

Two-List Scheme with Personalized Electronic Program Guide for Fast IPTV Navigation

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Abstract

The adoption of the shift from one-way push-based traditional media broadcasting to an interactive pull-based Internet Protocol Television (IPTV) service has seen significant growth in recent years due to the vast number of television (TV) channels and applications it provides. Despite the increase in the deployment of the IPTV systems around the world, channel switching a major functionality in every TV system needs further improvement. Zapping delay in IPTV, a delay that occurs during channel switching brings a major setback to the IPTV system, especially when compared with the traditional television services. A new fast channel navigation framework in IPTV was proposed in achieving a drastic zapping delay reduction during channel switching. Instead of analyzing the behavior of channels, switching and predicting channels based on behavior analysis, the proposed approach will enable subscribers to choose their favorite channels from a different genre, into the hot and cold channel list, where hot channels are channels regularly viewed by the subscriber and cold channels are channels not viewed by subscribers. This approach saves subscribers a painstaking amount of time in searching for the desired channel to watch. This will be effective in reducing zapping delay when compared with several state-of-the-art approaches.

Keywords: *zapping delay, Internet Protocol Television, two-list scheme, electronic program guide, channel navigation, bag-of-words*

Introduction

The rapid spread of IPTV, an evolution of digital broadcasting service, has become a force to reckon with, emerging as an alternative to traditional TV broadcasting delivery systems (Manzato, and da Fonseca, 2013). IPTV offers an attractive package for a diverse range of applications to subscribers providing tremendous flexibility to network and content providers, opening an avenue for expansion and serving as a great source of income. IPTV services can be subdivided into two major categories: live TV and video-on-demand. Due to bandwidth, limitations, live TV is transmitted over a multicast network after the live raw video has been encoded and forwarded to subscribers at the request of the subscriber, while VoD is stored media content delivered to subscribers anytime when it is requested. Despite the advantages posed by IPTV in offering a vast range of live TV channels and videos across different categories of digital multimedia in different countries, subscribers still find difficulties in choosing desired channels to watch, which then get heightened by zapping delay. It is imperative that IPTV network providers guarantee a higher level of quality of experience than that offered by conventional traditional broadcast TV services.

Subscribers tend to switch between TV channels in no longer than 13 minutes in an IPTV multi-channel system due to the diversity of channel content being aired, or through the natural curiosity of the subscribers, or through the subscribers' inclination to skip commercial breaks (Yang and Liu, 2015). According to Abreu et al., (2013) subscribers preferred ways to switch between TV channels include pushing the TV channel number on the TV remote control or pushing the remote

control button in a sequential way or using the up and down remote buttons both with a preference of 57 percent. Other ways of switching channels are the use of an electronic program guide or navigation between channels in the same category. These are the least preferred ways, both with 14 percent preferences.

Diverse approaches have been suggested to guide subscribers in finding the desired channel of interest quickly, an approach implemented to lure traditional TV users to adopt the IPTV service. Such approaches include a recommendation system, EPG and a search engine (Zhang et al., 2016; Yu et al., 2017). The recommendation system enables users to filter preferences and use that information as a point of reference when selecting channels by making a good recommendation to meet subscriber needs of choosing the desired channel, capturing their preferences using either explicit or implicit methodology to create preferences profiles based on their channel viewed history and channel switching behaviour, VOD purchased transactions and demographic information (Elmisery et al., 2016).

The recommendation system adopts many technologies such as advanced machine learning techniques, collaborative filtering, natural language processing, data mining, information retrieval and multimedia content analytics. These methods have been developed to automatically generate recommendations for subscribers by suggesting channels that might interest them. Currently, Amazon, MovieLens, Netflix, and Spotify are companies that have deployed the recommendation system to enhance subscribers' quality of experience (Chang et al., 2014). Since recommendation systems rely solely on information obtained from subscribers such as history logs, Unger et al., (2016) claim that the recommendation system may raise privacy issues since network providers are aware of the subscribers' content and such content can be extracted. Furthermore, the service provider can obtain latent content automatically by applying unsupervised learning techniques, although obtaining such content may lead to zapping delay by interfering with subscribers' activities due to a resource demanding task at the back-end.

In some cases, to avoid lawsuits from subscribers due to information extraction, service providers came up with another technique by motivating their subscribers to provide explicit feedbacks based on their preferences. Such techniques include star ratings of content viewed by the subscriber on a scale of one to five. However, Zhang et al., (2016) queried this star rating technique because such explicit information is not always available due to subscribers' poor participation in rating, and the central characteristics it possesses give a scalability problem, making IPTV channel recommendation sometimes unrealistic and undependable.

Although search engines are used by subscribers to query matching content searched for, in order to locate TV channels and other IPTV content they cannot recommend or predict to subscribers the preferred choice of channel and content to watch. Furthermore, the EPG is also used to guide subscribers' channel switching. It is a program schedule organized in a multi-layer menu that contains the programs' information such as titles, names, specific start and end times, and their playing periods which acts as a guide in an IPTV multi-channel environment stored on the IPTV set-top-box. The importance of this service is increasing due to the ability to obtain scheduling information for both current and future events of TV channels (Beyragh and Rahbar, 2014; Manikandan et al., 2016; Park and Lee, 2016).

Approaches to reduce IPTV Channel Switching

In traditional broadcast television service, a study of subscribers' channel switching was not necessary because it was not a challenge. All TV channels are sent to the subscriber at once and the channel change time is less than half a second, making it acceptable to subscribers. With the introduction of IPTV, where a vast number of TV channels is made available to subscribers, network

bandwidth became a limitation invariably affecting channel switching and hence, causing zapping delay. Various techniques and approaches have been adopted to reduce zapping delay in IPTV.

One of the prominent approaches was the context-aware recommender systems which deal with modeling and predicting subscriber tastes and preferences by incorporating available contextual information into the recommendation process adding explicit categories of data such as time and place in contrast to the traditional recommender system that only deals with two types of entities, the users and items, and does not include these entities when making a recommendation (Adomavicius and Tuzhilin 2011; Steeg, 2015). Furthermore, a context-aware recommender system is based on neural networks (Krstiæ and Bjelica, 2012) for live channels to aid subscribers to find channels that would interest them. The neural network is used as a classifier tool which estimates whether a certain program is of substantial interest to the observed subscriber; this network is fed with the data on both program genre and the temporal context related to the subscriber's watching habits.

Later Chang et al., (2014) propose a cloud-assisted channel-recommendation system under a cloud computing environment, to speed up the performance of channel switching, in order to help subscribers find their favorite channels in less time. The latent Dirichlet allocation (LDA) based model (Zhang et al., 2016) is another improved recommendation system which considers subscribers playing behavior as well as the implicit feedback of surfing and collecting, to capture the inherent viewing preference of individual subscribers'. The implicit feedback of the LDA is integrated via TV program characteristics. A collaborative privacy framework for minimizing privacy risks in an IPTV social recommender service (Elmisery et al., 2016) was presented running a middleware on the subscribers' side in order to conceal their profile data when being released for the recommendation purposes. This concealed data is used for computation of recommendations. Their proposed middleware is equipped with a distributed data collection protocol along with a two-stage concealment process to give the end-users complete control over the privacy of their profiles.

A TV channel prefetching scheme based on channel popularity (Oh et al., 2010; Lee et al., 2014) was introduced in order to reduce zapping delay in IPTV with hopes of improving subscribers' quality of experience. Bahn (2016) further presented hybrid schemes that combine channel prefetching and reordering schemes to reduce zapping delay in IPTV, while personalized channel lists (Kim et al., 2016) for individual subscriber was proposed to also reduce zapping delay. The motivation behind fully intelligent personalized EPG (Kwon and Hong, 2011; Narducci et al., 2017) is that it is supposed to analyze subscribers' behavior, such as watching history, in order to discover subscribers' interests, which are included in a personal profile and exploited to recommend the interested programs at the right times.

In recent times much media research has been adopting EPG personalization by using context-aware recommender systems to deliver recommended TV programs to subscribers in order to meet their program needs and to increase their media experience. However, Sailaja et al., (2017) explore subscribers' attitudes towards a personalized Electronic Programme Guide which tailors media recommendations based on subscribers' personal data. According to their findings, users appreciated the functionalities afforded by the personalization of media but were apprehensive about the implications of the personal data being collected about them, particularly in the context of their homes. This claim served as a motivation for us in this paper by giving subscribers the autonomy to personalize their EPG with a reminder, without prying into their personal information, an approach that has long been called for by IPTV subscribers, to enjoy the benefits of a personalized EPG while their personal information remains unexploited, in order to increase the level of media experience. A channel change acceleration scheme delivery (Cha et al., 2008) was proposed, which consists of deploying one Fast Channel Change Server (FCC) in the IP backbone in order to send the unicast stream to the STB before sending the normal multicast stream after each channel change. However,

deploying such a solution would cause high bandwidth usage in the network because of the huge unicast traffic sent by the FCC server to the STBs (Uzunalioglu, 2009). However, Khabbiza et al., (2017) improved on it by proposing a new solution to reduce zapping delay by using a peer-to-peer approach that reduces bandwidth occupancy of the unicast traffic. Instead of deploying a fast channel change server at the IP backbone they proposed a deployment of the FCC server at the subscriber level that is, on the STB of the subscriber, which implies that the STB will receive the unicast traffic from another STB instead of the central server. However, this approach will cause buffer overload on the subscriber's STB which aids zapping delay

Methods

In Figure 1.1 a novel channel switching framework technique was described, based on keywords using the Explicit Semantic Analysis Bag-of-Words (ESA-BOW) model to enrich the program descriptions with new information of channels in a hot channel list. This framework aims to reduce channel switching delay and increase subscribers QoE by giving them autonomy based on their preference using personalized EPG.



Figure 1.1 Fast Channel Switching Framework

Two-list Scheme

The Two-list scheme identifies hot and cold channel lists where channel preferences are determined from previous channels watched by the subscriber based on frequency and recency of watching such channels. In the two-list scheme, channel popularity is arranged by placing the most popular hot channel in a separate list in the inner circle. Channels with even ranking and odd rankings are placed on the right and left side respectively based on subscribers preference, cold channel list is also placed on a separate list in the outer circle with even ranking and odd rankings placed on the right and left side respectively as shown in Fig 1.1. Hence eliminating the possibility of unpopular channels being adjacent to the most popular channels.

The two-listschemereduces zapping delay by minimizing total seek distance and total seek time that is, an approach that promotes faster channel switching. Selecting the desired program in IPTV can be difficult among hundreds to thousands of channels available, thereby increasing the channel switching rate. This scheme groups similar programs of channels into similar categories e.g. genre such as news, movies, sports, music, documentary etc.

All channels in different categories are placed in the cold channel list. At setup stage, subscribers can then choose channels based on preference with the help of genre description and channel description to suit their channel preferences. Channels selected based on preference will be placed into the hot channel list such channels will remain in the hot channel list as long as subscribers keep viewing the channel otherwise the channel will be removed from the hot channel list to the cold channel list. The advantage the two-list scheme provides is that channel preferences can be updated at subscribers' will.

The algorithm which recommends that programs of TV channels are scheduled on EPG is based on the most popular channels, where channel popularity is computed on a per-subscriber basis on channels in the hot channel-list. The popularity of a channel is defined in terms of the rate (R) of watching a channel over a period of time (T). This popularity of channels (Pi) in the hot channel list is therefore defined as:

$$P_i = R_i T_i \tag{1.1}$$

Electronic Program Guides Personalization

The advent of digital television and IPTV coupled with the unprecedented volume of live TV channels and video content available for subscribers to choose from has caused a new level of information overload leading to channel switching delay time. The electronic program guide (EPG) which provides IPTV subscribers with continuous updated scheduling information for current and upcoming programming events is seen as a partial solution to reduce the channel switching time because presently, the traditional EPG as shown in Figure 1.2, on the traditional broadcasting service only itemizes programs being broadcast by the providers and it gives an electronic equivalent of a printed guide with no form of personalization or recommendation to match subscribers' program needs and preferences. This personalized EPG removes the traditional channel boundaries, by providing subscribers with personalized channels, which include only programs fitting subscribers' chosen channels in the hot channel list.

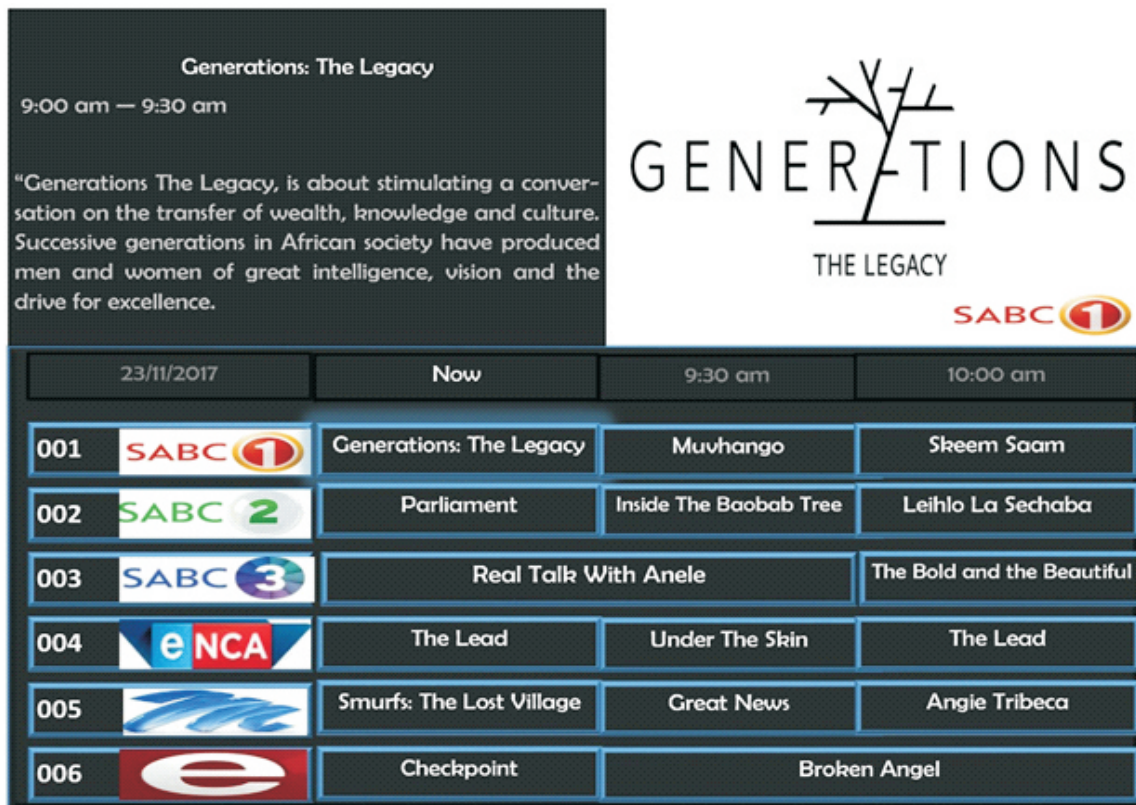


Fig. 1.2

Typically, recommendation technologies are seen as a way of making traditional EPG intelligent; the ability to personalize EPG gives subscribers a level of support to find and watch programs that interest them. Therefore, this research work exploited the use of reminders giving

subscribers the ability to set what program they are interested in based on the explicit preference of channels in the hot channel list, thus giving them the ability to personalize their EPG.

Two-list Scheme with Personalized Electronic Program Guide Dataset

We used user behavior-based synthesis dataset (Abdollahpouri et al., 2017) for modeling IPTV subscribers' preference. This dataset was created from MovieLens dataset collected by the GroupLens Research Project at the University of Minnesota. The data was collected through the MovieLens web site (movielens.umn.edu) from September 1997 through August 2017. The information of the dataset was streamlined in order to create a subscriber's preference trace file an artificial dataset based on subscriber's preference of channels available in the hot channel list (<http://eng.uok.ac.ir/abdollahpouri/UBSDI/UBSDI%28Preferences%29.txt>).

This dataset was adapted because regular IPTV datasets are not available in the public domain hence, the adapted dataset consists of a trace file captured for a period of two months for 6040 subscribers. The items in the dataset were assigned to 50 channels and they are composed of 588,698 TV shows. In Figure 1.3 the distribution of program descriptions on the 17 different genres and the number of TV shows per genre was illustrated. The genres include the following headings: Action, Adventure, Animation, Children, Comedy, Crime, Documentary, Drama, Fantasy, Horror, Musical, Mystery, Romance, Sci-Fi, Thriller, War, and Western. Figure 1.3 depicts a descriptive analysis of the dataset, however, the dataset is quite unbalanced towards some genres (i.e. program types) such as Comedy, Drama, Action, and Thriller unlike other types of the genre with small numbers such as Fantasy and War.

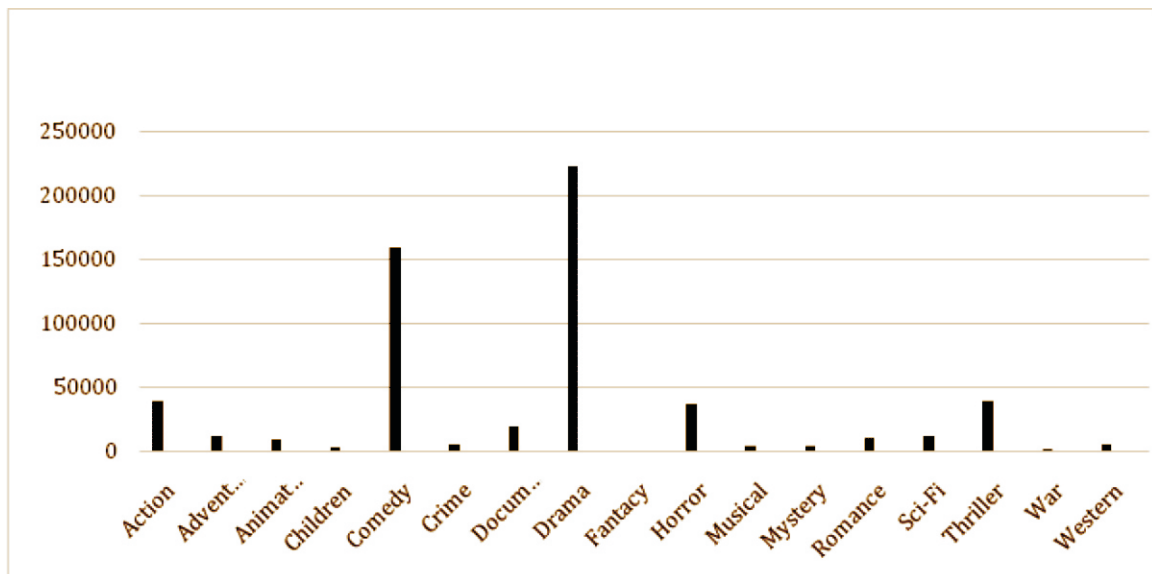


Figure 1.3: Distribution of TV shows among 17 different genres

After the genre distribution into the 50 channel list, Table 1.1 depicts an instance of the dataset; the first 50 IPTV subscribers with their subscriber identity along with the number of switches that occurred at peak period over a period of a week. It also depicts the number of channels in the hot-list based on subscribers' preferences across the number of genres the channels are being selected from. The minimum and maximum duration before channel change was also represented and finally the most popular channel based on the rate of watching a channel over a period of time. It can be seen that channel 14 from the drama genre was the most watched channel.

Table 1.1: Number of Channel Switches for 100 IPTV Subscribers

No/ Sub_ID	Number of switches	Number of channels	genre	Min duration before switch	Max duration before switch	popularity
1 (2)	84	22	10	2s	3770s	14
2 (3)	56	17	10	2s	2178s	14
3 (4)	66	23	14	2s	2940s	14
4 (6)	113	21	10	2s	2687s	14
5 (7)	121	20	11	2s	3775s	14
6 (8)	44	14	11	2s	2819s	14
7 (9)	77	17	11	2s	2835s	14
8 (10)	70	20	13	2s	1098s	14
9 (12)	174	25	13	2s	4154s	14
10 (13)	31	12	7	2s	1509s	14
11 (15)	89	20	11	2s	3128s	14
12 (17)	84	23	10	2s	2234s	14
13 (18)	98	22	13	3s	2722s	14
14 (19)	77	21	14	2s	1611s	14
15 (21)	127	22	13	2s	3092s	14
16 (22)	18	8	4	2s	5416s	11
17 (23)	138	27	14	2s	3020s	14
18 (24)	114	22	12	2s	2804s	14
19 (26)	29	12	9	2s	3262s	14
20 (27)	167	31	14	2s	4383s	14
21 (29)	34	17	10	3s	2599s	14
22 (30)	147	26	13	2s	4481s	14
23 (31)	33	11	7	2s	2376s	14
24 (32)	50	19	12	2s	3097s	14
25 (33)	27	12	8	3s	4179s	14
26 (35)	450	26	16	2s	4362s	14
27 (36)	107	23	12	2s	2334s	14

No/ Sub_ID	Number of switches	Number of channels	genre	Min duration before switch	Max duration before switch	popularity
28 (37)	163	21	12	2s	4232s	14
29 (40)	22	10	7	3s	2979	6
30 (41)	97	25	13	2s	2585	14
31 (42)	73	23	12	2s	3092s	14
32 (43)	147	26	12	2s	3181s	6
33 (44)	293	31	15	2s	3985s	14
34 (46)	64	19	11	2s	2781s	14
35 (47)	103	21	11	2s	2880s	14
36 (48)	194	26	13	2s	3997s	14
37 (51)	31	15	9	2s	4419s	14
38 (54)	28	15	10	2s	2816	14
39 (56)	8	6	5	6s	1685s	18
40 (57)	597	36	16	2s	6393s	14
41 (58)	90	23	14	3s	2999s	14
42 (59)	45	18	12	2s	2651s	7
43 (60)	34	14	9	2s	1969s	14
44 (61)	42	16	11	2s	1041s	7
45 (64)	170	29	15	2s	4918s	14
46 (65)	19	8	6	2s	3254s	7
47 (66)	57	16	10	2s	3867s	14
48 (67)	84	21	12	2s	2169s	14
49 (68)	125	22	11	2s	4285s	14
50 (71)	39	18	10	3s	2516s	14

Implementation of Two-list Scheme with Personalized Electronic Program Guide

This research work implemented the two-list scheme with personalized EPG on a raspberry pi 3 B model using free IPTV channels. It is worth noting that these IPTV channels were only used for educational purposes and for the purpose of this research with no intention of commercializing. Result achieved were analyzed and compared with various OTT services and YouTube.

45 channels were selected into the hot channel list from over 500 working channels available across different genres which can be accessed on <https://pastebin.com/9rnRHnhx>. The result, shown in Figure 1.4, shows that the two list scheme with personalized EPG outclassed the YouTube

recommended system and other Internet TV services. This implementation setup was configured over a Durban University of Technology network that entails a converged network.

Figure 1.4 shows the average time it takes for channel switching across five different platforms compared with the proposed methodology over a period of a month. It can be seen that the proposed approach has the lowest channel switching time when compared to YouTube that makes use of the recommendation system and other approaches that make use of the search engine approach. Based on this experiment it can be seen that the proposed methodology gives subscribers the ability to dictate their priority based on preference per subscribers and not based on popularity and recommendation approach.

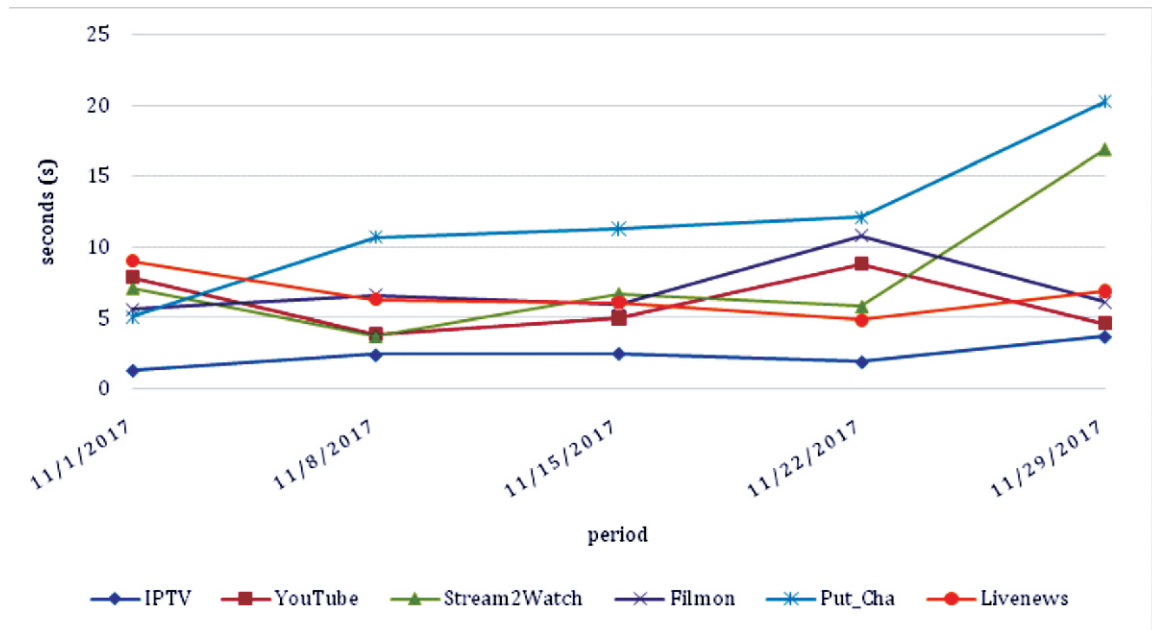


Figure 1.4: Time Taken for Channel Switching

Conclusion

This research work developed a fast channel navigation using a two-list scheme with personalized EPG. A description of the program using the personalized EPG through text classification with the help of ESA-BOW techniques which help aid subscribers in choosing the desired channel into the hot-list of the two-list scheme was highlighted. Although IPTV dataset is not made public for security reasons this research work adopted a dataset crafted from the MovieLens dataset to explain channel switching in the hot-list based on the subscriber's preference. Finally, the framework was implemented on the raspberry pi 3B and compared with five other OTT service applications and it can conclude the proposed approach outclassed other approaches with regard to performance.

Future work will focus on automatically classifying program genre into similar groups using classification algorithm instead of grouping TV channels manually. In addition, we also recommend rich site summary (RSS) feed to be implemented in order to notify IPTV subscribers to update in the IPTV system.

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