Optimising the Quality of Experience during Channel Zapping

The Impact of Advertisements during Channel Zapping

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Abstract—**Nowadays various digital television services are available. However, the user of these services experiences longer delays than the traditional analog TV while switching from channel to channel. The digital TV operator usually displays a black screen with the channel number during zapping. However, it could be interesting for the TV viewer, if the operator displays a screen with information instead of just a black screen. This information may be an advertisement, information about the target channel, personalized content of the user etc. In this paper, we describe a subjective experiment where the Quality of Experience (QoE) of channel zapping was quantified, while displaying a random set of advertisement pictures during zapping. It is found that, for longer zapping times, advertisements give better QoE than the black screen. However, when zapping times are small, users prefer a black screen over a glance of an advertisement picture. Based upon our findings we propose a system for optimal zapping experience. The system first estimates the zapping time (per target channel) and then, depending on this estimation, displays either a black screen, a picture or a clip.**

Keywordst; Channel Zapping, Quality of Experience, Mean Opinion Score, IPTV, advertisements.

I. Introduction

This paper is an extended version of [1]. The extensions and new contributions over [1] are as follows: the number of persons that have participated in the subjective experiments has been increased from 12 to 30; a subsection has been added about measurements that have been performed to get insight about zapping times for today's digital television services; a completely new section has been added about how the finding of this research can be used to design a system for optimal zapping experience.

Telecom Service Providers around the world are in a race to deploy new revenue generating services in order to offset the accelerating decline in voice revenues. For instance, US based providers faced a decline of 34% in voice-related revenues between 2000 and 2006 [2]. Among others, Service Providers came up with a new service called "triple play", which is the commercial bundling of voice, video and data on a common IP based network infrastructure. This IP based network infrastructure allows providing enhanced applications and services such as IPTV, VoIP, video telephony and Video on demand (VoD). However, as providers deploy new services, they also have to provide optimal Quality of Experience (QoE). QoE takes into account how well a service meets customers goals and expectations rather than focusing only on the network performance. In this highly competitive market Service Providers which are offering high quality IPTV services should address the QoE requirements of IPTV.

One of the key elements of QoE of IPTV is how quickly users can change between TV channels, which is called channel zapping. The zapping time is the total duration from the time that a viewer presses the channel change button, to the point the picture of the new channel is displayed, along with the corresponding audio. Minimum quality requirements for a lot of aspects related to IPTV have been specified by both the ITU [3] and the DSL Forum [4]. However in the ITU document there are no recommendations at all related to zapping times, while in the DSL forum document it is recommended to limit zapping time to an arbitrary maximum of 2 seconds. Additionally it is noticed in the document that providers should strive for zapping times in the order of 1 second.

Because these quality requirements are rather vague Kooij et al. [5] conducted a number of subjective tests in order to get insight in the relation between QoE and zapping time. For the tests described in [5], during channel zapping a black screen was visible which contained the number of the target channel. The QoE was expressed as a so-called Mean Opinion Score (MOS). The test subjects (21 in total) could select one of the following five opinion scores, motivated by the ITU-T ACR (Absolute Category Rating) scale, see [6]: 5: *Excellent zapping quality*, 4: *Good zapping quality*, 3: *Fair zapping quality*, 2: *Poor zapping quality*, 1: *Bad zapping quality*.

The main result of [5] is an explicit relation between the user perceived QoE and the zapping time. From this relation it was deduced that in order to guarantee a MOS of at least 3.5, which is considered the lower bound for acceptable quality of service, see [6], we need to ascertain that Zapping

Time < 430 ms. Note that for MOS = 3.5 the average user will detect a slight degradation of the quality, of the considered service. The requirement on the zapping time mentioned above is currently not met in any implementation of IPTV, see for instance [7], and also subsection E in section 2. To increase the QoE of channel zapping, two approaches are possible. In the first approach the actual zapping time is reduced. An example of this method is given by Degrande et al. [8]. They suggest to retain the most recent video part in a circular buffer and display this video until the incoming channel is ready.

In the second approach the QoE is (possibly) increased by showing information while the user waits for the target channel to appear. The displayed information could be about the target channel, personalized content or advertisements, see also [9].

The aim of this paper is twofold. The first aim is to assess the QoE of channel zapping when, during zapping, advertisements are displayed, instead of the usual black screen. The second aim is to propose a system for optimal zapping experience. The system first estimates the zapping time (per target channel) and then, depending on this estimation, displays either a black screen, a picture or a clip.

The rest of this paper is organized as follows. In section 2, the possible effect of advertisements on IPTV perceived quality is analyzed and various factors that contribute to the results are listed. In Section 3 the experiment performed to quantify the user perception is described. In section 4, the results obtained from the subjective tests are presented. Section 5 describes a system for optimal zapping experience. Finally, conclusions are given in Section 6.

II. Quality of Experience and Advertisements

A. *Quality of Experience of IPTV*

Quality of Experience is the quality as judged by the user. QoE for IPTV is a subjective measure of the IPTV service that is evaluated by test subjects and depends on two types of factors. The first type of factors is due to the actual Quality of Service (QoS) or network quality being provided. The other type of factors result in a change of the user perception even though the QoS being provided remains the same.

Some of the factors that affect the QoE resulting from the actual QoS of the network are,

a) The zapping time;

b) The visual quality: this factor depends on the quality of encoding and decoding and on the packet loss in the network;

c) Synchronization between video and audio.

The other factors which result in variation in the user perception, even though the QoS remains the same, are:

a) The user device: the equipment the user is using to watch the channel is also important, for instance, the screen resolution of the TV;

b) The educational level, age and the TV watching experience of the customers;

c) The mood and concentration of the customer;

d) Viewing conditions, such as room illumination, display type (brightness, contrast), viewing distance etc.;

e) The IPTV service cost.

Measuring the QoE is very important for the service provider. Once the quality perceived by the user is measured, the vendor can determine the minimum requirements on the IPTV service quality (such as the maximum tolerable zapping time). Moreover, the vendors can provide additional services or use techniques to boost the user perception with the same QoS level being provided. For example, using advertisements during channel zapping may increase the QoE.

B. *Effect of Advertisements on QoE*

Using advertisements during the IPTV zapping times is an approach that tries to increase the QoE while the service quality or zapping time remains unchanged. Obviously, not all people would be happy to see advertisements during zapping. Therefore one could also think of educational or entertainment content during zapping. However, in this paper we focus only on advertisements because the business driver for this case is stronger. In fact, there are two major consequences that are expected to boost the QoE in the case of the actual implementation of this approach.

a) Users will watch the advertisements during the channel zapping, so they will not be bored with the longer zapping times. Hence, the perception of the user for the channels with advertisements could increase with respect to the black screens. This is actually what we have measured in the conducted subjective experiment.

b) The second consequence is that the providers will earn money from these advertisements. So, they can lower the price of the service. Obviously, a lower price is one of the factors that can boost the QoE.

It should be noted that the effect of advertisements on QoE is not just straightforward if it would be implemented. Rather, it depends on various factors which could affect the QoE positively or negatively.

a) The type of advertisement: A particular user could like some sort of advertisements and dislike other advertisements.

b) The content of the advertisement picture with respect to the length of the zapping time: For example, a glance of an advertisement that stays for a very short duration or a picture advertisement that stays static for a zapping time of 5 sec could be annoying for the user. Advertisements containing much text or video advertisements may be of little importance if zapping time is short.

c) The advertisement between the channels may need to be made random for better user perception; moreover, the advertisement set should be changed after some time.

Some of the factors above could positively affect the user perception. However, the implementation complexity also increases if all these issues are to be properly addressed. The best approach to use these advertisements is to select an advertisement randomly from a set of advertisements pre-rendered and stored in the Set-top Box (STB) when the user zaps to a different channel. Using pre-rendered advertisements is important because the zap screen can then be displayed immediately in this case.

III. THE EXPERIMENT

A. Design of the experiment

For the IPTV channel zapping experiment, a HTML page containing five animated gifs in different layers is implemented in JavaScript. These five animated gifs correspond to 5 different TV channel contents: an orchestra scene, two film trailers, a cartoon scene, and a sports scene. These animated gifs do not contain audio. Audio can be added but the synchronization problem will be another cause for quality degradation. So, to assess the quality experienced for zapping times, it is better to make the experiments with no sound, because otherwise the test subjects opinions might be biased by the synchronization quality. The animated gifs are displayed in a screen of size of 720x576 pixels in the HTML page. The page is designed in layers such that when the user zaps to a particular channel all animated gif layers become invisible except the layer containing the required animated gif.

In the experiment reported in [1], seven zapping times between 0 and 5 second were implemented in arrays in the javascript code. These zapping times were 0, 0.1, 0.2, 0.2, 0.5, 0.5, 1, 2, 2 and 5 sec. Some of the zapping times were repeated to see the consistency of the users. Moreover, a random ordering of these zapping times is implemented for each of the 12 test subjects that participated in the subjective experiment in [1]. When the user zaps to a new channel, the page sleeps for a time corresponding to the implemented zapping time before the requested channel is displayed. During this time a random advertisement picture is selected from a set of advertisement pictures and it is displayed. This chain of events is depicted in Fig. 1. For all advertisements we have used logo-like pictures.

Figure 1. Showing an advertisement during zapping

When the user zaps to the next channel the same step is repeated, but an advertisement different from the advertisement shown during the previous zapping epoch is selected in random manner.

In order to increase the number of test subjects involved, we have set up an additional subjective experiment with 18 additional test subjects. This time the zapping times were 0.5, 1, 2, 3, 4 and 5 sec. The reason to include “new” zapping times (3 and 4 sec) is that we did not have acquired data for these zapping times. We left out some of the original zapping times in order to keep the length of the test sufficiently short, thus preventing fatigue of the test objects.

B. The actual experiments

In this subsection we list the outcomes of the original experiment with 12 test subjects and the additional experiments with 18 test subjects. The test subjects consisted of a total of 30 people at TNO ICT in Delft, the Netherlands. The test subjects varied in age, gender and experience.

To view the channels a laptop (Pentium 4, 2GB RAM, windows vista, 1500x750 pixels screen resolution) is used as a TV set. The experiment that we have conducted is of ‘lean backward zapping’ type. That means the user will sit back in a chair and use the remote control to zap between the channels. A Sony Ericsson Bluetooth enabled mobile phone is used as a remote control device. The experiment contains two parts, the training and the actual experiment.

In the training session, we show the test subjects three zapping times: instantaneous, intermediate and slow to give them an example of how the zapping times in the actual experiment are to be assessed. During this session, the test subject will get used to the ITU MOS scale.

During the actual experiments the test subjects were asked to experience the zapping times by zapping between the channels using the remote control (mobile phone) then to evaluate the experienced quality. For the test in [1] they evaluate their perception for the different zapping times, first using black screen and then using advertisements during zapping. For the new subjective test only the perception when using advertisements during zapping was asked. The users are also given the chance to give open suggestions. The handouts and scoring tables are given in Appendix A. To our knowledge these experiments were the first ever to assess the Quality of Experience when pictures are displayed during zapping.

IV. RESULTS

A. MOS results

The results obtained for each zapping time are analyzed and averaged over the number of test subjects to obtain the MOS for each zapping time. This is done for both the case where a black screen is shown during zapping and the case where an advertisement is shown. From now on we will refer two these two cases as ‘black screen’ and ‘advertisement’. The obtained results are shown in Table 1 and Table 2, respectively. Note that the results in Table 1 are completely based upon [1] while Table 2 is based upon [1] and the additional subjective experiment.

Table 1. MOS for ‘black screen’

Zapping Time(sec)	MOS	Std. Dev.

0	4.75	0.62
0.1	4.83	0.39
0.2	4.42	0.67
0.2	4.25	0.62
0.5	3.33	0.89
0.5	3.50	0.67
1	2.75	0.75
2	1.83	0.83
2	1.83	0.58
5	1.08	0.29

Table 2. MOS for 'advertisement'

Zapping Time(sec)	MOS	Std. Dev.
0	4.42	1.24
0.1	2.92	1.38
0.2	3.04	1.20
0.5	3.40	1.27
1	3.37	0.85
2	2.71	0.97
3	2.17	1.04
4	1.61	0.85
5	1.77	1.01

As seen from the tables, the standard deviation is lower for the MOS of the black screen experiment. This implies the opinion of the users for the black screen zapping is quite stable. However, for an advertisement related MOS the opinion of different people shows more variance.

The MOS results, together with their 95% confidence intervals, are also shown in Fig. 2 and Fig. 3.

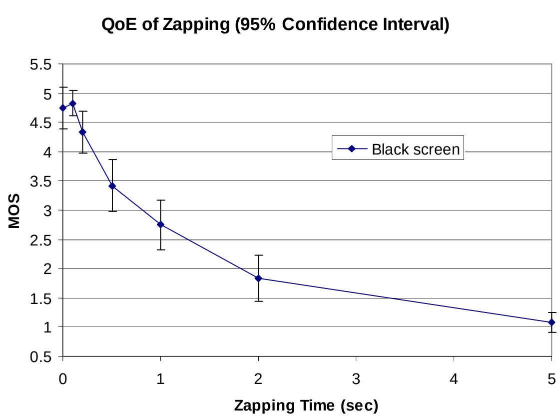

Figure 2. MOS for 'black screen'

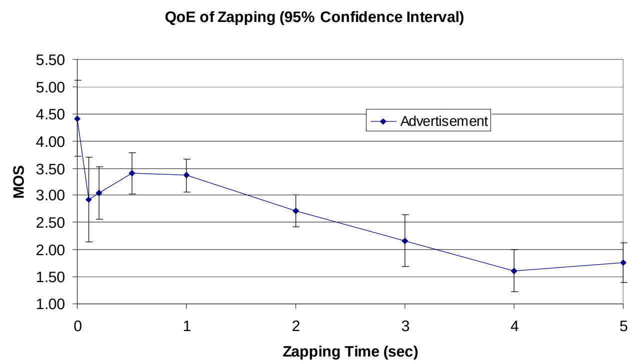

Figure 3. MOS for 'advertisement'

In order to compare the two cases, Fig. 4 contains the MOS results for both 'black screen' and 'advertisement'. The following important insights can be obtained from Figure 4:

- The QoE decreases as the zapping time increases, both for 'black screen' and 'advertisement', except for 'advertisement' for zapping times between 0.1 sec and 1 sec, and for 'advertisement' for zapping times between 4 sec and 5 sec.
- The MOS for 'advertisement' exceeds the MOS for 'black screen' for zapping times greater than 0.65 sec. This implies that the users prefer 'advertisement' only when the zapping time is sufficiently large. For zapping times of 1, 2, 3, 4 and 5 sec, the anticipated QoE increment is clearly seen, as the 'advertisement' curve for these zapping times shifts upwards with respect to the 'black screen' curve.
- The 'advertisement' MOS is more or less constant, for zapping times less than 1 sec. However, it decreases when the zapping time increases to 2 sec and 5 sec. This means users are still annoyed with longer zapping times, even though advertisements are shown during zapping.
- The QoE curve for 'advertisement' drops with high slope from zero zapping time to a zapping time of 0.1 sec. Because the 'black screen' curve decreases smoothly, we conclude that it is a bad idea to show advertisements in case of short zapping times.

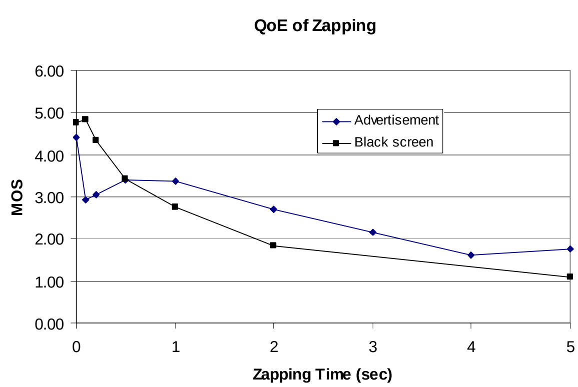

Figure 4. MOS for 'black screen' and 'advertisement'

B. *Comparison for 'black screen' with previous results*

The 'black screen' experiment was conducted before, see [5]. Our test scenarios are similar to the one reported in [5], except for some minor changes in the setup, like the laptop used for the experiment, the experiment room and the test subjects. The results obtained from the two tests are compared in the table below.

Table 3. 'Black screen' MOS for our experiment and previous experiment in [5]

Zapping Time(sec)	MOS Our experiment	MOS Experiment in [5]
0	4.75	4.90
0.1	4.83	4.90
0.2	4.42	4.60
0.2	4.25	4.50
0.5	3.33	3.50
0.5	3.50	3.30
1	2.75	2.30
2	1.83	1.60
2	1.83	2.00
5	1.08	1.10

It is clear that the outcome of the experiments is almost similar. In fact, the correlation between the two experiments is as high as 0.99.

The authors of [5] suggested the following model for the relation between zapping time (in sec) and QoE (expressed in MOS), for the 'black screen' case:

$$MOS = \max\{1, \min\{-1.02 \cdot \ln(ZappingTime) + 2.65, 5\}\} \quad (1)$$

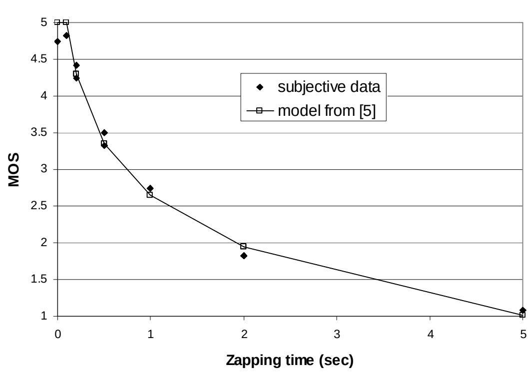

Figure 5. Comparing our 'black screen' results with the model from [5]

C. *QoE model for 'advertisement'*

Analogous to the QoE model for 'black screen' in [5] we will now suggest a QoE model for 'advertisement'. Using curve fitting on the following intervals (in seconds) for the zapping time: [0,0.1], and [0.1,5], we arrive at the following QoE model:

$$MOS = \max\{y_1, y_2\} \quad (2)$$

where

$y_1 = -15 \cdot (ZappingTime) + 4.42$,

$y_2 = 0.0194x^5 - 0.2583x^4 + 1.307x^3 - 3.0864x^2 + 2.7366x + 2.6466$,

with x = Zapping Time (in seconds). Eq. (2) holds for Zapping Times on the interval [0, 5].

Using Table 2 we can validate the QoE model suggested in Eq. (2). This validation is visualized in Fig. 6.

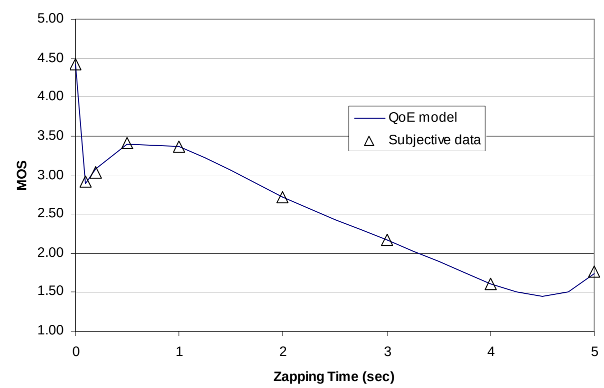

Figure 6 . MOS versus Zapping Time

It turns out that the correlation between the subjective data and the QoE model is 0.99 which is very high. In addition, the RMSE (Root Mean Square Error) equals 0.055 while the MCI (Mean Confidence Interval) satisfies 0.46. Therefore we conclude that the QoE model given by Eq. (2) is very useful for assessing the QoE of zapping for 'advertisement'.

D. *Discussion on user comments*

In addition to evaluating the MOS, users were asked to comment on the usability of advertisements during the zapping times and the reasons behind the MOS scores they gave.

The following are the main comments of the users,

a) A logo advertisement is not good enough for longer zapping times: Most users get annoyed with a single picture advertisement that is displayed for 2 or 5 seconds. It is better to put a video advertisement for such long zapping delays.

b) Advertisements which have darker (non-bright) colors are better for the user perception: A white background picture advertisement is not good if the channels have a black background. So, it is good to avoid dynamic changes in the frame color.

E. *Typical zapping times*

To obtain an indication of zapping times that are found in practice in today's digital television services, we performed some simple measurements. These measurements were carried out manually with the use of a stopwatch. For each of the services the test methodology used was the same. However it should be noted that testing of each of the services was performed only once, at one arbitrarily selected location during an arbitrary time of the day. Additionally, for each service, the measurements were carried out with the use of a single STB (Set-top Box). For most services it is possible to choose between several types of STB's. This means that none of the results necessarily is a good representation of the general performance of this service. However, in the assumption that providers aim to offer a constant quality level to all customers, these test results should give a reasonable indication for the overall service performance. The services that we have measured, all offered by Dutch providers, are:

- Provider 1: Digital TV service based upon DVB-T
- Provider 2: Digital TV service 1 over cable
- Provider 3: Digital TV service 2 over cable

In order to get a good indication of the overall zapping behavior of both services it is necessary to have a sufficiently large number of sample zapping times. For our test we switched channels in total 90 times. 45 times we used the arrow buttons to zap sequentially from channel 1 to 10 and back to channel 1. Subsequently we followed the same procedure to measure zapping delays while using the number buttons of the remote control. Since we did the tests manually with a stopwatch, the tests were performed with the volume of the TV turned off (muted). In this way the person performing the measurement would not be influenced by the sound that belongs to the image (sometimes "sound switching times" show different zapping behavior than the "image switching times").

We limited the test between channels 1 to 10 because all three services in this test offered the "main channels" on these channel numbers. These channels were; NED1, NED2, NED3, RTL4, RTL5, SBS6, RTL7, Veronica/Jetix, NET5 and RTL8.

To measure the zapping time between channels we started the stopwatch simultaneously with the push of the button on the remote control (in case we zapped to e.g. channel 14 we started the stopwatch at the moment that the button for the second figure was pushed, in this case 4). As soon as we saw an image we stopped the time. Then we subtracted 0.2 seconds from this time in order to compensate for the human response delay.

In Table 4, the mean delays and the variations in zapping delay are listed for all measured services.

Table 4: Measured zapping times from existing services

Service	**Provider 1**	**Provider 2**	**Provider 3**
STB type	Samsung SMT-1000T	Thomson 52UPC01	Humax IR-Fox C
Arrows			
Mean delay	2,12 s	1,30 s	1,82 s
Variation	0,44 s	0,09 s	0,23 s
Numbers			
Mean delay	3,65 s	1,36 s	4,45 s
Variation	0,33 s	0,11 s	0,25 s
Combined			
Mean delay	2,89 s	1,33 s	3,14 s
Variation	0,97 s	0,10 s	1,99 s

Notice the large differences between the average zapping times for "zapping by arrows" and "zapping by numbers" in the Provider 1 and Provider 3 case. These differences are caused by the implementation of the STB's. When using the arrows, the STB starts fetching the new channel immediately. When pushing a number, the STB "waits" a short period for an additional number. For example: if a user pushes number 1 on the remote control in order to zap to channel 1, then the STB waits a short period for an additional number in case a user intends to zap to a different channel. This could be e.g. number 2 to zap to channel 12 or number 3 to zap to channel 13. Only after this short period, if the second number is not detected, then the STB starts fetching channel 1. From the differences between the averages we can conclude that this "waiting period" is about 1.5 seconds in the Provider 1 STB implementation and about 2.5 seconds in the Provider 3 STB implementation.

V. System for Optimal Zapping Experience

From our conducted subjective experiment, it is found that, for some ranges of zapping times, advertisements lead to a better QoE than black screens. However, for small zapping times black screen is found to be better, see also Fig. 4. However, users also commented that for longer zapping times, i.e. in the order of at least 2 seconds, a video advertisement is preferred over a picture advertisement. Thus it can be anticipated that in order to compare the QoE of 'black screen', 'still picture' and 'clip', Fig. 7 can be used.

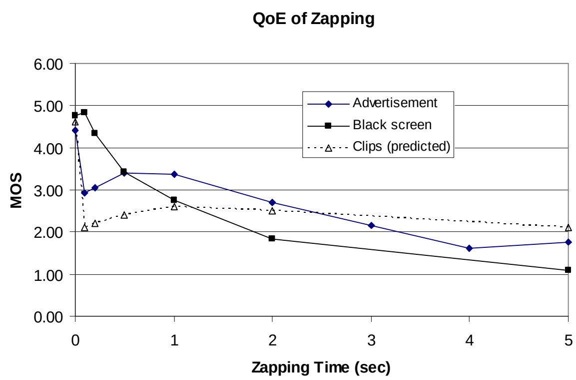

Figure 7. MOS for 'black screen', 'still picture' and 'clip'

Note that the MOS curve for 'clip' in Fig.7 is an anticipated prediction; it is not based upon actual subjective experiments with 'clips' during channel zapping. Based upon Fig.7, we propose a system for optimal zapping experience.

A. Requirements

In the IPTV provider network usually not all streams originate from the same source. The most popular ones are streamed from the 'edge' of the network so as to enhance startup times. Less popular channels are streamed from a more central location as this reduces bandwidth consumption and hence reduces cost [10]. The system is subject to a number of imminent changes in the environment, e.g. channels that change the source of origin, new home network equipment and a change of service provider, etcetera. A system like this one needs to adapt to such changes itself, in an automated manner.

Related, but slightly different is the requirement that the system must be zero-configuration. A STB is a device with limited user interfacing capabilities. Configuring one with only a remote control is a daunting task for most regular users already, so having users configure initial settings regarding the ISP or SP network settings should be avoided whenever possible.

Many other requirements exist, but these are considered out of scope.

B. System Overview

The main task of the system is to first estimate the zapping time and then, depending on this estimation, display either a black screen, a picture or a clip. As we learn from the requirements above, its secondary task is to constantly improve the prediction.

Three main functional blocks can be distinguished within the system: *(i)* the Set-top Box (STB) functionality, *(ii)* the Delay Predictor and *(iii)* the Content Selector. These components work together to fulfill the two tasks stated above. Fig. 8 depicts the system overview. The system boundary is indicated with a dashed line.

All messages referenced in the text below refer to the numbered arrows in this figure. Arrows with filled solid heads indicate that a result is received in response to the corresponding message. E.g. message 2.2 actually returns a value; the delay. It is therefore required that the Delay Predictor itself finishes the calculation of that value. During this processing time the message sender must wait. This behavior is referred to as blocking, or synchronous. Arrows with stick heads on the other hand indicate asynchronous messages. The sender does not need to wait for the receiving module to process the message and come up with a result.

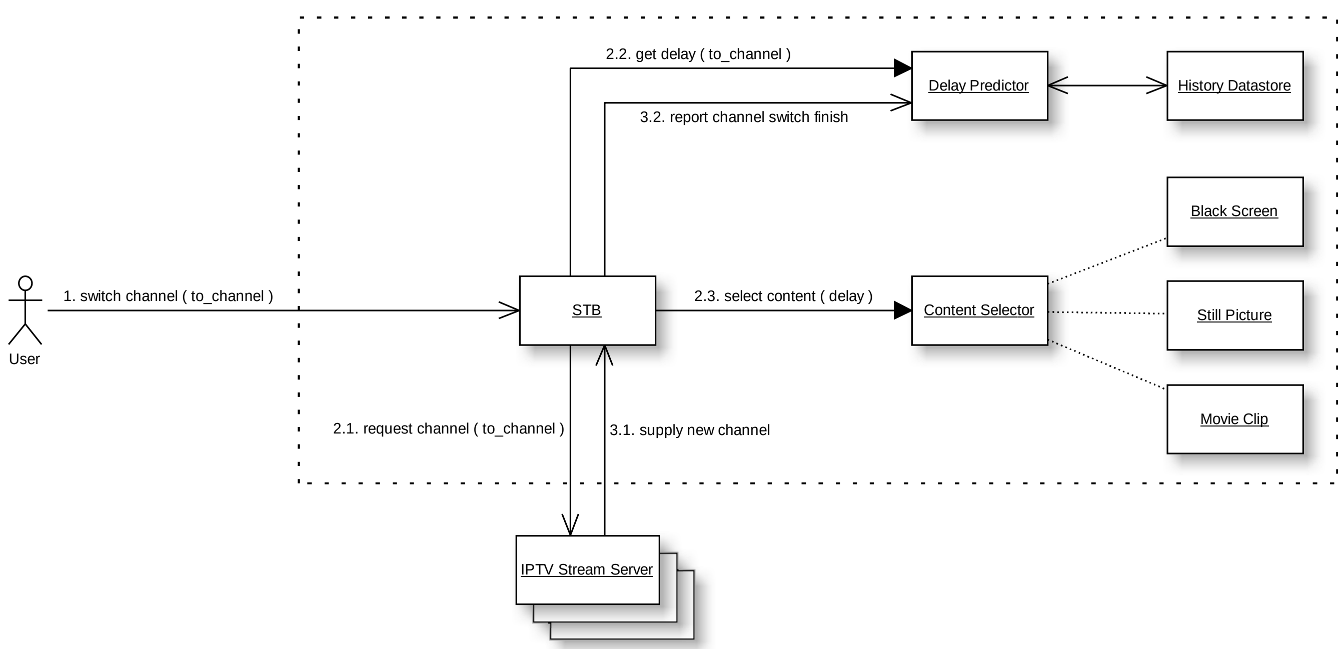

Figure 8. Overview of System for Optimal Zapping Experience

Instead, the sending party treats such messages as “fire and forget”.

C. Selection

The STB comprises all functionality of a regular STB. It listens for user requests, e.g. by means of an infrared receiver and a remote control. It requests video streams from external sources, e.g. through multicast joins and it renders the picture to an external television set.

In the presented system it also manages the in-between content. It does so by first querying the Delay Predictor to get the delay for the user-selected channel (message 2.2). The returned value is the estimated waiting time or delay, which is forwarded to the Content Selector (message 2.3). The Content Selector determines the recommended action to be taken to optimize the waiting experience. The set of actions is a mapping from a time interval to a preferred action, as shown in the table below.

Table 5. Mapping of Time interval to Action

Time interval (seconds)	Action
$0 < \tau \leq a$	Do nothing
$a < \tau \leq b$	Show black screen
$b < \tau \leq c$	Show picture
$c < \tau \leq d$	Show video clip
$\tau > d$	Show sequence of video clips

In this table values *a* through *d* depict time values, where $0<a<b<c<d$ and τ represents the predicted time.

Finally, the determined action is returned in response to message 2.3., accompanied by a reference to the content to use. The STB displays the indicated content item until the new channel stream is ready to be displayed (message 3.1).

D. Adjusting the prediction

In order to be able to adjust its future estimations, the Delay Predictor must be aware of the actual duration of channel switches. A new waiting time measurement is triggered by the “2.2 get delay” message. The time instance this message is received is recorded as T_0. The time measurement ends when a “report channel switch finish” message is received. The time instance this event is received is recorded as T_1. Based on T_0 and T_1 the waiting time for this request is determined:

$$T_{waiting\_time} = T_1 - T_0 \,. \qquad (3)$$

The measurement is stored in the History Datastore, along with an identifier for the request that comprises the target channel (`to_channel`) which can be a Uniform Resource Identifier (URI).

E. Prediction

Using the identifier for the user request as presented above, a prediction is made for the expected waiting time from previous measurements for the same request (requests with the same identifier). It is assumed here that the expected delay is dependent only on the newly selected channel. The prediction is a default value when no measurements are available, otherwise it is the exponential weighted average like:

$$S_t = (1-\alpha)\cdot S_{t-1} + \alpha \cdot x_t \qquad (4)$$

where S_t is the estimation, S_{t-1} is the previous estimation, α is the smoothing constant and x_t the last measurement.

While being simple to implement on a limited resources device like a STB, this still provides a zero-configuration solution that adapts well to a changing environment.

F. Optional Changes

- The prediction as performed by the Delay Predictor may be based on other parameters like the time of day, the number of concurrent users (the system load) or anything else that could influence the waiting time.
- The system may be adapted as to provide an ‘optimal waiting experience’, i.e. not only for use in IPTV environments but also in ATMs, web browsers and any other situation where a user has expressed a wish to some machine while the waiting time is non-deterministic.

VI. CONCLUSIONS

Measuring the QoE of IPTV is an important issue for vendors and service providers. Channel zapping time is a major factor that affects QoE in IPTV. One of the ways to increase the user perceived quality of channel zapping, is to display advertisements during zapping, instead of the usual black screens. From our conducted subjective experiment, it is found that, for some ranges of zapping times, advertisements lead to a better QoE than black screens. However, for small zapping times black screen is found to be better. For intermediate zapping times picture advertisements are convenient. For longer zapping times picture advertisements give a better QoE than black screens; however, using video advertisements might give even better QoE in that situation. In the future we would like to conduct subjective tests where advertisement clips are used during long zapping times. This work might lead to the establishment of two zapping time thresholds: a black screen should be used below the lower threshold and video advertisements above the higher threshold. We also plan to conduct subjective tests in other countries, to see whether or not regional differences occur.

Lastly, we have shown how to implement a ‘System for Optimal Zapping Experience’. In the near future we will implement the system in a field trial and will conduct further subjective experiments with the system, taking into account longer time scales, i.e. we will assess QoE after a period of for instance 3 months. Finally we suggested that the system might be adapted to function as a broader 'System for Optimal Waiting Experience'. Hopefully this inspires others to improve the quality of experience in our day to day activities.

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REFERENCES

[1] B.E. Godana, R.E. Kooij and O.K. Ahmed, Impact of Advertisements during Channel Zapping on Quality of Experience, Proc. of The Fifth International Conference on Networking and Services, ICNS 2009, Valencia, Spain April 20-25, 2009.

[2] Spirent communications white paper, "Delivering optimal QoE for IPTV success", Feb.2006.

[3] ITU Focus group on IPTV, "Quality of Experience requirements for IPTV", FG IPTV-DOC-0118, July 2007.

[4] DSL Forum, "Triple Play Services Quality of Experience (QoE) Requirements and Mechanisms", Technical Report TR-126, December 2006.

[5] Robert Kooij, Kamal Ahmed, Kjell Brunnström, "Perceived Quality of Channel Zapping", Proc. of the fifth IASTED International Conference, Comm. Systems and Networks, Aug. 28-30, 2006, Palma de Mallorca, Spain, pp. 155-158.

[6] ITU-T Rec. P.800, "Methods for Subjective, Determination of Transmission Quality", July 1996.

[7] Nick Fielibert, "Quality Issues in IP Delivery: Set-top boxes", September 2008,
http://www.ieee.org/organizations/society/bt/08iptv3.pdf

[8] N. Degrande, K. Laevens, D. De Vleeschauwer, R. Sharpe, "Increasing the user perceived quality for IPTV services", IEEE Communications Magazine, Vol. 46, Issue 2, Feb. 2008, pp. 94-100.

[9] Bigband Networks, "Methods and apparatus for using delay time during switching events to display previously stored information elements", US Patents 7237251, March 2000.

[10] J. Caja, "Optimization of IPTV Multicast Traffic Transport over Next Generation Metro Networks," in Telecommunications Network Strategy and Planning Symposium, 2006. NETWORKS 2006. 12th International, Nov. 2006, pp. 1–6.

APPENDIX A: QUESTIONAIRE FOR SUBJECTIVE ASSESMENT

Objective: To assess the user perceived quality of digital TV when displaying advertisements during zapping.

General introduction

Nowadays various digital television services are available. But, the user of digital TV experiences longer time delays than the traditional analog TV while switching from channel to channel. The digital TV operator usually displays a black screen during these switching times. However, it could be interesting for the user of digital TV, if the operator displays advertisements instead of a black screen. In this experiment we want to quantify the quality the end user perceives when advertisements are displayed during these switching times.

Introduction to the experiment

In the following experiments you will be asked to assess a total of 10 switching times. The first set of experiments will be done for a black screen and the second set of experiments with advertisements. For this purpose five pre-programmed TV channels are used. You can switch between the channels by pressing the keys 1 to 5 on the mobile phone ("the remote control device"). To change to a different switching time, use the volume up/down keys on the mobile phone. The task is to assess the duration of these switching times using Mean Opinion Score values shown in the table.

Mean Opinion Score:	Explanation:
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

Training

Three switching times are shown in the training. These switching times will be rated as shown in the following table.

Switching Time	MOS
instantaneous	5
intermediate	between 5 and 1
slow	1

The actual experiment

Follow the instructions below for both Set 1 (black screen) and Set 2 (advertisement) experiments.

1. In the opening screen: select your subject number.
2. Select "switching time 1" in the drop-down list on the bottom of the screen.
3. Experience the switching time and write down the MOS value in the table for this switching time.
4. Then select "switching time 2" in the drop-down list (can also be changed using the volume up/down button of the mobile phone) and repeat step 3 until you have assessed all 10 switching times.

Usage note:

Action	Key to use on mobile
Zap between channels	1 to 5
Change switching time	volume up/down

Form:

	Black screen MOS	**Advertisement MOS**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Further Suggestions:

1. …

2. …