A Platform for Gaming in Digital Interactive TV[*]

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Abstract: **Digital Television has increased its popularity the last years. Its' main advantage over traditional analogue TV is that it offers the viewers the ability to use their TV system in order to view or search for information in a way that is impossible with analogue TV. The next important step is the offer of interactivity with Service Providers, exchanging information, with the use of a return channel. Modern Set-Top-Boxes are not just decoders of the transmitted digital signals, but can be programmed to execute complex applications that can interact with the user through the use of the remote control and with Service Providers using a built-in modem and the PSTN network. Applications can be downloaded from satellite, loaded and executed dynamically, multiplexed with video and audio streams, along with the data needed, while a viewer changes the channel he/she watches. Using these types of applications the viewer becomes a user, using the provided services, despite of passively watching TV channels.**
In this paper, we describe an Interactive Digital TV platform being developed for delivering statistical and interactive services to the public. In particular, we use it for offering statistical data and an interactive game in which the users of the platform can compete by answering questions and making predictions.

1. INTRODUCTION

Users want the quality of services offered by television companies to be improved all the time. They want more choices that were not possible until now. Especially the last five years that the use of the Internet had a tremendous growth and gave to the wide public many new chances for entertainment, television businesses are trying to invent new ways for attracting more viewers. But, as long as the companies are functioning in the established analogue terrestrial, cable or satellite platforms, the quality of the video streams cannot be improved and the only new services that can be delivered to the public are teletext and subtitles. The new and innovating technology of Digital Interactive Television can offer essential improvements on the entertainment services offered by television and many benefits for the public and TV businesses.

The incomes that the analogue TV systems can produce are limited because of the limited bandwidth that is available. With digital TV, video and audio streams are compressed together. Having the same video and audio quality, requires only 2% of the bandwidth the analogue TV uses. The rest of the available bandwidth can be filled by other programs or services, like Video-On-Demand (VOD) or Internet Services. Also, by using digital broadcasting, many of the problems of analogue transmission (like noise and interferences by other signals) are solved.

The next step, after the introduction of Digital TV, is *Interactive (Digital) TV*. Interactive TV is the term used for Digital TV services that deliver interactive services to the users, by using advanced Set-Top Boxes (also known as decoders). Such services can be chat, e-mail, e-voting, interactive virtual channels, etc. The degree of interactivity can differ among various implementations of Interactive TV Applications. Interactive TV Services can be separated in three categories: a) 'Enhanced TV', in which the users can just navigate in screens with information, that are transmitted constantly, multiplexed with the video and audio streams, b) Interactive Services with a non-permanent return channel (i.e. a return channel that is not open constantly, but for a few, small periods of time) and c) Interactive Services with a permanent return channel, which provides a permanent connection of the set-top boxes of the users with the Internet or an Application Server.

Interactive Services have been presented to the public in Europe and USA in various formats, but they are used only by a small number of users. However, market analysts predict a significant increase in the use of interactive services (and in the benefits of the businesses that offer them). Some say that in 4 years time, 25% of the households in Europe and USA will be using Interactive TV. In the year 2004 the digital interactive TV will be a 20 billion dollars industry.

Many companies are trying to get a bigger share from the growing market of Digital TV. The one that has the biggest success is OpenTV [1-3]. OpenTV is the largest company for interactive television, providing ready Interactive Client/Server solutions. The OpenTV operating system is used in more than 13 million Set-Top Boxes all over the world and has been chosen by at least 50 digital terrestrial, satellite and cable networks in more than 50 countries, including BskyB, TPS, QuieroTV, EchoStar's DISH Network and DIRECTV Latin America. Over 30 manufacturers sell set-top boxes using OpenTV middleware,

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including Motorola, Panasonic, Pace and Sony. It is also used in the STB of our platform.

However, the delivery of Interactive Services through Digital TV is not an easy task. Until now, for the delivery of TV channels, there was only one-way transmission of signals: the broadcast of the TV signal from the broadcaster to the users. Now, we also need the flow of information in the opposite direction: from the user to the service provider. This requires a lot of money to be spent for investments in hardware equipment (both at the user side and at the service provider side) and for software development (for the GUI of the application presented to the TV screen and for the manipulation of the services in the Service Providers side). However, these investments are necessary, especially considering the 'threat' of the Internet, as they will give birth to the Television of the new century.

In this paper we will describe a platform being developed for offering interactive services for Digital Satellite Television. In particular, we have developed an application for offering statistical data for football matches and offering the viewers the ability to play and compete in an interactive game, in which they have to answer some questions and make some predictions about the match.

In section 2 of the paper we will describe the architecture of the platform, emphasizing on the server side of the system. We will describe the main subsystems and how they interoperate. In section 3 we will give a detailed description of the overall system implementation issues. In Section 4 we describe the services that the platform offers to its users and the UI presented in the TV screen. In section 5 some enhancements are proposed that could be made in the future and finally, some conclusions that induced from our current work in the Digital TV field are presented.

2. SYSTEM ARCHITECTURE

Offering interactive TV services, requires the cooperation of many different subsystems, which will be described in the following paragraphs. Figure 1 gives a graphical representation of the overall platform architecture.

2.1 Historical Sports Data Service Provider

The Historical Sports Data Service Provider provides the Application Server with data about past competitions or games and statistical information about the schedule of the current competition, the players, teams, etc. All these data are called historical, because they exist before the start of the match being broadcasted. Before the start of the match, all the information we need is extracted from the Historical Data DB, stored in a specific format and after that we don't use the DB again.

This DB belongs to the Historical Sports Data Service Provider and is administered by it. The Application Server cannot access directly the DB, mainly for security and performance reasons. So, there is a program (called

DBClient), that runs inside the intranet of the Historical Sports Data Service Provider, creates some files with the information we need, and after that it connects to the Application Server and sends these files. The RDBMS used by the Historical Sports Data Service Provider is Oracle 8i, but this could change, without affecting the platform.
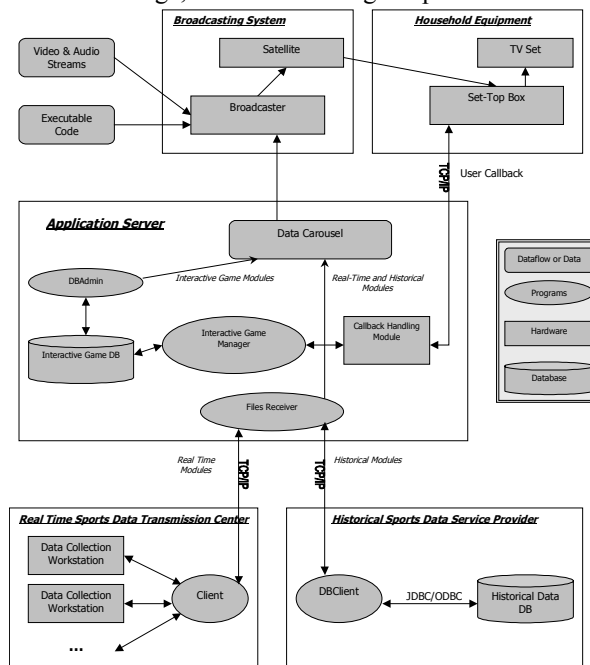

Figure 1 - System Architecture

2.2 Real-Time Sports Data Transmission Center

All the information used in the previous category is available before the start of the match being broadcast. Our platform, however, is used also for delivering statistics about the current match. In the stadium that the match takes place there is a team of statistics experts, gathering information about the progress of the match. They use a number of Data Collection Workstations, connected together in a network and insert data using some specialized programs. These data are collected together in the Real-Time Data Server and a text file is produced, containing all these statistics, every time data changes. Another program, running in the Real-Time Data Server, connects to the Application Server for sending the statistical data. This program analyses the statistics text file, creates some other files containing only the information we need, in a special format, and sends these files to the Application Server. So every time a change in the statistics file occurs, the Application Server receives within a few seconds the updated data.

When the match being broadcast is finished, the data of the match are not stored in the Historical DB by some program of the platform. Instead, the Historical DB is updated manually by people of the Historical Sports Data Service Provider. This happens because they want to be sure that the data they insert are correct and because they don't

want anyone outside their company to have the right to insert data in their Database.

2.3 Application Server

The Application Server is the coordinator of the whole system. It provides means of communication for all the other subsystems of the platform. The Application Server isn't one program running in one machine. It is a collection of programs that are running in multiple machines. The Application Server gathers all the information from the various subsystems, evaluates them and provides the broadcasting system the data to be broadcast.

The functionality of the Application Server can be split in two parts: the administration of the Interactive Game and the administration of the Statistical Services.

First of all, the Interactive Game needs a database for keeping records of the users competing in the interactive game, the questions the operator of the interactive game asks the users and the answers each user has given. We are using SQL Server 7 at the moment for this database, but in the future this could be changed. The DB is administered using a Java-based program, called DBAdmin. Using this program, the operator can enter questions, the expiration time for each question, possible answers for the question and the question points for the correct answers. He also inserts the correct answer for the questions, when they become available.

For the connection with the Set-Top Boxes of the Users, there is a system called Callback Handling Module. In this system, there are modems in which the Set-Top Boxes dial-in. This way a connection is established between the STB and the rest of the system. The STB communicates with the Application Server, using the HTTP protocol. The Interactive Game Manager handles the requests of the STBs, which could be requests for logging in, for first-time registration or for sending answers or other requests. After the end of the match and when all the questions have expired and are not valid anymore, the Interactive Game Manager evaluates them and assigns each user the number of points he has gathered. After that, the names of the 10 users with the higher score are extracted from the DB and are sent to the broadcaster.

Besides the administration of the interactive game, the application server receives the text files containing the real-time or historical statistics and forwards them to the broadcaster. For this reason, there is a program (File Receiver) that runs in the Application Server and receives these files from the Historical Sports Data Service Provider and the Real-Time Sports Data Transmission Center.

The data (interactive game, historical and real-time) which are stored as text files, in a specific format, are ordered in a continuous stream and are passed to the broadcaster. Some of these files, like the historical data, need to be broadcast only once, while some others need to be broadcast very often (like the real-time). The broadcaster decides how often a file is sent, the order of the files, etc. The broadcaster is also responsible for multiplexing the video/audio streams

with the data and executable code. This continuous stream of data is called *data carousel*.

2.4 Broadcasting System

The broadcaster is the system that does all the actual work of transmitting the executable code of the application, the data it needs and the video and audio streams. In this paper we are not interested in describing the broadcasting system, since it is quite complicated. When our platform goes to the market, a satellite broadcasting system will be used, but there are other ways of transmitting digital TV signal, like cable or DSL.

2.5 Household Equipment (Set-Top Box)

STB is a computer-like decoder of the digital signal transmitted through the broadcasting system. It decodes the signal and executes the software that is transmitted together with the audio and video streams. Also, it has a modem for connecting to the Internet, which is used as a callback channel. The operating system used in the STB is supplied by OpenTV. The STB executes the application and presents in the TV screen a user interface for navigating in the services that our platform offers. It has also the capability of storing data in EEPROM memory. The input of data and the navigation in the application is done through the use of a remote control.

3. IMPLEMENTATION ISSUES

The programming language used for developing most of the programs of the platform is Java. The reason behind our choice was the portability and interoperability of the Java language and the powerful and easy network capabilities it has. We have developed our programs without considering what hardware or operating systems will be used in the various subsystems of the platform. We can use x86 processor based machines with Windows, Linux or Solaris operating system or Unix machines or even Macintosh!

The delivery of the services the platform offers, is based on the interaction of the subsystems described earlier. We will describe how this interaction works in the next paragraphs.

Before the start of a match that is about to be broadcast, all the historical data must become available to the broadcaster. These data are transformed to text files having a specific format (historical modules), and are sent to the Application Server for broadcasting along with the video and audio streams and the executable code of the application. So, before the match starts, users have the ability to watch all this kind of information that pre-exists. The files are sent using an Internet connection. The program that sends these text files, called DBClient, is written in the Java language. For the connection with the RDBMS (Oracle 8i) we use the JDBC/ODBC Driver. We could use Oracle's JDBC driver, which would lead to faster execution of the queries to the

database, but one of the main design goals was to make the platform and the software used, as portable as possible. The connection with the Application Server is done using Secure Sockets (normal TCP/IP Sockets that add a new layer over the underlying network transport protocol, called Secure Socket Layer), which results to a higher level of security.

During the match, when a change happens in the file that describes the progress of the match, in the Real-Time Data Transmission Center, the file is parsed and analysed by a program running there. Since we don't need all the information it contains, we take what we need and compose four other text files with information about the major highlights (goals, penalties, fouls, etc) of the match (general statistics file), about the progress of the match (min-to-min file), about the composition of the teams and about changes in the score of the match. After that, these files are being sent to the Application Server. If a change in the original file doesn't cause a change in some of these derived files, the files that remain the same are not sent. So, we decrease the total size of information being sent. This is very important, since we use a dial up Internet Connection for sending the files and the bandwidth is limited. Again, we use Secure Sockets for the connection with the Application Server.

The Interactive Game is an application that provides the users some questions they have to answer. The user inserts data in the Set-Top Box Application, using his remote control (these data can be his personal data or answers to questions of the Interactive Game). These questions can be of two types, related to their content: Prediction Questions, related with the football match that is broadcast, or Knowledge Questions, related to the history of the teams and the football league in general.

The interactive game uses "two-way" interactivity. A list of questions is made by an operator using a program called DBAdmin, that updates the Interactive Game DB. These questions are sent to the STB of the Users by the broadcasting system in a text file with a specific format. In the STB the application software presents these questions to the users and provides a mechanism for accepting the user's answers from the remote control. Another mechanism of the application software forwards the users' answers and other type of requests to the callback handling module of the Application Server. The connection with the Application Server is done through dial-up networking using the PSTN or ISDN network. Normally, if we had a permanent return channel, these data would be sent immediately to the Application Server, but we don't. This happens mainly for cost reasons, because the return channel is a normal PSTN or ISDN phone line. If the Interactive Game required a continuous existence of network connection, very few users would use it. To overcome this problem, we have added the capability to store data in the EEPROM of the STB. So, the data the user inserts in the application is stored locally, until his STB connects with the Application Server. Then, the data is sent using the HTTP protocol. The connection with the

Callback Handling Module happens at certain times during the match. A session is opened during the first 10-20 minutes of the game and a second session during the last 10-20 minutes of the game. All the requests of the user, that are stored in the STB, are served during these sessions.

The data is sent to the Application Server, as mentioned above, using the HTTP protocol. In particular, we use an HTTP request (post method) for sending the users' data to the Application Server. In the Application server there is a web server running (at the moment we use Apache, but in the future this could be changed), which receives the requests of the Set-Top Boxes and passes them to PHP scripts. For every possible request of the STB, there is a relevant PHP script, that handles the request. These requests are: User registration, user login, delete user, change user record, send user answers, player evaluation, referee evaluation and coverage evaluation. The scripts update the interactive game database and send a response to the STB, in order to inform it for the success or not of the update and to return the needed data. If there is any problem with the update of the database or the user's request, the STB is informed of the problem and it decides when to try sending the request again. Normally it retries immediately and if the problem is encountered again, it waits a few minutes, before retrying. The Web Server and the PHP Scripts are called 'Interactive Game Manager' in the System Architecture diagram.

In the Application Server, the data is evaluated (the login and password entered are checked and if they correspond to an existing user, the answers are evaluated) and the DB is informed for the total points the user has scored.

The interactive game lasts for the whole football season and the winners are announced at the end of the football season.

4. UI AND SERVICES OF THE PLATFORM

The application presented to the user aims to inform and entertain viewers of football matches through Digital Interactive Television. The services of the Application are delivered through a unified and usable User Interface. During the design and development of the UI the most important aspect was to make it easy and intuitive for the users to navigate in the various screens of the UI. The basic principles that characterize the UI and the navigation system are:

- Delivery of services through a tree-like top-down environment, using menus. The delivery of services follows the rule of navigating from the general to the specific, top-down.

- Simple navigation, using the only device for interaction between the user and his Set-Top Box, which is the remote control of the Set-Top Box.

- Design and handling of the "windows" of the application, based on tested techniques from other applications of Digital Television [5]. The basic goal is

the presentation of the available information with friendly and clear way, in order to be easily comprehended by the user.

- When the user is watching a football match that is being broadcast through our platform, the user can press a special button in his remote control and the User Interface of the application will be presented on the screen. The UI is separated in six components, as shown in figure 2.
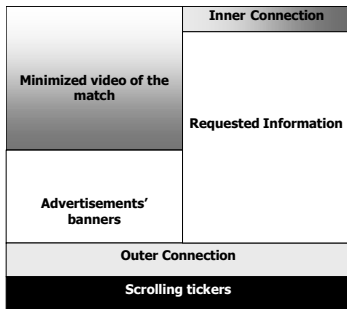

Figure 2 - UI on the TV Screen

The video of the match is presented minimized on the upper left corner of the TV screen, while the user is using the application, because this will make the application more user friendly. As you might also have noticed, the UI resembles most of the digital TV applications' user interfaces, so users that have used digital TV in the past will find quite easy the use of it.

The Services offered by our platform, using the User Interface presented above, can be separated in three basic categories, depending on the degree of interactivity between the User and his Set-Top Box (STB) and the degree of interactivity between the STB and the Service Provider. The categories of the services are:

Basic (Pseudo-Interactive). These are the services in which the User interacts with the STB, using his remote control and the information he chooses to see is stored in it. The STB does not interact with the Service Provider.

Enhanced (Pseudo-Interactive). These are the services in which the User interacts with the STB using his Remote Control and the information he chooses to see is received periodically from the STB, through the satellite.

Interactive. These are the services in which the user interacts with the STB and this interaction causes the transmission of data from the STB to the Service Provider and vice versa.

5. RELATED WORK

Almost all of the Digital TV platforms today offer applications for sports coverage. The capability to find historical statistical information, information about the current match progress or the league is not unique, but very common. In fact, these kinds of extra features was what made digital TV platforms audience to grow so much. OpenTV offers ready complete solutions for soccer games broadcasting (OpenTV Soccer [3]), offering all the kinds of statistical information we do. But real interactive applications, like the one we have presented here, have just started to be presented to the wide public (ie, from BBCi in UK [4]). This is what makes our platform one of the first of its kind.

6. FUTURE WORK

The use of a non-permanent return channel restricts the interactivity of the Interactive Game. The STB connects to the Callback Handling Module, sends the information it has stored and disconnects. In the future this could change by using permanent connection with the Internet (i.e. DSL). This will enable the delivery of much more interesting and complicated applications, since the users will be able to use their Digital TV like we are using today the Internet. Our interactive application could be enhanced by several ways. First of all the evaluation of the users' answers and the announcement of the best players could be done within seconds. This will make the interactive game much more interesting and competitive. We could also offer services, like chat, browsing in the WWW or email, which is impossible with a non-permanent connection. Of course, offering these kinds of services, requires much more than using a permanent Internet Connection.

7. CONCLUSIONS

Everybody understands that interactive services are going to have more and more increasing influence in the way of our lives. People will use their TV set not just for receiving information, but for searching specific information or having transactions. Digital Interactive Television provides users with many new features and ways for entertainment, since it brings the habits of the Internet to the TV set. Developing Digital Interactive TV applications requires huge investments in money and time, which perhaps won't be profitable in the next years, but surely will set the bases for future economic growth, when a big part of the public will be using Digital TV.

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