Common guidelines on minimum quality of service standards for communication services

Final report

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Abbreviations

3GPP	Third Generation Partnership Project
ACA	Australian Communications Authority
ACIF	Australian Communications Industry Forum
ACMA	Australian Communications and Media Authority
AFUR	African Forum for Utility Regulators
ARICEA	Association of Regulators of Information and Communications technologies for Eastern and Southern Africa
ARN	Arab states telecommunications Regulators Network
ARTAC	Association of Regulators of Telecommunications of Central Africa
ATU	African Telecommunications Union
AU	African Union
AUB	African Union of Broadcasting
CENELEC	European Committee for Electrotechnical Standardization
COMESA	Common Market of Eastern and Southern Africa
CQE	Conversational Quality Effect
CRASA	Communications Regulators Association of Southern Africa
DAB	Digital Audio Broadcasting
DVB	Digital Video Broadcasting
EAC	East African Community
EARPTO	East African Regulatory, Postal and Telecommunications Organization
EBU	European Broadcasting Union
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community Of West African States
ECTEL	Eastern Caribbean Telecommunications authority
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission
FRATEL	Francophone network of Telecommunication regulators
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
ICT	Information and Communication Technology
IETF	Internet Engineering Task Force
IIA	Internet Industry Association
INMD	In-service Non-intrusive Measurement Device
IP	Internetwork Protocol
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
ITU-D	ITU – Telecommunication Development Sector
ITU-R	ITU – Radiocommunication Sector
ITU-T	ITU – Telecommunication Standardization Sector
LQO	Listening Quality Objective
MMS	Multimedia Messaging Service
MOS	Mean Opinion Score
NGN	Next Generation Network

OECD	Organisation for Economic Co-operation and Development
PESQ	Perceptual Evaluation of Speech Quality
SADC·	Southern Africa Development Community
SMS	Short Messaging Service
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UK	United Kingdom
US	United States
USSD	Unstructured Supplementary Service Data
WATRA ·	West Africa Telecommunications Regulators Assembly

Tables and Figures

1 Executive summary

The African Forum for Utility Regulators (AFUR) has been established with the objective of encouraging the development of effective utility regulation within Africa by promoting cooperation and fostering dialogue between regulators. PricewaterhouseCoopers Associates Africa Ltd has been appointed by AFUR to carry out a consultancy on the elaboration of common guidelines on minimum quality of service (QoS) standards for communication services. The objectives of the project are to:

- Review quality of service standards for communication services in Africa and benchmark these against international best practice quality of service regulation;
- Develop common guidelines on minimum quality of service standards for communications;
- Facilitate a participatory consultation workshop with AFUR members and other critical stakeholders.

As part of this project, the Consultant carried out a survey amongst AFUR members and observers on the existing quality of service regime in countries affiliated to AFUR. Furthermore, a workshop was held in Pretoria on the 3rd and 4th of April 2008.The findings and recommendations arising from this project are summarised in the four sections below.

1.1 Fundamentals of quality of service regulation

Section 3 provides an overview of the fundamentals of quality of service regulation. In the first part of this section, we provide some definitions and terminology used throughout the report.

- 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. Accordingly, our project and this report concentrate on quality of service, not on network performance.
- We use a consistent terminology throughout the guideline document. We use the term “parameter” 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.
- We define three classes of parameters that determine user experience: “customer interface” parameters, “network infrastructure” parameters, and “service functionality” parameters. Furthermore, this report organises 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.

- The report names parameters 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.

Following the discussion of definitions and main terminology, we list the main 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, we provide some guidance principles that would help regulators select parameters to be monitored, measurements to be published and targets to be set.

- 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.

We have argued 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. We suggest 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. In our report, we list 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, we recognise 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.

Furthermore, in our report, we discuss six activities in relation to quality of service regulation which emphasise the institutional and operational aspect of these activities:

- Defining parameters: When defining parameters, the involvement of operators is beneficial and desirable. However, we also point to the 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 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. We list a range of techniques 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, we recommend that encouragements and enforcements should be graduated and proportional.

Furthermore, we discuss measurement methods and the extent to which they are preferred for this project and the proposed AFUR parameters:

- Subjective and objective methods: Subjective methods involve surveying users whereas objective methods typically involve testing, sampling, and counting complaints. Some parameters are more suitable for subjective measurements, but often (and also for the proposed AFUR parameters) objective parameters are preferred.

- Network-by-network and end-to-end methods: Network-by-network measurements consider individual networks in isolation and represent what operators control directly. End-to-end measurements measure what users experience directly and thus are generally preferred (but may be outside the control of operators)

- Real and test traffic: These measurement methods are used for “service functionality” parameters. Real traffic measurement uses an automatic data collection system that counts and analyses traffic, whereas test traffic measurement initiates test transmissions to sample the experience of users.

In addition, we introduce three main publication formats that could be used by regulators to achieve maximum impact in publishing measurements:

- Tables: Tables assist with comparing operators. They should avoid numbers that are meaningless or irrelevant, they should be confined to the main points, and explain any unusual quality levels.

- Bar charts: One bar chart represents the measurements for all the operators of one parameter. Multiple bar charts can be put on a shared axis, if their scales are compatible.

- Star ratings: Star ratings are useful to summarize quality of service measurements, perhaps for publication as press releases, text messages and radio broadcasts. They can combine weighted measurements for some or all of the parameters for each operator into a figure of merit.

1.2 Existing quality of service frameworks

Section 4 of the report provides an overview of the best practices of international, regional and national quality of service regulation which we used for developing the proposed AFUR parameters. It also sets out our findings from the survey we carried out on existing quality of service regulation in AFUR member and observer countries.

We describe the international and regional framework of quality of service regulation and point to some noteworthy examples in Africa and elsewhere in the world:

- International Telecommunication Union (ITU): The ITU, through the ITU –Telecommunication Standardization Sector (ITU-T) and the ITU – Radiocommunication Sector (ITU-R), has developed perhaps two hundred recommendations that concern quality of service or network performance. However, they have been developed by different groups over many years and

therefore they do not provide a consistent set of measurement methods. In addition, they focus on network performance (which does not deal with user experience directly) more than on quality of service and on “service functionality” parameters, not “customer interface” or “network interface” parameters.

- European Telecommunications Standards Institute (ETSI): Many of the ETSI definitions are suitable as inputs into national definitions, but few are detailed enough to ensure that measurements from different operators are comparable. Furthermore, ETSI does not consider targets and thus do not provide any guidance to AFUR in that respect.

- There is no international organization for broadcasting that is comparable with ITU. ITU-T and ITU-R have been performing many relevant functions. Much the same is true at a regional level; for instance, the European Broadcasting Union helps to develop specifications but they are published through the ETSI and other organizations.

- We reviewed the activities of several regional groupings of regulators such as the Communications Regulators Association of Southern Africa (CRASA), the West Africa Telecommunications Regulators Assembly (WATRA), the Association of Regulators of Information and Communications Technologies for Eastern and Southern Africa (ARICEA), the Association of Regulators of Telecommunications of Central Africa (ARTAC) and the East African Regulatory, Postal and Telecommunications Organisation (EARPTO). So far none of these have proposed quality of service parameters, though they have worked on related topics, such as interconnection.

- The best known regional initiative that has developed quality of service regulations is the Eastern Caribbean Telecommunications Authority (ECTEL). It names parameters and suggests targets, but does not describe measurement methods for these parameters.

- We provide examples of emerging economies with quality of service regulation that are potentially relevant to AFUR members and other countries in Africa. These countries include India, Malaysia, Mauritania and Nigeria.

- We also identify the principal parameters used in various countries where quality of service regulation applies, including many in Africa, and list targets and real measurement results from several countries. These targets and real measurement results can be used by AFUR member countries to select their own targets and to pursue a process of continued information sharing, so that the targets of AFUR member countries follow a common path as the networks develop.

Furthermore, we reviewed experiences in quality of service regulation and carried out a survey across AFUR member and observer countries.

- In total, seven countries responded to the survey. There are some emerging patterns across these countries that allow for some general statements with regard to the services that are subject to quality of service regulation, the selection of parameters and targets have been selected, the reporting period, the audit of measurements, and the way compliance is ensured.

- In many countries, quality of service regulation is still limited because regulators tend to turn to consumer protection and consumer enforcement after dealing with competition problems as the communication markets mature. Furthermore, the high cost may prevent some regulators from implementing an effective quality of service framework. Across Africa, for broadcasting there has been little quality of service regulation.

1.3 Outline and details of proposed AFUR parameters

In Section 5 of the report we outline and discuss the choices made with regard to the proposed AFUR parameters. Details of the proposed AFUR parameters, including application, measurement methods and publication measurements, are provided in Section 6 of the report.

The parameters selected are most closely related to ETSI documents. They differ from ETSI in that they extend their application to cover other retail services and wholesale services; they restrict the allowed measurement methods to make measurements more readily comparable between operators; and they make minor changes to names, definitions and (very few) numerical values to simplify implementation or use. An overview of the proposed AFUR parameters is provided in Table 1 below.

Table 1: List of proposed AFUR parameters (executive summary)

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

For each of the parameters, we provide a brief description, propose an application, list the measurements that need to be published (since some of the measurements need to be made but not necessarily published), the unit of measures and provide values for the targets to be set.

We describe measurement methods that help with making measurements comparable between operators. However, other measurement methods can sometimes be better suited to local conditions, so we discuss their selection. If other measurement methods are adopted in some countries the measurements will not necessarily be comparable between operators in different countries. We also expect there to be national variation in the most suitable medium and format for publication for measurements, so we put forward many possibilities with advice on their merits.

We mention additional considerations affecting the choice and design of the proposed AFUR parameters. Among these are:

- Distinctions between account complaints and other complaints and possible variations depending on the country specific circumstances;
- Appropriateness of answer seizure ratio as quality of service parameter;
- Use of names (ratios and times) for proposed AFUR parameters;
- Current state of audio and video quality assessment; and
- Expectations for Next Generation Networks (NGNs).

2 Introduction

2.1 Project background

The regulation of Quality of Service (QoS) provided by communications providers has received increasing attention from regulatory authorities over the past few years. One obvious reason is that the provision of modern and high quality communications services is in the interest of consumers, businesses and the economic development of any country. Furthermore, the debate on QoS has gained in importance due to the introduction of competition in the communications sector in Africa, regional initiatives which aim at increasing the availability of borderless communications services, and recent discussions in many African countries on consumer rights and effective consumer protection in communications and other public services.

Despite the importance of QoS, there have been a number of challenges in practice: many regulators have found it difficult to keep QoS regulation at the top of their list of priorities and even more established regulators have struggled with defining and prioritising the 'right' parameters as well as effectively measuring and monitoring the standards set for these indicators.

The African Forum for Utility Regulators (AFUR) has been established with the objective of encouraging the development of effective utility regulation within Africa by promoting cooperation and fostering dialogue between regulators. Within AFUR, the Communications Sectoral Committee has recently been established as one of three sectoral committees of AFUR (water and energy sector committees being the other two).

PricewaterhouseCoopers Associates Africa Ltd has been appointed by the AFUR to carry out a consultancy on the elaboration of common guidelines on minimum quality of service (QoS) standards for communication services. The objectives of the project are to:

- Review quality of service standards for communication services in Africa and benchmark these against international best practice quality of service regulation;
- Develop common guidelines on minimum quality of service standards for communications;
- Facilitate a participatory consultation workshop with AFUR members and other critical stakeholders.

As part of this project, the Consultant carried out a survey amongst AFUR members and observers on the existing quality of service regime in each country. A workshop has been held in Pretoria on the 3rd and 4th of April 2008. The results of the survey and the workshop have been incorporated in this report.

As suggested by delegates at the workhop, regulators in Africa can apply the guidelines now while working in close co-operation with other bodies such as the ITU-T Study Group 12 Africa Regional Group on Quality of Service and the ITU-T Study Group 2 Quality of Service Development Group to develop further guidelines.

2.2 Scope and structure of report

In this report, we followed the Quality of Service definition of the International Telecommunication Union (ITU). The organisation defines quality of services as the "collective effect of service performances, which determine the degree of satisfaction of a user of the service".[1]

As a result, quality of service concerns aspects of services that users experience directly. Quality of service regulation is an important part of customer protection. However, there are other aspects of customer protection and how operators manage their business that are not covered by quality of service regulation, but are subject to codes of practice and other form of performance regulation (e.g. itemised billing, disconnection policies, complaint resolution processes).

Furthermore, quality of service can be contrasted with network performance and network planning. This report does not cover network standards and is only concerned with network performance as it has a direct effect on users of services.

A key objective of this assignment has been to propose common guidelines on minimum quality of service standards for communications services. These guidelines would be recommendations issued by AFUR to its members and observers. The specific objectives of these guidelines are:

- To provide information on principles of quality of service regulation to assist countries develop and improve on their existing quality of service regulations;
- To develop a harmonised framework in the area of quality of service regulation across African countries;
- To set minimum standards to ensure that consumers across Africa do not suffer from unacceptable levels of service;
- To hold service providers accountable for their performance and thus improve service levels across AFUR members and other countries.

The remainder of the document is structured in four parts:

- Section 3 sets out the fundamentals and serves as information on key principles and tools with regard to quality of service regulation.
- Section 4 provides the results of our review of existing quality of service frameworks including international standards, examples from some selected countries and responses from survey questionnaires.
- Section 5 outlines the choices the Consultants made to develop the proposed AFUR parameters.
- Section 6 lists all proposed parameters and provides details with regard to the application, measurement method, publication, target and related parameter for each parameter.

[1] ITU-T Recommendation E.800.

3 Fundamentals of quality of service assessment

3.1 Definitions

The terminology used in discussions of quality of service in electronic communications (telecommunications and broadcasting) varies from one document to another. Even the term 'quality of service' has been used in several ways. In this section the terminology used in this report is explained and the scope of quality of service regulation is outlined.

3.1.1 Quality of service and network performance

The global organisation for standards in telecommunications is the International Telecommunication Union (ITU), particularly through ITU – Telecommunication Standardization Sector (ITU-T). In ITU-T Recommendation E.800, quality of service is "the collective effect of service performances, which determine the degree of satisfaction of a user of the service"[2]. This definition is adopted in this report.

However, sometimes 'quality of service' has had much more restricted meanings. For instance, it has also been used to refer to the effects of networks on user satisfaction, or even to various techniques for carrying multiple traffic types well over Internet Protocol (IP) networks; the term 'quality of experience' is then sometimes used to describe what in this report is called 'quality of service'[3].

Quality of service concerns aspects of services that users experience directly. It can be contrasted with network performance, which, again according to E.800, is "the ability of a network portion to provide the functions related to communication between users". In this report it is not limited to the effects of networks: in various countries users complain more about the accuracy of billing than about the ability to make calls across the networks.

Quality of service regulation, in this report, is part of consumer protection (and consumer empowerment, which involves providing information to consumers to help them make choices), not network planning: regulators, on behalf of the public, might specify the desired quality while operators design networks to achieve that quality[4]. However, consumer protection is broader than quality of service regulation: it also involves regulating sales and other activities that are not usefully measured in the ways characteristic of quality of service regulation. In particular, the content transmitted using electronic communications, such as broadcast programmes, might be inside the scope of consumer protection but is outside the scope of quality of service regulation: quality of service for broadcasting concerns the reception, not the content, of programmes.

The distinction between communication services and content services is not always easy to make. The use of telephony to support financial services is a case that can be difficult, at least if calls and

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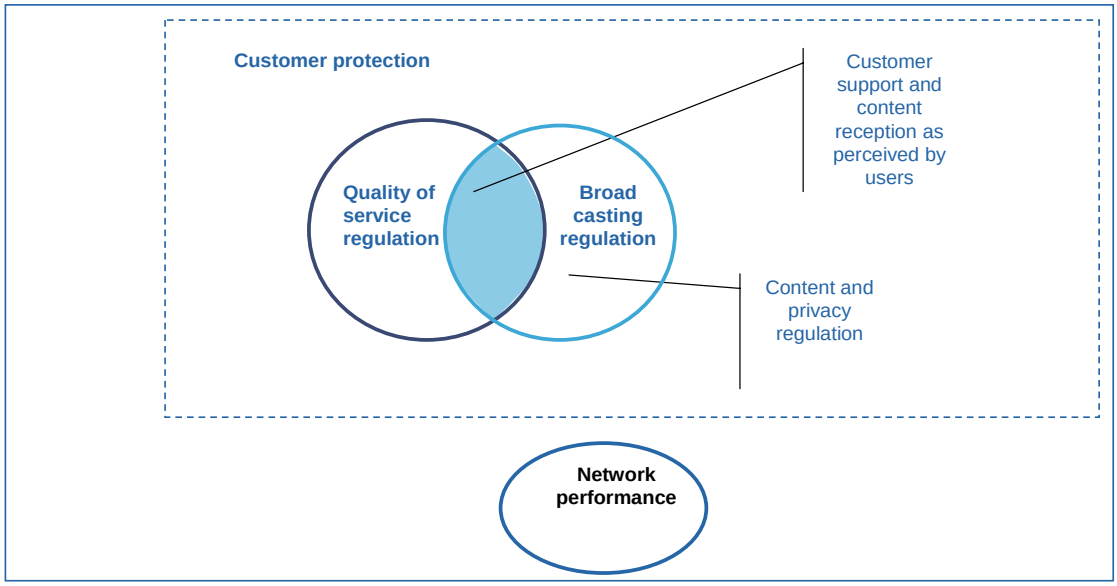
[2] See ITU-T Recommendation E.800, *Terms and definitions related to quality of service and network performance including dependability*, August 1994, at http://www.itu.int/rec/T-REC-E.800.
[3] See ITU-T Recommendation P.10 Amendment 1, *Amendment 1: New Appendix I – Definition of Quality of Experience (QoE)*, January 2007, at http://www.itu.int/rec/T-REC-P.10.
[4] In this report the term 'regulator' covers government ministries, not just separate regulators, and the term 'operator' covers all service providers, not just network operators

financial transactions appear on the same bills. In this report, financial services are considered only in so far as they use the customer interface (for complaints about bills and other matters) that is used by electronic communication services. For telephony, consumer protection might have secondary importance to people for whom any service is better than none; for financial services this is not so. Financial services need to be regulated, especially as they are becoming available to low-income people through telephony, but their regulation is outside the scope of this report.

Figure 1 illustrates the definition of quality of service regulation against other meanings.

Figure 1: Relation of quality of service regulation to broadcasting regulation



3.1.2 Parameters and targets

Quality of service regulation needs measurements that characterise the quality of aspects of services. The measurements are made according to prescribed methods. The definitions of the measurements to be made are called ‘parameters’, ‘indicators’, ‘metrics’, ‘measures’, ‘indices’, or ‘determinants’ in different documents[5]. The term ‘parameter’ is used in this report, because it is perhaps the most widely used in discussions of electronic communications.

The measurement method associated with a parameter can sometimes provide multiple measurements almost as easily as single measurements; for instance, a measurement method that provides the average time taken to repair faults might also provide the proportion of faults repaired after 1 day. Typically, some measurements characterise quality in a way that is helpful enough to publish. Other measurements might be useful for other purposes, such as analysing trends. For all purposes parameters need clear and precise definitions and measurement methods.

[5] The AFUR *Final Common Guidelines on Minimum Quality of Service for Water and Sanitation Standards* and *Common Guidelines on Minimum Quality of Service and Reliability Standards for Electricity* use the terms ‘measures’ and ‘indices’ respectively.

Measurement methods describe how measurements are made, not how operators manage their businesses. For instance, methods of measuring complaints do not usually require that bills are itemised, that emergency calls are permitted despite disconnection, that trouble tickets are allocated to complainants or that complaints are resolved by independent adjudicators. Such requirements are the subjects of codes of practice and periodic reports by operators about obligations to customers.

A target is a potential value (or range of values) for a parameter that must be reached if quality is to be regarded as satisfactory. Targets are called 'objectives', 'benchmarks', 'thresholds', 'minimum standards' or 'reference values' in different documents[6]. Unfortunately, all of these terms have other meanings, too; for example, targets sometimes represent quality levels that are desirable but not mandatory or that are to be reached after some number of years[7]. Overall, for electronic communications 'targets' is perhaps the most usual of these terms.

This variation in terminology reflects a variation in practice. Some targets are intended for maintaining quality above levels that have already been reached in the country; to set them, regulators have to know what quality levels have been reached. Other targets are intended for improving quality from levels that have already been reached in the country, so they represent desired quality levels that are typically set during successive years; to set them, regulators have to know what quality levels could be reached, in what times and at what costs.

3.1.3 Classes of parameters

The "degree of satisfaction of a user of a service" is determined by user experiences of the customer interface (how the service is presented), the network infrastructure (how the service is provided) and the service functionality (what the service provides, such as voice calls or television broadcasts). For instance, telephone users want to know that bills are correct, that faults are rare and that conversations are audible.

These classes of user experience have corresponding classes of quality of service parameter. They concern:

- **The customer interface independent of network infrastructure and service functionality**. The "customer interface" parameters are relevant to all services and might have the same targets for all services. An example is the frequency of billing complaints.

- **The network infrastructure independent of service functionality**. The "network infrastructure" parameters are relevant to all services but might have different targets for different services. An example is the time taken to repair faults.

[6] The AFUR *Final Common Guidelines on Minimum Quality of Service for Water and Sanitation Standards* and *Common Guidelines on Minimum Quality of Service and Reliability Standards for Electricity* both use the term 'minimum standards'.

[7] The AFUR *Final Common Guidelines on Minimum Quality of Service for Water and Sanitation Standards* suggests times by which its minimum standards should be reached. The AFUR *Common Guidelines on Minimum Quality of Service and Reliability Standards for Electricity* use the term 'target' to refer to quality levels that are desired but not mandatory.

- **The service functionality**. The “service functionality” parameters are specific to particular services and might have their own targets. An example is the quality of voice conversations.

In fact, “customer interface” and “network infrastructure” parameters are relevant not only to electronic communications services but also to services provided by utilities such as electricity supply and water supply (and “customer interface” parameters are relevant even more widely than that). However, users might have different expectations for different services, so parameters that are monitored for one service might not be monitored for another.

Because it concerns user experience, quality of service regulation should be neutral about technology as far as possible; for instance, the parameters for voice calls or television broadcasts should be independent of whether the access is wireline or wireless. However, in practice some technologies are much better suited to some aspects of services than others. Also, often different technologies are adopted by different operators or available under different licences, with the effect that some operators are much better equipped to fulfil some obligations than others. For instance:

- Voice calls with wireline access are less likely to fail after being answered than voice calls with wireless access, and indeed the call retention ratio (the proportion of calls that are kept up after being answered) is often not even measured for them.

- If (as is quite common) cable television operators have local licences while satellite television operators have national licences, then cable television operators might be able to monitor parameters separately for separate areas much more readily than satellite television operators.

Thus users of similar services from different operators might be interested in different parameters Also, some measurements will be difficult to make for some operators but easy to make for others.

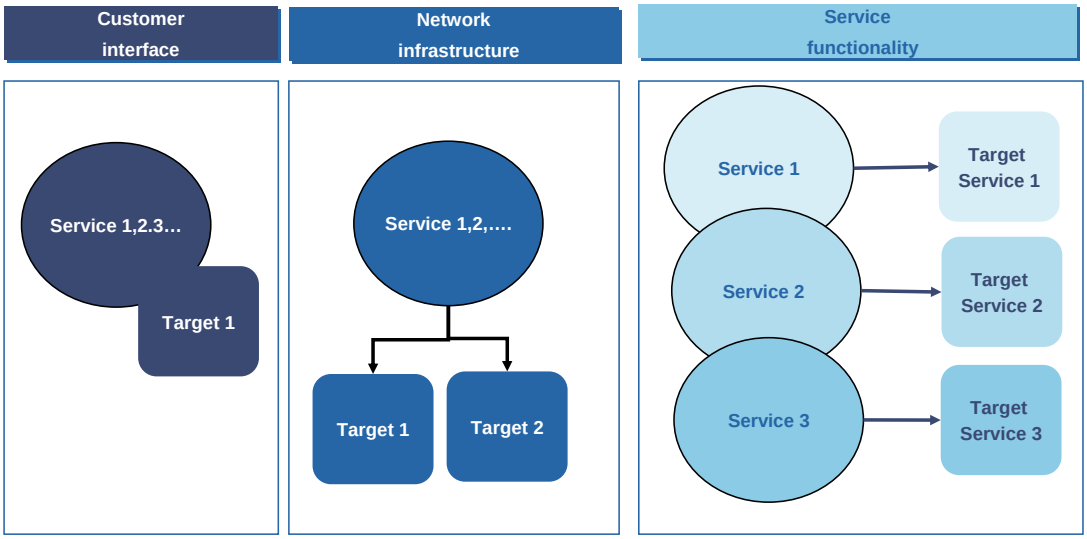
Conventionally, parameter definitions and published measurements are organised not according to service type (such as voice calls or television broadcasts) but according to operator type (such as fixed wireless access network operator or cable television operator). In this report they are organised according to service type, because doing so clarifies and shortens comparisons between countries with different licence classifications. Both ways of organising the parameters have advantages and disadvantages. In particular:

- For users seeking to choose between operators, organising published measurements according to operator type is appropriate. However, organising parameter definitions according to operator type leads to duplication and confusion if different licence classifications (with or without fixed wireless access network operators, for example) are considered or new licence classes (such as unified licences) are introduced.

- For regulators seeking to achieve consistency in their treatments of different operator types, organising parameter definitions according to service type is preferable. However, they need to remember that users of similar services from different operators might be interested in different parameters.

Figure 2 provides an overview of different classes of parameters as defined in this report and the use of targets.

Figure 2: Classes of parameters



3.1.4 Names for parameters

Many parameters that are widely used have different names in different countries. To simplify comparisons and introduce the proposed AFUR parameters, in this report parameters are generally named according to the same conventions, irrespective of how they are named in the countries where they are used. Typically:

- The frequency of actions (such as fault report submissions) per customer per reporting period (which is a time period for which the measurement of a parameter is reported) is assessed by a "rate"[8]. Thus the parameter named "fault report submissions rate" signifies the number of fault report submissions per customer in a reporting period. The rate depends on the reporting period: there will be approximately four times as many fault reports and other events in 12 months as in 3 months. The names of rate parameters are chosen so that lower rates indicate better quality.

- The proportion of actions (such as setting up calls) that succeed is assessed by a "ratio"[9]. Thus the parameter "call setup ratio" signifies the proportion of calls that are set up successfully; it is also known by such names as "call setup success ratio" and has as its complement a parameter with names such as "unsuccessful call ratio" and "probability of end-

[8] In this report the term 'rate' has a meaning that is slightly different from its meaning in the background paper *ICT Quality of Service Regulation: Practices and Proposals* and the workshop presentation that preceded this report.

[9] In this report the term 'ratio' has a meaning that is slightly different from its meaning in the background paper *ICT Quality of Service Regulation: Practices and Proposals* and the workshop presentation that preceded this report.

to-end blocking"[10]. The names of ratio parameters are chosen so that higher ratios indicate better quality.

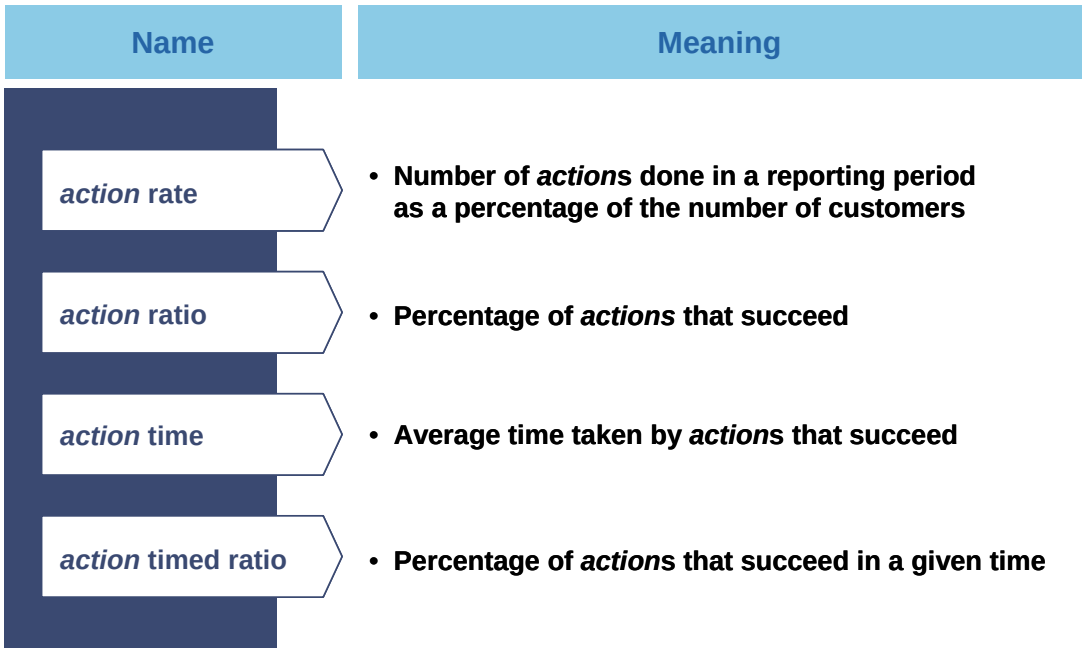
- The average time taken by actions that succeed is assessed by a "time". Thus the parameter named "fault repair time" signifies the average time that is taken to repair faults. In practice other times are often provided besides the average; a widespread one is the 95th percentile of the distribution of times, which is the upper bound on the times taken by 95% of the actions. The names of time parameters are chosen so that lower times indicate better quality.

- The proportion of actions that succeed within a given time is assessed by a "timed ratio"[11]. Thus the parameter named "fault repair timed ratio" signifies the proportion of faults that are repaired within a time identified by the parameter; this time might be 1, 2 or 3 days, for example. Parameters that are timed ratios are therefore generalisations of parameters that are ratios: ratios implicitly depend on the maximum times taken by actions that succeed, while timed ratios relate to times besides those maximum times. The names of timed ratio parameters are chosen so that higher timed ratios indicate better quality.

The figure (Figure 3) below provides examples of names and their meanings.

Figure 3: Examples for parameter names and meanings

[10] The 'complement' of a parameter that has measured value *m* is a parameter that has measured value 100%-*m*. This is not a standard definition, but it is a useful one, as lower values for a parameter can indicate either better or worse quality, depending on the definition of the parameter.
[11] In some documents parameters having names ending in 'time' are actually timed ratios. The term 'timeliness' is used instead of 'timed ratio' in the background paper *ICT Quality of Service Regulation: Practices and Proposals* and the workshop presentation that preceded this report.



3.2 Rationale for quality of service regulation

Utilities such as electricity supply and water supply are often dominated by single suppliers. Also, a faulty supply can cause death. Quality of service regulation has then a particularly important role in ensuring that the performance is adequate and the supply is safe.

For electronic communications the rationale for quality of service regulation is not always so straightforward, as there are often competing operators and the supply itself does not raise questions of safety (though, of course, the availability of the supply is important in emergencies). For instance, mobile telephony might be provided by three or four networks, and television might be available from various satellites and cables, as well as terrestrial (land-based) wireless. However, there are still likely to be some operators in dominant positions: a historic incumbent operator often has a large part of the market for fixed telephony (and for internet) and a public service broadcaster sometimes has the only terrestrial television channels[12]. Moreover, even where there are competing operators,

[12] The definition of 'dominance' varies from country to country and is not always applied to wholesale products as well as to retail ones. In the European Union, for example, dominance (Significant Market Power) is now defined to be "a position of economic strength that lets a company, individually or jointly with others, behave to an appreciable extent independently of competitors and customers". Assessing individual dominance involves examining at least market shares, the scope for price competition, product similarities and the barriers to market entry. Assessing joint dominance involves

quality of service regulation has been shown to be useful in several circumstances in various countries.

In this section these circumstances, and the corresponding uses of quality of service regulation, are discussed; several of them hold in almost every country in Africa[13].

3.2.1 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 rollout 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.

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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.

[13] For discussions of these circumstances in greater detail, with examples from several countries, see Robert Milne, ITU Global Seminar on Quality of Service and Consumer Protection, *ICT Quality of Service Regulation: Practices and Proposals*, August 2006, at www.itu.int/ITU-D/treg/Events/Seminars/2006/QoS-consumer/documents/QOS_Bkgpaper.pdf.

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.

3.2.2 Limitations on targets

The different aims in Section 3.2.1 point in slightly different directions: some point to publishing quality levels while others just point to monitoring them. Also, they indicate that targets would not necessarily be applied, or might be applied only to dominant operators, not to other operators. Of course, dominant operators might suggest that “to protect customers” any quality of service obligations imposed on them should be imposed on other operators too, but doing this could build barriers to entry by limiting the speed and flexibility with which other operators could offer services.

In fact, targets might limit customer choices between quality and price unnecessarily. In some countries, both business and residential customers can choose between services offering better guarantees and services offering lower prices; targets might narrow the choices.

Targets might be set for any subsidised universal service provider. As the subsidy is justified by the reluctance of operators to serve an area, the universal service provider is the dominant, and even the only, operator in the area, and targets can be justified as for any other dominant operator. Accordingly some groups have suggested that universal service providers should be obliged to offer services that reach the quality levels reached by services elsewhere in the country. Others suggest that a different trade-off between quality and cost would be appropriate in such areas, essentially because any service is likely to be better than none, particularly for users who have not already experienced high quality levels.

If there is a policy that emergency calls can be made from any telephone, targets might be needed for all telephony networks. However, there have been cases in developed countries where networks have barred lower priority traffic so that emergency services could operate; more demanding targets would simply be too expensive. In general, making emergency support function throughout the entire country quickly raises many challenges for Africa; making sure that emergency calls can be made is only one of them.

3.3 Principles underlying quality of service standards

As Section 3.2.1 indicates, there are essentially three levels of quality of service regulation: monitoring parameters, publishing measurements and setting targets, each of which builds on the one before.

There are very many possible parameters. Those that are adopted must be selected carefully, to avoid burdening regulators and users with information that cannot be assimilated easily and to avoid burdening operators with tasks that cannot be done economically. The criteria for selecting parameters to be monitored, measurements to be published and targets to be set are outlined in this section[14].

3.3.1 Parameters to be monitored

Because this report is concerned with quality of service, not network performance, the parameters monitored should be important to users. They should also be practical for operators, as monitoring can be inconvenient and costly. In particular: ·

- They should relate to the aspects of services that have the biggest impact on users as a whole. (Often the services will be the most widely used ones, but this might not be so: the degradation of a service used by people with disabilities might have a bigger impact than the degradation of a more common service.) However, they should also relate to matters that operators can control, such as numbers of base stations.

- They should be defined precisely enough that differences in interpretation and implementation do not lead to systematic (non-random) differences in measurements. However, as far as possible, they should have methods of measurement, periods of measurement and geographic areas for measurement that are already used by the operators.

- They should be reported in ways that distinguish between different services, times of year and geographic areas for which there could well be perceptible differences in quality. However, as far as possible, they should not require more measurements than are likely to be needed to establish these differences.

- They should be consistent between services (so that the same parameter is used for different services when it has approximately the same importance to users of the services), at least if the services are substitutes for one another.

There are, of course, conflicts here; for instance, if two operators are measuring similar parameters in different ways, defining a parameter precisely enough is likely to entail introducing methods of measurement that are not used by one of the operators. In general, being precise is preferable to adhering to the existing practice of operators.

[14] For discussions of these criteria in greater detail, with examples from several countries, see Robert Milne, ITU Global Seminar on Quality of Service and Consumer Protection, *ICT Quality of Service Regulation: Practices and Proposals*, August 2006, at www.itu.int/ITU-D/treg/Events/Seminars/2006/QoS-consumer/documents/QOS_Bkgpaper.pdf.

3.3.2 Measurements to be published

Parameters often have published measurements. (Having many published measurements might confuse users, so there might also be measurements that are just seen by the regulator, for purposes such as analysing trends.) These should be helpful to users. At the same time they should be fair to operators; for instance, there might need to be an explanation of why a service had poor quality, if the operator of the service was not directly responsible. In particular:

- They should relate to the aspects of services that users experience directly, not to underlying technical causes. For instance, for traffic handling there should be end-to-end measurements, if possible; network-by-network measurements might be useful for monitoring, but not for publication.

- They should reach their intended listeners or readers (who are typically either users or journalists and others active on behalf of users). Radio broadcasts or calls to freephone numbers, for example, might reach many more people than newspapers or websites. (The times and locations of publication should be widely publicised, whatever medium is adopted.)

- They should be described in terms that users can understand. This is easier if they are presented consistently with each other (so that, for example, higher ratios always indicate better quality).

- They should be presented in ways that assist with comparisons between different operators (by having measurements for different operators side-by-side, for example). However, they might need to be accompanied by explanations when an operator depends on another operator in ways detrimental to quality (perhaps through inadequate interconnection capacity or resilience).

- They should be expressed as precisely as is needed to show perceptible differences in quality and to hide random differences between measurements. However, they might need to be accompanied by explanations when they might not reflect true or lasting states of affairs (because, for example, a service has too few users for measurements to be precise enough).

- They should not be accompanied by extra, irrelevant, numbers. For instance, the number of test calls made for measurements does not help users: auditors should have already checked that the number is large enough to make the measurements precise enough.

Again there can be difficulties in providing published measurements that satisfy all these criteria; for instance, there can be difficulties in expressing measurements precisely enough to show perceptible differences in quality without sometimes drawing attention to random differences between measurements. In such cases an explanation by the regulator (or by the operator, with vetting by the regulator) can help.

3.3.3 Targets to be set

The targets should be both useful to users and realistic for operators. In particular:

- They should relate to the quality levels that users want. (These might vary according to the state of development of the service, the market segment and the geographic area.)
- They should avoid limiting customer choices between quality and price. This might point to setting them for dominant operators but not for alternative operators.
- They should be set by adapting values determined through earlier measurements by the operators, used in other countries or proposed in international standards. By observing what the operators in the country achieve in practice, the regulator can appreciate what quality levels have been reached and what quality levels could be reached. Values from other countries might not be appropriate to the country or might be for subtly different parameters.

Unfortunately, external pressures sometimes force targets to be devised using insufficient information about what users want and what operators can achieve. In these circumstances, ultimately the targets are disregarded and regulation becomes discredited.

3.4 Distinctions within quality of service parameters

The classification of parameters in Section 3.1.3 still leaves much room for flexibility in the form of quality of service regulation. The measurements of a parameter might still distinguish between different market segments, times of year and geographic areas, as well as operators and services. The extents to which measurements should make these distinctions are discussed in this section.

3.4.1 Market segments

In some countries there are differences in quality between offerings to private individuals, offerings to small businesses and offerings to large businesses. (Often the differences relate to the customer interface.) An operator maintaining such differences is in effect offering separate services to different market segments. These services should be separated from each other for the purposes of quality of service regulation. Once competition is well established, the offerings to large businesses might not need monitoring in urban areas; however, private individuals and small businesses are likely to continue to need published measurements.

An operator (especially a dominant operator) is also likely to have separate offerings for other operators; for instance, it may provide leased lines to other operators (who themselves use or resell leased lines), as well as to large businesses. In making such offerings, a dominant operator should not be able to discriminate against alternative operators, who should get the same quality level from the offerings as the dominant operator gets. Here again the separate offerings should be treated as separate services for the purposes of quality of service regulation. The service offered by a dominant operator to alternative operators might be required to reach targets that are high enough to prevent discrimination against the alternative operators.

3.4.2 Reporting periods

Quality of service regulations call for measurements of parameters to be reported periodically, at the end of each 'reporting period'. In some countries the reporting period is 1 month and in other countries the reporting period is 12 months, but it is most commonly 3 months.

A very short reporting period might be appropriate in a market that is developing very rapidly (though quality of service might be maintained better if the operators did not have the distraction of providing measurements to the regulator). A very long reporting period might be appropriate where the market is mature and quality does not vary much throughout the year. However, generally 3 months seems satisfactory for the reporting period. It is perhaps the smallest period in which seasonal variations in quality, or the effects of actions to improve quality, will be perceived by users as a whole.

3.4.3 Reporting areas

In many countries there are differences in quality between urban areas and rural areas (and, sometimes, between rich areas and poor areas). These differences might be inevitable when investment is determined purely by financial considerations, without taking into account social factors. However, they should at least be understood. Accordingly, as noted in Section 3.3.1, parameters should be monitored separately (and measurements should be published separately) for separate areas where there are likely to be differences in quality. Each such area is a 'reporting area'.

How many reporting areas there should be depends heavily on the country. Ideally:

- Reporting areas should have boundaries that match the boundaries of administrative areas used for indicators of development.
- Reporting areas should separate out large metropolitan areas. (These often house at least 10% of the population or 1 million people.)
- Reporting areas should be separate from each other if they have different dominant operators for the services being monitored. (This applies in particular to areas that have operators subsidised by universal service funds, as such operators are typically the only operators in their areas.)

However, small operators might need to be allowed to combine areas for measurements, because the costs of measurements bear most heavily on them; for example, the number of test calls needed to make precise enough measurements in a given area is independent of the size of the operator.

Geography affects the network infrastructure much more directly than it affects the customer interface. Usually the published measurements for "customer interface" parameters do not vary much between areas. Some regulators also take the view that the published measurements for "network infrastructure" and "service functionality" parameters should not be allowed to vary much between areas; they then need to impose targets on operators subsidised by universal service funds. Other regulators take the view that some differences in quality are acceptable when the costs of provision are different.

3.4.4 Operators

Section 3.2.1 suggests various circumstances in which quality of service regulation (in the forms of monitoring parameters, publishing measurements and setting targets) is appropriate. In these circumstances, if monitoring parameters or publishing measurements is appropriate for some operators then it is generally appropriate for all operators. Still, some operators might be exempted on the grounds of practicality (reducing inconvenience and cost) mentioned in Section 3.3.1. In particular:

- Operators with few customers might be exempted, because measurements could be unrepresentative or burdensome, especially for a new service; however, some operators and regulators argue that the benefits are so great and the burdens are so light that a service should not be launched without being monitored in the same ways as competing services.

- Resellers can be exempted to the extent that they simply resell services using the infrastructures of others that are subject to monitoring.

By contrast with monitoring parameters or publishing measurements, setting targets is not necessarily appropriate for all operators if it is appropriate for some. Dominant operators might need to reach targets to guard consumers and the other operators against detrimental effects of cutting costs and against unfair or inadequate interconnections; though other operators might also try to reduce quality, they are less likely to retain their customers if they do so. There are, of course, cases in which rapid customer acquisition overstretches operators; in these cases, setting targets might help, but publishing measurements, so that potential customers can choose between competing operators, is perhaps more likely to do so.

When quality of service regulation is appropriate, monitoring parameters and publishing measurements is necessary for all operators (except in the cases mentioned above), but setting targets is necessary mainly for dominant operators.

3.4.5 Services

As noted in Section 3.3.1, the parameters monitored should relate to the aspects of services that have the biggest impact on users as a whole. Typically there would be no parameters specific to obsolescent services, such as telex. Also, there might be no parameters specific to services which have very few users, unless those users are very heavily dependent on the services; for instance, there might be no parameters monitored for the non-voice features of multimedia calls unless either such calls have become widely used or people with impaired hearing or speech depend heavily on them for effective communication.

In most countries the services that are most important to users are:

- **Voice calls**. Voice calls might be made by fixed or mobile telephony and might use the internet. Only calls between numbers in the national numbering plan would be considered for the purposes of quality of service regulation. Most quality of service requirements are the same for modem calls (for facsimile and data) as for voice calls.

- **Text messages**. Text messages might be sent over GSM and CDMA networks and might use the internet. Only messages between numbers in the national numbering plan would be considered for quality of service regulation. Unstructured Supplementary Service Data (USSD) is available on GSM networks but not on CDMA networks, unlike Short Messaging Service (SMS); it would not be regarded as providing text messages for the purposes of quality of service regulation.

- **Internet sessions**. Internet sessions can be established by dial-up or "always on" connections through fixed or mobile networks. Often dial-up and "always on" connections are distinguished in quality of service regulation; however, there are awkward cases like ISDN and GPRS which use dial-up connections but give the appearance of being always on. To be neutral about technology, dial-up and "always on" connections should be grouped together in one service type. Similarly, narrowband and broadband connections should be grouped together. Applications using internet sessions (such as email and web access, and indeed voice over the internet) do not need to have their own quality of service parameters, if the targets for internet sessions are adequate to meet their demands.

- **Television broadcasts**. Terrestrial television, cable television and satellite television (and indeed television delivered by telephony operators, over their own fixed and mobile networks) are all forms of television. The basic requirements for quality of service can be independent of the technology adopted for transmission. However, hand-held devices have such different screen sizes from conventional televisions that there is still limited understanding of appropriate parameters and targets..

- **Radio broadcasts**. Radio (in the sense of audio broadcasting) is believed to be almost universally available now in its conventional terrestrial form. It is also now popular when delivered over the internet. Nonetheless, formal quality of service obligations have rarely been associated with it.

- **Leased lines**. Leased "lines" (which could easily be microwave radio links, not lines) are very important to large businesses and alternative operators. Quality of service regulation might not be needed for retail leased lines offered to large businesses in urban areas, but it is likely to be needed for wholesale leased lines offered to alternative operators by dominant operators.

This list of services excludes some, such as voice chat ("push to talk"), that are popular in some countries but not very widespread, and all, such as virtual private networks, that are aimed only at large businesses.

Even with these exclusions, the list could be too long for several countries. Imposing quality of service regulation on all these services is not always necessary or desirable: it can increase overheads without improving quality. Exempting some services from mandatory monitoring, while encouraging voluntary monitoring, is preferable except in the circumstances listed in Section 3.2.1.

Universal service providers often have quality of service obligations that go beyond those of other operators. In particular, they may be obliged to ensure that the public sites where they offer service,

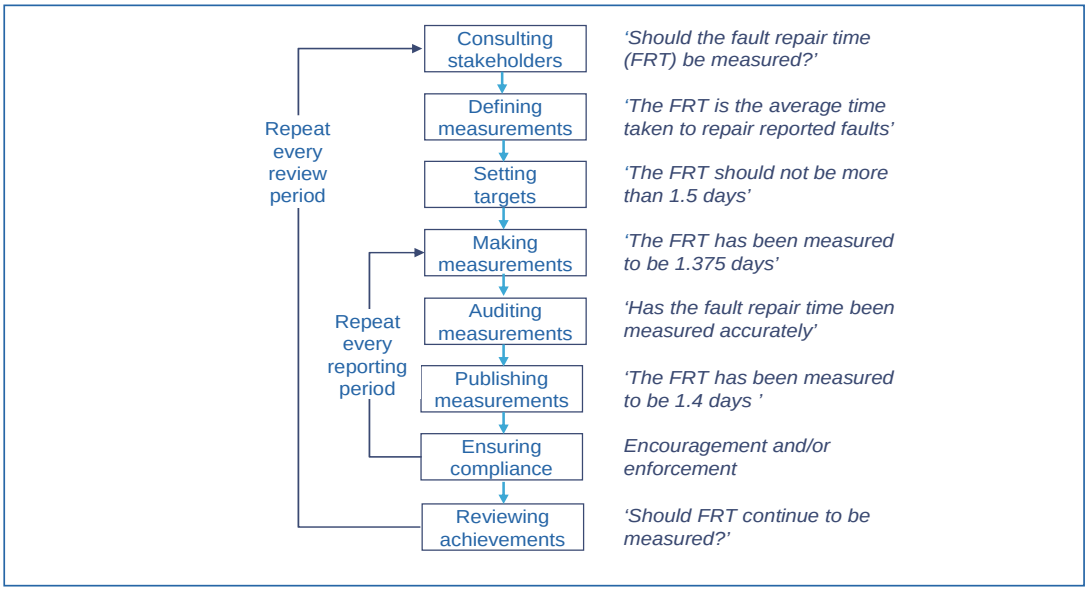
such as pay telephone stands and internet access centres, provide assistants and working equipment for enough time.

3.5 Activities in quality of service regulation

In this section the main activities required by quality of service regulation, and the organisations that perform them, are considered[15]. Some of them can be performed by operators or even users instead of the regulator.

Figure 4 provides an overview of the main activities in quality of service regulation as described in this report.

Figure 4: Activities in quality of service regulation



Adopted from Milne, R Robert Milne, ITU Global Seminar on Quality of Service and Consumer Protection, ICT Quality of Service Regulation: Practices and Proposals, August 2006.

3.5.1 Defining parameters

Operators have great knowledge and experience that can contribute to defining parameters: they typically make measurements even if there is no regulation, they understand how their networks work, and they appreciate what the concerns of users are. Other organisations might also be able to contribute, especially if they represent consumers. Regulators generally benefit by involving operators and other organisations in industry groups for defining parameters.

[15] For discussions of these activities in greater detail, with examples from several countries, see Robert Milne, ITU Global Seminar on Quality of Service and Consumer Protection, *ICT Quality of Service Regulation: Practices and Proposals*, August 2006, at www.itu.int/ITU-D/treg/Events/Seminars/2006/QoS-consumer/documents/QOS_Bkgpaper.pdf.

Industry groups might take many months to agree on definitions, partly because individual operators wish to minimise their own disruption and expense and partly because they might need to examine measurement procedures in detail. Regulators need to ensure that the parameters are defined fairly rapidly and are not distorted by particularly powerful operators. They also need to verify that the definitions are not open to slightly different interpretations that could invalidate comparisons between operators.

Then the parameters might be acceptable to everyone. However, they would still need to be reviewed from time to time to check their continuing relevance. Different aspects of services might have the biggest impact on users as networks develop. In a country with a long waiting list, the number of years taken to get a telephone might be the focus of interest. As the network expands, the ease of making a successful call might predominate. Once the network is fully developed and adequately dimensioned, support services like billing might attract most complaints.

3.5.2 Setting targets

Usually, regulators set whatever targets there are. Yet there are alternatives to this. For instance, operators could set their own targets, so they could offer varied choices of quality and price but would be obliged to publish their targets and whether their targets were reached; however, in at least one country where this is done, regulators still need to ensure that the targets are demanding enough.

Setting targets needs less detail than defining parameters, so industry groups are less useful for it. In its case, regulators that wish to set targets can take the knowledge and experience of operators into account by due consultation and prior monitoring to determine realistic quality levels. The possible targets mentioned in the parameter definitions are intended to help with this process, not to replace it.

3.5.3 Making measurements

Different organisations might be responsible for making measurements of different parameters. In fact:

- For most “customer interface” and “network infrastructure” parameters the measurements are conveniently made by operators. In particular, the operators might be obliged to check customer satisfaction by holding customer surveys; these might include questions wanted by the operators (to assess interest in new services, for example), as well as questions wanted by the regulator (about complaint handling, for example).

- For many “service functionality” parameters the measurements are best made by external measurement agencies, because doing so allows clear comparisons between operators and, sometimes, lowers the costs of measurements. In particular, drive-around tests for mobile telephony are more easily compared and less costly if they are done at similar times, between similar places and in similar circumstances for all operators. (The costs of such measurements can be covered by the operators through licence fees or directly, perhaps in proportion to subscriber numbers, coverage or revenue.) Co-operation between the operators in defining the parameters can be valuable in identifying occasional anomalies due to faulty measurement equipment or incorrect applications of measurement procedures.

- For some “service functionality” parameters the measurements might be made by users. Thus some regulators ensure that internet users can perform tests and report results for comparisons. Such tests and results might provide useful information for enthusiastic users, even if they do not do so for all users. They could become more significant in the future, as end terminals, including telephones, are becoming “intelligent” enough to monitor and report quality levels automatically.

3.5.4 Auditing measurements

Measurements that are seen by the operators before they are submitted to the regulator should be signed off by senior employees in a ‘self-certification’ process. They are therefore probably audited for accuracy by or for the operators. Measurements made by external agencies can be submitted to the regulator or even published before the operators see them.

The regulator might still want measurements to be audited independently. Doing this can be inconvenient and costly and can delay publishing measurements. To increase confidence in the measurements but limit costs the regulator might audit just some measurements, selected at random or through being suspect. The regulator can also check measurements in other ways, such as comparing them with the complaints received or performing “mystery shopping” to test complaint handling. All these checks need careful design, as audit procedures can easily become too lax or too burdensome. The possibility of independent auditing can itself be quite effective in ensuring the accuracy of measurements: quality of service measurements might not hit the headlines, but legal proceedings for falsifying them will.

3.5.5 Publishing measurements

Publishing measurements is essential if customers are to base choices of services on general observations, not just personal anecdotes. It is best done by the regulator, not the operators, as comparisons between operators can then be made directly, by putting measurements for different operators next to each other. If it is done by the operators then the regulator might issue press releases to draw attention to particular features, but fairness to operators requires prior formalisation of which features will have attention drawn to them. (The formalisation might involve setting targets or devising weightings to apply to the measurements.)

Publishing many measurements from many operators at many times is a complex task. However, the task can be simplified by reducing the numbers of measurements published. This can be done by requiring measurements for fewer market segments, longer reporting periods, larger reporting areas, fewer operators or fewer services.

3.5.6 Ensuring compliance

Operators are only likely to fulfil quality of service obligations if legitimate concerns are addressed. A requirement for successful quality of service regulation, therefore, is to take into account the opinions of operators and consumers fully and openly. This can be achieved through formal consultations.

In fact, the regulator might not need to impose obligations. One possible practice is to begin with recommendations, rather than obligations: operators could choose whether to take part in monitoring parameters and publishing measurements, which might have indicative targets. Recommendations can be used to test both the importance and practicality of parameters and the willingness of

operators to take part. Obligations can follow fast, if the parameters are important and practical but operators are not willing to take part.

Even after making recommendations and conducting consultations, regulators need techniques for ensuring that operators fulfil obligations. These techniques might rely on encouragement (and, in particular, on the power of publicity) or on enforcement (and, in particular, on immediate effects on profits). The power of publicity is greatest when published measurements distinguish between competing operators: condemning operators collectively may achieve little. Immediate effects on profits attract attention from senior management in operators but may distort measurement reporting within operators and to regulators.

There is a range of techniques that regulators can adopt for ensuring that operators fulfil obligations, particularly when quality levels are not high enough. For instance:

- They can publicise deficiencies to customers by issuing text messages, bill inserts or radio advertisements. This amounts to “naming and shaming”.

- They can demand extra measurements, shorter reporting periods, or detailed targets. (They might also demand a halt to all promotional activities if the quality levels have fallen drastically because of rapid growth in customer numbers.) This might be appropriate when the actions needed to improve quality can be effective fast.

- They can require the adoption of remedial plans that are monitored by external agencies skilled in network design and operation.

- They can require the payment of compensation to customers. This is most useful when customers can notice different quality levels very easily, can request compensation directly and have accounts into which compensation can be paid. It is therefore well suited to wholesale services. In some countries it is made available for retail services when, for example, customer complaints or fault reports are handled too slowly.

- They can impose fines. However, doing this can involve extensive legal processes and may take a long time.

- They can change prices (by introducing quality factors into price controls, effectively with rewards for good quality as well as penalties for bad quality). However, tighter price control might lead to cost cutting and quality reductions.

- They can take even more drastic enforcement techniques that are not related directly to quality of service, such as excluding access to government contracts, withdrawing licences or transferring franchises. These are difficult to make proportionate to the infringements.

3.6 Measurement methods

The methods of measuring parameters affect both the practicality of monitoring parameters and the helpfulness of publishing measurements: though different operators might need to adopt slightly different methods to reduce the inconvenience and cost, users must be sure that the resulting measurements are comparable with each other.

Broad distinctions between measurement methods are discussed in this section, to indicate why certain methods are preferred in this report.

3.6.1 Subjective and objective measurements

Some parameters are measured by 'subjective' methods (surveying users) as opposed to 'objective' methods (making tests, sampling calls, counting complaints and so on).

Generally objective methods do not exclude subjectivity completely; for example, counting complaints depends ultimately on subjective decisions, about whether to complain and about what constitutes a complaint (as opposed to a query, for example). Still, they clearly limit areas of subjectivity.

Some parameters have more obviously subjective measurement methods. In particular, customer surveys that ask for opinions (about responsiveness to customer enquiries or comprehensibility of service descriptions, for example) are subjective. There are great difficulties in designing a survey and obtaining results that could be published as a fair and comprehensive statement about the quality of all important aspects of services for all operators. Nonetheless, customer surveys could be valuable in checking whether particular parameters are important to users and whether quality of service assessments match the perception of users. Indeed, there are countries where they provide the only way in which the regulator assesses quality of service.

3.6.2 Network-by-network and end-to-end measurements

In general, "network infrastructure" and "service functionality" parameters relate to paths through networks; for example, the delay between a user on one network (X) and a user on another network (Z) that passes through exactly one further network (Y) is the sum of three delays (from the user in X to a point of interconnection of X with Y, from the point of interconnection of Y with X to a point of interconnection of Y with Z, and from the point of interconnection of Z with Y to the user in Z).

These parameters can be measured network-by-network or end-to-end. Thus:

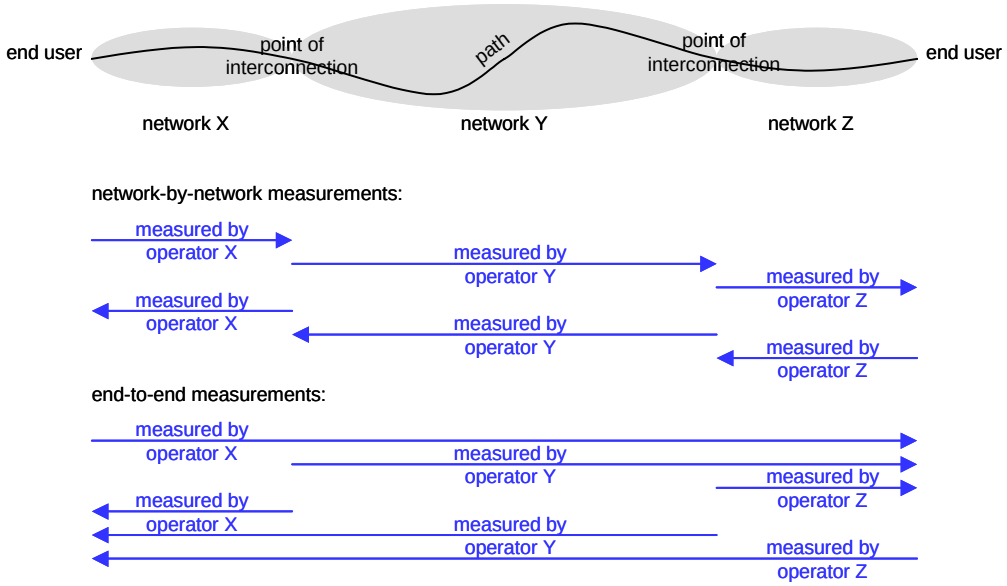
- When measurements are made network-by-network, individual networks are considered in isolation; if, for example, an end-to-end delay along a path is to be published then it must first be calculated by summing the network-by-network delays across the individual networks used by the path. The network-by-network measurements individually do not represent what users experience when paths end in other networks, but they do represent what different operators control directly.

- When measurements are made end-to-end, individual networks are considered in combination, so an end-to-end delay along a path is measured directly (and the delay averaged over all paths through a network takes account of paths ending outside the

network). The end-to-end measurements therefore represent what users experience on average, but they do not represent what different operators control directly.

The measurements are shown in the figure below.

Figure 5: Network-by-network and end-to-end measurements



Source: Robert Milne (Antelope Consulting)

Publishing end-to-end measurements is consistent with limiting attention to aspects of services that are directly perceived by customers. It should not be unfair to operators, if they can add notes to published measurements to explain service deficiencies due to other operators.

The parameters with end-to-end measurements characterise quality levels as experienced by the users that pay for the services of an operator. For retail users, these parameters deal with paths from end terminals such as telephones. For wholesale users (who are other operators), these parameters deal with paths from points of interconnection to representative destinations (which might be end terminals or other points of interconnection); these parameters therefore provide insight into individual network performance, just as parameters with network-by-network measurements do.

3.6.3 Real traffic and test traffic measurements

In general, “service functionality” parameters can be measured using real traffic or using test traffic. For measurements from different operators to be comparable, they should all use either real traffic or test traffic. Here:

- When real traffic is used, an automatic data collection system, with counters in network elements, counts and analyses the traffic (especially the signalling). The measurements do not typically match the experiences of users, because the traffic is analysed only if it flows successfully along the links from end terminals into the networks (so a transmission that fails on its first link is not counted). Also, the counts need to be interpreted carefully, because there can be different counting mechanisms and different signalling modifications in different types of network elements. However, the measurements do not depend on particular end terminals

attached to the networks, so they can be made even for wireline access networks in which all the end terminals are in private houses.

- When test traffic is used, test transmissions are initiated using end terminals, so the experiences of users can be sampled. Measurements are collected less cheaply and easily than when real traffic is used, particularly if the parameters have end-to-end definitions instead of network-by-network ones.

If the measurement methods use test traffic, there needs to be at least a minimum number of tests per reporting period, reporting area, operator and service. This minimum number affects how well the measurements reflect the true state of affairs. The table below illustrates this.

Table 2: Number of tests and confidence intervals in test traffic measurements

required number of tests {more accurately stated required number of tests}	**95% confidence interval for a measured percentage of 99.0%**	**95% confidence interval for a measured percentage of 96.0%**	**95% confidence interval for a measured percentage of 90.0%**	**95% confidence interval for a measured time of *m* if the observed standard deviation is at most twice the observed mean**
1500 {1537}	98.5%-99.5%	95.0%-97.0%	88.5%-91.5%	*m*x90%-*m*x110%
1000 {1068}	98.4%-99.6%	94.8%-97.2%	88.2%-91.8%	*m*x88%-*m*x112%
750 {784}	98.3%-99.7%	94.6%-97.4%	87.9%-92.1%	*m*x86%-*m*x114%
600 {601}	98.2%-99.8%	94.4%-97.6%	87.6%-92.4%	*m*x84%-*m*x116%

Source: Robert Milne (Antelope Consulting)

The test traffic should flow at traffic-weighted times between traffic-weighted locations, but achieving this can be inconvenient and costly. One approximation to it is obtained by making the measurements during the 6 hours when the traffic is expected to be most intense on certain days. Other possible approximations are to make the tests throughout 12 or even 24 hours and to make the tests during just 1 busy hour; the first of these would not assess quality at the time when user experiences are most severely affected by poor performance and the second would not make very efficient use of equipment and staff, particularly for drive-around tests for mobile telephony.

Successive tests of the same network should be separated by a long enough time to ensure the release of the network resources and to eliminate the effects of transient network problems; 60 seconds is usually a long enough time.

The traffic-weighted locations for test traffic are such that:

- If they act as sources of traffic for retail services then they represent points inside the reporting area where there are end terminals connected to the network of the operator.

- If they act as sources of traffic for wholesale services then they represent points of interconnection inside the reporting area where the traffic flows into the network of the operator.

- If they act as destinations of traffic then they represent points inside or outside the reporting area where there are end terminals or international routes at international gateways (which are in fact particular points of interconnection).

The traffic-weighted locations should represent points that are responsible for a large enough proportion (perhaps 90%) of the real traffic for the service. They could be selected so that each access network element (such as a local exchange, for a wireline access network, or a base station, for a wireless access network) was exercised in enough tests; however, doing this could be unnecessarily expensive unless large local variations in quality levels are expected.

3.7 Publication formats

Websites and paper reports are the commonest places in which quality of service measurements are published. However, their immediate users are then limited (though they include journalists, consumer representatives and enthusiastic users who might tell other people). Other ways of reaching a wider public include text messages, bill inserts, radio advertisements and recorded freephone calls. Radio programmes, newspaper articles and even web sites allowing user feedback on communications services can be very valuable, at least when they are not controlled by the same companies as the operators.Some of the forms of publication discussed in this section are suitable for presentation in speech as well as in writing and in summary as well as in full.

There is evidence from psychological experiments that people make judgements that are no better than random when they must judge against too many standards: for example, five standards produce judgements that are better than random but twelve do not. Accordingly several published measurements might need to be combined before being presented to users. One way of doing this combines all the measurements of the parameters in the “customer interface”, “network infrastructure” or “service functionality” class; it results in three measurements (indicating the quality levels of the customer interface, the network infrastructure and the service functionality).

3.7.1 Tables

When measurements are published in writing they are usually organised in tables. These tables should assist comparisons between operators and be accompanied by any necessary explanations of unusual quality levels. (The explanation would be written or vetted by the regulator.) They should not present numbers that are meaningless or irrelevant; they should confine themselves to the main points, with links to annexes for further details if necessary. For some countries, the tables are very large, because there are many parameters and many operators. In these circumstances the tables are likely to have few users but might be used by operators seeking to compare themselves with other operators.

Separate services should be reported separately. In particular, if business and residential services have different terms and conditions that result in different quality they are in fact two separate services and should be treated as such for quality of service monitoring. Consequenctly, tables of measurements should name the service, not just the operator, when the operator offers different

terms and conditions.

The figure below illustrates this for three parameters for four services in one reporting area. For three out of the four services there are explanations of why quality levels fell short of what might be desired.

Table 3: Use of tables in publishing measurements

Service name	Fault repair time (target: 1.5 days)	Packet delay (target: 40 milliseconds)	Packet loss (target: 1.0%)	Explanatory remark
X Supernet	3.5 days	34 milliseconds	3.5%	The quality was affected by slow fault repair by the backhaul operator.
Z Business Net	0.3 days	26 milliseconds	0.5%	The measurements were made when the service had very few customers.
Z Residential Net	1.1 days	38 milliseconds	1.2%	The measurements were made for this area jointly with others, not for this area separately.
Y Packetspeed	1.4 days	34 milliseconds	0.8%	

Note: The numbers with grey backgrounds in the table indicate measurements worse than the targets. The numbers and the uses of targets for internet services in the table are not intended to represent best practice.
Source: Robert Milne (Antelope Consulting).

Ideally, published measurements should be rounded so that published differences between measurements are statistically significant but correspond only with differences in quality that are perceptible to users. This ideal can be approached by schemes that round measurements, at least for measurements in widely found ranges. The published measurements could be rounded in the direction of better quality (which could sometimes mislead users) or in the direction of worse quality (which could sometimes displease operators). For instance, if parameters are defined in such a way that lower measurements indicate better quality, and if published measurements are rounded in the direction of better quality, the published measurements are rounded downwards.

Any rounding scheme has the disadvantage that some measurements that are close together move further apart when rounded. The best that can be hoped for is to move further apart only those measurements that many people would already regard as far apart because their leading digits differ; from that point of view rounding downwards (moving 15.9 to 15 and 16.0 to 16) is better than rounding upwards (moving both 15.9 and 16.0 to 16).

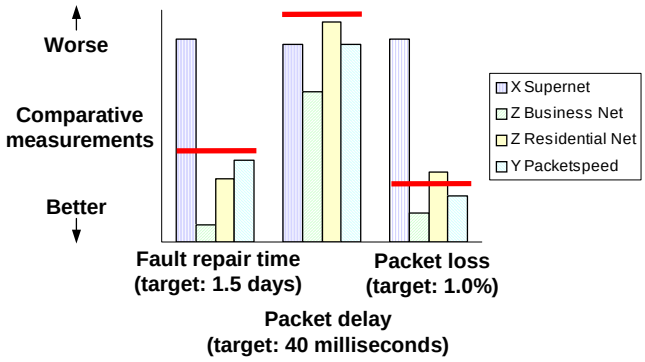
One rounding scheme that often works quite well entails rounding measured percentages down to one percentage point and rounding measured times down to two significant figures; thus fault repair times of 1.1 days and 1.9 days are treated as different (and are written as “1.1 days” and 1.9 days” respectively), but fault repair times of 15.1 days and 15.9 days are treated as the same (and are both written as “15 days”). For the measurements that occur in practice, rounding schemes like this correspond very loosely to assuming that with roughly 95% confidence the measured times are within 10% of the “actual” values.

3.7.2 Bar charts

An alternative to the use of tables is to organise the measurements as bar charts. There can be one bar chart per parameter; alternatively, multiple bar charts can be clustered on a shared axis, with each group of bars representing the measurements of all the operators for one parameter.

The figure below organises the earlier example table as bar charts. There are three parameters for each of four services, just as in the example table.

Figure 6: Use of bar charts in publishing measurements



Note: The horizontal lines represent the targets. The numbers and the uses of targets for internet services are not intended to represent best practice.
Source: Robert Milne (Antelope Consulting).

In effect, bar charts make implicit the rounding that is explicit for tables, because users will ignore minor differences in heights of bars more readily than they will overlook differences between numbers such as “15.9” and “16.0”. Bar charts also allow confidence intervals (based on the observed measurements) to be drawn around the published measurements, to illustrate how significant the apparent differences between operators are.

Other graphical formats are also used occasionally. In particular, individual measurements resulting from drive-around tests for mobile telephony are sometimes overlaid on maps. Publishing individual measurements does not provide a usable overall picture, but it does let users focus on the locations that are most important to them.

3.7.3 Star ratings

Star ratings might be devised to summarise quality of service measurements, perhaps for publication as press releases, text messages or radio broadcasts. The ratings would combine weighted measurements for all the parameters (or all the parameters in the “customer interface”, “network infrastructure” or “service functionality” class) for each operator into a figure of merit that would in turn be mapped to a five-point scale. The weightings and mapping would best be designed according to the results of customer surveys or, failing that, consultations with consumer representatives. (Also, they might need to express a non-linear relation between consumer dissatisfaction and measured values for parameters.).

The figure below summarises the earlier example table as star ratings. There are two star ratings for each of four services, to assess how each service is provided (according to the “network infrastructure” parameter) and what each service provides (according to the “service functionality” parameters). (The example table does not include any “customer interface” parameters.) The two “service functionality” parameters are mapped into one star rating by giving them equal weight but regarding the star rating as failing to reach a target if either of the parameters fails to reach its target.

Table 4: Use of star ratings in publishing measurements

Service name	How the service is provided	What the service provides
X Supernet	★	★★★
Z Business Net	★★★★★	★★★★★
Z Residential Net	★★★	★★★
Y Packetspeed	★★★	★★★

Note: The stars with grey backgrounds indicate measurements worse than the targets. The numbers and the uses of targets for internet services in the table are not intended to represent best practice.
Source: Robert Milne (Antelope Consulting).

Though percentages (such as rates, ratios and timed ratios) can be weighted and combined, measurements that are not percentages (such as times) are not so readily weighted and combined; they must first be normalised as percentages. The normalisation techniques might depend on the beliefs about the likelihood of particular measurements. For instance, measured times might be normalised by assuming a truncated negative exponential relation between measured times and likelihoods that would be determined by the average measured time and a worst case time (the longest allowed duration of an event).

4 Existing quality of service frameworks

4.1 Sources of quality of service parameters

The sources of parameters that are most relevant to this report are described in this section. Both international and national sources deserve attention: the international ones provide the most extensive parameter definitions and the national ones indicate what is important to users and practical for operators in some countries.

4.1.1 International Telecommunication Union

The International Telecommunication Union was originally concerned with making sure that electronic communications operated coherently across national boundaries, through the use of compatible international standards and radio frequency management. Standards were developed through ITU – Telecommunication Standardization Sector (ITU-T) and radio frequencies were managed through ITU – Radiocommunication Sector (ITU-R).

Quality of service activities were often related to international telephone traffic (with notions such as the answer seizure ratio) and to transmission systems (with notions such as the bit error ratio). The ITU-T activities then grew. Thus ITU-T Recommendations E.721 and E.771 provide definitions of parameters with targets for typical telephone network reference connections (local, national, international, fixed and mobile)[16]. E.721 describes for fixed network services the times taken by various actions (mainly portions of the call setup time) and the complement of the call setup ratio. E.771 describes similar parameters for mobile network services and identifies one further parameter (the probability of unsuccessful handover). It analyses features that point to having less stringent targets for mobile network services than for fixed network services, such as limitations of the radio interfaces, the authentication of terminals, the paging of called users and the interrogation of home (and visited, in the case of roaming) network databases.

The ITU-T activities have now expanded further through the development of parameters and targets dealing with quality of service and network performance in IP networks, in ITU-T Recommendations G.1010 and Y.1541[17]. G.1010 summarises some empirical work on the targets needed by audio, video and data applications in IP networks[18]. Y.1541 demonstrates that the targets can depend heavily on the applications expected to use the IP networks: acceptable packet loss ratios, for example, can vary by several orders of magnitude between IP networks that just transfer files and IP

[16] See ITU-T Recommendation E.721, *Network grade of service parameters and target values for circuit-switched services in the evolving ISDN*, May 1999, at http://www.itu.int/rec/T-REC-E.721; ITU-T Recommendation E.771, *Network grade of service parameters and target values for circuit-switched public land mobile services*, October 1996, at http://www.itu.int/rec/T-REC-E.771.
[17] See ITU-T Recommendation G.1010, *End-user multimedia quality of service categories*, November 2001, at http://www.itu.int/rec/T-REC-G.1010; ITU-T Recommendation Y.1541, *Network performance objectives for IP-based services*, February 2006, at http://www.itu.int/rec/T-REC-Y.1541
[18] For a review of this and related material, see ETSI TR 102 479 V1.1.1, *Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Review of available material on QoS requirements of Multimedia Services*, February 2002.

networks that carry “clear channel” ISDN. Overall, several targets need in IP networks are still rather tentative, as some applications have not been assessed widely by users.

There are now perhaps 200 ITU-T recommendations that to some extent concern quality of service[19]. However, they have been developed by different groups over many years and do not provide consistent sets of measurement methods covering all aspects of services[20]. Generally, they only consider “service functionality” parameters, not “customer interface” or “network interface” parameters. Though their targets often relate to network performance, rather than quality of service (as they are calculated “bottom up”, from network equipment, not “top down”, from user experience), there are exceptions[21].

ITU-R has also gone beyond its central domain (radio frequency management). It has specified, identified and tested subjective and objective methods for assessing audio and video quality, sometimes jointly with ITU-T. Its investigations even extend to IP networks and multimedia services in ITU-R Recommendations BT.1720 and BT.1788[22]. It, too, sometimes provides targets intended to suit user experience[23]. Thus though ITU-R is formally concerned with wireless, not with broadcasting, it is increasingly involved in broadcasting. There is no international organisation for broadcasting that is strictly comparable with ITU; in an era of convergence, ITU-T and ITU-R are likely to fulfil that function.

Additionally, ITU – Telecommunication Development Sector (ITU-D) includes some quality of service parameters among its telecommunication indicators[24]. Currently these parameters relate to the

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[19] For descriptions of the ITU recommendations, see ITU, *Quality of Service and Network Performance*, January 2004, at http://www.itu.int/publ/T-HDB-QOS.02-2004.

[20] For ways of structuring the aspects of services that require quality of service assessment, see: ITU-T Recommendation E. 802, *Framework and methodologies for the determination and application of QoS parameters*, February 2007, at http://www.itu.int/rec/T-REC-E.802. ITU-T Recommendation G.1000, *Communications quality of service: A framework and definitions*, November 2001, at http://www.itu.int/rec/T-REC-G.1000. ITU-T Recommendation I.350, G*eneral aspects of quality of service and network performance in digital networks, including ISDNs*, March 1993, at http://www.itu.int/rec/T-REC-I.350.

[21] For instance, an ITU-T recommendation states what delays prevent conversations from deteriorating because speakers “talk through” each other or believe that nobody can hear them; see ITU-T Recommendation G.114, *One-way transmission time*, May 2003, at http://www.itu.int/rec/T-REC-G.114.

[22] See: ITU-R Recommendation BT.1720, *Quality of service ranking and measurement methods for digital video broadcasting services delivered over broadband Internet protocol networks*, July 2005, at http://www.itu.int/rec/R-REC-BT.1720; ITU-R Recommendation BT.1788, *Methodology for the subjective assessment of video quality in multimedia applications*, January 2007, at http://www.itu.int/rec/R-REC-BT.1788.

[23] For instance, an ITU-R recommendation states what delays prevent audible speech and visible lip movement from seeming out of synchronisation; see ITU-R Recommendation BT.1359, *Relative Timing of Sound and Vision for Broadcasting*, November 1998, at http://www.itu.int/rec/R-REC-BT.1359.

[24] For discussions of earlier ITU indicators, see ITU, *Telecommunication Indicators Handbook*, at http://www.itu.int/ITU-D/ict/material/handbook.pdf.

number of potential users waiting for fixed access connections, the proportion of faults cleared by the next working day and the fault report rate. As ITU-D recognises, these will be measured differently in different countries but can provide a general impression when they are put with the other telecommunication indicators.

4.1.2 European Telecommunications Standards Institute

Discussions with consumer representatives and industry groups in the European Union (EU) many years ago identified quality of service parameters for retail services that were important to users and practical for operators. These parameters were adopted by the EU, which gave the European Telecommunications Standards Institute (ETSI) the responsibility for defining the parameters more exactly. ETSI has refined the parameters for fixed and mobile retail telephony, and, following user surveys, has defined some parameters for retail internet[25]. ETSI has also provided variants for wholesale telephony[26]. The definitions provide "customer interface" and "network infrastructure" parameters as well as "service functionality" parameters, and include measurement methods. However, the definitions exclude targets, in the absence of information about what targets would be useful to users and realistic for operators.

The ETSI definitions leave open many choices: many of them are suitable as inputs to national definitions, but few of them are detailed enough to ensure that measurements from different operators are comparable. Countries both inside and outside the EU have taken them as inputs to national definitions (without always adding the details needed to make measurements comparable). Moreover, the Organisation for Economic Co-operation and Development (OECD) used the EU parameters as the basis of its biannual analysis of the outlook for telecommunications but omitted some parameters that made international comparisons difficult.

Though the ETSI definitions are used as the basis of quality of service regulation in the EU, practice across the EU varies greatly. For instance, a survey of 14 countries in the EU in 2003 established that:

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[25] See: ETSI EG 202 057-1 V1.2.1, *Speech Processing, Transmission and Quality Aspects (STQ); User related quality of service parameter definitions and measurements; Part 1: General User related quality of service*, August 2005, at http://pda.etsi.org/pda/queryform.asp. ETSI EG 202 057-2 V1.2.1, *Speech Processing, Transmission and Quality Aspects (STQ); User related quality of service parameter definitions and measurements; Part 2: Voice telephony, Group 3 fax and modem data services*, October 2005, at http://pda.etsi.org/pda/queryform.asp. ETSI EG 202 057-3 V1.1.1, *Speech Processing, Transmission and Quality Aspects (STQ); User related quality of service parameter definitions and measurements; Part 3: quality of service parameters specific to Public Land Mobile Networks (PLMN)*, April 2005, at http://pda.etsi.org/pda/queryform.asp.ETSI EG 202 057-4 V1.1.1, *Speech Processing, Transmission and Quality Aspects (STQ); User related quality of service parameter definitions and measurements; Part 4: Internet access*, October 2005, at http://pda.etsi.org/pda/queryform.asp. ETSI TR 102 276 V1.1.1, *User Group; Users' Quality of Service Criteria for Internet Access in Europe*, October 2003, at http://pda.etsi.org/pda/queryform.asp.

[26] See ETSI TR 101 949 V1.1.1, *Speech Processing, Transmission and Quality Aspects (STQ); QoS parameter definitions and measurements for use in network-to-network narrowband interconnection*, July 2002, at http://pda.etsi.org/pda/queryform.asp.

- 11 countries required publication of some quality of service measurements for operators with universal service obligations.

- 10 countries had some quality of service targets for operators with significant market power or with universal service obligations (and 3 of those had targets for other operators).

- 8 countries had powers to impose penalties for failures to reach targets.

- 5 countries had independent audits of quality of service measurements.

Currently quality of service regulation in the EU appears to be becoming stronger; for example, it is being introduced for retail fixed network services in France and for some wholesale services of the incumbent fixed network operator in the UK.

ETSI has also devised quality of service parameters for mobile network services with the Third Generation Partnership Project (3GPP)[27]. The services are video telephony, multimedia messaging, video streaming, file transfer, web browsing and email, as well as voice telephony and text messaging. The parameters are defined both "outside" and "inside" application interfaces (so they take into account more or less of the user experience). The measurement methods are accompanied by information on test procedures and on making measurements comparable between operators. Again, targets are excluded, though some experimental investigations of targets have been done[28].

ETSI is concerned with telecommunications. The European Broadcasting Union (EBU) is concerned with broadcasting. However, the EBU is not an international standardisation organisation in the same

[27] See: ETSI TS 102 250-1 V1.2.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 1: Identification of Quality of Service aspects*, March 2007, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-2 V1.5.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 2: Definition of Quality of Service parameters and their computation*, October 2007, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-3 V1.3.2, Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 3: Typical procedures for Quality of Service measurement equipment, September 2005, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-4 V1.2.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 4: Requirements for Quality of Service measurement equipment*, July 2007, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-5 V1.4.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality* of service aspects for popular services in GSM and 3G networks; Part 5: Definition of typical *measurement profiles*, August 2007, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-6 V1.2.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 6: Post processing and statistical methods*, October 2004, at http://pda.etsi.org/pda/queryform.asp; ETSI TR 102 274 V1.1.2, *Human Factors (HF): Guidelines for real-time person-to-person communication services*, January 2004, at http://pda.etsi.org/pda/queryform.asp.

[28] See ETSI TR 102 274 V1.1.2, *Human Factors (HF): Guidelines for real-time person-to-person communication services*, January 2004, at http://pda.etsi.org/pda/queryform.asp.

sense that ETSI is. It has developed specifications for broadcasters, but its new specifications are typically submitted to ETSI, the European Committee on ELEctrotechnical Standardization (CENELEC) or other organisations for standardisation; its work on Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB), for example, is published through ETSI and CENELEC. It also relies on ITU-R for the development of audio and video quality measurement methods.

4.1.3 Regional initiatives

Within Africa groupings of regulators of electronic communications are associated with overall regional organisations. They are:

- Communications Regulators Association of Southern Africa (CRASA) for the Southern Africa Development Community (SADC).
- West Africa Telecommunications Regulators Assembly (WATRA) for the Economic Community Of West African States (ECOWAS).
- Association of Regulators of Information and Communications Technologies for Eastern and Southern Africa (ARICEA) for the Common Market of Eastern and Southern Africa (COMESA);
- Association of Regulators of Telecommunications of Central Africa (ARTAC) for the Economic Community of Central African States (ECCAS).
- East African Regulatory, Postal and Telecommunications Organization (EARPTO) for the East African Community (EAC).

The African Telecommunications Union (ATU) and the African Union of Broadcasting (AUB) are associated similarly with the African Union (AU). There are also other groupings, such as the Arab states telecommunications Regulators Network (ARN) and the Francophone network of Telecommunication regulators (FRATEL).

So far none of these have proposed quality of service parameters, though, for example, CRASA has published guidelines on wireless regulation, WATRA has adopted guidelines on licensing, interconnection, numbering, spectrum and universal access, and ARICEA has drafted guidelines on interconnection and universal access.

The best known regional initiative that has developed quality of service regulations is due to the Eastern Caribbean Telecommunications authority (ECTEL). It names parameters and suggests targets for fixed and mobile retail telephony and for retail internet[29]. However, it does not describe measurement methods for the parameters. (As the dominant operators in the ECTEL countries are often affiliated to each other, the measurement methods chosen by them, at least, may be the same

[29] See ECTEL, *ECTEL's Consultation Document: Telecommunications (Quality of Service) Regulations*, November 2005, at http://www.ectel.int/ectelnew-2/consultations_files/QoS%20Regulations%20Consultation.pdf.

throughout the countries; however, these methods might not produce results comparable with measurements from other operators.)

4.1.4 National initiatives

In various countries there are quality of service regulations that are potentially relevant to Africa. For instance:

- In India, there are now regulations that cover fixed and mobile telephony, broadband internet, and cable and satellite television[30]. Some of the parameters chosen deal with network performance, not quality of service. Also, they have been developed at different times are influenced heavily by local differences between services, so they are not consistently applicable (as, for example, cable television is treated differently from satellite television).

- In Malaysia, for several years there have been regulations that cover fixed and mobile telephony, dial-up and "always on" internet, leased lines, public payphones and content supply (by telecommunications and broadcasting)[31]. The parameters chosen are important to users and consistently applicable (so billing complaints, for example, are treated in the same way for all services). The measurement methods defined for the parameters are objective (but sometimes not well stated).

- In Mauritania, every few months there are end-to-end tests of fixed and mobile telephony in different areas of the country[32]. The tests assess modem calls (for facsimile and data), as well as voice calls and text messages. The published measurements provide full details of where and how the tests were performed, including the products used as end terminals.

- In Nigeria, there are draft regulations that consider wholesale services as well as retail ones[33]. In various respects they resemble the regulations for Malaysia: they have a similar coverage

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[30] See: TRAI, *Regulation on Quality of Service of Basic and Cellular Mobile Telephone Services, 2005*, July 2005, at http://www.trai.gov.in/trai/upload/Regulations/3/regu1jul05.pdf ; TRAI, *Quality of Service of Broadband Service Regulations 2006*, October 2006, at http://www.trai.gov.in/trai/upload/Regulations/57/regulation6oct06.pdf; TRAI, *The Standards of Quality of Service (Broadcasting and Cable services) (Cable Television - CAS Areas) Regulation, 2006*, August 2006, at http://www.trai.gov.in/trai/upload/Regulations/52/qos220806clean.pdf. TRAI, *The Direct to Home Broadcasting Services (Standards of Quality of Service and Redressal of Grievances) Regulations, 2007*, August 2007, at http://www.trai.gov.in/trai/upload/Regulations/69/regulation31aug07.pdf.

[31] See MCMC, *What We Do: Quality Of Service*, at http://www.skmm.gov.my/facts_figures/codes_gl/index.asp.

[32] For a recent example of the test reports see ARE, *Contrôle de la qualité de service des opérateurs de télécommunications MAURITEL sa, MATTEL sa, et CHINGUITEL sa: Période du 07 au 24 janvier 2008*, at http://www.are.mr/rapportqos0108.htm.

[33] See NCC, *Nigerian Communications Act 2003: Quality Of Service Regulations 2006*, December 2006, at http://www.ncc.gov.ng/RegulatorFramework/Guidelines%20on%20QoS%20-%20100706.pdf.

(except for considering wholesale services as well as retail ones) and a similar emphasis on objective measurement methods.

The table below summarises the principal parameters used in these and other countries (keys are provided below the table). Where possible, the parameters have been named (and, if necessary, turned into their complements) according to the conventions described in Section 3.1.4. This summary inevitably omits many details. Also, it might contain misinterpretations, as in many cases there are no adequate definitions of the parameters.

Constructing such tables as this needs considerable care, because two parameters that have the same names in different countries are not necessarily comparable with one another. Full descriptions of the parameters must be examined to check whether they are comparable. For instance, calls that set up connections but that remain unanswered might or might not be counted as successful.

Table 5: The principal parameters used in various countries

Parameter: measurement specialisation (if any)	India	Malaysia	France[34]	UK	Egypt	Gambia	Ghana[35]	Kenya	Madagascar	Mauritania	Morocco-co	Niger	Nigeria[36]	South Africa	Swazi-land	Tanzania[37]	Uganda
Customer complaint submission rate		FT,MT,NI,R,CV,SV,TV														PP	
Customer complaint submission rate: account complaints	ET,ST,BI	FT,MT,NI,R,CV,SV,TV	FT	FT			MT	FT,MT				FT	ET,ST,NI,BI,LL			FT,NI,BI	FT,MT,NI,BI,LL
Customer complaint submission rate: disconnection complaints													ET,ST,NI,BI,LL				
Customer complaint submission rate: miscellaneous complaints								FT,MT[38]					ET,ST,NI,BI,LL			MT,NI,BI	
Customer complaint resolution time			FT														

[34] The regulations covering fixed voice services have been issued for consultation but not yet brought into force.
[35] The regulations including all these parameters have been issued for consultation but not yet brought into force.
[36] The regulations covering all the services have been issued for consultation but not yet brought into force.
[37] There appear to be conflicting parameters and targets.
[38] Miscellaneous complaints are subdivided further.

Parameter: measurement specialisation (if any)	India	Malaysia	France[34]	UK	Egypt	Gambia	Ghana[35]	Kenya	Madagascar	Mauritania	Morocco-co	Niger	Nigeria[36]	South Africa	Swazi-land	Tanzania[37]	Uganda
Customer complaint resolution time: account complaints													ET,ST,NI,BI,LL				
Customer complaint resolution time: disconnection complaints													ET,ST,NI,BI,LL				
Customer complaint resolution timed ratio		FT		FT					MT		FT,MT,BI					FT,MT,LL	FT,MT,NI,BI,LL
Customer complaint resolution timed ratio: account complaints	ET,BI,CV,SV	FT,MT,NI,R,CV,SV,TV													FT	NI,BI	FT,MT,NI,BI,LL
Customer complaint resolution time: miscellaneous complaints													ET,ST,NI,BI,LL				
Customer service answer ratio													ET,ST				
Customer service answer time							MT						ET,ST				
Customer service answer, timed ratio	ET,ST,BI,SV						MT										
Deposit or credit refund timed ratio	ET,ST															MT	
Customer satisfaction	ET,ST.MT,BI	FT,MT,NI,EBI,BI,R,CV,SV,TV					MT									FT,MT,PP	
Coverage: population																	
Coverage: area	ST				MT		MT			MT		MT			MT		
Service supply time			FT	FT			MT		FT				ET,ST,NI,BI,LL			FT	FT,MT,NI,BI,LL
Service supply timed ratio	ET,BI	FT,EBI, LL										FT			FT,MT,NI,BI	FT	
Fault report submission rate	ET	FT	FT	FT	MT			FT	FT			FT	ET,ST,NI,BI,LL			FT,MT	
Fault repair time	ET		FT		MT		MT		FT				ET,ST,NI,BI,LL			FT,PP	

Parameter: measurement specialisation (if any)	India	Malaysia	France[34]	UK	Egypt	Gambia	Ghana[35]	Kenya	Madagascar	Mauritania	Morocco-co	Niger	Nigeria[36]	South Africa	Swazi-land	Tanzania[37]	Uganda
Fault repair timed ratio	ET,BI, CV,SV	FT,EB I, LL		FT		FT,MT		FT				FT			FT	FT,MT ,PP	FT,MT
Availability	ST,BI	EBI, LL,PP, R, CV,SV ,TV			NI,BI	MT		MT,P P	MT						FT,MT ,NI,BI	BI,PP	FT,MT ,NI,BI, LL
Community isolation	ST								MT							MT	
Call setup ratio	ST	FT,MT	FT		MT	FT,MT	MT	MT	FT,MT	ST	MT	FT	ET,ST		MT	MT	FT,MT
Call setup time			FT				MT	MT							MT		
Call setup timed ratio		FT															
Call retention ratio	ST	MT[39]	MT[40]	MT[41]	MT	MT	MT	MT		ST	MT		MT		MT	MT	MT
Listening voice quality: objective			FT,M T	MT	MT		MT						ET,ST				
Listening voice quality: subjective	ST		FT		MT					MT	MT					MT	
Call completion ratio	ET							FT								FT	
Grade of service	ET							MT				MT				FT	FT
Value-added service call answer ratio: emergency assistance		FT,MT															
Value-added service call answer ratio: dial-up internet access							MT				MT		NI,BI				
Value-added service call answer time: operator assistance			FT														
Value-added service call answer timed ratio: emergency assistance		FT,MT										FT				FT	
Value-added service call answer timed ratio: operator assistance			MT														

[39] The call retention ratio is combined with the call setup ratio.
[40] The call retention ratio is combined with the call setup ratio.
[41] The call retention ratio is combined with the call setup ratio.

Parameter: measurement specialisation (if any)	India	Malaysia	France[34]	UK	Egypt	Gambia	Ghana[35]	Kenya	Madagascar	Mauritania	Morocco-co	Niger	Nigeria[36]	South Africa	Swazi-land	Tanzania[37]	Uganda
Value-added service call answer timed ratio: dial-up internet access		NI	MT													NI	
Message transmission ratio: SMS			MT								MT		MT				
Message transmission ratio: MMS			MT								MT						
Message transmission time: SMS										MT							
Message transmission time: MMS																	
Message transmission timed ratio: SMS			MT								MT						
Message transmission timed ratio: MMS			MT								MT						
Packet transmission ratio	EBI	EBI	MNI		NI,BI		MNI						NI,BI			BI	
Packet transmission time	EBI	EBI											NI,BI			BI	
Data transmission capacity	EBI	NI,EBI					MNI						NI,BI			BI	

Key:

FT Fixed Telephony
ET Wireline Telephony
ST Wireless Telephony
MT Mobile Telephony
NI Narrowband Internet
MNI Mobile Narrowband Internet
BI Broadband Internet
EBI Wireline Broadband Internet
LL Leased Lines
R Radio Broadcasting
TV Terrestrial Television Broadcasting
CV Cable Television Broadcasting
SV Satellite Television Broadcasting
PP Public Payphones

For reasons discussed in Section 5.5.4 not all of these parameters are given definitions in this report. The table below (Table 6) concentrates on those that are given definitions. It displays the targets that have been proposed or adopted in various relevant countries, along with the results of measurements that have been made in some other countries. (It lists the targets for timed ratio parameters as targets for either ratio parameters or time parameters, as appropriate.) It possibly contains misinterpretations, because the definitions provided in some countries are inadequate; it certainly contains simplifications, because, for example, in some countries measurements are made only during busy hours.

The intention behind this table is to allow further choices of targets for these parameters to be made by reference both to targets proposed or adopted elsewhere and to real measurement results. Just relying on targets proposed or adopted elsewhere could be misleading: in some countries, targets have been defined without taking full account of what is realistic and are not enforced. Both targets and real measurement results vary greatly between countries; of course real measurement results also vary within countries and over time. The real measurement results in the table are only examples taken at different times from different countries, but they illustrate the diversity that must be accommodated.

Table 6: Examples of targets and real measurement results from various countries

Parameter	Country: service specialisation (if any): measurement specialisation (if any)	Examples of targets for retail services[42]	Examples of real measurement results for retail services[43]
Customer complaint submission rate	India: wireline telephony: account complaints	0.1% in 1 billing period	0.1%-4% in 1 billing cycle
	India: wireless telephony: account complaints	0.1% in 1 billing period	0%-1% in 1 billing cycle
	India: broadband internet: account complaints	2% in 1 billing period	
	Malaysia: fixed telephony	5% in 12 months	1%-2% in 12 months
	Malaysia: mobile telephony	5% in 12 months	1%-3% in 12 months
	Malaysia: narrowband internet	5% in 12 months	0%-15% in 12 months
	Malaysia: radio broadcasting	5% in 12 months	
	Malaysia: television broadcasting	5% in 12 months	
	Malaysia: fixed telephony: account complaints	2% in 1 billing period	0%-2% in 1 billing period
	Malaysia: mobile telephony: account complaints	2% in 1 billing period	1% in 1 billing period
	Malaysia: narrowband internet: account complaints	2% in 1 billing period	0%-1% in 1 billing period
	Malaysia: radio broadcasting: account complaints	2% in 1 billing period	
	Malaysia: television broadcasting: account complaints	2% in 1 billing period	
	Singapore: mobile telephony: coverage complaints		0%
	Singapore: broadband internet: quality complaints		0%
	Brazil: fixed telephony: account complaints: local	2% in 1 month	0% in 1 month
	Brazil: fixed telephony: account complaints: national	2% in 1 month	0%-5% in 1 month
	Brazil: fixed telephony: account complaints: international	2% in 1 month	0%-4% in 1 month
	Brazil: mobile telephony	1% in 1 month	0%-2% in 1 month
	Brazil: mobile telephony: coverage complaints	0.4% in 1 month	0%-0.2% in 1 month
	Nigeria: account complaints	3% in 3 months	
	Nigeria: disconnection complaints	1% in 3 months	
	Nigeria: miscellaneous complaints	2% in 3 months	

[42] The targets for ECTEL, Jamaica and Nigeria have not yet been put into practice.

[43] The results for India and Brazil vary with the operator and the location. The results for Singapore and the UK vary with the operator. The results are those obtained in particular reporting periods, which are not the same for all the countries.

Parameter	Country: service specialisation (if any): measurement specialisation (if any)	Examples of targets for retail services[42]	Examples of real measurement results for retail services[43]
Customer complaint resolution time	India: wireless telephony: account complaints	4 weeks for 100%	4 weeks for 100%
	India: broadband internet: account complaints	4 weeks for 100%	
	India: cable television broadcasting: account complaints	7 days for 100%	
	India: satellite television broadcasting: account complaints	7 days for 100%	
	Malaysia: fixed telephony: account complaints	15 days for 90% and 30 days for 95%	15 days for 96%-100% and 30 days for 99%-100%
	Malaysia: mobile telephony: account complaints	15 days for 90% and 30 days for 95%	15 days for 91%-100% and 30 days for 96%-100%
	Malaysia: narrowband internet: account complaints	15 days for 90% and 30 days for 95%	15 days for 92%-100% and 30 days for 97%-100%
	Malaysia: radio broadcasting: account complaints	15 days for 90% and 30 days for 95%	
	Malaysia: television broadcasting: account complaints	15 days for 90% and 30 days for 95%	
	UK: fixed telephony: residential		28 days for 80%-100%
	UK: fixed telephony: business		28 days for 40%-100%
	Nigeria: account complaints	15 working days for the mean	
	Nigeria: disconnection complaints	1 working day for the mean	
	Nigeria: miscellaneous complaints	3 working days for the mean	
Customer service call answer ratio	India: wireline telephony: human response	80% in 60 seconds and 95% in 90 seconds	0%-96% in 60 seconds and 0%-100% in 90 seconds
	India: wireline telephony: electronic response	80% in 20 seconds and 95% in 40 seconds	0%-99% in 20 seconds and 0%-100% in 40 seconds
	India: wireless telephony: human response	80% in 60 seconds and 95% in 90 seconds	35%-100% in 60 seconds and 48%-100% in 90 seconds
	India: wireless telephony: electronic response	80% in 20 seconds and 95% in 40 seconds	40%-100% in 20 seconds and 75%-100% in 40 seconds
	India: broadband internet: human response	60% in 60 seconds and 80% in 90 seconds	
	India: satellite television broadcasting: human response	80% in 60 seconds and 95% in 90 seconds	
	India: satellite television broadcasting: electronic response	80% in 20 seconds and 95% in 40 seconds	
	Singapore: wireline telephony: fault reports	95%	
	ECTEL	70% in 20 seconds, 75% in 20 seconds and 80% in 20 seconds during successive years	
	Jamaica: wireline telephony: fault reports	95% in 20 seconds	
	Brazil: fixed telephony: day	98%	96%-100%
	Brazil: fixed telephony: night	98%	99%-100%
	Brazil: mobile telephony: morning	98%	95%-99%
	Brazil: mobile telephony: afternoon	98%	86%-99%
	Brazil: mobile telephony: night	98%	77%-99%
Coverage			

Parameter	Country: service specialisation (if any): measurement specialisation (if any)	Examples of targets for retail services[42]	Examples of real measurement results for retail services[43]
Service supply time	India: wireline telephony	7 days for 100%	7 days for 10%-100%
	India: narrowband internet	6 hours for 100%	6 hours for 100%
	India: broadband internet	15 days for 100%	
	Malaysia: fixed telephony	24 hours for 80%, 48 hours for 90% and 7 days for 100%	24 hours for 98%-100%, 48 hours for 98%-100% and 7 days for 100%
	Malaysia: wireline broadband internet	24 hours for 80%, 48 hours for 90% and 7 days for 100%	24 hours for 0%-99%, 48 hours for 0%-99% and 7 days for 40%-100%
	Malaysia: leased lines: local	1 week for 90% and 2 weeks for 100%	1 week for 13%-100% and 2 weeks for 17%-100%
	Malaysia: leased lines: national	2 weeks for 90% and 3 weeks for 100%	2 weeks for 30%-100% and 3 weeks for 32%-100%
	Malaysia: leased lines: international	4 weeks for 90% and 5 weeks for 100%	4 weeks for 26%-100% and 5 weeks for 86%100%
	Taiwan: mobile telephony	8 hours for the mean, 6 hours for the mean and 4 hours for the mean during successive years	
	Singapore: wireline telephony: residential	5 working days for 95% and 9 working days for 100%	5 working days for 95%
	Singapore: wireline telephony: business	5 working days for 95% and 9 working days for 100%	5 working days for 98%
	ECTEL: wireline telephony	14 days for 100%, 10 days for 100% and 7 days for 100% during successive years	
	ECTEL: mobile telephony	3 days for 100%, 2 days for 100% and 2 days for 100% during successive years	
	ECTEL: narrowband internet	5 days for 100%, 3 days for 100% and 2 days for 100% during successive years	
	Jamaica: wireline telephony: rural	48 hours for 80%	
	Jamaica: wireline telephony: urban	48 hours for 90%	
	Romania: wireline telephony	60 days for 95% and 75 days for 99%	
	Nigeria: wireline telephony	5 working days for the mean	
	Nigeria: wireless telephony	5 working days for the mean	
	Nigeria: narrowband internet	3 working days for the mean	
	Nigeria: broadband internet	3 working days for the mean	
	Nigeria: leased lines	5 working days for the mean	
Fault report submission rate	India: wireline telephony	5% in 1 month	1%-17% in 1 month
	Malaysia: fixed telephony	50% in 12 months	1%-23% in 12 months
	Singapore: wireline telephony	0.5% in 1 month	
	ECTEL: narrowband internet	3% in 1 month	
	Brazil: fixed telephony	1% in 1 month	1% in 1 month
	Romania: wireline telephony: direct	30% in 12 months	
	Romania: wireline telephony: indirect	40% in 12 months	
	UK: fixed telephony: residential		2%-32% in 6 months
	UK: fixed telephony: business		1%-15% in 6 months
	Nigeria	4% of customers in 3 months	

Parameter	Country: service specialisation (if any): measurement specialisation (if any)	Examples of targets for retail services[42]	Examples of real measurement results for retail services[43]
Fault repair time	India: wireline telephony	8 hours for the mean	1 hour-613 hours for the mean
	India: wireline telephony	1 working day for 90%	1 working day for 2%-100%
	India: narrowband internet	72 hours for the mean	1 hour-23 hours for the mean
	India: broadband internet	1 working day for 90% and 3 working days for 99%	
	India: cable television broadcasting: "no signal"	24 hours for 90%	
	India: cable television broadcasting: "some signal"	48 hours for 90%	
	India: satellite television broadcasting: "no signal"	24 hours for 90%	
	India: satellite television broadcasting: "some signal"	48 hours for 90%	
	Malaysia: fixed telephony	24 hours for 80% and 48 hours for 90%	24 hours for 94%-100% and 48 hours for 98%-100%
	Malaysia: wireline broadband internet	24 hours for 80% and 48 hours for 90%	24 hours for 63%-100% and 48 hours for 85%-100%
	Malaysia: leased lines	24 hours for 80% and 48 hours for 90%	24 hours for 87%-100% and 48 hours for 96%-100%
	Singapore: wireline telephony: residential	24 hours for 90% and 72 hours for 99.9%	24 hours for 92%-100% and 72 hours for 96%-100%
	Singapore: wireline telephony business	24 hours for 90% and 72 hours for 99.9%	24 hours for 96%-100% and 72 hours for 100%
	Singapore: leased lines	3 hours for the mean	
	ECTEL: narrowband internet	24 hours for 80%, 24 hours for 90% and 24 hours for 95% during successive years	
	ECTEL: narrowband internet	72 hours for 95%, 72 hours for 97% and 72 hours for 99% during successive years	
	ECTEL: narrowband internet	7 days for 98%, 7 days for 99% and 7 days for 99.5% during successive years	
	Jamaica: wireline telephony	24 hours for 80%, 48 hours for 98% and 72 hours for 100%	
	Macedonia: wireline telephony	1 working day for 93%, 2 working days for 94% and 5 working days for 98%	
	Romania: wireline telephony: access	14 hours for 80% and 16 hours for 95%	
	Romania: wireline telephony: transit	24 hours for 80% and 48 hours for 95%	
	Nigeria: wireline telephony	2 working days for the mean	
	Nigeria: wireless telephony	2 working days for the mean	
	Nigeria: narrowband internet	2 working days for the mean	
	Nigeria: broadband internet	2 working days for the mean	
	Nigeria: leased lines	2 working days for the mean	

Parameter	Country: service specialisation (if any): measurement specialisation (if any)	Examples of targets for retail services[42]	Examples of real measurement results for retail services[43]
Call setup ratio	India: wireless telephony: own network	95%	97%-100%
	Malaysia: fixed telephony: own network	94%	
	Malaysia: fixed telephony: other network	94%	
	Singapore: mobile telephony		100%
	ECTEL: local	85%, 95% and 98% during successive years	
	ECTEL: international	80%, 85% and 90% during successive years	
	Jamaica: wireline telephony: local	98%	
	Jamaica: wireline telephony: national	95%	
	Jamaica: wireline telephony: international	75%	
	Brazil: fixed telephony: local: day	96%	98%-99%
	Brazil: fixed telephony: local: night	96%	98%-100%
	Brazil: fixed telephony: national: day	96%	98%-99%
	Brazil: fixed telephony: national: night	96%	94%-99%
	Brazil: fixed telephony: international: day	96%	96%-99%
	Brazil: fixed telephony: international: night	96%	91%-99%
	Brazil: mobile telephony: morning	95%	97%-99%
	Brazil: mobile telephony: afternoon	95%	97%-99%
	Brazil: mobile telephony: night	95%	83%-99%
	Macedonia: wireline telephony: local	97%	
	Macedonia: wireline telephony: national	95%	
	Macedonia: wireline telephony: international	65%	
	Romania: wireline telephony: local	92%	
	Romania: wireline telephony: national	90%	
	Mauritania: mobile telephony	95%	0%-100%
	Morocco: mobile telephony		96%
	Nigeria	90%	
Call retention ratio	India: wireless telephony:	97%	90%-100%
	Malaysia: mobile telephony: own network	95% (of attempted call setups, not successfully answered calls)	
	Philippines	96%, 97% and 98% during successive years	
	Taiwan	93%, 95% and 97% during successive years	
	Singapore: mobile telephony		100%
	Brazil: mobile telephony: morning	98%	98%-99%
	Brazil: mobile telephony: afternoon	98%	98%-99%
	Brazil: mobile telephony: night	98%	95%-99%
	France: mobile telephony: city		98% (of attempted call setups, not successfully answered calls)
	France: mobile telephony: motorway		94% (of attempted call setups, not successfully answered calls)
	France: mobile telephony: local train		86% (of attempted call setups, not successfully answered calls)
	France: mobile telephony: national train		70% (of attempted call setups, not successfully answered calls)
	Egypt: fixed wireless telephony	98%	
	Mauritania: mobile telephony	97%	86%-100%
	Morocco: mobile telephony		98%
	Nigeria	95%	
Listening voice quality			

Parameter	Country: service specialisation (if any): measurement specialisation (if any)	Examples of targets for retail services[42]	Examples of real measurement results for retail services[43]
Value-added service call answer ratio	Malaysia: emergency assistance	90% in 10 seconds and 100% in 20 seconds	
	Malaysia: dial-up internet access	95% in 40 seconds	
	Jamaica: directory assistance	80% in 10 seconds and 90% in 20 seconds	
	Brazil: fixed telephony: operator assistance: day	95% in 10 seconds	97%-99% in 10 seconds
	Brazil: fixed telephony: operator assistance: night	95% in 10 seconds	96%-99% in 10 seconds
	Brazil: mobile telephony: operator assistance: morning	95% in 10 seconds	96%-100% in 10 seconds
	Brazil: mobile telephony: operator assistance: afternoon	95% in 10 seconds	83%-100% in 10 seconds
	Brazil: mobile telephony: operator assistance: night	95% in 10 seconds	88%-100% in 10 seconds
	France: directory assistance		96%-100% in 40 seconds
	Romania: operator assistance	90% in 30 seconds	
Message transmission ratio	Morocco: mobile telephony: SMS		97%
	Morocco: mobile telephony: MMS		65%
	France: mobile telephony: SMS		99%
	France: mobile telephony: MMS		96%
	Nigeria	90%	
Packet transmission ratio	India: wireline broadband internet	99%	
	Malaysia: wireline broadband internet	99%	99%
	Egypt	99%	
	Nigeria	99%	
Packet transmission time	India: wireline broadband internet: national	60 milliseconds	
	India: wireline broadband internet: international: terrestrial	175 milliseconds	
	India: wireline broadband internet: international: satellite	400 milliseconds	
	Malaysia: wireline broadband internet: local	42.5 milliseconds for 95%	42.5 milliseconds for 90%-98%
	Singapore: broadband internet: local	42.5 milliseconds for 95%	3 milliseconds-12 milliseconds for 95%
	Singapore: broadband internet: international	150 milliseconds for 95%	109 milliseconds-136 milliseconds for 95%
	Egypt	250 milliseconds	
	Nigeria	150 milliseconds for the mean	
Data transmission capacity	India: wireline broadband internet	80% for 95%	
	Malaysia: narrowband internet: local	80% for 95%	
	Malaysia: wireline broadband internet: local	70% for 95%	70% for 90%-99%

4.2 Practices in quality of service regulation

For many countries there is publicly available information about quality of service regulations. However, this information can be misleading: regulations might be drafted but not enacted, enacted but not enforced, or enforced initially but not enforced now. To obtain better information for this report, regulators in Africa were sent a questionnaire that not merely asked about the publicly available information but also asked about what happens in practice. An extract from the questionnaire is reproduced in Annex 1. In this section the responses to, and conclusions from, the questionnaire are summarised while respecting confidentiality.

4.2.1 Questionnaire responses

There were seven responses to the questionnaire (from Gambia, Ghana, Kenya, Madagascar, Niger, South Africa and Swaziland). This is too few to permit statistical inference, but the following general statements can be made:

- There are quality of service obligations for fixed and mobile calls in all of the countries, for leased lines and public payphones in several of the countries, and for mobile messages, dial-up and "always on" internet and telephony interconnect in some of the countries.
- The obligations typically apply only to operators that have their own networks (not to resellers, for example). In some countries they apply just to operators that are large or dominant or that have universal access obligations.
- The parameters and targets are chosen by consulting standards from international organisations (especially ITU) and by using experience in particular countries (such as India). In one country the operators were obliged to commit to parameters that they defined and targets that they set; however, often the parameters were related too directly to the networks and the targets were insufficiently demanding, so the regulator is now proposing new parameters and targets.
- There is wide variation in how often the measurements are reported: the reporting period can be 1 month, 3 months or 12 months.
- The measurements are usually not audited. However, in some countries there are audits every 6 or 12 months or if there are serious concerns about quality.
- The measurements are usually not published. In one country the (annual) measurements are published in newspapers and on the web site of the regulator. In other countries publication is being planned.
- The operators are encouraged to fulfil quality of service obligations by requiring that defaulting operators implement plans for improvements. In one country there is a proposal to award the title "best operator of the year" annually.
- The measurements are used to investigate complaints by users in several countries and to analyse trends in performance in some countries.

- In some countries quality of service regulation is thought to have improved quality (by reducing congestion or enhancing interconnect). In other countries it is thought merely to have maintained quality: in its absence the operators would prefer to increase coverage and their numbers of customers.

- There is some uncertainty about whether and how to monitor quality of service for dial-up and "always on" internet.

4.2.2 Questionnaire conclusions

In many countries in Africa, quality of service regulation is in practice very limited, for the following reasons:

- The regulators of electronic communications services typically begin by trying to create a competitive environment: their first concerns are competitor protection (ensuring effective competition) and competitor empowerment (encouraging private investment). They turn their attention to consumer protection and consumer empowerment as the markets matures. Thus consumer protection and consumer enforcement are only now becoming the focus of attention.

- Implementing quality of service regulation demands attention to details when measurements are made, audited and published, continuity of effort (as measurements must be repeated regularly), and consistency in encouraging and enforcing compliance. It is also expensive.

- Sometimes quality of service regulation is thought just to consider incumbent fixed telephony network operators (which in Africa are often much less significant than mobile telephony network operators). Of course, quality of service regulation started when countries typically had one fixed telephony network operator and no mobile telephony network operators. The first parameters were therefore selected to deal with aspects of fixed telephony having the biggest impact. However, there have been for many years parameters intended for mobile telephony.

For telecommunications there are good examples of quality of service regulation, as is shown in Section 4.2.1. Certain themes recur among the parameters from different countries: as is illustrated in Section 4.1.4, customer complaint submission rates, customer complaint resolution times, service supply times, fault report submission rates, fault repair times, call setup ratios and call retention ratios are monitored in many countries. (In fact timed ratios appear to be monitored more commonly than times, but for the present discussion they are treated as equivalent.)

For broadcasting there has often been very little quality of service regulation. Even coverage obligations have sometimes been left unstated, though surveys have shown that people in areas with poor reception are often more concerned about television coverage than about mobile telephony coverage. Nonetheless, customer complaint submission rates, customer complaint resolution times, service supply times, fault report submission rates or fault repair times are monitored in some countries for services that are not free to receive.

5 Outline of the proposed AFUR parameters

5.1 Choice of quality of service parameters

Quality of service parameters related to several of the "proposed AFUR parameters" defined in this report have existed for many years; they are defined in documents published by the European Telecommunications Standards Institute (ETSI), the International Telecommunication Union – Telecommunication Standardization Sector (ITU-T) and other organisations. The proposed AFUR parameters are intended to be applicable in many circumstances throughout Africa. They therefore adapt these earlier, related, parameters in ways outlined in this section.

5.1.1 Parameters to be monitored

The existing parameters most closely related to the proposed AFUR parameters are defined in ETSI documents[44]. These documents contain useful extra information, especially about measurement methods. The proposed AFUR parameters have descriptions that identify the ETSI parameters related to them. However, they differ from the ETSI parameters in that:

- They extend their application to cover other retail services and wholesale services.
- They restrict the allowed measurement methods to make measurements more readily comparable between operators.
- They make minor changes to names and definitions to simplify implementation or use.

Many parameters that are widely used have different names in different countries. For simplicity, the proposed AFUR parameters are named consistently using the conventions described in Section 3.1.4.

[44] See: ETSI TS 102 250-1 V1.2.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 1: Identification of Quality of Service aspects*, March 2007, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-2 V1.5.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 2: Definition of Quality of Service parameters and their computation*, October 2007, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-3 V1.3.2, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 3: Typical procedures for Quality of Service measurement equipment*, September 2005, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-4 V1.2.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 4: Requirements for Quality of Service measurement equipment*, July 2007, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-5 V1.4.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 5: Definition of typical measurement profiles*, August 2007, at http://pda.etsi.org/pda/queryform.asp; ETSI TS 102 250-6 V1.2.1, *Speech Processing, Transmission and Quality Aspects (STQ); quality of service aspects for popular services in GSM and 3G networks; Part 6: Post processing and statistical methods*, October 2004, at http://pda.etsi.org/pda/queryform.asp.

Table 7: List of proposed AFUR parameters

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

The descriptions of the parameters in this report might need to be adapted to conditions in particular countries. Adaptations might range from changing some details of the measurement methods to replacing parameters by others that reflect different concerns of users. Industry groups like those discussed in Section 3.5.1 that benefit from the knowledge and experience of operators and other organisations would be well suited to making such adaptations.

Having too many parameters simply burdens regulators, operators and users without providing genuinely helpful information. In some countries only some of the proposed AFUR parameters will be useful. Generally the proposed AFUR parameters exclude measurements that have lost their usefulness through changes in technologies and markets. (For these reasons they do not represent all the possible parameters; in fact describing all the possible parameters would be counter to the original AFUR request for guidelines, as guidelines make selections.)

5.1.2 The proposed AFUR parameters are widely applicable because they are general, not specific. For instance, among them is a parameter dealing with value-added service calls. This parameter is proposed instead of separate parameters dealing with operator service calls, voice mail calls and internet access calls (for example). However, making parameters general instead of specific might sometimes preclude catering for special features of services. Regulators might then need to adapt the descriptions of the parameters for their own purposes. Measurements to be published

Not all measurements need be published: some measurements might be valuable mainly for analysing trends. The descriptions of all of the proposed AFUR parameters mention published measurements and, in some cases, other measurements.

The published measurements indicate the unit of measure (such as percentage, seconds or days). and are rounded.

5.1.3 Targets to be set

The targets given for the proposed AFUR parameters are intended to correspond broadly with subjective assessments of “mediocre” (or “poor”) quality levels, in the sense of ITU-T recommendation P.800, but of course subjective assessments depend heavily on expectations. These targets might be regarded as “minimum standards” (though some of them are maximum values, not minimum values). They relate to international practice, but that practice varies very

widely. Individual countries might set targets different from those given for the proposed AFUR parameters; to help with doing this, the examples of targets and real measurement results from several countries worldwide are provided in Section 4.1.4.

Any targets chosen should be reviewed in view of what would be appropriate to each country since local conditions are very important in determining the quality levels that are useful to users and realistic for operators. In addition, AFUR member countries can share information on how those quality levels are changing and thereby adapt the targets according to international and regional best practice.

Requirements in codes of practice, such as those mentioned in Section 3.1.2, can influence which targets are appropriate. For instance, a target for the frequency of billing complaints might depend on whether bills are itemised, and a target for the frequency of disconnection complaints might depend on whether emergency calls are permitted despite disconnection.

Codes of practice can sometimes even act as substitutes for quality of service measurements. For instance, one way of informing customers about broadband speeds is to place constraints on descriptions of “headline” speeds, which are only attained in ideal conditions; as actual experience of broadband depends on several characteristics of the user location and equipment, such constraints might be more useful than measurements of “average” quality.

The targets given for the proposed AFUR parameters are those for retail services. The corresponding targets for wholesale services (in particular, wholesale services of dominant operators) would be more demanding than these; they would be derived from the targets for retail services by making allowance for the actions taken by the staff or network of the operator that purchases the wholesale services to create the corresponding retail services. As wholesale services have rather few customers, measurements of parameters for them depend on small sample sizes. Targets for wholesale services that lay down upper bounds on proportions of customers (“those making complaints”, for instance) can therefore be very misleading and have therefore not been used in this report.

5.2 Distinctions within quality of service parameters

The extent to which the proposed AFUR parameters can vary is summarised in this section. It should be read along with the earlier consideration of market segments (as discussed in Section 3.4.1), reporting periods (as discussed in Section 3.4.2), reporting areas (as discussed in Section 3.4.3), operators (as discussed in Section 3.4.4) and services (as discussed in Section 3.4.5).

5.2.1 Market segments

Market segments should be distinguished from each other only if services to different market segments are designed to have different quality levels. Services offered by an operator to other operators should be treated as wholesale services for the purposes of quality of service regulation.

5.2.2 Reporting periods

Reporting periods should usually be 3 months.

5.2.3 Reporting areas

Urban areas should be distinguished from rural areas where possible and necessary; this might not be possible for measurements made by small operators and might not be necessary for measurements made for “customer interface” parameters.

5.2.4 Operators

Operators that have few customers or that resell services from other operators might be exempted from monitoring parameters and publishing measurements (and from reaching targets). Operators other than dominant operators might be exempted from reaching targets.

5.2.5 Services

The services for which there is quality of service regulation should usually be at most:

- Voice calls.
- Text messages.
- Internet sessions.
- Television broadcasts.
- Radio broadcasts.
- Leased lines.

For some of these services no “service functionality” parameters are defined in this report, for reasons like those discussed in Section 5.5.6.

In some countries there might be obligations for universal service providers to ensure that public payphone sites provide assistants and working equipment for enough time. However, as styles of universal service provision vary between and within countries, parameters corresponding to these obligations are not defined in this report.

5.3 Measurement methods

The measurement methods for the proposed AFUR parameters share several characteristics. These are described in this section, to avoid duplications in the descriptions of the individual measurement methods.

Measurements obtained using these measurement methods should be comparable with each other. (However, they are not always comparable with measurements for parameters having similar names in different countries.) To assist with comparability, as far as possible the measurement methods are objective (in the sense of Section 3.6.1), provide end-to-end results (in the sense of Section 3.6.2) and use test traffic (in the sense of Section 3.6.3).

5.3.1 Subjective and objective measurements

The measurement methods defined in this report aim to be objective, though some of them do not exclude subjectivity completely. Subjective measurement methods, such as customer surveys, could be valuable in various ways, but in this report they are not proposed as the main means of assessing quality.

5.3.2 Network-by-network and end-to-end measurements

The measurement methods defined in this report apply end-to-end (instead of network-by-network). However, network-by-network measurements are suitable when the published measurements are end-to-end versions obtained by combining network-by-network measurements.

5.3.3 Real traffic and test traffic measurements

The measurement methods defined in this report use test traffic (instead of real traffic). However, using real traffic is necessary if there are not enough public places where tests can be made; appropriate measurement methods can be devised by adapting the measurement methods for the related ETSI parameters (for which using real traffic is presented as an alternative to using test traffic).

For test traffic, the considerations of section 3.6.3 should be used to determine in the same way for each operator:

- The minimum number of tests per reporting period, reporting area, operator and service.
- The hours of the day when the tests are performed.
- The time between successive tests of the same network.
- The traffic-weighted locations that act as sources or destinations of test traffic.
- The points to be represented by the traffic-weighted locations.

Each operator will need to provide telephone numbers or IP addresses (as appropriate) that other operators can regard as destinations for test traffic. Audits of measurements for regulators need to check that network routing and management does not discriminate in favour of these destinations.

5.4 Publication formats

The formats for published measurements are likely to vary between countries, according to the intended purposes of publication. In this section the implications of the proposed AFUR parameters for the formats are mentioned for tables (as described in Section 3.7.1), bar charts (as described in Section 3.7.2) and star ratings (as described in Section 3.7.3). Some at least of these publication formats can be adapted to speech as well as writing.

Even though there are relatively few parameters, combined measurements (one for each of the “customer interface”, “network infrastructure” and “service functionality” classes) might be better suited to publication than separate measurements. The measurements would be combined by normalising them as percentages (if they were not already percentages) and forming weighted sums.

5.4.1 Tables

The published measurements can be organised in tables because there are relatively few parameters; if necessary, there can be separate tables for the parameters in the “customer interface”, “network infrastructure” and “service functionality” classes. The tables should be accompanied by any necessary explanations of unusual quality levels.

To avoid presenting meaningless numbers, the published measurements should be rounded as discussed in Section 3.7.1.

5.4.2 Bar charts

The published measurements can be presented in bar charts. However, if there were a separate bar chart for each of the proposed AFUR parameters there would probably be too many bar charts. The separate bar charts would need to be clustered on the same axis, with each group of bars representing the measurements of all the operators for one parameter. This clustering is only feasible if there are few operators.

5.4.3 Star ratings

The published measurements can be combined into star ratings. Usually doing this entails normalising measured times as percentages before forming weighted combinations of the measurements that can be mapped to stars. As mentioned in Section 3.7.3, the normalisation techniques, weightings and mapping might vary between countries, as ideally they depend on preferences expressed in customer surveys.

5.5 Comments on quality of service parameters

The proposed AFUR parameters in this report have both similarities to, and differences from, many quality of service parameters that have been proposed. The reasons why various parameters are changed or omitted are discussed in this section. Some of these parameters might be desirable in some countries, depending on local conditions.

5.5.1 Complaints

Often distinctions are drawn between account complaints and other complaints. (The related ETSI parameters distinguish between account complaints for prepaid services and account complaints for postpaid services.) In this report this distinction is only one of many that could be drawn, according to the needs of the country. For instance, a distinction can be drawn between disconnection complaints and other complaints; disconnections are often an important source of complaints, second only to accounts, and complaints about them are often resolved in entirely different times from complaints about accounts.

Issuing trouble tickets is a good practice in complaint handling. It could be encouraged in a code of practice for complaint handling and dispute resolution that would also deal with several matters besides the procedures, such as compensation when complaints are upheld.

Codes of practice can be important also in indicating the grounds for complaints and reducing the causes of complaints. For instance, a code of practice for sales and marketing could encourage efforts to ensure that customers understand their tariff packages; they might even require that calls that might have charges out of line with customer expectations (such as those to value-added

services) might be begun by free announcements of the charges. However, such a code of practice might require that tariff packages be simple enough to understand but would would not generally require uniform pricing between operators, to allow different services to have different quality levels and features.

In considering parameters dealing with complaints the “number of customers” is important. There is a choice here between something that every operator can measure easily (such as the number of customers measured every three months) and something that some operators (in particular, fixed network operators) might find difficult to measure (such as the number of customers measured every day). In this report the "number of customers" has been chosen to be something that can be measured easily.

The whole notion of "number of customers" differs between operators and can be misleading, particularly for mobile pre-paid customers. Some operators maintain that the number of E.164 numbers that they need is twice as large as the number of separate customers that they have, because there are many SIM cards held in shops or in phones that are rarely used; this is why in this report "active" customers are considered.

5.5.2 Metering and billing accuracy

Monitoring account complaints might not be the only way in which account correctness is regulated. In particular, the regulator might require systematic assessments and tests of metering and billing systems; this is done in Hong Kong and India, following the example of the UK, for example. However, doing this is expensive and requires rather specialised expertise. It is not generally regarded as part of quality of service monitoring. For these reasons assessments and tests of metering and billing systems are not among the measurements for the proposed AFUR parameters.For such assessments and tests, account accuracy must be defined. For instance, in Hungary:

- Charges are usually regarded as having proper metering only if the quantities are recorded to within +0.5 billable units and -0.5 billable units and the times of day, if relevant to the charges, are recorded to within +2.0 seconds and –2.0 seconds.

- Charges that are not determined by the tariff or that do not have proper metering must not amount to more than 0.01% in number and 0.005% in value of the charges made to accounts.

Undercharging, as well as overcharging, can cause concern where there are calls to value-added services, particularly where charities collect the revenues.

5.5.3 Answer seizure ratio

The answer seizure ratio is sometimes used in international comparisons. It usually indicates the proportion of calls that are not only set up successfully but also answered. To operators it is interesting particularly for international calls, because it indicates the proportion of calls that generate revenue. However, it is not a quality of service parameter: its numerical value depends on whether people have equipment such as fax machines, when people are close to their phones, and how fixed and mobile tariffs compare; its value rarely rises above 70% because of these dependencies, which obscure the effect of the network on user experience.

Similar remarks apply to the term ‘call completion ratio’, which is sometimes left undefined and sometimes taken to refer to calls are answered.

5.5.4 Ratios and times

Actions such as setting up calls or transmitting messages can have their quality levels assessed in the following ways (according to the conventions described in Section 3.1.4):

- A ratio parameter such as the call setup ratio or the message transmission ratio can indicate the proportion of successful actions.
- A time parameter such as the call setup time or the message transmission time can indicate the average time taken by successful actions.
- A timed ratio parameter such as the call setup timed ratio or the message transmission timed ratio can indicate the proportions of actions that succeed within given times.

If specific distributions of times are known or assumed, measurements obtained in one of these ways can sometimes be converted into numbers that would be obtained in one of the other ways.

The proposed AFUR parameters in this report mostly provide the ratios (the proportions of successful actions) but not the times (the times taken by successful actions), which tend to be less important to users. However, actions that might take noticeable lengths of time to succeed have their quality levels assessed by times. Occasionally the quality levels of actions need to be assessed by measuring the times taken by successful actions as well as the proportion of successful actions; parameters can then be defined for them that bear the same relation to the parameters that provide the ratios as the packet transmission time does to the packet transmission ratio.

Customer complaints provide a typical case in which actions might take noticeable lengths of time to succeed: the time taken to resolve customer complaints might be assessed by finding average times (along with the 95th percentile of the distribution of times, for example) or examining the proportions of customer complaints resolved after 1, 2 and 3 days. In this report, average times are used because they is probably slightly simpler for users and are more conventional for “service functionality” parameters concerned with delays in communication. However, when the distributions of times have long tails, timed ratios (the proportions of actions that succeed within given times) might be more helpful.

5.5.5 Audio quality

The most important feature of voice calls is that they allow voice communication. However, quality of service parameters are often concerned with how often calls fail before or after set up, not with whether calls allow comprehensible conversations. There is a good reason for this: how to assess voice quality remains inadequately understood, despite considerable research.

There are several options for assessing audio quality for voice calls. However, they all have disadvantages: subjective assessments might not be reproducible, and objective assessments either do not consider important factors such as delay or are burdensome. In fact, as all the options are laborious or expensive, audio quality for voice calls should only be assessed if there are serious

concerns about it. Using PESQ to monitor listening voice quality, perhaps with supplementary information (such as delay), is the most realistic option for voice calls at the moment. However, using the E-model is likely to become a more attractive option with the growth of voice over IP. The options available now are examined below. Further options (for monitoring conversational voice quality) are under study in ITU-T and are likely to be introduced in the future.

Whatever option is chosen, the end-to-end quality is affected greatly by the performance of the terminals at each end of the call. Users will need to be told what is assumed about the terminals used in the assessments.

The options overall are:

- **Subjective assessments through surveys of MOS**. Surveys of Mean Opinion Score (MOS) are described in ITU-T Recommendations P.800 and P.830[45]. They have results that are strongly affected by the attitudes and environments of the survey participants and might differ between apparently similar surveys.

  Subjective assessments of MOS are difficult to make comparable with one another or to reproduce. Calls within a set of calls sometimes tend to be rated according to the quality level reached in the set as a whole. Also, different cultures and other groups attach different meanings to terms like “excellent”, “good”, “fair” “poor” and “bad”, so the MOS (which lies between 0 and 5) can have very different interpretations.

  Subjective assessments of MOS can be difficult to perform, especially with mobile users, if there are enough users present to average out some differences between people. Consequently subjective tests of MOS are likely not to be appropriate for regular drive-around tests. However, they might be useful in calibrating or validating other assessments from time to time.

  In some ways, broadcasting places more demands on audio quality than telecommunications does; in particular, sound quality for radio broadcasts and television broadcasts must be good for music as well as speech. Subjective assessments are generally used to determine whether quality is satisfactory. However, these subjective assessments, as described in ITU-R Recommendation BS.1284, cover several dimensions of audio quality: several separate attributes of transmitted sounds are evaluated, independently from each other as far as possible[46]. There are also methods for assessing audio quality in the presence of pictures, such as those in ITU-R Recommendation BS.1286[47].

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[45] See: ITU-T Recommendation P.800, *Methods for subjective determination of transmission quality*, August 1996, at http://www.itu.int/rec/T-REC-P.800; ITU-T Recommendation P.830, *Subjective performance assessment of telephone-band and wideband digital codecs*, February 1996, at http://www.itu.int/rec/T-REC-P.830.

[46] See ITU-R Recommendation BS.1284, *General methods for the subjective assessment of sound quality*, December 2003, at http://www.itu.int/rec/R-REC-BS.1284.

[47] See ITU-R Recommendation BS.1286, *Methods for the subjective assessment of audio systems with accompanying picture*, October 1997, at http://www.itu.int/rec/R-REC-BS.1286.

- **Objective assessments of listening voice quality using monitoring tools**. Perceptual Evaluation of Speech Quality (PESQ) is described in ITU-T Recommendation P.862[48]. It assesses listening (one-way) audio quality for voice calls objectively by comparing the signal received with the signal sent. Usually it is used in intrusive tests that put known inputs into networks and analyse the outputs.

  ITU-T Recommendation P.862 lists factors for which PESQ might make inaccurate, or even no, predictions. Among them are delay, echo, room noise, sidetone, clipping of various sorts and packet loss for PCM codecs. PESQ only measures the effects of one-way speech distortion and noise: calls could have high PESQ scores but poor quality.

  Conversational (two-way) voice quality depends on these other factors. In particular, when delays in communication become excessive (as they can do over some satellite connections or in voice over IP) conversations break down: one person can listen to another, but two people cannot exchange words. If PESQ is adopted for voice quality assessment, measurements of delay should be made at the same time, at least if the delay is not easily predicted; in particular, measurements of delay should be made in IP networks. However, in this report no parameter is defined for measuring delay except in IP networks, as related options for monitoring conversational voice quality are under study in ITU-T.

  PESQ scores lie between –1.0 and 4.5. A mapping from PESQ scores to MOS-LQO (LQO="Listening Quality Objective") is defined in ITU-T Recommendation P.862.1, based on data from tests in several languages; it can be used to re-express PESQ scores on the MOS scale, but it does not necessarily represent subjective experience well[49]. Comparability rules out mixing MOS from subjective assessments with MOS from PESQ scores: though PESQ scores are said to correlate well with subjective listening test scores for various languages and networks, they might not correlate well with any particular test score.

  PESQ and related systems (such as PAMS and PSQM) have been implemented in equipment intended for end-to-end tests of mobile and fixed networks. Some of this equipment can also provide statistics on the call setup ratio and the call retention ratio; it can even calculate E-model ratings.

  Objective methods of assessing listening (one-way) audio quality for radio broadcasts and television broadcasts go beyond PESQ in ITU-R Recommendation BS.1387[50].

- **Objective assessments of conversational voice quality using planning tools**. The E-Model is described in ITU-T Recommendations G.107 and G.108[51]. It assesses

[48] See ITU-T Recommendation P.862, *Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs*, February 2001, at http://www.itu.int/rec/T-REC-P.862.
[49] See ITU-T Recommendation P.862.1, *Mapping function for transforming P.862 raw result scores to MOS-LQO*, November 2003, at http://www.itu.int/rec/T-REC-P.862.1.
[50] See ITU-R Recommendation BS.1387, *Method for objective measurements of perceived audio quality*, November 2001, at http://www.itu.int/rec/R-REC-BS.1387.

conversational (two-way) voice quality objectively by calculating the effects on voice quality of reference paths formed from network elements that have had their impairments of quality calibrated. In doing so it takes into account many factors on which conversational voice quality depends. Usually it is used for network planning; however, it has been suggested for non-intrusive tests that use measurement devices in the network, following ITU-T Recommendation P.562 [52].

ITU-T Recommendation G.107 lists factors for which the E-model might make inaccurate predictions. Among them are room noise, sidetone, and concatenation of low bit-rate codecs. The impairments due to various codecs, and the extent to which those impairments can simply be added in the way adopted in the E-model, have not yet been investigated fully. Also, because the E-model deals with particular reference paths and requires impairments to be known for particular codecs, it might be applied wrongly or in situations that are not comparable.

The E-model ratings lie between 0 and 100. A mapping from the E-model ratings to MOS-CQE (CQE="Conversational Quality Effect") is defined in ITU-T Recommendation G.107 but not justified there; it could be used to re-express the E-model ratings on the MOS scale, but it would not necessarily represent subjective experience well. Comparability rules out mixing MOS from subjective assessments with MOS from E-model ratings: though E-model ratings are said to correlate well with subjective conversational test scores for various languages and networks, they might not correlate well with any particular test score.

The E-model is being implemented in equipment intended for end-to-end tests of voice over IP. Some of this equipment might be used in other types of network too.

5.5.6 Video quality

There are both subjective and objective methods for assessing video quality. They are not generally used in quality of service regulation: broadcasters have tended to set their own quality levels, either because they have public service responsibilities or because they have commercial incentives. With both radio and television becoming available through telephony and IP networks, on hand-held terminals and on computers, this might change. However, currently these methods are not needed by regulators.

The subjective methods of assessing video quality have been developed both for broadcasting and for films. They are documented in such reports as ITU-R Recommendation BT.500[53]. They have now

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[51] See: ITU-T Recommendation G.107, *The E-model, a computational model for use in transmission planning*, March 2005, at http://www.itu.int/rec/T-REC-G.107; ITU-T Recommendation G.108, *Application of the E-model: A planning guide*, September 1999, at http://www.itu.int/rec/T-REC-G.108.

[52] See ITU-T Recommendation P.562, *Analysis and interpretation of INMD voice-service measurements*, May 2004, at http://www.itu.int/rec/T-REC-P.562.

[53] See ITU-R Recommendation BT.500, *Methodology for the subjective assessment of the quality of television pictures*, June 2002, at http://www.itu.int/rec/R-REC-BT.500.

been developed for IP television and other multimedia services, in ITU-R Recommendations BT.1720 and BT.1788[54].

Testing has demonstrated that some objective methods of assessing video quality correlate well with subjective methods, at least for conventional television; such methods are listed in ITU-T Recommendation J.144 and ITU-R Recommendation BT.1683[55]. Objective methods that deal with multimedia, in most one-way and some two-way forms (such as video telephony), are described in ITU-T Recommendations J.148 and G.1070[56].

Generally, if there are no serious concerns about audio and video quality for radio broadcasts and television broadcasts, there is no need to use "service functionality" parameters for these services. The "customer interface" and "network infrastructure" parameters might still be relevant, at least for services that are not free to receive.

5.5.7 Quality of service in next generation networks

Next Generation Networks (NGNs) have been attracting attention for several years. An NGN is often described, in the words of ITU-T Recommendation Y.2001, as "a packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users."[57]

For users, an NGN should permit the continued use of existing services but also provide new services and allow same services to be used over different access networks. The new services are likely to provide new combinations of audio, video and text, with radio broadcasts and television broadcasts, for example, using the same networks as voice calls and text messages.

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[54] See: ITU-R Recommendation BT.1720, *Quality of service ranking and measurement methods for digital video broadcasting services delivered over broadband Internet protocol networks*, July 2005, at http://www.itu.int/rec/R-REC-BT.1720; ITU-R Recommendation BT.1788, *Methodology for the subjective assessment of video quality in multimedia applications*, January 2007, at http://www.itu.int/rec/R-REC-BT.1788.

[55] See: ITU-T Recommendation J.144, *Objective perceptual video quality measurement techniques for digital cable television in the presence of a full reference*, March 2004, at http://www.itu.int/rec/T-REC-J.144-200403-P; ITU-R Recommendation BT.1683, *Objective perceptual video quality measurement techniques for standard definition digital broadcast television in the presence of a full reference*, June 2004, at http://www.itu.int/rec/R-REC-BT.1683.

[56] See: ITU-T Recommendation J.148, *Requirements for an objective perceptual multimedia quality model*, May 2003, at http://www.itu.int/rec/T-REC-J.148; ITU-T Recommendation G.1070, *Opinion model for video-telephony applications*, April 2007, at http://www.itu.int/rec/T-REC-G.1070.

[57] See ITU-T Recommendation Y.2001, *General overview of NGN*, December 2004, at http://www.itu.int/rec/T-REC-Y.2001.

Existing services will continue to be important to users, who should not need to know whether those services are provided by an NGN or by a “legacy” network. Consequently quality of service regulation, which concerns user experience, should be as appropriate to an NGN as to a “legacy” network. In particular, the proposed AFUR parameters will remain relevant to an NGN. Moreover, the parameters are defined in ways that avoid unnecessary dependence on technologies and services; they are designed for the “unfettered access” and “generalized mobility” promised by an NGN.

New services will combine audio, video and text in new ways. As indicated in Section 5.5.5 and Section 5.5.6, appropriate ways of assessing the quality of audio and video, separately or together, are under active investigation. They might lead to the development of further parameters later.

In this report, parameters such as the packet transmission ratio and the packet transmission time, with the associated targets, can be used to ensure adequate quality for some real-time services in NGNs and other IP networks. However, they are influenced by the requirements of audio; they might ultimately need to be supplemented to handle some combinations of audio, video and text. Also, any such parameters describe the quality available from the networks, not the quality available to the users: the user experience of IP networks is influenced heavily by the performance of the end terminals in which the applications operate.

Finally, techniques for carrying multiple traffic types well over IP networks, such as those called “differentiated quality of service” and “integrated quality of service”, are outside the scope of quality of service in the sense of this report. They are instead implementation techniques intended to allow quality of service requirements to be fulfilled. They can also be used to give higher priority to traffic from some sources, which is opposed by advocates of “network neutrality”; discussions of this topic, too, are outside the current scope, as they relate to competitor protection more than consumer protection.

6 Details of the proposed AFUR parameters

6.1 Customer complaint submission rate

6.1.1 Brief description

The number of customer complaints received by an operator per customer per reporting period.

6.1.2 Suggested application

All retail services and, for dominant operators, all wholesale services.

6.1.3 Measurement method

A customer complaint is an adverse comment about a service (other than a fault report) that is made by a customer. A customer complaint about a retail service may be submitted in a customer service call, by personal contact at a customer service centre or in writing. A customer complaint about a wholesale service must be submitted in writing.

The number of customer complaints received during the reporting period should be divided by the average number of active customers for the operator during the same period; for this purpose, the average number of active customers is the mean of the numbers of active customers at the beginning of the reporting period and the end of the reporting period, and the active customers are the customers that have not been disconnected from the network (even if they have not recently used or paid for the service).. The result should be provided as a measurement. Separate numbers might be provided as measurements for particular classes of customer complaint, depending on which problems are most pressing in the country; for those measurements there might be separate targets.

The measurements should include all customer complaints received during the reporting period for the reporting area, regardless of the validity, extent of repetition, and subject of the complaint.

Particular classes of customer complaint for which separate measurements are provided often relate to accounts and sometimes relate to disconnections. An account is a statement made in writing or otherwise about money owed or paid for a postpaid or prepaid service. A disconnection is a way of deliberately preventing a customer from using a service, by unplugging physical connections or otherwise.

6.1.4 Published measurement

The number of customer complaints as a percentage of the number of active customers in the reporting period, rounded down to the nearest percentage point.

6.1.5 Retail target

10% of the active customers for the service in the reporting period (and proportionately more if the reporting period is longer than 3 months)

For particular classes of customer complaint (such as those related to accounts), and particular types of service, separate targets might be set from within this overall “budget”. Further information is

provided in Section 4.1.4 to help with setting targets that are helpful to users and realistic for operators.

6.1.6 Related parameters

ETSI EG 202 057-1 Section 5.9. ETSI EG 202 057-1 Section 5.11 and ETSI EG 202 057-1 Section 5.12.

6.2 Customer complaint resolution time

6.2.1 Brief description

The time taken to remove the causes for customer complaints.

6.2.2 Suggested application

All retail services and, for dominant operators, all wholesale services.

6.2.3 Measurement method

The time to resolve a customer complaint is the working time (not the elapsed time) from when the complaint is received by an operator to when the cause for the complaint has been removed. (The use of elapsed time instead of working time becomes appropriate when people depend very heavily on services.)

The mean, standard deviation and 95th percentile of the distribution of times to resolve customer complaints, and the number of customer complaints resolved, should be provided as measurements. Separate numbers might be provided as measurements for particular classes of customer complaint, depending on which problems are most pressing in the country; for those measurements there might be separate targets.

The measurements should include all customer complaints resolved during the reporting period for the reporting area, regardless of the validity, extent of repetition, and subject of the complaint.

Particular classes of customer complaint for which separate measurements are provided often relate to accounts and sometimes relate to disconnections.

6.2.4 Published measurement

The mean time in working days taken to resolve customer complaints in the reporting period, rounded down to two numerically significant figures

6.2.5 Retail target

15 working days for the mean.

For particular classes of customer complaint (such as those related to disconnections), and particular types of service, the target might be made more demanding. Further information is provided in Section 4.1.4 to help with setting more ambitious targets that are helpful to users and realistic for operators.

6.2.6 Related parameters

ETSI EG 202 057-1 Section 5.10.

6.3 Customer service call answer ratio

6.3.1 Brief description

The proportion of successfully set up calls to the customer services of an operator that are answered fast enough.

6.3.2 Suggested application

All retail services and, for dominant operators, all wholesale services.

6.3.3 Measurement method

A customer service call is successfully answered if, following successful setting up, it is answered in a suitable way within a suitable time from when the call is set up. Customer service calls include those for customer complaints, service requests, fault reports and help requests.

The number of customer service calls that are successfully answered should be divided by the number of customer service calls that are successfully set up. The result, and the number of customer service calls that are successfully set up, should be provided as measurements.

The measurements should be obtained from end-to-end test calls to customer services. The calls should occur at times and between locations chosen by the rules mentioned in Section 5.3.3.

Measurements are comparable with each other only if they give the same meaning to “answered in a suitable way and within a suitable time”. A customer service call is being “answered in a suitable way” only if information valued by the customer has started to be provided; responses that just invite the customer to select items by voice or key are not regarded as providing such information. The “suitable time” might be 40 seconds. A former ITU-D telecommunication indicator referred to the proportion of calls answered in 15 seconds (but did not distinguish customer service calls from value-added service calls).

Customer service calls are distinguished from value-added service calls, such as those to obtain operator assistance, directory assistance or emergency assistance. Customer service calls have quality levels relevant to the customer interface for any service, while value-added service calls have quality levels relevant to the service functionality of one specific service (calls). In particular, general requests to an operator for help with using a service are different from specific requests to an operator for assistance in setting up a call.

Much customer service takes place in response to personal contact in customer service centres, not through calls. However, the quality levels of customer service centres are difficult to assess objectively; for example, the time spent queuing in customer service centres is not on its own an adequate measure, because more, smaller, customer service centres might offer customers both shorter travelling times and longer queuing times than fewer, larger, customer service centres.

6.3.4 Published measurement

The number of customer service calls that are successfully answered as a percentage of the number of customer service calls that are successfully set up, rounded down to the nearest percentage point.

6.3.5 Retail target

90% of the number of customer service calls that are successfully set up (with 40 seconds as the "suitable time").

Further information is provided in Section 4.1.4 to help with setting more ambitious targets that are helpful to users and realistic for operators.

6.3.6 Related parameters

None.

6.4 Coverage

6.4.1 Brief description

The proportion of potential users with convenient access to locations where the service is offered and is in working order.

6.4.2 Suggested application

All retail services and, for dominant operators, all wholesale services.

6.4.3 Measurement method

The coverage is the proportion of potential users with convenient access to locations where the service is offered and is in working order. For a retail service, the potential users can be all residents, adult residents or all households (and the locations represent points where the potential users might want to have end terminals); users roaming from other reporting areas are excluded. For a wholesale service, the potential users can be the other operators (and the locations represent their required points of interconnection).

The average number of potential users with convenient access to locations in the reporting area where the service is offered and is in working order during the reporting period should be divided by the average number of potential users in the same area during the same period; for this purpose, the average number of potential users is the mean of the numbers of potential users at the beginning of the reporting period and the end of the reporting period. The result should be provided as a measurement.

This parameter is likely to have measurements that vary greatly between urban areas and rural areas, so the definition of the reporting areas is particularly important for it.

Measurements are comparable with each other only if they give the same meaning to "a service in working order"; for wireless networks, for example, the meaning might relate to in-building signal strength (among other things). The meaning of "convenient access to locations" depends on the service; a universal access obligation, for example, might require public payphones to be located within 5 kilometres of every household.

6.4.4 Published measurement

The percentage of potential users in locations where the service is offered and is in working order in the reporting period, rounded down to the nearest percentage point.

6.4.5 Retail target

The target depends on the national policy for universal service; for particular types of service separate targets might be set.

There is often a “market gap” between actual coverage and desired coverage, which can be filled by commercial services as they develop. There is sometimes also an “access gap”, where subsidies extend coverage beyond the market gap, and an “affordability gap”, where subsidies let everyone afford the service.

6.4.6 Related parameters

None.

6.5 Service supply time

6.5.1 Brief description

The time taken to provide a service in working order in locations where the service is offered.

6.5.2 Suggested application

All retail services and, for dominant operators, all wholesale services.

6.5.3 Measurement method

The service supply time is the working time (not the elapsed time) from when a service request is accepted by an operator to when the service has been supplied in working order. (The use of elapsed time instead of working time becomes appropriate when people depend very heavily on services.) A service request is a request to be supplied a service that is made by a customer. A service request about a retail service may be submitted in a customer service call, by personal contact at a customer service centre or in writing. A service request about a wholesale service must be submitted in writing.

Service requests that are unable to be fulfilled because the operator does not offer that particular service in the requested location are excluded. If the operator and the customer agree that more than one service will be provided at a location or that a service will be provided at more than one location, the provision of each service at each location should be counted as a separate service request. Otherwise, service requests concerning single physical connections should be counted as a single service request, regardless of the number of channels activated or affected; multiple analogue lines sharing the same physical path to a customer should be regarded as a single physical connection.

The mean, standard deviation and 95th percentile of the distribution of service supply times, and the number of service supply times, should be provided as measurements.

The measurements should include all service requests fulfilled during the reporting period for the reporting area.

Measurements are comparable with each other only if they give the same meaning to “a service in working order”; for wireless networks, for example, the meaning might relate to in-building signal strength (among other things).

6.5.4 Published measurement

The mean time in working days taken to fulfil service requests in the reporting period, rounded down to two numerically significant figures.

6.5.5 Retail target

5 working days for the mean.

For particular types of service, the minimum standard might be made more demanding. Further information is provided in Section 4.1.4 to help with setting more ambitious targets that are helpful to users and realistic for operators.

6.5.6 Related parameters

ETSI EG 202 057-1 Section 5.1 and ETSI EG 202 057-1 Section 5.2.

6.6 Fault report submission rate

6.6.1 Brief description

The number of valid fault reports received by an operator per customer per reporting period.

6.6.2 Suggested application

All retail services and, for dominant operators, all wholesale services.

6.6.3 Measurement method

A fault report is a report of disrupted or degraded service that is made by a customer. A fault report about a retail service may be submitted in a customer service call, by personal contact at a customer service centre or in writing. A fault report about a wholesale service must be submitted in writing.

Faults traced to other networks or to customer equipment behind network termination points are excluded (though, of course, the appropriate operators and users should be notified). Fault reports that are not valid are excluded. Faults reported for single physical connections should be counted as a single fault, regardless of the number of channels activated or affected; multiple analogue lines sharing the same physical path to a customer should be regarded as a single physical connection.

The number of valid fault reports received during the reporting period should be divided by the average number of active customers for the service during the same period; for this purpose, the average number of active customers is the mean of the numbers of active customers at the beginning of the reporting period and the end of the reporting period, and the active customers are the customers that have not been disconnected from the network (even if they have not recently used or paid for the service). The result should be provided as a measurement. Separate numbers

might be provided as measurements for particular classes of fault report, depending on which problems are most pressing in the country.

Fault reports should be assumed to be valid unless there is a specific reason to consider that they are not valid. Fault reports for which the faults are found to be cleared when tested should be counted as valid unless the operator has reason to believe that the faults did not occur. Multiple customer reports about the same fault should be regarded as separate fault reports.

6.6.4 Published measurement

The number of valid fault reports as a percentage of the number of active customers in the reporting period, rounded down to the nearest percentage point.

6.6.5 Retail target

10% of the active customers for the service in the reporting period (and proportionately more if the reporting period is longer than 3 months)

For particular types of service, the minimum standard might be made more demanding. Further information is provided in Section 4.1.4 to help with setting more ambitious targets that are helpful to users and realistic for operators.

6.6.6 Related parameters

ETSI EG 202 057-1 Section 5.4.

6.7 Fault repair time

6.7.1 Brief description

The time taken to restore a service to working order after receiving valid fault reports.

6.7.2 Suggested application

All retail services and, for dominant operators, all wholesale services.

6.7.3 Measurement method

The fault repair time is the working time (not the elapsed time) from when a valid fault report is received by an operator to when the service has been restored to working order. (The use of elapsed time instead of working time becomes appropriate when people depend very heavily on services.)

The mean, standard deviation and 95th percentile of the distribution of fault repair times, and the number of fault repair times, should be provided as measurements.

The measurements should include all faults cleared during the reporting period for the reporting area, but exclude those traced to other networks or to customer equipment behind network termination points where the operator has not been told that the faults have been cleared.

Measurements are comparable with each other only if they give the same meaning to “a service in working order”; for wireless networks, for example, the meaning might relate to in-building signal strength (among other things).

6.7.4 Published measurement

The mean time in working days taken to clear faults in the reporting period, rounded down to two numerically significant figures.

6.7.5 Retail target

2 working days for the mean.

For particular types of service, the target might be made more demanding. Further information is provided in Section 4.1.4 to help with setting targets that are helpful to users and realistic for operators.

6.7.6 Related parameters

ETSI EG 202 057-1 Section 5.5.

6.8 Call setup ratio

6.8.1 Brief description

The proportion of calls that are set up successfully.

6.8.2 Suggested application

Voice call retail services and, for dominant operators, voice call wholesale services.

6.8.3 Measurement method

A call is successfully set up if, following dialling from a location where the service is offered by the operator to a location where the telephone number dialled is valid and the service is offered by the same or a different operator, the called party busy tone, ringing tone or answer signal is recognised at the calling network termination point within a suitable time from when the last digit of the destination subscriber number is received by the network.

The number of calls that are successfully set up should be divided by the number of call setups that are attempted. The result, and the number of call setups that are attempted, should be provided as measurements.

The measurements should be obtained from end-to-end test calls. The calls should occur at times and between locations chosen by the rules mentioned in Section 5.3.3.

The “suitable time” can be taken to be 40 seconds (though 30 seconds is adequate for fixed networks).

6.8.4 Published measurement

The number of calls that are successfully set up as a percentage of the number of call setups that are attempted, rounded down to the nearest percentage point.

6.8.5 Retail target

90% of the number of call setups that are attempted.

Further information is provided in Section 4.1.4 to help with setting more ambitious targets that are helpful to users and realistic for operators.

6.8.6 Related parameters

ETSI EG 202 057-2 Section 5.1, ETSI EG 202 057-3 Section 6.4.1 and ETSI TS 102 250-2 Section 6.5.2.

6.9 Call retention ratio

6.9.1 Brief description

The proportion of successfully answered calls that are kept up for long enough..

6.9.2 Suggested application

Voice call retail services and, for dominant operators, voice call wholesale services.

6.9.3 Measurement method

A call is successfully retained if, following successful answering, it does not appear to end for a suitable time unless it is ended normally by a user.

The number of calls that are successfully retained should be divided by the number of calls that are successfully answered. The result, and the number of successfully answered calls, should be provided as measurements.

The measurements should be obtained from end-to-end test calls. The calls should occur at times and between locations chosen by the rules mentioned in Section 5.3.3.

The “suitable time” can be taken to be 120 seconds (on the assumption that test traffic, not real traffic, is used in making the measurements).

6.9.4 Published measurement

The number of calls that are successfully retained as a percentage of the number of calls that are successfully answered, rounded down to the nearest percentage point.

6.9.5 Retail target

95% of the number of calls that are successfully answered

Further information is provided in Section 4.1.4 to help with setting more ambitious targets that are helpful to users and realistic for operators.

6.9.6 Related parameters

ETSI EG 202 057-3 Section 6.4.2.

6.10 Listening voice quality

6.10.1 Brief description

The quality of voice calls as experienced by a listener (not as experienced in a conversation).

6.10.2 Suggested application

Voice call retail services and, for dominant operators, voice call wholesale services.

6.10.3 Measurement method

Perceptual Evaluation of Speech Quality (PESQ) should be used.

The mean, standard deviation and 95th percentile of the distribution of PESQ scores, and the number of PESQ scores, should be provided as measurements.

The measurements should be obtained from end-to-end test transmissions of speech samples. The transmissions should occur at times and between locations chosen by the rules mentioned in Section 5.3.3.

This parameter should be accompanied by measurements of voice delay (speech sample transmission time), to counteract some of its limitations in assessing conversational (two-way) voice quality.

6.10.4 Published measurement

The percentage obtained by mapping the PESQ score (defined to be between –1.0 and 4.5) to the MOS scale (defined to be between 0.0 and 5.0) according to ITU-T recommendation P.862.1 and then multiplying by 20, rounded down to the nearest percentage point.

6.10.5 Retail target

40%

6.10.6 Related parameters

ETSI TS 102 250-2 Section 6.6.3 and ITU-T recommendation P.800.

6.11 Value-added service call answer ratio

6.11.1 Brief description

The proportion of successfully set up calls to value-added services that are answered fast enough.

6.11.2 Suggested application

Voice call retail services and, for dominant operators, voice call wholesale services.

6.11.3 Measurement method

A value-added service call is successfully answered if, , following successful setting up, it is answered in a suitable way within a suitable time from when the call is set up. The term “value-added services” covers operator assistance, directory assistance, emergency assistance, voice mail and dial-up internet access, as well as commercial shared cost and shared revenue content services. The number of value-added service calls that are successfully answered should be divided by the number of value-added service calls that are successfully set up. The result, and the number of value-added service calls that are successfully set up, should be provided as measurements. Separate numbers should be provided as measurements for particular value-added services,

depending on which problems are most pressing in the country; for those measurements there might be separate targets.

The measurements should be obtained from end-to-end test calls to value-added services. The calls should occur at times and between locations chosen by the rules mentioned in Section 5.3.3.

Measurements are comparable with each other only if they give the same meaning to “answered in a suitable way and within a suitable time”; the meaning can be different for different value-added services, even in the same country. For operator assistance, directory assistance and emergency assistance, a human should answer (but the “suitable time” might depend on which service is being provided). For voice mail, an announcement should be the answer. For dial-up internet access, a “welcome” screen should be the answer. For other content services, the expected content, or information about the price of the call if the caller continues with it, should be the answer, delivered by a voice or through a modem (for facsimile and data calls), as appropriate.

6.11.4 Published measurement

The number of value-added service calls that are successfully answered as a percentage of the number of value-added service calls that are successfully set up, rounded down to the nearest percentage point.

6.11.5 Retail target

90% of the number of value-added service calls that are successfully set up (with 40 seconds as the “suitable time”).

For particular types of service (such as emergency assistance), the target might be made more demanding, typically by reducing the “suitable time” (perhaps to 10 seconds). Further information is provided in Section 4.1.4 to help with setting more ambitious targets that are helpful to users and realistic for operators.

6.11.6 Related parameters

ETSI EG 202 057-4 Section 5.4.

6.12 Message transmission ratio

6.12.1 Brief description

The proportion of messages that are transmitted successfully.

6.12.2 Suggested application

Text message retail services and, for dominant operators, text message wholesale services.

6.12.3 Measurement method

A message is successfully transmitted if, following dialling from a location where the service is offered by the operator to a location where the telephone number dialled is valid and the service is offered by the same or a different operator, it is transmitted completely without errors between the network termination points, irrespective of whether the receiving network termination point is connected to its network when the message reaches its network.

The number of messages that are successfully transmitted should be divided by the number of message transmissions that are attempted. The result, and the number of message transmissions that are attempted, should be provided as measurements.

The measurements should be obtained from end-to-end test transmissions of 120-character messages. The transmissions should occur at times and between locations chosen by the rules mentioned in Section 5.3.3.

This parameter can be modified to apply to MMS messages as well as to SMS messages. A parameter like it can also be applied to email; however, in this report the view is taken that applications such as email that just use IP networks without originating and terminating at points with telephone numbers are not to be subject to quality of service monitoring (though the IP networks themselves might be subject to it).

6.12.4 Published measurement

The number of messages that are successfully transmitted as a percentage of the number of message transmissions that are attempted, rounded down to the nearest percentage point.

6.12.5 Retail target

9% of the number of message transmissions that are attempted

Further information is provided in Section 4.1.4 to help with setting more ambitious targets that are helpful to users and realistic for operators.

6.12.6 Related parameters

ETSI EG 202 057-2 Section 5.6.2 and ETSI TS 102 250-2 Section 7.4.4.

6.13 Packet transmission ratio

6.13.1 Brief description

The proportion of packets that are transmitted successfully.

6.13.2 Suggested application

Internet session retail services and, for dominant operators, internet session wholesale services.

6.13.3 Measurement method

A packet is successfully transmitted if it is transmitted completely without errors between the network termination points.

The number of packets that are successfully transmitted should be divided by the number of packet transmissions that are attempted. The result, and the number of packet transmissions that are attempted, should be provided as measurements.

The measurements should be obtained from end-to-end test transmissions of ICMP Echo Request/Reply (Ping) messages. If the transmissions provide round-trip results, the counts of lost

packets should be taken to be half those in the results. The transmissions should occur at times and between locations chosen by the rules mentioned in Section 5.3.3.

This parameter can be modified to apply in other packet networks as well as in IP networks. It assesses packet loss.

6.13.4 Published measurement

The number of packets that are successfully transmitted as a percentage of the number of packet transmissions that are attempted, rounded down to the nearest percentage point.

6.13.5 Retail target

97% of the number of packet transmissions that are attempted

The target might be made more demanding, typically by raising the percentage (perhaps to 99%) to make listening voice quality acceptable for wider varieties of coding equipment and bursts of lost packets. The target is not needed in this form for data file transfers.

6.13.6 Related parameters

None.

6.14 Packet transmission time

6.14.1 Brief description

The time taken to transmit packets.

6.14.2 Suggested application

Internet session retail services and, for dominant operators, internet session wholesale services.

6.14.3 Measurement method

The packet transmission time is the time from when the packet is sent to the network to when the packet is received by the receiving equipment. Unsuccessful packet transmissions are excluded.

The mean, standard deviation and 95th percentile of the distribution of packet transmission times, and the number of packet transmission times, should be provided as measurements.

The measurements should be obtained from end-to-end test transmissions of ICMP Echo Request/Reply (Ping) messages. If the transmissions provide round-trip results, the packet delays should be taken to be half those in the results. The transmissions should occur at times and between locations chosen by the rules mentioned in Section 5.3.3.

This parameter can be modified to apply in other packet networks as well as in IP networks. It assesses packet delay, through the mean, and packet jitter, through the standard deviation.

6.14.4 Published measurement

The mean time in milliseconds taken by successful packet transmissions, rounded down to two numerically significant figures.

6.14.5 Retail target

100 milliseconds for the mean

Coding and other delays consumer part of the “budget” of 150 milliseconds suggested for voice transmission in ITU-T recommendation G.114;

The target might be made more demanding, typically by reducing the mean (perhaps to 50 milliseconds) to make conversational voice quality acceptable for wider varieties of coding equipment and coding conversions in series. The target is not needed in this form for data file transfers.

6.14.6 Related parameters

ETSI EG 202 057-4 Section 5.5 and ETSI TS 102 250-2 Section 6.3.1.

6.15 Data transmission capacity

6.15.1 Brief description

The proportion of the advertised data transmission speed that is obtained in practice.

6.15.2 Suggested application

Internet session retail services and, for dominant operators, internet session wholesale services.

6.15.3 Measurement method

The data transmission capacity is the percentage of the data transmission speed advertised for the service that is obtained by continuous transmission. The data transmission speed obtained for the service and the data transmission speed advertised for the service are averaged over traffic-weighted locations for sending and receiving data.

For each test transmission the data transmission time should be measured. The sum over all test transmissions of the lengths of the transmitted data should be divided by the sum over all test transmissions of the products of the data transmission time and the corresponding data transmission speeds advertised for the service at the location from which the data is sent. The result should be provided as a measurement that can be regarded as the data transmission capacity for the service.

The measurements should be obtained from end-to-end test transmissions of incompressible data files. The transmissions should occur at times and between locations chosen by the rules mentioned in Section 5.3.3.

The incompressible data files may be obtained by generating random numbers, taking the digits of transcendental numbers, or using data values that are already compressed. Each should be large enough that it would take at least 2 seconds to be transmitted over a link performing at the advertised data transmission speed.

Differences between downstream and upstream internet data transmission speeds can be accommodated by ensuring that the transmissions are from traffic-weighted locations.

This parameter is intended for easy measurement, but is otherwise not entirely satisfactory. In an IP network, speeds should ideally be measured at the IP level in the stack, not at any other level; however, with this parameter, the measurements are influenced by the performance of the protocols for reliable data transmission implemented in the end points (and any intermediate caches), not just network performance. These protocols are not the ones used for voice over IP, which can be assessed quite well using the packet transmission ratio and the packet transmission time. However, the packet transmission ratio and the packet transmission time are measured using small packets; they therefore do not always indicate the speed with which data files can be transferred, because data files are transferred in large packets.

6.15.4 Published measurement

The percentage of the advertised data transmission speed that is obtained in practice, rounded down to the nearest percentage point.

6.15.5 Retail target

The target depends on the national codes of practice relating to how prominently advertisements display “optimistic” and “pessimistic” statements about the possible data transmission speed. The data transmission speed is influenced by the quality and length of the link of the customer equipment from the nearest access network element (such as a local exchange, for a wireline access network, or a base station, for a wireless access network). The operator is not necessarily able to assess this influence fully until after the service is operating.

6.15.6 Related parameters

ETSI EG 202 057-4 Section 5.2.

Annex 1: Extract from quality of service questionnaire

I Document requirements

1. If not readily accessible from your website, please provide us with official documents setting out QOS requirements and requests, such as licences, regulations and guidelines (or state 'not applicable' if no QOS regulations are in place)

2. Please include with these documents information about QOS parameters, QOS targets and QOS measurement methods.

3. Please provide us with actual up to date measurements for each of these parameters, and numbers of complaints by users, arranged by type of complaint, if possible.

II Your experience

Please tell us more about your experience with regard to QOS regulation:

In the answers to the following questions, please tick all the relevant boxes and distinguish if necessary:

- *Between different services (A, B, C, … below).*
- *Between different customer categories (residential customers, business customers and wholesale customers (other service providers or content providers)).*
- *Between different QOS tasks*
- *Between measurements made for the country as a whole and measurements made for separate localities in the country.*

4. For which services do service providers have obligations to perform QOS tasks?

   A. fixed wireline telephony access

   B. fixed wireless telephony access

   C. mobile voice calls

   D. mobile text messages

   E. dial-up internet access

   F. always-on internet access

   G. telephony interconnect

H. internet interconnect

I. leased lines

J. pay phones

K. radio

L. terrestrial television

M. satellite television

N. cable television

O. others [please describe]

P. none

5. Which service providers are obliged to perform QOS tasks?

- those authorised to provide the service
- those operating their own networks for the service
- those having a certain number of users for the service [please specify]
- those providing the service since a certain time [please specify]
- those having ‘significant market power’ (dominance)
- those acting as universal service providers for the service
- those qualifying under some other rule [please describe]

6. How *in practice* are QOS parameters and QOS targets chosen?

- by asking groups representing users
- by conducting surveys of users
- by examining complaints by users
- by asking service providers
- by considering remarks by opinion-formers (journalists, politicians and so on)
- by consulting standards from international organisations [please specify]

- by using experience in this and other countries [please specify]
- in other ways [please describe]

7. Which QOS parameters are measured by 'subjective' methods (surveying users) as opposed to 'objective' methods (making tests, sampling calls, sampling complaints and so on)?

8. How often *in practice* are measurements of QOS parameters reported to the regulator or ministry?

9. How often *in practice* are procedures for measuring QOS parameters audited by the regulator or ministry?

10. How often *in practice*, and in what way, are measurements of QOS parameters published?

11. How *in practice* are service providers given incentives to perform QOS tasks?
    - by publishing information about relative QOS performance of service providers
    - by publicising service providers with unsatisfactory QOS performance
    - by requiring service providers to implement improvement plans
    - by requiring service providers to give service credits or rebates to users
    - by imposing fines
    - by making price controls more demanding
    - by making licence conditions more restrictive
    - in other ways [please describe]

12. How *in practice* are measurements of QOS parameters used?
    - for publishing information about QOS performance
    - for investigating complaints by users
    - for analysing trends in QOS performance
    - for introducing general network (or other system) design rules
    - for other purposes [please describe]

13. What changes in QOS performance have probably been caused by QOS obligations (as opposed to staff training, equipment deployment, extra investment and so on that would have happened even if there were no QOS obligations imposed by the regulator or ministry)?

III Outlook

14. Please make any further comments that you would like to make at this point e.g. your views on the need for QOS regulation, the parameters you believe are essential to be included, implementation challenges and how they can be resolved etc.

IV Contact information

Please provide us with details of the person you would like us to contact if we have any need for clarifications (if different from the CEO of the organisation)

15. Organisation/Country:

16. Name:

17. Position:

18. Telephone number:

19. Email address.