Developing Applications for Interactive Digital Television Systems: Experiences and Practices Based-On the Lifecycle of Interactive Programs

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Abstract — This work aims to present strategies for implementation of a prototype of a sufficient platform for building Interactive Services Provider (ISP), which can store, analyze and generate reports based on information derived from the interaction of TV viewers with applications in Digital Interactive Television, characterized by the use of a back channel. In case of brazilian scenario (Brazilian Digital Television System), this work is placed in the context of programs for Interactive Digital TV, considering the communication aspects of applications developed in a generic middleware. Strategies are presented for the development of a layer of software residing on the viewer terminal access. This layer has the ability to communicate with an external server to provide a wide variety of interaction services. The results are shown as well as future work.

Keywords: Interactive Multimedia; Digital Television; ISDTV-T Middleware. Tools.

1. INTRODUCTION

The increasing processing power of different kinds of devices (mobile phones, set-top boxes, computers, among others) along with the broadening networks bandwidth and content availability are substantial reasons for the need of information and communication convergence. The digital convergence results on the production of a new way to interchange and interconnect different types of media [1].

As a consequence, general changes related to media and to communication vehicles are emerging. The Internet and mobile communication technologies have been providing several digital services. The TV, for example, has been following this trend through the digitalization process that occurs in this whole chain, starting from production, passing through edition, transmission and reception of the content.

One of the main innovations that are expected with the advent of the Interactive Digital Television (ITV), especially in the context of Brazil, is the possibility of providing a wide range of new services and applications (e-commerce, distance education and the electronic government) with possibility of interaction of the TV viewer, offering forms of interactivity unknown in the analogical television system [11]. However, as a relatively new technology, with few patterns and research in progress, the building of applications, services and systems for ITV still is a challenge, especially for those who have their business or personal interests associated to the television system, but not dominate technologies and computational tools. In this sense, it is actually a complex and new universe for activities such as planning and development, especially in terms of strategies to be adopted for the interaction of the TV viewer.

This work is inserted on JiTV (Java Interactive Television) Platform which covers the complete stages of the life cycle of an interactive digital television program (iDTVp). This life cycle starts with the production and distribution of the data carousel (streams of audio, video and data), followed by formatting of audio-visual content and controls of interaction for presenting on the access terminal of the digital television system [8][9]; the last stage is centered on TV viewer interaction, both the local level (resident applications without back channel) and full-time interaction (with the use of a back channel via any communication infrastructure) [7].

2. SYSTEM DEVELOPMENT

The digital standard of content provided by Digital TV enables a great exchange of information between the television system and the Internet, with a great potential for education [12], entertainment and cultural applications. This trend is intensifying with the evolution of mobile phones and recent developments in IPTV (Internet Protocol Television) and 3DTV (Three-Dimension Television) [2].

The Digital TV system combines several technologies to improve image quality. The reception and decoding of the signal is performed by a highly compact system known as set-top-box. Aiming at portability, the Brazilian Digital Television System (SBTVD) was developed based on the Java applications model [3]. The environment in which applications are executed is called middleware. It consists of several modules, including a compact Java Virtual Machine (JVM) for the execution of applications [4][5].

In the Brazilian case, the middleware has been developed in a joint work of researches from Federal University of Paraiba and Catholic University of Rio de Janeiro, called Ginga (additional information available at http://www.gingancl.org.br). An application to run on Digital...
TV follows a pattern called Xlet, which is a simplification of
the applet model designed to support applications for Digital
TV. Thus, a Xlet is a Java application that, similarly to the
applet, can be controlled in different ways by the user.

Several Brazilian research groups were gathered in a
consortium with the aim of developing technologies for the
deployment of Digital TV in the country. The objective of
the consortium was to develop the following: a) hardware
technology; b) software components (middleware); and c)
novative applications to run on the system. Also, it was
considered the following scenario for the Brazilian Digital TV
applications: 1) TV without return path (i.e. back channel to
connect to the Internet); 2) TV with intermittent return path
(i.e. dial up, cable, wireless, among others); 3) TV with
permanent return path, such as a broadband IP connection.
When available, the return path can be used to provide
interactivity in applications, such as real-time live voting, for
instance.

The work presented in this paper was developed as an
application of this consortium. Also, in order to allow a
process of social inclusion, it was established that the
application should have a minimal cost to consumers, and
therefore the first scenario was chosen as more appropriate for
the proposed application. However, even without return path
the proposed application can provide a highly interactive
experience to the users.

2.1 Infrastructure and middleware

Unlike in other contexts (United States, Europe and
Japan), where digital television systems have been developed
and are in use [2][12], the conditions for deployment and use
of the system of digital television in Brazil have very specific
characteristics, such as the case of the need for digital/social
inclusion of the brazilian people.

The layers of middleware (Figure 3) must provide resources
for hardware and software components (TV viewer’s access
terminal) operate together and transparent way to the TV
viewer, providing robust interfaces and simplified use. In this
proposal, the interactive program is the central element of an
interactive television system. The interactive program can be
defined as the set of all the medias (and its descriptions),
scenes (and its descriptions), a summary (or synopsis) and its
programming, as it shows the Figure 1.

Initially, the use of profiles allows better adaptation of
interactive programs to the TV viewer. The Figure 2 presents a
UML (Unified Modelling Language) sequence diagram, which
shows the essential functionality of the actions that are
performed between actors of the system (producer/sender, set-
top box and TV viewer/user).

As showed in the Figure 2, the sequence of events has
beginning when the TV viewer (user actor) decides which
interactive program will go to attend; chosen the program,
STB (STB actor) requests the delivery (sender actor) of the
authorized profiles; then, these profiles are sent to the STB,
which presents the options to the TV viewer; the TV viewer
chooses the profile then the STB makes the calling to the
sender; in this solicitation is requested the audio/video

![Figure 2: UML Sequence Diagram for entities of interactive program](image)

![Figure 1 - The Essential Components of the Interactive Television Program](image)

![Figure 3 - Layers of the Brazilian Digital Television System (extended from Sun JavaDTV Specification)](image)
streams and XML metadata for the desired program [13].

In this kind of environment, software agents can provide contextual information to the STB, enhancing the capabilities of the profile. Thus, the STB can use this information (contextual data), for the automatic adaptation of the interactive program to the TV viewer interests (profile).

2.2 JiTV Platform

The current approach to the development of interactive applications in worldwide provides [1][2], in most cases, the addition of some controls of interactivity, such as menus and buttons, to the audio-visual content of the traditional TV. Practices included in this context have led to applications such as Enhanced Television, for example. However, with a similar technological framework it is possible to develop applications and services with other levels of interactivity and high level of adaptation to classes of users/TV viewers of a digital television system, such as the ISDTV-T (International System for Digital Television Terrestrial), which has particularities and specific characteristics in relation to other international systems (DVB – Digital Video Broadcasting, ATSC – Advanced Television System Committee, ISDB – Integrated System for Digital Broadcasting) [2]. In this context, one aspect is desirable to subsidize the developer of iTVP: the possibility to offer the same interactive program to TV viewers with different interests (profiles) [6].

In designing the platform JiTV, the program (iDTVP) is the central element of an interactive application, being composed by the set of all elements of media (audio, video and images), a summary (or synopsis) containing the content television descriptors, bytecodes and information elements, as showed in the Figure 2.

2.3 Building Interactive Programs with JiTV Platform

For the implementation level, the iTVDP is structured with the use of XML (Extensible Markup Language) schema, as encapsulated in two other macro-structures: a) issuing b) programming. Additionally, external structures also affect the definition of iDTVP: a) genera catalog of the program; b) catalog of languages; c) special services (close caption and translation to LIBRAS – Brazilian Sign Language, by example). Some details of these structures can be seen at recent work published about the JiTV platform[8][9][10][11].

From the media elements, the bytecodes and of the information available on the synopsis, it is possible format the multimedia content for the different TV viewers, allowing different levels of interactivity, which is compatible with traditional proposals related to the Multimedia Home Platform, as far as presentation of multimedia content [2].

In general lines, the tools of the platform should allow sufficient shares of authors to build a iDTVP structure and its distribution to TV viewers. Moreover, in terms of the receiver, tools should be available to format the content according to the access terminal of the TV viewer (TV, PDA, personal computer, mobile phones, among others) and present it in that terminal, allowing the actions of interactivity previously set in the construction of iDTVP. The Figure 4 presents the architecture of the JiTV platform, with focus on the production side and transmission of iDTVP; a similar architecture exists on the reception side and interactivity, and is not reported here for reasons of space [11].

![Figure 4 - Architecture of the JiTV Platform (production, distribution, interaction and back channel)](image)

For the televiewing side, the JiTV Platform contains a lot of tools and applications for enabling interaction. The Figure 5 shows the interface of the multimedia player based on multiple channels of programming. On the screen, it is possible to control the presentation of a channel of audio and recorded video, a channel of live audio and video, a channel audio, a connection with a web browser, as well as areas for viewing, interaction objects and widgets (menus, quiz, captions, among others).

![Figure 5 - Screenshot of the JiTVPlayer showing support for multi-programming](image)

In the Figure 5, there is a set of icons for flagging (upper right of the screen) which enables the TV viewer to select the desired programming among the four schedules available on the system. In this player, it is possible to control the
presentation of live/recorded audio and video, starting resident/broadcasted applications and to access back channel for interaction.

3. TELEVIEWING INTERACTION

In a typical TVDI system, the treatment of televiewing interaction can be classified in three ways: a) from local/resident applications without back channel (a recommender TV system, for example); b) a semi-interactive system (an application for collecting data on disease, for example); c) full-interactive system (a voting system for political elections, for example).

In this context, the back channel is one of the most important parts of a ITV system due the fact it is involved with the revolution of the system as whole. Another important factor is the presence of Interactive Services Providers (ISP), which acts between the broadcaster and the TV viewer.

In the semi-interactive system, the treatment of interactivity is processed into access terminal of the TV viewer and there is no full-dedicated link to return information to the ISP.

In other hand, in a full-interactive system, information generated from the TV viewer's interaction can be sent to the broadcaster anytime, using both full-dedicated communication link and ISP infrastructure for data (Figure 6).

3.1 Applications

For validating aspects of televiewing interaction (specially in terms of the JiTVPSIStudio), three applications have been developed. The first one, called RecommenderTV, it was developed for local/resident interaction purposes; the second, called JiTVDengue, it was developed for collecting information about possibilities occurring a kind of disease at home environment; a third application, called JiTVElection, it was developed for supporting a voting system.

The Electronic Program Guide (EPG) helps the TV viewers. However, as new channels are available, an information overload is unavoidable making the EPG system inappropriate. The traditional EPG system became unattractive because it takes too long for the viewers to search in the hundreds of options available to find their favorite program. In face of this situation, the personalized recommendation systems are necessary. A recommendation system called RecommenderTV is shows in Figure 7 and it is implemented according to the standards of the digital television Brazilian system. The RecommenderTV allows the TV viewer to search the recommendation list selecting the wanted program [14].

The application JiTVDengue has been developed in order to investigate the possibilities of the occurrence of dengue (a typical disease which occurs in tropical countries, like is the case of Brazil) into a residence, allowing to the viewer to interact with the interactive application in order to answer four questions concerning the possible cause of dengue. Soon after the interaction of the viewer, the data are stored in the STB as a XML structure and sent to the JiTVPSIStudio, which store these data for use in government actions. In this context, the JiTVPSIStudio offers a set of tools for filtering data before sending reports to the government entities, as showed in Figure 8.

The application JiTVElection (Figure 9) was developed to simulate a political election system in a city, state or country, allowing to the TV viewer to interact with the interactive program in order to select in which candidate he wants to vote. After the interaction and confirmation of the vote, the data related to the candidate are stored in an XML file and sent to the JiTVPSIStudio, which store these information for later access of the Electoral Supreme Tribunal (which is brazilian department responsible for election system).
4. RELATED WORKS

Some authors approach the new way of developing applications for the receiver to access in order to describe the development process, but without worrying about the type of application that will result from the process. As an example is cited by Jones [15], which offers detailed steps for creating and publishing systems, giving emphasis to the stages of development and addressing small details of the system (life cycle, access control and file communication channel external). Its methodology involves the development of an implementation and usage of emulators for testing. Initial applications developed for the Digital TV environment have a tendency to bring TV to the context of the same features found in the Internet environment. Ferretti [16] proposes a simplification of the pages in HTML to a language called XHTML Basic to enable viewing on television, following the evolutionary line of Gil [17], which describes the existing functionality in the MHP middleware regarding the display of HTML. According to Gil, the DVB-HTML provides enough flexibility for the environment than traditional terminal receiver, despite the necessary adjustments to adapt the language for these new devices. Other authors deal to use email tool in the environment of Digital TV [18]. Mesquita has created a prototype email client to run the receiver through communication with a specific mail server. This server converts the e-mail messages in Internet format to a standard designed for communication with the access terminal. As one of the major goals of Digital TV in Brazil is the digital divide [19], a very important trend is the growth of studies on applications related to distance education in the context of Digital TV. Several authors address this issue and propose applications for the access terminal with the goal of education through the television channels. The applications of distance learning are called t-learning instead of e-learning for learning applications used on the Internet. A comparative t-learning and e-learning is shown in [20], stressing the differences between TV and Internet environment, and detailing the difficulties and obstacles encountered in developing applications for the TV receiver. More recently, it emerged other types of applications for digital TV. Batista et al. [21] propose to use the processing power of TV receivers as terminal processing parallel tasks. Through the communication channel idle are transmitted applications to run when the receiver is also idle, thus forming a network of receivers working on complex tasks and being coordinated by a remote server. In another study of a generic application is shown a framework for developing applications for digital TV [22]. This framework was aiming to abstract some important phase of development, allowing developers to build complex applications without having detailed knowledge of implementation details. The implementation of the system was made with the use of XML that would represent important functions such as data validation, security, support for multiple languages, and other authorization.

5. FINAL REMARKS

This work presented the design and implementation aspects of strategies for prototyping applications for digital TV using an interactive system to support interactivity using Interactive Services Providers, focused on the life cycle of applications, the prototype of interactive programs and treatment of interactivity in Digital Television. In this scenario, the JiTV platform is used to support the life cycle of interactive digital television programs. As a result of this proposal, further studies are under development with the objective to propose a bus of communication to be loaded into the environment of the TV viewer access terminal, given any choice of middleware, to provide all the support necessary for the transmission data to/from the ISP, through a return channel, allowing transmission of information to the broadcaster and storage. The Java APIs implement some strategies to communicate with back channel. However, the communication layer independent of the network environment (telephone line, ADSL, Wireless) is innovation in brazilian digital television system. Furthermore, records were not found
in the literature concerning the creation of a service of general communication with the back channel in digital television domain, which could provide mechanisms for data processing applications for Digital Interactive Television, which is an important point explored by this proposal.

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