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ROBUST MEDIA STREAMING STRUCTURE OVER THE INTERNET

BY

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Abstract. Media streaming applications over the Internet often have to respect relatively tight effective bandwidth and delay constraints, and yet to achieve acceptable visual quality at the receiver. This paper presents a hardware structure for efficiently streaming scalable video from multiple servers over heterogeneous network paths, in order to implement a flexible and adaptive live and on-demand video experience. This heterogeneity must therefore be considered to enable each client to receive the video stream that best fits with its networking and processing capabilities. We provide a solution for many scenarios where the loss probability on each server–client path is not known. Simulation results and the implementation finally demonstrate the efficiency of the proposed structure, in distributed streaming scenarios over heterogeneous network.

Key words: scalable video compression; internet video streaming; video servers.

1. Introduction

Media streaming applications over the Internet often have to respect relatively tight effective bandwidth and delay constraints, and yet to achieve acceptable visual quality at the receiver (Alpcan *et al*., 2009). This paper

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proposes a hardware structure for efficiently streaming scalable video from multiple servers over heterogeneous network paths. We use Windows Media Servers and Adobe Streaming Servers, each server acts as an independent source, without the need to coordinate its sending strategy with other servers (Daily, 2010; Microsoft, 2011). This work deals with the streaming of videos, which are either dynamically produced or pre-recorded, to clients who receive and play information on-the-fly. It targets a massively scalable distribution, with potentially several hundred of concurrent clients, and multicast-IP is therefore unavoidable. This heterogeneity must therefore be considered to enable each client to receive the video stream that best fits with its networking and processing capabilities (Hsu *et al*., 2010).

2. Analysis of Media Streaming User Types

The present paper draws on a two-year study conducted for the Alfa Omega TV station. Although the first streaming services were provided by this TV station in 2002, they have been constantly developed and upgraded following a thorough analysis of the users' needs, on the basis of the connection logs and statistics retrieved from the local servers, of the regular reports issued by specialized sites (Google Analytics, Trafic.ro), and of various surveys. Lately, social networks such as Facebook and Youtube have been used for promotion, which led to the emergence of important demographical indicators.

Whereas in the early years, the initial number of connections was extremely reduced due to the fact that not all users owned a high-speed connection, starting with 2009, a significant increase in the number of bandwidth users that can view video materials online was noted. Over the last years, the demand for increased quality-broadcast signal has risen and has generated a top-quality IPTV signal, as well (Tu *et al*., 2008).

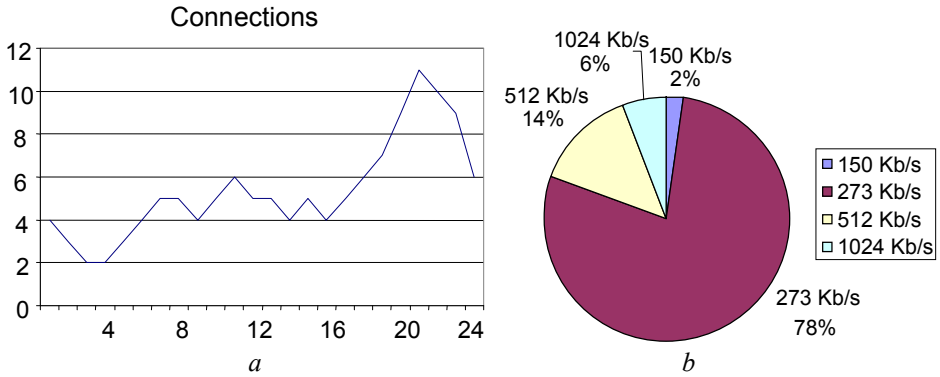
Four years later, three topic-oriented LIVE channels (a children's channel, a cultural/documentary channel, a movie channel) were introduced to meet users' needs. The children's channel has shown a steady number of connected customers and extensive duration of connections, pointing to the fact that they were constantly used in the daytime and less at night. The connections from the USA and Australia were the most preponderant. In the evening, the users seemed to prefer the movie channel or the documentary channel.

Initially, the quality of the video streams was less important so that compression rates of 150…273 Kb/s were regarded as sufficient. Gradually, however, the shift of compression to a multi-bitrate scalable option, capable of transmitting programs using more quality levels, has become necessary. Thus, the server can decide on the optimal stream for a user, according to the quality of the connection. A higher definition stream was introduced six months ago, but its maintenance in financial terms has required a paid subscription IPTV system, the number of customers slightly increasing from one month to another.

The Fig. 1 shows an one-year graph of the mean connections made throughout a day. One may notice an uneven load during a day and, as a

consequence, less-demanding time intervals are used to provide servers with fresh programs.

Analysing the evolution of clients for video on demand and for live channels, one can note an increasing attraction for video on demand, compared to live programs. This tendency is quite predictable, users prefer to access favorite programs in their own time and pace.



a *b*

Fig. 1 – The load of servers load during a day (*a*); the users distribution of the used video streaming quality (*b*)

A clear difference has been remarked when analysing the connections from the United States, the second-largest source of connections, whose users prefer video on demand in a larger proportion than the rest of the users (presented in Figs. 2 and 3). The sole exception to the VOD (video on demand) dominance is represented by live broadcasts of highly- promoted special events, when peak numbers of viewers were observed, connection levels climbing 10…25 times higher than average.

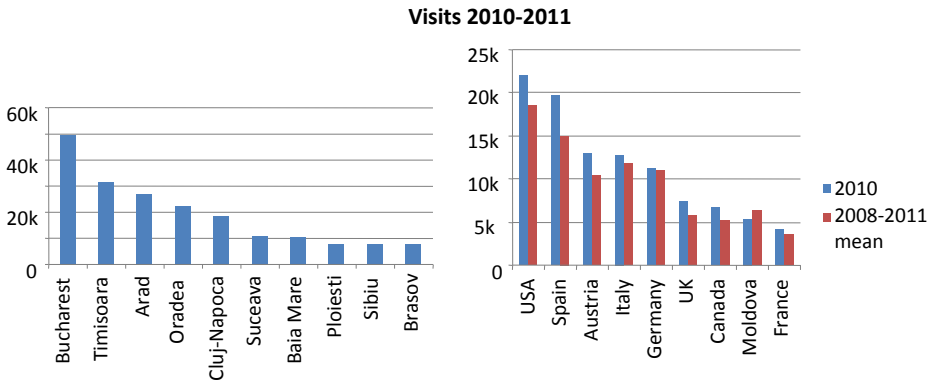
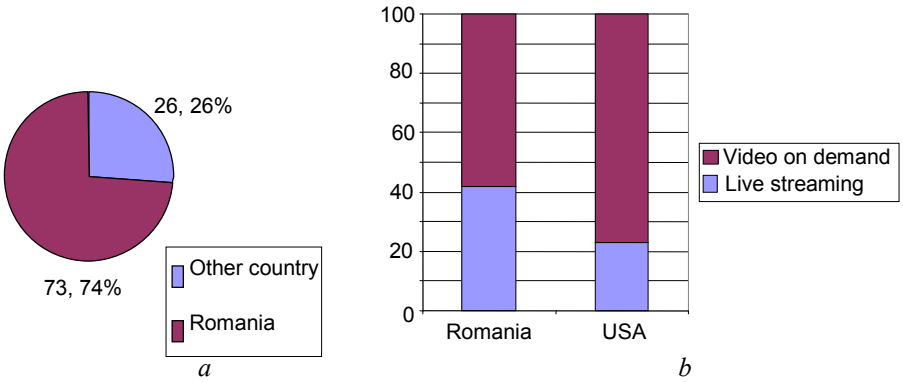


Fig. 2 – The Romanian and international visitors' distribution.

The rapid development of social networks over the last few years has enabled the direct or indirect (based on users' recommendations) promotion of

streaming channels and of video-on-demand programs. Connecting an individual user's social network profile to a certain video program allows detection of personal preferences and details such as age, a key parameter that cannot be inferred from streaming server logs. Consequently, policies to promote certain programs or to stimulate different age groups can be established. Several studies on connections over programs *via* Facebook and Youtube have been carried out.

The development of forums and message posting has enabled a more detailed understanding of the users' interest in online video.



a *b*

Fig. 3 – The rate of the users from Romania and other country (*a*); live streaming *vs*. Video on demand in Romania and USA. (*b*)

Interestingly enough, the Youtube demographics reflect the television audience of Alfa Omega TV. The target audience, adults of age 35…55, is revealed as the dominant Youtube group, accounting for around 50% of the total views, making Youtube an effective, cheap way to mirror and complement one's streaming strategy. However, even though the video content is clearly targeting adults, 30% of the video views were from the 13…24 age range, a good indicator that the Youtube medium can bring other audiences to one's video content. Facebook, while still a social medium, proved to be radically different than Youtube with regards to demographics. The Youtube-dominant people aged 35…55 represented only 23% of the total number of Facebook fans, with young adults aged 13…24 dominating the spectrum. This can be explained by Facebook's late appearance in Romania compared to Youtube and the slow penetration with the target audience of 35…54 that generally lacks time for social media. Nevertheless, this discrepancy dictated that different approaches need to be taken with regards to placing content on these two social media platforms to target the particular audiences.

Another important aspect is the analysis of fees and of the infrastructure of the internet providers. In Romania, one notes a very low fee for the majority of providers, especially for metropolitan traffic and for the ISP's national

network, encouraging users to cluster around a single provider in order to have high speed for transfers among themselves and the lowest possible cost. Inter-network traffic between different internet providers and the international traffic are more expensive. A structure for media streaming should offer, in addition to its technical performance, the lowest possible cost for transmission and maintenance, therefore its design has considered these aspects, as well.

3. The Proposed Robust Structure for Media Streaming over Internet

Following the analysis of studies and statistics described above, we designed the streaming architecture that meets the users' needs, represented in Fig. 4.

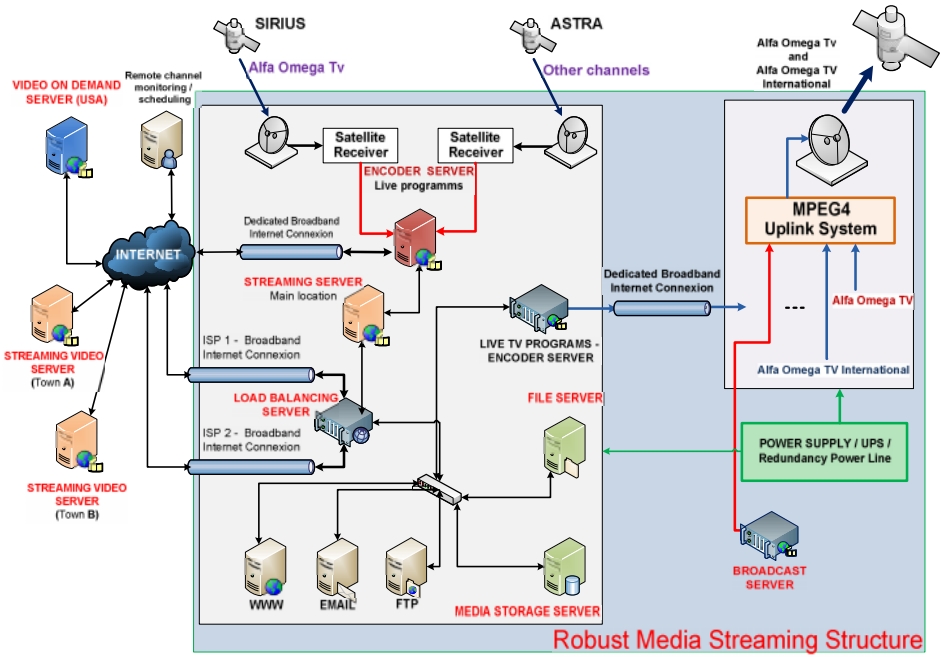


Fig. 4 – Robust media streaming structure over the Internet.

This complex system must allow two types of services – Video on Demand, and Live Streaming (both from live sources, as well as channels scheduled from pre-encoded files). The live sources are TV channels received *via* satellite or other video sources, encoded in real-time by a computer operating dedicated compression boards (ENCODER SERVER). Other file-based thematic 24/7 channels are generated by the server in the main location (STREAMING SERVER – Main location). On this main server will also reside the Video on Demand programs.

A Load-Balancing Gateway Server should be also used to balance the load between the two most important local Internet providers. In various situations and locations, there can be more than two local providers, so the optimal load-balancing solution can vary. Behind this Gateway server there are the other dedicated servers: WWW, Mail, FTP, FileServer, and Media Storage Server.

To make the most of metropolitan bandwidth (cheapest), we reached the conclusion that to achieve an optimal quality, bandwidth for the lowest possible cost, it is more advantageous to operate mirror servers in key cities generating heavy video traffic, thus removing load from the main server. In this case it was optimal to co-locate a mirror server in a datacenter where access to local Internet providers' metropolitan networks was easy. For redundancy, a small Internet bandwidth was also acquired which should the main server reach 100% load, but the primary purpose of the collocated mirror servers was to operate in high-speed metropolitan networks. To achieve this, a geo-location script was developed on the main streaming server that allocates users according to their location to secondary servers to optimize the streaming load. This was very helpful for special events viewed by a larger audience. To feed these mirror servers with Video on demand and live video streams for rebroadcast, dedicated high-quality broadband connections were used.

Following the Video-on-Demand studies, we deployed a dedicated server for video on demand, collocated in the United States, for the Diaspora users. For the live channels, these users connect to the main server, as this server is under reduced load at the time they access the live stream due to the different time zone.

4. Conclusions

We provide a solution for many scenarios where the loss probability on each server client path is not known. Simulation results and the implementation finally demonstrate the efficiency of the proposed structure in distributed streaming scenarios over heterogeneous network. The usage of multiple streaming servers provides better robustness in case when one of the channels becomes congested. As the data packets most likely take different paths from their respective source to the client, the overall network load can be balanced, and the most reliable paths can be exploited more efficiently.

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STRUCTURĂ ROBUSTĂ PENTRU MEDIA STREAMING PRIN INTERNET

(Rezumat)

Se prezintă o structură pentru o configurație de echipamente ce asigură servicii de media streaming care realizează o bună redundață a funcționării precum şi servicii distribuite. Utilizând această structură se pot evita întreruperile în furnizarea serviciilor datorate defectelor hardware la nivel de server, precum şi asigurarea calității serviciului de streaming la costuri rezonabile prin utilizarea unei structuri distribuite, scalabile, care să compenseze problemele de rutare, congestionare şi heterogenitate ale Internetului. Este adaptată la cerințele utilizatorilor studiate pe o perioadă de peste 12 luni.