

# **DELIVERING INTERACTIVE ENHANCED SPORTS CONTENT TO THIN-CLIENT DTV STBS**

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**Abstract:** Digital Television (DTV) was the first major advance in the television industry since the establishment of color TV sets in the 50's. However, despite the ambitious anticipations, most DTV operators offering subscriber TV services are facing serious economic problems. Many believe that significantly increasing the DTV operator revenues is closely linked to the provision of advanced interactive TV applications which, on one-hand, based on content enhancements will attract more subscribers, and on the other hand will also generate indirect revenues through services like TV-commerce or on-line betting. In this paper an end-to-end interactive TV application is presented. The application has been developed for accompanying sport broadcasts, given that sports content is very attractive for the majority of subscribers. This application enhances sport broadcasts with relevant content (statistics, news, information) appearing on user-demand, as well as with an innovative interactive entertaining game of predictions challenging users to make predictions and to prove their anticipatory skills and sport knowledge. The application supports multiple types of forward and return channels and STB middleware systems. Furthermore, its components can be used in content distribution networks targeting multiple network-enabled information appliances.

**Key words:** Interactive, DTV, Thin-Client STB

## 1. INTRODUCTION

Television, by its nature, is not an interactive medium. However, introduction of digital television (DTV) technology allowed for serious progress towards that direction. It made possible to multiplex information and data together with the video and audio streams and broadcast them to the viewers. Using a set-top box (STB) connected to their TV sets, users may receive information and data related to the broadcasted programs (“Electronic” or “Interactive Program Guides” [1]) or to several other kinds of services [2], and have on-demand access to it simply with the aid of a remote-control unit. Instead of just passively watching a TV channel, viewers get the impression of interacting with the service provider since they are able to view information selectively. But this selection is usually made out of a predefined and limited set of information pieces repeatedly broadcast by the service provider in the form of a data carousel. Services of this kind are termed *one-way interactive* or *pseudo-interactive*, because of the illusion of interactivity that the viewers perceive. The main characteristic of *fully interactive* (also termed *two-way interactive*) services is not just the ability of selecting from a set of choices, but also the transmission of data from the viewer to the service provider.

Delivery of interactive services requires several structural changes in the traditional TV networks used for transmitting analogue or digital signals through various means, such as satellite, cable or terrestrial, from the broadcaster site to the viewers. Interactivity means supporting transmission of data in the opposite direction too. While content is delivered over a broadband *forward* channel, viewer requests or data are transmitted over the *return channel*. It is possible for the two channels to be implemented over the same medium (e.g., cable, ADSL), but there are cases, such as satellite and terrestrial forward channels, where for technical and economic reasons the return channel is usually implemented via PSTN, using a modem embedded into the STB. It is worth noting that the data traffic is one-way over the forward channel, but bi-directional over the return channel.

Development of Digital Television in the past decade was enormous. Initially, the offered interactive services were limited to pseudo-interactive services. In the last few years however, several fully interactive services have been deployed (e.g. BskyB, TPS, Canal+). Some of the existing interactive TV platforms are so advanced (e.g. AOLTV, UltimateTV), that one could say they bring the Internet to TV.

This paper presents an interactive application developed for enhancing sport broadcasts in general, through digital interactive TV (DiTV) platforms [3]. It offers viewers the ability for on-demand access to real-time and historical statistics about the match, the players, the teams and the league

among others. Also viewers have on-demand access to continuously updated information and news. But the main innovation of this application lies on its fully interactive part, an entertaining game, in which questions with corresponding expiration times are presented to the viewers. Some of the questions are general knowledge questions, while others challenge viewers to prove their anticipatory skills (e.g. to predict the final score of the game). Moreover, the application is designed to support multiple types of forward channels (DVB Satellite, Cable or Terrestrial, and any IP based network like xDSL, ETTH), multiple types of return channels (PSTN, ISDN, xDSL, SMS) and multiple STB middleware systems (OpenTV [4], Java, DVB-MHP [5]). Furthermore, its modular design allows for re-using its components in content delivery networks targeting several information appliances other than DTV STBs, like mobile phones and network enabled devices in general.

The present paper is organized as follows: In section 2, a detailed description of the end-to-end system architecture of the interactive application is given. In section 3, the interactive entertaining game scenarios, including all possible user actions, are presented. In section 4, the user interface and the services offered by the interactive application are briefly described. In section 5, implementation and testing issues are discussed. In section 6, future work and extensions of this application are presented. Finally, the paper is concluded with section 7.

A longer version of this paper can be downloaded from <http://ru6.cti.gr/Publications/cmsd2003long.pdf>

## **2. END-TO-END SYSTEM ARCHITECTURE**

The end-to-end system architecture of the interactive TV application is depicted in figure 1. The following describes its basic components.

### **2.1 Household Equipment**

Household Equipment refers to all equipment a user needs in order to get access to the application. This includes a TV set, a Set-Top Box (STB) and the corresponding antenna (e.g. a satellite dish), a return channel (e.g. a telephone line) as well as a remote control. The Set-Top Box is a device which when connected to a TV set provides the viewer with additional services. These services include reception and decoding of the video/audio signals, execution of the applications used to enhance TV viewing and connection with service providers through a modem and a return line. The

TV set is the output device for the STB, while the remote control is the input device used by the viewer for interaction with the STB.

## 2.2 Broadcasting System

The broadcasting system, located at the DTV operator premises, is used for transmitting the multiplexed audio-video information, data and the application code to the viewers. The transmission of the digital signal may take place over various media: satellite (DVB-S), cable (DVB-C), digital terrestrial (DVB-T) or any broadband IP based network, like xDSL or ETTH. The application was originally developed for satellite environment (which is the main case for Digital TV in Greece) but it can be easily retargeted to any of the aforementioned networks.

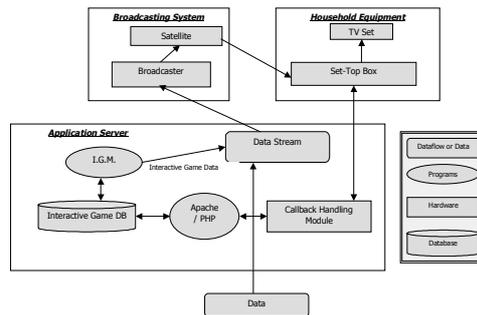


Figure 1. System Architecture

## 2.3 Application Server

The Application Server is the component of the system, which is aware of the target platform (STB) and the broadcaster environment. It holds the application code, which is executed at the STB, and the application data (information, statistical data or data related to the interactive quiz game) in proper format and delivers them to the broadcaster. It also receives the viewer feedback/requests, interprets them, stores received data in the proper database and performs corresponding actions.

The statistical data about the sport event are either *Historical* or *Real-Time*. The former category includes data existing before the start of the sport event (i.e. statistics about the teams, the players, the league or general information), while the latter includes information obtained dynamically in real-time while the event progresses. Historical and real-time data are received by the broadcaster in the form of simple text files (modules) in

specific format that is understood by the application software running in the STB. These data, multiplexed with the application code and the video/audio streams, are broadcasted to the viewers.

As mentioned earlier, the return channel is usually implemented through a common telephone line (PSTN or ISDN network). All the user requests submitted in the STB arrive at the application server accompanied by related data through the return channel in the form of an HTTP request (POST method) to be served by a Web Server. Apache was chosen for the implementation mainly because it is widespread, quite powerful, lightweight, free and ported on many computer platforms. Moreover, Apache supports the PHP scripting language, which is also free. PHP is used for getting and parsing the user requests and for updating the corresponding database. The RDBMS used for the database of the interactive game is SQL Server 7, a powerful and thoroughly tested product.

'*Interactive Game Manager*' is a Java program used by the interactive game administrator for feeding the Interactive Game database with the questions the users are challenged to answer. It also provides the capability for registering new users, deleting users, updating user records, inserting names in the MVP candidate list, and finally collecting the users votes. Interactive Game Manager produces three text files (the *Interactive Game Modules*) corresponding to: a) the questions, b) the MVP candidates and c) the top scores achieved by the user and extracted at the end of each game. These scores are sent to the broadcaster for delivery.

### 3. INTERACTIVE GAME

The application supports an interactive entertaining game in which questions arrive to the users before the start and during the course of the match [3]. The process of transmitting the questions is under control of the Interactive TV program director at the broadcaster site. The questions can be classified into two categories: *prediction* questions, related to the progress of the match and *knowledge* questions related to past events. Each question arrives with an expiration time after which no answers are accepted. This feature adds excitement and increases the challenge of the game while ensures game validity as well as fairness among the participants.

Users are able to submit their responses aiming to answer correctly as many questions as possible during each sport event. Individual scores are computed by a weighted sum that takes into account the degree of difficulty of each question. The interactive game terminates with the end of the sport event. However a "cumulative" game is also supported, in which the user scores (earned points) for a series of sport events (e.g. a football league) are

accumulated and a total score is calculated. Thus, at the end of the league, the user with the higher total score wins a “big” prize.

Questions arrive to the STB over the forward channel in a text-file format multiplexed with the audio/video signals, while the user feedback is submitted through the return channel.

The following section describes in detail the actions the user can perform using this interactive entertaining game application.

### **3.1 User Registration**

Only registered users can participate in the interactive game. For this purpose, the user has first to fill a registration form with use of the remote control. The registration form requests information such as First Name, Last Name, Telephone Number, Username and Password. The collected data are sent to the application server through an HTTP request. A PHP script gets and parses the data and updates the corresponding database. Then, the primary key of the new database entry, which is unique, is returned to the STB to accompany all the future requests made by the particular user. After a successful registration a user record is created and stored in the STB persistent storage (non-volatile memory - NVM). This record remains in the persistent storage until the user decides to stop participating in the game and selects to erase it.

### **3.2 User Login**

For registered users, logging-in is necessary to participate in the interactive game. The login procedure requires authentication and thus connection with the application server and the database. Obviously, more than one user can participate in the interactive game from the same set-top box.

### **3.3 User Deletion**

Users wishing to stop participating in the interactive game can choose the “Delete User” option from the application’s interface. The application sends a “Delete User” request to the application server to delete the specific entry from the database and erases the user record from the Set-Top Box’s NVM.

### **3.4 User Record Modification**

The application software gives users the capability to modify their profiles (first name, last name, phone number, username, and/or password)

stored in both the STB NVM and the application server. The users might also change their answers to the questions of the interactive game (if the time permits it) and/or their evaluation of the most valuable player of the match, the referee and the event coverage.

### **3.5 User Answers**

As mentioned earlier, questions may arrive to the users before the start and also during the match. Most of them are presented as multiple-choice questions to make answering easy for the users. To minimize traffic towards the callback server, the entire user feedback (answers and votes) is gathered in the set-top box non-volatile memory and submitted at the end of the interactive game.

The user answers sent to the server are compared with the corresponding correct answers and a score for each user for the specific sport event is calculated. This score is added to the user total score in case the user participates in a cumulative interactive game (e.g. since the start of the season). The top ten scores are broadcasted while the individual ones are returned to the STBs and stored in the user records in the NVM, to be visible by the users.

### **3.6 Evaluation of MVP Player, Referee and Coverage**

The STB application software allows the users to vote for the most valuable player (MVP), and to express their opinion about the Referee and the quality of the event's Coverage. Only one vote is permitted for each user in each category. For the MVP voting, a list with all the players participating in the match is given and the user has to select one of them. For the referee and coverage quality the user has to select among five choices (Excellent, Very Good, Good, Adequate and Poor). The voting results are broadcast to the users after the end of the sport event.

## **4. USER INTERFACE AND OFFERED SERVICES**

The described application supports both one-way interactive and fully interactive services. In the former case, users are able to navigate through a set of 'screens' offering pre-selected information, by simply using their remote control. In this case, there is no need for a return channel since the requested information is either locally stored or received periodically from the data carousel transmitted via the forward channel. In the latter case, a return channel (not necessarily permanent) is used for submitting user

requests and responses to the service provider. For some of the requests a response is coming via the return channel (e.g. user login), while for others some kind of processing takes place and the response is sent to the broadcaster for public delivery (e.g. voting results).

The services offered by the application can be classified into three categories: basic, enhanced and interactive. Basic services are services such as ‘help’, ‘general statistics’, ‘team information’, ‘player information’, ‘settings for score-time window’ and ‘settings for the scrolling messages’. These kinds of services are quite common in applications for sports broadcasting in digital TV platforms. Enhanced services is a category that includes services such as ‘score and time’, ‘statistics – game information’, ‘camera angle selection’ and ‘highlights’. Finally, interactive services are services related to the interactive game. These services include ‘adding users – updating user’s information’, ‘user predictions’, ‘game points’ and ‘interactive game rules’.

While watching a sport event broadcast enhanced with the interactive application described above, a small icon at the bottom right corner of the TV screen informs the viewers of the availability of various features, and their accessibility via a special button of the remote control. After pressing the specific button the viewers can see the application Graphical User Interface (GUI) appearing on their TV screen. The GUI, quite intuitive and very friendly, is split into six components, as shown in figure 2.

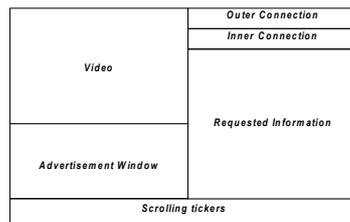


Figure 2. GUI on the TV Screen

Because of limited space, only two actual screenshots of the application can be presented. In figures 3 and 4 the ‘team line up’ screen and a screen of the interactive game are shown.



that bandwidth is very costly and that operators usually require quick integration times, an end-to-end lab environment was set-up for implementation and testing of the application. Intracom's DTV lab was used and enhanced for that purpose. More specifically, in the lab environment:

A Personal Computer (PC) is acting as the *application server*, gathering data/statistics from the databases and "live data" from another PC. It is also loaded with the application code. The application server, via Ethernet, feeds the *application playout server*. The latter is another PC equipped with a special PCI card supporting *Asynchronous Serial Interface (ASI)*, a standard interface for broadcasting equipment. Via the ASI interface, the playout server connects to the DVB multiplexer, where the application code and data is multiplexed with video and audio into an MPEG-2 transport stream. The latter feeds the *DVB-S modulator*.

The modulator output is looped-back to an OpenTV development STB, thus simulating very closely a real DVB-S environment. The user interacts with the STB via the *remote control* to test and experiment with the ITV application.

The STB, through its embedded PSTN modem connects to the *callback server*, which consists of a PC with a modem. The callback server submits user requests / feedback to the application server.

The lab set-up described above provides a very convenient, autonomous and realistic simulation environment for application development and testing. It is scalable, as it allows usage of several STBs through the cable network of Intracom's DTV lab. It also allows experimentation with real bandwidth, as the STBs are connected to the modulator output directly. Last but not least, the lab set-up is modular and extendable.

After its initial development in OpenTV, the application is being currently retargeted in Java, mainly for two reasons: First, to be supported by the Etherbox Home Gateway [6] as well as by other Java / DVB-MHP STBs and second, to allow portability to any Java powered information appliance with network connection (personal computers, mobile phones, PDAs, VoIP phones, etc.).

## 6. FUTURE WORK

The application presented in this paper, as most of the interactive TV applications, assumes usage by a single person. It is quite difficult for two or more persons to simultaneously use the interactive game. However, it can become possible for several viewers in the same room to simultaneously participate in the interactive game via a combination of two devices, an STB/TV set and a mobile phone. More specifically, questions can be

transmitted over the forward channel and be viewed by the whole group of viewers, while user answers can be submitted via Short Message Service (SMS) supported by mobile telephony operators. A further extension is usage of multiple TV screens, each presenting a different part of the application: one or more cover the sport event video, while others present the relevant information (statistics, questions for the interactive game). To support those extensions, this interactive TV application is in the process of integration with *I-Star*, a system for information presentation on multiple screens over a wide geographical area [7].

In the “convergence” era, Internet and Interactive TV are not the only mediums for the provision of interactive services. Several information appliances have been already deployed, including PDAs, mobile phones and advanced phones in general (ISDN, VoIP) and even white-appliances (such as refrigerators and washing machines) that incorporate microprocessors and have network connectivity potential. Content providers are interested in providing their content to different types of networks and devices to increase their revenue. Consumers, also, benefit from this kind of unified service provision as they may receive the same content or service, independently of place and terminal device. The field of *cross-media publishing* has emerged to cover those needs. In the application presented, content consists in three main ingredients: a) the sport event video/audio, b) the historical and real-time statistics and information relevant to the event, and c) the interactive game questions. The next step for the application is to offer this content to other devices, starting with Internet connected PCs and mobile phones. The video/audio is best targeted to TVs, but can be also streamed over the Internet. Provision of video over 3<sup>rd</sup> generation mobile phones is going to be possible, but it is questionable whether it will raise significant consumer interest (excluding small duration clips like highlights of the game). The statistical content as well as the most interesting part of the application, the interactive game, can be easily accessed over the internet, and can be also made available in the form of mobile phone services (SMS, MMS alerts).

To support other information appliances except for STBs, some of the components of the system architecture have to be modified. Those include the application server interfaces to the different networks (forward and return channels), as well as the graphical user interfaces of the target terminal devices. The application server as well as the data collection mechanisms can remain the same.

## 7. CONCLUSIONS

Sports content has always attracted lots of TV viewers, while digital interactive television is anticipated to be an important part of the worldwide entertainment market in the near future. For this purpose, an interactive TV application that enhances conventional sport event broadcasts with relevant historical and real-time statistics and information, as well as with an innovative interactive entertaining game of predictions, has been developed and presented in this paper. The application initially targets thin client STBs that still dominate the market, with OpenTV or Java/DVB-MHP middleware and different types of forward and return channels. In this paper the system architecture of the application was presented, including its main underlying components (STB, graphical user interface, databases and application server) as well as the interactive game scenarios and services offered. Future research plans for extending the application for group-TV entertainment and for targeting multiple types of network-enabled information appliances were also presented.

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## NOTES

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