Development of an Academic Laboratory of Interactive Digital TV in Amazon, Objectives and Main Projects

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ABSTRACT
As the main goal of this workshop is to bring together researchers, educators, and industry related people working in the deployment of Interactive Digital TV Systems and Applications in developing countries, we decided to write about the establishment of a laboratory in the most important university of Amazon in Brazil that works with this technology. This laboratory is located in the CETELI/UFAM and was built to help the local technical community to make experimentation on Digital TV related themes. In fact, the most important goal of this technological center is the teaching of undergraduate and master of science students as it servers the electrical and computer engineering courses as well as the master of engineering program of the Federal University of Amazon. In the next pages a description of the main projects running in this laboratory is going to be made in order to give an insight about its potential and objectives.

Categories and Subject Descriptors
B.0 [**Hardware**]: General; D.2.0 [**Software**]: Software Engineering: General; I.0.m [**Computing Methodologies**]: General; J.7 [**Computer Applications**]: Computers in Other Systems;

General Terms
Management, Documentation, Performance, Design, Experimentation, Human Factors, Standardization, Languages, Theory, Legal Aspects, Verification.

Keywords
Interactive Digital TV Systems, Digital TV Standards, ISDB System, New Applications for Interactive Digital TV.

1. INTRODUCTION
The city of Manaus, located in the center of the Amazon Forest in Brazil, is home to the largest global free trade zone for the production of electronics and the manufacturing of digital television sets. The eighth largest city in Brazil, and the largest industrial park of its kind in South America, Manaus is a microcosm for the political, economical, and social transformations implicated in recent debates over Digital TV [1, 2]. Because of its economical characteristics, Manaus has several universities, technical colleges and institutes of research and development, and one of its challenges is the improvement of professionals and technologies to support the industrial pole. Indeed, the academy has many difficulties to follow the fast changes in technology and to attend the industries' necessities.

With the deployment of Digital Television in Brazil there is a growing demand for new services and contents to be provided, as well as many ways of integrating these new features with existing technologies [3]. The popularity of TV in Brazil opens a window of opportunities for many people working with related topics. New solutions and new business approaches are supposed to be born from this scenario, creating many new job opportunities [4, 5]. The University of Amazon, particularly the CETELI in Manaus, hosts a modern laboratory working with topics related to these new technologies. The Interactive Digital TV laboratory was built with governmental funding and is sponsored by the local industries, having a relevant importance in the teaching of new engineers and scientists.

In this report we are going to describe the most recent projects under development at UFAM. Indeed, application like T-Health, T-Government, T-Commerce, and T-Learning are some examples of value-added services (VAS) investigated in this laboratory. We start with the integration system between the Brazilian DTV model and the ODGi framework that lead us to implement some automation home features. The second project is an extension of this first and deals with health monitoring using the TV set as a comfortable user interface. Education and social insertion is a very important topic in Brazil, section 4 describes a T-Education project that wants to help game developers in their jobs. Finally, in section 5 a software engineering experiment focused on Digital TV is presented. With these descriptions we hope to give a brief overview of the themes under development in our institution.

2. COMMUNICATION SOFTWARE BETWEEN THE BRAZILIAN iDTV AND RESIDENTIAL DEVICES

The characteristics of new interactive Digital TV (iDTV) systems are assuming a very important role in modern life. In fact, these features are being increasingly expanded, from simple signal decoders to sophisticated devices that allow the execution of interactive applications related to the content displayed, providing services of all kinds like internet access, TV-Banking, TV-Mail, TV-Commerce, Games and so on [6, 7]. This new world is about to be established in the Brazilian market.

In a Residential Automation System, various consumer devices such as microwave, air conditioning, and temperature sensors, can be integrated into a single interface with which the user can control/monitor through operations available by them. Due to a wide range of communication technologies there are different ways for interconnecting them in a Home Network [8].

Nowadays the common way of expanding the functionalities of a Set-Top Box (STB) is to connect it with other devices equipped with some computational power such as the electronic equipments of a Home Network (HN). This is possible through the use of the STB as the central processing unit of networked devices architectures, also known as Residential Gateways [9]. The exploration of iDTV interactivity to access devices lead to many usage scenarios providing a networked entertainment environment to the consumer, allowing for example, sending a message to a cell phone in the house, turn on/off the lamp or fan or managing the energy consumption of the residence.

We developed a collaboration model between the Brazilian iDTV system and Home Networks exploring particular features of the Ginga declarative and procedural environments (Ginga-NCL and Ginga-J). This brings new applications and scenarios to the Brazilian market, allowing the consumers to immerge themselves into an interconnected home, using Ginga's interactivity to manage devices and sharing information among them. The development was split into two phases: (1) choosing the communication technologies and (2) choosing the proper approach for managing of the electronic devices in a Home Network.

We focus on Wireless (WiFi, Bluetooth and ZigBee) network due to the following reasons: no use of cables to connect the electronic devices, easy integration of several types of equipments, the low energy consumption, and the small signal range between the connected devices.

From (2), the Open Services Gateway initiative (OSGi) specification was chosen because the services are managed locally by this framework, the devices identification is offered by a Java interface, the discovery of the services is done by searching in a Service Registry, and it supports communication with other specification for Home Networking, such as UPnP and Jini.

Finally, we created a platform constructed on a component-based model for the Ginga middleware and the OSGi framework. The general architecture of this model is shown in Figure 1. In this figure are Ginga-J, Ginga-NCL and OSGi components and the software bridge between them.

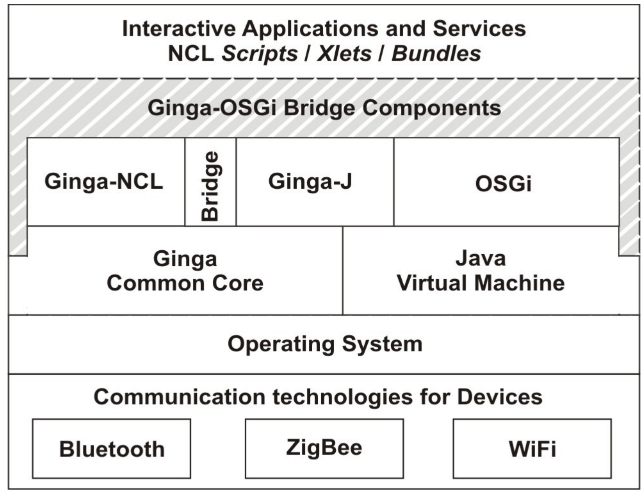

Figure 1. General Ginga-OSGi Architecture

Some functions for the new Ginga-OSGi model have been identified to meet the needs of integration between Home Networks and the Brazilian Digital TV. They are:

Allowing the registry and the discovery of OSGi services in a Home Network – Services are the basis of OSGi model. A service is an interface to operations provided by the networked devices. The service discovery in a Home Network is a key step for integrating with interactive Digital TV applications.

Interoperation Between OSGi services and Ginga functionalities – The environment must allow Ginga to access OSGi services. It is a difficult task because it requires an effort to integrate these different software platforms. Similarly, this model should enable the access of Ginga functions by OSGi.

Providing a useful description of the services to the user – Service description is the key to success in attracting a user. In addition to the information provided by OSGi services, such as name, version, and provider, other information should be released, such as device name and methods description.

We developed some strategies for collaboration between Ginga and OSGi: Ginga-NCL to OSGi, OSGi to Ginga-NCL, Ginga-J to OSGi and OSGi to Ginga-J. After the developing of Ginga-OSGi platform, we created three integration scenarios to validate this platform: (1) sending a message to TV screen by a mobile phone over Bluetooth; (2) monitoring temperature sensors located in some rooms of the house over ZigBee by iDTV application; and (3) managing a home access control by the Digital TV over WiFi.

The Ginga-OSGi model contributes to consolidate an iDTV-HN collaboration model, allowing the emergence of useful Home Automation applications and improving the user's experience and quality of life. In addition to the model based on the procedural specification (using Ginga-J middleware), the novelty of the work is in using declarative middleware features (through Ginga-NCL) to provide integration between script-based content and OSGi services. It considerably extends the scope of home automation applications that can be constructed using this new model.

3. HealthcareTV: AN INTEGRATION ARCHITECTURE AMONG MEDICAL DEVICES AND THE BRAZILIAN DTV

The architecture developed in this study used the specification of the Brazilian DTV middleware presented in [10], specifically the layer Ginga-J, which allows the Xlet Java applications to be executed.

The system collects data from a device equipped with a pulse oximeter, a temperature sensor and a blood pressure tester that sends information to a central computer at home equipped with a message alert system.

We can see in Figure 1 (B) this scenario based on an automated home, which has a local network integrated with an Internet router and a gateway to manage the devices in the house. Thus, taking advantage of this infrastructure, we insert the sensors and medical devices in the network using wireless networks connecting to the gateway.

The equipment is connected via Local Area Networking (LAN) and Wireless Local Area Networking (WLAN) and is used to transmit SMS messages via mobile phones integrated with the gateway. Completing the scenario, Figure 1 (A) represents the mobile system receiving warning messages via cellular network and the registration system accessing the data from home via WEB.

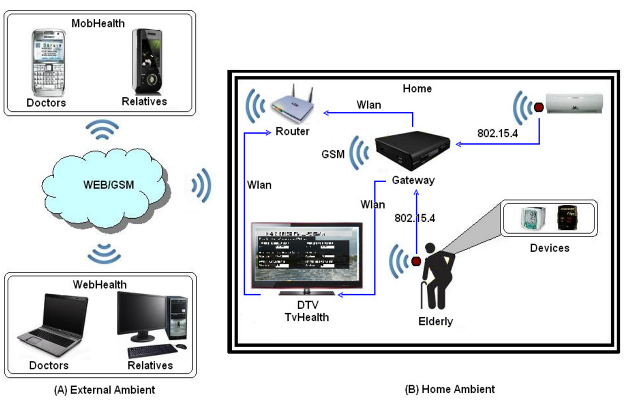

Figure 1: Scenario for a Monitored Residence

In our work we focus on the development of software architecture in X86 platform that encapsulates the virtual machine JAVA and JADE, installed in a Linux distribution, an application to monitor blood pressure, heartbeat and the patient's temperature. Moreover, our gateway has a WEB server, an application for digital TV and a mobile phone connected to provide SMS for doctors, nurses and relatives of patients being monitored

The system architecture has five layers, namely: Application, Decision, JAVA Virtual Machine (JVM), Operating System (OS) and Communication (COMM) (Fig. 2). The following description will show in details each layer of the system and their implemented functions.

The application layer is responsible for integrating all applications developed, such as WEB applications, mobile and DTV. This layer uses the JVM and WEB Server installed in the operating system, though the architecture which allows applications to be developed without the use of the JVM, for example particular applications developed in C running directly in the native operational system.

The decision layer is implemented using the JVM through Java Agent Development Framework (JADE) presented in [11] that is responsible for managing applications, exchange messages and updating the system status. This is done through the use of behavior supervision with pre-established agents which are capable of deciding whether to send SMS based on the changes observed in the sensors.

The decision layer is instructed to monitor the heartbeat received from the pulse oximeter, check the temperature received from the sensor and check the temperature and pressure measured by the patient through the blood pressure tester. If the parameters are normal, agents continue monitoring and do not send messages. However, if the parameters are abnormally exceeded, the supervisor agent sends a message to a second agent that triggers an SMS to mobile phone users and sends an alert to the Set Top Box which is presented on the DTV screen.

The protocol messages of agents have the format of the Agent Communication Language (ACL) defined in [12] and have a number of predefined fields such as: the sender of the message, the list of receivers, the communicative intention, the content and the ontology.

In the OS layer, there is a Linux operating system, customized for the operation of the gateway to healthcare, which has been configured in the JVM, WEB Apache Server, PHP, JADE, Zig Bee, and RXTX API for USB support, RS232 and SMSLIB API support for sending SMS. Figure 2 presents a high level division of the modules through all the layers presented.

In the application layer, the modules *DataRegister*, *HcMonitor*, *SendSMS* and *DTVAlarm* were implemented by fully sharing the same Extensible Markup Language (XML) file, located in the root directory of the gateway. This XML file is monitored by *HcMonitor* and classes *Oximeter*, *Pressure* and *Temperature*, responsible for collecting data from sensors.

Through the registration of users and sensors, the module generates the XML *DataRegister* collects initial information from patients and *HcMonitor* module does the monitoring and updating of such information. Figure 2 shows the architecture.

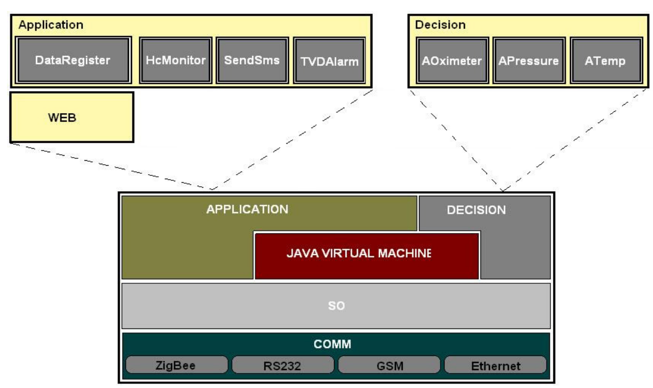

Figure 2: The General Architecture Dived by Layers

4. GameTV: A GAME FRAMEWORK FOR THE BRAZILIAN DIGITAL TV

The development of commercial interactive applications for Digital TV in Brazil is in its initial stages. Indeed there are a few consolidated experiences in creating educational applications for the Brazilian system available in the literature. Moreover, there are numerous difficulties in achieving quality education in large Brazilian regions like the Amazon State, where the use of Interactive Digital Television, that will be available to everyone in a few years, seems to be the most promising way for the educational inclusion of people who live in isolated, hard-to-reach cities. According to actual statistics more than 97% of the Brazilian families have access to the analog TV broadcasted signals and it is expected that at least the same amount of families will receive the digital signals in a very short time.

This scenario supports the proposal of this work, which is to investigate the environment of Digital TV and the necessaries characteristics for the development of educational games. The main goal is to propose a conceptual framework developed to help programmers to create games to digital television systems. It should assist the developer in the creation of these educational games, facilitating the construction of graphical user interface, handling of events and control of navigation.

As an experimental result we show that the platform contributes positively to the development of an educational game to teach engineering concepts, making the workflow of software developers and content television providers easier, abstracting the specific characteristics of the platform and the implementation of routines used in games. The easy usability of the framework permits that the teachers involved do not need to be professional software developers; they can use it to develop educational games to a specific content, including theory, goals and evaluation of the game itself, improving their classes and more interesting, reaching a large amount of families using the available Digital TV infrastructure.

4.1 Framework Architecture

The goal of this project was to propose a framework architecture for handling with games in Digital TV systems taking in account the Brazilian system and involving the study of the characteristics and requirements that such a framework should provide, within the limitations imposed by the Digital TV environment.

A study of the main characteristics of digital games was made in order to identify the features needed to be implemented and to propose an architecture for the conceptual framework. The requirements for the framework for digital games were defined as:

- It should provide support for the implementation of games running in Digital TV sets or STBs using the Brazilian system;
- The framework should use the paradigm of object oriented programming and give technical guidance to engineers and software developers in order to enjoy the benefits and ease of this paradigm;
- It should be constructed on basis of free software license, stimulating the research and share of ideas and experiences with the community;
- The Framework may initially operate in the Windows platform, but should be extended to support the operating system; GNU / Linux;
- The implementation of the Framework will be in Java because it offers portability, high performance and is object oriented.

The architecture suggested for the framework of games for Digital TV is explicit in Figure 1.

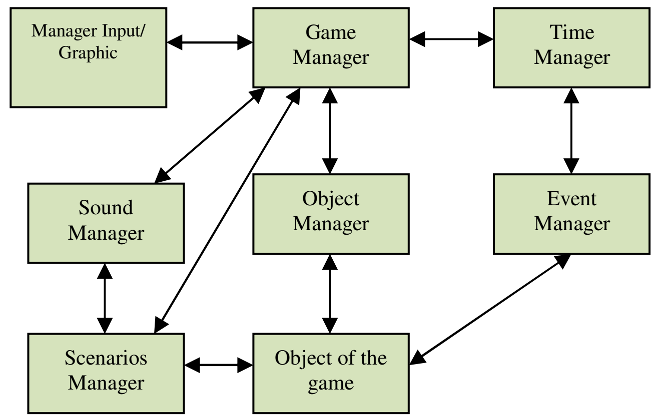

Figure 1. Conceptual model of the architecture of the Framework.

4.2 Implementation

Aiming to assist the development process of the architecture we present a survey of the main processes in relation to the functionality in the framework. Such processes have a simpler system functionality, and each process may involve one or more classes of control according to analysis. In the analysis phase we defined four basic processes:

- The main process is the system initialization and coordinator of other processes, responsible for creating the life cycle Xlet;
- Process of adding objects is the process responsible for creating objects such as text, image and sounds. Allowing the loading and manipulation of objects in memory;
- Procedure for handling events: responsible for all events in and out of the system by user interaction with the game;
- Process of converting the game to Digital TV: is the fundamental process as it allows the insertion of each object and performs the processing of them in Xlet to run the game in the STBs.

A tool named GameTv was developed and is responsible for the creation of graphical interfaces of games related to the main functional processes. The implementation is accomplished through the development of the following modules: Game Manager, Graphic Manager, Sound Manager, Event Manager, Object Manager, Scenarios Manager that will be presented in a future paper.

5. INTERACTIVE DIGITAL TV NAVIGATION SYSTEM PRODUCT LINE

An iDTV Navigation System combines program recommendation, sorting and retrieval to make it easier for the viewer to select programs based on various individual viewing habits [13], and is the guide to select services and applications, initiate interoperable applications, boot loading, and store user profiles [14]

In this Section we describe an iTV navigation system software product line (SPL), defining its reference architecture, and product backlog, that were described through a process called ScrumPL, that combines Software Product Line Engineering (SPLE) [15] and the agile method Scrum [16, 17].

This SPL is designed to create many products to be used in several parts of the word, for ISDB [18], DVB [19] and ATSC [20] standards and several languages, allowing a manufacturer to develop several iTV navigation systems at reasonable costs, enhanced quality and reduced time to market, each with similar user interface, the same recommendation system and Electronic Program Guide, and one of the available iTV standards (ISDB, DVB or ATSC), one language for a low-end, mid-end or high-end set-top-box market segment. Those reference architecture and product backlog are designed to be implemented and tested by several scrum teams.

5.1 ScrumPL Process

The ScrumPL process is composed of the Scrum lifecycle phases planning, staging, development and release [16]; and the SPLE processes domain engineering and application engineering [15]. During the planning phase, domain and application requirements are provided and added to the product backlog through the domain requirements engineering and application requirements engineering sub-processes respectively.

Those requirements are inputs to the staging phase, where the reference architecture is created and maintained through the domain design sub process, and the applications architectures are created and maintained through the application requirements engineering sub process. The architect, who is also the product owner, is responsible to create and maintain the reference and applications architectures, and to add each of its components, descriptions and interfaces to the product backlog as product backlog items.

The development phase starts when the product backlog is prioritized and made ready for estimation. The pre-game phase is finished and the Scrum team works according to Scrum process [17]. The results from Scrum team activities are potentially shippable components realized and tested, as well as unit and integration test cases (from domain tests and application tests) used to perform Scrum acceptance tests in this sprint (a 30 days iteration), and to be used in future regression tests. Those test cases are reusable.

During the 30 day sprint, the Scrum team can provide the domain realization goals: the detailed design and implementation of reusable software assets; or provide the application realization goals: applications that can be tested and brought to the market after ensuring sufficient quality.

Although Scrum states that the product owner is not able to change the product backlog items being realized by Scrum teams, the architect, as product owner, can make any changes in other product backlog items. Those changes are made due to, for instance, problem reports, new requirements, changes in interfaces, defects in interface descriptions, issues in realizing domain and application artifacts, and other.

In the release phase, applications are deployed. Before that, system integration and tests are performed and eventual bugs are fixed by Scrum teams through scrum process.

5.2 ITV Navigation Reference Architecture

The reference architecture is a core architecture that captures the high level design for the applications of the SPL. It includes the variation points and variants documented in the variability model realized by components [15]. The iDTV navigation system variability model contains 3 variation points: language, market segment and standard. The *language* variation point has variants representing languages for the iDTV navigation system, depending on the countries which it will be used. At least one of those languages is required for each application.

The *market segment* (MS) variation point has variants representing *low-end*, *mid-end* and *high-end* market segments. Each application requires only one market segment variant. The *low-end* variant contains *this channel information* and *block programs* components. The *mid-end* variant contains the *low-end* variant and *reminder, search programs and full guide* components. The *high-end* variant contains the *mid-end* variant and *recommendation* and *personal video recorder* components.

The *standard* variation point has variants representing the ISDB [18], DVB [19] and ATSC [20] digital TV system information standards, which are realized by parser. Each application requires only one standard. The system information standards provides information about TV programs and events, like start time, duration, synopsis, etc.

5.3 ITV Navigation System Product Backlog

The iDTV navigation system product backlog contains all packages, components and interfaces from reference architecture as product backlog items. In this product backlog, the column *story detail* provides detailed requirements; *prioritization* defines the product backlog item priority; *estimate* is the product backlog item estimation size; and *sprint* is the planned sprint that product backlog item will be realized. Those columns are part of any common product backlog.

In application design sub-process, beside other activities, variants are selected to be part of specific applications. To identify the product backlog items that are part of a variant, we added the columns *variant* and *variation point*, and to identify the applications that the product backlog items will be part, we added the *application* columns representing each application of this software product line.

The product backlog is ready to be estimated and detailed by scrum teams, and to manage the iDTV navigation system SPL development using the ScrumPL process.

6. CONCLUISONS

The television sets are present in more than 97% of homes in Brazil, which represents approximately 70 million of families. The Brazilian Digital Television System is working hard to reach all these people as soon as possible. Indeed, Brazil's main objective is somehow different than any other country that has adopted Digital TV: besides improving the reception quality and increasing the amount of programs, among other benefits, Brazil wants to carry on the digital inclusion of the population.

In fact, the growth in Interactive Digital Television technology in Brazil provided an extraordinary opening to significantly broaden the role of television. Applications like T-Health, T-Government, T-Commerce, and T-Learning are some examples of value-added services offered over digital television infrastructures that start to be present in the daily life of the Brazilian population. It also provides scenarios for integrating Digital TV with other areas of knowledge such as smart environments and ubiquitous systems, allowing access to services until now not easily achievable.

The University of Amazonas, in particular the CETELI – Electronics and Information Technology Research and Development Centre – is contributing to the establishment of this new technology. We have been teaching young students and scientist, as well as proposing innovative solutions for the local market.

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