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Multimedia Quality of Service and performance – Generic and user-related aspects

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Quality of service metrics for the assessment of the impact of fixed geographic structures on telephony quality and call stability

Recommendation ITU-T G.1027

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Quality of service metrics for the assessment of the impact of fixed geographic structures on telephony quality and call stability

Summary

Often poor call stability or degradation in speech quality is associated with natural or artificial, geographic or topological structures such as tunnels, ravines, or noise barriers. Recommendation ITU-T G.1027 is an extension of Recommendation ITU-T G.1034 where it defines a set of metrics that describes call stability and changes of speech quality related to the above structures.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

Call stability, mobile network, quality of experience (QoE), quality of service (QoS), spatially resolved information.

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Introduction

Recommendation ITU-T G.1027 builds on the concepts and definitions given in Recommendation ITU-T G.1034. While Recommendation ITU-T G.1034 defines metrics for mobile telephony communication during rail travel, based on actual measurement data from telephony tests on trains. Also defining two key metrics i.e., local drop probability (LDP) that describes the local call stability, and call completion probability (CCP) which predicts the expected call stability or telephone calls of selected length. This Recommendation defines a set of respective metrics that describe call stability and speech quality related to fixed geographical structures.

Often poor call stability is associated with geographic or topological structures which are a challenge when attempting to achieve good mobile network coverage. Tunnels are a prime example of these types of structures however, there can be other areas along a track where mobile network coverage is poor (e.g., ravines or noise barriers), or where other degradations take place such as larger areas with radio signal interference.

Since typically the duration to travel through such structures are rather short, usage of CCP (or the conventional key performance indicator (KPI) "call-drop rate", for this matter) can be deemed unnecessary. To provide some typical real numbers: With a travel speed of 60 km/h, the time per km of the tunnel length is only one minute. Even in a country like Switzerland, only a few tunnels are longer than three km, so the travel time in the tunnel would be three minutes, and respectively shorter when higher speeds are considered. In contrast, it takes about 15 to 30 seconds of poor coverage to seriously degrade speech quality. Even though a shorter time of poor network coverage may suffice, negative impacts of call stability has direct effects on handover/handoff failures or even other hard effects of poor call continuity management.

Typically, quality of service (QoS) is not uniform over a given travel time or route. To improve overall QoS, places or structures where call stability or call quality is especially poor need to be identified; this basic task is conveniently supported by the LDP. Since, actual improvements require an optimization effort or investment, respective metrics play a key role in this process by providing guidance on prioritization and result verification.

Recommendation ITU-T G.1027

Quality of service metrics for the assessment of the impact of fixed geographic structures on telephony quality and call stability

1 Scope

This work item is an extension of the metrics provided in [ITU-T G.1034] to cover quality-relevant metrics of fixed geographic structures, e.g., tunnels on telephony call stability and speech quality. It builds upon actual measurement data to create spatially resolved information and provides metrics that can be used in the performance assessment and the optimization of networks.

This Recommendation does not introduce new modelling for perceptual effects; it provides a way to put existing data into a context related to geographical structures.

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 G.1034] Recommendation ITU-T G.1034 (2020), *Quality of experience metrics for mobile telephony communication during rail travel*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 call completion probability (CCP) [ITU-T G.1034]: The probability that a telephone call started at a given location can be completed as intended (i.e., without being dropped).

3.1.2 geographical unit (GU) [ITU-T G.1034]: A segment of a road or railway track, or a square or rectangular shaped area, with given coordinates on a map. Used to aggregate measurement data based on their geographical coordinates.

3.1.3 local drop probability (LDP) [ITU-T G.1034]: An indicator, computed from drive test data, to indicate the call-drop probability for a given geographical unit (GU).

3.1.4 quality of experience (QoE) [b-ITU-T P.10]: The degree of delight or annoyance of the user of an application or service.

3.1.5 quality of service (QoS) [b-ITU-T E.800]: The totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service.

3.1.6 virtual call [ITU-T G.1034]: A concept using the local drop probability (LDP) values in a route profile to compute the call completion probability (CCP) for a call of a given duration.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 structure-related call-drop probability (SCDP): The probability that a telephone call drops when the device traverses through the given geographical structure.

3.2.2 structure-related speech quality degradation (SSQD): The (positive or negative) difference of speech quality (expressed in the native units of the speech quality metric) attributed to the given geographical structure.

3.2.3 tunnel-related speech quality degradation (TCDP): Same as SCDP, when applied specifically to tunnels.

3.2.4 tunnel-related speech quality degradation (TSQD): same as SSQD, when applied specifically to tunnels.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

KPI Key Performance Indicator

MOS Mean Opinion Score

MOS-LQO Mean Opinion Score, Listening Quality Objective

QoE Quality of Experience

QoS Quality of Service

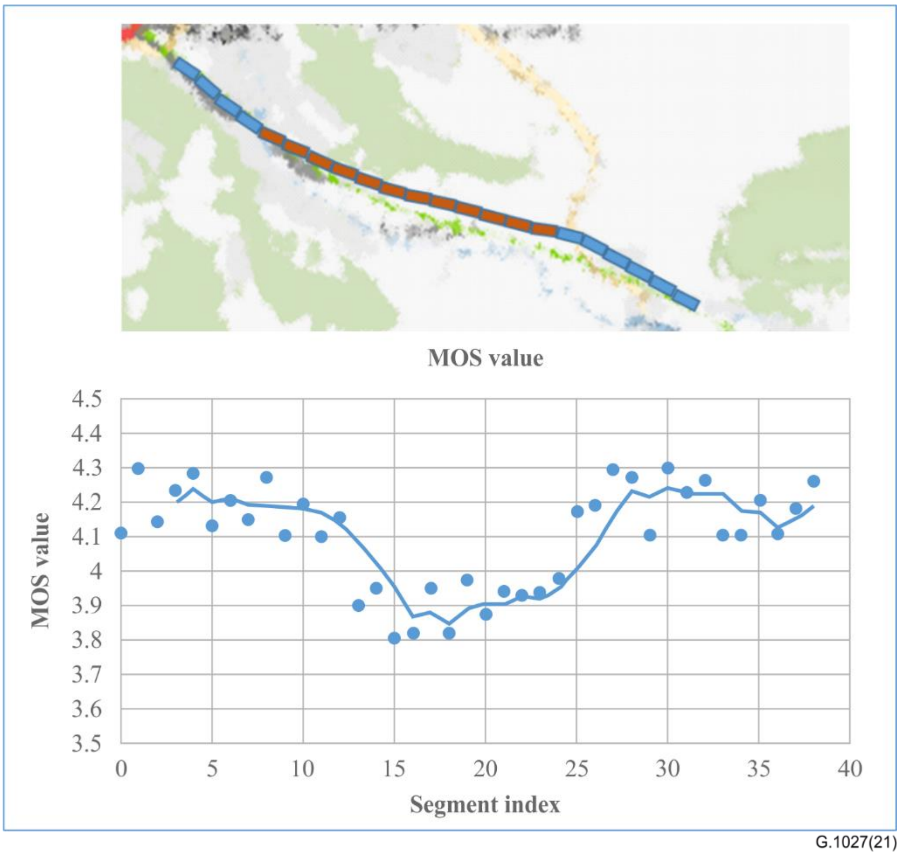
5 Conventions

This Recommendation uses the conventions established in [ITU-T G.1034].

6 User perspective of structure-related call stability and other quality metrics

The following example is given for a typical case of a railway tunnel that has poor mobile network coverage.

The use case at hand is a subscriber making a phone call while approaching the tunnel. When entering the tunnel, the call may drop, or the speech quality may decrease. The figure below graphically shows this situation for the example of speech quality.



Constructed image for explanatory purposes; assuming structure-dependent effects with superimposed random variations as in real-world measurements. The solid line has been added for more visual clarity, it represents the floating average over four segments.

Figure 1 – Example: Railway tunnel and the associated speech quality mean opinion score (MOS) values per track segment

NOTE 1 – This diagram is constructed for explanatory purposes. It uses typical speech quality values and patterns seen in real measurement data. It is however not visualizing actual measurement data.

In the case of call stability, the question associated with the metric is "how probable is a call drop caused by this tunnel"? For speech quality, the corresponding question would be "What is the degree of speech quality degradation caused by this tunnel"?

NOTE 2 – The term "speech quality" is used as a generic term for related metrics. Today, it is assumed that this practically means using the MOS – listening quality objective (MOS-LQO, [b-ITU-T P.863] "POLQA"). In the future, the spectrum may also include listening effort (LE) or other metrics dealing with perceptual quality of speech communication between persons.

NOTE 3 – This Recommendation does not introduce a new modelling for perceptual effects; it provides a way to put existing data into a context related to geographical structures.

For the following considerations, the abbreviations SCDP (structure-related call-drop probability) and SSQD (structure-related speech quality degradation) are introduced. When specifically tunnels are addressed the narrower terms TCDP and TSQD are used.

7 Computation of structure-related call drop probability (SCDP)

Using LDP as defined in [ITU-T G.1034], the computation of SCDP is straightforward:

Equation 1: Calculation of SCDP and TCDP

$$SCDP = 1 - SCSP = 1 - \prod_{Involved\ segments}(1 - LDP(x)) \quad (1)$$

The term SCSP is used as an intermediate definition, expressing the cumulated "call survival probability" which is simply the product of segment-wise LDP values. Therefore, SCSP is similar to

ITU-T G.1034's CCP, with the difference that CCP is computed from a "virtual call" with a given duration, whereas SCSP is related to the structure itself, i.e., does not depend on any other parameter.

NOTE 1 – If the calculation is done on values specifically for a tunnel, the entity calculated is termed as TCDP.

NOTE 2 – The selection of involved segments to be considered may also include adjacent segments, i.e., those which do not belong to the structure itself but are assumed to be part of the effect.

NOTE 3 – With a corresponding definition of the call drop which is at the basis of LDP, extensions such as "soft drops" can be seamlessly integrated into the concept. A soft drop would be a situation where the call is technically stable, but speech quality is so poor that the participants of the call agree to end the call and try again later.

8 Computation of structure-related speech quality degradation (SSQD)

By using the same concept, i.e., spatial aggregation of data, degradation of speech quality is addressed. It is assumed that the following will be based on MOS-LQO, b-ITU-T P.863 "POLQA", as the best-suited metric which supports temporal and spatial resolved speech quality assessment with the required granularity.

The calculation starts with averaging the MOS values belonging to the structure's segments (or, in the more general definition of [ITU-T G.1034], geo units).

In order to express a degradation, this value is then put into relation to a reference value, i.e., the average of the MOS values for the areas adjacent to the structure. Again, the user-perception is straightforward; it expresses the perceived change in speech quality when traversing the structure.

NOTE 1 – If the calculation is done on values specifically for a tunnel, the entity calculated is termed TSQD.

NOTE 2 – Conceptually, it is also possible to get a positive change of speech quality, e.g., in cases where improvement measures enhanced the quality beyond, that is experienced in the surrounding area.

9 Indicator variants

The definition of SCDP does not depend on the actual dimension of the structure it only looks at the effect on the perceived quality. The underlying assumption is that a subscriber does not care about the dimension of the structure, e.g., the length of a tunnel.

This is of course a matter of discussion and there will be cases where the dimension of a structure does matter, e.g., when looking at very long tunnels.

Also, especially in the case of tunnels, one may argue that this length can be perceived and be given credit for. For such cases, a secondary metric can be introduced, where the structure's dimension is entirely or partially taken into account.

For full normalization, a respective normalized indicator would be defined as NSCDP = SCDP / L with L the length of the structure in the direction of travel. The denominator may also be a function of L, e.g., the square root of L, to introduce a more QoE-related way of perception.

Likewise, instead of the physical dimension, the time to traverse the structure may be taken into account with a corresponding mathematical expression. For this variant, a larger structure that traverses faster would have the same indicator value i.e., the same severity of effect as a smaller structure that traverses with a lower travel speed.

With this spectrum of indicator variants the one which fits best to support a particular periodization strategy for resource usage, can be selected.

10 Spatial and temporal resolution

With reference also to [ITU-T G.1034], the spatial resolution used i.e., the actual length of a track segment or geo unit (GU) is a parameter of the metrics. The GU size, along with the speed of motion provides a transformation between the spatial and the temporal dimension. Practical values for segment sizes are in the range of 100 to 200 m, which equals a time of two to four seconds when travelling at 160 km/h. Achieving a higher spatial or temporal resolution is possible by selecting a smaller segment size; this would however require higher sample numbers to populate each segment adequately and to avoid excessive fluctuations of values per segment. Likewise, spatial resolution can be lowered to larger segment sizes when required.

Appendix I

Calculation examples for SCDP and SSQD

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

This appendix shows practical examples for calculating SCDP and SSQD. As a basis, the constructed example shown in Figure 1 in the main text in clause 6 is used. From there, the example calculation of SSQD is demonstrated straightforward. For SCDP, the data base of the example is expanded to contain segment-wise call-drop probabilities (i.e., LDP values).

The following diagrams show the data base of values used (constructed values but structurally close to real measurement data). Please note that for explanatory purposes, the display style is different from Figure 1. The x-axis now shows the actual length (using the relative segment index and a segment length of 100 m) with the zero-point set at the position of the left-side tunnel entrance. The basic principle of the construction is however the same.

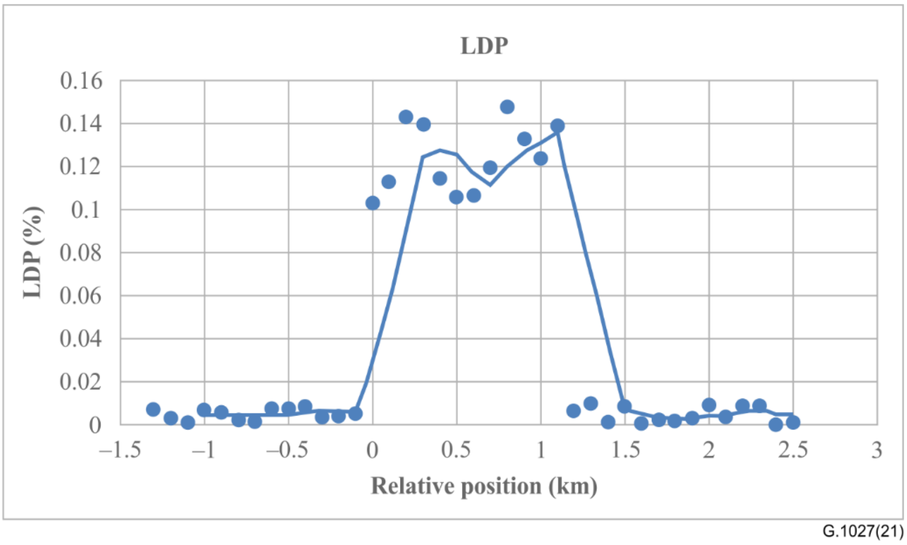


Figure I.1 – Constructed values for SCDP example

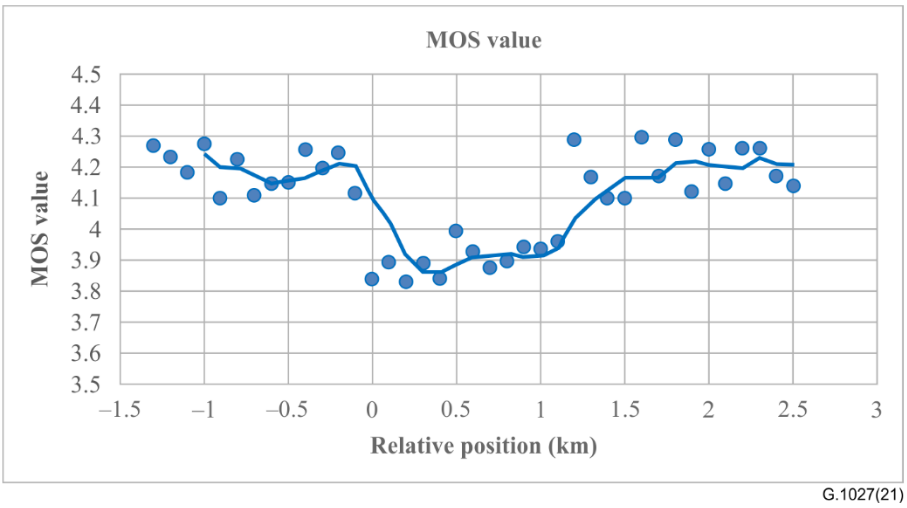


Figure I.2 – Constructed values for SSQD example

For these examples, random noise has been deliberately added to underline that in real-world situations, data is never noise-free. Even if segment-wise data comes from multiple passes of measurements there will still be some fluctuation due to the overall measurement process and dynamic interactions between a mobile device and a network.

The table below shows the values used or the computation of the examples. Please note that this table displays only the core part of the data, sufficient to demonstrate calculations, while the figures show a larger range of segments before and after the structure.

Table I.1 – Numerical values of LDP and MOS values used for the examples

Segment index	In tunnel	Rel. position (km)	LDP	MOS value
6	0	−0.7	0.0017	4.11
7	0	−0.6	0.008	4.152
8	0	−0.5	0.0079	4.154
9	0	−0.4	0.0089	4.262
10	0	−0.3	0.0038	4.202
11	0	−0.2	0.0047	4.25
12	0	−0.1	0.0059	4.118
13	1	0	0.1035	3.84
14	1	0.1	0.113	3.896
15	1	0.2	0.143	3.832
16	1	0.3	0.14	3.89
17	1	0.4	0.1145	3.844
18	1	0.5	0.106	3.996
19	1	0.6	0.1065	3.93
20	1	0.7	0.12	3.878
21	1	0.8	0.148	3.898
22	1	0.9	0.133	3.946
23	1	1	0.124	3.938
24	1	1.1	0.139	3.962
25	0	1.2	0.007	4.292
26	0	1.3	0.01	4.172
27	0	1.4	0.0017	4.104
28	0	1.5	0.0093	4.104
29	0	1.6	0.0012	4.298
30	0	1.7	0.0028	4.174
31	0	1.8	0.0022	4.292

The column "In tunnel" indicates if a data point is assumed to belong to the structure (value 1) or not (value 0).

It should also be noticed that the LDP outside the structure is typically not zero. For this example, it is assumed that the outside LDP values are however small against those that are inside (i.e., under the influence of) the structure. In practical situations, using offset or baseline values (acting as an offset to SCDP) will be considered on a pragmatic, case-by-case basis.

For SCDP, the calculation is done using Equation 1 given in clause 7 which is reproduced for the convenience of reading here:

$$SCDP = 1 - SCSP = 1 - \prod_{Involved\ segments} (1 - LDP(x))$$

Based on the above definition, the product is calculated over segments 13 to 24. For the example given, SCDP computes to (rounded to 3 after-comma digits) 0.797 which means a near 80% probability that a telephone call would drop during the passage of the structure.

As this example describes a tunnel, the more specific indicator name TCDP would be used, so the final result would be TCDP = 0.979.

The calculation of SSQD (or, analogously to the above, TSQD), follows the procedure described in clause 8. Averaging the MOS values for segments belonging to the structure (segments 13 to 24) yields (rounded to 2 digits) 3.90.

For the reference value outside the structure, values for segments 6 to 12, and segments 25 to 31, are averaged, resulting in a reference value of 4.19. This computes to an SSQD or TSQD value of 0.29, meaning that under the influence of the structure, speech quality will be degraded by 0.29 MOS.

For this example, a rather small number of segments have been used so that too much space is not taken up for the table of values. In practical situations, typically a larger number of segments will be used. The actual number of segments will be determined following the targets of using enough elements to provide a sufficiently robust value while on the other hand maintaining a sufficiently localized picture of the QoS situation. For guidance, the segment number could be selected to represent one to two minutes of travel time before and after the structure. For example, at 100 km/h and 1.5 minutes travel time, this would lead to using 25 segments of 100 m length from each end of the structure.

Bibliography

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

[b-ITU-T P.10] Recommendation ITU-T P.10/G.100 (2017), *Vocabulary for performance, quality of service and quality of experience*, including Amendment 1 (2019).

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

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