Republic of Lebanon
Telecommunications Regulatory Authority

Decision No: 6/2009

Technical Quality of Service and Key Performance Indicators Regulation

The TRA, during its meeting held on 18/03/2009

Pursuant to law No 431 dated 22/07/2002 (Telecommunications Law), in particular Article 25,

Pursuant to Decree No 14264 dated 4/03/2005 (Financial and administrative management of the Telecommunications Regulatory Authority),

Pursuant to Decree N^{o} 1 dated 08/02/2007 (Appointment of the TRA Board),

And upon the advice of the Council of State (Opinion No. 41/2008-2009 dated 29/01/2009),

Issued the following regulation:

CHAPTER 1. Purpose and Scope of the Regulation

Article 1. Background

1. This Technical Quality of Service (QoS) & Key Performance Indicators (KPI) Regulation (the Regulation) forms part of the regulations issued by the Telecommunications Regulatory Authority (the Authority) of Lebanon in accordance with the Telecommunications Law – Law No. 431 of 2002 (Telecommunications Law). This Regulation is designed to serve potential and current market participants in the telecommunications sector by providing clear and concise explanations concerning all technical elements of QoS and KPI.
2. This Regulation is a binding regulation that states the official policies and procedures of the Authority. It may be subject to review and amendment as deemed necessary by the Authority in light of the development of the Lebanese telecommunications market, changes to Lebanese national laws impacting the telecommunications sector, or other factors.

Article 2. Legal basis

1. The Telecommunications Law grants the Authority the power to issue regulations pertaining to competition, quality of service, interconnection, dispute resolution, pricing, consumer affairs, spectrum and any matter which the Authority deems necessary to implement the Telecommunications Law.
2. To that end, Article 25 of the Telecommunications Law addresses specific responsibilities of the Authority in matters related to Technical QoS and KPI and directs the Authority to ensure:
    a. Any public telecommunications services license shall include mandatory and optional infrastructure expansion targets related to the scope of services, and standards that ensure high quality of service, as deemed appropriate by the Authority in the public interest.
    b. QoS standards include, but are not limited to, requirements related to the service availability access delay, call completion rates, fault incidence and time to repair, dial tone delays and other faults that occur during the call.
    c. The Authority shall establish procedures for standards, reporting and monitoring compliance with infrastructure expansion targets, and QoS standards.

Article 3. Interpretation

1. Individual clauses containing the word ‘shall’ are mandatory requirements and are binding on service providers.
2. Individual clauses containing the word ‘should’ are recommendations to service providers but are not mandatory.
3. Individual clauses containing the word ‘may’ are permissions to service providers.

Article 4. Purpose of the Regulation

1. The Authority's principles pertaining to the Technical QoS and KPI Regulation are based on the development of a competitive environment. These principles are detailed in Appendix A of this Regulation.

   Through this Regulation the Authority aims to assure consumers of quality service, fairness in tariffs, and transparency in billing.

2. Specifically, the Authority will ensure that all service providers shall take measures to ensure:
   a. billing accuracy;
   b. detailed and per service billing and charging;
   c. proper procedures for the resolution of customer disputes.
3. The Authority will ensure that all services provided by service providers include requirements concerning:
   a. service availability;
   b. QoS;
   c. network performance.
4. This Regulation is designed to define a minimum set of standards that service providers shall meet; the Authority will ensure that these KPIs are regularly published to assist users to make informed decisions as to their service provider(s).

Article 5. Scope of the Regulation

1. This Regulation applies to all service providers and users of public telecommunications services in Lebanon. It does not apply to users of private telecommunications services. The service providers should undertake the changes to their systems and processes allowing the application of this regulation. Service providers may request the Authority to grant additional time to undertake the required changes.
2. The attached annexes are deemed to be an integral part of this regulation, but the Annexes (a) and (b) contain a scientific study about ITU recommendations and KPIs and do not contain any binding provisions.

CHAPTER 2. Definitions

Article 6. Definitions' Basis

In the event of conflict or ambiguity between the terms defined herein and the terms defined in a license or in the Telecommunications Law, then the following order of precedence shall apply:

a. Telecommunications Law.

b. Technical QoS & KPI Regulation.

c. Service provider license.

Article 7. Definitions

In this Regulation, the following terms shall have the corresponding meanings:

Authority - **the** telecommunication regulatory authority

Busy hour - the sliding 60-minute period during which the maximum total traffic load occurs in a given 24-hour period. The service provider is required to indicate the busy hour during which the measurement is taken.

Consumer - any person, other than a service provider, who is or may become a customer or user.

Emergency Services - the ability to connect in priority, from any service area via any subscriber or public terminal or device to national pre-defined numbers regardless of the subscription validity. Emergency service obligations will be addressed in a separate regulation by the TRA.

Network Performance - The ability of a network portion to provide the functions related to communication between users (ITU-T Rec. E.800).

Quality of Service - The collective effect of service performance which determines the degree of satisfaction of a user of the service. The level of quality required by the users of a service may be expressed non-technically.

Service Provider – A Person that is licensed by the TRA to provide, directly or indirectly, Telecommunications Services.

CHAPTER 3. Rights and Obligations Regarding QoS and KPIs

Article 8. General Obligations

1. The parameters along with corresponding target levels specified in Article 10 of this Regulation are mandatory minimum standards that service providers, shall comply with. The Authority will publish by way of a decision, on an annual basis, target levels for defined QoS and KPI parameters. The initial parameters and corresponding target levels are those set out in Article 10 of this Regulation.

2. The QoS and KPI parameters set in Article 10 may be amended from time to time, as the Authority shall determine after due consultation, following the introduction of new telecommunications technologies, or research performed by the Authority or any other recognized national or international technical research institute, or any other technical events that the Authority consider appropriate.

3. The target levels for QoS and KPI parameters may be amended by the Authority from time to time taking into account, inter alia, the level of competition in the market, the state of development of the market, consumer complaints, technology developments or other matters that the Authority may consider appropriate.

4. If a relevant market is determined to be competitive pursuant to the SMP Regulation, then the QoS targets for that market become recommendations instead of mandatory.

Article 9. QoS Regulation

1. There exist two generally accepted methods for a regulator to regulate the QoS of a service provider:

   a. the traditional approach where QoS targets are set, against which service provider performance is measured, followed by a system of penalties and rewards based on those QoS targets; and

   b. the alternative approach where a QoS variable is incorporated in a price cap formula as the Q-factor where lower quality leads to lower consumer prices, while higher quality may lead to higher prices.

2. Until further notice, the Authority will adopt the traditional approach as described in paragraph (a) above, and will consult on the alternative approach based on price cap before deciding on its adoption.

Article 10. Target Levels for QoS and Network Performance Parameters

Fixed Network Services	
QoS/Network Performance Parameter	**Target Level**
Availability of Telephone Exchange Equipment	≥ 99.99%
Call Set Up Time (Post dialling delay to ring tone)	≤ 3 seconds national at busy hour ≤ 8 seconds for international at busy hour
Billing Accuracy (valid accuracy-related complaints)	≤ 3 complaints per 1000 bills
Unsuccessful Call Ratio (% of call attempts)	≤ 1% On-Net National at busy hour ≤ 2% International at busy hour
Supply Time for Connection	90% within 3 working days
Fault Rate per Access Line	≤ 3 failures per 100 lines per month
Fault Repair Time (except for outages reports outlined in Article 11)	95% within 72 hours
Response Time for Operator Services (Time to answer from last digit dialled)	90% within 15 seconds

International Voice Services	
QoS/Network Performance Parameter	**Target Level**
Call Set Up Time (Post dialling delay to ring tone)	≤ 5 seconds for international
Echo Cancellers Usage at the Central Office	≥ 99.9% of each International Gateway Switch is using Echo Canceller for each Speech connection

Total delay in International Calls	≤ 250 ms
Unsuccessful Call Ratio (% of call attempts)	≤ 2% International at busy hour
Resolution time of International Gateway fault impacting traffic (except for outages reports outlined in Article 11)	Within 1 hour

Domestic Leased Line Services	
QoS/Network Performance Parameter	**Target Level**
Supply Time for Connection	≥ 90% completed on agreed day (as per the terms and conditions of the service)
Fault Repair Time (except for outage reports outlined in Article 11)	95% within 24 hours
Service Availability	≥ 99.70

International Leased Line Services	
QoS/Network Performance Parameter	**Target Level**
Service Availability	≥ 95%
Fault Repair Time (except for outages reports outlined in Article 11)	90% within agreed repair time
Supply Time for Connection	90% completed on agreed day (as per the terms and conditions of the service)

Mobile Telecommunications Services	
QoS/Network Performance Parameter	**Target Level**
Supply Time for Connection	On demand for pre paid and within 3 hours for post paid

Mobile Telecommunications Services	
QoS/Network Performance Parameter	**Target Level**
Call Set Up Time (Post dialling delay to ring tone)	5 seconds On-Net national at busy hour 10 seconds for international at busy hour
Unsuccessful Call Ratio (% of call attempts)	≤ 1% National at busy hour ≤ 2% International at busy hour
Dropped calls Per Cell	1 dropped call per 100 calls per Cell at busy hour
Congestion Factor	5 % of all Cells at busy hour
SMS Mobile Originated/Terminated Delivered	95% Delivered with 24 hours
Average Time to Respond to Customer Calls	85% of calls in less than 35 seconds
Billing accuracy (valid accuracy – related complaints)	≤ 3 complaints per 1000 bills
Fault repair time (except for outages reports outlined in article 11)	95% within 72 hours.

Wireless Data Services (<2048 bit/s)	
QoS/Network Performance Parameter	**Target Level**
Service Availability	≥ 99.00%
Supply Time for Connection	90% completed on agreed day (as per the terms and conditions of the service)
Fault Repair Time (except for outage reports outlined in Article 11)	95% within 24 hours
Ratio of Packet Loss	≤ 5% Packet Loss
Round trip Delay	≤ 95 milliseconds (ms) for national reference < 250milliseconds for International reference
Jitter	< 50milliseconds

Wireless Broadband Data Services (≥ 2048 bit/s)	
QoS/Network Performance Parameter	**Target Level**
Service Availability	≥ 99.00%
Supply Time for Connection	95% completed on agreed day
Customer Fault Rate per leased line	1.25 failures per 100 customers per month
Fault Repair Time	95% within 24 hours
Ratio of Packet Loss	≤ 5% Packet Loss
Round trip Delay	≤ 95 milliseconds (ms) for national reference < 250 milliseconds (ms) for International reference
Jitter	< 50 milliseconds

Fixed Prepaid Card Services	
QoS/Network Performance Parameter	**Target Level**
Debit Accuracy	99.99 %

Audio Text Services	
QoS/Network Performance Parameter	**Target Level**
Service Supply Time	95% completed on agreed day
Bill correctness complaints	3 complaints per 1000 bills

Premium Charge Services	
QoS/Network Performance Parameter	**Target Level**
Service Supply Time	On demand
Bill correctness complaints	3 complaints per 1000 bills

Wireline Data Services	
QoS/Network Performance Parameter	**Target Level**
Dial-Up Call Set Up Time (Post dialling delay to ring tone)	1.9 seconds national
ADSL Service Availability	≥ 99%
Unsuccessful Connect Ratio (per Number of call attempts)	10 per 1000 attempts
ADSL Throughput x Kbits downstream / y Kbits upstream at busy hour	Upstream 90% of time y kbits Downstream 90% of time x kbits
Ratio of Packet Loss	≤ 5% Packet Loss
Round trip Delay	< 95 milliseconds (ms) for national reference < 250 milliseconds for international reference
Jitter	< 50 milliseconds

Article 11. Outage Reporting and Reparation Requirements

All service providers shall provide the Authority with network outage reports whenever any outage occurs as described in the clauses below.

1. Critical Outages are defined as those affecting the entire network, the core of the network or greater or equal to (=>) 30% of the traffic. The condition includes a critical work stoppage during the customer's normal working hours that affects multiple sites or Core Network Elements affecting functions of a customer's business. Examples of Critical Outages include, but are not limited to:

A. **Mobile services**: outages affecting MSC/VLR, HLR/AUC, BSC, transmission (main hub or multiplexer node of SDH/ PDH) …

B. **Fixed services**: outages affecting central offices serving more than 40,000 subscribers, transit switches, international switches, Transmission (main hub or multiplexer node of SDH/ PDH), fiber optic cable affecting the serving ring without redundancy, Intermediate Data Rate Earth Stations, Layer2 Switches...

C. **Internet services**: outages affecting core routers, the Network Operation Centers, International Exchange Points, International Gateway…

D. **Data services**: outages affecting BRAS, core routers, International Exchange Points, DSLAMs, Layer2 Switches, Network Operation Center…

2. Major Outages are defined as those affecting a part of the network (or the components of the aggregate part of the network), and influencing less than (<) 30% of the traffic. Examples of Major Outages include, but are not limited to, outages affecting the same network elements listed in clause 25 of this Regulation.

3. Minor Outages are defined as those affecting individual sites, and/or components at the edge level of the network that do not interrupt service or performance. Examples of Minor Outages are those affecting BTS, trunk cable, or E1 transmission link.

Article 12. Outage reparation and reporting

1. Critical Outages shall be repaired within one (1) hour. All service providers shall inform the Authority immediately of such outages and shall submit to the Authority an outage report, as per Appendix C, immediately after the problem is resolved and the service is restored. In the event that a Critical Outage cannot be repaired in the required period, a justification report shall be submitted to the Authority immediately; the outage report shall then be submitted, as per Appendix C, when the outage is repaired.

2. Major Outages shall be repaired within four (4) hours. All service providers shall submit to the Authority an outage report, as per Appendix C, within two (2) days. In the event that a Major Outage cannot be repaired in the required period, a justification report shall be submitted to the Authority immediately; the outage report shall then be submitted, as per Appendix C, when the outage is repaired.

3. Minor Outages shall be repaired within one (1) day. All service providers shall submit to the Authority an outage report, as per Appendix C, within seven (7) days. In the event a Minor Outage cannot be repaired in the required period, a justification shall be attached to the outage report submitted to the Authority as per Appendix C, when the outage is repaired.

4. Outages affecting Emergency Services shall be repaired within thirty (30) minutes. All service providers shall inform the Authority immediately of such outages and shall submit to the Authority an outage report, as per Appendix C, immediately after the problem is resolved and the service is restored. In the event an Emergency Services Outage cannot be repaired in the required period, a justification report shall be submitted to the Authority immediately; the outage report shall then be submitted, as per Appendix C, when the outage is repaired.

CHAPTER 4. Compliance and Penalties

Article 13. General Compliance Provisions

1. The service provider shall submit to the Authority, within one hundred and twenty (120) days from the date of publication of this regulation in the Official Gazette, the schedule by which he shall comply with his obligations under this Regulation. Full compliance with the obligations according to this Regulation shall be complete after one (1) year from the date from the date of publication of this regulation in the Official Gazette.

2. Service providers shall monitor their compliance on a monthly basis and shall report their findings on a rolling basis to the Authority as follows:

- by the 15th day of April for the period January – March,
- by the 15th Day of July for the period April – June,
- by the 15th day of October for the period July-September, and
- by the 15th day of January for the period October to December.

3. The Authority will monitor the compliance of service providers with mandatory QoS requirements.

For any regulatory period determined by the Authority, the performance of service providers should be reviewed annually and compared to QoS KPI targets, based on monthly reporting.

The Authority may impose upon service providers whose QoS indices are deteriorating, mandatory QoS improvements for failure to meet QoS requirements within the timeframe stipulated by the Authority.

4. Where the Authority is satisfied that a service provider has not met its mandatory QoS obligations for a period of any two (2) quarters within four (4) consecutive quarters, the Authority may treat such failure as a breach of the service provider's license and may take any enforcement step accordingly.

5. The Authority shall impose one or more of the following penalties, pursuant to the Telecommunications Law, on service providers that do not meet the QoS targets set by the Authority:

a. amendment of conditions of the service provider's license or imposition of new terms to ensure compliance with the Technical QoS and KPI Regulation;

b. suspension of the service provider's license for a limited period or the final cancellation thereof upon repeated violation, as determined by the Authority;

c. Imposition of fines to be evaluated by the Authority in light of the seriousness of the violation or its recurrence. The Authority shall have the right to impose an additional fine for each day of delay in eliminating such violation according to article 41 of the Law 431/2002

6. Non-compliance due to Force Majeure events or external interference affecting radio cells located within 10 km from the international borders of Lebanon will exempt service providers from the above mentioned penalties. Nevertheless, QoS mandated measurements still need to be reported clearly citing the Force Majeure event and radio cell site.

Article 14. Audit Powers

Where the Authority is not satisfied with the accuracy or methodology used by a service provider in its periodic reports, the Authority may, without prejudice to its power to request information pursuant to the Telecommunications Law, regulations or license, require the service provider to provide such information, at the service provider's cost, with independently verified information for the services and period specified by the Authority.

Article 15. Publication

The Authority may publish on its website and/or in any other form or manner, as it considers appropriate, the details of the measurements supplied by the service providers pursuant to this Regulation either on an individual service provider basis or in such manner that it considers best with a view to carrying out its duties and obligations under the Telecommunications Law. For the avoidance of doubt such information provided by the service providers shall not be considered as confidential information.

CHAPTER 5. Abbreviations

Article 16. Abbreviations'meanings

Unless otherwise specifically indicated by context, abbreviations used in this Regulation shall have the meaning as identified below:

AUC	Authentication Centre
BTS	Base Transceiver Station
BSC	Base Station Controller
BRAS	Broadband Access Server
DSLAM	Digital Subscriber Line Access Multiplexer
HLR	Home Location Register
MSC	Mobile Switching Center
PDH	Plesiochronous Digital Hierarchy
RSU	Remote Switching Unit
RNC	Radio Network Controller
SDH	Synchronous Digital Hierarchy
VLR	Visitor Location Register

Article 17. This Regulation will be published and entered into force upon its publication in the Official Gazette.

Beirut on the 18th of March 2009

Dr. Kamal Shehadi

Chairman of the Telecommunications Regulatory Authority

Appendix A Technical Quality of Service

A.1 Theory for QoS Measurements

1. Like all services, telecommunications services have a quality component and a price component. In theory, the price component should relate closely to the quality component. But in telecommunications markets this may not always be true. Telecommunications markets are imperfect, and as a result service providers can, in some cases, increase profits by lowering QoS, hence uncoupling the price component from the quality component.
2. The prospect of increasing profit by lowering QoS increases when the service provider is a monopolist or is dominant so that its service levels are not subject to effective competitive pressure from other service providers. Regulators attempt to counteract this problem by, among other things, mandating QoS targets and promoting competition.
3. Designing a service quality monitoring system and analyzing the results is key to an effective QoS regime. Issues that need to be considered include factors such as:
    a. the relationship of quality of service to its costs and its value to the consumer;
    b. the identification of areas to be covered;
    c. the identification of information sources;
    d. the establishment of a balance between outcomes (i.e. QoS parameters), outputs (i.e. QoS measurements) and inputs (measured QoS performance submitted by service providers);
    e. the establishment of criteria for reliability, verifiability and comparability of the available information;
    f. an assessment of the costs of providing and processing the information; and
    g. the identification of performance indicators that are to be made available for public disclosure.

A.2 Grade of Service

1. A service provider must decide what services should be delivered to the user and the level of service quality that the user should experience. This is true for any telecommunications network independent of the transmission technology applied, whether it is circuit- or packet-switched, wired or wireless, or optical or copper-based. Further choices to be made may include the type and layout of the network infrastructure to support the services, and the choice of techniques to be used for managing the information transport. These choices may differ between service providers depending on whether the service provider concerned is already present in the market, or is starting service in a green field situation (i.e. a situation where there is no legacy network in place to consider).
2. QoS is defined in ITU-T Recommendation E.800 as “the collective effect of service performance, which determines the degree of satisfaction of a user of the service”. QoS consists of a set of parameters that pertain to the traffic performance of the network, but in addition to this, it also includes other parameters defined in the recommendation, such as:

- service support performance;
- service operability performance;
- serviceability performance; and
- service security performance.

3. Grade of Service (GoS) is defined in ITU-T Recommendation E.600 as “a number of traffic engineering variables to provide a measure of adequacy of a group of resources under specified conditions”. These GoS variables may include probability of loss and dial tone delay among others. In the recommendation, the values assigned for GoS parameter variables are termed GoS standards and the values of GoS parameters achieved under actual conditions are termed GoS results.
4. The key challenge in the determination of GoS standards involves the apportioning of individual values to each network element in such a way that the target end-to-end QoS is obtained.
5. Due to difficulties in establishing GoS and QoS parameters, Service Level Agreements (SLA) have been adopted. An SLA is a contract between a customer and a service provider, or between two service providers. It defines the parameters in question in such a way that they are understood in the same manner by the customer and the service provider. Furthermore, an SLA provides for penalties and remedies in cases where certain terms of the contract are violated. Some service providers have chosen to issue an SLA governing all customer relationships while others have adopted SLAs only in their dealings with larger customers. Regulations regarding SLAs and terms of service will be published as part of the Consumer Affairs Regulation.

A.3 Overall performance

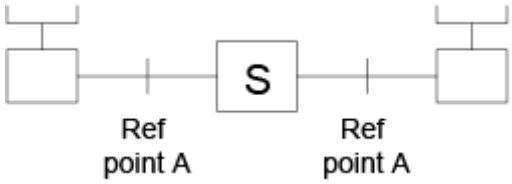
1. As mentioned above, network performance concerns the ability of a network or network portion to provide the functions related to communications between users. In order to establish how a certain network performs, it is necessary to perform measurements covering performance parameters (i.e. traffic, dependability, transmission and charging).
2. Network performance parameters in the context of GoS pertain only to factors related to traffic performance. In the context of QoS, network performance also includes the following concepts:
    a. dependability;
    b. transmission performance; and
    c. charging and billing accuracy.

A.4 Reference Configurations

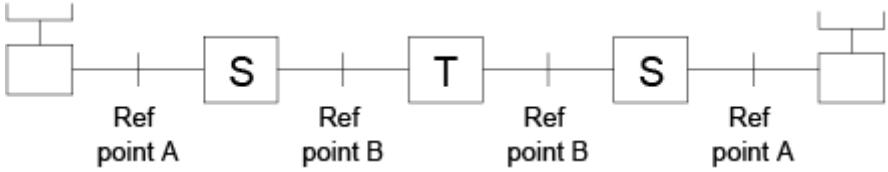
1. In order to obtain an overview of the network under consideration, it is often useful to produce a reference configuration. This consists of one or more simplified drawing(s) of the path a call or a connection can take in the network including appropriate reference points, where the interfaces between entities are defined. In some cases the reference points define an interface between two operators, and it is therefore important to watch carefully what happens at this point. From a GoS perspective the importance of the reference configuration is the partitioning of the GoS as described below. Consider a telephone network with terminals, subscriber

switches and transit switches. In this example we ignore the signaling network and we suppose the call can be routed in one of three ways:

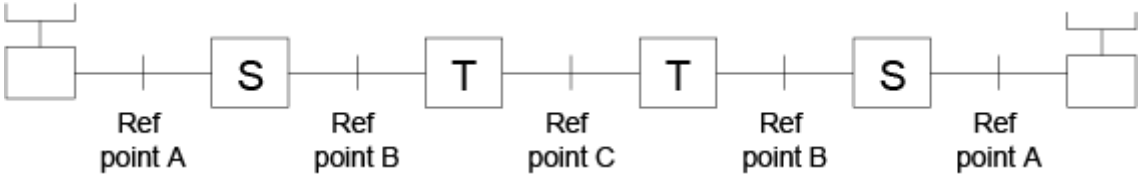
a. Terminal → subscriber switch → terminal



b. Terminal → subscriber switch → transit switch → subscriber switch → terminal



c. Terminal → subscriber switch → transit switch → transit switch → subscriber switch → terminal



2. Based on a given set of QoS requirements, a set of GoS parameters are selected and defined on an end-to-end basis within the network boundary for each major service category provided by a network. The selected GoS parameters are specified in such a way that the GoS can be derived at well defined reference points (i.e. traffic significant points). This is to allow the partitioning of end-to-end GoS objectives to obtain the GoS objectives for each network stage or component, on the basis of some well-defined reference connections.
3. As defined in ITU-T Recommendation E.600, for traffic engineering purposes a connection is an association of resources providing means for communication between two or more devices in, or attached to, a telecommunication network. There can be different types of connections as the number and types of resources in a connection may vary. Therefore, the concept of a reference connection is used to identify representative cases of the different types of connections without involving the specifics of their actual realizations by different physical means.
4. Typically, different network segments are involved in the path of a connection. For example, a connection may be local, national, or international. The purpose of reference connections is to clarify and specify traffic performance issues at various interfaces between different network domains. Each domain may consist of one or more service provider networks. ITU-T Recommendations I.380/Y.1540 defines performance parameters for IP packet transfer; its companion ITU-T Draft Recommendation Y.1541 specifies the corresponding allocations and performance objectives. ITU-T Recommendation E.651 specifies reference connections for IP-access networks. Other reference connections may be specified.

5. From the QoS objectives, a set of end-to-end GoS parameters and their objectives for different reference connections are derived. For example, end-to-end connection blocking probability and end-to-end packet transfer delay may be relevant GoS parameters. The GoS objectives should be specified with reference to traffic load conditions, such as under normal and high load conditions. The end-to-end GoS objectives are then apportioned to individual resource components of the reference connections for dimensioning purposes. In an operational network, to ensure that the GoS objectives have been met, performance measurements and performance monitoring are required.
6. In IP-based networks, performance allocation is usually done on a cloud (i.e. the set of routers and links under a single or collaborative jurisdictional responsibility, such as an ISP). A cloud is connected to another cloud by a link (i.e. a gateway router in one cloud is connected via a link to a gateway router in another cloud). End-to-end communication between hosts is conducted on a path consisting of a sequence of clouds and interconnecting links. Such a sequence is referred to as a hypothetical reference path for performance allocation purposes.

A.5 Fixed Telephony QoS

1. In the field of telephony engineering, the term QoS comprises all the aspects of a connection, such as time to provide service, voice quality, echo, loss, reliability and so on. A subset of telephony QoS is GoS, which comprises aspects of a connection relating to the capacity of a network. In circuit-switched networks, GoS is the probability of one party not being able to initiate a call to another party (i.e., a call attempt blocked and lost owing to congestion).
2. When looking at circuit-switched networks, QoS is affected by various factors, which can be divided into "human" and "technical" factors. Human factors include stability of service, availability of service, delays, and user information. Technical factors include reliability, scalability, effectiveness, maintainability, and GoS. In circuit-switched networks, the GoS expresses the call blocking experienced due to congestion that can result in calls being lost. It is the responsibility of the service provider to monitor and manage the GoS of all its services to ensure that the GoS is maintained for every origin and destination pair.

A.6 Mobile Telephony QoS

1. Many factors affect the QoS of a mobile network. It is appropriate to look at QoS mainly from the customer's point of view, that is, QoS as judged by the user. There are standard metrics of user QoS that can be measured. These metrics are coverage, accessibility (including GoS), and audio quality. For coverage, the strength of the signal is measured using test equipment to estimate the size of the cell. Accessibility is about determining the ability of the network to handle successful calls from mobile-to-fixed networks and from mobile-to-mobile networks. Audio quality involves the monitoring of successful calls for a period of time for clarity of the communication channel. These indicators are used by the telecommunications industry to rate the QoS of a network.
2. QoS is also measured from the perspective of an expert (e.g., a teletraffic engineer). Such a measurement involves assessing the network to see if it delivers the quality that the network planner has been required to deliver. Certain tools and methods (e.g., protocol analyzers, drive tests, and Operation and Maintenance measurements) are used in such a measurement.

a. Protocol analyzers are connected to Base Transceiver Stations (BTS), Base Station Controllers (BSC), and Mobile Switching Centers (MSC) for a period of time to check for problems in the cellular network. When a problem is discovered the staff can record it and it can be analyzed.

b. Drive tests allow the mobile network to be tested through the use of a team of people who take the role of users and take the QoS measures discussed above to rate the QoS of the network. This test does not apply to the entire network, so it is always a statistical sample.

c. In Operation and Maintenance Centers (OMCs), counters are used in the system for various events which provide the network operator with information on the state and quality of the network.

d. Finally, customer complaints are a vital source of feedback on QoS, and must not be ignored by service providers. They must be reported as part of QoS and Consumer Affairs reporting requirements.

3. In general, GoS is measured by looking at traffic carried and traffic offered, and by calculating the traffic blocked and lost. The proportion of lost calls is the measure of GoS. The GoS standard is thus the acceptable level of traffic that the network can lose. GoS is calculated from the Erlang-B Formula, as a function of the number of channels required for the offered traffic intensity.

4. The audio quality of a cellular network depends on, among other factors, the modulation scheme (e.g., Frequency Shift Keying (FSK), Quadrature Phased Shift Keying (QPSK)) in use, matching channel characteristics, and the processing of the received signal at the receiver using Digital Signal Processing (DSP).

A.7 Packet-switched Network QoS

1. In the field of packet-switched network and computer network engineering, the term QoS refers to control mechanisms that can assign different priorities to different users or data flows, or guarantee a certain level of performance to a data flow in accordance with requests from an application program. QoS guarantees are important if network capacity is limited, especially for real-time streaming multimedia applications such as Voice Over Internet Protocol (VoIP) and Internet Protocol Television (IP-TV), since these often require a fixed bit rate and are delay sensitive.

2. A network or protocol that supports QoS may agree on a traffic contract with the application software and reserve capacity in the network nodes during a session establishment phase. During the session it may monitor the achieved level of performance, for example the data rate and delay, and dynamically control scheduling priorities in the network nodes. It may release the reserved capacity during a tear down phase.

3. The term QoS is also sometimes referred to as a quality measure as opposed to as a control mechanism. In computer networking, a good QoS may mean the use of advanced QoS mechanisms or a high probability that the network is able to provide the requested level of performance. High QoS is often confused with a high level of performance, for example high bit rate, low latency and low bit error probability.

4. Another widespread definition used especially in VoIP and streaming video is "user perceived performance" or "degree of satisfaction of the user". In this context, QoS is the cumulative effect on user satisfaction of all imperfections affecting the service. This definition includes a human error in the assessment and demands an appropriate subjective weighting of diverse defects such as response time, interrupts, noise, cross-talk, loudness levels, frequency response, noticeable

echoes, etc., as well as GoS. This definition resembles the Mean Opinion Score (MOS) value, which is a subjective quality measure that can be predicted based on objective performance measures.

5. When the Internet was first deployed many years ago, it lacked the ability to provide QoS guarantees due to limits in router computing power. It therefore ran at default QoS level, or "best effort". There were four "Type of Service" bits and three "Precedence" bits provided in each message, but they were ignored. These bits were later re-defined as Differentiated Services Code Points (DSCP) and are largely honored in peered links on the modern Internet.
6. Many things can happen to packets as they travel from origin to destination, resulting in the following problems as seen from the point of view of the sender and receiver
    a. Dropped packets
    Routers might fail to deliver (*drop*) some packets if they arrive when their buffers are already full. Some, none, or all of the packets might be dropped, depending on the state of the network, and it is impossible to determine what will happen in advance. The receiving application may ask for this information to be retransmitted, possibly causing severe delays in the overall transmission.

    b. Delay
    It might take a long time for a packet to reach its destination because it gets held up in long queues, or takes a less direct route to avoid congestion. Alternatively, it might follow a fast, direct route. Thus delay is very unpredictable.

    c. Jitter
    Packets from the source will reach the destination with different delays. This variation in delay is known as jitter and can seriously affect the quality of streaming audio and/or video.

    d. Out-of-order delivery
    When a collection of related packets is routed through the Internet, different packets may take different routes, each resulting in a different delay. The result is that the packets arrive in a different order than they were sent. This problem requires special additional protocols to rearrange out-of-order packets to an isochronous state once they reach their destination. This is especially important for video and VoIP streams where quality is dramatically affected by both latency and lack of isochronicity.

    e. Error
    Sometimes packets are misdirected, combined together, or corrupted while *en route*. The receiver has to detect this and, just as if the packet was dropped, ask the sender to resend it.
7. The problems encountered in a connection-less packet-switched network like the Internet can include insufficient throughput, packet loss, latency and jitter, which may cause different problems for different services. Insufficient throughput, latency and jitter cause problems for real time video; latency and jitter are problematic in relation to VoIP services; and packet loss may constitute a problem in connection with the transmission of data files. There are two basic solutions to these problems. One is to have sufficient or too much (i.e. over-provisioning) capacity in the network and the other one is to prioritize communications so that, for instance, real time communications are given priority over less time-dependent services. Such prioritization is presently implemented along two different levels of quality,

integrated services (IntServ) and differentiated services (DiffServ). IntServ allows finer grained prioritization than DiffServ. IPv6 also includes functionalities allowing for the prioritization of different kinds of communication.

8. It is important to note that in this context, QoS mechanisms are simply prioritization or rationing schemes for available capacity. QoS mechanisms do not create any additional capacity. Queuing theory shows that for a fixed network load, the sum total of disservices (delay, jitter, and loss) is a constant. QoS mechanisms allow some of this disservice to be shifted from one group of users to another.
9. A defined QoS may be required for certain types of network traffic, for example:
    a. streaming multimedia requires guaranteed throughput;
    b. VoIP requires strict limits on jitter and delay;
    c. video teleconferencing requires low jitter;
    d. dedicated link emulation requires both guaranteed throughput and limits on maximum delay and jitter; and
    e. safety-critical applications, such as remote surgery and alarm signaling, may require a guaranteed level of availability (or *hard QoS*).

    These types of network traffic or services are called *inelastic*, meaning that they require a certain level of bandwidth to function - any more than required is unused, and any less will render the service non-functioning.

    By contrast, *elastic* applications can take advantage of however much or little bandwidth is available. For example, a remote system administrator may want to prioritize variable, and usually small, amounts of Secure Shell (SSH) traffic to ensure a responsive session even over a heavily-laden link.

Appendix B Set of Quality of Service Parameters

Definitions and Calculation Methodologies for Major Parameters

1. **Availability of Telephone Exchange Equipment -** Telephone exchange equipment is unavailable when there are exchange faults such as those related to switching or transmission. Availability calculation is based on inputs obtained from all local switches only. Outage time includes software and hardware faults.

$$\boldsymbol{Availability} = \left(\sum_{i=1}^{n} \frac{\textbf{Per local switch(i)minutes} - \textbf{Per local switch (i) outage minutes}}{\textbf{Per local switch (i)minutes}}\right) \textbf{x 100}$$

   Per local switch minutes = No. of days in the month x 24 hours x 60 minutes
   Per local switch outage minutes = Cumulative duration of outage per local switch in the month

2. **Call Set Up Time -** The call set up time is the period starting when the address information required for setting up a call is received by the network and finishing when the called party busy tone or ringing tone, or answer signal is signaled by the access network to the terminal.

   The call set-up time will be calculated for all successful call attempts in the network during the network busy hour on the busiest day of each week during the reporting period. The average of the weekly call set-up times in the reporting period is then calculated. This value must be less than or equal to the specified call set-up time target. A successful call attempt refers to a call from a calling party who is successfully switched through to the called party, or receives busy tone when the called party is engaged speaking.

3. **Fixed Unsuccessful Call Ratio -** An unsuccessful call is defined as a call attempt where the caller does not hear either a standard busy or a ringing tone.

$$\boldsymbol{Unsuccessful\ Call\ Ratio} = \frac{\text{Number of unsuccessful calls}}{\text{Total number of call attempts}} \times 100$$

4. **Fault Rate per Access Line -** Access lines are the distribution circuits from the exchange to the distribution point, including the fiber, copper, access multiplexers and any other access equipment where applicable.

5. **Response Time for Operator Services -** The duration from the instant when the address information required for setting up a call is received by the network (e.g., recognized on the calling user's access line) to the instant the human operator answers the calling user to provide the service requested. Interaction time with

automatic systems should be excluded. The services covered are the services for operator controlled and assisted calls that are accessed with special access codes. Access to emergency services is excluded.

6. **Domestic / International Leased Lines Service Availability** - the measure of the degree to which the access network is operable and is not in a state of failure or outage at any point in time. It measures the total downtime of the network, including the ATM switches, multiplexers, routers, e-mail facilities (if provided) and connection to the Internet backbone over a month. All scheduled downtime for the purposes of maintenance and upgrading of the network system will be excluded from the calculation. However, all service providers must keep their users informed of such maintenance times. Please note that reported downtime should include any downtime caused by upstream service providers.

$$\boldsymbol{Availability} = \frac{\textbf{Total operational minutes} - \textbf{Total minutes of service downtime}}{\textbf{Total operational minutes}} \times \mathbf{100}$$

Operational minutes = No. of days in the month x 24 hours x 60 minutes
Minutes of service downtime = Cumulative duration of outage per circuit in the month

7. **Mobile Unsuccessful Call Ratio -** Unsuccessful call ratio is defined as the ratio of unsuccessful calls to the total number of call attempts in the collection period. An unsuccessful call is a call attempt to a valid number, while in a coverage area, where neither the call is answered nor called party busy tone, nor ringing tone, nor turned off, is recognized at the access of the calling user within 40 seconds from the instant when the subscriber number is received by the network.

$$\boldsymbol{Mobile\ Unsuccessful\ Call\ Ratio\ Mobile\ Unsuccessful\ Call\ Ratio} = \frac{\text{Attempts at seizing TCH for a call} - \text{Successful seizing of TCH for a call}}{\text{Attempts at seizing TCH for a call}} \times 100$$

The formula includes the attempts to seize a TCH for an originated or terminated call and the success at assigning a TCH for an originated or terminated call.

8. **Dropped Call Ratio –**

$$Dropped\ Call\ Ratio = \frac{\text{number of dropped calls}}{\text{Total number of established calls on the TCH}}$$

9. **Congestion Factor –** measures the ratio of congested radio cells (BTS) to the total radio cells (BTS) at the network's busiest hour of the month.

$$Congestion\ Factor = \frac{\text{number of congested cells}}{\text{Total number of cells}} \times 100$$

A cell is deemed congested at the busiest hour of the month if the carried traffic is greater or equal than the permissible traffic calculated with the Erlangs B table for a 2% blocking factor probability.

10. **Packet Loss -**

$$\textbf{Packet Loss} = \frac{\textbf{sent ICMP requests} - \textbf{received ICMP requests}}{\textbf{sent ICMP requests of these same ICMP}} \times \mathbf{100}$$

Echo requests for a server at an international exchange in the USA must be less than or equal to the ratio of packet loss.

11. **Delay -** Providers are required to send a PING packet from a reference server on the customer side of a network access node to (a) a server at a point of traffic exchange with another service provider in Lebanon and (b) a router at an International exchange in the USA. For the avoidance of doubt, PING packets are Internet Control Message Protocol (ICMP) echo requests, which are 32 bytes in size for MS DOS and 56 data bytes for UNIX/MAC. PINGs will be sent at not less than sixty second intervals, to each of the case (a) and case (b) servers, during the three busiest hours of the week for each week in the reporting period. The average round trip delay for all these ping packets and their respective echoes are calculated separately for case (a) and case (b). The value for case (a) must be equal to or less than the target for national delay, and the value for case (b) less than the target value for international delay.

12. **Jitter -** The standard deviation of the received times of these same ICMP echo requests at a server at an international exchange in the USA must be less than or equal to the JITTER target.

13. **ADSL Throughput -** throughput should be reported for all available speeds Throughput will be determined from the download and upload timings of a File Transfer Protocol (FTP) file to and from a reference server, placed at a point of traffic exchange, in Lebanon, between service providers. The throughput for each file is calculated for the downstream test as:

$(5 \times 8 \times 10^6)$/(Time the first byte of file data is received-Time the last byte of file data is received)

And for the upstream test as:

$(1 \times 8 \times 10^6)$/(Time the first byte of file data is received-Time the last byte of file data is received)

Downstream test

10 test files, each 5Mbytes in size, will be downloaded from the reference server to a download host on the user side of each and every access network node during the busiest hour of the busiest day of the week of the respective access node. The throughput for all such downloaded files for all access nodes during the reporting period should be arranged in ascending order and the 90th-percentile reading must be taken. This value must be greater than or equal to the target value for downstream throughput.

Upstream test

10 test files, each 1Mbyte in size, will be uploaded to the reference server, from an upload host on the user side of each and every access network node during the busiest hour of the busiest day of the week of each access node. The throughput for all such uploaded files for all access nodes during the reporting period should be arranged in ascending order and the 90th-percentile reading must be taken. This value must be greater than or equal to the target value for upstream throughput.

Appendix C Network Outage Report

NETWORK OUTAGE REPORT

CONTACT INFORMATION

Name of Reporting Entity (e.g., company)	SP License No.
Primary Contact Person:	E-mail:
	Phone No.

OUTAGE INFORMATION

Type of outage

- ☐ Emergency Services outage
- ☐ Critical
- ☐ Major
- ☐ Minor

Date of Incident (dd/mm/yyyy): ----------

Local Time Outage Began (24-hr hh:mm): ----------

Outage Duration: ----- hrs ----- min

Outage status when filing this report: ----------

Local Time Outage Resolved (24-hr hh:mm): ----------

Effects of the Outage

Network Element(s) Affected ----------

Percentage of Traffic Affected ----------

Geographic Area Affected

- ☐ Cities: ----------
- ☐ Affected Sites: ----------

Description of the Outage:

Explanation of Outage Duration

Cause:

Actions:

DECLARATION

I am authorized by the Service Provider to legally bind the provider to the truth, completeness, and accuracy of the information contained in this report. I on oath depose and state that the information contained therein is true, correct, and accurate to the best of my knowledge and belief, and that the Service Provider on oath deposes and states that this information is true, complete, and accurate.

Name:

Signature:

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