Robust and Scalable P2P Streaming for Future Media Internet

A. J. Gonzalez [a b], A. Rios [a b] and J. Alcober [a b]
[a] *Universitat Politècnica de Catalunya, Barcelona, Spain*
[b] *i2CAT Foundation, Barcelona, Spain*

Abstract. Future Media Internet will require to share and distribute high quality multimedia contents and services in a flexible, efficient and personalized way through dynamic and heterogeneous environments. One approach for fulfilling this is by means of taking advantage of P2P distribution techniques and the use of source coding techniques such as MDC and SVC. This paper discusses these issues based on the real experience of the authors and highlights their applicability in Future Media Internet initiatives in order to solve future challenges.

Keywords. Media, Streaming, MDC, SVC, P2P, Future Internet

Introduction

The impact of Peer-to-Peer (P2P) traffic is growing fast and supposes the major part of current Internet traffic. However, today, video streaming applications are the bandwidth most-hungry applications and this tendency is envisaged to grow exponentially, even more with P2P streaming applications.

P2P technology, as an alternative to traditional client-server model, has provided a scalable framework for any kind of content distribution. Currently, this kind of applications are arousing great interest both in academic research and industry. In fact, P2P inherently solves some problems considered in Future Internet discussion [1][2]. P2P techniques offer important benefits in terms of scalability, robustness, fault-tolerance, self-organization, low-cost deployment, etc. However, they still have to cope with important challenges [7] due to the heterogeneity and dynamicity of this kind of networks. Nowadays, there are initiatives such as P4P (Proactive network Provider Participation for P2P) [3], DSN (Distributed Services Network)[4] or PPSP (Peer-to-Peer Streaming Protocol) [5], which are supported by industrial and developers of P2P applications, which try to take advantage of applying P2P techniques in the proposal of new ISP architectures for content distribution or creating new standardized protocols for streaming media over the Internet, thus solving some interoperability issues among applications.

In this context, we have been working in the distribution of media contents in Peer-to-Peer applications. Our experience is focused in the study and application of source coding techniques, concretely in the use of Multiple Description Coding (MDC) and Scalable Video Coding (SVC) in P2P applications. We have experimented and checked the correct operation of these techniques in P2P environments and observed the benefits in terms of robustness and scalability. Robustness is given by introducing some redundancy in the information, which is going to be distributed through multiple paths under different network conditions (high packet loss rate, high latency, etc.). Scalability is obtained because it is possible to reach heterogeneous terminals (from a powerful PC to a low-capacity mobile phone) connected by different types of networks (wired or wireless). These features are key for the success of future media streaming services because they allow to provide adapted and personalized media according to the specific context of users while achieving better performance of streaming applications in high dynamic and heterogeneous environments such as P2P.

Nowadays, it is being discussed how the Future Internet should be. It is possible to identify two types of views in the scientific community: incremental/evolutionary or clean-slate (proposes to start from scratch). These proposals try to solve current Internet problems by means of more efficient and flexible architectures and protocols. In this sense, this work proposes the use of source coding techniques as a promising solution in the design of Future Internet protocols and media streaming components. They provide solutions to some current and future challenges in media streaming, and also we remark their benefits when applying them to a P2P streaming platform both for distributing live content and pre-recorded files.

This work makes an overview of MDC and SVC source coding techniques in section 1. Section 2 describes how some Future Media Internet challenges can be fulfilled by using P2P and source-coding techniques. Finally, Future work and the inferred conclusions are presented in sections 3 and 4.

1. Robust and scalable media coding techniques overview

This section briefly describes two of the main media source-coding techniques: MDC and SVC.

1.1. Multiple Description Coding (MDC)

MDC is a source coding technique, which encodes a signal (this case a media resource) into a number of N different sub-bitstreams (where $N \geq 2$). Each bitstream is called "descriptor" or "description". The descriptors, which are all independently decodable, are meant to be sent through different network paths in order to reach a destination. The receiver can make a reproduction of the media when any of the descriptors is received. The quality of the reproduced media is proportional to the number of descriptors received. Thus, the more descriptors are received, the better the reconstruction quality is. The idea of MDC is to provide error-resilience to media streams. Since an arbitrary subset of descriptors can be used to decode the original stream, network congestion or packet loss, which are common in best-effort networks such as the Internet, will not interrupt the reproduction of the stream (continuity) but will only cause a (temporary) loss of quality.

1.2. Scalable Video Coding (SVC)

SVC, also called Layered Coding (LC), adapts the video information to the network constrains splitting the images into different hierarchical layers (similar to MDC descriptors). These layers represent the quality of the image, so, from the base layer, each successive layer improves the image quality, getting the full picture quality with the total amount of layers used. Concretely, SVC is the name given to an extension of the H.264/MPEG-4 AVC video compression standard. It must be noticed that the main difference between MDC and SVC is that MDC creates independent descriptors (can be balanced or unbalanced) while SVC creates hierarchical dependent layers (unbalanced).

2. Future Media Internet trends and challenges and source coding

Many efforts around the definition of future trends and challenges have been realized in order to serve as guidelines for future research. Regarding to Future Media Internet, studies such as [1], offer an overview of them. Future Media Internet is envisaged to provide efficient mechanisms to share and distribute rich multimedia contents and services with higher quality and flexibility anywhere, anytime and using any terminal, allowing to improve the quality of experience of users. In this environment, the following issues will be required: to create new transport protocols, new multimedia encodings, "Cross layer" interaction, efficient intercommunication among machines, creation and distribution of rich contents (such as new 3D contents), community & cooperative networks and to take advantage of P2P mechanisms. Research on these topics will allow to develop and deploy novel applications covering Future Internet requirements while improving the Quality of Experience (QoE) of the users.

Considering Future Internet challenges and requirements, we checked that both MDC and SVC are a good approach in order to cover some of them (see Table 1).

Table 1. Future Internet Requirements covered by source-coding techniques

Requirement	MDC	SVC
Content adaptation (personalization and adaptability to network and terminal conditions)	Yes	Yes
Robustness against loss effect	Yes	No
Scalability	Yes	Yes
Flexibility	Yes	No (Codec dependent – H.264)
Real-time communication	Yes (live and pre-recorded contents)	Yes (pre-recorded content) / No (live content)

From Table 1, one can deduce that MDC is a more flexible encoding technique than SVC. This is mainly due to strict hierarchical dependence that exists among layers. In addition, SVC is an extension of the H.264 media codec, while MDC is a pre-processing stage of media where each generated descriptor can be encoded later with any current of future codec in order to be transmitted over the network. However, MDC and SVC can also work together if necessary, so, they can complement to each other in terms of functionality. Another important issue that must be taken into account is that encoding SD and HD contents with SVC in real-time by software using a domestic PC is not currently possible due to the high processing capacity which is required. This makes difficult to apply this technique to the distribution of live contents. On the other hand, we could achieve to encode up to 720p HD content in real-time using MDC with a Pentium Quad Core@2.4GHz, thus, allowing to distribute live content gathered from a DV Cam.

By applying MDC techniques in a P2P streaming platform (CoolRuc[6]), we could achieve to enhance the robustness of high quality (SD and HD contents) media distribution by improving the continuity index and the received objective quality (measured by means of PSNR) under the effects of high packet loss in comparison with sending a single descriptor, thus, improving the Perceived Quality of Service (PQoS) of the users. On the other hand we were able to send a content in several resolutions allowing the users to receive the contents in a personalized way. Due to space limitation, simulation and experimentation results are omitted.

3. Future Work

Currently we are using balanced MDC in order to reduce the start-up delay in P2P streaming applications. In addition, we are also researching the applicability of incentive mechanisms in order to improve the performance of these applications in terms of continuity index, experimented delay and global received quality under the effects of churn and the presence of free-riders.

4. Conclusions

This work has presented an overview of MDC and SVC as source coding techniques for media content distribution over heterogeneous networks. These coding schemes allow to provide robustness and scalability to media streaming communications. In addition, they can enrich P2P streaming applications as checked by means of an experimental P2P prototype called CoolRuc. The combination of these techniques and P2P are expected to fulfill some Future Media Internet challenges. Concretely, they suppose a good approach to enable future personalized applications and services, operating under high heterogeneous and dynamic environments while maximizing the QoE of the users. Additionally, we remark the flexibility of MDC vs. SVC and the possibility of using both together. Finally, we encourage Future Internet initiatives to take into consideration these techniques when designing new protocols and architectures as possible enablers of innovative services and applications.

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