A HOME CARE PROTOTYPE BASED ON THE DIGITAL TV BRAZILIAN SYSTEM FOR A HEALTH MANAGEMENT SYSTEM

Mauro Oliveira
Federal Institute of Ceará (IFCE)
Fortaleza, Brazil
amauroboliveira@gmail.com

Odorico Andrade
Federal University of Ceará (UFC)
Fortaleza, Brazil
odorico@ufc.br

Marcos Santos
State University of Ceará (UECE)
Fortaleza, Brazil
marcose.eduardo@uece.br

João Batista Frota
State University of Ceará (UECE)
Fortaleza, Brazil
jbfrota2009@gmail.com

César Moura
Federal Institute of Ceará (IFCE)
Fortaleza, Brazil
cesarolavo@ifce.edu.br

Leonardo Gardini
State University of Ceará (UECE)
Fortaleza, Brazil
lgardini@gmail.com

ABSTRACT

Systems based on Information and Communication Technology have been designed to meet needs related to the management of processes involved in home care activities. However, most products on the market today are expensive and there is a great need of low-cost products, accessible to all people in disadvantage (Classes D and E). This paper presents the Diga-Saúde, a low-cost prototype that provides home care services through a main user Digital TV Interactive interface. It takes advantage of the popularity scheduled for the Brazilian Digital TV. The Diga-Saúde has been used on the LARIISA project, a governance decision-making support model for public health systems centered on the family. To connect LARIISA and the Diga-Saúde, we use LISA – LARIISA Integration System – a highly expansible system that aims at facilitating the inclusion and exclusion of context providers, even if they have not originally been conceived for the LARIISA interface.

KEYWORDS

Home Care; Health; LARIISA Project; LISA; Diga-Saúde; Digital TV.

1. INTRODUCTION

This paper proposes specification of a home care prototype system to support some activities of home care services through the Diga-Saúde [1][2]. This is a proposal for a low-cost system that consists of a website that provides/receives data from a second module: a digital TV application expected to be shipped into the Set-Top Box (STB) connected/integrated to the patient's TV. Main features of this prototype are: monitoring of medication use; remote access to patient vital signs; messages or advices sent by health professionals; and dynamic texts or motivational and educational videos.

It must be emphasized that the Diga-Saúde platform uses GINGA [10], a middleware developed for the Brazilian Digital TV. The main feature of GINGA is its interactivity, and Diga-Saúde takes advantage of this feature.

These solutions have been used within the scope of LARIISA Project (Laboratoire Réseaux Intelligence Intégration Santé Aplication) [3]. LARIISA proposes a decision-making support model for public health management systems, where the information model is centered on the concept of a family. Based on the Dey's definition of context [4], we consider health context as "any information that can be used to characterize the situation of an entity in a health system. An entity can be a family member, a health agent, a health manager, etc., that is considered relevant to the interactions between a health manager and a health care system in order to make decisions."

This paper describes both an application scenario and a prototype that illustrates how these two components can be used in interactive applications. To connect the Diga-Saúde to LARIISA, we use LISA

(LARIISA Integration System Architecture) [13], a highly expansible system that aims at facilitating the inclusion and exclusion of new home care services.

This paper is organized as follows: Section II describes the Brazilian Digital TV and its features. Section III shows the DIGA-SAÚDE application, architecture and implementation aspects. Section IV describes LARIISA and LISA framework and the integration of Diga-Saúde and LISA. Section V presents related work. Finally, Section VI concludes the paper and discusses future work.

2. BRAZILIAN DIGITAL TV

The impact of the new generation of television is much more significant than the simple technological upgrade from an analogical transmission to a digital one, or even an improved quality of image and sound [5]. An important component of this system is its ability to expand the functions of the system for applications constructed on the base of a referenced standard system. Such applications are computational programs installed in a receiving device. New services are available, as electronic guides of programs, banking services (T-banking), health services (T-health), educational services (T-learning), services of government (T-government), etc. But the most important characteristics of the Brazilian Digital TV technology is the interaction of the user, which could take control of the flow of a televising program, determining if one content must be shown or not. The necessary computational capacity to the new system can be integrated in the proper display device: a device of digital TV, a cellular, PDA etc.[6]. The main innovation is taking advantage of a break of a paradigm in the Brazilian scenario, when a Digital TV will take the place of the omnipresent analog TV, now available in practically all residences. Figure 1 presents the architectures of the digital TV where the Brazilian solutions/choices are highlighted.

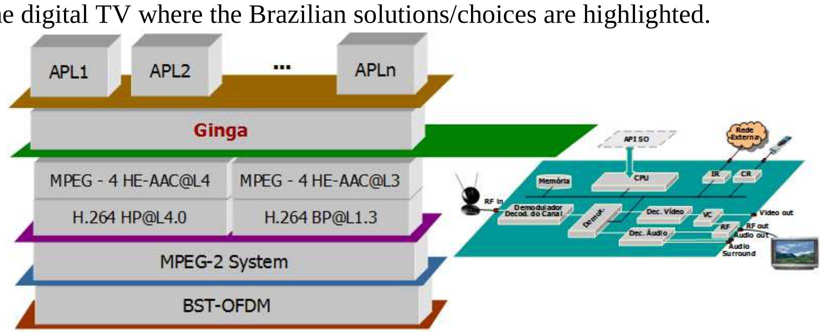

Figure 1. Architecture of the Brazilian Digital TV

The SBTVD-T [7][8], the Brazilian model for Digital TV, uses in the Compression Layer the H.264 video codec instead of ISDB-T's MPEG2 and an improved tuner1. DVB and ISDB also provide for other video compression methods to be used, including JPEG and MPEG-4, although JPEG is only a required part of the MHEG standard. In fact, Brazil is using ISDB for terrestrial broadcasting (ISDB-T). This video is encoded with MPEG-4 AVC (H.264) and the audio with MPEG2-AAC [9]. GINGA [10] became, recently, a recommendation H.761 of the International Telecommunications Union (ITU-T). In fact, this recommendation gives the specification of the Nested Context Language (NCL) and of an NCL presentation engine called GINGA-NCL to provide interoperability among multimedia application frameworks [9].

3. THE DIGA-SAÚDE

The Diga-Saúde [11] integrates devices used for monitoring vital signs from people that require intensive health care. Supported by a TV set top box, the Diga-Saúde allows the assessment of patients' physical status and the assessment of some types of vital signs, such as body temperature, heart rate, pulse, respiratory rate and also blood pressure. In addition, the Diga-Saúde provides remote access to medical services. For instance, Diga-Saúde sends messages (and programming announcements) through the television to the users, telling them the exact time for taking medicines. This kind of service improves the life quality of old people with memory problems.

To capture and store vital signs from patients, this paper proposes the use of specific equipment (available on the market), such as the set top box and medical devices (e.g. pulse oximeter, sphygmomanometer, blood glucose meter and accelerometer sensors) that can be placed on the patient's body. The information collected from these devices can then be provided (by Diga-Saúde) to health professionals.

While Diga-Saúde performances the patient health monitoring process via Digital Interactive TV, it gives to the patient good autonomy through sensors added to the patient’s body. Diga-Saúde helps patients’ recovery while they are at home. For patients that have suffered some type of surgery (e.g. postoperative), Diga-Saúde assess their health status in order to provide a better recovery process and starts any needed action by health professionals. Motivational videos are a great tool that can be sent using Diga-Saúde to help a person during his/her recovery process. Currently, people in these situations are usually admitted to health facilities (with high costs). Regarding professional advices, this system contributes to improve the doctor-patient interaction, even the patient being in his/her own residence.

Finally, the Diga-Saúde increases the potential of GINGA in the health care area through its modules, sensors and other components, and Diga-Saúde also serves as proof of concept for an extra set of applications that can be developed.

3.1 View of the Execution

The vision is based on the implementation processes in the environment activities of system users: Hospital; Payer Source; Home Care Company; and the patient's home. Figure 2 illustrates these environments, which are included in the steps that lead patients to be admitted to the home care service. Our proposed system emphasizes these environments. Hospital: starts the process to include the patient in the home care process. Payer Source: environment where the family members, government agents or healthcare plans approve the transfer request of a patient. Home Care Company: company that assess the risks in transferring the patient to a home care process. Patient’s home: environment where all activities related to the home care process happen, starting when patient leaves the hospital until the patient’s total recovery.

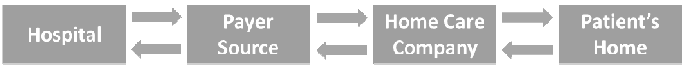

Figure 2. Environments in the process of home care

The Diga-Saúde is a proposed system that consists of two modules. There is a web module and a Digital TV module that embeds features to support the activities performed in the two environments: Home Care Company and Patient’s Home. Figure 3 illustrates an overview of the Diga-Saúde.

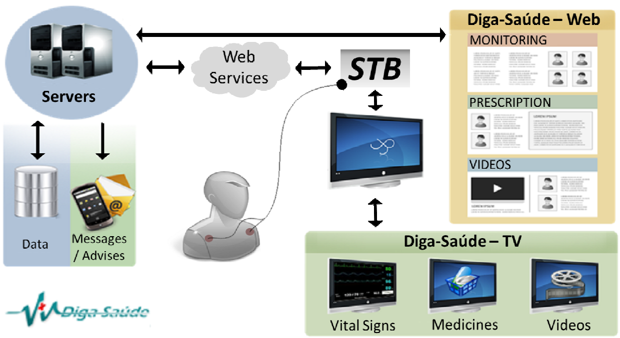

Figure 3. Overview of Diga-Saúde

- The Diga-Saúde TV is a Digital TV application that will be embedded in the STB connected to the patient’s TV. The Diga-Saúde TV application will support home care services through the following features: supporting management of medicines, receiving messages and advises, displaying health tips, and monitoring vital signs. Management of medicine occurs by receiving automatic reminders that are sent by this module (Diga-Saúde TV) at the moment that the medicine should be used. Displaying of health tips will depend of a broadband connection to receive video and text stored in the the Diga-Saúde Web module. Monitoring of vital signs happens in periods previously scheduled in the Home Care Plan.

- The Diga-Saúde Web is the module that enables the system to send information to health professionals, as well as receiving data generated by patients. The data generated by patients are: vital signs, medication use status and the situation of messages to identify whether they have been read or not. The data transmission is performed through an Internet channel. Management of administrative information that encompasses other elements of business is performed by this module. The Diga-Saúde Web module also assists the end-to-end process of monitoring patients (since the creation of a treatment until the end of it).

3.2 Diga-Saúde Architecture

Figure 4 shows the architecture based in layers of the Diga-Saúde. Because Diga-Saúde has two modules, that are partially independents, figure 4 shows the structure that best aligns with a client-server model.

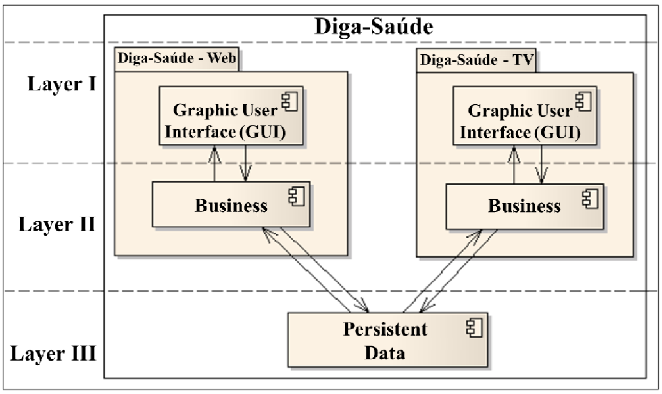

Figure 4. Diga-Saúde’s architecture diagram

- The first layer (Layer I) has the Graphic User Interfaces (GUI) of both system modules. The Graphic User Interface of Diga-Saúde Web runs in Web browsers and can be developed with the following technologies: Java, Java Server Faces and RichFaces. It can be accessed from a Web browser installed on any computer with Internet access. In the Diga-Saúde TV, the GUI runs on a patient’s TV, and it will use the component GINGA-J or GINGA-NCL (for building graphical user interfaces based on Java programming language). Both interfaces access the resources available in their respective business layers.
- In the second layer are all features offered by the Diga-Saúde. The business layer of the Diga-Saúde Web accesses the third layer via HTTP using components written in the Java language. The business layer of Diga-Saúde TV accesses the third layer via web services. This module uses the channel return component to establish the communication. To meet all features that build the whole system, both modules have business rules written in Java.
- The third layer is the Persistent Data layer. All of Diga-Saúde’s system data is stored at this layer. This layer has components to access the database, which are available to the second layer. This layer has components written in Java language – these components access data through the use of an object-relational framework like Hibernate. This layer also contains the DBMS of the Diga-Saúde (e.g. PostgreSQL).

3.3 Implementation Aspects of the Prototype

This section describes the implementation aspects of the Diga-Saúde prototype. The prototype is implemented with three distinct variants. Although not fully integrated, they proved some concepts related to the proposal, and they evaluate the complexity of using GINGA in the context of home care systems. Thus, each variant is created in a different phases.

In the first phase, we have implemented the first interactive application of the Diga-Saúde. In this application we present the API AI3D proposal (Integration API among devices used in the Diga-Saúde), created exclusively for this system. This proposal aims the integration and communication of the sensors and middleware components to enable portability of the Diga-Saúde to another middleware if required. To implement the graphic interface user, we use the Xlet technology based on the Java-TV that is specified in the middleware GINGA and MHP. The Xlets are used for the development of DTV applications based on the Java programming language, which is object-oriented, portable, mature, and widespread in the market.

In the second phase we have analyzed the use of sensors in the proposed system. The Diga-Saúde has a special characteristic - it checks patients' vital signs. The STB performs this task within the Diga-Saúde. It is required to integrate the sensors to the system, which requires the use of libraries or APIs (Application Programming Interface) of third parties. These libraries convert the signal generated by the sensor into a signal understandable by the system. They are generally written in the C programming language.

The GINGA-NCL is based on the LUA language, and the GINGA-J is based on the Java language. Both of them are APIs that access components written in the C programming language. For the test here proposed, we use the Java version. Using this version of GINGA contributes to the use of libraries also written with the Java language. Using GINGA-NCL has the restriction of using only libraries written in C language. Furthermore, there are no sensors that use the LUA language. However, there are no restrictions in using also the GINGA-NCL in implementations of the Diga-Saúde. To perform a test with a sensor (to replace the simulator) we uses the pulse oximeter CMS-P20, illustrated in figure 5, which is used to check vital signs: pulse and SPO2 – Blood Oxygen Saturation. After testing it, we found out that the use of sensors in Digital TV system is feasible and could be implemented.

Figure 5. Pulse and SPO2 sensors

Figure 6. Medicine list on a Digital TV application

Figure 6 illustrates the navigation menu of Mockflow (an online wireframe tool), and displays in the left corner a hypothetical TV. At the center of this TV is a screen that contains the medicine list that needs to be taken by the patient.

4. LARIISA PROTOTYPE

LARIISA is a project that makes use of intelligent systems for helping decision-making in the area of public health governance. It uses mobile devices, embedded systems, and also the set top box appliance of the Brazilian System of Digital Television- SBTVD as context providers and, in its first version, LARIISA uses the Ceará Digital Belt [12] as the communication infrastructure. LARIISA is also designed to provide health professionals with an intelligent governance framework that will support them in decision-making processes, concerning the basic health care network from the Brazilian Unified Health System (SUS).

The LARIISA Project aims at researching and developing a framework that uses information primarily collected from and sent to the families. Once processed by knowledge management mechanisms, this information will guide health professionals in the decision-making process. With this purpose, LARIISA collects real-time information from Digital TV set top boxes and mobile devices - providing further elements that improve the quality of the decision-making process.

LARIISA runs over the Ceará Digital Belt in addition to other existing communication links, like WiMax, WiFi e GPRS and it is based on inference systems that works with ontologies adjusted for model context information.

For instance, let's consider a health agents' work plan being dynamically changed (in other words, a context-aware work plan). Or, as another example, health managers taking decisions based on real-time information, enabling proactive actions.

LISA [13] is a solution to integrate context providers, like Diga-Saúde, to the LARIISA framework. LISA was designed to address some system integration issues, privileging expansibility, flexibility and facility to connect/disconnect context providers even if they have not originally been conceived for interfacing with LARIISA. Figure 7 depicts LISA's architecture:

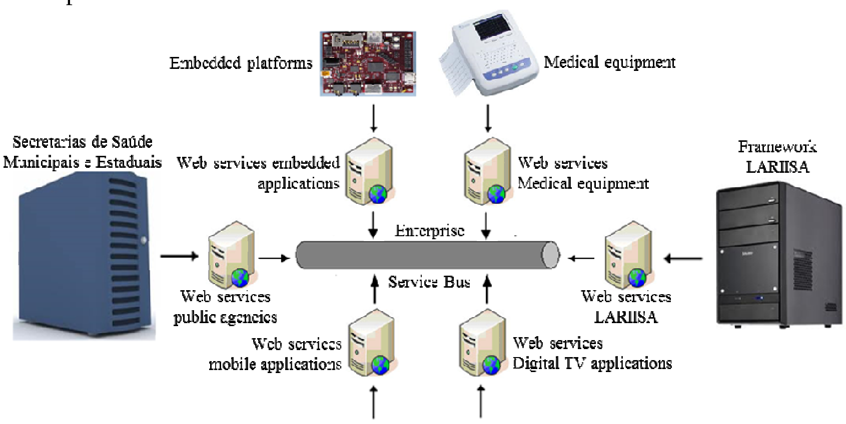

Figure 7. LARIISA prototype

LISA's main objective is to enable the connection of context providers to LARIISA, regardless of software or hardware platform. Taking into account LISA purpose, context information is delivered without changes in their protocol, format or any further prerequisite, considering the difficulties of any changes in embedded systems.

Another LISA's objective is to define a way to regulate the access of the context providers, offering them a single interface to LARIISA (Figure 7). After adoption of the file transfer-based integration model, context providers are supposed to write to a file that is understandable by the LARIISA framework.

Shared databases would hardly be a reasonable choice, since context providers are not known a priori. Including new context metadata (and context presents a very accommodating nature) would require adjustments in the database. In addition to being error-prone, this strategy is far from scalable.

Remote Procedure Call would not be a good choice due to its synchronous and blocking characteristics, and it would also strongly impact on LARIISA's overall performance. Someone could argue that it is no longer accurate to say that RPC applications are necessarily bound to synchronous interactions, considering that it is now possible to simulate degrees of asynchronicity (e.g., DCE threads). However, such choice would make application development more difficult since complex programming must be done to handle multiple simultaneous calls.

Due to all the above "misdemeanors" of the alternative solutions, Messaging has been appointed the integration model that best suits LARIISA's requirements. Being loosely coupled (minimizes dependency among applications), minimally invasive, mostly asynchronous (again, one could point out that messaging can be synchronous as well – but we just don't look for this feature in it) and reliable, Messaging brings together all characteristics required by LARIISA in one single solution. Figure 8 and 9 show the mechanism used to integrate Diga-Saúde to LISA Architecture.

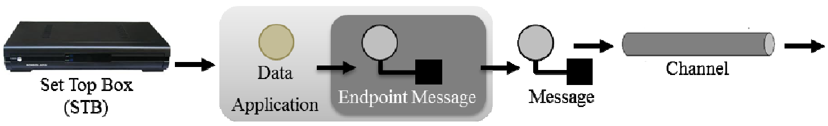

Figure 8. Integration Mechanism from Diga-Saúde to LISA (1)

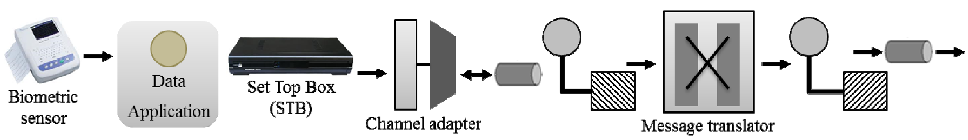

Figure 9. Integration Mechanism from Diga-Saúde to LISA (2)

5. RELATED WORKS

There are various types of interactive applications, such as: health services, information, communication, entertainment, government programs, education etc. In the case of health services, they may be classified as T-Health or T-Care. The first one covers all services related to health and well-being, delivered and executed on the TV screen. The second service, that is object of study of this paper, is a special variant of T-Health that covers the communication services that link patients to health professionals through applications based on Digital TV to support the activities of home care [14].

The T-Care, which joins these two interrelated themes, Digital TV and Home Care, has the purpose of making use of technology to provide healthcare services to the society. These two areas together confirm the opinion of Barra [15], in other words, they link computing and health to enhance the health sciences through the use of new technologies, created by the man, to serve the man. However, in the Brazilian home care, there are few T-Health solutions and no specific solutions for T-Care. Unlike what happened in other countries that have few researchers and companies that designed some systems: Philips Motiva [16], the U.S.; the MHhomecare [17], in Italy; and the PANACEIA-TV [19], created in Greece and tested in the England. The applications more easily spread in Brazil are not based on Digital TV and they meet a business model focused on an administrative scope of the home care process.

The Interactive Digital TV allows the creation of a large number of services of interest to our society, among whom the area of interactive applications for home care, for example, the Philips Motiva [16], The PHPhomecare [17] and Panaceia-TV [19] and GlowCaps [20].

The ideas and discussions raised in these studies were the basis for the preparation of our proposal: The Diga-Saúde, a support system for home care services based on Interactive Digital TV and Internet technologies. He has the same scope of work mentioned in the differential, as well as having interactive services - monitoring of vital signs, health tips and messaging for patients - already present in related work, propose service support service monitoring and medication administration. The latter was not found in any of the related work. The panaceia-ITV suggests something along those lines, but it does not automates part of this process, as with GlowCaps, which possess in order to support this service, but is not based on DTV and is not sold to the Brazilian public.

From the above, we emphasize again the importance of Diga-Saúde in the context of home health care, especially the interactivity characteristic of the largest GINGA. This interactivity adds to the Diga-Saúde a particularly unique and highly advantageous to the home care system in Brazil. Thus, use of these resources to increase the quality of life (especially of elderly people), is one of the benefits that most reaches with our proposal. Especially because people has already been using the TV as a form of entertainment.

6. CONCLUSION

The main difference between the Brazilian Digital TV model and others DTV standards is that the Brazilian model was developed with interactivity features [21][22]. One feature is the interaction of the TV user, which could take control of the flow of a televising program, determining if one content may be shown or not. Because of this, the impact of the Brazilian Digital TV should be much more significant than the simple exchange of an analogical system of transmission for digital transmission. And Digital TV is much more than set top boxes that improve the quality of image and sound. New services could be made available with the advent of Digital TV, as banking services, services of government, in especial the educational and health services [2] [23].

This paper describes the Diga-Saúde, a low-cost prototype that provides home care services, and shows its integration on the LARIISA, a decision-making support model for public health systems centered on the family. These solutions of home health care, developed in the context of the GINGA CDN project, were supported by the RNP.

Health systems worldwide have to deal with a constantly changing environment, but they are not responding satisfactorily to these situations. Western society has been built its healthcare systems centered in hospitals, but the needs now are being converted to families' houses. It turns out that traditional tools cannot handle this new scenario. It is precisely in this scenario that the LARIISA Project may represent a paradigm shift in health access for the whole society. The Brazilian model of Digital TV/Set-top box is contemplated strategically to serve as a terminal access in the LARIISA, considering that Digital TV/Set-top box will be soon delivered to the households in Brazil. By doing this, LARIISA will allow the less privileged class in Ceará to have access to context-aware service-oriented applications for health care **Erro! Fonte de referência não encontrada.** [23].

REFERENCES

[1] SANTOS, Lenir; ANDRADE, Luiz Odorico Monteiro de. SUS: atenção primária ou prioritária: Site. 2010. http://blogs.bvsalud.org/ds/2010/04/12/sus-atencaoprimaria-ou-prioritaria

[2] Oliveira, M.; Tonieto, M.; Faustino J.; Moura Filho, C.O. Pirambu Digital, a Social Inclusion Project using Information Technology IFIP I2TS IX World Conference in Computing on Education. PortoAlegre (Br), 2009.

[3] Oliveira M., Andrade O.M., Hairon C.G., Moura R.C, Fernandes S., Bringel J.,Gensel J., Martin H., Sicotte C., Denis J-L. A Context-Aware Framework for Health Care Governance Decision-Making Systems: A model based on the Brazilian Digital TV. Second IEEE Workshop on Interdisciplinary Research on E-health Services and Systems (IREHSS).

[4] Dey, A.K., Understanding and Using Context. Personal Ubiquitous Computing 5(1), 4–7 , 2001

[5] Tonieto, M.T. Sistema Brasileiro de TV Digital - SBTVD. A policy analysis and technology on social inclusion. Dissertation (Professional Masters in Computer Science) - University of Ceará. 2006

[6] Soares, L.F.G; Souza, Filho G.L. Interactive Television in Brazil: System Software and the Digital Divide. In Proc. of EuroiTV 2007. Avaliable at: http://www.ncl.org.br/ docs.php

[7] BRASIL. Presidential Act #4,901 of November 26, 2003. Establishing the Brazilian System of Digital Television - SBTVD. DOU. Issue No .231, 27/11/2003. Available at: <http://www.mc.gov.br/tv_digital>

[8] BRASIL. Presidential Act #5,820 of June 29, 2006. Implementation of the Brazilian System of Digital Terrestrial Television - SBTVD-T. DOU of 27/11/2006. Available at: <http://www.mc.gov.br/tv_digital>.

[9] Soares, L.F.G. Standard 06 - ISDTV-T Data Codification and Transmission Specifications for Digital Broadcasting, Volume 2 – GINGA-NCL: Environment for the Execution of Declarative Applications. São Paulo, SP, Brazil. ISDTV-T Forum. 2006.

[10] GINGA. Portal do Middleware GINGA. Available at: <http://www.ginga.org.br/>.

[11] Oliveira, M; Cunha, P.R.F. Implementing Home Care Application in Brazilian Digital TV. IEEE GIIS Global Information Infrastructure Symposium. Tunisia, 2009.

[12] Cinturão Digital – Governo do Estado do Ceará, Available at: http://www.ceara.gov.br/portal_govce/ceara/governo/projetos-estruturantes-1/cinturao-digital, 2010.

[13] OLIVEIRA, Mauro; FROTA, João B. B.; ANDRADE, Luiz O. M.; BARRETO, Ivan; FILHO, César O. M. Integrating Mobile Devices In a Brazilian Health Governance Framework. Fortaleza, 2011.

[14] MHP-KDB, MHP KNOWLEDGE DATABASE MHP-Guide: Guia completo com recomendações relevantes uso da tecnologia mhp. [S.1.], 2006. http://www.mhpkdb.org/publ/mhpguide.pdf

[15] BARRA, Daniela Couto Carvalho et al. Evolição histórica e impacto da tecnologia na área da saúde e da enfermagem. Revista Eletrônica de Enfermagem [Internet], Faculdade de Enfermagem-UFG, v. 8, p. 422-430, nov 2006. ISSN 1518-1944.

[16] MOTIVA: Gerenciamento remoto do paciente através de uma televisão na casa do paciente. 2010. Disponível em: <http://www.healthcare.philips.com/in/products/telehealth/products/motiva.wpd>. Acesso em: 18 jan. 2010.

[17] ANGIUS, G. et al. A tele-home care system exploiting the dvb-t technology and mhp. Methods of Information in Medicine, v. 47, n. 3, p. 223-228, jul 2008. ISSN 0026-1270.

[18] ASSAF, P.L. et al. Tele home care: uma revisão bibliográfica das experiências e percepções atuais. In: CONGRESSO BRASILEIRO DE TELEMEDICINA E TELESSAÚDE, 4., 2009, Belo Horizonte. Telessaúde direito de todos: contribuindo para a universalização da atenção e qualidade dos serviços. 2009

[19] MAGLAVERAS, N. et al. Congenital heart disease patient home care services using the interactive tv: the panaceia-itv approach. In: Computers in Cardiology, 2003. [S.l.: s.n.], 2003. p.665 – 668. ISSN 0276-6547.

[20] GLOWCAPS. Vitality - GlowCaps: Site. 2011. Disponível em: <http://www.vitality.net/>. Acesso em: 21 jan. 2011.

[21] SBTVD, Sistema Brasileiro de TV Digital. Avaliable at: <http:// sbtvd.cpqd.com.br//>.

[22] Cesar, P.; Bulterman, D.C.;Soares, L.F.G. Human-Centered TV: Directions in Interactive Digital Television Research. ACM Transactions on Multimedia Computing, Communications and App., v. 4, p.24:1-24:7, 2008.

[23] Oliveira, A.M.B; Gaiti, D.; Castro, M.F.; Pujolle, G. RE-Invente, Um Environnement Multimédia pour l'Enseignement Technique à Distance. Colloque Francophone de Gestion Réseau - GRES, Fortaleza, 2003.

[24] M. Khedr, A. Karmouch, “A Semantic Approach for Negotiating Context Information in Context Aware Systems’, IEEE Intelligent Systems, Vol. 19, No. 6, Dec.-Nov. 2004.