Implementing Home Care Application in Brazilian Digital TV

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***Abstract*— GINGA, today an ITU-T Recommendation H.761, was developed to be the middleware of the Brazilian Digital TV model. The DIGA GINGA (Digital Automation Monitoring and Control using GINGA technology) is part of the GINGA CDN project (Code Development Network), a Brazilian research network that aims to add value to GINGA, producing components and applications. The main idea of DIGA GINGA is to share a computational structure of the digital TV set-top-box adding services to users, such as tracking the physical environment (home security), personal monitoring (vital signs) and other applications for home automation. The DIGA GINGA environment will test two of the components specified in the GINGA CDN project, data persistence and channel of return (interactivity channel), which are being implemented at the Group of Computer Networks - GREAT. This study will also present the implementation of a prototype, which provides monitoring and support for who are in a state of recovery or are carriers of diseases that require intensive medical supervision.**

Keywords: Digital TV, Middleware, Ginga, home care.

I. INTRODUCTION

GINGA is the middleware developed for the Brazilian Digital TV model [1]. It 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 [2] .

The DIGA GINGA project (Digital Automation in Monitoring and Control using GINGA technology) [3] is an innovative system in residential automation and domotic (management of resources housing) that has as its objective the implementation of four components: DIGA Health, DIGA Home, DIGA World and DIGA Here. It proposes to add features to GINGA [4], such as monitoring and control of applications in the residential automation, thus optimizing the use of set-top-box that is being made to the Brazilian System of Digital TV model (SBTVD) [5].

In order to do that, DIGA GINGA makes use of devices (sensors) that access the set-top-box of Digital TV via wireless network (IEEE 802.11x) inside the residence. These services incorporated to the set-top-box (software and content) can also be accessed externally via Internet or cellular technology.

Therefore, the central idea of DIGA GINGA project is to share the computational structure of the set-top-box aggregating services to citizens at their residence, such as tracking the physical environment (residential and companies security), personal monitoring (vital signs), home automation and applications that stimulate the production of content between users, such as P2P applications from communities with common interests in areas of the project area.

The set-top-box of the DIGA GINGA also works as a "gateway" between the tracking and control devices at the home and an external database DIGA Bum (Digital Automation Monitoring Based in Ubiquity Model), a component of the project related to RE-Invente [6], other research of the Group of Computer Networks, Software Engineering and System (GREAT) about Context Aware Ubiquitous Learning Environments. DIGA GINGA is used for the monitoring the context detection aspects in the RE-Invente project.

II. THE DIGA PROJECT AND THE GINGA

Figure 1 presents the architecture of the Brazilian Digital TV [7], organized in layers. It deserves a prominent Middleware layer, which serves as the interface between applications and the rest of the system. It is this layer that makes the main difference between the Brazilian Digital TV model and other international models. It permits the digital TV interactivity, the main characteristic of GINGA-NCL [8].

NCL is a language that holds media objects together in a multimedia presentation, no matter which object types they are. It treats an HTML document as one of its possible media objects. Thus, NCL does not substitute but embed XHTML-based documents. The same reasoning applies to other multimedia objects. GINGA-NCL is an NCL presentation engine built as a component of an IPTV middleware. A very special NCL object type defined in GINGA-NCL is NCLua, an imperative media-object with Lua code [9].

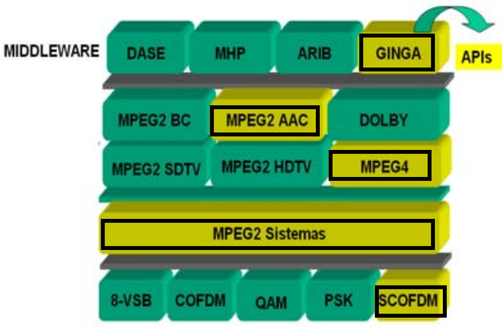

Figure 1. Architecture of the Brazilian Digital TV.

Figure 2 shows the set-top-box hardware, that can be inlaid or not on the TV. It notices in the figure that the set-top-box has access to another net (Internet, for example) through which it can receive or send data, as commanded by the interactive application. The access to this net is called channel of return or interactivity channel.

The main innovation of the DIGA project is to take up the broken paradigm in the Brazilian scene, when a digital TV will take the place of the ubiquitous analog TV, now available in almost all households in the country. Thus, when considering the universality of the set-top-box at Brazilian homes, which probably will happen before the year 2015 (Act 4901 of November 2006) [10], the possibility of universal services of monitoring (physical safety, personal health, etc.), today restricted to wealthy public, will cause significant impact on society, probably the same magnitude of what was found with cellular telephony, whose growth rate beyond quondam expectations.

The DIGA project arrives in order to participate in the new Digital TV will be present, in the near future, on the day-to-day of the Brazilian people. Join the fact the tendency of GINGA middleware is to be incorporated into the set-top-box of the Brazilian Digital TV model. The DIGA takes advantage of the GINGA, since several applications of DIGA has characteristics of interactivity, greater legacy of GINGA in the development of technologies for digital TV.

III. The DIGA Project and the Ginga

The four components of DIGA (DIGA Health, DIGA Home, DIGA World, DIGA Here) have been benefited from the GINGA's interactivity. The user of DIGA Home, for example, will can configure the set-top-box and track his residence remotely, warned about events that happen when he is away from home. This monitoring can be done in real time (SMS, web, etc.) or offline (reports, etc.). As the set-top-box will be permanently connected, the user will have constant and customized monitoring.

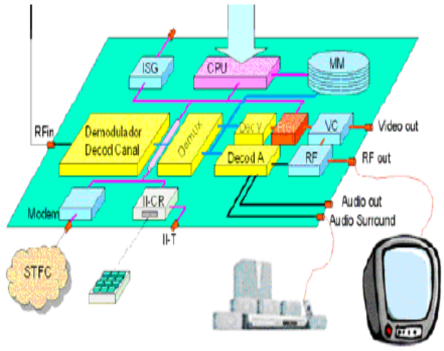

Figure 2. Set-top-box Hardware.

In DIGA Health, the user can have his vital signs monitored remotely, and store such information in a database - DIGA Bum (Based in Ubiquity Model) -, or make this information available to another health professional, if he is traveling or decides to receive a second medical opinion, for example. Many life-threatening situations can be avoided. People with hypertension or with problems requiring immediate action from a health professional, can be benefited with the knowledge of their online status.

Using the DIGA World, all the benefits of DIGA Health have been added to the monitoring of a system of care 24 hours [11], able to act pro-actively and reactively in monitoring health, with the help of intelligent systems, as previously described.

The DIGA Here allows users to interact electronically. Each user may have information on various topics at any time and can also work with interactive content in this case. These experiences can help the daily lives of people and facilitate the exchange of information on various subjects, to increase the interpersonal relationship, which has vital importance, especially to elderly, or those involved in diseases that impede their social living.

The DIGA Health is a DIGA GINGA component that integrates devices (pulse oximeter, sphygmomanometer, blood glucose meter, accelerometer, etc) in order to carry out the monitoring of Personnel Health Vital Signs (PHVS) from people with diseases that require intensive medical supervision. To focus on health signals of these people, the idea is to make use of specific equipment on the market, as the Sun Spot [12]. A device of DIGA Health can be placed next to the body of the patient to allow him to move normally. The information of vital signs could be available by the user to any institution or health care professional. The DIGA health makes use of the database DIGA Bum.

Finally, the DIGA Health project in addition to expanding the potential of GINGA with tracking features in the health's area with their modules, sensors and other components, serves as proof of concept for an extra set of applications to be developed, as in the prototype implementation, described in the session 4.

IV. The DIGA Doctor Prototype

The DIGA proposes to make use of set-top-box that is being made to the Brazilian System of Digital TV (SBTVD) model. This takes advantage GINGA's interactivity to host in the set-top-box applications developed for the residential environment, especially the monitoring in the areas of personnel health, like the PIMENTER project [11], developed in Laboratory of Computer Networks of Ceara -LAR.

To monitor the vital signs of health is being implemented the prototype DIGA Doctor, whose components are illustrated in Figure 3: widescreen monitor, set-top-box; sun spot on the bottom and left, and a pulse oximeter on the right bottom.

Figure 3. Components of the DIGA Doctor Prototype.

By making use of set-top-box, a device that will be present in Brazilians' residences in the near future, the DIGA becomes affordable to the public the services of its four components, described above.

A. *Project Requirements*

Following are the requirements of hardware and software to be adapted to the set-top-box, based on PIMENTER project [11] that serves as a reference to the DIGA Doctor prototype:

1) Development of portable hardware that integrates monitoring devices of Vital Signs, such as pulse oximeter, sphygmomanometer, blood glucose meter, accelerometer and so on. DIGA Doctor concentrates the signals of the devices cited above and sends them via wireless or cable to the set-top-box of digital TV. DIGA Doctor can be placed near the patient's body to allow him to move normally.

These devices, whose features are presented below, may be connected to DIGA Doctor, as an extra source:

- Oximeter measures the amount of oxygen in the blood and also the number of heart beats;
- Sphygmomanometer measures blood pressure;
- The blood glucose meter is useful for diabetics who want to constantly monitor the level of blood sugar;
- Accelerometer measures the acceleration of a mobile, would be useful to identify beatings or falls in children and the elderly.

2) Development of hardware devices that integrate tracking physical movements, such as temperature, presence sensors and magnetic sensor, the last one used to detect the opening of doors, windows, etc. DIGA Security Center could also include up to 16 video cameras. Its function is to monitor the environment and send signals from sensors and cameras to the Brazilian Digital TV set-top-box. The sending of signals can be done via wireless or with cables.

3) Adequacy of middleware GINGA so that it can receive the signals sent by the hardware DIGA Doctor and DIGA Security Center.

4) Development of software to expose, store and share with safety information about the vital signs of the monitored person. This software will run on set-top-box, with support from middleware GINGA.

5) Development of software to expose, store and safely share information on the environment physically monitored. This software will run on set-top-box of Brazilian Digital TV, with support from middleware GINGA.

6) Development of interactive application capable of integrating the communities of DIGA users. The main goal is to provide an environment in which citizens with a specific disease can interact, primarily with other people in similar condition, for example. Thus, these people can exchange knowledge, views, testimonials, health tips, etc.

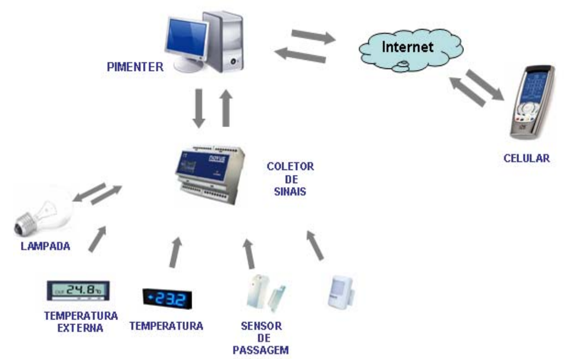

Figure 4. PIMENTER's Hardware.

Figures 4 and 5 show, respectively, the hardware and the interface implemented in the prototype of PIMENTER Project, which serves as a reference to the DIGA Doctor prototyping. The prototype consists of sensors and actuators connected to the data collector DAQ (Data Acquisition). It communicates with the Personal Computer. The device managed in this prototype is a lab gateway. The actuators devices of the environment are a lamp, a webcam and a siren.

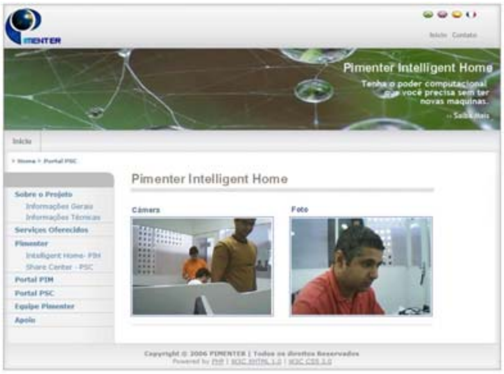

Figure 5. PIMENTER's Interface.

The sensors used are the presence, temperature and smoke detection. Opening the door or supervised the performance of any of the sensors (presence, temperature or smoke) involve the lighting of the lamp and trigger the alarm. Besides supervision and performance of some sensors, a picture, taken by the webcam, is sent to the website. Then, a Short Message Service (SMS) is also sent to the owner's cell phone previously registered described above.

B. Implementation Aspects

Below are described the aspects of DIGA implementation for software and hardware.

- **Aspects of Software**

To develop DIGA Doctor prototype, it was made an evaluation of the PIMENTER Project, with the aim of assessing the viability of the same security features in residential and vital health signs, seeking their aggregation of set-top-box. Currently, is being held throughout the elicitation of requirements and analysis of the proposed software, not only the ones which will be aggregated to GINGA to enable the PIMENTER's features, but also the applications for interactive communities of users. To allow such aggregation, the GINGA's middleware provides an infrastructure for implementation of applications based on Java language, with facilities specifically geared to the environment of digital TV.

- **Aspects of Hardware**

To construct the hardware of the DIGA Doctor prototype is necessary to develop a MDA (Mechanism for Data Acquisition). This will serve as the interface for communication between DIGA devices (sensors, cameras and devices for tracking patient's vital signs) and digital TV set-top- box. The communication of DIGA with the digital TV set-top-box will be done via USB (Universal Serial Bus).

An example of a receiving unit that uses this connection is the AIKO's set-top-box. This, among other features, uses middleware GINGA and has two USB outlets, connection to local network and another connection dial-up. Due to this premise, the integration of MDA with the set-top-box becomes quite possible.

The connection of cameras and sensors with the DAC will be made via conventional cables and DAC connection with the DIGA Doctor will be wireless. The technology that will be used to wireless transmission is the ZigBee, wireless technology networks based on IEEE 802.15.4 standard that makes the interconnection of small units of data communication in very limited areas. The ZigBee is a technology similar to Wi-Fi networks and Bluetooth and differentiates itself due to the fact that it consumes little power, an essential factor to DIGA Doctor.

C. Applying the DIGA Doctor

The DIGA Doctor is the prototype of the DIGA Health Component. It integrates devices (Sun Spot, Set-top-box and sensors) to conduct the monitoring SVSP, ie DIGA Doctor is a program (run on the Digital TV's platform), which unites the Application Programming Interfaces (APIs) with the Sun Spot GingaJ API (Digital TV) to provide services for Home Care[1].

As we can see in Figure 6, the Sun Spot consists of two facilities, a hub/transmitter (concentrator, placed near the body of the patient) and a receiver, whose size is similar to a cell phone. The concentrator has digital and analog ports, which serve to connect devices and sensors (oximeter, sphygmomanometer, accelerometer and blood glucose meter). The receiver obtains data from the transmitter and passes them to a computational device (in our case, the set-top-box) via USB port. Taking ownership of these data, the DIGA Doctor will use the channel of return[2] of the set-top-box and sends that information to a health professional (responsible for the care of the patient) to take the appropriated decisions.

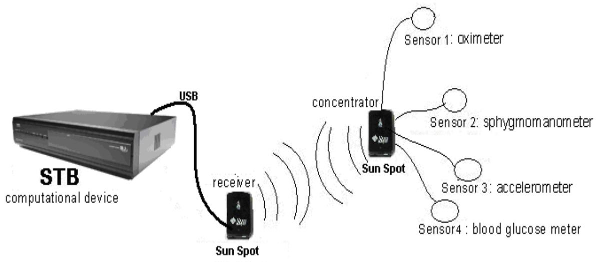

Figure 6 - Integration of the devices DIGA Doctor

The figure 7 shows the typical situation of the DIGA Doctor's application. This comes with the premise of providing the monitoring and support to people who are in their state of recuperation or have diseases that require intensive medical supervision. It illustrates the scenario of an elderly lady receiving, through a terminal for mobile TV, professional advice on how to perform the measurement of their blood pressure. In the case of surgery and postoperative patients, they need careful attention with regard to the recovery and

[1] Patients can receive home care services whether they live in their own homes, with or without family members, or in an assisted living facility. The purpose of home care is to promote, maintain, or restore a patient's health and reduce the effects of disease or disability.

[2] Canal of return is the channel of transmission of data from set-top-box of digital TV for broadcast television.

monitoring of certain variables for assessing their status (physical or psychological). Currently, people in this type of situation are usually admitted to the health units (high cost).

With the DIGA Doctor doing the monitoring via digital TV, using sun spot, software installed on set-top-box and Sensors (used to receive and send vital signs of people who use the system), patients may have a better recovery at their residences.

In addition to monitoring variables for assessing the physical state and / or the patient's psychological, using the DIGA Doctor can also perform the monitoring of a set of critical variables such as temperature, heart rate, oximetry, respiratory rate and blood pressure, as suggested in the figure 7.

Figure 7. Monitoring vital signs made by the DIGA Doctor.

Considering professional advice, the user can get a better doctor-patient interaction. Moreover, the DIGA Doctor allows access to services such as the timing of announcements on TV telling the exact time for taking drugs, consequently, facilitating the life of older people with problems of lack of memory.

The DIGA Doctor also provides to users, with some king of diseases, a sufficient autonomy to be at their residences without life risks. Otherwise, the user would have to be admitted to hospitals for long periods of time.

V. DIGA DOCTOR IMPLEMENTATION

This session presents the technical aspects used in the implementation of the DIGA Doctor prototype.

A. The Technology Sun Spot

Based on a 32-bit ARM CPU and a radio, 11 channels of 2.4 GHz. The device Sun Spot (Sun Small Programable Object Technology), developed by Sun Microsystems [12], gives developers the ability to compile and run applications transducers with wireless software and use Java IDEs[3], such as Eclipse or Netbeans, to write the codes.

Developers can create applications in Java, load them on the device of Sun Spot and use it to send and receive data. This system works independently of a computer, and runs through the virtual machine included in the device, the Squawk Virtual Machine (VM).

The VM is a small virtual machine, based on the Java Micro Edition (JME). Being based in JMe, the implementation of the application (filled in Sun Spot) is defined by a class that extends MIDlet[4]. A MIDlet is usually packaged in a Java Archive (JAR)[5] and then deployed on the Spots.

A Sun Spot has a set of components responsible for interacting with the environment, called a panel of sensors (Sensor Board) which contains the follow resources: accelerometer, temperature sensors, temperature sensors, and light, five pins of entry and exit of general use, eight LEDs in three colors, four-pin high voltage output and a USB interface for transferring data with a computational device (computer or set-top-box, for example). These components can be accessed through of primitives available in its API specification [13].

The next section provides further details about the component used to establish communication between "Sun Spots" concentrator and receiver of the DIGA Doctor.

B. Communication Between Sun Spot's Devices

Communication is done through a wireless connection between two Sun Spot that can be based on two models, streams or datagrams, as described below:

Streams: This connection type is comparable with a socket, a protocol providing reliable and based on streams for the exchange of messages between the spots.

To establish a communication is necessary to have two components that open a connection in the same port and additional addresses. That is, open a connection with the identifier of the target component. The port can vary between 0 and 255 and an address is represented in 64 bits as the IEEE standard for radio. The code below illustrates the opening of connection. The Figure 8 shows the code used to open this type of connection.

```
StreamConnection conn = ( StreamConnection )
Connector.open(”radiostream://nnnn.nnnn.nnnn:xxx”);
```

Figure 8. Opening of connection with the model streams.

After the connection established, each sun spot can create streams to send and receive data. The Figure 9 shows the code used send and receive data.

```
DataInputStreamdis = conn.openDtaInputStream( );
DataOutputStreamdos = conn.openDataOutputStream( );
```

Figure 9. Code used send and receive data.

Datagrams: The connection is opened in a similar way to streams, through an address and port. Similarly, after the connection open, you can send datagrams between peers, as illustrated below. The Figure 10 shows the code used to open this type of connection.

```
DatagramConnection conn = (DatagramConnection)
Connector.open(“radiogram://”+targetIEEEAddress+“:100”);
```

[3] The IDE - Integrated Development Environment - is a tool used, for programdores, to produce Java code.

[4] MIDlet is the standard Java programs for devices shipped, for example mobile phones.

[5] Java Archive (JAR) file a packaged composite of other files that make up the program.

```
Datagramdg =    conn.newDatagram(conn.getMaximumLength( ));
dg.writeUTF("State of Health in perfect condition.") ;
conn.send( dg ) ;
```

Figure 10. Opening of connection with the model datagrams.

Note that the keyword, radiogram and radiostream identify which type of protocol will be used.

C. The API of DIGA Doctor

As the DIGA Doctor is a system implemented to run on receivers (set-top-box) with the middleware (Ginga) of the Brazilian System of Digital Television (SBTVD) was required for implementation of the system using the Interface Programming of these middleware applications, the GINGA-J that provides the definitions of the part procedural of GINGA.

The GINGA-J is an API designed to meet all the features necessary for the implementation of applications for digital TV that make use of features of manipulation of to multimedia and protocols of access the datas.

Aiming to integrate the devices (Sun Spot, set-top-box and sensors) used in the DIGA Doctor was created an API to integrate devices of the DIGA Doctor (AI3D). The API is very simple, small and presents an interface to be used in the construction of Xlets implemented in DIGA Doctor. The API AI3D only specifies a package, the package br.uece.DIGAdoctor. Integration, whose components are classes detailed below:

- Class SunSpotMananger:

The class SunSpotMananger makes use of the features, available in the API Sun Spot, to set an object designed to collect information from sensors connected to the Sun Spot.

- Class StbMananger:

The class StbMananger defines an object created to prescind some features provided by the API Ginga-J, as the multimedia features and interactivity through the transmission of data sent by the channel to return[6] of the set-top-box.

- Class DIGADoctorIntegration:

The class DIGADoctorIntegration defines an object that should integrate all features defined in class SunSpotMananger and StbMananger. It is the class responsible for uniting the resources of the Sun Spot with the resources of the Digital TV to provide the services of Home Care of the DIGA Doctor.

D. The DIGA Doctor Interface

Making use of Xletview[7] emulator for simulation of a Java environment TV in a Personal Computer (PC), a small application is being created so a user can, through a PC, simulate the use of DIGA Doctor. In the application that users can view and request the services of: see the exact time for taking medication; monitor (on the TV screen) the patient's vital signs, and get help for using the system.

The Figure 11 illustrates the initial screen of the DIGA Doctor. It displays a brief description of the system on the left side of the screen and the menu created to redirect the user, using the remote control, for the other functions of the system.

Figure 11: Inicial Screen of the DIGA Doctor

VI. CONCLUSION

The impact of the new generation of television is much more significant than the simple exchange of an analogical system of transmission for digital, and much more than set-top-box improves of the quality of image and sound. An important component is the ability to expand the functions of the system for applications constructed on the base of a system reference standard. But the most important characteristics in the Digital TV technology is the interaction of the viewing user, which could be delegated the control of the flow of a televising program, deciding if one determined content must be shown or not, and the form as it will be shown.

The DIGA GINGA project proposes the use of set-top-box that is beginning to be made to the Brazilian System of Digital TV (SBTVD) model. The major idea of the project is, therefore, share the computational structure of the set-top-box adding services to citizens at their residence, such as the tracking of the physical environment (residential security), the monitoring personnel (vital signs) and other applications for home automation. Although compatible with any type of set-top-box, the DIGA is oriented to the GINGA [14] [15], the middleware, result of research carried out by SBTVD and that became, recently, a Recommendation H.761 of the International Telecommunications Union (ITU-T) [2].

This study adds to the DIGA GINGA an environment of applications for home care. In it we present its implementation, the DIGA Doctor, which has as its premise provide the monitoring and support for people who are in their state or the healthy carriers of diseases that require intensive medical supervision. This takes advantage of the fundamental characteristic of the GINGA's interactivity, to stay in the set-top-box applications developed for the residential environment.

With DIGA Doctor it will be easy to notice when the vital signs monitored by a citizen are about to reach thresholds of

[6] Channel of return is the channel of transmission of data from set-top-box of digital TV for broadcast television.

[7] Available at: http://sourceforge.net/projects/xletview/

life risk. In such cases, provide care in the timing of the need is a task of the DIGA Doctor. Thus, it is expected that the number of hospitalizations from public and private health care tends to fall, bringing economy to the Brazilian government and its citizens, especially those who need special medical care: people with chronic diseases will have their vital signs monitored remotely.

In Brazil, 95% of the people have analog TV at their homes, but only 20% use computers and Internet. Nowadays, TV system is in transition from analog to digital technology. Within the projection of the universalization of the Interactive Digital TV in the Brazilian homes (in 2016, finishes the analogical transmission), the products generated by the project DIGA Doctor can help the Brazilian people.

Finally, the DIGA GINGA also serves as platform to other project related to Context Aware concept, an emerging field of research that has been advocated as a mechanism for providing the ability of an application or a service to reason about a situation and to adapt its behavior in response to environmental changes. In this case, DIGA GINGA has been used for the monitoring the context detection aspects in the RE-Invente [6], a new researching project called LARA [16] about Context Aware Ubiquitous Learning Environments [17][18]. This project is resulted of the collaboration between the Imagine Laboratory, from Ottawa University, and the Group of Computer Networks, Software Engineering and System - GREAT, from Federal University of Ceará (Brazil).

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