Toward a model for Quality of Experience and Quality of Service in e-health ecosystems

Veronica A. Rojas-Mendizabal\textsuperscript{a}\textsuperscript{*}, Arturo Serrano-Santoyo\textsuperscript{a}, Roberto Conte-Galvan\textsuperscript{a}, Amanda Gomez-Gonzalez\textsuperscript{b}

\textsuperscript{a}CICESE Research Center, Carretera Ensenada-Tijuana No. 3918, Zona Playitas Ensenada, B.C., CP 22860, Mexico

Abstract

In this paper we propose a health ecosystem involving the quality of experience and quality of service in e-health systems. This e-health ecosystem incorporates elements of the context and the interaction between actors. We identified the key factors to develop a comprehensive model in order to determine the level of acceptance of end users, in this case the patient and the physician.

© 2013 The Authors Published by Elsevier Ltd. Open access under CC BY-NC-ND license. Selection and/or peer-review under responsibility of SCIKA – Association for Promotion and Dissemination of Scientific Knowledge

Keywords: QoE; QoS; e-health; Telemedicine; ICT.

* Corresponding author. E-mail address: vrojas@cicese.edu.mx
1. Introduction

The increasing penetration of ICT in the health sector provides important opportunities for developing efficient systems and processes to improve the quality and coverage of health services in developing countries. The understanding of the elements and context of the e-health ecosystem and the development of a comprehensive framework that includes human, technical and socioeconomic factors provide a foundation to fully capitalize the applications and adoption of ICT in the health sector. Our proposal takes into account the multidimensional and complex nature of the e-health ecosystem and the importance of the interactions among all the actors involved.

E-health has been defined as: “The combined use in the health sector of electronic communication and information technology (digital data transmitted, stored and retrieved electronically) for clinical, educational and administrative purposes, both at the local site and at a distance” [1]. It has also been defined as: “An emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology” [1]. E-health systems provide a wide variety of development of applications to provide medical assistance and diagnosis to patients irrespective of their location.

In order to guarantee the quality of medical assistance, it is necessary to develop a robust telecommunication network. According to [2], the most important determinants for successful e-health implementations are shown in Table 1. As can be seen, user acceptance is the most important factor for any healthcare service implementation.

Table 1: Determinants for successful e-Health implementation [2]

<table>
<thead>
<tr>
<th>Determinants</th>
<th>Influence in implementation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>User acceptance</td>
<td>37%</td>
</tr>
<tr>
<td>Technology deployment factors</td>
<td>29%</td>
</tr>
<tr>
<td>Leaving behind the organization</td>
<td>13%</td>
</tr>
<tr>
<td>Policy and Legislation</td>
<td>11%</td>
</tr>
<tr>
<td>Financing factors</td>
<td>10%</td>
</tr>
</tbody>
</table>

Technology and network design factors have been important to ensure the performance of e-health systems, however, recent contributions demonstrate that it is also key to consider the importance of human components. In this respect, the ITU introduced the term Quality of Experience (QoE) and defined it as: “The overall acceptability of an application or service, as perceived subjectively by end-user”[3]. In this scenario, the patient becomes the center of gravity in systems operation. By the same token, ITU considers the Quality of Service (QoS) as: “collective effect of service performances that determines the degree of satisfaction by a use of service”[4]. QoS depends on some parameters and metrics like: delay, jitter, throughput, Bit Error Rate (BER), Packet Loss Rate (PLR).

QoE and QoS are interdependent. The technical (QoS) and the human components contribute to degree of acceptance by the end user (QoE). Fig 1 shows the elements involved in the conceptualization of QoE where the efficiency of the telecommunications network will be defined in terms of the user satisfaction. The user acceptance of the applications is influenced by the user expectations and the context.
As shown in table 1, technology development is important to implement an e-health network, but it is also important to determine the user acceptance. The objective of this paper is to propose a framework that includes the definition of an e-health ecosystem structured for different contexts. This framework will constitute a platform for developing a model of QoE/QoS for different e-health scenarios. We also identified the key factors that would constitute such model. The aim of our research is to develop a standard for the delivery of medical services taking into account the technological aspects, as well as the socioeconomic and cultural factors involved.

Fig. 1. QoE dimension [3].

This paper is organized as follows: in section 2 we described the proposed e-health ecosystem in which we based our analysis. In section 3, we present an overview of related work in the area of QoE/QoS and describe the elements towards a model for user acceptance in e-health ecosystems. The conclusions are presented in section 5.

2. The e-health ecosystem

As it was defined in [5] the communications ecosystem is: “the systematic interaction of living (human) and non-living (technology, and business) in a particular context”. In order to define an e-health ecosystem we suggest that it is necessary to incorporate the characteristics of the socio-economic and technical contexts. It is also important to understand the interactions among all the stakeholders involved in the system. These interactions are particularly important for the health sector because they will be crucial to determine the ecosystem’s life cycle. As mentioned above, to accomplish a successful implementation of an e-health system, the most important parameter is the user acceptance. For this reason, a study of all the elements of the context and the definition of the ecosystem structure is essential.

Kilkki [6] includes in the ecosystem the technical, business models and human behavior elements and explains the importance of the participation of engineers, entrepreneurs, scientists and their interactions with the end user and the customer. Rehman et al. [5] defines a communication ecosystem incorporating technology, business and human behavior elements. They also explain the human-to-technology, technology-to-business and human-to-business interactions.

In our paper, we propose an e-health ecosystem (see Fig. 2), which considers three principal aspects: human, economic and technological. The human context involves the participation of physicians and patients. We also incorporate an agent to perform the evaluation of the behavior of both the physician and the patient. The technological context includes devices and systems in order to process and deliver the information needed for patient care, such as biomedical data, image, video and audio files. In our proposal we consider that the
economic context must take into account the delivery and medical service implementation in both private and public health instances. Finally, the economic context takes into account the budgeting aspects of the service implementation either for business or not for profit scenarios.

Additionally, the interaction between technological, economic and human aspects is crucial to accomplish an integral vision of the proposed ecosystem. The human and technological aspects are related to social and cultural factors. This is of particular importance in projects for digital inclusion in rural and underserved communities. In this case, technology adoption becomes an important factor to attain an adequate degree of user acceptance. In other words, the technologies involved should be user friendly and must be designed based on human concerns according to the requirements of the agents involved, i.e., the patient and the physician. The relation between human and economic factors includes the analysis of the infrastructure, the elements of the physical context, the quality of life and the living conditions of the population. The World Health Organization in [7] defines the living conditions of individuals as: “the everyday environment of people, where they live, play and work. These living conditions are a product of social and economic circumstances and the physical environment – all of which can impact upon health – and are largely outside of the immediate control of the individual”. In our proposal, the technological and economic contexts are related by a business plan for the case of a private project or by a sustainability endeavor for the case of a not for profit project. Both approaches are required to ensure the continuous operation of the e-health system.

Fig. 2. The proposed e-health ecosystem.
3. Exploring a QoE/QoS model

QoE is an essential parameter to understand the human requirements of a communications system. As it was mentioned in the introduction part, QoS is necessary to satisfy technological expectations. The efficiency of the e-health systems relies on the service infrastructure and on the end-to-end communications system for the delivery of health services, which are provided by multiple network segments. The type of e-health services depends on the particular medical application, its purpose, the content type and context of use. These factors in turn will define the QoS requirements of the end-to-end communications system and contribute to improve the user perception.

Some models for QoE and QoS have been developed by different authors, all of them explain the importance of the relationship between context and human behavior. Gong Y. et al. [8] define five QoE factors: usability, availability, service instantaneousness, service integrity and service ratability. They focus on the correlation between QoS and QoE in order to obtain the user acceptance. Perkins A. et al. [9] introduce measurable (objective) and non-measurable (subjective) elements associated with QoS and QoE to obtain the user acceptance. These authors do not consider in their contribution the definition of a context. Möller S. et al. [10] propose a taxonomy of QoS aspects such as influencing and interaction performance factors, and for QoE human perception and judgment processes. In this case the context is not considered. Laghari R. et al. [5] present a model based on a complete communications ecosystem, consequently they show all the interactions within such ecosystem. Technological, human and business aspects are considered in this model. We pose in this paper, that for the case of e-health, a more comprehensive context is necessary, one that takes into account factors of anthropological and cultural nature, which give rise to the emergence of an open complex system.
The objective of our research is then to arrive at a mathematical model for obtaining the user acceptance of an e-health ecosystem. This model will be configured taking into account the elements shown in Fig. 3. We center our approach in the user acceptance. The human context involves the participation of the patient and the medical specialist, the economic context considers the participation of for profit and not for profit agencies, and the technology context includes the network, data processing and user interface parameters.

We stress the importance of evaluating the perception and behavior of both the patient and the medical specialist. The specialization level of the involved health professionals is also very important, since this issue determines the different complexity levels for medical devices and software. The most commonly observed patient pathologies in the diverse target communities where this e-health ecosystem is being evaluated must be studied and defined, since this model’s implementation will definitely have an impact on the regional economy. When the implementation of a service will help the development of any community, it is important to analyze the cultural environment, lifestyle and quality of life of the communities that will have access to e-health, in order to determine its approximate economic impact and expected user willingness to adopt new technologies. The current access routes (roads and communication lines) and basic services into the targeted communities may predict its future response towards the adoption of new technologies. Private entities will need sound business and marketing analyses, where the proposed services fulfill existing needs, have enough financing to cover the needed investment and show future profits. From the technology standpoint, the applications and the user interface issues must be carefully designed to achieve adequate adoption of the e-health services. Regarding to communications network, it is expected to deploy a robust system to obtain a high degree of
quality perception on the part of the end users. Network security is one factor that is increasingly gaining importance in e-health environments.

Understanding the social reality of the community where the e-health services are going to be implemented is crucial for the success of this model. Infrastructure and the financial resources allocated to the e-health project must be taken into account. Finally, the proposed services and products must deliver the required e-health quality, while keeping user friendliness in order to be widely adopted by the communities served. This model aims to define a high-quality, successful and sustainable e-health ecosystem for communities and societies worldwide, considering a careful balance among its human, economic and technological contexts, as described previously. We feel that a model where both parameters, Quality of Experience (QoE) and Quality of Service (QoS), are aligned to work together will definitely have a positive impact on the successful offer and acceptance of a comprehensive e-health ecosystem, for the benefit of both patients and physicians worldwide.

4. Conclusions

The purpose of this paper has been to provide an initial platform for constituting a comprehensive model of user acceptance for QoE and QoS e-health ecosystems. Our approach takes into account the human, economic and technical dimensions involved in the deployment of e-health services. Our aim is to use such model for developing e-health standards in which the context and the agents involved play an essential role in the definition of those technical parameters that will provide the best user acceptance.

It is our view that the deployment of e-health projects centered only on technical requirements tends to provide marginal results. We pose that the starting stage must be the understanding of the patient and medical specialist needs, the understanding of the context and its social reality. Sustainability is another element to consider. This is particularly important in rural and under served communities where e-health has the potential to trigger social and economic development.

References


[6] “Quality of Experience in Communications Ecosystem.”


