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

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

Application guide for Recommendation ITU-T E.804 on quality of service aspects for popular services in mobile networks

Recommendation ITU-T E.804.1

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Recommendation ITU-T E.804.1

Application guide for Recommendation ITU-T E.804 on quality of service aspects for popular services in mobile networks

Summary

Recommendation ITU-T E.804.1 provides detailed guidance on the application of quality of service (QoS) metrics defined in clause 7 of Recommendation ITU-T E.804.

History

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Guidance, metrics, mobile services, QoS, trigger points, user perception.

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FOREWORD

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Introduction

The list of services presented in clause 7 of [ITU-T E.804], and the associated list of metrics defined, is rather large and include:

– 11 service independent QoS parameters (clause 7.2)

– 14 direct services, with a total of 175 QoS parameters (clause 7.3)

– 3 store-and-forward services, with a total of 70 QoS parameters (clause7.4)

When readers and potential users (mostly service providers and national regulation authorities, for monitoring purposes) consider this material, and before considering the provision in the following clauses of [ITU-T E.804], the first principal question arising is how to practically use it.

The solution to this question can be divided into two separate threads:

1) The prioritization of services and metrics[1]. Indeed, the supervision of a network cannot be based on a too large number of criteria. A subset of relevant services and metrics must be identified. To do so, recent evolutions in the usage of mobile applications, as well as new philosophies for monitoring, which are not yet incorporated in the current version of [ITU-T E.804], must also be taken into account.

2) The application of the selected metrics. Even if [ITU-T E.804] provides trigger points as well as instantiation across various access technologies or guidance for the usage of measurement tools, in some cases the elements provided need to be completed to achieve an applicable measurement procedure.

This Recommendation answers both parts of the question, taking into account the relevance of the service or metric for end-users. To do so, the information below is provided in the following clauses of this Recommendation:

– In clause 6, service independent QoS parameters from clause 7.2 of [ITU-T E.804] are reviewed, a subset of meaningful key performance indicators (KPIs) is proposed, and when needed detailed information provided to better apply them practically.

– In clauses 7 and 8, services and applications from clauses 7.3 and 7.4 of [ITU-T E.804] respectively are reviewed and a subset of services is proposed; then for each selected service, corresponding parameters are reviewed, a subset of meaningful QoS parameters is proposed, and when needed detailed information provided to better apply them practically.

The proposal made in this Recommendation for services is based on assumptions mostly related to an average business model of a mobile operator. This selection may differ from the appropriate one (potentially operator-specific) at local level. On the other hand, commercial considerations may suggest a set of services which cover the largest possible ground, in the sense that a particular service may not be the most popular service but its KPI could be good proxies for a large set of actual use cases. In that perspective, [ETSI TR 103 559] contains an agreed collection of test scenarios that can be considered relevant. A more generic recommendation can also be found in [ITU-T E.830].

Detailed information is provided on metrics only in case of incompleteness of the definition and trigger points in [ITU-T E.804]. Otherwise, users will refer to information already present in [ITU-T E.804]. A summary of all recommended services and metrics and the respective placeholders for relevant information is provided in clause 9.

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[1] Since the adoption of ITU-T E.804 (in 2014), the usage of vocabulary around mobile services has slightly evolved. The term "service" itself in ITU-T E.804 corresponds to what end users experience, while nowadays it is often understood with a meaning restricted to the access to network interface, and replaced by the term "application" taken from the vocabulary of Google and Apple. The usage of mobile services or applications has also become less monolithic than before, what could result in some difficulty to apply the categories (both in terms of services and parameters) defined in ITU-T E.804. In the current version of this Recommendation however, most of the vocabulary and assumptions of ITU-T E.804 are kept.

The material provided in this Recommendation is a complement to [ITU-T E.804]. It does not replace the provision contained in clause 6 and clauses 8 to 12 of [ITU-T E.804].

The lists of services and metrics in this Recommendation, and associated information, can be expanded in the future based on new contributions.

Recommendation ITU-T E.804.1

Application guide for Recommendation ITU-T E.804 on quality of service aspects for popular services in mobile networks

1 Scope

This Recommendation provides detailed guidance on the application of QoS metrics defined in clause 7 of [ITU-T E.804] on the definition of quality of service parameters and their computation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T E.804] Recommendation ITU-T E.804 (2014), *Quality of service aspects for popular services in mobile networks*.

[ITU-T E.807] Recommendation ITU-T E.807 (2014), *Definitions, associated measurement methods and guidance targets of user-centric parameters for call handling in cellular mobile voice service*.

[ITU-T E.830] Recommendation ITU-T E.830 (1992), *Models for the specification, evaluation and allocation of serveability and service integrity*.

[ITU-T G.1028] Recommendation ITU-T G.1028 (2019), *End-to-end quality of service for voice over 4G mobile networks*.

[ITU-T G.1028.1] Recommendation ITU-T G.1028.1 (2019), *End-to-end quality of service for video telephony over 4G mobile networks*.

[ITU-T G.1028.2] Recommendation ITU-T G.1028.2 (2019), *Assessment of the LTE circuit switched fall back – Impact on voice quality of service*.

[ITU-T J.343] Recommendation ITU-T J.343 (2014), *Hybrid perceptual bitstream models for objective video quality measurements*.

[ITU-T P.501] Recommendation ITU-T P.501 (2020), *Test signals for use in telephony and other speech-based applications*.

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

[ITU-T P.862.1] Recommendation ITU-T P.862.1 (2003), *Mapping function for transforming P.862 raw result scores to MOS-LQO*.

[ITU-T P.862.2] Recommendation ITU-T P.862.2 (2007), *Wideband extension to Recommendation P.862 for the assessment of wideband telephone networks and speech codecs*.

[ITU-T P.862.3] Recommendation ITU-T P.862.3 (2007), *Application guide for objective quality measurement based on Recommendations P.862, P.862.1 and P.862.2*.

[ITU-T P.863] Recommendation ITU-T P.863 (2018), *Perceptual objective listening quality prediction*.

[ITU-T P.863.1] Recommendation ITU-T P.863.1 (2019), *Application guide for Recommendation ITU-T P.863*.

[ITU-T P.1201.1] Recommendation ITU-T P.1201.1 (2012), *Parametric non-intrusive assessment of audio-visual media streaming quality – Lower resolution application area*.

[ITU-T P.1202.1] Recommendation ITU-T P.1202.1 (2012), *Parametric non-intrusive bitstream assessment of video media streaming quality – Lower resolution application area*.

[ITU-T P.1203.1] Recommendation ITU-T P.1203.1 (2019), *Parametric bitstream-based quality assessment of progressive download and adaptive audio-visual streaming services over reliable transport – Video quality estimation module*.

[ITU-T P.1203.2] Recommendation ITU-T P.1203.2 (2017), *Parametric bitstream-based quality assessment of progressive download and adaptive audio-visual streaming services over reliable transport – Audio quality estimation module*.

[ITU-T P.1203.3] Recommendation ITU-T P.1203.3 (2019), *Parametric bitstream-based quality assessment of progressive download and adaptive audio-visual streaming services over reliable transport – Quality integration module*.

[ITU-T P.1204.3] Recommendation ITU-T P.1204.3 (2020), *Video quality assessment of streaming services over reliable transport for resolutions up to 4K with access to full bitstream information*.

[ITU-T P.1204.4] Recommendation ITU-T P.1204.4 (2020), *Video quality assessment of streaming services over reliable transport for resolutions up to 4K with access to full and reduced reference pixel information*.

[ITU-T P.1204.5] Recommendation ITU-T P.1204.5 (2020), *Video quality assessment of streaming services over reliable transport for resolutions up to 4K with access to transport and received pixel information*.

[ETSI TR 101 578] ETSI TR 101 578 V1.3.1 (2018), *Speech and multimedia Transmission Quality* (STQ); *QoS aspects of TCP-based video services like YouTube™*.

[ETSI TR 103 138] ETSI TR 103 138 V1.5.1 (2018), *Speech and multimedia Transmission Quality (STQ)*; *Speech samples and their use for QoS testing*.

[ETSI TR 103 559] ETSI TR 103 559 V1.1.1 (2019), *Speech and multimedia Transmission Quality (STQ)*; *Best practices for robust network QoS benchmark testing and scoring*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the terms defined in [ITU-T E.804].

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

2G	Second generation of mobile networks
3G	Third generation of mobile networks
4G	Fourth generation of mobile networks
CLIP	Calling Line Identification Presentation
CSFB	Circuit Switched Fall Back
DNS	Domain Name System
FB	Full Band (telephony)
HD	High Definition (for voice)
HTTP	Hypertext Transfer Protocol
IMS	IP multimedia system
KPI	Key Performance Indicator
MMS	Multimedia Messaging Service
MOS	Mean Opinion Score
MOS-LQO	MOS – Voice Listening Quality (Objective assessment)
MTSI	Multimedia Telephony Service for IMS
NB	Narrow Band (telephony)
PDP	Packet Data Protocol
QoS	Quality of Service
QoE	Quality of Experience
RF	Radio Frequency
RSCP	Received Signal Code Power
RCS	Rich Communication Service
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
RTP	Real time Transport Protocol
RTSP	Real Time Streaming Protocol
SMS	Short Messages Services
SWB	Super Wide Band (telephony)
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UMTS	Universal Mobile Telecommunications System
VoLTE	Voice over Long Term Evolution of mobile networks
WAP	Wireless Application Protocol
WB	Wide Band (telephony)
WLAN	Wireless Local Access Network

5 Conventions

None.

6 Service independent QoS parameters

The parameters described in this clause are taken from clause 7.2 of [ITU-T E.804].

6.1 Radio network unavailability

See clause 7.2.1 of [ITU-T E.804].

Unavailability describes the probability that a network or service is not offered to a user (see clause 6.4.1 of [ITU-T E.804]). This is a basic notion of network performance for all stakeholders (for operators it is a sign that network operations failed somehow, whereas for end users or regulatory authorities it is the symptom that the promise of access to the services is not kept) and a quality of service (QoS) criterion independent on the considered service. This means that it has a much more global application scope than other parameters defined in clause 7.2 of [ITU-T E.804] and must be considered in priority.

With this definition, it is not possible to distinguish between the case when the operator is systematically and deliberately not offering the network or the service, and the one when they should be offered but are not. These different cases are linked to potentially separate regulatory requirements, and to separate expectations which are part of at least QoS if not quality of experience (QoE).

Radio network unavailability is highly linked with underlying radio technical key performance indicators (KPIs) and can be derived from the computation of statistics on these KPIs.

From a practical point of view, some end-to-end service KPIs (such as the one mentioned in clause 7.2.2 for telephony, for instance) implicitly contain the element of unavailability. The result will basically be the same if there is no network at all or if there is a network that cannot handle the set-up attempt. Finding which was the case would then be part of "drilldown".

6.2 Other parameters

Other interesting parameters are well defined in clause 7.2 of [ITU-T E.804] and do not require any further definition. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Network selection and registration failure ratio (7.2.2.1)

– Network selection and registration time (7.2.2.2)

Furthermore, as described in clause 6.1, other service independent QoS parameters defined in clause 7.2 of [ITU-T E.804] are more specific to a limited aspect of service delivery, represent a sub-part of radio network unavailability, or can be redundant with service-specific parameters closer to real users' perception. It is not a priority to implement them. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Attach failure ratio (7.2.3)

Attach set-up time (7.2.4)

– PDP context activation failure ratio (7.2.5)

– PDP context activation time (7.2.6)

– PDP context cut-off ratio (7.2.7)

– Data call access failure ratio (7.2.8)

– Data call access time (7.2.9)

– DNS host name resolution failure ratio (7.2.10)

– DNS host name resolution time (7.2.11)

7 QoS parameters for direct services

The parameters described in this clause are taken from clause 7.3 of [ITU-T E.804].

Out of the 14 services identified in [ITU-T E.804], three of them represent the large majority of usage and network throughput and will be addressed in this clause. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Audio-visual streaming (7.3.5) [2]

– Telephony (7.3.6)

– HTTP-based data services (7.3.8)[3]

7.1 Audio-visual streaming

This service is not defined in [ITU-T E.804]. Instead, the triggers for a streaming session are given, in terms of signalling messages (mostly RTSP), which is normally enough for defining metrics based on detection of events. It has to be noted that the name of this service has been modified in this Recommendation in comparison with [ITU-T E.804] (where the term "video streaming" is used with its common meaning including audio-visual contents) in order to avoid misinterpretation and to highlight the fact that video contents are not the only ones concerned; indeed, audio signal is also streamed at the same time (and [ITU-T E.804] is proposing metrics concerning the audio medium).

Clause 7.3.5.3 of [ITU-T E.804] provides a description of a typical audio-visual streaming session. This description requires some updates or complements as follows:

– Signalling flows, described in clause 7.3.5.3.1 and Figure 7-21, are representative of a part of use cases only since they take the assumption that the audio and video payload is carried by real time transport protocol (RTP) packets over user datagram protocol (UDP). In reality, HTTP packets on TCP are often used in most cases. Anyway, the protocol for the transport of real-time packets has no influence on the metrics and the way in which they are measured.

– The different phases of the session, described in clause 7.3.5.3.2, and associated trigger points t0 to t3 in Figure 7-22 can be completed to reach a more complete view of the session as shown in Figure 1 below, taken from [ETSI TR 101 578]. Trigger points t0 to t3 correspond respectively to each of the 4 first vertical bold (plain or dashed) lines (starting from the left) in Figure 1.

[2] Note that the respective clause of [ITU-T E.804] is entitled "Video streaming"

[3] Note that the respective clause of [ITU-T E.804] is entitled "Web browsing"

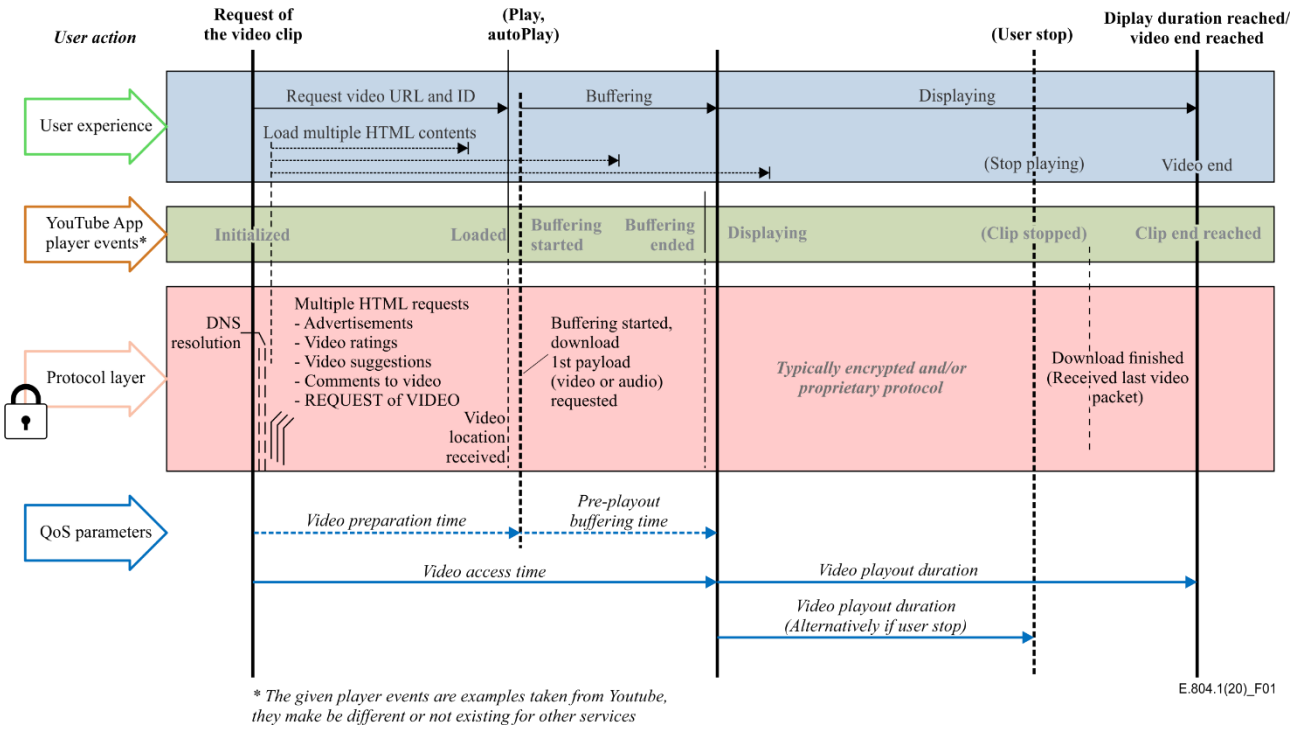

Figure 1 – Typical phases of IP-based audio-visual services, based on [ETSI TR 101 578]

7.1.1 Streaming service non accessibility

See clause 7.3.5.4 of [ITU-T E.804].

This parameter corresponds to the probability that a request for a session started at time trigger t0 never reaches the status defined for time trigger t1 (based on Figure 7-22 of [ITU-T E.804]).

The technical description of trigger point t0 is currently restricted to wireless application protocol (WAP). In reality, this protocol is almost never used for streaming audio-visual contents. A more generic description is provided in Table 2 of [ETSI TR 101 578] and must be used instead: "The corresponding event in the application or browser".

7.1.2 Streaming service access time

See clause 7.3.5.5 of [ITU-T E.804].

This parameter corresponds to the time between time triggers t0 and t2 in Figure 7-2 of [ITU-T E.804].

The information provided in clause 7.1.1 on trigger point t0 also applies here.

[ETSI TR 101 578] proposes a timeout associated to this metrics at a value of 60 seconds.

7.1.3 Streaming video quality

See clause 7.3.5.8 of [ITU-T E.804]. This clause states that there are no standardized solutions yet. Since the adoption of [ITU-T E.804], this situation has evolved and several relevant ITU-T Recommendations can be mentioned:

– ITU-T P.1201 and P.1202 series of Recommendations apply for UDP-based streaming, with specific documents for mobile applications:
  - [ITU-T P.1201.1] is parametric (it uses packet header information only) and provides audio, video, and audio-visual quality estimates.
  - [ITU-T P.1202.1] is bitstream-based and addresses only video quality. This model is dedicated to performance and quality assessment of live networks including the effect due to encoding and transmission errors.

– ITU-T P.1203 series of Recommendations is bitstream-based and applies for TCP-based streaming, with four different modes of operation depending on the level of encryption of the application, and provides audio ([ITU-T P.1203.2]), video ([ITU-T P.1203.1]) and audio-visual ([ITU-T P.1203.3]) quality estimates.
– ITU-T P.1204 series of Recommendations applies to adaptive streaming with video resolution up to 4k (but includes formats adapted to a usage on mobile phones):
  • [ITU-T P.1204.3]: Video quality assessment with access to full bitstream information
  • [ITU-T P.1204.4]: Video quality assessment with access to full and reduced reference pixel information
  • [ITU-T P.1204.5]: Video quality assessment with access to transport and received pixel information
– In case access to image information is given, image-based measures are preferred (ITU-T J.343.x, P.1204.4 and .5). In case no access to image is available, bitstream measures as in ITU-T P.1203.x can be applied.

Streaming video quality is estimated between trigger points t2 and t3.

NOTE – Model architecture is modular, and as such, it should be possible to combine building blocks from different Recommendation series (for instance a model for video quality could be combined with a model for global audio-visual quality from another Recommendation). However, there is no description of how that could and should be done in current Recommendations, and it is not just a straightforward plug and play.

7.1.4 Streaming reproduction metrics

See clauses 7.3.5.6 (cut-off ration), 7.3.5.10 (start failure ratio) and 7.3.5.11 (start delay) of [ITU-T E.804].

The most up to date definitions of some of these metrics can be found in [ETSI TR 101 578]:

– Video access failure ratio: The overall failure ratio for the video access between t0 and t2
– Video playout cut-off ratio: The overall cut-off ratio for the video playout between t2 and t3.

Although these definitions are given for video only, they can easily be expanded for the whole content of audio-visual clips.

7.1.5 Streaming rebuffering metrics

See clauses 7.3.5.14 (failure ratio) and 7.3.5.15 (time) of [ITU-T E.804].

The most up to date definitions of some of these metrics can be found in [ETSI TR 101 578]:

– Video freezing: The proportion of the accumulated video freezing duration in relation to the actual video playout duration (including freezing) for successful playout starts, considered between trigger points t2 and t3.

Furthermore, [ETSI TR 101 578] proposes timeouts associated to rebuffering events:

– Rebuffering timeout (Single) 30 s
– Rebuffering timeout (Total) 75 % of session time
– Max allowed rebuffering frequency 20 rebuf/min.

7.1.6 Other parameters

Other interesting parameters are well defined in [ITU-T E.804] clause 7.3.5 and do not require any further definition. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Streaming audio quality (7.3.5.7)
– Streaming audio/video de-synchronization (7.3.5.9)

Furthermore, other QoS parameters defined in clause 7.3.5 of [ITU-T E.804] are less important to implement and supervise, since they concern the process of audio-visual session termination (i.e., after the usage of the service). These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Streaming teardown failure ratio (7.3.5.12)

– Streaming teardown time (7.3.5.13)

7.2 Telephony

From end-user's point of view, the IP multimedia system (IMS) multimedia telephony (MTSI) direct service (see clause 7.3.12 of [ITU-T E.804]), corresponding to packet-switched IMS voice over 4G networks (VoLTE), is a sub case of telephony and does not need to be separated from it. All parameters identified and defined in this chapter apply also to this service.

For additional considerations on end-to-end quality of service for voice over 4G mobile networks see [ITU-T G.1028] and [ITU-T G.1028.2].

7.2.1 Speech quality metrics

See clauses 7.3.6.3 (quality on call basis) and 7.3.6.4 (quality on sample basis) of [ITU-T E.804]. These clauses recommend the use of either [ITU-T P.862] or [ITU-T P.863]. In what follows, guidance is provided on the choice of the right algorithm and operation mode.

The most challenging question when it comes to speech quality measurement is about test campaigns where various systems and networks are tested in sequence or in parallel. Some of them can be purely restricted to narrowband telephony when others can use wideband audio or even upper audio bandwidth. This is the practical case in most mobile networks, where 2G (NB and sometimes WB), 3G (NB and WB) and 4G (NB, WB and now also SWB) networks co-exist, with no prior knowledge of when exactly they will be considered during a test.

In this situation it is possible to apply separate models or separate modes of the same model (here [ITU-T P.863]):

– NB mode for tests where one can make sure that 100 % NB calls are involved (e.g., 2G only).

– Full band (FB) mode for ALL other tests.

The fact is that the results of these various tests will be expressed in terms of statistics on mean opinion scores (MOS) that cannot be compared with each other, since the respective benchmarks are different. Practically, a condition with a MOS score of 4.5 in NB mode will be scored only 2.8 in FB mode. If the probability exists (even if it is very small) that the results of tests performed on network with different radio technologies are compared with each other or with a single performance threshold, then a solution combining tests with different modes of [ITU-T P.863] is no longer valid.

For simplicity reasons, it is therefore recommended in such cases to adopt the mode of [ITU-T P.863] with the widest scope, i.e., the FB mode. Anyway, the scope of the FB mode of [ITU-T P.863] fully englobes the scope of the NB mode, as illustrated in Figure 2.

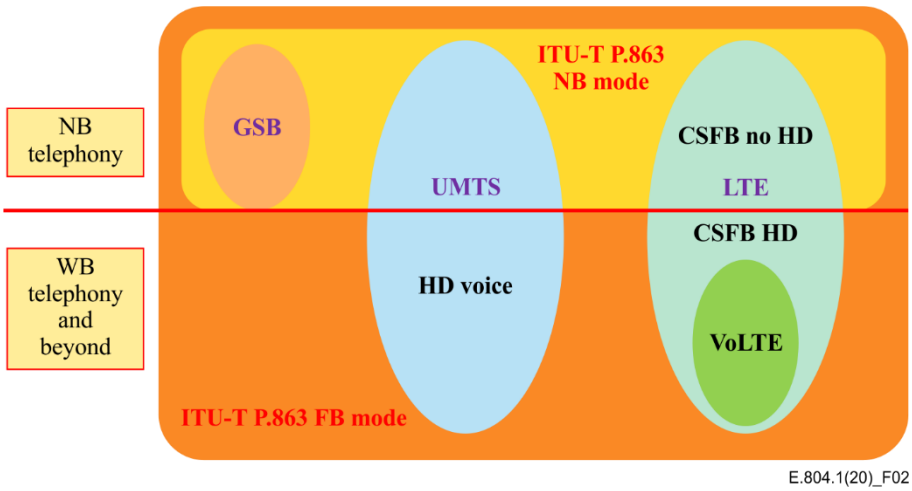

Figure 2 – Scopes of [ITU-T P.863] application modes

This Recommendation is also justified beyond simplicity considerations, i.e., from a QoS perspective which also includes the user's expectation. In a contemporary mobile network, users have experience of, and are likely to expect, high voice quality. So, if they do not get it due to any reason, respective MOS values are justified and cannot be hidden by the usage of another MOS scale.

In complement with the information provided above, Recommendations ITU-T P.862.3 and P.863.1 provide clear guidance on the application of the standard models for voice quality prediction:

– Clauses 7.2 and 7.3 of [ITU-T P.863.1] state clearly in which cases the NB and FB modes and scales of [ITU-T P.863] must be used.

– Clause 10.5 of [ITU-T P.863.1] explains also what happens when a narrow-band conditions is assessed with the FB mode of [ITU-T P.863].

– Clause 8.8 of [ITU-T P.863.1] gives a check list for the selection of appropriate reference signals. Such signals, as mentioned in clause 8.1 of [ITU-T P.863] can be found in [ITU-T P.501].

– Clause 12 of [ITU-T P.862.3] thoroughly explains the differences between the applications of the NB and the WB scales of [ITU-T P.862.1] and [ITU-T P.862.2] respectively.

To be valid and applicable, any specification from network operator or national regulator addressing the estimation of speech quality with objective measurements must comply with the following instructions:

The objective estimation of the end-to-end quality of a telephone communication is made using MOS-listening speech quality objective (MOS-LQO) scales. These scales describe the opinion of users with speech transmission and its troubles (e.g., noise, robot voice, dropouts, etc.) according to:

– [ITU-T P.863] (NB or FB mode), to be preferred,

– or alternatively [ITU-T P.862], in conjunction with [ITU-T P.862.1] (NB mode) or [ITU-T P.862.2] (WB mode).

The selection of the most appropriate algorithm, application mode and reference files must comply with the rules explained in [ITU-T P.863.1] and [ITU-T P.862.3]. One can also refer to [ETSI TR 103 138] on which speech samples to use and how.

– In most cases, where telephony service is available or will be available for users in WB audio or beyond, or when the quality of the service is expected to be compared with the quality of another service running in WB audio or beyond, Recommendation [ITU-T P.863] FB mode is the only algorithm to apply, with FB or SWB reference speech files.

– NB modes of [ITU-T P.863] and [ITU-T P.862] can be applied, with NB reference speech files, only in very limited contexts where there is the absolute certitude that only NB conditions will be tested, and that the results of the tests will not be compared with other tests performed on conditions where WB audio (or beyond) is used.
– For the time being, it is not recommended to use the WB mode of [ITU-T P.862.2].

In any case, the algorithm used ([ITU-T P.862] or [ITU-T P.863]) and its application mode (NB, WB or FB) must be reported.

7.2.2 Other parameters

Other interesting parameters are well defined in clause 7.3.6 of [ITU-T E.804] and do not require any further definition. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Telephony service non accessibility (7.3.6.1)
– Telephony set-up time (7.3.6.2)
– Telephony cut-off call ratio (7.3.6.5)

For this last parameter, it must be mentioned that a variant, mentioned in [ITU-T E.807], uses the number of call-set up tries in the denominator (when the one from [ITU-T E.804] the number of actually established calls), can be preferred in some cases. The choice of either parameter will have an impact on numbers reported and corresponding targets. Furthermore, the information on cut-off call ratio is incomplete without information on the test call duration. This needs to be reported alongside any such results.

Furthermore, another QoS parameter defined in clause 7.3.6 of [ITU-T E.804] is less important to implement and supervise since it addresses an additional, non-mandatory, feature. This is (the number in bracket corresponds to the respective clause in [ITU-T E.804]):

– telephony CLIP failure ratio (7.3.6.6)

7.3 HTTP-based data services

The metrics reported in this clause apply to web browsing as well as to other HTTP-based services such as HTTP based data transfer (down/upload). This larger scope, compared to [ITU-T E.804], corresponds to the actual usage of mobile data services. This is in accordance with the introduction of this Recommendation, where it is stated that there are special test types which do not directly represent a user scenario but are understood as a useful proxy for a wide range of actual usages. The most prominent member of this category is data downloading and uploading using the HTTP(s) protocol. Appendices I and II of this Recommendation provide examples of approaches based on this larger understanding of HTTP-bases services.

Clause 7.3.8 of [ITU-T E.804] introduces a difference between the service (i.e., the corresponding PDP context, covered in clauses 7.3.8.1 to 7.3.8.2), the IP service (i.e., the TCP connection, covered in clauses 7.3.8.3 to 7.3.8.4), a session of the service (covered in clauses 7.3.8.5 to 7.3.8.6), and the data transferred during sessions (covered in clauses 7.3.8.7 to 7.3.8.8). The concept with more relationship to the end-user perspective is the session, and it must be considered in priority.

Relevant KPIs must refer to successful (or unsuccessful) events in the session. For each event, the logical KPIs are measured by the success rate and the timing.

There are two practical ways to test HTTP-based data services.

– The most classical one consists in transferring a fixed amount of data and measuring the transfer time. For this first method, the session events are:
  • when a visible reaction of the service occurs (session set-up),
  • when the session is fully completed (session completion, or session failure).

– An alternative method consists in using a fixed time window for transfer without specifying the amount of transferred data. Here, the event "session completion" and the corresponding KPIs are no longer considered. Instead, the mean data rate is computed via the data volume which has been transmitted during this time.

Scenarios using a fixed amount of data face a practical problem coming from the fact that in different radio access technologies there are huge differences in maximum data rate. This leads to the situation where, for a data volume sufficient to determine data rate in, e.g., 4G, this volume would always cause a time-out in 2G or even 3G. This is the reason for introducing the alternative method. In practice, this means transmitting a data file of a very large size and stopping the transmission after the given time is reached. A detailed description of the rationale associated with this alternative approach is given in Appendix III.

7.3.1 HTTP set-up time

See clause 7.3.8.2 of [ITU-T E.804].

Although not directly related to the notion of session, HTTP set-up time is the most important metric for this type of service from an end user perspective. It must be monitored and reported. It corresponds to the measurement of time of the first event (session set-up).

The time trigger point for stopping the measurement of HTTP set-up time corresponds to the starting point for the measurement of HTTP session time. Thus, the sum of both corresponds to the total time spent by an end-user when experiencing this service.

7.3.2 Other parameters

Other interesting parameters are well defined in clause 7.3.8 of [ITU-T E.804] and do not require any further definition. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– HTTP session failure ratio (7.3.8.5). It corresponds to the measurement of success rate of the second event (session completion) in test scenarios with a fixed amount of data.

– HTTP session time (7.3.8.6). It corresponds to the measurement of time of the second event (session completion) in test scenarios with a fixed amount of data.

– HTTP mean data rate (7.3.8.7). It corresponds to the measurement of data volume transferred in test scenarios with a fixed duration. It can also be derived from HTTP session time in test scenarios with a fixed amount of data.

In [ITU-T E.804], there is no parameter to characterize the success rate of the event "session set up". It is recommended to implement such a parameter in complement to the four parameters selected in clauses 7.3.1 and 7.3.2 with similar triggers as for HTTP set-up time.

Furthermore, other QoS parameters defined in clause 7.3.8 of [ITU-T E.804] are less important to implement and supervise. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– HTTP Service non-accessibility (7.3.8.1)

– HTTP IP-service access failure ratio (7.3.8.3)

– HTTP IP-service set-up time (7.3.8.4)

– HTTP data transfer cut-off ratio (7.3.8.8)

7.3.3 Summary of parameters

Table 1 presents the proposed parameters mentioned in clause 7.3 with their practical application area:

Table 1 – Summary of parameters for HTTP-based data services and practical application area

Parameter	Measurement approach	HTTP-based data services
HTTP session set-up success ratio	Both	Web browsing ; UL/DL
HTTP (session) set-up time	Both	Web browsing ; UL/DL
HTTP session failure ratio	Fixed amount of data only	Web browsing ; UL/DL
HTTP session time	Fixed amount of data only	Web browsing ; UL/DL
HTTP mean data rate	Fixed duration	UL,DL

7.4 Other direct services with lower usage and less priority for QoS supervision

This Recommendation does not give any emphasis to services other than the three outlined in clauses 7.1 to 7.3, and therefore provides no further definition of corresponding parameters. The following are other direct services with lower usage and less priority for QoS supervision (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– File-transfer protocol (7.3.1): no big usage on mobile devices

– Mobile broadcast (7.3.2): similar characteristics to video streaming

– Ping (7.3.3): not a service

– Push to talk over cellular (PoC) (7.3.4): almost no usage

– Video telephony (7.3.7): almost no usage

  • For additional considerations on end-to-end quality of this service see [ITU-T G.1028.1].

– Web Radio (7.3.9): similar characteristics to video streaming (audio part)

– WLAN service provisioning with HTTP based authentication (7.3.10): contributes to the access and usages of other services, but not a service by itself

– Wireless application protocol (WAP) (7.3.11): almost no usage

– IMS multimedia telephony (7.3.12): included in telephony service in clause 7.2 above

– E-mail (7.3.13): no specific parameters, only service independent QoS parameters which are identified in [ITU-T E.804],

– Group call (7.3.14): included in telephony service in clause 7.2 above

8 Store and forward services

The parameters described in this clause are taken from clause 7.4 of [ITU-T E.804].

Out of the three services identified in [ITU-T E.804], only SMS (clause 7.4.4 of [ITU-T E.804] represents a broad usage and will be addressed in this clause.

The most relevant store and forward applications corresponding to the actual usage in mobile networks are rather over the top applications or rich communication service (RCS). These services (with features making them also pertaining to the category of direct services) are not considered in [ITU-T E.804]. A need has been identified to specify test cases and triggers in an application-agnostic way. This will be addressed in a future revision of this Recommendation.

8.1 Generic parameters

Clause 7.4.1 of [ITU-T E.804] defines several parameters that apply to any store-and-forward service. Indeed, the users' experience is similar for all these services.

It has to be mentioned that all these parameters correspond to the use case where the users are at the origin of the interaction with the service. There are no parameters in [ITU-T E.804] to quantify the

performance in use cases where the application server is initiating the interaction (by sending notifications to the user). A need has been identified to specify parameters for such use case. This will be addressed in a future revision of this Recommendation.

8.1.1 Message upload session metrics

See clauses 7.4.1.2 (failure ratio) and 7.4.1.3 (time) of [ITU-T E.804].

A store and forward session is characterized mostly by the two dimensions of completion and duration, reflected respectively by these two metrics.

These metrics rely on the notion of message upload session. A session is considered successful (or successfully completed) when some conditions are met. From an end user perspective, this means that a message is received back from the network within a given delay by the party originating the upload to indicate this success. The nature of this message is highly dependent on the type of service and on the way information is provided to users. For instance, an SMS upload is successful for a user on a smartphone when the sending time is displayed before a given timeout on the screen of his device (this corresponds also to the reception of the delivery report message 7b in Figure 7-59 of [ITU-T E.804]).

Such a distinction between services is not necessary for download sessions. The reception of the required payload and the possibility to use is not an observation specific to a given service.

8.1.2 Other parameters

Other interesting parameters (addressing also completion and duration) are well defined in clause 7.4.1 of [ITU-T E.804] and do not require any further definition. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Message download session failure ratio (7.4.1.16)
– Message download session time (7.4.1.17)
– End-to-end failure ratio (7.4.1.24)
– End-to-end time (7.4.1.25)

Furthermore, other QoS parameters defined in clause 7.4.1 of [ITU-T E.804] are less important to implement and supervise. They are generally specific to a limited aspect of service delivery or of the customer journey, or can be redundant with other parameters closer to real users' perception. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Message upload access failure ratio (7.4.1.4)
– Message upload access time (7.4.1.5)
– Message upload data transfer cut-off ratio (7.4.1.6)
– Message upload data transfer time (7.4.1.7)
– Notification start failure ratio (7.4.1.8)
– Notification start time (7.4.1.9)
– Notification download session failure ratio (7.4.1.10)
– Notification download session time (7.4.1.11)
– Notification download access failure ratio (7.4.1.12)
– Notification download access time (7.4.1.13)
– Notification download data transfer cut-off ratio (7.4.1.14)
– Notification download data transfer time (7.4.1.15)
– Message download access failure ratio (7.4.1.18)
– Message download access time (7.4.1.19)

– Message download data transfer cut-off ratio (7.4.1.20)
– Message download data transfer time (7.4.1.21)
– Notification and message download failure ratio (7.4.1.22)
– Notification and message download time (7.4.1.23)
– Login non-accessibility (7.4.1.26)
– Login access time (7.4.1.27)

8.2 SMS

See clause 7.4.4 of [ITU-T E.804].

From an end-user's point of view, the multimedia messaging service (MMS) (see clause 7.4.3 of [ITU-T E.804]) is a sub case of SMS and does not need to be separated from it. All parameters identified and defined in this clause apply also to this service.

The interesting parameters for SMS are well defined in clause 7.4.4 of [ITU-T E.804] and do not require any further definition. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Service non-accessibility (7.4.4.2)
– Completion failure ratio (7.4.4.4)
– End-to-end delivery time (7.4.4.5)

Furthermore, other QoS parameters defined in clause 7.4.4 of [ITU-T E.804] are less important to implement and supervise. These are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– Access delay (7.4.4.3)
– Receive confirmation failure ratio (7.4.4.6)
– Receive confirmation time (7.4.4.7)
– Consumed confirmation failure ratio (7.4.4.8)
– Consumed confirmation failure time (7.4.4.9)

8.3 Other store-and-forward services with lower usage and less priority for QoS supervision

This Recommendation does not give any emphasis to other services SMS, and therefore provides no further definition of corresponding parameters. These services are (the numbers in bracket correspond to the respective clause in [ITU-T E.804]):

– E-mail (7.4.2), mostly used on fixed access, less often on mobile phones
– MMS (7.4.3), included in SMS service in clause 8.2 above

9 Summary

Table 2, provides a recapitulation of the currently proposed list of services and parameters to be selected from [ITU-T E.804], as described in clauses 6 to 8. For each parameter in this table, the corresponding reference in [ITU-T E.804] and trigger point are given.

Table 2 – Proposed list of services and parameters to be selected from [ITU-T E.804]

Service type	Service	QoS parameter	Reference in [ITU-T E.804]	Further or new information in this Recommendation	Trigger points (see definition in clause 7.1.4 of [ITU-T E.804]
Service-independent (clause 6)		Radio network unavailability	7.2.1	Yes	2G, 3G: see clause 7.2.1.3 of [ITU-T E.804] 4G: same as 3G (S-criteria based on RSRP and RSRQ instead of Ec/No and RSCP)
		Network selection and registration failure ratio	7.2.2.1	No	See clause 7.2.2.1.3 of [ITU-T E.804]
		Network selection and registration time	7.2.2.2	No	See clause 7.2.2.2.3 of [ITU-T E.804]
Direct services (clause 7)	Audio-visual streaming	Streaming service non accessibility	7.3.5.4	Yes	Timers t0 and t1 based on Figure 7-22 from [ITU-T E.804] – t0 defined in table 2 of [ETSI TR 101 578] (the corresponding event in the application or browser). – for t1, see clause 7.3.5.4.3 of [ITU-T E.804]
		Streaming service access time	7.3.5.5	Yes	Timers t0 and t1 based on Figure 7-22 from [ITU-T E.804] – t0 defined in table 2 of [ETSI TR 101 578] (the corresponding event in the application or browser). – for t1, see clause 7.3.5.4.3 of [ITU-T E.804]
		Streaming reproduction cut-off ratio	7.3.5.6	Yes	Timers t2 and t3 based on Figure 7-22 from [ITU-T E.804]
		Streaming audio quality	7.3.5.7	No	See clause 7.3.5.7.3 of [ITU-T E.804]
		Streaming video quality	7.3.5.8	Yes	See clause 7.3.5.8.3 of [ITU-T E.804]
		Streaming audio/video de-synchronization	7.3.5.9	No	See clause 7.3.5.9.3 of [ITU-T E.804]
		Streaming reproduction start failure ratio	7.3.5.10	Yes	Timers t0 and t2 based on Figure 7-22 from [ITU-T E.804]
		Streaming reproduction start delay	7.3.5.11	Yes	Timers t0 and t2 based on Figure 7-22 from [ITU-T E.804]

Table 2 – Proposed list of services and parameters to be selected from [ITU-T E.804]

Service type	Service	QoS parameter	Reference in [ITU-T E.804]	Further or new information in this Recommendation	Trigger points (see definition in clause 7.1.4 of [ITU-T E.804]
		Streaming rebuffering failure ratio	7.3.5.14	Yes	Timers t2 and t3 based on Figure 7-22 from [ITU-T E.804]
		Streaming rebuffering time	7.3.5.15	Yes	Timers t2 and t3 based on Figure 7-22 from [ITU-T E.804]
	Telephony	Telephony service non accessibility	7.3.6.1	No	User's point of view: see clause 7.3.6.1.3 of [ITU-T E.804] Protocol part: – 2G, 3G: see clause 7.3.6.1.3 of [ITU-T E.804] – 4G: see Table 3 of [ITU-T G.1028]
		Telephony set-up time	7.3.6.2	No	User's point of view: see clause 7.3.6.2.3 of [ITU-T E.804] Protocol part: – 2G, 3G: see clause 7.3.6.2.3 of [ITU-T E.804] – 4G: see?Table 3 of [ITU-T G.1028] and associated comment
		Speech quality on call basis	7.3.6.3	Yes	User's point of view: see clause 7.3.6.3.3 of [ITU-T E.804] Protocol part: – 2G, 3G: see clause 7.3.6.3.3 of [ITU-T E.804] – 4G: see Table 3 of [ITU-T G.1028]
		Speech quality on sample basis	7.3.6.4	Yes	User's point of view: see clause 7.3.6.4.3 of [ITU-T E.804] Protocol part: – 2G, 3G: see clause 7.3.6.4.3 of [ITU-T E.804] – 4G: see Table 3 of [ITU-T G.1028]
		Telephony cut-off call ratio	7.3.6.5	No	User's point of view: see clause 7.3.6.5.3 of [ITU-T E.804] Protocol part: – 2G, 3G: see clause 7.3.6.5.3 of [ITU-T E.804]

Table 2 – Proposed list of services and parameters to be selected from [ITU-T E.804]

Service type	Service	QoS parameter	Reference in [ITU-T E.804]	Further or new information in this Recommendation	Trigger points (see definition in clause 7.1.4 of [ITU-T E.804]
					4G: see Table 3 of [ITU-T G.1028]
	HTTP-based data services	HTTP set-up time	7.3.8.2	Yes	See clause 7.3.8.2.3 of [ITU-T E.804] Protocol part: starting point command will depend on access technology
		HTTP session set up success ratio	none	Yes	Same as last parameter
		HTTP session failure ratio	7.3.8.5	No	See clause 7.3.8.5.3 of [ITU-T E.804]
		HTTP session time	7.3.8.6	No	See clause 7.3.8.6.3 of [ITU-T E.804]
		HTTP mean data rate	7.3.8.7	No	See clause 7.3.8.7.3 of [ITU-T E.804]
Store-and-forward services (clause 8)	All (generic parameters)	Message upload session failure ratio	7.4.1.2	Yes	See clause 7.4.1.2.3 of [ITU-T E.804]
		Message upload session time	7.4.1.3	Yes	See clause 7.4.1.3.3 of [ITU-T E.804]
		Message download session failure ratio	7.4.1.16	No	See clause 7.4.1.16.3 of [ITU-T E.804]
		Message download session time	7.4.1.17	No	See clause 7.4.1.17.3 of [ITU-T E.804]
		End-to-end failure ratio	7.4.1.24	No	See clause 7.4.1.24.3 of [ITU-T E.804]
		End-to-end time	7.4.1.25	No	See clause 7.4.1.25.3 of [ITU-T E.804]
	SMS	Service non-accessibility	7.4.4.2	No	Timers t1 and t3 based on Figure 7-58 from [ITU-T E.804] Protocol part: see clause 7.4.4.2.3 of [ITU-T E.804] On 4G, SMS relies on CSFB to 2G or 3G.
		Completion failure ratio	7.4.4.4	No	Timers t1 and t9 based on Figure 7-58 from [ITU-T E.804] On 4G, SMS relies on CSFB to 2G or 3G.
		End-to-end delivery time	7.4.4.5	No	Timers t1 and t9 based on figure 7-58 from [ITU-T E.804] On 4G, SMS relies on CSFB to 2G or 3G.

Appendix I

Experience of a multinational operator

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

The example below is submitted based on an operational feedback of a multinational mobile operator present in many different countries.

Quality of service is an essential matter for all stakeholders for the following reasons:

– for national regulation authorities, it is a crucial lever in the framework of their development policies towards telecommunication and information services,

– for end users, it helps in making the right choices in terms of services, depending on their respective use cases (domestic, traveling, professional), taking into account other criteria other than only the price,

– for operators, this provide a lever for differentiation, with a potential competitive advantage against competitors, eventually with better users' satisfaction and less churn.

In the specific case of an operator present in several different countries, there is a large variety of national and market contexts, with a potential high heterogeneity between them. Such an operator will have difficulties to monitor all performance indicators required in all of these contexts (mostly through national operating licenses). These difficulties will consist in:

– operational (manpower) and economical (purchase of tools) issues to implement holistic supervision policies and provide regular and relevant feedback,

– lack of proofs about the reality (or at least the magnitude) of the impact of all required indicators on perceived quality, and therefore issue to decide and implement relevant correction or optimisation actions.

[b-ITU-T E.806] provides a collection of best practices on how to address these challenges in terms of measurement campaigns or tools and sampling methodologies as well as some useful information to build a comprehensive answer.

For a better efficiency of QoS monitoring, this multi-national operator took the decision in 2019 to base actions in all countries of its footprint on a simple approach, where less indicators are measured (not more than three KPIs per service, with the possibility of instantiation depending on the context, e.g., between indoor and outdoor situations), if possible taken from [ITU-T E.804], covering the widest spread of usages and services, but only indicators with a strong link with end users' perception and allowing a quality feedback towards operations and end users' information. Depending on specific national context, this core of meaningful metrics can be complemented by a number of other metrics selected locally.

Radio coverage

In this domain, it is important that an indicator:

– reflects the efforts of operators to deploy and optimise their networks,

– can be easily checked and counter-measured by any third party,

– can be easily used to build coverage maps accessible to end users.

To do so, the best parameter is the simplest one, i.e., the signal power, expressed in decibels, and depending on radio technology.

– 2G: RxLev (dB)

– 3G: RSCP (dB)

– 4G: RSRP (dB)

The targets for this parameter (absent in [ITU-T E.804]), as well as the measurement profiles, must be adapted to various contexts: outdoor vs. indoor, cities vs. countryside vs. roads, etc.

Although signal power is the metric selected for the core set of metrics for reporting in this example, other radio frequency (RF) metrics are actually supervised for troubleshooting and network optimization purposes.

Voice telephony

For voice telephony, the goal of end users consists in having straightforward conversations, easily and readily accessible, in good quality conditions. The list of parameters from [ITU-T E.804] to apply is therefore:

– Service non accessibility (clause 7.3.6.1 of [ITU-T E.804])
  - Other possible name and definition: Call set up success ratio, the ratio of the total number of successful call attempts to the total number of call attempts made
– Cut-off call ratio (clause 7.3.6.5 of [ITU-T E.804])
  - Other possible name and definition: Drop call rate, the probability that a successful call attempt is ended by a cause other than the intentional termination by A- or B-party
– Speech quality on call basis (ITU-T 7.3.6.3 of [ITU-T E.804] completed with clause 7.2.1 of this Recommendation)
  - Other possible definition: Values on a predefined scale that subjects assign to their opinion of the performance of the telephone transmission system used for listening to spoken material.

SMS

SMS users simply want to send and receive messages, quickly and safely. The list of parameters from [ITU-T E.804] to apply is therefore:

– Service non-accessibility (clause 7.4.4.2 of [ITU-T E.804])
– Completion failure ratio (clause 7.4.4.4 of [ITU-T E.804])
– End-to-end delivery time (clause 7.4.4.5 of ITU-T [E.804])

Data services

Three use cases of data service have been selected in priority, with associated metrics:

– Web browsing: seamless consultation of internet pages
  - HTTP session time (clause 7.3.8.6 of [ITU-T E.804])
  - HTTP session failure ratio (clause 7.3.8.5 of [ITU-T E.804], completed with clause 7.3.2 of this Recommendation)
– Data exchange: quick and safe upload and download of data in HTTP protocol
  - Download mean data rate (no direct correspondence in [ITU-T E.804], but clause 7.3.8.7 provides an applicable definition)
  - Upload mean data rate (no direct correspondence in [ITU-T E.804], but clause 7.3.8.7 provides an applicable definition)
– Video streaming: quick access and safe viewing of contents
  - Video access time: The time it took for the video to start displaying – also known as " time to first picture" (no direct correspondence in [ITU-T E.804], but clause 7.1.2 of this Recommendation provides an applicable definition)
  - Video playout duration: The time it took for the video to playout (no correspondence neither in [ITU-T E.804], nor in this Recommendation).

Appendix II

Example of a recent work on best practices, as proposed by ETSI

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

The material in this appendix is based on recent works contributed to ETSI by actors from the field of QoS monitoring and benchmarking of mobile networks and services. It reflects the current state of the art (as for 2019) in this area, when the latest version of [ITU-T E.804] was published in 2014.

ETSI, in the Technical Report [ETSI TR 103 559] entitled " *Speech and multimedia Transmission Quality (STQ)*; *Best practices for robust network QoS benchmark testing and scoring*", provides several practical principles to help designing efficient mobile QoS benchmarking. The recommended tests concern telephony, video streaming, data throughput and more interactive applications such as browsing, social media and messaging. According to this Technical Report, the main governing principles for mobile benchmarking are:

– Fair play: Steps should be taken to ensure that the measured results are truly representative of the real customer experience.

– Coverage extent: Benchmarking should be performed in such a way that it highlights coverage differences in the results.

– Radio technology in use: Benchmark scoring should account for operators who offer performance differentiation through early adoption of new technologies by way of a 'bonus' for such deployment.

– Test device selection: Care should be taken in the selection of such devices to ensure they do not favour one operator's network over another in the results.

– Test server selection: Test servers should be selected so they do not favour one network compared to another. Web pages should be selected such that they represent a cross section of pages commonly used by customers and that they ensure a representative performance comparison.

– Transparency: Given the importance of the clear interpretation of benchmark results, all results should be accompanied by a declaration containing information about factors required to understand them fully.

The recommended test metrics are the following:

Telephony

Telephony tests are tests with a fixed call length where two terminals, either both mobile or one landline and one mobile call each other. To consider unsustainable quality in a call, for a low speech quality score (e.g., MOS < 1,6) or silent periods for consecutive measurement samples (e.g., > 20 s), the call can be counted as unsustainable, and as an unsuccessful call or treated by a separate indicator.

– Telephony success ratio: The success rate of the voice service independent of access or relay technology is the telephony non accessibility and the telephony cut-off call ratio in clauses 6.6.1 and 6.6.5, respectively, of [b-ETSI TS 102 250-2].

– Set-up time: Defined in clause 6.6.2 of [b-ETSI TS 102 250-2]. It starts with the initiation of the call and ends when the alerting of the called side is indicated. Alternatively, the time when the acceptance or successful set-up of the call is signalled to the user can be used as the end trigger.

– Listening quality: The value is calculated on a per sample basis as described in clause 6.6.4 of [b-ETSI TS 102 250-2], where Recommendation [ITU-T P.863] in FB mode needs to be used.

Video testing

Video testing is in the standard case IP based video streaming. A smartphone app based testing as in Figure 1 of [ETSI TR 101 578] is used. In order to collect details of the transport and reproduction, the length of the observation period of the video should reflect the relevant delivery mechanisms and the typical usage profile of a mobile user.

– Video streaming service success ratio: The end-to-end success ratio of the requested video stream. It starts with the request of the video and ends with the end of the playout. This is derived from the metrics in [ETSI TR 101 578] as a combination of video access failure ratio and video playout cut-off ratio.

– Set-up time: The time from stream request to the display of the first picture and start of playout. This is video access time discussed in [ETSI TR 101 578].

– Video quality: A comprehensive measure for the perceived quality that combines the impact of parameters such as freezing, frame rate, resolution and compression depth and scheme by the codec is the mean opinion score (MOS) scale and is done according to clause 6.5.8 of [b-ETSI TS 102 250-2]. In the case of video streaming with a respective app on the smartphone, an encrypted stream and a range of different resolutions (up to HD) is expected. The video quality parameter outlined in [ETSI TR 101 578] reflects such measure. In addition to this, video freezing time proportion discussed in [ETSI TR 101 578] provides an insight about the proportion of the accumulated video freezing duration in relation to the actual video playout duration.

Data testing

For data testing the throughput bandwidth for the user is tested. This is done by downloading and uploading incompressible files over HTTP. In clause 6.8 of [b-ETSI TS 102 250-2] the up and download of entire files is described. The description of an upload and download using fixed duration is described in clause 5.2 of [b-ETSI TR 102 678]. Both approaches can be used, either alone or combined, for the purpose of evaluating throughput bandwidth.

– Success ratio: The determination of the success ratio for HTTP uploads and downloads is included in clause 6.8 of [b-ETSI TS 102 250-2] and in clause 5.2 of [b-ETSI TR 102 678].

– Throughput (upload and download): The determination of the mean data rate or throughput for HTTP uploads and downloads is included in clause 6.8 of [b-ETSI TS 102 250-2] and in clause 5.2 of [b-ETSI TR 102 678]. The best view of the actual download bandwidth is provided by a multi-threaded HTTP download test.

Service testing

Besides the browsing of web pages, services like social media and messaging systems (SMS is not considered) are not described or standardized for mobile testing. Some overall interesting aspects of all of these services are:

– Success ratio,

– Duration or timing of the interaction.

The Technical Report also provides some recommendations on the selection of test areas (cities, roads, complementary areas) and of typical user profiles. It also includes examples of weighting of individual test results depending on test area type, tested service type and metrics for each tested service. These metrics can be the raw ones described above, or more elaborated ones like percentiles or proportion of individual measurements above a given threshold. Finally, it elaborates on statistical confidence and robustness of results.

Appendix III

Alternative approach for performance measurement of HTTP-based data transfer services

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

These practices have a long history of usage in commercial network performance measurement as well as in regulatory contexts, and they are covered in various technical documents issued by standardization bodies. For instance, [ETSI TR 101 578] describes the principle, and [b-ETSI TR 103 501] takes this further towards KPI computation based on events taken from the application plane or corresponding operating-system application programming interface levels. This takes care of the fact that in HTTPs, transport layer events (e.g., HTTP resp. TCP-layer events) are not visible anymore even if packet capture tools are used. Also, on the background that testing is typically done using smartphones, using packet capture tools requires system-level (root) access. This would in any case create a gap of direct comparability to measurements done by crowdsourcing, where such access is practically unfeasible and also not desirable because it would remove crucial security mechanisms.

[b-ETSI TR 103 501] also introduces a consistent terminology for different methods of upload and download testing, that is, using transfer of a fixed amount of data, typically a data file, and measuring the transfer time is known as fixed-size method whereas transferring data for a given amount of time and measuring the data volume transferred is known as fixed-time method. The data rate is in both cases calculated by the quotient of data volume and time.

For the actual calculation, a spectrum of additional rules is common practice, which are aimed at dampening extremes due to the packet nature of data transfer. The purpose of such measures is to increase the applicability of results in the aforementioned sense, i.e., usability as a proxy to assess the performance of actual services.

Commonly used is time windowing which excludes the first data packet of content, or a certain amount of time at the beginning of the transfer. This serves to get a better approximation to steady-state data rates by at least partially removing the ramp-up phase which is e.g., typical for TCP (slow-start).

The definition of stop method A depicted in [ITU-T E.804] (ETSI-A in the original TS 102 250-2) is a standardized example of the former approach where the reception of the first packet of content also serves as a trigger point for respective KPI definitions, making the measurement easily implementable.

Also, when data is taken in a time-resolved way (e.g., recording samples of data volume every second), other techniques are used such as removing the sample with the lowest and the highest data rate from the set before averaging.

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