International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

E.802

(02/2007)

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

Quality of telecommunication services: concepts, models, objectives and dependability planning – Terms and definitions related to the quality of telecommunication services

Framework and methodologies for the determination and application of QoS parameters

ITU-T Recommendation E.802

ITU-T E-SERIES RECOMMENDATIONS

OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

INTERNATIONAL OPERATION	
Definitions	E.100–E.103
General provisions concerning Administrations	E.104–E.119
General provisions concerning users	E.120–E.139
Operation of international telephone services	E.140–E.159
Numbering plan of the international telephone service	E.160–E.169
International routing plan	E.170–E.179
Tones in national signalling systems	E.180–E.189
Numbering plan of the international telephone service	E.190–E.199
Maritime mobile service and public land mobile service	E.200–E.229
OPERATIONAL PROVISIONS RELATING TO CHARGING AND ACCOUNTING IN THE INTERNATIONAL TELEPHONE SERVICE	
Charging in the international telephone service	E.230–E.249
Measuring and recording call durations for accounting purposes	E.260–E.269
UTILIZATION OF THE INTERNATIONAL TELEPHONE NETWORK FOR NON-TELEPHONY APPLICATIONS	
General	E.300–E.319
Phototelegraphy	E.320–E.329
ISDN PROVISIONS CONCERNING USERS	E.330–E.349
INTERNATIONAL ROUTING PLAN	E.350–E.399
NETWORK MANAGEMENT	
International service statistics	E.400–E.404
International network management	E.405–E.419
Checking the quality of the international telephone service	E.420–E.489
TRAFFIC ENGINEERING	
Measurement and recording of traffic	E.490–E.505
Forecasting of traffic	E.506–E.509
Determination of the number of circuits in manual operation	E.510–E.519
Determination of the number of circuits in automatic and semi-automatic operation	E.520–E.539
Grade of service	E.540–E.599
Definitions	E.600–E.649
Traffic engineering for IP-networks	E.650–E.699
ISDN traffic engineering	E.700–E.749
Mobile network traffic engineering	E.750–E.799
QUALITY OF TELECOMMUNICATION SERVICES: CONCEPTS, MODELS, OBJECTIVES AND DEPENDABILITY PLANNING	
Terms and definitions related to the quality of telecommunication services	**E.800–E.809**
Models for telecommunication services	E.810–E.844
Objectives for quality of service and related concepts of telecommunication services	E.845–E.859
Use of quality of service objectives for planning of telecommunication networks	E.860–E.879
Field data collection and evaluation on the performance of equipment, networks and services	E.880–E.899
OTHER	E.900–E.999

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation E.802

Framework and methodologies for the determination and application of QoS parameters

Summary

ITU-T Recommendation E.802 provides a framework and methodologies for the identification of QoS criteria relevant to users and guidelines for conversion of these criteria into QoS parameters that can be used to evaluate the QoS of telecommunication services.

Guidelines are also given to obtain user's QoS requirements and to prioritize the criteria or parameters. All these may be applied to services supported by the terrestrial and wireless legacy networks as well as services supported by the emerging IP network.

Source

ITU-T Recommendation E.802 was approved on 8 February 2007 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.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

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, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

CONTENTS

		Page
1	Scope	1
2	References	2
3	Definitions	3
4	Abbreviations and acronyms	5
5	Conventions	5
6	Methodology for identification of QoS criteria and parameters	5
	6.1 General considerations	5
	6.2 Identification of user's QoS criteria	8
	6.3 Conversion of QoS criteria to QoS parameters	12
	6.4 Publication of QoS parameters	13
	6.5 Practical issues when using QoS parameters	14
7	Measurement of QoS parameters	14
	7.1 Objective measurements	15
	7.2 Subjective measurements	16
	7.3 Who should perform the measurements	16
8	Guidelines for defining quality objectives	17
	8.1 General considerations	17
	8.2 Defining initial quality objectives	18
	8.3 Defining target values	18
	8.4 Tuning quality objectives	19
	8.5 Verification of QoS objectives	20
Appendix I – References for the development of QoS metrics and examples of QoS parameters		22
	I.1 Examples of QoS parameters	22
	I.2 Development of QoS metrics	23
Appendix II – Quality objectives		24
	II.1 Voice telephony and voiceband services	24
	II.2 Services over packet-based networks	25
Appendix III – Examples for the usage of the three models		27
	III.1 Universal model	27
	III.2 Performance model	28
	III.3 Four-market model	29

ITU-T Recommendation E.802

Framework and methodologies for the determination and application of QoS parameters

1 Scope

This Recommendation provides a framework and methodologies for the identification of QoS criteria relevant to users and guidelines for conversion of these criteria into QoS parameters that can be used to evaluate the QoS of telecommunication services.

Guidelines are also given to obtain user's QoS requirements and to prioritize the criteria or parameters. All these may be applied to services supported by the terrestrial and wireless legacy networks as well as services supported by the emerging IP network.

These QoS criteria are primarily of interest to users and service providers. Those criteria which are of primary concern to the service/network providers (e.g., network performance parameters that contribute to QoS and other performance criteria) to ensure the delivery of the required level of QoS to the user are not covered in this Recommendation.

NOTE – For information on performance measures from the service/network provider's perspective, refer to [ITU-T E.419] on key performance indicators (KPI).

The QoS criteria are based on the 'QoS Requirements of the User', one of the four viewpoints mentioned in Figure 1 of [ITU-T G.1000]. These criteria, with slight modifications, may be used for expressing the offered QoS, the delivered QoS and the perceived QoS as described in [ITU-T G.1000]. The particular use/application of each of these four QoS viewpoints is given in clause 6.1.1.

This Recommendation introduces three models for the identification of QoS criteria of any telecommunication service. All models or a combination of these models may be used for a particular service to enable most, if not all, QoS criteria to be identified. For a particular purpose, a selection of QoS criteria may be chosen from the list of criteria identified. Guidelines are given on how to convert the identified criteria into measurable QoS parameters and on the adoption and measurement of the parameters.

The QoS parameters may be used for various purposes including:

- Specifying the level of quality of service in customer telecommunication service contracts or in the description of terms and conditions of the service.
- Comparing the level of quality and quality commitments of services of different service providers.
- Preparing long-term studies on the level of quality attributes of a specific service.
- Preparing statistics, reports and publications of the quality of a service.
- Regulatory purposes including specification of the minimum level of quality (e.g., for universal service, interconnection regulations) and monitoring of services by, for example, reports on a regular basis and statistics for specific situations.

Appendix I provides references for the development of QoS metrics and examples of QoS parameters.

Appendix II gives quality objectives that are currently available in standardization.

Appendix III gives examples for the use of the three models for the identification of QoS criteria.

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.419] ITU-T Recommendation E.419 (2006), *Business oriented key performance indicators for management of networks and services*.

[ITU-T E.470] ITU-T Recommendation E.470 (2005), *Operational considerations for QoS of voice over IP-based networks with PSTN-IP-PSTN architecture*.

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

[ITU-T G.1000] ITU-T Recommendation G.1000 (2001), *Communications quality of service: A framework and definitions*.

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

[ITU-T G.1020] ITU-T Recommendation G.1020 (2006), *Performance parameter definitions for quality of speech and other voiceband applications utilizing IP networks*.

[ITU-T G.1030] ITU-T Recommendation G.1030 (2005), *Estimating end-to-end performance in IP networks for data applications*.

[ITU-T G.1040] ITU-T Recommendation G.1040 (2006), *Network contribution to transaction time*.

[ITU-T G.1050] ITU-T Recommendation G.1050 (2005), *Network model for evaluating multimedia transmission performance over Internet Protocol*.

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

[ITU-T O.211] ITU-T Recommendation O.211 (2006), *Test and measurement equipment to perform tests at the IP layer*.

[ITU-T Y.1540] ITU-T Recommendation Y.1540 (2002), *Internet protocol data communication service – IP packet transfer and availability performance parameters*.

[ITU-T Y.1541] ITU-T Recommendation Y.1541 (2006), *Network performance objectives for IP-based services*.

[ITU-T Hdbk QoS] ITU-T Handbook (2004), *Quality of Service and Network Performance*.

[ISO 9000] ISO 9000:2005, *Quality management systems – Fundamentals and vocabulary*.

[ISO/IEC Guide 62] ISO/IEC Guide 62:1996, *General requirements for bodies operating assessment and certification/registration of quality systems*.

[ISO/IEC Guide 65] ISO/IEC Guide 65:1996, *General requirements for bodies operating product certification systems*.

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

[ETSI EG 202 057-1] ETSI EG 202 057-1 V1.2.1 (2005), *Speech Processing, Transmission and Quality Aspects (STQ); User-related QoS parameter definitions and measurements; Part 1: General*.

[ETSI EG 202 057-2] ETSI EG 202 057-2 V1.2.1 (2005), *Speech Processing, Transmission and Quality Aspects (STQ); User-related QoS parameter definitions and measurements; Part 2: Voice telephony, Group 3 fax, modem data services and SMS*.

[ETSI EG 202 057-3] ETSI EG 202 057-3 V1.1.1 (2005), *Speech Processing, Transmission and Quality Aspects (STQ); User-related QoS parameter definitions and measurements; Part 3: QoS parameters specific to Public Land Mobile Networks (PLMN)*.

[ETSI EG 202 057-4] ETSI EG 202 057-4 V1.1.1 (2005), *Speech Processing, Transmission and Quality Aspects (STQ); User-related QoS parameter definitions and measurements; Part 4: Internet access*.

3 Definitions

This Recommendation defines the following terms:

NOTE – Several terms and definitions used in this Recommendation are defined in [ITU-T E.800] and [ITU-T G.1000].

3.1 accuracy: A performance criterion that describes the degree of correctness with which a function is performed. (The function may or may not be performed with the desired speed.)

3.2 availability: Availability of an item to be in a state to perform a required function at a given instant of time or at any instant of time within a given time interval, assuming that the external resources, if required, are provided.

3.3 criterion: A single characteristic of a product or a service that is observable and/or measurable.

3.4 customer: The party that uses a telecommunication service(s) under a contractual agreement.

3.5 flexibility: The degree of variations in the function within the boundaries of technical and operational characteristics of the service.

3.6 measure: A unit by which a parameter may be expressed.

3.7 network operator: An organization that provides and operates a telecommunication network for the purpose of transporting bearers of telecommunication services.

NOTE – If the same organization also offers services, it also becomes a service provider.

3.8 quality: The totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs, where the characteristics should be observable or measurable. When the characteristics are defined, they become parameters and parameters are expressed by measures.

3.9 quality of service:

1) Totality of characteristics of a telecommunication service that bear on its ability to satisfy stated and implied needs of the user of the service.

2) The collective effect of service performances, which determine the degree of satisfaction of a user of the service.

NOTE – These definitions may be seen to be considered complementary, and either or both definitions may be used.

3.10 four viewpoints of QoS: Concept for clarifying the management of QoS by sub-classifying QoS into four viewpoints:

3.10.1 QoS requirements of user/customer: A statement of the level of quality required by the applications of customers/users of a service, which may or may not be expressed non-technically.

3.10.2 QoS offered by the service provider: A statement of the level of quality expected to be offered to the customer by the service provider.

3.10.3 QoS delivered/achieved by the service provider: A statement of the level of the actual quality achieved and delivered to the customer.

3.10.4 QoS perceived by user/customer: A statement expressing the level of quality that customers believe they have experienced.

3.11 QoS parameter: A definition of the scope of a QoS criterion with clear boundaries and explicit measurement method to enable a quantifiable or qualifiable value to be assigned.

3.11.1 objective (quantitative) parameters: Parameters that may be measured with instruments and the performance value assigned may be classified as objective parameters.

3.11.2 subjective (qualitative) parameters: Parameters that can be expressed using human judgement and understanding may be classified as subjective or qualitative parameters. Qualitative parameters are expressed by opinion ratings.

3.12 reliability:

1) Probability that a product or system will perform as required for a specified period of time.
2) The ability of an item to perform a required function under given conditions for a given time period.

NOTE 1 – It is generally assumed that the item is in a state to perform this required function at the beginning of the time interval.

NOTE 2 – The term reliability is used as a measure of reliability performance.

3.13 security:

1) 'Security' is the protection of information availability, integrity and confidentiality.
2) The term 'security' is used in the sense of minimizing the vulnerabilities of assets and resources. An asset is anything of value. A vulnerability is any weakness that could be exploited to violate a system or the information it contains. A threat is a potential violation of security.
3) The ability to prevent fraud as well as the protection of information availability, integrity and confidentiality.

3.14 service provider: An organization that offers a telecommunication service to the customer and/or users.

3.15 simplicity: Ease and lack of complexity in the benefit to the user of a function of the service.

3.16 speed: A performance criterion that describes the time interval required to perform a function or the rate at which the function is performed. (The function may or may not be performed with the desired accuracy.)

3.17 telecommunications: The technical process of sending, transmitting and receiving any kind of message in the form of signs, voice, images or sounds by means of telecommunications systems.

3.18 telecommunication service: The provision of telecommunications and the provision of other additional services that are closely related to the provision of telecommunications, e.g., billing, directory services.

3.19 telecommunications systems: The technical equipment or systems capable of sending, transmitting, switching, receiving, steering or controlling as messages identifiable electromagnetic signals.

3.20 user: An individual or organization using or requesting publicly available telecommunications services.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CDR	Call Detail Record
INMD	In-service Non-intrusive Measurement Device
IP	Internet Protocol
KPI	Key Performance Indicator
KQI	Key Quality Indicator
NI	Network Interface
NP	Network Performance
POTS	Plain Old Telephone Service
QoS	Quality of Service
SLA	Service Level Agreement

5 Conventions

None.

6 Methodology for identification of QoS criteria and parameters

6.1 General considerations

6.1.1 Viewpoints of QoS criteria

Management of QoS may be clarified by sub-classifying this into four viewpoints. These viewpoints cover all aspects of QoS, both from the service provider's and user's (and customer's) viewpoints.

NOTE – The concept of the four viewpoints of QoS is copied from and explained in detail in [ITU-T G.1000]. An overview on this concept is given here for convenience.

These four viewpoints are:

- customer's QoS requirements;
- service provider's offerings of QoS (or planned/targeted QoS);
- QoS achieved or delivered;
- customer perception (survey ratings of QoS).

The four viewpoints are to be applied as follows:

Customer's QoS requirements This is an expression of the level of QoS required by the customer. The criteria and parameters identified to express these reflect the requirements.

Service provider's offerings of QoS The QoS criteria or parameters offered by the service provider are formal terms specified unambiguously and may be used for the following:

- As the basis for SLA between the service provider and clients on a bilateral basis of agreement.
- Public declaration by the service provider about the level of quality that can be expected by the users at large.
- As the basis for planning and maintaining the service at the level of performance being offered.
- As the basis for users to choose a level of quality to meet their particular requirements among the service provider's offerings.

QoS achieved or delivered The QoS delivered is the actual level of quality achieved or delivered by the service provider and may be used for the following:

- As the basis to compare the delivered with the offerings by the users, regulators and as a check in the SLAs.
- As the basis for any corrective action by the service providers.

Customer/User perception The QoS perceived by the user may be expressed by ratings based on customer surveys and is an indicator of what the user thinks the level of quality received or experienced. This data may be used for:

- Comparison with delivered quality and identifying causes of any ambiguities.
- Planning any corrective actions.

When identifying the quality criteria of a telecommunication service, these different viewpoints need to be taken into account. The pertinent QoS criteria or parameters should be used for a given application or context. This consideration is necessary for sharply focused interpretation of the meaning of the values represented by the QoS criterion or parameter. Based on this approach, the QoS parameters that are relevant to the users can be defined and measurement methods as well as quality assessment methodologies can be elaborated.

6.1.2 General aspects of quality of service criteria and parameters

The following basic aspects of QoS criteria and parameters have to be considered when identifying the criteria and determining the scope and measurement methods of parameters:

NOTE – Detailed information on these aspects is given in the following clauses.

- QoS criteria and parameters are to be considered on a service-by-service basis.
- QoS criteria are to be specified on an end-to-end basis, the end-to-end being the points at which the user's terminals are connected.
- QoS criteria and parameters are to be specified in terms understandable to the customers. In addition, where necessary, these criteria and parameters may also be specified in more technical terms for use within the industry. (Both customer terms and industry terms may use ITU-T recommended definitions to eliminate ambiguity and to provide the most efficacious understanding.)

- Different segments of the customer population may require different orders of priorities for the various performance parameters.
- The preferred levels of performance for diverse segments of the population may be different for various user population segments.
- The QoS profile of a customer segment may vary with time and it is essential for the service provider to ascertain the customer's changing requirements. The profile consists of order of priority of QoS parameters as well as the preferred levels of performance for each parameter.

6.1.3 Choice of QoS parameters

Sets of QoS parameters are designed to be understood by the users of various telecommunications services. However, subsets of these parameters can be selected for use in different circumstances. For example, a specific parameter might be relevant for many users in some countries or markets but the same parameter might not be of relevance in others, e.g., call set-up time could be pertinent in an all-analogue network but not on an all-digital network.

Therefore, users, customers, regulators, service providers, network operators and other parties interested in the use of QoS parameters may decide which parameters should be used in their particular situation with the cooperation of the relevant parties.

This decision should take account of:

- The precise purpose for which the parameters will be used.
- The quality and performance as expected by the users of state-of-the-art technology.
- The usefulness and relevance of the parameters from the users' perspective.
- The degree to which the parameters will provide a reliable comparison of performance.
- The cost and resources needed in order to measure and report each parameter.

All these aspects will influence the decision on the kind of parameters (quality criteria to be examined) and the number of parameters (granularity of quality analysis) to be chosen for a specific purpose.

However, even though parties may design their own set of QoS parameters according to their needs, the usage and application of internationally agreed upon parameters should be aimed at. For the determination of additional parameters, it should be considered to use already existing standards as a basis for further work.

6.1.4 Application of QoS parameters

A common application of QoS parameters will be the monitoring of telecommunication services and cross-checking whether quality objectives/goals have been met. In order to set up useful and meaningful quality objectives, it is especially important to take into account on the one hand, the areas of application and the technical potentials of the parameters and, on the other hand, the resources and costs for measuring the parameters.

QoS parameters can also be used by service providers to manage and improve how they offer their services, as well as by the customers to ensure that they are getting the level of quality according to their contractual agreements. They may also be used in call-minute trading, where price is determined by volume and quality grade. Another application of QoS parameters is that they can be used by regulatory authorities for defining quality levels for regulatory purposes of interconnection and interoperability aspects of networks and services.

QoS parameters are used to assess the quality of certain aspects of a service. Depending on the objective of the quality assessment, appropriate parameters with the desired granularity of quality evaluation may be determined. Quality of service parameters may also be selected to measure the overall quality of a service as perceived by the user. Thus, the range of usage of QoS parameters

may range from an in-depth quality assessment to a simple assessment of the general perception of a service.

6.2 Identification of user's QoS criteria

Before defining QoS parameters, the relevant QoS criteria relevant to the users must first be identified. For this purpose, three models (Tables 1, 2 and Figure 1) are presented in this clause.

The basic approach of the models is to provide a matrix or table; by filling in each field of the matrix or table, quality criteria can be identified and allocated to functional elements of the service. The intention is to establish a list with all (relevant) aspects that might have an influence on the quality of service. The models are applied by various means like expert consultations, questionnaires, face-to-face and telephone interviews, analysis of complaints or case studies.

The first model (universal model) illustrates the generic categories under which all QoS criteria may be grouped. Thus, most, if not all, QoS criteria may be grouped under performance criteria, aesthetic criteria, presentational aspects and ethical aspects. The QoS criteria for any telecommunication service may be determined by an iterative process of evaluating the issues for each of the cells formed by these four categories against the functional elements of a service. The functional element of a service is a uniquely identifiable segment of a service, which collectively comprises all features of a service.

The second model (performance model) is predominantly suitable for services based on the legacy network, both terrestrial and wireless.

The third model (four-market model) is more suited for multimedia services offered on IP-based network.

Appendix III gives examples of QoS criteria to illustrate the use of these models.

Depending on the granularity of the QoS criteria to be identified, the number of criteria for a given service may be specified. For example, for basic POTS as many as 43 QoS criteria have been identified using the model in Figure 1. However, in practice as few as 10-13 criteria are adequate for management of the service for most of the population.

All models or a combination of these models may be used for a particular service to enable most, if not all, QoS criteria to be identified. For a particular purpose, a selection of QoS criteria may be chosen from the list identified.

6.2.1 Universal model

This model (shown in Table 1) is generic as well as conceptual. In this model all QoS criteria may be grouped under four categories, performance, aesthetic, presentational and ethical. With breaking down a service into uniquely identifiable functional elements, it is shown that QoS criteria may be reached at for each of the cells arising out of the resulting matrix. The objective is to provide a structured approach and the template in the model should facilitate this activity.

Each functional element of the service is cross-checked against the four predefined quality components and criteria. There is no fixed list of functional elements on the y-axis because the nature and number of elements depend on the service under investigation and could change with the service chosen. An example of applying this model is shown in Appendix III.

Functional elements comprise all the uniquely identifiable components of the service that, put together, cover all the functional aspects of the service. These elements essentially cover the product life cycle from the provision of the service to the end of its life.

By going through each cell of the matrix, the quality criteria of a service may be determined. It may be necessary to indulge in an iterative process and to check relevance before determining one or more set of quality criteria.

One functional element may need to be considered in more than one column. All cells may not be populated for every element. In the end, the model produces a list of functional elements of the telecommunication service with associated quality criteria. These may then be specified as parameters with suitable measures, where necessary, to represent indicative values.

The models in Table 2 and Figure 1 are an expansion of the portion of the model comprising performance criteria and functional components. The model in Table 2 is a direct expansion of this portion. The model in Figure 1 uses a different concept. However, the results obtained fulfil the determination of QoS criteria of a service. These models are explained in more detail in clauses 6.2.2 and 6.2.3.

The QoS criteria obtained from application of this model for a particular service may be defined as parameters as explained in clause 6.3.

The elaboration of adequate definitions and measurement methods for the quality parameters to measure the quality criteria is not part of the model. This has to be done in a subsequent separate step. This may be done by taking existing parameters in standardization as they are already defined or one can take them as a basis and use modifications. It may also be necessary to define new parameters. Further details can be found in clause 6.3.

Table 1 – Universal model

	Quality components and criteria			
	Performance criteria	**Aesthetic criteria**	**Presentational aspects**	**Ethical aspects**
Functional elements				
1. ... 2. ... 3. ... ... n. ...				

Performance criteria: Criteria covering technical and operational elements inherent to a telecommunication service. The criteria are used to assess the characteristics of these elements, the way how they perform and meet the expected results and modes of operation. Performance criteria may be quantitative or qualitative or a combination of both. (The performance component of the above model is further elaborated in Table 2 and Figure 1.)

Aesthetic considerations: Criteria and considerations related to the ease of interaction between the user and the telecommunication service/product and the sensual perception of the service/product by the user. Examples of aesthetic criteria are ergonomic considerations, simplicity, functionality and clarity of design, optimum use of resources, style, etc. The aesthetic quality criteria are less quantifiable than the performance criteria; however, these play an important part in how an entity is held in esteem or otherwise.

Presentational aspects: Criteria determining the quality aspects of the manner in which a service is marketed or supplied to the customer. Examples of presentational aspects are: service surround; packaging of entity to the user; customization of bills; tariff packages/options, etc.

Ethical aspects: Criteria associated with how a service or product is offered to the user. These aspects may be classified as quality components, such as acceptable use of labour (evidence of lack of exploitation of labour) and 'green' issues. Examples of ethical aspects are conditions for cutting off services, subsidies for the poor and the disabled, services for the disabled, etc.

6.2.2 Performance model

This model is more suited for determining the performance criteria of a telecommunication service. The objective is to provide a structured approach to analyse the performance aspects in detail. The benefit of this model is that the quality criteria identified can be easily transferred into QoS parameters since it is very detailed and close to the understanding of network performance parameters and management functions. Thus the definitions and measurement methods of the QoS parameters can be expressed on commonly used and well-understood technical terms.

Table 2 – Performance model

		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 establishment 7							
	Information transfer 8							
	Connection release 9							
Billing 10								
Network/service management by customer 11								

The model is basically a matrix with a list of service functions on the y-axis and quality criteria on the x-axis. The service functions are uniquely identifiable performance elements of a service, which when put together, cover most, if not all, aspects of a telecommunication service. For each service function, it can be determined what kind of quality criterion is applicable to it by going through the 77 cells of the matrix. This is illustrated in Table 2.

Each cell of the matrix is investigated in an iterative process. All cells may not be populated for every service function. The number of cells to be populated depends upon the kind of service under investigation or upon the desired granularity of the quality criteria. It would be rare for all cells to be populated for any one function.

After determining the quality criteria, quality and performance parameters can be defined as described in clause 6.3.

6.2.3 Four-market model

This model (in Figure 1) is especially suited for multimedia services since the separation between the transport and service layer is taken into account. There is a complex chain of actions for multimedia services, from content creation, service management, delivery network and customer equipment.

Different parties may be in charge of transport, provision and content and the supply of terminal equipment. Thus the overall quality of a service (as perceived by the user) is a combination of different elements that are working independently of each other. Therefore a model is needed that allows for a separate investigation of these different elements and identification of respective quality criteria. This is achieved by the four-market model that consists of four components that are used to describe the different elements of the services that contribute to the QoS. The model enables to identify and categorize more easily the QoS criteria that are pertinent to this type of services.

For a given telecommunication service, the model can be used to focus on each of the four components separately and to identify quality criteria. It is not necessary to analyse all components. Depending on the aspects of a service under consideration, it may be sufficient to only identify quality criteria of one or more components.

After determining the quality criteria, quality parameters may be defined as described in clause 6.3.

An overview of the model and explanation of the four components is given in Figure 1.

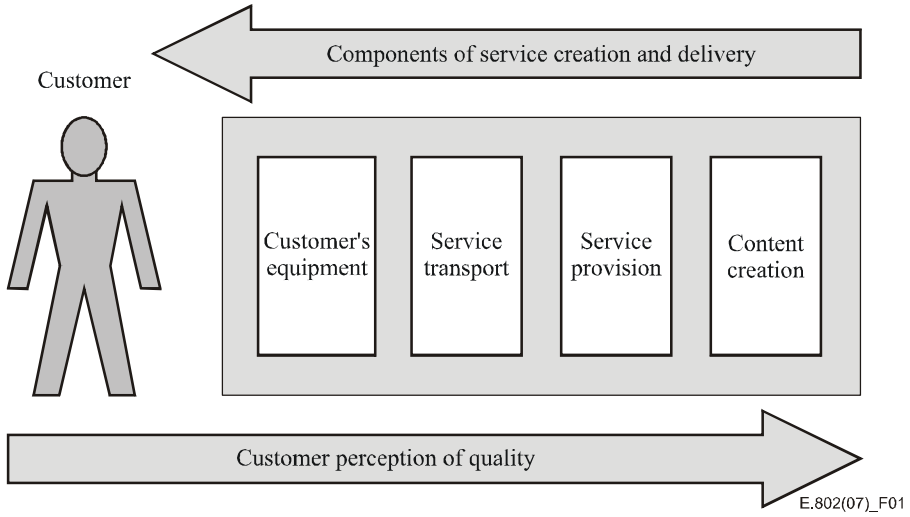


Figure 1 – Four-market model

Customer's equipment: All kinds of equipment that is needed by the user to gain access to the network and thus the service. This equipment consists of personal computers, television sets, set-top boxes, video recorders, modems, multimedia kiosks, etc. Not only the hardware but also the software needed for correct operation of the equipment has to be taken into account.

Service transport: All kinds of telecommunication networks that are used for the distribution of telecommunication services like terrestrial (fixed and wireless) and satellite broadcast networks.

Service provision: All activities and functions related to the packaging, presentation and management of telecommunication services.

Content creation: All activities related to the generation, distribution and packaging of content that is offered via a telecommunication service.

Appendix III lists the QoS criteria for a multimedia service obtained using this model.

6.3 Conversion of QoS criteria to QoS parameters

Quality criteria identified from one or more of the above models have to be converted into quality parameters before they can be used to express quantitatively or qualitatively the QoS of telecommunication services. This is done in order to exactly specify the scope of the quality to be determined and to allow for reproducible measurements and comparable quality figures. The aim is to arrive at a harmonized set of quality parameters that can be used for evaluating the quality of a telecommunication service and to allow for the comparison of different service offers in a specified population.

A quality criterion, which is usually descriptive, needs to be tightly defined both in its scope and boundary to enable an unambiguous understanding of its functionality. This is necessary for use by all parties associated with the use of this performance criterion. When specified as such, the criterion becomes a parameter.

It is essential that QoS parameters are defined so that there are no ambiguous interpretations and any service provider may be able to carry out the measurements. Where parameters are defined quantitatively, explicit calculating rules have to be recommended. When they are defined qualitatively, e.g., helpfulness of operator services, a suitable definition based on opinion rating has to be recommended.

When converting a quality criterion into a parameter, there are usually different possibilities for the specification of the definition and measurement method. For example, a user may state the number of outages she/he may put up with over a period of one year. This may be specified as a parameter as:

a) number of outages over a cumulative period of one year = n;

b) a period in which the user cannot use the service for more than = 'b' units of time;

c) maximum duration of any one outage = not more than 'p' seconds;

d) minimum duration between outages = 'q' hours.

A single, all or a combination of the specifications may be chosen; the decision depends on the intended use and purpose of the parameter.

Therefore, the following main applications for QoS parameters should be considered when specifying the parameters:

- They characterize the quality level of a service being offered, and ultimately the user satisfaction. QoS parameters represent subjective and user-perceived quality expressed in numeric ratings.
- They may be used as the basis for SLAs as well as in a public manner for promotion purposes.
- Service providers and network operators may use these parameters as the basis for planning purposes. It may be necessary to decompose the end-to-end performance parameters into network element performance parameters for planning purposes. NP parameters derived from the end-to-end QoS requirements or planning targets may not be of interest to the users.
- QoS parameters may be used to specify the delivered quality (the third element in the four viewpoints of QoS).

6.3.1 QoS parameter definition and measurement method

The definition of a parameter determines the range of application and thus the intended use of the parameter. Therefore, the scope of the parameter needs to be precise and well-defined. There is also a close dependency between the scope of a parameter and the possible and most suitable measurement methods.

Thus, the definition of parameters and the recommended measurement method have to be seen as a package. Even if the scope of two parameters is the same, a difference in measurement methods may lead to a situation where different aspects of the QoS criteria are measured. In this case, the information provided by the parameters would not be the same.

Therefore, in order to ensure repeatable and comparable performance values, an aligned definition/scope and a recommended method of measurement need to be specified for QoS parameters. A universally agreed measure enables comparisons to be made between various organizations within a country as well as internationally.

6.3.2 Prioritization of QoS parameters and establishing preferred values

Besides identifying quality criteria, a prioritized list of parameters and the preferred performance values are required to complete the user's QoS requirements.

NOTE – The elaboration of comprehensive guidance on the prioritization of parameters is still under study. The following text provides a list with basic aspects that should be considered.

Different segments of the population could have differing priorities for the QoS parameters or there may be different quality expectations for different pricing levels. Moreover, each segment may require a preferred value of performance for each parameter. Profiling the segments of the user population requiring their own order of priorities and preferred performance values would complete the mapping of user requirements of QoS.

To identify these groupings, if not already known, a start may be made by finding out the QoS requirements of the user groupings of the Standard Industrial Classification (SIC). The service provider may identify further uniquely identifiable groupings.

Besides a segmentation based on different user groups and applications, it may be necessary to take geographical aspects into consideration, for example, if QoS parameters are intended to be used for monitoring trends in different developed areas of a country.

An issue to be considered is a reasonable number of criteria/parameters in order to achieve the right compromise between the number of parameters and a meaningful QoS evaluation. Too many parameters will bring unnecessary high costs while too few will result in overlooking some key aspects.

When QoS parameters are defined or measured, it has to be done according to the target study area. Therefore, it is very important that the identification of the quality criteria is done carefully in accordance with the aim of the study and usage of the service and the results weighted according to the type of user.

6.4 Publication of QoS parameters

Parties who publish QoS statistics in accordance with this Recommendation should provide explanatory text in order to facilitate the understanding of the statistics. If the statistics is based on parameters that require knowledge of basic technical and operational background of the provision and function of telecommunication services, this information should also be provided. It may be assumed that a reader who is interested in comparable QoS statistics and parameters is willing to become acquainted with technical and operational aspects.

It is important to choose the scope of parameters so as to minimize the risk that measurement results could be misinterpreted. It is recommended that reference be made to the document which describes the measurement method, so that the background of the definitions and measurement methods are readily available. A fair and justified comparison of the published data of the different services offered, i.e., quality aspects of different telecommunication services, is only possible if the data is strictly used according to the scope of the defined QoS parameters.

Parameters should not need to be measured with high precision and published in ways which suggest that measured differences are perceptible to users when they are not.

The auditing of the processes, in accordance with international standards, the determination of raw data and the presentation of results for publication are recommended for establishing the credibility of the published QoS data. The [ISO/IEC Guide 62] and [ISO/IEC Guide 65] may be considered for this purpose.

The frequency of publication may be left to the individual nations and/or the service providers. The publication media may also be left to the individual organizations. However, for international comparisons, it is suggested that a 6-month or yearly interval should be considered for the publication of the delivered quality for each of the main services.

6.5 Practical issues when using QoS parameters

QoS parameters of a telecommunication service are normally specified in a way that they can be applied to numerous service offers of different providers in order to allow for comparison. So the definitions and measurement methods need to cover different technologies, technical implementations and business models, and therefore they are written in a more generalized manner. This should be kept in mind when determining and using sets of QoS parameters to produce quality statistics over a number of networks/services (e.g., for national comparisons).

For the preparation of comparison and benchmarking of different networks/services, it is important to be aware of the impact that the individual ways of implementation/application of technology and equipment of the network operator and service providers will have on the significance of the QoS parameters. This may have an influence on the measured data and may lead to an adoption of the measurement concept, post-processing of the data and presentation of the statistics of the quality campaign. Therefore the following aspects should be considered:

- Depending on the exact purpose and field of application of QoS parameters, different concepts may be followed: A parameter may be designed in order to explicitly measure the quality of a service aspect with high accuracy and thus it will provide precise results. Or a parameter is suitable for comparison of a wide range of service offers with less significant results.
- Measurement methods are triggered by certain technical processes and service events (physical parameters, protocol information, operational processes). These trigger points may vary or have tolerances. This can lead to the situation in which, with different implementations or use of different technologies, the results are not directly comparable even if the same quality criteria are measured (or intended to be measured).
- QoS parameters only provide a statistical representation of the service quality that a certain population of users is likely to perceive; they are not intended to provide quality statements for individual users (e.g., as used in SLAs).
- It is important to understand the context the parameters are used within, to be aware of the design concept of the parameters that has been followed and to know the underlying measurement and publication policy for producing final QoS statistics.

7 Measurement of QoS parameters

QoS parameters are measured either objectively by technical means (by measuring physical attributes of circuits, networks, network elements and signals) or subjectively (perceived QoS) via surveys and subjective tests amongst users.

Subjective measurements are performed in order to measure the QoS as perceived by the user. This of course is a time-consuming and expensive procedure. The results of subjective measurements often provide highly variable results that need to be carefully analysed. Therefore, objective

measurements are often used where specific network-related technical parameters (network performance parameters) are measured, when those parameters can be correlated to the user's perception of QoS (either directly or by the use of models).

QoS parameters are user-oriented and end-to-end (i.e., service), while network performance parameters may or may not be end-to-end. While QoS and network performance parameters are different in nature and serve different purposes, it is clear that there exist intrinsic relationships between QoS and NP parameters, one having a direct or indirect, and sometimes even inverse, influence on the other.

Since the term QoS is a measure for "the degree of satisfaction of a user of a service", one would assume that ideally subjective measurement methods should be used to measure the quality of a service. However, subjective measurements bear the risk that individual opinions are overestimated and that human judgements and misunderstandings falsify the results. Therefore subjective measurements are complex and time consuming. So, wherever possible, objective measurements are preferred since they often provide a good correlation to the results of subjective measurements. Objective measurements of network performance parameters can be used to identify and examine specific network-related problems with QoS.

A QoS measurement policy has to take into account parameters influencing the resulting quality of a service including both ends of the communication and telecommunication network architecture aspects. Therefore, both objective and subjective measurement methods have to be considered to get the whole QoS picture.

Objective measurements are carried out in the case of network performance parameters and other QoS parameters where these can be quantified. Subjective measurements are carried out in the case of subjective aspects and also for quantifiable parameters to determine how the customers perceive the quality they think they receive.

NOTE – For a more detailed overview on measurements and further information, see also [ITU-T Hdbk QoS].

7.1 Objective measurements

Criteria like call set-up time, call failures and interruptions can quite easily be measured with appropriate probes in appropriate locations. Measurements can be made either on real traffic or on artificially generated traffic on public traffic or private networks.

Since QoS may be different with respect to location, the geography of the network should be taken into account for the measurements, particularly if the choice is not to monitor all parts of the network.

A compromise should be reached between the choice of sampling rates to reflect an adequate confidence in the measurements and the costs of taking these measurements. Optimization of the measurements may also need to focus on some key points of the network or to perform the measurements at the busiest hours of the day or week.

7.1.1 Intrusive measurements

This type of measurements is performed on artificially generated traffic and can provide more information since the traffic can be tailored to check almost everything. The drawback of intrusive measurements is to add traffic to the actual one and therefore to lead to additional costs and some possible disturbance.

7.1.2 Non-intrusive measurements

This type of measurements is performed on real traffic conditions and therefore is expected to give a more realistic vision of the QoS but its drawback is that some deficiencies might be missed since not all the possibilities are checked.

7.1.3 Use of models

Models attempt to map objective measures of network performance to subjective opinions. The objective measurements needed as input values for the mapping function are normally taken from INMD measurements. The customer opinion model for INMDs should be able to relate the network performance (as represented by the objective measurements such as speech level, echo loss, etc.) to customer perceived performance (represented by an opinion score).

7.1.4 Monitoring and analysis of signalling information

Objective measurements may also be based on the monitoring and analysis of signalling information. These measurements are performed on real customer live traffic. They are often based on counters or CDRs from network elements. But more and more, with the increase in complexity of networks and services, especially in mobile networks, the use of network-independent monitoring, based on non-intrusive Signalling System No. 7 (SS7) and IP probes, and exploiting the richness of signalling data, allows to provide more real-time and more service-related xDRs, KPIs/KQIs and alarms related to QoS.

The advantage of internal monitoring is that a large volume of records can be collected which allows day-to-day evaluation of network performance. The disadvantage is that this method does not have the capability of detecting tones or speech and therefore cannot present a complete representation of all call dispositions.

7.2 Subjective measurements

Subjective measurements are the only means to assess the user perception aspects of the QoS, e.g., those aspects that cannot be measured easily by technical means or that may be missed due to a reduced number of measurement points. This is the case for instance for billing accuracy, quality of customer care or relevance of the answer of the help desk.

Subjective measurements when compared to objective measurements could indicate whether improvements in the network or customer education are needed. However, due to the characteristics and individual variations of human judgement, subjective measurements should be carefully designed and it should be kept in mind that they may not always measure the projected quality aspects or produce reliable results.

7.3 Who should perform the measurements

If the QoS parameters are used by a service provider for its own purposes, e.g., SLAs, promotion purposes and service monitoring, the measurements will be performed by the provider itself or contract the measurements to another party. The service provider may wish to improve the confidence in the quality of the statistics, by having the measurements audited by an authorized body in accordance with international standards.

QoS measurements are also carried out in order to compare the quality provided by different service providers, to comply with quality requirements and to produce regular QoS reports. In most cases, this will be done for regulatory purposes but also independent organizations may be interested in quality statistics.

If a third party is involved, that is a party other than the affected service providers, there are in principle two ways to perform the measurements; direct and indirect measurements:

- Direct measurement – The third party, e.g., a regulatory authority, itself performs the measurements. That means that it is responsible to take all the necessary steps to conduct the measurements and to analyse the data in order to calculate the quality ratings of the parameters.

- Indirect measurement – The third party authorizes other parties to perform the measurement. This may be the service providers themselves or any other independent party, e.g., independent audit companies, organizations of certification.

When using indirect measurements, the quality information is obtained by the third party without intervening directly in the process. Thus it has to be considered whether the measurements should be certified. The certification of the QoS measurements have to be done by qualified independent organizations.

The advantages and disadvantages of the direct and indirect measurements can be seen in the table below:

Measurement		Advantages	Disadvantages
direct		High confidence in the information provided Immediate proactive action by the third party is possible (e.g., adoption of measurement methodology, additional parameters if needed)	High costs mainly if measurements have to be performed on a number of providers and services
indirect	certified	Confidence in the information provided	Another party is involved that has to be managed. (e.g., independent certification offices)
	uncertified	Low cost	Low confidence in the QoS statistics provided

One good commitment between cost and confidence of the information is to use indirect measurements (with certification) and to perform additionally direct measurements randomly.

8 Guidelines for defining quality objectives

8.1 General considerations

Quality objectives are used to determine minimum and maximum performance limits and the desired (optimum) performance level of QoS parameters. For each parameter, a reference value can be specified. However, for interoperability issues, mandatory parameters or international comparisons, it should be considered to use generally accepted reference values for the main services.

Depending on the QoS parameter under consideration, the reference value can consist of a threshold value (e.g., the performance should be better than a minimum threshold) or of an acceptable performance range. The final determination of a specific reference value depends on the kind of parameter (e.g., whether it is based on network performance parameters or subjective aspects), the technology involved and the kind of verification methodology used.

The intended purpose of the reference value should also be taken into consideration. Quality objectives can be used in order to report on the present quality of a telecommunication service, cross-checking whether quality obligations have been fulfilled or for setting targets in order to improve the quality of general available services within a certain time-frame.

Since the QoS parameters are focused on the user requirements with regard to quality, it should be kept in mind that the user must be able to understand the meaning of the reference value and be capable of comparing the (subjectively) perceived quality with the reference value. Thus, the end user's perspective should be considered before deciding for which QoS parameters quality objectives should be set and how they should be specified.

8.2 Defining initial quality objectives

If there is no quality reference – either in standardization or by experience – for a specific service available, one has to determine quality objectives from scratch. This process involves the following steps:

- The service under consideration must be analysed and the quality criteria and the resulting QoS parameters must be identified. Depending on the intended purpose, a set of QoS parameters that are thought of being of utmost importance must be determined. For these QoS parameters, quality objectives can be specified.
- In order to acquire information on the present performance of a service, a time period for measurements is set to collect data. Based on this data, a first impression on reasonable limits for the quality objectives can be obtained. The methodology used to collect data has to be clearly defined in order to eliminate whatever kind of doubt in the validity of the data obtained. This is especially important in a multi-operator environment.
- The user's perspective needs to be considered. Therefore surveys among users have to be conducted in order to assess the users' perception and demand of the service quality.
- In a conciliation process, the quality references obtained from the collected data (the service providers perspective) and the surveys (the user's perspective) need to be combined into final quality objectives.

8.3 Defining target values

Target values are determined in order to improve the quality of a service within a specified period of time. Depending on the service aspect that is subject for improvement, target values are fixed for specific QoS parameters.

When establishing targets, the following points should be considered:

- The target values should be realistic, i.e., the service provider should be capable of achieving the quality level within the fixed time period. Any improvement of quality is associated with investments and binding of resources. The efforts needed and the degree of improvement to be achieved should be well-balanced.
- The target values should be beneficial to the users, i.e., the QoS parameter targets should be set so as to be meaningful to the users and aim at quality aspects that are relevant to the users. They should be able to perceive easily an increase or decrease in quality. In this way, the accomplishment of the target can be verified by surveys, and problems can be identified in an early stage through user complaints.
- The target values should be based on well measurable QoS parameters allowing for a straightforward verification procedure. There should be clear objectives directly linked to network performance objectives or service operational aspects so that the accomplishment of the targets can be easily verified and failures can be dedicated to specific service/network elements.
- The establishment of target values should consider diversities of services. One target value that is appropriate for a specific situation may not be good for another. If target values are determined for services available in huge areas and/or many customers, the intrinsic diversity of the service shall be analysed. Diversities may be presented, for example, in terms of geography, user expectation, social aspects, applications.
- The implementation stage of the service should be considered. Services that are in a transitory stage have to be treated in a different way than those whose operation is already in a stable phase. This may occur if new technology is introduced or technology is changed (e.g., GSM to WCDMA) or if a substantial rate of growing of the service in terms of users or infrastructure takes place.

8.4 Tuning quality objectives

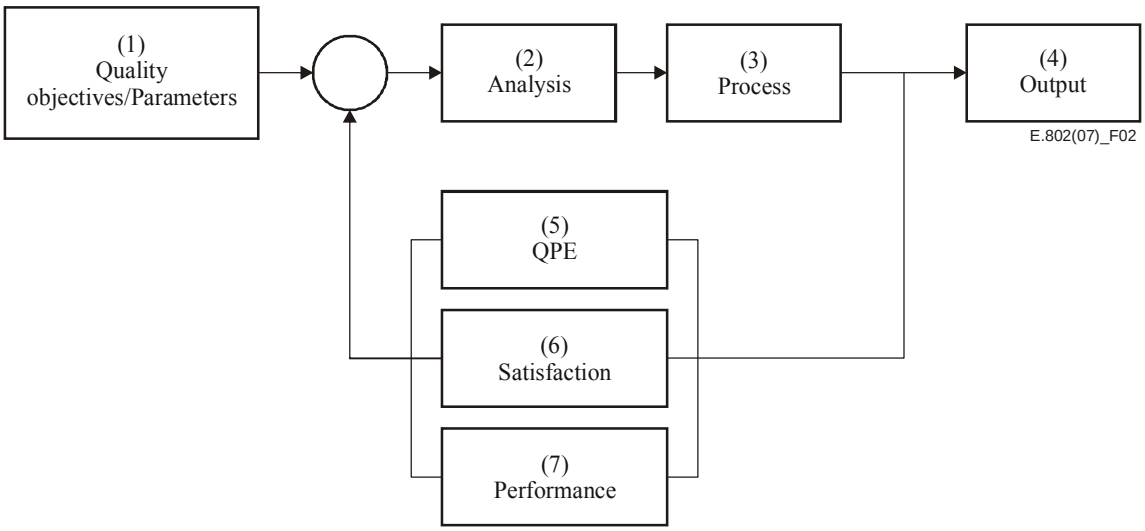
In order to adopt the quality objectives to changes in technical development and user perception, and to verify their fitness for purpose, the values should be audited on a regular basis.

It should be cross-checked whether:

- the quality objectives reflect the user perception and expectation of quality;
- the originally determined initial quality objectives are still valid;
- the quality objectives need to be adjusted to reflect improvements in technology;
- additional quality objectives are needed to cover additional services or service elements;
- there are mismatches between the underlying QoS parameters and the intention associated with the quality objectives;
- the targets are still up to date, i.e., the target values should be reviewed constantly;
- the determined target values correspond to internationally agreed performance levels;
- the frequency of evaluation of parameters or target value is still appropriate concerning the type of service and the geographical area (region) under consideration.

The adjustment of quality objectives is in general terms a process of management of quality policy and, due to this, it involves a process of information feedback. Within this process, the particularities of each service, the effectiveness of the parameters or quality objectives in order to ensure a level of quality, the perception of customers and the information provided by service providers have to be taken under consideration.

Figure 2 illustrates the process of managing a quality policy:



1) Quality objectives: The service provider (or a regulatory body) first defines the target values to be applied to the telecommunication service. The respective parameters have already been created and the quality objectives were established within a close observation of the customer's requirements, historical evolution, benchmarking, etc.
2) Analysis: Initially, the action represented by this block is not applied. This block represents the action where studies, reflections, weights and comparisons are done taking into consideration the quality objectives established and the information provided by the feedback channels.
3) Process: This block represents the process developed by the service provider in order to deliver a service with a level of quality as specified by the quality objectives.
4) Output: It is the quality effectively delivered to the customer by the service provider as the result of the quality process.
5) QPE (Quality Perception): This feedback channel provides information on the perception of quality delivered by the service provider to the customers.
6) Satisfaction: This feedback channel provides information on the customer's level of satisfaction with the provided service.
7) Performance: This feedback channel provides information on the quality parameters as a result of the process of each service provider (the values reached, evolution in the period observed, difficulty to measure, etc.).

Figure 2 – Process of managing quality policy

8.5 Verification of QoS objectives

Quality objectives for telecommunication services are set by determining quality objectives for deliberately chosen QoS parameters. It has to be verified on a regular basis whether the objectives are met, i.e., a service is working within its stated quality limits. To achieve this, a verification campaign that specifies the required procedures and operations needs to be elaborated. The accomplished campaign will result in a report that allows for a decision in terms of conformity or non-conformity.

The verification campaign is performed by measuring QoS parameters and checking whether the associated quality objectives are met. The QoS parameters and quality objectives are well known and have been predetermined according to the guidelines in this Recommendation. Thus there are clearly defined measurement methodologies available. Based on this information, measurement samples may be taken. The remaining task is to specify a sampling methodology that ensures that the results adequately reflect the QoS as it is perceived by the user.

There are two basic methods of sampling:

- Simple sampling/random sampling – It consists of the selection of a random sampling of a universe, where the probability is equal for everyone.
- Cluster sampling – The service/network under consideration is divided into clusters and a few of these (often randomly selected) clusters are sampled.

Since performance and quality may be different with respect to location, the geography of the network carrying the service should be taken into account for the measurements, particularly if the choice is made not to monitor all parts of the network. In addition, the number and temporal distribution of the measurement samples taken need to be considered.

The selection of representative samples is a process that is heavily influenced by specific technical and operational conditions of the measurement task. Therefore a detailed guidance cannot be given.

The following aspects should be considered when setting up a verification campaign:

The verification campaign should be dedicated to the specific services/parameters that are to be measured, i.e., the particularities need to be considered.

In cases where the measurements are performed by parties other than the network provider (third parties), it must be ensured that all relevant information that may influence the results is at hand. Normally only the network operator is aware of the specific technical characteristics of the network access, software implementations, routing, etc. Depending on the parameters measured, often additional information is needed in order to obtain comparable results. This is especially valid for measurements of connections over more than one network.

Samples should ensure that traffic variations during the measurement period are taken adequately into account.

Depending on the kind of network(s) under study, i.e., fixed, mobile or a combination of both, network specific characteristics and user behaviour need to be taken into account.

Network performance measurements are often based on the analysis of signalling information or on tones. When using such information, the measuring party must know in detail what type of signalling system and/or tones are used in the network(s) under consideration. Especially any deviations to existing standards must be known.

Measurements of parameters such as call set-up time should take account of whether the calls are terminated on a user terminal or a function such as a mail box within the network. Such parameters will also be affected by some supplementary services (e.g., call forwarding). Moreover, the performance for different number ranges may be different, e.g., number translation services such as free phone and shared cost services may have increased call set-up times.

Optimization of the measurements may need to focus on some key points of the network or to perform the measurements at the busiest hours of the day or week.

In most cases, objective measurement methods are used as they can quite easily be measured via adequate probes in appropriate locations. Measurements can be made either on real traffic or on artificially generated traffic.

Both intrusive and non-intrusive methods are useful and can be combined. Besides active and passive measurement methods, performance and quality evaluations can also be based on the analysis of automatically stored signalling and protocol data.

It is obvious that there is a high correlation between the kind of QoS parameters, i.e., measurement method, and the sampling methodology finally chosen. Therefore, when specifying the verification campaign, it may likely be that different QoS parameters or even quality objectives are found to be more suitable than those previously chosen. The most satisfying solution may be found by an iterative process of defining parameters, setting quality objectives and specifying the verification campaign. However, for interoperability issues, mandatory parameters or international comparisons, the verification campaign should correspond to the generally accepted and agreed upon standards.

Appendix I

References for the development of QoS metrics and examples of QoS parameters

(This appendix does not form an integral part of this Recommendation)

This appendix provides references to standards that are either ready to use QoS parameter definitions and measurement methods or useful for the elaboration of adequate parameters.

The intention is not to provide a comprehensive list of QoS parameters and measures but to assist parties in determining parameters for QoS measurements and reporting.

I.1 Examples of QoS parameters

Table I.1 gives a list of QoS parameters that are currently available in standardization:

Table I.1 – Examples of QoS parameters

Service	QoS parameter	Reference
Applicable to any service	Supply time for fixed network access Supply time for Internet access Proportion of problems with number portability procedures Fault report rate per fixed access lines Fault repair time for fixed access lines Response time for operator services Response time for directory enquiry services Response time for admin/billing enquiries Bill correctness complaints Prepaid account credit correctness complaints Bill presentation quality Frequency of customer complaints Customer complaints resolution time Customer relations Professionalism of help line	ETSI EG 202 057-1
Voice telephony (and voiceband related services like fax, data transmission and SMS)	Unsuccessful call ratio Call setup time Speech connection quality Fax connection quality Data rate of dial-up access to the Internet Successful SMS ratio Completion rate for SMS End-to-end delivery time for SMS	ETSI EG 202 057-2

Table I.1 – Examples of QoS parameters

Service	QoS parameter	Reference
Mobile services	(Voice telephony parameters as listed above also apply) Unsuccessful call ratio Dropped call ratio Coverage	ETSI EG 202 057-3
Internet access	Login time Data transmission speed achieved Unsuccessful data transmissions ratio Successful log-in ratio Delay (one-way transmission time)	ETSI EG 202 057-4

I.2 Development of QoS metrics

A comprehensive and detailed analysis of existing standards, terms and concepts can be found in the [ITU-T Hdbk QoS]. The references given there provide a sound basis for the development of QoS metrics and parameters. Important network performance related parameters, terms and concepts and other measures that are useful to develop the necessary measurement methods are listed.

For specific guidance on measures for emerging packet-based networks and technology, the following ITU-T Recommendations provide substantial information: [ITU-T G.1020], [ITU-T G.1030], [ITU-T G.1040], [ITU-T G.1050], [ITU-T O.211], [ITU-T Y.1540] and [ITU-T Y.1541].

Appendix II

Quality objectives

(This appendix does not form an integral part of this Recommendation)

This appendix provides quality objectives for various telecommunication services where available. These values are not normative but represent commonly accepted quality requirements for end-to-end services that are achievable when using state-of-the-art technology.

Guidance on specific performance and QoS parameters for various telecommunication services that can be used as a reference for determining minimum quality requirements and objectives is given below.

NOTE – Most reference values given cover aspects of information transfer and connection establishment and release. In order to ensure adequate performance of services over interconnected networks, there are several Recommendations dealing with these aspects. But for operational and maintenance aspects of the end user access to the service, e.g., availability, fault rate and billing, there are no generally recommended limits as it is up to the network/service operator to decide on performance levels.

II.1 Voice telephony and voiceband services

Since voice services are very sensitive to variations in delay and transmission quality (information loss and transmission impairments), special care needs to be taken to ensure an adequate quality.

ITU-T Rec. G.109 defines five categories of speech transmission quality from mouth to ear for 3.1 kHz handset telephony across networks in terms of "user satisfaction". These categories are tied to the so-called R-values of the E-model, a transmission rating model for assessing the combined effects of variations in several transmission parameters that affect conversational quality of 3.1 kHz handset telephony.

Table II.1 – Definition of categories of speech transmission quality (from ITU-T Rec. G.109)

R-value range	Speech transmission quality category	User satisfaction
$90 \leq R < 100$	Best	Very satisfied
$80 \leq R < 90$	High	Satisfied
$70 \leq R < 80$	Medium	Some users dissatisfied
$60 \leq R < 70$	Low	Many users dissatisfied
$50 \leq R < 60$	Poor	Nearly all users dissatisfied
NOTE 1 – Connections with R-values below 50 are not recommended. NOTE 2 – Although the trend in transmission planning is to use R-values, equations to convert R-values into other metrics, e.g., MOS, %GoB, %PoW, can be found in Annex B/G.107.		

Detailed information on delay requirements specific to voice telephony can be found in ITU-T Rec. G.114. Guidance on one-way delay for voice over IP is given in Appendix II/G.114.

ITU-T Rec. G.114 provides guidance on the effect of end-to-end one-way delay (sometimes termed latency), and an upper bound one-way network delay. While it is recommended that a one-way delay of 400 ms should not be exceeded for general network planning, it is important to appreciate that highly interactive tasks (e.g., many voice calls, interactive data applications, video conferencing) can be affected by much lower delays. The effects of delays below 500 ms on conversational speech are estimated using a curve derived from the E-model (ITU-T Rec. G.107).

For mixed traditional telephony and VoIP based services over IP and PSTN architectures, [ITU-T E.470] should be consulted.

II.2 Services over packet-based networks

[ITU-T G.1010] defines a model for multimedia quality of service (QoS) categories from an end-user viewpoint. By considering user expectations for a range of multimedia applications, eight distinct categories are identified, based on tolerance to information loss and delay. These categories form the basis for defining realistic QoS classes for underlying transport networks, and associated QoS control mechanisms.

[ITU-T G.1010] can be used to determine quality objectives for services provided over packet-based networks. The basic performance objectives of [ITU-T G.1010] are reproduced in Tables II.2 and II.3.

Table II.2 – Performance targets for audio and video applications (transported from Table I.1/G.1010)

Medium	Application	Degree of symmetry	Typical data rates	Key performance parameters and target values			
				One-way delay	Delay variation	Information loss (Note 2)	Other
Audio	Conversational voice	Two-way	4-64 kbit/s	< 150 ms preferred (Note 1) < 400 ms limit (Note 1)	< 1 ms	< 3% packet loss ratio (PLR)	
Audio	Voice messaging	Primarily one-way	4-32 kbit/s	< 1 s for playback < 2 s for record	< 1 ms	< 3% PLR	
Audio	High quality streaming audio	Primarily one-way	16-128 kbit/s (Note 3)	< 10 s	<< 1 ms	< 1% PLR	
Video	Videophone	Two-way	16-384 kbit/s	< 150 ms preferred (Note 4) < 400 ms limit		< 1% PLR	Lip-synch: < 80 ms
Video	One-way	One-way	16-384 kbit/s	< 10 s		< 1% PLR	

NOTE 1 – Assumes adequate echo control.

NOTE 2 – Exact values depend on specific codec, but assumes use of a packet loss concealment algorithm to minimize effect of packet loss.

NOTE 3 – Quality is very dependent on codec type and bit-rate.

NOTE 4 – These values are to be considered as long-term target values which may not be met by current technology.

Table II.3 – Performance targets for data applications (transported from Table I.2/G.1010)

Medium	Application	Degree of symmetry	Typical amount of data	Key performance parameters and target values		
				One-way delay (Note)	Delay variation	Information loss
Data	Web-browsing – HTML	Primarily one-way	~10 KB	Preferred < 2 s /page Acceptable < 4 s /page	N.A.	Zero
Data	Bulk data transfer/ retrieval	Primarily one-way	10 KB-10 MB	Preferred < 15 s Acceptable < 60 s	N.A.	Zero
Data	Transaction services – high priority e.g., e-commerce, ATM	Two-way	< 10 KB	Preferred < 2 s Acceptable < 4 s	N.A.	Zero
Data	Command/ control	Two-way	~1 KB	< 250 ms	N.A.	Zero
Data	Still image	One-way	< 100 KB	Preferred < 15 s Acceptable < 60 s	N.A.	Zero
Data	Interactive games	Two-way	< 1 KB	< 200 ms	N.A.	Zero
Data	Telnet	Two-way (asymmetric)	< 1 KB	< 200 ms	N.A.	Zero
Data	E-mail (server access)	Primarily one-way	< 10 KB	Preferred < 2 s Acceptable < 4 s	N.A.	Zero
Data	E-mail (server to server transfer)	Primarily one-way	< 10 KB	Can be several minutes	N.A.	Zero
Data	Fax ("real-time")	Primarily one-way	~10 KB	< 30 s/page	N.A.	$< 10^{-6}$ BER
Data	Fax (store & forward)	Primarily one-way	~10 KB	Can be several minutes	N.A.	$< 10^{-6}$ BER
Data	Low priority transactions	Primarily one-way	< 10 KB	< 30 s	N.A.	Zero
Data	Usenet	Primarily one-way	Can be 1 MB or more	Can be several minutes	N.A.	Zero

KB kbyte

MB Mbyte

NOTE – In some cases, it may be more appropriate to consider these values as response times.

Appendix III

Examples for the usage of the three models

(This appendix does not form an integral part of this Recommendation)

This appendix provides examples for the usage of the three models. The examples are tentative. They do not claim to be outright; other parties may come to different results and conclusions when applying the models.

III.1 Universal model

Usage of the universal model for a mobile telephony service:

	Quality components and criteria			
	Performance criteria	**Aesthetic criteria**	**Presentational aspects**	**Ethical aspects**
Functional elements				
1) Hardware (terminal equipment)		Ergonomic design of handset usability		Disposal and ecological aspects
2) Service usage	Connection set-up and release Transmission quality Fault repair time Service availability		Customization of service features Customization of billing and payments Bill presentation quality	Security features
3) Contract	Supply time			
4) Customer relations	Hotline availability Response time Complaint resolution			Disabling mobile set when reported stolen

Performance criteria are further elaborated in III.2 by means of the performance model.

III.2 Performance model

Usage of the performance model for a mobile 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	Processing time						
	Provision 2	Supply time		Coverage				
	Alteration 3	Processing time						Ease of change in contract
	Service support 4	Response time		Availability of call centre			Professionalism of help line	
	Repair 5	Response time						
	Cessation 6	Processing time					Ease of contract cessation procedure	
Connection quality	Connection establishment 7	Call set-up time	Unsuccessful call ratio	Service availability				
	Information transfer 8	One-way delay	Speech quality		Dropped call ratio within a specific time period			
	Connection Release 9	Release time	Unreleased call ratio					
Billing 10		Billing frequency	Bill correctness complaints Bill presentation quality		Number of billing complaints within a specific time period	Fraud protection/ prevention		Availability of different billing methods (e.g., online billing)
Network/Service management by customer 11							Ease of software updates	

III.3 Four-market model

Usage of the four-market model for music streaming and download service:

Content creation:

- suitability of content;
- technical quality of original content;
- popularity of content and artists;
- repurposing of original content to a specific codec format (e.g., Ogg Vorbis) with minimum distortion;
- piracy and IPR aspects.

Service provision:

- ease of navigation to required music;
- security;
- fair contracts;
- pricing (value for money) and method of charging;
- customer care.

Service transport:

- bandwidth;
- latency;
- jitter and error;
- contention;
- round-trip delay [server + application + network];
- distortion.

Customer equipment:

- ease of selection and playback;
- ease of navigation and downloading;
- storage capacity;
- quality of playback;
- ergonomic considerations of devices.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	**Overall network operation, telephone service, service operation and human factors**
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects and next-generation networks
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2007