# ITU-T STUDY GROUP 12

# Workshop on Quality of Service and user-perceived transmission quality in evolving networks

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## An Assessment of IP-related Quality of Service work in the ITU-T

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**Abstract**

This paper has two parts. The first part reviews the QoS-related activities in the ITU-T and highlights the generic QoS activities. The second part looks at the lack of consensus in the ITU on a QoS framework and for definitions for QoS, and proposes an approach to be adopted. The goal is to improve the impact on IP-based networks and services of the ITU-T QoS expertise.

### Introduction

At the recent World Telecommunications Standardization Assembly, ITU-T Study Group 12 was named the Lead Study Group on Quality-of-Service (QoS) and Performance. A main reason for this decision was that the mandate of Study Group 12 includes guidance on the end-to-end transmission performance of all types of networks (e.g., PDH, SDH, ATM and IP), terminals (e.g., handset, hands-free, headset, mobile, audiovisual) and their interactions, in relation to the perceived quality and acceptance by users.

As the Lead Study Group on Quality-of-Service and Performance, Study Group 12 provides leadership for the ITU-T in dealing with QoS-related issues. Internal to the ITU-T, this leadership involves providing a roadmap for QoS activities that can be used to identify and resolve QoS-related issues across Study Groups. External to the ITU-T, this leadership involves active communication with other organisations, with a goal of improving the visibility of ITU-T expertise in QoS and more effectively leveraging this expertise in specifications being developed elsewhere in the industry.

Accordingly, this report summarizes an investigation into the current QoS related activities of the ITU-T. This report was motivated by the clear need to make an assessment of the ITU-T QoS activities in light of the rapidly changing services marketplace, in particular those that are IP-based. Additionally, this document proposes a path forward for the collective QoS activities of the ITU-T, so that this very important core competence is most effectively utilized and leveraged as the industry moves toward IP-based networks intended to support all user QoS needs.

## A Taxonomy of QoS Activities in the ITU-T

In striving to do a thorough assessment of ITU-T QoS activities, a large amount of information was noted. Searches on the ITU website yield hundreds of references, contributions and recommendations. The work programme of every Study Group was reviewed, as was the list of Questions under study by each Study Group. Additionally, information was collected from every Study Group by a personal request from each Chairman, to put all the other material in context.

This survey led to a very large amount of information, which is not reproduced here because almost all of it is readily available from the web pages of each Study Group. This information naturally lent itself to a type of triage, where ITU-T Study Group activities were sorted into three buckets:

1. A work programme with very little direct QoS content (e.g., producing a QoS recommendation).
2. A work programme that includes the consideration of QoS mechanisms, but indirectly and/or in isolation for specific technologies, such as QoS capabilities for multimedia, cable or Frame Relay;
3. A work programme that has direct and/or extensive QoS involvement, with milestones of producing generic QoS-related recommendations that were basically technology-independent;

The Study Groups that fell into the first category of very little QoS work were SGs 3, 5, 6, 10 and SSG. Nothing more will be said about these, which is not meant to sound critical or negative—it is just that their mandate and work programme does not currently include much QoS activity.

The middle category of QoS mechanisms for specific systems captures SGs 4, 7, 9, 11, 15 and 16. These SGs have at least one question that involve QoS, as per the following examples (not exhaustive):

- SG 4 has some QoS content in two questions related to operations supporting SLAs;
- SG 7 has one question on Frame Relay QoS;
- SG 9 studies QoS signaling for cable systems, and has questions on video quality assessment;
- SG 11 is developing capabilities to have BICC be able to signal QoS;
- SG 15 works on system-specific requirements for network and transport equipment, and
- SG 16 is looking at QoS mechanisms primarily for H.323-based multimedia systems and the Mediacom2004 framework.

Another reason for putting these groups in a separate category is that their work is not highly dependent on the work of others. In this case, the usual liaison process is effective in communication status and progress.

For information only, the filtered work programmes of these groups are annexed (see Annex A) to this paper. They were filtered to show only the items that are both IP-related as well as QoS-related. Obviously the accuracy of the information in this Annex is only as good as the information available from the most recently published work programme of each Study Group.

The last category of QoS work in the ITU-T covers “generic” QoS work and includes the remaining ITU-T Study Groups, namely Study Groups 2, 12 and 13. Here we want very careful assessment and coordination, because the activities of these groups are interdependent. Also, if generic QoS-related guidance is to come out of the ITU-T and be well utilised by other bodies, such as the IETF, it is critical that any such guidance (for example on allowable levels of packet loss) be consistent with the experts across the ITU-T. Otherwise, ITU-T guidance on QoS-related topics will be confusing and misleading, and credibility will be lost.

Therefore, the remainder of this paper deals with the QoS activities of Study Groups 2, 12 and 13 because of their unique interdependency. Additionally, since it was stated that a major concern today is the QoS of the rapidly evolving IP-based networks and services, only the IP-related activities in these three SGs are focused upon here. Their QoS-related work that also involves IP aspects is as follows:

- SG 2 has one question on QoS, but several other questions on routing, traffic engineering, network management are tightly linked with QoS. SG 2 (via Q.5/2) also oversees a separate experts group known as the Quality of Service Development Group (QSDG) that has many Working Groups that engage active discussions on many QoS-related topics. The QSDG does not exist with a primary purpose of developing recommendations. To date very little of its subject matter has been IP-oriented.

- SG12 has all of its 16 questions directly related to QoS, mostly from a transmission quality perspective (the mandate of SG12 was given in the opening paragraph of this paper). Of particular relevance to the IP focus of this paper is the work of WP 3/12 which is almost completely dedicated to the performance of IP-based networks and terminals; however, the other questions in SG12 also clearly impact user-perceived QoS, just not as IP-centric.

- SG13 has an entire Working Party dedicated to Network Performance, WP 4/13, which looks at everything from physical layer performance to connection set-up times. A subset of this work is focused on IP layer performance, in particular the work of Q.6/13, which is working on defining IP network QoS classes in draft Recommendation Y.1541.

For information only, the filtered work programmes of these three groups follow. The list of draft recommendations, which is only as accurate as the information from the individual Study Group web pages, was filtered to show only the items that are both IP-related as well as QoS-related.

# IP-related QoS Activities in Study Group 2

| Recommendation | ST | Ques | Timing | Pri | Pg | Liaison | References | Subject |
|---|---|---|---|---|---|---|---|---|
| E.TE1 | N | 1, 2, 6, 9/2 | 2002 | M | 30 | SGs 4, 11, 12, 13, 15, 16 | SG 2 iFTP | Framework for traffic engineering and QoS methods for IP-, ATM-, and TDM- based multiservice networks |
| E.TE2 | N | 1, 2, 6, 9/2 | 2002 | M | 30 | SGs 4, 11, 12, 13, 15, 16 | SG 2 iFTP | Traffic engineering and QoS methods - Call routing and connection routing methods |
| E.TE3 | N | 1, 2, 6, 9/2 | 2002 | M | 30 | SGs 4, 11, 12, 13, 15, 16 | SG 2 iFTP | Traffic engineering and QoS methods - QoS resource management methods |
| E.TE4 | N | 1, 2, 6, 9/2 | 2002 | M | 30 | SGs 4, 11, 12, 13, 15, 16 | SG 2 iFTP | Traffic engineering and QoS methods - Routing table management methods and requirements |
| E.TE5 | N | 1, 2, 6, 9/2 | 2002 | M | 30 | SGs 4, 11, 12, 13, 15, 16 | SG 2 iFTP | Traffic engineering and QoS methods - Transport routing methods |
| E.TE6 | N | 1, 2, 6, 9/2 | 2002 | M | 30 | SGs 4, 11, 12, 13, 15, 16 | SG 2 iFTP | Traffic engineering and QoS methods - Capacity management methods |
| E.TE7 | N | 1, 2, 6, 9/2 | 2002 | M | 30 | SGs 4, 11, 12, 13, 15, 16 | SG 2 iFTP | Traffic engineering and QoS methods - Traffic engineering operational requirements |
| E.QOS-VOIP | N | 5/2 | 2001-10 | M | 6 | SG 13 | COM 2-R 81 | Operational considerations for QoS of voice and facsimile over IP-based networks |
| E.hfc | N | 7, 8, 9/2 | 2001-10 | H | 7 | SGs 13, 15 | SG 2 iFTP | Traffic engineering considerations for IP access networks based on hybrid fibre-coaxial systems |
| E.ipvpn | N | 9/2 | 2002 | H | 10 | SGs 3, 11 | SG 2 iFTP | Traffic engineering methods for network-based IP virtual private networks |

# IP-related QoS Activities in Study Group 12

| Recommendation | ST | Ques | SG | Timing | Pri | Pg | Liaison | References | Subject |
|---|---|---|---|---|---|---|---|---|---|
| P.GTWY | N | 2/12 | 12 | 2002 | H | | SG 15 | | Performance specifications for gateways |
| P.VoIP | N | 2/12 | 12 | 2002 | H | | SG 15 | | Performance specifications for VoIP terminals |
| P.PAC | N | 7/12 | 12 | 2003 | | | | | Subjective evaluation of the effects of time-varying impairments (eg. Packet loss) |
| G.107 | R | 8/12 | 12 | 2004 | M | | SG 2; ETSI | | The E-model, a computational model for use in transm. planning |
| G.113 Appendix I | R | 10/12 | 12 | 2002 | H | | SGs 15, 16 | | Transmission impairments |
| G.108 | R | 11/12 | 12 | 2004 | M | | SGs 11, 13, 15, 16; ETSI | | Application of the E-model: a planning guide |
| G.177 | R | 11/12 | 12 | 2002 | M | | SG 11; ETSI | COM 12-86 | Transmission planning for voiceband services over hybrid Internet/PSTN connections |
| G.17x | N | 12/12 | 12 | 2002 | M | | SG 11; ETSI | | Transmission planning for voice-band services over IP connections |
| G.IPP | N | 12/12 | 12 | 2003 | H | | | | Transmission performance parameters for IP networks affecting perceived speech quality and other voiceband services |
| G.QoSRQT | N | 13/12 | 12 | 2001 | H | | | | Multimedia QoS requirements |
| G.VBS-Islands | N | 14/12 | 12 | 2002 | H | | | | Transmission planning for interconnected IP-based networks supporting PSTN-type speech and voiceband data services |
| G.VoIP-Islands | N | 14/12 | 12 | 2002 | H | | | | Transmission planning for interconnected IP-based networks supporting Vo IP services |
| QoS coordination activities | N | 15/12 | 12 | Cont. | H | | | | Coordination of QoS/performance studies |

# IP-related QoS Activities in Study Group 13

| Recommendation | ST | Ques | SG | Timing | Pri | Pg | Liaison | References | Subject |
|---|---|---|---|---|---|---|---|---|---|
| Y.iptc | N | 4/13 | 13 | 2002-02 | H | 50 | ITU-T/R as required; IETF, ETSI, ISO/IEC JTC1, ATMF, MPLS | COM 13 R-16 | Traffic control and congestion control in IP networks |
| I.350 | R | 6/13 | 13 | 2004-02 | L | 20 | ITU-T/R as required; IETF, ETSI, ISO/IEC JTC1, ATMF, MPLS | | General aspects of QoS and NP |
| I.351 | R | 6/13 | 13 | 2004-02 | M | | ITU-T/R as required; IETF, ETSI, ISO/IEC JTC1, ATMF, MPLS | | Relationship among ISDN, IP and GII performance Recommendations |
| Y.800 (Y.perf) | N | 6/13 | 13 | 2002-11 | M | 20 | ITU-T/R as required; IETF, ETSI, ISO/IEC JTC1, ATMF, MPLS | | Performance framework for the GII |
| Y.1540 | N | 6/13 | 13 | 2002-02 | H | | ITU-T/R as required; IETF, ETSI, ISO/IEC JTC1, ATMF, MPLS | | IP packet transfer and availability performance parameters |
| Y.1541 | N | 6/13 | 13 | 2002-02 | H | | ITU-T/R as required; IETF, ETSI, ISO/IEC JTC1, ATMF, MPLS | COM 13 R-16 | IP packet transfer performance objectives |
| G.optperf | N | 8/13 | 13 | 2004-02 | H | | ITU-T/R as required; IETF, ETSI, ISO/IEC JTC1, ATMF, MPLS | | Error & availability performance parameters and objectives for international paths in OTN |
| Y.1530 | N | 9/13 | 13 | 2002-11 | M | 30 | | COM 13 R-7 | Call processing performance for voice service in hybrid IP-based networks |

### Generic QoS Work across the ITU-T

The strong interdependence of the work of these three groups (SG 2, 12 and 13) makes it clear why they should be well coordinated. Fortunately all evidence points to a level of communication and cooperation that is healthy for each of the three groups as well as the ITU-T in general. For example, in previous study periods there was a Joint Coordination Group (JCG) on QoS, and a careful examination of the work of these groups resulted in very few problems in areas considered by the JCG to be "critical dependencies." An examination of the related areas being studied in the current study period supports this view. As examples, SG 12 is making sure that the IP QoS classes being proposed by SG 13 can support most user applications; and SG 2 is coordinating its IP-related traffic engineering activities across the ITU-T.

But a critical question is, if QoS coordination and communications are sufficient, then why is the QoS expertise of the ITU-T not better utilized by other key industry forums such as the IETF? (Asking this way might sound judgmental, but in fact very few IETF activities make use of ITU-T performance and quality efforts.)

Based on the present assessment of QoS work in the ITU-T, there is at least one likely answer to this issue of others not readily using the ITU-T work on QoS. A probable root cause may be the widely varying QoS-related definitions and related frameworks used by different SGs. Consistent guidance from the ITU-T is simply not seen or heard by others outside the ITU, so our work is difficult to use.

Accordingly, the remainder of this paper addresses the use of a consistent approach to IP QoS, with a goal of a set of well-defined and relevant (e.g., customer-affecting) measures that can be readily used to plan and deploy networks, as well as to monitor service quality. If all ITU-T Study Groups were to use a consistent QoS approach, with consistent definitions, then the respective products of each SG would be better leveraged outside the ITU-T. This is the fundamental conclusion of this paper.

### 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 effective, robust and scalable standard mechanisms for:

- signaling desired end-to-end QoS across both network and peer interfaces;
- dynamic allocations of resources (like delay) among network segments;
- assuring end-to-end network performance objectives are achieved; and
- performance monitoring of IP-based networks and services that are consistent with the methods used for network and service planning, and meaningful to the user experience.

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

### QoS definitions and frameworks

The term Quality-of-Service (QoS) is extensively used (and mis-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. The good news is that networks and systems are gradually being designed to meet the end-to-end service performance required by user applications; the bad news is that the term QoS is usually not defined, is used loosely, or worst of all, misused.

As noted, Study Group 12 is charged with a leading role for the QoS-related work program of the entire ITU-T. For this exercise to have any real meaning, it is clear that first a solid foundation must be provided. Accordingly, it is necessary to establish a basic framework and definitions for QoS.

Regarding definitions of QoS, the Quality of Service Development Group of SG 2 has a very active, ongoing debate over what QoS is or isn't. Without re-playing the entire debate, one especially intriguing position is that defining QoS may be an irrelevant exercise in many situations in which it could be argued that all that really matters today is what performance levels are required in a given Service Level Agreement (SLA). While acknowledging the obvious utility of this view, it is suggested here that rigorously defining QoS to cover all user application needs is still worthwhile because:

- Many in the IP-related arenas have little or no knowledge of QoS at the application level;
- Many users (e.g., residential) are not explicitly covered by any SLA; and
- It is desirable to have designers of network elements use the same performance parameters and definitions being used by service providers and their customers.

It is therefore reasonable to assume that re-visiting the basics of QoS is a necessary first step towards a consistent, industry-wide use.

The thorough review of all QoS-related work done for this paper indicates that there are very few formal and/or robust definitions of QoS. Additionally, most publications, including many standards, use QoS but either do not define it, or else point to one of these other few definitions. For example, filtering through many ETSI reports and specifications, it is seen that either QoS is not clearly defined, or else reference is made to ITU-T Recommendation E.800.

In looking for candidate definitions of QoS, we see that ISO 8402 actually provides a definition of quality itself, whereas E.800 provides a definition of QoS. The framework described in E.800 is useful in the sense that it interrelates the various operational aspects of providing networks and services, but suffers from not being very application-oriented, and in some areas too vague to implement. This may be why the E.800 framework has not seen widespread adoption outside of the telecom industry, and even many segments of the telecom industry do not use it.

## Quality, QoS Definitions and Four Viewpoints of QoS

A definition of quality itself 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 9000-2000 defines quality as the "*degree to which a set of inherent characteristics fulfills requirements*." The 8402 definition seems to be better from the user's view. In any event, QoS is clearly a subset of overall quality.

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

Taking ISO 8402 (or 9000) as a definition of quality, and E.800 as a definition of QoS, are instructive first steps, but hardly sufficient to provide an approach or methodology for ensuring user satisfaction when using IP- and/or multimedia-based services. Some way is needed of relating the application-affecting communications functions of a service to the various criteria used to assess the quality with which these functions are performed. Filling this need was the purpose of the communications services quality framework proposed by Richters and Dvorak in the October 1988 issue of the *IEEE Communications Magazine*. This framework was later refined and 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 next elaborated.

### Matrix for the determination of QoS criteria for a telecommunications service:

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 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.

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.

| | | 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 MANAGMENT BY CUSTOMER 11 | | | | | | | | |

Figure 1: Matrix to facilitate identification of QoS criteria for a telecommunication service

### Relationship between QoS and Network performance (NP)

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 Recommendations, 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 E.800 remains the most meaningful ITU-T definition from the user's perspective--even though, as mentioned, the framework of E.800 is vague in areas and has thus led to a variety of interpretations. So while the framework of E.800 needs to be more concrete and more application-oriented, its basic definition of QoS is adequate.

## 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 all of these 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 paper. (The point of this paper is that a single QoS definition and framework can support all of the viewpoints of Figure 2.)

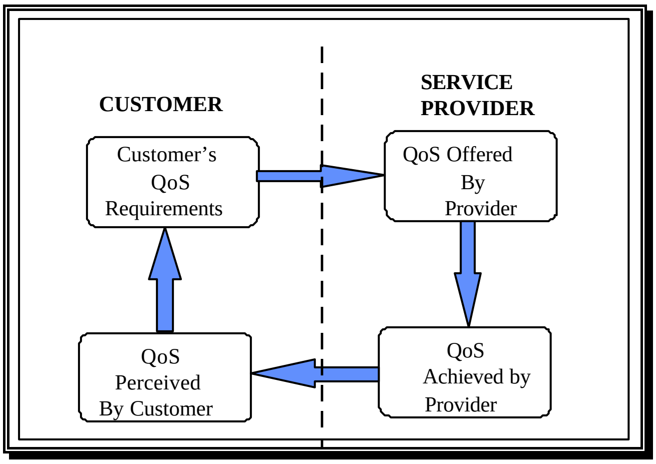


Figure 2: The four viewpoints of QoS

## 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 the recommendation (G.qosrqt) under development by Study Group 12, on the performance requirements of end users for all their applications. This draft recommendation explicitly addresses the "customer requirement" viewpoint.

### 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 Recommendation Y.1541 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.

For example, a service provider may state, for the benefit of customers, that the availability of basic telephony service is planned to be 99.995% in a year with not more than a 15 minute break at any one occasion and not more than 3 breaks over the year.

### 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. 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.

### 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. For example, a customer may state that on 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.

### Relationship between the four viewpoints of QoS

The customer's QoS requirements (such as those given in G.qosrqt) 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. Implementation and engineering considerations can be critical. Considerations such as cost, strategic aspects of the service providers' business, benchmarking (world's best) 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.

### Summary, a Recommendation and Needed Work

In summary, we have ISO 8402, ITU-T Recommendations E.800 and I.350, and the QoS definition matrix of ETSI ETR003 to take us from a general quality definition down to a functional breakdown of the components of quality, such as those given in draft Recommendations Y.1541 and G.qosrqt. Additionally we have the four viewpoints of QoS that make the definitions and framework meaningful and practical for everyone—users, vendors, network operators, service providers, etc. This overall approach should be the global, industry-wide "standard" for QoS.

Still missing is a thorough mapping between the top-down, framework-like approaches to QoS and the bottom-up, operational measures made at network elements, like IP routers. Equally critical is the lack of any demonstration of robust and scalable mechanisms capable of successfully getting dynamically achieved QoS classes across multiple large, heavily loaded networks. These areas are where attention is needed from the industry, which can be pursued more uniformly if the basic ITU-T approach of QoS laid out here is used as a guide.

Additionally, specific aspects of the QoS matrix need serious attention for use in IP space. A particular problem is that of *reliability* for IP-based networks and services, because reliability is used in too many different ways. Making matters worse, E.800 does not speak of *service reliability* at all, only *reliability performance* as a subset of *availability performance*, which is a subset of *trafficability performance*, which is a subset of even other "abilities." The relationship between service and network reliability is not addressed, despite this being a critical need with the rapid deployment of IP-based networks and services. No known QoS mechanisms are capable of rapid and complete restoration of IP-based service capabilities after a severe network outage. Obviously there is much to be done.

In closing, the message is repeated for clarity: A consistent QoS approach is required if the ITU-T core competency on QoS is to be appreciated in the industry. This paper proposes a way forward.

### Acknowledgments

Antony Oodan of Telecommunications Quality Consultancy made many valuable contributions to this paper, especially those regarding his previous QoS-related leadership positions in Europe. Thanks also go to the Study Group and Working Party chairs, and all others who responded on behalf of their SGs.

# ANNEX A: IP-related QoS Activities (non-generic) in Study Groups 4, 7, 9, 11, 15 and 16

## Study Group 4

| Recommendation | ST | Ques | SG | Timing | Pri | Pg | Liaison | References | Subject |
|---|---|---|---|---|---|---|---|---|---|
| M.23ip | N | 3/4 | 4 | 2002 | H | 20 | SGs 2, 12, 13, 15, 16 | COM 4-?? + WD15 Mar 01 | Performance objectives, allocations and limits for provisioning and maintenance of IP-based networks |
| M.QoS | N | 9/4 | 4 | 2002 | H | 15 | | D12 (1/2001) | Requirements for QoS/SLA Management over the TMN X interface (provisional) |

## Study Group 7

| Recommendation | ST | Ques | SG | Timing | Pri | Pg | Liaison | Area | Subject |
|---|---|---|---|---|---|---|---|---|---|
| X.14frip | N | 2/7 | 7 | 2002-03 | M | | SG 12, SG 13, FRF, IETF | 08 | IP Performance over a FR net. and FR service when interworked w/ IP |

## Study Group 9

| Recommendation | ST | Ques | SG | Timing | Pri | Pg | Liaison | References | Subject |
|---|---|---|---|---|---|---|---|---|---|
| J.aqr | N | 4/9 | 9 | 2001-12 | H | | ITU-T SG 16; ITU-R SG 6 | COM 9-R 25, Annex 6 | Objective perceptual video quality measure. techniques for digital cable TV in the presence of full reference |
| J.lpl | N | 4/9, 21/9 | 9 | 2001-12 | M | | ITU-T SGs 13, 16 | TD 037R1 | Loop latency in conversational television programme transmission |
| J.noref | N | 4/9 | 9 | 2001-12 | M | 40 | ITU-R WP 11E; ITU-T SG 12 | COM 9-R 22, D 7 | Perceptual video quality measurements for digital cable TV in the absence of a reference |
| J.qweb | N | 7/9 | 9 | 2001-12 | H | | ITU-T SGs 13, 16 | D 5, TD 045 | Quality control protocol for Webcast |
| J.ids | N | 13/9 | 9 | 2001-12 | H | | ITU-T SGs 11, 15, 16 | | Interdomain signal. for IPCablecom |
| J.iqos | N | 13/9 | 9 | 2001-12 | H | 19 | ITU-T SGs 11, 15, 16 | COM 9-25 | IPCablecom interdomain QoS |

## Study Group 11

| Recommendation | ST | Ques | SG | Timing | Pri | Pg | Liaison | References | Subject |
|---|---|---|---|---|---|---|---|---|---|
| TRQ.ARCH | N | 6/11 | 11 | 2002-05 | H | | | | SIP interworking architectures |
| TRQ.2420 | N | 8/11 | 11 | 2002-05 | H | | | | MPLS signaling requirements |
| TRQ.2142 series | N | 9/11 | 11 | 2002-05 | H | 45 | | TD-GEN/11-51 (May 2001 mtg) | Signaling reqts. for narrowband serv. via broadband transport, CS 3 |
| TRQ.2411 | N | 9/11 | 11 | 2002-05 | H | | | | IP signaling CS2 requirements |

## Study Group 15

| Recommendation | ST | Ques | SG | Timing | Pri | Pg | Liaison | References | Subject |
|---|---|---|---|---|---|---|---|---|---|
| G.ipcme | N | 5/15 | 15 | 2002-05 | H | 30 | | | Digital Circuit Multiplication Equip. Optimized for IP-Based Networks |
| G.ved | N | 6/15 | 15 | 2003-01 | H | 20 | | iFTP sg15/wp2/q6 | Voice Enhancement Devices |
| G.799.1/Y.1411 | N | 7/15 | 15 | 2001-10 | H | 50 | | TD 16 WP 2/15 | Transport Network Equipment for interconnecting GTSN and IP Networks |

## Study Group 16

| Recommendation | ST | Ques | SG | Timing | Pri | Pg | Liaison | References | Subject |
|---|---|---|---|---|---|---|---|---|---|
| H.323 V5 | R | 2/16 | 16 | 2003 | M | 233 | IETF, IMTC | | Packet based multimedia systems |
| H.323 Annex I | N | 2/16 | 16 | 2002 | M | 20 | IETF | | Packet based MM telephony over error prone channels |
| H.323 Annex N | N | 2/16 | 16 | 2002 | M | 65 | ATMF, IETF, TIPHON, SGs 11, 13 | | QoS |