An Architecture for Personalized Electronic Program Guide to Access Online Television Content

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Abstract

Television viewing is changing with a growing trend towards online consumption of content and a proliferation of providers. This is now starting to bring into question the future of the traditional television channel as the program itself becomes more dominant. However, this, in turn, poses a problem for the viewer in that it will become increasingly difficult to locate those programs of interest across such a broad range of providers. While broadcasters and content providers currently offer an Electronic Program Guide (EPG) to allow viewers to browse through their offerings, these are limited in scope. This is warranting an EPG that can truly work across all online providers. This paper introduces a new architecture for EPGs that has been developed to meet this challenge. A key feature of this architecture is the way in which it can access content from multiple providers and be personalized depending on viewer's preferences and interests, viewing device, internet connection speed and their social network interactions. The results that have been included shows that the system is able to communicate with different content sources and recommend a list of programs that match the user viewing pattern and their friends' recommendations within the social networks.

1. Introduction

Nowadays, watching television has become a daily part of our digital lives, especially with the growth in the range of content sources available. This has seen a switch from traditional linear viewing of broadcast content to time shifted or on-demand online viewing through providers such as YouTube, Amazon and Netflix [1]. Data published by Ofcom (UK Communication Regulator) in 2016 clearly supports this trend showing that 74% of UK adults have viewed an on-demand and online service in the past 12 months. Moreover, their data showed that 50% of young people in the UK are no longer watching live TV [2].

Hence there is a continuing move away from viewing programs on a traditional television towards the smartphone and tablet; providers of 4G mobile services are reporting significant growth in video streaming traffic on their networks [3]. Cisco similarly predicts that consumer online video traffic will exceed 80% of all consumer Internet traffic by 2019 [4]. Finally, social networking is impacting viewing habits not only in terms of its influence in marketing programs to watch but also how it is transforming the actual viewing experience itself through social engagement and the use of second screen applications [5].

Extrapolating these trends suggests an acceleration in the move to consumption of television content online, a proliferation of online providers and a need to better support non-traditional television viewing devices. This therefore brings into question our current model of television. As online viewing continues to grow both in the volume of content and the number of providers, this will bring into question the whole purpose and relevance of a traditional television channel. Viewers will increasingly first and foremost be seeking content based on the program they want to view rather than its provider and with that comes a major challenge.

Viewers will need significantly enhanced levels of support to find the programs that they want or that might be of interest them. Presently, television providers offer viewers an Electronic Program Guide (EPG) that itemizes the programs being broadcast but only within the channel mix offered by that provider. This type of EPG is not, however, sustainable for what is now required is a new generation of EPG that is able to search all available providers and sources of online content in one integrated, easy to use, but personalized search.

This paper presents a new form of generic EPG that has been developed as program orientated EPG with an architecture that is capable of interfacing to any online television content provider. Users are then able through a single search operation to find the content they desire. In addition, this EPG offers a comprehensive recommendation system that is based on the user's viewing history, viewing habits and specific context, including the time of day and device they are currently using to view television content. This generic EPG architecture has now been further extended to integrate it fully with a user's social networks. This addition significantly enhances the recommendation system by being able to consider the interests of other people who are close to the user.

2. Related Work

2.1. Multiple Search Agents

One of the most important parts of any EPG is its ability to search for specific programs or program types in a specific content provider. Providers who offer content, especially online, often categorize that content differently and use different formats of meta-data to describe it. Searching for content across these providers then necessitates multiple search engines, each passing their query terms to the appropriate Application Programming Interface (API) offered by the provider. After that, the various results could be combined in one list to display to the user [6]. Multi-level searching agents have also been tested where the first level searches the Internet while the second level gets its input from the results of the first level searching agents and so on. The searching criteria being decided is based on a neural network to find the best matching between the query terms and the searching results [7].

Another searching system has been proposed that integrates the searching of TV programs with Web pages for particular keywords. However, the idea of searching TV programs and data information in the same operation opened the door to start supporting the selected TV program with additional relevant information extracted from the web. This can then be subjected to several operations such as indexing, similarity calculating and ranking to obtain a more efficient result [8]. One Smart TV company has incorporated a search system based on multi-level searching across three multimedia content sources. Keywords that have been entered by a user through the Smart TV browser are sent to the searching system which in turn searches a local repository for matching content. The second searching level is implemented by sending the search keywords to the EPG repository, which contains the program schedule and the global repository (Internet). The results that are received from the other repositories are combined with the local repository searching results. Thereafter, the searching system ranks, indexes and displays the final result to the user through their TV screen [9].

However, these systems depend on search keywords that are provided by a user or extracted from information about program that a user has watched. The new generic EPG aims to extend searching beyond this by introducing automation whereby searches can also be implemented based on an analysis of the user's personal and social network profile to generate results that are better tailored to their interests.

2.2. Recommendation Techniques and Personalization

Recommendation and rating systems have become a major research area due to the spread of using these features in many applications such as Internet shopping and tourism. Consequently, there are several recommendation techniques available. One method is the content-based approach which means analyzing the user's profile and the items (programs) that have been highly rated by the user and then recommending only those items (programs) that have a high degree of similarity with the user rated programs. Another method is the collaborative filtering approach which depends on recommending programs or items based on the ratings from other users who have the same tastes as the target user. This method does of course; need to have more information about each user in order to group users with similar interests. A system can then recommend the programs or items which have been watched by the members of the group but not yet by the specific user [10]. A hybrid technique which combines both the content-based and collaborative filtering techniques has been proposed to offer an enhanced recommendation for use within an EPG [11].

However, the content rating process is not always accurate due to the variability in a user's interpretation and interest in specific content. Therefore, instead of a user's rating, a user's viewing characteristics can be used to predict their behavior and create a profile. Observing user behavior based on what content they watch provides the system with more information about a program's features that a user prefers which then leads to a prediction of the programs that could be interesting to that user. This approach has been applied to the content based recommendation method by analyzing the selected programs and generating a recommended list of programs relevant to the user profile [12].

Another technique that has been used is the context-aware recommendation. Here context definitions can be different based on the type of information that is needed. There are many types of context that should be gathered such as user context, device context, network context, content context and dynamic context [13].

Social networks have become a very popular and important way of keeping in contact with friends and family members. People regularly exchange their ideas, interests and important moments through these networks. Consequently, many researchers have investigated the effect of these relationships on users' choices and interests. Demographic information such as age, gender and location has an important effect on the similarity of users' interests especially in respect of movies, TV programs and music. Moreover, friends have a higher similarity than strangers in their choices and interests and this

similarity increases when those friends share more than one common friend. Online social networks have therefore enhanced these relationships between people through supporting interaction and creating a sense of community. The psychological effects of social network relationships illustrate that a high proportion of social network friends, who share the same interests, can interact with each other far more effectively than strangers. These relationships and influences can therefore be exploited within an EPG to enhance its recommendation processes using collaborative techniques [14, 15].

One of the most popular social networks is Facebook that now boasts over 1.5 billion registered users worldwide. A study has demonstrated the power of exploiting Facebook information to personalize the recommendation of books, movies, TV programs and so on, based on a user and their friends' recommendations [16]. As an example, a movie recommending application has been created within Facebook that users can join to benefit from recommendations based on their friends' list. This method uses a questionnaire to specify movie categories which are of interest to the users [17].

Another proposal includes creating a website for recommending films to a user's friends by rating the watched films. The website has its own social network and by asking users to rate the watched films, the website can build up a group of rated films that could be used by friends for recommendation purposes. The results show that recommendations based on social networks are more accurate and generate higher satisfaction scores for users [18].

However, each one of those existing systems either used one technique and studied the effect of that technique on the precision of the recommendation or combined two techniques to improve the recommendation quality by overcoming the drawbacks of each technique separately. The new generic EPG system however, exploits and integrates content-based, collaborative filtering, context-awareness techniques and social networks to deliver an enhanced recommendation for each user.

3. System Structure

The new generic EPG system operates as a central online service for which users are required to create accounts and log in when they wish to access its services. Its architecture has been designed to allow a user to search for program content across any number of online television providers. This is achieved through the provision of a separate search engine for each content provider that is able to extract program metadata and convert this into an internal standard format that is then used by the remainder of the system. In that way, apart from the search engine, the remainder of the system architecture is generic. Each of the key components of this architecture will now be considered in more detail.

3.1. Multiple Sources Search System

The search system is the most important part of any EPG system. Our system includes multiple search agents, each one of them connected with one provider of online content as shown in Fig. 1. These separate search agents are analogous to a television tuner where it allows the system to receive and translate the information provided by each source. Each search agent retrieves metadata about each program offered by the provider to which it is connected. Due to the many different formats of metadata used by online providers, each search agent includes an interpreter to unify the received metadata into unified format which is then used within the remainder of the EPG system. These different search agents are controlled by a single search agent leader, which controls the overall searching operation and prepares all of the metadata files for the next steps in the EPG process.

Presently, the searching operation is based on keywords where the system searches for programs that have a similarity with those keywords. The search agent leader controls all of the searching operations including the search for the programs that have similarity with those that have been watched before, those which are recommended by users of the system based on either a clustering approach or via social networks and those that are searched based on keywords directly entered by the user. The search agent leader collects all of these keywords and forwards them to each of the multiple search agents so that they can search their respective online provider's content.

3.2. Recommendation System

Another important part of the EPG system is the recommendation process and to maximize its effectiveness, the new generic EPG integrates multiple recommendation schemes that use content-based, collaborative filtering, social networks and context-awareness techniques. Three lists of programs are created based on these various recommendation approaches. The first list is generated based on the user viewing history where the titles of watched programs are sent to the search agent leader to search for new programs that are similar. Thereafter, the translator contained within each search agent translates the retrieved program's metadata to a unified format. Programs are represented by matrices; each matrix contains 22 key features such as the title, description, name of main actor, genre, type, date of production, language, subtitle, duration, director, ratings and other features that described the video content metadata.

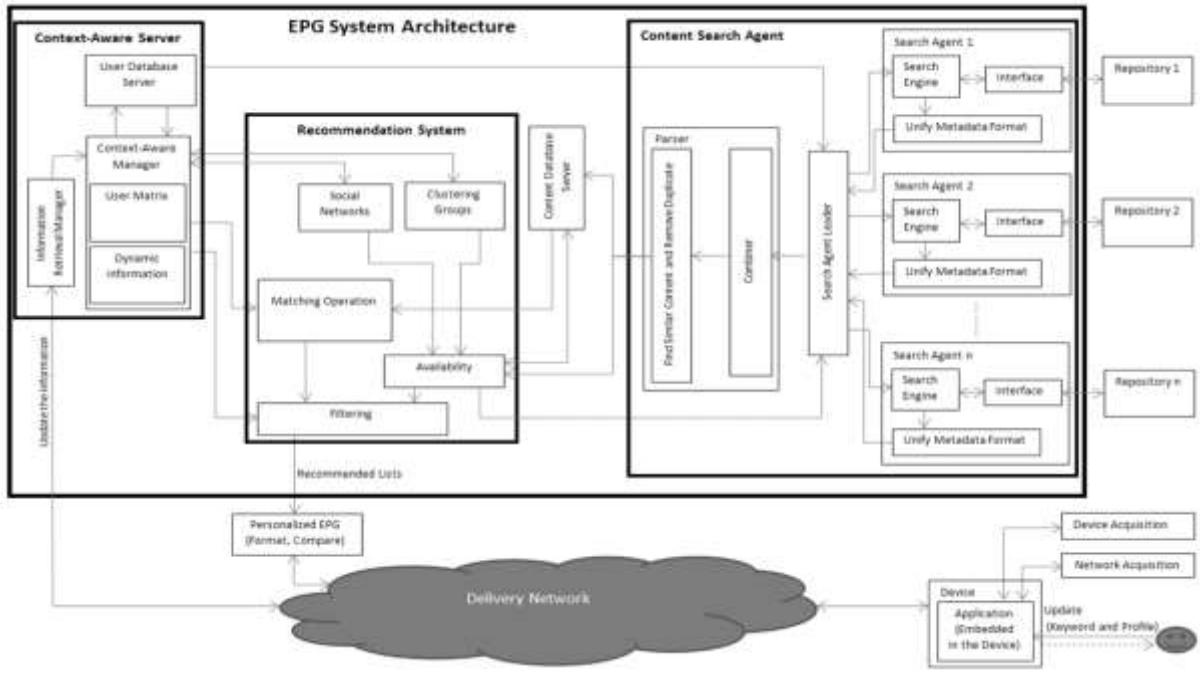


Figure 1. Overall System Configuration

These details are then passed to the search agent leader to combine them with others, parse them to remove any duplicates and then save the final results in the content database server. Similarity calculations are then carried out between each program in the final list which is then saved in the content database server together with each program in the viewing history. The second list is based on a collaborative filtering approach. Here users are placed into groups depending on their selected program categories. The number of program categories that the system currently uses is 36. The clustering operation is done by retrieving the combined viewing history of each user which is then saved in the context-aware server. Information is then extracted from this relating to program categories. Then, the system uses a k-means algorithm to cluster the users into their appropriate groups. Finally, the programs that have been watched by users in the same group, but haven't yet been watched by the target user, are recommended to the target user.

The third list is based on the contribution of social networks. This list includes content that has been recommended by the user themselves plus the programs that have been recommended by their friends within the social network. This is done by creating a software application in the social network and asking users to join it in order to benefit from the EPG service.

This application then extracts some information from each user account such as the liked and watched movies and TV shows and their list of friends but only those friends who have also joined the EPG application. Thereafter, the system analyses this information and translates the resulting data into the same unified format which is used in the searching part and the content database server.

As a final stage, the three program lists are passed through a filtering functional block which takes as its other input the user's context features (dynamic information) which are retrieved from the user's environment. The purpose of doing this is to ensure that the programs being recommended are capable of being watched on the user's device and current network connection. All of the searching and recommendation operations run as background tasks and do not require the user to be logged into the system. The only function that has to be carried out in real time when the user logged onto the EPG is the final filtering operation. Hence, this approach decreases the perceived searching time and thereby helps to enhance the user experience.

3.3. Content-aware Server

The context-aware server is responsible of storing the user viewing history, user ID and friends' information (for social networks), user preferences and dynamic context information. All of this information is saved in a matrix which is built by the context-aware manager. This part includes two main functions: context-aware manager and information retrieval manager. The function of the context aware manager is to build the user matrix which comprises the user name (which should be unique and will be used later in the social networks), ID of the user social network account, user friends, the preferred programs which are retrieved from the social network (including those programs which are found in their friend list) and their viewing history.

The information retrieval manager retrieves information related to the user's viewing device such as device type, resolution and currently connected network bandwidth. This information is then used by the filtering operation to ensure that the user is provided by a list of programs that match their viewing environment.

4. Implementation and Results

Having reviewed the overall system structure and internal functional blocks of the EPG system, this section presents results to show how the EPG has been implemented and is able to deliver the desired functionality.

4.1. Retrieving Metadata from Multiple Content Sources

The system has been implemented to access online content sources such as the BBC-iPlayer, The Movie Database (TMDb), YouTube and Dailymotion. As an illustration of the differences in these systems, the BBC-iPlayer presents its metadata in XML format whilst TMDb, YouTube and Dailymotion present theirs using JSON.

a. Program Retrieved Information in JSON

b. Translated Program Information in XML

215
HAPPY FEET
INTO THE WORLD OF THE EMPEROR PENGUINS, WHO FIND THEIR SOUL MATES THROUGH SONG,...
MUSIC, ANIMATION, COMEDY, FAMILY
Null
2.190875
HAPPY FEET
2006-11-16
Null
EN
AUSTRALIA, UNITED STATES OF AMERICA
RELEASED
Null
Null
Null
Null
Null
Null
Null
Null
Null
Null
https://www.fan.tv/movies/9836

c. Program Information Matrix in Content Database Server

Figure 2. Program Metadata Stages

The metadata is retrieved from these various content sources and translated into XML format which is subsequently used by the functions which control the analyzing operations. The search agent leader reads these results and creates the contents' matrix which contains the key features of each program such as title, genre (category), type, date of product, subtitle, leader actor, language, description and so on.

Figure 2a shows the retrieved metadata from a program on The Movie Database web site which is written in JSON format while Figure 2b. shows this metadata after having been translated. Figure 2c shows this metadata after representing each program as a matrix of 22 features in the content database server where all the programs' metadata that has been retrieved from the different sources is described in that way. Note that the system will insert 'Null' where particular metadata information is not available.

For any new content source that has to be added to the EPG system, all that is required is to write a new search agent that is able to communicate with that content source, retrieve the program metadata, extract the needed program features and translate the extracted information into the unified format (XML) that is used within the system.

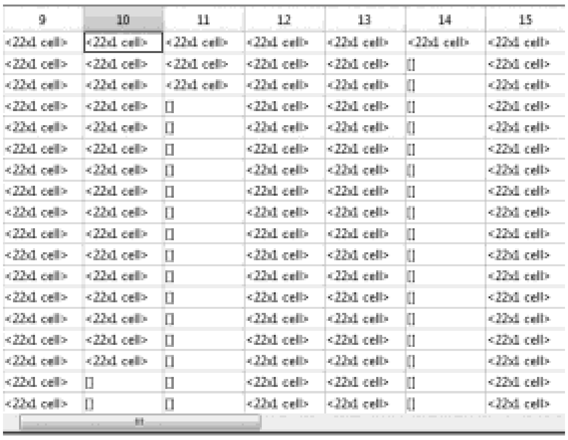
4.2. Recommendation Results

As mentioned previously, there are three lists of programs presented to the viewer based on the recommendation approaches that have been used. The first list is based on the watched programs by each user which forms their viewing history.

The viewing history of each user is saved in the context-aware server as a matrix comprising 24 columns representing each hour of the day. Each column contains the programs that the user watched during that particular hour.

Based on this, the recommendation system produces a list as shown in Figure 3 which covers the period between 9 am and 3 pm. Each of these entries appears as a '22x1' cell entry in this matrix but when expanded will reveal the full details of that program where the cell ('22x1' cell) contains a program represented by a matrix of 22 elements (22 program features as shown Figure 2c).

This process is repeated every day where the system updates the viewing history automatically after as each program is watched.



9	10	11	12	13	14	15
<22x1 cell>	<22x1 cell>	<22x1 cell>	<22x1 cell>	<22x1 cell>	<22x1 cell>	<22x1 cell>
<22x1 cell>	<22x1 cell>	<22x1 cell>	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	<22x1 cell>	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	<22x1 cell>	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	[]	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>
<22x1 cell>	[]	[]	<22x1 cell>	<22x1 cell>	[]	<22x1 cell>

Figure 3. List of recommended programs for each hour

The second list of recommended programs results from the collaborative filtering approach. Figure 4 shows this list of programs where the number next to the program title represents the number of users who have watched that program. The system ranks the programs within the list according to the popularity of each program (number of users who watched it).

Figure 4 Program List Based on Collaborative Filtering Approach

With regard to the use of social networks, the EPG has been implemented with an interface to Facebook. Within Facebook, a bespoke application has been authored and included to support the EPG system. Facebook provides its information in JSON format which the system then processes and converts into the same unified format that is used in the searching operation and content database server as shown in Figure 2.

Then the system analyses the retrieved information to find the common programs and differences between the user and their friends' choices to create a list of programs containing all the programs that have been retrieved. Thereafter, this list is ranked based on the number of friends who watch or recommend the same program. The ranked list is then forwarded to be checked against the content database server to find the contents which match the programs' titles. The programs which haven't been found in the content database server are forwarded to the search agent leader to search the different content sources for those programs. Thereafter, all the programs' metadata will be defined as a matrix as shown in Figure 2c and a list of those programs will be displayed to the user when they next log on to the EPG as shown in Figure 5.

Figure 5. Programs List Based on Facebook Contribution

5. System Evaluation

This section focuses on validating the ability of the EPG system to access multiple content providers in a single search operation and evaluates the effectiveness of the recommendation process.

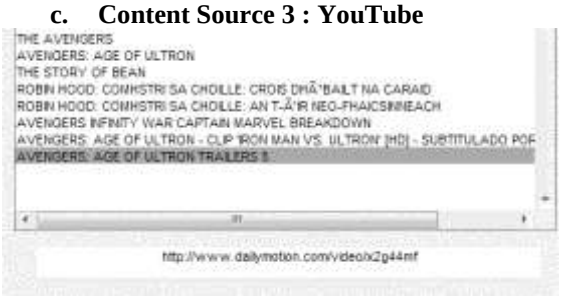
An initial user interface was created to allow the users to access the system, create an account, select the preferred categories and display the recommended results. Additionally, this interface allowed the user to watch their selected programs by opening an Internet browser.

In order to evaluate the ability of the designed system, the address of the selected program was added so that it would be easy to determine the different content sources. Fig. 6 shows part of a recommended list for a particular user. It is clear from the selected programs' addresses that the programs are retrieved from all of the connected online sources and that they have been listed in a single EPG. Note that the recommended list of programs shown was created based on three searching keywords: Avengers, Robin Hood and Mr. Bean.

a. Content Source 1 : The Movie Database

b. Content Source 2 : BBC iPlayer

c. Content Source 3 : YouTube



d. Content Source 4 : Dailymotion

Figure 6. Part of EPG Snapshot Showing the Program Address of Recommended List

In order to overcome the cold-start problem and provide more interaction with social networks, the registration process includes selecting categories which match the user's interests. These features provide recommendations to the user when the user uses the system for the first time. In order to analyze the performance of the recommendation system, the precision of recommendations has been calculated by asking a group of users to interact with the system as part of a series of user trials. Figure 7 shows the average precision for the cold-start problem where the precision values (y-axis) are shown as a fraction of the number of recommendations. Here two cases are compared. The first is where the system depends on the collaborative filtering approach only (lower curve) while the second case is when the system integrates the Facebook recommendations (upper curve). It is clear that social network contribution has enhanced the precision of recommendations by 6% to 12%.

The same cases have also been compared when a viewing history becomes available. Figure 8 shows the average precision for those two cases versus the number of recommendations. The results show that the system precision is increased by 6 to 10% when the Facebook recommendations are included within the recommended list. Additionally, the system provides almost the same value of precision compared to cold-start scenario which means that the system can predict the recommendations that match the user's viewing pattern even when there is not enough information about their viewing history.

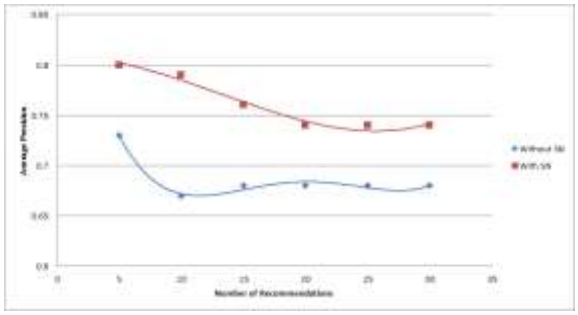


Figure 7. Average precision vs number of recommendations for cold-start problem

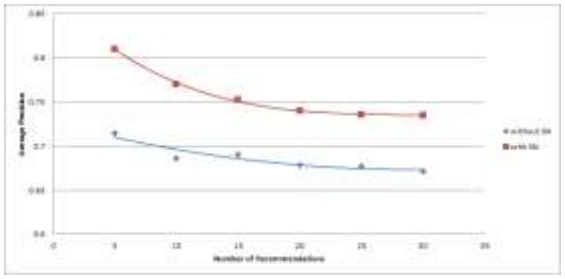


Figure 8. Average precision vs number of recommendations when viewing history is available

Finally, the filtering stage is performed on the recommended lists of programs to filter out the programs that do not match the user's context features. This information should be provided to the system through an application that is installed in the user device. However, for the prototype implementation, this information was provided manually. During the user trials, three different values of network bandwidth were used, 10, 3 and 1.5 Mbps. The results showed that the system was able to filter out those programs which did not match the available network bandwidth resulting in a final

list of recommended programs which contained 21, 18 and 13 entries respectively. The filtered out programs were with High definition and 3D movies therefore, the system remove them from the final list when the available network bandwidth decreased to less value.

6. Conclusions

The latest trends show that watching television is no longer limited to using traditional television set to watch linear broadcasted content. There is a huge growth in the consumption of time-shifted and online content which inevitably will start to challenge the future of the traditional television channel as more and more viewers become focused on the programs, rather than the broadcaster or provider who distributes them. Therefore, this new world of online viewing requires a single EPG that is provider agnostic being able to offer the viewer a single point of interface for all content providers. With such a broad and growing choice of content, it is also important to offer the viewer greater levels of guidance and assistance in locating content that matches their interest.

This paper has presented a new design for an EPG that offers a generic system which is able to interface to any online content provider and to fully integrate a user's profile, viewing habits and social networks to offer, through a single interface, a more tailored set of viewing recommendations. Additionally, the use of dynamic context features has been taken into account to filter the list of recommended programs to ensure that they match user's device, its resolution and currently available network bandwidth.

In the future we'll implement this system on the other viewing systems of television content such as IPTV with integrating the other content sources such as terrestrial channels and satellite channels besides the online video content sources.

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