IP Television (IPTV) is a new service that is growing up very quick in recent years. Its implementation is performed as a Triple-Play service, being the integration of voice, high-speed data and television. Moreover, the network traffic has been increased due to the use of VoIP, video or P2P. It is also creating congestion problems to the network provider and has high impact on the quality of IPTV. For this reason, it is necessary to provide tools in order to reduce the congestion and provide the maximum Quality of Experience to the customers. In this paper we analyze the bandwidth used by a movie and we propose a video transcoder as a tool to control the congestion in IPTV networks. The results obtained are similar to the traffic shaping. The measurements obtained in our test bench shows that a video transcoder can be used to guarantee a certain QoE, in the presence of congestion.

Keywords-IPTV; Congestion control; Transcoding; Rate adaptation.

I. INTRODUCTION

One of the major issues that have to be taken into account in data networks is the congestion. There are many new services such as video, VOIP, P2P, etc., which are used massively at present that increase significantly the traffic. IPTV is being implemented by many network operators, using Next Generation Networks (NGN), in order to support adequately the new service. IPTV networks are not immune to congestion, for this reason it becomes necessary a congestion management in order to avoid the congestion state. When the traffic of the network is high, the services offered begin to degrade rapidly.

The management to avoid congestion in a network is done by the routers. They are responsible for applying different disciplines to avoid congestion on the links, and prevent deterioration of the overall network performance.

Usually network congestion is avoided by establishing a system to discard some packets from the interface queue, such as the RED [1] (Random Early Detection) which is an active queue management algorithm, or establishing a preference system for the packets or classifying the type of packets that an interface is able to forward.

Figure 1. Policing versus Shaping
II. TRANSCODER

A video transcoder is a system that converts a video stream into another stream that has more convenient video parameters in order to achieve a specific purpose (better performance, better quality image, more available bandwidth, etc.). The parameters used in the transcoder can be the bit rate, frames per second (fps), spatial resolution, coding syntax and content, as shown in figure 2.

The main application of transcoding is to enable multimedia devices of diverse compatibilities and formats to exchange video content on heterogeneous networks. A video transcoder can convert a high bit-rate TV program (as HDTV), into a lower bit-rate TV program (as SDTV), achieving to transmit more channels in the same IP network, but such reduction of bit rate will compromise the quality of video that is transmitted in the network [5]. Therefore, a video transcoder must hold a compromise between the bit rate and the visual quality, to suit the final application.

A simple approach, that let us to implement a video transcoder, is to decode completely a video stream and to re-encode the stream, creating a new video sequence containing new encoding parameters. This approach is known as cascaded transcoder, because it is a concatenation of a decoder and an encoder. A typical example is shown in figure 3.

The implementation of a cascaded transcoder is computationally expensive, because it includes among others, the motion estimation module. Therefore, to reduce the complexity of a cascaded transcoder is being studied by many research work groups.

III. RELATED WORK

Nowadays, various techniques for controlling network congestion have been proposed in order to guarantee QoE. Their main purpose is to allow the transmission of a high bit rate without problems as it is needed in IPTV. We focus the related work section on the transcoding technique as a base to control network congestion.

In [6] the authors give an overview of various techniques and research issues about video transcoding. There is a method for controlling the congestion that is based on the relationship between video contents and objective video quality, where there is a degree of influence of each network QoS parameter and the video quality. In [7], the authors have found this relationship using multiple linear regression analysis, and finally they applied the results to rate control methods.

In [8], a robust mechanism is introduced for managing network resources using application-specific characteristics of web services. They use transcoding to allow web servers to customize the size of objects constituting a web page, and hence the bandwidth consumed by that page, by dynamically varying the size of multimedia objects on a per-client basis. The main contribution of this work is to demonstrate that it is possible to use informed transcoding techniques to provide differentiated service and to dynamically allocate available bandwidth among different client classes. It is performed while delivering good quality of data content for all clients.

According to [9], the main problem in Web service is the dynamic adaptation. The reason is that there are many types of client devices with different types of communication links, thus it is needed to adapt the source to their features by varying the transmission bandwidth and to handle the heterogeneity. This paper presents an analytical framework for determining to transcode an image for the following two cases: stored-and-forward transcoding and streamed transcoding. We must take into account that these methods require different predictions such as transcoding delay, transcoded image size and network bandwidth.

In [10], the authors focus their work on the transcoded output video streams to estimate a picture-complexity, which is used for a bit-allocation strategy for joint transcoding of multiple pre-encoded MPEG video streams. Simulation results show that their proposed algorithm can achieve better video quality compared to other reported algorithms. According to this paper, it is important to emphasize that the complexity measure does not reflect the complexity of the transcoded output video.

The authors of the work in [11] have implemented an algorithm that it is responsible for manipulating the original set of video bit streams given an object-based framework. They introduced a new framework for video content delivery that is based on the transcoding
of multiple video objects. In the paper, they consider manipulations of object-based video content (and more specifically, the manipulation from one set of bit streams to another trying to reduce the bit-rate without losing quality of service), where the transcoder attempts to satisfy network conditions or user requirements.

There is a proposal of a novel architecture for the transcoding of Fine Granularity Scalability (FGS) coded video to a single-layer format in [12]. The conclusion is that their architecture has almost the same performance as the cascaded transcoding method, but with much lower complexity.

In [5] the authors discuss some techniques for reducing the complexity related to video transcoding.

In [13], the authors propose other IPTV architecture, which fully takes the advantages of scalable video for adaptation to full-duplex networks.

An important part in an IPTV system is the set-top-box. It decodes digital multimedia streams into legacy video signals for the customers. In [14], an interesting conclusion is given: IPTV problems are caused by transfer network deficiencies, and they are detectable using a relatively simple analysis. An exhaustive analysis in the client side has been realized at [15]. This paper concludes that transcoding process depends on performance of the Personal Computer, and unexpectedly MPEG-2 and MPEG-4 had better performance compared to H.264. But using a personal computer with higher hardware features, it is possible to make better results with H.264 codec.

IV. BANDWIDTH TEST IN A IPTV SERVICE

The transcoding technique improves the performance of a transportation system and its consumed bandwidth by reducing the parameters of a video. Traffic shaping technique can adjust the flow of data to achieve stability in the traffic, so we can use the technique of transcoding to get the effect of traffic shaping on the bandwidth of an IPTV service.

A. Test Bench

In order to make our tests, we simulated a network with an IPTV video server that transcodes a movie in DVD which has the following characteristics:

- MPEG-2 coding
- Resolution of 720x576
- 25 fps
- 120 minutes long
- DVD-Quality

The choice of DVD standard due to its intrinsic high performances in terms of resolution, frame rate and bit rate.

We used VLC Media Player [16] as an IPTV video server to send the SDTV video streams, and the Clearsight Analyzer Software [17] to capture packets of video and measure the visual quality. This is the visual quality that will receive IPTV customer. The topology of the test bench used is shown in figure 4. We used a switch to connect all the devices of the IP network.

B. Bandwidth needed by different compression format types

The estimated capacity for IPTV services is 1.5 Mbps for each Standard Definition Television (SDTV) channel and around 8 Mbps for each High Definition Television (HDTV) channel. Around 1 Mbps has to be added to this bandwidth values because of the headers of the low-layer protocols used to access the IP network. Depending on the bandwidth offered by the service provider, several channels can be offered simultaneously (2 or 3 SDTV channels plus 1 HDTV channel).

Before using a video transcoder to reduce congestion on a network, we analyze the bandwidth used by a short test video with 5 different compression format types, in order to get a reference bandwidth model to be used in our test bench.

We selected the same compression bit rate value for all video formats types; because different compression bit rate will have an impact in the bandwidth measurement. The selected compression bit rate value was 2000 Kbps; due it was the highest value in common for our selected compression formats types at our video converter software [18].

Where MPEG-2 was used as our primary compression format, while MPEG-4, H.264, Divx and Xvid, were selected as secondary compression formats to create the short test videos. Nowadays, they are widely used as video encoders. We play the movie in the VLC Media Player and we measured the bandwidth received by a customer to get our bandwidth model.

In figure 5, the bandwidth required by the streams of all compression formats in our tests is shown. We started the transmission in the 15th second. The lines presents bursts traffic (peaks values), due to an increase in the size of the frames (Intraframes, Interframes) in the video stream. Figure 6 shows the comparison of the average bandwidth value used by the four codec, which was used to create table1.
In order to show the how much the bandwidth is reduced, we compared MPEG-2 with all secondary compression formats. It is shown in table 1. The largest reduction is made by MPEG-4 with a 9.26%.

### Table 1. Bandwidth reduction compared with MPEG-2

<table>
<thead>
<tr>
<th>Compression Format</th>
<th>Reduction percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.264</td>
<td>1.95%</td>
</tr>
<tr>
<td>Xvid</td>
<td>4.39%</td>
</tr>
<tr>
<td>Divx</td>
<td>7.31%</td>
</tr>
<tr>
<td>MPEG-4</td>
<td>9.26%</td>
</tr>
</tbody>
</table>

In order to show the how much the bandwidth is reduced, we compared MPEG-2 with all secondary compression formats. It is shown in table 1. The largest reduction is made by MPEG-4 with a 9.26%.

#### A. Bandwidth for IPTV

We play the DVD movie in the VLC Media Player and we measured it by the Clearsight Analyzer Software. In figure 7 the behaviour, that presents the bandwidth on a network during the transmission of a movie without applying transcoding, is observed. Its bit rate was 4500 Kbps.

The authors of [19] say that a MPEG-2 encoder for DVD can be designed for a Variable Bit Rate (VBR) or Constant Bit Rate (CBR) using a bit rate from 0 to a maximum of 1000 Kbps. Our DVD movie has a VBR coding scheme, which create an irregular bandwidth waveform on the network. Data bursts are produced by the variation of size of the frames (I, B, P) of the DVD movie. By studying the values of figure 7, we can conclude that the bandwidth is very irregular along the time, and there are a lot of bursts in the video stream. The highest peak had 8.5 Mbps, the lowest peak was 3.3 Mbps and the average value was 6.2 Mbps. As an IPTV network transmits more than one channel simultaneously, thus it is logical that it could reach the point of congestion and produce the effects aforementioned in section 1.

#### B. Using transcoding in IPTV

In order to test the transcoding, we transmit the movie using the test bench shown in figure 4. The video transcoder is implemented using the VLC software, which has the capability to stream and to transcode simultaneously.

For our test we set the video transcoder to a bit rate of 4500 Kbps, lower bit rate are not recommended for STDV. We kept the other parameters of our movie unchanged. These parameters are: the resolution to 720x576, 25 fps, and MPEG-2 coding. Figure 8 shows the bandwidth consumed when the video transcoder is implemented. It is a regular bandwidth because the original movie has been transcoded using a CBR. When CBR is used, the encoded video has similar frame size (I, B, P), and therefore the use of bandwidth in the network is a constant value. Observing figure 8 we can conclude the following: There are not bursts in the video stream, with an average value near to 5.2 Mbps, and a regular bandwidth across the time, which result very similar to the traffic shaping technique performed by a router.

#### C. Bandwidth comparison

In this section we are going to compare the values of the bandwidth obtained in previous sections, with the aim of analyzing the network optimization. The statistical values of the figure 7 and figure 8 are detailed in table 2.
When analyzing the average bandwidth of the 2 examples, we see that when we implement a transcoding system, there is a decrease of 16.1% of the bandwidth consumed. The variance is reduced to 86.9%, which indicates the presence of almost no traffic in bursts, allowing us to conclude that our transcoding system can be considered as a data shaper.

D. Visual quality when the transcoding is applied

QoE is a term standardized by the ITU (International Telecommunication Union), which is quantified in terms of Media Opinion Scores (MOS) [20]. MOS scores are used for the subjective assessment of the quality of television pictures. MOS scores are rated on a scale of 1 to 5, where 5 is the best possible score, and indicates the degree of the user’s satisfaction. In order to evaluate our proposal of transcoding, we have used a monitoring application [17], which provides an assessment of MOS for an IPTV service.

The valuation obtained by the monitoring application, is shown in figure 9. It indicates a reduction in the visual quality of the transcoded movie to values close to 4.21 points on the MOS scale. It also indicates that the movie without transcoding maintains a value above the 4.33 points, which is slightly higher than the first case. But according to the valuation of the MOS scale [20], values between 4.0 and 5.0 are considered high satisfaction.

V. TRANSCODING PROPOSAL FOR IPTV

One advantage of having a traffic management scheme is the ability to guarantee a certain QoS (delay, jitter and packet loss). When the data traffic of a link is increased and reach its maximum capacity, the performance at the customer side will decrease considerably.

An example of the above issue is shown in figure 10, where there are 6 IPTV users watching different movies. If we take the average bandwidth from table 2 (movie without transcoding) as reference, we need 37.2 Mbps to give service to all users (from the VoD server to the ADSL distribution router).

We will assume that the link between the Core MPLS network and the ADSL distribution router is a T-3 link (45 Mbps), and the users will connect to the VoD server sequentially with an interval of 5 minutes. The IPTV visual quality and the QoE of the users will decrease rapidly when there are many users. Although the link has a bandwidth of almost 45 Mbps, it is insufficient for 6 users, because we only have taken the average value and not the maximum value for the bandwidth estimation.

A solution to this issue is the implementation of the QoE management system proposed in [4] by the same authors. It could activate a video transcoder to reduce the bit rate of video flows, when the link capacity becomes full. According to this, if we take the average bandwidth given in table 2, 31.2 Mbps is needed for the transcoding technique, which is 16.1% lower than for the first case and fits very well to a T-3 link.

Figure 11 is an example of how all users can access the VoD server, where a QoE management system activate a transcoding system, allowing all users to continue watching their TV programs, while the QoE assessment remains at an optimum value for users.

VI. CONCLUSIONS

In this paper we proposed a system that adapts the variations of traffic of an IPTV service, in order to avoid network congestion and, therefore, packet losses that affect the visual quality and therefore the User’s QoE. We have implemented a video transcoder as an alternative technique to traffic shaping to reduce the bit rate of a video stream, since traffic shaping generate some delay, that affect the Network’s QoE, for this reason our proposal in for IPTV system, and not for traditional data services like Internet.
In our tests we have verified that the proposed system achieves a very effective video adaptation, attenuating the burst of video and getting a lower consumption of bandwidth in a network. Although, this reduction produces lower visual quality, when the reduction in bit rate does not exceed a certain value, it is not perceptible by the user.

Our proposed transcoding system can be implemented in a QoE management system, as a proactive method of congestion control, or as a method to reduce the bit rate of IPTV’s channels and adapt them to links that have a lower transport capacity.

Our future work will be focused on changing other video parameters, such as the resolution and the frames per second, designing an algorithm to maximize the QoE of the user, and integrate the transcoding technique in a QoE management system.

VII. REFERENCES


[16] VLC Media Player. At http://www.videolan.org/vlc/


