

Interactive Videos in IPTV using Hypervideo Links

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Abstract

One of the main advantages of Internet Protocol Television (IPTV) is the capability of full duplex communication between the Television (TV) provider and the clients which permits the interactivity of both. From this interactivity, TV providers can obtain extra information from clients. Moreover, clients can even take profit from this type of communication that allows them surfing between videos. However, this feature cannot be used in Digital Terrestrial Television (DTT). This paper shows the design and development of an interactive video for IPTV services that contains hypervideo links with additional information and content that is very useful for viewers. Furthermore, we detail the protocol used to maintain the service between the TV provider and the clients to maintain the service. Finally, the system is tested in a real scenario and the resulting measurements are provided in order to evaluate the network performance needed to offer an adequate service to each client because according to results shows, the use of hypervideo links does not imply an important increase in the ratio of packets per second.

Keywords: Adobe Flash, Interactive TV, Hypervideo, Hypervideo links, Programming, RTP.

1. Introduction

Year by year, the technology in terms of network communication has reached unexpected limits. Due to the improvement in the techniques of capturing and reproducing images, as well as the technology and instruments to perform these tasks, the human being has achieved many inventions related to multimedia entertainment, and more specifically the digital video.

The term hypervideo refers to a video sequence that contains embedded clickable links allowing user to interactively navigate inside a video. This concept merges two powerful communicative media, i. e., the videos and information technology. The simultaneous implementation of a video sequence and a program code is possible through the use of specific software that matches with both concepts.

During the last decade, the newest technologies have broken into the daily lives of most citizens of developed countries, multiplying the possibilities of viewing videos, especially with the foray of smartphones into the current society. Platforms such as Youtube [1] are evolving the way to serve, through the Internet, contents like advertising to the users where they can select the specific content that they wish to see. A recent study conducted by Cisco Systems [2] affirms that in 2017 69% of Internet traffic corresponds to online video content. This is due to its correlation with platforms such as Youtube and social networks such as Instagram [3], Facebook [4], Pinterest [5] or Twitter [6] that have modified the way these platforms share their content adapting it to a video format.

The evolution of these technologies pushes more and more the users to exercise an active role in making decisions about the multimedia content that they want to visualize. Analogous to the hypertext that allows the user to access information from a link in a document to another document or another place within the same document, it is not uncommon then to think about the possibility of an interactive video in which the user can navigate without being limited to the classic navigation buttons (pause, play, and rewind). In this sense, we are talking about the possibility of embedding new content as clickable buttons that allows the option of pressing them according to the users' criteria. However, the main requirements for hypertext and hypervideo are different, since the first one is a static link and the second one is dynamic.

Interactive videos therefore combine a flow of video based on frames that are played according to a certain frequency and a line of programmable code in charge of including interactive buttons (known as hypervideo links) that allow users to browse and to choose content. An interesting tool that allows combining the video and the hypervideo links is the Adobe Flash Builder [7].

Adobe Flash is a software that permits the creation and edition of vector graphics with the possibility of handling the code through a scripting language called ActionScript [8]. It works over video frames and is intended for the production and delivery of interactive content. The generated files usually have the .swf file extension and can be used as a part of the content in a web page to be viewed in a web browser or they can independently be played by the Adobe Flash Player [9]. Initially, Adobe Flash Player was not oriented to inserting

interactive video with jump scenes. This is one of the main motivations of performing this work, i.e., we want to analyze the possibility of deploying interactive videos and determining the limitations of the application in the tasks of developing interactive content.

Currently, Adobe Flash is an obsolete application which is out of the market. Its successor, Adobe Animate, is nowadays the tool developed for this sector. This Adobe Flash application has an improved user interface adapted to the modern times and requirements. Adobe Flash, unlike the other mentioned applications, allows access to the elaboration ins and outs, the modification of the programming language or precise design tools.

The use of interactive content and specifically the use of hypervideo links can evolve the way of transmitting information through online advertising, e-learning courses or business applications. Due to this fact, this paper presents the development of an interactive video or hypervideo that contains several hypervideo links through which the users can access to the desired content without viewing a conventional video. To develop this video, we use tools such as Adobe Flash and ActionScript. Additionally, because the final goal is to transmit this kind of content through an IPTV service provider, we transmit the video along a network and the generated traffic is analyzed. Based on the results, we evaluate if this proposal can be considered as an effective tool for developing interactive videos for IPTV and if it could also be used to know the preferences of the clients' visualization.

This paper is organized as follows. Section 2 contains some of the most interesting previous works related to the inclusion of hypervideo links in conventional multimedia content. Section 3 presents the protocol operation to visualize the hypervideos. In order to test the viability, firstly we need to design a hypervideo. Section 4 shows the design of our hypervideo. The hypervideo development is show in Section 5. Section 6 presents the performance evaluation of our hypervideo. Finally, the conclusion and future work is presented in Section 7.

2. Related Work

Up to now, we can find countless applications focused on the development of interactive videos for different commercial goals that are changing the way of launching advertisements.

The commercial effectiveness of having an interactive video embedded in the sales website of a company is a reality and, more and more, we can find a bigger competence between software platforms to be the flagship in the interactive video creation market. The missing Soo Meta and Narrable, WireWAX [10], Meograph [11] or Pixorial [12] are some of the free software applications that promise the development of interactive videos and nevertheless limit most of the functions that remain only available to premium users. So, these applications can constitute the simple applications oriented to immediate profit that satisfy the demands of small clients.

Additionally, we can find different work carried out to analyze and study the use of hypervideos. For example, there is a patent [13] that proposes a system for selling digital

video information over a communications network such as the Internet. It basically includes a filtering server and a service administration system. In [14], it is proposed an apparatus and method for interfacing with a hypervideo multimedia application when composing and playing the interactive videos. This patent presents a novel hypervideo control and interface that provides for either user-actuated or automatic transitioning between a plurality of video, graphics, textual, animation, and other types of multimedia files.

On the other hand, Chambel et al [15] use hypervideo for teaching. They propose studying how new video-based technologies, such as hypervideo, can provide authentic contexts to support meaningful learning. Authors approach the issue from both cognitive-psychological and technological perspectives. Tiellet et al [16] also present the design and evaluation of a hypervideo environment to support learning of veterinary surgery called Hvet. The design was based on both cognitive and media theories and the evaluation process was based on the opinions of veterinary students that use Hvet to test its efficacy in substitution of learning and training with live animals. The results support the initial hypothesis, showing the potential of hypervideo as a valuable and effective tool to support and complement the learning process regarding surgery techniques and reveal the most appreciated design options.

Doherty et al [17] demonstrate the use of detail-on-demand hypervideo in interactive training and video summarization. Detail-on-demand video allows viewers to watch short video segments and to follow hyperlinks to see additional information. Authors affirm that Hyper-Hitchcock authoring tool helps users to create hypervideos by automatically dividing video into clips that can be combined in a direct manipulation interface.

Mujacic et al [18] focus their work on the design, development and evaluation of a hypermedia e-Learning tool for university students. Student learning results showed that students who had access to hypervideo content performed significantly better than the comparison group that did not had access to hypervideo content

Authors such as Girgensohn et al. [19] introduce detail-on-demand video as a simple type of hypervideo that allows users to watch short video segments and to follow hyperlinks to see additional content. Guided by user feedback, they iterated designs for a detail-on-demand video player. Authors also conduct two studies with users' opinions to obtain information regarding people's understanding of hypervideo to improve the user interface and content. According to the obtained results, the interface design seemed to be tightly coupled to understand the hypervideo structure. Additionally, the parts of the video people accessed were greatly influenced by the hypervideo design. The studies also suggested new guidelines for hypervideo authoring.

Chambel et al in [20] identify potential benefits this kind of videos can contribute. Authors also describe some challenges and guidelines to follow for obtaining immersive and interactive 360° videos based on hypervideos.

Meixner et al [21] present the SIVA Suite. It is an open source framework to create, playback, and administrate hypervideos. The SIVA Suite consists of an authoring tool based

on a HTML5 hypervideo player and a Web server for users and video management. This framework has been successfully used for creating hypervideos in different use cases such as medical hypervideo training. It was evaluated in several usability tests and improved step-by-step since 2008.

As main difference with the existing works, our hypervideo is generated using the Flash tool. Its visualization does not represent any additional cost and the hypervideo can be used with all browsers and most of the available freeware viewers.

3. System Operation

In order to start playing a video we need to follow a process composed by three phases, i.e., connection phase, forwarding phase and disconnection phase. This section details the protocol operation to visualizing the hypervideos.

3.1 Connection phase

During the first phase, a client sends a connection request message "Request Connection" to the device that acts as server where the video database is located. If the client has the appropriate permissions to connect to the server, the server will accept the client's request and will send the "Establish Connection" response accepting and establishing the connection.

3.2 Forwarding

When playing videos without hypervideo links, after establishing the connection with the server, the client requests the video content with the message "Request Video" to the server and the server forwards it to its database. When the server finds the video in the local database, the server will reply to the client with the message "Send Video". After that, the video will be sent to the client and if no problem has happened during the transmission, the database will send a message to the client to finish the connection with an "End Transmission" message.

When playing a hypervideo, the client will send the initial request "Request Video" and the server will send a "Send Video" response as in the previous case. Moreover, if during the viewing of the primary video, the client clicks on some hypervideo link, the client will send a new video request through a "Click Hypervideolink - Request New Video" message. The request will reach the video server and it will forward this message to the data server and start the new video transmission using a "Send New Video" message". This process will be repeated as many times as the client clicks on hypervideo links. In the same way as in the previous case, if no problem happens during the transmission, when all the video has been transmitted to the client, the "End Transmission" signal will be sent from the database indicating that the video has been correctly sent.

3.3 Disconnection

When the "End Transmission" message is received by the client sends a "Disconnect" message to the server to start with the disconnection process and the server replies

accepting and disconnecting the client with a "Disconnect" message.

Figure 1 shows the three phases when a normal video without hypervideo links is played. As we can see, it is required to establish a connection between the client and the server. After that, the video transmission can be considered as secure. When finishing the video transmission, it is important to close the connection in order to release resources.

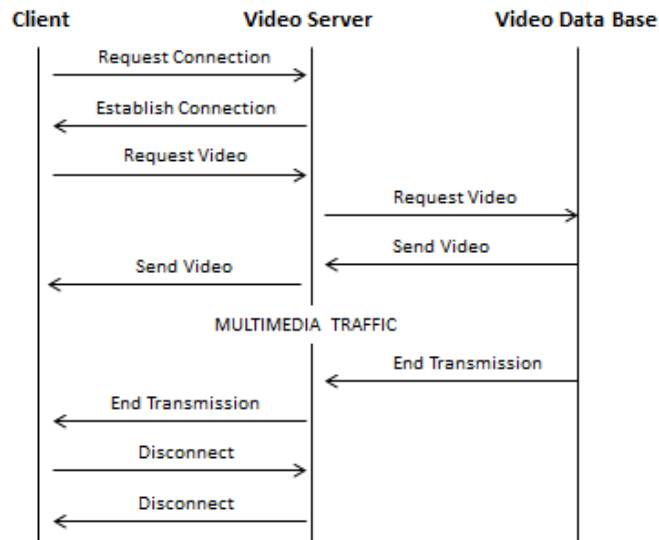


Figure 1. Message exchange when a traditional video without hypervideo links is requested to be played.

Fig. 2 shows the three phases carried out when a video with hypervideo links is played. In this case, it is also required to establish a connection between the client and the server before requesting the video. As particular case, when a hypervideo link is pushed, the system has to be able of storing the timing where the original video was interrupted in order to come back to it when the hypervideo accessed from the link finishes. After finishing the video transmission, the connection should also be closed in order to release resources.

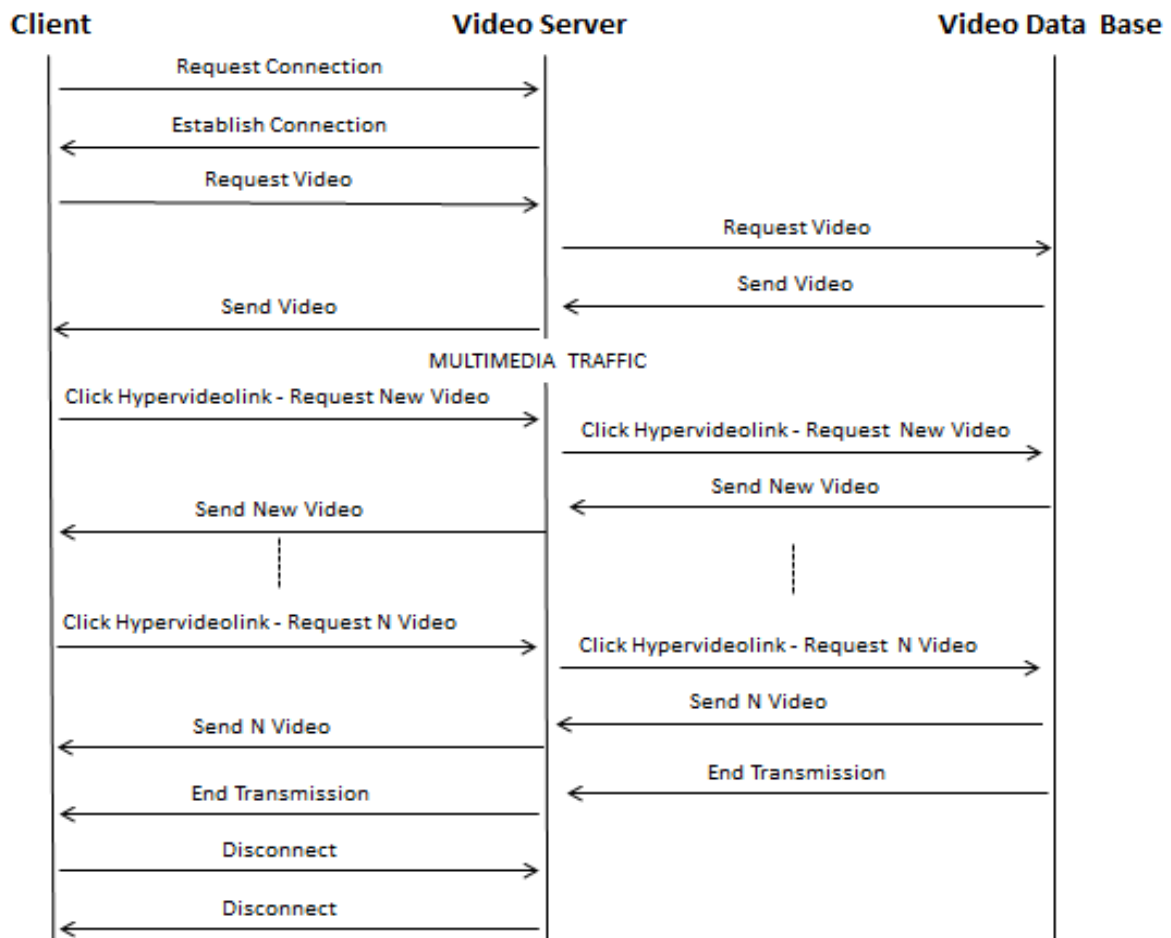


Figure 2. Message exchange when a video with hypervideo links is requested to be played.

4. Proposed Hypervideo

This section explains the proposed hypervideo designed to carry out our tests. The main objective is to create an interactive video that can reflect the instructional, advertising or explanatory benefits of the videos with hypervideo link.

4.1 Main Idea

To develop our interactive video, we have selected a wide spread topic as is the drones operation. It is an explanatory video in which the "basics of a drone" are shown. With this idea, we have tried to create an interactive video, with different scenes that revolve around a main video driver. In these scenes (See Table 1), the drone is presented showing the assembly process or the installation of the wings and the battery. The hypervideo links also show explanations about the physical and mathematical phenomena that govern the flight, the geolocation and certain aspects that they concern the drone.

As a summary, it is an interactive video about a drone that combines the visual aesthetics of a flying device with the explanatory interest of the science that the quadcopters hide.

Table 1. Different scenes that composes our video.

Scene	Scenes that composes the hypervideo	
	Name	Subhead
1	Parts of the drone	The main pieces to mount a drone are analytically shown
2	Jello effect	It contains an illustrative film on the phenomenon of the Jello effect and a brief explanation.
3	Orientation	It shows the main operation of the orientation module in a computer simulation: gyroscope, accelerometer and magnetometer.
4	Propellers	It shows the particularities of this element whose shape enables the flight of the drone.
5	Principle of lift	It shows the Bernoulli's Principle. A brief explanation on blackboard of the forces that act on the aerodynamic profile of an airplane wing.
6	Principle of Trilateration	It shows the mathematical explanation of the geolocation that the drone needs to establish the relative position in which it is in each moment.
7	Ascend / Descend	It shows the motor process of takeoff and land as well as the power applied to each propeller.
8	MIMO technology	It is an instructive video that demonstrates the efficiency of this technology in a flying object whose transmission is a vital aspect in the proper functioning.
9	Translation	The way in which the drone applies power to each propeller to achieve lateral displacement is illustrated.
10	Yaw	It explains the way in which the drone is able to turn on itself in both directions, clockwise and counterclockwise.

4.2 Tree of scenes

By using the scene tree showed in Figure 3, we convert the main idea into a sketch of an organized video with beginning and end, emulating a flow diagram.

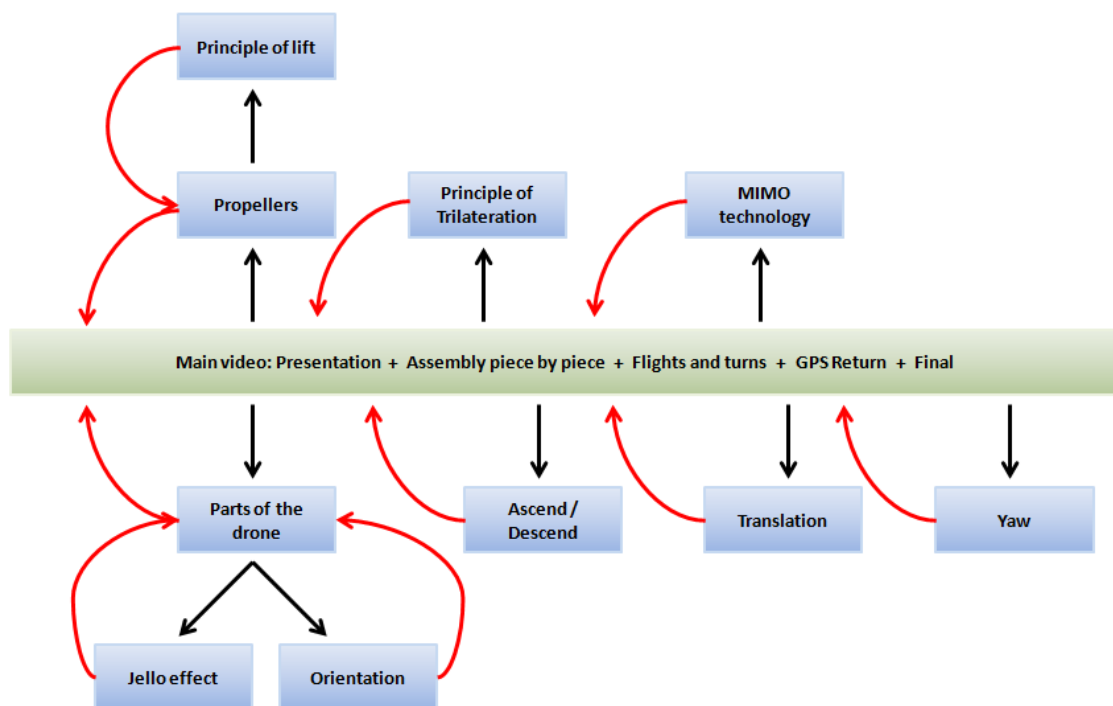


Figure 3. Tree of scenes of our video with hipervideo links.

Once the main idea and the scenes tree are designed, we establish the steps that we will follow to develop the interactive video:

1. Filming of the main video and adjacent scenes (1-10).
2. Editing videos with Sony Vegas to correct duration, speed, color, etc.
3. Rendering de video and conversion to .flv (it is the only format that Flash supports to work frame by frame).
4. Dumping of videos on the Adobe Flash platform and classification by scenes.
5. Design of interactive buttons, animations and structure.
6. Programming the code in ActionScript version 3.0.
7. Correction of errors and export to SWF

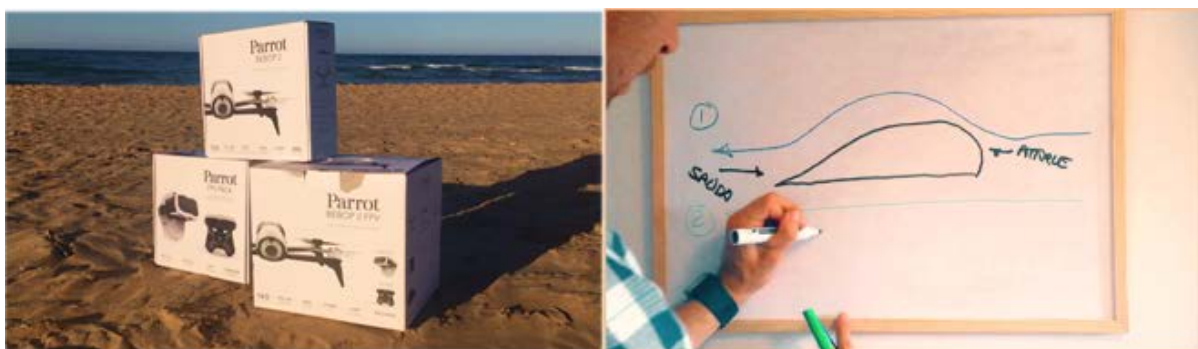
The last step is the most laborious in the process, since there are many combinations of video execution and some links can be canceled, so it is possible that appear some combinatorial order errors.

5. Development of our hypervideo

This section shows the process of collecting images and editing the scenes to obtain the desired interactive video.

5.1. Scene filming

For the recording of scenes, a small shooting script is written that describes the plans, the considerations and the duration of each shot. As Figure 4 shows, the video is divided into outdoor scenes and indoor scenes. The outdoor scenes are recorded in the beach where there is no obstacles to fly the drone (see Figure 4a) while the indoor scenarios are explanations over a blackboard (see Figure 4b).



a) b)

Figure 4. Main scenarios to record our videos: a) outdoor scenario; b) indoor scenario.

5.2. Material used to record the videos

In order to record the audio and video sequences, the following elements are used:

- Video camera Canon Legría HFR306
- Drone Parrot Bebop 2
- iPhone SE
- Microphone Shure SM57

5.3. Audio and video postproduction

After recording all the gross shots of the scenes that will be part of the final interactive video, we proceed to edit the videos with the professional editing software Sony Vegas [22]. It is a high performance non-linear editing system designed to PC. The main control panel of Sony Vegas is shown in Figure 5.

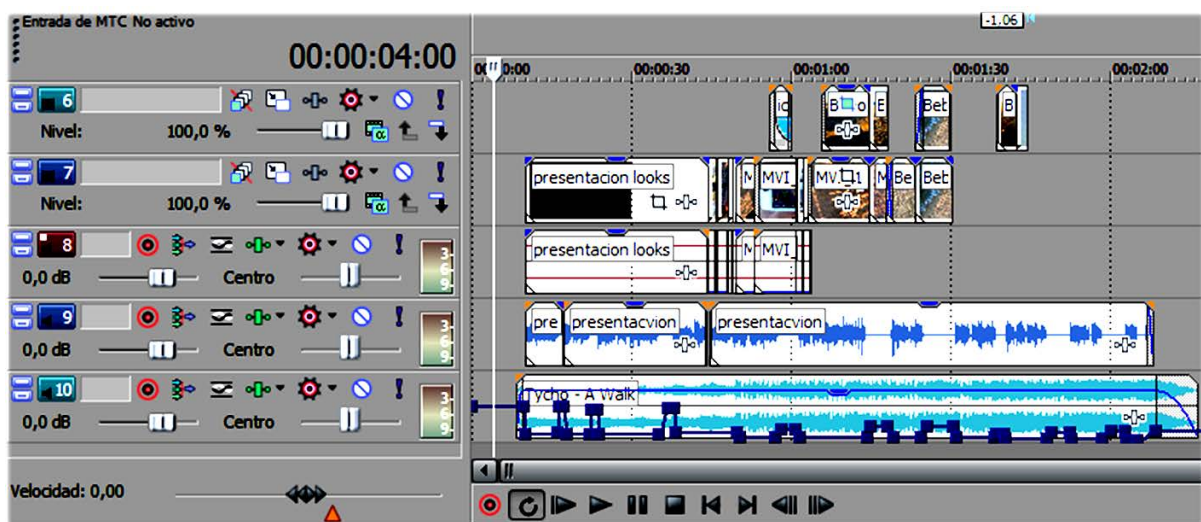


Figure 5. Main control panel of Sony Vegas.

5.4. Adobe Flash

Adobe Flash application allows us to computerize the scenes, including interactive buttons and hypervideo links. These buttons will allow the user to navigate through the different scenes.

Prior to the content dump, generated with Sony Vegas and converted to the .flv format, it is necessary to create a new ActionScript document based on the Adobe Flash language.

After the dump of the videos, we have to create the interactive buttons and animations, so that the user of the interactive video finds simplicity in its handling. These buttons and animations can be imported or generated using the application's own design tool, as Figure 6 shows.

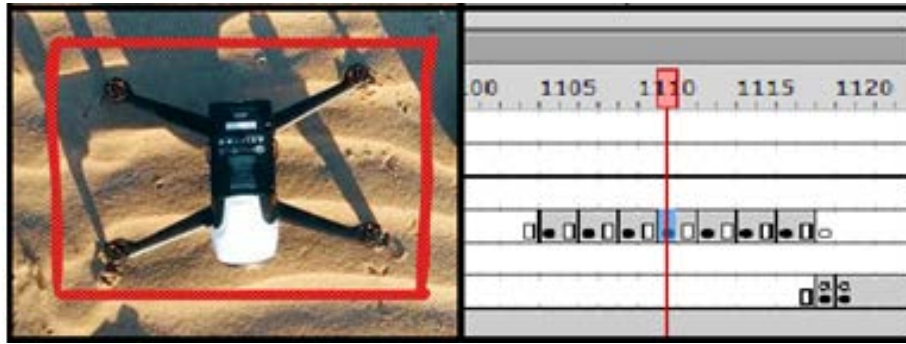


Figure 6. Animation design of a rectangle

After that, we include in the following six frames a pre-designed image with a hand-cursor shape. The idea is to simulate a large cursor that moves to rest on top of the red rectangle, as it is shown in Figure 7.

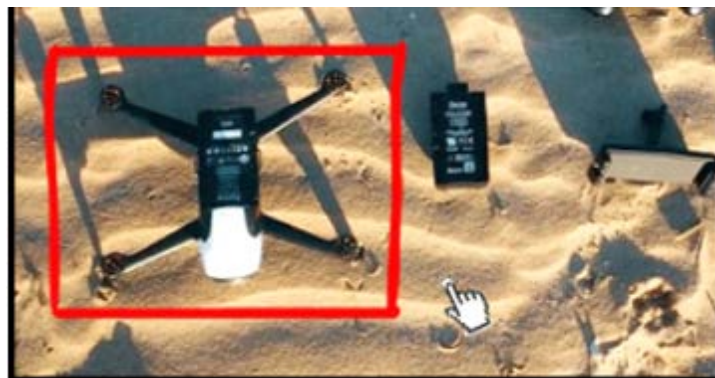


Figure 7. Cursor animation design

With that, we have completed the animation which has occupied 14 frames, i.e., 8 frames to complete the rectangle and 6 frames for the cursor movement. Once the animation is finished, we insert the interactive button with programmable code. As Figure 8 shows, the interactive button will lead the user to the next scene using the hypervideo links.

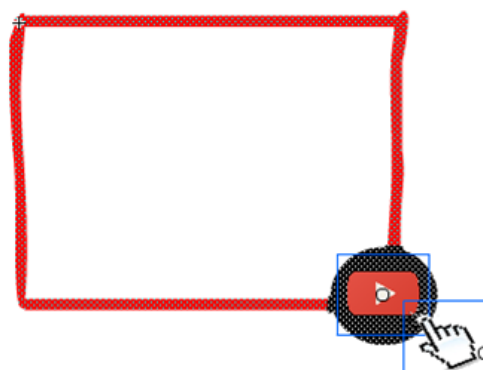


Figure 8. Interactive button design

The process is repeated ten times until completing the 10 buttons that lead the user to the 10 adjacent scenes. We also create 10 return buttons in each of the 10 adjacent scenes, since

the user should be able to come back to the main video in two cases, i.e., when a secondary video finishes and when the user decide to come back to the main video.

The next step is to create a navigation path between videos. Programming languages usually require high knowledge to be able to fluently use them. The case of ActionScript is a little different. Adobe Flash includes predefined tags that contain the code of the specific action that we want to program. In this way, any user, without previous programming knowledge can use these labels which include explanatory comments about how to use the code.

Figure 9 shows an example with the first the buttons that intervene in our interactive video. To include an action on the button, we access to the Actions menu and click on Code Snippets. This will display a menu with all the pre-programmed actions included in Adobe Flash.

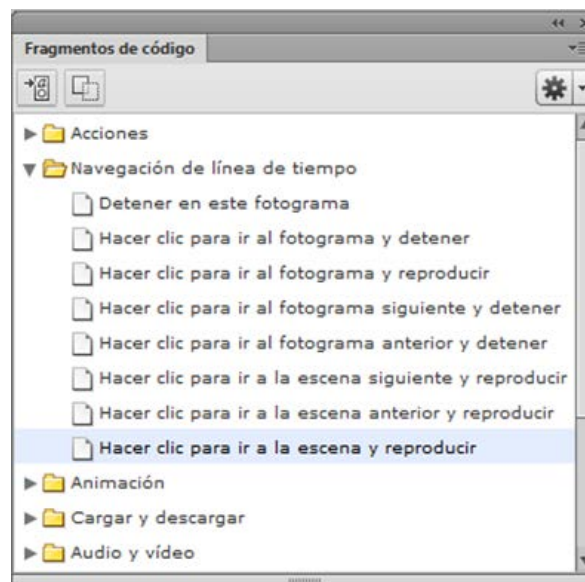


Figure 9. Window of code fragments

Specifically, we are interested in the timeline navigation function in which we jump to another scene by clicking on the button. With the help of the ActionScript code, we insert the code (see Figure 10):

Pseudo- Code: `Hypervideo link`

```
movieClip_1.addEventListener(MouseEvent.CLICK, fl_ClickToGoToScene_2);
function fl_ClickToGoToScene_2(event:MouseEvent):void
{
    movieClip_1.parent.gotoAndPlay(1, "Escena 2");
}
```

Figure 10. Pseudo-Code of Hypervideo link for the timeline navigation.

Figure 10 shows a new action on the "movieClip_1" button (that is, our red rectangle that operates as a button). In case of clicking on the interactive button, this action makes a call to the function "fl_ClickToGoToScene_2". After that, the function that appears between square brackets "fl_ClickToGoToScene_2" is defined. This function permits to jump to 'Scene 2' from frame 1. We repeat the process for each button we want to animate.

To automatically come back to the previous scene, i.e., when a video ends, the following code is used (see Figure 11):

```
Pseudo- Code: Return Hypervideo link  
got oAndPlay( "%Número de fotograma%", "Escena %Número de escena%");
```

Figure 11. Pseudo-Code of Hypervideo link for coming back to the previous scene.

This will make the video jump to the scene and the frame number that we indicate without the need of any user interaction.

6. Performance evaluation

In order to analyze the network performance when transmitting our hypervideo, we use different application layer protocols as Real-time Transport Protocol (RTP) and Real Time Streaming Protocol (RTSP) and players as videoLAN VLC [23] and Flash Movie Player [24] which allow playing and viewing the streaming of .swf files. Additionally, iPerf is used to show the connectivity and estimate throughput between devices. This is in order to ensure the downstream and upstream of the network connection. Finally, Wireshark is used as sniffer to collect the information regarding to the transmitted packets.

Figure 12 presents the results of packets sent as a function of the time when the RTP protocol is used for transmitting the video. Figure 12 shows two different captures, rtp1 and rtp2. The first one refers to the transmission of a traditional video and the second transmission (rtp2) corresponds to a video that use the hypervideo links.

As results shows, for rtp1 the throughput ranges between 14 and 23 packets per second. In rtp2, it is observed that the minimum value has dropped to 8 packets per second in the second 53. This is because at the second 50 a hypervideo link has been pushed to watch another video. Nevertheless, the rest of the transmission has similar rate than rtp1.

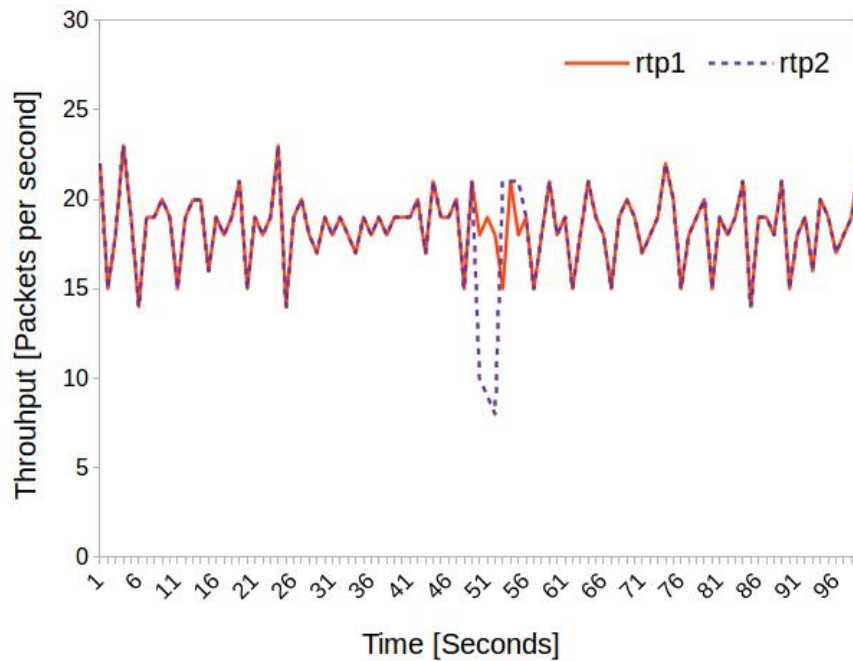


Figure 12. Throughput in RTP

Figure 13 shows the results of transmitting both videos using the RTSP protocol. As in the previous case, two different transmissions are performed. Rtsp1 shows the results when a traditional video is transmitted using RTSP and rtsp2 corresponds to a transmission of a video using the hypervideo links. In this case, the rtsp1 transmission presents a packet ratio that ranges from 38 to 52 packets per second. As in the previous case, the rtsp2 transmission has a minimum value of 15 packets per second at the second 52. This is because in the second 50th, the user has clicked on a hypervideo link in the video.

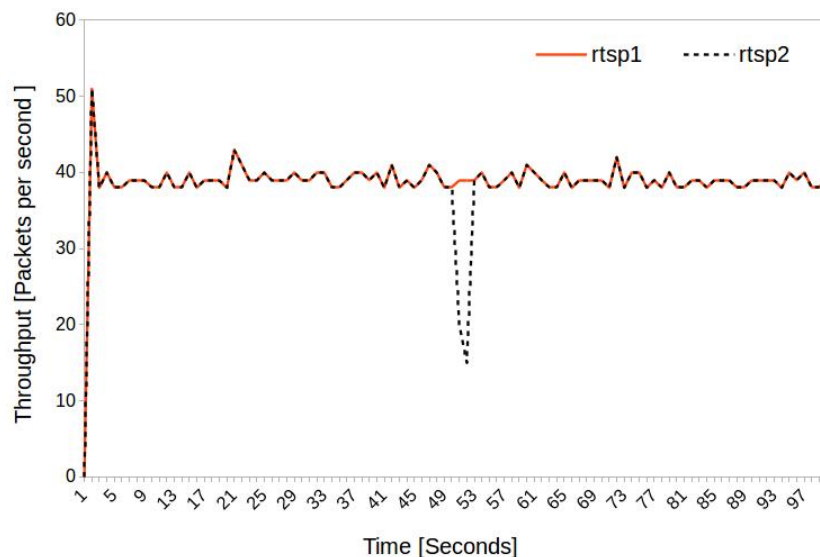


Figure 13. Throughput in RTSP

When the player is used and the client requests the video from the server, the video is

automatically downloaded to the application's buffer, before being viewed. Figure 14 shows the progression of throughput when a video is used. As we can see the number of received packets per second is very high and it ends at 10 seconds. These 10 seconds are used to download the entire hypervideo.

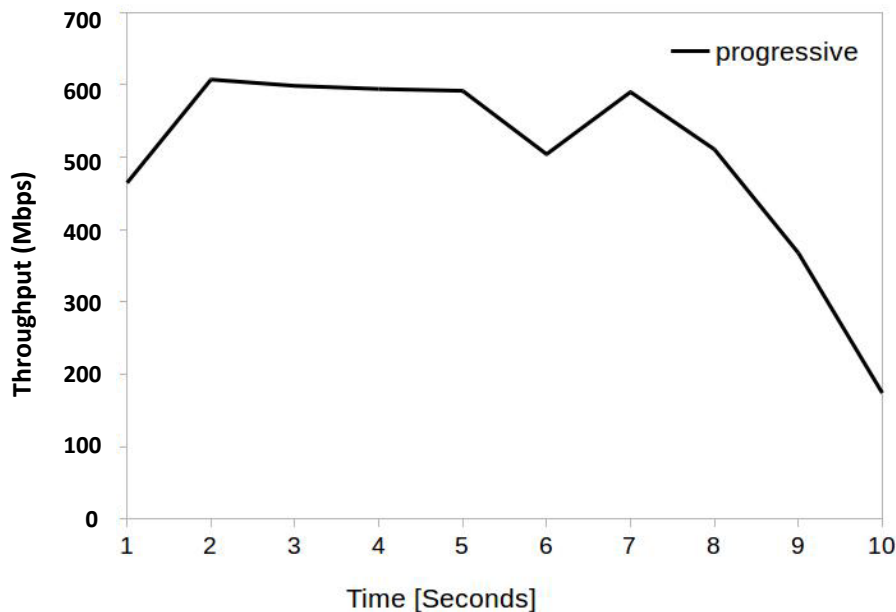


Figure 14. Throughput of a progressive download

7. Conclusion

The creation of interactive content as hypervideos is revolutionizing the way of teaching, the way of entertaining and even the way the advertisement is offered to the potential users.

In this paper, we have created a video with a set of hypervideo links using Adobe Flash. Unlike certain proprietary tools, the use of Adobe Flash for creating hypervideo content ensure us that the result will be reproduced in any Internet portal allowing the user to explore the content according to their criteria and interests. Furthermore, there are currently many applications capable of reading the .swf format, thus being able to be reproduced in mobile phones, smart televisions, etc. This fact implies a great applicability in the IPTV environment for streaming interactive content where users can select the parts of content they want to see.

However, we have found some limitations in the technical capacity of this program, although this drawback can be solved dividing the interactive video into several interconnected files. The results have highlighted very interesting aspects since the video works correctly thanks to the tight compression standard used to offer good image and video quality.

Regarding to the network performance, we have observed very slightly variation in the data transfer rate. When clicking on the hyperlinks that the hypervideos contain, the packet transfer rate per second decreases, although this difference is negligible comparing it when reproducing a traditional video. Finally, we have observed that some players need to carry out

the download of the entire hypervideo prior to its viewing.

This field of creating interactive content through hypervideo links is still evolving since there should be multiple possibilities to generate longer interactive videos. As future work, we plan to use other tools to create hypervideos and compare their ease of use, the results and the network performance when transmitting these interactive videos.

Acknowledgement

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