Chapter 2 of Network Performance and Quality of Service: Determination of Key Performance Indicator (KPI)

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1. The contents of Telecommunication Service Performance Indicators [20]

The performance indicators of telecommunications services consist of two inseparable things, that the performance parameters and the target value to be achieved on any parameter. Performance parameters are parameters that represent performance, there are two possible states, first in a positive statement, e.g. "availability", then the target value in this case the minimum value to be achieved, e.g. 95%. However, it can also be a parameter of performance in the form of a negative statement, e.g. "unavailability" then in this case the target value is the maximum number that can be reached, referring to the target value availability is 5%.

Basically, the performance parameters of telecommunications services are very many, refer to Chapter 1 of this book, there are many ways to categorize the performance parameters. Thus, there needs a guidance to composing a performance indicator groups are considered the most important to have become a KPI (Key Performance Indicator).

2. Procedure of Key Performance Indicators Determination

Technical considerations determining the QoS is also very complicated, as it include the selection of transport technology, topology, and reliability of the device.

Providers should develop the KPI (Key Performance Indicator), where KPI should be arranged on several considerations:

- 1) Should be fulfilled and is determined as the minimum standards for the telecommunications provider is a standard defined by the National Regulatory Body.
- 2) The company's performance standards should be wider (more performance parameters with better target values) than the standards set by the National Regulatory Body. For that purpose, the provider must learn and referring to the international standards and Recommendations of the ITU-T, ETSI, IEEE, ANSI and others.
- 3) Because the world recommendation or standardization is too many, the operator should elects the parameters which they think are the most important as the key parameter. For its task, is necessary to do the **benchmarking** with the standards of various world class telecom operators and National Regulatory Bodies in the world, and each performance parameter is accompanied by a target value. The key parameters must be ensured is in the agreement between the provider with the vendors.
- 4) Last but not least, the last consideration is the SLA (service level agreement) between providers and customers.

NOTE:

- 1) ITU-T is an agency under the United Nations, thus being the most fair of reference materials, all member countries, should pay attention to the recommendations of ITU-T. But, the ITU-T Recommendations are too many, thus every provider should have some staff, which specifically follows the state of the art of the recommendations issued by the ITU-T, particularly with respect to the performance of telecommunications networks and services.
- 2) The telecommunications regulatory body in each country has different quality, when the regulator is good, then it was able to formulate the key performance indicator of telecommunications services that should be fulfilled by every providers. The meaning of A good rule is that able to be met by the provider and also

satisfying the customers. Unfortunately, the customer satisfaction is influenced by the rates they pay, as an example: the customers will make a complain to the providers when they pay more expensive than other provider's rates, even though the performance is better.

- 3) SLA is one of the reasons that the provider should monitor the telecommunication traffic at every moment, in every place and at every service. Through SLA, the provider promises to serve customers by meeting specific performance requirements, while the SLA is not met, then the payment cannot be obtained, or may even the provider have to pay a penalty to its customers.

3. Target Values Determination

After selecting the KPI parameters, then we have to determine the target value of each parameter. Unfortunately, the determination of the target values are certainly needs the long time and often the target values should be change to adapt to the business and technology situation.

Here are some guidelines for determining the target values.

- 1) The target value of the KPI provider parameters should be higher than the target value set by the regulatory body. For example, regulators set a target value for chat success of 90% and end to-end delay is not allowed to exceed 1 minute, then the provider sets the target value, for example, are: 95 % and 30 seconds.
- 2) The provider should evaluate the target value in about 6 months to 1 year:
 - a. The provider increase the target if there are many complaints from customers in its performance indicator.

- b. The provider may declines the target value in the case of the service cost is more expensive.

4. Examples of the KPI (Key Performance Indicator)

Examples of KPI parameters are shown in the following table:

Table 1. The Example of Key Performance Indicator and Its target Value

Type of KPI	PERFORMANCE PARAMETER	TARGET VALUE
General Requirement of the World Class Operators (benchmark)	<ul style="list-style-type: none"> • Activation time of services • Malfunctioning rate of services for access to broadband internet • Repair time for services for access to broadband internet • Answer times to calls to customer assistance services • Bills challenged • Quality of Customer Experience • Quality Indicators for End Users Customer Care Services 	<ul style="list-style-type: none"> • 10 minutes - one hour • 1 minutes - 10 minutes • 30 minutes – 3 hours • 1 - 5 seconds • 0.00001 maximum error • 95 – 99 % • 95 – 99 %
Telephony Service Quality	Mean Opinion Score (MOS)	4 – 4.5 (maximum scale = 5) or 3.75 – 4.25 (maximum = 4.5)
General Requirement of National Regulatory Bodies (benchmark)	<ul style="list-style-type: none"> • Service Coverage • Network availability • Network Congestion (During Busy Hour) • Success rate of Telephony Calls • Set-up time for telephony calls • Drop call rate during busy hour • Complaints on coverage per 1000 subscriber • Service availability • Service accessibility • Metering and Billing error • Response time to the customer for assistance 	<ul style="list-style-type: none"> • 75 – 100 % • 95 – 99 % • 0.5 – 2 % • 80 – 98 % • 4 – 10 seconds • 0.5 – 2 % • 0.1 – 1 • 1 • 95 – 99 % • 92 – 99 % • 0.000001 (maximum) • 2 – 30 seconds

Table 2. Mobile Network Parameter Indicators

Type of Service	Examples of QoS Parameter Indicator
Network Accessibility	NER (Network Effectiveness Ratio)
Telephony Network	SCR (Successful Call Ratio)
	CCR (Call Completion ratio)
	NNGoS (End to end Grade of Service)
Mobile Telephony Network Accessibility	Location Update Success Rate
	Handover Success Rate
	Radio Network Unavailability
	Mean Data Rate
Telephony Service	Telephony Setup Time [s], In the past, often referred to PDD (Post Dial Delay)
	Telephony Speech Quality or MoS (Mean Opinion Score)
	Telephony Cut-off Ratio
SMS	SMS End-to-End Delivery Time
	Completion Rate or SMS loss Percentage
Internet Accessibility	PDP Context Activation Failure Ratio
	Attach Failure Ratio
Internet Service	HTTP Service Non-Accessibility & Session Failure Ratio
	FTP {Download Upload} Service Non-Accessibility & Session Failure Ratio
	E-Mail {Upload Download} Login Non Accessibility Session Failure Ratio
	Ping Round Trip Time
	Streaming Service Non-Accessibility & Reproduction Cut-off Ratio

5. Details of Quality Parameters in the Various International Standards

There are many international standards for telecommunication quality and experience, below are the summary.

Table 3. The Number of QoS parameters in Various International Institution

Service Category	Number of KPI	ETSI EG 202 009	ETSI EG 202 057	ETSI TS 102 250	ITU T E.800	3GPP TS 32 410	GSMA PRD IR.42	ITU-T E.771	3GPP 52 402
Telephony & Video Telephony	78	7	9	22	0	36	12	4	0
SMS & MMS	15	0	3	12	0	0	4	0	0
Internet	119	19	10	77	0	0	6	0	0
Customer Support & Maintenance	26	13	14	0	0	0	0	0	0
Total	238	39	39	111	0	36	22	4	0

5.1. ITU-T QoS Parameters

In the ITU-T Recommendation E.800, quality of service terms are classified into three broad areas: service, network and management.

Table 4 Quality of Service Terms in ITU-T E.800 [5], [6]

Service QoS Parameters	Network QoS Parameters	Management QoS Parameters
Service-provision	Customer premises equipment	QoS resource management
Call setup	Network/user interface	Class of service
Call progress	Interconnection	Customer relationship management
Service restoration/repair	Network accessibility	Benchmark
Service quality characteristics	Connection accessibility	Compensation schemes
Charging & Billing	Connection establishment error probability	Service level agreement (SLA)
Common	Connection establishment failure probability	Service quality agreement (SQA)
Service-specific terms	Unacceptable transmission probability	Time between interruptions
Security-specific terms	No tone probability	Interruption duration
	Misrouting probability	Mean time between interruptions
	Traffic ability performance	Mean time to restoration, Mean time to recovery, Mean time to repair
	Transmission performance	Fault coverage
	Bit transparency	Repair coverage
	Bit error ratio (BER)	Fault
	Error free seconds ratio	Corrective maintenance repair
	Propagation performance	Reliability performance
	End-to-end IP network	Failure rate acceleration factor
	End-to-end IP network performance	Disaster recovery, Business continuity
	Percent IP service availability (PIA)	Complaint
	Release failure probability	Discovery service
	Connection clearing failure probability	
	Connection establishment success ratio (CESR)	

Table 5 the ITU-T Performance targets for audio, video, and data applications [5], [6]

Medium	Application	Degree of Symmetry	Typical Data Rates	Key Performance Parameters & Target Values			
				One-way delay	Delay variation	Information loss (Note 2)	Other
Audio	Conversational voice	Two-way	4-64 kbit/s	<150 ms preferred (Note 1) <400 ms limit (Note 1)	<1 ms	<3% packet loss ratio (PLR)	
Audio	Voice messaging	Primarily one-way	4-31 kbit/s	<1 s for playback <2 s for record	<1 ms	<3% PLR	
Audio	High quality streaming audio	Primarily one-way	16-128 kbit/s (Note 3)	<10 s	<<1 ms	<1% PLR	
Video	Videophone	Two-way	16-384 kbit/s	<150 ms preferred (Note 4) <400 ms limit		<1% PLR	Lip-synch: <80 ms
Video	One-Way	One-Way	16-384 Kbit/s	<10 s		<1% PLR	
<p>NOTE 1: Assumes adequate echo control</p> <p>NOTE 2 – Exact values depend on specific codec, but assumes use of a packet loss concealment algorithm to minimize effect of packet loss.</p> <p>NOTE 3 – Quality is very dependent on codec type and bit-rate.</p> <p>NOTE 4 – These values are to be considered as long-term target values which may not be met by current technology.</p>							

Table 6 the ITU-T Performance targets for data applications [5], [6]

Medium	Application	Degree of Symmetry	Typical Data	Key Performance Parameters & Target Values		
				One-way delay	Delay variation	Information loss
Data	Web-browsing – HTML	Primarily one-way	~10 KB	Preferred < 2 s /page. Acceptable < 4 s /page	N.A.	Zero
Data	Bulk data transfer/retrieval	Primarily one-way	10 KB-10 MB	Preferred < 15 s Acceptable < 60 s	N.A.	Zero
Data	Transaction services – high priority e.g. e-commerce, ATM	Two-way	< 10 KB	Preferred < 2 s Acceptable < 4 s	N.A.	Zero
Data	Command/control	Two-way	~ 1 KB	< 250 ms	N.A.	Zero
Data	Still image	One-way	< 100 KB	Preferred < 15 s Acceptable < 60 s	N.A.	Zero
Data	Interactive games	Two-way	< 1 KB	< 200 ms	N.A.	Zero
Data	Telnet	Two-way (asymmetric)	< 1 KB	< 200 ms	N.A.	Zero
Data	E-mail (server access)	Primarily one-way	< 10 KB	Preferred < 2 s Acceptable < 4 s	N.A.	Zero
Data	E-mail server to server transfer	Primarily one-way	< 10 KB	several Minutes	N.A.	Zero
Data	Fax ("real-time")	Primarily one-way	~ 10 KB	< 30 s/page	N.A.	<10 ⁻⁶ BER
Data	Fax (store & forward)	Primarily one-way	~ 10 KB	several Minutes	N.A.	<10 ⁻⁶ BER
Data	Low priority Transactions	Primarily one-way	< 10 KB	< 30 s	N.A.	Zero
Data	Usenet	Primarily one-way	> = 1 MB	several Minutes	N.A.	Zero
NOTE – In some cases, it may be more appropriate to consider these values as response times.						

Based on the target performance requirements identified in table 5 and 6, the various applications can be mapped onto axes of packet loss and one-way delay as shown in figure 2.1.

Fig 2.1. Target Values of ITU-T's QoS

5.2. ETSI- QoS Parameters

There is the need to specify independent QoS criteria for each service, thus the relevant prerequisites may be required.

Table 7 QoS Criteria of ETSI

Service Independent QoS Criteria	Direct Services QoS Criteria	Store-and-Forward (S&F) Services QoS Criteria
Radio network unavailability	File Transfer (FTP)	E-Mail
Network non-accessibility	Mobile Broadcast	Multimedia Messaging Service (MMS)
Attach failure ratio	Ping	Short Message Service (SMS)
Attach Setup Time	Push to talk over Cellular (PoC)	
PDP context activation failure ratio	Streaming	
PDP context activation time	Telephony	
PDP Context Cut-off Ratio	Video Telephony	
Data call access failure ratio	Web Browsing (HTTP)	
Data call access time		

Table 8.1. Direct Services QoS Criteria -1 [2]

File Transfer (FTP)	Push to talk over Cellular (PoC)	Video Telephony	Mobile Broadcast
Service Non-Accessibility	Registration Failure Ratio	Service Non-Accessibility	Network Non-Availability
Setup Time	Registration Time	Service Access Time	Service Discovery Failure Ratio
IP-Service Access Failure Ratio	3 Publish Failure Ratio	Audio/Video Setup Failure Ratio	Service Discovery Time
IP-Service Setup Time	Publish Time	Audio/Video Setup Time	Bootstrapping Failure Ratio
Session Failure Ratio	Registration Failure Ratio (long)	Cut-off Call Ratio	Bootstrapping Time
Session Time	Registration Time (long)	Speech Quality on Call Basis	ESG Retrieval Failure Ratio
Mean Data Rate	Session Initiation Failure Ratio (on-demand)	Speech Quality on Sample Basis	ESG Retrieval Time
Data Transfer Cut-off Ratio	Session Initiation Time (on-demand)	Video Quality	Content Non-Accessibility

Table 8.2. Direct Services QoS Criteria -2 [2]

Streaming	Telephony	Web Browsing (HTTP)	Ping
Network Non-Availability	Service Non-Accessibility	Service Non-Accessibility	Round Trip Time
Service Discovery Failure Ratio	Setup Time	Setup Time	
Service Discovery Time	Speech Quality on Call Basis	IP-Service Access Failure Ratio	
Bootstrapping Failure Ratio	Speech Quality on Sample Basis	IP-Service Setup Time	
Bootstrapping Time	Cut-off Call Ratio	Session Failure Ratio	
ESG Retrieval Failure Ratio & time		Session Time	
Content Non-Accessibility		Data Transfer Cut-off Ratio	
Content Access Time			
Interactivity Response Failure Ratio & Response time			

Table 9. Store-and-Forward (S&F) Services QoS Criteria [2]

E-Mail	Multimedia Messaging Service (MMS)	Short Message Service (SMS)
Service Non-Accessibility	Send Failure Ratio	Service Non-Accessibility
Setup Time	Retrieval Failure Ratio	Access Delay
IP-Service Access Failure Ratio	Send Time	End-to-End Delivery Time
IP-Service Setup Time	Retrieval Time	Completion Failure Ratio
Session Failure Ratio	Notification Failure Ratio	
Session Time	Notification Time	
Mean Data Rate	End-to-End Failure Ratio	
Data Transfer Cut-off Ratio	End-to-End Delivery Time	

Table 10.1. ETSI QoS Parameters for VoIP -1

Qos Parameters Specific To PLMN	Call Delivery And Collection	Internet Access	Other Services
Unsuccessful call ratio for telephony	Unsuccessful call ratio for call delivery	Login time	Response times for answering fault reporting line
Dropped call ratio	Unsuccessful call ratio with carrier selection	Data transmission speed achieved	Billing queries
	Blocking at Busy Hour on the interconnection circuit groups	Unsuccessful data transmission ratio	Billing amendments
		Successful log-in ratio	Time to confirm that a number can or cannot be ported
		Delay (one way transmission time)	

Table 10.2. ETSI QoS Parameters for VoIP -2

QoS parameters for voice, data and fax Mobile Services accessed via the PSTN and SMS	Interconnection
Unsuccessful call ratio	Supply time for initial physical interconnection at a site
Call set up time	Supply time of E1 Interconnection circuits on an established interconnection link
Speech connection quality	Supply time for a call by call carrier selection facility to another operator
Fax connection quality	Supply time for handling customer originated carrier pre-selection requests from another operator
Data rate of dial-up access to the Internet	Availability of E1 interconnection circuits per interconnection link
Successful SMS Ratio	Fault rate per E1 interconnection circuit
Completion Rate for SMS	Fault repair time for the E1 interconnection circuits
Response time for admin/billing enquiries	
Frequency of customer complaints	
Customer complaints resolution time	
Bill correctness complaints	
Prepaid account credit correctness complaints	
Bill presentation quality	
Customer relations	
Professionalism of help line	

5.3. 3GPP Standard TS 23.207 Parameters

Table 11.1. The3GPP QoS Parameters - 1 [7]

RAB establishment success rate pS	Call drop rate	Outgoing Hard Handover success rate
RRC Connection Establishment Success Rate	Call Drop Rate (Cell Level)	Handover Success Rate (BSC and Cell)
UTRAN Service Access Success Rate	SDCCH Blocking Rate	
GERAN Service Access Success Rate for CS Domain	TCH Blocking Rate	
GSM PDP Context Activation Success Rate		
UMTS PDP Context Activation Success Rate		

Table 11.2. The3GPP QoS Parameters - 2 [9]

Utilization KPI	Availability KPI		Integrity KPI
Percentage of Established RABs, CS Speech	UTRAN Cell Availability	Mean User Data Throughput uplink on Iub interface (CS)	Uplink Block Error Rate
Percentage of Established RABs, CS 64kbps (Video telephony)	Cell Unavailability	Mean User Data Throughput downlink on Iub interface (CS)	TCH Traffic Carried
Percentage of Established RABs, TotalPS		Mean User Data Throughput uplink on Iub interface (PS)	
		Mean User Data Throughput downlink on Iub interface (PS)	
		Mean User Data Throughput uplink on IuCS interface	
		Mean User Data Throughput downlink on IuCS interface	
		Mean User Data Throughput uplink on IuPS interface	
		Mean User Data Throughput downlink on IuPS interface	

5.4. GSM Association Parameters

Table 12.1 QoS Parameters of GSMA - 1 [6]

Service Independent	Short Message Service	Packet Switched Data Service (General Packet Radio Service)
Network Accessibility Circuit Switched	Service Accessibility SMS MO	Service Accessibility Rate – Packet Switched Data
Network Accessibility Packet Switched	Access Delay SMS MO	Set-up Time – Packet Switched Data
	End-to-End Delivery Time SMS	Data Quality (DQ-PSD)
	Completion Rate SMS Circuit switched	Completed Session Ratio

Table 12.2 QoS Parameters of GSMA - 2 [6]

Telephony	Circuit Switched Data Service	Data Service Class Definitions and Measurements
Service Accessibility Telephony (SA-T)	Service Accessibility , Circuit Switched Data	Conversational Class Data
Setup Time Telephony (ST-T)	Set-up Time	Streaming Class
CSSR (Call Setup Success Ratio)	Data Quality (DQ-CSD)	Interactive Class
REL (ISUPv2 Signaling transparency)	Completion Rate Circuit Switched Data	Background class
OCN & RDN (ISUPv2 Signaling transparency)		
Call Completion Rate Circuit Switched telephony (CCR-CS-T)		
ALOC (Average Length of a Call)		
CLI Transparency		
Speech Quality (SpQ)		

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