

I n t e r n a t i o n a l T e l e c o m m u n i c a t i o n U n i o n

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

E.470

(02/2005)

SERIES E: OVERALL NETWORK OPERATION,
TELEPHONE SERVICE, SERVICE OPERATION AND
HUMAN FACTORS

Network management – Checking the quality of the
international telephone service

**Operational considerations for QoS of voice
over IP-based networks with PSTN-IP-PSTN
architecture**

ITU-T Recommendation E.470



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ITU-T Recommendation E.470

Operational considerations for QoS of voice over IP-based networks with PSTN-IP-PSTN architecture

Summary

It is recognized that IP-based networks are increasingly used to deliver voice services to customers. These networks can impact the end-to-end service quality perceived by users. In order to maintain network performance required to deliver the desired service quality, several operational issues have to be considered. These issues include defining network performance measures and their objectives, interworking issues between networks employing a variety of technologies, network measurement points, information to be exchanged between network operators, etc.

ITU-T Study Group 13 on "Next-generation networks" has defined four key scenarios to be considered in their IP framework document:

- Scenario a: A voice call from an IP terminal connected to an IP-based network to a PSTN phone;
- Scenario b: A voice call from a PSTN phone to an IP terminal connected to an IP-based network;
- Scenario c: A voice call from a PSTN phone to another PSTN phone via an IP-based network;
- Scenario d: A voice call from an IP terminal connected to an IP-based network to another IP terminal connected to an IP-based network via PSTN.

This Recommendation focuses only on Scenario c. In Scenario c, both ends are PSTN (telephone) terminals and connected to PSTN at least as a local access (PSTN-IP-PSTN architecture). This network architecture is employed or planned to be employed by many ROAs all over the world. In this case, the user may not be aware of the changes in the underlying technology and the QoS expectations may be expected to remain the same.

This Recommendation is for providing the general aspects of voice services in PSTN-IP-PSTN architecture, especially, for providing information whether or not the existing ITU-T Recommendations could be applicable to PSTN-IP-PSTN voice architecture. Also, it covers the general impacts of IP networks to voice services and provides an overview of the performance measurement/management scope.

Source

ITU-T Recommendation E.470 was approved on 24 February 2005 by ITU-T Study Group 2 (2005-2008) under the WTSA Resolution 1 procedure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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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ITU-T Recommendation E.470

Operational considerations for QoS of voice over IP-based networks with PSTN-IP-PSTN architecture

1 Scope

It is recognized that IP-based networks are increasingly used to deliver voice services to customers. These networks can impact the end-to-end service quality perceived by users. In order to maintain network performance required to deliver the desired service quality, several operational issues have to be considered. These issues include defining network performance measures and their objectives, interworking issues between networks employing a variety of technologies, network measurement points, information to be exchanged between network operators, etc.

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This Recommendation is for providing the general aspects of voice services in PSTN-IP-PSTN architecture, especially, for providing information whether or not the existing ITU-T Recommendations could be applicable to PSTN-IP-PSTN voice architecture. Also, it covers the general impacts of IP networks to voice services and provides an overview of the performance measurement/management scope.

The outline of this Recommendation is as follows. Clause 2 presents the normative references. In order to resolve operational issues, a reference architecture is presented in clause 3. In clause 4, the QoS framework is discussed along with the network performance and QoS parameter which were already defined by ITU-T Study Group 2 on "Operational aspects of service provision, networks and performance", Study Group 12 on "Performance and quality of service" and Study Group 13 that apply to the PSTN-IP-PSTN scenario. Clause 5 discusses key network performance parameters that are usually defined in the E-series Recommendations and identifies new parameters that may need to be defined. In clause 6, IP network impacts to voice services are discussed. Clause 7 describes QoS measurement and management sections with related issues. Lastly, in clause 8, several issues for further study are pointed out.

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 Recommendation E.425 (2002), *Internal automatic observations*.
- ITU-T Recommendation E.428 (1992), *Connection retention*.
- ITU-T Recommendation E.430 (1992), *Quality of service framework*.
- ITU-T Recommendation E.431 (1992), *Service quality assessment for connection set-up and release delays*.
- ITU-T Recommendation E.434 (1992), *Subscriber-to-subscriber measurement of the public switched telephone network*.
- ITU-T Recommendation E.437 (1999), *Comparative metrics for network performance management*.
- ITU-T Recommendation G.177 (1999), *Transmission planning for voiceband services over hybrid Internet/PSTN connections*.
- ITU-T Recommendation G.1000 (2001), *Communications Quality of Service: A framework and definitions*.
- ITU-T Recommendation G.1010 (2001), *End-user multimedia QoS Categories*.
- ITU-T Recommendation H.323 (2003), *Packet-based multimedia communications systems*.
- ITU-T Recommendation I.350 (1993), *General aspects of quality of service and network performance in digital networks, including ISDNs*.
- ITU-T Recommendation P.561 (2002), *In-service, non-intrusive measurement device – voice service measurements*.
- ITU-T Recommendation P.562 (2004), *Analysis and interpretation of INMD voice-service measurements*.
- ITU-T Recommendation 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 Recommendation Y.1530 (2004), *Call processing performance for voice service in hybrid IP networks*.
- ITU-T Recommendation Y.1540 (2002), *Internet protocol data communication service – IP packet transfer and availability performance parameters*.
- ITU-T Recommendation Y.1541 (2002), *Network performance objectives for IP-based services*.

3 Reference architectures for PSTN-IP-PSTN voice service

A basic reference architecture of PSTN-IP-PSTN VoIP services could be as in Figure 1.

Its difference from the existing PSTN for voice service is the addition of 'Interworking Function Block between PSTN and IP-based network (IWFB)' to the existing PSTN architecture.

This 'Interworking Function Block between PSTN and IP-based network':

- interworks between PSTN and IP-based network;
- is an essential part for voice services of PSTN-IP-PSTN architecture;
- is composed of Media Gateway Controller, Media Gateway and IP-based network.

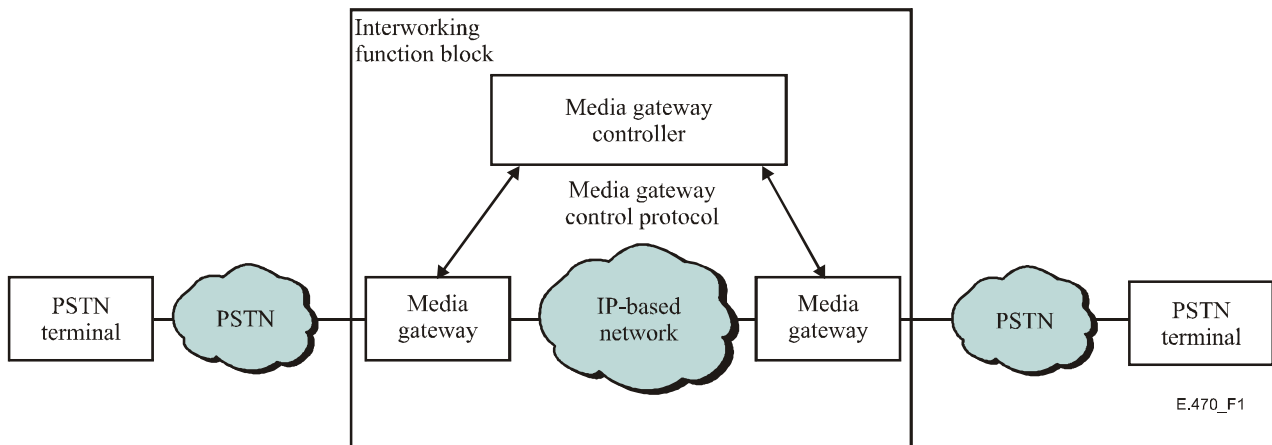


Figure 1/E.470 – General configuration of PSTN-IP-PSTN voice service

The elements in Figure 1 are as follows:

- PSTN terminal: PSTN telephone;
- PSTN clouds: Domestic and/or International Exchanges would be included;
- IP-based Network clouds: Internet Protocol based network;
- Media Gateway: Media conversion gateway between PSTN and IP network;
- Media Gateway Controller: Controller for Media gateway;
- Media Gateway Control Protocol: Control protocol for media gateway (e.g., H.323, SIP, MGCP, Megaco/H.248).

NOTE 1 – Figure 1 shows the generic architecture for interworking of PSTN and IP technologies. So, there could be more than one IP-based network cloud. The figure does not attempt to show ownership of network domains.

NOTE 2 – In Figure 1, there is no attempt to show a product-specific or vendor-specific name.

NOTE 3 – The interworking between circuit-switched signalling and IP signalling on the availability of features and the ability to accurately determine call disposition could be done by the Media Gateway control protocol and the SIGTRAN protocol.

Another view of PSTN-IP-PSTN architecture could be as in Figure 2, with the layout of PSTN clouds to Local exchange, Toll/Tandem/Transit exchange, and International exchange.

It is possible to consider the several configurations according to the types of interworking between the PSTN and the 'Interworking Function Block'.

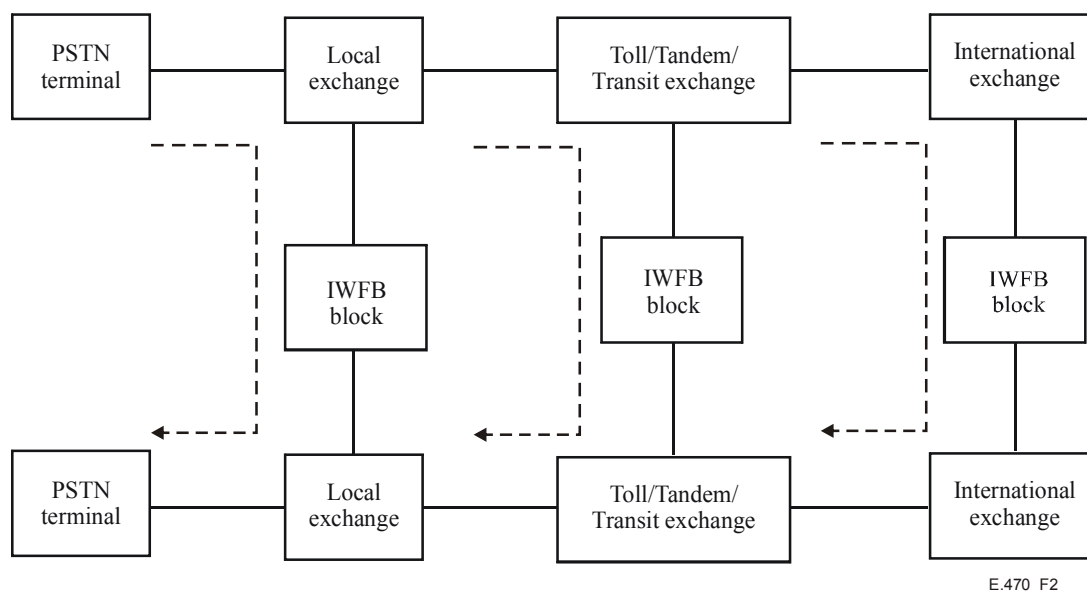


Figure 2/E.470 – Application of PSTN-IP-PSTN VoIP service to existing PSTN

4 QoS framework

The application of the existing QoS framework (as described in ITU-T Recs E.430 and I.350) to this PSTN-IP-PSTN VoIP architecture is possible from a service point of view (e.g., voice service). From a network point of view network, however, specific network performance parameters and associated objectives should be defined.

5 QoS categorization and applicability

The following paragraphs identify all relevant end-to-end performance parameters for the PSTN-IP-PSTN architecture.

It is expected that most quality metrics and measurement methods defined for telephone service by existing ITU-T Recommendations could possibly be applicable to PSTN-IP-PSTN network configuration with minor amendments:

- The existing two major telephone quality categorizations, namely Call Connectivity and Call Clarity, could also be adopted for PSTN-IP-PSTN.
- The metrics and methods defined in ITU-T Rec. E.437 can be useful in comparing performance of VoIP and circuit-switched routes between common origins and destinations.

5.1 Connection quality

As for the intrusive measurement method:

- end-to-end connection quality metrics and measurement for PSTN have been recommended in ITU-T Rec. E.434.
- ITU-T Rec. E.434 is believed to be also applicable to the PSTN-IP-PSTN configuration.

As for the non-intrusive measurement method:

- connectivity metrics and measurement method recommended in ITU-T Rec. E.425 are believed to be also applicable to the PSTN-IP-PSTN configuration.

5.2 Call clarity

As for call clarity, various existing metrics for PSTN, e.g., level, noise, echo, clipping, etc., could be applicable to PSTN-IP-PSTN configuration. These metrics can be commonly used for both intrusive and non-intrusive subjective measurement.

As for intrusive measurement:

- Study Group 12 is studying both subjective and objective measurement of QoS of Voice over IP.

As for non-intrusive measurement:

- Study Group 12 has produced ITU-T Rec. P.561 (07/02) for PSTN. ITU-T Rec. P.561 could be applicable to PSTN-IP-PSTN configuration, where packet loss could occur. In general, a short-time measurement of P.561 call clarity metrics (e.g., one minute) may not capture the potential variability in the quality of VoIP calls.

6 IP network impacts

In the PSTN-IP-PSTN architecture, voice quality is mainly affected by the characteristic of components of 'Interworking Function Block'. So, in order to study telephone service quality for PSTN-IP-PSTN, the quality factors for each component of 'Interworking Function Block' should include interactions with other components. Also, the quality deterioration factors for each major quality categorization should be identified and analysed.

Table 1 represents the voice quality related function and related QoS category of the 'Interworking Function Block'.

Table 1/E.470 – Components of the 'Interworking Function Block' and related QoS category with voice quality functions

Components	Related QoS category	Voice quality related functions
Media Gateway	<ul style="list-style-type: none">– Connection quality– Call clarity	<ul style="list-style-type: none">– Coding/transcoding– Packetization– Jitter buffer– Voice activity detection– Echo cancel, etc.
Media Gateway Controller	<ul style="list-style-type: none">– Connection quality	<ul style="list-style-type: none">– Call control– Call routing, etc.
IP network	<ul style="list-style-type: none">– Connection quality– Call clarity	<ul style="list-style-type: none">– Latency– Jitter– Packet loss, etc.

The following are assumed as major quality deterioration factors of the 'Interworking Function Block':

- Call processing delay in 'Interworking Function Block';
- Lack of DTMF transparency due to transcoding;
- Packet loss associated with IP packet congestion;
- Packet loss associated with packet arrival delay variation;
- Packet transfer delay and delay variation;
- Voice coding algorithm (e.g., in 'Interworking Function Block') and congestion status in IP network;
- Voice Activity Detection algorithm;

– Asymmetric nature of IP-based networks, etc.

The applicability of existing QoS metrics and measurement to the PSTN-IP-PSTN and the 'Interworking Function Block' impacts on voice quality are summarized in Table 2.

Table 2/E.470 – Applicability of existing QoS metrics and measurement to PSTN-IP-PSTN and IP network impacts

QoS category	Existing ITU-T Recommendations for PSTN	Applicability to PSTN-IP-PSTN metrics (Measurement)	IP network impacts
Connection quality	(Intrusive measurement) – Connectivity: E.434 – Call establishment/clearing delay: E.431 – Connection retention: E.428	YES (YES) YES (YES) YES (YES)	<ul style="list-style-type: none"> – Call connection processing delay in 'Interworking Function Block' – Lack of DTMF transparency due to transcoding – Packet loss associated with IP packet congestion – Packet loss associated with packet arrival delay variation – Packet transfer delay and delay variation
	(Non-intrusive measurement) – Connectivity: E.425 – Call establishment/retention: E.437	YES (YES) YES (YES)	
Call clarity	(Intrusive measurement) – Subjective/objective measurement – Intrusive Perception Model: P.862 (PESQ) – E-model: G.107, G.108, G.109	Under study (Under study)	<ul style="list-style-type: none"> – Packet loss associated with IP packet congestion – Packet loss associated with packet arrival delay variation – Packet transfer delay and delay variation – Voice coding algorithm (e.g., in 'Interworking Function Block') and congestion status in IP network – Voice Activity Detection algorithm
	(Non-intrusive measurement) – Objective measurement: P.561, P.562	YES (YES)	

7 QoS measurement and management of PSTN-IP-PSTN architecture

An overall viewpoint of QoS aspects should consider the QoS measurement and management for the PSTN-IP-PSTN architecture.

That is, measurement and management for the 'Interworking Function Block' including existing PSTN should be considered.

'Interworking Function Block' could be divided into two sections: the IP-based network itself, and the overall 'Interworking Function Block'.

Issues considered in each section are represented in Figure 3 and Table 3, respectively.

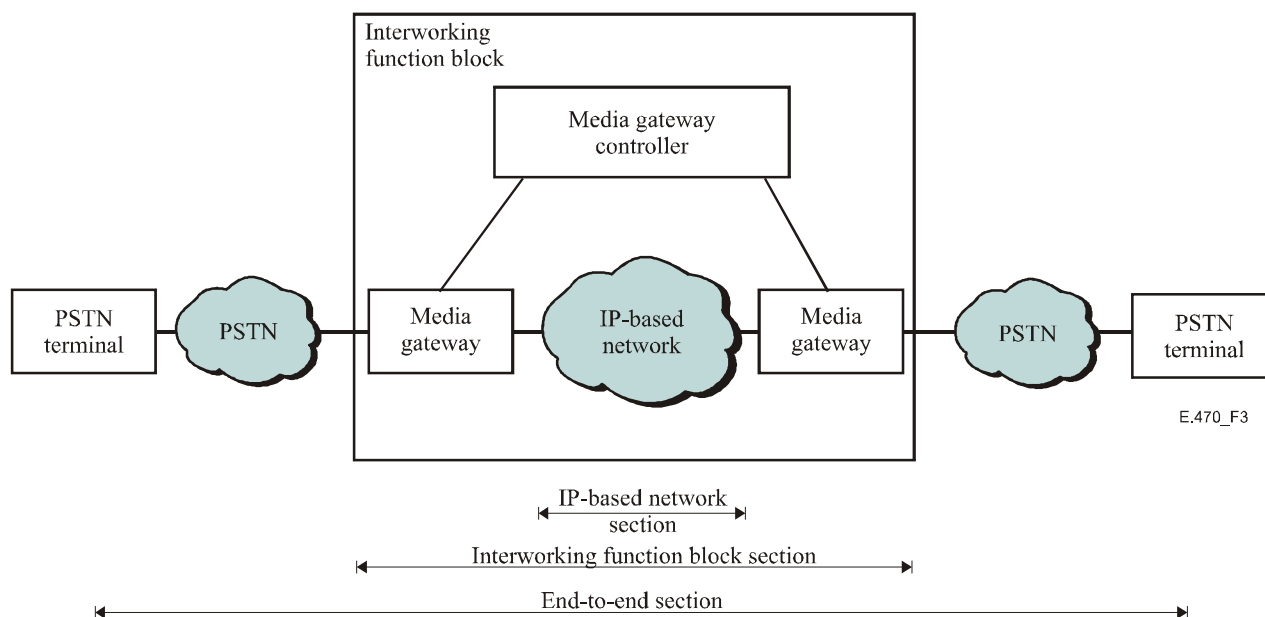


Figure 3/E.470 – Measurement and management scope of PSTN-IP-PSTN architecture

Table 3/E.470 – Measurement and management section with related issues

Section/Perspective area	Study issues	Related Study Group/ ITU-T Recs
A) IP-based network itself	<ul style="list-style-type: none"> – IP network impacts to QoS – IP network performance parameters 	SG13 – Y.1540 – Y.1541, etc.
B) Interworking Function Block	<ul style="list-style-type: none"> – Interworking functions related to voice services 	SG12 SG13 – Y.1530, etc. SG16 – H.323, etc.
C) End-to-end, including PSTN	<ul style="list-style-type: none"> – User perspective QoS parameters 	SG2 – E.437 – E.470, etc. SG12 – G.1000 – G.1010, etc.

In this PSTN-IP-PSTN architecture, the point of concentration of the international traffic, either in the circuit-switched network or in the IP network, has significant impact on the methods used to measure QoS.

As noted in the previous clause, the existing measurement methods (i.e., intrusive and non-intrusive) would be applicable to the PSTN-IP-PSTN architecture.

In case of non-intrusive measurement, monitoring can be made at the switching exchange (local/transit/international gateway) or the 'Interworking Function Block'.

On the other hand, considering the layered characteristics of IP protocol, measurement and management for each layer in 'Interworking Function Block' is desired.

8 Further study

- Statistical aspects: Sampling techniques, sample size for measurements are for further study.
- Asymmetric nature of IP-based communications: Impacts of symmetric nature of IP-based communications to voice quality is for further study.

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