Journal of Medical Systems (2019) 43: 213
https://doi.org/10.1007/s10916-019-1342-1

SYSTEMS-LEVEL QUALITY IMPROVEMENT

Measuring QoE of a Teleconsultation App in Mental Health Using a Pentagram Model

Isabel de la Torre Díez[1] · Susel Góngora Alonso[1] · Eduardo Motta Cruz[2] · Manuel A. Franco[3]

Received: 20 March 2019 / Revised: 3 May 2019 / Accepted: 13 May 2019 / Published online: 1 June 2019

Abstract

The QoE measurement has become a novel theme today. To achieve a quality service and minimize the negative impact that traffic on network can cause, it's very important to manage the devices that intervene in this service. Hence, the QoE evaluation allows obtaining benefits both customers and service providers. The main objective of this paper is to measure QoE of a teleconsultation application in Mental Health named Psiconnect, using an approach based on pentagram model. For the QoE evaluation of Psiconnect application we used the pentagram model based on the measurement of 5 factors (integrality, retainability, availability, usability, and instantaneousness). This model allows to design quantifiable metrics for quality evaluations. Using the model cited the value of QoE for Psiconnect is 1.793 (between 1.6 and 1.8). Comparing with Mean Opinion Scores (MOS) test, some users are dissatisfied with the use of the application although the result is near 1.8, so the most of users are satisfied with the use of teleconsultation service based in Skype in the Psiconnect app. There are different models to measure QoE having into account subjective parameters. This is important an estimation of QoE in a quantitative form. Other models can be used to improve the quality of apps.

Keywords Mental health · Pentagram model · QoE · Skype · Teleconsultation

Introduction

The prevalence of broadband wireless networks offering Internet connectivity today has opened up new possibilities for using wireless and mobile services in eHealth applications [1].

The available bandwidth and other parameters should be considered when transmitting multimedia signals in several wireless telecommunications systems. Therefore, the image and video content must be compressed to meet the bandwidth requirements. Hence, when designing an eHealth or mHealth service, QoE must be taken into account since it is one of most important factors in the implementation [2].

According to [3], QoE is "the degree of delight or annoyance of the user of an application or service. It results from the fulfillment of his/her expectations with respect to the utility and/or enjoyment of the app or service in the light of the user's personality and current state". To deal with user satisfaction and acceptance, the notions of expected and perceived quality are identified, since they influence the user's perception [4]. Therefore QoE is a measure of users' general perception for the QoS [5]. Some influencing factors of QoE are: mental and physiological state, expectation, background and experience [6]. QoE depends on QoS parameters. In many cases QoE factors can be evaluated through subjective surveys carried out on users of a determinate service. In this way, it is possible to measure their satisfaction with a service and produces a

This article is part of the Topical Collection on *Systems-Level Quality Improvement*

✉ Isabel de la Torre Díez
isator@tel.uva.es

Susel Góngora Alonso
suselgongoraalonso@gmail.com

Eduardo Motta Cruz
Eduardo.Mottacruz@univ-nantes.fr

Manuel A. Franco
mfm@intras.es

[1] Department of Signal Theory and Communications, and Telematics Engineering, University of Valladolid, Paseo de Belén, 15, 47011 Valladolid, Spain

[2] Bretagne Loire and Nantes Universities, UMR 6164, IETR Polytech, Nantes, France

[3] Psiquiatry Service, Hospital Zamora, Hernán Cortés, Zamora, Spain

Mean Opinion Score (MOS) indicator [7–9]. MOS is a quantitative method to measure QoE. In this method, the range is from 1 (bad) to 5 (excellent). This indicator is subjective and every individual has his/her own set of QoE values for a same service or application and with the same conditions. This limitation can be minimized categorizing the users with similar characteristics such as values or needs [10, 11]. There are other methods, for example in [12], the authors propose other method named pentagram model for measuring QoE. In [13] we present a review of existing research works in the literature, referring to QoS and QoE in telemedicine and eHealth applications. Some tools for measuring QoE are developed in the form of a survey. For the development of this survey, many time is necessary the help of psychologist [14–16]. In [17] discuss the QoE multidimensionality and importance of considering all influencing factors in QoE experiments. They describe the popular tools that can be used in subjective tests "survey-based" together with procedure for processing statistical results, providing ways to statistically evaluate and compare the performance of objective QoE estimators, using the data obtained.

In [18] we developed a system for communication between different agents in mental health named Psiconnect. It provides communication services, necessary for improving the treatment of the patients, a second medical opinion and solving doubts between patients and medical staff. Moreover, it incorporates a video conferencing service using Skype. Psiconnect tries to bring effectiveness to its users, i.e., a second medical opinion, remote diagnosis, etc. This application includes discussion forum, chat, videoconference, private messages, related news, online and printed resources [18].

In this paper we used a model-based approach [12] to measure the QoE of the teleconsultation service of Psiconnect. This approach can be applied to other teleconsultation apps in different specialties. The main aim of this work is to measure QoE of Psiconnect using an approach based on this pentagram model. This methodology can be applied to other ehealth applications and/or systems to compare it with other models.

The remainder of this paper is as follows. In Methodology section, the used model to measure the QoE of the teleconsultation application is presented. Next, the results are showed and by last, conclusion is described.

Table 1 Factors influencing in QoE and measures

QoE performance indicator	Measures	Used Symbol
Integrality	Jitter (Jit), delay (Del), packet loss ratio (Pl)	A
Retainability	Service interruption ratio	B
Availability	Success ratio of user access service	C
Usability	Service Usability	D
Instantaneousness	Response Time to establish and access service	E

Table 2 Integrality index

	Weight	Threshold
Delay	0.5	90 ms
Jitter	0.2	30 ms
Packet loss rate	0.14	6%

Methods

The model used in this work for QoE evaluation use the Eq. (1). It allows to design quantifiable metrics for quality evaluations. QoE is presented and measured through using a pentagram diagram based on the measurement of five factors. The measurement result of each factor is a value from 0 to 1, where 0 indicates the minimum value and 1 indicates the maximum value. These factors are show in Table 1,where we indicated the relation between the symbols in the equation, performance indicators and most important measures [12].

$$QoE = \frac{1}{2} sin\ 72^{\circ} U(AB + BC + CD + DE + EA) \tag{1}$$

Integrality depends on factors as jitter, delay and packed loss rate. In Eq. (2) we can see D_A as the sum of the QoE of the service integrality.

$$D_A = \propto_1 \cdot Del + \propto_2 \cdot Jit + \propto_3 \cdot Pl \tag{2}$$

Where $\propto_i$ defines the consistency ratio complied with contract. If $\propto_i$ is bigger the QoE is better.

As retainability service, we represent the service interruption ration in Eq. (3)

$$D_B = 1 - \delta \quad \text{where} \quad \delta = \frac{n}{\sum_{i=1}^{n} t_i} \tag{3}$$

The availability ratio is defined in Eq. (4)

$$D_C = 1 - \frac{m}{n} \tag{4}$$

where m is the number of access service failure and n the total of access services.

We consider three dimensions of usability as are effectiveness, efficiency and satisfaction using the model defined in [12]. The instantaneousness ratio is defined in Eq. (5).

$$D_E = \frac{m}{n} \tag{5}$$

Table 3 Ratios results

D_A	D_B	D_C	D_D	D_E
0,93	0,96	0,71	0,78	0,94

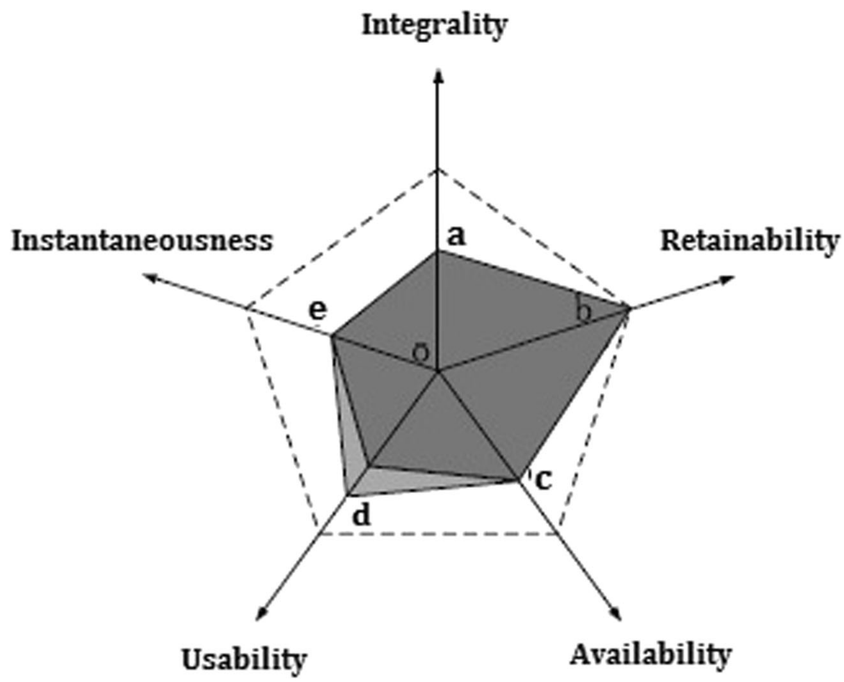

Fig. 1 QoE pentagram model [12]

where m is the number of $\partial \geq 1, \partial = {}^{O}/_{M}$, O represents the target value.

The usability service contains a series of metrics such as: task completion, error counts, task times and satisfaction, which are responsible for quantifying the dimensions of the service (effectiveness, efficiency and satisfaction).

Results and Discussion

In this section the results of the QoE evaluation of Psiconnect app using a model-based approach [12] are presented. Delay, jitter and packet loss rate are influencing in the transmission of video and audio. In Table 2 appear the characteristics of the

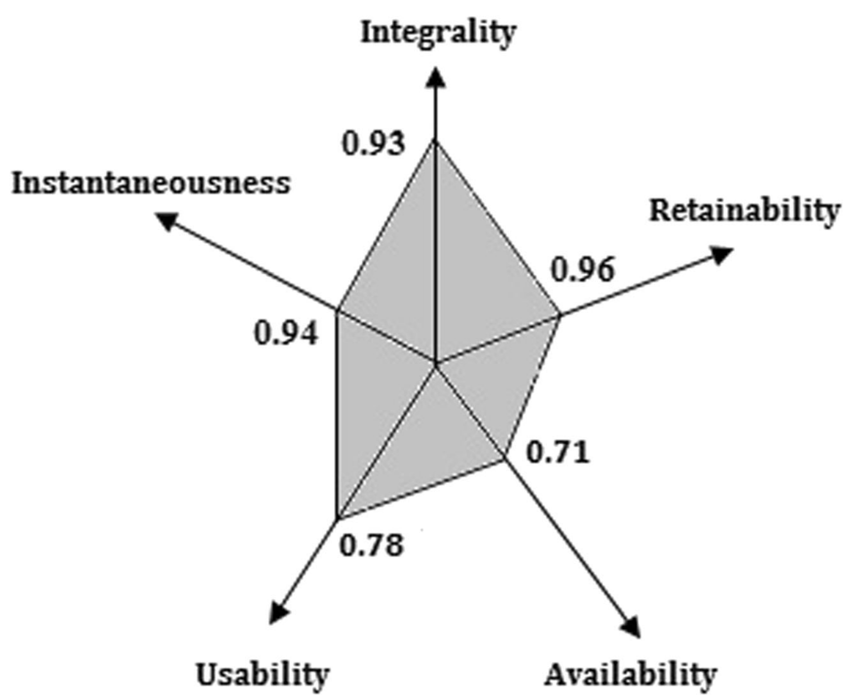

Fig. 2 QoE pentagram model for measurements of our application

integrality measure and Table 3 shows the different ratios D_A, D_B, D_C, D_D, D_E.

The values shown in Table 3 are the results obtained by applying eqs. (2)–(5). DA represents the sum of the QoE of the service integrality. The different D_i for i = B, C, D, E are explained in the methods section. We calculate the final QoE for Psiconnect as follows:

$$QoE = 0.48*[(0.93*0.96) + (0.96*0.71) + (0.71*0.78) + (0.78*0.94) + (0.94*0.93)] = 1.793$$

Taking into account the pentagram model (See Fig. 1) to measure the five QoE factors, we show in Fig. 2 the calculated values for our application.

This model shows that few users aren't satisfied at all with the model-based approach because the value is between 1.6 and 1.8 [12]. The impact of poor QoE and low QoS in eHealth can result not only in poor quality of the health care service but can also lead to false judgments in diagnosis, data latency can affect the accuracy and time of completion time of surgical task, or the delay in remote surgery can significantly degrade remote surgeon's task performance and may result in overall poor performance, which in turn affects their confidence level [4, 19].

Conclusion

QoE estimation and management has become an increasingly important element for telecommunications service providers, since this is a reflection of acceptance or opinion that users have about the services they consume [20].

The growth of video traffic poses new challenges for service providers, on the one hand, they pretend to increase the QoE perceived by end users and on the other they are immersed in minimizing costs of the delivery infrastructure that is responsible for serving to millions of concurrent viewers [21].

QoE is closely related to QoS. The wide variety of eHealth services imposes different QoS requirements on the underlying networks. Aspects such as tolerance to delay are service requirements ranging from strict real-time and delay intolerant data transmission [22, 23]. Another aspect is application data sensitivity to loss, with conversational voice based applications that often tolerate some packet loss, while data transmission (e.g., medical image transfer) is highly losses intolerant [24].

The model of QoE in areas such as Mental Health applying the standards of usability, accessibility, efficiency, efficacy and quality of clinical processes offers a integral eHealth system that benefits both patients, physicians and specialists [25].

QoE is an important parameter to measure due to its subjectivity. This paper measures the QoE of a teleconsultation app in mental health using a model-approach [12]. The obtained values cannot be considered good at all. As future work, after comparing different QoE models we will propose a new model to use with this application and other applications in mental health.

Acknowledgements This research has been made within the Program "Movilidad Investigadores UVA-BANCO SANTANDER 2018", and it has been partially supported by European Commission and the Ministry of Industry, Energy and Tourism under the project AAL-20125036 named "Wetake Care: ICT- based Solution for (Self-) Management of Daily Living".

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Ojanpera, T., Uitto, M., and Vehkapera, J., QoE-based management of medical video transmission in wireless networks. Proceeding of the IEEE Netw Oper Manag Symp.:1–6, 2014.
2. Péteri, T., Varga, N., Bokor, L., A Survey on Multimedia Quality of Experience Assessment Approaches in Mobile Healthcare Scenarios. *In: Springer, editor. eHealth 360°*. 484–491, 2016.
3. Floris, A., and Atzori, L., Quality of experience in the multimedia internet of things : Definition and practical use- cases. Proc IEEE Int Conf Commun Work.:1747–1752, 2015.
4. Ullah, M., Fiedler, M., and Wac, K., On the ambiguity of quality of service and quality of experience requirements for eHealth services. *Proceeding of the6th*. Int Symp Med Inf Commun Technol.:1–4, 2012.
5. Li, L., Rong, M., and Zhang, G., An internet of things QoE evaluation method based on multiple linear regression analysis. Proc10th Int Conf Comput Sci Educ.:925–928, 2015.
6. Ikeda, Y., Kouno, S., Shiozu, A., and Noritake, K., A framework of scalable QoE modeling for application explosion in the internet of things. ProcIEEE 3rd World Forum Internet Things, WF-IoT.:425–429, 2016.
7. Kim, H. J., and Choi, S. G., QoE assessment model for multimedia streaming services using QoS parameters. Multimed. Tools Appl. 72(3):2163–2175, 2014.
8. Gómez, G., Hortigüela, L., Pérez, Q., Lorca, J., García, R., and Aguayo-Torres, M. C., YouTube QoE evaluation tool for android wireless terminals. EURASIP J. Wirel. Commun. Netw. 164, 2014.
9. Skorin-kapov, L., Varela, M. A., Multi-Dimensional View of QoE : the ARCU Model. *Proceeding of theMIPRO, 2012 Proc 35th Int Conv.* 662–666, 2012.
10. Lounis, A., Alilat, F., Agoulmine, N., Neural Network Model of QoE for Estimation Video Streaming over 5G network. *In: 2018*

International Workshop on ADVANCEs in ICT Infrastructures and Services (ADVANCE'2018). 21, 2018.
11. Volpato, F., Da Silva, M. P., Goncalves, A. L., and Dantas, M. A. R., An autonomic QoE-aware management architecture for software-defined networking. *Proceeding of theIEEE 26th*. Int Conf Enabling Technol Infrastruct Collab Enterp WETICE 2017:220–225, 2017.
12. Gong, Y., Yang, F., Huang, L., and Su, S., Model-based approach to measuring quality of experience. Proceeding of the2009 First Int Conf Emerg Netw Intell:29–32, 2009.
13. De la Torre Díez, I., Góngora Alonso, S., Hamrioui, S., López-Coronado, M., and Motta Cruz, E., Systematic review about QoS and QoE in telemedicine and eHealth services and applications. J. Med. Syst. 42(10):182, 2018.
14. Martínez-Pérez B, De La Torre-Díez I, Candelas-Plasencia S, López-Coronado M. Development and evaluation of tools for measuring the quality of experience (QoE) in mHealth applications. J. Med. Syst. 2013;37(5):9976.
15. Jing, H., and Wendong, W., A service implementation scenario measuring users' QoE. J Beijing Univ Posts Telecommun. 30(2): 106–109, 2007.
16. Sauro, J., and Kindlund, E., A method to standardize usability metrics into a single score. Proc SIGCHI Conf Hum factors Comput Syst.:401–409, 2005.
17. Krasula, L., and Le Callet, P., Emerging science of QoE in multimedia applications: Concepts, experimental guidelines, and validation of models. *In: Academic Press Library in*. Signal Process.:163–209, 2018.
18. Velasco-Morejón, D., and Martínez-Pérez, B., de la Torre-Díez I, López-Coronado M. PSICONNECT: A platform for communication between medical staff, caregivers and patients with psychiatric problems. e-Society. 101, 2014.
19. Shin, D. H., Conceptualizing and measuring quality of experience of the internet of things: Exploring how quality is perceived by users. Inf. Manag. 54(8):998–1011, 2017.
20. Moya Neyra, J., Alonso Irizar, C., and Anías, C. C., Evaluación de QoE en servicios IP basada en parámetros de QoS. Ing Electrónica, Automática y Comun. 38(3):36–46, 2017.
21. De Cicco L, Mascolo S, Palmisano V. QoE-driven resource allocation for massive video distribution. Ad Hoc Netw.2019; 89:170–176.
22. Skorin-Kapov, L., and Matijasevic, M., Analysis of QoS requirements for e-health services and mapping to evolved packet system QoS classes. Int. J. Telemed. Appl. 9, 2010.
23. Montero, R., Pagès, A., Agraz, F., and Spadaro, S., Supporting QoE/QoS-aware end-to-end network slicing in future 5G-enabled optical networks. Proc Metro and Data Center Optical Networks and Short-Reach Links II. International Society for Optics and Photonics.:109460F, 2019.
24. Khokhar Muhammad, J., Saber Nawfal, A., Spetebroot, T., and Barakat, C., An intelligent sampling framework for controlled experimentation and QoE modeling. Comput. Netw. 147:246–261, 2018.
25. Cavaro-Ménard, C., Lu, Z. G., Le Callet, P.. QoE for telemedicine: Challenges and trends. *Proc Applications of Digital Image Processing XXXVI. International Society for Optics and Photonics*. 88561A, 2013.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.