON).

Introduction

The present document forms one of a series of technical specifications and technical reports by TIPHON Working Group 5 for TIPHON Quality of Service (QoS) classification. The structure of this work is illustrated in Figure 1.

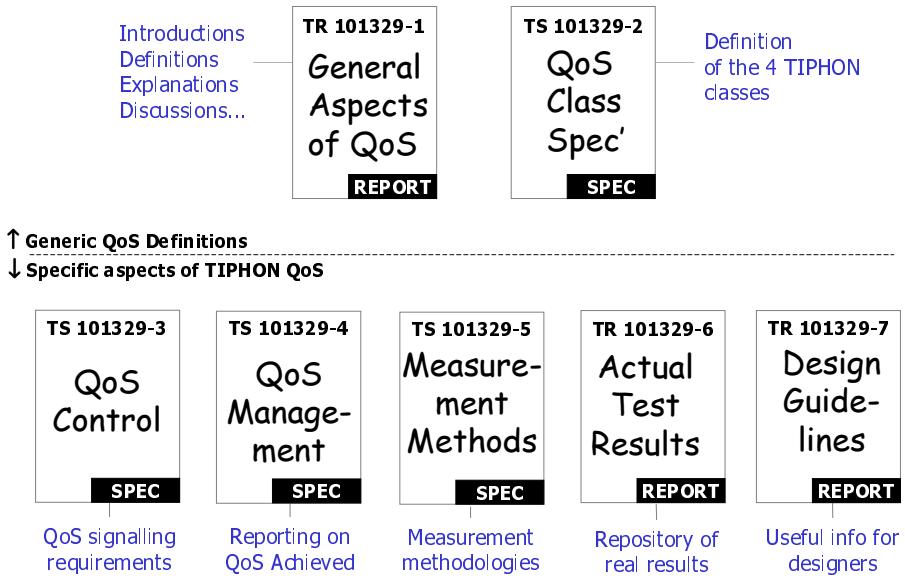

Figure 1: Structure of TIPHON QoS Documentation

1 Scope

The present document defines four classes of Quality of Service for characterizing the performance of TIPHON compliant IP voice telephony networks. The classes of service apply to all the defined TIPHON Scenarios.

The classes are specified in terms of "Overall Transmission Quality Rating", "Listener Speech Quality" (one-way non-interactive speech quality) and "End-to-end Delay".

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] ETSI ETS 300 580-2 (1994): "Digital cellular telecommunications system (Phase 2); Full rate speech; Part 2: Transcoding (GSM 06.10)".

[2] ETSI ETS 300 726 (1997): "Digital cellular telecommunications system; Enhanced Full Rate (EFR) speech transcoding (GSM 06.60)".

[3] ETSI TS 101 329-5 (V1.1): "Telecommunications and Internet Protocol Harmonisation over Networks (TIPHON); End to End Quality of Service in TIPHON system; Part 5: Quality of Service (QoS) Measurement Methodologies in TIPHON Systems".

[4] ITU-T Recommendation E.721 (05/99): "Network grade of service parameters and target values for circuit-switched services in the evolving ISDN".

[5] ITU-T Recommendation G.107 (05/00): "The E-Model, a computational model for use in transmission planning".

[6] ITU-T Recommendation G.109 (09/99): "Definition of categories of speech transmission quality".

[7] ITU-T Recommendation G.711 (11/88): "Pulse code modulation (PCM) of voice frequencies".

[8] ITU-T Recommendation G.726 (12/90): "40, 32, 24, 16 kbit/s Adaptive Differential Pulse Code Modulation (ADPCM)".

[9] ITU-T Recommendation P.310 (02/96): "Transmission characteristics for telephone-band (300-3 400 Hz) digital telephones".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following definition applies:

Codec: Combined speech encoder and decoder

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

EFR	Enhanced Full Rate
FR	Full Rate
GSM	Global System for Mobile communications
IP	Internet Protocol
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector (former CCITT)
LAN	Local Area Network
PSTN	Public Switched Telephone Network
QoS	Quality of Service

4 Definition of TIPHON QoS Classes

Four classes of end-to-end QoS are defined for TIPHON systems. The TIPHON QoS definitions include both the network and the TIPHON terminal characteristics:

- BEST: This is a type of IP telephony service that has the potential to provide a user experience better than the PSTN. It is expected that these systems will to be implemented using wideband codecs (codecs encoding analogue signals with bandwidth in excess of 3,1 kHz) and QoS-engineered IP networks and LAN environments.

- HIGH: This is a type of IP telephony service that has the potential to provide a user experience similar to PSTN (or recent wireless mobile telephony services in good radio conditions, for instance GSM networks using EFR codecs [2], or systems using G.726 [8] codecs). It is expected that such systems would be implemented over QoS–engineered IP networks where bandwidth usage is optimized.

- MEDIUM: This is a type of IP telephony service that has the potential to provide a user experience similar to common wireless mobile telephony services, for instance GSM networks using FR codecs [1]. It is expected that such systems would be implemented over QoS-engineered IP networks, where network losses or end to end delay are not tightly controlled.

- BEST EFFORT: This type of service will provide a usable communications service but may not provide guarantees of performance. There may be periods of significantly impaired speech quality, and large end-to-end delays which are likely to impact the overall conversational interactivity. It is expected such communications will operate over non QoS-engineered IP networks such as the public Internet.

NOTE: Connections that include a geostationary satellite will incur long propagation delay and consequently will fall into the BEST EFFORT QoS class. It is well recognized that such a satellite section may nevertheless be assumed to be well engineered. QoS characteristics, other than end-to-end delay, may be experienced by the user as corresponding to higher classes as defined in this Document.

For the purposes of voice quality, each of the above classes is defined by three performance metrics, as specified in clause 5:

- Overall Transmission Quality Rating (R);

- Listener Speech Quality (One-way non-interactive end-to-end Speech Quality);

- End-to-end (mean one-way) Delay.

For a TIPHON system to be considered as achieving a specified QoS class, it shall meet all the three specified performance metrics for that particular class, for 95% of all connections.

It is anticipated that metrics for parameters other than voice quality, for example call set-up time, will be specified in the future. This is discussed in clause 6.

5 TIPHON End-to-End QoS Budgets

The measurements for "Overall Transmission Quality Rating (R)", "Listener Speech Quality" and "End-to-end Delay" are described in ETSI TS 101 329-5 [3].

5.1 Overall Transmission Quality Rating

Overall transmission quality rating (R) describes the full acoustic-to-acoustic (mouth to ear) quality, experienced by a user, for a typical situation using a "standard" telephony handset.

The overall transmission quality rating is calculated using the E-Model (G.107 [5]). For calculation purposes the use of traditional telephone handsets (ITU-T Recommendation P.310 [9]) at both sides of the connection is assumed.

Table 1: **Overall Transmission Quality Rating (R) for TIPHON Systems**

	4 (BEST)	3 (HIGH)	2 (MEDIUM)	1 (BEST EFFORT)
Overall Transmission Quality Rating (R)	See note 2	> 85	> 70	> 50, note 3
NOTE 1: The R-value incorporates all degradations, including the effects of packet loss. NOTE 2: The R-value characterization of systems employing wideband codecs is under study. NOTE 3: The rating for the best effort class is a target value and can be treated as a guaranteed service if the target value is achieved.				

Figure 2 shows the mapping between the "TIPHON QoS Classes" specified in this document and the "Categories of Speech Transmission Quality" as defined in ITU-T Recommendation G.109 [6].

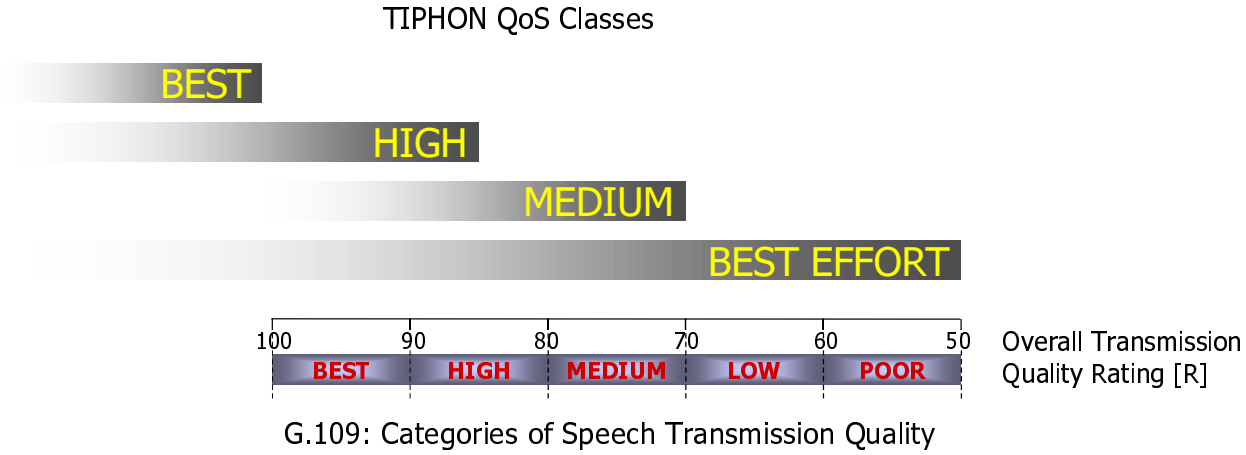

Figure 2: Mapping of TIPHON QoS Classes to ITU-T Categories

The relation between overall transmission quality rating (R) and user perception of quality is defined in ITU-T Recommendation G.109 [6]. Table 2 is extracted from this Recommendation.

Table 2: Categories of Speech Transmission Quality as defined in ITU-T

Overall Transmission Quality Rating	90 ≤ R < 100	80 ≤ R < 90	70 ≤ R < 80	60 ≤ R < 70	50 ≤ R < 60
User's satisfaction	Very satisfied	Satisfied	Some users dissatisfied	Many users dissatisfied	Nearly all users dissatisfied

5.2 Listener Speech Quality of TIPHON Systems

Specifications of listener speech quality for TIPHON QoS classes are given in Table 3.

Table 3: Listener Speech Quality of TIPHON Systems

	4 (BEST)	3 (HIGH)	2 (MEDIUM)	1 (BEST EFFORT)
Listener Speech Quality (one way, non interactive speech quality)	Better than G.711[7]	Equivalent or better than G.726 [8] at 32 kbit/s [8]	Equivalent or better than GSM-FR []	Not defined
NOTE 1: The descriptions in this table include the effects of packet loss. NOTE 2: Listener speech quality may not describe the full acoustic-to-acoustic (mouth to ear) quality that will be experienced by a user, which is dependent on the acoustic quality of the TIPHON terminal as well as the quality of the TIPHON network.				

NOTE: The use of codec examples in Table 3 indicates a minimum expected end-to-end speech quality, not a recommended codec for implementation. The performance levels include any degradation caused by network or terminal, such as packet loss.

5.3 End-to-end Delay

Specifications of end-to-end (mean one-way) delay for TIPHON QoS classes are given in Table 4.

Table 4: End-to-end Delay for TIPHON Systems

	4 (BEST)	3 (HIGH)	2 (MEDIUM)	1 (BEST EFFORT)
End-to-end Delay	< 100 ms	< 100 ms	< 150 ms	< 400 ms
NOTE: The delay for best effort class is a target value.				

6 Call Set-up Time

The "Call Set-up Time" is defined as "Post Dial Delay" ($D_2 - C$); see ETSI TS 101 329-5 [3].

Detailed specifications for call set-up time are still under study but as a starting point reference is made to ITU-T Recommendation E.721 [4].

As guidance, E.721 [4] recommends the following mean values for "post selection delay":

- Local call < 3 sec,
- Toll* calls < 5 sec, and
- international calls < 8 sec.

* Toll calls are here assumed to refer to national long-distance calls.

7 TIPHON QoS parameter allocation

The intent of this section is to allocate the end-to-end performance parameters of the TIPHON QoS classes between terminal and network.

Table 5 shows the main parameters which impact end-to-end speech quality in VoIP systems, and their association with the terminal, the network, or both. Note that echo control is assumed to be taken care of.

Table 5: Main IP voice quality parameters and their association

Parameter	Associated with	
	Terminal	Network
Codec type	Yes	No
Packet Loss	No [1]	Yes
Delay	Yes [2]	Yes [3]
Delay variation	No [4]	Yes [5]
NOTE 1: Assumes jitter buffer appropriately sized to avoid packet loss due to overflow. NOTE 2: Due to speech coding/packetization and to delay variation buffers. NOTE 3: Due to network routing/propagation. NOTE 4: Assumes any delay variation from sending client is included in terminal delay. NOTE 5: Delay variation is introduced by the network, but compensated in the terminal.		

Inspection of Table 5 shows that, with some simplifying assumptions, three of the four parameters – codec type, packet loss and delay variation – are associated with either the terminal or the network alone, but not both. This means that the end-to-end budget for these parameters can be totally allocated to the corresponding element. On the other hand, delay is associated with both the terminal and the network, and the overall end-to-end delay budget shall be allocated between them.

Recognizing that:

- overall end to end delay =
  (speech coding and packetization delay) + network routing delay + propagation delay + delay variation buffer size;

- and that jitter is introduced by the network, but compensated in the terminal, it is clear that delay in the terminal is essentially fixed, but delay in the network will be a function of distance and the number of router hops.

Therefore three terminal "Modes" A, B, C are defined on the basis of delay to allow for different speech encoding and packetization schemes as shown in Table 6. In this context, terminal delay includes encode/decode and packetization operations, but not jitter compensation (see later).

Table 6: Definition of Terminal Modes

Terminal Mode	Delay	Application
A	< 50 ms	Allows for small speech frame duration and small number of frames per IP packet
B	< 75 ms	Allows for larger speech frame duration and/or small number of frames per IP packet
C	< 100 ms	Allows for larger speech frame duration and multiple frames per packet

Three network "Classes" I, II, III are also defined on the basis of packet loss and delay variation, but not propagation and routing delay as shown in Table 7.

Table 7: Definition of Network Classes

Network Class	Packet loss	Delay variation
I	< 0,5%	< 10 ms
II	< 1%	< 20 ms
III	< 2%	< 40 ms
NOTE: Values of packet loss are based on subjective speech quality test results given in DTR/TIPHON 05004 [1]		

Taking the values of delay for the specific Terminal Mode and Network Class given in Tables 6 and 7 and noting that (Network Routing Delay + Propagation Delay) = Overall Delay for the TIPHON QoS class - (Speech Coding and Packetization Delay + Jitter Compensation Delay) where the jitter compensation delay shall at least equal the network delay variation, Table 8 shows the propagation and routing delay available to meet a given TIPHON QoS class.

Table 8: Available propagation and routing delay as a function of TIPHON QoS class, Terminal Mode and Network Class

Network Class	TIPHON QoS Class	Terminal Mode		
		A	B	C
I	High	40 ms	15 ms	X
	Medium	90 ms	65 ms	40 ms
	Best effort	340 ms	315 ms	290 ms
II	High	30 ms	5 ms	X
	Medium	80 ms	55 ms	30 ms
	Best Effort	330 ms	305 ms	280 ms
III	High	10 ms	X	X
	Medium	60 ms	35 ms	10 ms
	Best Effort	310 ms	285 ms	260 ms

NOTE: X = QoS Class can not be met (on the basis of delay) with this combination of Terminal Mode and Network Class.
Figures in *italics* indicate where the QoS Class may not be met due to the combination of network packet loss and type of speech coder failing to meet the Listener Speech Quality requirements of Table 3.

Bibliography

The following material, though not specifically referenced in the body of the present document (or not publicly available), gives supporting information.

- ETSI TR 101 329-6 (V1.1): "Telecommunications and Internet Protocol Harmonisation over Networks (TIPHON); End to End Quality of Service in TIPHON Systems; Part 6: Actual measurement of network and terminal characteristics and performance parameters in TIPHON networks and their influence on voice quality".

History

Document history		
V1.1.1	July 2000	Publication