# TV Recommendation and Personalization Systems: Integrating Broadcast and Video On-demand Services

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***Abstract*—The expansion of Digital Television and the convergence between conventional broadcasting and television over IP contributed to the gradual increase of the number of available channels and on demand video content. Moreover, the dissemination of the use of mobile devices like laptops, smartphones and tablets on everyday activities resulted in a shift of the traditional television viewing paradigm from the couch to everywhere, anytime from any device. Although this new scenario enables a great improvement in viewing experiences, it also brings new challenges given the overload of information that the viewer faces. Recommendation systems stand out as a possible solution to help a watcher on the selection of the content that best fits his/her preferences.**

**This paper describes a web based system that helps the user navigating on broadcasted and online television content by implementing recommendations based on collaborative and content based filtering. The algorithms developed estimate the similarity between items and users and predict the rating that a user would assign to a particular item (television program, movie, etc.). To enable interoperability between different systems, programs' characteristics (title, genre, actors, etc.) are stored according to the TV-Anytime standard. The set of recommendations produced are presented through a Web Application that allows the user to interact with the system based on the obtained recommendations.**

***Index Terms*—collaborative filtering, content filtering, recommendation systems, TV-Anytime.**

## I. Introduction

The proliferation of video programs provided by television and telecom operators, although contributing to attract new customers to these services does also raise some difficulties to the viewer on the selection, from the available assets, of content of his interest.

The traditional tools for television content search, the Electronic Program Guides (EPGs), do not efficiently meet the viewer's needs. These guides provide extensive lists of television programs that require the user to spend too much time in order to find a program of potential interest. A similar situation occurs in Video on Demand systems (VoD), where the search functionalities are usually pretty limited.

Overloaded with a lot of programs, many viewers systematically give up watching a program and tend to zap between different channels or always watch the same shows or channels.

In this scenario, assisting tools that guide the viewer in the content selection process can contribute to increase his loyalty to a specific service/product and thereby contribute to improved cost-effectiveness for the service provider.

Recommendation systems do usually rely on information that enables creating a user or group profile and, based on available content descriptions, suggest new content that best fits this profile.

This paper describes a Web based Application that integrates a recommendation engine to help navigating and accessing broadcasted and on demand audiovisual content. The proposed solution takes into account the differences between these two services and implements distinct functionalities and recommendation techniques.

The rest of this paper is organized as follows. In Section 2 we make a brief introduction to some basic concepts related to recommendation systems. Section 3 presents some of the solutions developed in the area of television while in Section 4 we detail our proposal, including the description of the architecture and of the available functionalities, the metadata elements used and the algorithms developed. Finally, in Section 5 some conclusions are taken and future developments are highlighted.

## II. Recommendation Systems

Having emerged as a reaction to the increase of the amount of information available to the user, recommendation systems may be defined as any system that can make recommendations or orientate a user to services, products or content potentially interesting among several alternatives [2]. Shafter et al [8] describe the operation mode and a general structure that recommendation systems should implement. Recommender systems are usually classified according to the approach that is used to find information that may fit the user's interest [1],[9]:

*Content-based systems* – The system tries to find new items that are similar to the ones a user has shown interest in the past.

*Collaborative filtering systems* – Recommendations are based on the analysis of the similarity between

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users and suggested items are those that users with similar preferences have liked in the past. This approach is the most commonly used, although it requires a large number of active users in order to be able to enable good results [10].

*Hybrid systems* – Implement a combination of two or more recommendation techniques. These systems try to take advantage of all techniques used, to improve system performance, and to reduce the disadvantages of each technique used individually.

The implementation of any of these approaches requires gathering information concerning the satisfaction of the users regarding the watched items. Two different approaches have been proposed: a classification range is defined and users are required to explicitly input their degree of enjoyment, or the system automatically infers user's rating by monitoring his activity while using the service.

## III. Related work

Some research has been conducted for the development of recommendation systems in the context of television programs. The PTV project (Intelligent Personalized TV Guides) [5] was one of the first systems implemented in this area, and is a reference to many other solutions that came later. PTV is described as a system that learns users' preferences and provides a personalized program guide based on their profiles. Recommendations are generated using a hybrid recommendation approach that combines content-based and collaborative recommendation strategies. Information on user's preferences is collected explicitly and the user is required to indicate his main interests including e.g. favorite television channels, preferred watching periods, genre, etc. To enhance the system performance, the user can also provide some feedback and negatively or positively acknowledge the recommendations he is provided. Besides a Web-based version, a WAP-based version was also developed for mobile phones.

The proposal described in [7] uses not only historical information (e.g. ratings or gender preferences) but also information that can change in each access to the system (e.g. mood). The recommending mechanism is based on some user characteristics such as Activities, Interests, Moods, Experiences, and Demographic information (AIMED). According to the authors, results indicate that the AIMED model increases recommendation accuracy and decreases prediction errors when compared to the conventional model.

A different paradigm is presented in the TV4M system [11]. This proposal is based on the idea that very often several people share the same living room and watch television at the same time. Recommendations should then take into account not only one user profile but should be able to link a set of profiles. Initially, all user profiles are grouped in order to build a common profile and, afterwards, the system makes several recommendations that reflect the majority preferences of the group.

According to the authors, for the system to be reliable, it is crucial that a significant sample of the group watch TV together for a long time so that the algorithm is able to converge.

The work described in this paper is in line with some of these approaches but presents a solution that is able to integrate two different usage scenarios (broadcasted and on-demand content) and to adapt the recommendation algorithms to the specific characteristics of the services.

## IV. Description of the System

### A. Architecture

Figure 1 depicts the architecture of the system developed where two main parts can be considered: the client and the server. On the client side we can find the Web interface, based on Java Server Pages (JSP), with which the user interacts and from where information will be collected by the system. The information resulting from user interaction is collected through JavaScript and AJAX and is processed by a set of Servlets, which are responsible for storing the data in the MySQL database server. Implicit and explicit data is considered.

The server is based in the Apache Tomcat and a MySQL database, used to store information related to the user (authentication, usage history, profile, recommendations, etc.) and content (EPGs and on-demand content description).

Program guides are obtained from a public site using a Web Service. Information about broadcasted content includes the title, program description, show-time and duration. The set of all programs make up the EPG, which will be made available in the Web interface.

The core component of the system is the recommendation engine, developed in Java and responsible for generating the recommendations using both a content-based and a collaborative filtering approach. The engine is executed periodically in order to consider updated information that matches current user's behavior.

### B. Metadata schema for user and content description

Generically, metadata is data about data, such as actors, genre or duration of a television program.

Metadata can be used in the context of television to describe a set of different aspects that range from low level descriptions of the content, such as the coding format or the histogram of colors used, to high level semantic characterization of the content, identification of the service provider, or even usage history and user profile.

For the work presented in this paper, program characteristics (title, genre, actors, etc.) and usage history are described according to the TV-Anytime (TVA) standard and are used to identify the similarity between programs and between users so that recommendations can be constructed.

Established by the TV-Anytime Forum, TV-Anytime is a full and synchronized set of specifications which allow description, selection, acquisition and manipulation of content on local and/or remote personal storage systems from both broadcast and online services.

Based upon MPEG-7, TV-Anytime defines the following types of metadata [6]:

*Content description metadata* - Includes attributes such as title, description or genre. Examples of metadata elements used by the TV-Anytime to describe contents are shown in Figure 2.

*Instance description metadata* - Deals with aspects such as location, usage conditions and the audio/video format.

*Consumer metadata* - Includes user preferences and usage history. The user history allows monitoring user actions during content consumption. The user can, for example, record, stop, forward, among other actions permitted by TVA. Monitoring of these actions allows creating a user profile that is being used to match the content available to the user preferences.

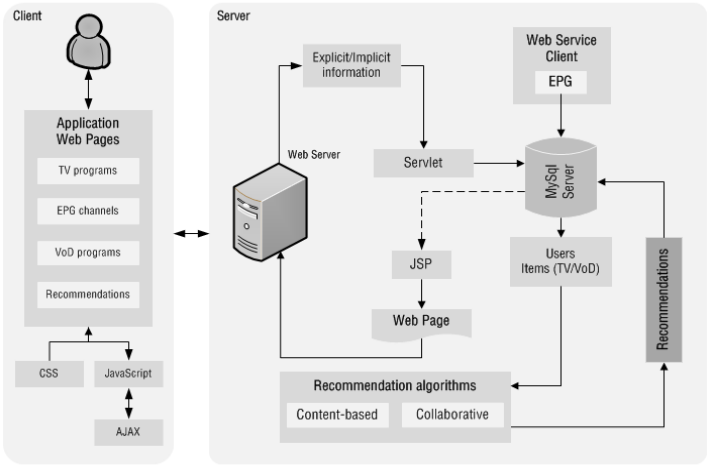


Figure 1. System architecture

Given that the objective of this application is twofold, covering the scenarios of broadcasted TV and VoD, the metadata schema to be used had to take into account some specific characteristics of each of the services. As EPGs are the support for the broadcasted content description, the type of information used in this scenario was constrained to the available information.

In order to enable the collection of implicit data that helps characterizing the consumer, the TVA usage history is used to describe the actions (play, stop, pause) associated with a program and executed by the user during a period of time. The data model used is illustrated in Figure 3.

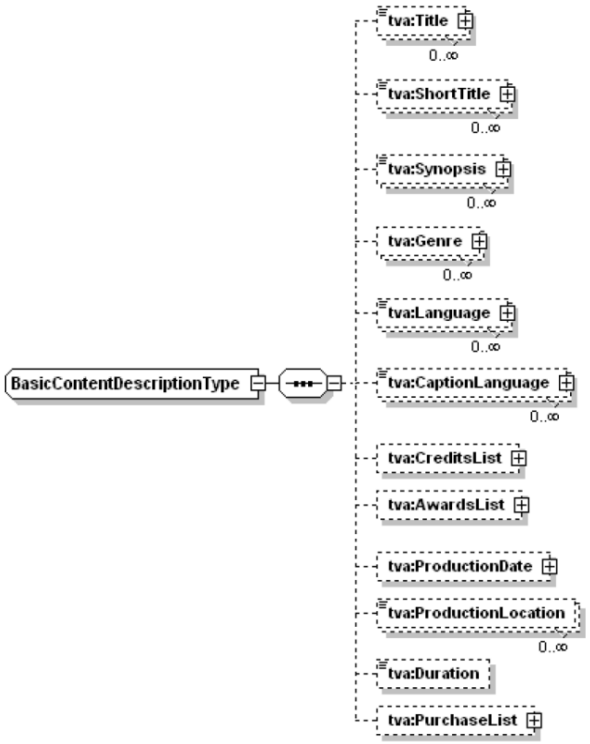


Figure 2. Examples of metadata for content description used by TV-Anytime

The data model is divided into the set of metadata elements used to describe the programs for each application scenarios (TV and VoD) as well as the set of actions performed by users while they are watching a program. The action *WatchDuration* enables storing the total period a user was watching a given program and *ServiceAcessTime* is the time of day the user accessed a program (either VoD or broadcasted TV). The action *RatingAction* is linked to the act of the user to classify a given program.

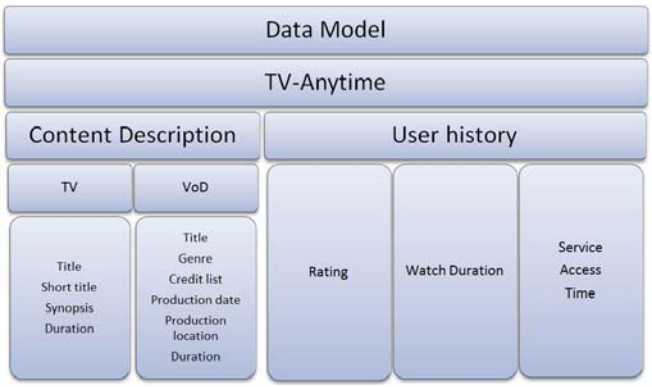


Figure 3. Data model

## C. *Profile information collection*

The user profile required by the recommendation engine is constructed using information collected both explicitly and implicitly. Explicit information corresponds to classifications given to watched programs (1 to 5). The user can however decide voluntarily not to assign any classification to a program and, in such a case, the system automatically ascertains the amount of time that he remains watching a program ("Watch Duration"). The ratio between the viewing interval and the duration of the program is then transformed into a quantitative classification ranging from 1 to 5 and assumed as the rating that the user would have given to that program.

This mechanism can have some weaknesses since the user can have watched the full program and even though not

have enjoyed it or may even have been absent in a substantial part of the program. However, this approach can contribute to solve the problem known as "cold start" (when the system does not yet have ratings provided in order to apply the recommendation algorithms) and it is regarded as an estimation that can always be modified by an explicit classification provided by the user.

In addition, by collecting implicitly the time of day the user accesses the system, it is possible to predict the schedule that best fits users' preferences. This information can be used to adjust the list of recommendations related to broadcasted programs.

### *D. Recommendation algorithms*

Two recommender algorithms were developed based on the work described in [1].

#### *1) Collaborative Algorithm*

The main objective of the user-to-user collaborative filtering technique is to estimate the rating that a user would assign to a particular item based on ratings assigned to that same item by other users having a profile similar to the user under consideration.

Being R(u',i) the rating that user u' (similar to user u) would give to item i, the rating that user u would give to item i, represented by R(u,i), is given by:

$$R(u,i) = z \sum_{u' \epsilon N(u)} sim(u,u') \cdot R(u',i) \quad (1)$$

where z is a normalizing factor and is usually set to:

$$z = 1 \Big/ \sum_{u' \epsilon N(u)} |sim(u,u')| \quad (2)$$

and N(u) represents the users that are similar to user u.

The size of the set N(u) can range from one to all users in the dataset. Limiting the size to some specific number (e.g. two) will determine how many similar users will be used in the computation of rating R(u,i).

The similarity between two users, sim(u,u'), is calculated by the cosine similarity. Assuming that I(u,u') represents the set of items rated by both users, u and u', the cosine similarity is calculated according to equation:

$$sim(u,u') = \frac{\sum_{i \in I(u,u')} R(u,i) R(u',i)}{\left( \sqrt{\sum_{i \in I(u,u')} R(u,i)^2} \sqrt{\sum_{i \in I(u,u')} R(u',i)^2} \right)} \quad (3)$$

#### *2) Content-based algorithms*

The content-based approach estimates the similarity between items, using the metadata information that describes them. Different metrics were used depending on the metadata element under consideration to calculate the similarity.

The cosine similarity was used for words' sequences where the order is not relevant. One example is the analysis of the gender of a movie, where A={Romance, Comedy} is considered alike to B={Comedy, Romance}.

For other metadata attributes, as the list of actors or directors, in which the order may have some relevance, the inverse rank measure was used. This metric calculates the similarity between two sequences taking into account the order of the elements and assigning different weights depending on the position of each element, according to the following expressions [2]:

$$N^{(k_1,k_2)}(\sigma_1,\sigma_2) = \sum_Z \left| \frac{1}{\sigma_1} - \frac{1}{\sigma_2} \right| + \quad (4)$$

$$+ \sum_S \left( \frac{1}{\sigma_1(j)} - \frac{1}{\sigma_2(j)} \right) + \sum_T \left( \frac{1}{\sigma_1(j)} - \frac{1}{\sigma_2(j)} \right)$$

where Z is the set of elements that appear in both the first and second list, $\sigma_1$ is the position of element i in the first set and $\sigma_2$ is its position in the second set. In turn, S is the set of elements that appear in the first list but not in the second, while T is the set of elements that appear in the second list, but not in the first. $k_1$ and $k_2$ are the number of elements of each set [3].

This measure is normalized as follows:

$$M = 1 - \frac{N^{(k_1,k_2)}}{\max N^{(k_1,k_2)}} \quad (5)$$

where:

$$\max N^{(k_1,k_2)} = \sum_{i=1}^{k_1} \left( \frac{1}{i} - \frac{1}{k_2+1} \right) + \sum_{i=1}^{k_2} \left( \frac{1}{i} - \frac{1}{k_1+1} \right) \quad (6)$$

The final similarity between the items under analysis is obtained by weighting, with different factors ($p_i$), the individual values obtained for each of the attributes considered (genre, actors and directors, etc.) as presented in (7).

$$sim(i,i') = \frac{\sum_{a \in A} sim_a(i,i') * p_a}{\sum_{a \in A} p_a} \quad (7)$$

Being i' an item similar to item i (not yet rated), sim(i,i'), the similarity between items, and R(u,i') the rating that the user u assigns to i', the classifications of user u assigned to item i, represented for R(u,i) is given by:

$$R(u,i) = z \sum_{i' \epsilon N(i)} sim(i,i') \cdot R(u,i') \quad (8)$$

where N(i) represents the set of items similar to item i.

### *E. User Interface*

A Web based interface allows the user to interact with the system, to watch the video content, to navigate in the EPGs and to get the recommendations.

FlowPlayer, an Open Source Video Player developed in Flash, was used and a script was developed to allow monitoring user interactions with the currently running audiovisual program. Actions like play or pause for on-Demand content are detected and, in addition, the watch duration is monitored for both usage scenarios.

Extra information about the recommended items, including a short synopsis of the program, the gender, actors, production year, total program duration and broadcast schedule, for the television scenario, is easily accessible.

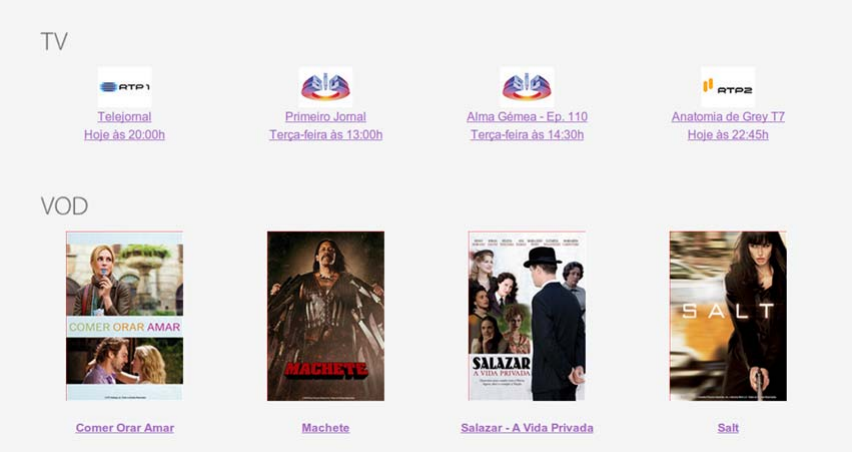


Figure 4. Presentation of the recommendations available for different programs environments

Figure 4 illustrates an example of a list of generated recommendations. For the TV domain, a temporal order, related to the EPG schedule, is considered. This list is available from every page of the application allowing an easy access to the recommended items.

In the main television environment page, besides the recommendation of programs, a list of the existing channels is provided (Figure 5).

For each of available channels, EPGs for the next few days are offered, enabling navigation and browsing information as shown is Figure 6. Rating of the program is provided through the standard star representation. A user can always reevaluate his previous feedback opinion and input a new rating which will be used in the next execution of the recommendation engine.

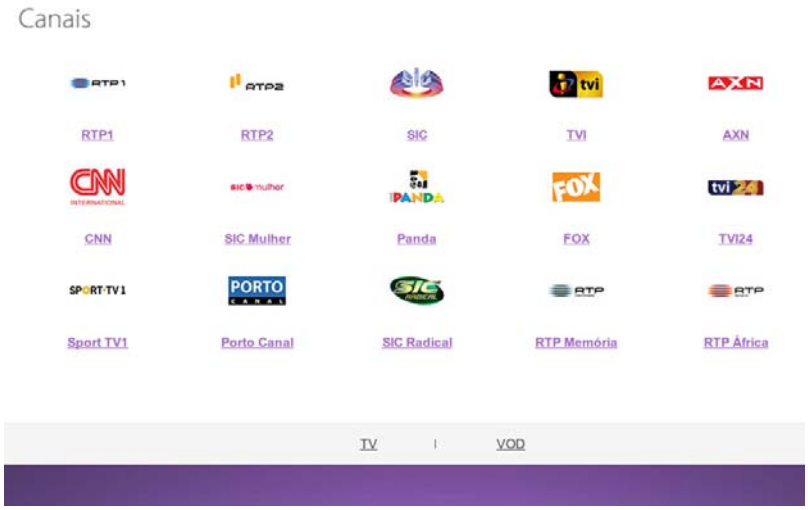


Figure 5. List of channels available for viewing EPG and display programs.

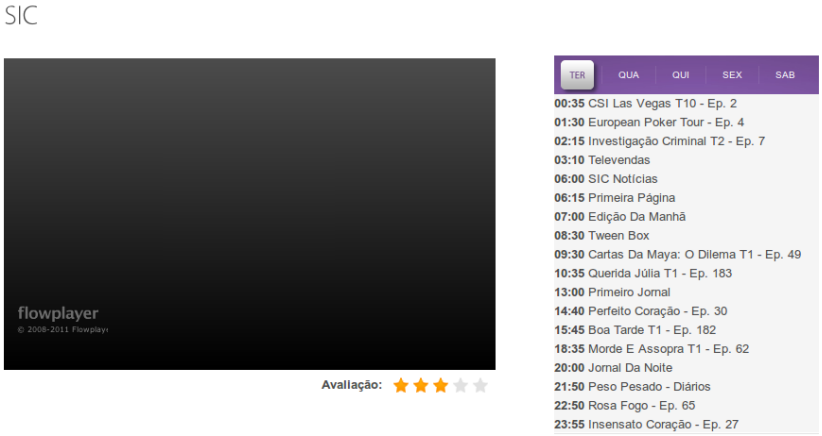


Figure 6. Presentation of the EPG for the SIC channel

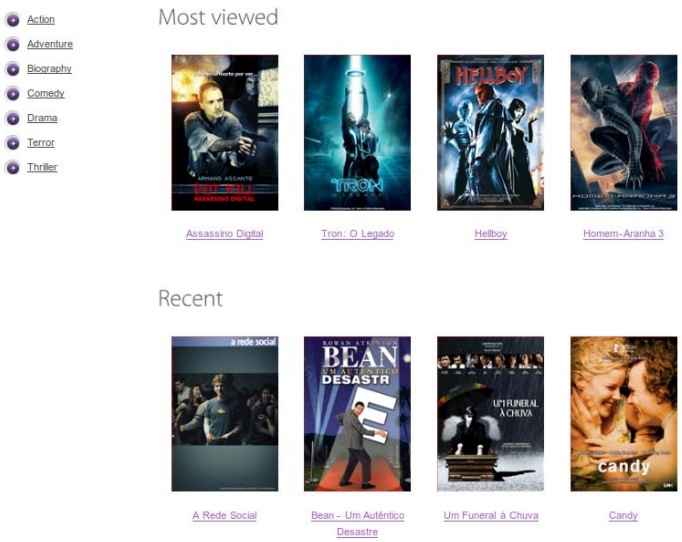


Figure 7. Programs presentation of most viewed and recently added to the system

In addition to the recommendations, and as a stimulus to content consumption, the VoD environment includes also a list of the most viewed programs and of the recently added ones (Figure 7). This is organized in a set of categories (gender) to facilitate navigation. This functionality is useful in situations when the user does not show interest in any of the presented recommendations, does not have a concrete idea of what to see, or is a recent user of the service not allowing the recommendation engine to make worthy guesses.

## V. Conclusions

The interest on recommendation systems has been growing significantly over the past years. Different systems have been made available using various techniques in order to make access to large amounts of information more efficient. In the audiovisual domain, only recently this research area has been attracting the interest of academics and service providers.

This paper presents an application developed to provide recommendation of TV and VoD programs that is able to collect information implicitly and to adapt the recommendation engine to specific characteristics of the services by using different metadata attributes.

In order to be able to incorporate specific characteristics of the viewing devices and to enable a better list of recommendations, new features are to be added to the system to adapt the recommendations to the usage scenario. Examples include using information about the current location of the user and the capabilities of the terminal.

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