Digital TV: The Effect of Delay when Watching Football

Rufael Mekuria
CWI
Sciencepark 123
1098 XG Amsterdam
+31(0)20 592 4020
Rufael.mekuria@cwi.nl

Pablo Cesar
CWI
Sciencepark 123
1098 XG Amsterdam
+31 (0)20 592 4332
P.S.Cesar@cwi.nl

Dick Bulterman
CWI
Sciencepark 123
1098 XG Amsterdam
+31 (0)20 593 4300
d.c.a.bulterman@cwi.nl

ABSTRACT
Hearing a neighbor cheer for a goal seconds before you see it can be very annoying. Currently, many people that upgrade their TV service from analog to digital TV are experiencing this. We briefly describe causes of these (relative) delays. To support this with practical evidence, we report field measurements of relative delays from 19 different receivers that show that up to 5 seconds occurs between technologies like IPTV, analogue cable, digital cable (both SD and HD), digital satellite, terrestrial and web TV. We present a controlled experiment that simulates the football watching experience with 18 participants watching clips in different rooms cheering over an audio connection. The results show that delays measured in practice disturb the experience significantly. Moreover it often took participants little time to find out if they were ahead or behind. Also many participants felt inclined to change their service to a provider with less delay. The results emphasize that delay is a quality factor that needs to be taken into account and minimized in digital TV. This is crucial for digital TV providers to entice consumers that want to be the ones to first cheer for a goal.

Categories and Subject Descriptors
H.5.1 [**Multimedia Information Systems**]: Video, Broadcasting,

General Terms
Measurement, Experimentation, Human Factors.

Keywords
Digital Video Broadcasting, Football, Quality of Experience, Delay

1. INTRODUCTION
The national team is playing a play-off match for the FIFA world championship football. John recently subscribed to his high definition TV package, and invited friends to watch the game at home. The streets are empty as John is not the only one watching the game. The striker has the ball and heads towards the goal. As he gets closer, John suddenly hears his neighbors shouting and cheering. Some seconds later John and his friends indeed see the goal scored. The striker passed back and a second line shot flew in. After the excitement, John and his friends realize that they are not watching the match live as others are ahead of them. Some other tense moments in the match occur and a second goal is scored. Every time the neighbors are cheering and shouting before John and his friend. John gets the question, how much money he is paying for his subscription. At half time John and his friends decide to watch in a local bar so that they can cheer all together when a goal is scored.

This experience has happened to many digital TV subscribers. Posts in popular media and Dutch national TV indicate that people are frustrated by this[1]. With increased urbanization, people tend to live closer to each other, and sounds from neighbors are often present. Especially for the continents where live football is popular such as Latin America and Europe this is true. As live football matches are very popular, these delays give many people a reason *not* to switch to digital TV despite its better visual quality. As this drawback is becoming well known to customers, digital TV service providers cannot keep ignoring this effect, as it may damage their current and future revenues. Football watching is a serious business for TV broadcasters. To give an indication, the owner of the rights to the English premier league is reported to have paid over £1 billion for them.

Digital TV broadcasting consists of multiple digital processing steps, the delay that each processing step introduces accumulates and can be large compared to analogue transmission. While much literature and standardization work on digital TV is available, the delays introduced in each step and the effect when watching football have not been studied systematically. This leads to our first research question:

1. What are the causes of delay in digital TV and how much difference between closely located receivers are common in real situations?

We will provide a table with delay causes in digital TV and a measurement study comparing different receivers in an urban area in the Netherlands. The second research question will be related to the Quality of Experience, the subjective experience of the user by answering the following questions:

2. How much (relative) delay makes people notice or get annoyed when watching football and does this discourages people from using digital TV?

This, we will investigate by simulating the football watching experience with audio feedback in a controlled trial with eighteen participants and artificially introduced relative delays.

The rest of the paper is structured as follows: in section 2 we present related work. In section 3 we identify the causes of delay in digital TV. In section 4 we present and analyze the results of a measurement study of relative delays between channels and technologies in a single urban area. In section 5 we present the

EuroITV'12, July 4–6, 2012, Berlin, Germany.

[1]http://wk2010.eenvandaag.nl/home/36140/irritatie_door_vertraging_digitale_tv (in Dutch)

setup of the controlled experiment for the user experience and its results. The paper concludes in section 6.

2. RELATED WORK

In most countries, analog TV broadcasts are phased out and are replaced by digital TV broadcast. An overview of digital TV standards worldwide is given in [1]. The compression and digital techniques employed in these standards introduce some delay that is taken into account in these standards. However minimizing these delays was not a primary design goal in digital TV. For example the DVB project described in [2] aims for constant delay in a given configuration. This resulted in different digital TV users experiencing different delays affecting the user experience when talking over an audio connection or when watching football. For example, a prototype to synchronize online video playback was presented in [3] for the talking/chatting scenario online where users watch content and communicate simultaneously. It showed initial evidence that elimination of relative delay is desirable in such scenarios. The authors investigated the effects in a controlled study in [4]. We found that when friends are watching a sociable genre, a quiz in this case, they may notice a relative delay of 1s or more when talking over a voice connection and when using text chat, the more active chatters noticed 2s or more. The study in [9] presented the idea that synchronization benefits the football watching experience. However, the result from the controlled study in [4] does not apply to football as large differences in viewing experience between different genres have been reported in [5]. Another use case where TV broadcasting delays can be annoying that received attention is the case when it causes channel zapping delay as in IPTV. Causes and possible ways to reduce channel zapping delays are described in [6] and the QoE of channel zapping delay was studied in [7]. The ITU Quality of Experience standard for IPTV [8] adapted these values and gives values for channel zapping and broadcasting delays. A paper [9] provides a use case for synchronizing receivers of IPTV, as it should benefit watching football.

These studies do not cover the QoE of the popular and commercially relevant case of watching football using digital TV. This paper aims to fill this gap by presenting a controlled studies of this effect. Moreover we will focus on digital TV in general which is currently widely deployed and used. As cheering neighbors can use different types of digital TV, such local differences between technology types will be measured here.

3. Delay in Digital TV

Some of the sources that cause delay in digital TV are presented in Table 1. Encoding and Capturing introduce delays at the studio/ broadcast source. This can introduce a relative delay between different TV stations when the broadcast the same live content. A conversion of the digital image format (for example to adapt to the screen size in DVB-H) can also introduce extra delay. Modulation, coding and propagation as used in digital TV can also introduce delays.

Table 1 Delay Sources in Digital TV

Delay Source	Location
Generation	Broadcast source/studio
Transcoding/image conversion	Operator
Modulation/ error coding	Operator
Propagation	Between operator and Source
Buffering, decoding, rendering	Receiver

For example when a satellite signal is used already a two way propagation delay of 120 ms occurs. In the case of IPTV, the access network may introduce some delays around 100 ms. Moreover decoding, buffering and rendering steps also introduce a delay based on the digital TV and set-top box hardware.

4. DELAY MEASUREMENT STUDY

A mobile TV receiver was deployed in homes with different TV services. A camera connected to a laptop recorded both the home TV image and the laptop image. The mobile TV receiver is shown in top of figure 1 and consists of a laptop connected to the portable DVB-T Anysee device. By comparing the scene changes happening on the TV with the ones at the mobile receiver, differences between the two were measured. An example front recording is shown in Fig. 1. By measuring at many different homes, we indirectly compared many TV services, resulting in a broad measurement study (17 locations, over 30 different setups). The results were collected in a spreadsheet and plotted in Fig 2 as error bars around the mean difference with the DVB-T laptop.

Fig. 1 Anysee DVB-T receiver (left) and the front recording of home TV and mobile receiver (right)

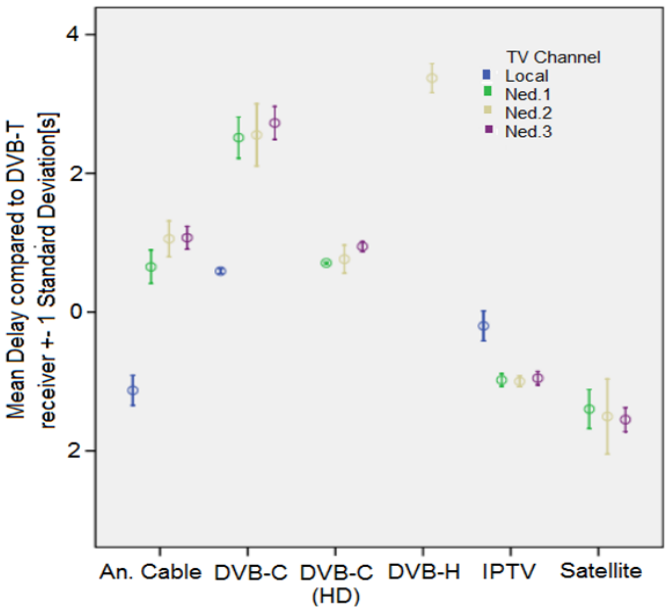

Fig. 2 Comparison study of synchronization between TV-based technologies

Fig. 2 shows the mean difference with the mobile DVB-T receiver and the standard deviation. The national broadcasting stations are represented by green, gray and purple and the local TV broadcast, recorded if available, in blue. Fig. 2 also shows that the means and standard deviations are clustered around the service type (technology) and channel. Analysis of Variance confirms this: (8,249) =37,38 p<0.001. The DVB-C/HD difference showed that a large difference between quality level can exist, and that, in this case, the HD version was (somewhat surprisingly) faster. The digital satellite signal DVB-S was the fastest, maybe because other operators used DVB-S as source (we could not verify this). The DVB-H receiver, a broadcast technology optimized for mobiles, showed the highest delay caused either because of buffering or screen size conversion or other factors causing overhead.

5. FOOTBALL WATCHING EXPERIMENT

In this section we study the impact of the impact of such (relative) delay when watching football matches on the user experience.

5.1 Technical setup

The experimental setup involves two laptops that display football clips. The laptops run Ubuntu 11.10. The laptops are synchronized in time by setting the same local time server in the ntp.conf file and calling the system command ntpd to synchronize the stations. Then, to artificially introduce relative delays, we developed a small media player using gstreamer[2], an open source framework for developing media streaming applications. The media player asseses the Linux system time to start g-streamer playback at the two machines at (almost) exactly fixed or synchronized starting times of 0, 500, 1000, 2000 and 4000 ms. The program was written in C and uses the time.h library and the sys/timeb.h that provide millisecond accuracy. The system was validated by listening to the audio synchronization of the two laptops displaying the same video, a difference that was close to inaudible (a very small difference audible to the sensitive ear). To enable speech communication we used cisco IP telephones on speaker mode. The speech audio and voice audio were tuned in such a way that feedback from the football video through the speech interface was inaudible. A schematic of the experimental setup displaying the laptops, the NTP server and the phones is shown in Figure 3. Figure 4 displays a screenshot of the banshee media player initialized by gstreamer for playback of the football clip. The initialization and setting of the timing of each clip was handled by a bash script. After each clip the users are given time to fill the questionnaires and when they finish and when they press to continue, and the bash script starts the media player.

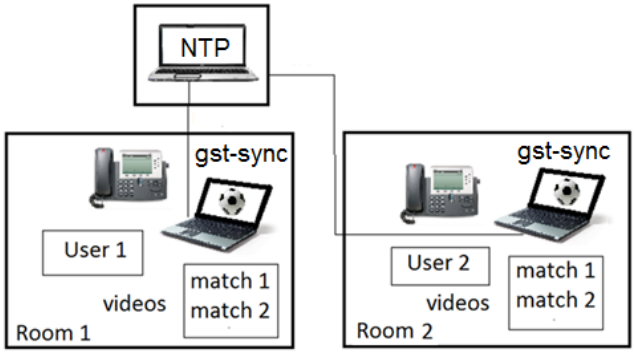

Fig. 3 Experimental setup

[2] http://gstreamer.freedesktop.org/

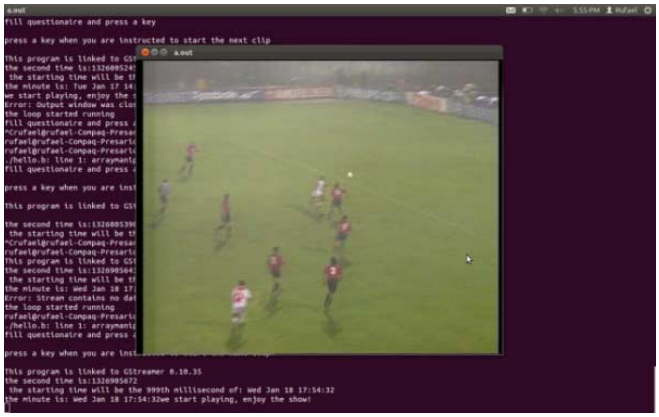

Figure 4 Banshee synchronized video player

5.2 Video Content

During the 90 minutes of a match, parts with more activity and parts with less activity occur. Intuitively, relative difference tends to be more disturbing in active parts than in quiet parts. To avoid this possible bias, we use 10 minute summaries that emphasize on the active parts and display goals and chances. Each clips show an approximately equal amount of possibilities to cheer or shout. The summaries presented contain the matches of one season of champions league in 1995 of Ajax, the team that eventually won and present very entertaining football to keep the participants interested. Another reason for choosing an old match is that participants will not have recently seen it recently, avoiding this type of user anticipation.

5.3 Experimental procedure

We utilize methodology and approach as in our earlier work presented in [4] where we measured the effect of such differences in Social TV .We are aware that a controlled setup takes away some realism from real world situations, but allows to test the specific different conditions in isolation and find the threshold values. We situated two participants behind their laptop in different rooms and asked them to cheer for the winning team in each of the ten minute videos. In order to avoid habituation effects, conditions are presented in randomized order. The values of the relative delays are selected as 0, 500, 1000, 2000 and 4000 ms, corresponding to real world measurements shown in section 4. After each ten minute clip participants are demanded to fill in the questionnaire. In fact the questionnaire is an adapted version of the degradation category MOS scale [10] shown in table 2. This scale is commonly used in QoE experiments. The participant is also asked in if this difference would encourage him to change service provider and if paying more would be an option. Recruitment was performed in friends, work, acquaintances and family circles. The participants were both men and woman of ages in the range of 20-40 years old. Most were at the time pursuing Masters or PhD degrees.

Table 2 Assessment scores on DCR scale

Score	Impairment
5	the play-back difference is not perceptible
4	the difference is perceptible but not annoying
3	the difference is perceptible and slightly annoying
2	The difference is perceptible and annoying
1	the difference is perceptible and very annoying

We asked participants to cheer as much for the goals as possible. In this way the effect of audible/noticeable difference was tested, instead of the more social/cultural aspects of this situation.

5.4 RESULTS

The majority of participants also watched football matches in their private time, mostly the European leagues or the leagues in Brazil or Turkey. Figure 5 shows the percentage of persons that noticed/and or got annoyed by the relative delay. At 1 second more than half the participants notice the differences, while at 4s most participants notice it and are annoyed.

Table 3 Participant willingness to change service

Difference[ms]	NO	MAYBE	YES
0 ms	78%	22%	0%
500 ms	72%	22%	6%
1000 ms	72%	22%	6%
2000 ms	39%	55%	6%
4000 ms	11%	28%	61%

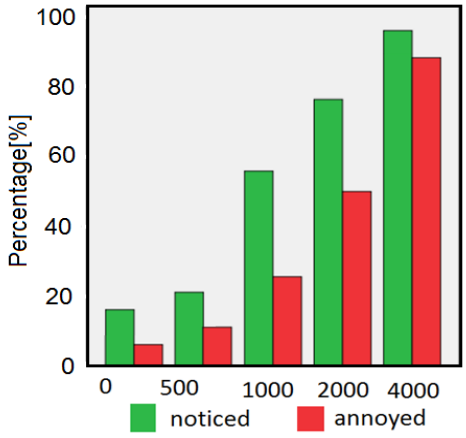

Figure 5 Experimental results

We also posed the question if such difference would make participants consider changing their service provider. The aim was to measure the intention of people. The responses are shown in Table 3. The results show a clear trend: at 2s people start to doubt and at 4s more than half indicates willing to change their service. Also, in that case 28% considers changing their service as an option. From the collected data, especially, the people that watch football often indicate the possibility to change provider.

6. CONCLUSIONS

In this paper we presented empirical evidence that relative delays encountered in digital TV degrade the football watching experience. Especially large differences are noticed quickly by participants and are a plausible reason to change provider. As the experiment had 18 participants, we refrained from statistical analysis. However from the results, 1 second is noticeable in over 50% of the cases and 4 seconds is annoying in more than 50% of the cases. These values can be used a motivation to develop solutions to palliate this problem and motivate business decisions to upgrade current digital TV infrastructures.

ACKNOWLEDGEMENTS

We thank all the participants for their time watching the matches. Moreover we thank Dr.Oskar van Deventer and Hans Stokking for their contributions. The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement no. ICT-2011-7-287723 (Reverie project).

REFERENCES

[1] Wu, Y. Hirakawa,S .Reimers, U. Withaker, J. 2006. Overview of Digital Television Development. *Proceedings of the IEEE*, Volume 94 Issue 1 8-21. DOI=10.1109/JPROC.2005.861000

[2] Reimers, U. 2005. DVB *The Family of international standards for digital video broadcasting*. Springer , signals and communication technology, Braunschweig.

[3] Shamma, D.A. Bastea-Forte, M. Joubert, N. Liu Y. 2008. Enhancing online personal connections through synchronized sharing of online video. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Florence, Italy), April 05 - 10, 2008). CHI '08. ACM, New York, NY, 2931-2936. DOI= 10.1145/1358628.1358786.

[4] Geerts, D. Vaishnavi, I. Mekuria, R. Van Deventer, M.O. Cesar, P. 2011. Are We in sync? Synchronization requirements for watching online video together. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Vancouver, Canada), May 07 - 12, 2011. CHI '11. ACM, New York, NY, 311-314. DOI=10.1145/1978942.1978986

[5] Geerts, D. Cesar, P. Bulterman, D.C.A.. 2008. The implications of program genres for the design of social television systems. *Proceedings of the first international Conference on Designing Interactive Experiences for TV.* (Vancouver, Canada, October 22 - 24, 2008). UXTV '08. ACM, New York, NY, 71-80. DOI=10.1145/1453805.1453822

[6] Ramosa, F. Crowcroft, A. Gibbensa, R. Rodriguez, P. White, A. 2011. Reducing channel change delay in IPTV by predictive pre-joining of TV channels. *Elsevier Signal Processing: Image Communication* Vol. 26 Issue 7. pp. 400-412. DOI= 10.1016/j.image.2011.03.005

[7] Kooij, Ahmed, K. Brunstrom. K. 2006 . Perceived Quality of Channel Zapping. *Fifth IASTED Conference on Communications Systems and Networks,* Citeseer 2006 155-158.

[8] ITU-T. G.1080 Quality of experience requirements for IPTV services. (2008), ITU.

[9] Van Deventer, M. Stokking H., Niamut O., Walraven F., Klos V. 2006. Advanced interactive television services require content synchronization. *Proceedings of the 15th international conference on Signals Systems and Image Processing.* (Bratislava, Slovakia June 22-25 2008). IWSSIP'08 109- 112. DOI= 10.1109/IWSSIP.2008.4604379

[10] ITU-T. *ITU P.800 Mehods for objective and subjective quality assesment*. 1993-1996.