Towards A Cost-Effective Homecare for A Public Health Management System In Brazil

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***Abstract* — During the last decade, several ICT systems have been proposed to fulfill the needs of managing individuals' physical activities at home. Unfortunately, most of the developed products have been so far expensive and could not be afforded by the large majority of the population, especially in underdeveloped countries. Therefore, developing a low-cost system accessible to large portion of population in these countries or even in developed ones (Classes D and E) is still necessary. This paper presents a prototype called Diga-Saúde which proposes to develop a low-cost system using mobile phones and the Brazilian set-top box (stb) receptor for digital TV to provide home care services. Diga-Saúde is part of a larger project called LARIISA, a governance supporting framework for public health systems centered on the family.**

Keywords - context-aware; Home Care; Health; LARIISA Project; Diga-Saúde; Digital TV

I. INTRODUCTION

The objective of this paper is to present the Diga-Saude prototype, a low-cost system that takes benefit from existing devices in the user's premises such as mobile devices and the Set-Top Box (STB) receptor for digital TV to provide home care services. Using already available equipments at home allows to reduce the costs of such solutions and to make them available to a large portion of the population. The initial services that have been designed are: the monitoring of self-medication; remote access to patient vital signs; messages or advises sent by health professionals; and motivational and educational information.

The benefit of such a system is that it allows to easily develop and deploy new types of applications that take advantage of home devices and medical or environmental sensors. Diga-Saude system relies on the GINGA middleware [10], a component of the Brazilian Digital TV model. The main feature provided by GINGA is the possibility to interact with users at home.

Diga-Saúde system is developed in the frame of the LARIISA Project, **Erro! Fonte de referência não encontrada.** which proposes a governance framework to help decision-making in public health systems. It´s capable to build a health context based on the collected data. According to Dey [3], a health context is defined 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, health agent, health manager, etc. Diga-Saude platform expands the capabilities of a set-top box to detect context at home using several sensors. Diga-Saúde takes benefit of LARIISA platform and expands it to include front-end applications and backend services. A prototype was implemented and is presented I this paper that illustrates how these two systems are integrated.

This paper is organized as follows: Section 2 describes the Brazilian Digital TV and its features. Section 3 describes LARIISA framework; Section 4 presents the Diga-Saúde system architecture and its integration with LARIISA. Section 5 presents related work. Section 6 describes the Diga-Saúde prototype with some implementation details. Finally, Section 7 concludes the paper and discusses future work.

II. BRAZILIAN DIGITAL TV

Brazil has recently introduced the digital TV transmission. In addition to a better image and sound [5], the Brazilian digital TV provides the capabilities to expand the system with virtually any type of application or service. Such applications are computational programs that can be hosted in the STB or distributed between the STB and some back office servers. New services are already available, such as Electronic Program Guides (EPG), banking services (T-banking), health services (T-health), educational services (T-learning), services of government (T-government), etc. Actually, the most important characteristics of the Digital TV technology is the interaction with end users [6].

Nowadays, STB are capable to provide numerous type of communication interfaces such as USB, Ethernet, NFC, ZigBee, mobile phone, etc. Each interface provides a different means for the user to interact with the environment.

The SBTVD-T [7][8], the Brazilian standard for digital TV, has adopted GINGA [10], a middleware that abstracts out the complexity of the underlying layers. GINGA was also recently adopted as the Recommendation H.761 of the International Telecommunications Union (ITU-T). This, recommendation provides 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].

III. LARIISA PROJECT

LARIISA is a project that aims to define a framework helping decision-making in the area of public health governance (Figure 1). It advocates the use of mobile devices, embedded systems and also the set-top box appliance of the Brazilian System of Digital Television- SBTVD as context providers.

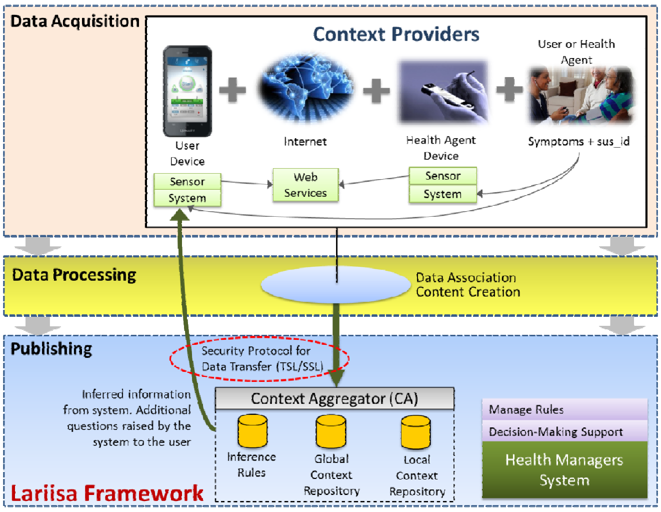

Fig. 1. Lariisa Architecture

LARIISA Project objective is to develop a framework that uses information primarily collected from and sent to households. Once transformed into knowledge, it will guide health managers in decision making process. The idea is to capture real-time information from digital TV settop boxes and mobile devices and provide health authorities with further elements to make more knowledgeable decisions.

The Considered scenario is the following:

"Context information will be captured by smartphones operated by health workers (health agents, inspectors, auditors, etc.), by biometrical data collecting devices(Figure 1- Global Services) or even by set-top boxes operated by users - who will interact with TV programs (Figure 2 –Local Services). Context information will be transmitted to LARIISA's "smart components"(i.e., inference mechanisms, ontologies, knowledge management database). In turn, these components will hand over information to governance-aid applications running in situation rooms to provide health managers (state governors, mayors, hospitals, community health centers, etc) with appropriate recommendations, priorities, policies, etc."

LARIISA has the following components:

- Embedded Hardware and software:
- Software Engineering: SOA-based system that offers dedicated services to support health managers with decision-making at the primary care level.
- Ontology-Based Knowledge Management System: A knowledge database to consolidate the various collected data.
- e-Health applications: Intelligent applications to help decision make in areas such as epidemiology and clinics for the maternal-infantile health;
- socio-economic viability analysis of the decision-making process leveraged with real-time and quality information taking account of the acceptability by the user.
- Interactive Content: Development of interactive content to be conveyed to the user via Digital TV.

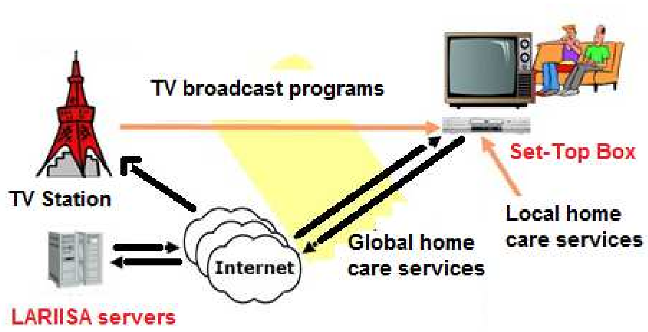

Fig. 2. Diga-Saúde Snerario

LARIISA framework relies on the Ginga Middleware, which provides for the needed interactivity [7] (Figure 2)-, from smartphones, which can, for example, be used by health agents to collect information directly from the population, and from specific environmental and biomedical sensoring devices (Figure 3).

IV. DIGA-SAÚDE PROPOSAL

Diga-Saúde is an implementation of LARIISA framework. It aims to support the easy deployment of e-health applications such as services to monitoring vital signs of elderly and people with specific diseases that require medical supervision at their own home. By allowing the usage of already deployed home devices such as the television, the system not only reduces the cost of deployment of such solutions but also facilitates the acceptability of such systems.

With Diga-Saúde vital signs monitoring service, the physical status of patients such as temperature, heart rate, pulse, respiratory rate and also blood pressure can be displayed on the screen of the TV so that the inhabitant can easily notice any anomaly. In addition, the Diga-Saúde provides access to communication services such as short message messaging to inform relatives of any emergency situation, programming announcements on TV reminding inhabitants of the medication time, facilitating the daily lives of elderly by reminding them important events related to their wellbeing (doctors' visits, etc.).

A. High level Deployment Architecture

The high level architecture of Diga-Saude relies on a process workflow of activities involving a set of actors towards the healthcare services consumer (i.e. the patient): Health provider; Payer; Homecare services provider; and the end user at home. Figure 4 illustrates this environment, where an individual requiring particular health care could benefit from such homecare service when leaving hospital.

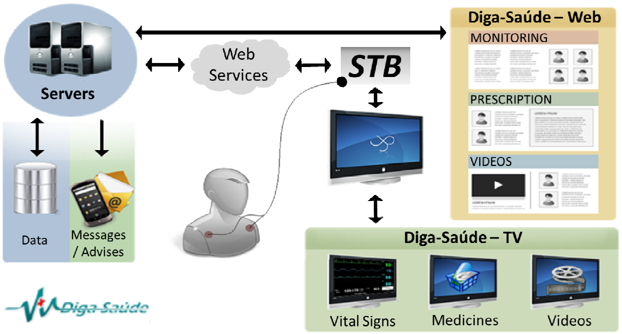

Fig. 4. Diga-Saúde homecare environment

Diga-Saúde aims to facilitate such remote health assistance that could have a high impact in the reducing high costs of hospitalization and reducing the health divide. Hospitals and Health expenses payers (health insurance companies), with their respective processes, are part of the big picture as their role is predominant. Say, there is agreement between the homecare provider and hospital to ensure the quality of heath provided at home.

The funding sources (government, private companies, etc.) will benefit from this schema since the cost to handle patients will be significantly reduced, positively impacting on the healthcare system. Diga-Saúde mainly focuses on the relation between the homecare service providers and the home environment. The funding source is also an important part of the process, since it is the link between hospitals, the homecare providers and patients. Once the hospital authorizes the patient to go home, the homecare service takes on providing the needed services for the patient.

As illustrated in the figure 4, the Diga-Saúde system consists of two main modules: the home part and the homecare service provider part. The home part aims at collecting context information and interacting with the patient and the home inhabitants. The homecare service provider part aims at hosting the main part of logic of the services, databases related to patients HER (Electronic Health Record), payments and so on. These components that are further described in the following:

- The Diga-Saúde – TV Homecare Apps is a set of Digital TV services hosted by the STB that uses the home TV to interact with the patient and inhabitants. The Diga-Saúde – TV Homecare Apps provide the following services: Medicines Time Management (MTM), Healthcare Messages Video Advises (HMVA), Health Tips Tweet (HTT), Vital Signs Monitoring (VSM). MTM service allows the automatic displaying of reminders to the patient to take his medicine at the right time. The messages are displayed on the TV (that could be switched on automatically if necessary). HMVA is a service that provides a library of video files that can be displayed by the inhabitants to know more about how to have a healthy life. HTT is a service that provide short audio/video/text message provided by the back end system to inform the inhabitants about important personal or public health messages. Finally, VSM service aims at collecting and displaying vital signs about the patient(s) at home.

- The Diga-Saúde – Backoffice is the module that enables the configuration of the whole system and also the collection and transmission of information from the home to Diga-Saúde backend and therefore to the health professionals. The backoffice hosts the service logic (parts are running in the STB and parts are running in the back office, as explained latter). The data about the patients that is collected at home is transmitted to the backoffice for processing. These data are: vital signs, medication status, health messages reading status, any other information that could be important for the health providers. The data transmission is performed through Internet thanks to the connection of the STB to the broadband network. In term of configuration, the web interface provided by the back office allows to introduce all information that allow the system to properly work as well as administrative information related to the subscriber, the patient, the inhabitants and so on. Diga-Saúde – Web also assists the end-to-end process of monitoring the patient (since the creation of the treatment until the end of it).

B. Diga-Saúde Architecture

Diga Saude architecture is based on several layers. Since Diga-Saúde is composed of two main modules that are partially independent, the architecture relies then on a client-server model.

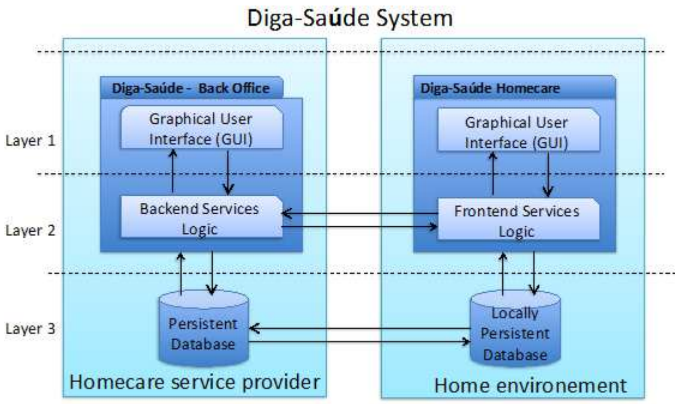

Fig. 5. Diga-Saúde's architecture diagram

The first layer (Layer I) contains the Graphic User Interface (GUI) of both system modules. Il runs in the internet.

In the second layer contains all features offered by the Diga-Saúde. It contains all the services.

The third layer is the persistent data layer. All of Diga-Saúde’s system data is stored at this layer.

C. Diga-Saúde Scenários

To retrieve vital signs information, the system can make use of additional health devices (more and more available on the market) such as medical sensors (pulse oxymeter, sphygmomanometer, blood glucose meter and accelerometer) that can be placed at the patient’s home or on her body. The Diga-Saúde provides interfaces to connect to these devices (using protocols such as BT, ZigBee, WiFi, etc.) provided by STB and could transmit them to health providers and doctors for remote monitoring and diagnosis.

Next, we describe 4 different scenarios where mobile devices are used to capture context aware information used in LARIISA:

1. Heart rate is 120 bpm and blood pressure is 140/90. These were taken at 4.14° S, 40.58° W (Reriutaba) on March 2nd, 2013 at 17:00h. The weather was rainy and cold. I am not feeling good.
2. Heart rate is 120 bpm and blood pressure is 140/90. These were taken at 4.14° S, 40.58° W (Reriutaba) on March 2nd, 2013 at 17:00h. The weather was rainy and cold. The patient was not feeling good and I took him to the nearest health center.
3. Heart rate is 120 bpm, body temperature is 40° and blood pressure is 140/90. These were taken at 4.14° S, 40.58° W (Reriutaba) on March 2nd, 2013 at 17:00h. The weather was sunny. I saw a dengue fever mosquito within my house and I am afraid I got dengue.
4. The photo IMG001 was taken at 4.13° S, 40.47° W (Reriutaba) on March 2nd, 2013 at 17:00h. The weather was sunny. Input from system: Dengue habitat.

As shown in Figure 3, the GPS coordinates now have an important role within the context of Lariisa for decision-making. It demonstrates a real scenario of decision-making process after correlation between personal tracking and health information.

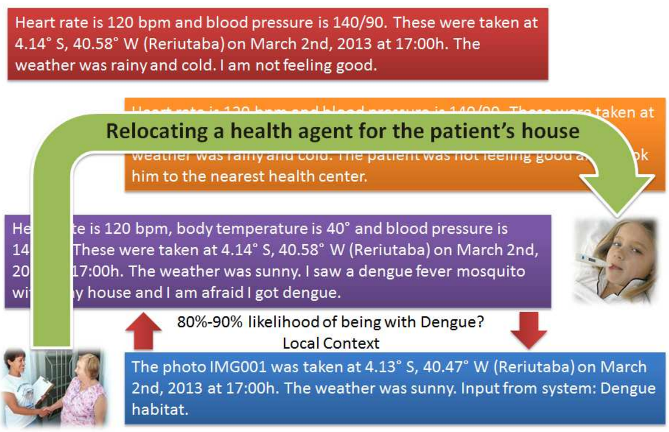

Fig. 3. Context-aware applications scenario

With the locally retrieved information, doctors could follow, almost real time, the patients’ situation from afar. Patients that have made a surgery, for example, need careful surveillance to assess their health status (physical or psychological). Today, these people have to stay in the hospital although it is widely known that the recovery of this type of patient is faster if there are at their own home. In addition, the hospital costs is very high - a major problem for many health systems worldwide.

V. DIGA-SAUDE PROTOTYPE

We have implemented the first interactive application of the Diga-Saúde. In this application, the API called AI3D proposal (Integration API among devices used in the Diga-Saúde) is proposed and allow the integration of any home device. It permits in particular the integration and communication of medical sensors and middleware components in a transparent way so that the future portability of Diga-Saúde to any another middleware is facilitated. We have also analyzed the possibility of using medical sensors in the proposed system. The Diga-Saúde VSM service aims at monitoring patients’ vital signs and displaying the result on a TV screen. Diga-Saúde installs the VSM service in the STB, which in turn interacts with medical sensors installed on the body of the patient. This requires the interfacing of the medical sensor with the system.

To perform tests with real sensors, we have used the pulse oximeter CMS-P20. It allows to collecting vital signs such as pulse and SPO2 – Blood Oxygen Saturation. The experimentation has shown that it was feasible for the STB to collect data from medical sensors and process the data in the STB and display the result on the TV screen.

A. Hardware specification

The figure 6 shows the Diga-Saude,prototype´s hardware: a board of peripherals was prototyped on FR4 glass fiber on 4 layers, two layers for signals and two layers for power planes.

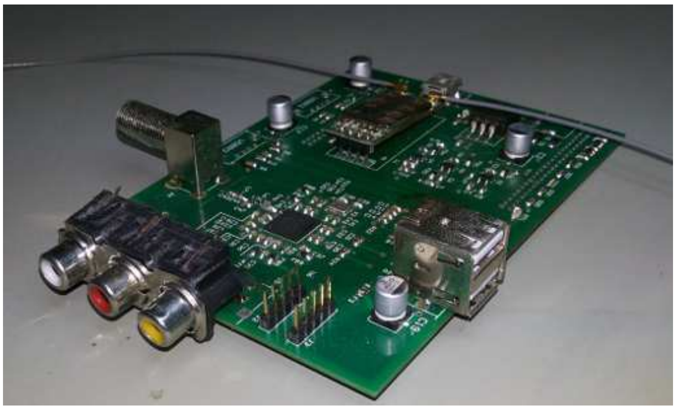

Fig 6: Diga-Saude Prototype´s Hardware

A stack of layers appropriate been used to provide impedance 50 Ohms on the trails and RF 100 Ohms differentials transmission lines in USB.

On this board were inserted: Tuner, Hub USB, Wi-Fi and power supplies required. In terms of connections, the board has 3 USB 2.0 interfaces, 1 mini USB interface, connection to Digital TV Antenna, RCA, and the connection to the processor board.

- Tuner (Digital TV Tuner)

The Siano SMS2270 was a tuner selected for the project, provides a single-chip solution (9mm x 9mm x 0.9mm BGA 0.8mm pitch, 116 pins) with full support ISDB-T.

- Hub USB

The Hub USB controller AU9254A21 (28-pin SSOP package) is one chip controls up to 4 USB 2.0 downstream ports, view the version 1.1 specifications of the USB standard. It has an internal 3.3V voltage regulator and operates at a frequency of 12MHz.

- Processor board

The selected architecture has followed the trend of the market for such devices, with the use of an ARM processor unit 2D video with embedded. In this scenario both processors were tested and enabled technically the Broadcom BCM2220 and the A10/A20 Allwinner. The option to use a peripheral module coupled to the board brings a reduction in the total per-unit cost and allows easy expandability of the platform.

B. Prototype Interface

The figure 7 shows the integration of the Diga-Saude (hardware and web interface) to the LARIISA Data Base.

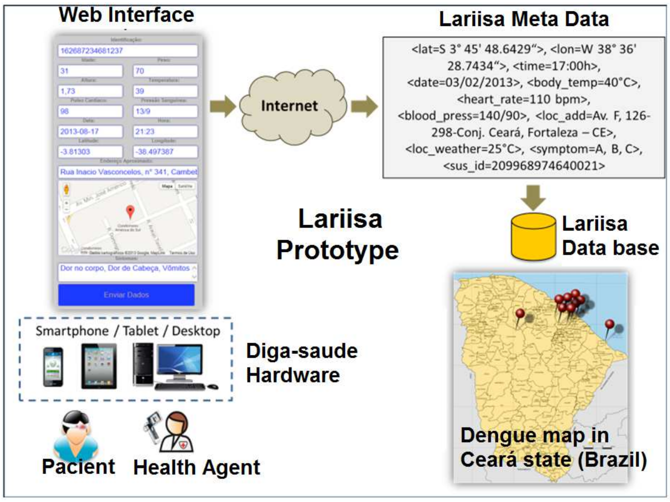

Figure 7: Integration Diga-saúde and Lariisa

The web interface of the Diga-Saude builds a metadata (LARIISA Meta Data) containing geolocation information of the agents involved (patient, Health Agent, specialist.), health information of the patient (figure 3), and SUS-ID, the patient identifier in Brazilian Unified Health System (Sistema Único de Saúde - SUS).

At first, the web interface identifies (figure 7) who is using the application: the patient, the health agent or specialist. Thus, according to the selected profile, the web interface of Diga-Saude can send specific information to LARIISA Data Base. This, in turn, sends a group of specific questions to be answered by the user of the system.

Starting this interaction, the LARIISA can now give the sequence a series of actions of inference that result in actions, from simple diagnostics urgent measures (eg, detection of a case of dengue hemorrhagic fever) [21].

The implementation of web interface the following tools were used: JavaScript, HTML5, CSS3.

VI. RELATED WORKS

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.

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 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 TVDI and is not sold to the Brazilian public.

I. CONCLUSIONS

This work described the Diga-Saúde, a low-cost prototype that aims to provide homecare services to patients, elderly or any person in need of health services. The Diga-Saúde system is aligned with LARIISA project, a model for public health systems centered on the family that is developed in the context of the GINGA CDN project, and supported by the RNP Brazilian agency.

Health systems have to evolve to cope with changes in the World. Western society has built its healthcare systems centered on expensive institutions such as hospitals, clinical and so one. With the increase of the elderly population, this system is under high pressure that could lead to its degradation if innovative solutions are not developed.

The rescue of a model for health where the family takes center stage, along with the possibility to provide high quality healthcare services directly at home using ICT are regarded as cost-efficient solutions.

It is precisely in this scenario that the LARIISA Project and the Diga-Saúde are being developed. Besides, the Brazilian model of Digital TV/Set-top box will offer a low cost interactive terminal for individuals at home. It is also designed to provide health managers with an intelligent governance framework that will support them in making decisions concerning the Basic Attention network from the Brazilian Unified Health System (Sistema Único de Saúde - SUS).

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 ContextAware 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). 2010.

[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. 2007

[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] GARDINI, L. M. et al. Clariisa, a Context-Aware Framework Based on Geolocation for a Health Care Governance System. 5TH International Conference on e-Health Networking, Application & Services. IEEE Healthcom, Lisbon. 2013.