International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Series E

Supplement 9

(12/2013)

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

Supplement 9 to ITU-T E.800-series Recommendations (Guidelines on regulatory aspects of QoS)

ITU-T E-series Recommendations – Supplement 9

International Telecommunication Union

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
INTERNATIONAL OPERATION	
Numbering plan of the international telephone service	E.1100–E.1199
NETWORK MANAGEMENT	
International network management	E.4100–E.4199

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

Supplement 9 to ITU-T E-series Recommendations

Supplement 9 to ITU-T E.800-series Recommendations (Guidelines on regulatory aspects of QoS)

Summary

Supplement 9 to ITU-T E.800-series Recommendations provides guidelines on regulatory aspects of quality of service (QoS) and it focuses on end-to-end QoS as perceived by the user when using modern mobile and broadband services. Network performance is outside the scope of this supplement.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T E-800 series Suppl. 9	2013-12-12	12	11.1002/1000/12112-en

Keywords

End-to-end, QoS.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). 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 publication, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this publication is voluntary. However, the publication may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the publication 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 publication is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this publication 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 publication development process.

As of the date of approval of this publication, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this publication. 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/.

Table of Contents

Supplement 9 to ITU-T E-series Recommendations

Supplement 9 to ITU-T E.800-series Recommendations (Guidelines on regulatory aspects of QoS)

1 Scope

This supplement provides guidelines on regulatory aspects of Quality of Service (QoS). The intent here is to assist regulators or administrations who need to achieve desired levels of QoS for one or more ICT services under their jurisdiction.

This supplement focuses on end-to-end QoS as perceived by the user when using modern mobile and broadband services. Nevertheless, the guidance provided in this supplement can correspondingly be used for traditional wire-bound and legacy services.

Network performance is outside the scope of this supplement.

2 References

[ITU-T E.800] Recommendation ITU-T E.800 (2008), *Definitions of terms related to quality of service.*

[ITU-T E.803] Recommendation ITU-T E.803 (2011), *Quality of service parameters for supporting service aspects.*

[ITU-T E.804] Recommendation ITU-T E.804 (2014), *QoS Aspects for Popular Services in Mobile Networks.*

[ITU-T P.10] Recommendation ITU-T P.10/G.100 (2006), *Vocabulary for performance and quality of service*.

3 Overview of quality of service

Quality of service (QoS) is defined as the totality of characteristics of a telecommunication service that bear on its ability to satisfy stated and implied needs of the user of the service (see [ITU-T E.800]); these characteristics can be measured by objective means (e.g., by a level meter or a delay counter). QoS is frequently confused with elements of network performance (NP) because (signalling) functions inside the networks are sometimes referred to as "services"; IETF uses QoS to describe the performance of functional services in network layer models. In order to avoid that confusion, QoS is often more precisely expressed as "end-to-end QoS".

Another confusion should be avoided when network counters and key performance indicators (KPIs) are brought into discussions about QoS. Network counters are vendor-specific NP parameters which cannot be standardized due to their proximity to specific implementations. A majority of standardized KPIs are describing NP parameters and only a very limited number of such KPIs are truly related to end-to-end QoS.

Furthermore, the end-to-end QoS that is perceived at the user interface, which is basically summarizing the characteristics of the underlying in-service media streams, should not be mistaken for the QoS of non-utilization stages of ICT services, which describe the (customer) "service" surrounding ICT services offered by service providers that are outside the actual usage of services that are of interest and concern to the users, e.g., quality and content of information on a service and its features, the contractual conditions offered by the service provider, provisioning facilities, documentation, and service support after contract with customers (see [ITU-T E.803] – Quality of service parameters for supporting service aspects).

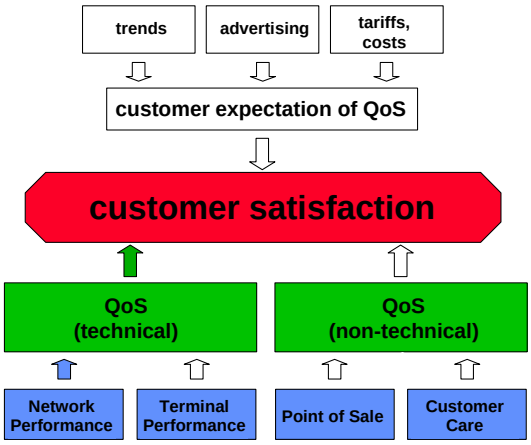

Figure 1 – Factors influencing customer satisfaction

The (average) user perception of end-to-end QoS can be assessed by subjective testing, but this is very costly; therefore, objective methods have been developed that help to predict user perception of QoS by objective measurement tools. The most prominent example has been recently standardized in [b-ITU-T P.863] (*Perceptual objective listening quality assessment*) and is intended for QoS assessment of voice services; this is the successor of [b-ITU-T P.862] (*Perceptual evaluation of speech quality*). Objective measurement methods for other services are available, e.g., in [b-ITU-T J.247] (for video). In addition, parametric models have been developed, which allow for the estimation of the end-to-end QoS perceived by the average user, e.g., the E-model of [b-ITU-T G.107] (for *a priori* transmission planning) or the [b-ITU-T P.12xx]-series (parametric assessment of streaming media) Recommendations.

The user perception of quality is, however, not limited to the objective characteristics at the man-machine interface, summarized in the QoS concept. What counts for end users is the quality that they personally experience during their use of a telecommunication service; Quality of Experience (QoE), therefore, takes into account additional subjective parameters stemming from user expectations and from the context, in which the user is embedded during the use of the service, typical examples of context-related influences being personal mood and environment. Also, QoE covers the potential discrepancy between the service offered and individual users reading additional features into the service.

4 Global challenges

With the move from traditional networks, which were based on dedicated service-channels and/or separate networks for each service, towards integrated (transport) services on a single packet-based transport infrastructure, which delivers all (transport) services via a single network access point, an access network and a unified so-called backbone, pre-defined transmission planning of QoS has become a major challenge.

In traditional networks, allocation of transmission impairments was based on a simple but effective concept: resources had been divided into the so-called international chain and both of the terminating national networks (including terminals) with heavy regulation in place, modern packet-based network quality parameter requirements are pretty much undefined and the impression is that the responsibility for end-to-end QoS has been lost; basically, in an IP environment, services must be considered as applications executed in the terminal devices; IP networks cannot provide for self standing end-to-end QoS, but only transport classes, which enable QoS differentiation.

The view on QoS related challenges depends strongly on the role of the stakeholders involved:

Standards development organizations (SDOs) like the ITU-T or the European Telecommunications Standards Institute (ETSI) or the Internet Engineering Task Force (IETF) have

the collective knowledge and expertise with respect to the QoS related problems inherited with the change of paradigms in networks and terminals and also with the aspects of planning and possible regulation of end-to-end QoS. However, SDOs are contribution-driven, which means that if stakeholders decide to rely on industry standards instead of globally recognized standards, and if stakeholders wish to keep control of their intellectual property and furthermore wish to not invest resources in globally recognized standards, then there is not very much for SDOs to do except to try to convince industry leaders, for example, in dedicated events such as conferences.

Network equipment manufacturers basically have to rely on the QoS related performance requests (of network and system functions) from network operators and service providers. Ideally, network equipment manufacturers would participate in the QoS work of SDOs in order to standardize the QoS and performance requirements between several parties involved in the network business. Unfortunately, for many network equipment manufacturers there is no visible incentive in the short-term which would make them participate in the work of SDOs related to end-to-end QoS; the return of investment (RoI) from this kind of engagement cannot easily be seen.

Terminal device manufacturers are confronted with a mass market today. In the past, terminal standards were for example targeting minimum attachment requirements, which were meant to not harm the network. Nowadays, there are terminal standards which target the possibility of provision of high-level end-to-end QoS to the customer. This is a challenge for terminal equipment manufacturers since the acceptance of terminals in the market is based on other factors (e.g., price, other functions of terminals (like MP3 players, GPS, etc.), applications available for that terminal (like games, etc.) and brand rather than end-to-end QoS – at least in the first place; "kids prefer the pink phone!").

Network operators and service providers are faced with the necessity of huge investments in both infrastructure and access technology. They are likely to react partially by investing in new capacity, and partially by rationing existing capacity. From their perspective, traffic management tools play an important role, increasing the efficiency with which operators can manage existing network capacity. "The appropriateness of different approaches to traffic management is at the heart of the Net Neutrality debate. Given the controversial nature of this debate, it is important to bear in mind that traffic management has always beneficial aspects to it. It is commonly used for example to protect safety-critical traffic such as calls to the emergency services. The question, therefore, is not whether traffic management is acceptable in principle, but whether particular approaches to traffic management cause concern."[1]

But also there remains the question whether network operators and service providers may or may not use traffic management as a welcome method towards suppressing competition from the so-called "un-managed" (i.e., not differentiating between traffic types, source or destination points) Internet or inhibiting the possibility of content or application providers with which it competes from introducing new innovative products. Opening access and core packet networks as pure bit pipes will probably not provide the revenues to match the huge investments mentioned; therefore, network operators and service providers will aim at providing services on top of the bit stream itself. From the beginning of the development of next generation networks (NGNs), which started in the mid-1990s with the ETSI project TIPHON the outcome of which finally was harmonized with ITU work in the NGN-GSI, network operators and service providers **claimed** that the so-called "guaranteed QoS" (which is only a statistical guarantee) requires service differentiation in the networks; in fact for the network this would be rather a traffic class differentiation, with different services then requesting a certain transport class from the network.

---

1 "Ofcom's approach to net neutrality" http://stakeholders.ofcom.org.uk/consultations/net-neutrality/statement/.

Regulators and administrations in general are challenged with their responsibility to consumer protection being affected by the rapid introduction of vendor-specific new services, which they have to take into account; in addition they are also required to strike a balance between service competition and infrastructure competition to address the challenges associated with QoS on the network[2]. In the early days of the move towards end-to-end services being no longer provided on a fixed, well-known platform, it still seemed to be fairly easy to require that the new technology provide QoS not less than in the ISDN era; however, today, it is easy to lose the overview of proprietary services, provided by various network operators and service providers "on-net" and the respectively offered QoS. The real problem seems to be that services are not standardized, which would mean that for interconnection scenarios (one of the major responsibilities of the ITU, and one of the main purposes of the ITRs) one would need specific service agreements for each network-to-network-interface (NNI).

In contrast, regulators and administrations have seen in the recent past that the un-managed Internet has led to the creation of new services offered "over the top" (e.g., Skype), which like network operators and service providers are an important factor contributing to the economical benefits of their respective countries; services on the Internet can be created, improved, judged and used by each individual within the legal context without restrictions.

Consequently, regulators and administrations have to take a close look at the conditions under which access to these services in comparison to the access to the Internet is being provided; e.g., in the access there may be a certain percentage of the bandwidth or of the capacity reserved for the on-net services which then are not available for access to the Internet; similarly the packed-based backbone of the network operator may serve for both the provision of their proprietary services (which are intended to secure their revenues) and for the carriage of open Internet traffic (which gives lower revenues); this may lead to a tendency to give lower priority to the open Internet traffic.

Consumers are challenged when using telecommunication services in their personal lives (i.e., the discrepancy between advertised and actual delivery speeds of the network). In the communications between the European Commission and the Body of European Regulators for Electronic Communications (BEREC), the need for clear and transparent communication of QoS parameters and network management practices has been a recurrent theme.

"Consumers may not be able to detect the actual applications of discriminating traffic management techniques and find it difficult to distinguish between the effects of traffic management techniques on QoS from the effects of other quality degrading factors. For instance, a consumer who is observing that traffic is routinely throttled may not know whether this is done by intention, or is caused by other factors such as network congestion, which is leading to the degradation of service. Even if [network] operators or ISPs are required to declare which traffic management techniques and policies are being used, consumers may find it difficult to act upon such information if it is presented in a highly technical way which does not explain the 'real world' effects. Thus, it will be important to monitor the effectiveness of transparency and QoS."[3]

In technical terms the global challenges can be summarized as follows:

Due to the dramatic increase in mobile communication, both in terms of the number of registered devices and of the volume of requested resources it is quite likely that migration scenarios and hybrid connections with existing wire-bound and traditional networks and terminals will be neglected and appropriate QoS standards will not be established or enforced.

---

2 ITU GSR10 Best Practice Guidelines for Enabling Open Access, http://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR10/consultation/index.html.

3 BEREC Response to the EU Commission's consultation on the open Internet and net neutrality in Europe, 30 Sep. 2010.

Service differentiation in modern packet based networks is facilitated with, e.g., the IP Multimedia Subsystem (IMS), which in its QoS part is basically a resource allocation tool. Again, the exact services are not defined or standardized which makes IMS less flexible for services to be offered across multiple packet networks. IMS is under the sole control of the 3rd Generation Partnership Project (3GPP), which is not an SDO in the classical sense; influence on the further development of IMS for ITU members is therefore very limited.

Therefore, the main technical parameters to consider will be:

- speed (data throughput) of the access network
- congestion in the backbone
- end-to-end delay (latency)
- delay-variation (jitter)
- packet loss (loss of information).

These parameters have multiple facets depending on which kind of gateways are used to interconnect IP networks: jitter is the variation in delay between different packets and its compensation (by de-jitter buffers) converts jitter into an additional delay which may build up and increase to unacceptable values; packet loss may be concealed to an extent where essential information is lost.

Bad terminal implementations may destroy reasonable performance delivered from the network(s); users will not be able to judge the difference in end-to-end QoS.

That leads to the current policy challenges:

Given rapid growth in the use of the network, there is a need to consider new approaches to anchor national strategies or regulatory frameworks around the multi-faceted concept of QoS, which may be required to set and keep the right balance between service and infrastructure competitions to address the challenges associated with QoS on the telecommunication network.

In particular, in order to continue providing adequate QoS, network operators and service providers claim to need a certain traffic management over increasingly congested networks. This might include data restrictions, traffic throttling, filtering and/or the use of data caps of thresholds. Once the cap is exceeded, customers or end users may be, knowingly or not, confronted with the fact that, "Internet access" provided to them is no longer Internet access, but a service provided by their ISP; this might have implications like reduced speed, additional unsolicited services, e.g., in case of entering wrong URLs, but also more serious service restrictions.

5 Selecting the appropriate regulatory approach

5.1 Options and principles

There are four possible elements in a regulator's approach to QoS:

- Obtaining appropriate information on the level of QoS and identifying the problem areas. This is essential since without the appropriate information the other elements cannot be undertaken;
- Publishing information on QoS performance so that customers can be better informed;
- Imposing regulations on performance such as required minimum levels and fines or compensation;
- Undertaking a constructive dialogue with the operator concerned to encourage and foster improvements.

There are basically two alternative approaches:

- A regulation orientated approach where:
  - Reporting is to the regulator;
  - Performance targets are set in regulations;
  - Fines are payable to the regulator if targets are not achieved.
- A customer orientated approach where:
  - Reporting is to the customer;
  - Targets and minimum performance levels are given in contracts;
  - Compensation for poor performance is payable to the affected customer.

In the early stages of market development, the regulation orientated approach may be more appropriate if the performance is poor and the focus is on achieving a basic minimum level of performance. In a later stage of development, the customer orientated approach may be preferable so that the regulator can reduce its involvement and the operator is pushed to have a closer relationship with the customer.

Setting performance targets needs to be treated with care and the distinction between the minimum level of performance and the desired level needs to be maintained clearly. There is a risk that if there is a minimum level of quality specified in a market with little competition, then this will be regarded as an acceptable level. It might be better either not to set a target at all and just to report achieved performance levels, or to set two levels – a minimum and a desired level.

QoS regulation has a cost and the costs should be assessed against the benefits. Efforts should be focused where there are known problems and problems areas change so there needs to be some flexibility. The same level of effort, e.g., the same requirements for measurement and reporting should not be applied to all possible parameters as this is needlessly expensive. One should "scratch where it itches, not everywhere". Highest effort levels should be focused on parameters that are both important to customers and where performance is poor or most at risk.

It is especially helpful if the legal system allows regulations to include some scope for subsequent decisions and determinations by the regulator without needing to go through the whole procedure for revising a regulation. For example, the regulation could include a formula such as "The regulator may revise the list of parameters, target levels or reporting requirements in the future by giving 3 months written notice to the operators".

6 Fundamentals of quality of service regulation

This clause provides an overview of the fundamentals of quality of service regulation. In the first part of this clause, some definitions and terminology are introduced.

- Quality of service is defined as the "collective effect of service performance, which determines the degree of satisfaction of a user of the service" ([ITU-T E.800]). Quality of service regulation is part of customer protection; however, customer protection is broader than quality of service regulation and covers, for example, sales activities, complaint resolution procedures and disconnection policies. Furthermore, quality of service is not the same as network performance, which is concerned not with user experience but with standards for network design.

- The term "parameter" is used to describe the definitions of measurements to be made. A target is defined as a potential value (or a range of values) for a parameter that must be reached if quality is to be regarded as satisfactory. Three classes of parameters determine user experience: "customer interface" parameters, "network infrastructure" parameters, and "service functionality" parameters organizes parameters according to service type (such as voice, SMS, etc.) rather than by operator type (fixed wireless, wireline, mobile, etc.) to help with comparability between countries and consistency in the treatment of operators.
- Parameters are named according to the same conventions irrespective of how they are named in different countries. As such, "rate" defines the frequency of actions, "ratio" stands for the proportion of actions that succeed, and "time" means the average time taken by actions that succeed.

6.1 Justifications for quality of service regulation

Quality of service regulation aims at:

- helping customers to make informed choices;
- checking claims by operators;
- understanding the state of the market;
- maintaining or improving quality in the presence of competition;
- maintaining or improving quality in the absence of competition;
- helping operators to achieve fair competition; and
- making interconnected networks work well together.

In addition, some guidance principles that would help regulators select parameters to be monitored, measurements to be published and targets to be set are:

- Parameters to be monitored should relate to the aspect of services that have the biggest impact on users; they should be well defined and be cost-effective to operators. For this reason, as far as possible they should have methods of measurement that are already in use by the operators. They should also reflect differences in, for example, services and geographic areas but should be consistent between services.
- Measurements to be published should relate to aspects of services that users experience directly (not the underlying technical cause). Publication of measurements needs to ensure that they reach beneficiaries, that they are easily understood without being misleading and that they allow for comparison between operators.
- Targets to be set should relate to the quality users want. They should avoid limiting customer choices between quality and price. Furthermore, values need to be determined through sufficient information such as earlier measurements by operators, used in other countries or proposed in international standards.

It was discussed that some variations of standard parameters may be necessary depending on the specific situation in a country or sector. As a result, the measurements of a parameter might need to distinguish between:

- Market segments: Quality of service may be different for private consumers, small and large businesses or for wholesale and retail offerings.
- Reporting areas: Another distinction may need to be created if there are reporting areas with likely differences in quality, such as rural and urban areas.

- Operators: Operators that have few customers, that resell services from other operators or that are not dominant in the market might be exempted from monitoring parameters or publishing measurements. Doing this could reduce inconvenience and costs. It is recommended that setting targets would be mainly necessary with dominant operators, whereas for other operators competition should help to reach the same results.
- Services: Parameters may also be specific to services such as voice, text messages and Internet, television and radio broadcasting as well as leased lines as the main services that have most impact on users. However, it is recognized that even this list may be too long and it may not always be desirable or necessary to impose quality of service regulation on all these.

Activities in relation to quality of service regulation that emphasize the institutional and operational aspect of these activities:

- Defining parameters: When defining parameters, the involvement of operators is beneficial and desirable. However, it also has to be noted that there is a risk that operators may exercise undue influence and that the consultation process can be lengthy. As a result, the regulator needs to exercise strong leadership while ensuring that stakeholders are consulted.
- Setting targets: Targets are normally set by the regulator based on consultation and prior monitoring of an operator's data. However, the report points to the possibility that the operators could also set their own targets and be obliged to publish their targets.
- Making measurements: For "customer interface" and "network infrastructure" parameters, measurements are conveniently made by operators, whereas many "service functionality" parameters are best made by external measurement agencies or by users to allow for comparison and reduce the cost of measurements.
- Auditing measurements: Measurements could be signed off by senior employees in a "self-certification" process, audited by external agencies including independent auditors or checked by regulators themselves. Important considerations are costs (for both the regulator and the operator) and the effectiveness of audits.
- Publishing measurements: Measurements should be published by the regulator to help with comparisons between operators. To simplify the task the number of measurements to be published could be reduced.
- Ensuring compliance: The regulator may start with recommendations and move towards obligations if the recommendations are important and practical, but the operator is not willing to take part. A range of techniques exists that the regulator can adopt, starting from "naming and shaming" strategies to tighter regulation, financial penalties and finally more drastic legal enforcements. As a general principle, it is recommended that encouragements and enforcements should be graduated and proportional.

Table 1 – List of proposed parameters

Customer interface	Network infrastructure	Service functionality
1. Customer complaint submission rate	4. Coverage	8. Call set up ratio
2. Customer complaint resolution time	5. Service supply time	9. Call retention ratio
3. Customer service call answer ratio	6. Fault report submission rate	10. Listening voice quality
	7. Fault repair time	11. Value added service call answer ratio
		12. Message transmission ratio
		13. Packet transmission ratio
		14. Packet transmission rate
		15. Data transmission capacity

6.2 Parameters and targets

Quality of service regulation can have several aims that justify it; some are more important when competition is strong, and others are more important when competition is weak. These aims are:

- Helping customers to make informed choices. The price is an important factor in choosing a service, but once customers have settled on the price they want the best quality available at that price. Indeed, quality can be more important than price, especially for business customers, because problems with quality are more likely to be costly. For services that are bundled together, with one price covering several services, the quality of specific aspects of the services can influence choices greatly. Publishing quality levels can help customers with this.
- Checking claims by operators. Operators sometimes make claims in advertisements about their services or the services of their competitors. Publishing quality levels can enable people to check this and help to ensure accurate claims.
- Understanding the state of the market. Figures about roll-out might not be enough to show how well policies are succeeding: they say nothing about how well equipment is maintained after installation. Monitoring and publishing quality levels can show gaps in performance that could be filled by market entry or that need new policies for particular groups of people, geographic areas or operating conditions (such as emergencies).
- Maintaining or improving quality in the presence of competition. Even in fully competitive markets quality might be poor because of rapid expansion or overstretched management: in various countries both the customer interface and the network infrastructure have become overloaded during aggressive marketing campaigns. Competition can also reduce quality if price cutting leads to cost cutting; quality reductions due to cost cutting can be difficult to reverse, as new staff might need to be trained or deferred investments might need to be brought forward. Publishing quality levels and having targets can help to maintain quality in these cases.

- Maintaining or improving quality in the absence of competition. A dominant operator might be subject to price controls, unwilling to boost supply or insensitive to customer wishes, also examining at least market and technology maturity, demand side growth, demand elasticity, countervailing buying power, cost structure and market share similarities, and supply side shortages. Then it might try to maintain margins by cutting costs and reducing quality; it might even introduce an "enhanced" service and lower the quality of the "standard" service to encourage customers to move to the "enhanced" service. Monitoring quality levels and having targets for the retail services of the dominant operator can help to maintain quality in these cases.
- Helping operators to achieve fair competition. An alternative operator often depends crucially on interconnecting with or reselling the facilities of a dominant operator. For competition to be fair, the alternative operator should get the same quality level from those facilities as the dominant operator gets. This is very difficult to ensure without firm regulation of the structure of the dominant operator. Having targets for the wholesale services of the dominant operator can help with it.
- Making interconnected networks work well together. An end-to-end path might pass through several networks, each controlled by a different operator. Then no individual operator has responsibility for the end-to-end path, but a dominant operator might have a serious effect on end-to-end paths set up by other operators. Having targets for the wholesale services of the dominant operator can help to ensure that end-to-end paths are satisfactory.

6.3 Activities in quality of service regulation

The main activities required by quality of service regulation, and the organizations that perform them, are considered; some of them can be performed by operators or even users instead of the regulator.

Figure 2 provides an overview of the main activities in quality of service regulation as described.

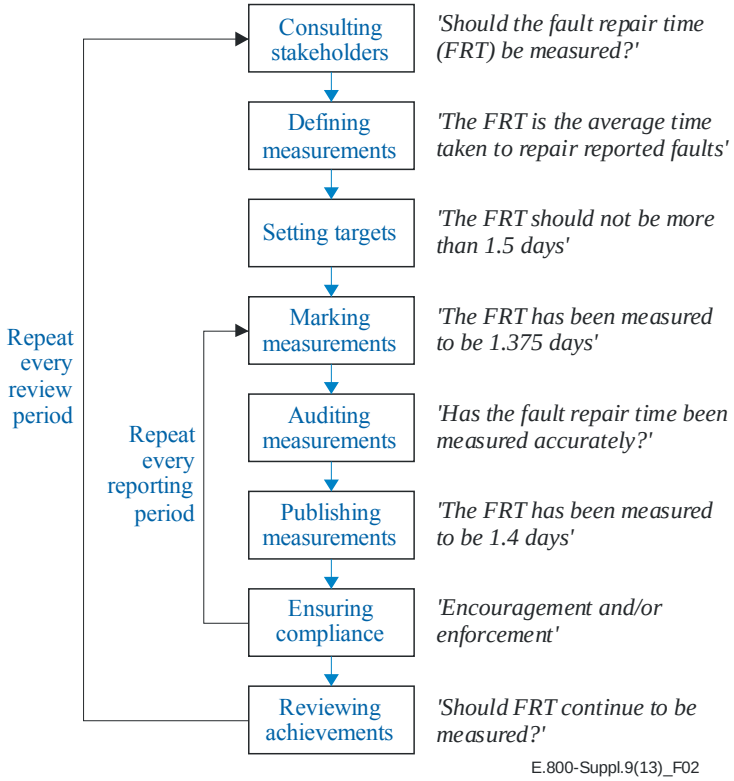

Figure 2 – Activities in quality of service regulation

7 Recommended approach

Information gathering and selection of parameters

Regulators should follow a combined approach of:

- Listening for problems through the press, through occasional meetings with the public and through monitoring the complaint statistics of the operators;
- Requiring regular reporting against parameters with both high importance and high risk. The selection of these parameters will change over time and will need to take account of the costs of monitoring and reporting. If costs are low because performance can be monitored easily and cheaply, e.g., automatically within the network then the parameters concerned can be included anyway, but if they require extra expenditure such as test calls then selection should be much more discriminating.

This could be called a "light touch" approach, i.e., one that focuses on pushing the service providers closer to the consumer on issues where there are problems and that avoids an excessive burden of reporting against all possible parameters.

Information publication

Regulators should both publish information on performance on its website and also require the operators to send the information periodically to subscribers with their bills. Any information should be as accessible as possible.

Target levels

Setting target levels is probably the most difficult aspect of QoS regulation. Levels should be based on both an understanding of what the customers require and what the operator can reasonably be expected to provide. If this is not clear, then it is better not to set a target but just to report the level of performance achieved.

If there is a good understanding, then it is recommended setting both a minimum level below which compensation is payable and a desired level for achieving good customer satisfaction.

Penalties

In general, ensuring compliance is highly recommended in QoS regulation. There are two approaches in implementing quality of service regulations – an encouragement and enforcement approach. Fines are generally tied to licence obligation to be agreed on by the regulator and operator. For the regulator to proceed with the enforcement approach, it may start with recommendations and move towards obligations if the recommendations are important and practical. The regulator can adopt a range of techniques, starting from "naming and shaming" strategies to tighter regulation, financial penalties and finally more drastic legal enforcements. However, doing this can involve extensive legal processes and may take a long time. A schedule of penalties may be gazetted to ease implementation.

As a general principle, it is recommended that encouragements and enforcements should be graduated and proportional.

It is also recommended that compensation should be payable to customers who are affected by particularly poor performance. This should be addressed through service level agreements in contracts where the agreements have to be approved by the regulator.

Service level agreements should be introduced only where there is some stability in supply. They should not be used for new services and new technologies until a reasonable level of experience has been gained with the technology.

Initial levels of compensation should be low; any such payments will be monitored by the management of the operators and experience is that the benefit in alerting management to problems far exceeds the value of the sums paid as they expose mangers to internal criticism. However for critical parameters that have a seriously damaging effect on customers the levels of compensation should rise depending on the extent on the problem with higher payments to business customers than to residential ones. For example, failure to repair a fault within a specified time would incur a penalty of say USDX per day but this rate should not be capped at a maximum of say 5 days but continue and possibly the rate per day should rise if the time exceeds say 10 days. This formulation is needed to ensure that the managers concerned take appropriate steps to resolve the issues and prepare adequately for the problems that inevitably will occur.

Constructive dialogue

Whenever feasible, the regulator should engage in constructive dialogue with the operators about quality problems. This should not be seen as a process of telling the operator how to run their business but of asking penetrating questions that will have the effect of causing the operators to review and reconsider their approach in areas with specific problems.

7.1 Service level agreements

The inclusion of "service level agreements" in contracts has become popular but such agreements are not always effective as the formulation may be vague and compensation terms may not be stated. Furthermore the process for claiming compensation may be made excessively complex to deter claims.

To be effective a service level agreement should state:

- The minimum level of performance offered to the customer, not the average level to be achieved for all customers.
- The compensation payment if the minimum level is not achieved with the sum at least proportional to the degree of failure.

The mechanism for claiming compensation: In most cases compensation should be paid automatically and the customer should not be required to make a claim.

8 Specifying parameters, levels and measurement methods

8.1 Parameters

The European Telecommunications Network Operators' Association (ETNO), the European "club" of incumbent operators proposed the following criteria for QoS parameters:

- QoS parameters should be easily understood by the public, and be useful and important to them.
- All parameters are applicable at the network termination point. Where measurements are possible, they should be made on the customer's premises, using in-service lines. To be as realistic as possible, real traffic rather than test calls should be used as a basis of the measurements, wherever possible.
- Parameters should be capable of verification by independent organizations. This verification might be made by direct measurements or by audit of the operator's measurements.
- The accuracy of QoS parameter values should be set to a level consistent with cost-effective available measurement methods.

- The parameters are designed for both statistical and individual application. The statistical values should be derived by the application of a simple statistical function to the individual values. The statistical function should be specified in the standard. The standard should also contain guidelines on how statistically significant samples should be selected.

However, making tests from the network termination point is normally not practicable. ETNO's focus is very much on aspect of network performance, whereas other aspects of performance are equally or more important.

The definition of parameters needs to take account of all the possible customer circumstances and this is not easy. Alternatively the definition needs specifically to exclude circumstances where the definition in not appropriate. Equally the definition should measure what will be perceived as good quality and not allow circumstances where the metric is good but the performance is in fact poor, or vice versa. For example, supply time for a new line cannot be defined just as the time between the order being placed and the line made available since some customers may order lines to be installed at a specific date in the future (e.g., when they are due to move in) and not as soon as possible. For them the important measure is whether the work is carried out on the date requested.

In some cases, it may not be possible to develop a suitable definition; in this case it is better not to require reporting than to require reporting against an inappropriate definition, otherwise an incentive may be created for actions that reduce rather than improve quality.

Definitions of QoS parameters for QoS of mobile services are given in [ITU-T E.804]; QoS parameters for the non-utilization stages of ICT services are given in [ITU-T E.803].

The bibliography provides a concise list of ITU-T Recommendations, currently in force, which are considered of high importance for achieving end-to-end QoS and users' satisfaction. Many of them cannot be used as direct basis for regulatory approaches. However, knowledge about their content will enable regulators to have more educated discussions with operators.

8.2 Formulation of the target levels

The issue of whether to set a specific target level and whether to set a single level or a separate minimum acceptable level and a desired level has been discussed earlier.

The levels for aggregated performance involving a number of different observations can be formulated in two different ways:

- The percentage of events that exceed or fail to meet a target level of performance (e.g., % lines delivered in more than X days). In this case, X indicates a target level.
- The number of days within which 90% of lines were delivered. In this case, no target level is indicated.

If compensation is going to be given, then the measure must have a simple pass or fail criterion for each individual customer.

8.3 Measurement methods

Measurement methods if possible should be objective. For some issues such as the effectiveness of call centres and help lines it may not be possible to specify a parameter that can be measured objectively, and subjective user assessments are used, e.g., the caller is asked at the end of the call to assess its effectiveness on a scale of 1-5. While this does give some measure of performance, it is not suitable for the application of penalties or compensation.

Measurement may be taken by third parties or reported by the operator itself. They may be based on sampling or include all events. Where measurements can be built into the network or support systems and be automatic then self-reporting covering all events is normally the best approach.

If sampling is used then consideration needs to be given to specifying criteria for the sample to be representative and comparable between networks.

8.4 Reporting

Reporting normally involves aggregated results. The question is whether they should be aggregated over:

- All parts of the network or aggregated separately for different areas;
- All customer types or reported separately for say business and residential customers.

This can only be decided on a case-by-case basis taking account of the local circumstances and quality problems.

Appendix I

List of telecommunications regulatory bodies

In order to keep regulatory efforts most effective, the QoS parameters reported, observed or monitored will have to be adapted from time to time to take into account changes in technology, user behaviour and general trends in society.

Therefore, the analysis of regulatory practices in other jurisdictions is best done in a real-time exercise at a point in time when existing regulations are under revision or new ones are to be established.

Therefore, this supplement does not contain copies of any current regulatory practices in force, but offers a collection of links to related documentation in selected countries. All links have been verified during the preparation of this supplement. However, such links may be unavailable temporarily or permanently.

List of telecommunications regulatory bodies:

Afghanistan	Afghanistan Telecom Regulatory Authority (ATRA)	http://www.atra.gov.af/index.php?lang=en
Albania	Electronic and Postal Communications Authority ([ITU-T P.10])	http://www.akep.al/
Algeria	Autorité de Régulation des Postes et Telecommunications (ARPT)	http://www.arpt.dz/
Angola	Telecomunicações Ministério das Telecomunicações e Tecnologias (MTTI)	http://www.mtti.gov.ao/
Argentina	Secretaría de Comunicaciones (SECOM)	http://www.secom.gov.ar/
Armenia	Public Services Regulatory Commission (PSRC)	http://psrc.am/en/
Australia	Australian Communications and Media Authority (ACMA)	http://www.acma.gov.au/
Austria	Austrian Regulatory Authority for Broadcasting and Telecommunications (RTR-GmbH)	http://www.rtr.at/
Bahamas	Utilities Regulation & Competition Authority (URCA)	http://www.urcabahamas.bs/
Bahrain	Telecommunications Regulatory Authority of Bahrain (TRA)	http://www.tra.org.bh/en/home.asp
Bangladesh	Bangladesh Telecommunication Regulatory Commission (BTRC)	http://www.btrc.gov.bd/
Barbados	Telecommunications Unit (Telecoms Unit)	http://www.telecoms.gov.bb/
Belarus	Ministry of Posts and Telecommunications (MPT)	http://www.mpt.gov.by/
Belgium	Belgian Institute for Postal services and Telecommunications (BIPT)	http://www.bipt.be/
Belize	Belize Public Utilities Commission (PUC)	http://www.puc.bz/
Benin	Transitory Authority for the Regulation of Posts and Telecommunications (ATRPT)	http://www.atrpt.bj/
Bolivia (Plurinational State of)	Superintendencia de Telecomunicaciones (SITTEL)	http://www.sittel.gov.bo/
Botswana	Botswana Telecommunications Authority (BTA)	http://www.bta.org.bw/

Brazil	Agencia Nacional de Telecomunicações (ANATEL)	http://www.anatel.gov.br/
Brunei Darussalam	Authority for Info-Communications Technology Industry (AITI)	http://www.aiti.gov.bn/
Bosnia and Herzegovina	Communications Regulatory Agency of Bosnia-Herzegovina (CRA)	http://www.cra.ba/
Bulgaria	Communications Regulation Commission (CRC)	http://www.crc.bg/index.php?lang=en
Burkina Faso	Autorite Nationale de Regulation des Telecommunications (ARTEL)	http://www.artel.bf/
Burundi	Agence de Régulation et de Contrôle des Télécommunications (ARCT)	http://www.arct.bi/
Cameroon	Agence de Regulation des Telecommunications (ART)	http://www.art.cm/
Canada	Industry Canada (ICRST)	http://www.ic.gc.ca/eic/site/ic1.nsf/eng/h_00077.html
Canada	Canadian Radio-television and Telecommunications Commission (CRTC)	http://www.crtc.gc.ca/eng/welcome.htm
Cape Verde	National Communications Agency (ANAC)	http://www.anac.cv/
Cayman Islands	Information and Communications Technology Authority (ICTA)	http://www.icta.ky/
Central African Republic	Agence chargée de la Régulation des Télécommunications (ART)	http://www.art-rca.org/
Chad	Office Tchadien de Regulation des Telecoms (OTRT)	http://www.otrt.td/
Colombia	Comisión de Regulación de Comunicaciones (CRCOM)	http://www.crcom.gov.co/
Comoros	Autorité Nationale de Régulation des Tics (ANRTIC)	http://www.anrtic.co.km/
Costa Rica	Superintendencia de Telecomunicaciones (SUTEL)	http://sutel.go.cr/
Côte d'Ivoire	Agence des Telecommunications de Côte d'Ivoire (ATCI)	http://www.atci.ci/
Croatia	Croatian Post and Electronic Communications Agency (HAKOM)	http://www.hakom.hr/default.aspx?id=7
Chile	Subsecretaria de Telecommunicacaiones (SUBTEL)	http://www.subtel.cl/prontus_subtel/site/edic/base/port/inicio.html
Curaçao (Former Netherlands Antilles)	Bureau Telecommunicatie & Post (BT&P)	http://www.btnp.org/
Cyprus	Office of Electronic Communications & Postal Regulation (OCECPR)	http://www.ocecpr.org.cy/ngcontent.cfm?a_id=767&tt=ocecpr&lang=gr
Czech Republic	The Czech Telecommunication Office (ČTÚ)	http://www.ctu.eu/main.php?pageid=178
Democratic Republic of the Congo	Autorite de Regulation de la Poste et des Telecommunications du Congo (ARPTC)	http://www.arptc.cd/
Denmark	National IT and Telecom Agency (NITA) NITA is closed since October 6, 2011	http://en.itst.dk/
Djibouti	Ministère de la Communication et de la Culture, chargé des Postes et Télécommunications, Porte-Parole du Gouvernement (MCCPT)	http://www.mccpt.dj/

Dominica	Eastern Caribbean Telecommunications Authority (ECTEL)	http://www.ectel.int/ntrcdominica.htm
Dominican Republic	Instituto Dominicano de las Telecomunicaciones (Indotel)	http://www.indotel.gob.do/
Ecuador	Consejo Nacional de Telecomunicaciones del Ecuador (CONATEL)	http://www.conatel.gov.ec/
Ecuador	Ministerio de Telecomunicaciones y de la Sociedad de la Información (MINTEL)	http://www.mintel.gov.ec/
El Salvador	Superintendencia General de Electricidad y Telecommunicaciones (SIGET)	http://www.siget.gob.sv/index.aspx?tipo=17
Egypt	National Telecommunications Regulatory Authority (NTRA)	http://www.tra.gov.eg/english/Main.asp
Estonia	Estonian Competition Authority (ECA)	http://www.konkurentsiamet.ee/?lang=en
Ethiopia	Ethiopian Telecommunication Agency (ETA)	http://www.eta.gov.et/
Finland	Finnish Communications Regulatory Authority (FICORA)	http://www.ficora.fi/en/
France	Autorité de Régulation des Communications Electroniques et des Postes (ARCEP)	http://www.arcep.fr/
Gabon	Agence de Regulation des Telecommunications (ARTEL)	http://www.artel.ga/
Gambia	Gambian Public Utilities Regulatory Authority (PURA)	http://www.pura.gm/
Georgia	Georgian National Communications Commission (GNCC)	http://www.gncc.ge/?lang_id=ENG
Germany	Bundesnetzagentur (BNA)	http://www.bundesnetzagentur.de/enid/2.html
Ghana	National Communications Authority (NCA)	http://www.nca.org.gh/
Greece	Hellenic Telecommunications and Post Commission (EETT)	http://www.eett.gr/opencms/opencms/EETT_EN/index.html
Grenada	Eastern Caribbean Telecommunications Authority (ECTEL)	http://www.ectel.int/
Guatemala	Superintendencia de Telecomunicaciones (SIT)	http://www.sit.gob.gt/
Guinea	Regulatory Authority for Posts and Telecommunications (ARPT)	http://www.arptguinee.org/
Guinea-Bissau	Ministry of Telecommunications (ICGB)	http://www.icgb.org/
Haiti	Conseil National des Telecommunications (CONATEL)	http://www.conatel.gouv.ht/
Honduras	Comisión Nacional de Telecomunicaciones (CONATEL)	http://www.conatel.gob.hn/
Hong Kong, SAR	Office of Communications Authority (OFCA)	http://www.ofca.gov.hk/
Hungary	National Media and Infocommunication Authority (NMHH)	http://www.nmhh.hu/
Iceland	Post and Telecom Administration (PTA)	http://www.pfs.is/default.aspx?cat_id=101
India	Telecom Regulatory Authority of India (TRAI)	http://www.trai.gov.in/
Indonesia	Badan Regulasi Telekomunikasi Indonesia/ Indonesian Telecommunications Regulatory Authority (BRTI)	http://www.brti.or.id/
Iran (Islamic Republic of)	Communication Regulatory Authority (CRA)	http://www.cra.ir/
Iraq	Communications and Media Commission (CMC)	http://www.cmc.iq/

Ireland	Commission for Communications Regulation (ComReg)	http://www.comreg.ie/
Israel	Ministry of Communications (MOC)	http://www.moc.gov.il/130-en/MOC.aspx
Italy	Autorità per le Garanzie nelle Comunicazioni (AGCOM)	http://www.agcom.it/
Japan	Ministry of Internal Affairs and Communications (MIC)	http://www.soumu.go.jp/english/index.html
Jordan	Telecommunications Regulatory Commission (TRC)	http://www.trc.gov.jo/index.php?lang=english
Kenya	Communications Commission of Kenya (CCK)	http://www.cck.go.ke/
Korea (Rep. of)	Ministry of Communications and Information (KCC)	http://www.kcc.go.kr/user/ehpMain.do
Kosovo	Autoriteti Rregullator i Telekomunikacionit (ART)	http://www.art-ks.org/
Latvia	Elektronisko sakaru direkcija (ESD)	http://www.esd.lv/index.php?lang=en
Lebanon	Telecommunications Regulatory Authority (TRA)	http://www.tra.gov.lb/
Lesotho	Lesotho Communications Authority (LCA)	http://www.lca.org.ls/
Liberia	Liberia Telecommunications Authority (LTA)	http://www.lta.gov.le/
Libya	General Telecommunications Authority (GTA)	http://www.gta.ly/
Liechtenstein	Office for Communications (AK)	http://www.llv.li/amtsstellen/llv-ak-english-page.htm
Lithuania	Communications Regulatory Authority (RRT)	http://www.rrt.lt/en/home.html
Luxembourg	Institut luxembourgeois de régulation (ILR)	http://www.ilr.public.lu/
Macau	Bureau of Telecommunications Regulation (DSRT)	http://www.gdtti.gov.mo/eng/News/index.html
Madagascar	Office Malagasy d'études et de Régulation des Télécommunications (OMERT)	http://www.omert.mg/
Malawi	Communications Regulatory Authority (MACRA)	http://www.macra.org.mw/
Malaysia	Malaysian Communications and Multimedia Commission (MCMC)	http://www.cmc.gov.my/
Mali	Ministere de la Communication et des TIC (MTCMTL)	http://www.mtcmtl.com/
Malta	Malta Communications Authority (MCA)	http://www.mca.org.mt/
Mauritania	Autorite de Regulation (ARE)	http://www.are.mr/
Mauritius	Information and Communication Technologies Authority (ICTA)	http://www.icta.mu/
Mexico	Federal Commission of Telecommunications (COFETEL)	http://www.cft.gob.mx/wb/Cofetel_2008/idioma
Moldova	National Regulatory Agency for Electronic Communications and Information Technology (ANRCETI)	http://en.anrceti.md/front
Mongolia	Communications Regulatory Commission of Mongolia (CRC)	http://crc.gov.mn/
Montenegro	Agency for Electronic Communications and Postal Services (EKIP)	http://www.ekip.me/eng/agency/
Morocco	L'Agence Nationale de Réglementation des Télécommunications (ANRT)	http://www.anrt.net.ma/
Mozambique	Instituto Nacional das Communicacoes de Mozambique (INCM)	http://www.incm.gov.mz/
Namibia	Namibian Communications Commission (NCC)	http://www.ncc.org.na/

Nepal	Nepal Telecommunications Authority (NTA)	http://www.nta.gov.np/en/
Netherlands	Autoriteit Consument & Markt (ACM) [previously Onafhankelijke Post en Telecommunicatie Autoriteit]	https://www.acm.nl/nl/
New Zealand	Commerce Commission of New Zealand (ComCom)	http://www.comcom.govt.nz/
Niger	L'Autorité de Régulation Multisectorielle (ARM)	http://www.arm-niger.org/
Nigeria	Nigerian Communications Commission (NCC)	http://www.ncc.gov.ng/
Norway	Norwegian Post and Telecommunications Authority (NPT)	http://www.npt.no/
Oman	Oman Telecommunications Regulatory Authority (TRA)	http://www.tra.gov.om/newsite1/
Pakistan	Pakistan Telecommunication Authority (PTA)	http://pta.gov.pk/
Papua New Guinea	National Information And Communication Technology Authority (NICTA)	http://www.nicta.gov.pg/
Peru	Organismo Supervisor de Inversión Privada en Telecomunicaciones (OSIPTEL)	http://www.osiptel.gob.pe/
Philippines	National Telecommunications Commission (NTC)	http://portal.ntc.gov.ph/
Poland	Prezes Urzędu Komunikacji Elektronicznej (UKE)	http://www.uke.gov.pl/
Portugal	Autoridade Nacional de Comunicações (ANACOM)	http://www.anacom.pt/
Qatar	Supreme Council of Information and Communication Technology (ictQatar)	http://www.ictqatar.qa/
Romania	National Authority for Management and Regulation in Communications of Romania (ANCOM)	http://www.ancom.org.ro/en/
Russian Federation	Ministry for Communications and Informatization of the Russian Federation (Minsvyaz)	http://www.minsvyaz.ru/
Rwanda	Regulatory Agency for Public Utility Services of Rwanda (RURA)	http://www.rura.gov.rw/
Saudi Arabia	Communications and Information Technology Commission (Saudi Arabia) (CITC)	http://www.citc.gov.sa/
Senegal	ART/Sénégal (ARTP)	http://www.artp-senegal.org/
Serbia	Republic Agency for Electronic Communication (RATL)	http://www.ratel.rs/
Seychelles	Ministry of Information Technology and Communication (MISD)	http://www.misd.gov.sc/
Sierra Leone	National Telecommunications Commission (NATCOM)	http://www.natcomsl.com/
Singapore	Infocomm Development Authority of Singapore (IDA)	http://www.ida.gov.sg/
Slovakia	Telecommunications Regulatory Authority of the Slovak Republic (TUSR)	http://www.teleoff.gov.sk/index.php?ID=9
Slovenia	Post and Electronic Communications Agency of the Republic of Slovenia (APEK)	http://www.apek.si/apek-ang
Somalia	Ministry of Posts & Communication (MPC)	http://www.somali-gov.info/
South Africa	Independent Communications Authority of South Africa (ICASA)	http://www.icasa.org.za/
Spain	Comisión del Mercado de las Telecomunicaciones (CMT)	http://www.cmt.es/

Sri Lanka	Telecommunications Regulatory Commission of Sri Lanka ([ITU-T E.800])	http://www.trc.gov.lk/
Sudan	National Telecommunications Corporation (NTC)	http://www.ntc.gov.sd/
Swaziland	Swaziland Posts & Telecommunications Corporation (SPTC)	http://www.sptc.co.sz/
Sweden	Post-och telestyrelsen (PTS)	http://www.pts.se/
Switzerland	Federal Communications Commission (ComCom)	http://www.comcom.admin.ch/
Taiwan, China	National Communications Commission (NCC)	http://www.ncc.gov.tw/english/index.aspx
Tanzania	Tanzania Communication Regulatory Authority (TCRA)	http://www.tcra.go.tz/
Thailand	National Broadcasting and Telecommunications Commission (NBTC)	http://nbtc.go.th/wps/portal/NTC/eng
The Former Yugoslav Rep. of Macedonia	Electronic Communications Agency (AEK)	http://www.aec.mk/
Togo	Autorité de Réglementation des Secteurs de Postes et Telecommunications (ART&P)	http://www.artp.tg/
Trinidad and Tobago	Telecommunications Authority of Trinidad and Tobago (TATT)	http://tatt.org.tt/
Turks and Caicos Islands	Telecommunications Commission (TCITC)	http://www.telecommission.tc/
Tunisia	de l'Instance Nationale des Télécommunications de Tunisie (INTT)	http://www.intt.tn/
Turkey	Information And Communication Technologies Authority (ICTA)	http://eng.btk.gov.tr/
Uganda	Uganda Communications Commission (UCC)	http://www.ucc.co.ug/
Ukraine	National Commission for the State Regulation of Communications and Informatization (NCCIR)	http://www.nkrz.gov.ua/
United Arab Emirates	Telecommunications Regulatory Authority (TRA)	http://www.tra.ae/
United Kingdom	Ofcom (OFCOM)	http://en.wikipedia.org/wiki/Ofcom
United States	Federal Communications Commission (FCC)	http://www.fcc.gov/ and individual states at http://www.naruc.org/Commissions/
Uruguay	Unidad Reguladora de Servicios de Telecomunicaciones (URSEC)	http://www.ursec.gub.uy/
Vanuatu	Telecommunications Regulator (Telecom Regulator)	http://www.trr.vu/
Venezuela	Comisión Nacional de Telecomunicaciones (CONATEL)	http://www.conatel.gob.ve/
Viet Nam	Vietnam Telecommunication Authority (VNTA)	http://www.vnta.gov.vn/
Zambia	Communications Authority (CAZ)	http://www.caz.cm/
Zimbabwe	Postal & Telecommunications Regulatory Authority (POTRAZ)	http://www.potraz.gov.zw/

Bibliography

[b-ITU-T E.421] Recommendation ITU-T E.421 (1988), *Service quality observations on a statistical basis*.

[b-ITU-T E.422] Recommendation ITU-T E.422 (1996), *Observations on international outgoing telephone calls for quality of service*.

[b-ITU-T E.423] Recommendation ITU-T E.423 (1988), *Observations on traffic set up by operators*.

[b-ITU-T E.424] Recommendation ITU-T E.424 (1992), *Test calls*.

[b-ITU-T E.425] Recommendation ITU-T E.425 (2002), *Internal automatic observations*.

[b-ITU-T E.427] Recommendation ITU-T E.427 (1988), *Collection and statistical analysis of special quality of service observation data for measurements of customer difficulties in the international automatic service*.

[b-ITU-T E.428] Recommendation ITU-T E.428 (1992), *Connection retention*.

[b-ITU-T E.430] Recommendation ITU-T E.430 (1992), *Quality of service framework*.

[b-ITU-T E.431] Recommendation ITU-T E.431 (1992), *Service quality assessment for connection set-up and release delays*.

[b-ITU-T E.432] Recommendation ITU-T E.432 (1992), *Connection quality*.

[b-ITU-T E.433] Recommendation ITU-T E.433 (1992), *Billing integrity*.

[b-ITU-T E.434] Recommendation ITU-T E.434 (1992), *Subscriber-to-subscriber measurement of the public switched telephone network*.

[b-ITU-T E.436] Recommendation ITU-T E.436 (1998), *Customer Affecting Incidents and blocking Defects Per Million*.

[b-ITU-T E.437] Recommendation ITU-T E.437 (1999), *Comparative metrics for network performance management*.

[b-ITU-T E.438] Recommendation ITU-T E.438 (2000), *Performance parameters and measurement methods to assess N-ISDN 64 kbit/s circuit-switched bearer service UDI in operation*.

[b-ITU-T E.440] Recommendation ITU-T E.440 (1996), *Customer satisfaction point*.

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

[b-ITU-T E.801] Recommendation ITU-T E.801 (1996), *Framework for Service Quality Agreement*.

[b-ITU-T E.802] Recommendation ITU-T E.802 (2007), *Framework and methodologies for the determination and application of QoS parameters*.

[b-ITU-T E-800 series Sup.8] Recommendation ITU-T E-800 series Sup.8 (2009), *Guidelines for inter-provider quality of service*.

[b-ITU-T G.101] Recommendation ITU-T G.101 (2003), *The transmission plan*.

[b-ITU-T G.107] Recommendation ITU-T G.107 (2014), *The E-model: a computational model for use in transmission planning*.

[b-ITU-T G.107.1] Recommendation ITU-T G.107.1 (2011), *Wideband E-model*.

[b-ITU-T G.108] Recommendation ITU-T G.108 (1999), *Application of the E-model: A planning guide*.

[b-ITU-T G.108.1] Recommendation ITU-T G.108.1 (2000), *Guidance for assessing conversational speech transmission quality effects not covered by the E-model*.

[b-ITU-T G.108.2] Recommendation ITU-T G.108.2 (2007), *Transmission planning aspects of echo cancellers*.

[b-ITU-T G.109] Recommendation ITU-T G.109 (1999), *Definition of categories of speech transmission quality*.

[b-ITU-T G.111] Recommendation ITU-T G.111 (1993), *Loudness ratings (LRs) in an international connection*.

[b-ITU-T G.113] Recommendation ITU-T G.113 (2007), *Transmission impairments due to speech processing*.

[b-ITU-T G.114] Recommendation ITU-T G.114 (2003), *One-way transmission time*.

[b-ITU-T G.115] Recommendation ITU-T G.115 (1996), *Mean active speech level for announcement and speech synthesis systems*.

[b-ITU-T G.121] Recommendation ITU-T G.121 (1993), *Loudness ratings (LRs) of national systems*.

[b-ITU-T G.131] Recommendation ITU-T G.131 (2003), *Talker echo and its control*.

[b-ITU-T G.136] Recommendation ITU-T G.136 (1999), *Application rules for Automatic Level Control Devices*.

[b-ITU-T G.173] Recommendation ITU-T G.173 (1993), *Transmission planning aspects of the speech service in digital public land mobile networks*.

[b-ITU-T G.175] Recommendation ITU-T G.175 (2000), *Transmission planning for private/public network interconnection of voice traffic*.

[b-ITU-T G.177] Recommendation ITU-T G.177 (1999), *Transmission planning for voiceband services over hybrid Internet/PSTN connections*.

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

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

[b-ITU-T G.1011] Recommendation ITU-T G.1011 (2013), *Reference guide to quality of experience assessment methodologies*.

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

[b-ITU-T G.1030] Recommendation ITU-T G.1030 (2014), *Estimating end-to-end performance in IP networks for data applications*.

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

[b-ITU-T G.1050] Recommendation ITU-T G.1050 (2011), *Network model for evaluating multimedia transmission performance over Internet Protocol*.

[b-ITU-T G.1070] Recommendation ITU-T G.1070 (2012), *Opinion model for video-telephony applications*.

[b-ITU-T G.1080] Recommendation ITU-T G.1080 (2008), *Quality of experience requirements for IPTV services*.

[b-ITU-T G.1081] Recommendation ITU-T G.1081 (2008), *Performance monitoring points for IPTV*.

[b-ITU-T G.1082] Recommendation ITU-T G.1082 (2009), *Measurement-based methods for improving the robustness of IPTV performance*.

[b-ITU-T J.247] Recommendation ITU-T J.247 (2008), *Objective perceptual multimedia video quality measurement in the presence of a full reference*.

[b-ITU-T P.310] Recommendation ITU-T P.310 (2009), *Transmission characteristics for narrow-band digital handset and headset telephones*.

[b-ITU-T P.311] Recommendation ITU-T P.311 (2011), *Transmission characteristics for wideband digital handset telephones*.

[b-ITU-T P.313] Recommendation ITU-T P.313 (2007), *Transmission characteristics for cordless and mobile digital terminals*.

[b-ITU-T P.340] Recommendation ITU-T P.340 (2000), *Transmission characteristics and speech quality parameters of hands-free terminals*.

[b-ITU-T P.341] Recommendation ITU-T P.341 (2011), *Transmission characteristics for wideband digital hands-free telephony terminals*.

[b-ITU-T P.342] Recommendation ITU-T P.342 (2009), *Transmission characteristics for narrow-band digital loudspeaking and hands-free telephony terminals*.

[b-ITU-T P.501] Recommendation ITU-T P.501 (2012), *Test signals for use in telephonometry*.

[b-ITU-T P.502] Recommendation ITU-T P.502 (2000), *Objective test methods for speech communication systems using complex test signals*.

[b-ITU-T P.505] Recommendation ITU-T P.505 (2005), *One-view visualization of speech quality measurement results*.

[b-ITU-T P.561] Recommendation ITU-T P.561 (2002), *In-service non-intrusive measurement device – Voice service measurements*.

[b-ITU-T P.562] Recommendation ITU-T P.562 (2004), *Analysis and interpretation of INMD voice-service measurements*.

[b-ITU-T P.563] Recommendation ITU-T P.563 (2004), *Single-ended method for objective speech quality assessment in narrow-band telephony applications*.

[b-ITU-T P.800] Recommendation ITU-T P.800 (1996), *Methods for subjective determination of transmission quality*.

[b-ITU-T P.800.1] Recommendation ITU-T P.800.1 (2006), *Mean Opinion Score (MOS) terminology*.

[b-ITU-T P.805] Recommendation ITU-T P.805 (2007), *Subjective evaluation of conversational quality*.

[b-ITU-T P.862] Recommendation ITU-T P.862 (2001), *Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs*.

[b-ITU-T P.863] Recommendation ITU-T P.863 (2011), *Perceptual objective listening quality assessment.*

[b-ITU-T P.880] Recommendation ITU-T P.880 (2004), *Continuous evaluation of time-varying speech quality*.

[b-ITU-T P.1010] Recommendation ITU-T P.1010 (2004), *Fundamental voice transmission objectives for VoIP terminals and gateways*.

[b-ITU-T P.1100] Recommendation ITU-T P.1100 (2011), *Narrow-band hands-free communication in motor vehicles*.

[b-ITU-T P.1110] Recommendation ITU-T P.1110 (2009), *Wideband hands-free communication in motor vehicles*.

[b-ITU-T P.12xx] Recommendation ITU-T P.12xx-series (2012), *Models and tools for quality assessment of streamed media*.

[b-ITU-T P.1201] Recommendation ITU-T P.1201 (2012), *Parametric non-intrusive assessment of audiovisual media streaming quality*.

[b-ITU-T P.1202] Recommendation ITU-T P.1202 (2012), *Parametric non-intrusive bitstream assessment of video media streaming quality*.

[b-ITU-T Y.1221] Recommendation ITU-T Y.1221 (2010), *Traffic control and congestion control in IP-based networks*.

[b-ITU-T Y.1530] Recommendation ITU-T Y.1530 (2007), *Call processing performance for voice service in hybrid IP networks*.

[b-ITU-T Y.1541] Recommendation ITU-T Y.1541 (2011), *Network performance objectives for IP-based services*.

[b-ITU-T Y.1542] Recommendation ITU-T Y.1542 (2010), *Framework for achieving end-to-end IP performance objectives*.

[b-ITU-T Y.1543] Recommendation ITU-T Y.1543 (2007), *Measurements in IP networks for inter-domain performance assessment*.

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	Terminals and subjective and objective assessment methods
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, 2014