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

Quality of service and performance

Communications quality of service: A framework and definitions

ITU-T Recommendation G.1000

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ITU-T Recommendation G.1000

Communications quality of service: A framework and definitions

Summary

This Recommendation gives a framework and definitions for communications quality of service so as to establish a uniform approach to quality of service across the ITU-T and eliminate the confusion resulting from different frameworks and inconsistent definitions. Improved consistency regarding quality of service is needed throughout the communications industry, especially in IP-related areas within and outside the ITU.

This Recommendation provides a practical "top-down" path from a general quality definition (ISO 8402) to a QoS definition (ITU-T Rec. E.800) to network performance (ITU-T Rec. I.350, and Y.1540) to a functional breakdown of all components of service quality (the QoS definition matrix of ETSI ETR 003). Additionally presented are four viewpoints of QoS that make the definitions and framework meaningful for everyone: users, vendors, network operators, service providers, etc.

This overall approach is believed to be highly useful because it encourages a consistent and uniform mapping between the top-down, framework definitions of QoS and the bottom-up, operational measures on network elements. Advantages of using this approach is that it not only helps identify QoS-related problems, but it also facilitates quantifying the problem from multiple views; the customer's (e.g. surveys and subjective tests) and the service provider's (network measurements). This helps assure that resolving the problem in one domain (e.g. the provider) also resolves it in the other (e.g. the customer).

Source

ITU-T Recommendation G.1000 was prepared by ITU-T Study Group 12 (2001-2004) and approved under the WTSA Resolution 1 procedure on 29 November 2001.

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.

NOTE

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, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Communications quality of service: A framework and definitions

1 Scope

This Recommendation addresses the need for a consistent approach to QoS, with a goal of setting a well-defined and relevant (e.g. customer-affecting) approach that can be readily used to plan and deploy networks, and to monitor service quality. Improved consistency regarding QoS is needed throughout the communications industry, especially in IP-related areas.

While there is an urgent need in the industry for more consistency and uniformity in QoS as it applies to IP-related networks and services, the QoS framework and approach presented here can be applied to all communications services, such as mobile, wireline, multimedia, etc.

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 published regularly.

NOTE – The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

– ETSI ETR 003 ed.2 (1994), *Network Aspects (NA); General Aspects of Quality of Service (QoS) and Network Performance (NP).*

– ISO 8402:1994, *Quality management and quality assurance – Vocabulary*.

– ISO 9000:2000, *Quality management systems – Fundamentals and vocabulary*.

– ITU-T Recommendation E.800 (1994), *Terms and definitions related to quality of service and network performance including dependability*.

– ITU-T Recommendation G.1010 (2001), *End-user multimedia QoS categories*.

– ITU-T Recommendation I.350 (1993), *General aspects of quality of service and network performance in digital networks, including ISDN*.

– ITU-T Recommendation Y.1540 (1999), *Internet protocol data communication service – IP packet transfer and availability performance parameters*.

3 Definitions

This Recommendation defines the following terms:

3.1 quality: the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs (ISO 8402).

3.2 quality of service (QoS): the collective effect of service performances, which determine the degree of satisfaction of a user of the service (ITU-T Rec. E.800).

3.3 QoS requirements of user/customer: a statement of the level of quality *required* by the applications of customers/users of a service, which may be expressed non-technically.

3.4 QoS offered/planned by provider: a statement of the level of quality *expected* to be offered to the customer by the service provider.

3.5 QoS delivered/achieved by provider: a statement of the level of the *actual* quality achieved and delivered to the customer.

3.6 QoS perceived by user/customer: is a statement expressing the level of quality that customers *believe* they have experienced.

4 Abbreviations and Acronyms

This Recommendation uses the following abbreviations:

ETSI European Telecommunications Standards Institute

FITCE Federation of Telecommunications Engineers of the European Community (*Fédération des ingénieurs et experts des télécommunications de la Communauté Européenne*)

IETF Internet Engineering Task Force

IP Internet Protocol

ISO International Organization for Standardization

ITU-T International Telecommunication Union – Telecommunication Standardization Sector

NI Network Interface

NP Network Performance

QoS Quality of Service

SLA Service Level Agreement

5 Communications Quality of Service: A framework and approach

5.1 An elaboration on definitions for Quality and Quality of Service

The term *quality of service* (QoS) is extensively used today, not just in the telecommunications world in which it has its roots, but increasingly regarding broadband, wireless and multimedia services that are IP-based. Networks and systems are gradually being designed in consideration of end-to-end performance required by user applications; however, the term QoS is usually not well-defined, is used loosely, or worst of all, misused.

In looking for candidate definitions of quality and QoS, ISO 8402 provides a general definition of quality itself, whereas ITU-T Rec. E.800 provides a definition of QoS:

As noted, a definition of general quality is provided in ISO 8402 as "*the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs.*" Similarly, ISO 9000 defines quality as the "*degree to which a set of inherent characteristics fulfills requirements*." The ISO 8402 definition seems better from the user's view. In any event, QoS is clearly a subset of overall quality.

As noted, ITU-T Rec. E.800 defines QoS as "*the collective effect of service performance which determine the degree of satisfaction of a user of the service.*"

Most publications, including many standards, use the term QoS but either do not define it, or else point to one of these other few definitions. For example, in many industry standards, reports and specifications, QoS is not clearly defined, or else reference is made to ITU-T Rec. E.800.

5.2 A framework for the quality of communications services

The framework described in ITU-T Rec. E.800 highlights some operational aspects of providing networks and services, but suffers from not being very application-oriented, and, in many areas, too

vague to use. So while the definition of QoS in ITU-T Rec. E.800 is fairly widely used, the E.800 framework is not.

Even if one adopts ISO 8402 as a definition of quality, and ITU-T Rec. E.800 as a definition of QoS, some way is still needed of relating the application-affecting functions of a service to the various criteria used to assess the quality with which these functions are performed. A telecommunications services quality framework [I.1] was adopted by the Federation of Telecommunications Engineers of the European Community (FITCE), with an extremely thorough assessment of how it could be used in practice. ETR 003 from ETSI provides a readily available source for this same framework and QoS approach, which is elaborated below.

5.3 Matrix for the determination of communications QoS criteria

Quality criteria of a telecommunications service may be derived from a matrix shown in Figure 1. Considerable thought has gone into its construction and has proven to be useful in identifying QoS criteria for customers before launching a new service (see ETSI ETR 003). The FITCE Study Commission found that, depending upon the granularity of QoS required for a service, as many as 43 QoS criteria may be deduced, and as few as 13 important ones for basic telephony service.

		Service Quality Criteria						
		SPEED 1	ACCURACY 2	AVAILABILITY 3	RELIABILITY 4	SECURITY 5	SIMPLICITY 6	FLEXIBILITY 7
Service Function								
SERVICE MANAGEMENT	Sales & Pre-Contract Activities 1							
	Provision 2							
	Alteration 3							
	Service Support 4							
	Repair 5							
	Cessation 6							
CONNECTION QUALITY	Connection Establsh. 7							
	Information Transfer 8							
	Connection Release 9							
Billing 10								
Network/Service management by customer 11								

Figure 1/G.1000 – Matrix to facilitate identification of communications QoS criteria

This matrix may be used for any telecommunications service to determine the requisite QoS criteria. After determining the quality criteria, parameters can be defined and performance objectives set.

5.4 Relationship between QoS and Network performance

Network performance contributes towards QoS as experienced by the user/customer. Network performance may or may not be on an end to end basis. For example, access performance is usually separated from the core network performance in the operations of single IP network, while Internet performance often reflects the combined NP of several autonomous networks

Other ITU-T Rec., such as I.350 and Y.1540, have gone on to develop far more detail for network performance and the NI-to-NI part of overall QoS, in addition to contrasting QoS and network performance. But ITU-T Rec. E.800 remains the most meaningful ITU-T definition from the user's perspective, even though, as mentioned, the framework of ITU-T Rec. E.800 is vague in areas and has thus led to a variety of interpretations. So while the framework of ITU-T Rec. E.800 needs to be more concrete and more application-oriented, its basic definition of QoS is good.

5.5 Four viewpoints of QoS

The QoS definition matrix of Figure 1 gives criteria for judging the quality of the communications functions that any service must support. However, even this definitional matrix can be viewed from different perspectives:

– Customer's QoS requirements;

– Service provider's offerings of QoS (or planned/targeted QoS);

– QoS achieved or delivered;

– Customer survey ratings of QoS.

For any framework of QoS to be truly useful and practical enough to be used across the industry, it must be meaningful from these four viewpoints, which are illustrated in Figure 2 and defined thereafter. While Figure 2 shows the "top down" relationship of these viewpoints, it does not indicate how, for example, QoS actually gets implemented by the service provider. This requires many detailed methods done in a more "bottom up" operation that is not addressed in this Recommendation. (The point of this Recommendation is that a single QoS definition and framework can support all of the viewpoints of Figure 2.)

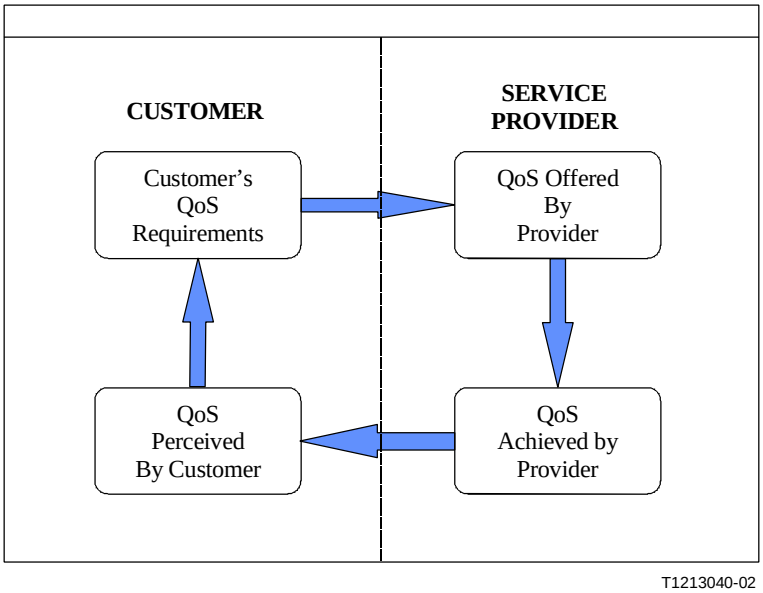

Figure 2/G.1000 – The four viewpoints of QoS

5.5.1 Customer's requirements of QoS

QoS requirements by the customer state the level of quality required of a particular service, which may be expressed in non-technical language. The customer is not concerned with how a particular service is provided, or with any aspects of the network's internal design, but only with the resulting end-to-end service quality. From the customer's point of view, quality of service is expressed by parameters, which:

– focus on user-perceived effects, rather than their causes within the network;

– do not depend, in their definition, on assumptions about the internal design of the network;

– take into account all aspects of the service from the customer's point of view;

– may be assured to a user by the service providers, sometimes in contractual terms;

– are described in network-independent terms and create a common language understandable by both the user and the service provider.

Of special interest is ITU-T Rec. G.1010 on the QoS requirements of end users for all their applications. This Recommendation explicitly addresses the "customer requirement" viewpoint, which can be used by the service provider to plan the network service level.

5.5.2 QoS offered by the service provider

QoS offered by the service provider is a statement of the level of quality expected to be offered to the customer by the service provider. The level of quality is expressed by values assigned to QoS parameters. The principal use of this form of QoS is for planning and for Service Level Agreements. Each service would have its own set of QoS parameters (as in the QoS Classes of ITU-T Rec. Y.1540 for IP service offers). The service provider may express the offered QoS in non-technical terms for the benefit of customers, and in technical terms for use within the business.

QoS offered by the service provider can be used in planning documents, to specify measurement systems and also can be used to form the basis of the SLAs.

For example, a service provider may state, for the benefit of customers, that the availability of basic telephony service is planned to be 99.95% in a year with not more than a 15-minute break at any one occasion, and not more than 3 breaks over the year.

5.5.3 QoS achieved or delivered by the service provider

QoS achieved by the service provider is a statement of the level of quality actually achieved and delivered to the customer. This is expressed by values assigned to parameters, which should be the same as specified for the offered QoS so that the two can be compared to determine what was actually achieved to assess the level of performance achieved. These performance figures are summarised for specified periods of time, e.g. for the previous month.

For example, the service provider may state that the achieved availability for the previous quarter was 99.95% with five breaks of service of which one lasted 65 minutes. The QoS achieved or delivered is used by the industry, sometimes by regulators, for publication in the interests of customers.

5.5.4 QoS perceived by the customer

QoS perceived by the users or customers is a statement expressing the level of quality experienced they 'believe' they have experienced. The Perceived QoS is expressed, usually in terms of degrees of satisfaction and not in technical terms. Perceived QoS is assessed by customer surveys and from customer's own comments on levels of service. Perceived QoS can be used by the service provider to determine customer satisfaction of the service quality. For example, a customer may state that on an unacceptable number of occasions, there was difficulty in getting through the network to make a call and may give it a rating of 2 on a 5-point scale: 5 indicating excellent service. Ideally there would be 1:1 correspondence between delivered and perceived QoS.

5.6 Relationship between the four viewpoints of QoS

The customer's QoS requirements (such as those given in ITU-T Rec. G.1010) may be considered as the logical starting point. A set of customer's QoS requirements may be treated in isolation as far as its capture is concerned. This requirement is an input to the service provider for the determination of the QoS to be offered or planned. The service provider may not always be in a position to offer customers the level of QoS they require. Considerations such as cost of quality, strategic aspects of the service providers' business, benchmarking ("best in class") and other factors will influence the level of quality offered. The customer's requirements may also influence what monitoring systems are to be instituted for the determination of achieved QoS for the purpose of regular reports on achieved quality. The combination of relationships forms the basis of a practical and effective management of service quality; one measure of progress could be considered to be when the four views of QoS begin to converge for a given service.

5.7 The Challenge of IP-related QoS

There are many issues presented by the use of IP-based networks and services, such as the lack of proven, robust and scalable standard mechanisms for:

– dynamic allocations of resources (like packet loss and delay) among network segments;

– assuring that required end-to-end network performance objectives are in fact achieved;

– seamless signaling of desired end-to-end QoS across both network and peer interfaces;

– performance monitoring of IP-based networks and services that are consistent with methods used for network and service planning, and also meaningful to the user experience; and

– rapid and complete restoration of IP layer connectivity following severe outages (or attacks) of heavily loaded networks.

If such issues are to be addressed in a timely fashion, a consistent QoS approach is clearly helpful.

6 Conclusion

In summary, this Recommendation provides a practical "top-down" path from a general quality definition (ISO 8402) to a QoS definition (ITU-T Rec. E.800) to network performance (ITU-T Rec. I.350 and Y.1540) to a functional breakdown of all components of service quality (the QoS definition matrix of ETSI ETR 003). Additionally presented are four viewpoints of QoS that make the definitions and framework meaningful for everyone: users, vendors, network operators, service providers, etc.

This overall approach is believed to be highly useful because it encourages a consistent and uniform mapping between the top-down, framework definitions of QoS and the bottom-up, operational measures on network elements. Advantages of using this approach are that it not only helps identify QoS-related problems, but it also facilitates quantifying the problem from multiple viewpoints: the customer's (e.g. surveys and subjective tests) and the service provider's (network measurements). This helps assure that resolving the problem in one domain (e.g. the provider) also resolves it in the other (e.g. the customer).

APPENDIX I

Bibliography

[I.1] RICHTERS (J.S.), DVORAK (C.A.): A Framework for Defining the Quality of Communications Services, *IEEE Communications Magazine*, Volume 26, Issue 10, pp. 17-23, October 1988.

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