Acta Universitatis Sapientiae
Electrical and Mechanical Engineering, 1 (2009) 143-154

Challenges in a Web-enhanced Personalised IPTV Service

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Manuscript received March 15, 2009; revised May 28, 2009.

Abstract: Internet protocol television (IPTV), one of the most emerging services, offers multimedia streaming services with security, reliability, and relevant quality of service (QoS) / quality of experience (QoE). It provides added values to all the involved players including customers and also brings technical and business challenges to those players. For IPTV services, we expect to adopt the managed network environment for high quality and the Web technologies for personalization to meet the customer's necessity. Web can provide an open, flexible, and agile platform. Therefore, in this paper, we propose personalized IPTV services based on Web-enhanced open platform and present the functional architecture. Technical issues for deploying the proposed services using Web are also provided. The objective of this paper is to analyze the critical architectural and design issues for developing an attractive, high-quality, viable and feasible model for personalised service.

Keywords: internet protocol television (IPTV), web-based television (WebTV), Electronic Programming Guide (EPG), metadata functionality, recommendation engine (RE)

1. Introduction

Currently, digital television is gradually replacing analogue TV. Although these digital TV services can be delivered via various broadcast networks (e.g., terrestrial, cable, satellite), Internet Protocol TV (IPTV) over broadband telecommunication networks offers much more than traditional broadcast TV. It can improve the quality that users experience with this linear programming TV service, but it also paves the way for new TV services, such as video-on-demand, time-shifted TV, and network personal video recorder services, because of its integral return channel and the ability to address individual users

[1]. IPTV service is considered as the emerging application that has a great potential to generate new revenues for contents and service providers.

In the last few years, we have witnessed a rapid growth of multimedia content delivery across the networks. Peer-to-Peer (P2P) networks and user generated content (UGC) are considered as one of the most suitable targeted infrastructure for supporting real time streaming and has played vital role in this growth. One of the major challenges of this approach is to reach the same quality of service of traditional television and commercial IPTV by employing only best effort network layer services. This service gives more choice to the end users to consume TV programs, on-demand content and UGC in a personalized way and beyond any geographical constraints [2], [3].

IPTV represents a solution for interactive television-like services. It combines streamed video, Web services, and eventually voice services. Personalized IPTV will be a key solution for value added services over the internet and the emergence of Web and next-generation networks (NGN) will provide open platforms and new business models for IPTV services in the future [4], [5].

The IPTV service stays in the centre of interest and is globally deployed. Web-based IPTV service is one scenario for efficient delivery of service. One can serve IPTV service through the internet, and IPTV subscribers can connect the service using the Web browser. Here, one can see that the existing Terrestrial / Cable / Satellite TV contents can easily deliver through the internet by integration of Web and IP data services (e.g. Joost, Zattoo). But the number of output channels to the subscribers is less than the number of input channels from existing broadcaster when existing broadcasting services are transmitted through the internet. In general, the output channel is allocated in the sequence required by the subscriber [6].

Current standardisation activities are presented in [7] for Web-based metadata applications, especially those of the ITU-T IPTV Focus Group, which is interested in service requirements, architecture and functionality to provide IPTV service. Among others, metadata functionality and Web technology are necessary to support interactive data service. Web technology is moving towards a so called Web 2.0, where one of the major features is to support more interactive capability.

The objective of this article is to present the design of a web-enhancement of an IPTV model, establish the associated framework for such IPTV services delivery, and contribute to discussions and research activities. At the same time, the conclusions and the proposed model will serve as a framework for future efforts in our laboratory test environment. Chapter 2 presents our modelling approach, explains the selected architecture, gives implementation details and describes the reasoning behind the selected programming techniques. Chapter 3

gives further details on the methodology of the implemented recommendation engine. In Chapter 4 we discuss the challenges during design and implementation phase. Our future plans are revealed in Chapter 5. Finally we draw our conclusions and provide a list of recent reference works.

2. Architecture of the web-enhancement of an IPTV service

At the beginning of our investigations we have analyzed tens of web-based applications, like youTube, joost, Zattoo, audiTv, videa, mySpace, flickr, hirTV, mtv, DunaTV, etc. We have looked for fancy design ideas, creative features and intuitive navigation with a clear target to create something new. Beside this, we have run speed tests and taken into account the usability, simplicity, platform independency, multiple tools and many features that web-based systems provided. Based on this learning, we started to design our own model. For example, we decided that the clients do not need to download any additional software when they open our web-based application, and there should not be any need for additional installation and configuration. A well-known WebTV application that started with downloadable client software is Joost. After a while they had to abandon the idea of using downloadable player and switched to an all web-based solution. But Joost is not the only one who realised that the future is a web-based solution. Others who had not switch to web-based applications failed or they are about to fail or simply they are not enjoying popularity.

For the design of our application, the main goal was to structure it in modules which can be easily maintained and extended in the future (see *Fig. 1*). Besides that, the optimization process will be easier too, namely because a well structured and clean code is easier to be optimized.

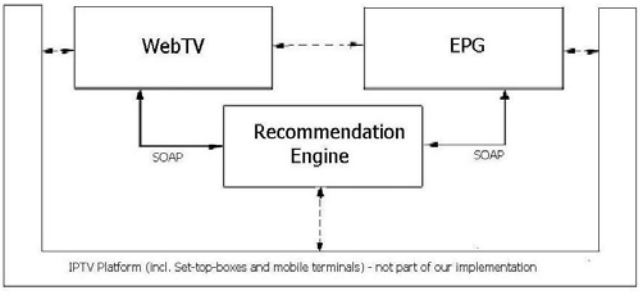

Figure 1: The basic modules of our implementation.

Our system consists of three main modules which are to be integrated into an IPTV platform in the future. However, currently these modules work stand-alone and co-exist without any background IPTV platform. The WebTV module

is responsible for displaying the aimed content on a PC or a TV set with integrated internet access. The consumer shall search for a specific video content or linear TV program. To ease the selection of a TV channel and that of a dedicated program within the channel, the EPG module was created. We have analysed the available EPG sites on the web, like tvtv.de, zingzing.co.uk, programy-tv.cz, port.ro, dunatv.hu, neuf.fr, then we have tried to take the best ideas out of them and implemented it in our own way. The third module is a so called recommendation engine (RE). Our aim is that the consumer after watching a movie or a TV program will be provided with a recommendation to watch another movie or program of the same category or with the same actor, or from the same author, etc. Our output is based on the personal profile of consuming movies and TV programs, while this profile will be updated continuously. Our recommendation engine is presented in more details in Chapter 3. *Fig. 2* presents more details on the modularity of our solution. The most important sub-modules, programming languages and interfaces are also depicted.

Without being subjective, we realized that one of the best web-based video-players is that of Adobe Flash, which is also easy to embed into our application. However, it is not optimal to implement the whole application in Flash technology. The main reasons are: long loading-time of the whole site, relatively big amount of data required, lack of modularity of the site, more time needed for development and difficulties in the personalization of the URL site. Presentation of text-based frames in Flash is difficult; copying text is simply not possible. In contrary, an html-based site performs better in all above examples. Therefore, it is straight-forward to decide for a flash player embedded into an html-based presentation layer.

Adobe ***Flash*** is a multimedia platform, Flash is commonly used to create animation, advertisements, and various web page components, to integrate video into web pages, and more recently, to develop rich Internet applications. Several software products, systems, and devices are able to create or display Flash content, including Adobe Flash Player, which is available for most common web browsers.

Ajax (Asynchronous JavaScript and XML), is a group of interrelated web development techniques used to create interactive web applications or rich Internet applications. With Ajax, web applications can retrieve data from the server asynchronously in the background without interfering with the display and behaviour of the existing page. The use of Ajax has led to an increase in interactive animation on web pages. Data is retrieved using the XMLHttpRequest object or through the use of Remote Scripting in browsers that do not support it. Despite the name, the use of JavaScript and XML is not actually required, nor do the requests need to be asynchronous.

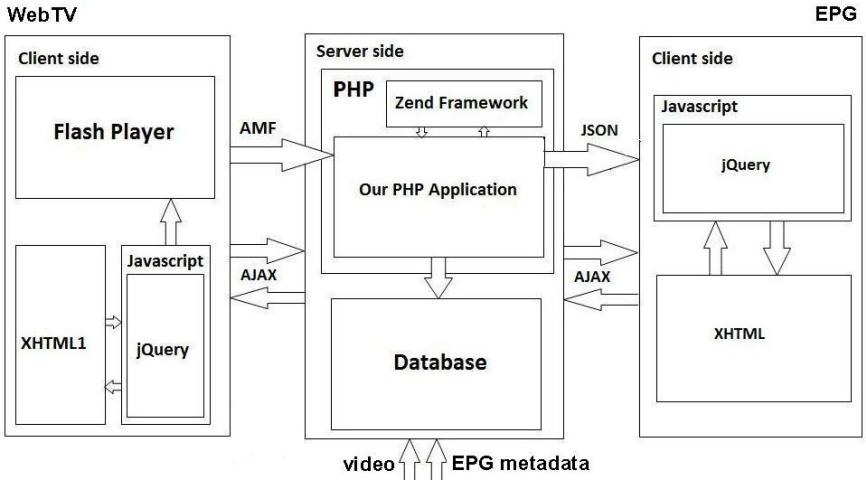

Figure 2: Sub-modules and interfaces of our WebTV and EPG modules.

XML (Extensible Mark-up Language) is a general-purpose specification for creating custom mark-up languages. It is classified as an extensible language, because it allows the user to define the mark-up elements. XML's purpose is to aid information systems in sharing structured data, especially via the Internet, to encode documents, and to serialize data; in the last context, it compares with text-based serialization languages such as JSON.

JSON (JavaScript Object Notation) is a lightweight computer data interchange format. It is a text-based, human-readable format for representing simple data structures and associative arrays (called objects).

PHP is a widely-used general-purpose scripting language that is especially suited for web development and can be embedded into HTML. It generally runs on a web server, taking PHP code as its input and creating web pages as output. It can be deployed on most web servers and on almost every operating system and platform free of charge.

Zend Framework (ZF) is an open source, object-oriented web application framework implemented in PHP 5. ZF is a use-at-will framework. There is no single development paradigm or pattern that all Zend Framework users must follow, although ZF does provide components for the Table Data Gateway, and Row Data Gateway design patterns. Zend Framework provides individual components for many other common requirements in web application development. Zend Framework also seeks to promote web development best practices in the PHP community; conventions are not as commonly used in ZF as in many other frameworks [8].

JavaScript is a scripting language used to enable programmatic access to objects within other applications. It is primarily used in the form of client-side JavaScript for the development of dynamic websites. JavaScript, despite the name, is essentially unrelated to the Java programming language even though the two do have superficial similarities. Both languages use syntaxes influenced by that of C syntax, and JavaScript copies many Java names and naming conventions. ***jQuery*** is a lightweight JavaScript library that emphasizes interaction between JavaScript and HTML [9].

Action Message Format or ***AMF*** is a binary format based loosely on the Simple Object Access Protocol (SOAP). It is used primarily to exchange data between an Adobe Flash application and a database, using a Remote Procedure Call. Each AMF message contains a body which holds the error or response, which will be expressed as an ActionScript Object.

SOAP, originally defined as Simple Object Access Protocol, is a protocol specification for exchanging structured information in the implementation of Web Services in computer networks. It relies on Extensible Mark-up Language (XML) as its message format, and usually relies on other Application Layer protocols (most notably Remote Procedure Call (RPC) and HTTP) for message negotiation and transmission. SOAP can form the foundation layer of a web services protocol stack, providing a basic messaging framework upon which web services can be built.

An electronic program guide (***EPG***) is a digital guide to scheduled broadcast television or radio programs, typically displayed on-screen with functions allowing a viewer to navigate, select, and discover content by time, title, channel, genre, etc. by use of their remote control, mouse or a keyboard.

We have used PHP script language to generate dynamic html pages, as PHP is easy to connect with html presentation. Thus we can refresh in background parts of mixed web pages using Ajax technology. The communication takes place in the background and remains invisible for the consumer. The above technologies are all open, so we had the possibility to embed these frameworks in order to support our work. We have selected the Zend Framework on the server-side and the jQuery Framework on the client-side, as being the fastest, most robust and extendable among many frameworks. Usually there is a non-trivial problem to communicate between PHP and Flash, but the selected Zend Framework provides an elegant solution to this using AMF format.

Our implemented EPG allows a very easy navigation and selection of 100+ broadcast TV programs. Radio programs are currently not included. A sample implementation can be found in *Fig. 3*.

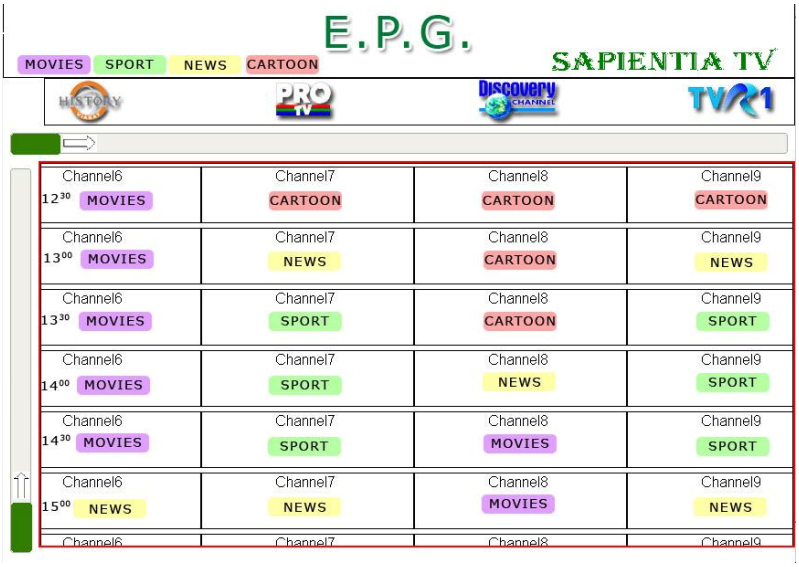

Figure 3: The EPG presentation allows easy navigation and selection (simplified).

All information about TV channels are stored in an XML file. This file is a Linux shell script, which is periodically updated with help of an external program. Data extraction from this XML file is processed in the server-side with help of the XPath expression that provides input to the PHP_simpleXML function. The server-side inserts the provided TV channels into the browser and generates a table that holds the daily channel information. The requested data arrives asynchronously to the client-side in JSON format, as reply to an XHTTP request generated by the client. The received data is processed by a JavaScript, and then displayed on the screen. The interaction with the browser is done by the same function. When the end-user navigates on the screen and moves the cursor, new data might be needed to replace old data. A JavaScript logic decides which data is necessary and if so, then generates new XHTTP requests to the server.

3. Recommendation Engine

The personalization and recommendation has more and more importance in today's TV consumption and web behaviour. More than 100 TV channels are a lot more than the consumer can easily manage; furthermore the internet is a huge information labyrinth, so our clear purpose is to make users' navigation and decision easier.

The manually filled profiles have risen seriously, but this is subjective and does not adapt to changing interests of users. There are two frequently used algorithms in today's recommendation systems: Slope one and Pearson Correlation [10]. These algorithms do not take into consideration the different kind of users and the human nature. A complete intelligent Web personalization system is generally based on Web usage data mining to discover useful knowledge about user access patterns, followed by a recommendation system to act on this knowledge in order to respond to the users' individual interest. The knowledge discovery component must discover distinct user profiles from Web usage data. Their unsupervised nature also avoids reliance on input parameters or prior knowledge about the number of profiles to be sought. A recent work [11], used item-to-item collaborative filtering as a recommendation strategy in Amazon.com. This approach matches each of the user's purchased and rated items to similar items then combines those similar items into a recommendation list. A similar-item table is built by finding items which customers trend to purchase together. Unfortunately, they do not present any empirical results, or sufficient details about the proposed technique. Moreover, it is not clear how this approach differs from standard frequent item-set based techniques.

There are three steps in the recommendation process: personalization, making clusters and decision-making with Fuzzy logic.

A. Personalization

This step is the automatic identification of the user profiles and updating these profiles via training with the newly mined information. At a first step it is better to use predefined user profiles. After the system collects enough information (e.g., about user's navigation activities and viewed content), we use clustering to give an updated description of the user's interest (e.g. in *Fig. 4*).

We implemented a hierarchical version of a robust genetic clustering approach. This process can be executed offline and periodically.

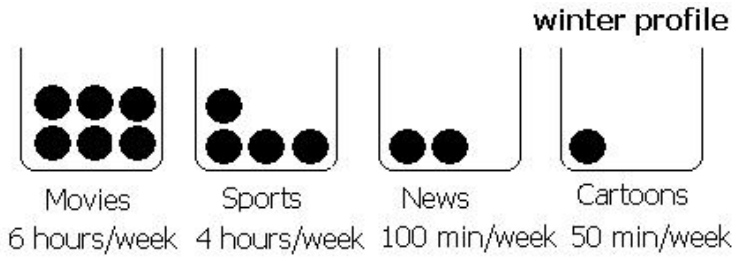

Figure 4: A sample viewing profile of a family member.

B. Making clusters

Our selected clustering algorithm is a so called Hierarchical Unsupervised Niche Clustering Algorithm (H-UNC). The basic steps of the algorithm are as follows:

- Encode binary session vectors;
- Set current resolution Level L = 1;
- Start by applying UNC to entire data set w/ small population size;
- Repeat recursively until cluster cardinality or scale become too small
  {
  - Increment resolution level: L = L + 1;
  - For each parent cluster found at Level (L-1)
    Reapply UNC only on data subset assigned to this parent cluster to
  - Extract more child clusters at higher resolution (L > 1)
  }

This clustering algorithm needs to execute in long periods (monthly or 3 monthly).

C. Decision making

Fuzzy approximate reasoning is an inference procedure that derives its conclusions from fuzzy rules and known facts. Generalized Modus Ponens is a generalization of modus-ponens which is the basic rule of inference in traditional two-valued logic. In two valued logic an implication (A _B) is used to infer the truth of proposition B from the truth of proposition A, and these truths can only be absolute (i.e., true or false). Generalized Modus Ponens performs logical implication in an approximate manner to deal with uncertainties in the facts (input) and in the implication itself. It is formalized as follows:

Fuzzy Rule: If x is A then y is B. Fact: x is A' → Conclusion: y is B' (1)

Where A and B are linguistic variables defined by fuzzy sets on the universes of discourse X and Y, respectively. A fuzzy If-then rule can be defined as a binary fuzzy relation R on the product space X × Y. The relation matrix R, which encodes the fuzzy implication, can be considered as a fuzzy set with a two-dimensional membership function: $\mu R(x,y) = f(\mu A(x), \mu B(y))$ that maps each element in X × Y to a membership grade in [0,1]. Using the compositional rule of inference, we can formulate the inference procedure in fuzzy reasoning as follows:

B' = A' ~ R (2) (2)

where ~ denotes a fuzzy composition operator, consisting of a conjunction, followed by a disjunction.

In the context of personalization, X denotes the space of profiles, Y denotes the space of visited contents, R is a relation that maps profiles in X to contents in Y with varying degrees of relevance. The rows of R can be defined by the relevance weights/components of the profile vectors. Input fact A' is a fuzzy set defined on X, thus naturally consisting of the memberships of a given session in each one of the profiles in X. Output B', the composition of A' and R is a fuzzy set defined on the set of contents, Y. This is the conclusion of the inference procedure, and compared to the original user session that was limited to a crisp set of contents, B' represents the possibility that each content on our website (or later on the TV screen) is of relevance to the current user as inferred via relation matrix R.

For better results we should train the membership-functions with a multilevel neural network. The "learning" data is the currently mined content information about the user, in this case the profile information we are storing in the weights of input membership-functions.

4. Challenges during design and implementation

Browser compatibility: Today we are over-flooded with a lot of different browsers on the market. Competition is good, but the disadvantage is that not all browsers support all the frameworks we are using, thus we have the challenge to test our solution with as many browsers as possible and provide compatibility. The jQuery framework helps a lot, but is still not so straight forward.

Common database: We faced some problems by database access from different modules. A common database offers advantages in many senses, but brings also a lot of disadvantages into the system, e.g., the concurrent access.

Modularity: We have decomposed our system into modules, aiming to define independent entities as much as possible. This is not so trivial. Due to security reasons the different modules cannot access the code of the other ones, thus we introduced the SOAP interface to realize the communication between modules.

Security issues: Due to the fact that parts of our source code are visible for smart users, it is extremely important to isolate the JavaScript on the client side from the rest of the modules. Another security threat could be any unverified input data from end users, therefore we strictly verify every input data before running, and this control is well supported by the Zeng Framework.

Concurrent usage: In case that our system is used by many users at the same time, we are challenged to run through an optimization process in the

current configuration. The availability of necessary external bandwidth is the problem no.1. As we already use the most modern and efficient encoding technology (H.264), it only remains to ensure more capacity. Suppose that we do not have a bandwidth problem, then our architecture could serve thousands concurrent users. This limits of course the usage of our solution in commercial systems, which can be easily solved by proper engineering (e.g. more HW).

Storage: Last but not least the storage space and its read/write speed is also a challenging problem in our solution. We did not go for expensive commercial solution, but selected a scalable file-server.

5. Next steps

At the moment we are still in the implementation phase, but our roadmap contains a couple of new elements. We aim to extend our PC-client based solution towards set-top-box based TV consumption and mobile handset. An important aspect will be adapting the display resolution to TV screen and mobile screen. Another aspect is derived from the consumer behaviour of leaning backward when watching TV, thus we need to adapt the size of the text which appears on the screen.

A third challenge is the integration of the remote controller into our application. We have started to create a new module which processes the necessary programs to interface with the remote controller. Basic functions are already available (like volume control). Exporting our application to mobile screens basically introduces similar problems as with the TV set, except the video resolution has to be reduced. The biggest challenge however is the unavailability of the right software for mobile handsets or the integration of our application into a handset, which does not necessarily provide or support open interfaces. A first approach is the use of Adobe flash lite, which is already implemented in a reduced number of mobile terminals.

Currently our web architecture supports only a video-on-demand solution, but we plan to integrate live TV sessions and IP cameras as well. Last but not least we also plan to introduce further features to support instinct navigation on the screen.

6. Conclusions

The IPTV service can deliver TV programs anytime anywhere. IPTV supports both broadcast and unicast services like Live-TV and Video-on-Demand. This paper identified the challenges in delivering web-enhanced IPTV and proposed a framework to provide solutions to those challenges. We have built a prototype of the system and demonstrated its flexible features, integrated

EPG, remote controller and recommendation engine. We are firmly convinced that our new EPG design is one of the most competitive designs on the market.

We are living in the content-centric world. The user experience of this new media is thought as a key factor for the success of an IPTV service. We are aware that still a lot of innovation is necessary in order to win the battle on "the last millimetres", namely between the consumer eyes and his brain.

Acknowledgements

The authors would like to express their gratitude to the Department of Electrical Engineering at the Sapientia University for providing the necessary hardware in order to support the ongoing research work.

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