MulticastVideo in nonQoS network

Multicast video transmission over best effort networks based on adaptive compression in a 3D subband coding

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Abstract

Multicast techniques are the only way to simultaneously provide flows of information from one source to several destinations. The intention of this paper is to study the feasibility and to evaluate the multicast techniques for video transmission over best effort network services, using a videocoder based on an adaptive video compression algorithm with a 3D subband coding. These best effort network services are Available Bit Rate (ABR) over Asynchronous Transfer Mode (ATM) and Internet services over IP (TCP/IP architecture). Due to this adaptation process, the videocoder will work trying to do its best independently of the network configuration by the feedback of each node within the multicast tree, using the available network resources. We discuss the results obtained by simulation and as a final conclusion we will see how this videocoder can adapt faster and easily to the changing network conditions.

1 Introduction

Different multicast techniques and different network technologies are being analyzed to determine which one offers better performance for multimedia traffic. This study is more relevant when the network offers best effort services because in this scenario it is more restrictive to maintain a certain Quality of Service (QoS) for this kind of applications using the available network resources.

These multicast techniques differ both for ATM and for TCP/IP (Transmission Control and Internet Protocol) in a best effort network service. For ATM we will consider Available Bit Rate (ABR) service, which is defined in ITU-T 371. Both ABR and TCP/IP class of service were initially conceived to support data traffic, but their service model is based on the best-effort paradigm but enhanced by some specific and particular characteristics.

Over ATM-ABR, we have to manage different Resource Management Cells (RM) for each destination, while QoS is more realistic. Nevertheless over TCP/IP, we have a similar mechanisms to RM cells using Real Time Control Protocol (RTCP) in RFC-1889, but we need to be more careful with the QoS. Interesting works related to this topic can be found in the bibliography at [1].

The rest of the paper is structured as follows: in Section 2 describes the operation of the adaptive videocoder based on 3D subband coding; in Section 3 describes the measures of quality in our proposed video system; in Section 4, we talk about the implementation over ATM and in Section 5 we describe the implementation over the TCP/IP architecture. Finally, Section 6 presents the conclusions and ideas for future work.
2 Subband VideoCoder

A video compression algorithm is based on three steps: a decomposition process, a quantization process and finally an entropy coding process. But if adaptive performance is required, each process requires a suitable design. Adaptability means multiresolution, and multiresolution can be implemented using a subband decomposition or subband coding. A subband decomposition is a process where the information is decomposed in subbands at different levels of resolution. A video signal can be decomposed in a 3D domain, see reference [2].

Each subband has a different resolution level of the original video. Obviously, depending on the video information of each subband, not all subband have same relevance from the Human Visual System (HVS) point of view, because the humans have different perceptual responses to these subbands. This perceptual priority will determine the order in which subband are going to be transmitted and also the amount of bits given to each subband by the Bit Allocation procedure. More details about this videocoder can be found in [3].

3 Quality parameter for video transmission over best effort networks

The objective of this paper is to evaluate the multicast transmission of video in best effort networks. For this evaluation process we will use the videocoder as described in Section 2.

We evaluate the quality of the video in two ways. These two ways of measure will show us the feasibility of the proposed system. First, we evaluate the visual quality of the reconstructed video when it is received in the decoder, using different network configuration. This subjective method is very interesting, because the final client is a human and the visual quality is an important information about the feasibility of the system, rather than other measures like Signal-to-Noise Ratio (SNR) which are based on Mean Square Error (MSE), certainly not a visual quality measure. Second, we estimate the probability of arrival of different subbands once the videocoder decided to transmit them. This is a conditioned probability. With this probability we can see how the videocoder adapts to the network changes, independently of the network configuration.

4 Implementation over ATM networks

In ATM networks, the ABR class of service was initially conceived to support data traffic. The ABR service implements a rate-based closed-loop congestion control to improve the best effort service. The ABR class of service has next characteristics: fair sharing of the available resources among the contending ABR connections and a closed-loop feedback mechanism with RM cells with each destination. This congestion control inserts periodically RM cells. The RM cells have a field called Explicit Rate (ER), which contains the suitable rate to avoid the network congestion, calculated by the switches within the multicast connection.

The congestion control is implemented in the ATM switches, by the switch algorithms [4] and [5]. This switch algorithm calculates the suitable rate to avoid the network congestion and write it in the ER field of the RM cells, when they pass through the switches. It is necessary two types of algorithms to support multicast connections in ABR: the unicast algorithm and the multicast algorithm.

The unicast algorithm calculate the available bandwidth in each individual link of the connection. The unicast algorithm calculate this bandwidth and distribute the available bandwidth between all ABR sources which share the link [4].

Nevertheless in a multicast tree, when different connections over the same source are running simultaneously, this closed-loop feedback with each destination becomes a problem, because
each destination is providing different information to the source. The switches within the multicast connection (or multicast tree) have to manage different RM cells to the same source, what is called a multicast congestion control.

The multicast algorithm has two main functions [5]: to decide when a backward RM cell has to be sent to the source and which bit rate has to be written in the ER field of the RM cell. To calculate this suitable value, the switch evaluates the external information, given by the RM cells which arrives through the all multicast links and also the internal information (state of overload) of the switch. The multicast algorithm take this two kind of information and calculate the suitable rate to avoid the multicast connection congestion, normally working at the bottle neck bandwidth. This task is called consolidation of the information.

An improvement about this multicast algorithms for multimedia traffic can be found in [6], which determines a trade-off between minimum and maximum available bandwidth.

5 Implementation over TCP/IP architecture

On the other hand, over IP networks we can find a similar features as described above, using the Differentiated Services (DS) and RTCP, but also in this case new problems appear when we are trying to manage QoS. This requirements are being studied from Integrated Services (IS) and Differentiated Services (DS) in RFC-2475. The latest publications suggest for scalability and flexibility reasons the usage of DS techniques.

Although multicast techniques differ from ATM and TCP/IP architecture, they show certain similarities. We must keep in mind that the RM cells behavior is similar to Real Time Protocol and Real Time Control Protocol (RFC-1889 and RFC-1990). Then, the feedback mechanism to the video source is available, which means that the same video adaptive mechanism for ABR-ATM is also suitable in these networks. It is also remarkable, that within a video stream we could select and assign different priorities using different labels by DS.

6 Conclusions and future work

6.1 Conclusions

![Figure 1. Allowed Cell Rate value for the videocoder in a multicast transmission](image.png)
We have simulated different ABR switch algorithms, to evaluate which of these algorithms works better with the subband videocoder over the Forest video sequence, see figure 2. For instance, in figure 1 we can see the available bandwidth given to the videocoder. Using this value as the available bandwidth for the videocoder, in the worst case in the multicast...
connection we have reconstructed two frames, both at 800 and 960 ms. The reconstructed frames are in figure 3 and 4, respectively. For these figures we have available 1.908 and 0.361 Mbps, which means a compression ratio of 10.62:1 and 56:1.

We have shown the feasibility of the multicast video transmission over a best effort network. As can be seen in figure 3 and 4, the proposed videocoder has a good performance in this kind of networks, and it is a suitable coder when the network does not guarantee QoS.

Also, because subband based videocoders must maintain subjective quality constant, they have to minimize the loss probability for the subbands that carries the most relevant information, as described in Section 3. When a subband is transmitted because the compression algorithm thinks so, then two things can occur, or a correct arrival \( p(A) \) or an incorrect arrival \( p(E) \), where probability of transmission is \( p(T) = p(AT) + p(ET) \). A further study can be found in [7]. From this study is derived that a good adaptive videocoder will keep a conditioned probability \( p(A|T) = p(AT)/p(T) \) nearly 1 over the most relevant subbands. In this case, the video transmission over ABR-ATM fits this condition.

### 6.2 Future work

Despite the benefits of our videocoder, the system can be improved in many ways.

In our ATM implementation, we can identify at least three types of traffic: data traffic (not real time), less priority video traffic (less important subbands for the HVS) and high priority video traffic (the most important subbands for the HVS).

Using this priority it would be a good idea to introduce a mechanism which let us discard cells taking into account these priority and the congestion level of the switch. Being assigned these priorities and with a random discard in the queues of the switches, it will be possible to avoid congestion. If there is low congestion, we only discard cells of the data traffic. If the congestion increases, we discard cells of data traffic and cells of the less priority video traffic. If the overload is heavy, we discard cells of all types of traffic.

### References


