Paper

The New Metric and the New Software Tool for Determining QoS in the Short Messages Service in Mobile Networks

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Abstract—With traveling professions and nomadic lifestyles on the increase there is a growing need for comprehensive mobile networking within the Next Generation Network, and the security, reliability and technical independency of the Short Message Service (SMS) is becoming more and more indispensable for business processes. Since competitiveness goes hand-in-hand with this business capability, and methods to determine the quality of this service are becoming equally indispensable. This paper presents possible methods to evaluate the "Completion Rate of SMS" and "End-to-End Delivery Time" and combinations of them (new metric in this paper). A software tool, QoSCalc(SMS), has been developed in collaboration with the authors in order to verify whether service providers are abiding by the Service Level Agreements. The tool has been tested in a real measurement environment and the results are presented graphically here and interpreted.

Keywords—communication network, ETSI TS 102-250-2, QoS measurement environment, QoS measurement techniques, queuing model, SMS service.

1. Introduction

3G networks are becoming more and more widespread every day. Their services also include the Short Message Service (SMS). Although their popularity has experienced a slight decrease in private use, the trend in business use is upward. Constant availability has become a prerequisite of both traveling professions and mobile lifestyles. Boarding passes via SMS, and SMS TAN (Transaction Authentication Number) for online banking have become common usages and are making SMS increasingly attractive for competitive businesses for which security, reliability and technical independency are crucial factors. "Service Level Agreements" are signed to guarantee a specific end-to-end quality of service, which can, however, seldom be verified conclusively by the average service subscriber.

In November 2009 the European Parliament and European Council adopted Directive 2009/136/EC [1] amending Directive 2002/22/EC [2] on universal service and users' rights relating to electronic communications networks and services, Directive 2002/58/EC [3] concerning the processing of personal data and the protection of privacy in the electronic communications sector and Regulation (EC) No. 2006/2004 [4] on cooperation between national authorities responsible for the enforcement of consumer protection laws. Within this directive, providers of electronic communications services that allow calls should not only ensure that their customers are adequately informed about the limitations of the services but also about the routing of emergency calls. Furthermore, information about services, which are not provided over a switched telephone network, should also cover the level of reliability of the access and provide caller location information in comparison with that of a service that is provided over a switched telephone network, taking into account current technology and quality standards and any quality of service parameters specified under Directive 2002/22/EC (Universal Service Directive) [2].

Especially with regarding to Quality of Service (QoS), Member States of EU shall ensure that national regulatory authorities empowered to require service providers to publish comparable, adequate and up-to-date information for end-users on the quality of their services, when requested. These national regulatory authorities may specify, amongst other things, the QoS parameters to be measured and the contents, form and manner in which the information is to be published. In addition, the national regulatory authorities should be able to set minimum QoS requirements to prevent degradation, traffic-slowing or traffic-hindering. As a result, it can be said that the European Parliament and the European Council are not only generally aware of QoS and all that it entails, but are also ensuring that the Member States apply their directives.

In 2011, the ETSI technical committee Speech and multimedia Transmission Quality (STQ) produced two multi-part technical specifications to cover "QoS aspects for popular services in mobile networks" [5] and "User related QoS parameter definitions and measurements" [6]. The second part of [5] in particular discusses the topic "Definition of Quality of Service parameters and their computation", and contains an abstract definition, which gives a generic description of the parameter, an abstract equation and the corresponding user and technical trigger points. The sec-

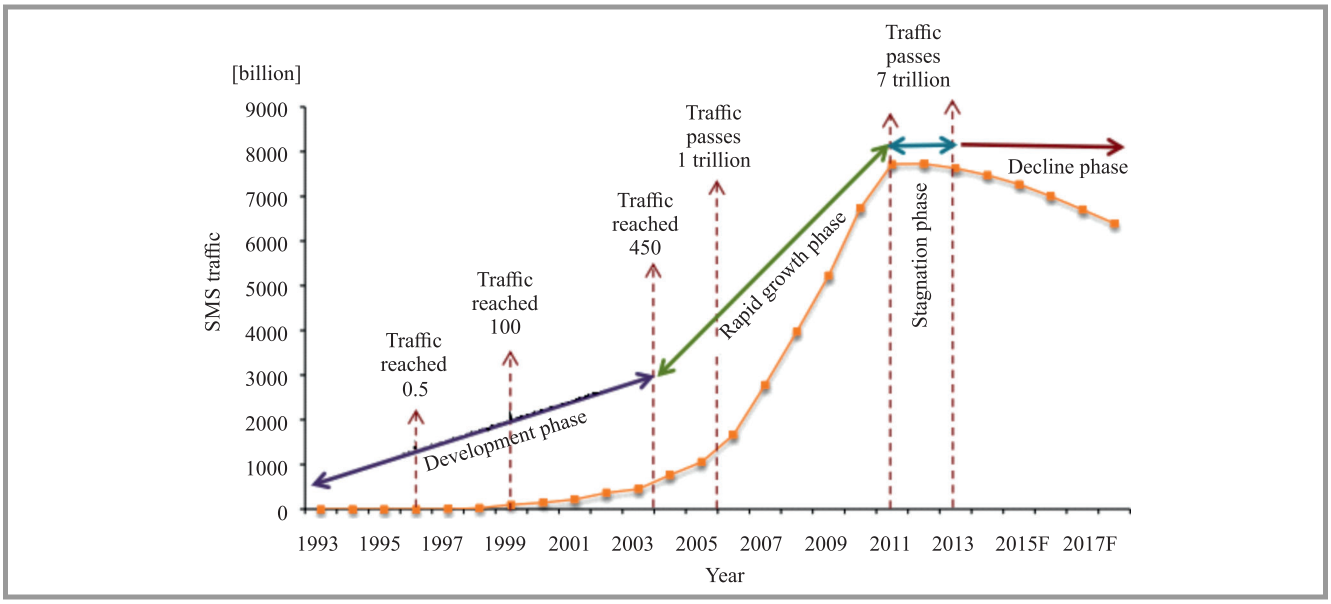

Fig. 1. SMS traffic growth in 1992–2013 and 2015–2017 forecast. (See color pictures online at www.nit.eu/publications/journal-jtit)

ond part of [6] is devoted to the topics "Voice telephony, Group 3 fax, modem data services, and SMS".

Research on the current telecommunications market has revealed that SMS still plays an important role even in the age of over-the-top (OTT) Messaging, which also has become very popular. In 2011 the world press declared SMS for "dead" and heralded OTT Messaging as its replacement. SMS continues to offer a few benefits such as its flexible platform and reliability. Figure 1 shows the growth of SMS traffic [7].

It is obvious that SMS was still popular with about 7.6 trillion messages in 2013. Although it has now entered the decline phase, it is worth taking a closer look at SMS nonetheless.

The examination will start with a presentation of the QoS parameters for SMS as they stand in the ETSI Recommendation TS 102-250-2 [6]. Then, a new metric for SMS will be defined and illustrated. The paper will then turn to an introduction of the new tool QoSCalc(SMS), beginning with its general architecture and functional principle. After that, there is a description of how the new tool was put to the test in a series of practical measurements. The paper closes with a conclusion and an outlook.

2. QoS Parameters for SMS

This chapter introduces the main QoS parameters recommended in ETSI TS 102-250-2 [6]:

SMS Service Non-Accessibility. The service non-accessibility denotes the probability that the end user cannot access the SMS when requested while it is offered by display of the network indicator on the user equipment.

SMS Service Access Delay. The service access delay is the time period between sending a short message to the network and receiving a send confirmation from the network at the origin side.

SMS Successful SMS Ratio. This ratio describes the probability that a user can send a short message from a terminal to the Short Message Center and is applicable for service providers offering the SMS. Therefore, it is recommended that result statistics should return the percentage of successfully sent short messages, the number of observations and its calculated absolute accuracy limits for 95% confidence.

Measurements should be scheduled so as to reflect accurately traffic variations over the hours of a day, the days of the week and the months of the year. The parameter is intended to measure a combination of network accessibility and congestion in the signalling channels of the SMS system throughout service operator's claimed area of coverage.

Completion Rate for SMS. This describes the ratio of correctly received short messages to those sent, and is also applicable to SMS service providers. It is recommended that the results that provide statistics should return the ratio of sent and correctly received short messages, the number of observations used and its calculated absolute accuracy limits for 95% confidence.

Measurements should be scheduled so as to reflect accurately traffic variations over the hours of a day, the days of the week and the months of the year.

End-to-End Delivery Time for SMS. This time is the period that elapses between the sending of a short message from the sender's terminal equipment to a Short Message Centre and the receiving of that message on the receiver's terminal equipment, and is applicable for service operators providing the SMS. Result-providing statistics should return the mean value in seconds for sending and receiving short messages, the time in seconds within which the fastest 95%

of short messages are sent and received and the number of observations performed.

Measurements should be scheduled so as to reflect accurately traffic variations over the hours of a day, the days of the week and the months of the year. The above-mentioned measurements for estimating QoS parameters should be done either on real traffic, on test calls for short messages sent among a representative population of local exchanges or on a combination of the above.

A measurement system can be designed for these QoS parameters that takes "Completion Rate for SMS" and the "End-to-End Delivery Time for SMS" into account.

Research of current QoS measurement techniques for the SMS has culminated in a large professional solution called QualiPoc Android, from SwissQual AG, a Rohde & Schwarz company [8]. An alternative system, QoSCalc (SMS), is presented in this work. The next section introduces the new metric for evaluating the QoS in SMS.

3. New Metric for QoS in SMS

The conceptual idea is to introduce the SMS Quality Factor (SMSQ-F), which takes completion rate and end-to-end delivery time into account. The formulas of this metric have the following definition:

$$SMSQ\text{-}F = CR_{Result} \cdot CR_{Weighting} + DT_{Result} \cdot DT_{Weighting}\,, \quad (1)$$

where:

$$CR_{Result} = \frac{\frac{1}{n}\sum Completicon\ Rate(n)}{Completation\ Rate\ Threshold}\,, \quad (2)$$

$$DT_{Result} = \frac{Delivery\ Time\ Threshold}{\frac{1}{n}\sum_{n=1}^{n} Delivery\ Time(n)}\,. \quad (3)$$

Both thresholds should be chosen judiciously depending on individual needs. Usually, completion rate threshold is 1, so that every short message should be successful delivered. The threshold in seconds for the delivery time will reflect professional requirements, e.g. alarm systems ≤ 3 or online banking ≤ 7.

The respective weightings must have the sum of 1 and should be chosen to reflect how the evaluator gauges their importance.

The following example is chosen:

- completion rate threshold = 1,
- delivery time threshold = 10 s,
- weighting completion rate = weighting delivery time = 0.5.

Table 1 gives some example results.

From Table 1 it can be seen that the proposed metric, based on Eq. (1), works well. Furthermore, it can be seen that the values of SMSQ-F are within the interval [0, 1]. To be able to adapt these values to a respective (Quality of Experience; subjective evaluation) QoE scale, the following relationship has been chosen, based on the QoS measurement technique "Apdex-Index" for the WWW service [9]–[10] (see Fig. 2).

Table 1
Example results of the new metric

n	Average CR	Average DT [s]	CR_{Result}	DT_{Result}	SMSQ-F
31	1	10	1.00	1.00	1.00
31	1	11	1.00	0.91	0.95
31	1	4	1.00	1.00	1.00
31	1	40	1.00	0.25	0.63
31	1	22	1.00	0.45	0.73
31	0.9	15	0.90	0.67	0.78
31	0.8	16	0.80	0.63	0.71
31	0.7	10	0.70	1.00	0.85
31	0.6	4	0.60	1.00	0.80
31	0.5	19	0.50	0.53	0.51
31	0.4	7	0.40	1.00	0.70

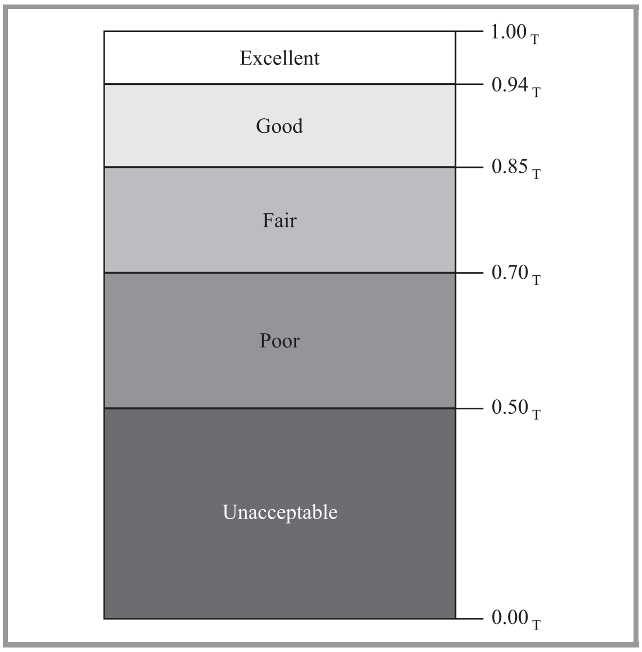

Fig. 2. Translation of QoS values into QoE values for the SMSQ-F.

In general, the proposed metric can be described as follows:

$$CR_{Result} = \begin{cases} 1 & \text{for } \frac{1}{n}\sum_{n=1}^{n} Completion\ Rate(n) = \\ & = Completion\ Threshold \\ 0 & \text{for } n=0 \cup Completion\ Rate\ Threshold = 0 \\ \text{else} & \frac{\frac{1}{n}\sum_{n=1}^{n} Completion\ Rate(n)}{Completion\ Rate\ Threshold} \end{cases}, \quad (4)$$

$$DT_{Result} = \begin{cases} 1 & \text{for } \frac{1}{n}\sum_{n=1}^{n} Delivery\ Time(n) = \\ & = Delivery\ Time\ Threshold \\ 0 & \text{for } n=0 \cup Delivery\ Time = 0 \\ \text{else} & \dfrac{Delivery\ Time\ Threshold}{\frac{1}{n}\sum_{n=1}^{n} Delivery\ Time(n)} \end{cases} . \quad (5)$$

Furthermore, this metric has been implemented in the new tool QoSCalc (SMS), neatly customizing it for the QoS evaluation for SMS. The next chapter introduces this tool.

4. The New Tool for Analysing QoS in SMS

The tool that was developed in the course of this work to analyze QoS in the SMS service has been called QoSCalc(SMS). It can be used for both objective and subjective analysis of service quality of SMS in mobile networks. Therefore, a concept for a new measurement system has been formulated that takes both the completion rate for SMS and the end-to-end delivery time for SMS into account. It is therefore necessary to understand the idea behind merging these QoS parameters.

Once a short message has been correctly sent and delivered, the completion rate for SMS provides statistics about the ratio of correct short messages received to short messages sent from all observations, while end-to-end delivery time for SMS provides statistics about the delivery time of short messages. By merging these QoS parameters it is possible to provide statistics about the QoE using the SMS.

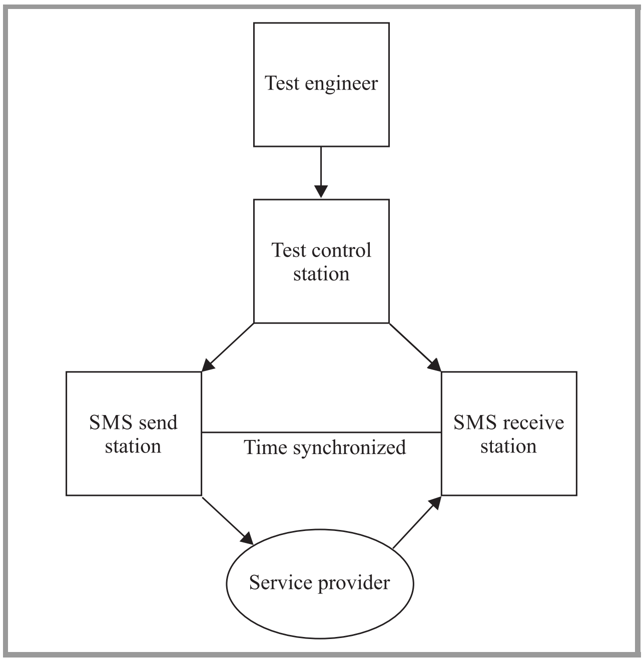

Fig. 3. Conceptual measurement environment.

In example users will be unsatisfied when a sent short message may be correctly received but delivered only after 10 minutes. They might be equally upset by promptly delivered but error-laden messages. In professional implementations, time-criticalness is just as important factor as reliability. When it comes to security and alerting systems, business implementations stand or fall depending on time-criticalness and reliability. This concept introduces an approach to estimate such appropriate QoS parameters.

The general architecture is described in Fig. 3.

The test engineer is responsible for the measurement setup and controls the test control station, which in turn controls the SMS send and receive stations. The send station and the receive station are synchronized and communicate via the service provider. The chosen hardware platform is the mobile phone HTC Desire 620G dual SIM on Android 4.4.2.

The implementation is based on the block diagram shown in Fig. 4.

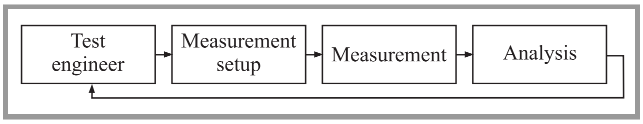

Fig. 4. Conceptual description for the implementation.

The entire solution was written in the programming language Java and developed in Android Studio 2.1.2. The compiled SDK Version is API 23: Android 6.0 and the Build Tools Version is 23.0.0. The dependencies are set as follows:

- support: AppCompat 23.1.1 and Design 23.1.1,
- visualization: MPAndroidChartLibrary 2.1.6,
- time synchronization via Network Time Protocol (NTP): Apache Commons Net 3.4,
- several permissions, such as Receive_SMS, Send_SMS and Access_Network_State, need to be set.

The basic implemented functionalities are:

- Time synchronization. The time synchronization is done via the NTP and the server involved is the default one configured in the system. Then the difference between the system and server time is calculated as an offset for the SMS timestamp. Note: it is not necessary to use the offset correction between sending station and receiving station time synchronization because the environment does not need to be accurate to within less than 10 ms.
- Send SMS. Each SMS starts with the string “Message”, followed by a zero-initialized, pre-increment counter and the respective synchronized timestamp. After 20 short messages have been sent the sending station goes into the idle state.

- Receive SMS. Each received SMS is stored as a structure with the message body, originating address, receive time and sending time.
- Analysis. The analysis is done for the "End-to-End Delivery Time for SMS", i.e. the difference between sending and receiving time, the "Completion Rate for SMS", i.e. the difference between successful sent and received short messages, and finally the calculation of the SMSQ-F.

After being defined, the functionalities have been linked to the control elements and are ready for the first tests, as shown in Figs. 5–8.

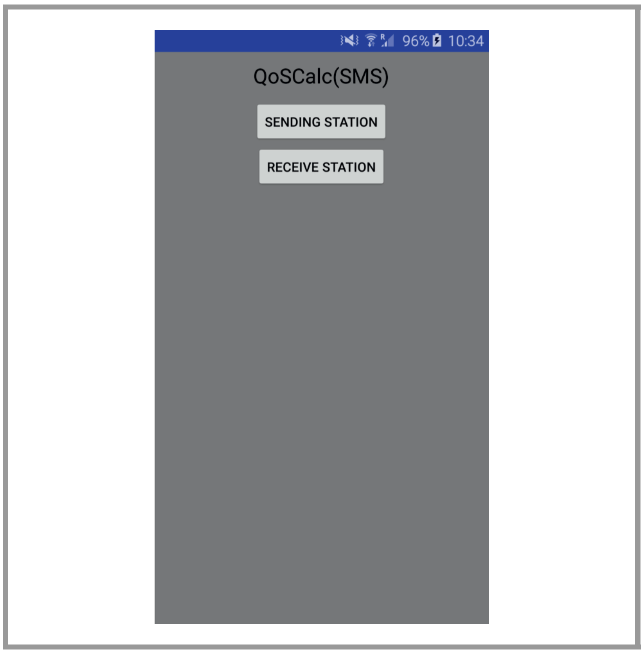

Fig. 5. Start-up screen QoSCalc(SMS).

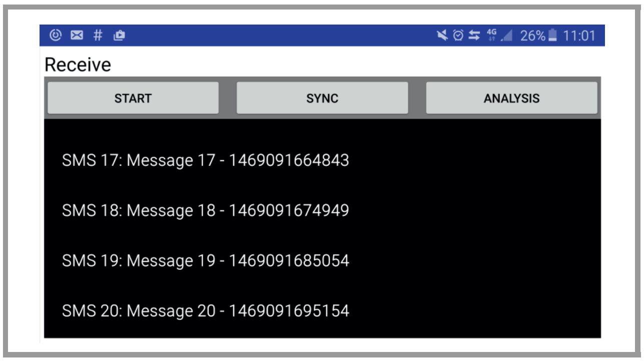

Fig. 6. Receive station QoSCalc(SMS) – LTE.

Start-up screen. The Start-up screen allows the user to choose between sending station and receive station. By default it is displayed whenever a synchronization error should occur.

Sending/receive station. The two stations can be time synchronized with the Sync button. Of course, the receive station must already have been started. After a measurement,

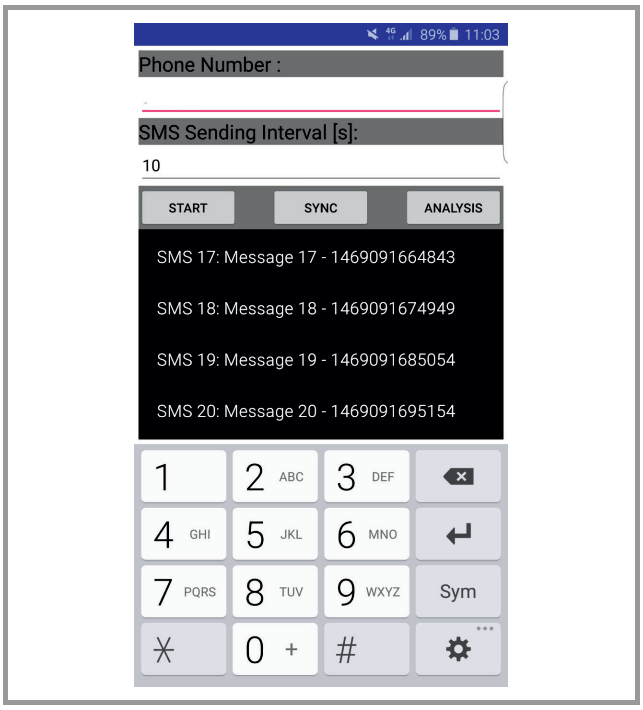

Fig. 7. Sending station QoSCalc(SMS) – LTE.

the analysis section can be initialized with the analysis button.

Analysis section. At the current state of development, this section is only active for the receive station. It provides the following information:

- "End-to-End Delivery Time for SMS" as a function of the short message number,
- average "End-to-End Delivery Time for SMS",
- "Completion Rate for SMS" for one measurement scenario,
- the calculated "SMSQ-F", based upon the user-specified thresholds for the completion rate and delivery time and their weightings.

Finally, the new tool has to be tested in a real testing environment to verify if it is working properly.

5. Measurement Environment and Measurement Results

The measurement environment for the chosen measurement scenario consists of two HTC 620G dual SIMs, each plugged with a SIM card from Swisscom with LTE functionality. Test location was 47°12'25.2" N, 7°33'17.3" E. Unfortunately, the HTC 620G is not suitable for LTE testing. Therefore, two Samsung Galaxy S6 Edge+ were been included in the environment. Then, the following measurement scenario was chosen.

Fig. 8. Analysis section QoSCalc(SMS) – LTE.

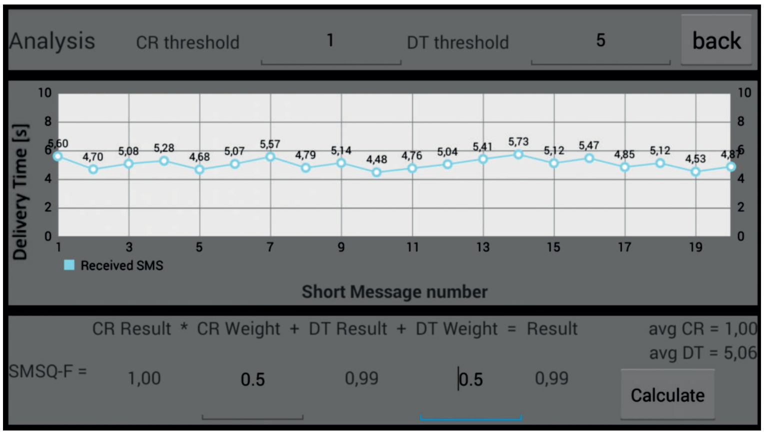

Fig. 9. Results QoSCalc(SMS) – EDGE.

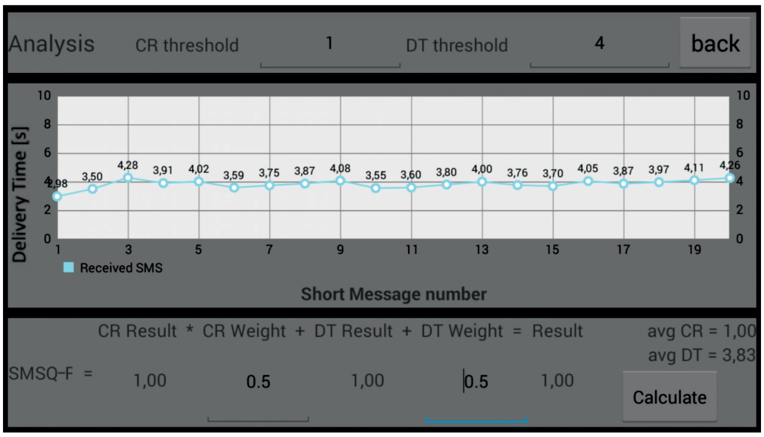

Fig. 10. Results QoSCalc(SMS) – UMTS.

Technology testing. Technology testing uses different mobile network technologies. These are 4G (LTE), 3G (UMTS) and 2G (EDGE). Each test consists of a set of 20 short messages sent at intervals of 10 s. The defined thresholds were as follows:

- completion rate for all technologies: 1,
- delivery time: LTE – 1.3 s; UMTS – 4 s; EDGE – 5 s,
- the weightings are to be considered as equal.

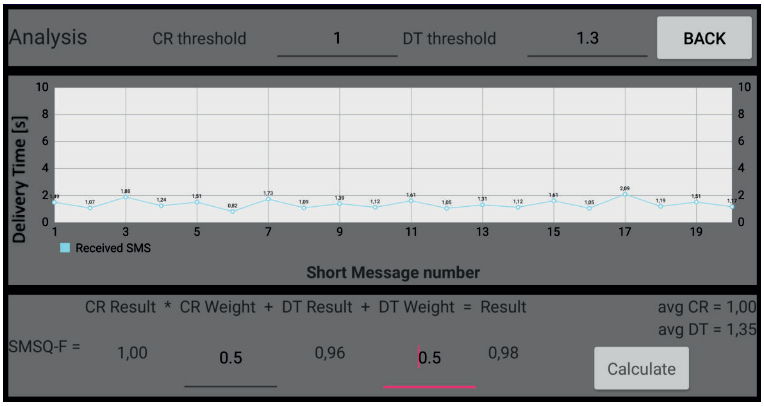

Fig. 11. Results QoSCalc(SMS) – LTE.

Being successful in the measurement environment, the new tool has delivered the results shown in Figs. 9 to 11.

EDGE results. These results show an average delivery time of 5.06 s within an interval of [4.48; 5.73] and a completion rate of 1. With the chosen threshold, the SMSQ-F is 0.99.

UMTS results. These results are showing an average delivery time of 3.83 s within an interval of [2.98; 4.28] and a completion rate of 1. With the chosen threshold, the SMSQ-F is 1.

LTE results. These results are showing an average delivery time of 1.35 s within an interval of [0.82; 2.09] and a completion rate of 1. With the chosen threshold, the SMSQ-F is 0.98.

Having analyzed all measurement results, one can conclude that the new tool QoSCalc(SMS) is robust and suitable for evaluating the QoS of SMS in different mobile networks, such as LTE, UMTS and EDGE. The implemented metric works properly and provides valuable results. It is possible to adjust the thresholds to suit the testers' needs, which increases the flexibility of the tool considerably.

6. Summary and Outlook

This paper has been devoted to the subject of QoS measurement within the SMS. It has focused on the creation of a tool for measuring QoS in SMS for mobile network testing. The new tool has been given the name QoSCalc(SMS). It is based upon a new metric "SMSQ-F", described in Section 3, which takes both end-to-end delivery time for SMS and completion rate for SMS into account. The implemented tool has been tested in a real mobile network environment. As far as the technology is concerned the underlying measurement scenario and the respective results display both a high degree of diversity, e.g. LTE, UMTS and EDGE, and a high degree of flexibility regarding the SMS quality factor, which is easily adjustable to meet the end users' needs when choosing the best service provider. With that, the tool has proved its practical capabilities and is ready to be used effectively in determining the quality of the SMS in mobile networks.

In future work it would be very worthwhile to compare the SMS service with OTT content messaging with regard to reliability and especially availability. In addition, the tool should be improved to be more suitable for test automation. Work in this direction is already in the offing.

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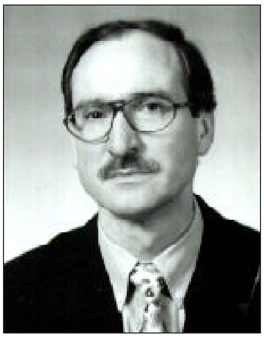

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