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QUALITY BY DATA

I. INTRODUCTION

Luxembourg, 09 November 2023

To : PC_EU_GLsQoSparameters_IAS@distro.berec.europa.eu

BEREC
QoS consultation
October and November 2023
Responses from Pirlys S.L. Luxembourg

Dear Sir/Madam, as requested by your authority in the "Public Consultation Procedure" we would like to send to BEREC our knowledge, thoughts and comments "regarding the guidelines on Quality of Service parameters".
Our company Pirlys S.L., based in Luxembourg, specialises in dimensioning mobile network capacity resources and investments. Our breakthrough innovative and unique solutions enable mobile operators and regulatory authorities to know the QoS and QoE values of 3G, 4G and 5G networks at any point in the network and at any time. Our solution and results, based on 30 years of research and development in the France Telecom and INRIA laboratories, calculate QoS and QoE values with unrivalled accuracy, using only performance data from the OSS (Operations Support System) of operators' mobile networks.

Note that this document is not confidential and may be published in full.

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2. THE PUBLIC CONSULTATION PROCEDURE

Legal basis. In accordance with Article 4(5) of Regulation (EU) 2018/1971 of the European Parliament and of the Council of 11 December 2018 establishing the Body of European Regulators for Electronic Communications (BEREC) and the BEREC Support Agency (BEREC Office) - the "BEREC Regulation" - BEREC must, where appropriate, consult interested parties before adopting opinions, regulatory best practices or reports, and give them the opportunity to send comments on draft documents within a reasonable period of time.

BEREC also has an obligation to make the results of each consultation procedure public, while taking into account issues of confidentiality.

In order to streamline the whole process of consulting interested parties on draft BEREC documents and to increase the transparency of its procedures, the Board of Regulators adopted Decision BoR (10) 27 on BEREC's procedures for public consultations organised by BEREC.

BEREC may also decide to organise a public hearing on subjects of significant interest.

3. DEFINITIONS OF QOS AND QOE

We begin by defining and differentiating QoS from QoE.

- **QoS or Quality of Service is often associated with the real capacity of the cell [in Mbps].** In other words, the maximum speed achievable by a single user in the cell. It is this capacity that is shared by the subscribers active simultaneously in the cell. In this document we related QoS to cell capacity. "*QoS (Quality of Service) appeared in the 90s to designate a set of techniques for ensuring the routing of traffic. Since then, the acronym QoS has been used to designate performance improvement. But QoS metrics such as bandwidth, delay, jitter and loss rate, which are generally used to guarantee services, fail to measure the subjectivity associated with human perception. Network operators are tending to move towards policies based on a global approach to end-to-end quality, and so Quality of Experience (QoE) was born*." [1]
- **The QoE or quality of experience delivered to subscribers, such as the connection speed of sessions when subscribers are active [in Mbps].** This QoE has a value at a given time and place. The sum of the QoEs of all subscribers active simultaneously in the cell cannot exceed the QoS value. In addition, as long as there is excess capacity in relation to the traffic load in the cell, the QoE of each subscriber will correspond to the speed requested by the desired service. For example, 5 HD video sessions at 18Mbps, 26

web browsing sessions at 200Kbps, etc … . If the aggregation of the usage, or load, continues approaching the QoS value, the QoE of subscribers will be progressively degraded.

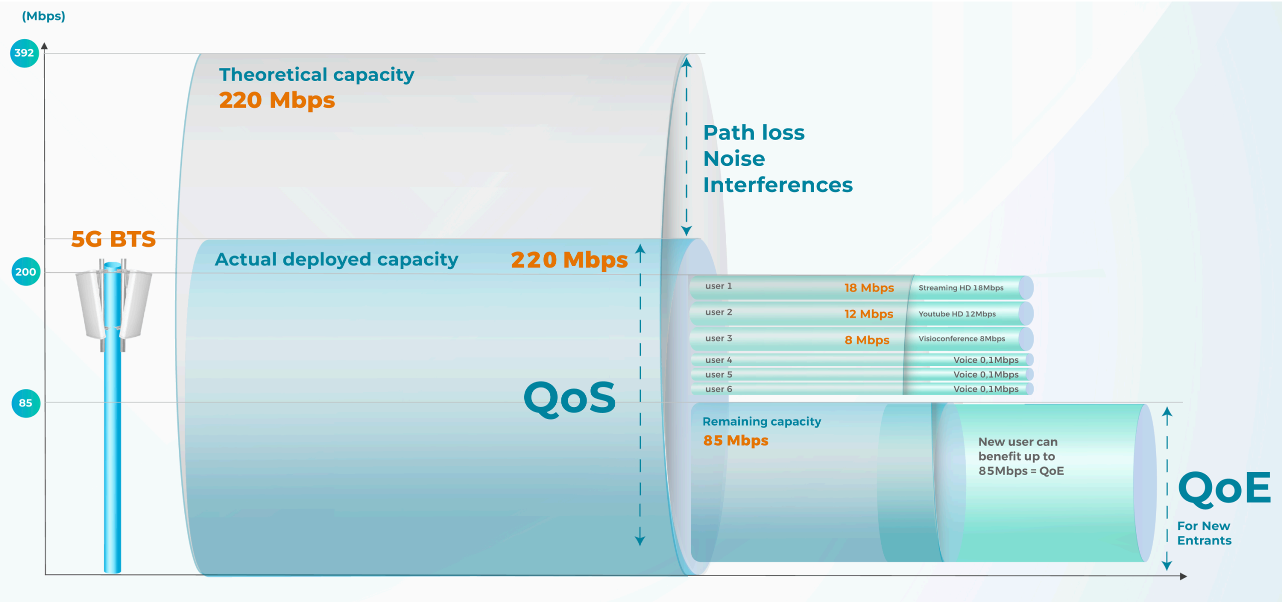


Figure 1. - *Representation of theoretical capacity versus actual capacity or QoS versus connection speeds or QoE*

Thanks to our innovation based on the exploitation of OSS data, coupled with an artificial intelligence engine based on the Kaufman-Roberts mathematical model, users can know at any time, and at any point in the network, what QoE they will benefit from (and not a theoretical QoS). They can also track the evolution of this QoE month after month.

4. DO THE EXISTING GUIDELINES DETAILING QUALITY OF SERVICE (QOS) PARAMETERS ASSIST STAKEHOLDERS? ARE THERE ANY CHALLENGES TO IMPLEMENTING THE GUIDELINES?

4.1.Context

We believe that the existing guidelines on quality of service parameters are only partially helpful to stakeholders. To address these difficulties, we would like to place the issue in a historical context. A useful reminder allows us to compare what has worked well in the past with what is no more working today. **For 2G-GSM technology**, in the 90s, t**he three relevant parameters for quality of service or QoS** were :

- The level of radio coverage
- Voice call rejection rates
- Quality of communications, or MOS [Mean Opinion Score].

By controlling these 3 relevant parameters for 2G, operators could ensure a good quality of service for their subscribers while guaranteeing the profitability of their investments.

4.2.The tools used in the past to adjust QoS

When these parameters were below threshold values, they corrected the problems:

- by deploying new sites when there was no radio coverage or when the strength of the signal received was insufficient (leading to low MOS). This work was carried out using traditional radio planning software tools
- by deploying additional capacity, as soon as the incoming call rejection rate was above 2% (ITU standard). This was done using the Erlang table and collected performance values, from the OSS

Radio planning tools were upgraded for 3G, 4G and 5G technologies, but the Erlang table is no more relevant. This is why the reconciliation of capacity planning and QoS adjustment is challenging. In fact, operators are measuring a QoE value, but they no longer have a tool equivalent to the Erlang table to assess and correct QoS. We provide an innovative solution.

4.3.An technological barrier

The problem is the technical barrier of dimensioning capacity resources, like the Channel Elements and Codes for UMTS and the Physical Resource Blocks for LTE/5G at base station levels. In general, on mobile telephony station, there is either not enough capacity, generating congestion, or there is too much capacity in relation to the cell load, generating low and long ROI. Investment is inefficient. PwC [2], Accenture [3], EY [4, 5], Analysys Mason [6] and the GSMA [7] all confirm the inefficiency of operators' investments and the need for rationalisation. Today, the guidelines are methods of measuring:

- Latency
- Jitter
- Packet loss

Admittedly, this information is important in real-time or near-real-time applications. But in all other use cases, these aspects are less crucial, because the user will eventually access his service, after a delay.

On the other hand, if the service is never provided because of saturation due to an under-dimensioning of resources, it is really detrimental to the end user. The service will never be provided if the QoS is too degraded in relation to the services requested. QoS measures or capacity measures were not included in the guidelines because there was no state of the art solution until now. This is no longer the case.

As for the measurement of QoE values, there are two main factors to be considered: the traffic model and the subscriber's location. At peak times, the QoE value [connection or session speed] will be low, and the closer the subscriber is to the cell edge, the lower the QoE value will be. Conversely, at off-peak times (at night, for example) the QoE value will be the highest, and the closer the subscriber is to the base station, the higher the QoE value will be.

In conclusion, we recommend that the measurement of QoS or cell capacity values and QoE values be included in the guidelines. We also recommend that the QoE measurement values be accompanied by information on the traffic model and the measurement location within the radio coverage footprint. These measurements are now available by combining the network performance values collected at OSS level with the Kaufman-Roberts model as in the Pirlys tool.

5. WHICH POINTS IN THE GUIDELINES COULD BE MORE DETAILED OR CLARIFIED?

As mentioned in the previous chapter, there is one measure that needs to be integrated and clarified, or at least what seems to be a misuse of language by the industry, needs to be corrected: "QoS". Is it a set or measures or the cell capacity? And if it is the cell capacity, is it properly defined?

Definition : 3G, 4G and 5G systems are trunked systems. This means that the performance of each, depends on the actual capacity deployed, the number of simultaneous active users and their respective activity ratios. Active subscribers share a single resource

We have already defined QoS, which is cell capacity, i.e. the maximum performance that the cell can provide. Despite random assertions in the industry, it is highly likely that QoS is in fact rarely, if ever, measured.

Why is this? Because the only measurement techniques available to mobile operators today are Drive Tests and Crowdsource. Both are measurements taken from mobile phones, hence, in the uplink direction only (from the mobile to the BTS). In the uplink direction, the only way to measure QoS is to be the only active user of the cell at the time of measurement.

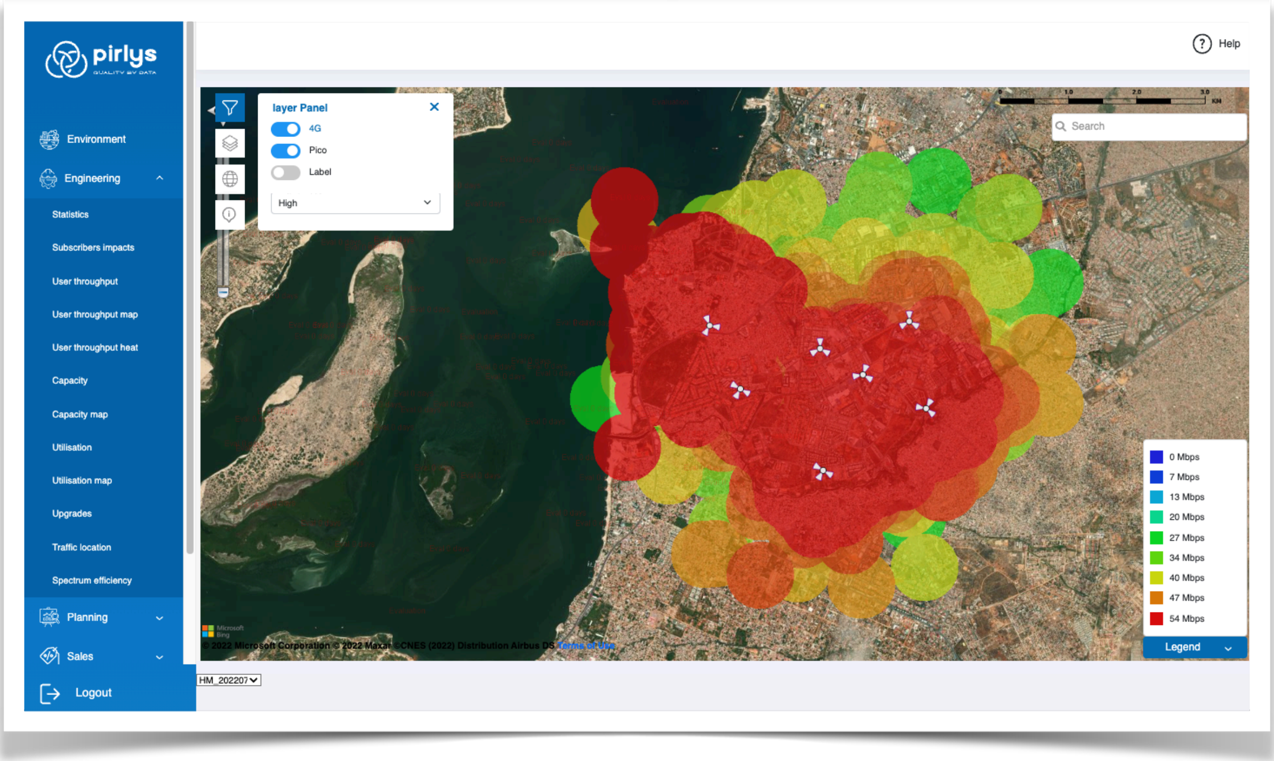
As a result, this is never the case with Crowdsource and Drive Test. As soon as 2, 3 or 4 mobile devices are active, what the 5th device measures is the remaining resource shared between the 5 active phones. In reality, it's a measure of QoE, Quality of Experience or Quality Delivered at a given point in time of all the active phones.

6. DO YOU HAVE ANY OTHER RELEVANT COMMENT?

According to BEREC, "QoS is becoming increasingly complex to manage, measure and regulate". We definitely agree with that statement. We can explain this, by the ambiguity of the definition and the lack of an equivalent technique to the past Erlang table.
As previously explained, we resolved that challenge thanks to the integration of Kaufman-Roberts model into an AI / ML engine.

Not only we can measure QoS and QoE values, but we can also make it easily visible to third parties and allow mobile operators to take efficient actions to ensure continuous best possible performance.

For example, please refer to the material below,



Map 1 - *QoE at low traffic hour (night), best QoE in red, lowest QoE in dark blue*

Map 2 - *QoE or subscribers experience at peak hour, best QoE in red, lowest QoE in dark blue*

User connection speed (Mbps)

SECTOR	Near Cell DL	Near Cell UL	Near Cell Traffic% 0-300m	Center Cell DL	Center Cell UL	Center Cell Traffic% 0,3-1Km	Median Cell DL	Median Cell UL	Median Cell Traffic% 1-4Km	Edge Cell DL	Edge Cell UL	Edge Cell Traffic% >4Km	Std dev DL	Std dev UL
S-V 1L	16.13	2.26	0.20	9.92	1.13	0.58	2.26	0.10	0.16	0.10	0.10	0.06	4.31	0.57
S-V 3L	16.82	14.47	0.20	13.30	1.59	0.58	1.29	0.41	0.16	0.10	0.10	0.06	5.27	3.42
S-V 2L	8.87	0.76	0.20	7.62	0.56	0.59	3.05	0.34	0.14	0.92	0.18	0.06	2.43	0.17
S-B CL	10.07	31.87	0.20	7.38	15.66	0.57	4.69	9.89	0.16	3.88	3.34	0.07	1.74	6.27
S-V 2L	29.83	5.55	0.20	20.17	2.16	0.56	9.88	0.97	0.16	5.27	0.53	0.07	7.17	1.16
S-V 2L	21.75	4.30	0.19	13.91	2.74	0.56	8.89	0.87	0.17	5.46	0.34	0.09	4.41	1.00
S-B AL	16.65	94.84	0.20	15.26	9.66	0.56	10.25	4.10	0.16	6.93	1.40	0.07	2.73	20.74
S-B CL	16.66	14.15	0.18	15.26	8.11	0.58	11.02	3.94	0.17	7.35	1.50	0.07	3.00	3.23
S-B CL	18.16	20.62	0.22	13.92	15.61	0.56	10.30	8.21	0.15	7.60	4.25	0.07	2.91	4.60
S-V 1L	25.96	46.39	0.20	25.12	11.89	0.57	14.52	4.08	0.16	8.02	1.71	0.07	5.80	10.27
S-B 3L	12.77	19.96	0.21	11.21	13.95	0.57	10.20	6.14	0.15	8.23	2.29	0.07	1.25	4.94

Table 1 - *QoE or Subscribers' experience values for different users locations at peak hour*

Actual cell capacity: 90Mbps near the station

Max cell capacity (Mbps)

SECTOR	Near DL	Near UL	Center DL	Center UL	Median DL	Median UL	Edge DL	Edge UL	Std dev	User Max	Estimated utilization (%) DL	Estimated utilization (%) UL
S- 92L	89.8	108.1	60.4	19.2	41.1	7.0	28.5	1.4	5.9	0	22%	35%
S- 23L	78.2	139.6	46.8	18.1	33.7	4.9	20.3	1.1	5.9	0	18%	73%
S- 02L	76.8	103.2	57.6	29.1	45.0	7.8	31.5	2.1	4.3	0	19%	14%
S- 81L	75.4	101.8	46.7	33.7	35.8	13.3	28.1	3.2	4.0	0	50%	15%
S- 03L	75.2	54.3	41.5	12.7	29.6	4.2	19.2	0.6	4.6	0	16%	4%
S- 11L	74.2	126.7	50.6	31.8	35.3	9.1	25.9	2.2	3.3	0	31%	13%
S- 93L	73.4	74.5	46.7	24.7	37.2	8.8	28.2	1.8	3.3	0	22%	6%
S- 83L	72.9	31.9	52.3	11.7	37.4	4.3	22.0	1.0	4.8	0	21%	4%
S- 81L	72.8	29.3	49.9	17.4	33.2	9.6	20.3	1.8	3.2	0	21%	11%
S- 52L	72.5	41.0	48.8	10.8	32.9	2.6	12.2	0.2	4.7	0	43%	3%

Table 2 - *QoS or Cells' real deployed capacity for different users locations*

The NRAs are empowered to monitor, through drive tests or crowdsourcing, but this is not done or with measures that are still too limited geographically and often useless for subscribers. In conclusion, they are barely made available to the public. Today, with OSS models, this information is available.

For example, with **our solution based on OSS data processed with the Kaufman-Roberts model, it is possible to monitor QoS and QoE, 24 hours a day, 365 days a year, over 100% of the network.** All subscribers can therefore be informed, with precision, of the possible level of quality in the area where they are active. They will also be able to follow the evolution of the quality of service and the quality delivered to them over the months, as the load, the number of subscribers and the network evolve.

Such an ability can revolutionise :

- **The work of NRAs**
- **The operators' Capex efficiency**
- **The subscribers' service quality perception**
- **The public authorities' funding efficiency**

References :

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ANNEXES

1. Is it complex to calculate QoS and QoE values? If so, what are the implications for the industry?

The level of connections delivered to mobile subscribers, the QoE (Quality of Experience), depends on a large number of parameters. Each of these parameters impacts the value of the QoE in one direction or another. We have listed some of these parameters in order to demonstrate the complexity of calculating them. We also wish to demonstrate that a measurement model in the uplink direction, i.e. acquiring and measuring the values of these parameters from the position of the mobile subscriber, would be both impractical and absolutely ineffective.

Below is a non-exhaustive list of the parameters that influence QoS and QoE values:

- The location of the active subscriber: is it close to the radio station, in the middle of the radio coverage area or on the edge of radio coverage?
- The time of connection: is it peak time, or during high traffic hours, or during off-peak hours?
- The topology: is it in a forest, an office zone, a commercial zone or a residential zone?
- Seasonality: is it summer, with leaves on the trees reducing radio coverage, a holiday period in a tourist area, or winter with no leaves on the trees?
- The weekly cycle: is it at the weekend, on a weekday or during an extended teleworking period?
- What types and categories of mobile phones are used by subscribers: smartphone cat. 11 or modem cat. 19?
- What is the configuration of the 4G or 5G cell: 2T2R or 4T4R or 8T8R, with 1, 2 or more carriers and what spectrum is used: 20MHz, 40MHz, ... 80MHz?
- What is the state of the radio cell: lightly loaded, degraded or saturated?
- Is the cell available permanently or intermittently?
- What is the ratio of user activity: sporadic, high, intense and permanent?
- What types of services are used (web browsing, YouTube, voice, SMS, WhatsApp, HD TV, etc.)? In what proportions?
- How many mobile customers are active simultaneously?
- Are active subscribers stationary, or do they move little or quickly? What are the travel speeds?

- Are the transport network and core network sufficiently dimensioned?

This list is not exhaustive, as there are many more parameters to list. We might therefore conclude that profiling models, which seek to measure and use 'all' the parameters, are neither viable nor effective. This technique covers both uplink and downlink direction, because it takes all the parameters into account.

In conclusion, QoS and QoE calculations based on the acquisition of all environmental parameters and the contribution levels of each are too complex. Calculations of the quality of connections provided to mobile phone subscribers using this type of model are ineffective. Mobile operators therefore use other tools, which are available on the market, to obtain session/connection speed values.

The other techniques, which all operate in the uplink direction, are described in the document, along with their current and future limitations. Finally, we describe our technology, which operates in the downlink direction only and is similar to the technology used for GSM: the Erlang table.

2. The state of the art in the industry?

There are currently three types of technique for measuring Quality of Service [QoS] and Quality of Experience [QoE] for 4G and 5G subscribers: drive tests, crowdsourcing and multi-parameter tools.

2.1.Crowdsourcing techniques

Crowdsourcing is the integration of code into certain mobile applications or the direct installation of an APK on the phone, which will automatically generate certain tests to measure data such as position, field levels, connection speed, etc. and report them to a server. An APK or Android Package Kit is a file format for the Android operating system.

- Crowdsourcing measurements are taken at user level, i.e. by a mobile phone, in the uplink direction.
- These measures generate additional traffic on the network

- These measures lead to abnormal use of the subscriber's package.
- The list of parameters in chapter 3. all apply. This means that in order to have a relevant measurement, it is necessary to be able to characterise each measurement with a value for all the parameters, which is impossible. Crowdsourcing providers overcome this problem by accumulating a large number of measurements for each zone, in order to obtain an average or a more or less relevant statistic.
- The accuracy of the QoE value therefore depends on the number of measurements taken in a given zone and over a given period.
- Commercial models base their price on the number of values acquired. So the more expensive it is, the more accurate it is.
- As technologies evolve, data acquisition is becoming increasingly complex. There are now restrictions on the iOS system and for the Android 5G system new locks have appeared.
- The crowdsourcing measurement values are averages of de-correlated values collected under different scenarios (night versus 18:00, indoor versus outdoor versus car, static versus mobile, etc.). This methodology distances the calculated average value from the real value.
- Continuous measurements every month or quarter over a large area are complex and of course costly.

In conclusion, with Crowdsourcing technology, measurements are taken in the upstream direction, from the mobile to the station, so it's a partial, very localised and very specific view of the network. Accumulations of measurements are necessary to achieve a minimum level of reliability. They are expensive for operators, place an additional burden on the network and data acquisition is becoming increasingly restricted.

2.2.Drive Test techniques

Drive Tests are campaigns to measure QoS, QoE, outage rates, handover efficiency, etc... Operators carry out these tests by installing several mobile phones in a vehicle, with a computer controlling the tests and automatically acquiring the data. At the end of the acquisition runs, the data is processed by engineers.

- Drive Tests measurements are collected at subscriber level, in the upstream direction.
- Measurements are precise
- Measurements are very limited in time and geography

- Acquisition is relatively expensive
- The wider the geographical coverage, the higher the costs

In conclusion, with Drive Test technology, the measurements are taken in an upward direction, so it's always a partial, localised and very punctual view of the network. The accumulation of measurements required to reach a geographical minimum is costly for operators

2.3.Multi-parameter tools

Finally, there are the so-called "multi-parameter" tools, which use data from network OSS (transmitted volume, interference levels, number of active customers, their locations, etc.) and combine this data with measurements from Drive Tests, Crowdsourcing, radio planning, etc. They attempt to infer QoE and QoS values, improving on the inaccuracies or limitations of previous measurements by correlations.

In conclusion, these techniques are, in spite of everything, measurements taken in the upward direction, and provide partial, occasional, geographically limited and sometimes imprecise visibility.